The STEEP Challenge of Dealing with PFAS

Rainer Lohmann
(rlohmann@uri.edu)
University of Rhode Island

THE UNIVERSITY OF RHODE ISLAND

HARVARD T.H. CHAN SCHOOL OF PUBLIC HEALTH

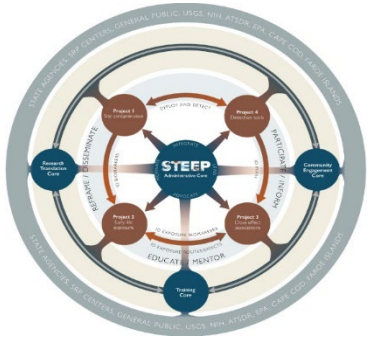
SILENT SPRING INSTITUTE
Researching the Environment and Women's Health

NIH NIEHS

STEEP is funded by the Superfund Research Program, National Institute of Environmental Health Sciences under award number P42ES027726.
More information about STEEP is available at: https://web.uri.edu/steep/ and https://tools.niehs.nih.gov/srp/programs/Program_detail.cfm?Project_ID=P42ES027706

STEEP
Sources, Transport, Exposure & Effects of PFASs
UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM

PFASs: Challenging compounds

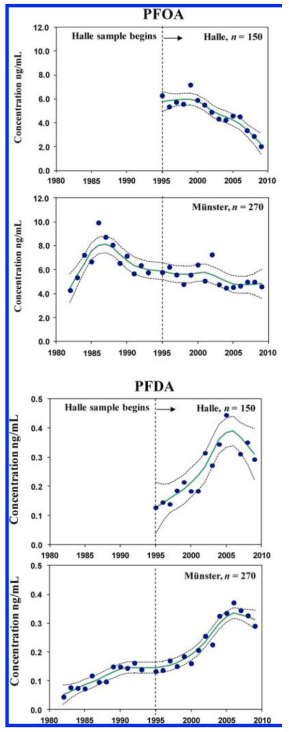


- Widespread human and environmental exposure
  - 100s of contaminated sites in U.S.
    - PFAS production sites, industrial users
    - Fire training sites, airports

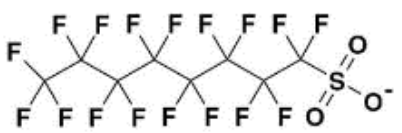
SCOTCHGARD PROTECTOR 3M

- Everyday exposure for all
  - Contaminated drinking water; Consumer products/dust, diet

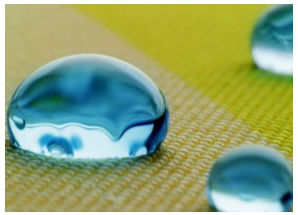
- Wide range of adverse effects (humans/animals)
  - Immunosuppression (Grandjean et al., 2013)
  - More PFOA, higher risk of being overweight (Haldersson et al., 2012)



- Unique physical-chemistry, unlike traditional hydrophobic POP
  - Amphiphilic compounds, ionized in solution; bind to proteins



- Regulatory action
  - PFOS withdrawal and PFOA action plan; novel chemistries (e.g., Gen X)



STEEP
Sources, Transport, Exposure & Effects of PFASs
UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM

The known unknowns are getting us

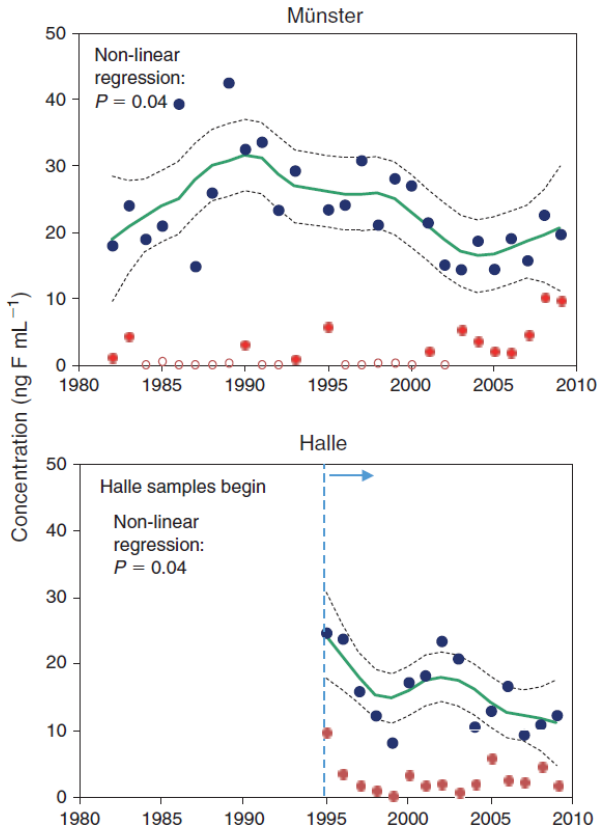


Fig. 3. Temporal trends of extractable organofluorine (EOF) and unidentified organofluorine concentrations (ng F mL^{-1}) in German plasma. (Blue dot indicates the mean value of EOF, dotted line indicates the 95 % confidence interval of the trend and green line indicates the trend generated using locally weighted regression smoother (LOESS); red dot indicates the mean value of unidentified organofluorine; open red dots indicates no unidentified organofluorine.)

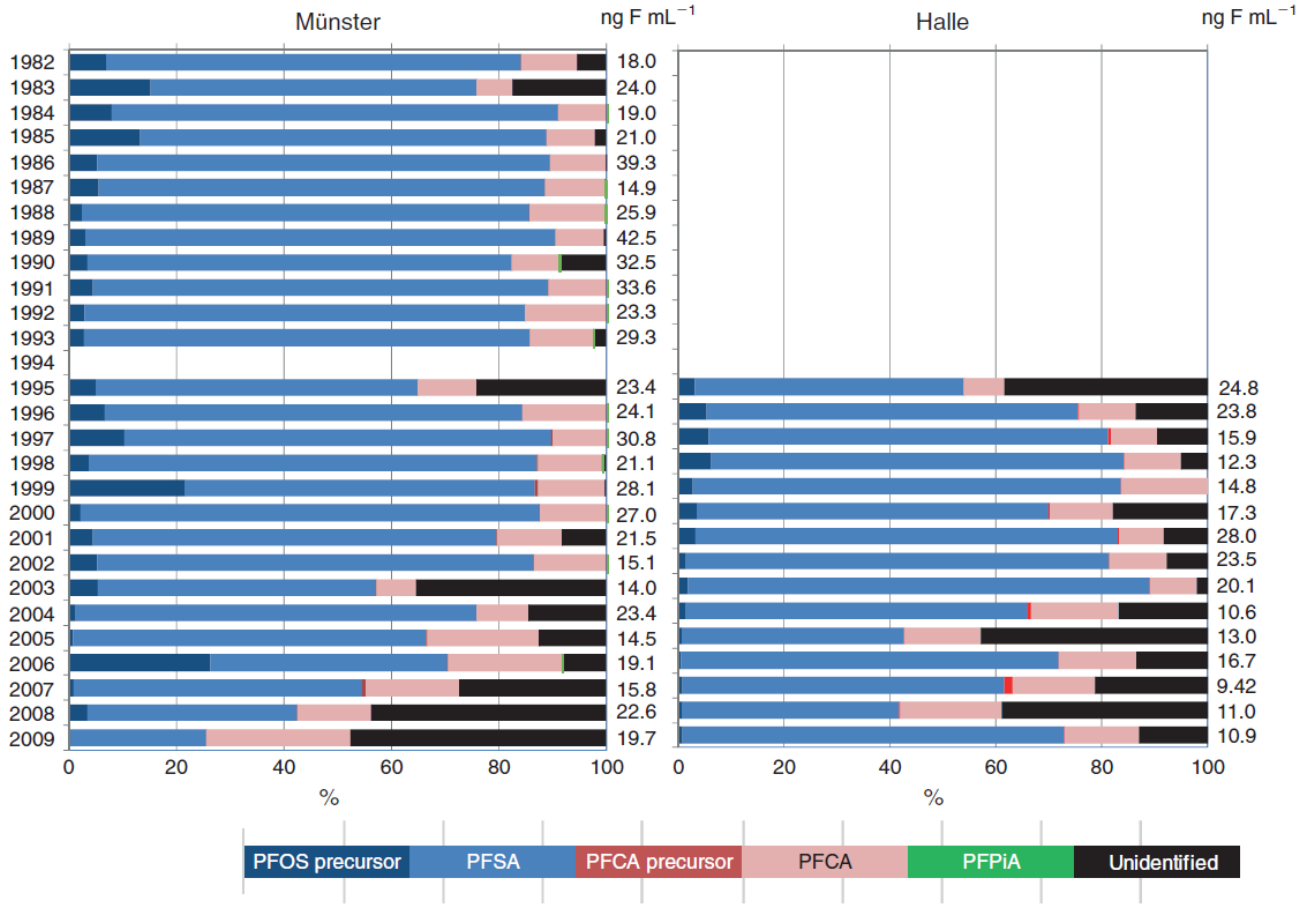
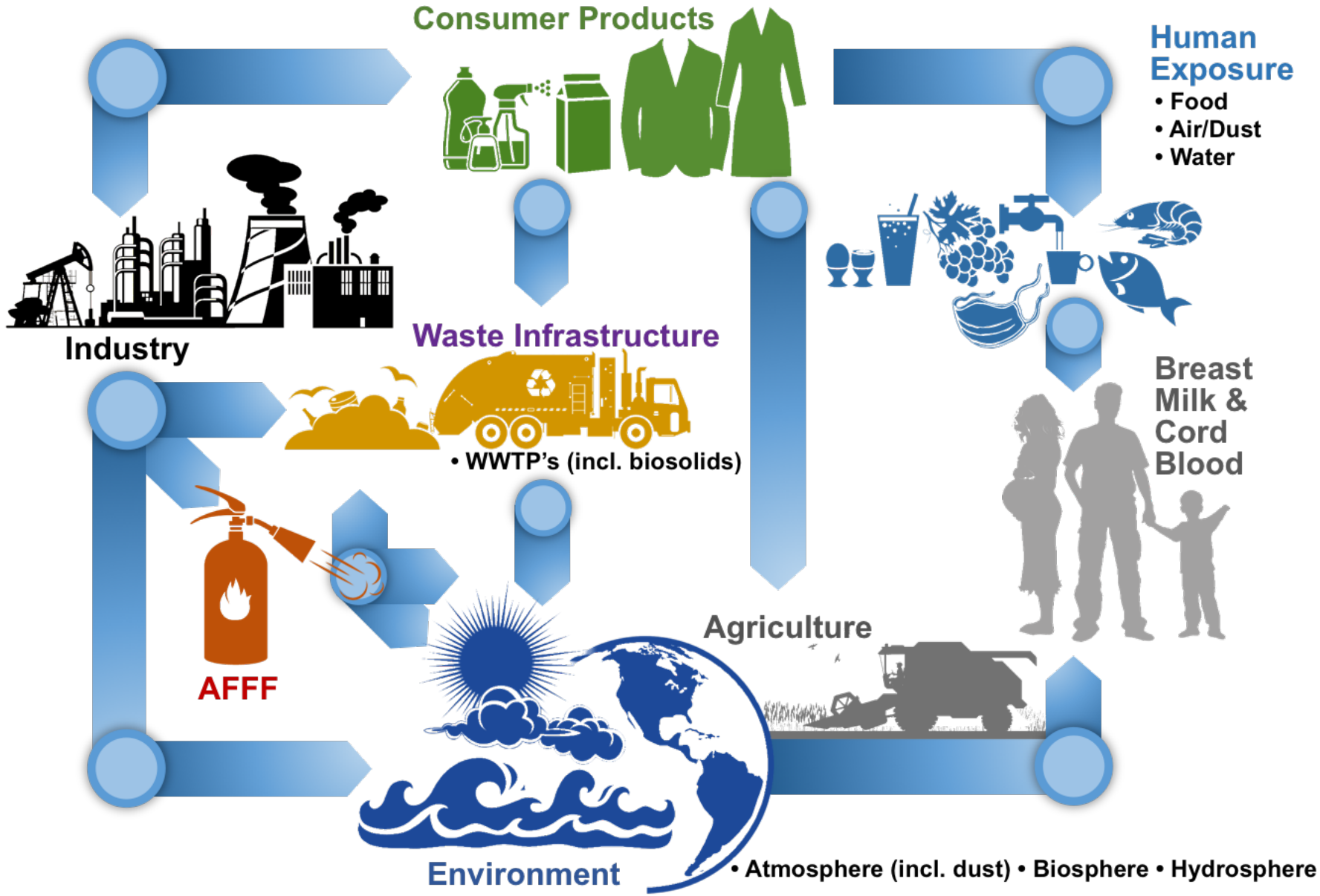


Fig. 4. Composition and concentrations (ng F mL^{-1}) of extractable organofluorine (EOF) in German blood plasma samples (perfluorooctane sulfonate, PFOS; perfluoroalkyl sulfonate, PFSA; perfluorinated carboxylates, PFCAs; perfluorinated phosphinates, PFPiAs).

(Yeung and Mabury, 2016)

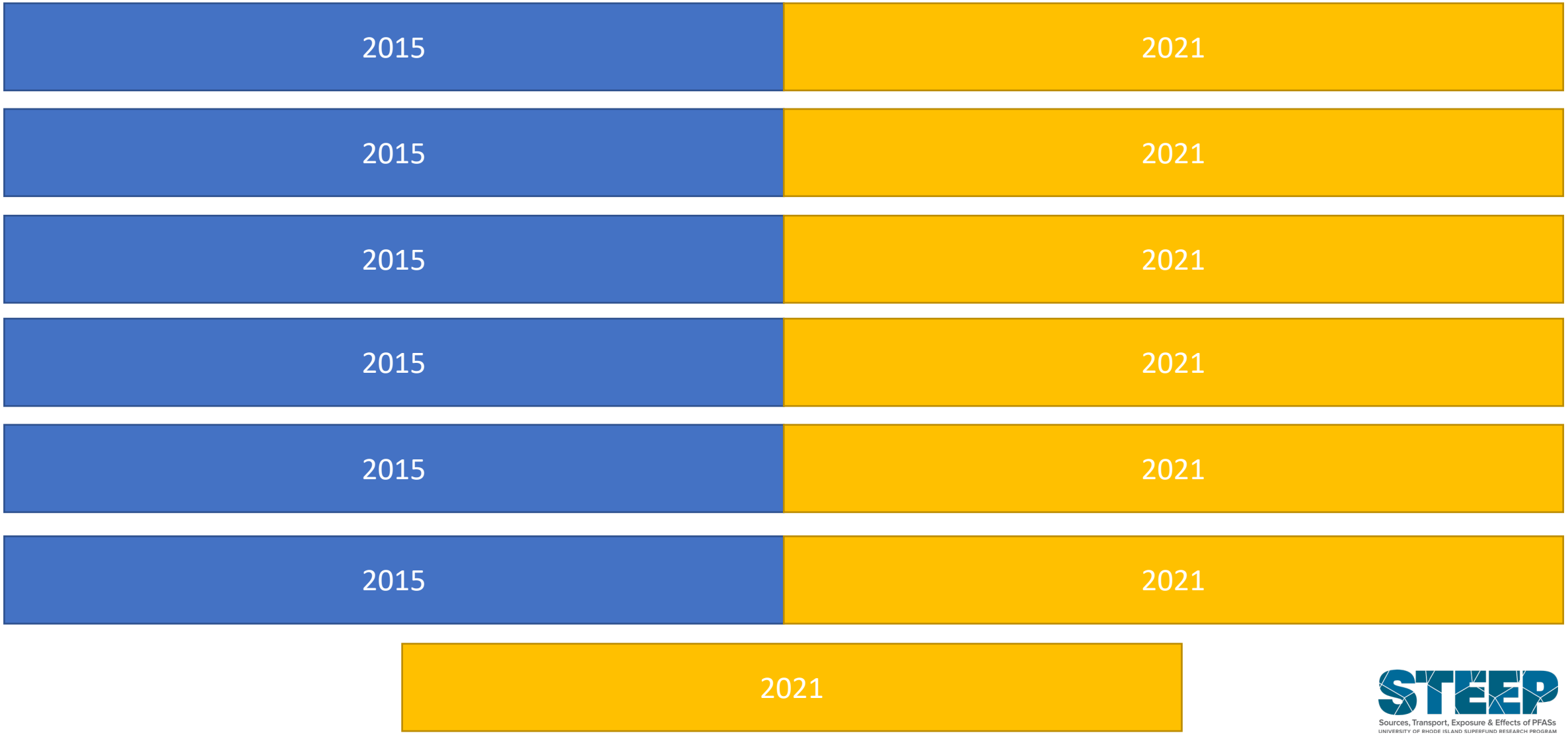
STEEP
Sources, Transport, Exposure & Effects of PFASs
UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM

Human Exposure Pathways

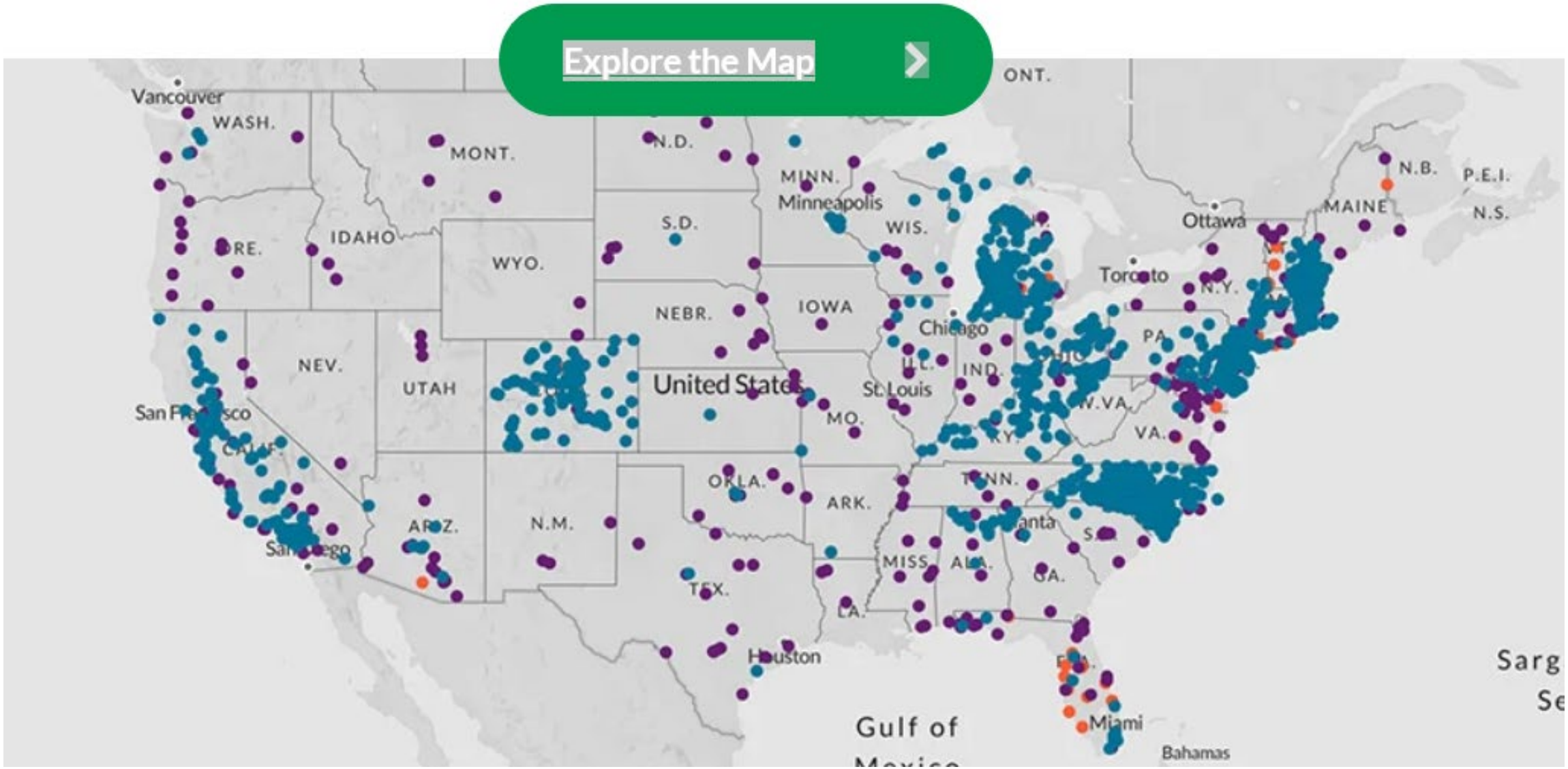


STEEP
Sources, Transport, Exposure & Effects of PFASs
UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM

What has changed since 2015 in the US?



STEEP
Sources, Transport, Exposure & Effects of PFASs
UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM



https://www.ewg.org/interactive-maps/pfas_contamination/

STEEP
Sources, Transport, Exposure & Effects of PFASs
UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM

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

- Categories:

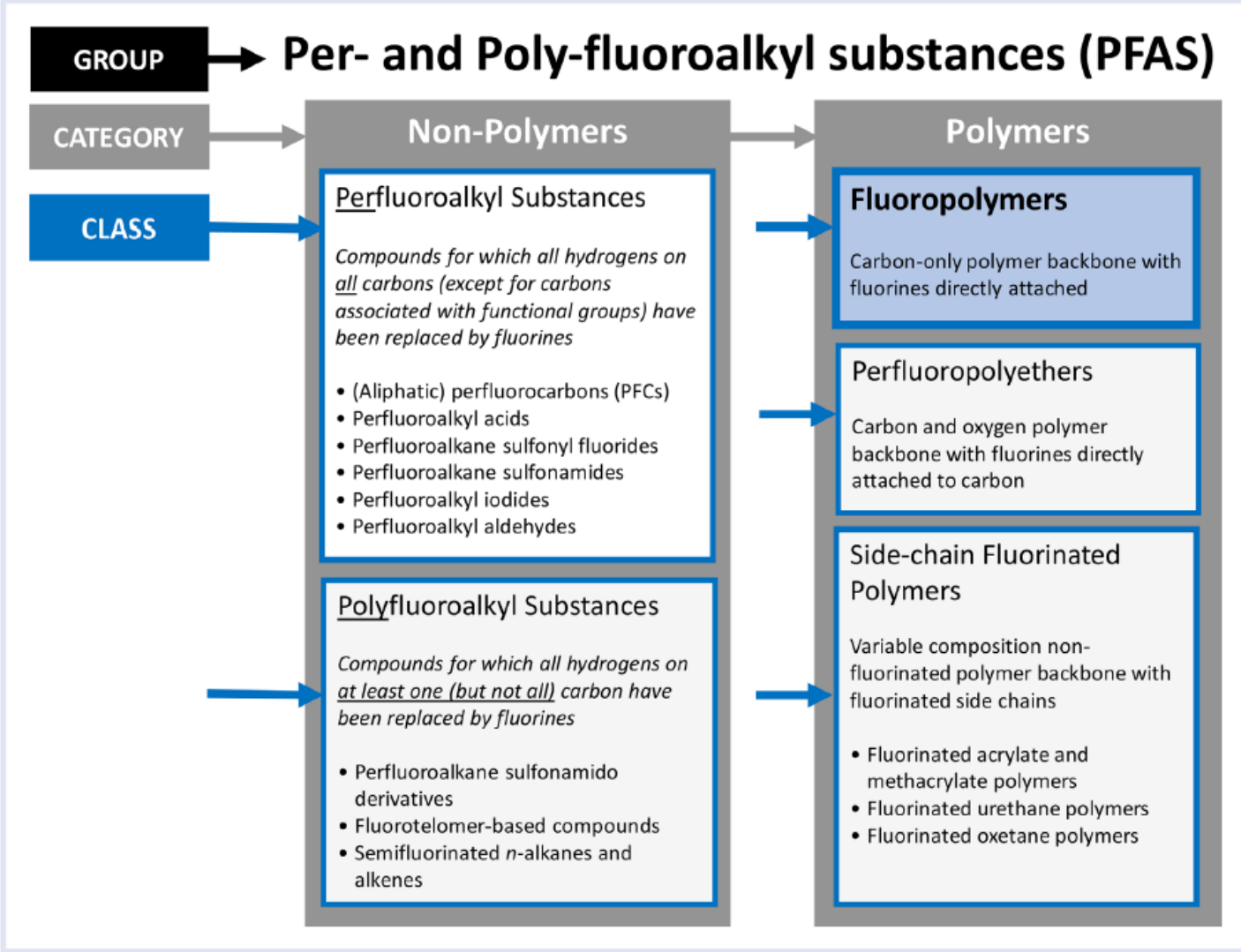


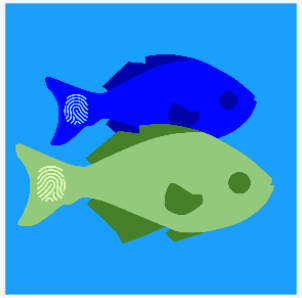
Figure 1. Per- and polyfluoroalkyl substances (PFAS).

STEEP

Sources, Transport, Exposure & Effects of PFASs

UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM

Connecting science and people

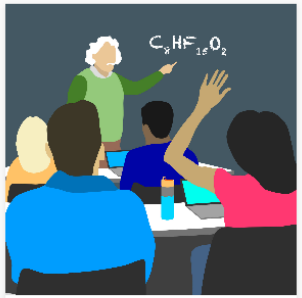


STEEP Research: Environmental Fate & Transport

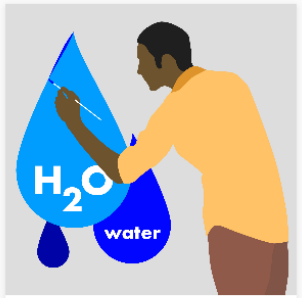
STEEP Research: Childhood Risk

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

STEEP

Sources, Transport, Exposure & Effects of PFASs

UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM

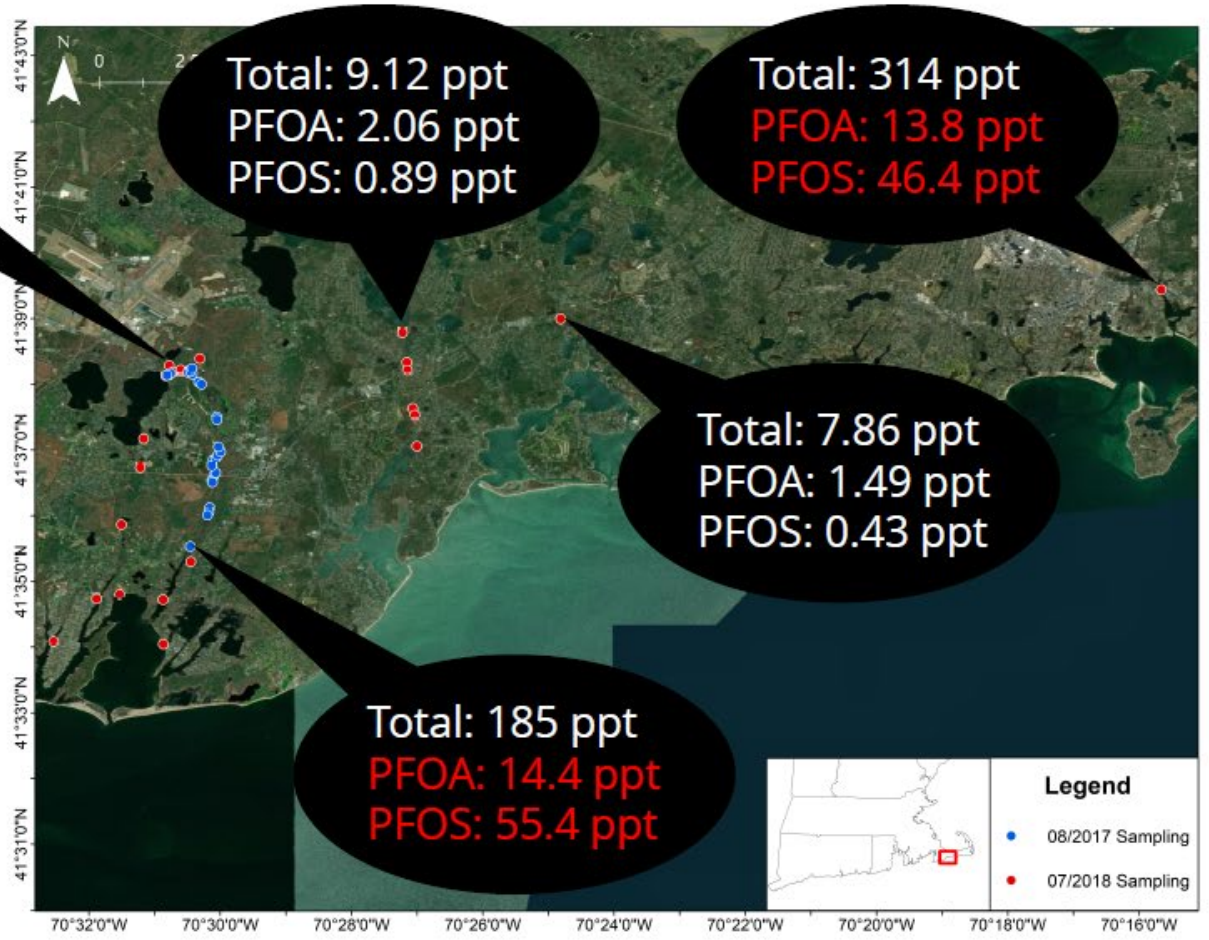
Project 1: Sources, fate and transport

PI: Elsie Sunderland (HU)

Collab: Dennis LeBlanc (USGS); Alan Vajda (CU)

Cape Cod: Linking local sources to global systems

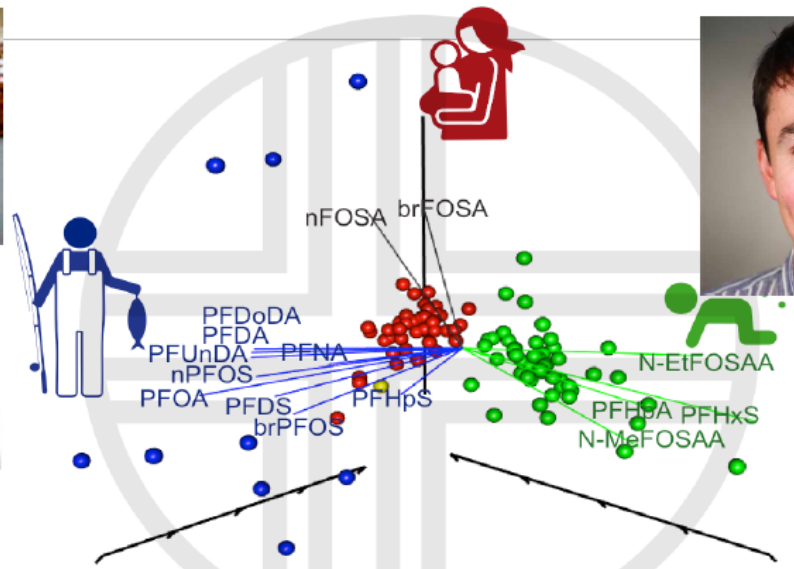
Biogeochemistry of Global Contaminants HARVARD

