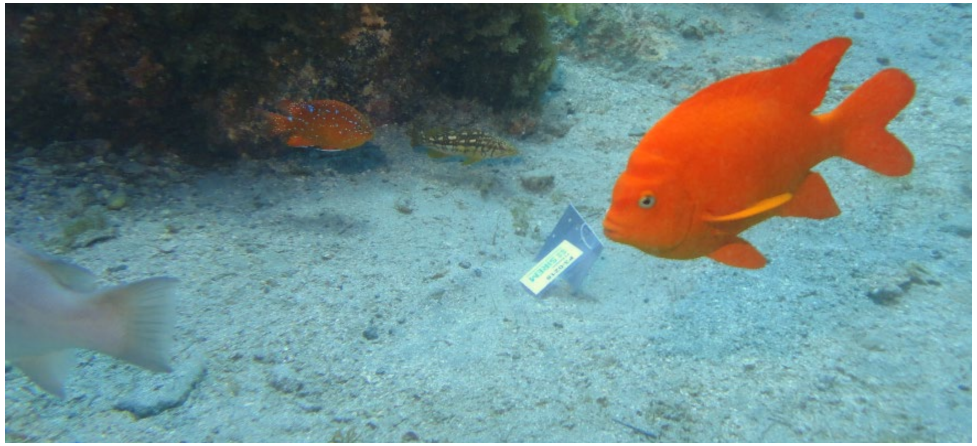
# How Passive Samplers can Optimize and Reduce the Costs of Environmental Sampling Programs

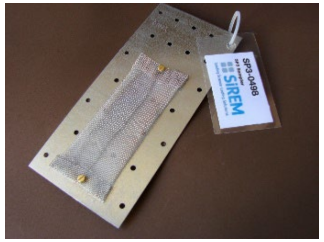
Rachel Zajac-Fay, M.S. (Geosyntec Consultants)
Brent G. Pautler, Ph.D. (SiREM)

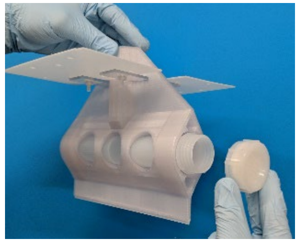
# Passive sampling Core Concepts and Advantages

# Passive Sampling

- Freely dissolved concentration ($C_{free}$) measurement
- Used for multiple media
  - Sediment porewater, surface water, stormwater, groundwater
- Provide Critical Data for:
  - Source identification, fate
  - Risk assessment, toxicity identification
  - Stormwater sampling
  - Remediation Design
  - Long Term Monitoring (including groundwater monitoring programs)



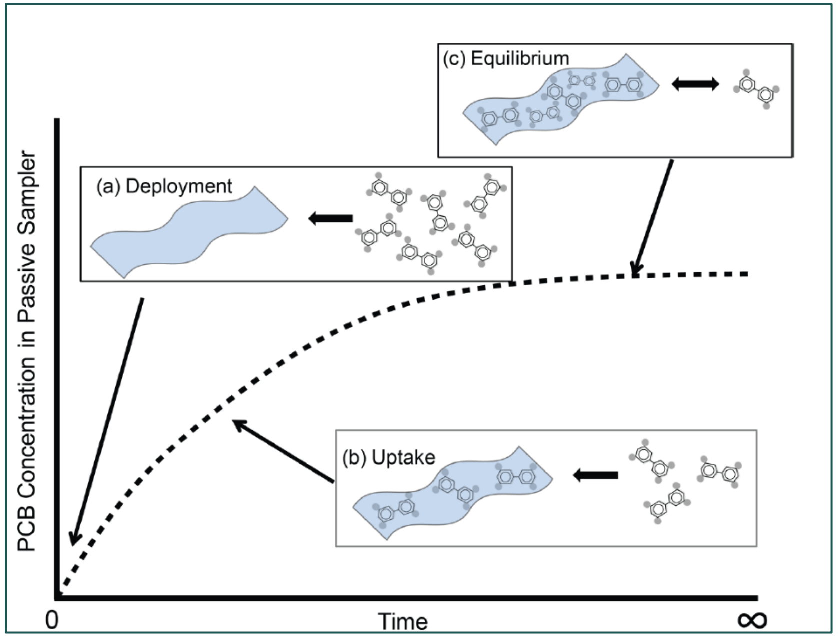


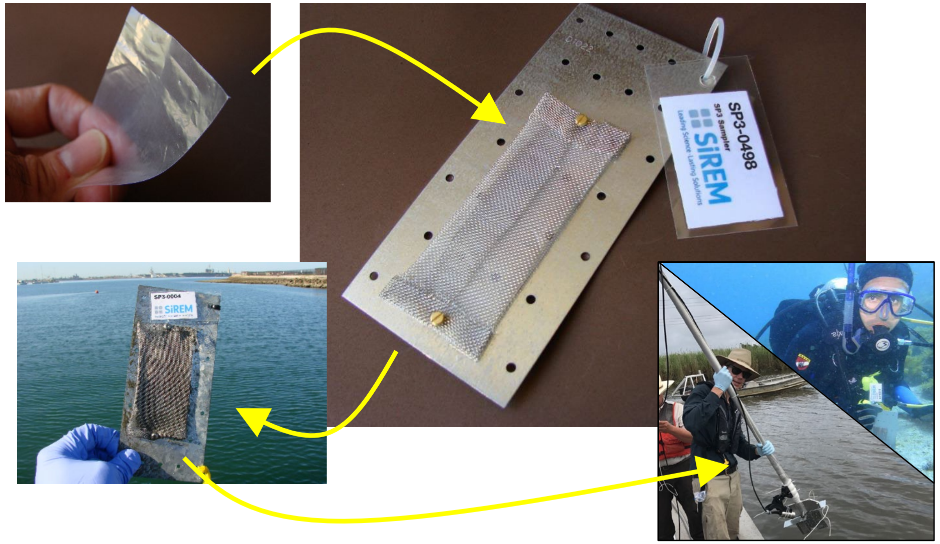



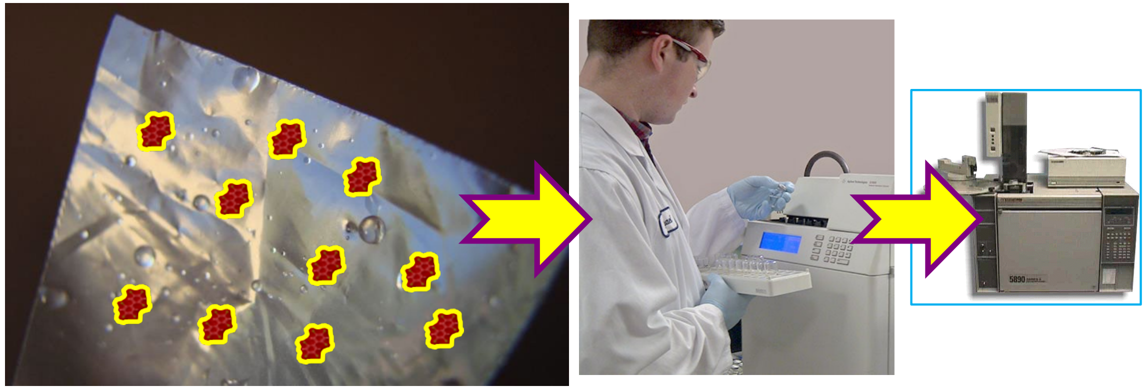
# Federal Project Passive Sampling Experience

