STEEP

Sources, Transport, Exposure & Effects of PFASs

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URI STEEP Superfund Research Center II:

Sources, Transport, Exposure and Effects of PFAS

(P42 ES027706)

1000s of PFAS
100s produced *
10s monitored
6+ targeted (EPA)

- Categories:

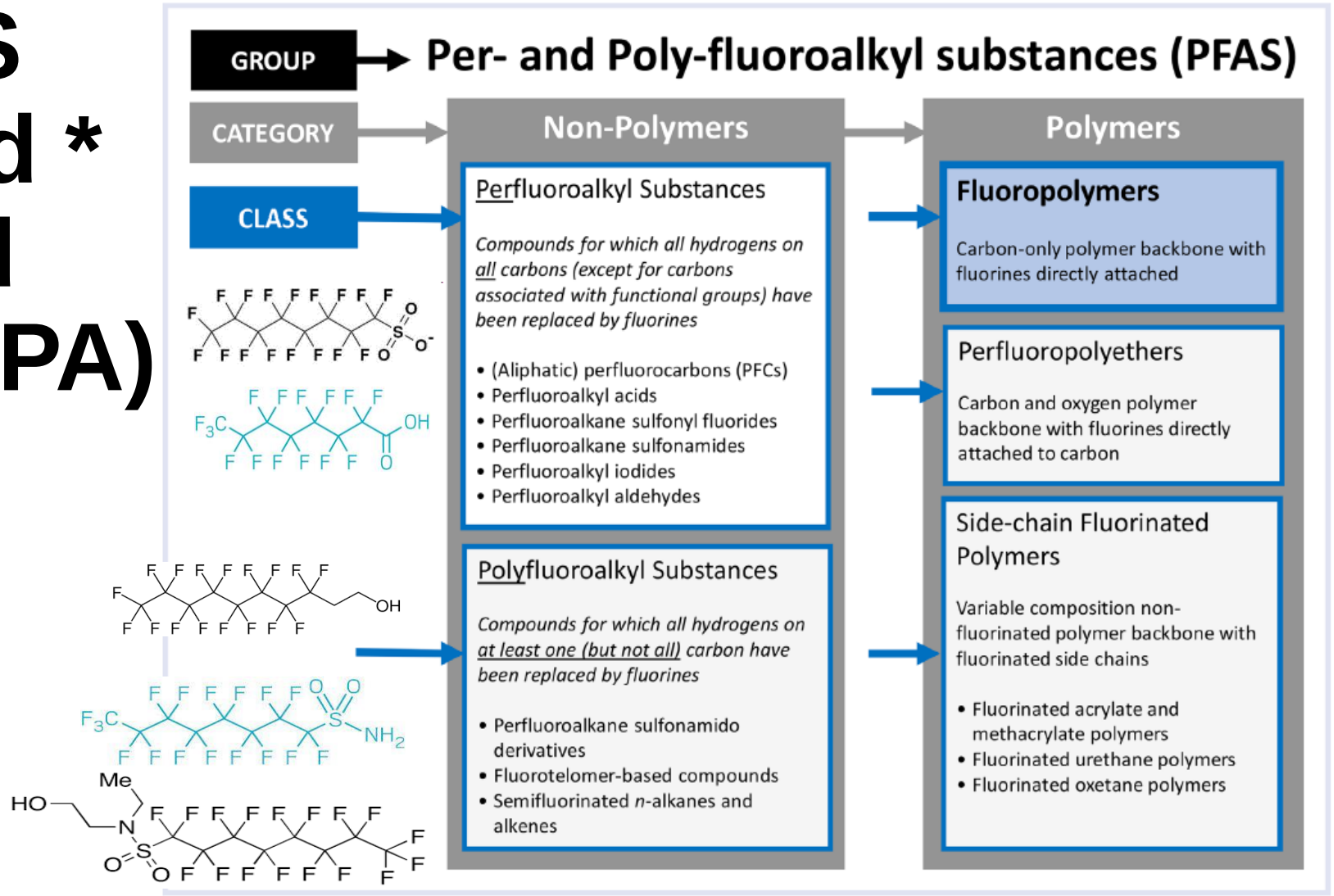

Figure 1. Per- and polyfluoroalkyl substances (PFAS).

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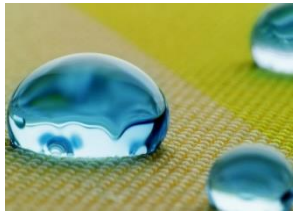
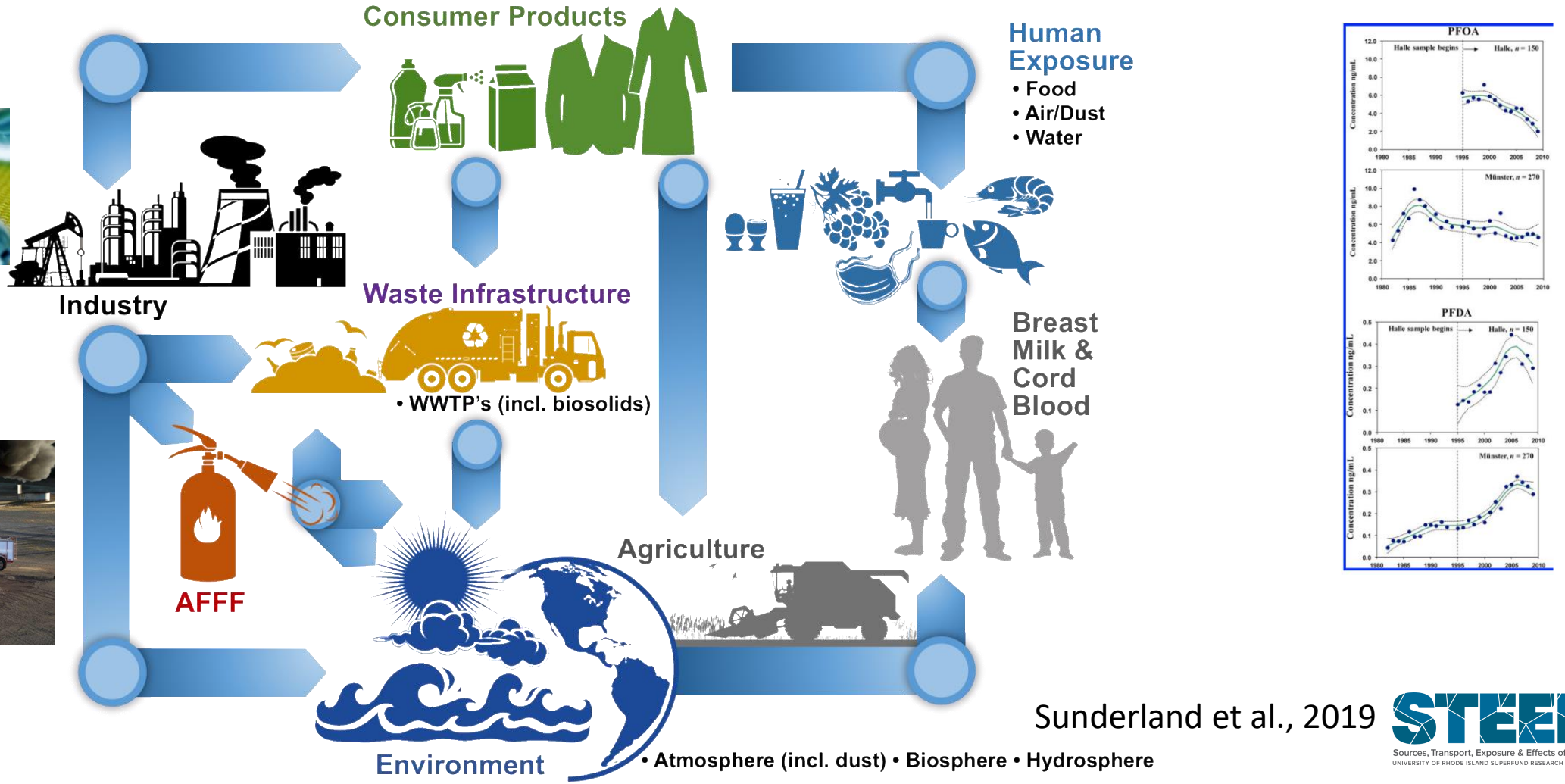
STEEP Integration:
Human Exposure Pathways





Sunderland et al., 2019

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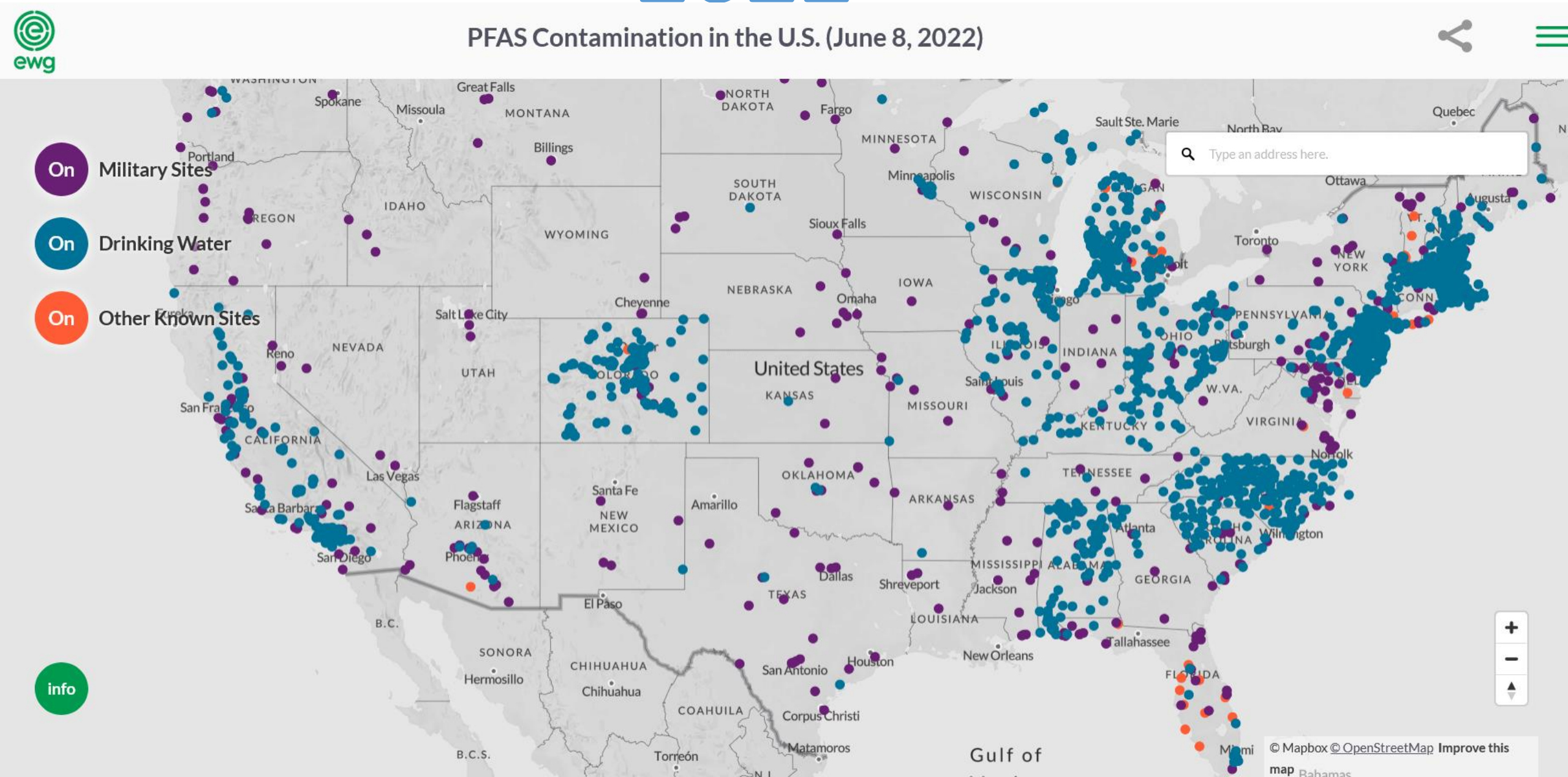
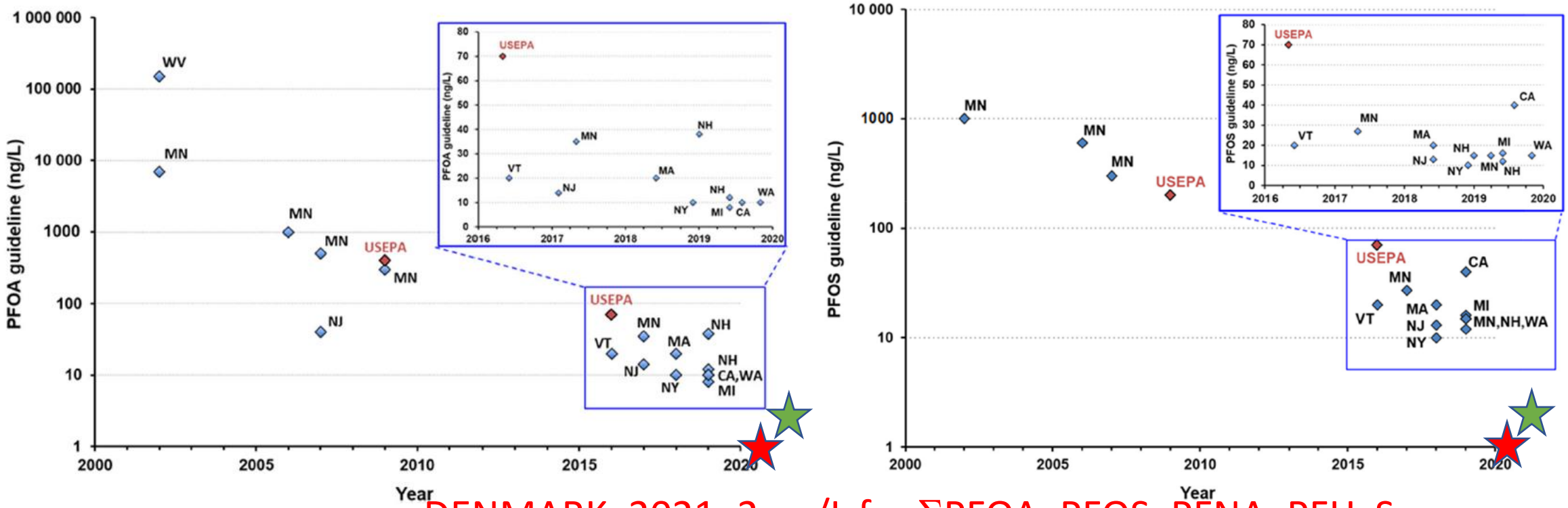
2022