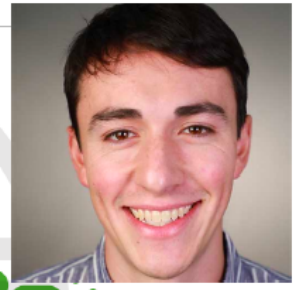


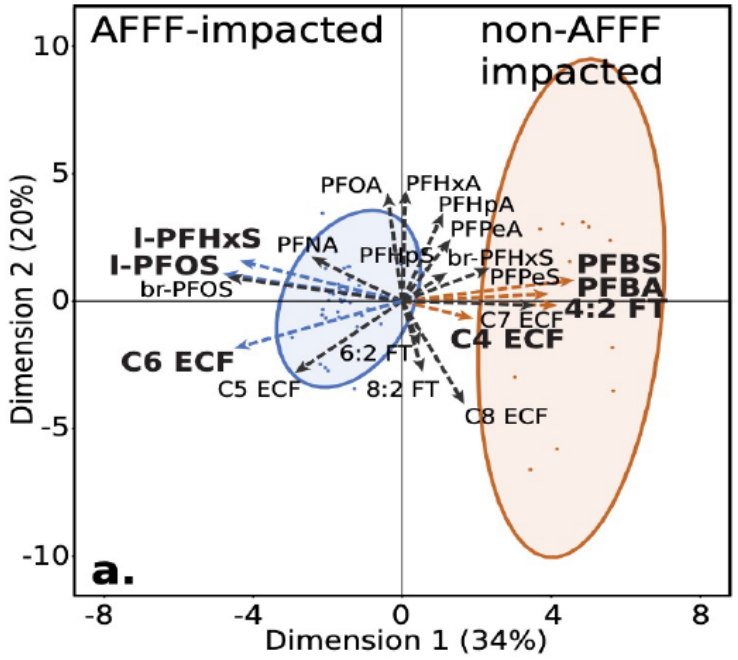
& Effects of PFASs
IND RESEARCH PROGRAM

Aim 1: Statistical fingerprinting of PFAS

Long-chain PFAS in serum (i.e., C>9) good tracer for seafood consumption (Hu et al., 2018; Dassuncao et al., 2018)



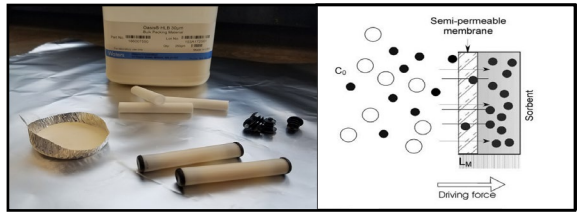




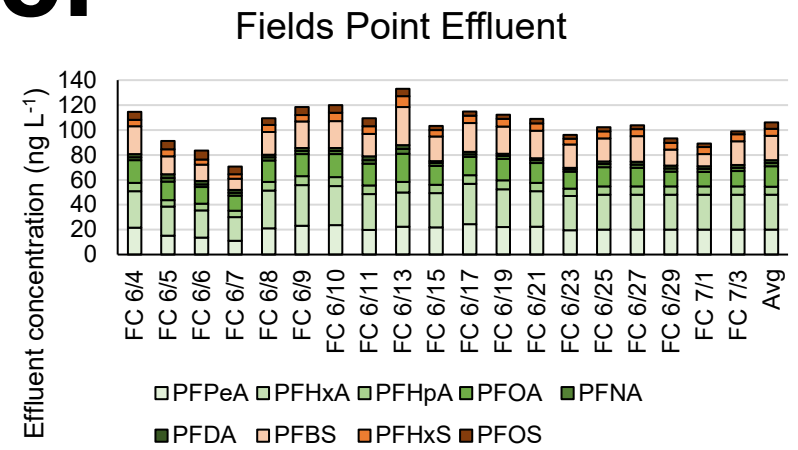
Also useful for source identification of AFFF on Cape Cod (Ruyle et al., 2020 a, b)

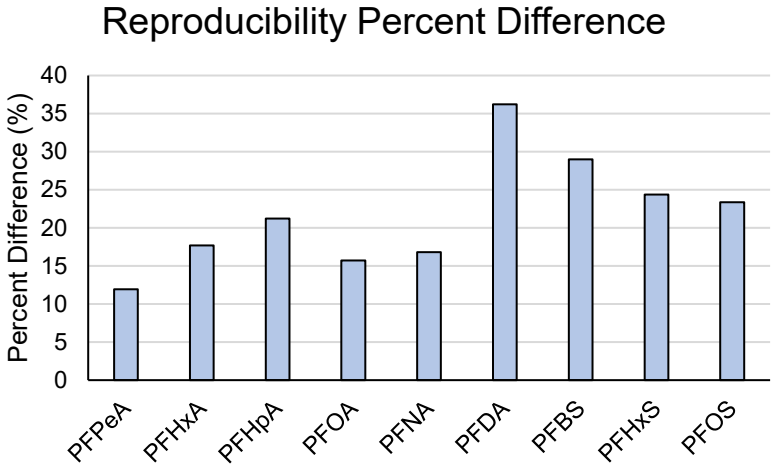
Sources, Transport, Exposure & Effects of PFASs
UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM

Project 4: Detection tools- A passive sampler for water

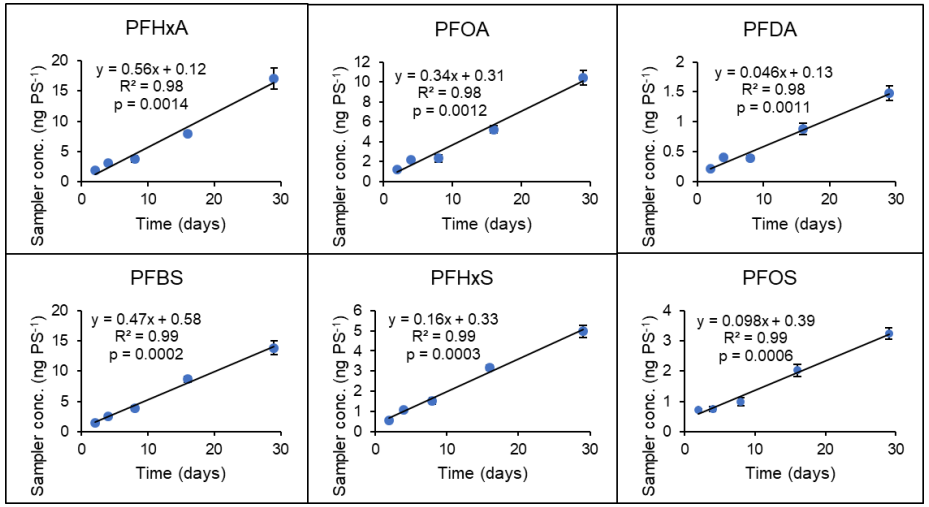


- 6 caged vs 6 “naked” deployments in the Bay.
- No sign. difference





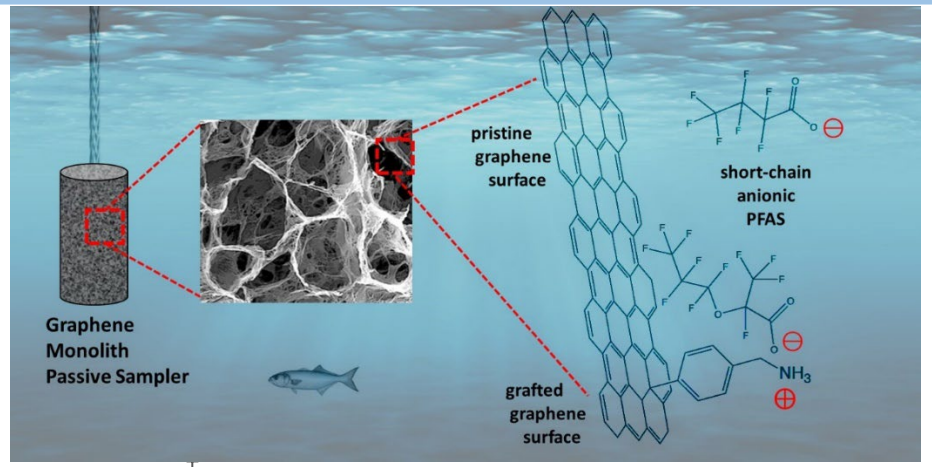
(Gardiner, 2019)

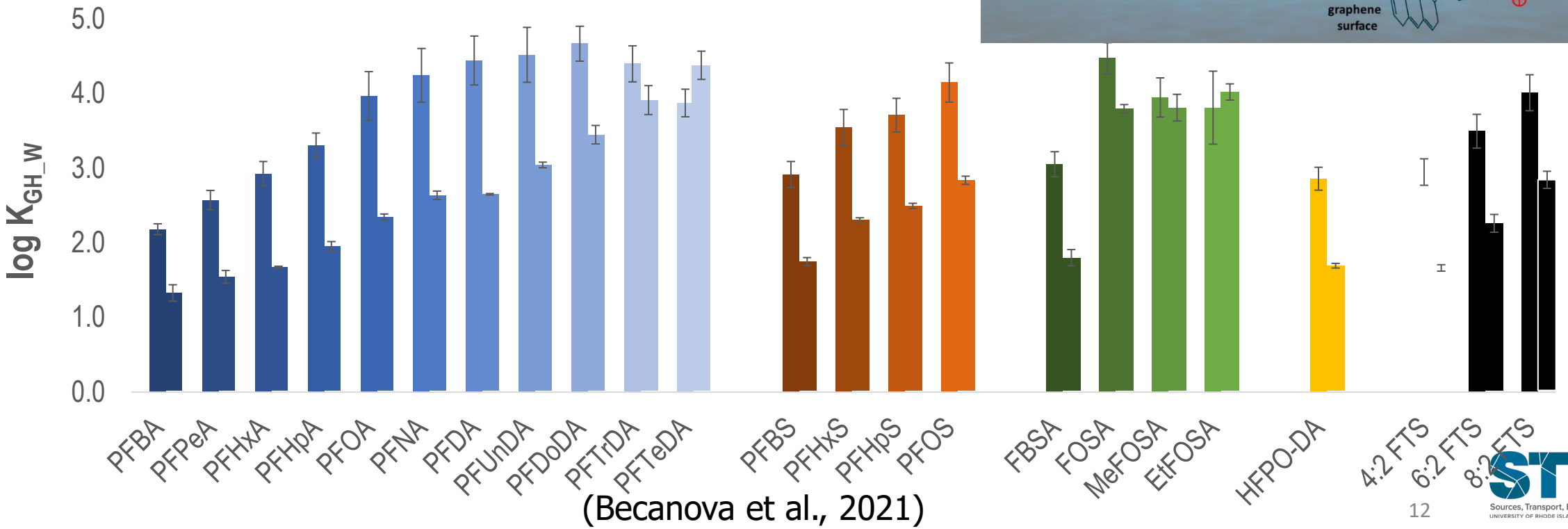


STEEP
Sources, Transport, Exposure & Effects of PFASs
UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM

Graphene monolith sampler (fast, equilibrium)

- modified/functionalized graphene oxide
- SPE sorbents – weak anion exchange STRATA X
- 4-Aminobenzylamine (4-ABA) → positively charged GO

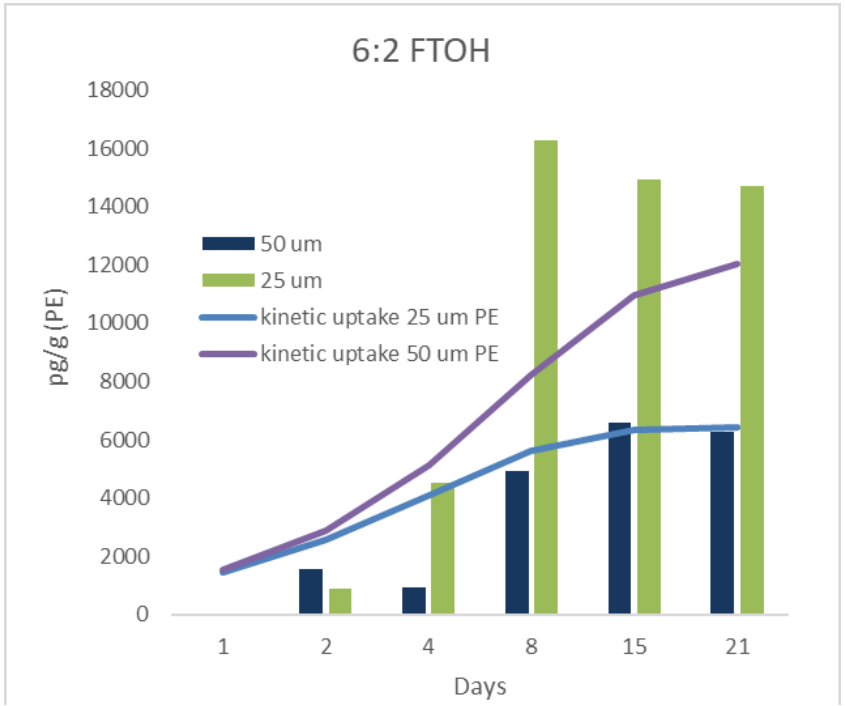


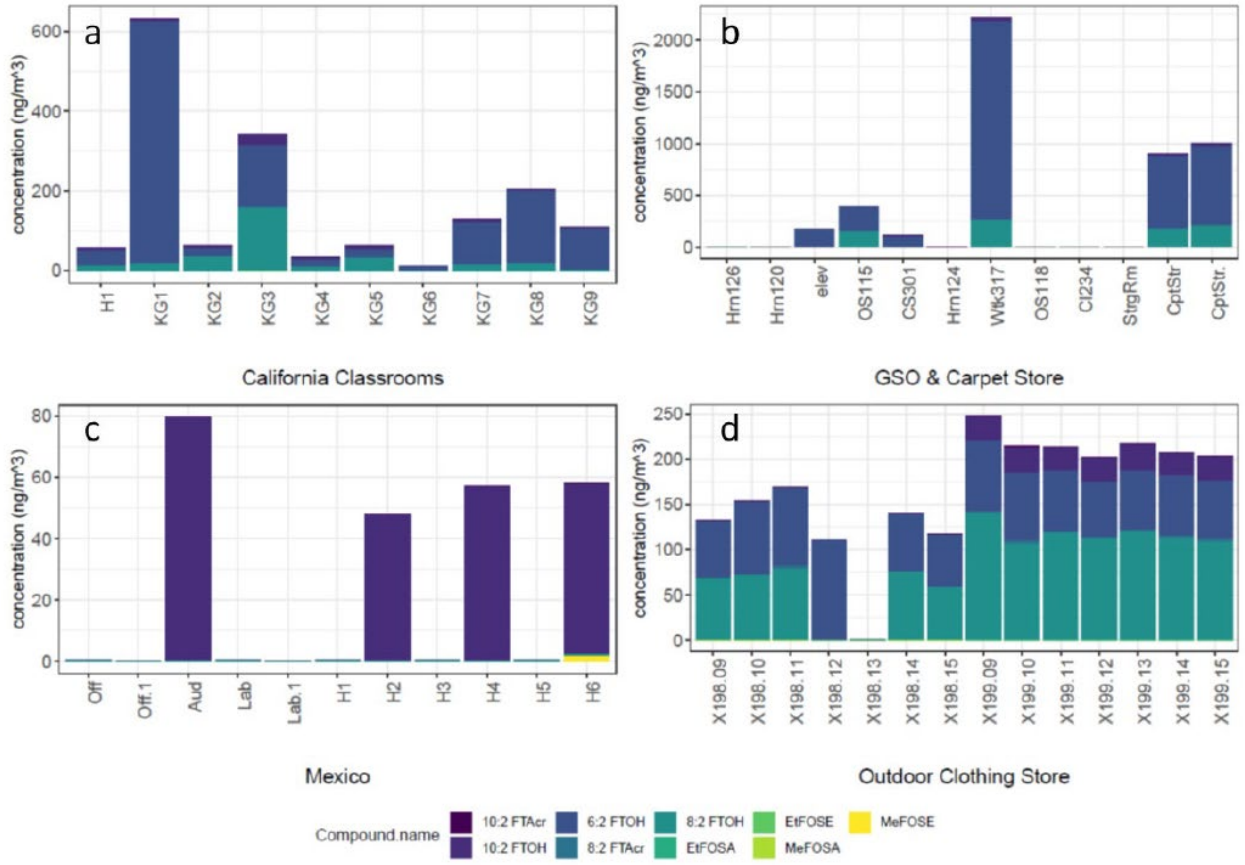


(Becanova et al., 2021)

