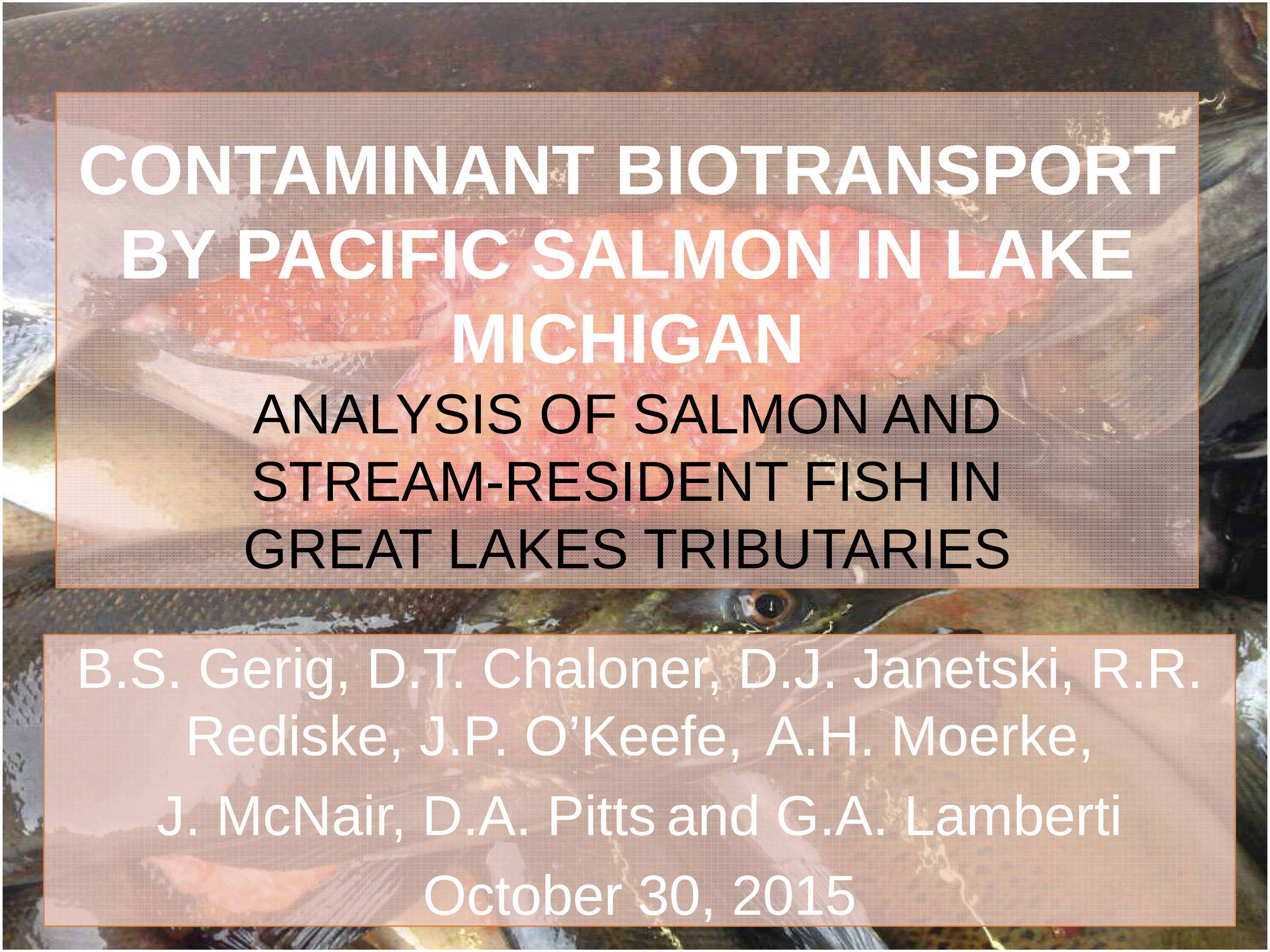


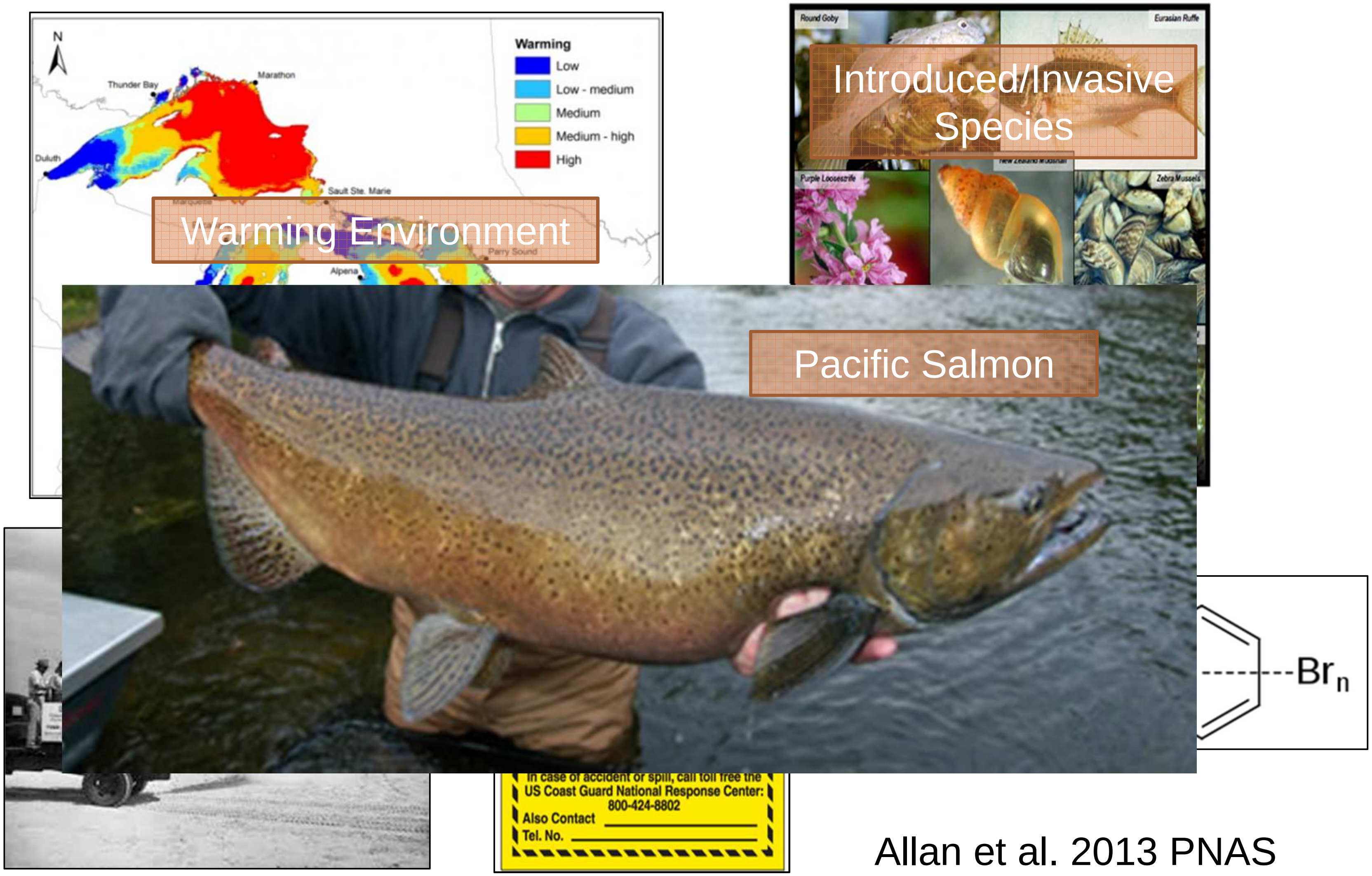
CONTAMINANT BIOTRANSPORT BY PACIFIC SALMON IN LAKE MICHIGAN

ANALYSIS OF SALMON AND STREAM-RESIDENT FISH IN GREAT LAKES TRIBUTARIES

B.S. Gerig, D.T. Chaloner, D.J. Janetski, R.R. Rediske, J.P. O’Keefe, A.H. Moerke,
J. McNair, D.A. Pitts and G.A. Lamberti

