PCB Bioaccumulation Model Calibration:

Food Chain Model (FCM)

General Electric
Housatonic River
Site, Rest of River

Public Meeting
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Pittsfield, MA

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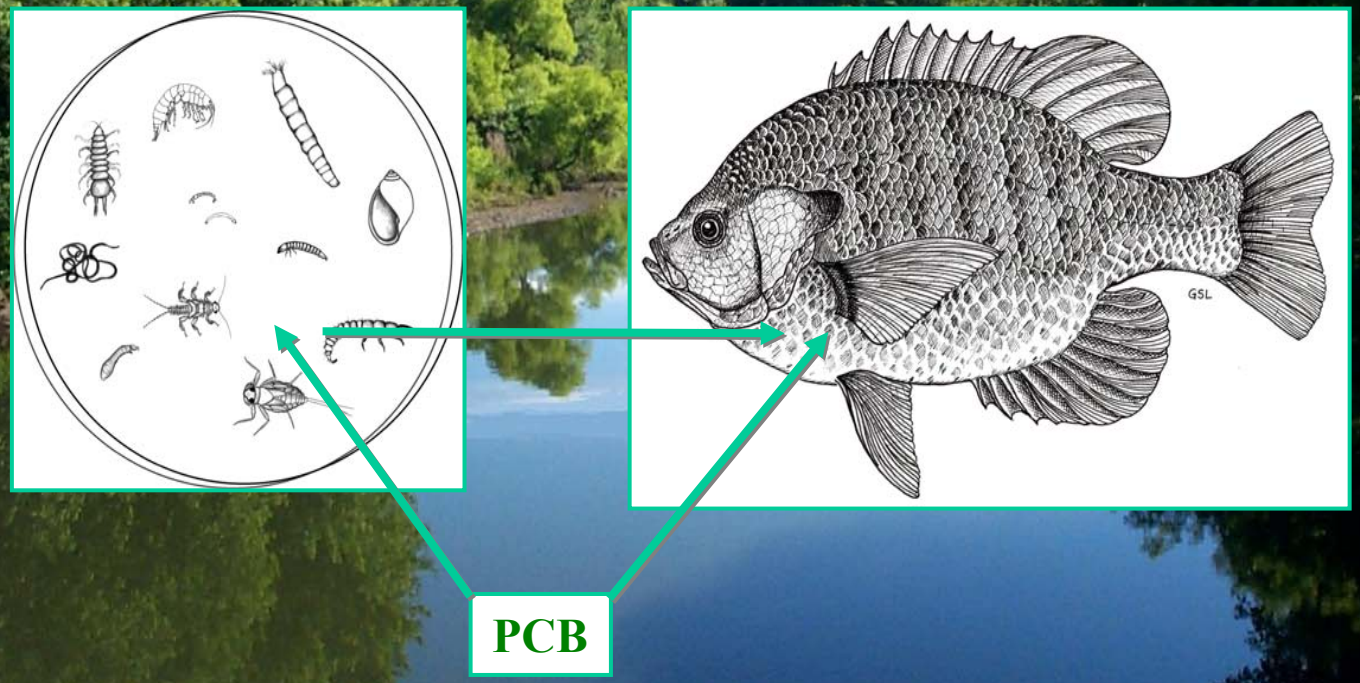
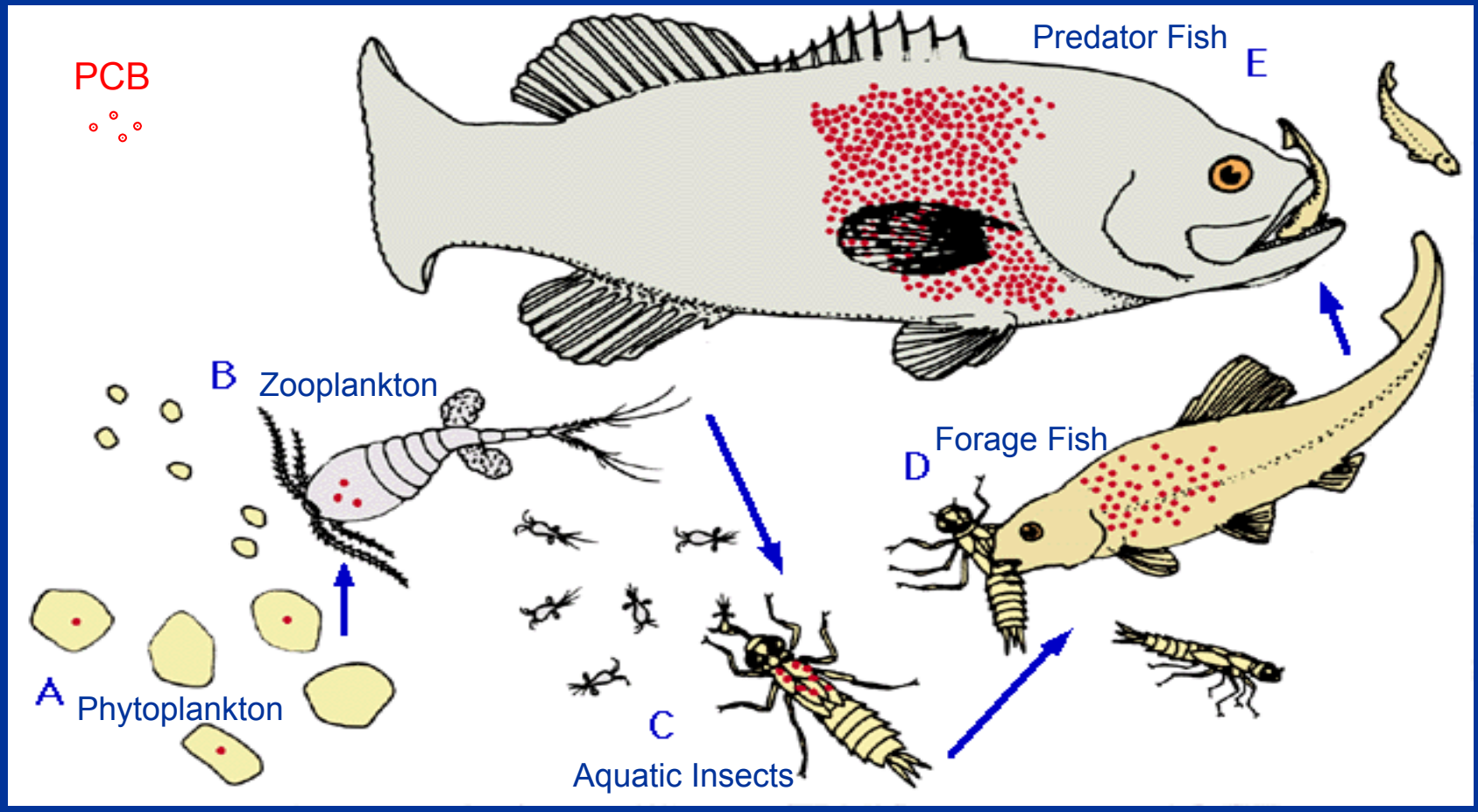
Bioaccumulation



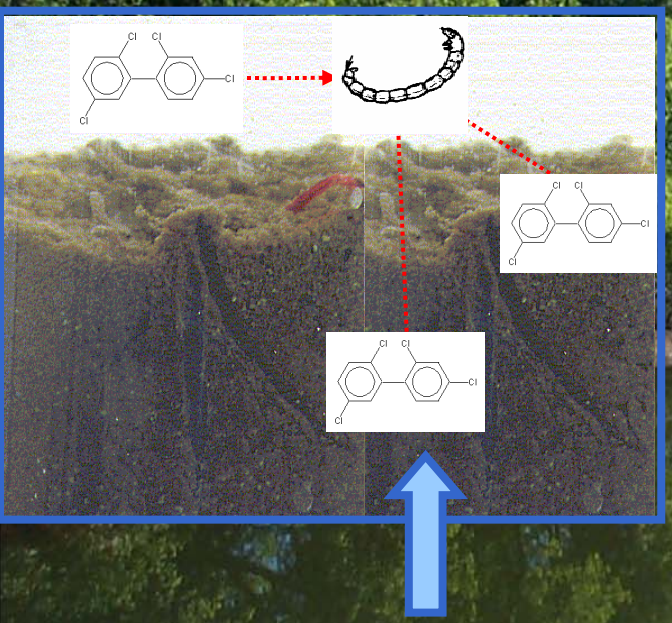
- Bioaccumulation = the process by which living things accumulate contaminants from their environment
- Occurs by feeding and by contact with water and solids