ewg
PFAS Contamination in the U.S. (June 8, 2022)
On Military Sites
On Drinking Water
On Other Known Sites
info
Type an address here.
United States
Spokane
Missoula
Great Falls
MONTANA
NORTH DAKOTA
Fargo
Billings
Portland
MINNESOTA
Minneapolis
Sault Ste. Marie
North Bay
Quebec
Ottawa
IDAHO
SOUTH DAKOTA
Sioux Falls
WISCONSIN
WYOMING
Toronto
NEW YORK
NEBRASKA
Omaha
IOWA
Cheyenne
Salt Lake City
Reno
NEVADA
UTAH
INDIANA
OHIO
Pittsburgh
PENNSYLVANIA
KANSAS
MISSOURI
W.VA.
KENTUCKY
VIRGINIA
CALIFORNIA
Las Vegas
Flagstaff
ARIZONA
Santa Fe
NEW MEXICO
Amarillo
OKLAHOMA
ARKANSAS
TENNESSEE
Norfolk
Atlanta
San Diego
Phoenix
El Paso
Dallas
TEXAS
Shreveport
Jackson
MISSISSIPPI
GEORGIA
LOUISIANA
New Orleans
Tallahassee
B.C.
SONORA
Hermosillo
CHIHUAHUA
Chihuahua
San Antonio
Houston
COAHUILA
Corpus Christi
Matamoros
B.C.S.
Torreón
Gulf of
Miami
Bahamas
© Mapbox © OpenStreetMap Improve this map

What is safe? It depends on where, when, which.



DENMARK, 2021: 2 ng/L for ΣPFOA, PFOS, PFNA, PFHxS

US EPA, 2023: proposed 4 ng/L for PFOA, PFOS; HI for PFNA, PFHxS

(Post, 2021)

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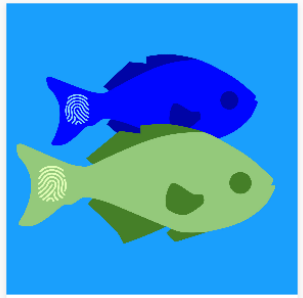
Connecting science and people

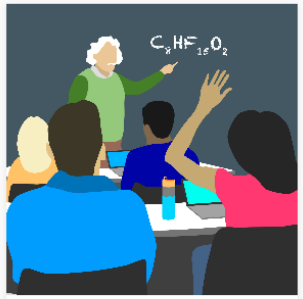


STEEP Research: Environmental Fate & Transport

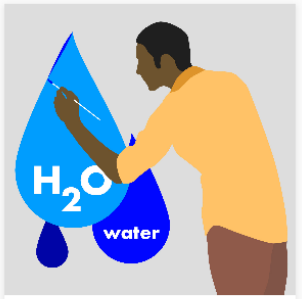
STEEP Research: Childhood Risk

STEEP Research: Metabolic Effects

STEEP Research: Detection Tools



STEEP Core: Next Generation



STEEP Core: Research Translation

STEEP Core: Community Engagement

STEEP Core: Administrative

www.uri.edu/steep

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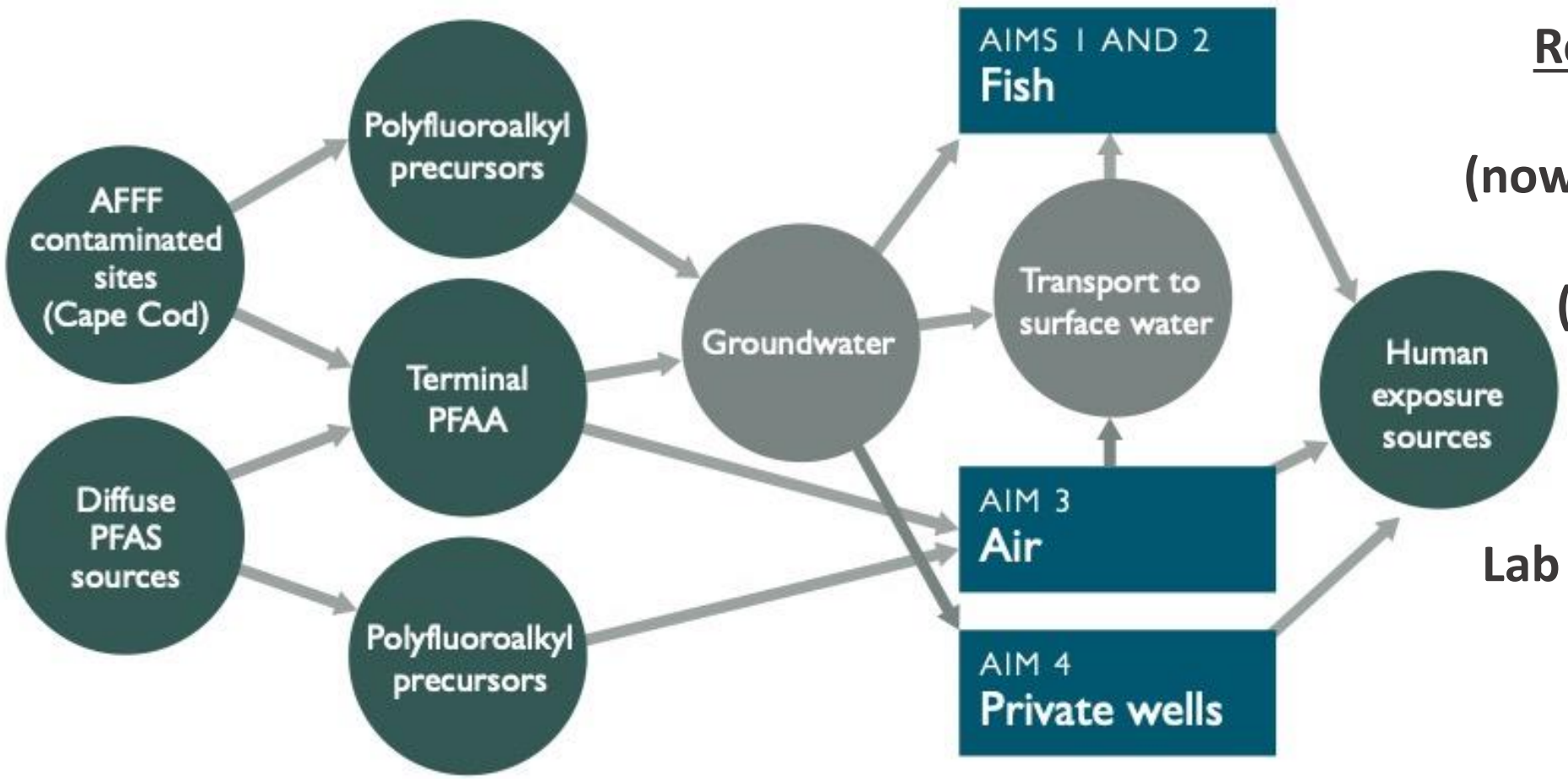
Project 1 new foci: Shift away from groundwater transport
Now: precursor transformations and relevance for atmospheric deposition, food web bioaccumulation, and drinking water

[Assessing the Contribution of Polyfluoroalkyl Precursors to Diverse PFAS Exposures near Contaminated Sites]

Project Lead: **Elsie Sunderland (Harvard)**



Recent P1 Trainees:

Bridger Ruyle (now postdoc@Stanford),
Fabian Fisher (soon Prof@URI),
Heidi Pickard,
Jennifer Sun,
Jahred Liddie
Lab Support: Faiz Haque

