Extent and Pathways of PFAS Bioaccumulation and Biomagnification in Aquatic Ecosystems

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DOE PFAS R&D Workshop, June 9-10, 2024
"Characterization of Sources and Exposure Pathways" Breakout

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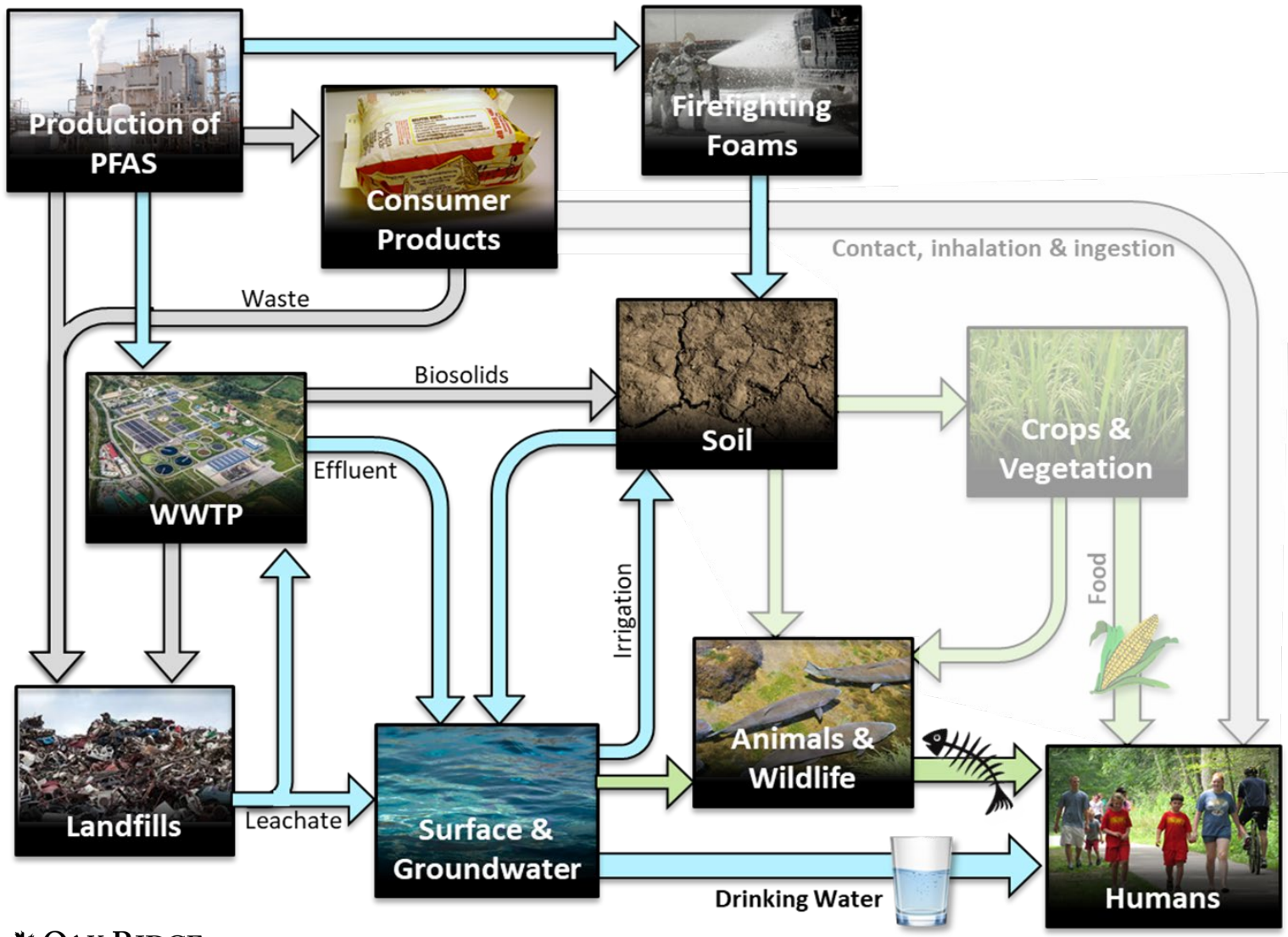
PFAS in Aquatic Ecosystems

