Site-Specific Concerns for Investigations at PFAS Sites: Bioaccumulation Factors for Freshwater Fish

GSI ENVIRONMENTAL

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SMWG

Sponsor Forum

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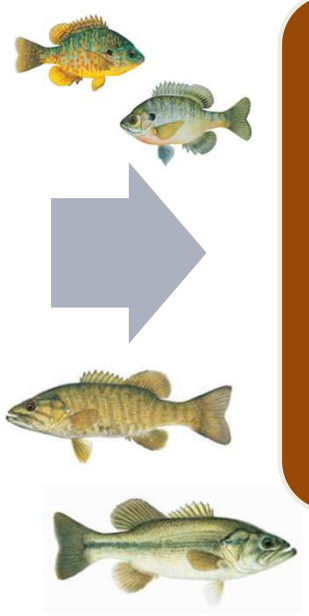
PFAS and Bioaccumulation

Bioaccumulation potential is a key factor in the development of protective risk-based criteria and site-specific remedy selection (including adaptive options).

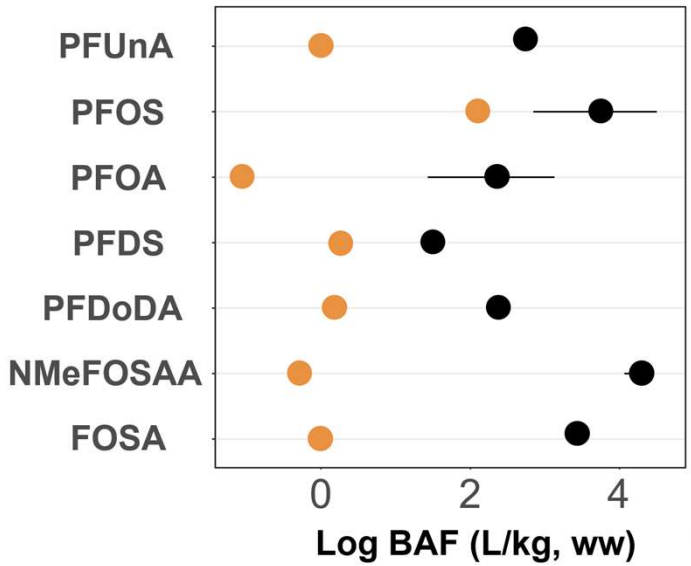


The diversity of PFAS characteristics, species-specific uptake and bioaccumulation, and geochemical modulators pose substantial challenges in the generalized applicability of bioaccumulation factors.

PFAS and Bioaccumulation

Published bioaccumulation factors can and are used in risk assessments, however…**their representativeness across environmental settings and species is uncertain.**

- Burkhard (2021) whole body fish BAFs compiled from the literature (multiple species)
- Rainbow Trout: "Site A"

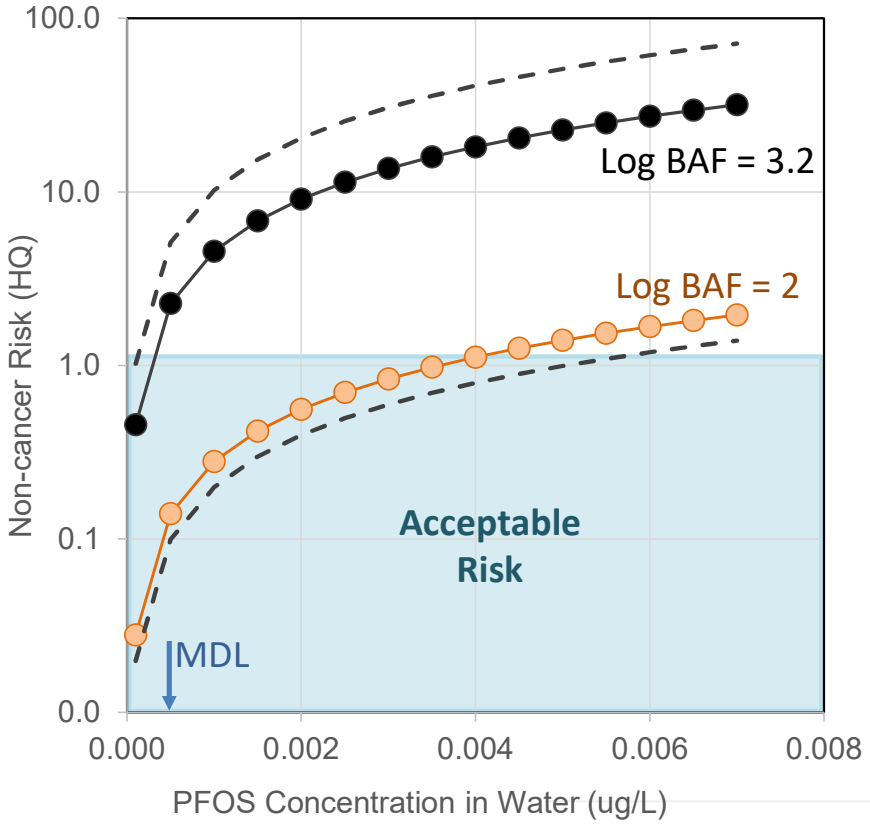


PFAS and Bioaccumulation – Impacts Risk

Adult Fish Consumption Risk (Noncancer) for different BAFs (water-to-fillet)