| Fed Agency | Installation | Client/Contract | Technology | Analytes | Year |
|---|---|---|---|---|---|
| Navy | Bremerton Naval Base | Geosyntec | SP3™ | PCBs & PAHs | 2016 |
| Navy | NIWC Clay Targets (ex situ) Study (variety of sites) | Geosyntec | SP3™ | PAHs | 2016 – 2021 |
| Navy | Marine Corps Base Quantico, VA | Geosyntec | SP3™ | PCBs | 2016 |
| Navy | Pearl Harbor | Geosyntec | SP3™ | PCBs | 2018 |
| Navy | Sinclair & Dyes Inlet | NIWC | SP3™ | PCBs | 2022 |
| Navy | NASNI Puget Sound Shipyard | NIWC | SP3™ | PCBs | 2022 |
| Navy | Naval Support Facility Indian Head | NIWC | SP3™ & SPeeper™ | PCBs + Metals | 2022 |
| Navy | Naval Base San Diego, Paleta Creek | ESTCP | SPeeper™ | Metals | 2022 – 2023 |
| Navy | Washington Naval Yard OU2 | Jacobs | SP3™ | PCBs | 2023 |
| Navy | Amchitka Naval Base, Alaska | Jacobs/Geosyntec | SP3™ | PCBs | 2024 |
| Navy | NAS Oceana | ESTCP | PFASsive™ | PFAS | 2024 |
| USACE | Eighteen Mile Creek OU3 | ENE Environmental (now WSP) | SP3™ | PCBs | 2021 |
| USACE | ACW Jackson, TN | USACE (Through Eurofins) | SP3™ | PAHs + PCP | 2022 |
| USACE | Seneca Army Deport, NY | HGL/Parsons | PFASsive™ | PFAS | 2023 |