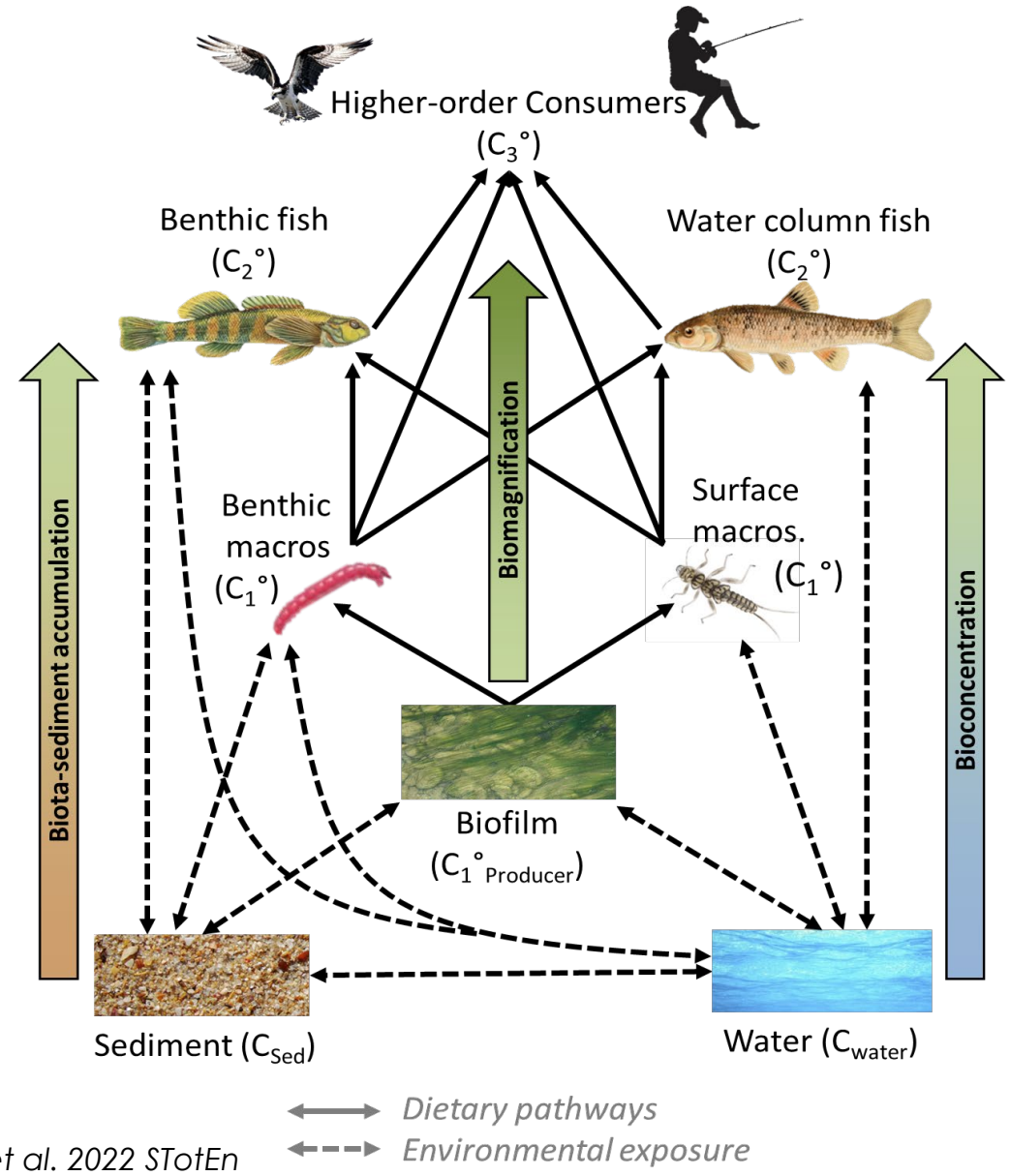


It is critical to understand the ecological and human health risks associated with the presence of PFAS in aquatic habitats

- Quantify extent, pathways and rates of PFAS uptake and bioaccumulation
- Inform accurate quantitative prediction of risks
- Evaluate potential pathways for human exposure

PFAS in Aquatic Ecosystems

- Multiple transfer pathways into tissue + excretion
- Bio-relevant properties & behavior of PFAS vary with functional head group + chain length
- Bioaccumulation of PFAS in aquatic food webs influenced by multiple environmental & organismal factors



Lewis et al. 2022 STotEn

PFAS Projects

- Uptake and Bioaccumulation/Biomagnification of Subsurface-Derived PFASs by Lotic, Warm Water Food Webs (ER19-1032)
  Lead PI: Marie Kurz; Co-Is: Erica McKenzie (Temple U), Chris Sales (Drexel U), Dan Spooner (Lock Haven U)

