Computational Toxicology and Exposure Communities of Practice

Sharing research and promoting collaboration

Thursday, July 25, 11 AM-12 PM ET

Agenda:

- **Introduction: Sammy Hanf**
  Communications Specialist, ORD Center for Computational Toxicology and Exposure
- **Presenters: Marina Evich and Anna Robuck**
  ORD Center for Environmental Measurement and Modeling (CEMM)
- **Q&A**
- **Closing remarks: Sammy Hanf**

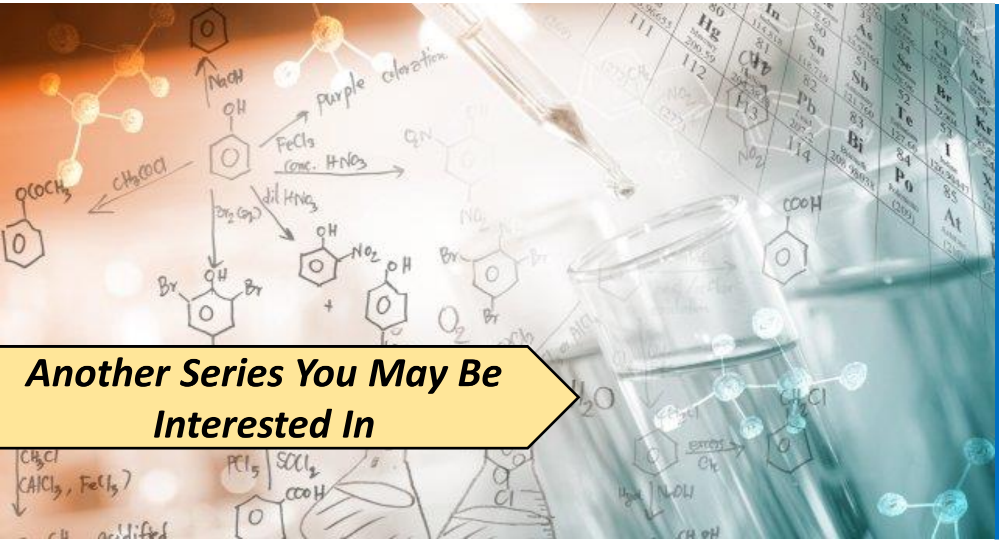
For more information on the CompTox CoP, visit:
epa.gov/chemical-research/computational-toxicology-communities-practice

PFAS in "Real World" Samples

Marina Evich
Research Chemist, CEMM

Anna Robuck
Physical Scientist, CEMM

Tools and Resources Webinar Series



Another Series You May Be Interested In

Innovations in EPA ORD's Human Health Assessments – EPA Transcriptomics Assessment Product

3:00-4:00 p.m. ET
Wednesday, August 21, 2024

This presentation will provide an overview of ORD assessment products and the types of decisions they inform. It will highlight innovations in different assessment approaches and will introduce the new EPA **Transcriptomics Assessment Product**, which is designed to address important gaps and target chemicals lacking traditional toxicity testing data.

Additional Information and Registration: https://www.epa.gov/research-states/epa-tools-and-resources-webinar-series

EPA

Computational Toxicology and Exposure Communities of Practice Webinar Series

Another Series You May Be Interested In

The Scientific Underpinnings of the EPA Transcriptomic Assessment Product (ETAP) and Value of Information (VOI) Case Study

11:00 a.m. – 12:00 p.m. ET
Thursday, August 22, 2024

This webinar will discuss the EPA **Transcriptomics Assessment Product**, which allows us to know what dose of a chemical humans can be exposed to without substantially risking adverse health effects. The presentation will provide a deeper dive on the scientific underpinnings of ETAP and discuss the value of information (VOI) case study on this new assessment product.

Additional Information and Registration: https://www.epa.gov/chemical-research/computational-toxicology-communities-practice

PFAS in "real world" samples: characterizing the complexity of PFAS using high resolution mass spectrometry

Marina Evich, Ph.D.

Anna Ruth Robuck, Ph.D.

CompTox Communities of Practice Webinar

25 July 2024

The views expressed in this presentation are those of the authors and do not necessarily represent the views or policies of the U.S. Environmental Protection Agency.

Meet your presenters

Anna Ruth Robuck, Ph.D
Physical Scientist in ORD/CEMM/ACESD

Marina Evich, Ph.D
Chemist in ORD/CEMM/EPD

Center for Environmental Measurement and Modeling

- Conducting research to advance the Agency's ability to measure and model contaminants in the environment, including research to provide fundamental methods and models needed to implement environmental statutes. Our research involves:
  - Occurrence, fate, and transport in the natural environment
  - Regulatory methods and models
  - Tools to inform and evaluate environmental management practices and policies
  - Environmental indicators
  - Contaminants of emerging concern

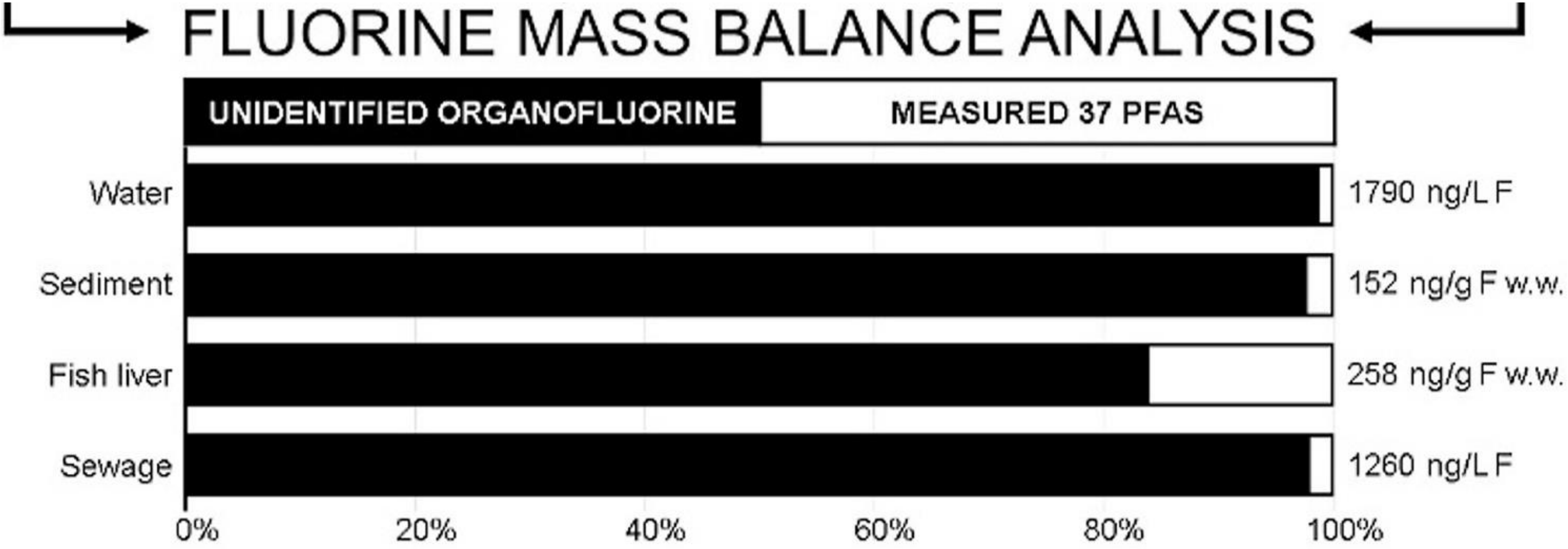
- CEMM hosts NTA expertise across several locations/Divisions
  - RTP: Strynar, McCord, Bangma, Newton, Liberatore
  - Athens, GA: Evich, Washington, Stevens, Weber, Henderson
  - Narragansett, RI: Robuck

Today's outline

- Review of NTA: what is it? Why is it important for PFAS?
- Case studies focused on "real world" samples:
  - Water
  - Sediment
  - Soil
  - Biota: Vegetation
    - Fish (not covered today)

Picture: a researcher sampling water in a river by dipping a sampling bottle into the water

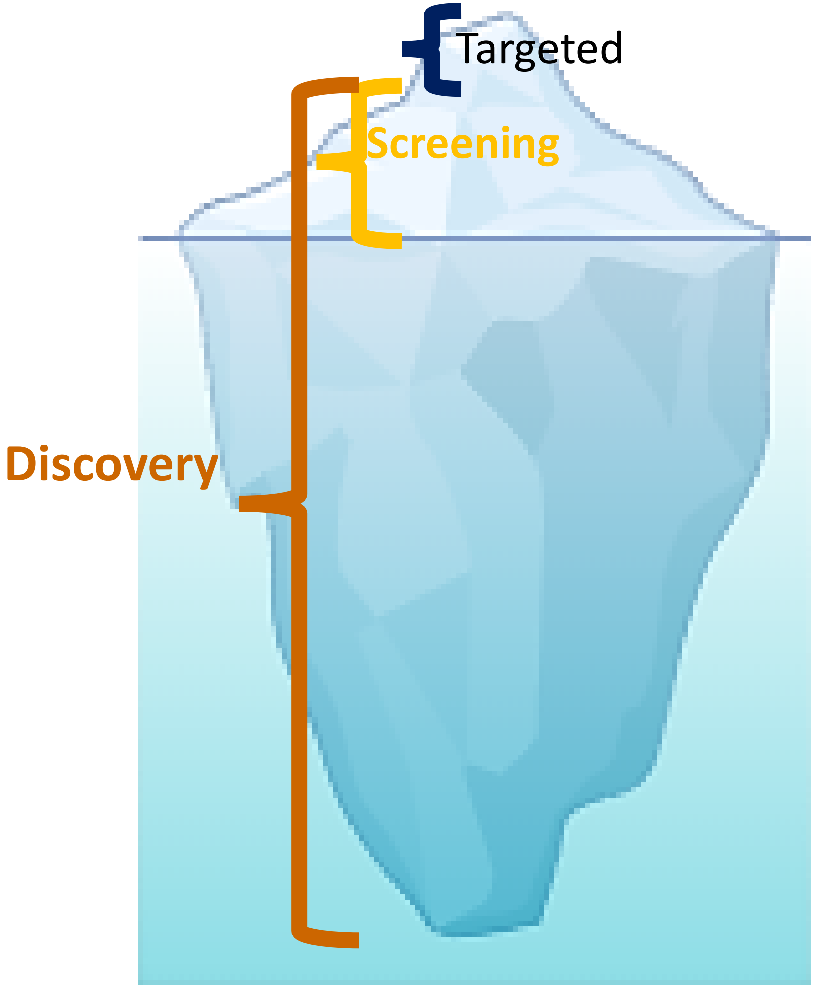
Measuring unknown or understudied PFAS is key to understand totality of exposure



