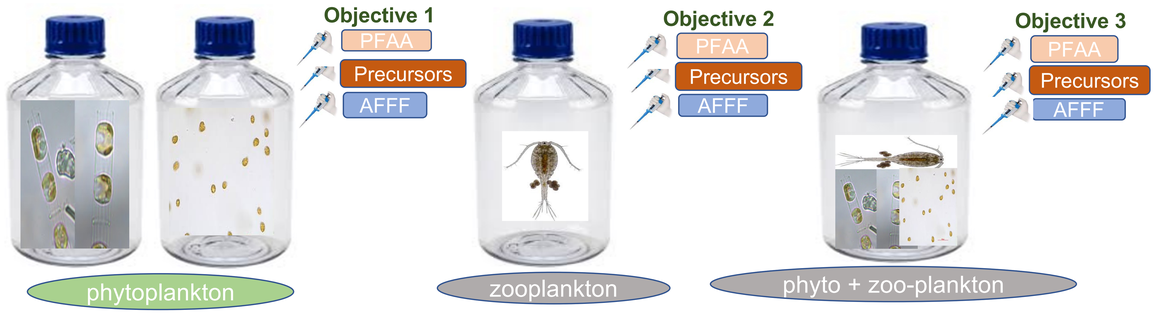
From The Bottom Up: Deciphering Bioaccumulation And Biomagnification Of PFAS In Plankton (ER22-3139)

Asta Habtemichael*; Jitka Becanova; Susanne Menden-Deuer; Rainer Lohmann
University of Rhode Island, Graduate School of Oceanography
Corresponding Author: ahabtemichael@uri.edu

Objectives

Objective 1: uptake, transformation and bioaccumulation of PFAS in phytoplankton
Objective 2: uptake, transformation and bioaccumulation of PFAS in zooplankton
Objective 3: bioaccumulation and magnification of PFAS from phytoplankton to zooplankton (diet effect)

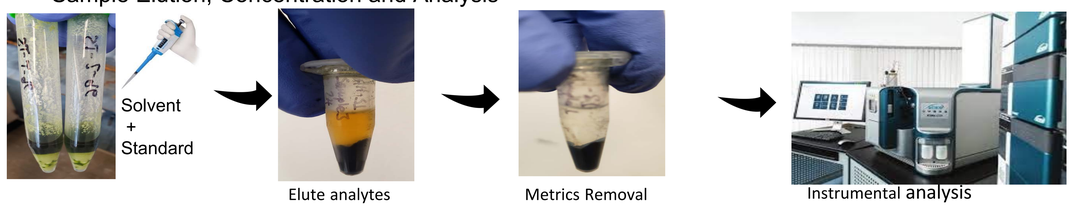
Technical Approach



- Exposure length experiment to determine establishment of partitioning equilibrium and uptake kinetics (24, 48, 96, and 192 hours)

Extraction of samples and Instrumental analysis

- Sample Elution, Concentration and Analysis



- measure $C_{plankton}$ (ng/g w.w.) and C_{water} (ng/mL)
- verify C_{water} with SPME fibers using $K_{SPME\text{-}water}$

$$K_{SPME-water} = \frac{\text{Conc. in } SPME}{\text{Conc. in } water} \quad \text{.....(Eq.1)}$$

- derive bioconcentration and bioaccumulation factors (BCF and BAF)

$$BCF = (\frac{\text{Conc. in plankton}}{\text{Conc. in } water}(, \quad \text{.....(Eq. 2)}$$

$$BAF = \frac{Conc.\ in\ predator}{\text{Conc. in } Pray} \quad \text{.....(Eq. 3)}$$

Schedule

Component	Deliverables	Yr 1	Yr 2	Yr 3	Yr 4
QA/QC for PFAS	PFAS Analyte List, PFAS Analytical Confirmation White Paper and 3 Standard Operating Procedures (SOP)				
Phytoplankton culturing and PFAS/ precursor/ AFFF exposure via water	BAF_{phyto} for PFAA, precursor formed PFAA, EOF and AFFF				
Zooplankton culturing and PFAS/ precursor/ AFFF exposure via water	BAF_{zoo} for PFAA, precursor formed PFAA, EOF and AFFF				
Water parameters affecting precursors transformation	Transformation rate as a function of temperature, salinity and pH				
Detailed reaction pathways	Identification of major PFAS intermediates and degradation products				
Zooplankton exposure to PFAS/ precursor/ AFFF via diet	$BAF_{zoo,}$ $BMF_{zoo/phyto}$ for PFAA, precursor formed PFAA, EOF and AFFF				
PFAS bioaccumulation from plankton to fish in Narragansett Bay	Trophic levels, PFAS in water, biota, BAF, BMF, TMF				