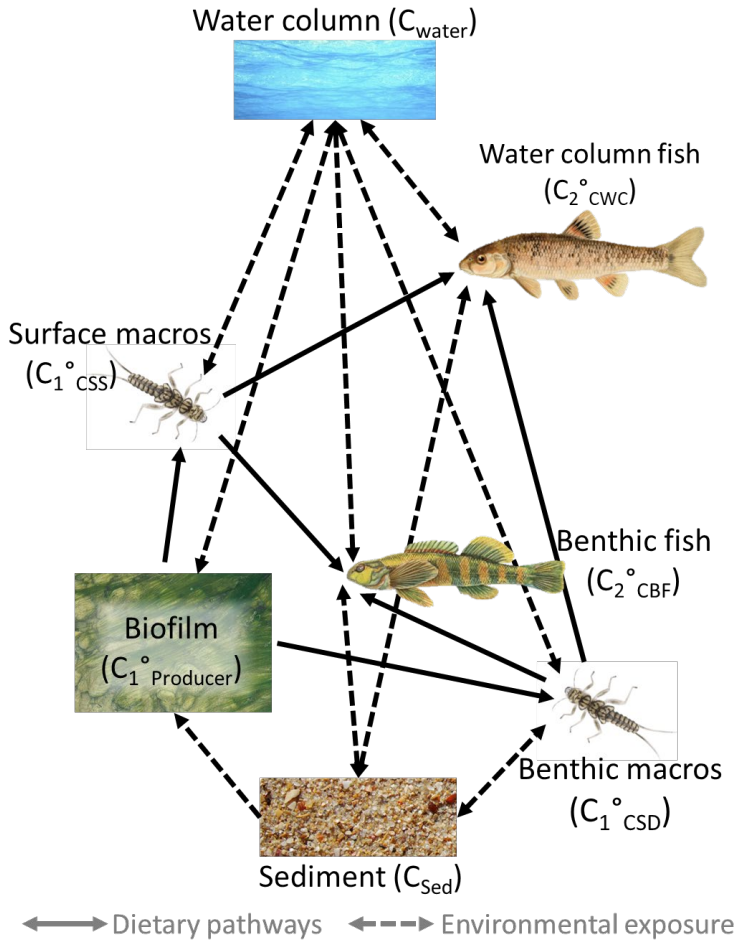
- Estimation of Fish Bioaccumulation Factors (BAF) for Selected PFAS Contaminants in Marine and Freshwater Systems
  Co-PIs: Marie Kurz, David Keller & Tim Maguire (ANSDU)

- Review of Human Health Effects of PFAS in Support of MCL Development
  PI: Richard Hamilton (Drexel U)

Bioaccumulation/Biomagnification of AFFF-Associated PFAS in Freshwater Food Webs

Objective: Improve our understanding of the pathways & rates of uptake, bioaccumulation & biomagnification of PFAS in warm water stream ecosystems.

- What are the **extent and pathways** of AFFF-attributed PFAS bioaccumulation within stream food webs?
- How does **sediments and water geochemistry** of affect the bioavailability and accumulation of PFAS in lower trophic level organisms?
- What are the **relative mechanisms** for PFAS contamination in freshwater ecosystems, esp. dietary vs. environmental?



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Study Approach

Microcosms

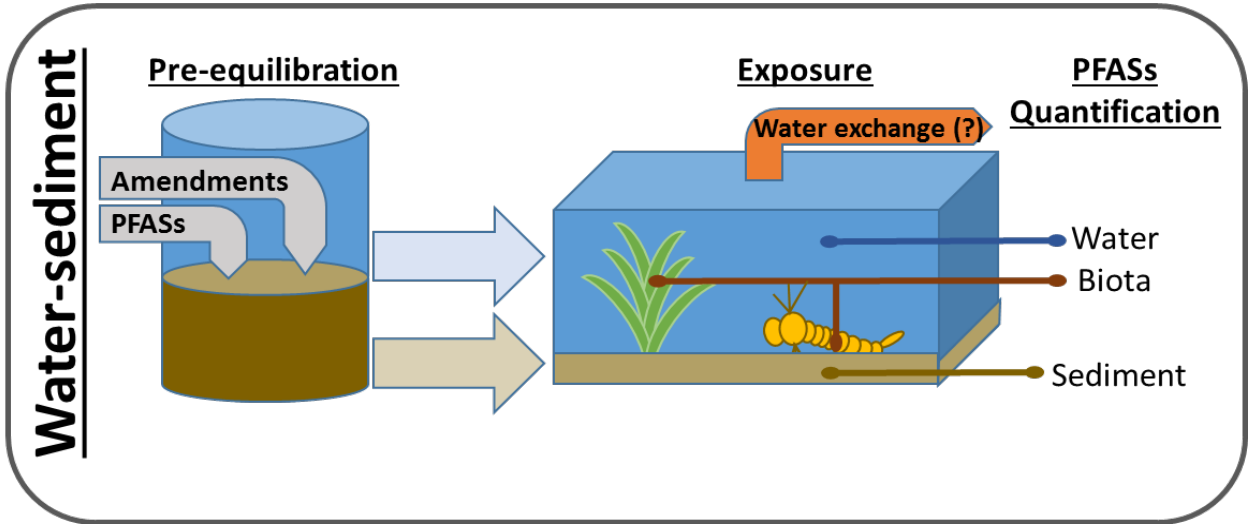
Mesocosms

Field

Increasing complexity

Microcosm Study

Evaluate the effects of organic carbon, solution chemistry and temperature on PFAS uptake by lower trophic level organisms, targeting DoD-relevant conditions.