Indoor air sampling tools

- PE-sheets, and 2 weeks





(Morales-McDevitt, 2021)

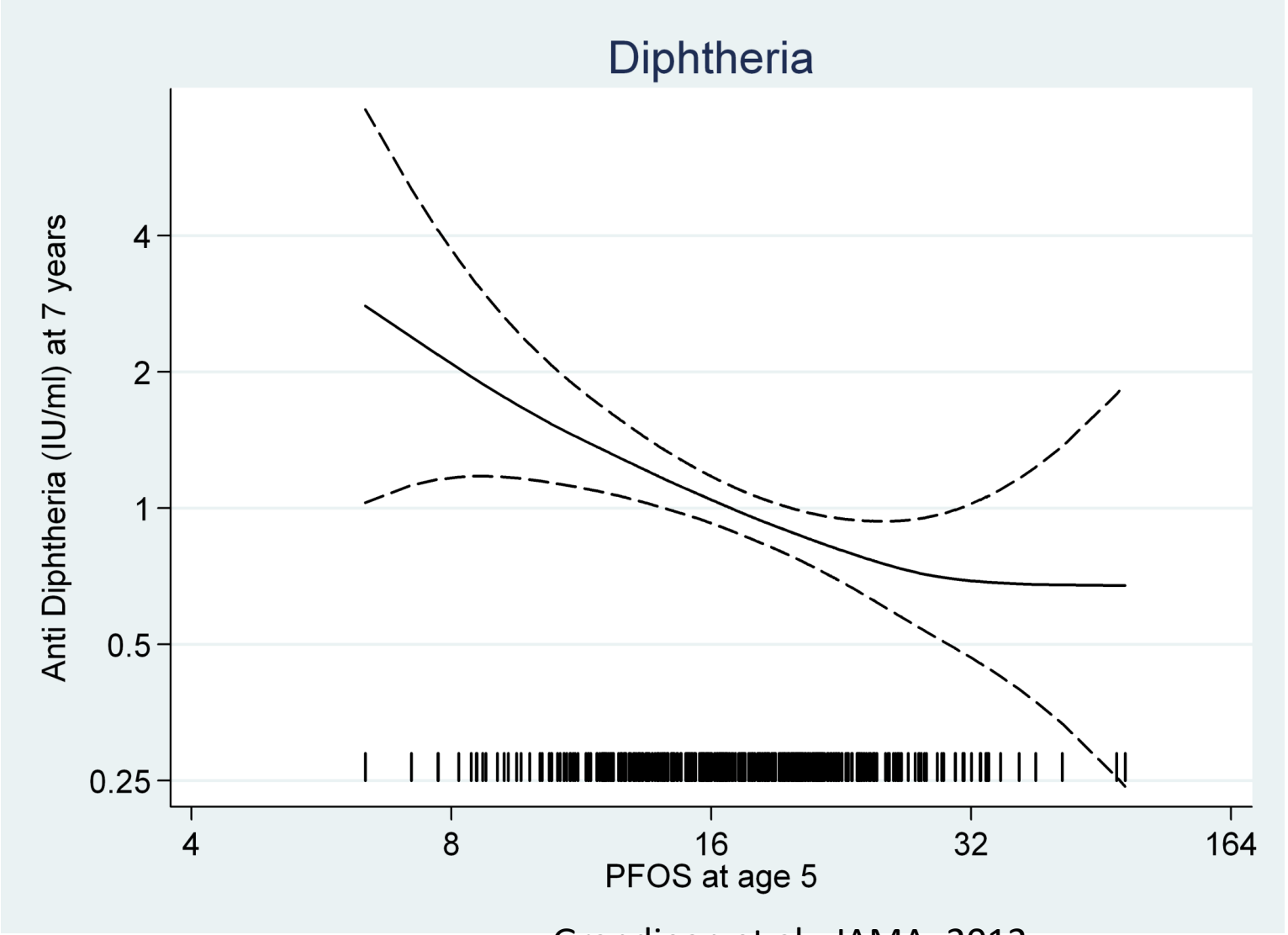
STEEP
Sources, Transport, Exposure & Effects of PFASs
UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM

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

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

STEEP
Sources, Transport, Exposure & Effects of PFASs
UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM

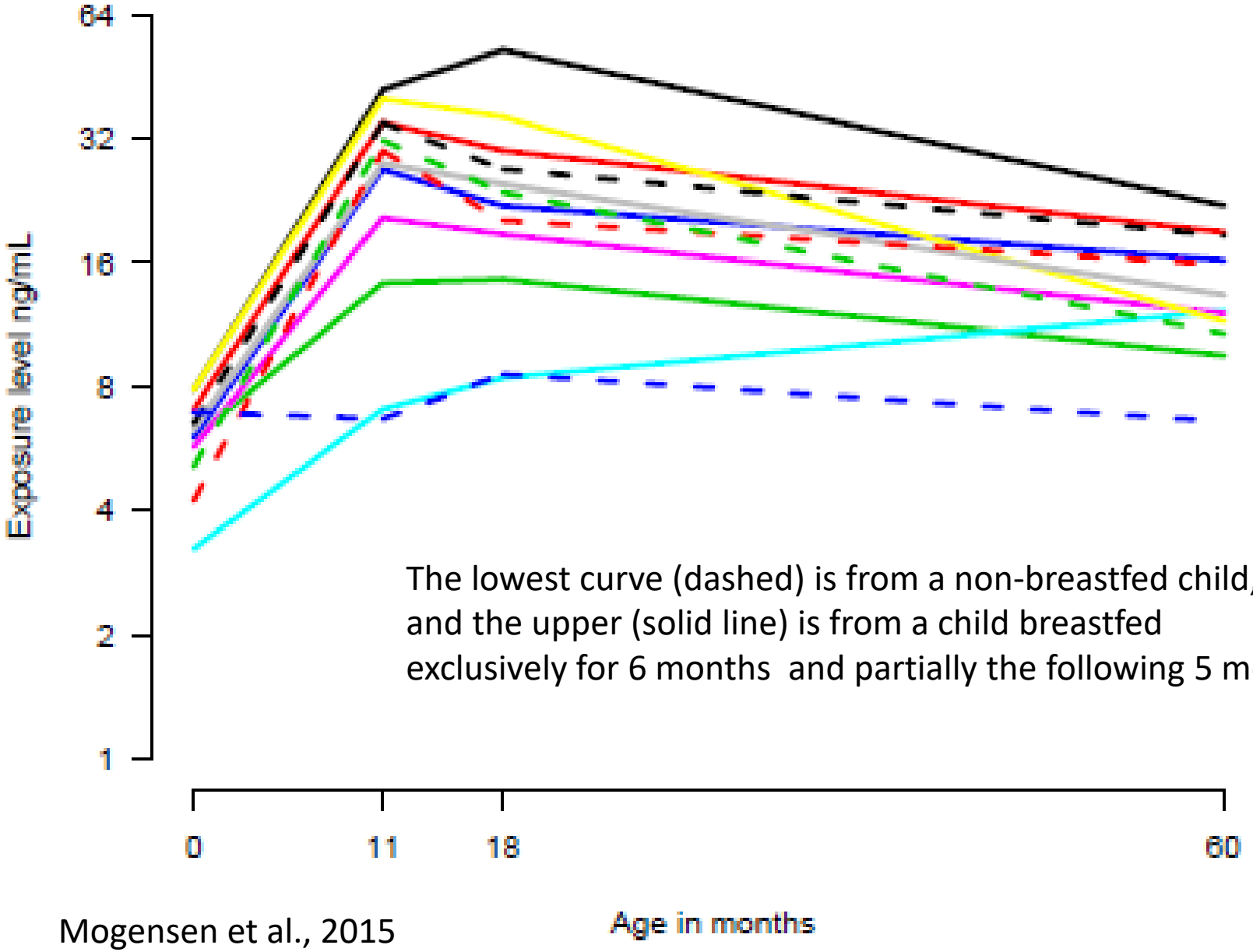
Childhood risks of PFAS



Grandjean et al., JAMA, 2012

STEEP
Sources, Transport, Exposure & Effects of PFASs
UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM

PFOS transfer via human milk impacts infant serum levels

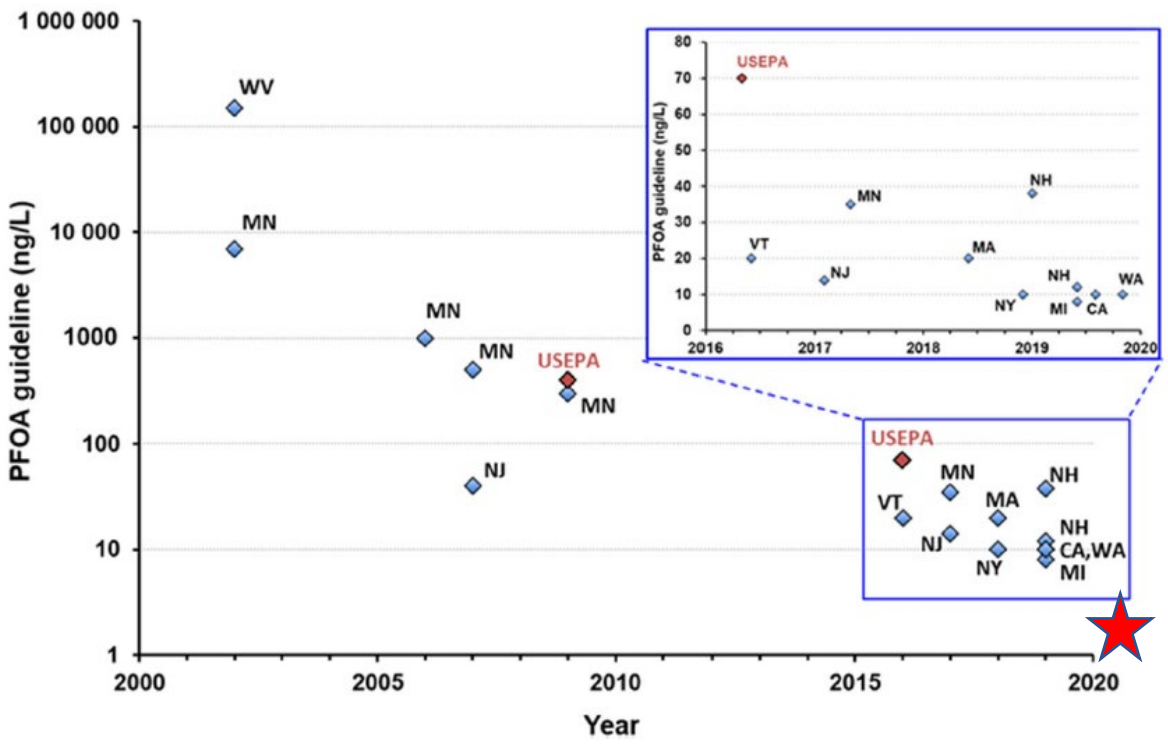


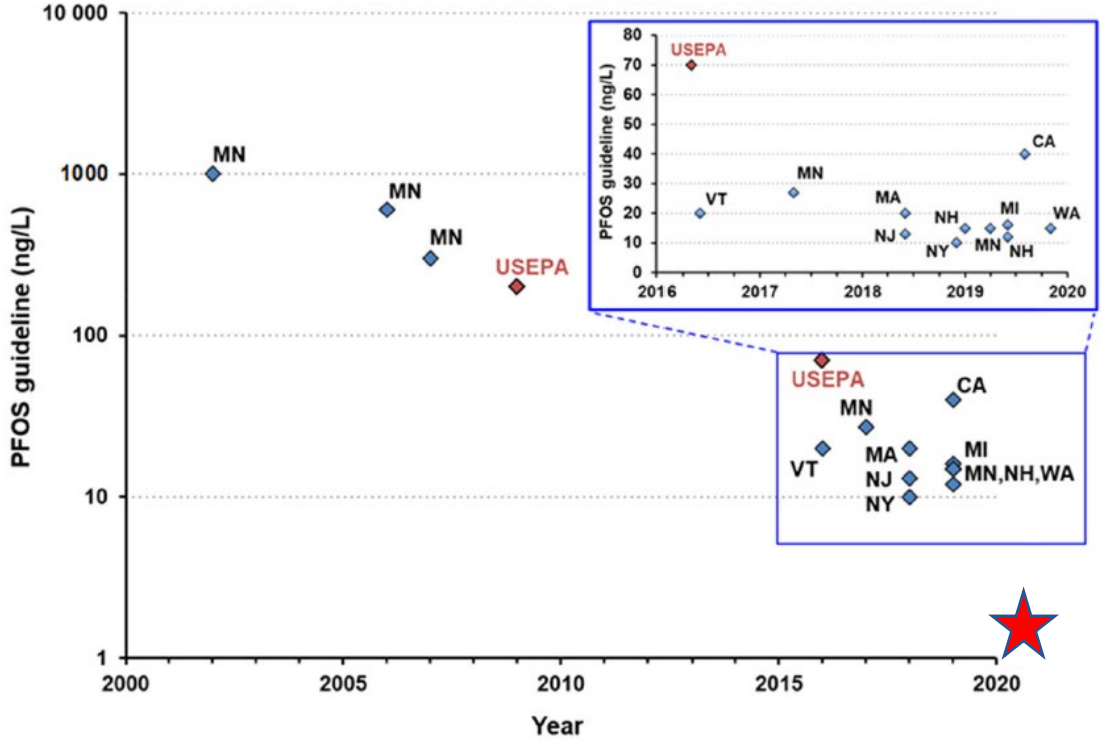
The lowest curve (dashed) is from a non-breastfed child, and the upper (solid line) is from a child breastfed exclusively for 6 months and partially the following 5 months.