- Burkhard (2021) fish fillet BAFs (median, +/-SD ---)
- Rainbow Trout: "Site A"

Acceptable risk threshold for non-cancer effects is HQ≤1 (rounded to one significant digit).



Bioaccumulation Factors are Ratios

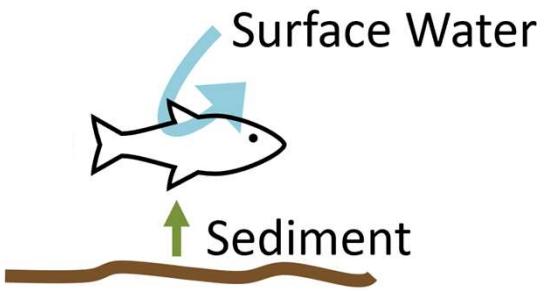
Bioaccumulation factors are a ratio-based calculation:

Bioaccumulation Factor (field)

$$BAF = \frac{Mean\ Tissue\ Conc.}{Mean\ Surface\ Water\ Conc.}$$

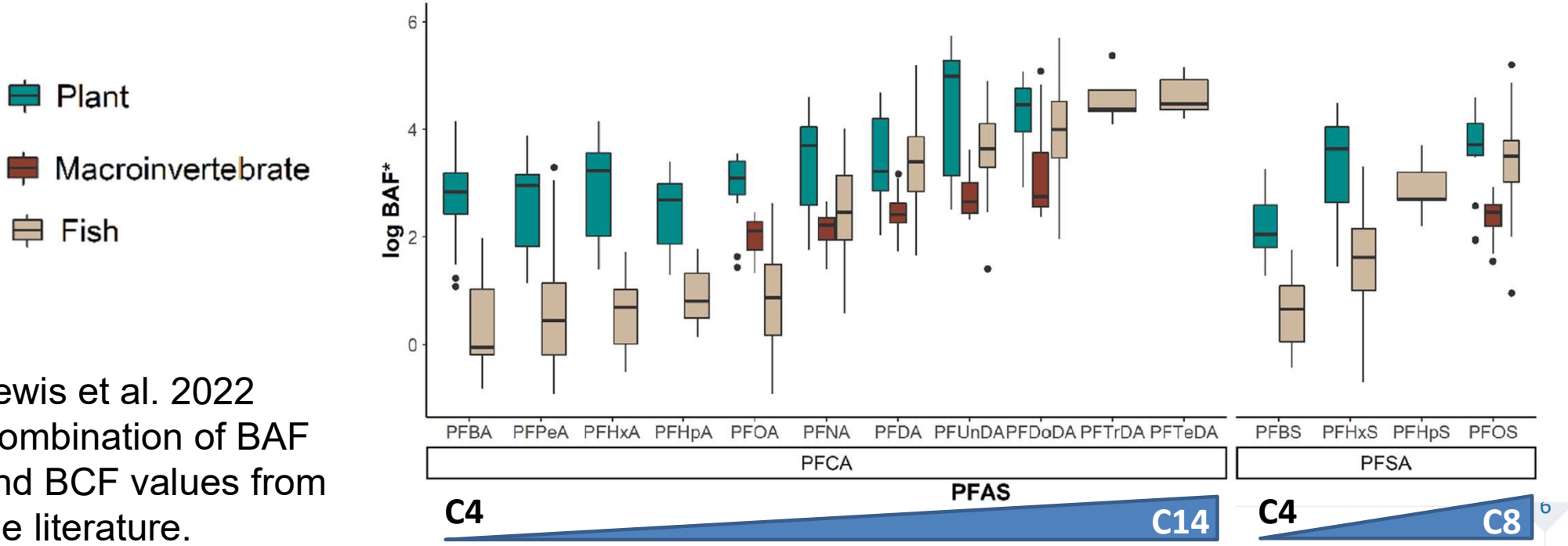