Physella acuta
Pond Snails

Eliptio Complanata
Mussels

Lumbriculus variegatus
Aquatic Earthworms

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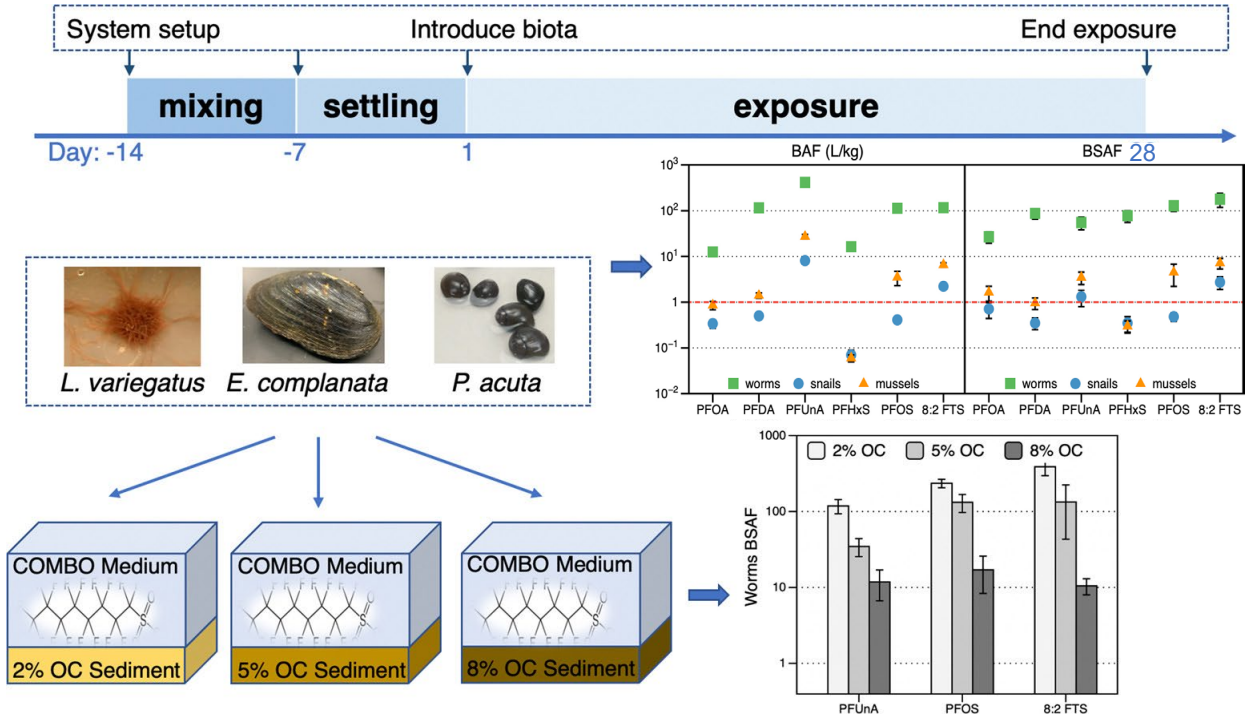
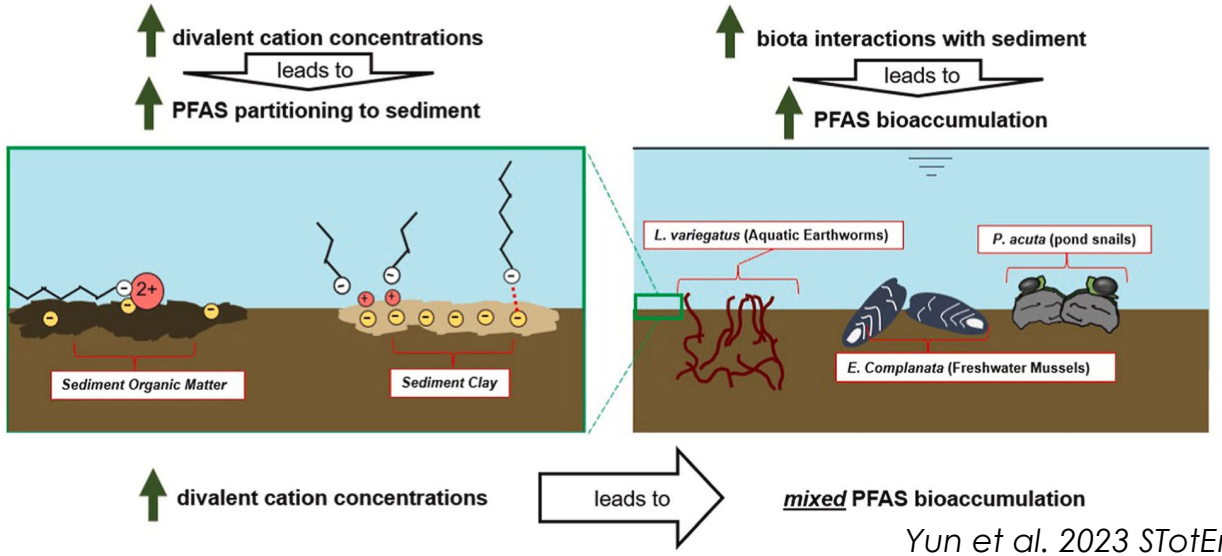
Microcosm Study