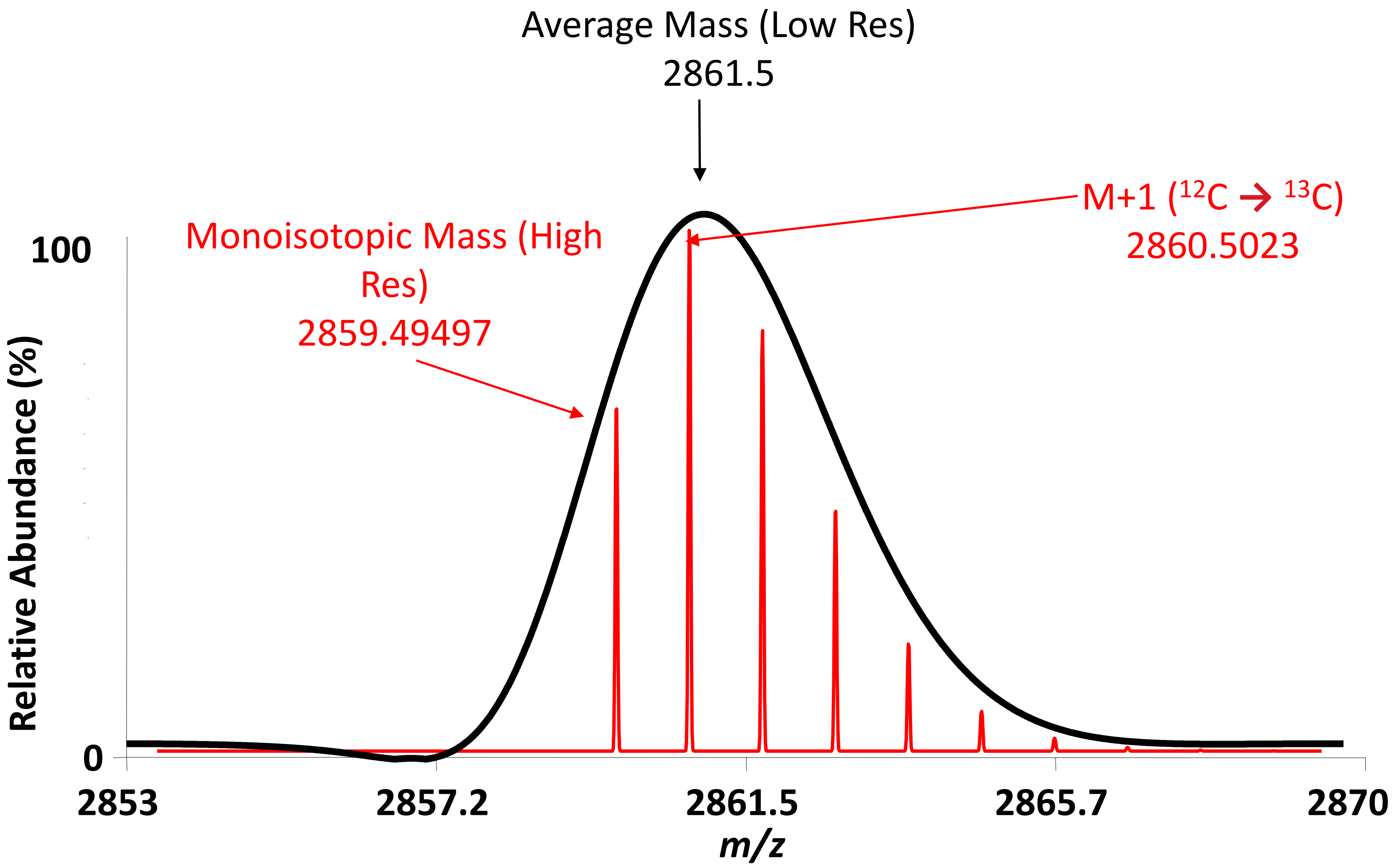
Aro et al. 2021, Chemosphere, https://doi.org/10.1016/j.chemosphere.2021.131200

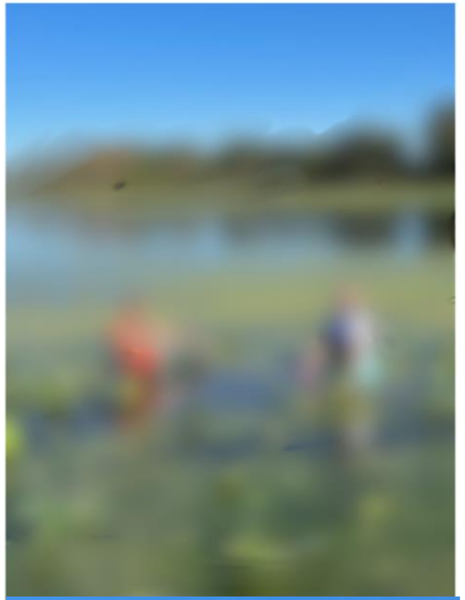
NTA facilitates discovery of novel chemicals

- **Targeted Analysis – "Known Knowns"**
  - Defined list of chemicals, requires standards
- **Suspect Screening – "Known Unknowns"**
  - Chemical identification compared to databases and libraries, limited to candidates in lists
- **Nontarget analysis – "Unknown Unknowns"**
  - Capable of discovering unknown chemicals in a given sample pending preparation and analysis conditions
  - Time- and effort-intensive

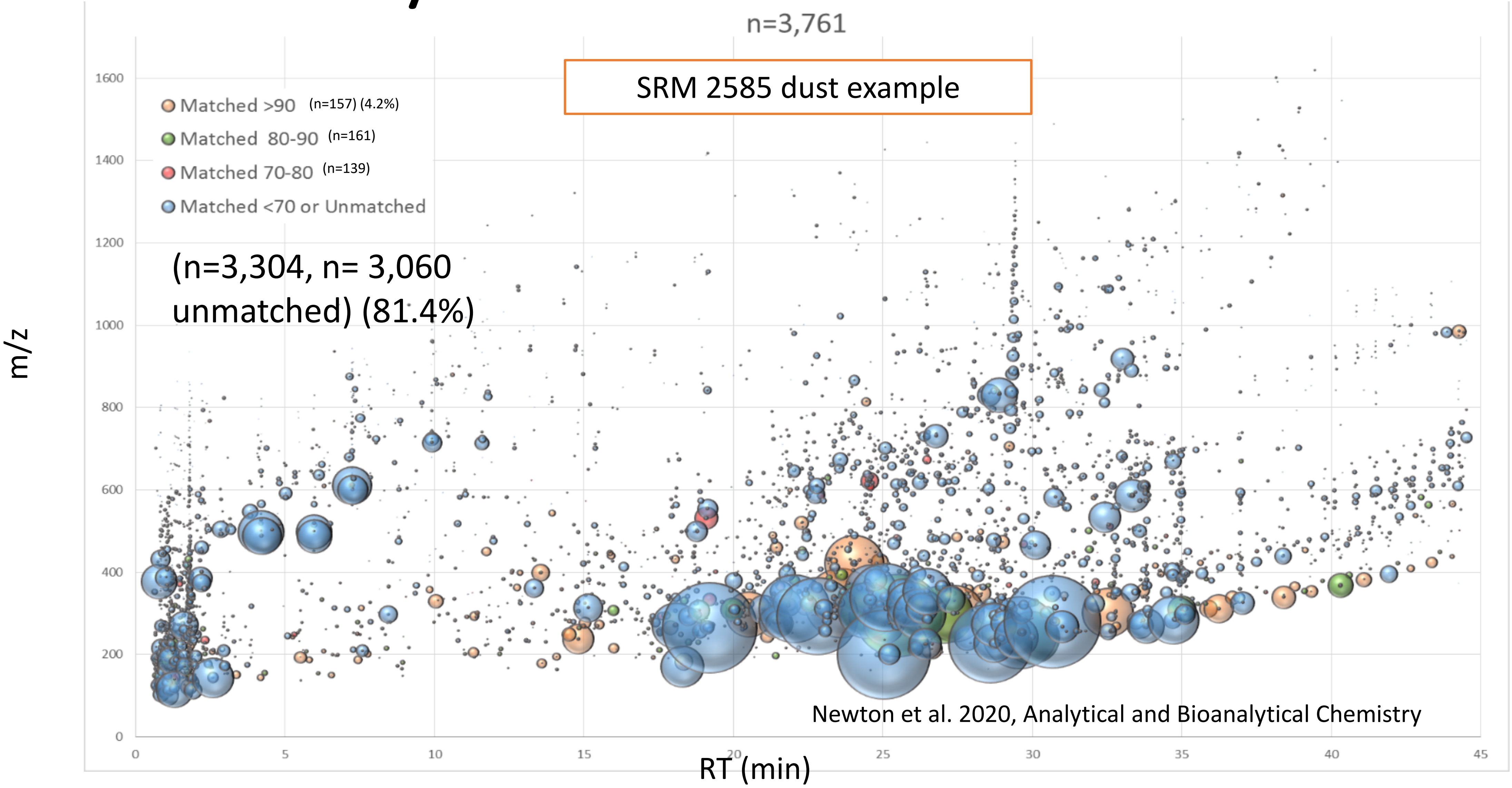


NTA is made possible by high resolution mass spectrometry (HRMS)





100s - 1000s of features may be detected via HRMS. Many of these are unknown unknowns.

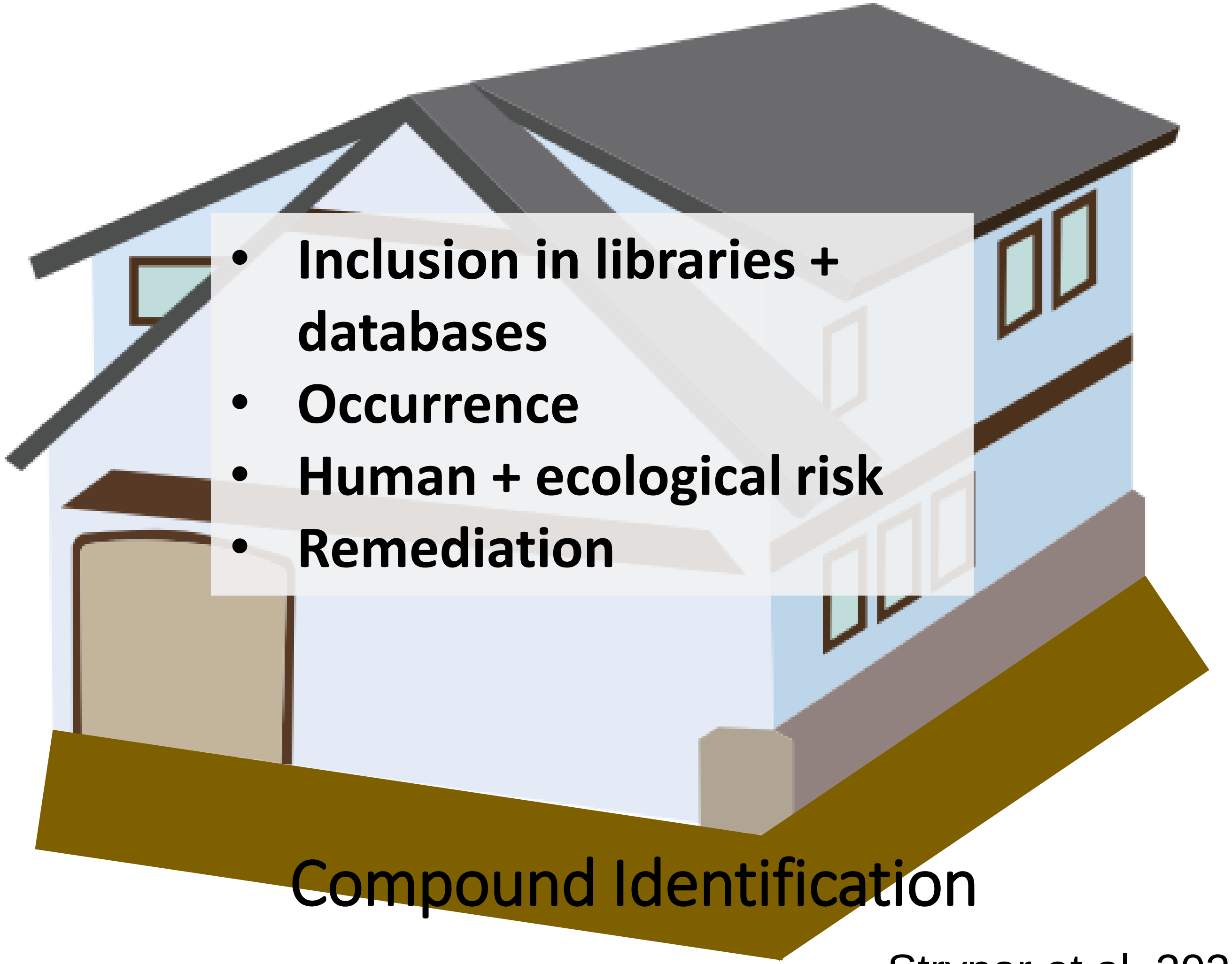


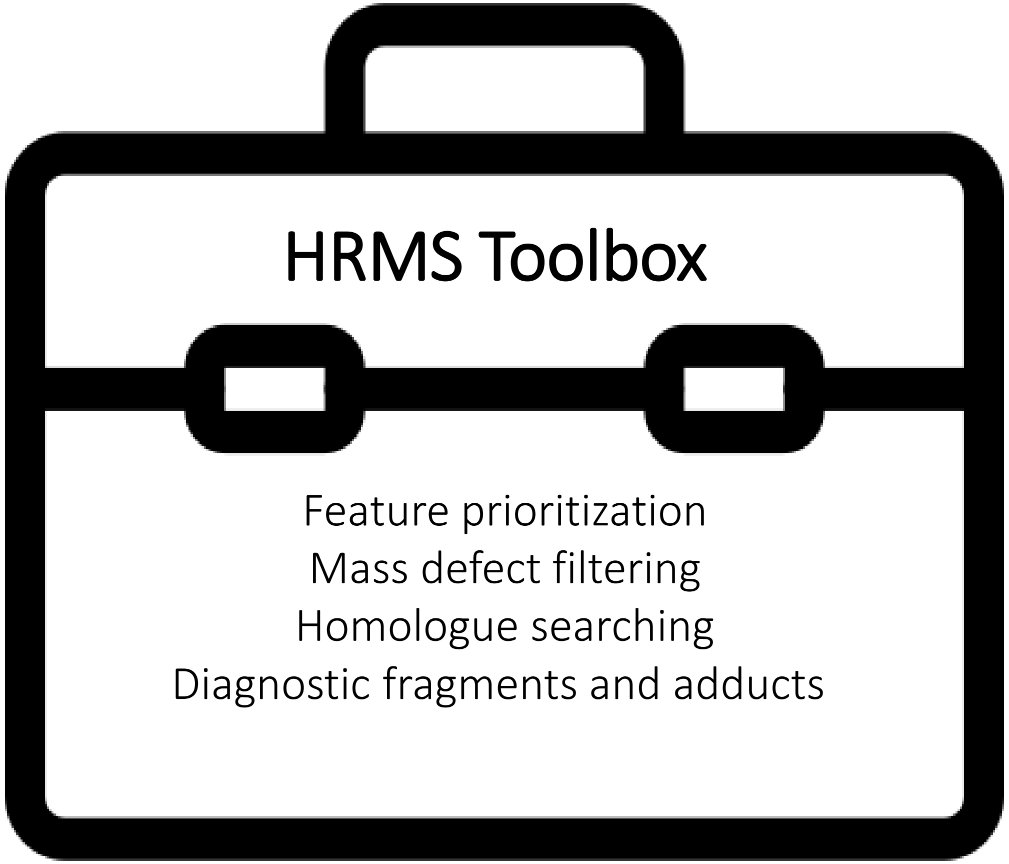
Prioritize:

