Wetlands and PFAS: Understanding the Potential for Impacts on Amphibian Communities

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- PIs: Maria Sepulveda, Jason Hoverman, Linda Lee
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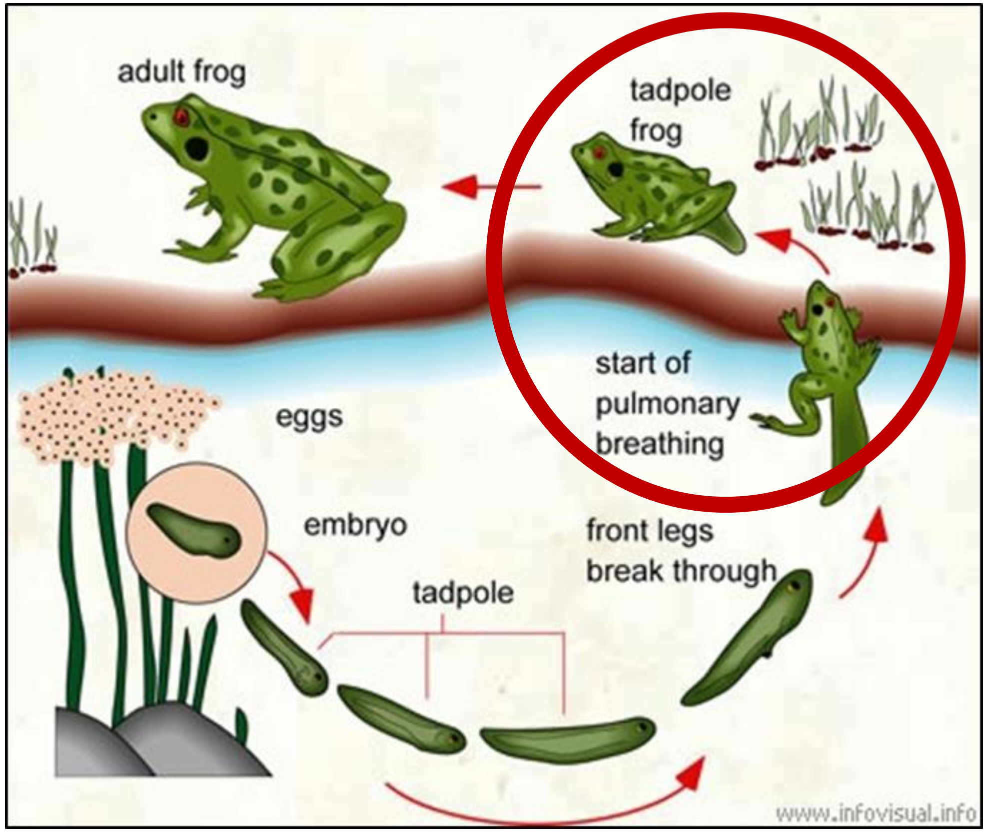
Overview

- Background
- Effects of PFAS on amphibians
- Incorporating environmentally relevant exposures
- PFAS in wetland ecosystems
- On-going and future directions

Why might PFAS present an exceptional risk to amphibians?

- Foraging strategy
  - Ingestion of sediments where PFAS levels are often high
- Life history
  - Transition between aquatic and terrestrial life stages mediated by thyroid
- Disease
  - susceptibility/impaired immune function



Bridging Gap Between Lab and Field studies

- Leverage strengths of lab and field projects
  - Do conditions at PFAS contaminated sites pose a risk to amphibian populations?
  - Do experimental conditions reflect environmental exposure conditions?

Overview of Amphibian Laboratory Studies

- Four species of amphibians native to Midwest
- Four PFAS commonly occurring at AFFF-sites (PFOS, PFOA, PFHxS, 6:2-FtS)
- Three routes of exposure: aquatic, dermal, dietary
- Acute and chronic tests
- Effects of PFAS mixtures
- Susceptibility to disease

Summary of PFAS Effects on Amphibians

- PFAS can reduce growth and development
- Lack of consistent dose-responses
- Variation in responses among species, chemicals, and exposure routes
- Potential for synergism
- Exposure can increase susceptibility to disease

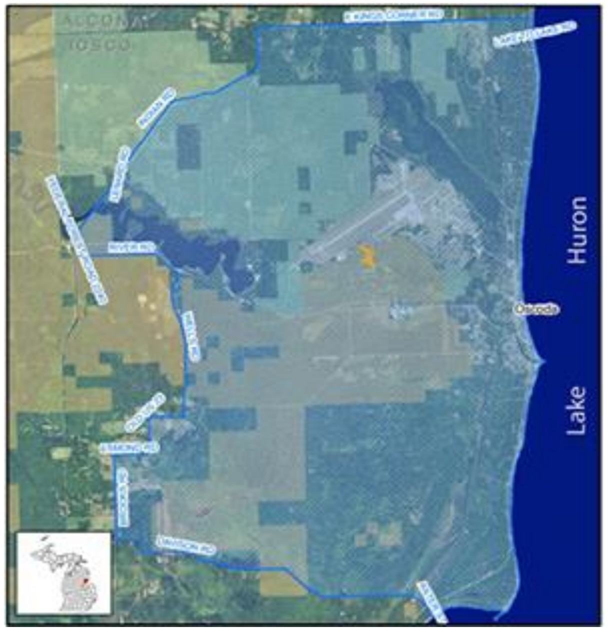
Big Question Remaining:

Are environmental exposures likely to negatively affect health?

Clark’s Marsh Wildlife Area

Clark’s Marsh Wildlife Area

- Wurtsmith AFB, Oscoda, MI
- Historic AFFF use
- Complex mixture
- PFOS levels in ground and surface water, sediment, and game fish exceptionally high
- Evidence of transfer into terrestrial ecosystem

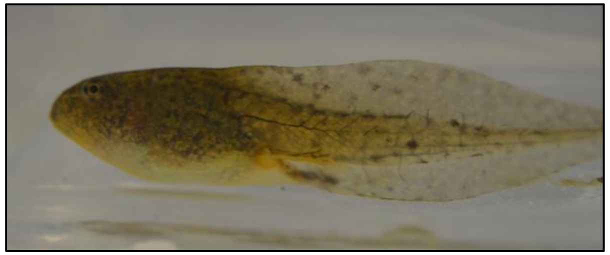


Transition to Environmentally Relevant Exposures

- Clark's Marsh ideal study system to assess effects of environmental exposure
  - Lots of data
  - Environmental gradient
  - Intact food web
  - Readily accessible
- Simulated pond communities

Effects of PFAS under Semi-realistic Conditions

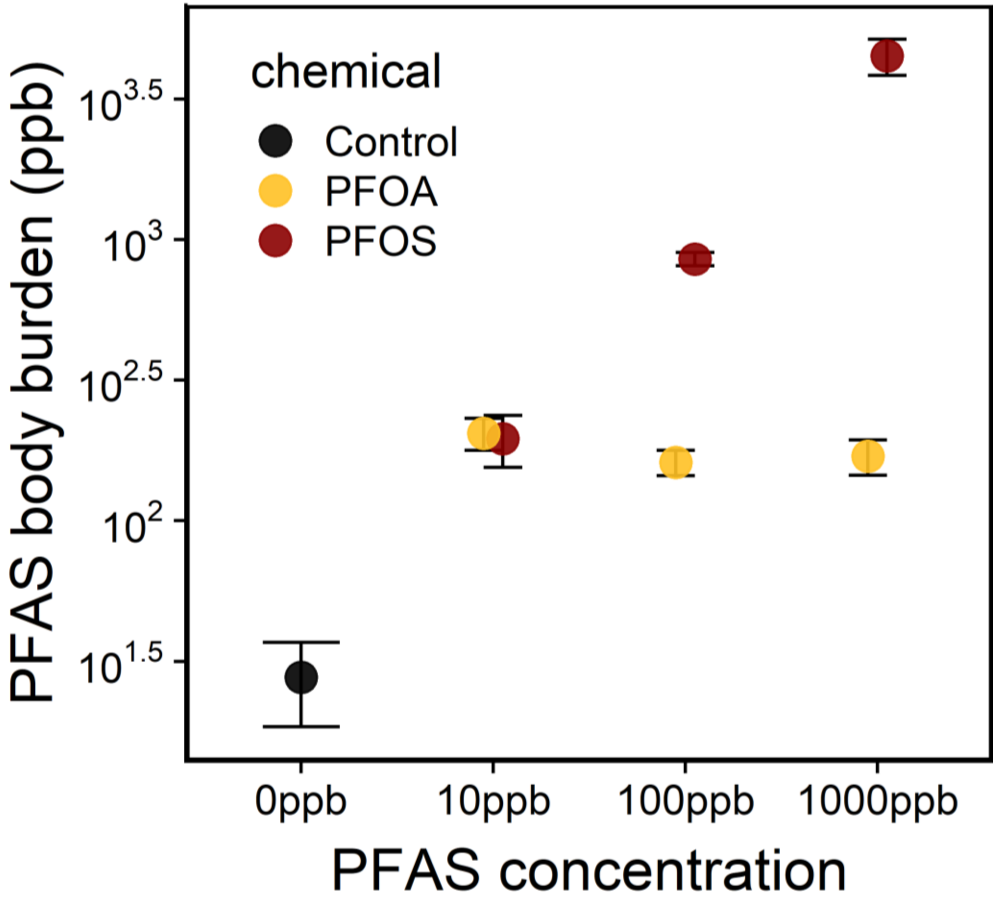
- Exposure to PFOS or PFOA spiked sediments for 30 d
- Achieved environmentally relevant water and sediment concentrations (PFOS)
  - This study
    - Water: <0.08 – 16 ppb
    - Sediment: 8 – 740 ppb
  - Clark's Marsh
    - Water: <0.07 – 7.4 ppb
    - Sediment: 10 – 313 ppb



Effects of PFAS under Semi-realistic Conditions

- Observed effects (PFOS)
  - Water: 0.08 – 16 ppb
  - Sediment: 8 – 740 ppb
  - **Tadpoles: 90 – 1465 ppb (dw)**
- Clark's Marsh (PFOS)
  - Water: <0.07 – 7.4 ppb
  - Sediment: 10 – 310 ppb
  - **Tadpoles: 230 – 2180 ppb (dw)**

- Tadpole development delayed in both PFOS and PFOA treatments, but no effects on growth



Modified from: Foguth, RM., RW Flynn, C De Perre, M Iacchetta, LS Lee, MS Sepúlveda, and JR Cannon. 2019. Developmental exposure to perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) selectively decreases brain dopamine levels in Northern leopard frogs. Toxicology and Applied Pharmacology 377(May)

Effects of Environmentally Relevant Mixtures

- Modelling exposure at AFFF-sites and Clark's Marsh
  - data sourced from EGLE and Anderson et al. 2016. *Chemosphere*
  - PFOS (40%), PFHxS (30%), PFOA (12.5%), PFHxA (12.5%), PFPeA (5%)
    - ~95% of total aquatic PFAS load
- Treatments designed to assess:
  - Is PFOS of most concern in complex mixtures?
  - Do PFOS and other mixture components interact to increase or decrease toxicity?

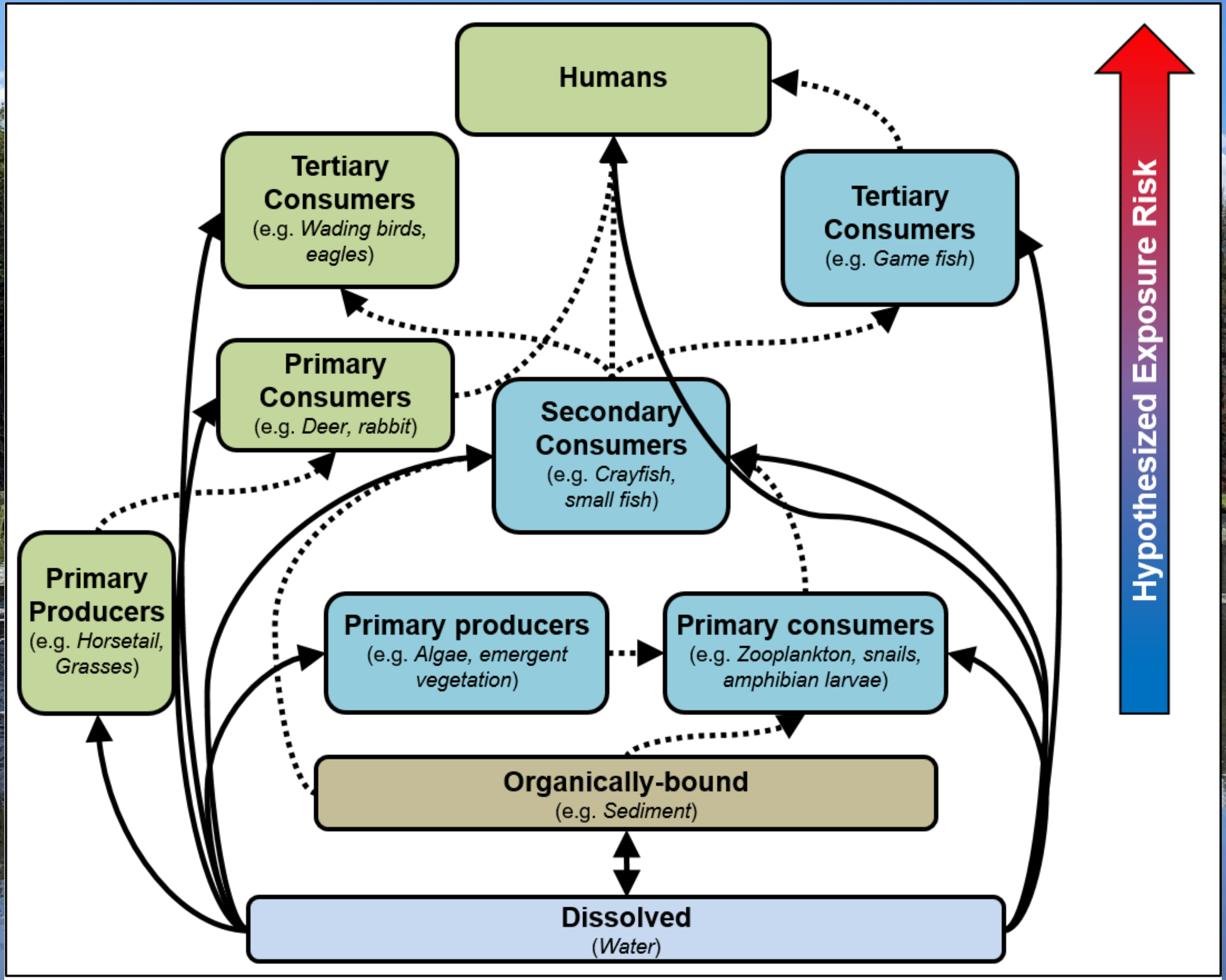
Summary: Environmentally Relevant Exposures

- Can simulate more realistic exposure conditions in mesocosms
- Toxicity derived from laboratory studies may underestimate risk in field if only considering PFAS in water
- PFAS exposure can delay development
- On-going and future work incorporating environmentally relevant mixtures into assessing effects of PFAS on amphibians and other wildlife

Ecosystem approach: On-going and future work

- Developing quantitative food web model to assess sources of PFAS
  - Identifying sources of PFAS transfer from aquatic to terrestrial ecosystems
- Quantifying accumulation among ecosystem compartments
- Linking effects of PFAS from controlled studies with accumulation seen at field sites

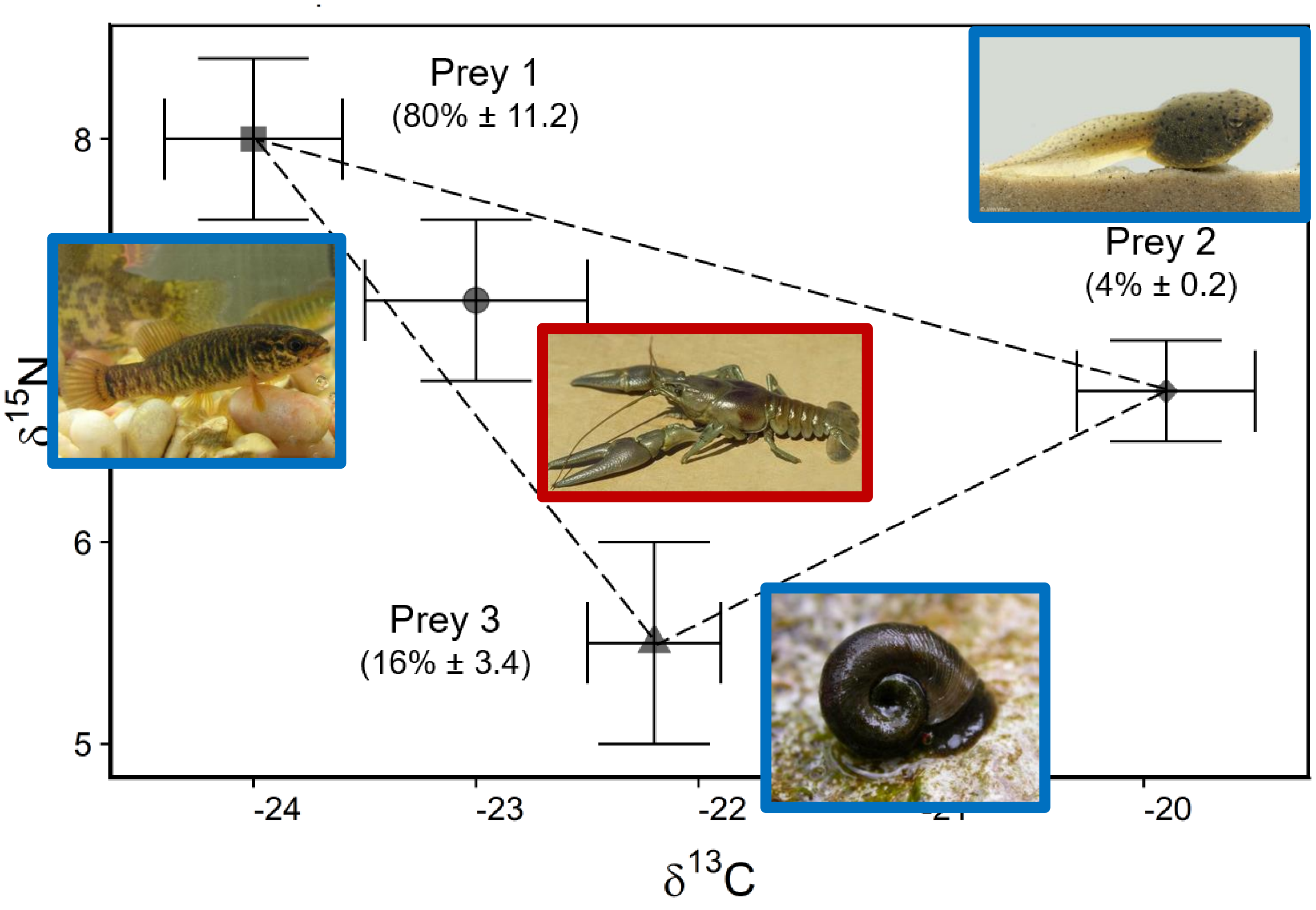
Quantifying Distribution and Transfer of PFAS in Wetland Food Webs



Summary of preliminary PFAS accumulation in aquatic food webs

- General trend in PFAS levels
  - Water < Sediment < Algae < Primary Consumers < Secondary Consumers < Fish
  - Accumulation in taxa more closely mirrors composition of sediment PFAS than PFAS in water
  - PFOS, PFOSA, and PFHxS largest contributors to PFAS body burdens
  - Clark's Marsh food web has higher concentrations and more diverse PFAS than wetland food web impacted PFAS tannery waste

Quantifying Trophic Interactions



Moving forward

- PFAS have potential to present ecological risk to amphibians
- Filling in knowledge gaps
  - Environmental relevance in toxicity
  - Mechanisms of action using *Xenopus*
  - Ecological interactions
  - Mixtures from different sources

Assessing impact of PFAS challenging, but possible with interdisciplinary and collaborative approaches

Questions