- PFAS uptake highly species dependent >> likely reflects differences in feeding behavior, exposure & metabolism.
- Incr. sediment org. carbon & dissolved cations both reduce PFAS bioavailability & uptake to biota; temperature response was non-linear
- Need to consider environmental ranges in results & organismal behavior relative to changes in environmental conditions.



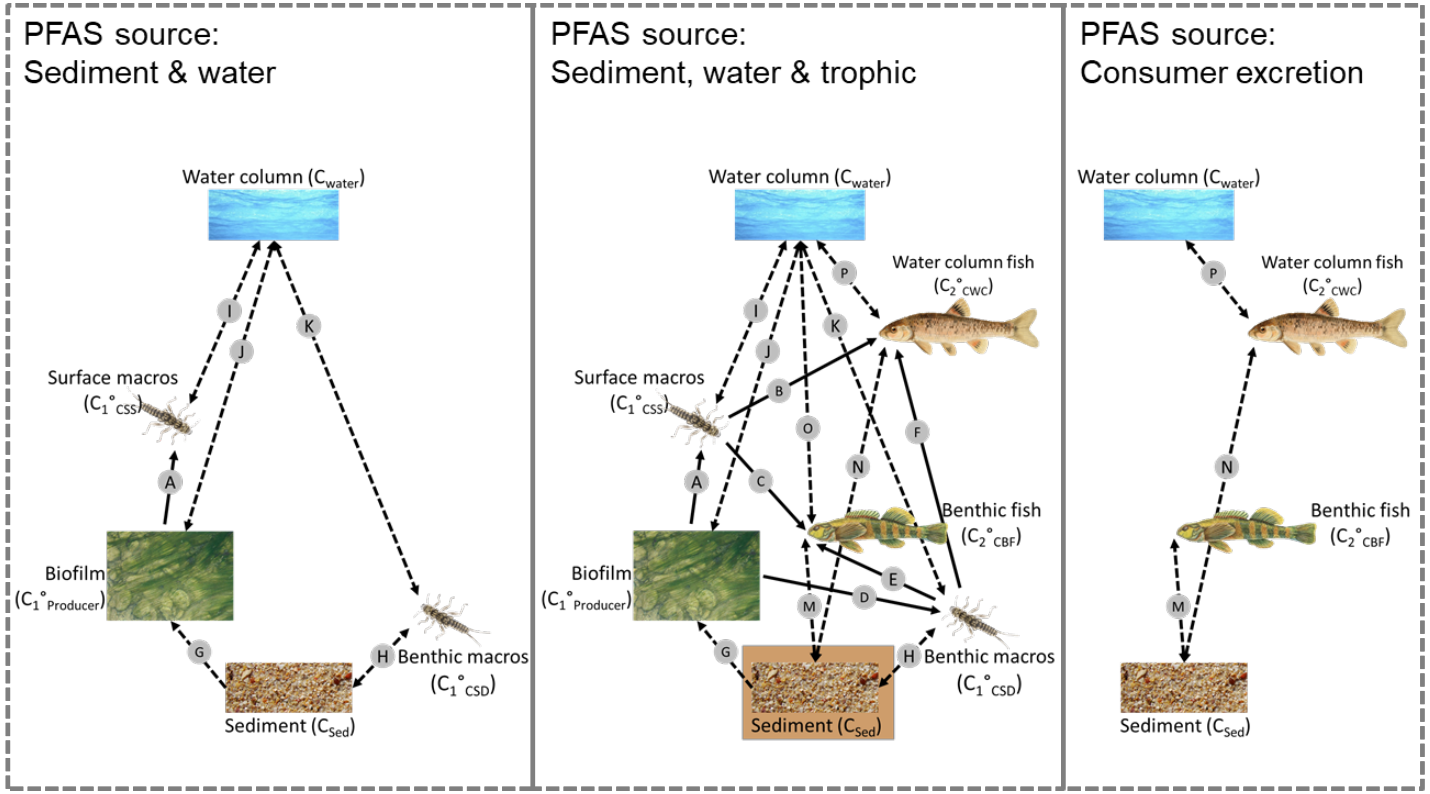
Lewis et al. 2023 Env. Pol.