- Large peaks
- Detection frequency
- Percent of feature space
- Contains halogens (F, Cl, Br)

Q: How do we identify and measure unknown features?

A: We use HRMS tools to prioritize and ID novel compounds to varying degrees of confidence

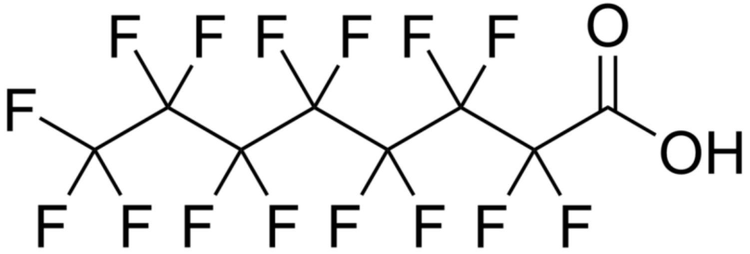


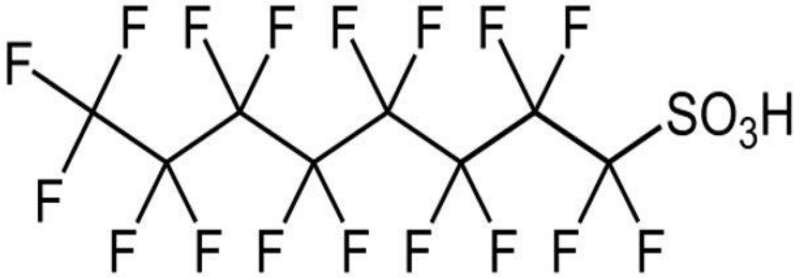


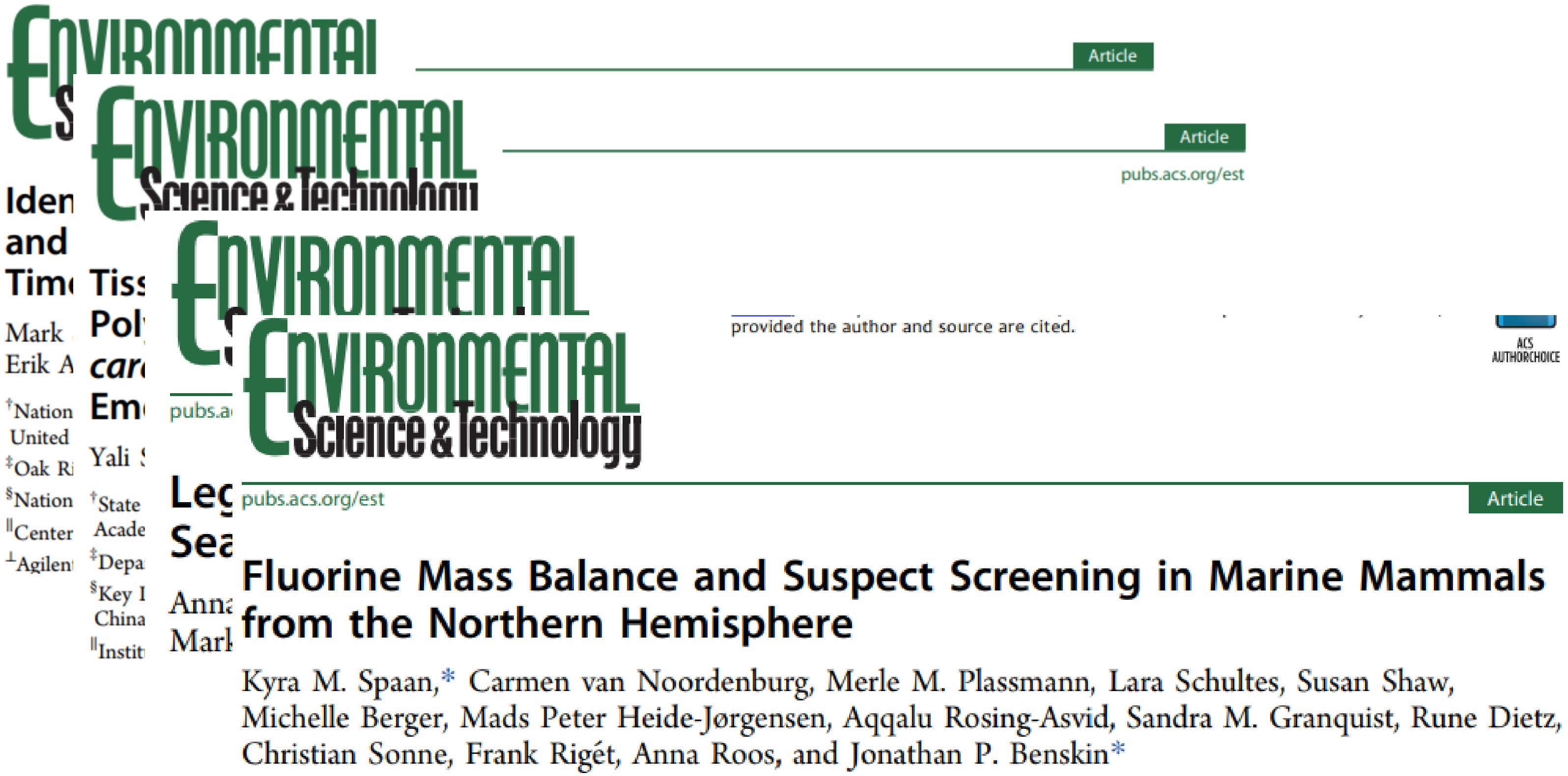
Strynar et al. 2023, JESEE, https://doi.org/10.1038/s41370-023-00578-2

Novel PFAS are increasingly found in environmental and biological matrices

Legacy PFAS → Novel PFAS






Environmental Science & Technology

Article

pubs.acs.org/est

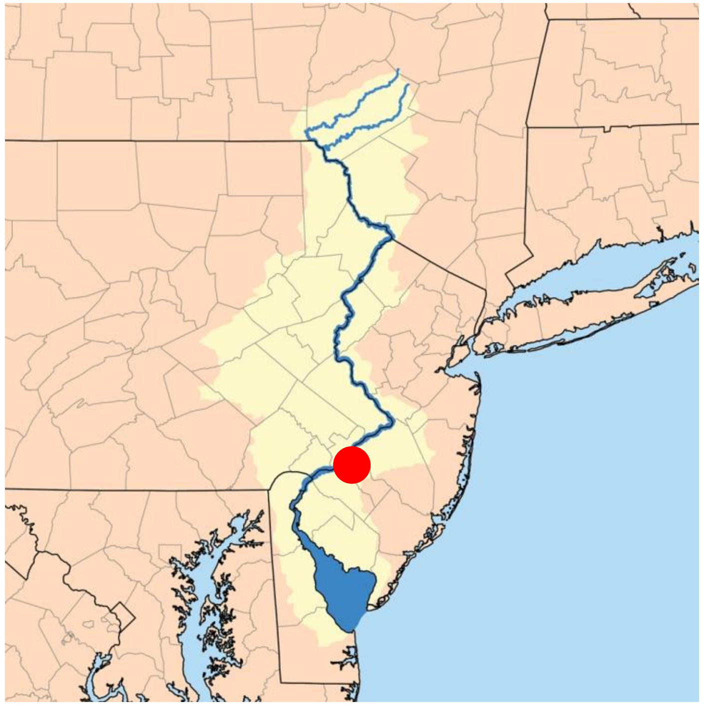
provided the author and source are cited.

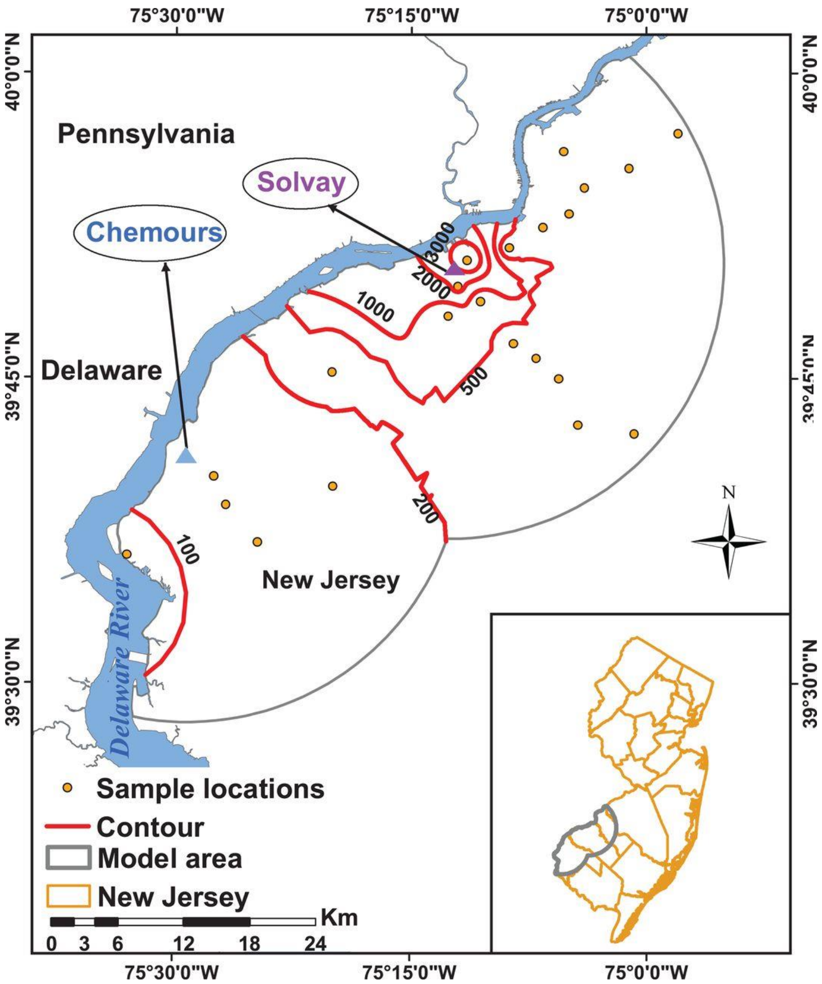
ACS AuthorChoice

Fluorine Mass Balance and Suspect Screening in Marine Mammals from the Northern Hemisphere