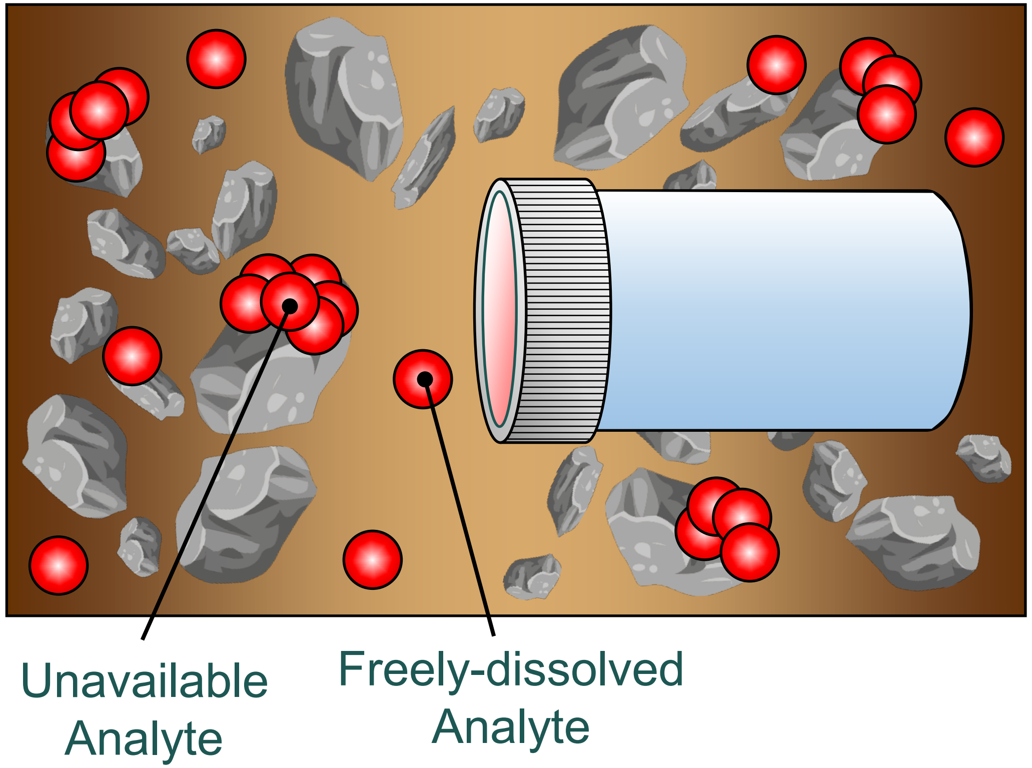
# Partitioning Based Samplers: Polymers



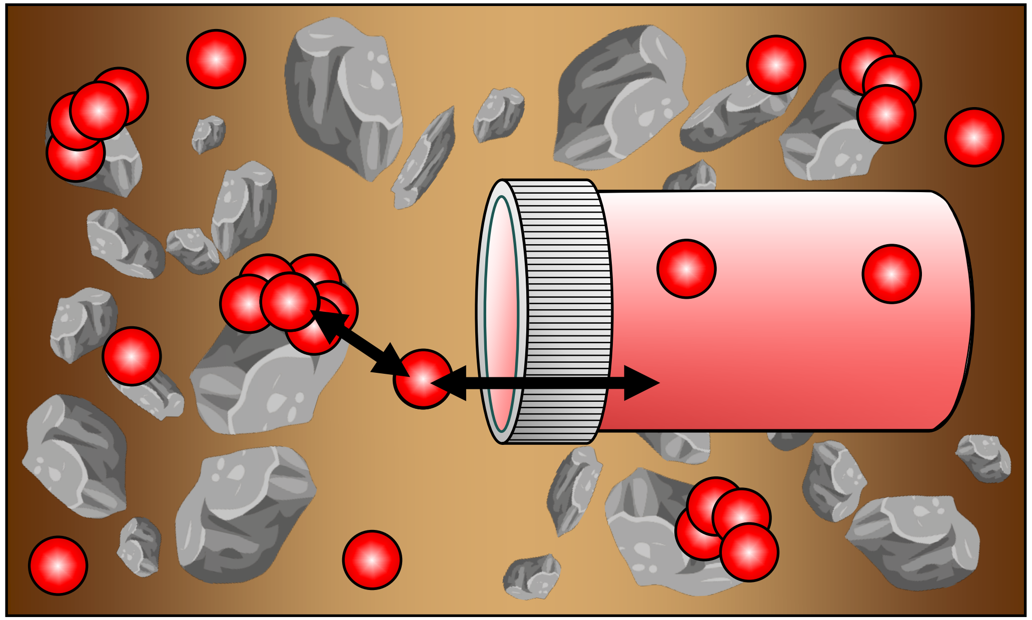



# Dialysis Based Samplers – Peepers

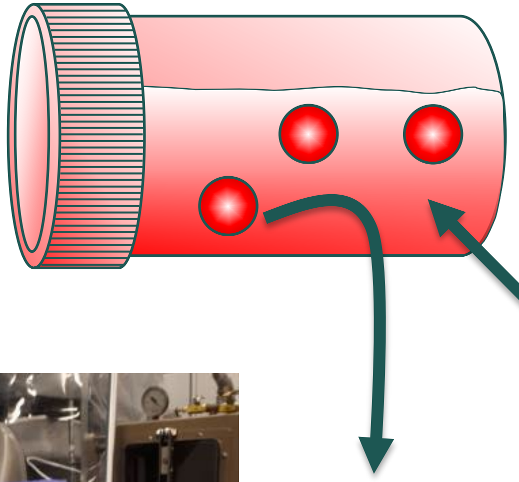


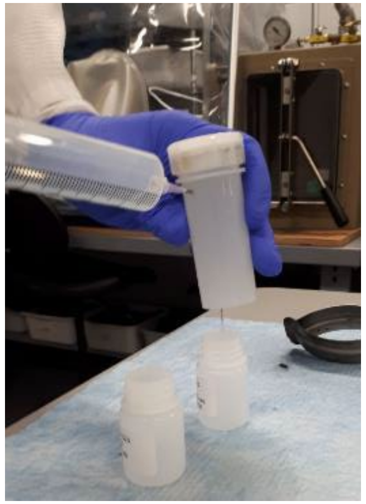

- Solution in peeper equilibrates with freely-dissolved species in sediment (days-weeks)



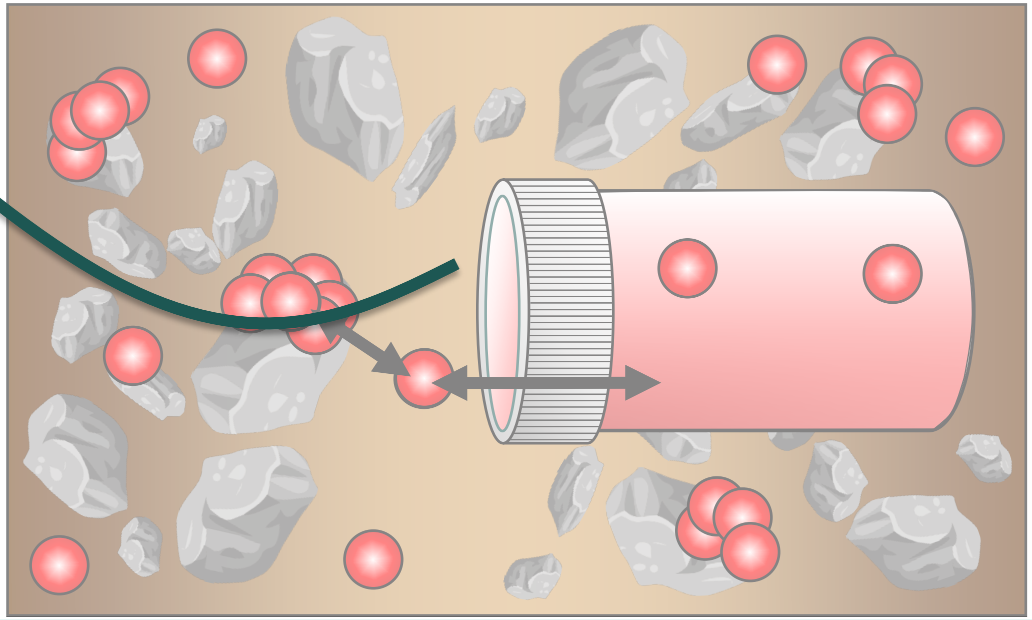
- Peeper inserted into sediment matrix

# SPeeper™ – Dissolved Inorganics





- Peeper removed from sediment, solution transferred and preserved, measured for target analytes using standard methods for water (e.g., EPA SW846)
- Results in ng/L



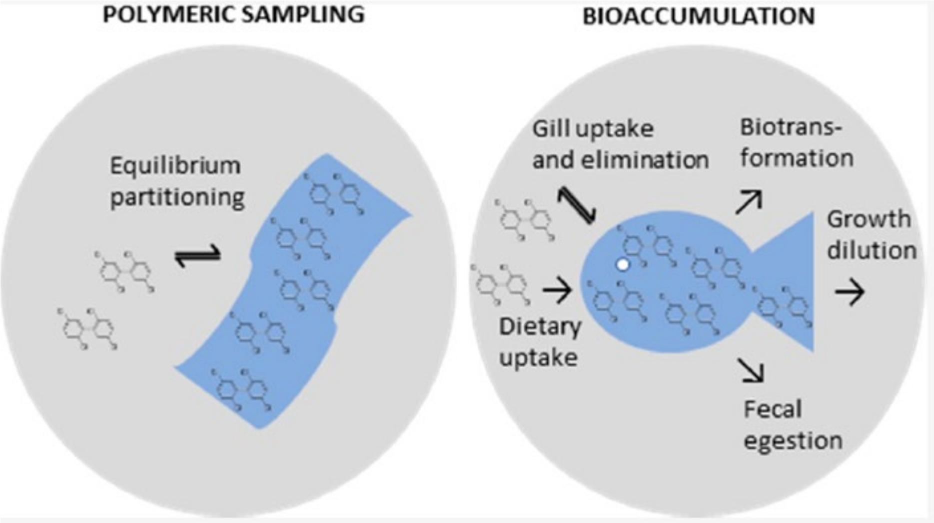
# Passive Sampling $C_{free}$: Bioaccumulation

Environmental Science & Technology
pubs.acs.org/est
Critical Review

**Evaluating Polymeric Sampling as a Tool for Predicting the Bioaccumulation of Polychlorinated Biphenyls by Fish and Shellfish**

Stine N. Schmidt* and Robert M. Burgess

Cite This: Environ. Sci. Technol. 2020, 54, 9729−9741
Read Online




Environmental Science & Technology
pubs.acs.org/est
Article

**Codeployment of Passive Samplers and Mussels Reveals Major Source of Ongoing PCB Inputs to the Anacostia River in Washington, DC**

Nathalie J. Lombard, Mandar Bokare, Rachel Harrison, Lance Yonkos, Alfred Pinkney, Dev Murali, and Upal Ghosh*