Yun et al. 2023 STotEn

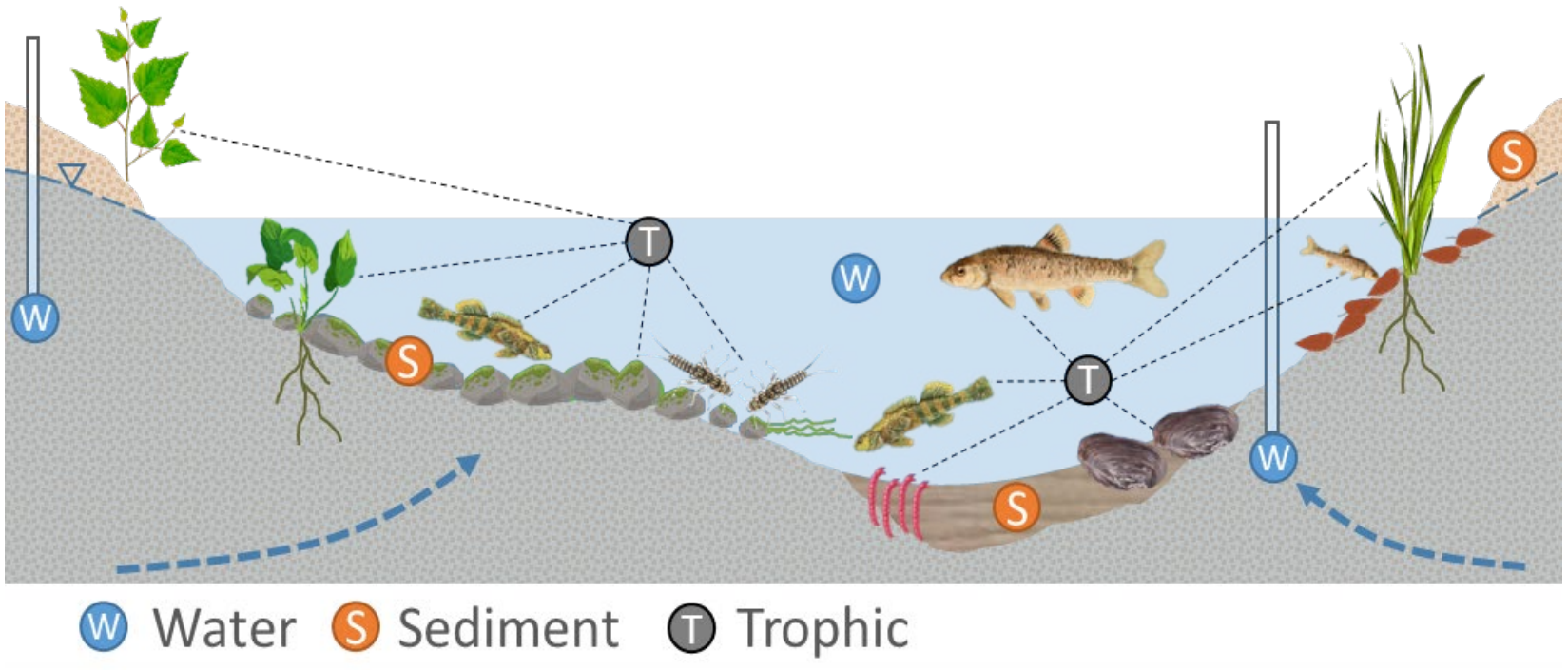
Mesocosm study

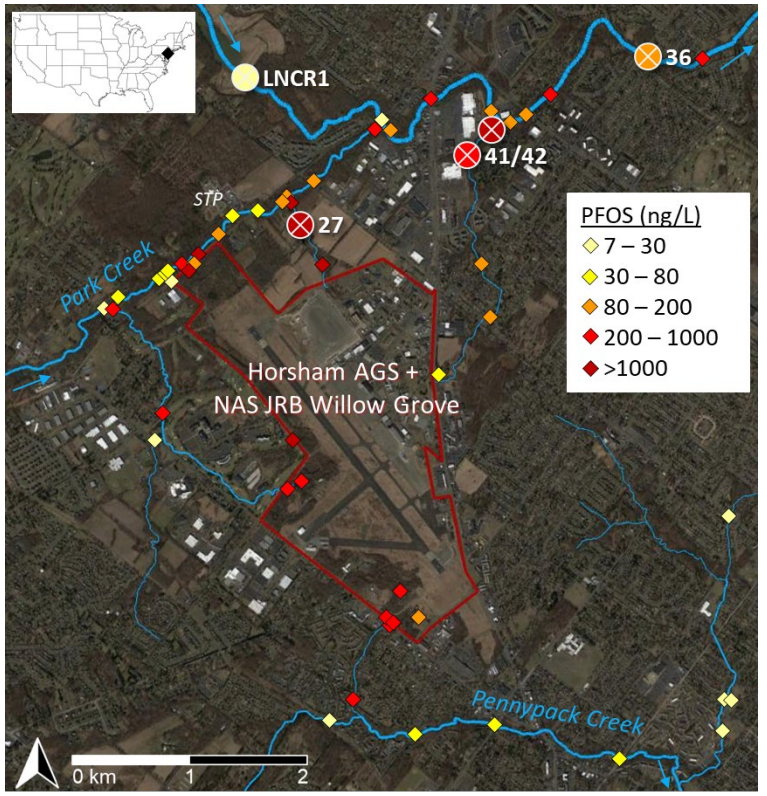
Quantify rates of PFAS transfer along controlled primary and trophic pathways to aquatic species representing multiple trophic levels and degrees of sediment association.



Field Study

Assess PFAS bioaccumulation and biomagnification across all trophic levels of stream food webs at 3 sites exposed to AFFF-attributed PFAS contamination, and 1 regional 'background' site.





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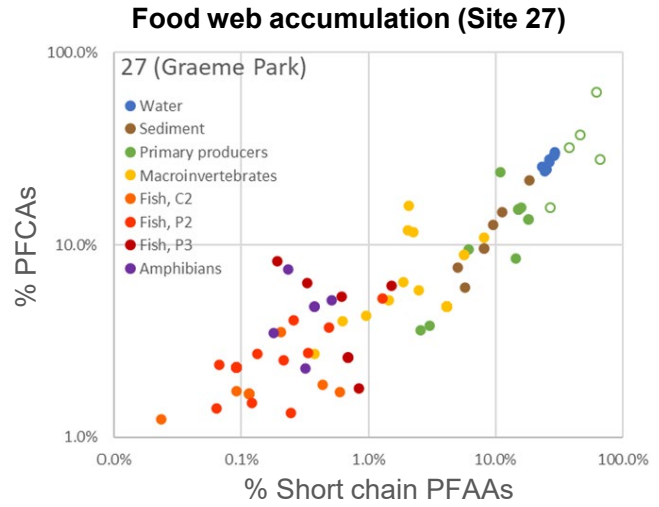
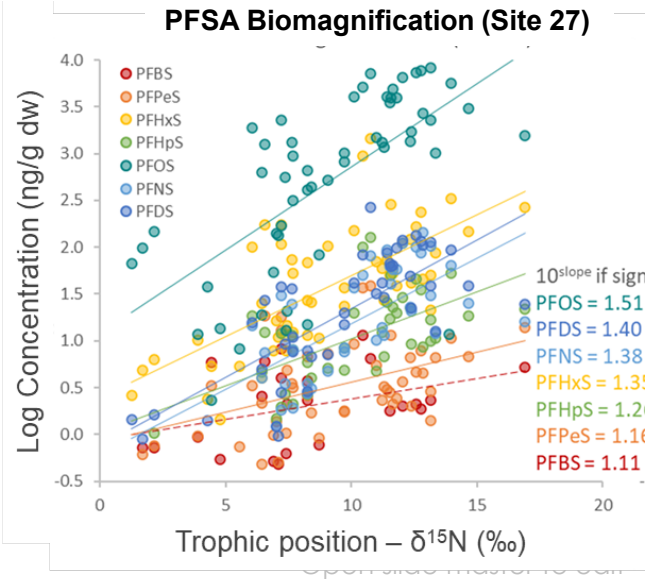
Field Study

- Site environmental [PFAS] & profiles consistent with expected PFAS source & transport pathways
- High spatial-temporal variability in water & sediment [PFAS] >> implications for quantifying bioaccumulation
- Clear accumulation across trophic levels: BAFs ↑ with chain length, PFCA < PFSA, and ↓ with [PFAS]
- Clear trophic magnification but less predictable
- Limited and inconsistent trends with trophic position or within organismal group.
- Effect of organism habitat, feeding behavior, etc. likely contribute to complexity





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Publications to-date

Contents lists available at ScienceDirect

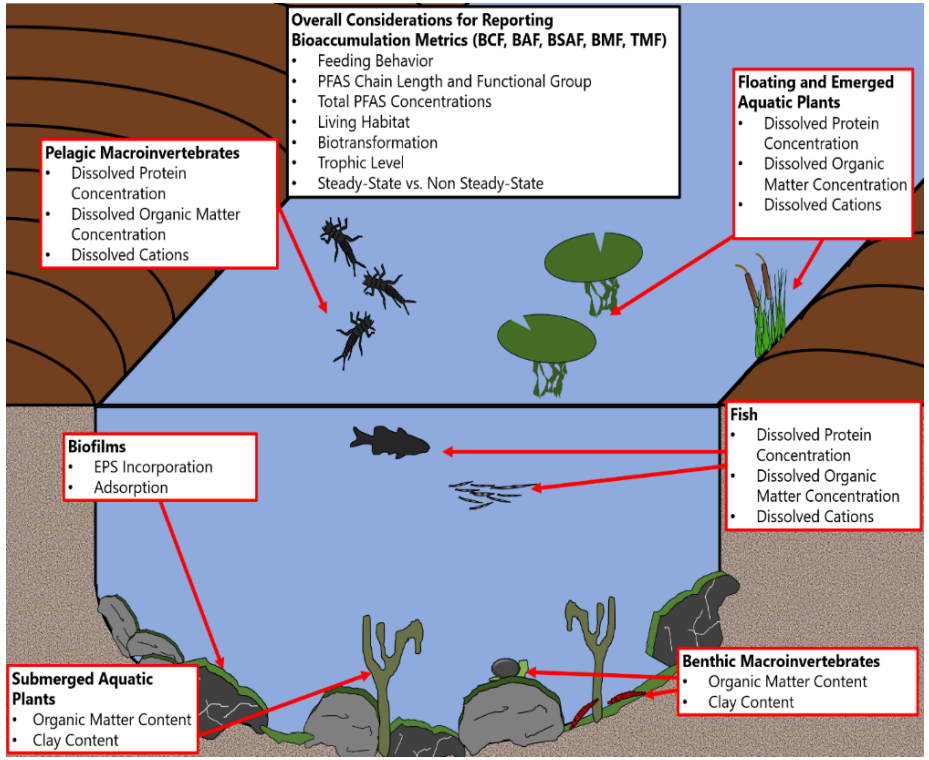
Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Review

Exposure pathways and bioaccumulation of *per*- and polyfluoroalkyl substances in freshwater aquatic ecosystems: Key considerations

Asa J. Lewis [a,*], Xiaoyan Yun [b], Daniel E. Spooner [c], Marie J. Kurz [d,1], Erica R. McKenzie [b], Christopher M. Sales [a]



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Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Bioaccumulation of *per*- and polyfluoroalkyl substances by freshwater benthic macroinvertebrates: Impact of species and sediment organic carbon content☆

Xiaoyan Yun [a], Asa J. Lewis [b], Galen Stevens-King [b], Christopher M. Sales [b], Daniel E. Spooner [c], Marie J. Kurz [d,e], Rominder Suri [a], Erica R. McKenzie [a,*]

Contents lists available at ScienceDirect

Environmental Pollution

journal homepage: www.elsevier.com/locate/envpol

Impacts of divalent cations (Mg^{2+} and Ca^{2+}) on PFAS bioaccumulation in freshwater macroinvertebrates representing different foraging modes☆,☆☆

Asa J. Lewis [a,*], Xiaoyan Yun [b], Max G. Lewis [c], Erica R. McKenzie [b], Daniel E. Spooner [d], Marie J. Kurz [e,f], Rominder Suri [b], Christopher M. Sales [a]

Contents lists available at ScienceDirect

MethodsX

journal homepage: www.elsevier.com/locate/methodsx

A modified QuEChERS sample processing method for the determination of per- and polyfluoroalkyl substances (PFAS) in environmental biological matrices☆,☆☆

Xiaoyan Yun [a], Marie J Kurz [b,c], Rominder Suri [a], Erica R McKenzie [a,*]

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Fish BAFs in Marine and Freshwater Systems

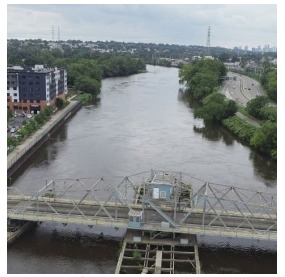
Objective: Develop statewide BAFs for 40 PFAS to aid NJDEP in development of surface water quality standards, accounting for the range of freshwater and marine environments and fish taxa across the state.

Approach: Classify waterbodies by salinity + tidal influence, lotic vs. lentic, DOC chemistry, and lake depth + turnover.

Classify fish by trophic level and habitat.

Quantify temporal variability in environmental PFAS concentrations and chemistry.

Calculate BAFs based on various data groupings (individual, species, etc.)



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Challenges looking forward…

- PFAS uptake is not well predicted by existing partitioning models
- Controlled + ecotox study design & results often not well aligned with field conditions & observations
- Environmental and organismal characteristics are as/more important than PFAS compound characteristics
- Environmental concentrations & stressors are highly variable
- Unknown effects of PFAS mixtures and/or precursors
- Analyses are costly, require significant material, and no method is superior across matrixes