October 30, 2015

Environmental Change

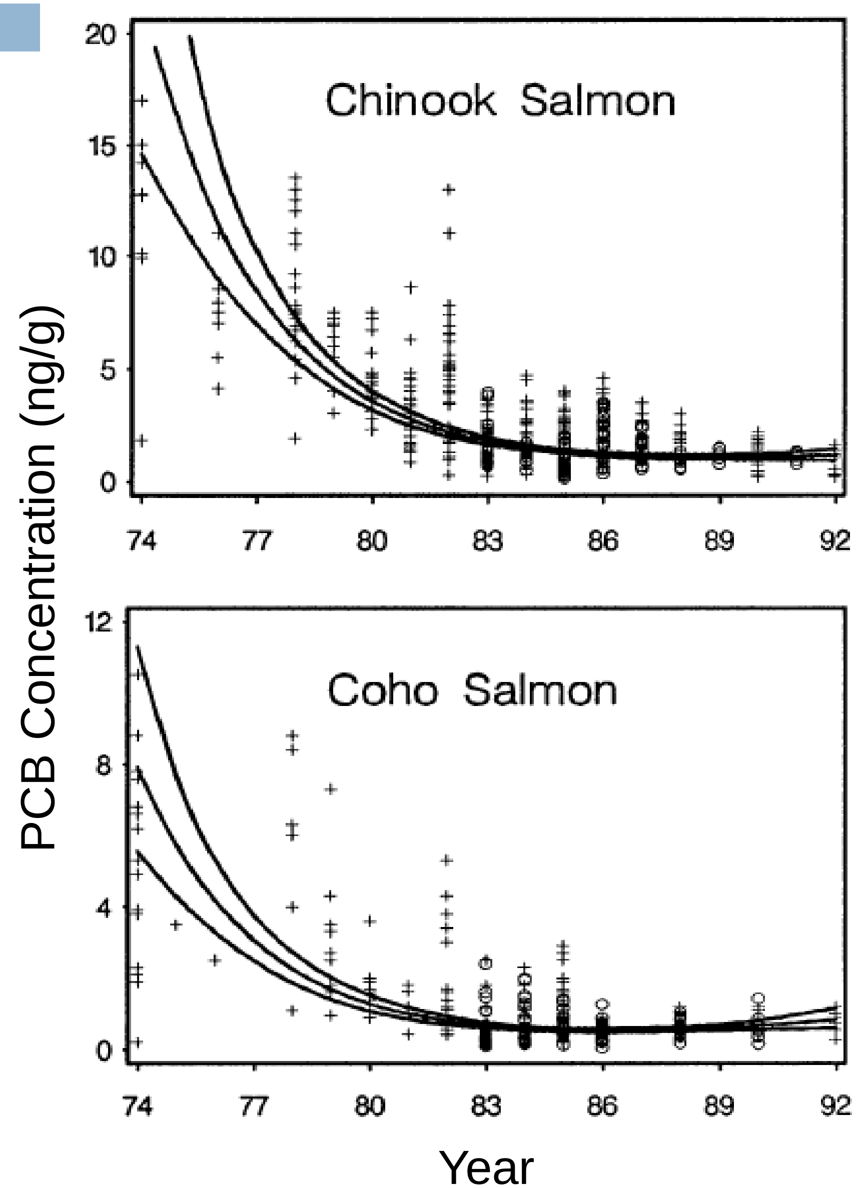


Allan et al. 2013 PNAS

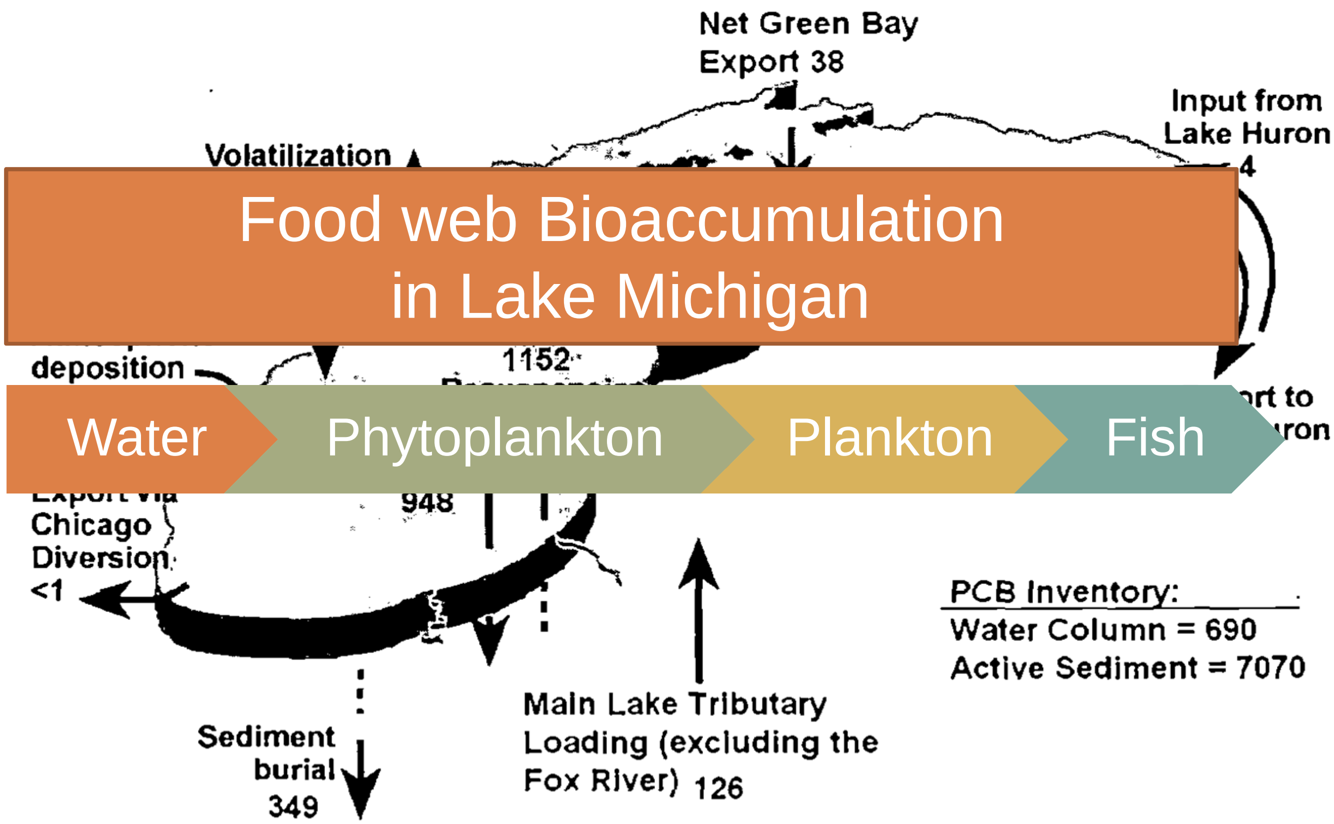
Salmon in Lake Michigan

Stocking facilitated high rates of POP bioaccumulation

Dettmers et al. 2012 Fisheries
Stow et al. 1995 Eco Apps



Contaminant Transport and Accumulation

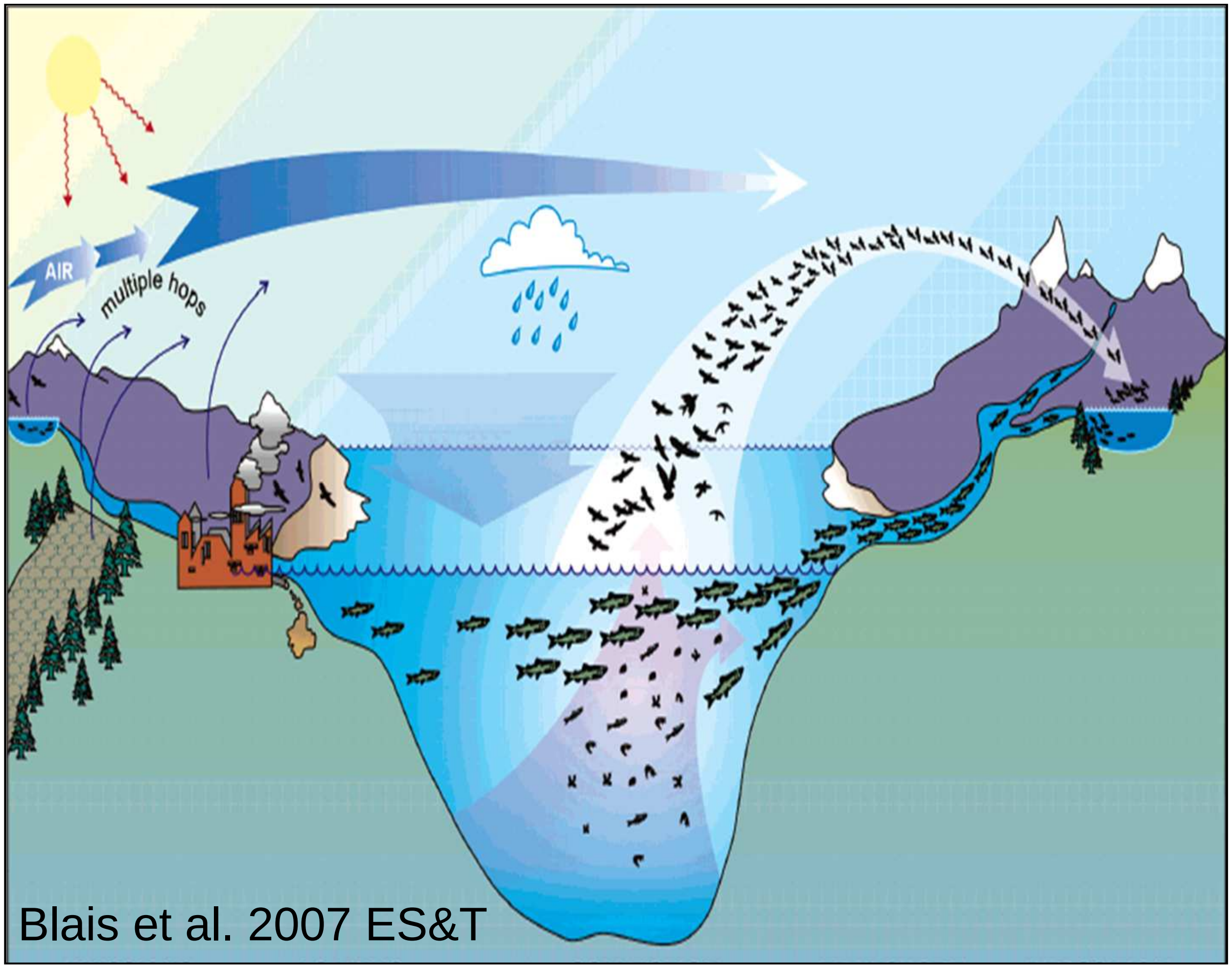


Food web Bioaccumulation in Lake Michigan

Water → Phytoplankton → Plankton → Fish

Hornbuckle et al. 2006

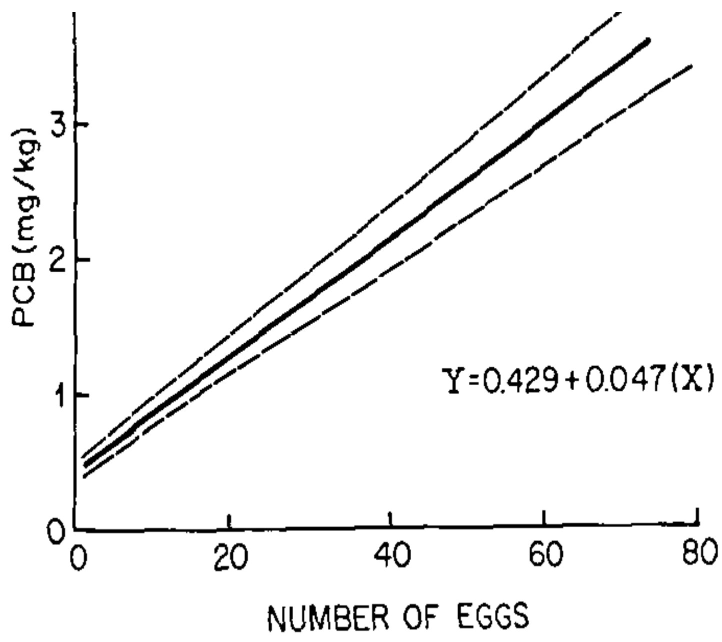