Results to Date

Preliminary trial

- *Heterosigma akashiwo* species were exposed to 14 PFAA at 100ng/L individual concentration for 24hrs and 96hr (Figure 2)
- long chain PFCA (>C8) and PFOS accumulated preferentially.
- PFAA accumulation increased with exposure time for most compounds

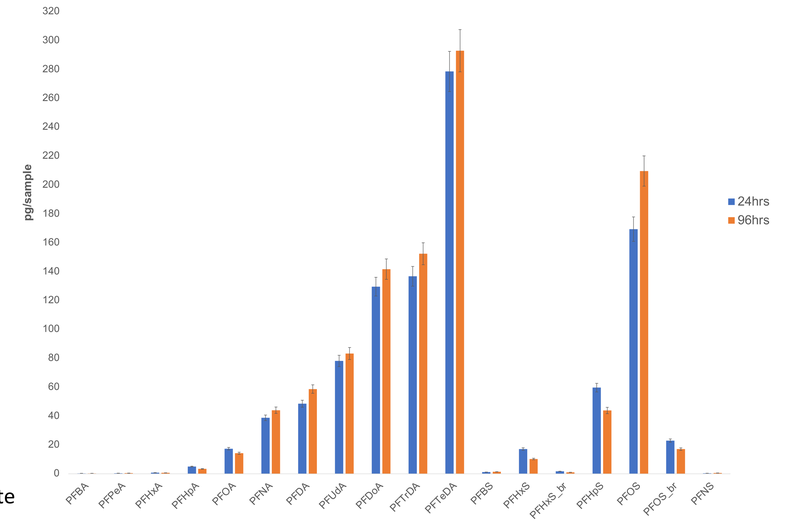


Figure 1. Preliminary results from an exposure Length trial of *Heterosigma akashiwo* (raphidophyte autotroph) exposed to PFAA of 100ul/L individual compounds in solution. PFAA accumulated in pg/sample of plankton is shown with the SD from triplicate samples.

Lessons Learned and/or data gaps

Next Steps

- Vary individual [PFAA] to identify concentration dependency of uptake; whether K values vary with [PFAS] in solution.
- Add 120hrs, 144hrs, 168hrs exposure to verify partitioning equilibrium has been reached
- Understand the impact of the plankton growth rate on the PFAA accumulation

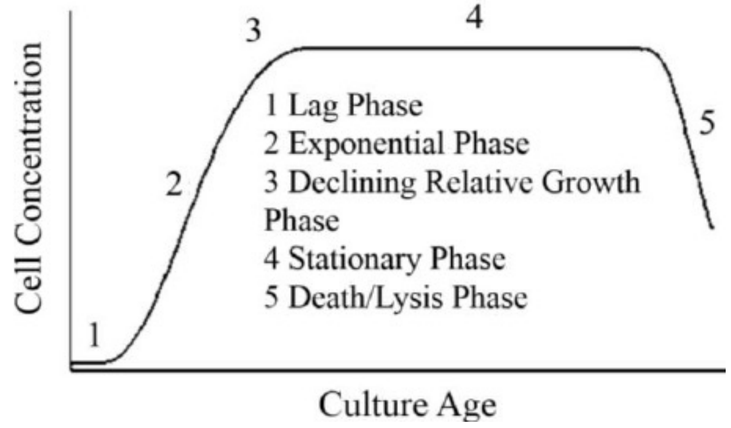
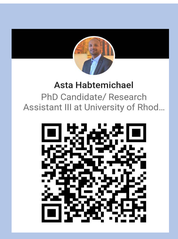


Figure 2. Plankton (microalgae) growth phase (Farag and Price, 2013)

Acknowledgments

Thanks to the Menden-Deuer lab group, especially Pierre Marrec and Jason Schaedler for their help in isolating and providing initial plankton cultures.
My appreciation goes to all members of the Lohmann lab group. A special gratitude for Simon Vojta for his support.



References

1. Yang et al. 2011. Occurrence and partitioning of per fluorinated compounds in water and sediment from Liao River and Taihu Lake, China. https://doi.org/10.1016/j.chemosphere.2011.02.075
2. Sunderland et al. 2019. A review of the pathways of human exposure to poly – and perfluoroalkyl substances (PFASs) and present understanding of health effects. https://doi.org/10.1038/s41370-018-0094-1
3. Zhang et al. 2019. Poly- and perfluoroalkyl substances in seawater and plankton from the Northwestern Atlantic Margin. https://doi.org/10.1021/acs.est.9b03230
4. De Silva, A. O., Armitage, J. M., Bruton, T. A., Dassuncao, C., Heiger-Bernays, W., Hu, X. C., & Sunderland, E. M. (2021). PFAS exposure pathways for humans and wildlife: a synthesis of current knowledge and key gaps in understanding. Environmental toxicology and chemistry, 40(3), 631-657. https://doi.org/10.1002/etc.4935