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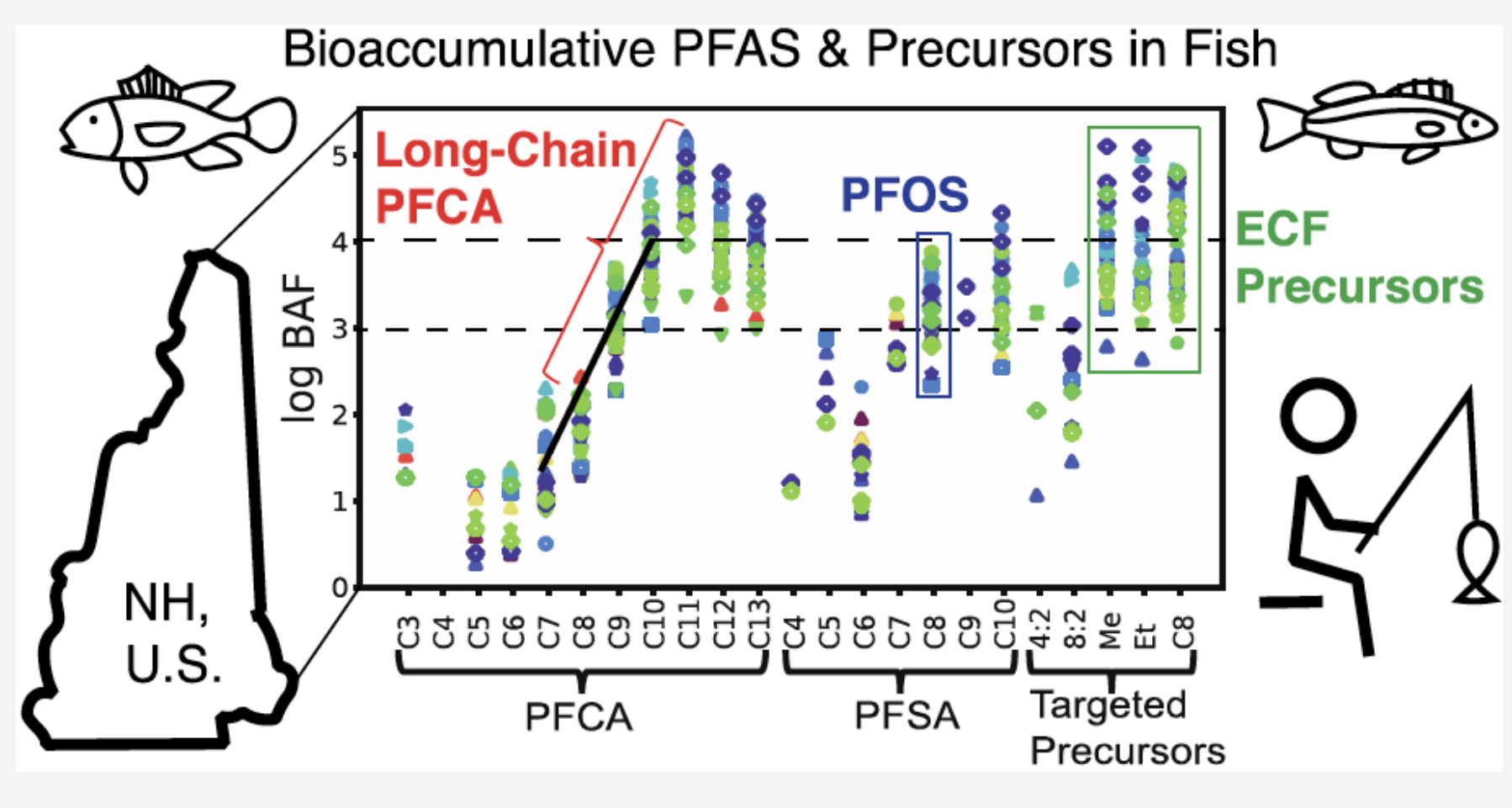
Aim 1: Quantify PFAS contributions from an AFFF-contaminated site to fish in downgradient ecosystems using measurements and statistical modeling in paired water and fish samples

Hypothesis: Abundant polyfluoroalkyl precursors contribute to bioaccumulation of terminal PFAS in fish.

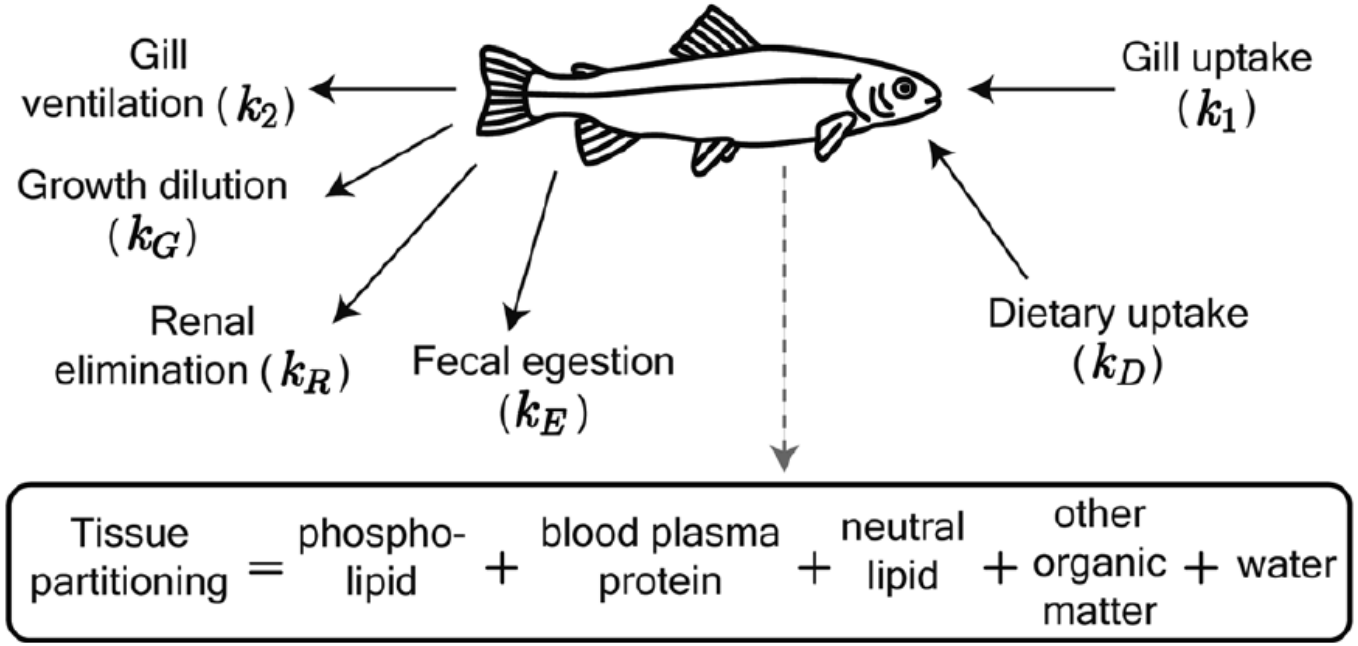


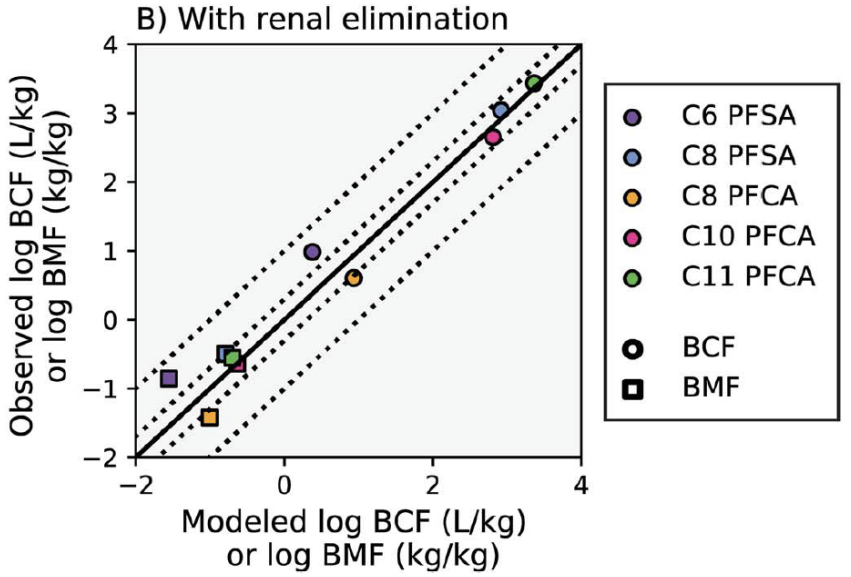
Pickard et al., 2022, ES&T

Aim 2: Develop a mechanistic model for PFAS bioaccumulation in fish based on understanding of PFAS binding to proteins and phospholipids and trophic interactions that can assist in informing fish advisories

Hypothesis: Model performance will be sufficient for explaining biological concentrations of PFAS with greater than 8 perfluorinated carbons but others will require new mechanistic adaptations.

$$C_{fish} = \frac{k_1 C_{water} + k_D C_{diet}}{k_2 + k_E + k_G + k_R}$$





Sun et al., 2022, ESPI

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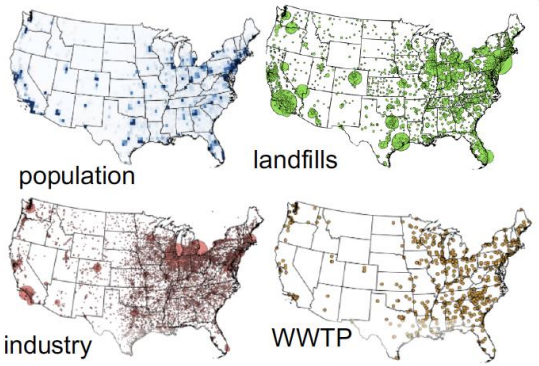
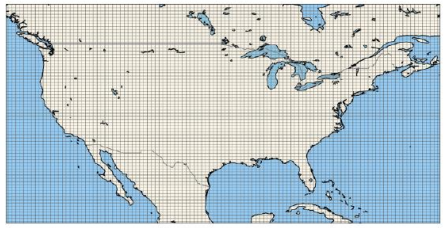
Aim 3: Use a chemical transport model to characterize the contributions of atmospheric PFAS emissions, including polyfluoroalkyl precursors, to PFAS inputs to ecosystems.

Hypothesis: Atmospheric oxidation of precursors and deposition is a large and previously overlooked source of PFAS, particularly downwind of point sources

Model Methods



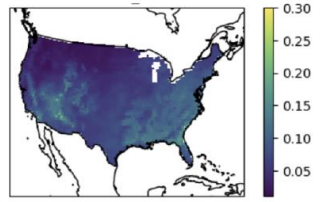
1. Source Sectors & Locations



- Assimilated meteorology drives transport
- *Young & Maybury 2010* chemistry
- gas & particle phase, wet & dry dep
- 0.5° x 0.625° horizontal grid

2. GEOS-Chem simulation

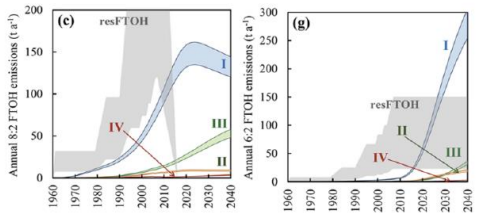
1 model run per source



Influence Functions

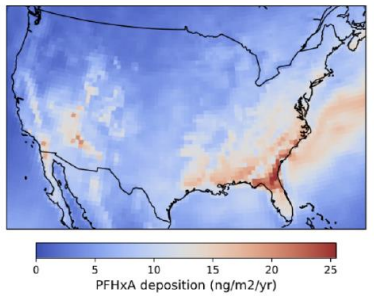
Modeled conc. / deposition per year per 1 kg total US emissions