Mogensen et al., 2015

STEEP
Sources, Transport, Exposure & Effects of PFASs
UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM

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





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

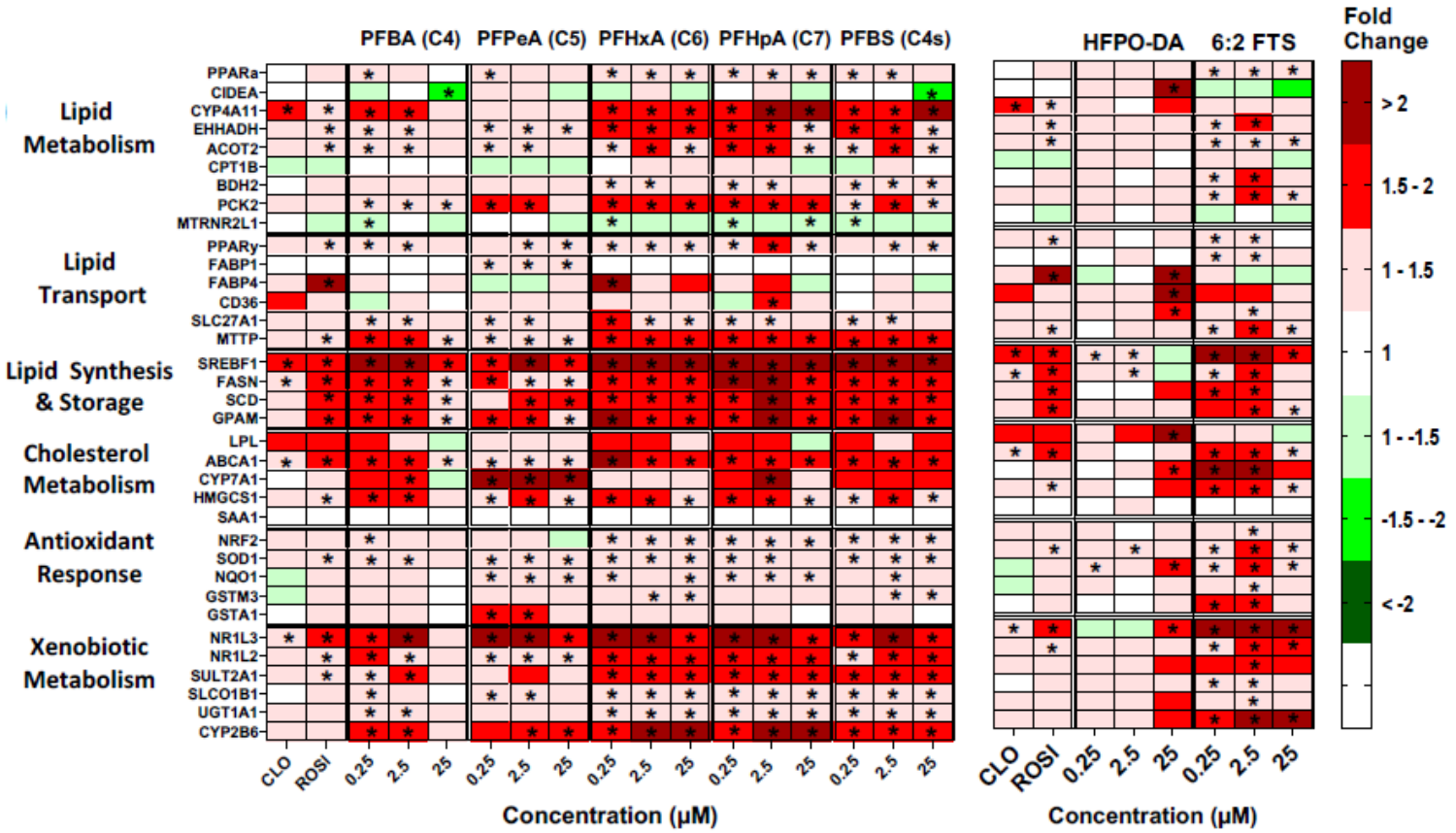
(Post, 2021)

STEEP
Sources, Transport, Exposure & Effects of PFASs
UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM

Project 3: Using Cell Based Assays to learn more about “emerging PFASs”

PI: Angela Slitt (URI); co-PI: Geoff Bothun (URI)

- Gene expression in human hepatocytes exposures

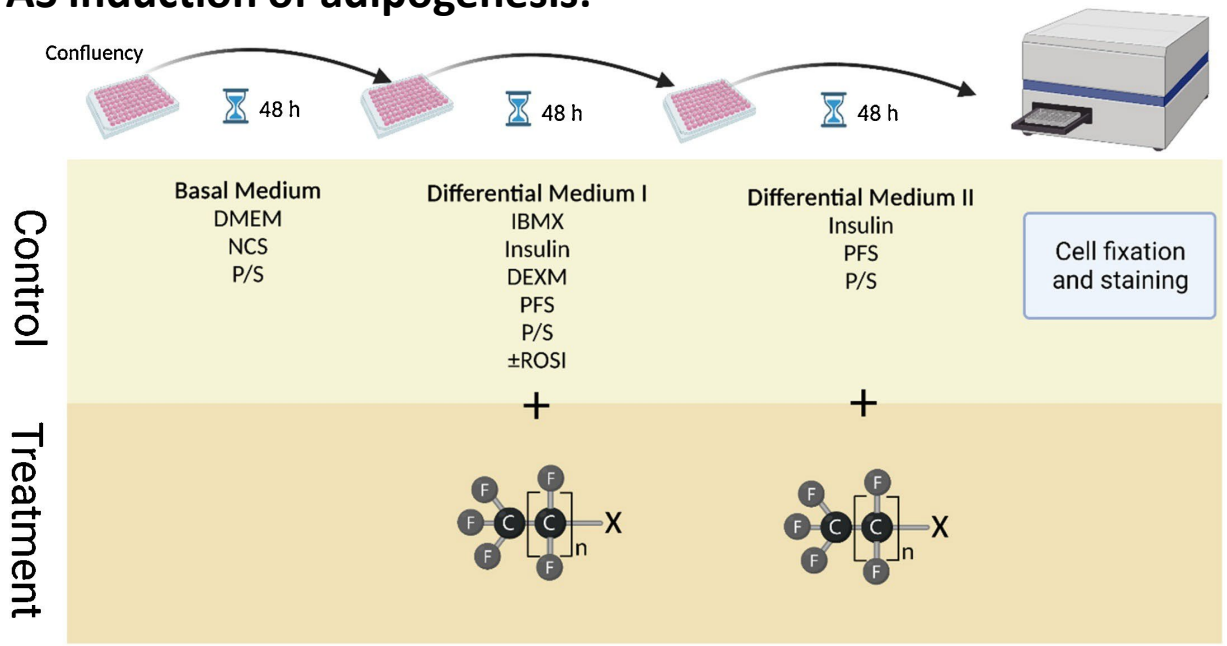


(Marques et al, Toxicology and Applied Pharmacology, 2022, 442, 11599)

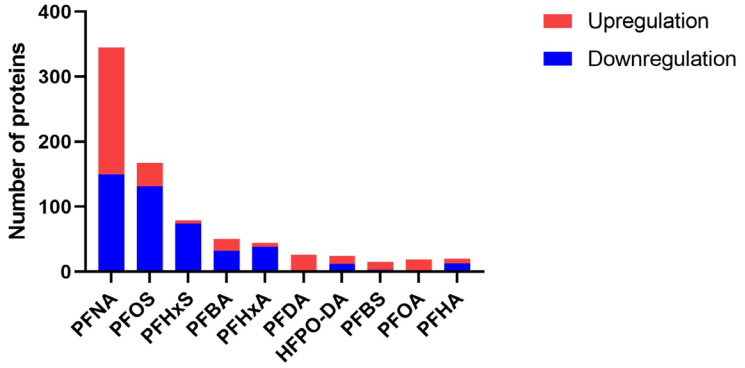
STEEP
Sources, Transport, Exposure & Effects of PFASs
UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM

PFAS augment adipogenesis and shift the proteome in murine 3T3-L1 adipocytes*

➢ **PFAS induction of adipogenesis:**



Treatment with PFAS started at day two in DMI and continued for four days. Ten different PFAS with 3 different concentrations each was added along with three different concentrations of the differentiation cocktail in the presence or absence of rosiglitazone.



PFAS	Change in lipid accumulation relative to untreated control	Fold-change
PFOS	↑	**1.66**
PFOA	↑	**1.37**
PFBA	↓	**-1.30**
PFHxA	↑	**1.35**
PFHA	↑	**1.17**
PFBS	↑	**1.40**
PFHxS	↑	**1.68**
PFNA	-	n/a
PFDA	-	n/a
HFPO-DA	-	n/a

Summary of lipid accumulation results at the 25 µM PFAS along with rosiglitazone made 6 out of 10 PFAS to significantly increase lipid content.

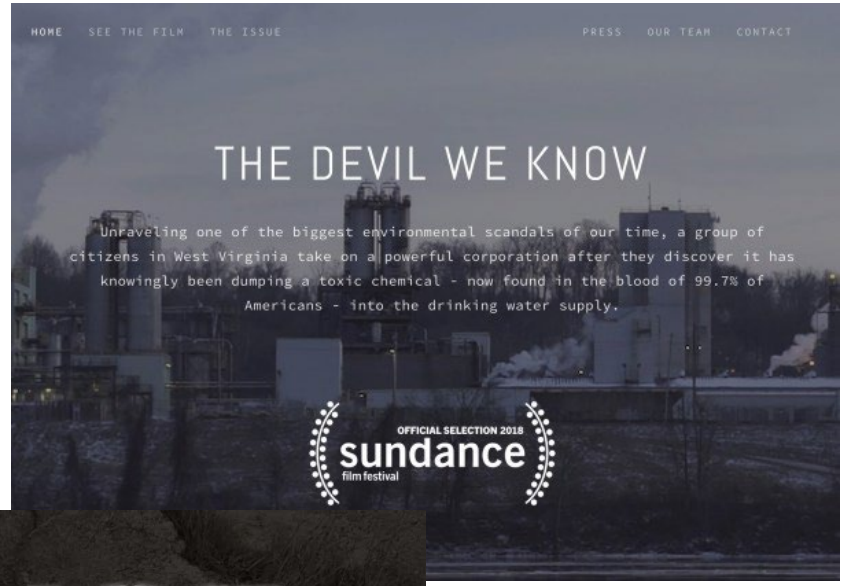
In this study, lipid content of cells exposed to 3 dilutions of the differentiating cocktail along with 10 different PFAS at 0.25, 2.5, and 25 µM with or without rosiglitazone was determined using Nile Red staining (all data not shown).

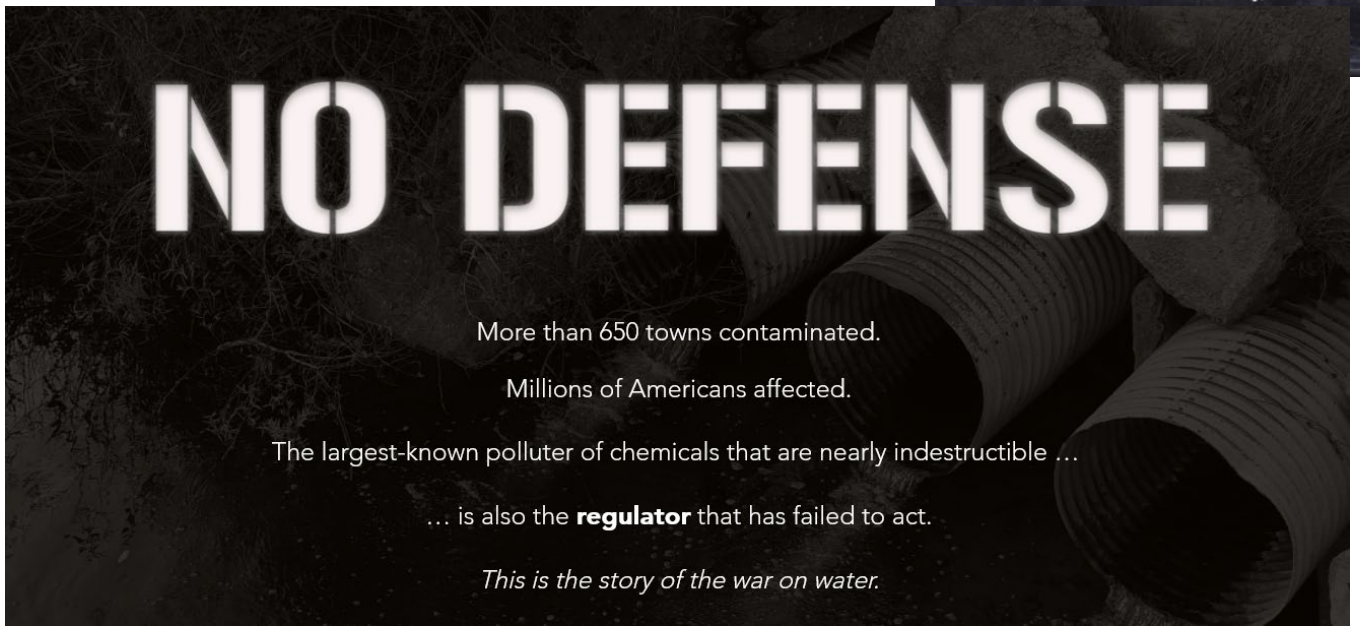
Modaresi SMS, Wei W, Emily M, DaSilva NA, Slitt AL. Toxicology 2022; 465:153044.

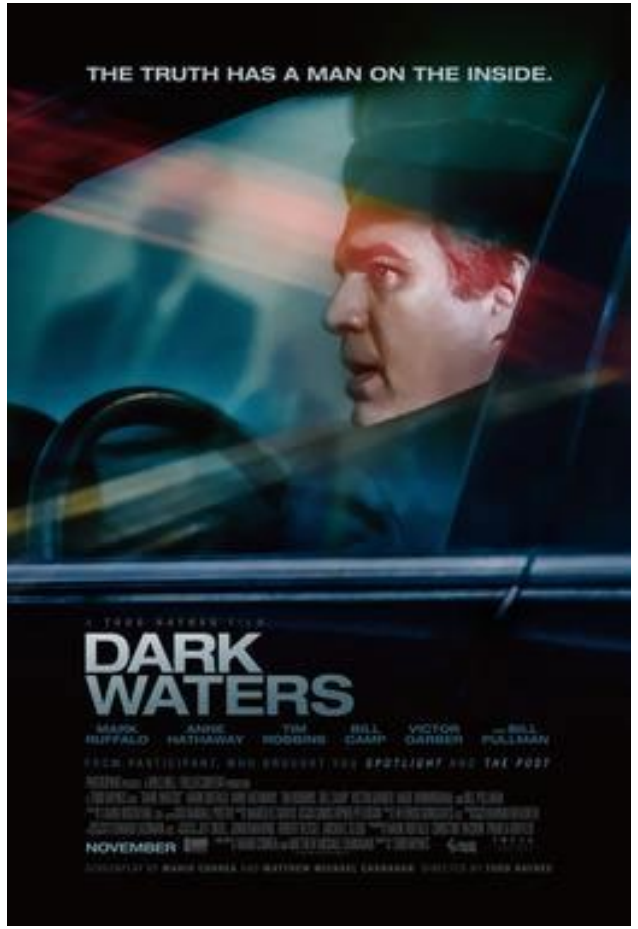
STEEP
Sources, Transport, Exposure & Effects of PFASs
UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM

How else to explain PFAS to the public?

- “forever chemicals”



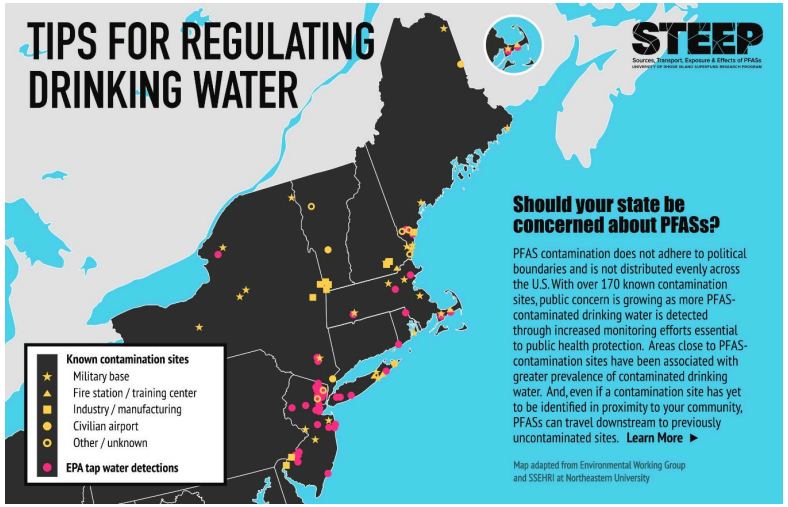


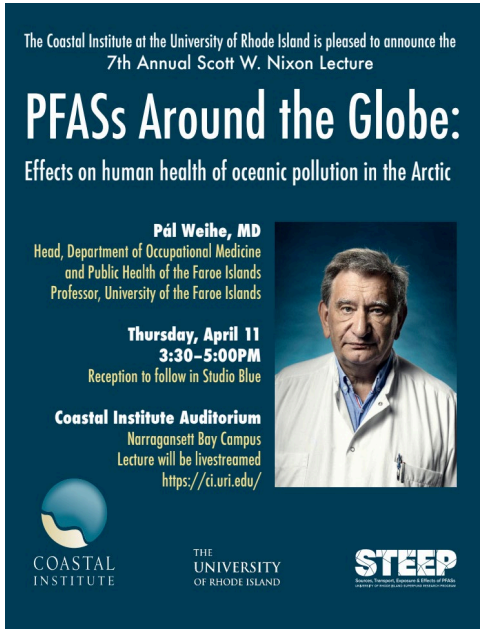


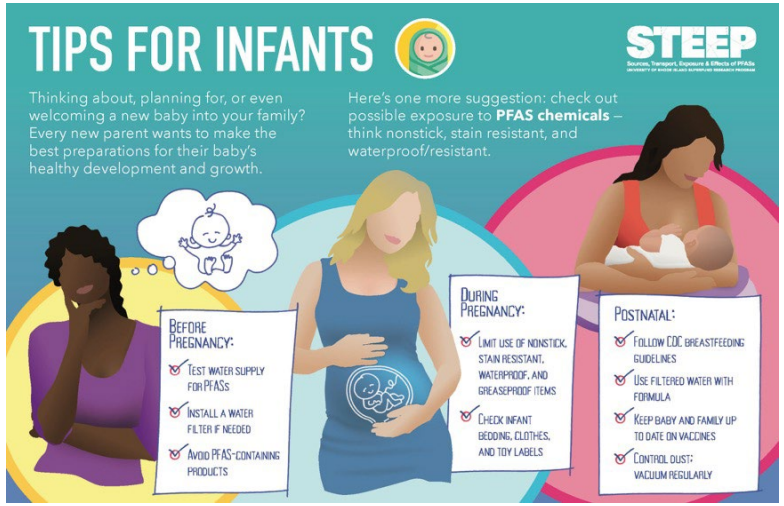
STEEP
Sources, Transport, Exposure & Effects of PFASs
UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM

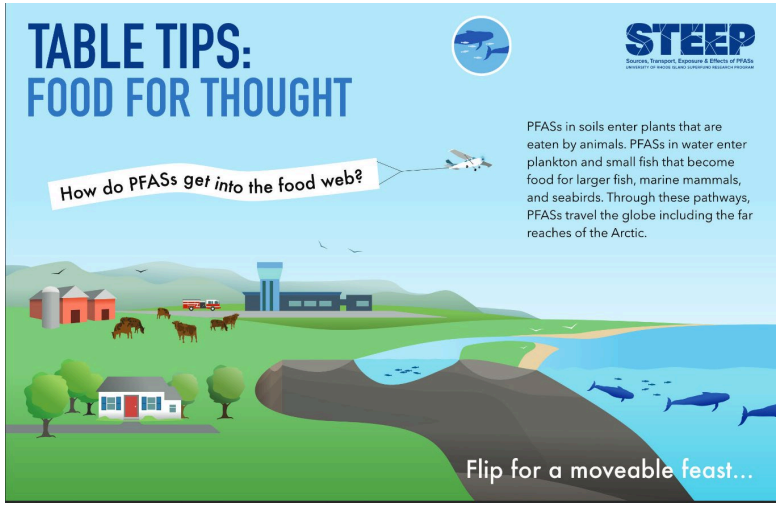
Research Translation Core

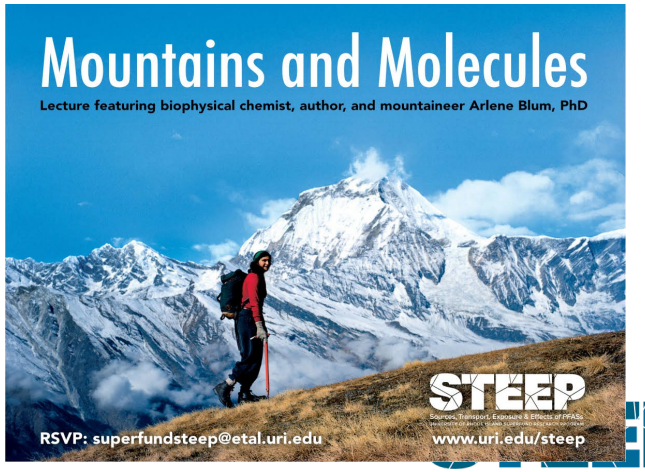
PI: Judith Swift; co-PI Nicole Rohr, Amber Neville (URI)









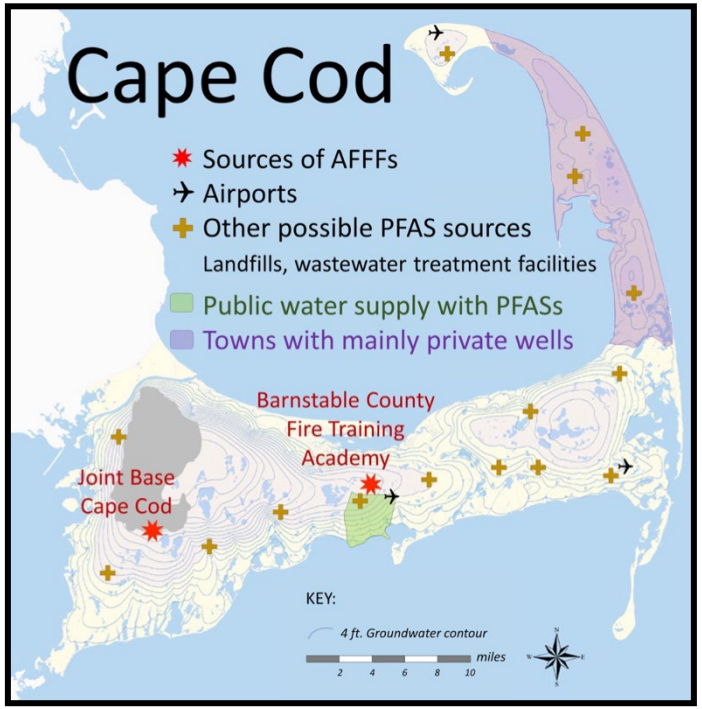


STEEP website: www.uri.edu/steep

STEEP
Sources, Transport, Exposure & Effects of PFASs
UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM

STEEP's focus on Cape Cod

- Vulnerable sole-source aquifer
- AFFF contamination of public and private drinking water wells
- Prior studies of septic systems as PFAS sources
- Community concerns about water quality and health



Community engagement Core

PI: Alyson McCann (URI)
Laurel Schaider (SSI)

Private well testing

Community events and presentations

Environmental Science
Processes & Impacts

CRITICAL REVIEW

View Article Online
View Journal

Check for updates

Cite this: DOI: 10.1039/c9em00163h

The concept of essential use for determining when uses of PFASs can be phased out

Ian T. Cousins, †*[a] Gretta Goldenman,[b] Dorte Herzke,[c] Rainer Lohmann,[d] Mark Miller,[e] Carla A. Ng,[f] Sharyle Patton,[g] Martin Scheringer,[h] Xenia Trier,[i] Lena Vierke,[j] Zhanyun Wang[k] and Jamie C. DeWitt[l]

Based on these definitions, how many use categories can we define for PFAS?

Based on the Montreal Protocol, which defined the concept of essential use for chlorofluorocarbons (CFCs).

- An essential use is a use necessary for health or safety or for the functioning of society.
- An essential use is a use for which there are no available technically and economically feasible alternatives.

STEEP
Sources, Transport, Exposure & Effects of PFASs
UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM

Essential use concept for PFAS

Table 1 Three essentiality categories to aid the phase out of non-essential uses of chemicals of concern, exemplified with PFAS uses

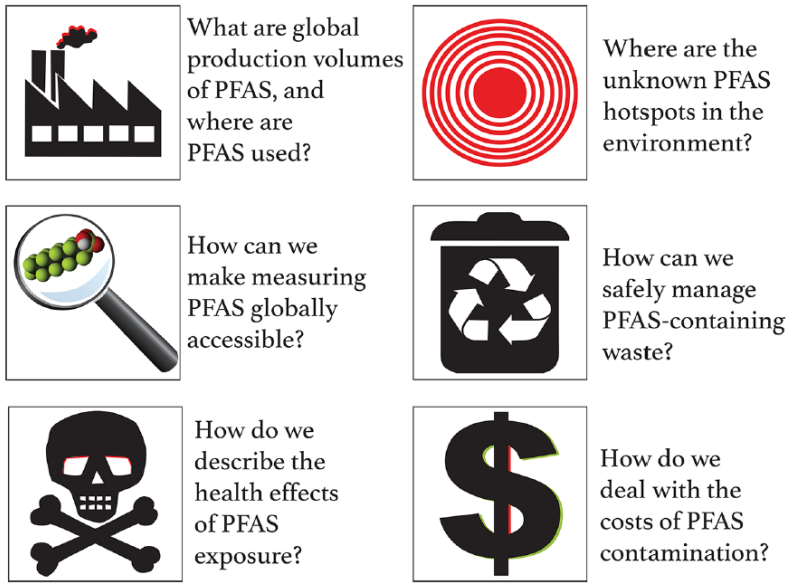
Category	Definition	PFAS examples
(1) "Non-essential"	Uses that are not essential for health and safety, and the functioning of society. The use of substances is driven primarily by market opportunity	Dental floss, water-repellent surfer shorts, ski waxes
(2) "Substitutable"	Uses that have come to be regarded as essential because they perform important functions, but where alternatives to the substances have now been developed that have equivalent functionality and adequate performance, which makes those uses of the substances no longer essential	Most uses of AFFFs, certain water-resistant textiles
(3) "Essential"	Uses considered essential because they are necessary for health or safety or other highly important purposes and for which alternatives are not yet established[a]	Certain medical devices, occupational protective clothing

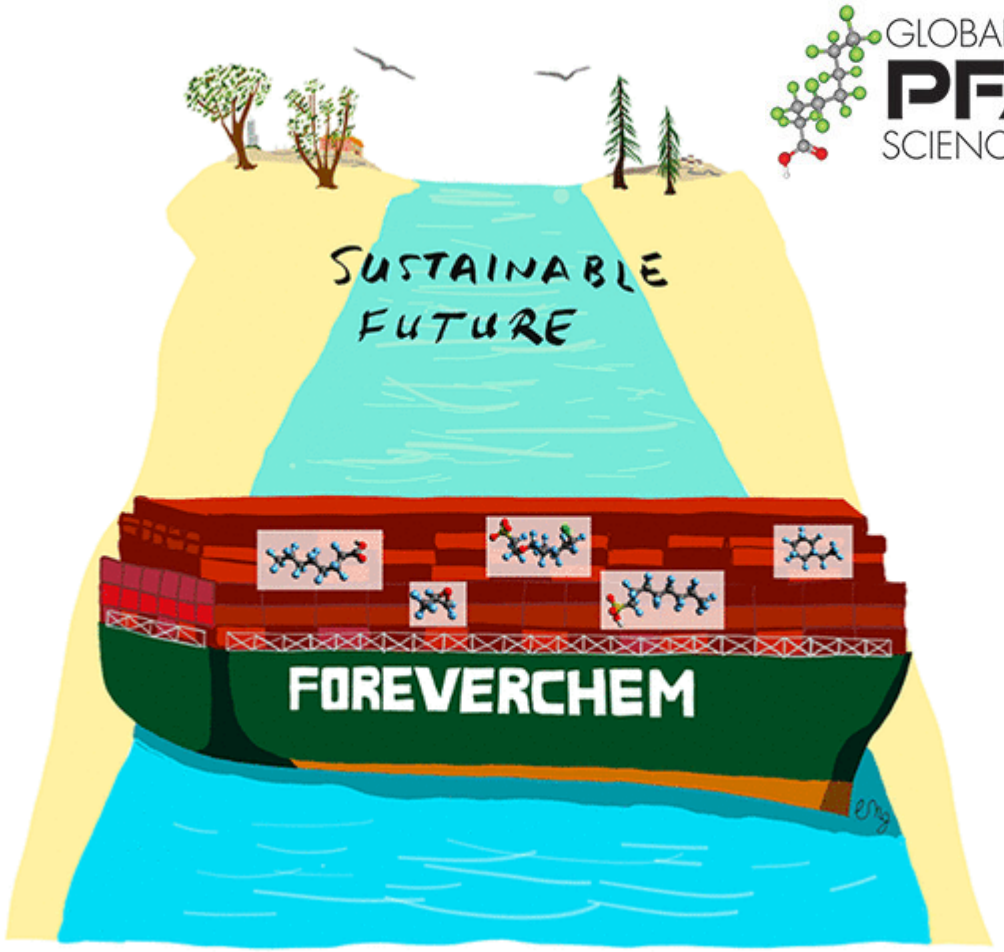
[a] This essentiality should not be considered permanent; rather, a constant pressure is needed to search for alternatives in order to move these uses into category 2 above.

STEEP
Sources, Transport, Exposure & Effects of PFASs
UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM

Table from: Cousins et al. 2019. Environmental Science: Processes & Impacts. DOI: 10.1039/c9em00163h

Outlook: Addressing Urgent Questions for PFAS in the 21st Century





Carla Ng,* Ian T. Cousins, Jamie C. DeWitt, Juliane Glüge, Gretta Goldenman, Dorte Herzke, Rainer Lohmann, Mark Miller, Sharyle Patton, Martin Scheringer, Xenia Trier, and Zhanyun Wang

Cite This: *Environ. Sci. Technol.* 2021, 55, 12755–12765 Read Online

STEEP Sources, Transport, Exposure & Effects of PFASs UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM

QUESTION 1: WHAT ARE THE GLOBAL PRODUCTION VOLUMES OF PFAS AND WHERE ARE PFAS USED?

Importance.

- Underlies effective measurements, assessment, and management strategies

Barriers.

- Regulations, CBI
- Producer interests
- Complexity of production chains

What are global production volumes of PFAS, and where are PFAS used?

Potential Paths Forward.

- New rules/regulations (TSCA)
- Consumer pressure; industry pushback

QUESTION 2: WHERE ARE THE UNKNOWN PFAS HOTSPOTS IN THE ENVIRONMENT?

Importance.

- Unknown sites (biosolids, etc)

Barriers.

- Country-specific uses (leaf ant control)
- Lack of capabilities

Potential Paths Forward.

- Country-specific inventories
- Emission reporting
- Testing, testing, testing

Where are the unknown PFAS hotspots in the environment?

QUESTION 3: HOW CAN WE MAKE MEASURING PFAS GLOBALLY ACCESSIBLE?

Importance.

- Lack of methods
- Lack of testing

Barriers.

- Lack of cheap/simple screening tests
- Lack of standards and affordable tools

Potential Paths Forward.

- Simpler tools (EOF/XRF) for totals
- Collaboration and exchange
- Capacity building

How can we make measuring PFAS globally accessible?

QUESTION 4: HOW CAN WE SAFELY MANAGE PFAS-CONTAINING WASTES?

Importance.

- Stockpiles, landfills, WWTPs
- Problem of persistence

Barriers.

- Pump and treat etc creates waste/rejects
- (In situ) destruction not widely used
- Incineration as panacea?

Potential Paths Forward.

- Turn off the tap
- R&D for mineralization; interim storage.

How can we safely manage PFAS-containing waste?

QUESTION 5: HOW CAN WE UNDERSTAND AND DESCRIBE THE HEALTH EFFECTS OF PFAS EXPOSURE?

Importance.

- Too many (unknown) understudied PFAS
- On-going exposures

Barriers.

- causality
- Many pathways
- Divers structures

Potential Paths Forward.

- Class-based approach
- Precautionary approach
- Combine different approaches

How do we describe the health effects of PFAS exposure?

QUESTION 6: WHO PAYS FOR THE IMPACTS OF PFAS CONTAMINATION?

Importance.

- Testing, treatment costs. (1-2 Bio EUR/yr Nordic)
- Health costs (10s Bio EUR /yr Nordic)

Barriers.

- Polluter pays??
- Responsible party
- Effects delay

Potential Paths Forward.

- Internalize costs
- PFAS in CERCLA
- PFAS-tax?

How do we deal with the costs of PFAS contamination?