Cite This: Environ. Sci. Technol. 2023, 57, 1320−1331
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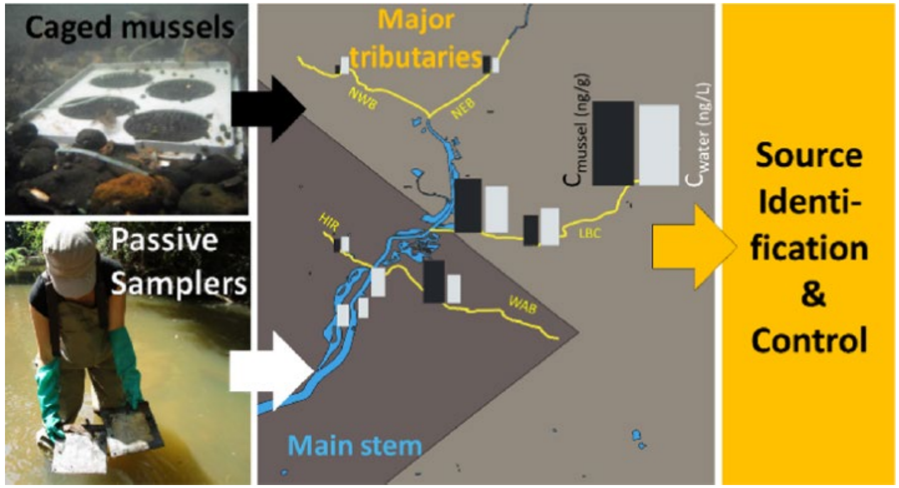
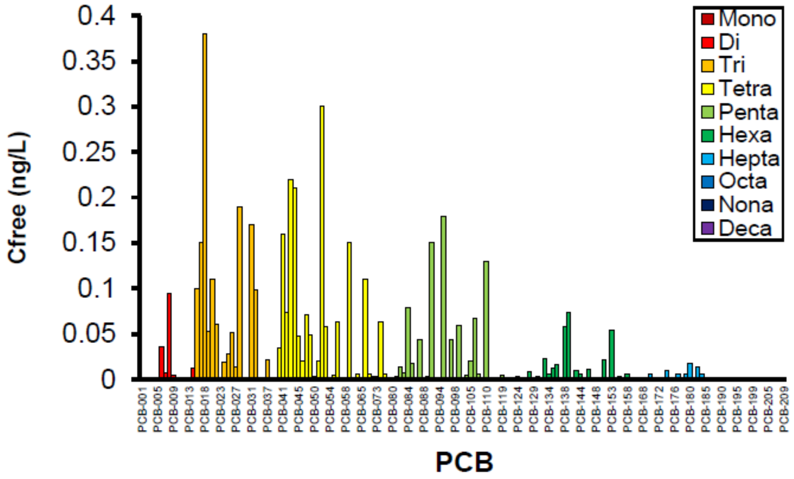
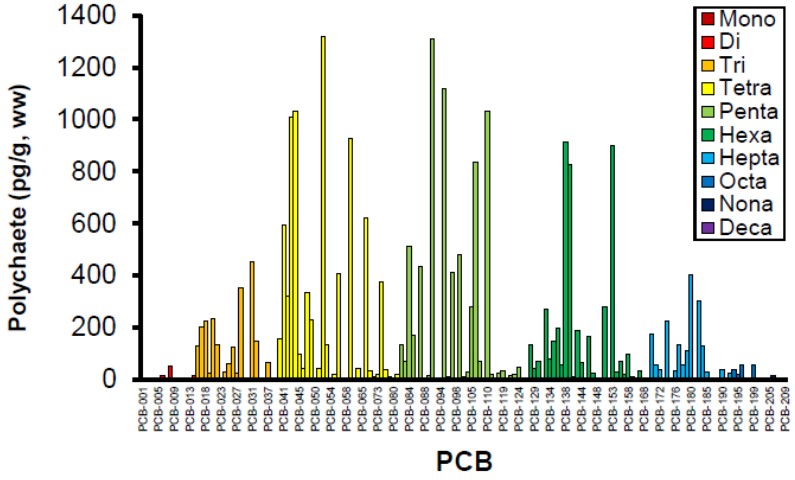
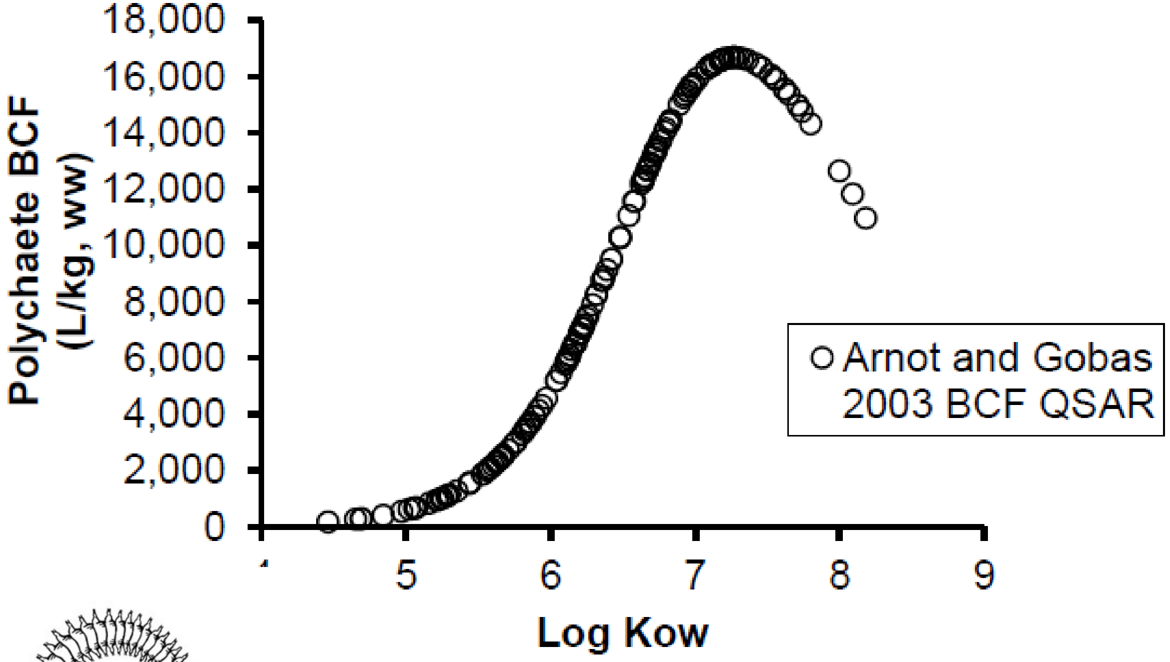
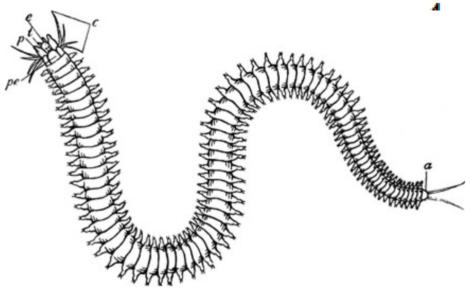


# $C_{free}$ Bioaccumulation: Lower Duwamish Waterway



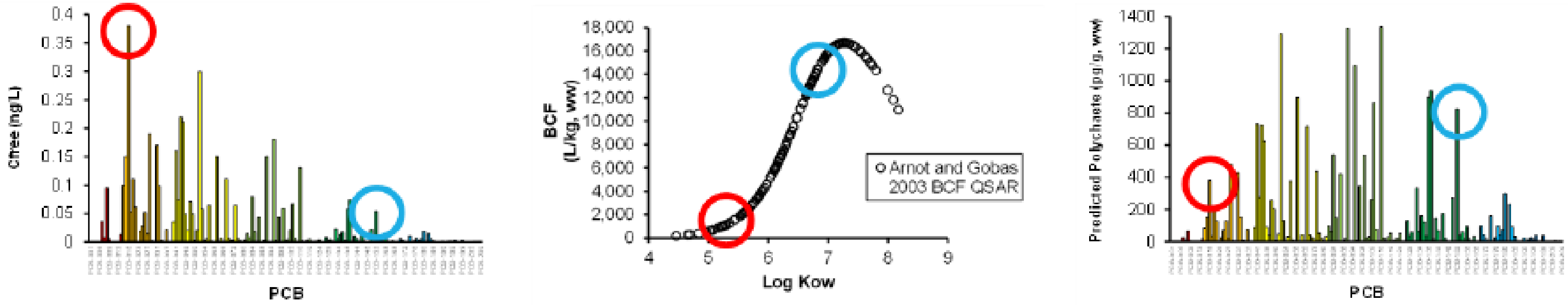



ENR/AC Pilot Study
Year 3 Monitoring Report
March 2021

# $C_{free}$ Bioaccumulation: Lower Duwamish Waterway



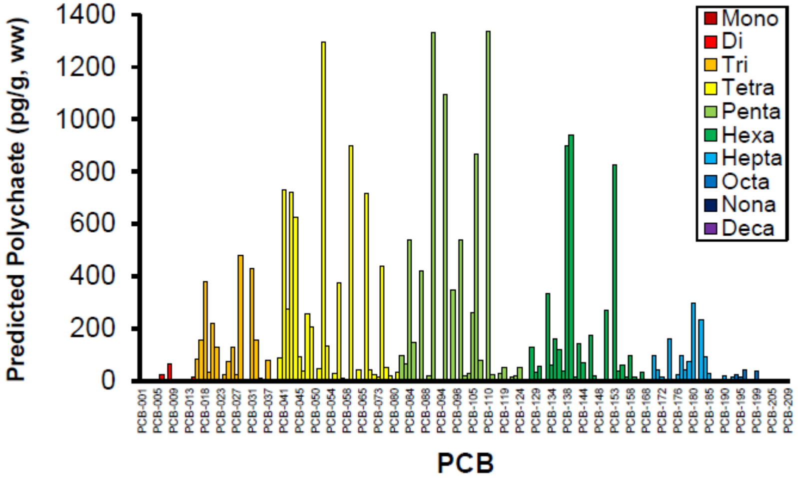

Measured Cfree × BCF (assuming 0.6% lipid, 0.003 g organism mass, and other default parameters, Arnot & Gobas (2003) model) = Predicted concentration in polychaete

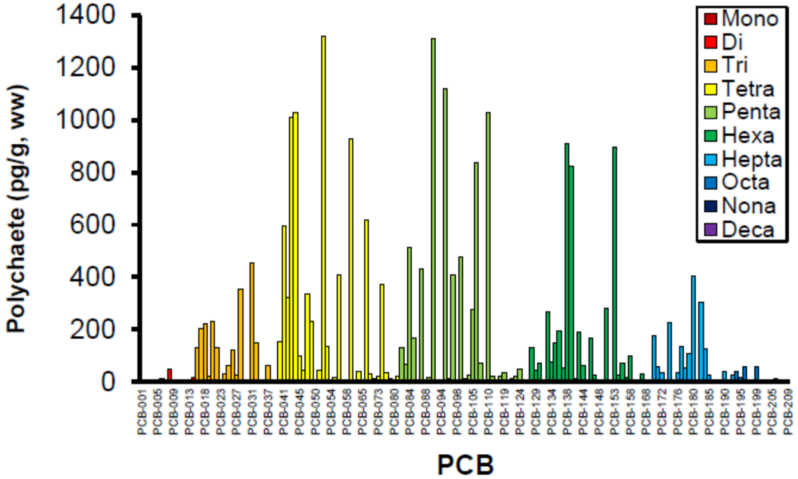
PCB-018: 0.4 ng/L × 1,000 L/kg ww = 400 pg/g, ww

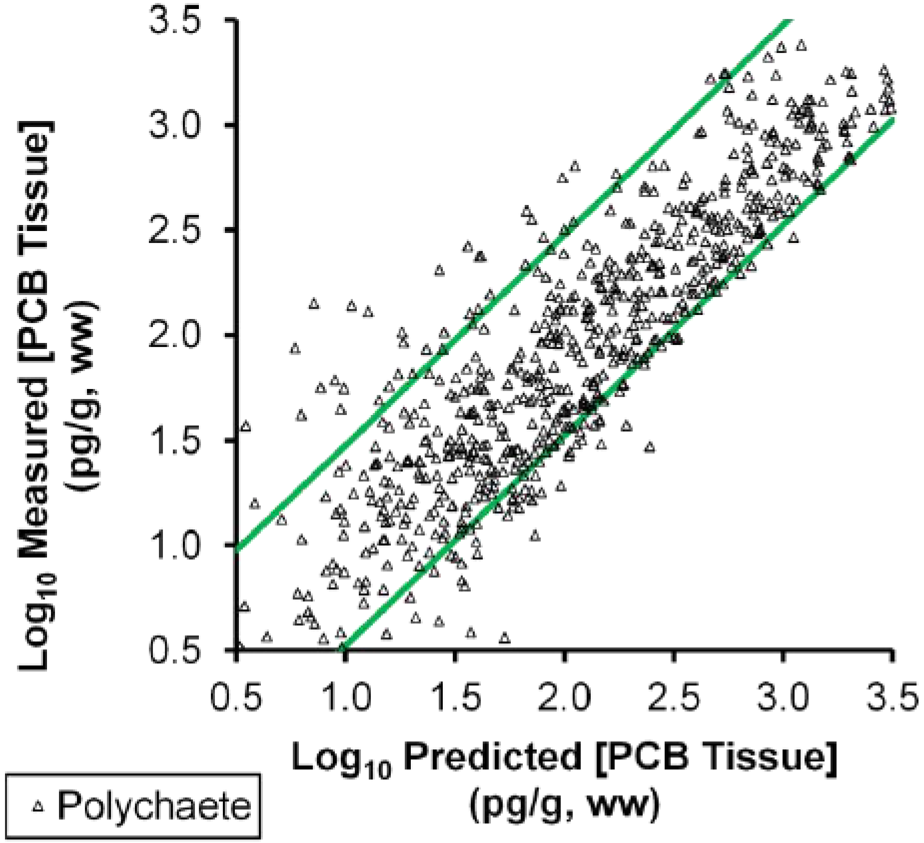
PCB-153: 0.05 ng/L × 15,000 L/kg ww = 750 pg/g, ww