+



Wang et al. 2014a,b; Li et al. 2017; Buser & Morf 2009

3. Emissions Volumes



Modeled Deposition/ Concentration

Gewurtz et al. 2013; Pfotenheimer et al. 2022 Rauert et al. 2018

4. Model Evaluation

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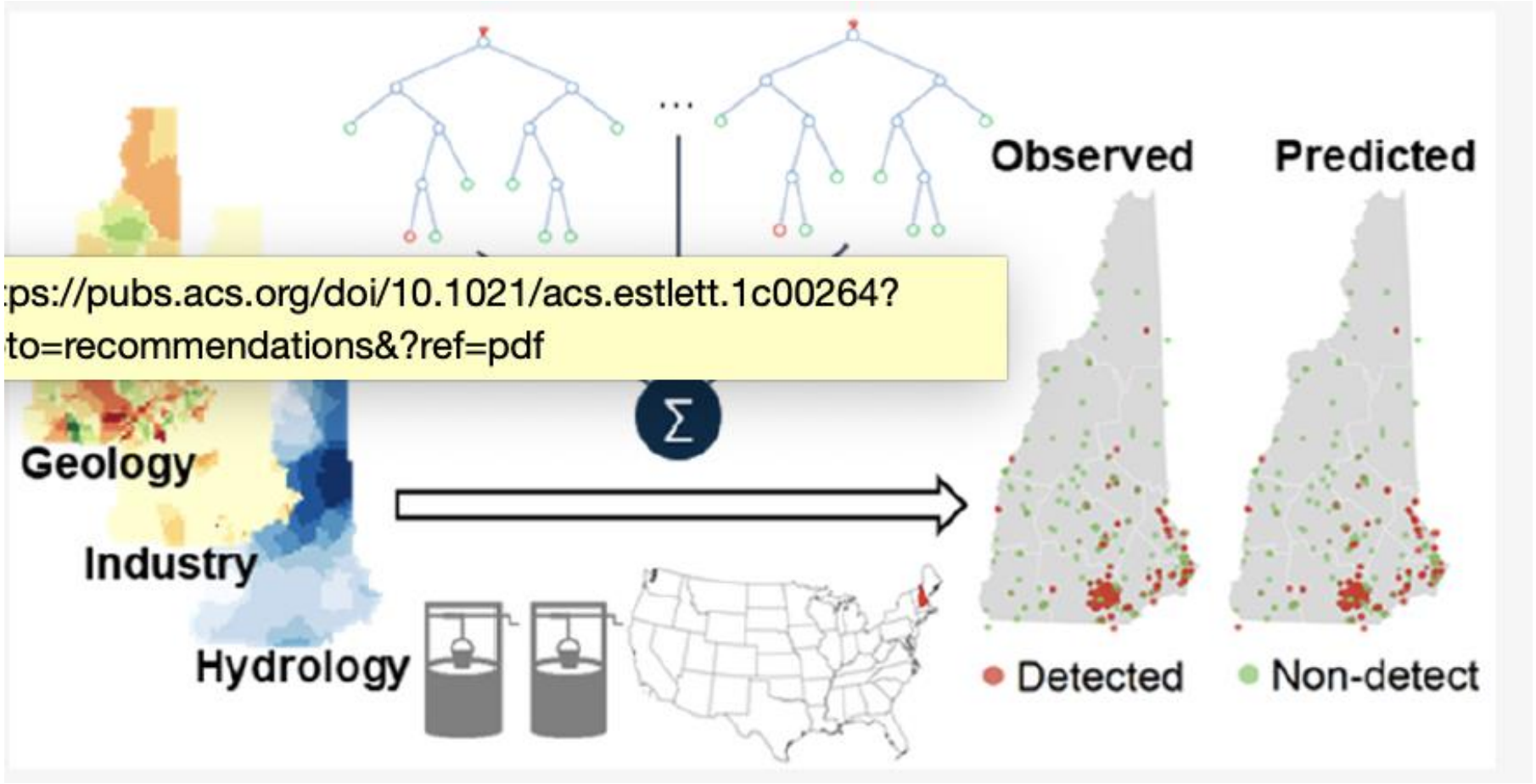
Aim 4: Develop a screening tool for identifying private wells with PFAS contamination for MI, NJ and MA by adapting a hybrid mechanistic-empirical model previously developed for NH.

Hypothesis: Data on PFAS source abundance and hydrological variables can accurately predict the likelihood of PFAS detection at levels of concern in private wells.



Hu et al., 2021, ES&T Letters

Project 2: Inflammation and Metabolic Changes in Children Developmentally Exposed to PFASs

PI: Philippe Grandjean (HU), w/Pal Weihe (Faroese Hospital)

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Faroes community

- The Faroe Islands are comprised of a dozen islands located between the Shetland Islands and Iceland
- Unique epidemiological setting, where birth cohorts have been formed and followed-up with minimal attrition
- The marine diet results in a wide range of PFAS exposures
- The Faroese are of Nordic and Irish origin and comparable in many ways to other Western populations.

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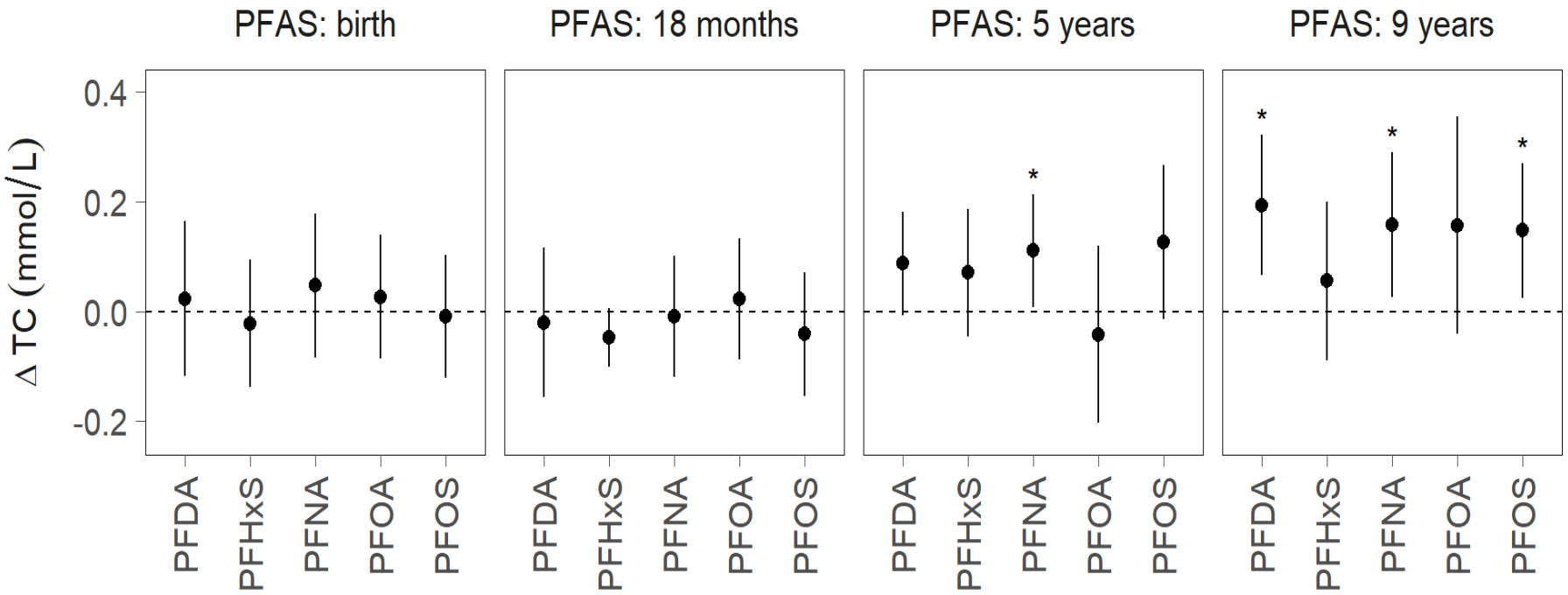
Change in serum total cholesterol associated with a doubling in serum-PFAS concentrations at four different childhood ages



What happens at age 15 years (and onwards)?

Blomberg et al., 2021

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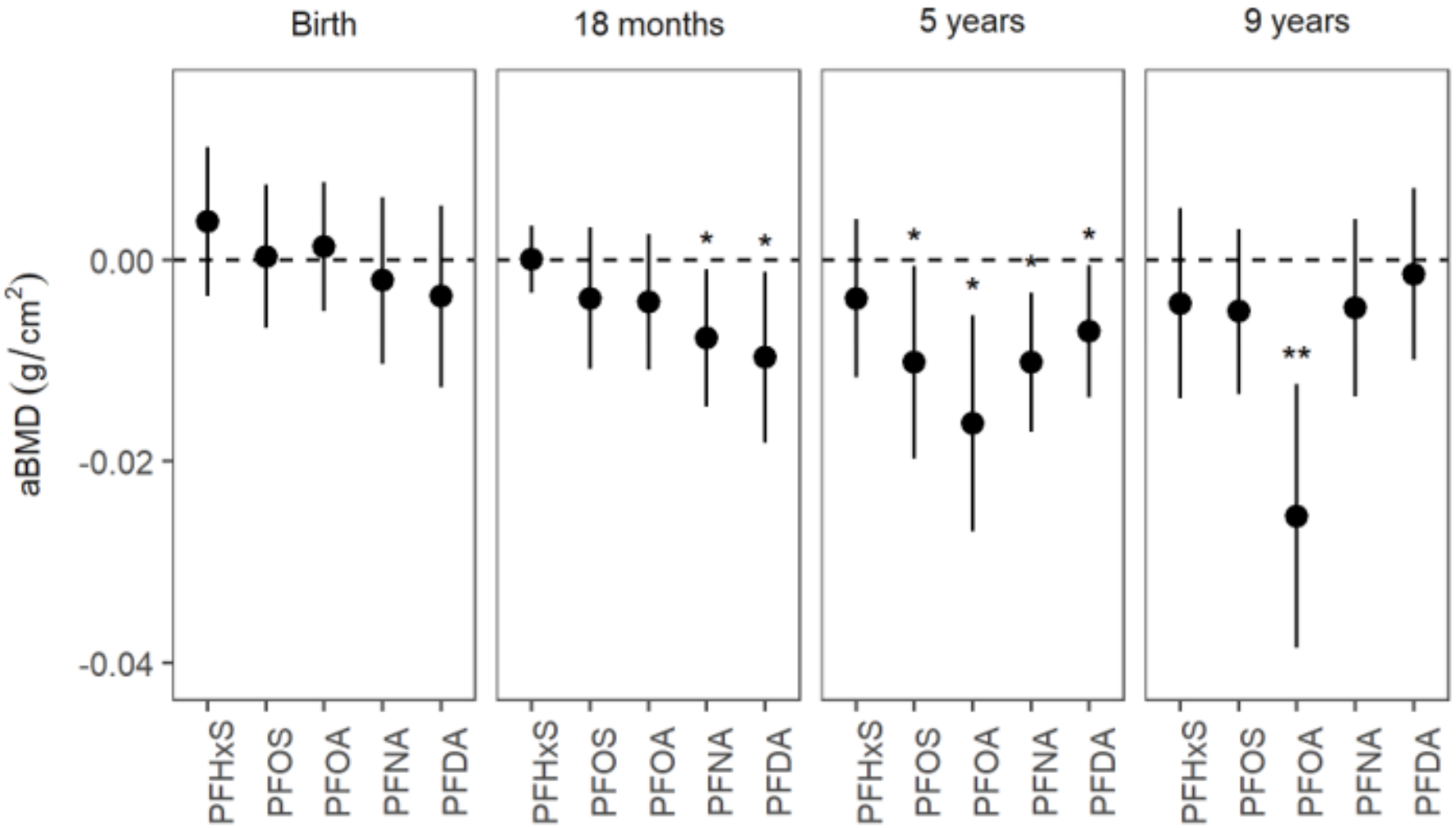
Areal Bone Mass Density at age 9 years associated with serum-PFAS



What happens at age 15 years (and onwards)?