Contaminant Biotransport



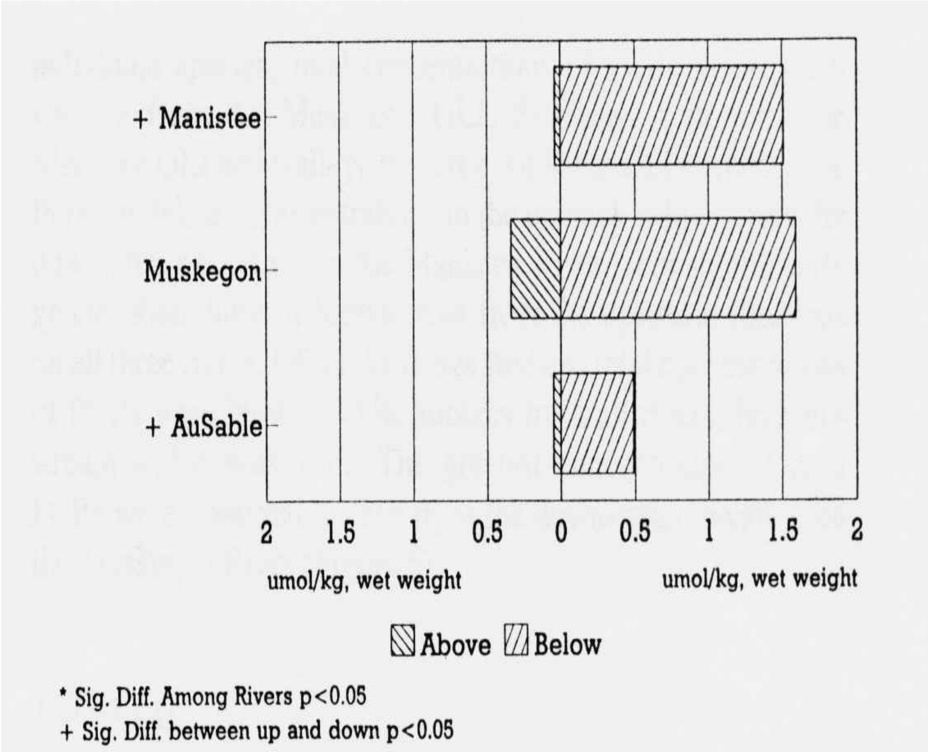
Blais et al. 2007 ES&T

- 3 Key Steps
  - Bioaccumulation
  - Transport of contaminant
  - Release of contaminant to recipient ecosystem

Contaminant Biotransport to Tribs



Merna 1986 Trans. Am. Fisheries



Giesy et al. 1994 Arch. Environ. Tox. Chem.

Research Motivation

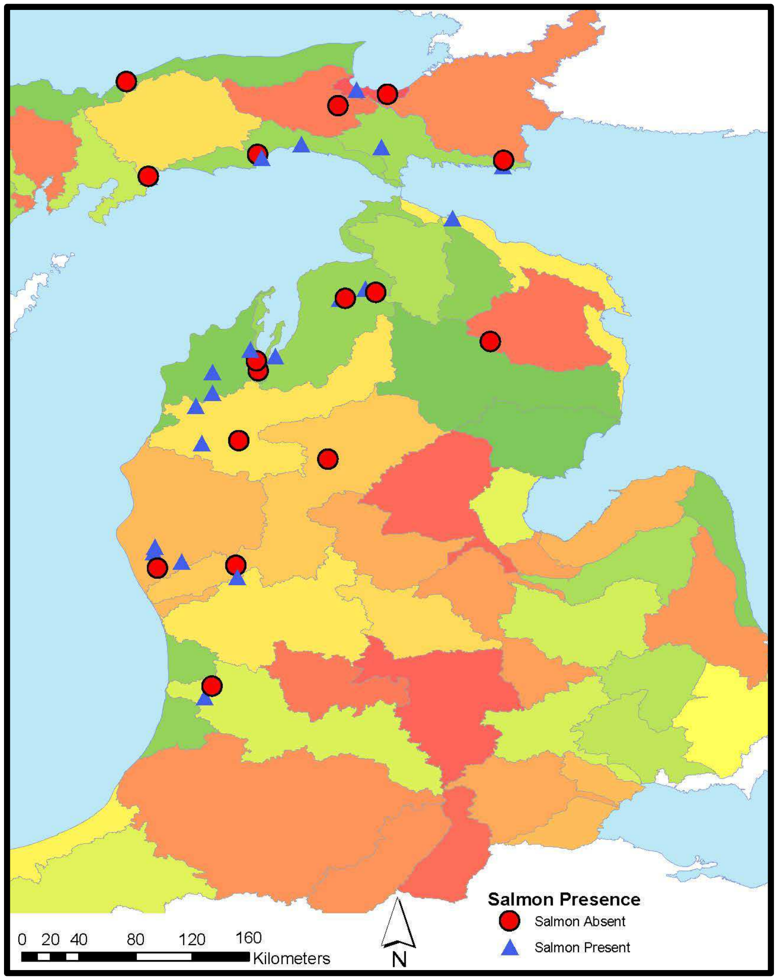
- What role do salmon play in transporting contaminants accumulated in Great Lakes to stream resident fish in tributaries?