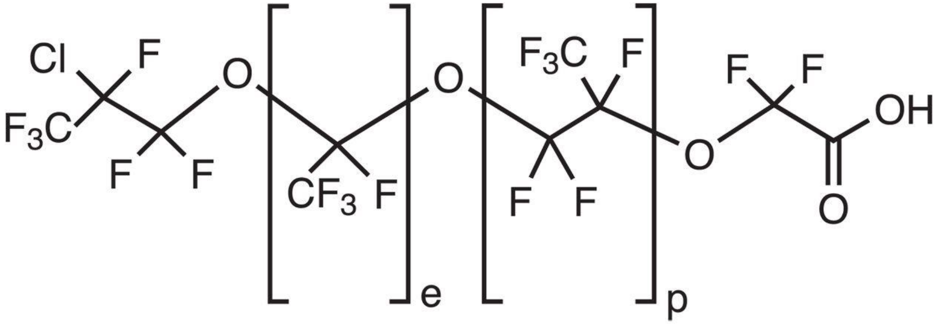
Kyra M. Spaan,* Carmen van Noordenburg, Merle M. Plassmann, Lara Schultes, Susan Shaw, Michelle Berger, Mads Peter Heide-Jørgensen, Aqqalu Rosing-Asvid, Sandra M. Granquist, Rune Dietz, Christian Sonne, Frank Rigét, Anna Roos, and Jonathan P. Benskin*

Novel, chlorine-containing PFAS were recently identified in the US and NW Italy





Cl-PFPECAs




Science

HOME > SCIENCE > VOL. 368, NO. 6495 > NONTARGETED MASS-SPECTRAL DETECTION OF CHLOROPERFLUOROPOLYETHER CARBOXYLATES IN NEW JERSEY…

REPORT

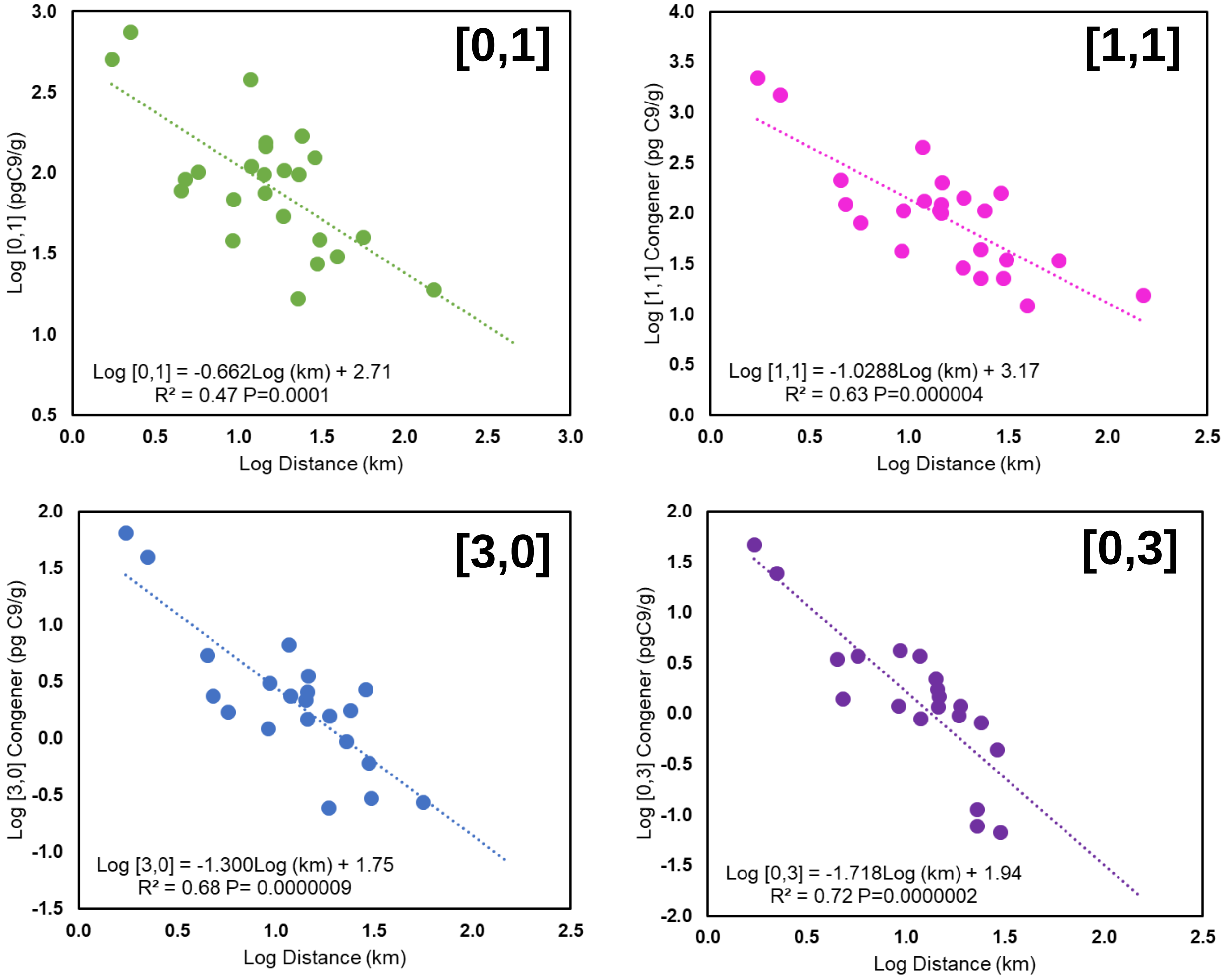
Nontargeted mass-spectral detection of chloroperfluoropolyether carboxylates in New Jersey soils

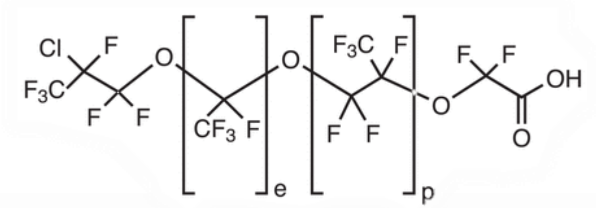
JOHN W. WASHINGTON, CHARLITA G. ROSAL, JAMES P. MCCORD, MARK J. STRYNAR, ANDREW B. LINDSTROM, ERICA L. BERGMAN, SANDRA M. GOODROW, HAILE K. TADESSE, ANDREW N. PILANT, [...], AND THOMAS M. JENKINS +3 authors Authors Info & Affiliations

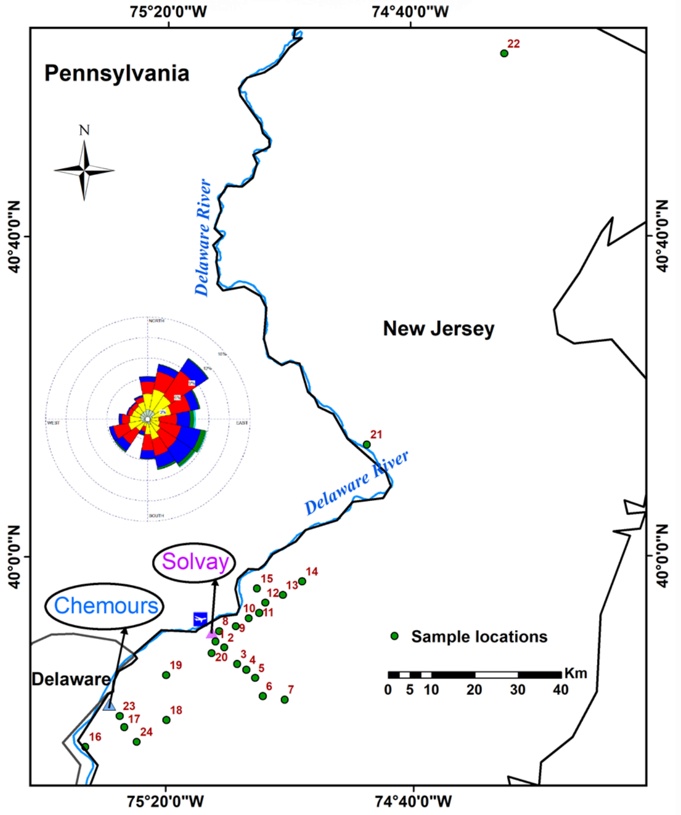
SCIENCE • 5 Jun 2020 • Vol 368, Issue 6495 • pp. 1103-1107 • DOI: 10.1126/science.aba7127

Washington et al., *Science* 368, 1103–1107 (2020)

Cl-PFPECAs in soils provide information on spatial distribution and transport based on molecular weight