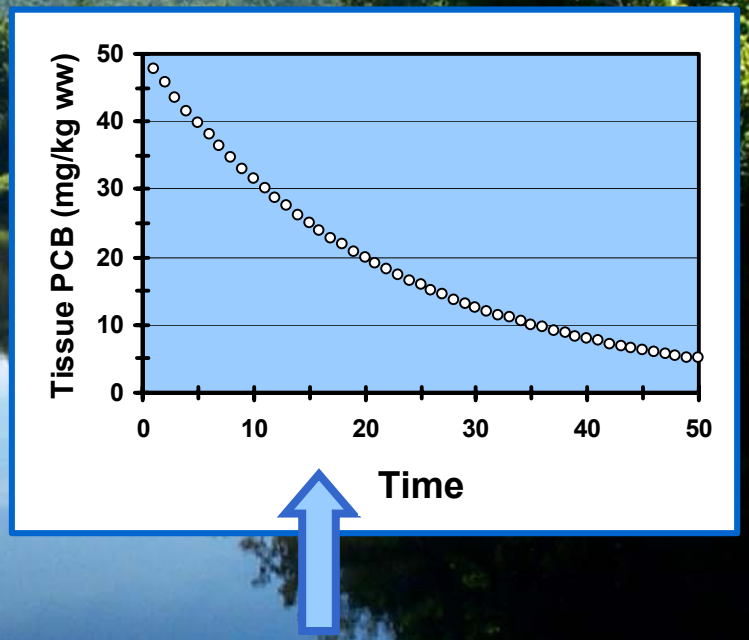
Biomagnification



- Biomagnification: concentration in the food chain
  - PCBs both bioaccumulate and biomagnify

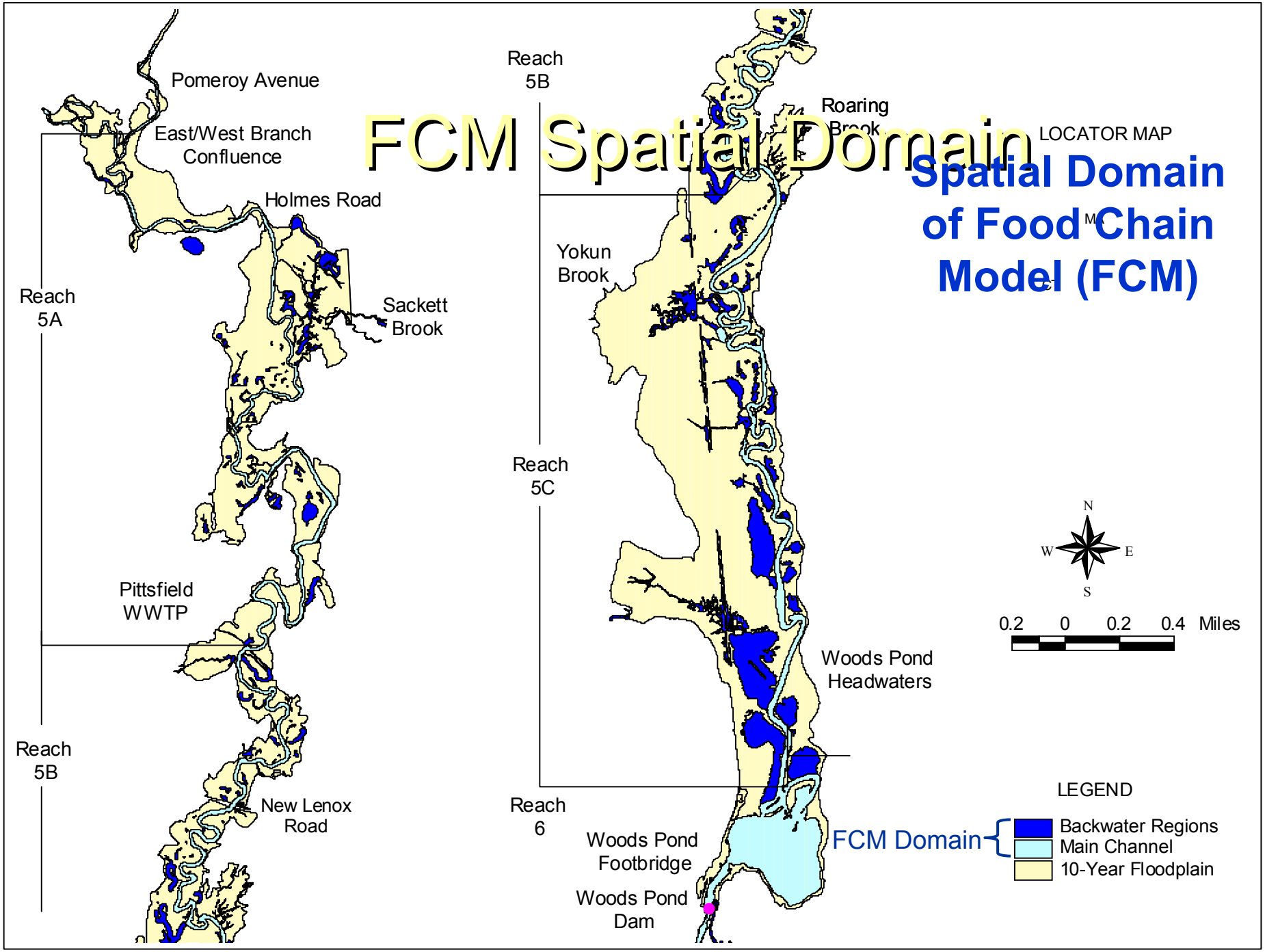
Purpose of Bioaccumulation Model





1. Identify how aquatic organisms obtain PCB burdens (e.g., from water or sediment)

2. Estimate the time needed for PCBs in biota tissue to be reduced to “safe” levels.


FCM Spatial Domain
Spatial Domain of Food Chain Model (FCM)
LOCATOR MAP
Pomeroy Avenue
East/West Branch Confluence
Holmes Road
Sackett Brook
Reach 5A
Reach 5B
Pittsfield WWTP
New Lenox Road
Reach 5B
Roaring Brook
Yokun Brook
Reach 5C
Woods Pond Headwaters
Reach 6
Woods Pond Footbridge
Woods Pond Dam
N
W
E
S
0.2 0 0.2 0.4 Miles
LEGEND
FCM Domain
Backwater Regions
Main Channel
10-Year Floodplain

Model Linkages

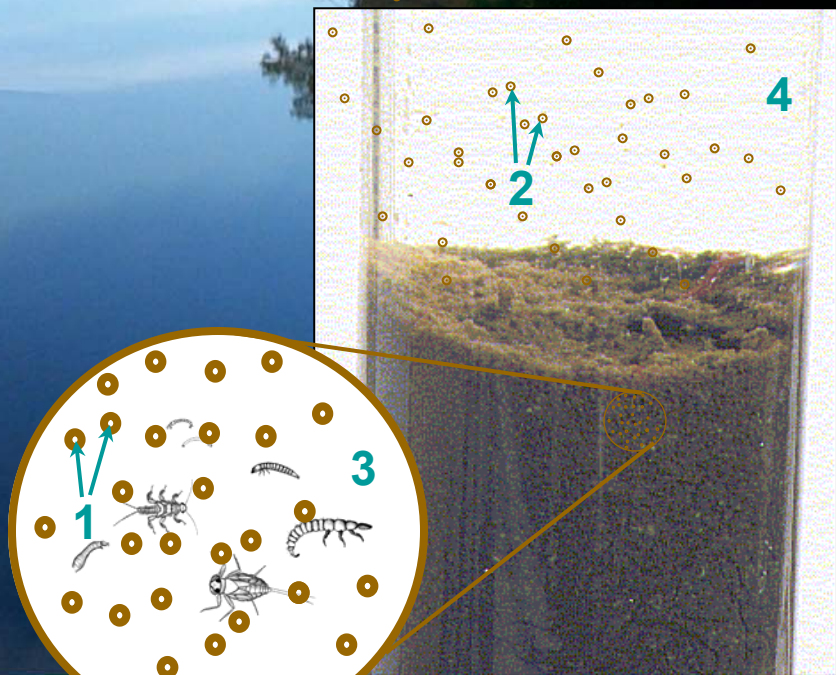
PCB Exposure Inputs (EFDC)

Temperature (HSPF)