Research Questions

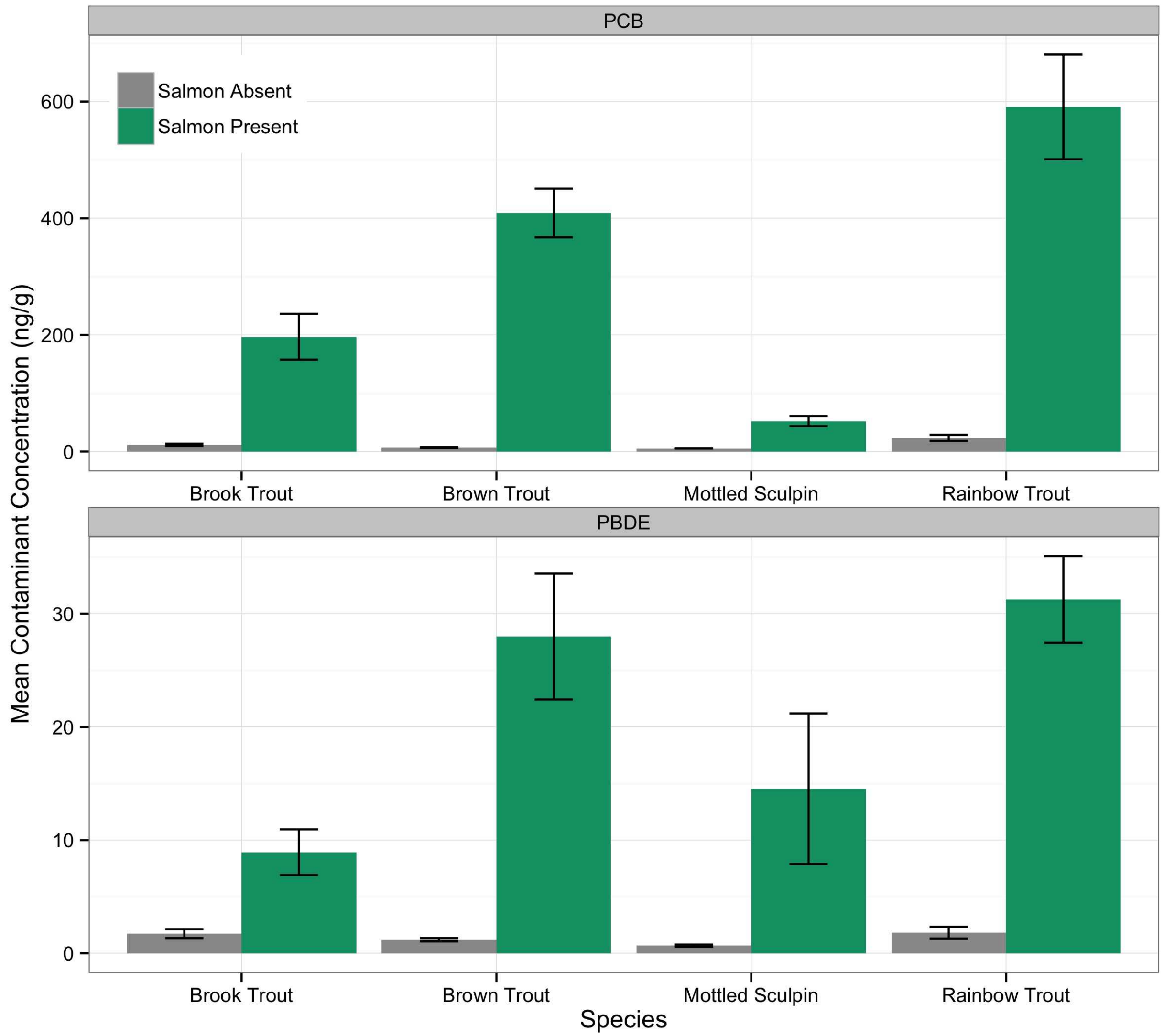
- **Observational Study**: What is the extent of contaminant biotransport by salmon to stream resident fish?
- **Manipulative Experiment**: Do salmon have direct effects on resident fish contaminant levels?
- **Simulation Model**: How does salmon run size mediate contaminant accumulation in resident fish?

Survey Study Design

- Paired Watershed
  - Salmon present
  - Salmon absent
- Salmon sampling
  - Early October
- Resident fish sampling
  - Late November/December
- Fish analyzed for:
  - POPs (PCB, PBDE): GC-MS
  - Total mercury (THg): DMA-80



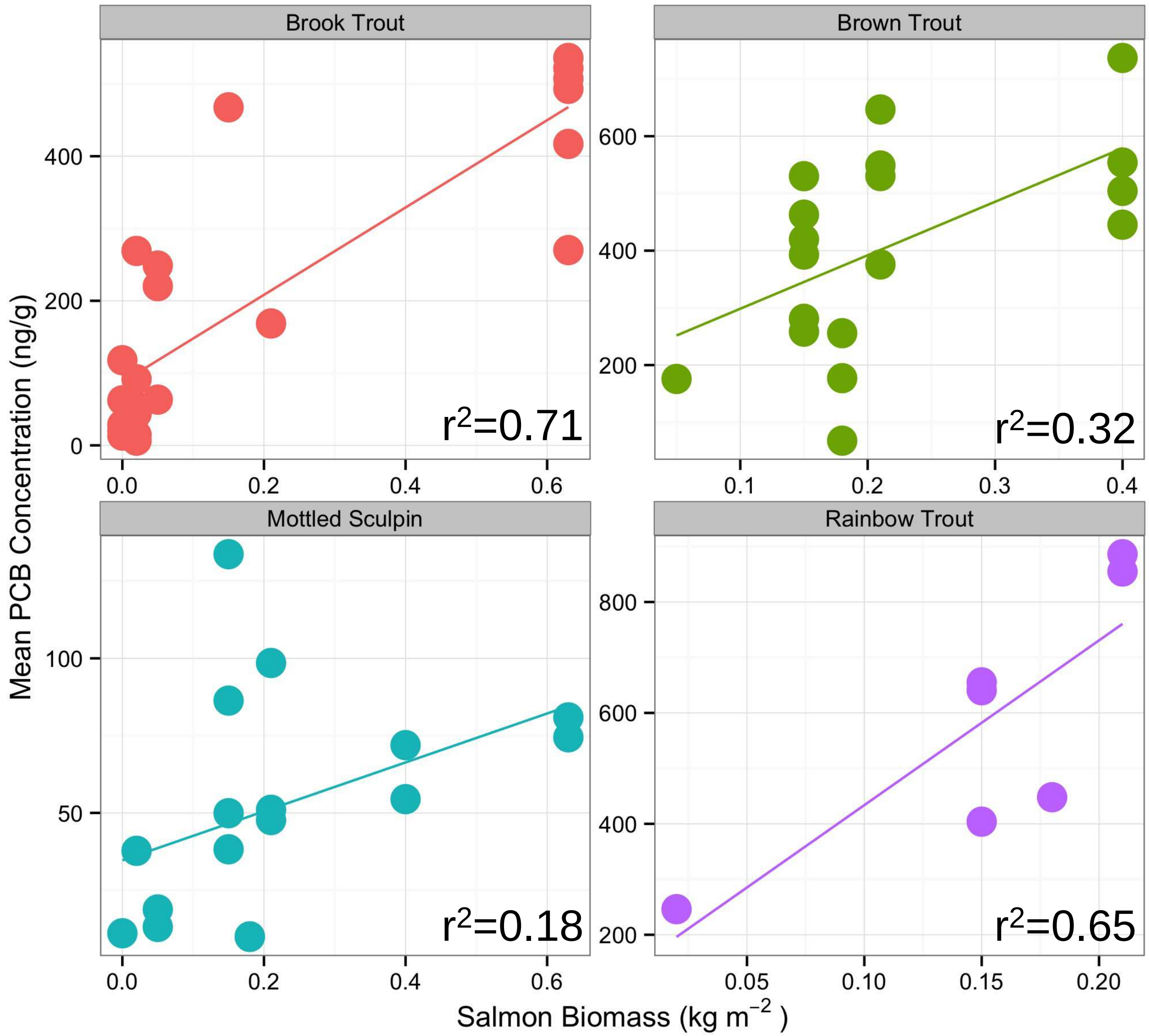
Salmon streams have higher POP levels



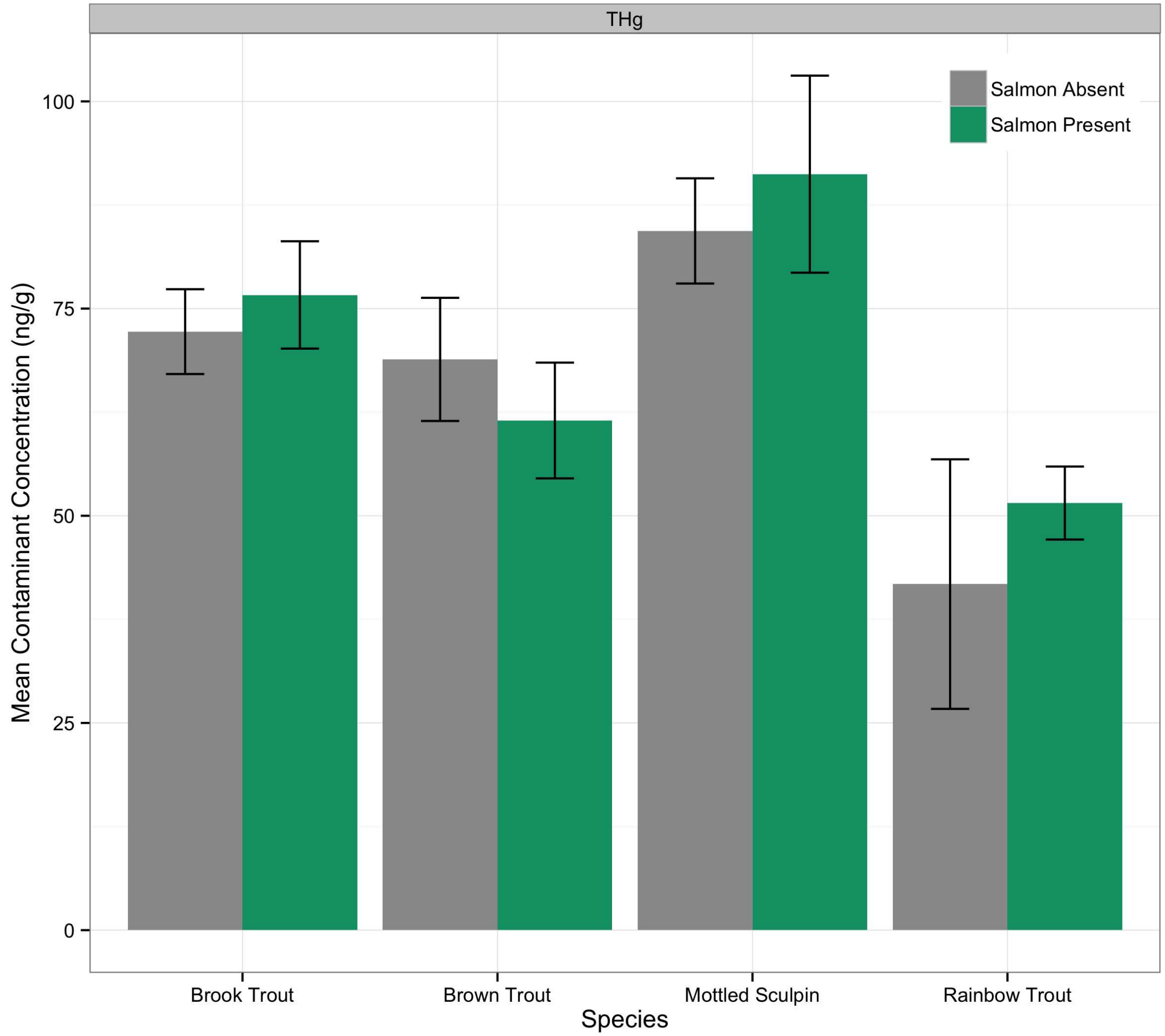
PCB 2-way ANOVA
Species: $p<0.001$
Reach: $p<0.001$
Interaction: NS

PBDE 2-way ANOVA
Species: $p<0.001$
Reach: $p<0.001$
Interaction: NS

POP levels reflect salmon biomass



Mercury levels *not influenced* by salmon

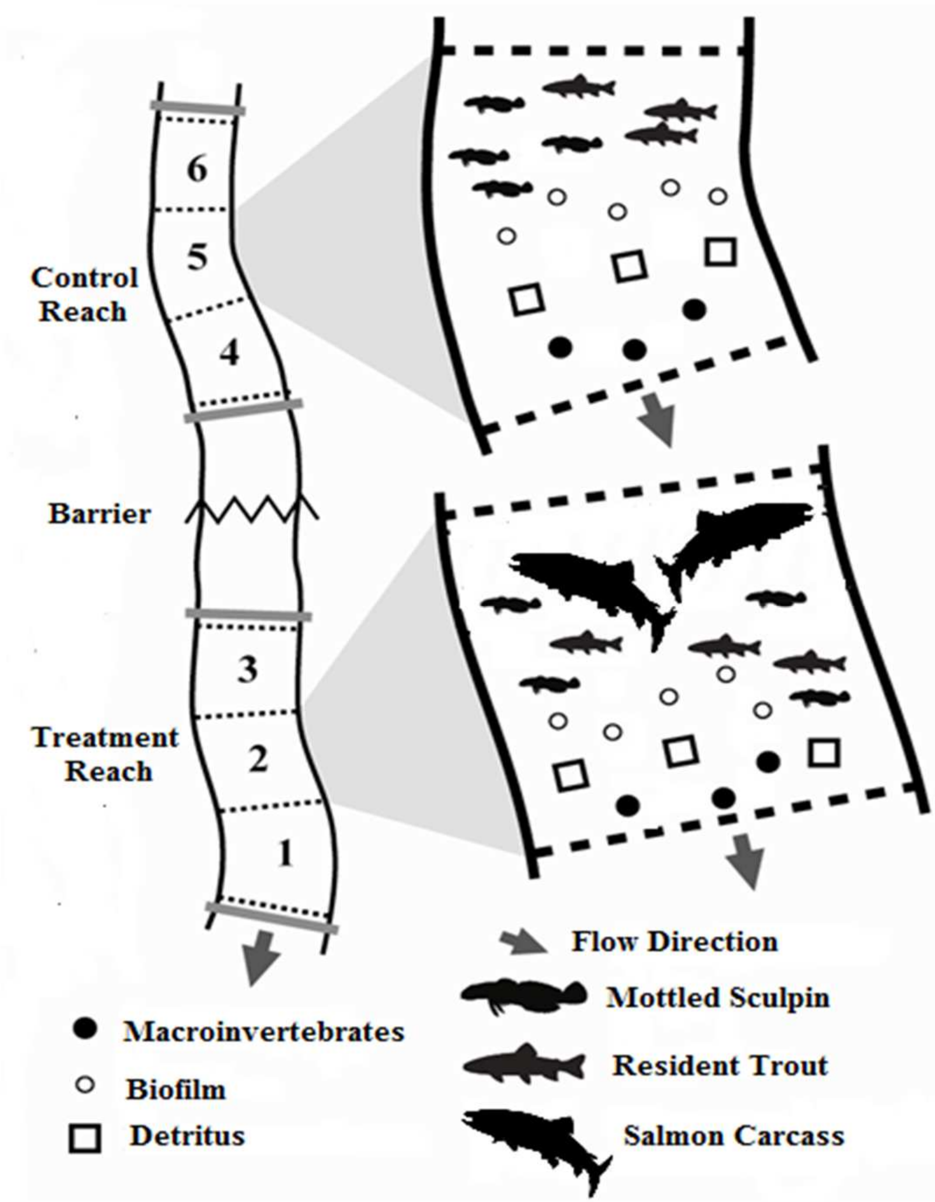


THg 2-way ANOVA

Species: p=0.038

Reach: p=0.19

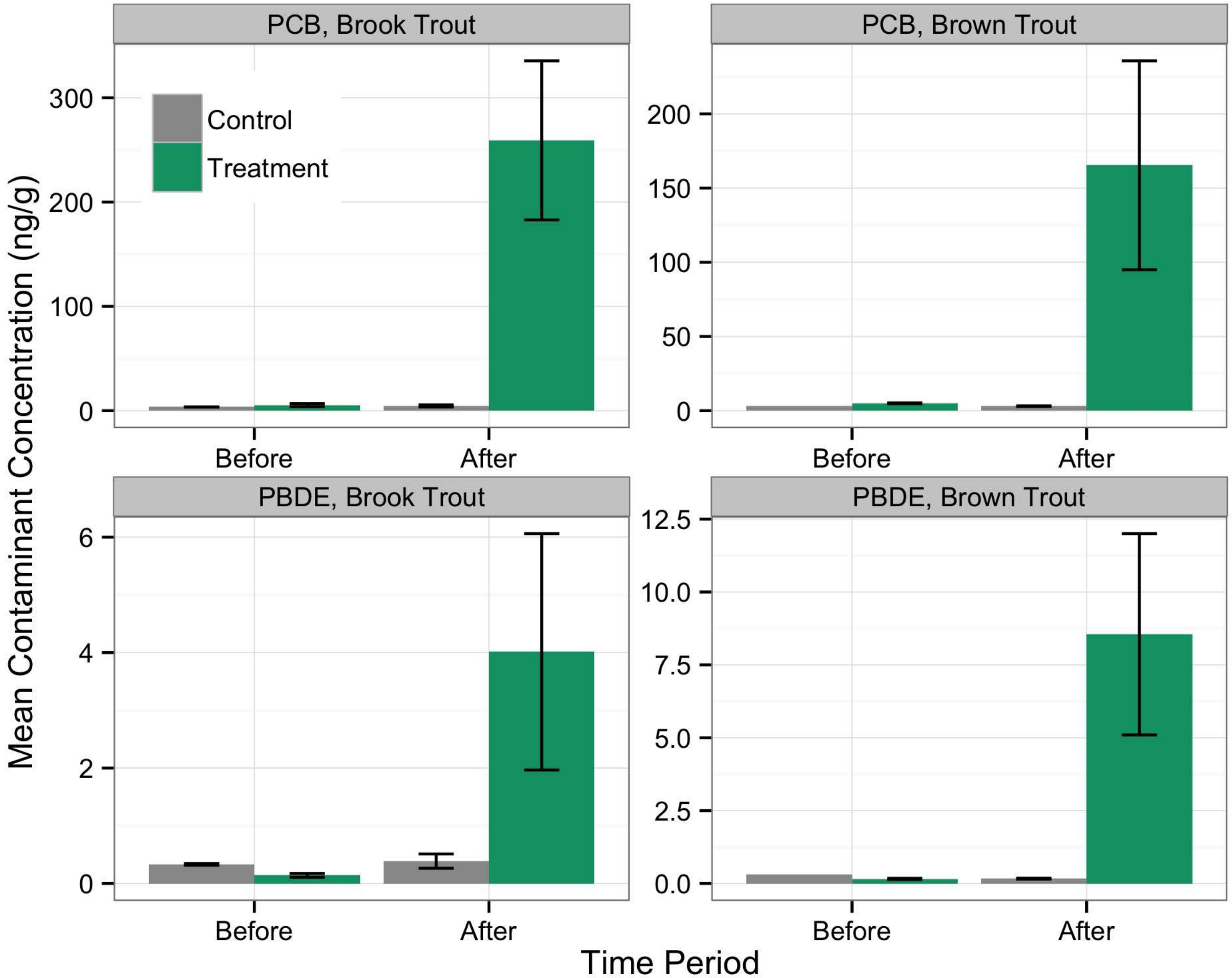
Hunt Creek Carcass Addition



Manipulative Experiment

- BACI study design
- 100 m treatment reach
  - Carcasses and eggs added
  - ~Medium to large salmon run
  - Experiment lasted 49 days
- Fish were analyzed for:
  - POPs (PCB, PBDE): GC-MS
  - Total mercury (THg): DMA-80