Biota-Sediment Accumulation Factor

$$BSAF = \frac{Mean\ Tissue\ Conc.}{Mean\ Sediment\ Conc.}$$



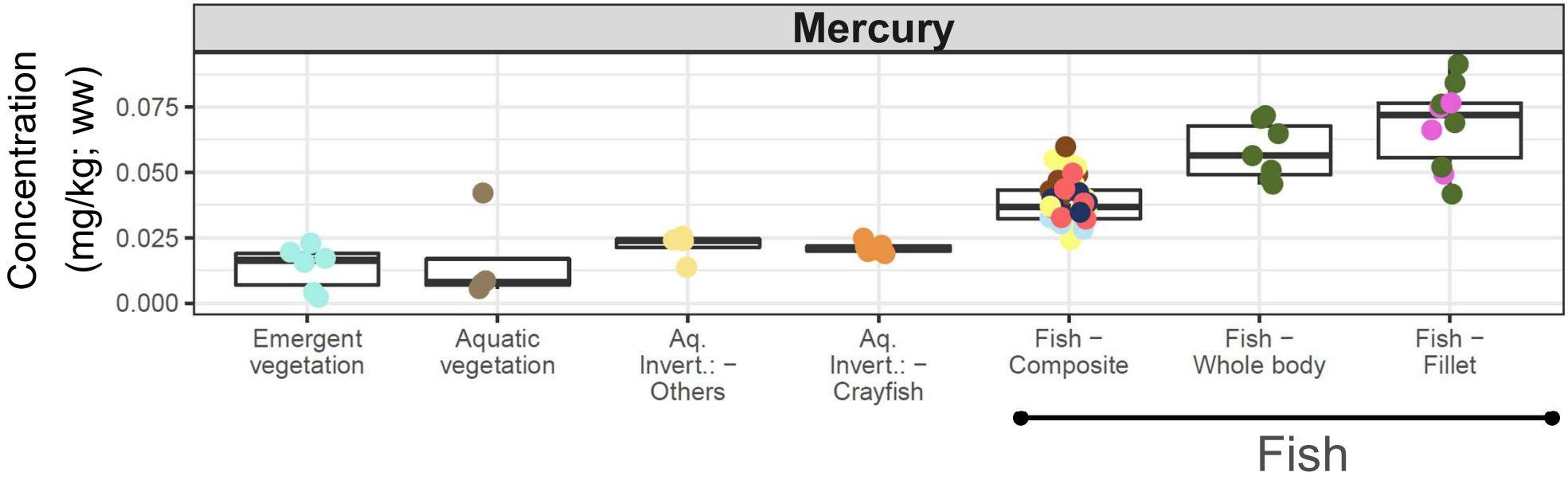
PFAS Bioaccumulation Factors are Variable

Field and lab derived bioaccumulation factors show significant variability, typically ranging several orders of magnitude.



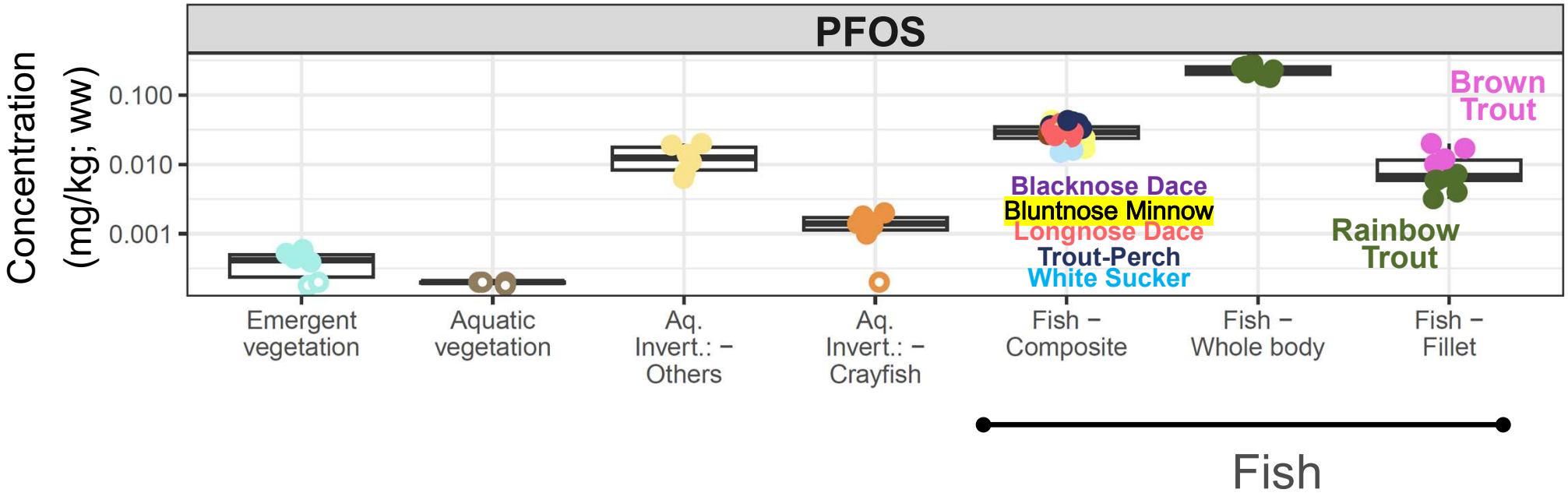
Lewis et al. 2022
Combination of BAF and BCF values from the literature.