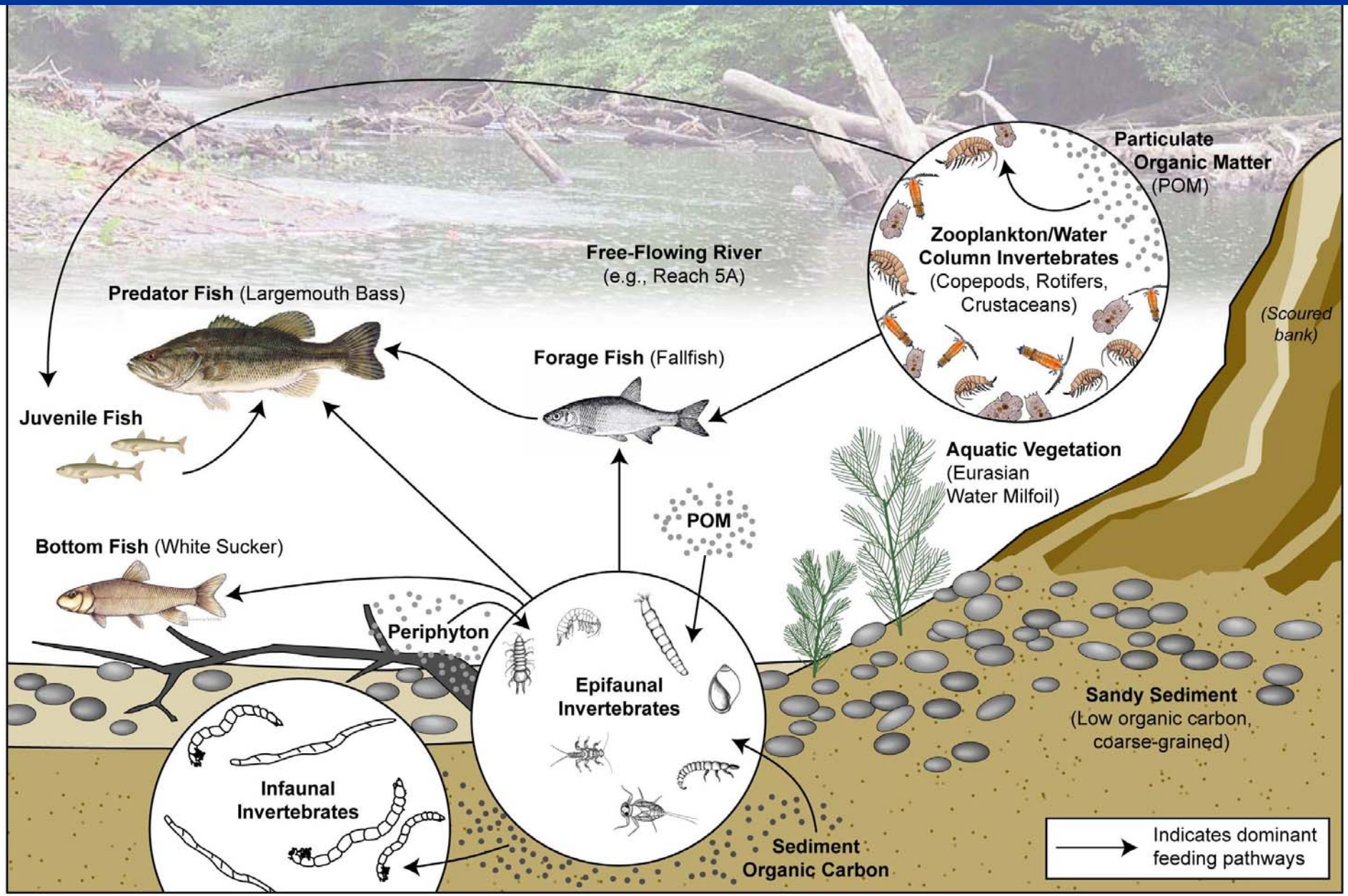
Bioaccumulation Model (FCM)

Exposure Inputs from EFDC:

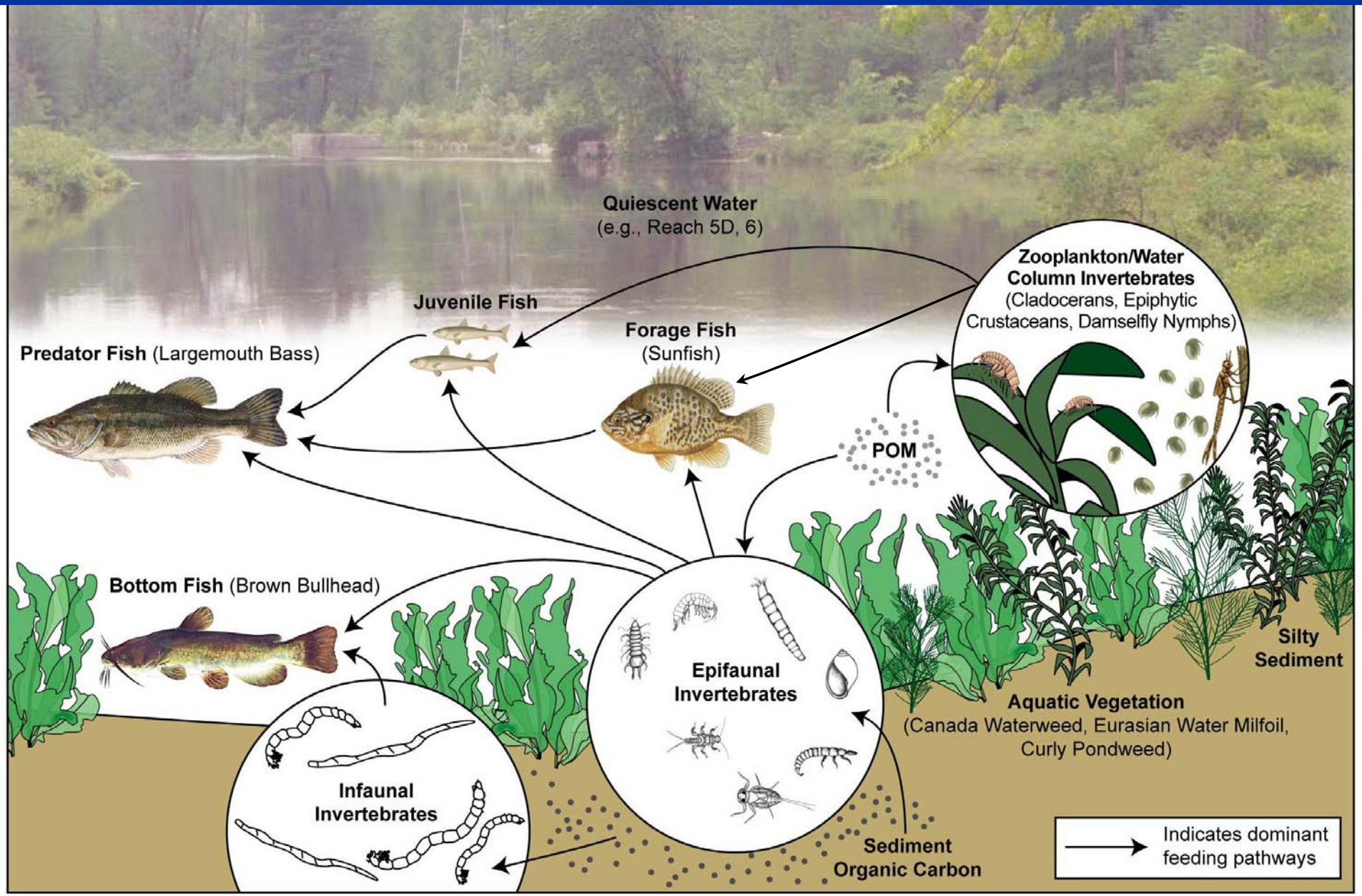
1. PCB in bed sediment organic carbon
2. PCB in water column organic matter (POM)
3. Dissolved PCB in sediment pore water
4. Dissolved PCB in water column



Conceptual Model – Upstream PSA

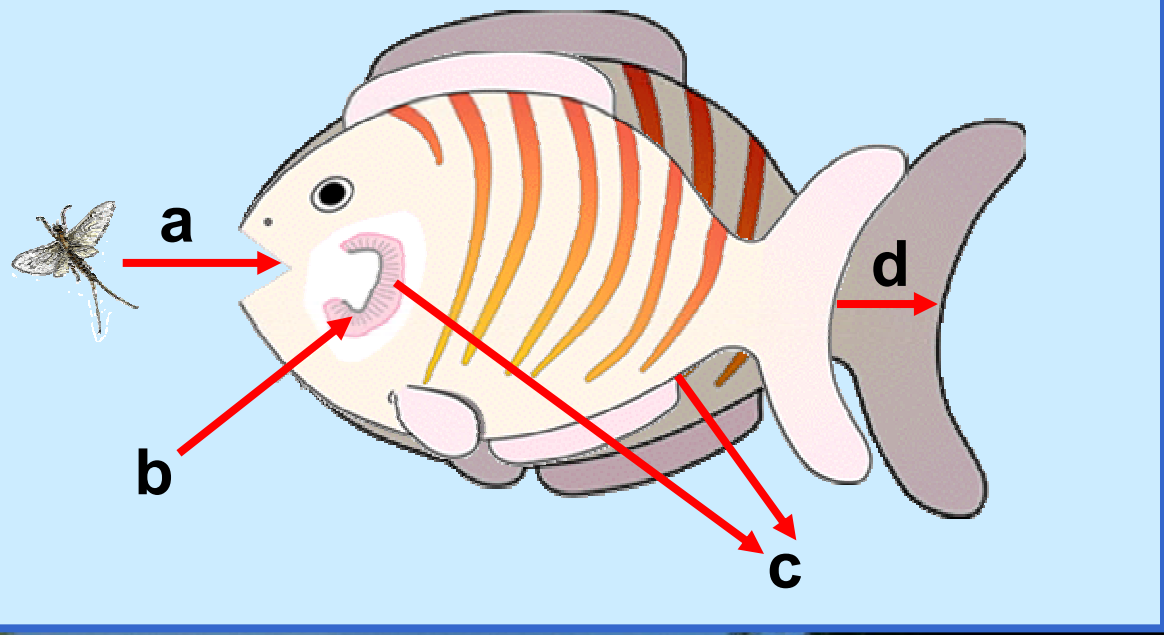


Conceptual Model – Downstream PSA



Bioaccumulation Processes

$$\frac{dv_i}{dt} = \underbrace{K_{ui}c}_{b} + \underbrace{\alpha_c \sum_{j=1}^{n} C_{ij}v_j}_{a} - \underbrace{(K_i + G_i)v_i}_{c\ \&\ d}$$