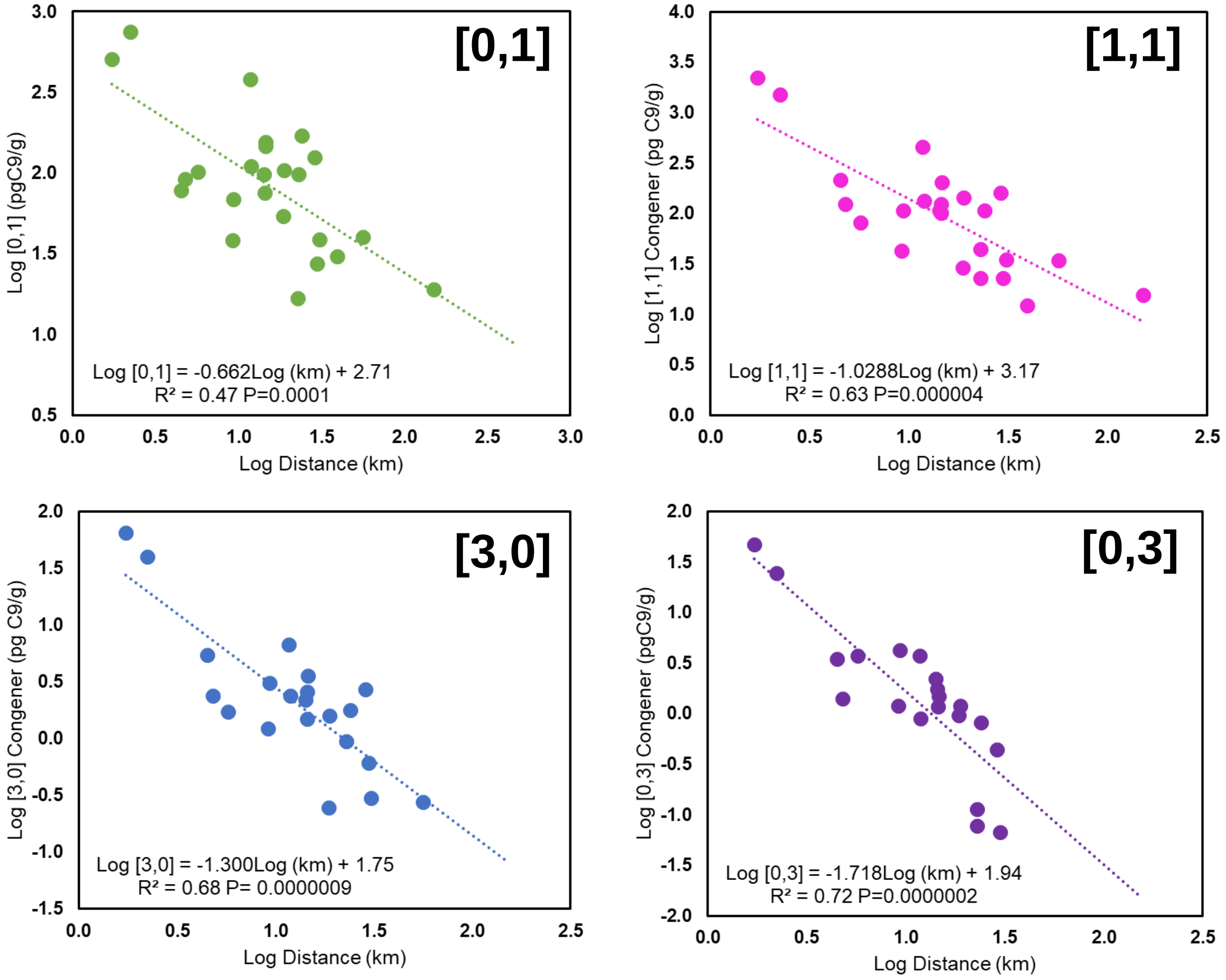


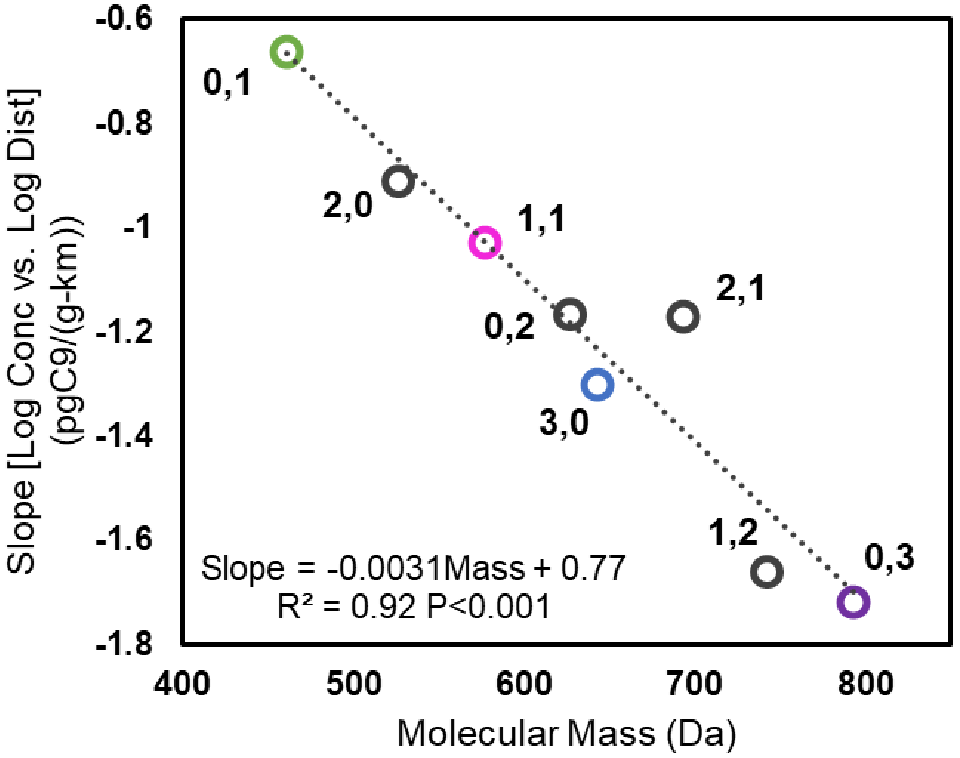




Washington et al., *Science* 368, 1103–1107 (2020)

Cl-PFPECAs in soils provide information on spatial distribution and transport based on molecular weight





- Lower slope indicates faster drop off in concentration
- Congeners with lower mass have slower drop off in concentration, indicating wider dispersion

Washington et al., *Science* 368, 1103–1107 (2020)

PFNA → Cl-PFPECAs → What Else? Where Else?
How are these novel PFAS behaving in the environment?

Vegetation
- Davis et al. 2023

Soil
- Washington et al. 2020
- Evich et al. 2022

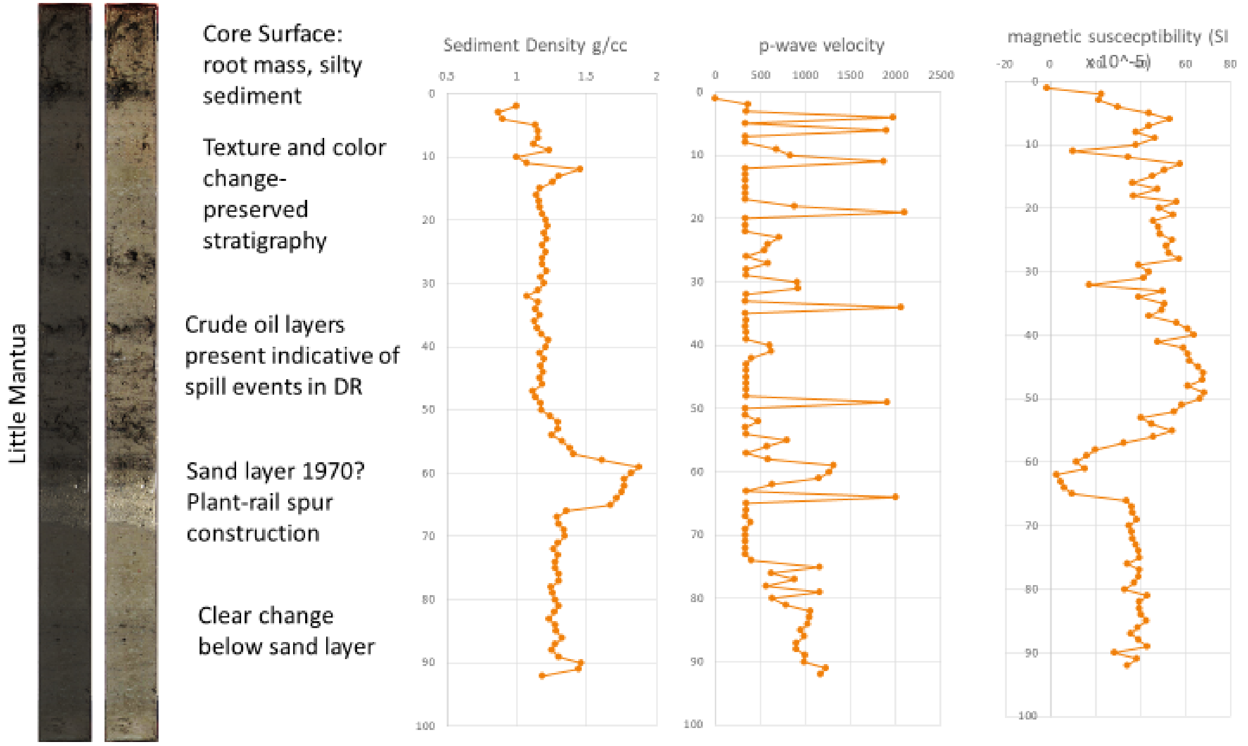
Sediment and sediment cores
- Ongoing work, Robuck and Cashman

Water
- Washington et al. 2020
- McCord et al. 2020
- Ongoing work, McCord
- Ongoing work, Robuck

Biota
- Ongoing work, Robuck and Cashman

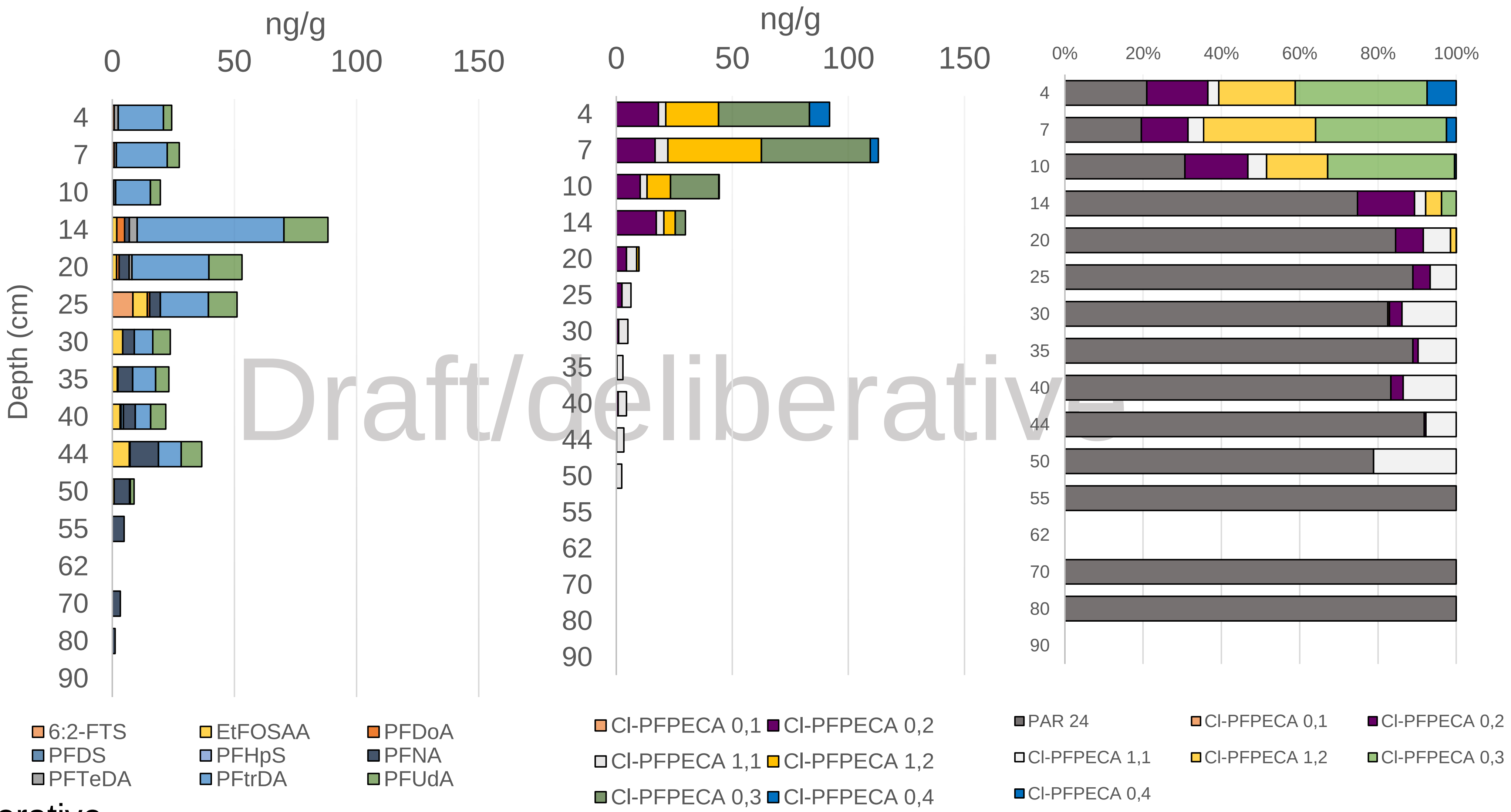
Sediment cores provide an opportunity to evaluate PFAS deposition over time

- Cores are characterized using physical and chemical measurements to understand geological context
- Each core subsampled at intervals based on logging data and visual information
- Site information used to estimate initial sedimentation rates
    - Radiometric dating of core underway
- Each horizon measured for PFAS via targeted and nontargeted analysis



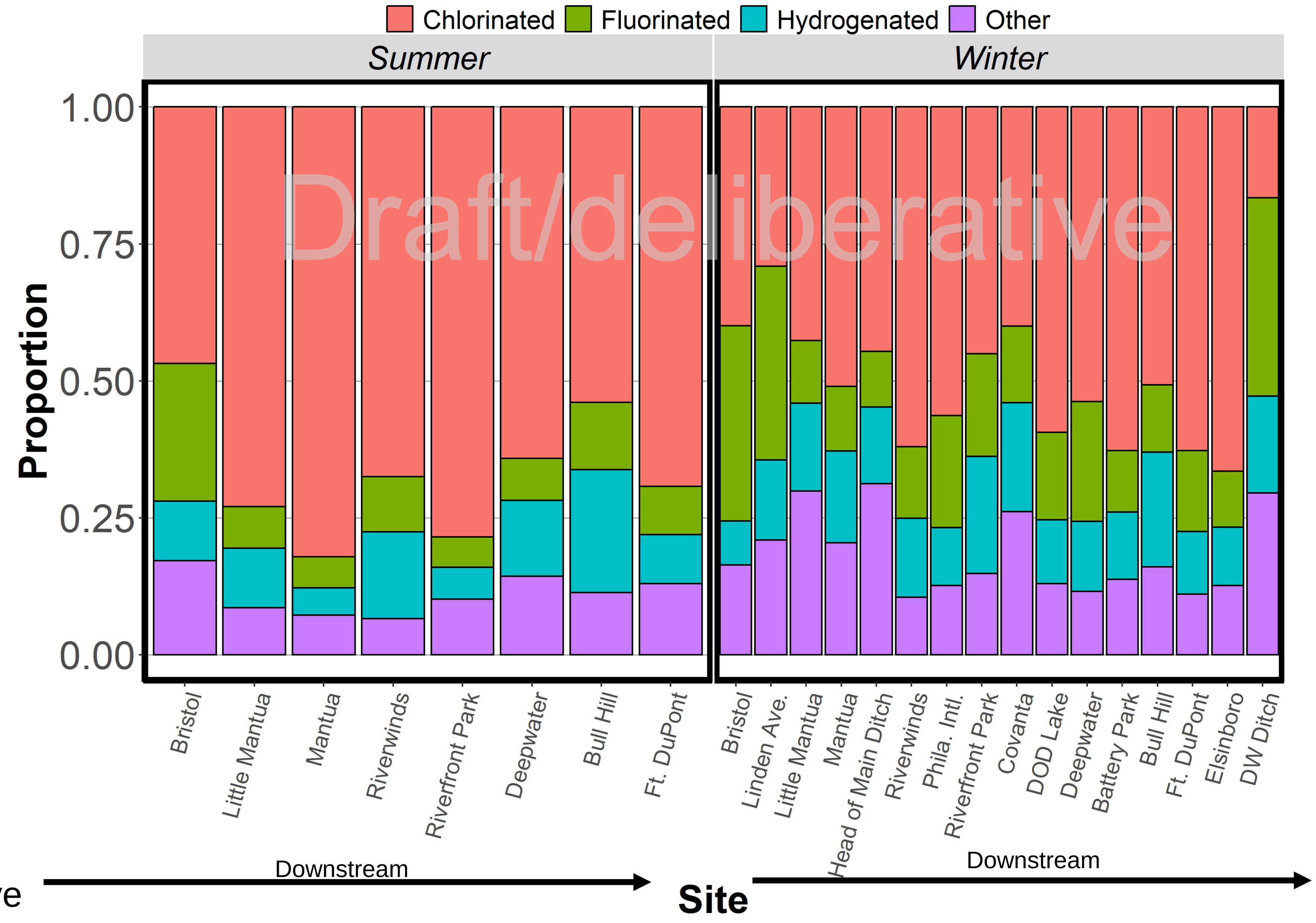

Pennsylvania
Delaware River
New Jersey
Suspected Source
Google
Imagery ©2020 Google, Landsat / Copernicus, NOAA, Map data ©2020 United States Terms Send feedback 100 ft