Distributions of Mercury Across Biota



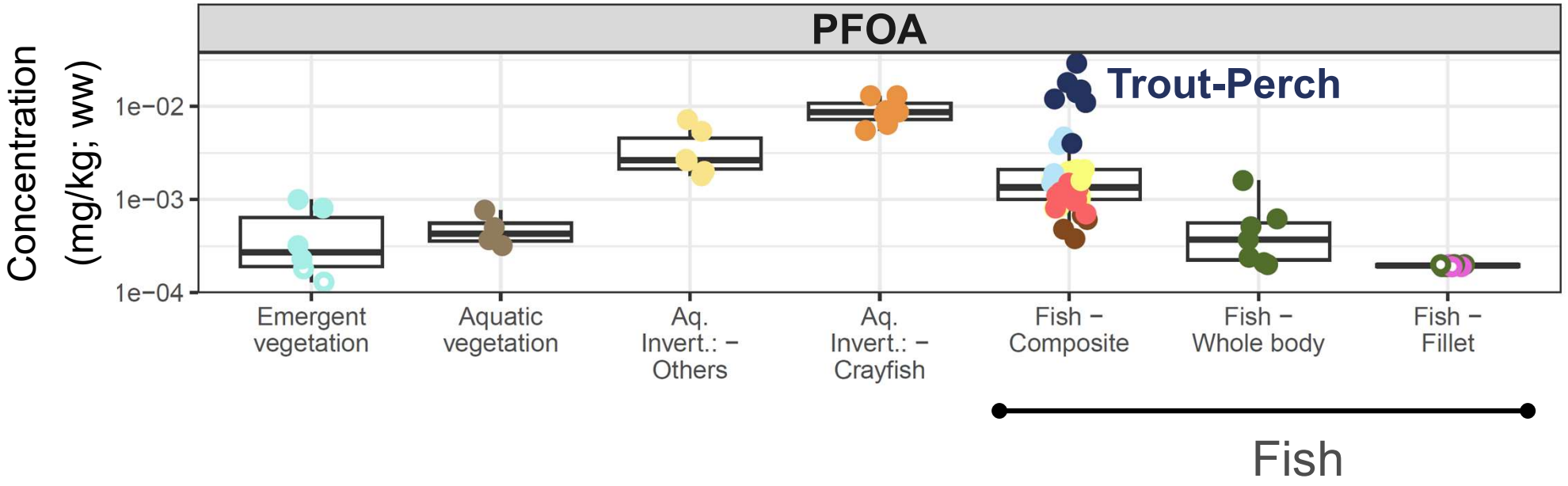
● Detect O Non-Detect

Distributions of PFOS Across Aquatic Biota



● Detect O Non-Detect

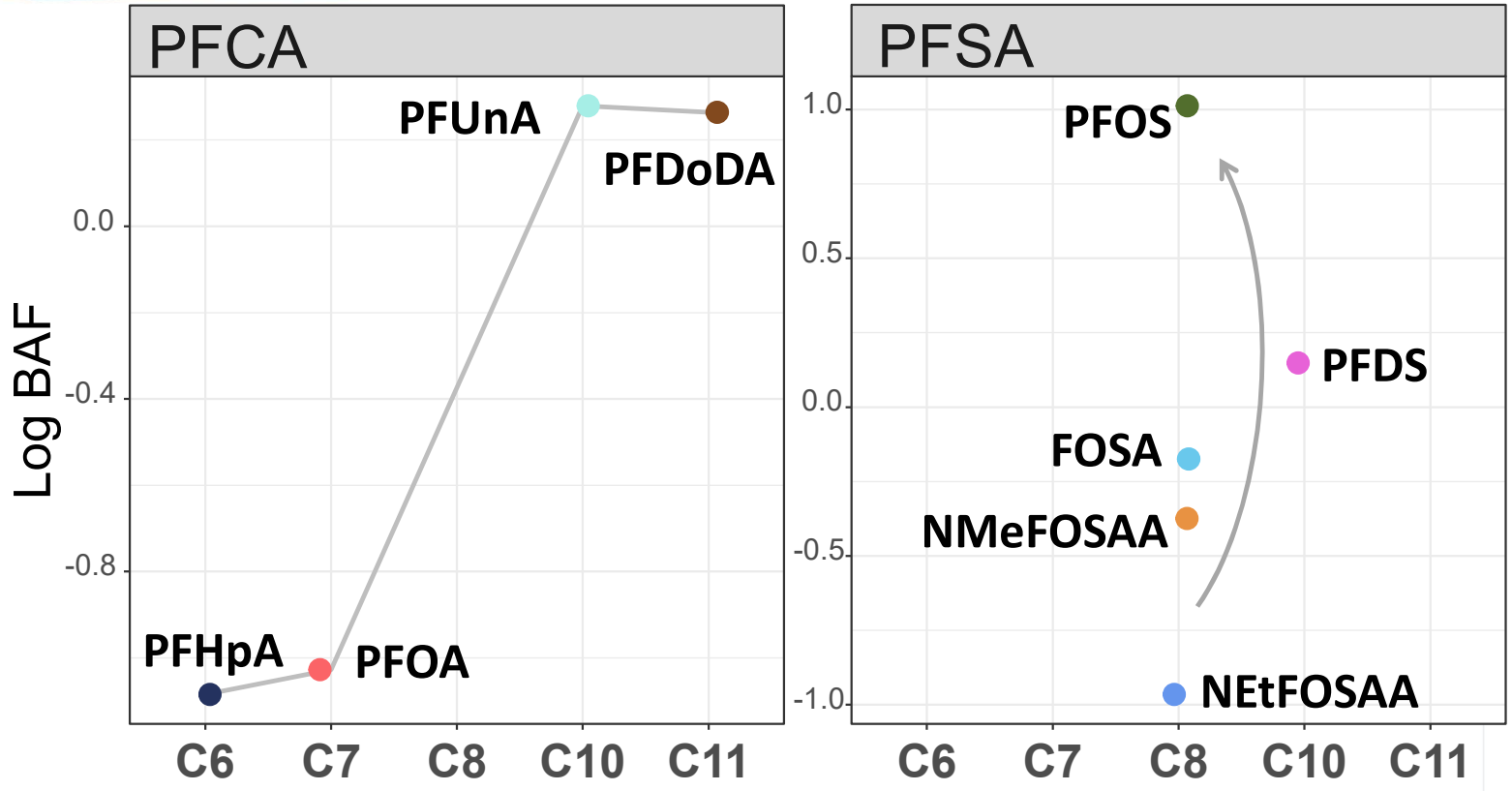
Distributions of PFOA Across Aquatic Biota



● Detect O Non-Detect

PFAS BAFs by Carbon Chain Length and Functional Group

BAF by chain length for Longnose dace (composite)