Blomberg et al., 2022

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National Institute of Environmental Health Sciences
Superfund Research Program

Faroe Islands (clinical)

Deildin fyri
Arbeiðs- og Almannaheilsu

Denmark (lab support)

SDU

Syddansk Universitet

THE UNIVERSITY OF RHODE ISLAND

HARVARD T.H. CHAN SCHOOL OF PUBLIC HEALTH
Department of Environmental Health

SILENT SPRING INSTITUTE
Researching the Environment and Women's Health

National Institute of Environmental Health Sciences
Superfund Research Program

STEEP is funded under award number P42ES027726.
More information about STEEP is available at: https://web.uri.edu/steep/

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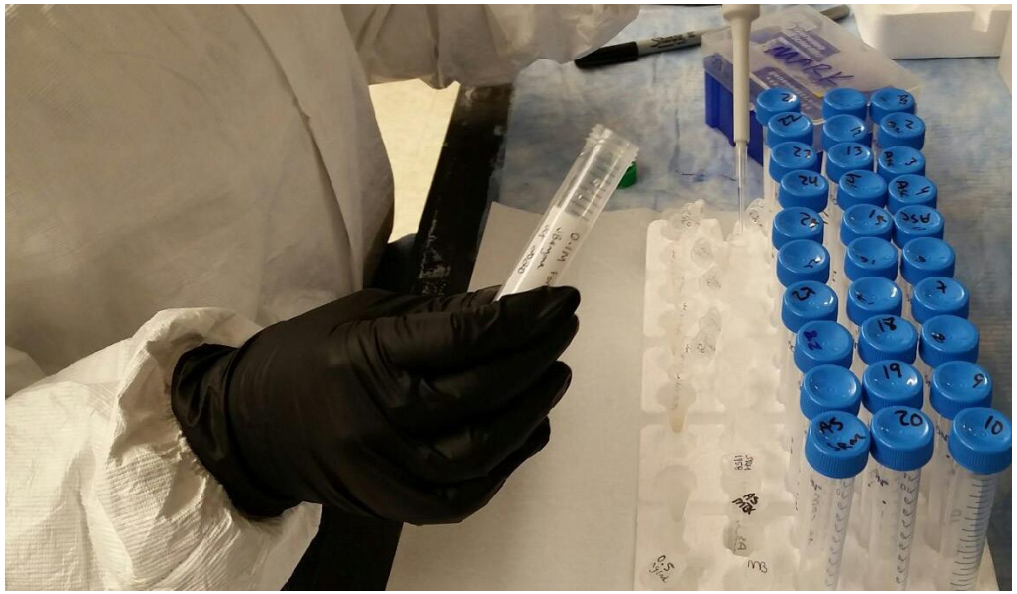
P3-Mechanisms of PFAS Toxicity

- Goal is to uncover key molecular and cellular mechanisms that contribute to PFA tissue distribution and elimination *in vivo*

Addresses SRP mandate #4 -
(basic biological, chemical, and physical methods to reduce the amount and toxicity of hazardous substances).
Addresses SRP mandate #2
(to develop methods and resources to methods to assess the risks to human health presented by hazardous substances).



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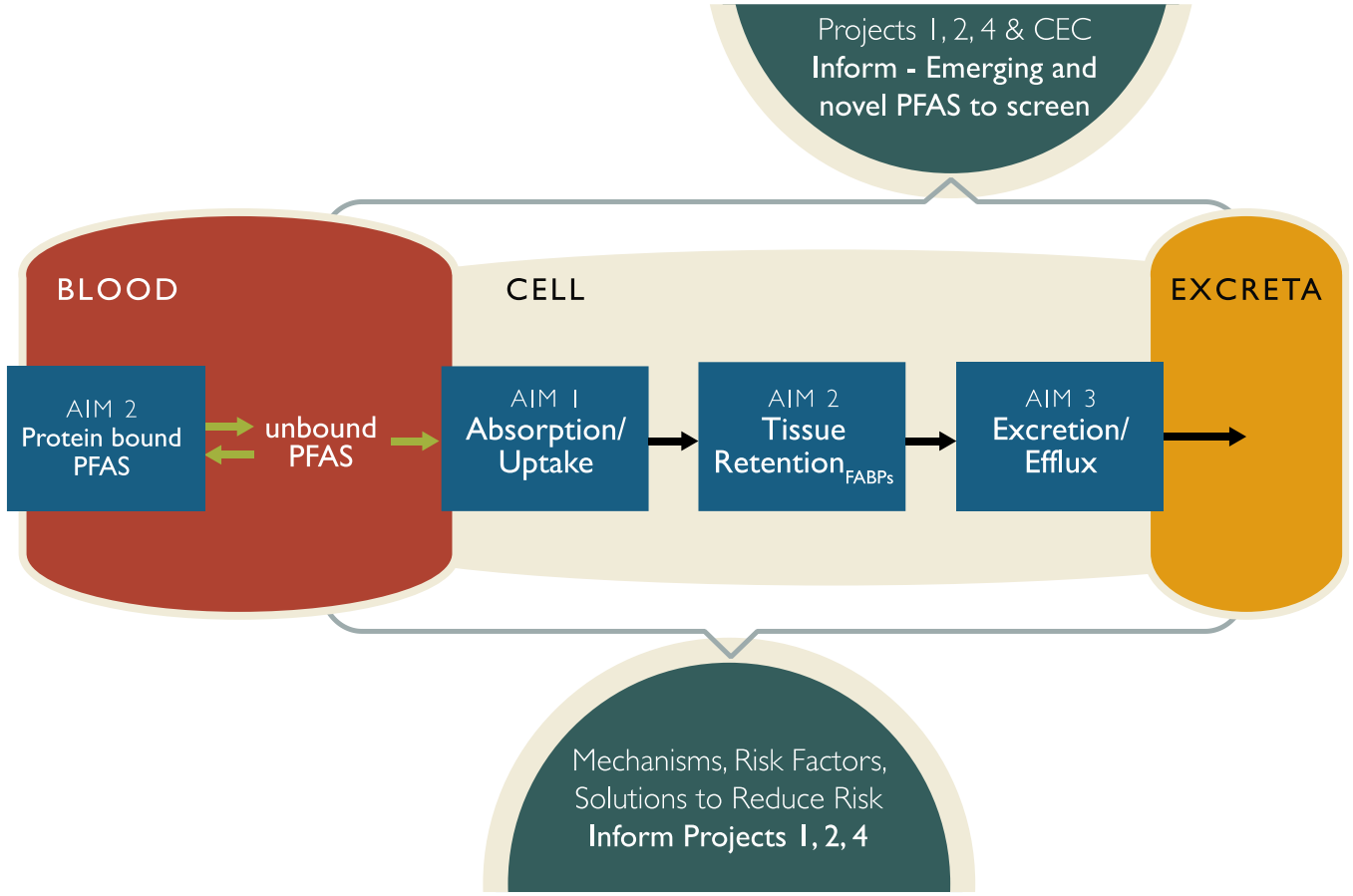
P3 Aims



Aim 1: Does the OATP2B1 transporter mediate PFBS, PFHxS, and PFOS uptake?

Aim 2: Do binding proteins, such as albumin and LFABP mediate PFBS, PFHxS, and PFOS tissue retention and elimination?

Aim 3: Do Efflux transporters, such as ABCG2 mediate efflux from the cell?

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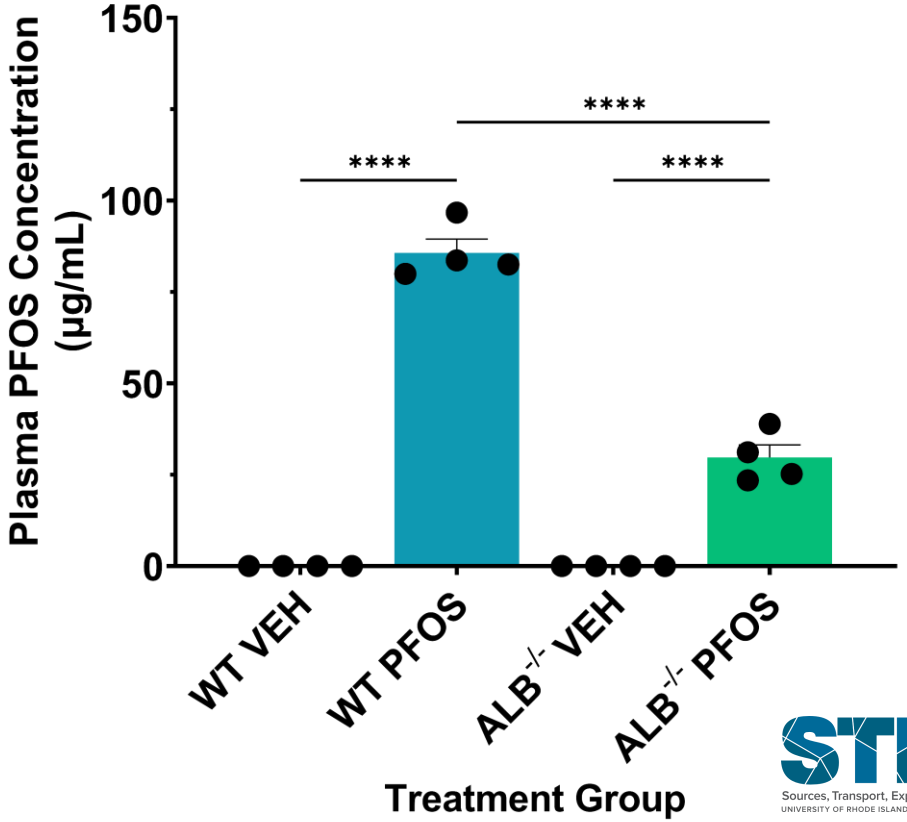
Key P3 Findings

- *In vitro:* many PFAS transported by OATP, OAT, and ABCG2.
- 6:2 FTS is impermeable, and a strong ”hit” for transporter interactions
- LFABP is less critical that hypothesized for tissue accumulation

- Mice lacking serum albumin were used
- Dosed 10 mg/kg x 7 days. Rationale: This dose regimen induces adverse liver outcomes in mice
- Confirms albumin as an important target for serum levels
- Being repeated with 1 mg/kg x 7 days; and single PK studies



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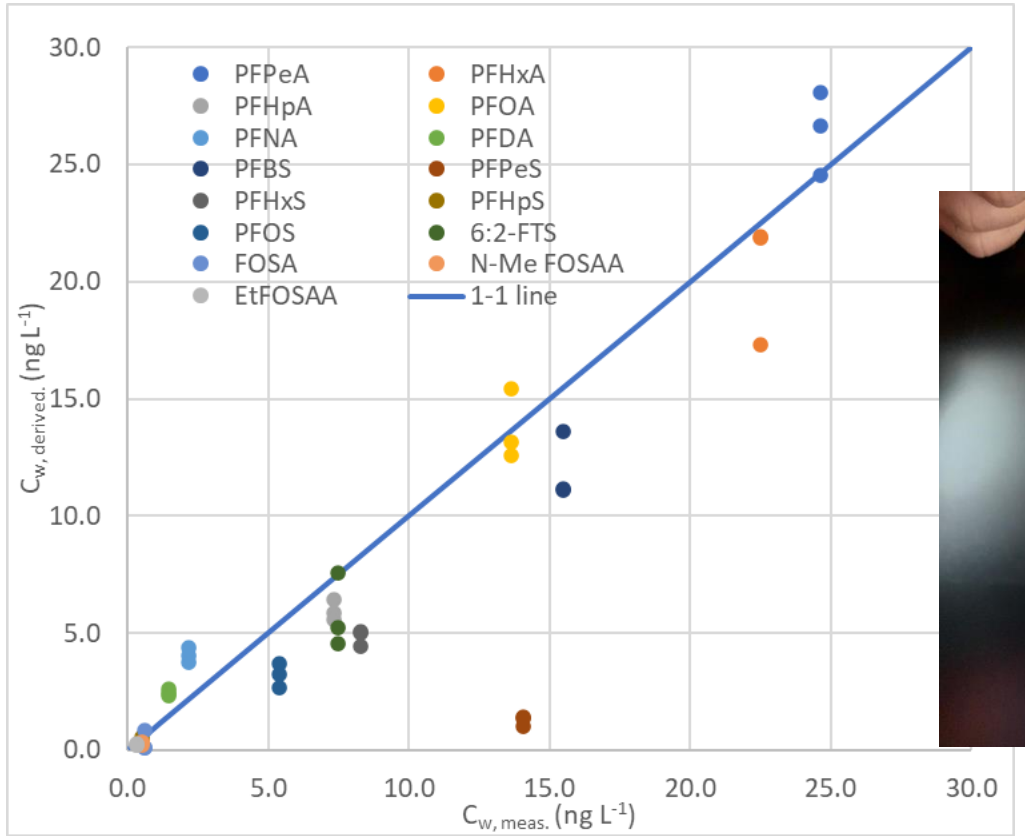
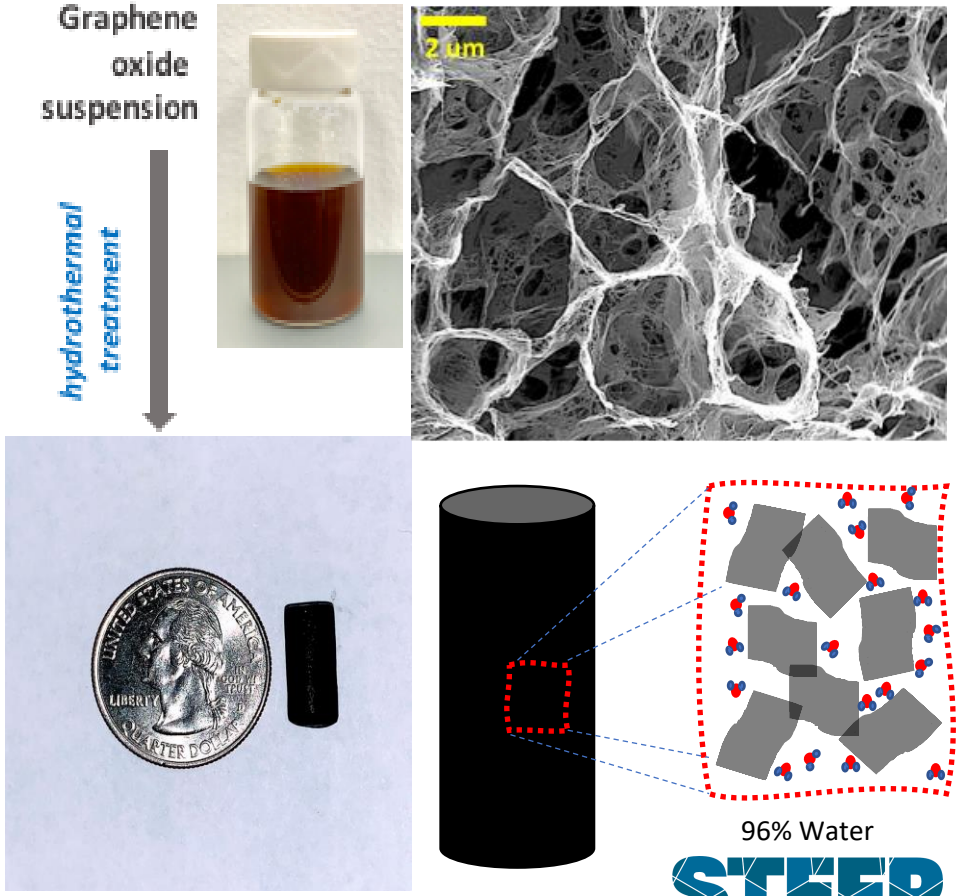
Project 4 – Detection, bioaccumulation and remediation

- Aim 1 – Detection and remediation with polymers



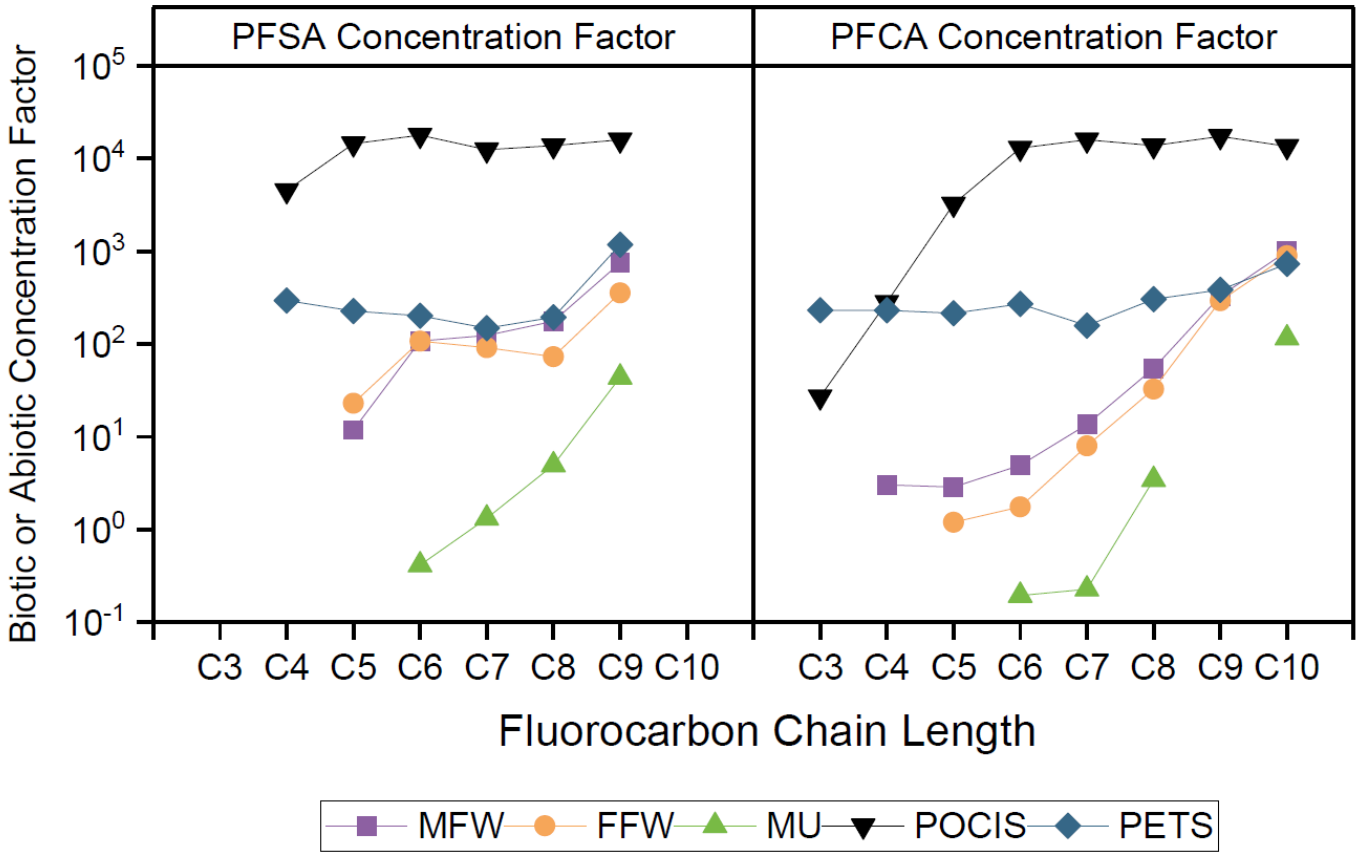
(Gardiner et al., 2022)

(Dunn et al., 2022)



(Becanova et al., 2021)

Aim 2: Passive samplers as proxies for PFAS bioaccumulation (lab/field)



(Barber et al., 2023)

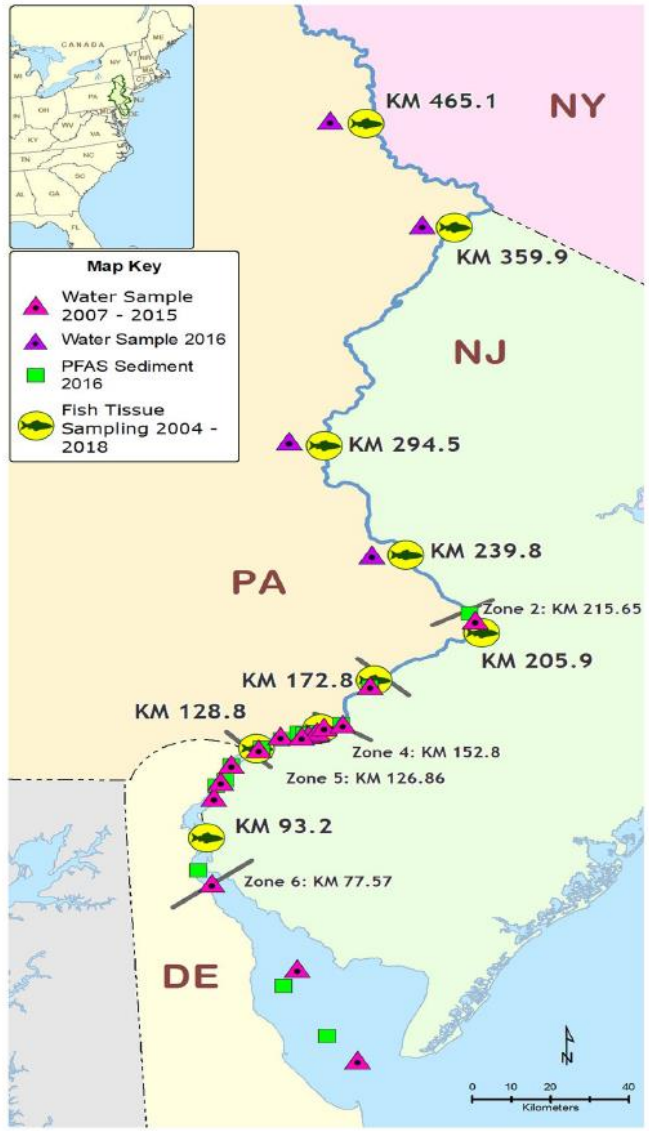


Figure 10. Proposed PFAS sampling sites along the Delaware River[62]

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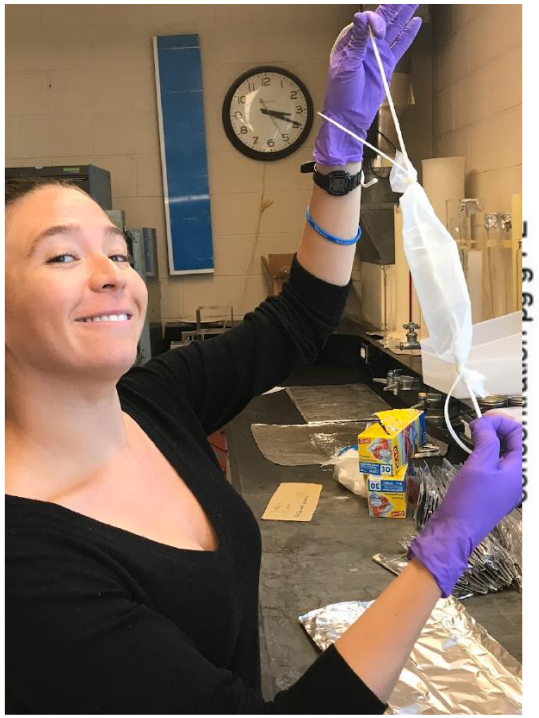
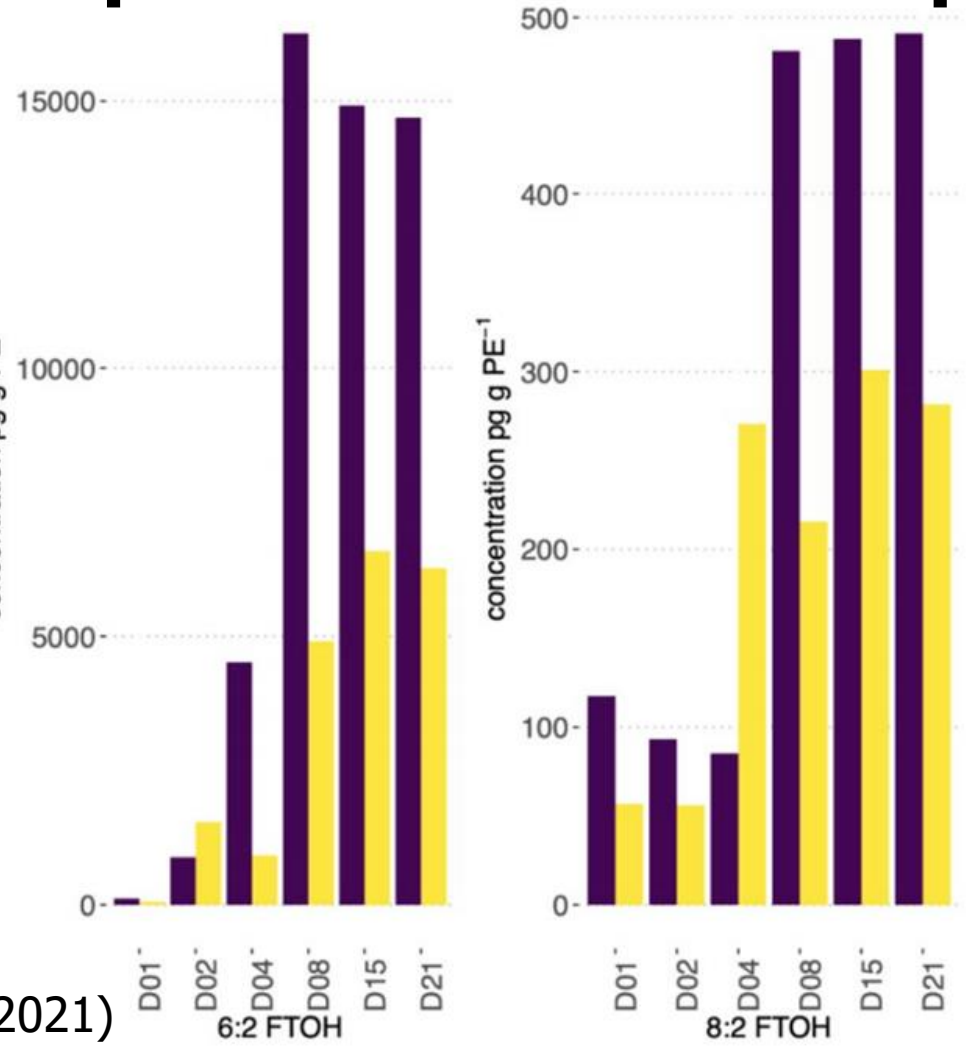
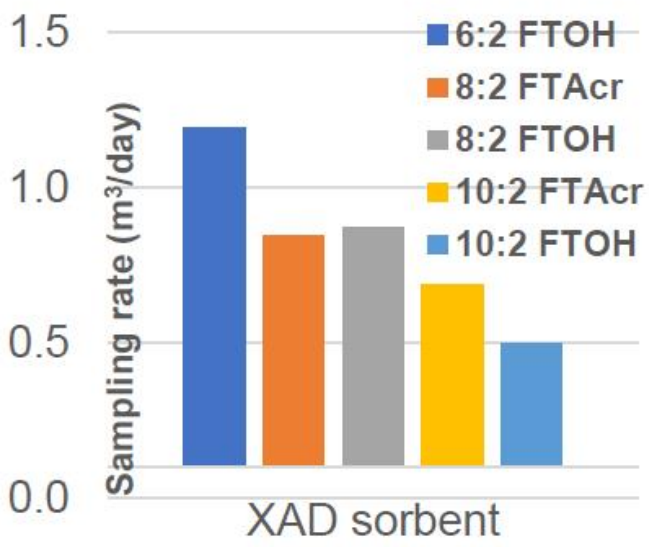
Aim 3: Atmospheric PFAS transport& exposure







(Morales-McDevitt et al., 2021)

Figure S1. Weight-normalized, blank-corrected concentrations of 6:2 FTOH and 8:2 FTOH per gram of PE sheet.

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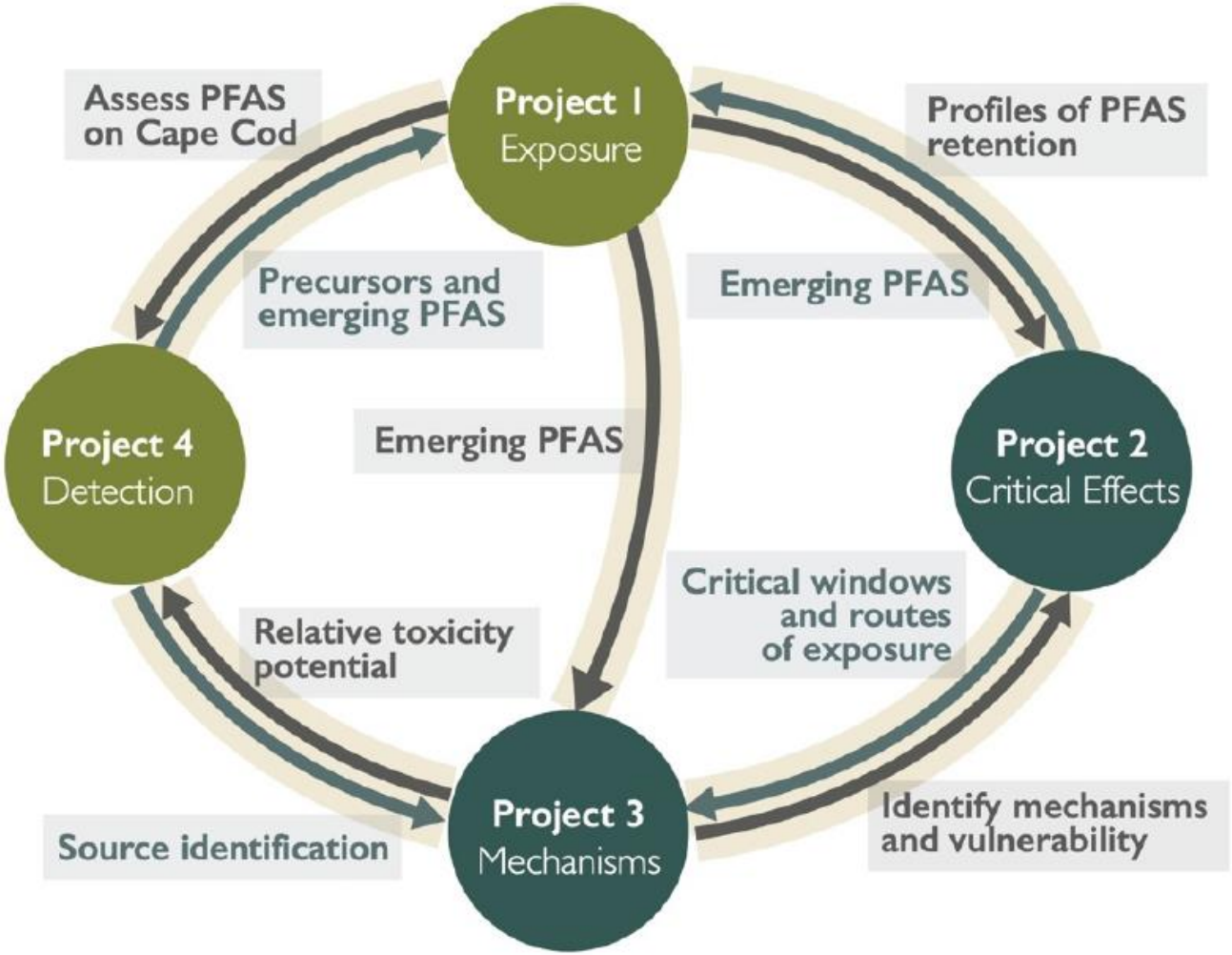
STEEP's integration at its core



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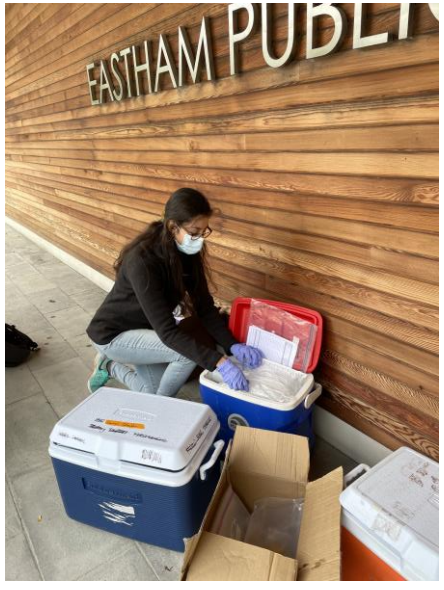
Community Engagement Core

Laurel Schaider, PhD
Silent Spring Institute
Emily Diamond, PhD
University of Rhode Island

Aim 1	Understand PFAS exposures through new pathways (e.g., homegrown produce, locally caught fish, indoor environments)
Aim 2	Collaborate with Mashpee Wampanoag Tribe to test fish and shellfish, and develop tailored risk messaging strategies to reduce PFAS exposure
Aim 3	Connect STEEP trainees with high schools on Cape Cod to enhance understanding of PFAS and other water quality issues
Aim 4	Collaborate with community organizations to empower communities affected by PFAS contamination.



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Research Translation Core

Amber Neville
URI Coastal Institute
Jaclyn Witterschein
URI Coastal Institute

Aim 1

Provide relevant and timely research translation and engagement

- STEEP website, social media posts and trainee social media takeovers
- Research podcasts, video segments and trainee clips
- Quarterly newsletter and annual report
- Public film screening of *Burned: Protecting the Protectors*

Aim 2

Identify and work with new/existing stakeholders and collaborators

- Partnership with the URI Harrington School of Communication and Media courses
- Continuous cycle of engagement for STEEP trainees to promote their research and accomplishments
- Trainee mentorship via the URI DWELL Lab
  - Visual rhetoric, digital media
  - PFAS augmented reality workshop

Trainee Spotlight: Asta Habtemichael

Asta Habtemichael inducted in the into the inaugural cohort of American Association of Colleges and Universities (AAC&U) Future Leaders Society, finalist for the honorary K. Patricia Cross Future Leaders Award ...Read more

"BURNED: Protecting the Protectors" short film screening & panel discussion

BURNED Protecting the Protectors, from Ethereal Films and produced by Mark Ruffalo, documents the true story of how the spouse of a firefighter revealed significant exposure to PFAS affecting the fire community. Please join us for this short film, followed by a panel discussion featuring Professor Rainer Lohmann (URI Graduate School of Oceanography), Professor Angela Slitt (URI College of Pharmacy), and Jason Burns (Fall River Firefighter & Executive Director, The Last Call Foundation). ...Read more

Data Management & Analysis Core

Harrison Dekker
University of Rhode Island
Marie-Abele Bind, *MGH*
Gavino Puggioni, *URI*

Aim 1	Develop and support infrastructure and processes for sharing data and metadata
Aim 2	Address metadata needs across all STEEP research data products
Aim 3	Provide integrative statistical support
Aim 4	Develop standards for and provide data quality assurance and quality control (QA/QC) across STEEP research projects

Data Management
The initial focus is on developing criteria and workflows for implementing FAIR data management practices across STEEP projects, with a specific emphasis on the curation of data from mass spectrometry analysis - a shared requirement across all STEEP projects.

Data Analysis
Based on our initial work with trainees, we have identified experimental design and reproducible research as major areas of need across all STEEP projects. To address these needs, we are exploring various modes of training and support.

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STEEP's organized

LEADERSHIP

Director Lohmann (University of RI)
Co-Director Grandjean (Harvard University)

COMMUNITY ENGAGEMENT CORE

Schaider (Silent Spring Institution)
Diamond (University of RI)

DATA MANAGEMENT AND ANALYSIS CORE

Dekker (University of RI)
Bind (Mass. General Hospital)
Puggioni (University of RI)

RESEARCH EXPERIENCE AND TRAINING COORDINATION CORE

Slitt (University of RI)
Sunderland (Harvard University)

ADMIN CORE

Lohmann (University of RI)
Grandjean (Harvard University)

Coordinator
Lucht (University of RI)

Research Translation Coordinator
Swift (University of RI)

BIOMEDICAL I

Critical Effects of PFAS

Grandjean (Harvard University)
Weihe (U of the Faroe Islands)
Nielsen (U of S. Denmark)

BIOMEDICAL II

Properties and key mechanisms of PFAS

Slitt (University of RI)
Bothun (University of RI)

ENVIRON ENG-SCI I

Environmental Exposure to PFAS

Sunderland (Harvard University)
Vecitis (Harvard University)

ENVIRON ENG-SCI II

Detection and Remediation of PFAS

Lohmann (University of RI)
Schaider (Silent Spring Institute)
Vecitis (Harvard University)
Boving (University of RI)

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Thanks – Questions?