Cl-PFPECAs increase with decreasing sediment depth in core taken from Little Mantua Creek



Chlorinated PFPECAs dominate in surface water, with discovery of new H- and F-substituted analogs

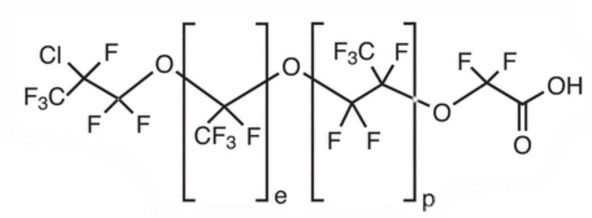
- Surface water data from mainstem DE sites
- Average abundance by season
- Normalized to summer flow levels



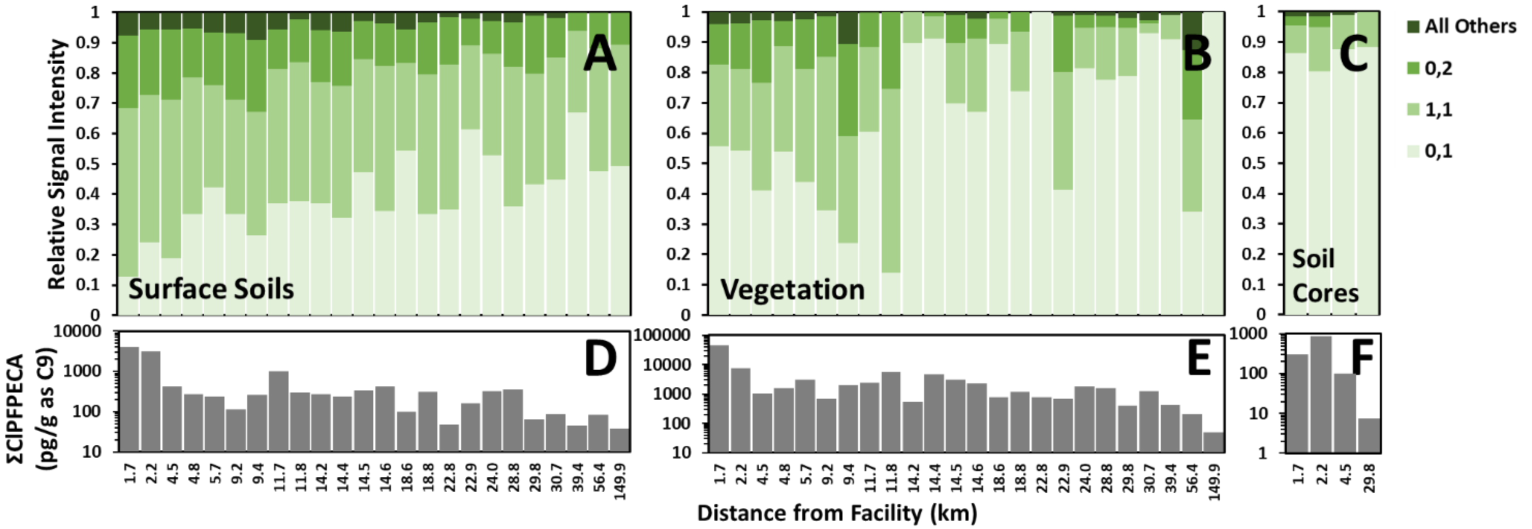
Changing use of Cl-PFPECAs?

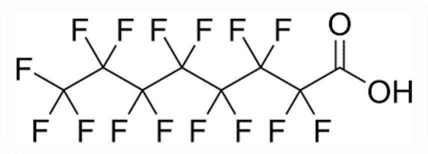
Seasonal environmental changes?

Paired vegetation is dominated by shorter chain Cl-PFPECAs and PFCAs

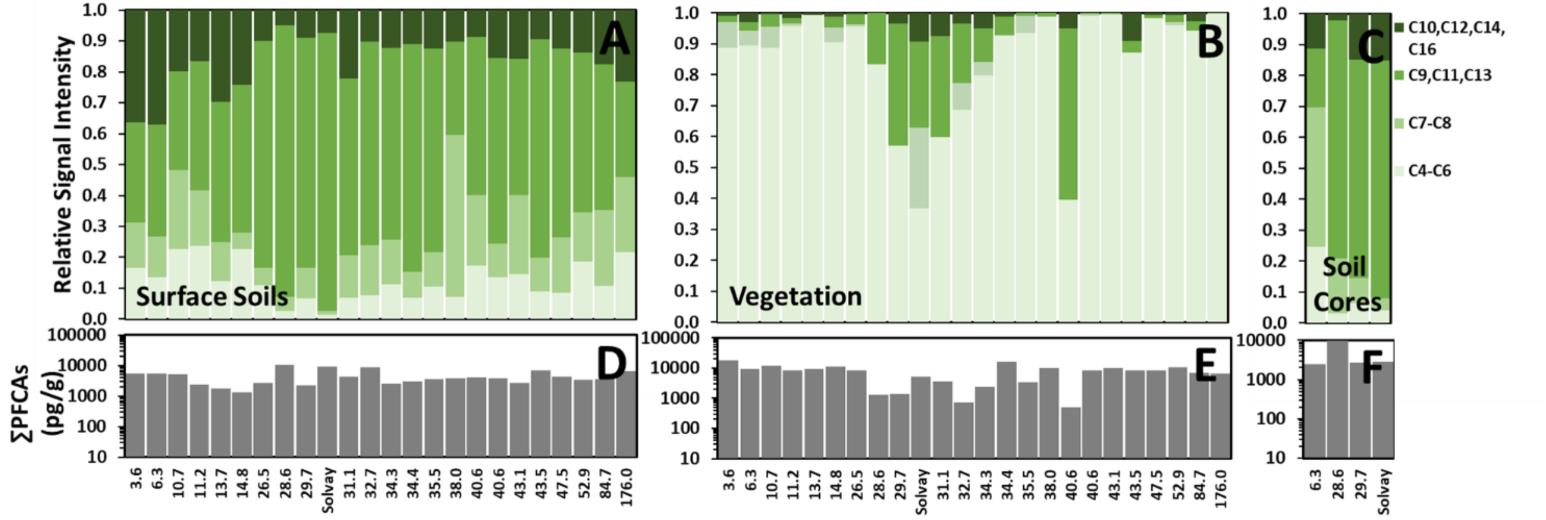


- Decrease in concentration with distance to facility ; ~ 6-fold higher in vegetation than surface soils
- Signal dominated by smallest congeners





- No obvious distance trend arranged in order of increasing distance from Solvay or Chemours (shown here) ; ~ 2-fold higher in vegetation than surface soils
- Vegetation also dominated by smaller PFAS
- Elevated C9, C11, C13 near Solvay ; Surflon was in use until 2003

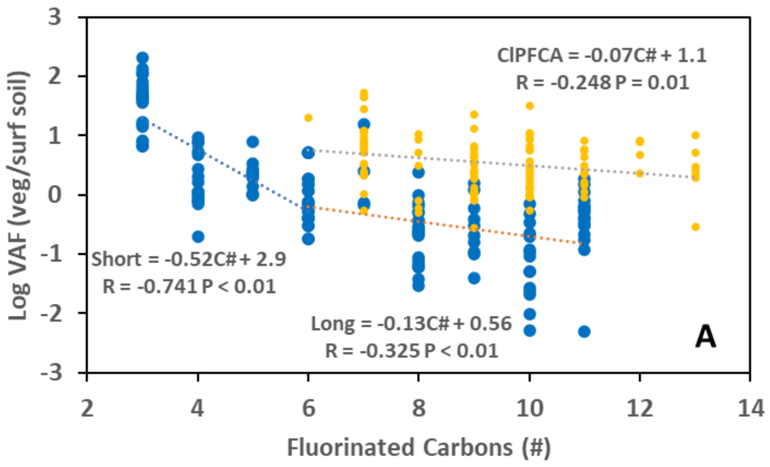


Davis et al., *Environ. Sci. Technol.* 57, 24, 8994-9004 (2023)

Paired vegetation is dominated by shorter chain Cl-PFPECAs and PFCAs

- Cl-PFPECA
- PFCA

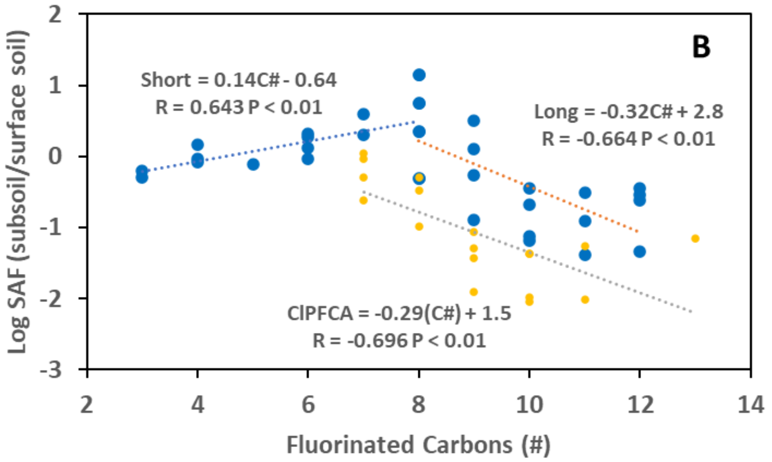
$$VAF\ (X) = \frac{[X]_{veg}}{[X]_{soil}}$$



Vegetation Accumulation Factor (VAF)

- Ratio enables comparison between different compounds
- Short-chain PFCAs exhibit stronger trend with chain length
- Long-chain PFCAs and Cl-PFPECAs follow similar trend with chain length

$$SAF\ (X) = \frac{[X]_{sub}}{[X]_{soil}}$$



Subsoil Accumulation Factor (SAF)

- Ratio enables comparison between different compounds
- For Cl-PFPECAs, significant reduction in subsoil accumulation factor with increased chain length
- Legacy PFCAs show similar trend with chain length, but overall higher accumulation in soil cores