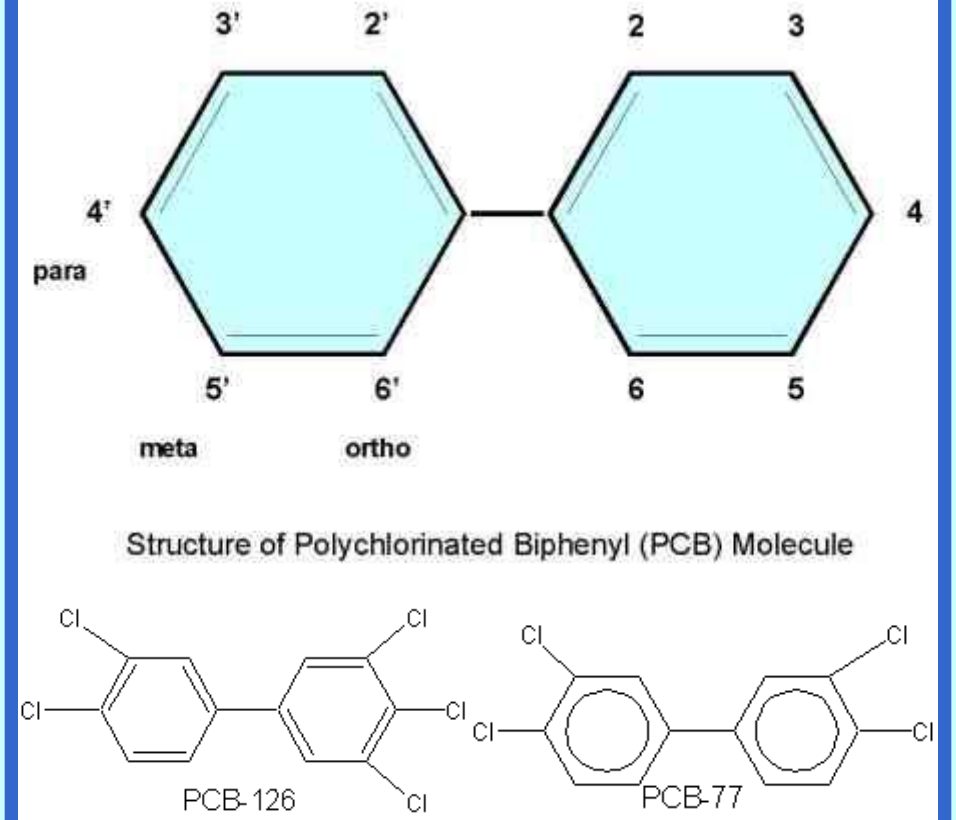


- **PCB Uptake:**
  a. Dietary uptake
  b. Respiration
- **PCB Elimination**
  c. Depuration (elimination via gill and feces)
  d. Growth dilution
- Fish modeled as "time-dependent"; invertebrates modeled as "steady-state":

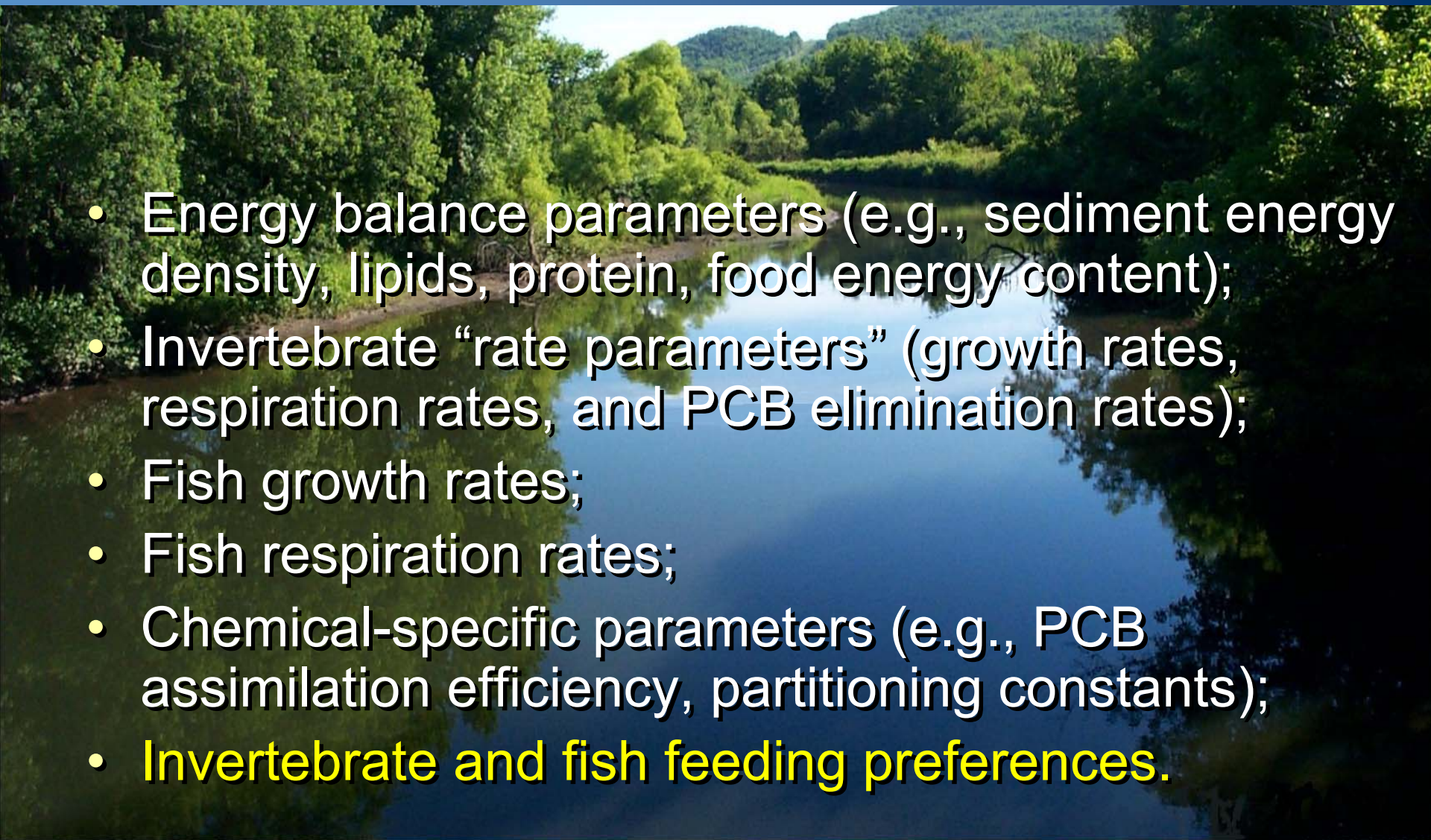
$$v_i = \frac{uptake}{loss} = \frac{a + b}{c + d}$$

Contaminants Simulated

- Total PCBs (similar to Aroclor 1260)
- 9 Individual congeners
  - "Dioxin-like" PCBs: (PCB-77, PCB-123, PCB-126)
  - High-concentration PCB congeners: (PCB-101, PCB-118, PCB-138, PCB-156, PCB-177, PCB-183)