ENR/AC Pilot Study Year 3 Monitoring Report March 2021

# $C_{free}$ Bioaccumulation: Lower Duwamish Waterway



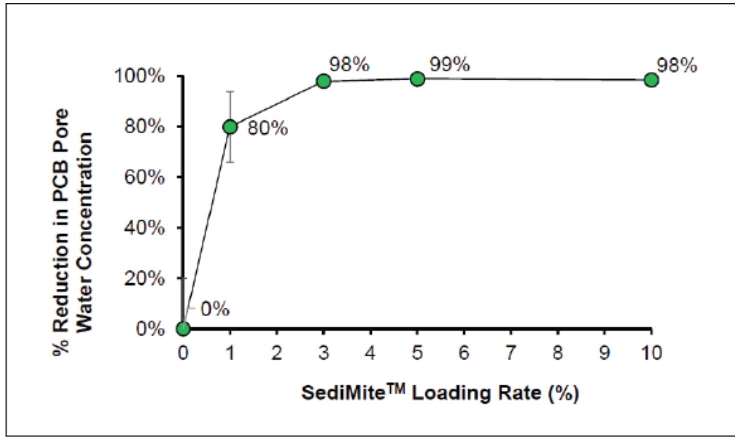




ENR/AC Pilot Study
Year 3 Monitoring Report
March 2021

# Amendment Study for PCB immobilization






- Activated carbon (AC) active cap
- 1%, 3%, 5% & 10% AC and porewater concentration determined via *ex situ* SP3™
- **Saved $375,000 in excess AC application**

# Amendment Study for PCB immobilization

- 6-inch EMNR layer amended with 3% AC placed over site evenly
- *In situ* SP3™ samplers deployed for 44 days in 10 locations
- **10- to 20-fold reduction** in bioavailable PCBs in porewater prior to remediation
- Regulatory Authority granted **NO FURTHER ACTION** at the site


# Former Wood Preserving Site, LA

- PAH exceedances determined from previous work Previous work over-estimated the need for corrective action at this site

Overall Goal – Ensure that there are **NO** surface water or sediment impacts on human health or ecosystem

- SP3™ identified locations and concentrations of COC flux with multiple lines of evidence


$2M - $5M in cost savings to client

# PFASsive™: Solution for PFAS Monitoring!

PFASsive™

- Medon et al.
- Environmental Science: Processes & Impacts, 2023 , 25(5) 980-995.


Environmental Science Processes & Impacts

ROYAL SOCIETY OF CHEMISTRY

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Cite this: *Environ. Sci.: Processes Impacts*, 2023, **25**, 980

## A field-validated equilibrium passive sampler for the monitoring of per- and polyfluoroalkyl substances (PFAS) in sediment pore water and surface water†

Blessing Medon,[a] Brent G. Pautler,*[b] Alexander Sweett,[b] Jeff Roberts,[b] Florent F. Risacher,[c] Lisa A. D'Agostino,[c] Jason Conder,[d] Jeremy R. Gauthier,[e] Scott A. Mabury,[e] Andrew Patterson,[f] Patricia McIsaac,[g] Robert Mitzel,[f] Seyfollah Gilak Hakimabadi[a] and Anh Le-Tuan Pham *[a]

A simple equilibrium passive sampler, consisting of water in an inert container capped with a rate-limiting barrier, for the monitoring of per- and polyfluoroalkyl substances (PFAS) in sediment pore water and surface water was developed and tested through a series of laboratory and field experiments. The objectives of the laboratory experiments were to determine (1) the membrane type that could serve as the sampler's rate-limiting barrier, (2) the mass transfer coefficient of environmentally relevant PFAS through the selected membrane, and (3) the performance reference compounds (PRCs) that could be used to infer the kinetics of PFAS diffusing into the sampler. Of the membranes tested, the polycarbonate (PC) membrane was deemed the most suitable rate-limiting barrier, given that it did not appreciably adsorb the studied PFAS (which have ≤8 carbons), and that the migration of these compounds through this membrane could be described by Fick's law of diffusion. When employed as the PRC, the isotopically labelled PFAS $M_2$PFOA and $M_4$PFOS were able to predict the mass transfer coefficients of the studied PFAS analytes. In contrast, the mass transfer coefficients were underpredicted by $Br^-$ and $M_3$PFPeA. For validation, the PC-based passive samplers consisting of these four PRCs, as well as two other PRCs (*i.e.*, $M_8$PFOA and $C_8H_{17}SO_3^-$), were deployed in the sediment and water at a PFAS-impacted field site. The concentration–time profiles of the PRCs indicated that the samplers deployed in the sediment required at least 6 to 7 weeks to reach 90% equilibrium. If the deployment times are shorter (*e.g.*, 2 to 4 weeks), PFAS concentrations at equilibrium could be estimated based on the concentrations of the PRCs remaining in the sampler at retrieval. All PFAS concentrations determined *via* this approach were within a factor of two compared to those measured in the mechanically extracted sediment pore water and surface water samples obtained adjacent to the sampler deployment locations. Neither biofouling of the rate-limiting barrier nor any physical change to it was observed on the sampler after retrieval. The passive sampler developed in this study could be a promising tool for the monitoring of PFAS in pore water and surface water.

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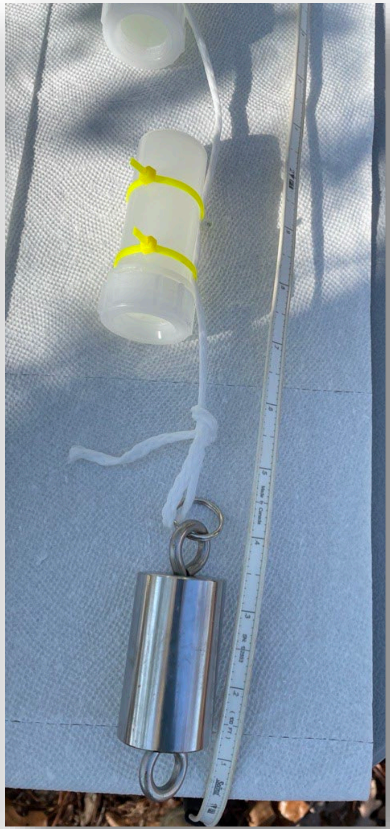
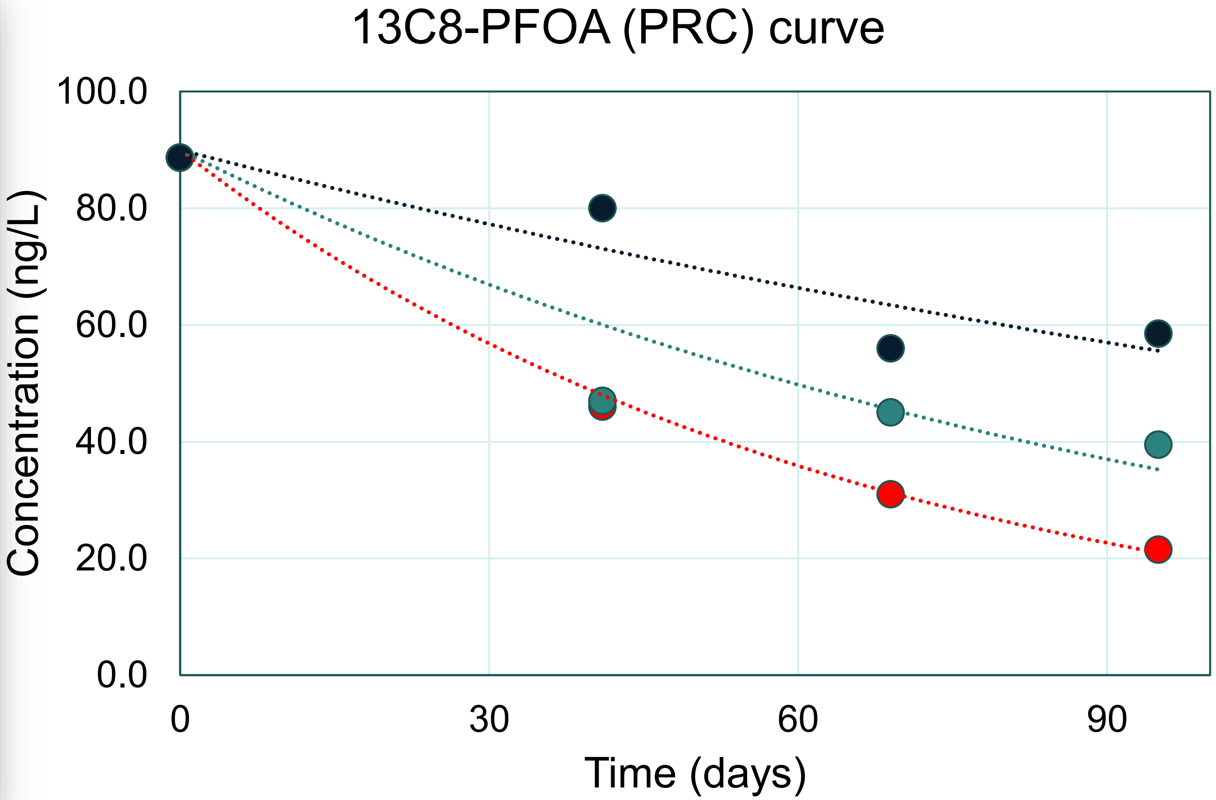
DOI: 10.1039/d2em00483f