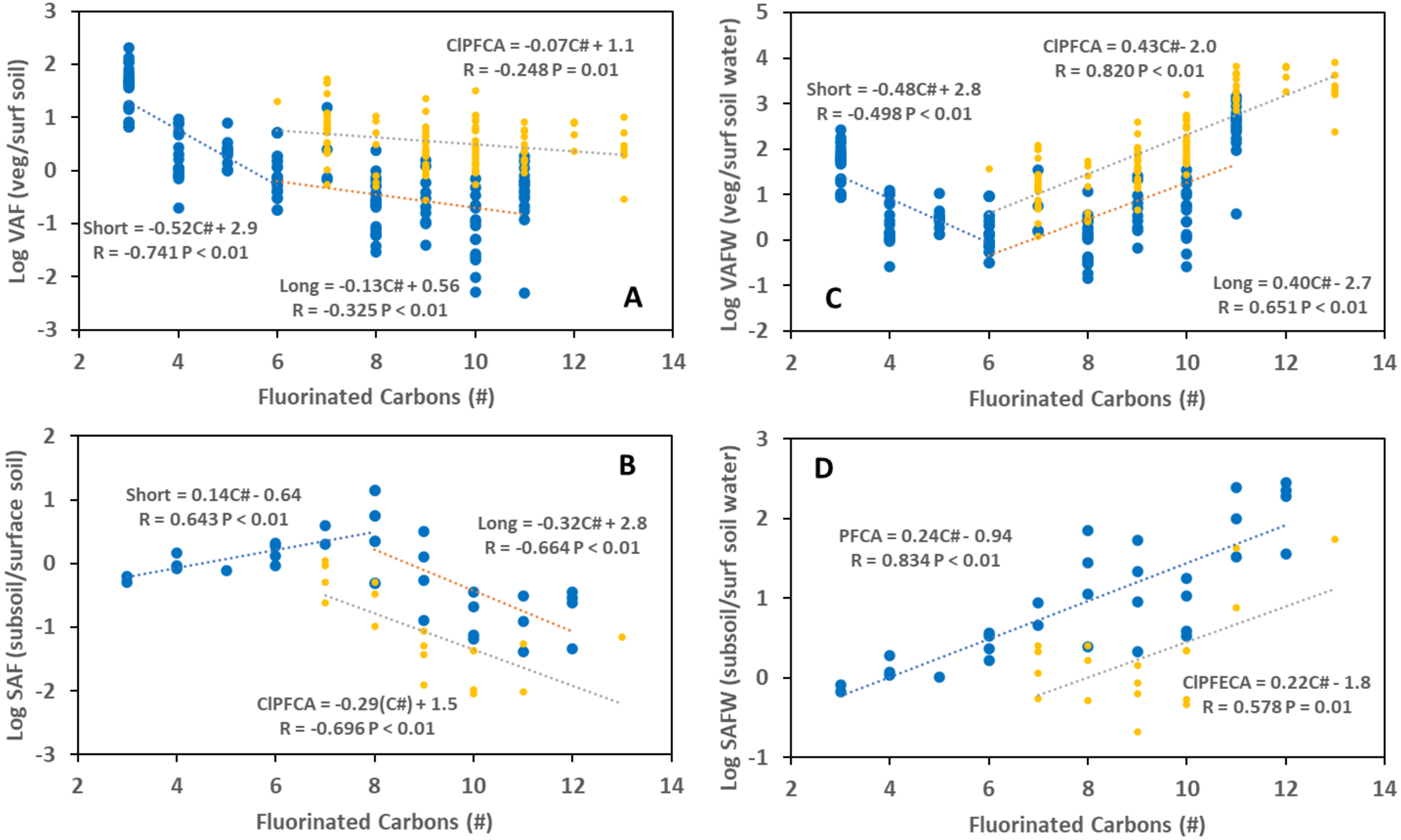
Davis et al., *Environ. Sci. Technol.* 57, 24, 8994-9004 (2023)

Paired vegetation is dominated by shorter chain Cl-PFPECAs and PFCAs

- Cl-PFPECA
- PFCA

$$VAF\ (X) = \frac{[X]_{veg}}{[X]_{soil}}$$

$$VAFW\ (X) = \frac{[X]_{veg}(K_d - 1)}{[X]_{soil}}$$



$$SAF\ (X) = \frac{[X]_{sub}}{[X]_{soil}}$$

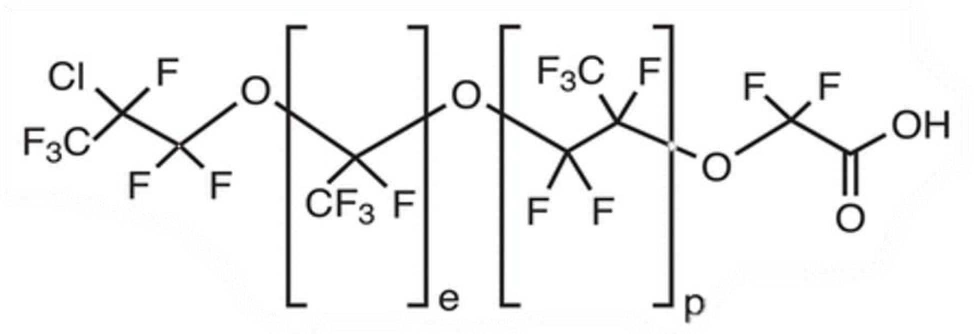
$$SAFW\ (X) = \frac{[X]_{sub}(K_d - 1)}{[X]_{soil}}$$

After normalizing PFAS in terrestrial vegetation to estimated soil water, the trends flip from negative to positive for the Cl-PFPECAs and long-chain PFCAs, becoming more consistent with reported aquatic accumulation patterns

Davis et al., *Environ. Sci. Technol.* 57, 24, 8994-9004 (2023)

Possibility of transformation?
CTS: PFAS Reaction Library

- Introduction of additional function groups
  - Potential for transformation in the environment – expanding list of possible PFAS exposure
- Chemical Transformation Simulator (CTS) web-based tool for predicting environmental and biological transformation pathways and physiochemical properties of organic chemicals
- Incorporates environmental and metabolic reaction schemes based on published literature
- 59 reaction schemes generated for PFAS transformation/metabolism
- 17 PFAS functional groups covered

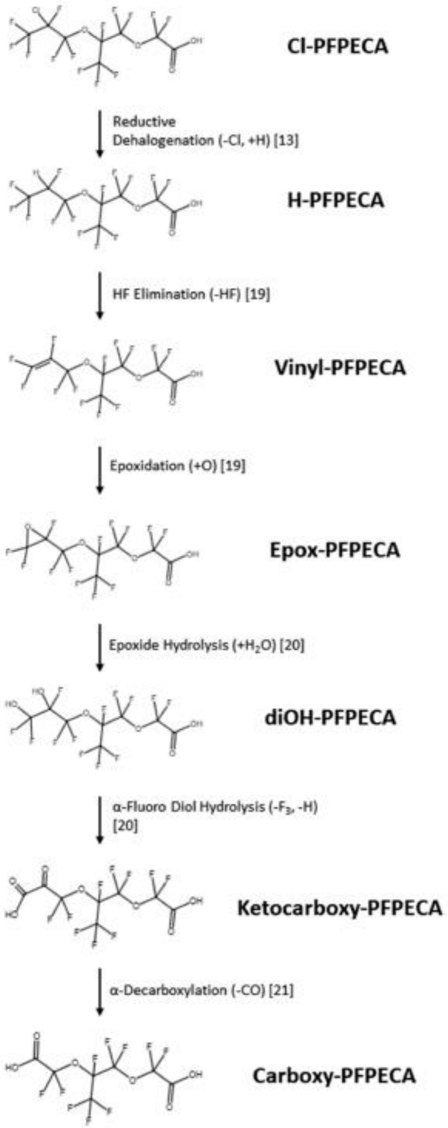


Reaction Process	Schemes
Decarboxylation	3
Desulfonation	1
Epoxidation	1
Hydrolysis	18
Hydroxylation	4
N-Deacetylation	2
N-Dealkylation	1
Oxidation	23
Reduction	6
Total	59

https://qed.epa.gov/cts/

Weber et al., *Environmental Science: Processes & Impacts,* 24(5), 689-753 (2022)

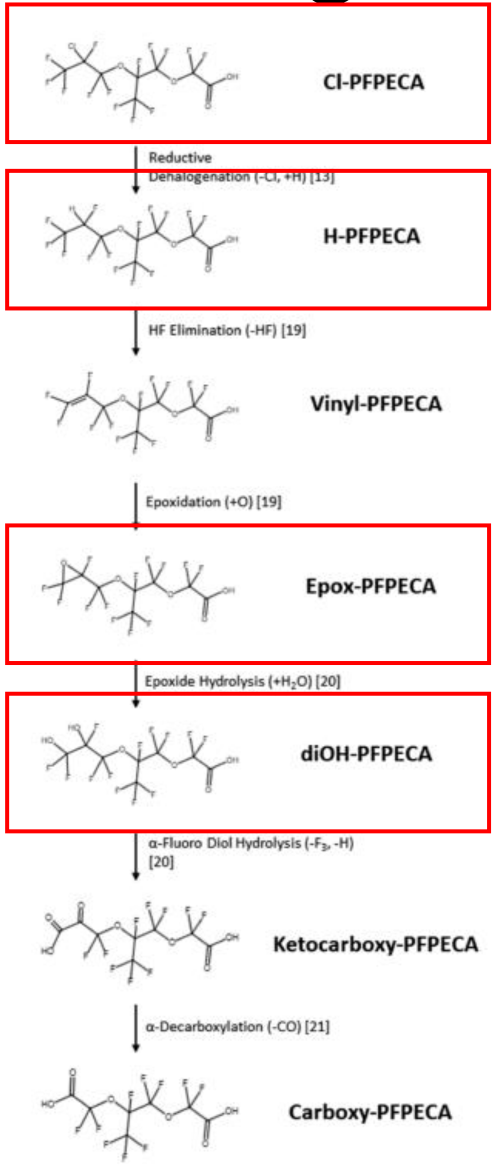
Predicting Cl-PFPECA transformation products



- Pathway predicted using PFAS module of CTS
- Example shown for (0,1) congener
  - These predicted degradation products are expected at low concentrations in nontargeted data – the CTS tool is vital in informing us on what to look for!

Evich et al., *Environ. Sci. Technol.* 56, 12, 7779-7788, (2022)

Predicting Cl-PFPECA transformation products



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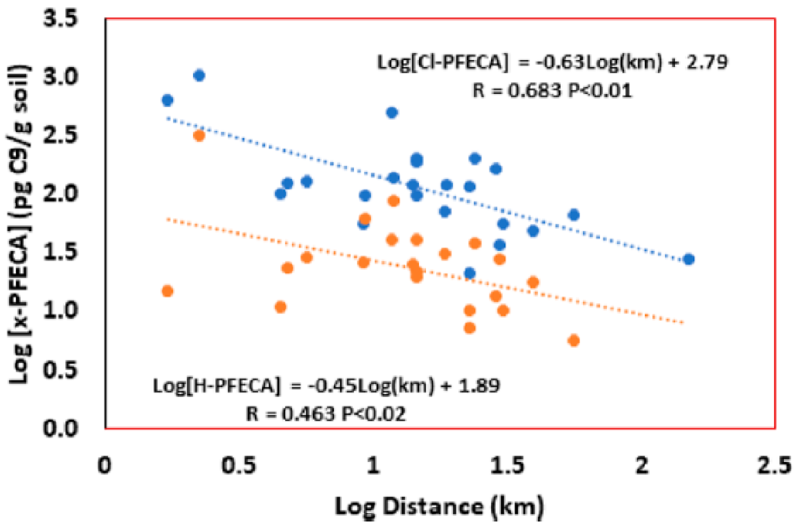
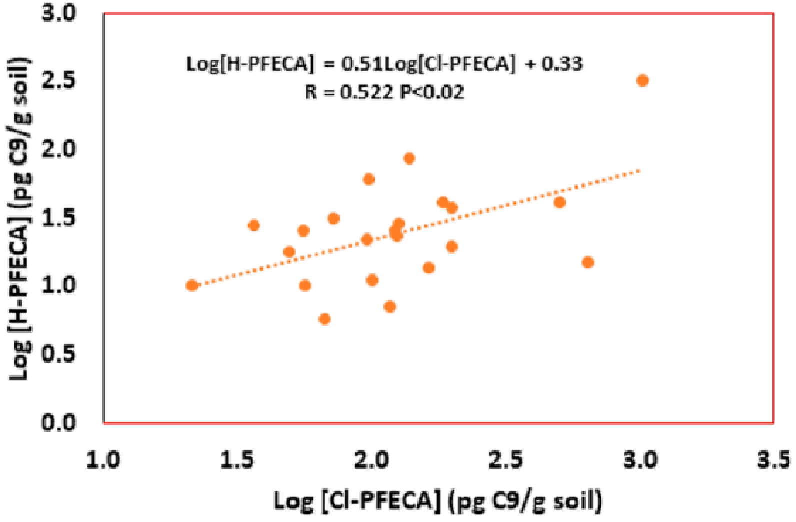




Evich et al., *Environ. Sci. Technol.* 56, 12, 7779-7788, (2022)