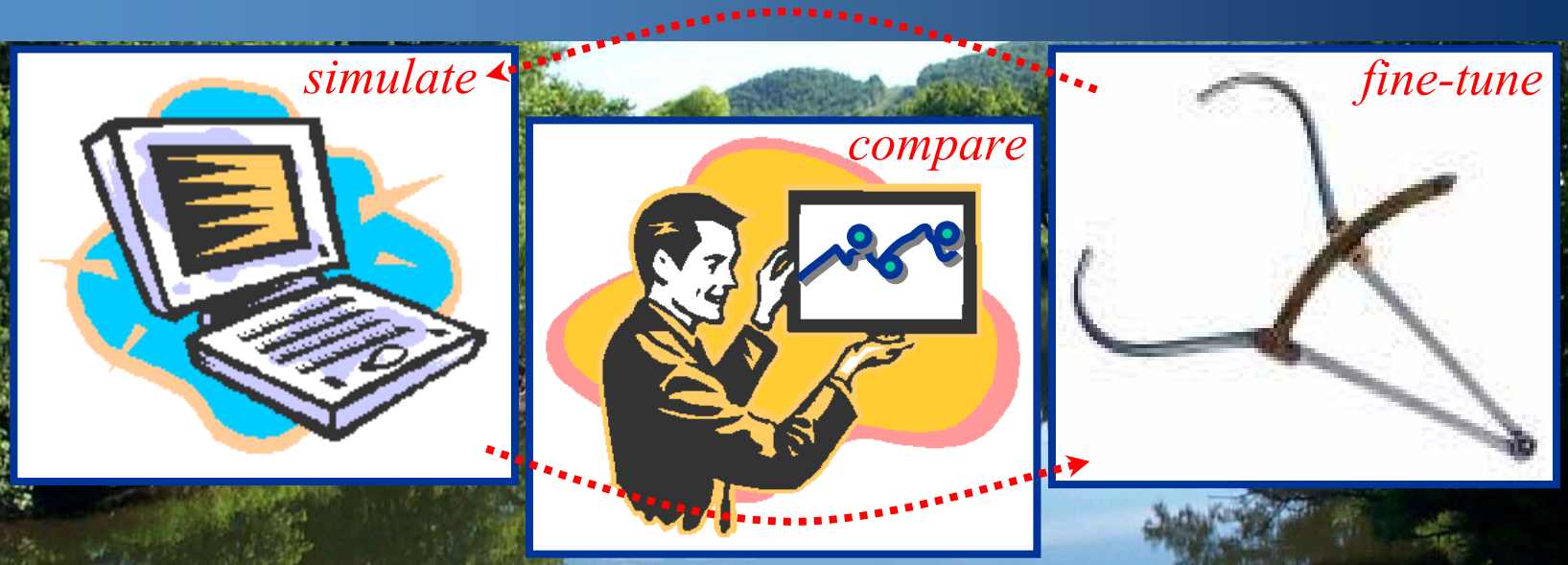


Model Parameterization



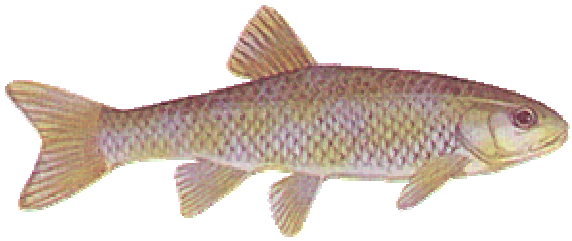
- Energy balance parameters (e.g., sediment energy density, lipids, protein, food energy content);
- Invertebrate “rate parameters” (growth rates, respiration rates, and PCB elimination rates);
- Fish growth rates;
- Fish respiration rates;
- Chemical-specific parameters (e.g., PCB assimilation efficiency, partitioning constants);
- Invertebrate and fish feeding preferences.

General Calibration Strategy



- Kept most parameters uncalibrated (e.g., used initial estimate from literature review)
- Some small-scale refinements to initial parameter estimates made to improve model
- Parameters always constrained to ranges of scientifically plausible values

Example Calibration Procedures



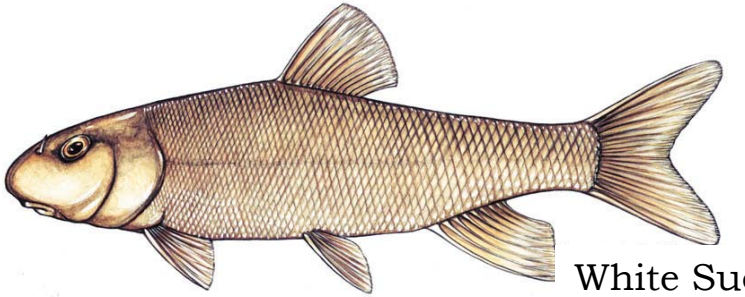
Fallfish [cyprinid benthivore]

(Average respiration rate between sucker and dace)

Shiner

[Small cyprinids]

Dace

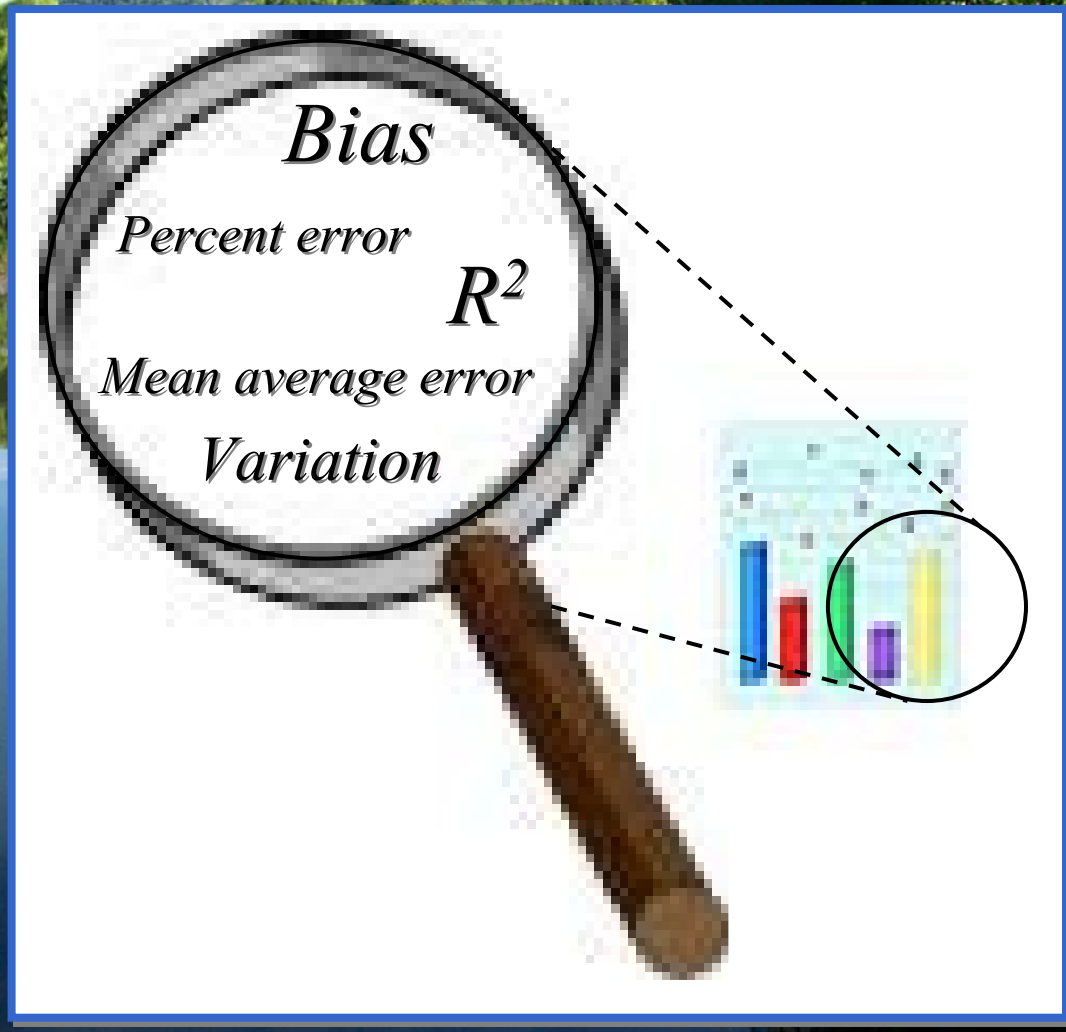


White Sucker [large benthivore]

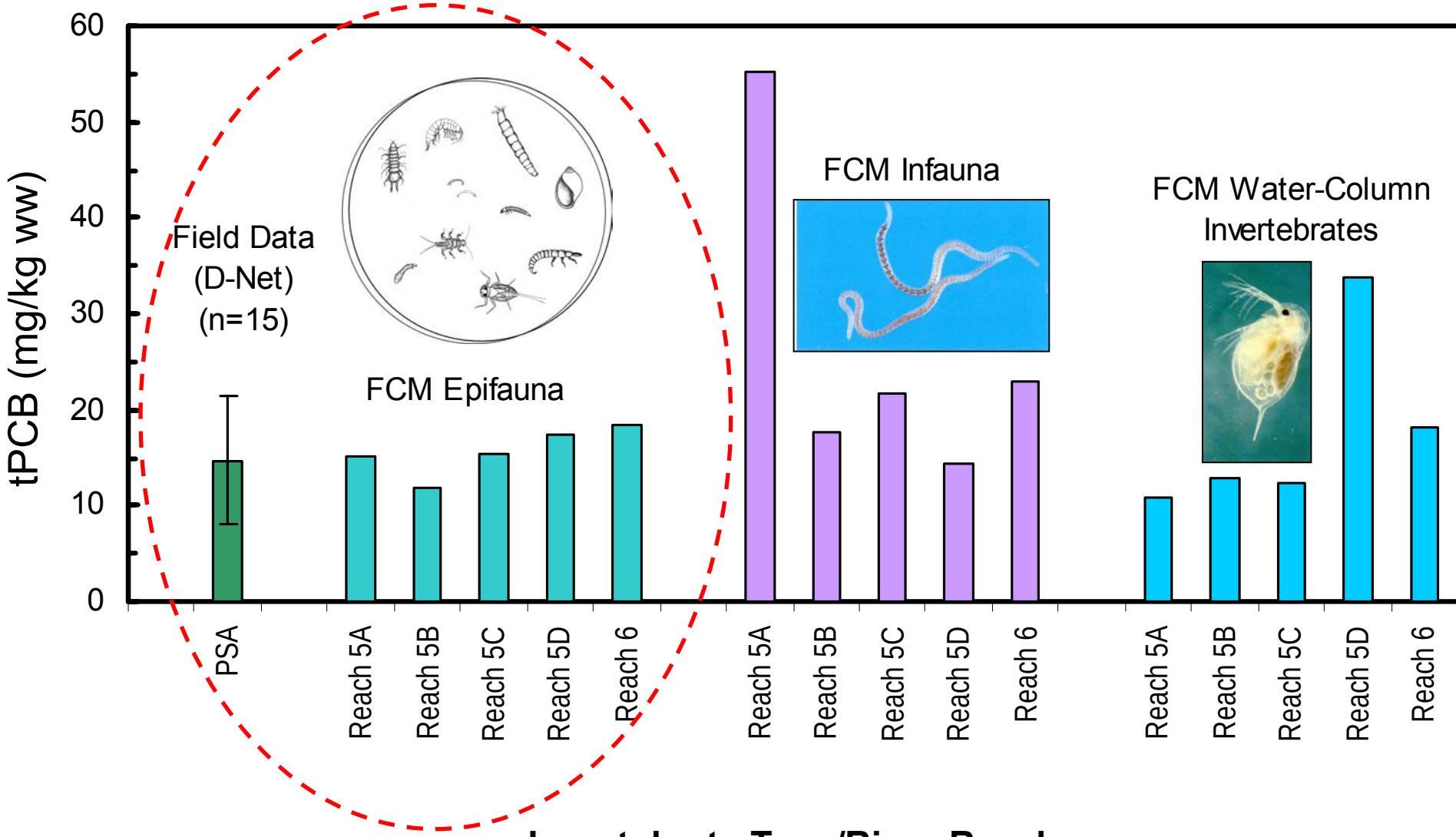
1. Cyprinid respiration in Reach 5A (above)
2. Seasonal fish growth (restricted to growing season)

Model Performance Measures

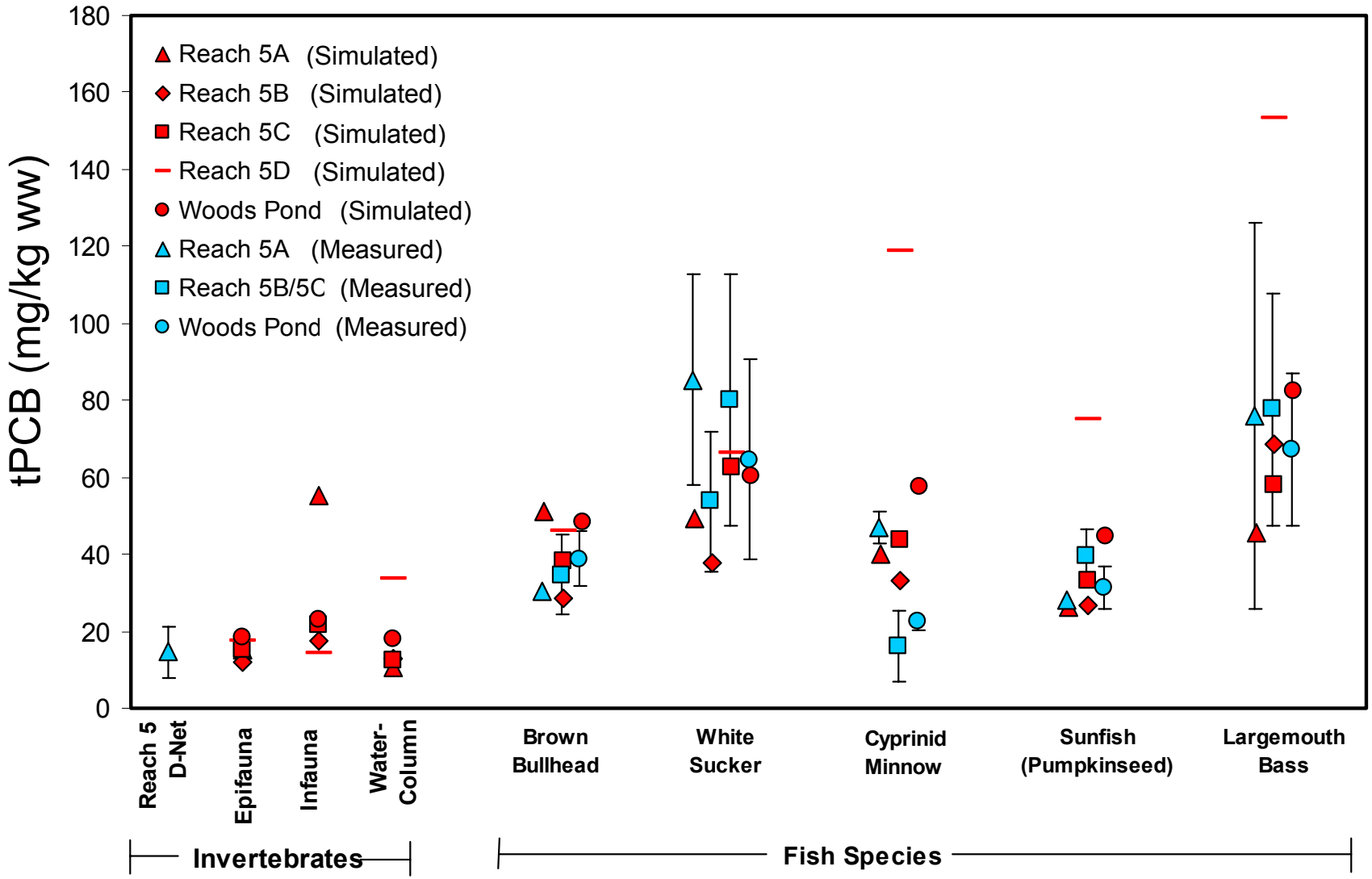
1. "Goodness-of-fit" statistics
2. Visual inspection of simulated versus measured PCBs:
   - by fish age
   - by species
3. Model bias check



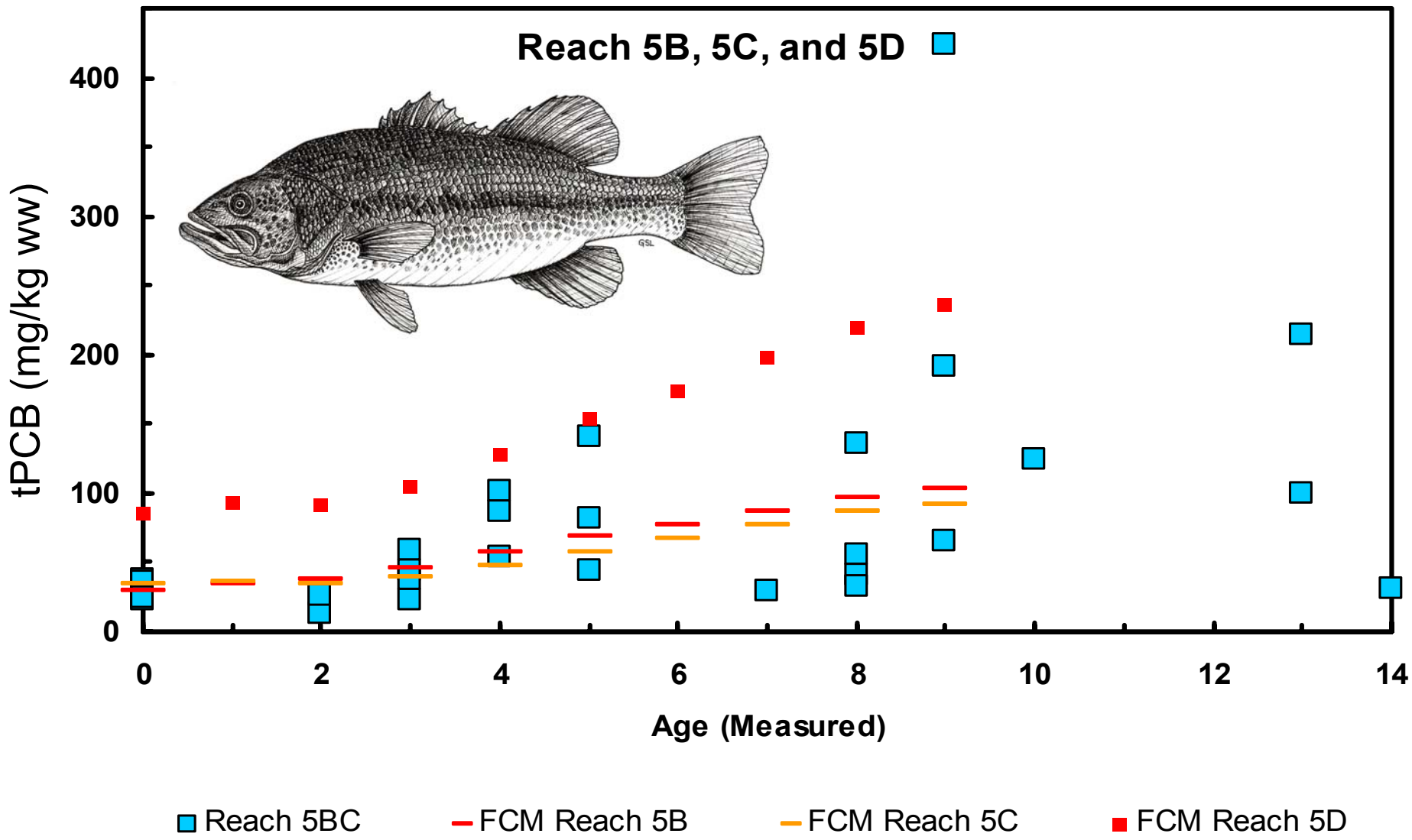
PCBs in Invertebrates (Simulated Versus Measured) – Linked FCM Model



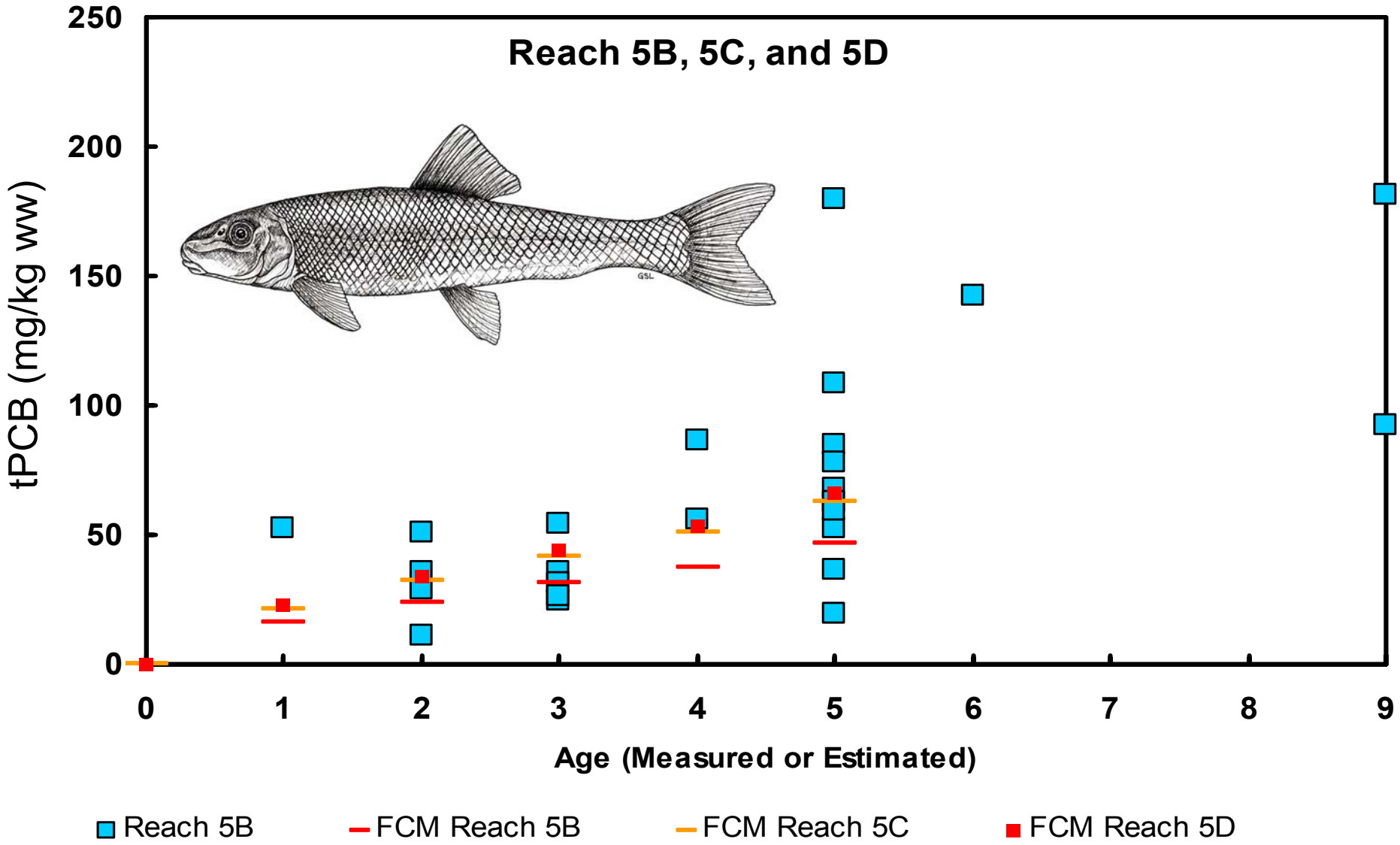
Comparison of Measured Biota Tissue tPCB Concentrations to Linked Model Simulations



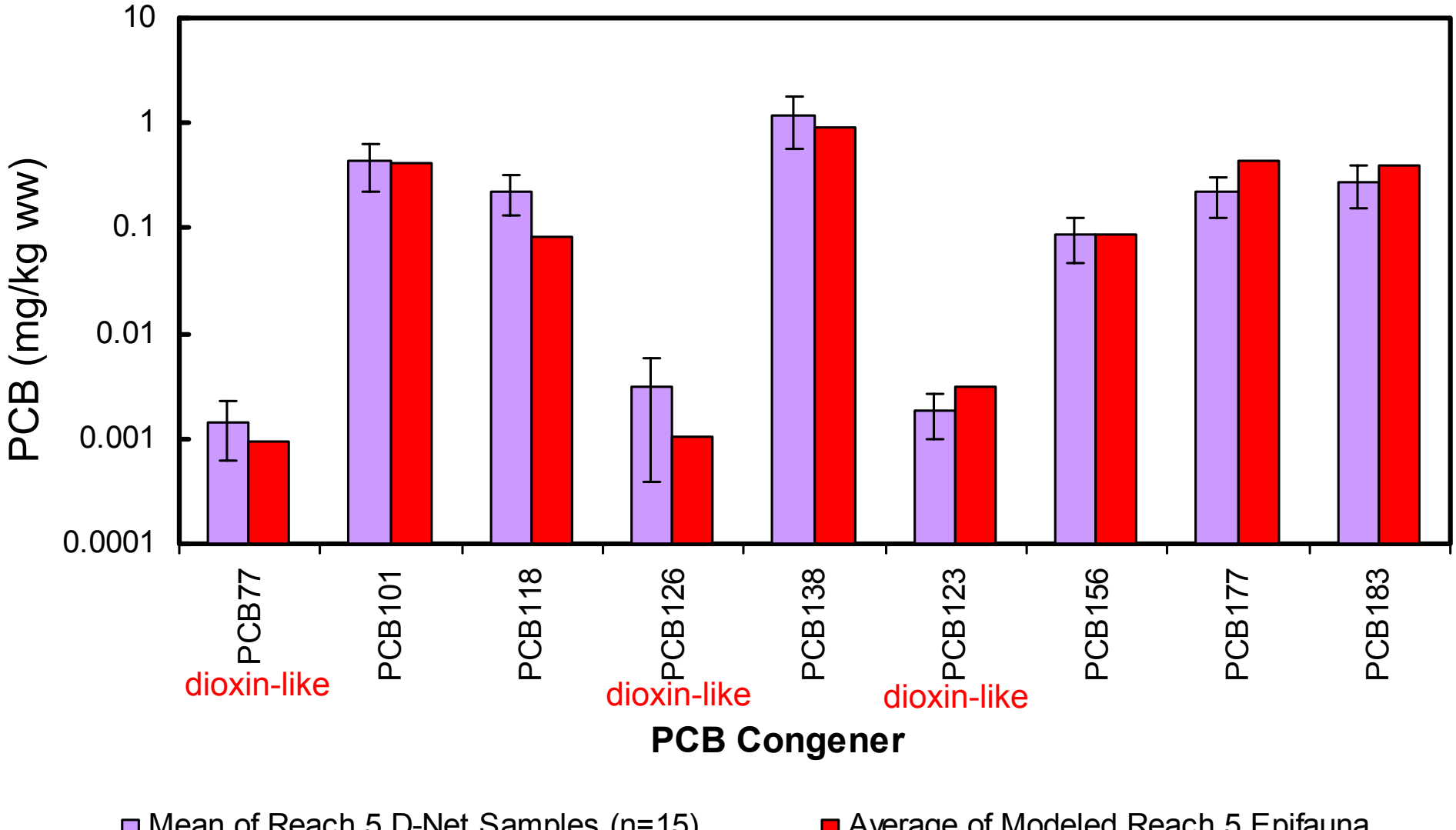
Largemouth Bass – tPCB Versus Age



White Sucker – tPCB Versus Age

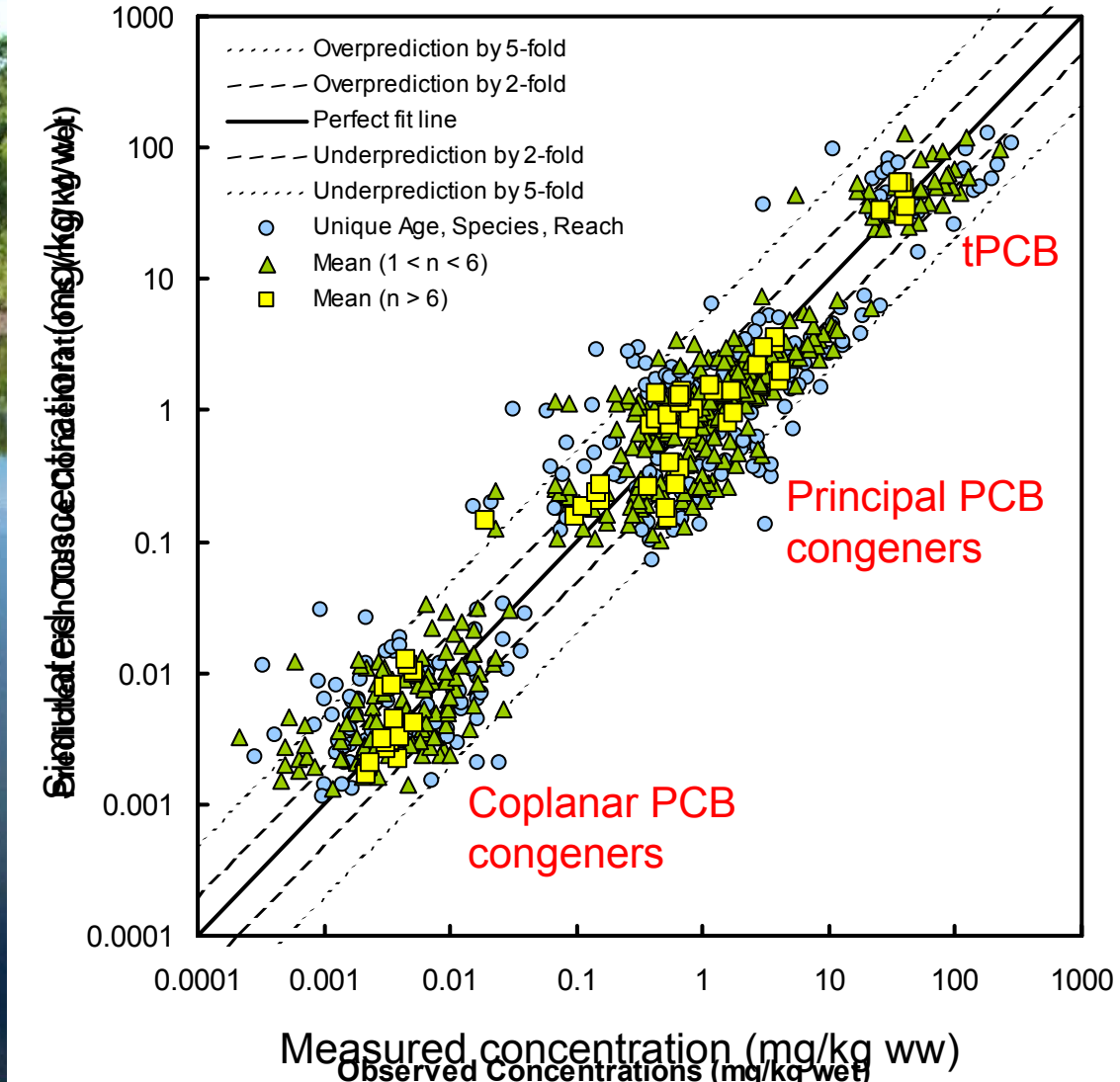


PCB Congeners in Invertebrates: FCM Simulations Versus Field Measurements

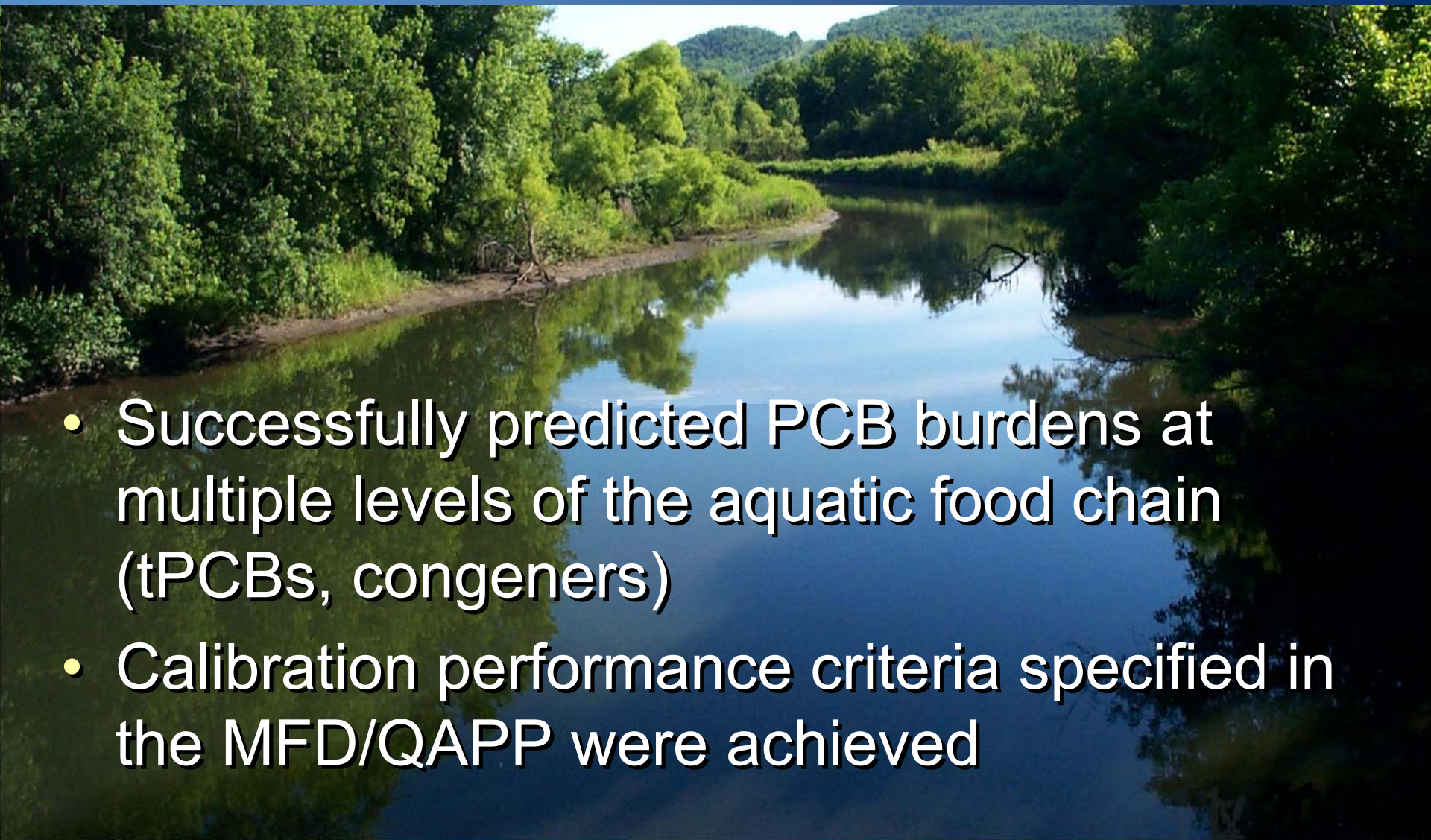


Check for Model Bias

- Looked for systematic over- or under-predictions
- No bias observed as function of:
  - PCB type
  - Trophic level
  - Age or lipid



Conclusions



- Successfully predicted PCB burdens at multiple levels of the aquatic food chain (tPCBs, congeners)
- Calibration performance criteria specified in the MFD/QAPP were achieved

Questions?