Rainer Lohmann rlohmann@uri.edu

Philippe Grandjean pgrand@uri.edu

Emily Diamond diamond@uri.edu

www.uri.edu/steep

THE UNIVERSITY OF RHODE ISLAND

HARVARD T.H. CHAN SCHOOL OF PUBLIC HEALTH Department of Environmental Health

SILENT SPRING INSTITUTE Researching the Environment and Women's Health

NIH National Institute of Environmental Health Sciences *Superfund Research Program*

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More information about STEEP is available at: https://web.uri.edu/steep/

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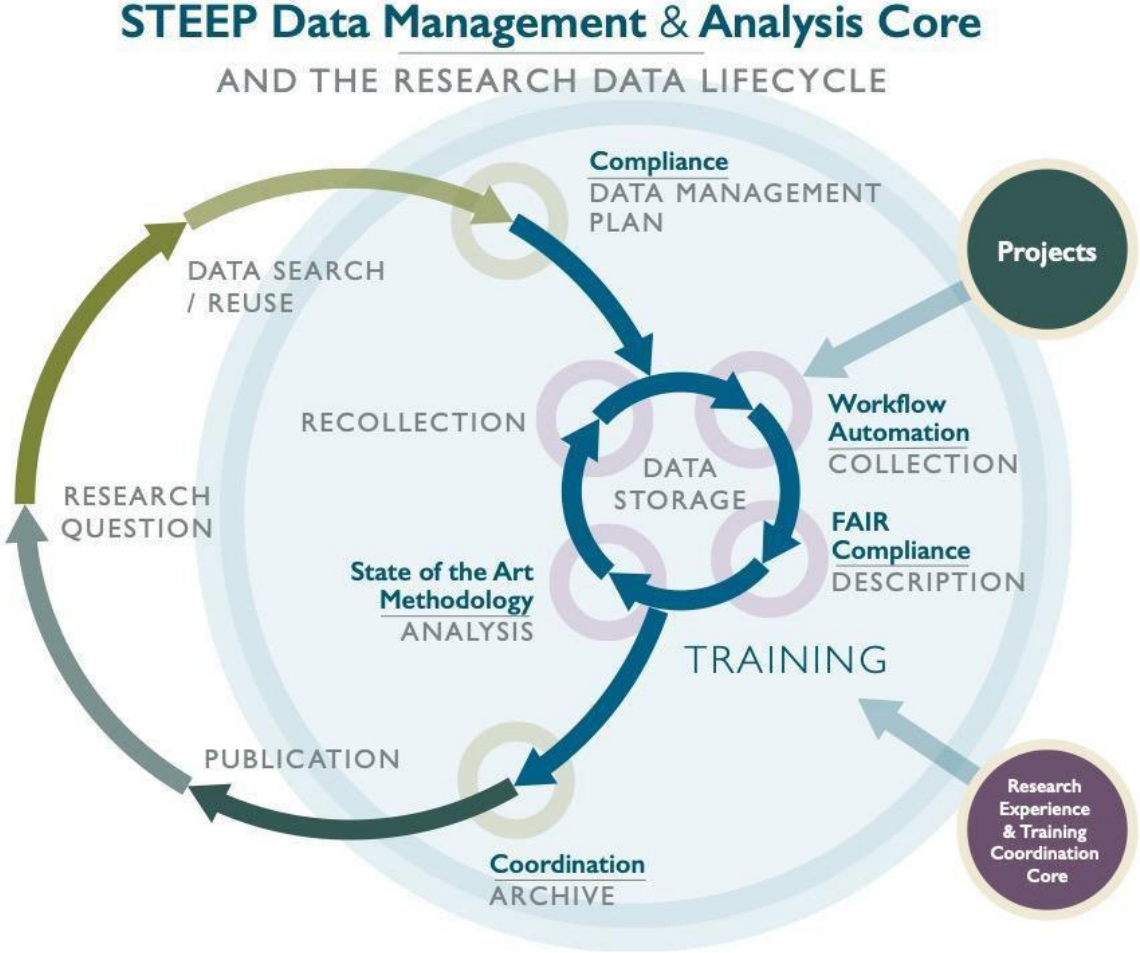
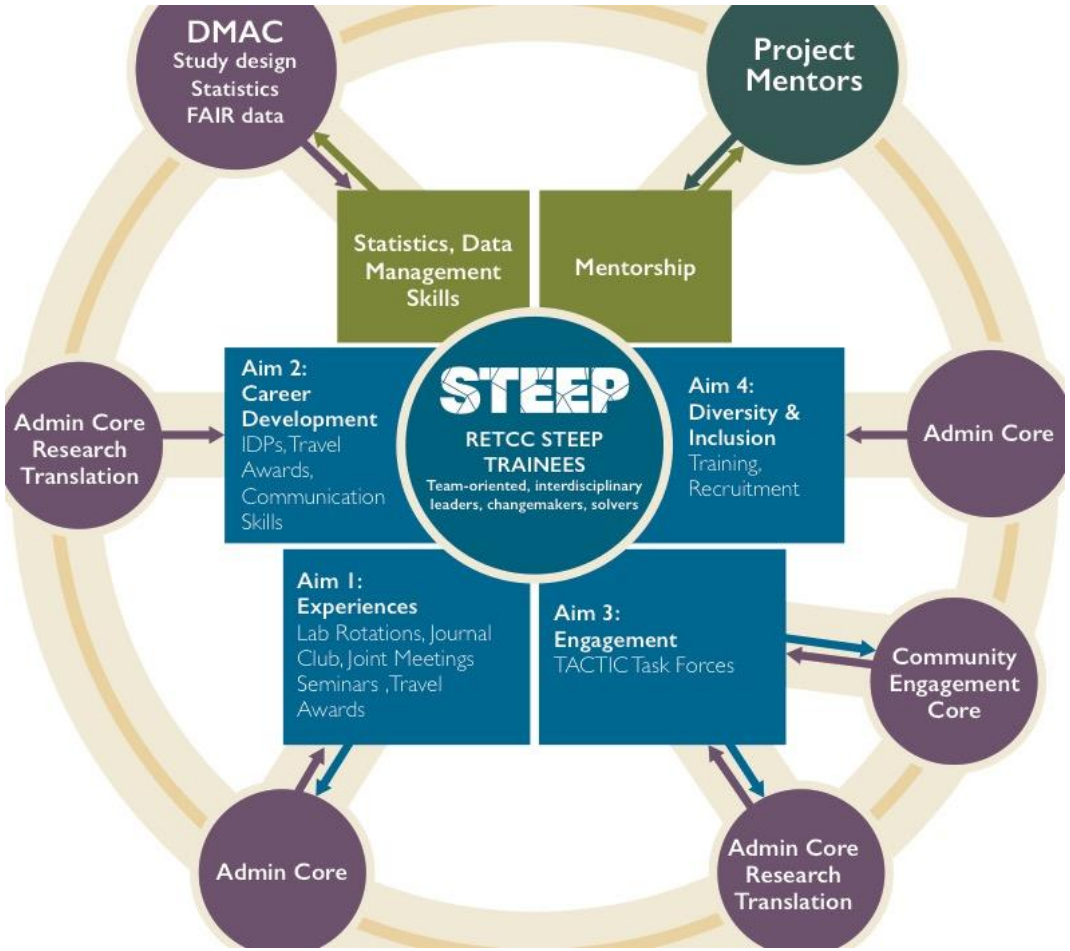
Integrated data management and trainees





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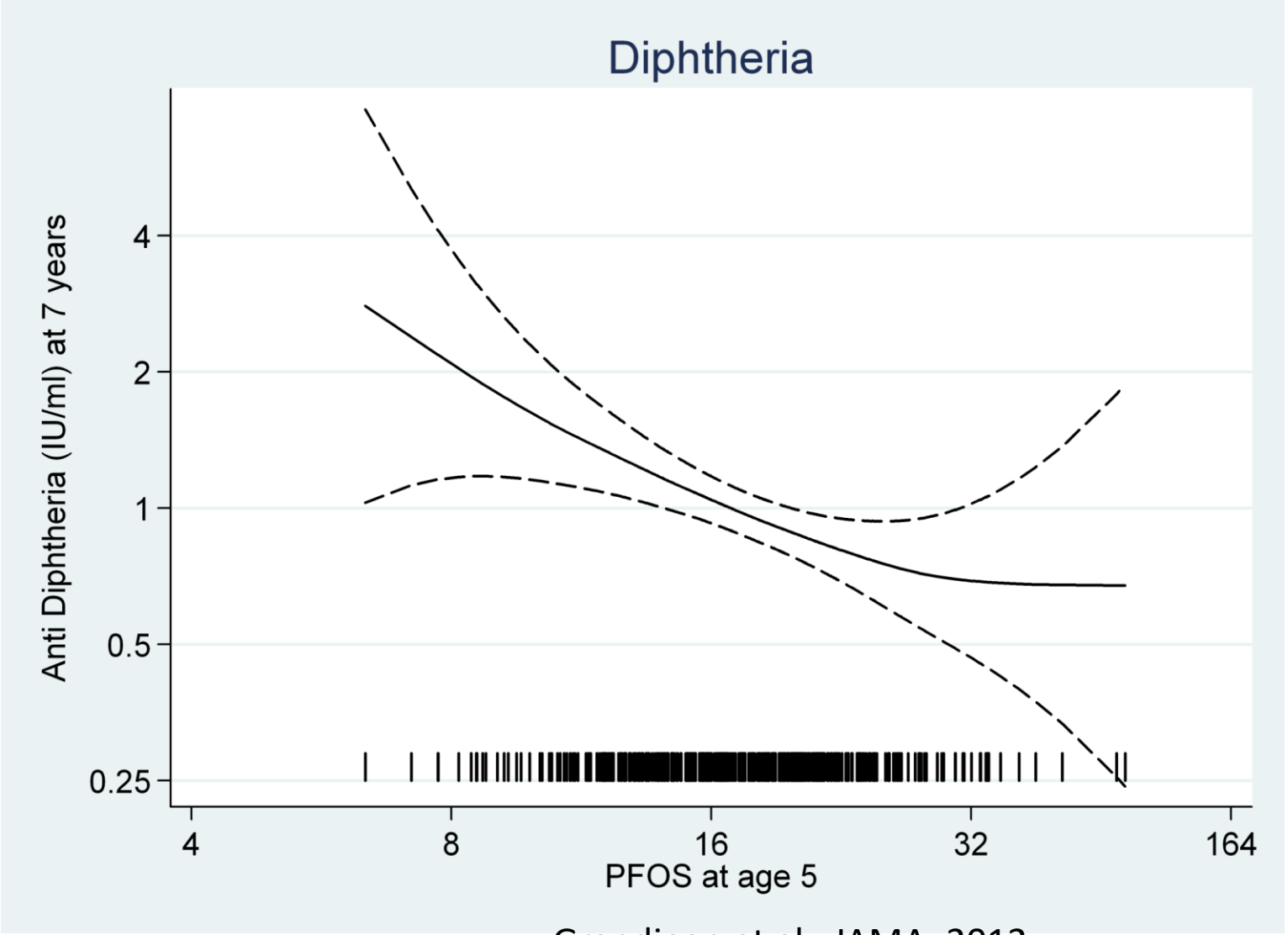
Childhood risks of PFAS



Grandjean et al., JAMA, 2012