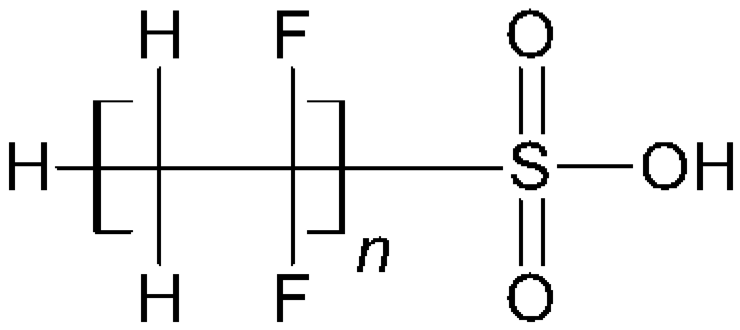
Iterative analysis of different environmental matrices provides insight about complexity of PFPECA exposure

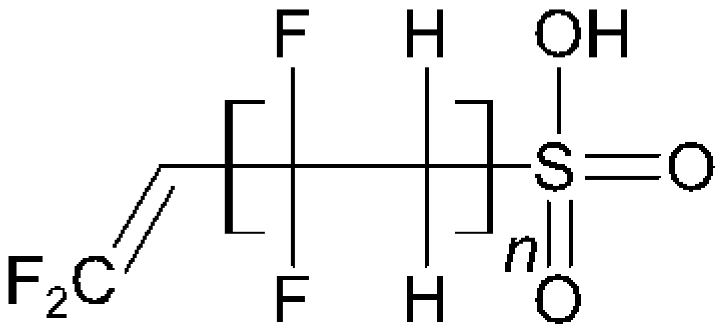
Compound Name	Cl 1,0	Cl 2,0	Cl 3,0	Cl 4,0	Cl 5,0	Cl 0,1 - (N2)	Cl 0,2 - (N3)	Cl 0,3 - (N4)	Cl 0,4 - (N5)	Cl 0,5
Environmental Occurrence	Washington 2020	Washington 2020	Washington 2020	Washington 2020	Likely Present	Washington 2020	Washington 2020	Washington 2020	Present	Present
Compound Name	H 1,0	H 2,0	H 3,0	H 4,0	H 5,0	H 0,1	H 0,2	H 0,3	H 0,4	H 0,5
Environmental Occurrence	McCord 2020	McCord 2020	Present		Present	McCord 2020	McCord 2020	Present		
Compound Name	F 1,0	F 2,0	F 3,0	F 4,0	F 5,0	F 0,1	F 0,2	F 0,3	F 0,4	F 0,5
Environmental Occurrence	Present	Present	Present	Likely Present		Present	Present	Likely Present		
Compound Name	diOH-1,0	diOH-2,0	diOH-3,0	diOH-4,0	diOH-5,0	diOH-0,1	diOH-0,2	diOH-0,3	diOH-0,4	diOH-0,5
Environmental Occurrence	Likely Present					Evich 2022				
Compound Name	epox-1,0	epox-2,0	epox-3,0	epox-4,0	epox-5,0	epox-0,1	epox-0,2	epox-0,3	epox-0,4	epox-0,5
Environmental Occurrence			Likely Present			Evich 2022	Likely Present			
Compound Name	Cl 1,1 - (M3)	Cl 1,2 - (M4)	Cl 1,3	Cl 2,1	Cl 2,2	Cl 2,3	Cl 3,1	Cl 3,2	Cl 4,1	Cl 5,1
Environmental Occurrence	Washington 2020	Washington 2020	Present	Washington 2020	McCord 2020		Present		Present	
Compound Name	H 1,1	H 1,2	H 1,3	H 2,1	H 2,2	H 2,3	H 3,1	H 3,2	H 4,1	H 5,1
Environmental Occurrence	McCord 2020	Present		Present	Present		Present			
Compound Name	F 1,1	F 1,2	F 1,3	F 2,1	F 2,2	F 2,3	F 3,1	F 3,2	F 4,1	F 5,1
Environmental Occurrence	Present	Likely Present	Likely Present	Present	Present		Present		Present	
Compound Name	diOH-1,1	diOH-1,2	diOH-1,3	diOH-2,1	diOH-2,2	diOH-2,3	diOH-3,1	diOH-3,2	diOH-4,1	diOH-5,1
Environmental Occurrence	Evich 2022									
Compound Name	epox-1,1	epox-1,2	epox-1,3	epox-2,1	epox-2,2	epox-2,3	epox-3,1	epox-3,2	epox-4,1	epox-5,1
Environmental Occurrence	Evich 2022			Likely Present						

Robuck, draft/deliberative

A Third Generation: Identification of Polymeric PVDF Byproducts in Surface Water

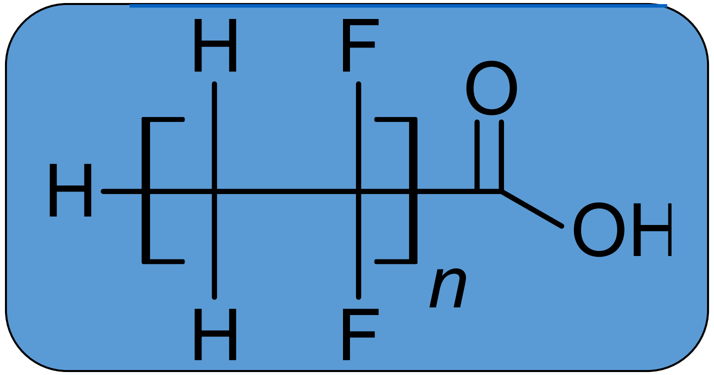
PVDF Sulfonate

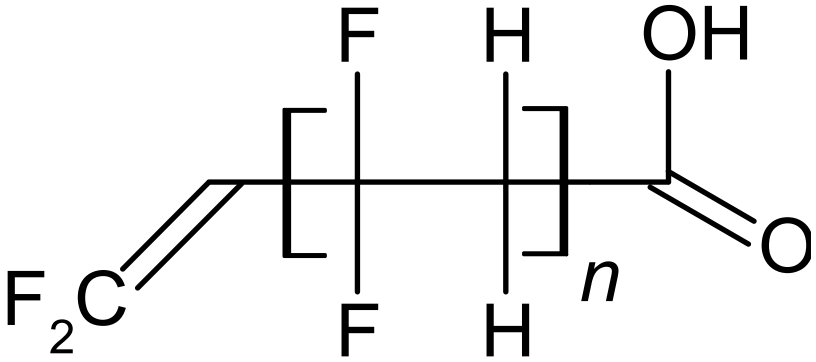




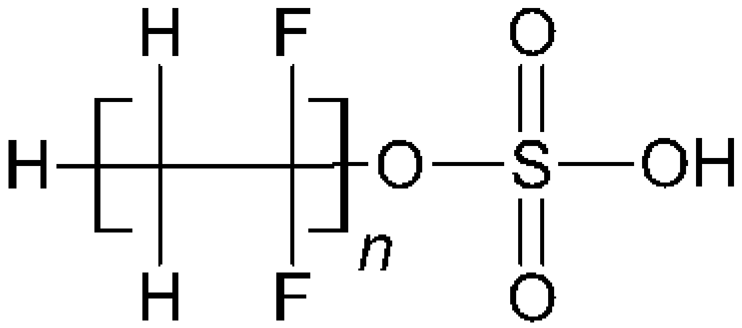
PVDF Carboxylate

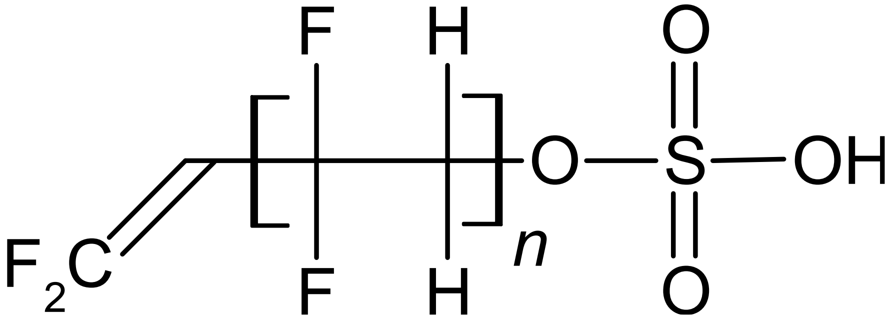
doi: 10.1021/acs.est.6b05330



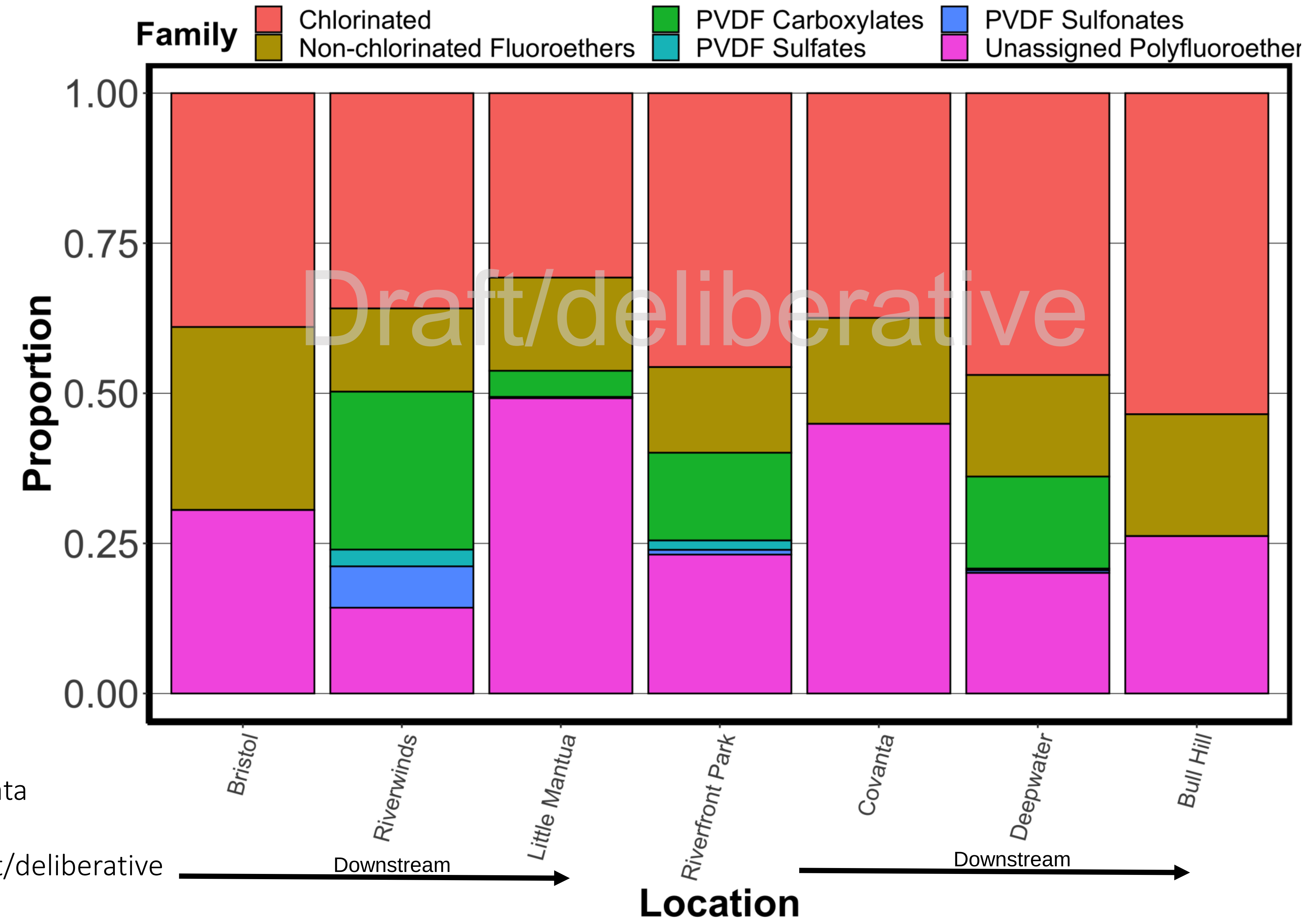


PVDF Sulfate





Slide courtesy Dr. James McCord



April 2021 data

Robuck, draft/deliberative

In summary…

- HRMS facilitates NTA of PFAS, allowing us to discover unknown or understudied PFAS beyond those typically monitored via targeted analysis
- A series of studies focused on samples from SW New Jersey demonstrate the utility of this approach
  - Multiple novel or understudied PFAS discovered across different environmental matrices over time
  - Discovery facilitates further evaluation of physicochemical properties, environmental behavior, etc.

Questions, comments, concerns?

Thank you to our colleagues and collaborators

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