rsc.li/espi

# PFASsive™: Preliminary Groundwater Validation





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OPERATION: COLLABORATION

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# Best Practices for Implementing psds into Field Programs

# PFASsive™ – Field Deployment

- Consider data quality objectives
  - What are we are using this data for?
  - Analytes, sample depth
- Site-specific considerations
  - Waterbody type, water depth, access
  - Deployment type: wading, boat, divers
  - Source, potential fate and transport
- Deployment time

# PFASsive™: Upcoming Project!

ESTCP

- FY 2023 ESTCP Project Funding
  - $1M value including additional client funding
  - Freshwater and marine site
  - Grab samples, PFASsive™, and bioaccumulation testing

- Additional Work outside of ESTCP Scope
  - Marine Design & Additional PRCs
  - Non-targeted PFAS analysis from PFASsive™ with Environment & Climate Change Canada

# The PFASsive™ Advantage

- Dialysis samplers in use for evaluating availability of inorganics for over 4 decades
  - ✓ Simple approach… easy to make, deploy, and analyze
- Confirmed design for use in sediment:
  - ✓ PFAS-inert chamber and membrane
  - ✓ One-compartment first-order kinetics, 2-4 week deployments
  - ✓ Performance Reference Compound (PRC) to verify sampling rates for each sample
  - ✓ Rugged and durable – Can survive being dropped on the deck of a boat

# PFASsive™: ESTCP ER23-7741

**Objective:** Demonstrate and validate PFASsive at two DoD Sites

**Task 1**
Demonstrate an *in situ* field deployment

- Logistics at a real world-DoD PFAS site, including preparation, deployment, retrieval, processing, costs, quality assurance/quality control (QA/QC), and data analysis

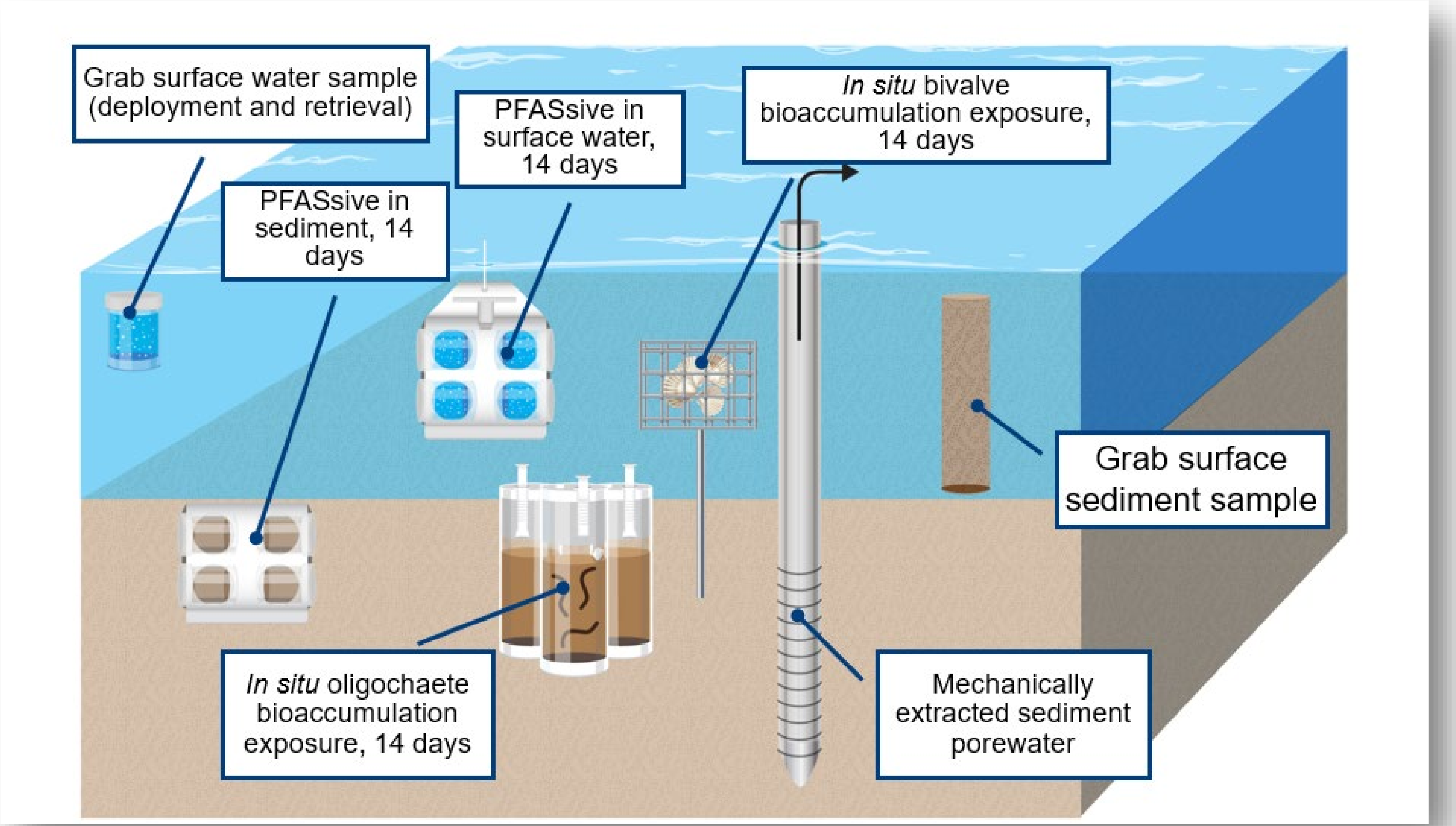
**Task 2**
Validate the ability of *in situ* passive sampler results in sediment porewater

- Compare freely dissolved concentration (Cfree) of PFAS measured with the passive samplers to:
  - PFAS in mechanically extracted co-located porewater samples
  - PFAS in benthic organisms exposed in co-located sediment

**Task 3**
Validate the ability of *in situ* passive sampler results in surface water

- Compare Cfree to:
  - PFAS in co-located surface water grab samples
  - PFAS in aquatic organisms exposed in the surface water column

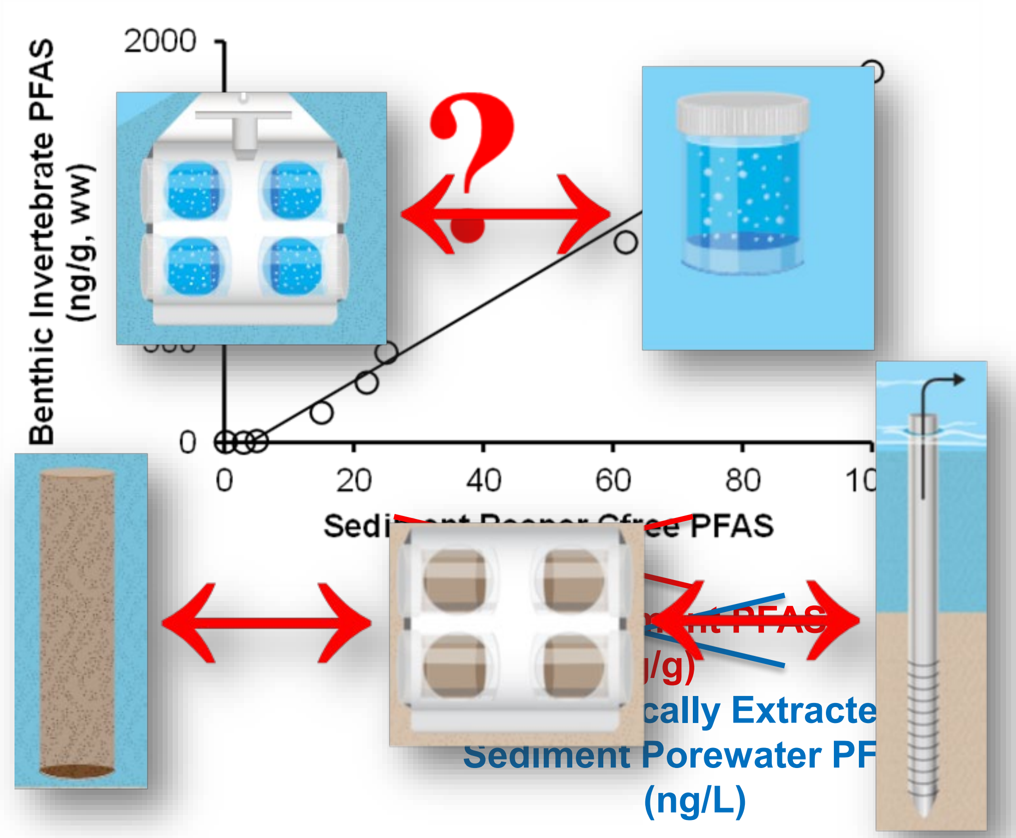
# PFASsive™: ESTCP ER23-7741



# PFASsive™: ESTCP ER23-7741

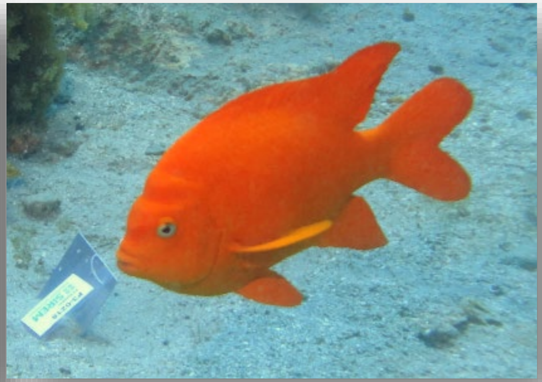
- How well does PFASsive Cfree PFAS data reflect PFAS bioavailability?
- Are PFASsive Cfree PFAS data better than other measures in terms of predicting PFAS bioavailability?
- Do PFASsive Cfree PFAS data relate to other traditional point sampling approaches?

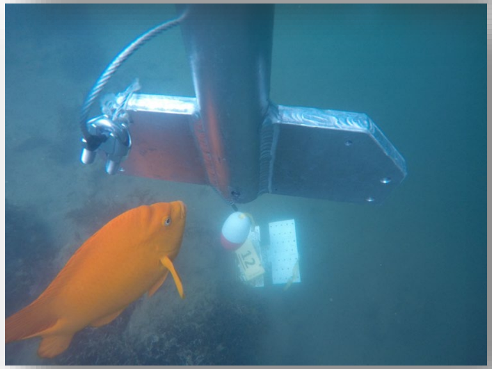
Any advantage to the “integrative” nature of passive samplers?



# Conclusions: Data Driven Decisions

- Can be used throughout site investigation timeline
  - ✓ Multi-media sampling abilities
- Established Sampling and Analytical Protocols
  - ✓ Mature technology, commercially available
  - ✓ Ability to test amendment performance
  - ✓ Less field equipment
- High Data Quality
  - ✓ More accurate risk-assessment
  - ✓ Smart, Data-Driven Decisions
- Cost Savings, Waste reduction, "Green Solution"
  - ✓ Less in shipping, less intensive field work
  - ✓ Reduction in unnecessary remediation





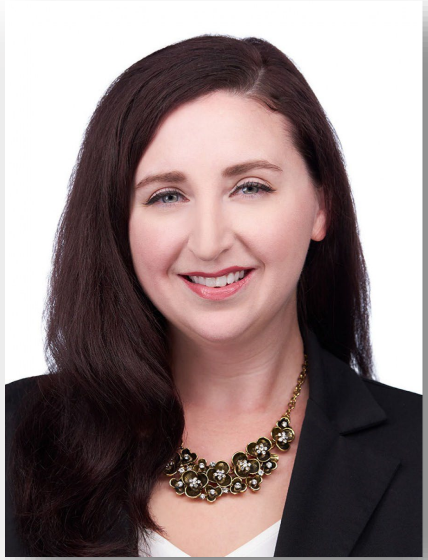
# Thanks for Listening!

**Reach out if you are interested in learning more and visit Geosyntec at Booth 909**

**Visit SiREM's Website:**

**SiREM**

Brent Pautler, PhD
Guelph, Ontario
(519) 515-0837
bpautler@siremlab.com



Rachel Zajac-Fay, MS
Tampa, Florida
(813) 379-4381
rzajacfay@geosyntec.com

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**Registration**