Salmon directly increase POPs



PCB 2-way ANOVA

Time: $p<0.001$

Reach: $p<0.001$

Interaction: $p= 0.02$

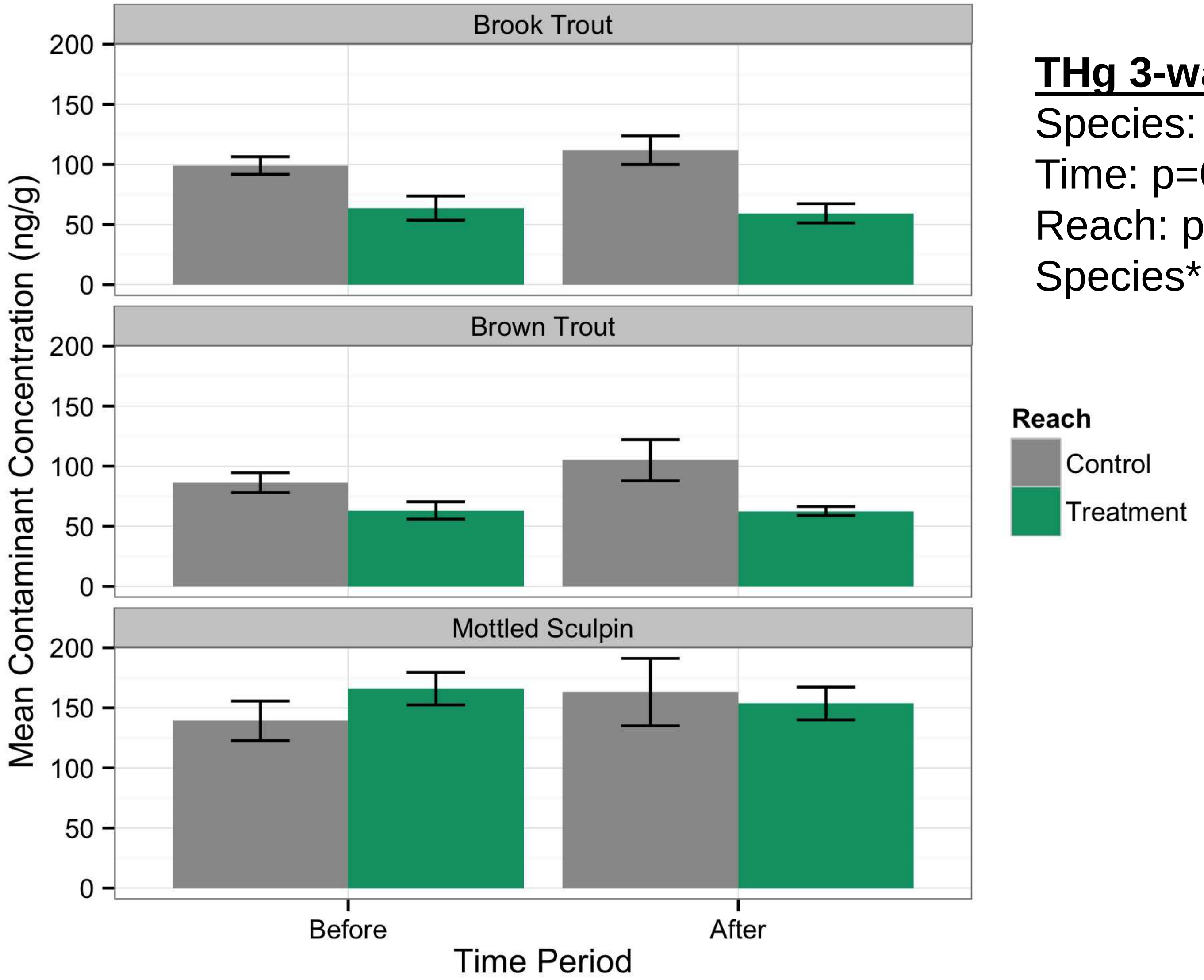
PBDE 2-way ANOVA

Time: $p=0.05$

Reach: $p=0.014$

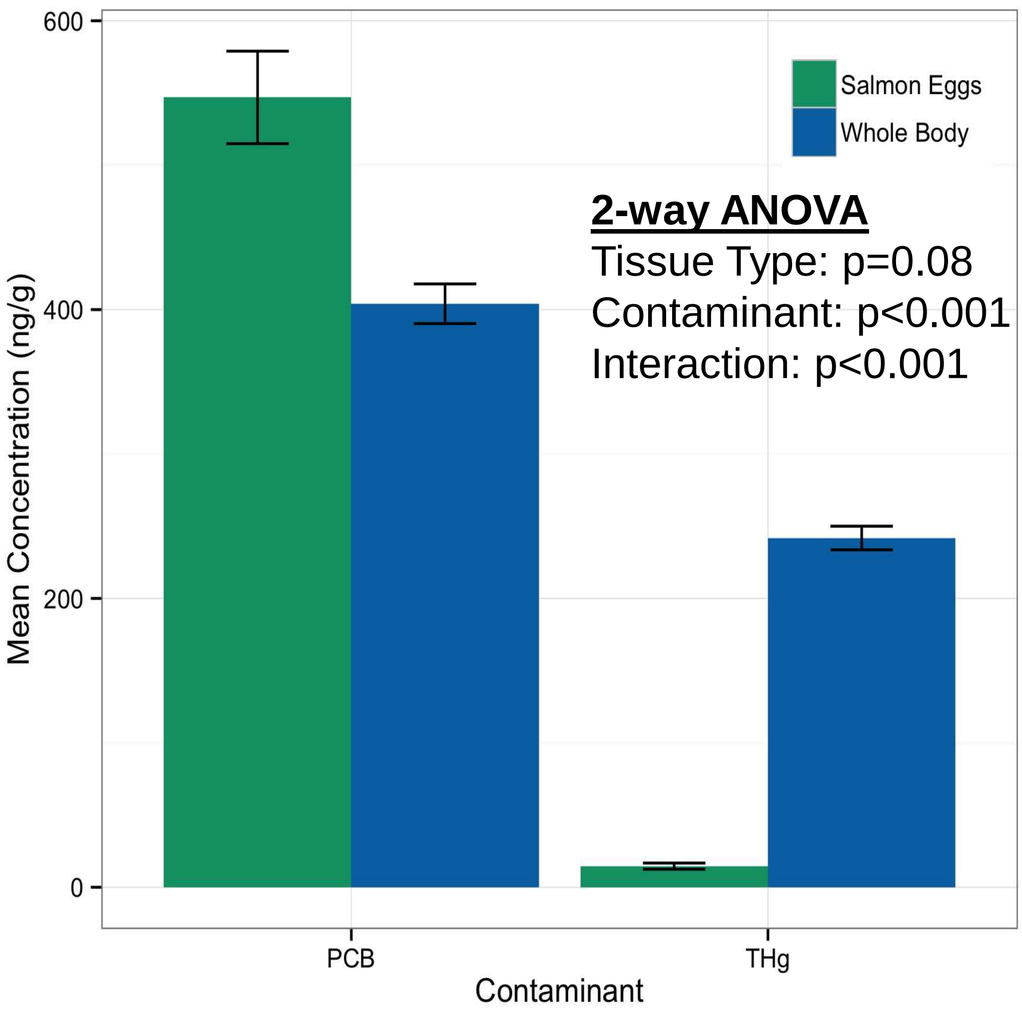
Interaction: $p= 0.06$

Salmon did not effect THg



THg 3-way ANOVA
Species: p<0.001
Time: p=0.63
Reach: p=0.005
Species*Reach=0.02

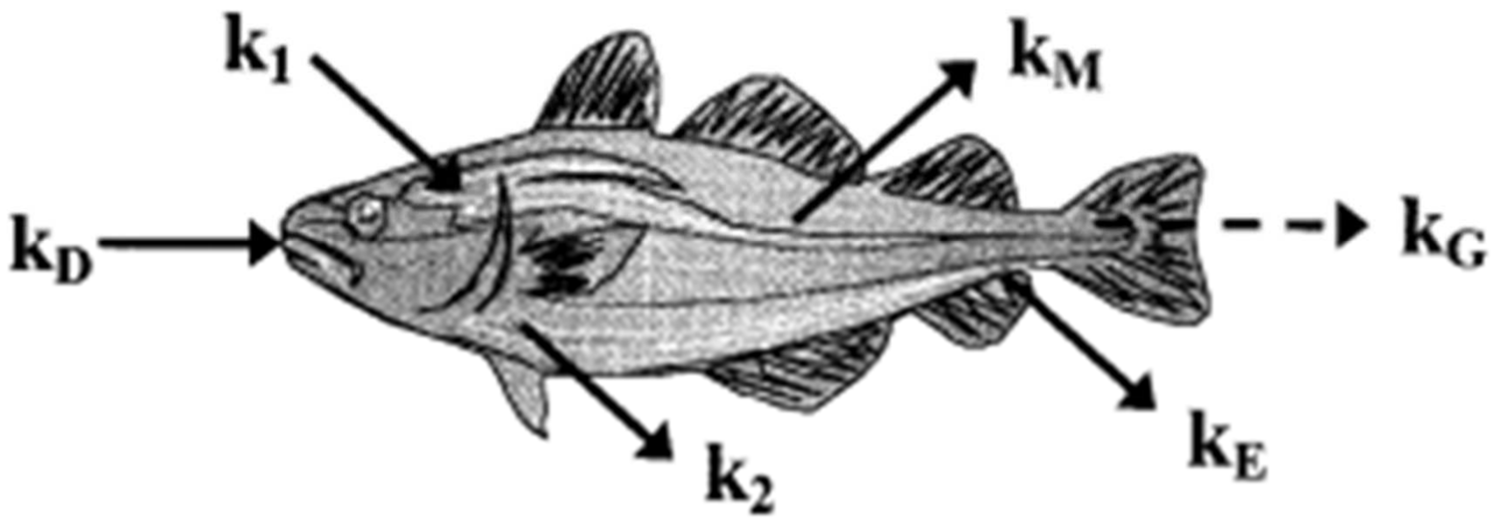
Trophic pathway to contamination



- Eggs *enriched* in PCBs
- Eggs *depleted* in THg

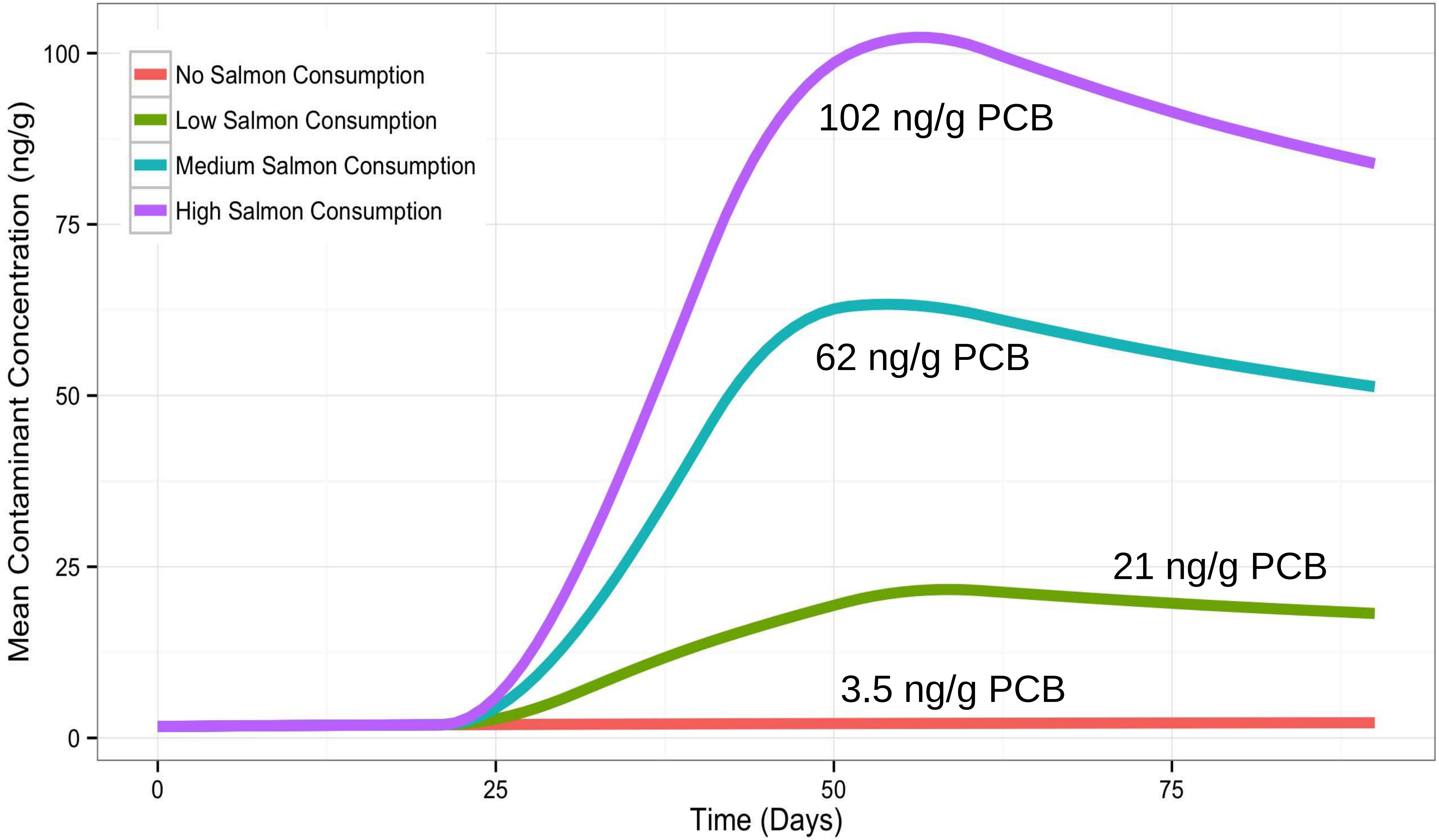
Modeling Salmon Biotransport

- Bioenergetics-Bioaccumulation model
- Predicts growth and contaminant concentration
  - 90-day simulation
  - Mottled Sculpin for PCB



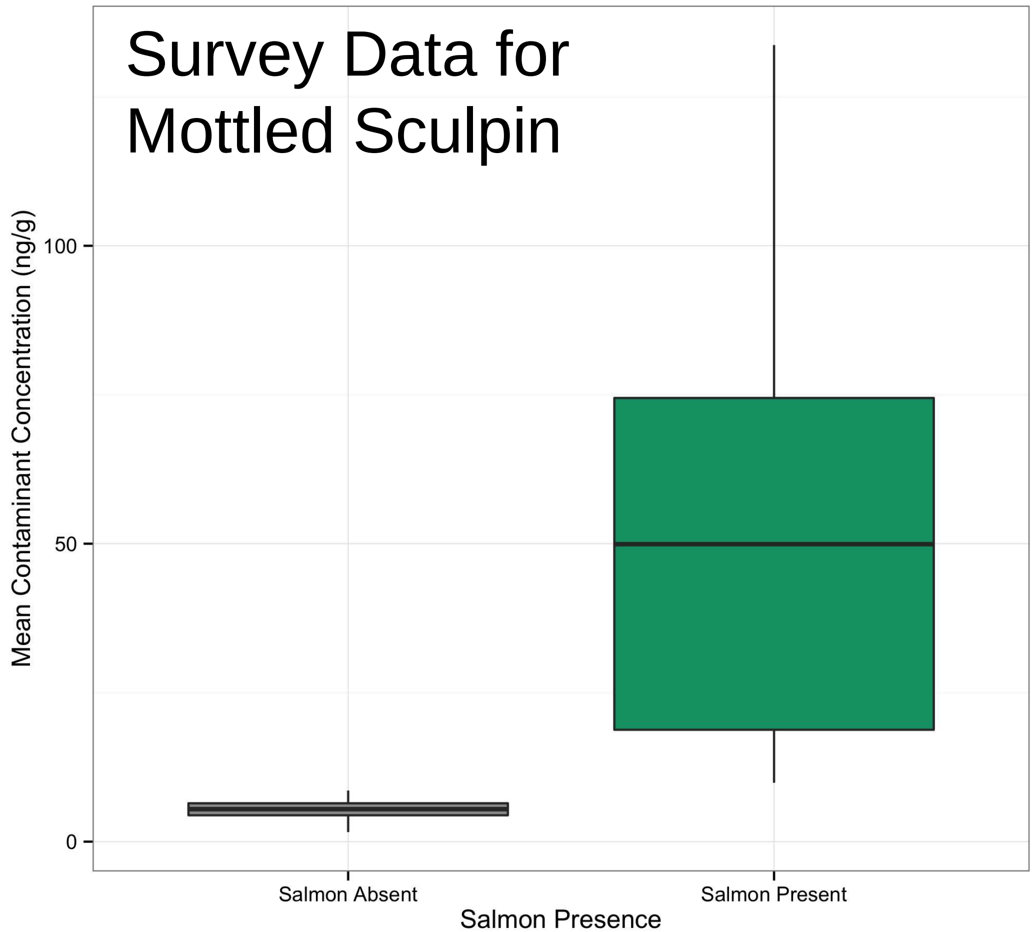
Arnot and Gobas 2004 Environ. Toxicol. Chem
Ng and Gray 2011 Global Change

Model Results for Mottled Sculpin



Model corresponds to Data

- Salmon Absent
  - Model=3.5 ng/g
  - Survey=1.2-8.2 ng/g
- Salmon Present
  - Model=21-102 ng/g
  - Survey=9.6-132 ng/g
- Future Directions
  - Additional scenarios
  - Add species
  - Expand contaminants

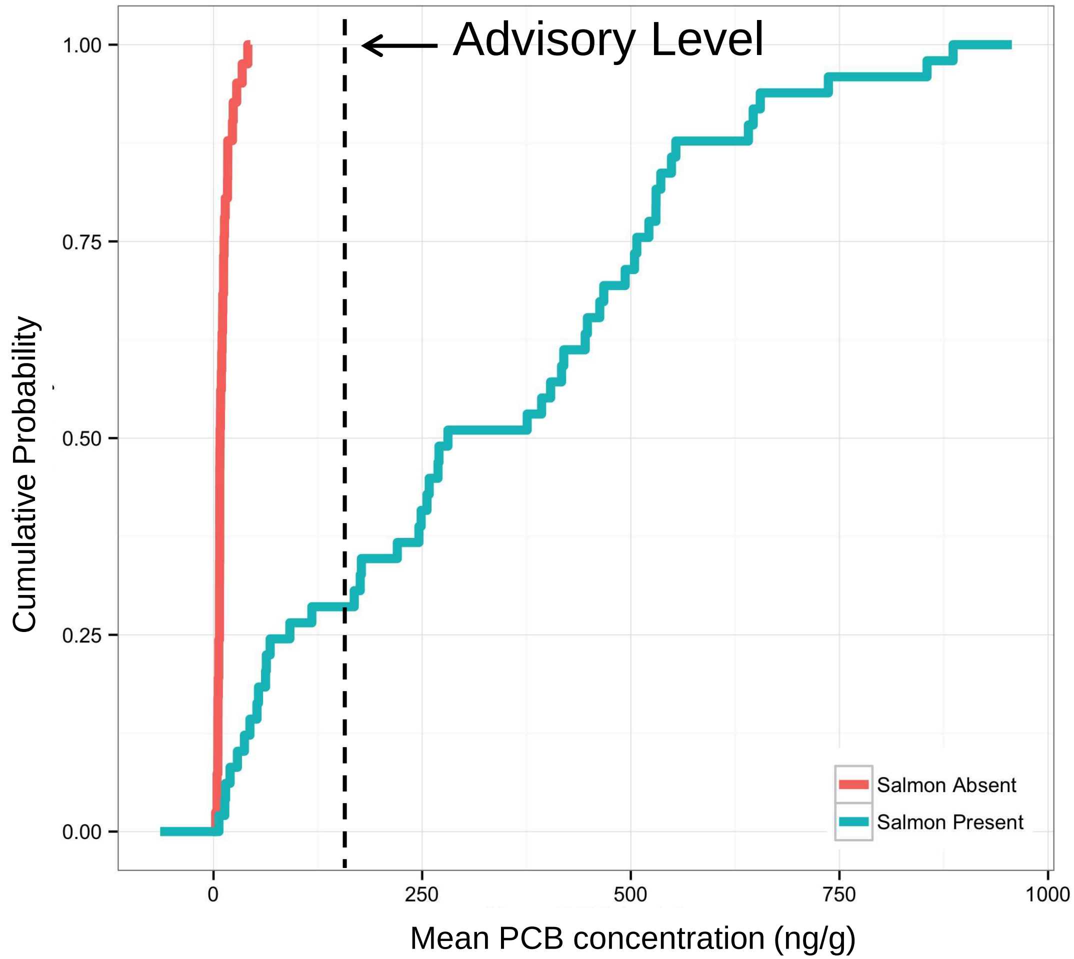


Implications for Management

- Dam Removal
  - Complex issue that must weight risk of invasive species, recreational interests, ecological connectivity
  - Contaminant transport should be considered in the risk assessment
- Uncertainties
  - Can we manage biotransported contaminants?
  - Do other species present a risk?
  - Are other contaminants being moved?

Implications for Human Health

- >70% of individual trout sampled in salmon streams exceeded the MDCH PCB consumption advisories of 1 meal per month.



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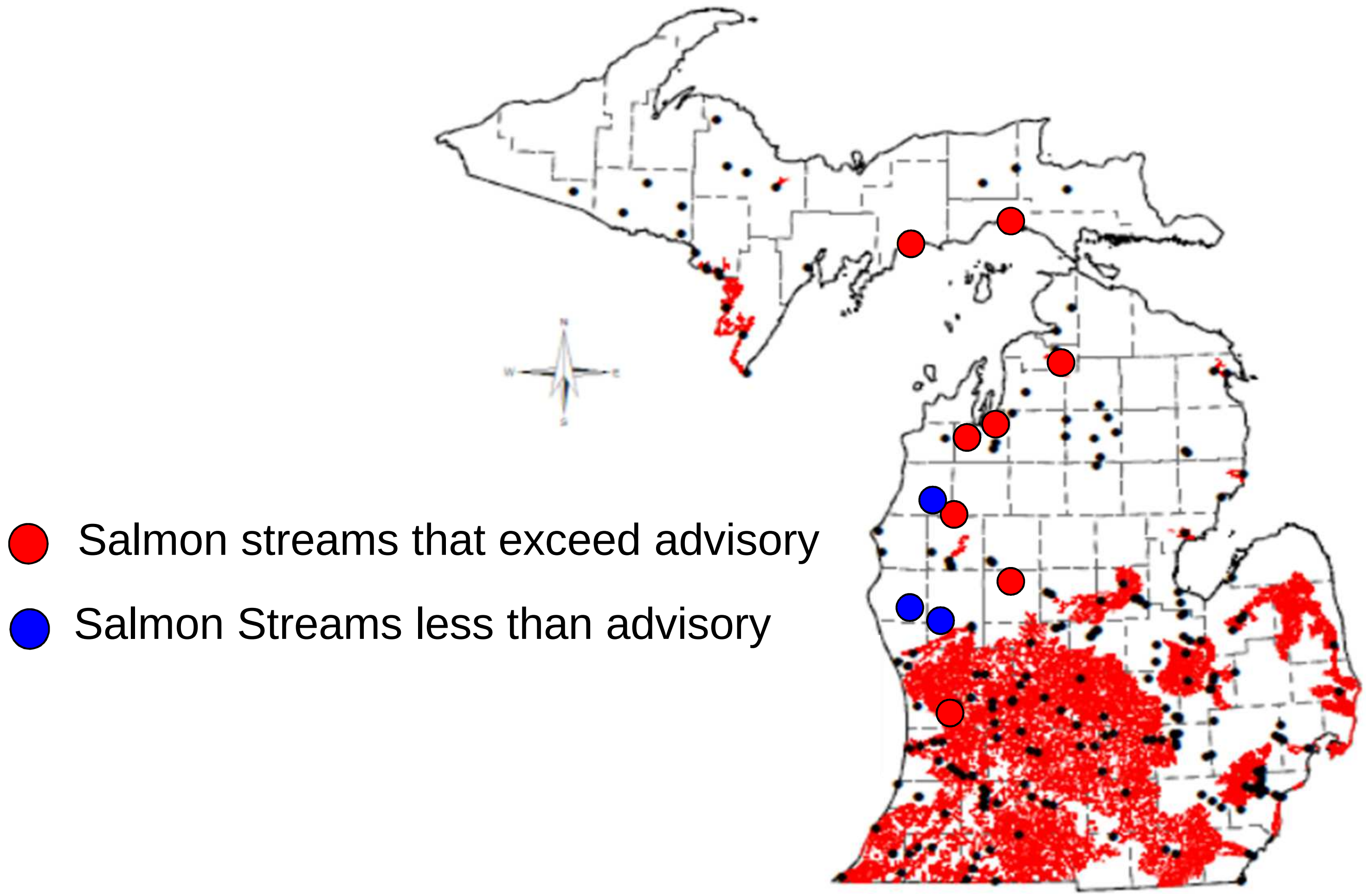

Conclusions

- Salmon <u>directly</u> influence POP concentrations of resident fish
- Salmon do not have detectable effects on THg in resident fish
- Egg consumption drives PCB and PBDE accumulation in resident fish
- Complimentary inference between survey, experiment, and model!

Acknowledgements

- UND Stream Ecology Lab @ ND
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  - GLFT (Grant # 2012.1244)
  - EPA STAR Graduate Research Fellowship

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Great Lakes Fishery Trust

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