Much progress, much more is needed

- EPA's decisions on MCLs (PFOA + PFOS+?); CERCLA, testing
- Progress in the EU, DC, and some states on
  - essential use, MCLs, PFAS restrictions
- Remediation, treatment, atmosphere?
- Health implications

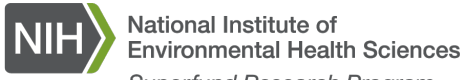
Thanks, again

- Tides Foundation (grant 1907-59084 for GPSP).
- NIEHS, of course (P42ES027706)
- RI STAC for passive sampling tube work
- SERDP ER 18-1280 (Sunderland, Harvard U)
- SERDP 20-2538 (Lohmann, URI)
- Partners/collaborators, grad students

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



STEEP is funded under award number P42ES027706.
More information about STEEP is available at: www.uri.edu/steep/

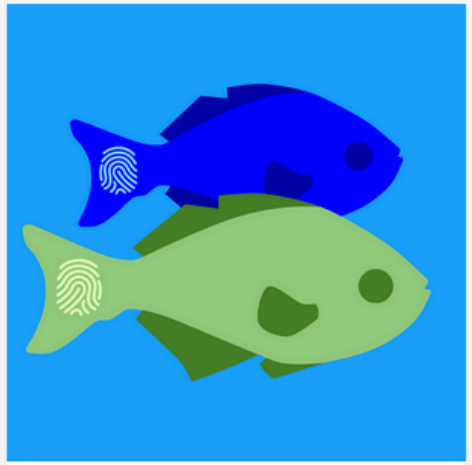
Thank you.

Questions?

Research Translation Core

PI: Judith Swift; co-PI Nicole Rohr, Amber Neville (URI)

STEEP website: www.uri.edu/steep



Environmental Fate & Transport

Environmental Engineering: Exposure assessment and chemometrics of PFASs.

Childhood Risk

Epidemiological Study: Inflammation and metabolic changes in children exposed to PFASs.

Metabolic Effects

Laboratory Study: PFAS compound effects on metabolic abnormalities in rodents.

Detection Tools

Environmental Engineering: Develop passive samplers for the detection and bioaccumulation of PFASs.

Social media

steepsuperfund

steepsuperfund

steepsuperfund

STEEP
Sources, Transport, Exposure & Effects of PFASs
UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM

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.

STEEP
Sources, Transport, Exposure & Effects of PFASs
UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM

Can consumers identify products containing PFAS?

Products that do or did contain PFAS

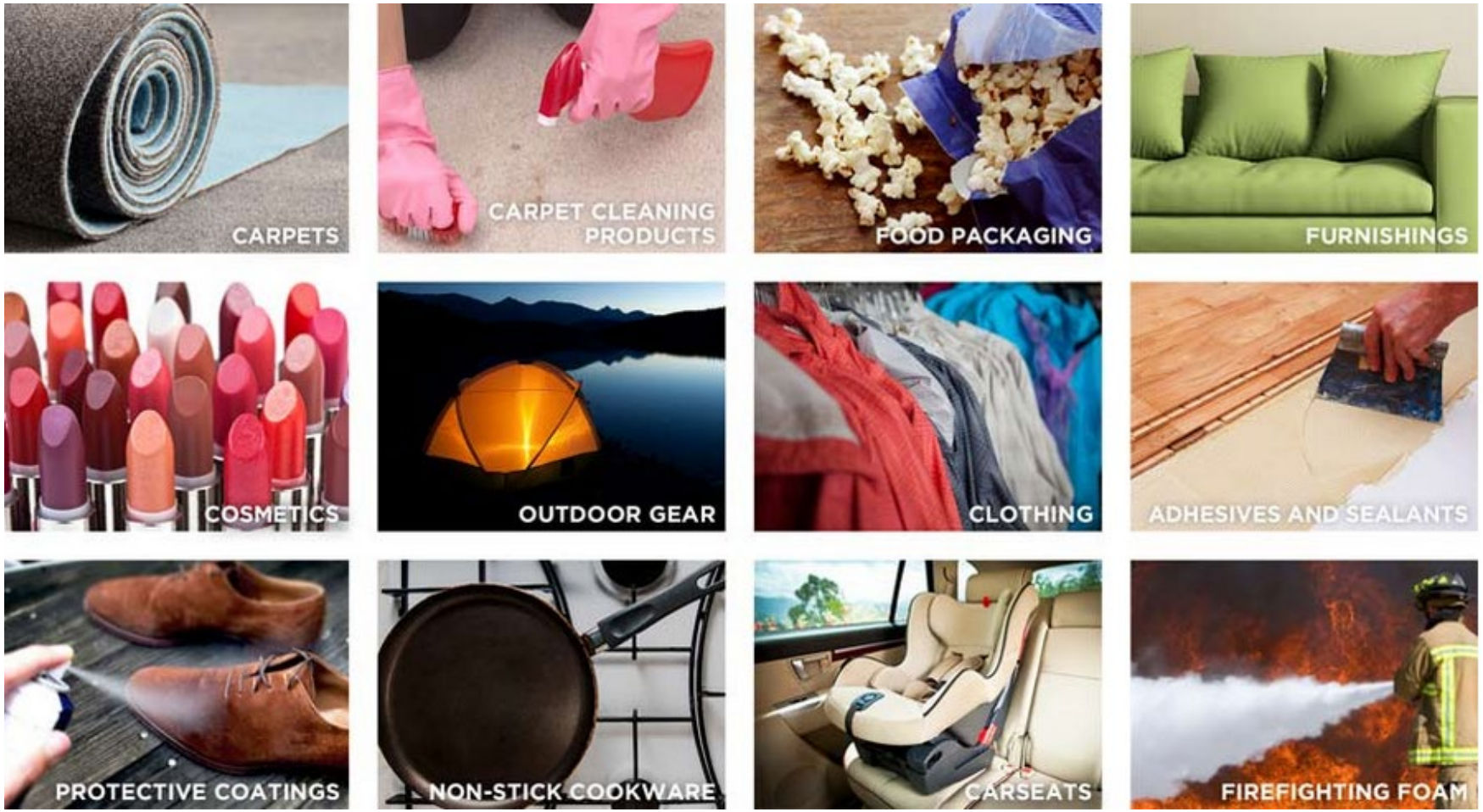


Image source: www.sixclasses.org/videos/highly-fluorinated-chemicals.

Something in the air..

… and in your blood

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

Airborne Precursors Predict Maternal Serum Perfluoroalkyl Acid Concentrations

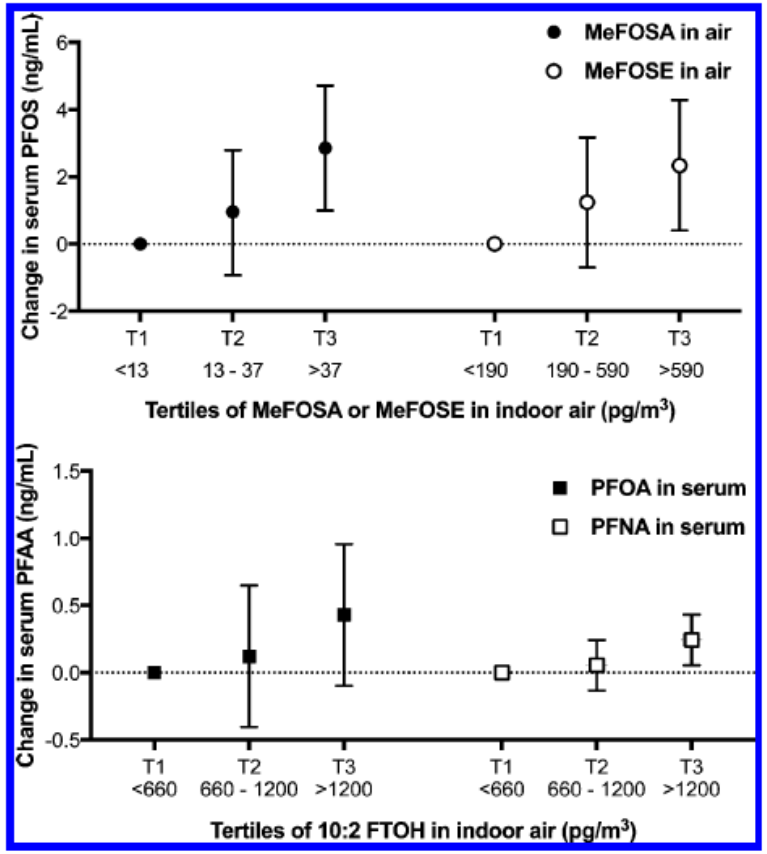


Figure 1. Exposure categories [low (n = 17), medium (n = 16), and high (n = 16)] of PreFAA in air predicting serum PFAA levels in 50 women.

(Makey et al. 2017)

Table 2 Essentiality of PFASs in selected use categories

Use	Table 1 Category[a]
Personal care products including cosmetics	1
Ski waxes	1
Fire-fighting foams (commercial airports)	2
Fire-fighting foams (military)	2 or 3
Apparel (medical: long operations)	3
Apparel (protective clothing oil and gas industry)	3
Apparel (medical: short operations, everyday)	2
Apparel (military: occupational protection)	2 or 3
Waterproof jacket (general use)	2
Easy care clothing	1
Food contact materials	1, 2 or 3
Non-stick kitchenware (fluoropolymers)	1 or 2
Medical devices (fluoropolymers)	1, 2 or 3
Pharmaceuticals	2 or 3
Laboratory supplies, equipment and instrumentation	1, 2 or 3
Perfluorosulfonic membranes in fuel cells	2
Perfluorosulfonic membranes in chlor-alkali process	3

[a] Note that the categories in the above table represent the current evaluation and may change in the future.

Essential use concept for PFAS

"When considering chemical alternatives for PFASs, the focus should be on the service the product should deliver. The compound should therefore be evaluated for performance using the specifications required for the product as opposed to comparing directly to the PFAS being replaced…

Additionally, the potential for health hazard and potential for exposure…must be considered…"

Sources, Transport, Exposure & Effects of PFASs
UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM

Table from: Cousins et al. 2019. Environmental Science: Processes & Impacts. DOI: 10.1039/c9em00163h

Concern about PFASs

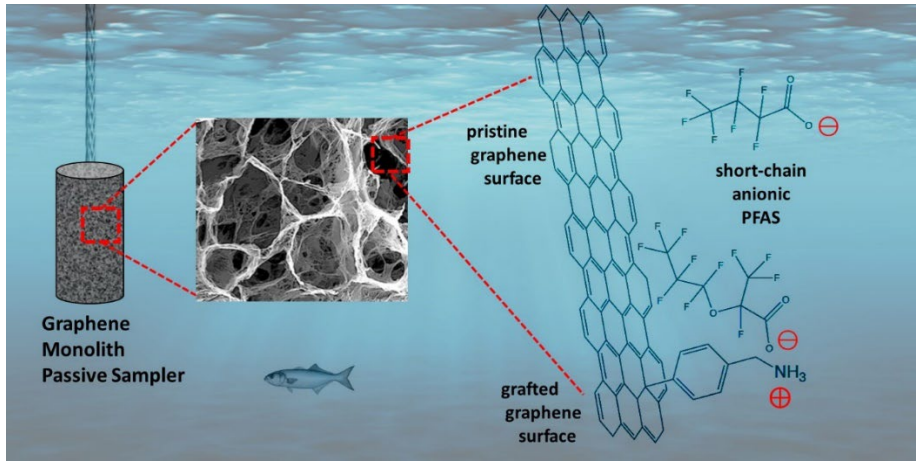
How do impacted communities contaminated with many different PFAS raw materials and by-products manage and/or mitigate public and environmental health risks?

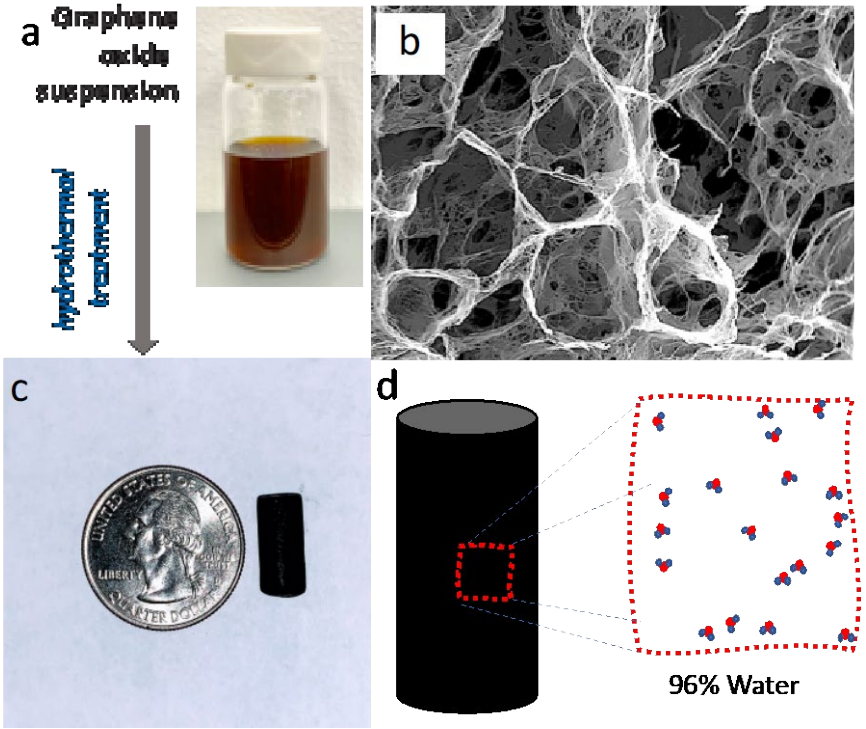
STEEP
Sources, Transport, Exposure & Effects of PFASs
UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM

Image source: https://www.ewg.org/research/update-mapping-expanding-pfas-crisis

A graphene-based hydrogel monolith with tailored surface chemistry for PFAS passive sampling

- *Jitka Becanova[1]*, Zachary Saleeba[2]*, Aidan Stone[2], Robert H. Hurt[2], Rainer Lohmann[1]*