PFAS BSAFs by Carbon Chain Length and Functional Group

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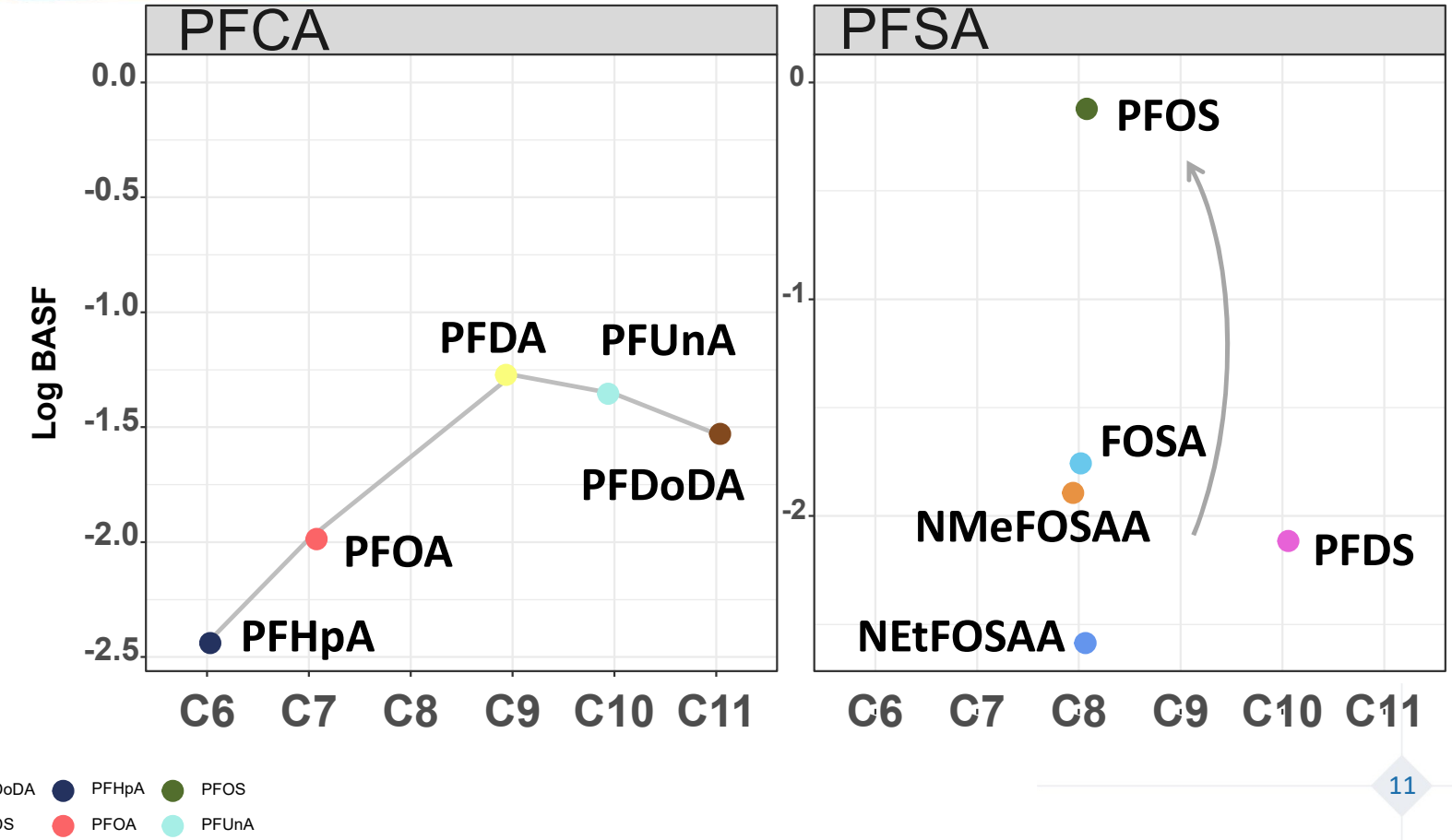
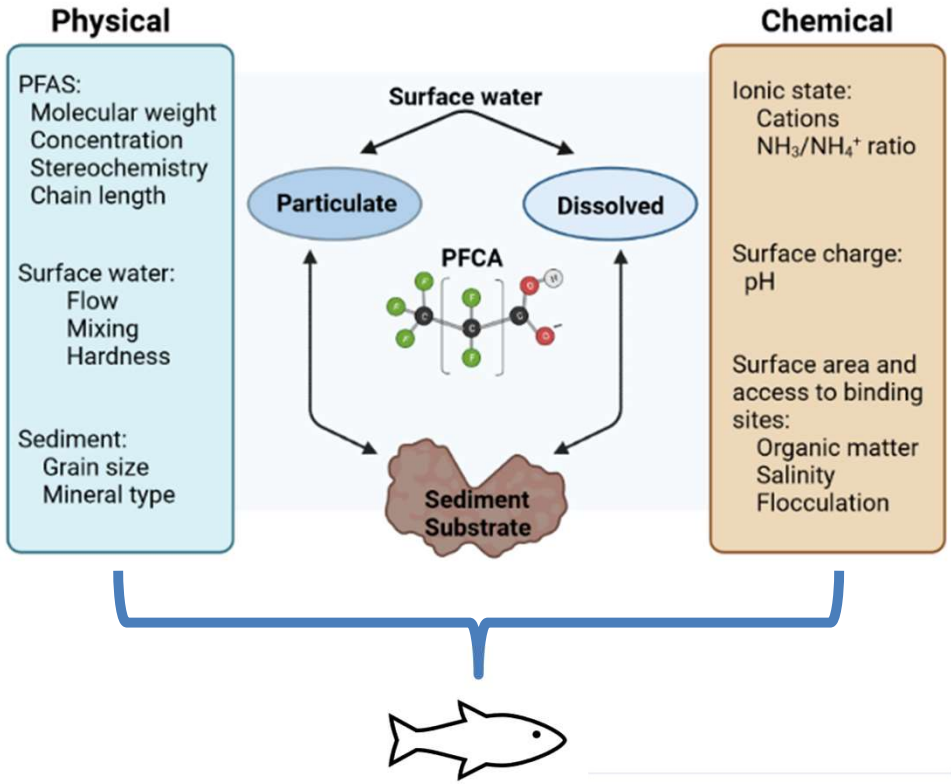


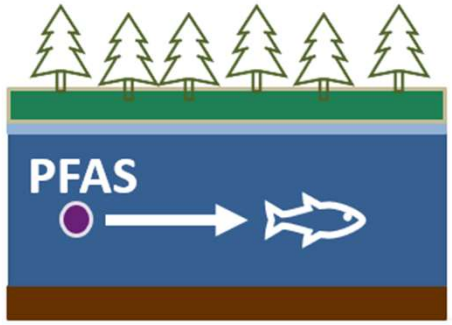
Potential Drivers of Variability in PFAS Bioaccumulation

- Physical and geochemical factors impact the partitioning of PFAS between abiotic compartments and hence modulate their biological uptake.
- Studies on PFAS bioaccumulation rarely collect the additional information on the physical and geochemical settings present at a site.
- There remains a need for integrative studies that assess bioaccumulation from a biogeochemical standpoint.



Key Questions for PFAS Investigations

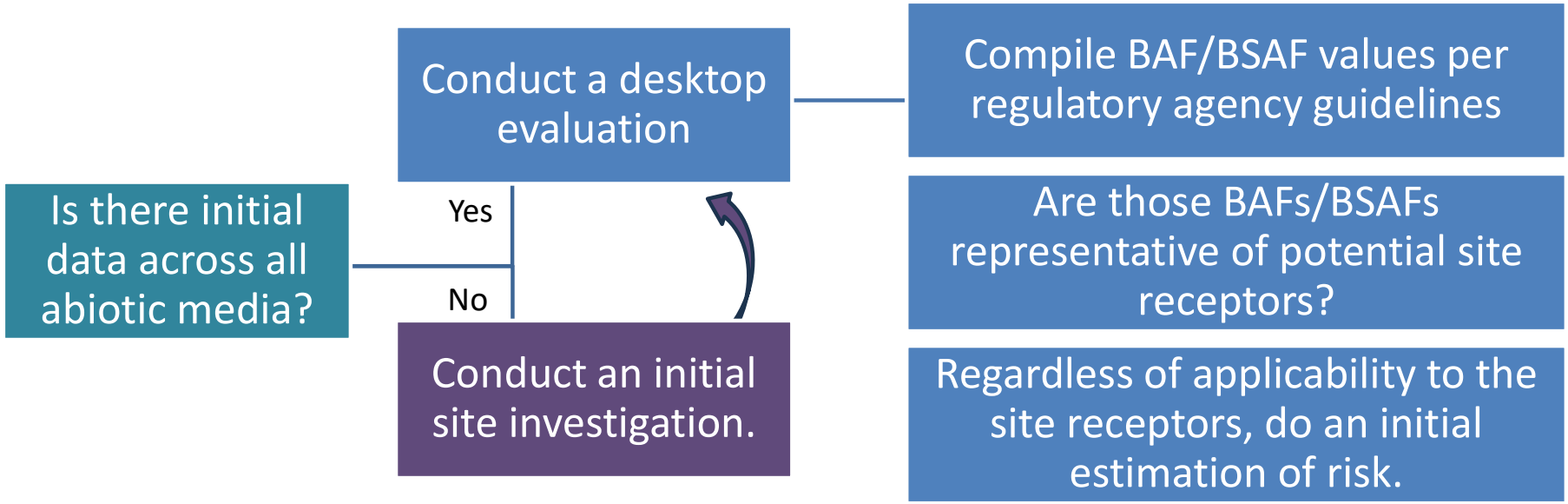
- When is it important to do a site-specific biota study?
- How do we improve our sampling designs to better describe site-specific conditions for estimating bioaccumulation?
- Can we refine the current approach for calculating bioaccumulation (BAFs and BSAFs) to be simple AND robust, by incorporating site-specific environmental metrics?



Recommendations for Biota PFAS Studies

Do the math

- Estimate risk based on available site information (before RI Work Plan).



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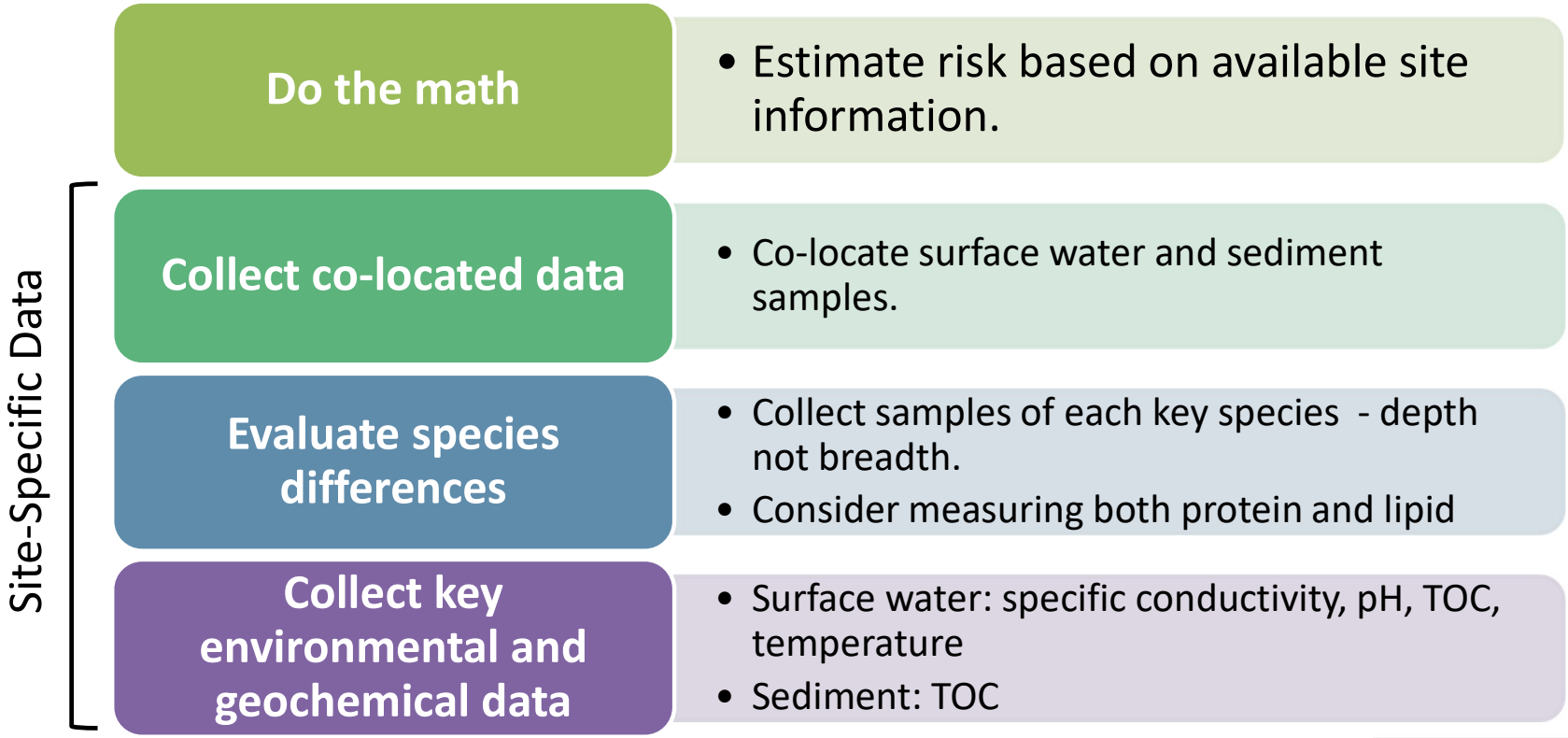
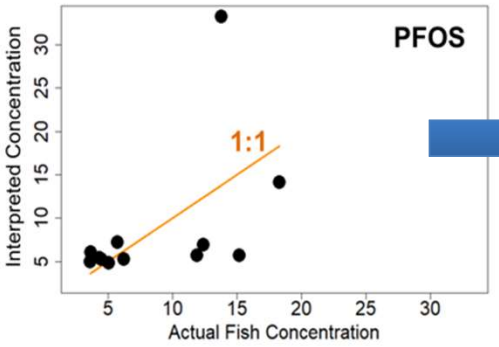


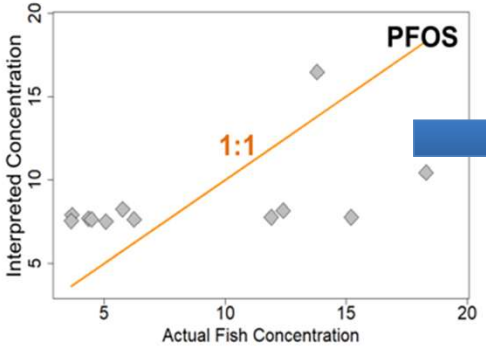
Example:
Environmental Parameters Play a Role

$C_{fish} = b_1 C_{water}$



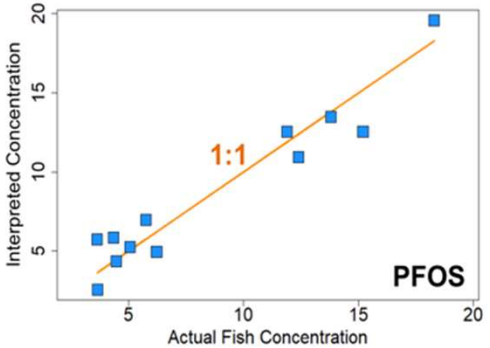
Back-calculated fish tissue concentrations using the BAF.

$C_{fish} = b_0 + b_1 C_{water}$



Bivariate linear regression (p-value = 0.11; r^2 = 0.2)

$C_{fish} = b_0 + b_1 C_{water} + b_2 SC$

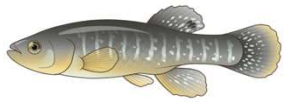


MLR with specific conductivity (p-value < 0.001; r^2 = 0.9)

Including specific conductivity in addition to surface water PFOS concentration in a simple regression-based approach provides a better estimation of observed fish PFOS concentrations, and likely BAF estimate.

NHDES multi-lake study (2021)

Summary



- BAFs for PFAS are highly variable:
  - Chemical properties of individual PFAS
  - Species-specific differences
  - Environmental and geochemical modulators
- **Site- and species-specific data** to directly support risk calculations reduces uncertainty, especially for decision making.
- Collect, analyze, and report environmental and geochemical parameters.

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