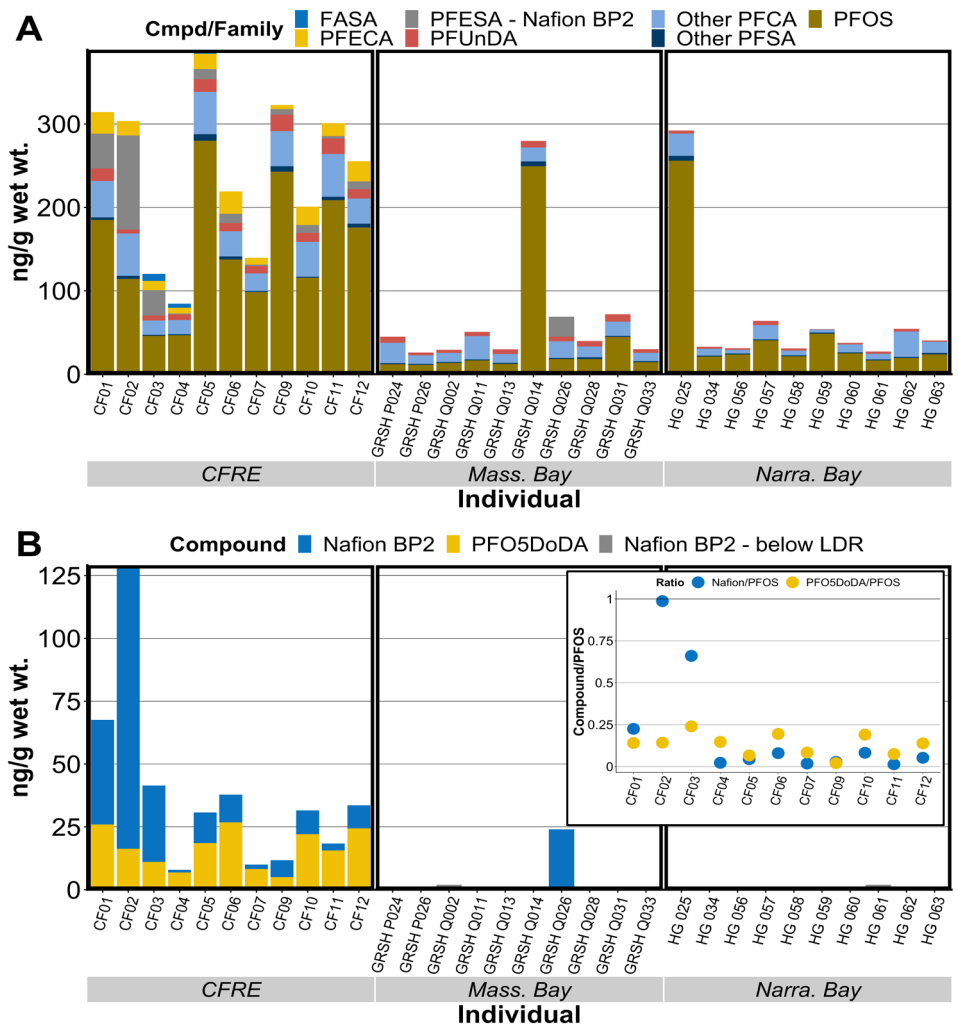




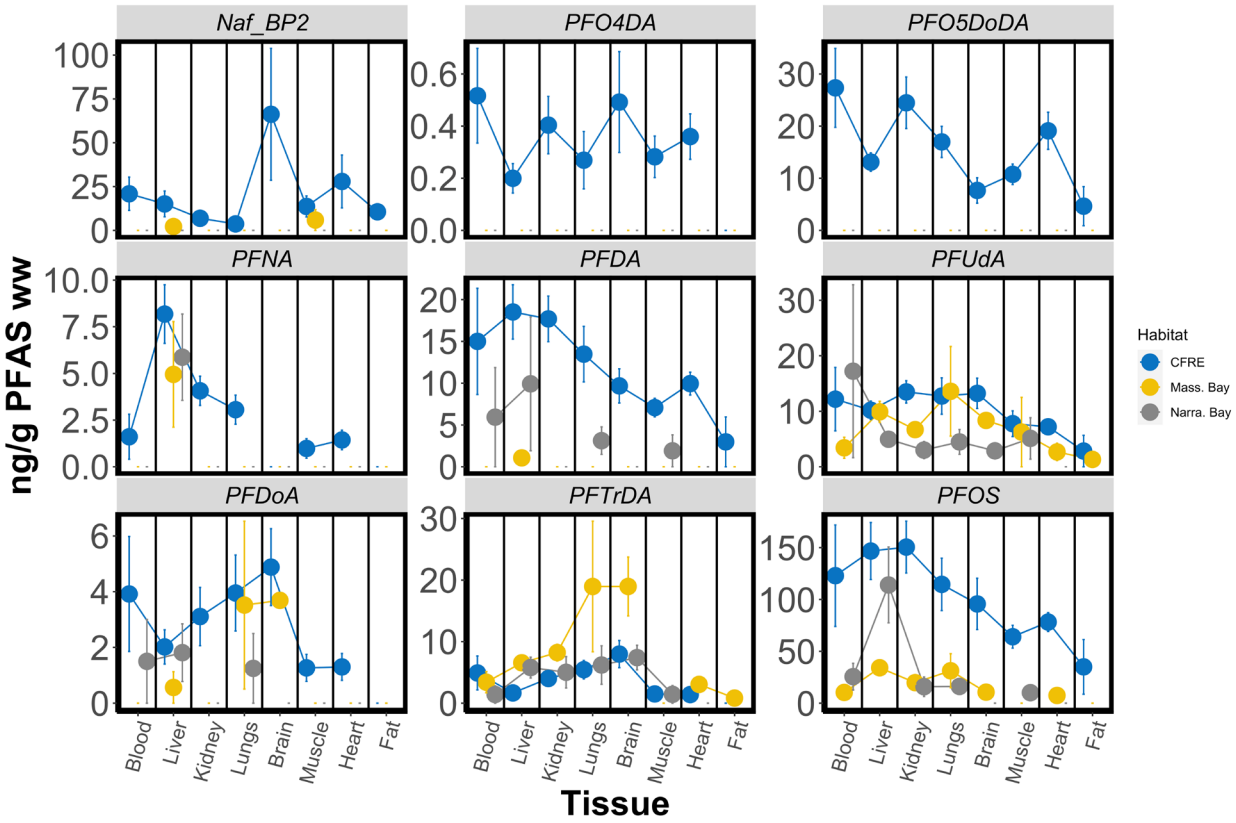
(Becanova et al., *2021*)

STEEP
Sources, Transport, Exposure & Effects of PFASs
UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM

Legacy and novel PFAS in birds



(Robuck et al, 2020)



(Robuck et al, 2021)

STEEP
Sources, Transport, Exposure & Effects of PFASs
UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM

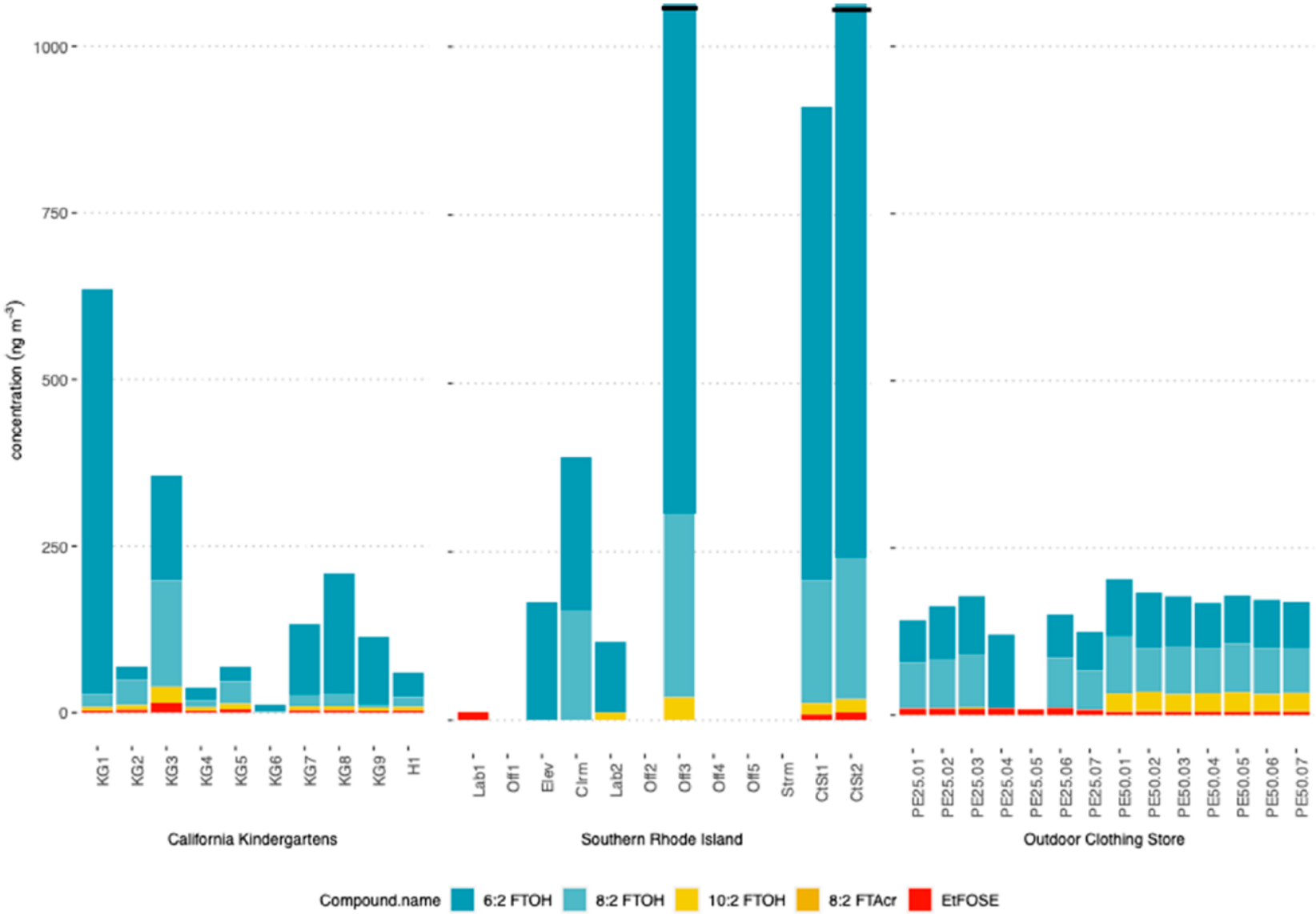


Figure 1. Indoor air concentrations measured in California kindergarten classrooms, an outdoor clothing store, university classrooms, offices and laboratories, and a carpet store in southern Rhode Island. Abbreviations: H, home; KG, kindergarten classrooms; Lab, laboratory; Off, office; Elev, elevator; Clrm, classroom; Ctst, carpet store; Strm, storage room. Numbers (i.e., KG7) are indicative of separate/individual samples. Off3 (2220) and CtSt2 (1040) have concentrations of >1000 ng m^{-3}.

Volatile and neutral PFAS were present at most locations, dominated by FTOHs

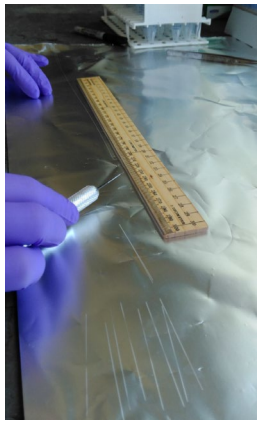
- (ME Morales-McDevitt et al., 2021)

STEEP
Sources, Transport, Exposure & Effects of PFASs
UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM

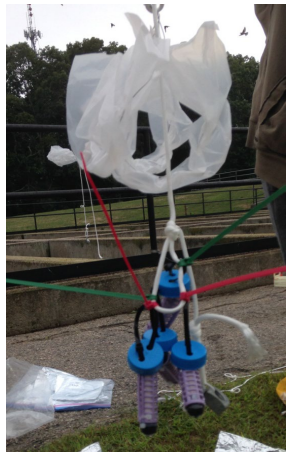
Project 4: Novel Detection tools

PI: Rainer Lohmann (URI)
Collab: Laurel Schaider (SSI); Barry Kim (U Guam)

- Develop novel sampling tools for PFASs and precursors in air, water, sediment and biota
- Support site characterization
- Enable stakeholder to deploy/use these samplers



- Aim 1: A thin fiber sampler for hotspots
- Aim 2: A passive sampler for water
- Aim 3: A sampler for (volatile) precursor PFASs



STEEP
Sources, Transport, Exposure & Effects of PFASs
UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM

Community engagement Core

Alyson McCann (URI), Laurel Schaider (SSI)

Project scope:

- Analyze samples from 250 wells
- 101 samples collected to date
- Analytes:
  - 25 PFASs (PFCAs, PFSAs, FtSs, FOSAAs)
  - Septic system markers (nitrate, boron)
- Questionnaires including well depth
- Report-back to participants using DERBI

Insights from meeting well owners:

- Perceptions of water quality challenges
- Barriers to water testing and treatment
- Common questions and concerns
  - Is my water safe to drink?
  - What do I do if my well is contaminated?
  - Are high cancer rates linked to water quality?

STEEP
Sources, Transport, Exposure & Effects of PFASs
UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM

Co-exposures to 5 main PFAS.. PFOS, PFOA, PFHxS, PFNA and PFDA

- BMDL of ~ 0.1 ng/mL serum for both PFOS and PFOA

RESEARCH ARTICLE

Application of benchmark analysis for mixed contaminant exposures: Mutual adjustment of perfluoroalkylate substances associated with immunotoxicity

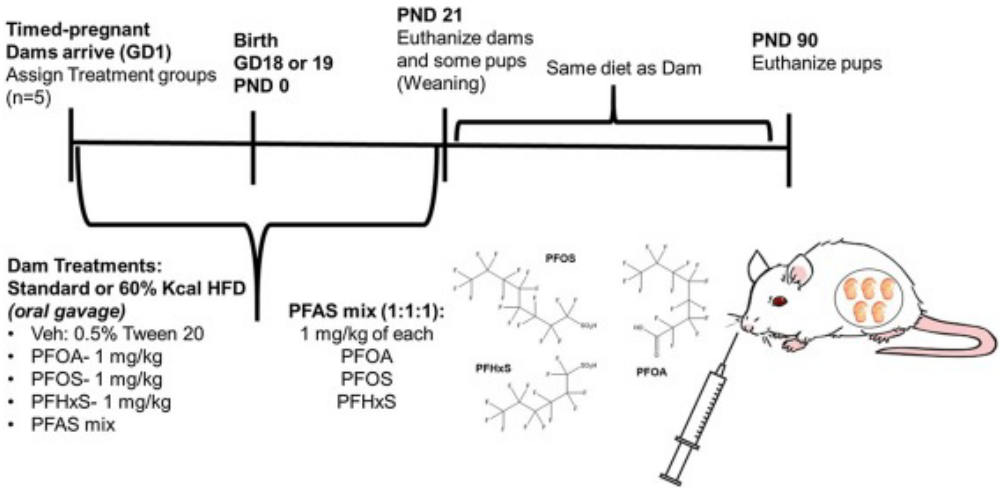
Esben Budtz-Jørgensen[1], **Philippe Grandjean**[2,3]*

1 Department of Biostatistics, Institute of Public Health, University of Copenhagen, Copenhagen, Denmark,
2 Department of Environmental Medicine, University of Southern Denmark, Odense, Denmark,
3 Department of Environmental Health, Harvard T.H. Chan School Public Health, Boston, Massachusetts, United States of America

* pgrand@hsph.harvard.edu

Our BMDL results, both before and after adjustment are generally below current exposure levels and therefore suggest that all five perfluorinated substances should attract regulatory attention, at least until additional evidence shows otherwise.

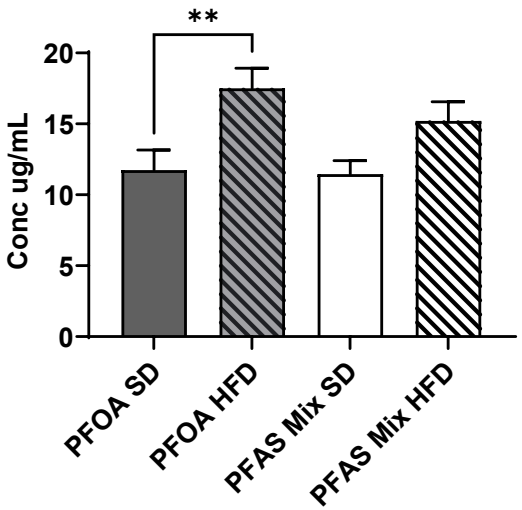
STEEP
Sources, Transport, Exposure & Effects of PFASs
UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM



Major Finding: Maternal diet and other PFAS can impact PFAS transfer (placental and lactational) from dam to pup.

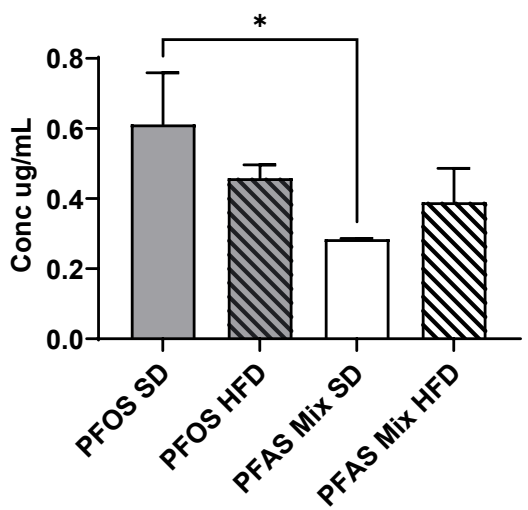
Check out the full Paper!

PND 21 Pups Serum PFOA



Maternal HFD increased Serum PFOA conc. in the pups

PND 21 Pups Serum PFOS



Serum PFOS conc. was lower in the pups of dams that received the mixture, where dam received same dose of PFOS as PFOS group alone

Symposium: PFAS Sum versus Some? The Science and Policy of Mixtures
(Thurs. March 31 in CC Room 7)
Dr Angela Slitt will be presenting some of this work in her talk entitled "Understanding PFAS-PFAS interaction in hepatocyte and Mouse Models of Steatosis

STEEP
Sources, Transport, Exposure & Effects of PFASs
UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM