Scaling a STEEP Summit

Fall 2019 Progress

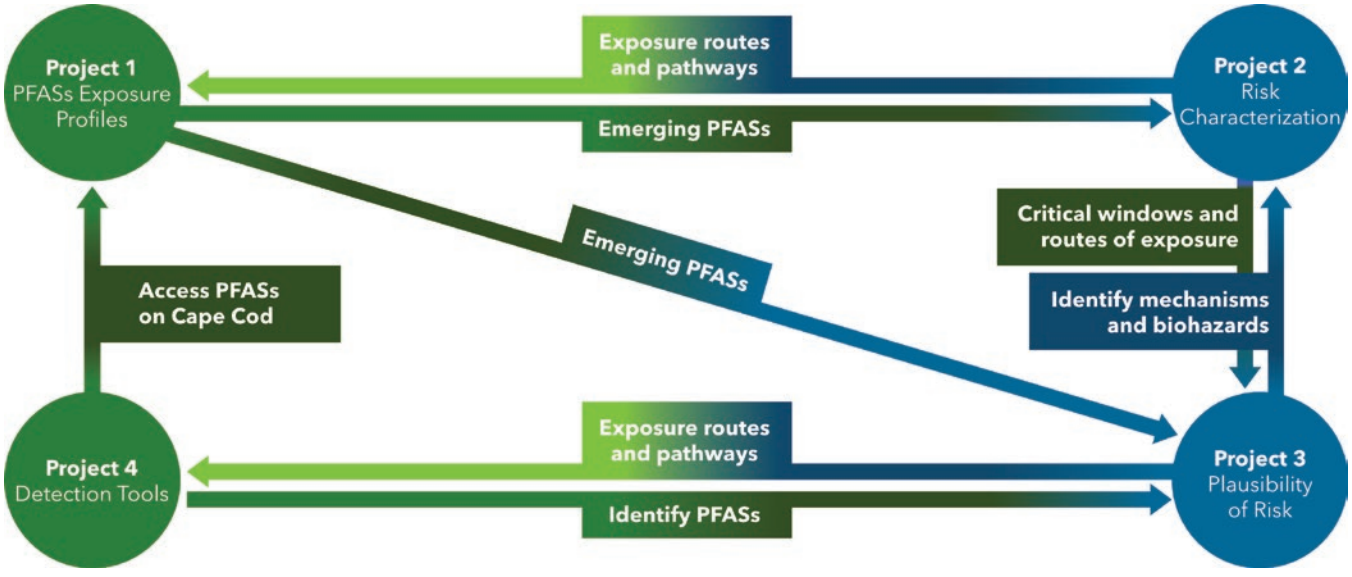
University of Rhode Island

I have been working for nearly 20 years in the field of emerging contaminants with particular focus on the coastal marine environment. From dioxins to PCBs, I have seen the damage that human-produced chemicals have wrought on human and environmental health; however, PFAS present a whole new level of challenges as they are extremely resistant to environmental degradation and are ubiquitous in groundwater and sediments as well as permeate the air. STEEP will continue to work with its stakeholders to ensure that the best available science is used to protect people from undue PFAS exposure.

For 30 years, I have dedicated my medical research to environmental epidemiology. My main emphasis is on the adverse health effects of environmental chemicals. As the fetus and the young child are likely to be highly vulnerable to toxic chemicals, most of my efforts have concentrated on studying the effects on early human development. To achieve the greater goal of prevention, we need to perturb this profound and insidious threat of PFAS exposure with science of the best possible quality. Through the support of NIEHS, STEEP supports our highest aspirations in addressing and preventing future health impacts caused by the ill-conceived use of untested chemicals.

Lead **Rainer Lohmann, PhD**
Graduate School of Oceanography
University of Rhode Island

Co-lead **Philippe Grandjean, MD DMSc**
Harvard T.H. Chan School of Public Health,
Department of Environmental Health



Director Lohmann and co-Director Grandjean combine complementary expertise in environmental and epidemiological science. They brought together a team of individuals that function as an effective and integrated interdisciplinary team. This includes researchers from the University of Rhode Island Graduate School of Oceanography, Coastal Institute, and Colleges of Pharmacy, Engineering, and the Environment and Life Sciences; Harvard T.H. Chan School of Public Health, Department of Environmental Health; and the Silent Spring Institute.

STEEP Overview

Per- and polyfluorinated alkyl substances (PFAS) are extremely resistant to environmental degradation and are found in humans and the environment around the world.

The most notable PFAS include perfluorooctanoic acid (PFOA) and perfluorooctanoic sulfonate (PFOS). In the U.S., there are industrial PFAS production and manufacturing sites, and over 600 fire/crash training sites nationwide where PFAS-containing aqueous film-forming foams have most likely contaminated groundwater and sediments. Additional human exposure results from widespread use of PFAS in consumer products, e.g., stain-resistant furnishings and carpets, grease-proof food packaging and wrappers. Production and use of PFOS and PFOA have declined in the U.S. since the early 2000s following a voluntary phase-out by 3M, and subsequent stewardship plans by U.S. EPA and international agreements. Industrial production in the U.S. shifted away from PFOA and PFOS as the public was provided evidence of their adverse human health impacts. As production decreased in the U.S., new fluorinated compounds have been and continue to be developed to meet society's demand. As a result, environmental contamination and human exposure continues.

Despite widespread PFAS use since the 1950s, there are still knowledge deficits about their environmental and public health impacts, thus this contaminant is considered emerging. STEEP is committed to researching compelling environmental and human health concerns to inform development of appropriate benchmark dose levels for PFAS. Moreover, STEEP will disseminate these research results to a variety of stakeholders as well as train the next generation of scientists essential to the management of these highly stable and ubiquitous compounds. In the past year, there has been a burgeoning awareness of the ubiquity of PFAS and its transport through consumer goods into the food web. From Vermont dairy farms to global applications of some 4700 permutations of PFAS, presence of these "forever chemicals" in humans and ecosystems is of growing concern and in urgent need of widespread attention.

RESEARCH PROJECTS OVERVIEW: STEEP Research Projects aim to better understand the pathways of PFAS contamination from entry into the environment through groundwater contamination, dispersal through the food web, and distribution to vulnerable human populations during early development, in part through breast milk. In addition, STEEP supports the development and deployment of in situ passive sampling techniques for PFAS and their precursors in water. STEEP is thereby addressing limitations in the current understanding of human exposure to PFAS by combining targeted human exposure assessment with chemometric approaches to characterize existing PFAS sources.

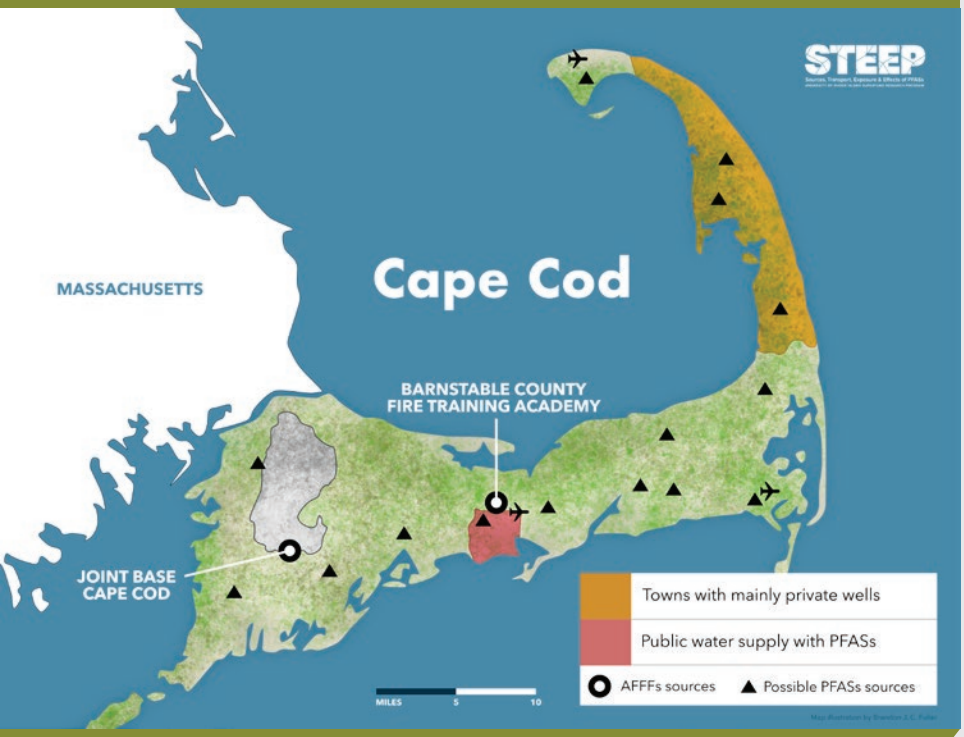
CORE OBJECTIVES OVERVIEW: To ensure a legacy of scientific awareness, dissemination of broadly accessible research findings, and practical application by affected communities, STEEP Cores serve to prepare the next generation of interdisciplinary emerging contaminant researchers, translate scientific findings generated by STEEP projects for internal and external stakeholders, and engage Cape Cod communities on the front lines of PFAS exposure through contaminated drinking water.

Communities

STEEP is focused on two study sites, one on Cape Cod and the other in the Faroe Islands. Barnstable County, MA, is STEEP's primary site for community engagement activities. STEEP partner Silent Spring Institute has conducted community-engaged research and activities focused on water quality and public heath on Cape Cod for more than 20 years.

Faroe Islands is STEEP's epidemiological research site, where for decades co-director Grandjean, in partnership with Pál Weihe, MD (Adjunct Professor, University of the Faroe Islands; Head, Department of Occupational Medicine and Public Health), has studied the impact of persistent chemicals on pre-natal and post-natal health which enriches STEEP's understanding of the adverse health impacts of PFASs.

The vast majority of people worldwide are exposed to some level of PFASs due to its presence in a wide range of manufactured products and consumer goods; however, some communities akin to STEEP study sites experience increased exposure from secondary sources. In Cape Cod, the additional exposure to PFASs is linked to contaminated groundwater that finds its way to residents' tap water. Communities in the Faroe Islands may experience additional exposure linked to a cultural tradition of consuming pilot whale meat and blubber.



Barnstable County, MA, is a Cape Cod area beloved for its sweeping coastline, quaint villages, and welcoming community ambiance. Groundwater on Cape Cod has been contaminated by PFASs from multiple sources. To date, these sources have been identified as fire training areas, airports, military bases, landfills, municipal wastewater, and septic systems. The spread of PFASs is exacerbated by Barnstable's location in an outwash plain with permeable soil. The result is that groundwater aquifers are highly susceptible to movement of contaminants from the surface of the ground—the place where surface water both contributes to aquifers and enters the food web. Once PFASs get into groundwater, they move with the groundwater and eventually can contaminate both public and private drinking water sources. Given these multiple inputs of PFASs and the unique geology of the area, there is an ongoing threat to Cape Cod's sole source aquifer that provides drinking water for 200,000 year-round and 500,000 summer residents.

The Faroe Islands consist of 18 remote, rocky, volcanic islands, which are connected by a network of roads, ferries, subsea tunnels, and bridges. Located in the Atlantic Ocean between Norway and Iceland, these remote islands are a self-governing archipelago of the Kingdom of Denmark. With a population of slightly more than 50,000, this prosperous fishing community is situated in the heart of the Gulf Stream in the North Atlantic, northwest of Scotland and halfway between Iceland and Norway. Faroese culture emphasizes tradition and the arts. In a generation, with the help of the fishing trade that accounts for approximately 20 percent of GDP, Faroese affluence has grown in the widespread use of technology and well-established infrastructure. Beginning in 1985, study cohorts of ~2300 Faroese children focused on the effects of mercury in their diet and later expanded to include PFASs. Consequently, the overall health threats from toxic chemicals to the current and future generations of Faroese are compelling and timely.

Project 1: Environmental Fate & Transport

Environmental Engineering: Exposure assessment and chemometrics of PFAS

CENTRAL HYPOTHESIS:

Some geochemical and hydrological conditions facilitate PFAS transport and precursor transformation near contaminated sites, increasing their propensity to enter drinking water and fish.

Lead: **Elsie Sunderland**
Harvard T.H. Chan School of Public Health, Department of Environmental Health (HSPH)
Harvard John A. Paulson School of Engineering and Applied Sciences (SEAS)

Key Personnel: **Alan Vajda**
University of Colorado-Denver (UCD)

Overview

More than 600 sites across the U.S. are contaminated by poly- and perfluoroalkyl substances (PFAS) but the extent of transport away from these sites and entry into human exposure pathways (drinking water and fish) is virtually unknown. This information is critical for assessing human health risks associated with exposures to PFAS from contaminated sites.

This project is investigating the diverse potential exposure pathways for PFAS. This work includes new measurements of PFAS present in water (surface waters, private wells, estuaries, tap water) and seafood in the Cape Cod/New England region and the Faroe Islands. The Joint Base Cape Cod (JBCC) is a contaminated superfund site located on Cape Cod. As part of project 1, STEEP researchers are investigating the fate of the

aqueous film forming foam (AFFF) contaminated plume as it mixes with other PFAS sources and enters surface waters, downstream rivers and ultimately the marine environment. In collaboration with Project 4, researchers at UC Denver are investigating the uptake and bioconcentration of PFAS in laboratory fish.

Aims of this project include:

- The development of novel statistical methods to fingerprint profiles of PFAS measured in fish and drinking water to better understand contamination sources. As part of STEEP research, this technique was applied to better understand sources of human exposure to different demographic groups in the Faroe Islands and North America (Hu et al., 2018). In addition, this technique was used to understand how PFAS exposure sources for children in the Faroe Islands have changed over time, following the phase-out in chemical production of PFOS and its precursors by 3M in North America (Dassuncao et al., 2018).
- Better understanding of how environmental factors influence the transport and transformations of PFAS away from contaminated sites and into surface waters and the marine environment. In collaboration with the USGS, Project 1 research has studied the dilution and transformations of PFAS and precursor chemicals as contaminated groundwater plumes from AFFF use enter surface waters and rivers on Cape Cod. This research is providing new insights into the lifetime of transport potential for PFAS precursors, measurements of PFAS accumulation at the air-water interface, and new insights into sorption mechanisms that retard PFAS transport.
- Improved understanding of the propensity of different PFAS in the contaminated groundwater environment to enter fish and the accumulation in different tissues. The University of Colorado Denver and USGS have developed a mobile laboratory/water-quality characterization approach to assess PFAS bioconcentration. Researchers are investigating associations between PFAS accumulation in laboratory fish and endocrine disruption, metabolic effects and immune responses.

One of the major expected outcomes of this work is a better understanding of the spatial extent of elevated PFAS concentrations in fish and drinking water from contaminated sites, which will also improve our understanding of the vulnerability of exposed communities to PFAS contamination.

Progress to date

New method for measuring organofluorine accumulation at the surface of consumer products

It is well-established that targeted mass-spectrometry is only able to capture a small fraction of the PFAS present in environmental samples, which may result in underestimates of the magnitude of contamination present in the environment and human exposure. In this work, STEEP researchers used a widely available instrument available at most major research centers (x-ray photoelectron spectroscopy: XPS) to measure the total organofluorine present at the surface of common consumer products. The new method development allows for a true surface measurement that can identify surface coatings (much shallower depth than the method developed using particle-induced gamma ray emission: PIGE) and also depth profiles for PFAS present at the surface of products. This allows investigators to determine the homogeneity in PFAS application to the product. Results based on XPS measurements agree well with other studies that have shown consumer products contain many PFAS that are not detected using targeted measurement techniques.

Understanding the relative importance of diverse human exposure pathways for PFAS

Project 1 researchers published a number of products this year aimed at better identifying the relative importance of drinking water, seafood and consumer products as exposure sources (reviewed in Sunderland et al., 2019). PFAS concentrations were measured in archived drinking water samples from 1989/1990 at locations across the United States. This work revealed significant associations between PFAS concentrations in drinking water and serum PFAS concentrations in the background US population (away from contaminated sites), indicating the ubiquity of drinking water exposures to PFAS for many US individuals (Hu et al., 2019). Work conducted in collaboration with Project 2 in the Faroe Islands revealed that even in a remote fishing community in the Faroes, a large fraction of exposure originates from use of diverse consumer products containing PFAS and non-seafood sources (Dassuncao et al., 2018, Hu et al. 2018). Researchers showed that concentrations of legacy PFAS in the serum of children declined rapidly following the phase-out in PFOS production between 2000-2002, likely reflecting the elimination of PFOS and its precursors from consumer sources. These “steep” declines indicate the potential benefits from coordinated global action controlling production sources.

Bioaccumulation of PFAS in the marine food web

Research conducted collaboratively between Project 1 and Project 4 is providing new insights on accumulation of PFAS in seawater and uptake of PFAS in marine food webs (Zhang et al., 2019). This work suggests that contaminated submarine groundwater discharge may be a concern for some Northeast estuaries and delay recovery of PFAS contaminated sites when sources have been eliminated. It also suggests that short-chain PFAS precursors are contributing to higher than expected concentrations measured in marine plankton from the Northeastern Atlantic Ocean shelf and slope, which is likely to influence their accumulation in higher trophic level organisms consumed by humans and wildlife.

Tissue distribution of PFAS in marine mammals

Project 1 research, in collaboration with Project 3, has also been studying the toxicokinetics of PFAS distribution among the tissues of marine mammals and the controlling role of phospholipids for tissue distribution (Dassuncao et al., 2019). This research focused on pilot whales, which are an important exposure pathway for individuals in the Faroe Islands — the focus of Project 2 research. Results have shown preferential accumulation of long-chain PFAS in the brain of pilot whales, likely indicating facilitated transport mechanisms for some PFAS. In addition, high concentration of the C-6 carboxylate were found in the liver, which is consistent with the role of specific binding proteins such as liver fatty acid binding proteins (FABP) affecting accumulation in different target sites. These hypotheses are being further evaluated by work associated with Project 3. Overall, this research has shown that a revised toxicokinetic model based on the phospholipid content of different organisms would improve the ability to represent tissue accumulation and bioaccumulation of PFAS.

Research highlight: Modeling human exposure to poly- and perfluoroalkyl substances (PFAS) from source to dose

Traditional approaches in exposure assessment rely on bottom-up estimates including contact frequency and environmental concentrations and are data intensive, which can result in large uncertainties. Xindi (Cindy) Hu and co-authors in the Sunderland Lab developed a source tracking approach that uses correlations among multiple chemical homologues in environmental samples to derive information on their origin. This process is referred to as “chemical fingerprinting” and has been applied to polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs). In a publication in Environmental Health, (Hu et al., 2018) contrasted unique serum PFAS profiles in whaling men, children, and pregnant women, and associated dominating exposure sources with elevated compositions of certain PFAS tracers. This method can be further enhanced with the expanded list of PFAS measured in multiple sources (such as food,

drinking water, indoor air, and dust) under other ongoing STEEP projects. Comprehensive data combined with this innovative source tracking approach will help impacted communities understand their major exposure source and help policy makers design the most effective public health intervention to prevent harmful health impacts of PFAS.

Clifton Dassuncao and co-authors in the Sunderland Lab developed statistical and toxicokinetic models to better understand how PFAS exposures of children from populations that frequently consume seafood were affected by changes in the use and release of legacy PFAS around the year 2000. Principal component analysis (PCA) identified two groups of PFAS that likely reflect exposures from diverse consumer products and a third group that consisted of perfluorocarboxylic acids (PFCAs) with nine or more carbons that were strongly associated with mercury in children's hair, a well-established proxy for seafood consumption. Researchers found that even in this remote population of frequent seafood consumers, rapid declines in PFAS measured in children's serum between 1993 and 2012 parallel those reported in other parts of the world, indicating the ubiquitous role of consumer products to overall exposures.

Research highlight: Determining PFAS fate and transport in groundwater and surface-waters

PFAS have been shown to be highly mobile in groundwater and surface-water, resulting in frequent contamination of drinking water supplies located near PFAS point sources. The geochemical mechanisms that dictate PFAS fate and mobility are not well understood. Andrea Tokranov and co-authors in the Sunderland Lab at Harvard and in the U.S. Geological Survey are investigating associations between chain length, head group, and geochemical tracers at a field site located on Cape Cod, MA. The research has shown that perfluoroalkyl acid (PFAA) precursors can be highly mobile in the field, suggesting that conventional methods significantly underestimate total PFAS exposure. Further, there is evidence suggesting these mobile precursors are highly

persistent in both oxic and anoxic conditions and are transported across groundwater/surface-water interfaces. Ongoing and future work will focus on how groundwater/surface-water interactions can influence PFAS concentrations, which is relevant for many drinking water supplies.

Plan for upcoming year

- Characterization of geochemical and hydrological factors controlling the spread and concentrations of PFAS surrounding downstream of AFFF impacts sites.
- A new method for modeling vulnerability of private wells for high PFAS concentrations using machine learning approaches and monitoring data from the state of New Hampshire.
- New work measuring and modeling PFAS bioaccumulation in freshwater fish and marine food webs in the Northeastern US.
- Results on bioconcentration of PFAS by Dr. Alan Vajda and colleagues at UCD and the USGS based on their mobile laboratory measurements and in collaboration with Project 4.

PROJECT 1 TRAINEES

Heidi Pickard, PhD Candidate, Harvard SEAS
Bridger Ruyle, PhD Candidate, Harvard SEAS

PROJECT 1 GRADUATES

Andrea Tokranov, PhD (June 2019), Harvard SEAS
Clifton Dassuncao, PhD (May 2018), HSPH
Xindi (Cindy) Hu, PhD (May 2018), HSPH

SELECTED ACCOMPLISHMENTS

Dassuncao C, **Hu XC**, Zhang X, Bossi R, Dam M, Mikkelsen B, & **Sunderland EM** (2017). Temporal shifts in poly-and Perfluoroalkyl substances (PFASs) in North Atlantic pilot whales indicate large contribution of atmospheric precursors. Environmental Science & Technology, 51(8), 4512-4521.

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X.C. Hu, **A.K. Tokranov**, J. Liddie, X. Zhang, **P. Grandjean**, J.E. Hart, F. Laden, Q. Sun, L.W.Y. Yeung, **E.M. Sunderland**. 2019. Tap water contributions to plasma concentrations of poly- and perfluoroalkyl substances (PFASs) in a nationwide prospective cohort of U.S. women. Environmental Health Perspectives. 127(6):067006.

C. Dassuncao, **H. Pickard**, **M. Pfohl**, **A.K. Tokranov**, M. Li, B. Mikkelsen, **A. Slitt**, **E.M. Sunderland**. 2019. Phospholipid levels predict tissue distribution of long-chained poly- and perfluoroalkyl substances (PFASs) in a marine mammal. Environmental Science & Technology Letters. 6(3): 119-125.

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C. Dassuncao, **H. Pickard**, **M. Pfohl**, **A.K. Tokranov**, M. Li, B. Mikkelsen, **A. Slitt**, **E.M. Sunderland**. 2019. Phospholipid levels predict tissue distribution of long-chained poly- and perfluoroalkyl substances (PFASs) in a marine mammal. Environmental Science & Technology Letters. 6(3): 119-125.

A.K. Tokranov, N. Nishizawa, C.A. Amadei, J.E. Zenobio, **H.M. Pickard,** J.G. Allen, C.D. Vecitis, **E.M. Sunderland**. 2019. How do we measure the poly- and perfluoroalkyl substances (PFASs) at the surface of consumer products? Environmental Science & Technology Letters. 6(1): 38-43.

X.C. Hu, **A.K. Tokranov**, J. Liddie, X. Zhang, **P. Grandjean**, J.E. Hart, F. Laden, Q. Sun, L.W.Y. Yeung, **E.M. Sunderland**. 2019. Tap water contributions to plasma concentrations of poly- and perfluoroalkyl substances (PFASs) in a nationwide prospective cohort of U.S. women. Environmental Health Perspectives. 127(6):067006.

Project 2: Childhood Risk

Epidemiological Study: Inflammation and metabolic changes in children developmentally exposed to PFAS

CENTRAL HYPOTHESIS:

Dietary exposure to PFAS during fetal development and childhood can interfere with immune system development and metabolism and thereby pave the way for later disease development.

Lead: **Philippe Grandjean**, Harvard T.H. Chan School of Public Health, Department of Environmental Health (HSPH)

Clinical Lead: **Pál Weihe, MD**, Adjunct Professor at The University of the Faroe Islands and Head of the Department of Occupational Medicine and Public Health

Overview

Poly- and perfluoroalkyl substances (PFAS) are widely used industrial chemicals, but widespread human PFAS exposures from contaminated sites and bioaccumulation in food-chains were discovered less than 20 years ago, and the full range of adverse health effects is not completely known. Recent evidence suggests that current PFAS exposures may cause adverse effects on the immune system and other sensitive tissues and organs, even at exposures far below provisional exposure limits. Early-life exposure to PFAS may contribute to the development of metabolic diseases, including obesity and type 2 diabetes. PFAS can also decrease antibody response to certain childhood vaccinations, and most PFAS are transferred through breast milk.

Relying on an already established birth cohort in the Faroe Islands that has been supported by NIEHS, this project is utilizing exposure and outcome data covering

a 9-year span to determine possible links between PFAS exposure profiles, immune dysfunction, and metabolic abnormalities. Due to the homogeneity of the Faroese population, the wide range of exposures, and the high participation rate in the clinical follow-up, this epidemiological setting represents advantages that would be nearly impossible to match anywhere else.

The data analysis takes into account additional factors, including exposures to other environmental chemicals, sex of the child, and diet. Overall, this will allow us to calculate benchmark doses for possible use in risk characterization in U.S. populations exposed to PFAS.

Progress to date

Through interdisciplinary collaboration and a shared commitment to bettering the health of communities impacted by environmental PFAS contamination, the STEEP Center team has made steady and promising progress in upholding the commitment to the Cape Cod and Faroe Island communities while advancing the science on PFAS exposure.

This project is an epidemiological study which takes advantage of a prospective birth cohort (N = 490) established in the Faroe Islands, a North Atlantic fishing community where early-life exposures to persistent environmental pollutants, such as PFAS, have been linked to obesity and related metabolic conditions in previous epidemiological studies. The cohort was generated from consecutive births between 2007 and 2009 and is the largest and most thoroughly examined group of PFAS-exposed children followed since birth. Progress to date includes:

- Completion of all clinical exams and blood work of the cohort members (8-9 years) who accepted the invitation to participate and re-consented (N = 407, 210 boys and 197 girls; 83% participation). Also, 385 DEXA scans have been completed and the remaining children will be re-invited.
- Clinical data have been entered into the database. Routine blood tests have been completed, and preliminary results show (anticipated) low vitamin D concentrations.
- Samples have been transferred to the analytical laboratories, where exposure biomarkers and inflamma-

tion/immune function variables will be determined. As several analyses are not considered routine, this work is being preceded by refinement and quality assurance.

- Serum-PFAS analytical methods have been upgraded and optimized on a new and more sensitive UPLC-MS/MS system comprising a Thermo Scientific EQuan MAX module for online solid-phase extraction and a TSQ Quantiva triple quadropole mass spectrometer. All exposure biomarker analyses have been completed.

Plan for upcoming year

- Completion of all serum parameters that reflect vaccine responses and indicators of inflammation and metabolism, followed by data entry for all Cohort 5 participants.
- Carry out initial analysis of clinical data, including DEXA scans, in regard to PFAS exposure biomarkers.
- Commence advanced statistical data analyses, including calculation of derived parameters, structural equation models, and benchmark dose, in collaboration with subcontractors.

PROJECT 2 TRAINEES

The previous trainee for Project 2, Damaskini Valvi, recently accepted a position at the Mount Sinai School of Medicine as an Assistant Professor in Environmental Medicine & Public Health (https://www.mountsinai.org/profiles/valvi-damaskini). A search is now underway for a new postdoc for the trainee role.

SELECTED ACCOMPLISHMENTS

Publications

Ammitzbøll C, Börnsen L, Petersen ER, Oturai AB, Søndergaard HB, **Grandjean P**, Sellebjerg F. Perfluorinated substances, risk factors for multiple sclerosis and cellular immune activation. J Neuroimmunol 2019; 330: 90-5. PMCID: PMC6461219

Barouki R, Melén E, Herceg Z, Beckers J, Chen J, Karagas M, Puga A, Xia Y, Chadwick L, Yan W, Audouze K, Slama R, Heindel J, **Grandjean P**, Kawamoto T, Nohara K. Epigenetics as a mechanism linking developmental exposures to long-term toxicity. Environ Int 2018; 114: 77-86. PMCID: PMC5899930

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Presentations

Grandjean P. New insights into risks to human health. 2019 Per- and Polyfluoroalkyl Substances: Second National Conference: Northeastern University, Boston, MA. June 12, 2019.

Grandjean P. New insights into risks to human health: The immune system. New England PFAS Workshop hosted by the American Groundwater Trust: Westford, MA. September 16, 2019

Project 3: Metabolic Effects

PFAS compound effects on metabolic abnormalities in rodents

CENTRAL HYPOTHESIS:

PFAS exposure leads to metabolic abnormalities in rodents and can be linked back to preferential sorption of PFAS to biomolecules.

Co-lead: **Angela Slitt**, URI College of Pharmacy (Pharm)

Co-lead: **Geoffrey Bothun**, URI College of Engineering (COE)

Overview

Human exposure to poly- and perfluoroalkyl substances (PFAS) has been linked to immunotoxicity and cancer as well as metabolic disorders and cholesterol levels. Specific to metabolic disorders, PFAS are known to concentrate in the liver and links have been established between PFAS serum levels, specifically perfluorooctanoic acid (PFOA) and perfluorosulfonic acid (PFOS), and liver injury. While these findings are insightful, these two common PFAS chemicals represent only a fraction of PFAS that exist within the contaminated sites. Mechanisms driving biological response to PFAS compounds are still being investigated.

This project will:

- Address whether environmental exposure to PFAS contributes an additional increase risk for obesity-induced fatty liver disease and metabolic disorders.
- Identify the physicochemical and partitioning behavior of PFAS that contribute to bioaccumulation.
- Test the hypotheses that (1) PFAS exposure increases diet-induced fatty liver disease and inflammation, and (2) that the biological changes in the liver can be correlated with the body's response to PFAS.

These project results will inform how PFAS exposure impacts risk factors common in the U.S. population (e.g., diet and obesity).

Progress to date

Slitt Lab

- Established adipocyte and hepatocyte assays and completed 100% of the screening efforts and also have screened additional emerging PFAS. Aim 1 of the parent proposal is >85% complete.
- Established methods for PFAS measurement in tissues by LC-MS.
- Established methods in untargeted proteomics to generate novel data using a state-of-the art and innovative platform; now able to detect and quantify >1000 proteins and detect induction of proteins known to be induced in mouse liver with PFOS treatment and a pipeline for proteomics data.
- A pilot study for PFOS perinatal exposure has been completed and the manuscript is currently being written. A larger study including the high-fat diet is underway. Dr. Slitt's lab will be collecting breast milk from mice to integrate with STEEP Project 2.

Bothun Lab

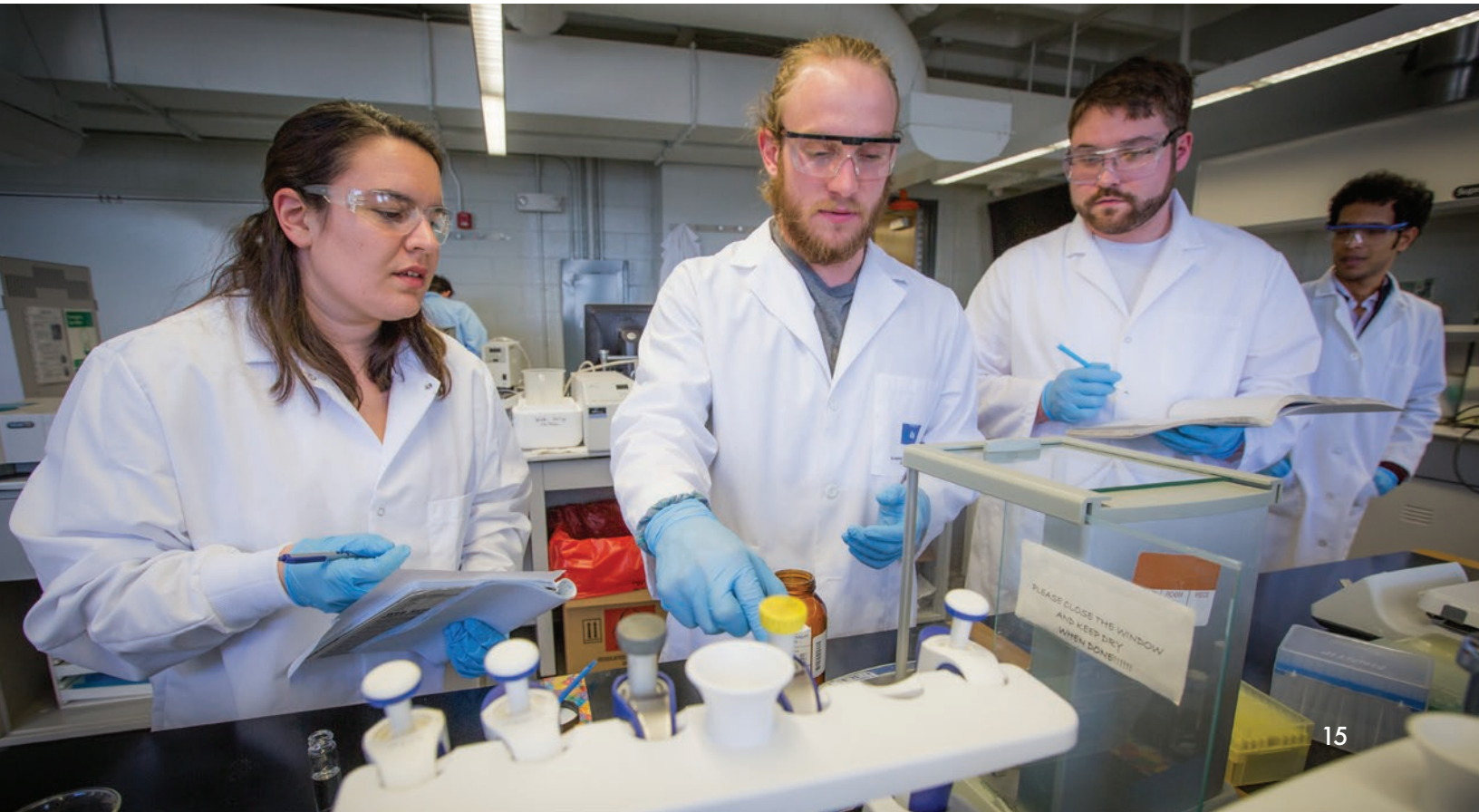
- Determined protein binding (BSA) for a series of carboxylates (PFOA, PFNA, PFDA, GenX) and sulfonates (PFBS, PFHxS, PFOS) and their hydrocarbon

analogs based on fluorescence quenching. Molecular volume (van der Waals) was identified as a good parameter to describe binding behavior for all PFAS studied. Fluorocarbons are more hydrophobic than their hydrocarbon analogs, leading to greater entropy gains with protein binding.

- BSA binding constants, which are based on PFAS intermolecular interactions, were correlated with proteomics data associated with lipid metabolism, transport, and synthesis, as well as drug metabolism, cholesterol, and redox potential. Lipid metabolism and synthesis showed the best correlation and suggest that PFAS with lower protein affinity lead to greater lipid metabolism and synthesis.
- Fluorine NMR has revealed mechanistic insight into PFAS binding (PFOA, PFNA, PFOS, PFHxS). This was achieved by monitoring the carbon at the hydrophobic end of the PFAS and the carbon connected to the charged PFAS headgroup. Experiments were conducted as a function of temperature to determine thermodynamic properties.
- Preliminary results demonstrate significant ordering effects of PFOA on a bacterium membrane, Alcanivorax borkumensis (hydrocarbon degrading marine bacteria). Fluorescence anisotropy (polarization) experiments were conducted by labelling the membrane with an anisotropic probe and exposing the bacteria during or after growth to increasing PFOA concentrations. Ordering was observed well below 1 mm PFOA, highlighting the importance (we hypothesize) of strong headgroup interactions between PFOA and membrane lipids or the ability of PFOA to occupy defect within the acyl tail region and increase van de Waals interactions.

Plans for upcoming year

- Publish manuscripts related to Aims 1 and 2 (specific Aims are in reference to parent proposal).
- Continue to integrate data sets from Aim 1 and Aim 3.
- Complete Aim 2 mouse study and analysis of key tissues of interest (i.e. liver, brain).
- Expand upon Aim 1 findings, to include proteomics for human hepatocyte work and evaluate mechanisms of cellular uptake.
- Transition from BSA to human proteins for protein binding studies.
- Extract membrane lipids from hepatocytes to conduct membrane partitioning studies using reconstituted bilayer membranes or monolayers.
- Solidify a vision for Project 3 aims for renewal



PROJECT 3 TRAINEES

Michael Fedorenko, MS Student, COE URI
Emily Marques (formerly **Martell**), PhD Student, Pharm URI
Jessica Alesio (formerly **Orr**), PhD Student, COE URI
Marisa Pfohl, PhD Student, Pharm URI

SELECTED ACCOMPLISHMENTS

Poster Presentations

Orr J, Fedorenko, **M, Bothun G**. Protein Pairing and Lipid Linking: Mechanistic Studies Reveal the Effects of Environmental Conditions and PFAS Mixtures. Spring ACS meeting, Orlando, FL, April 2, 2019.

Pfohl M*, Ma H, Aubustan M, **Martell E**, Seeram N, **Slitt A**. Low Dose Perfluorooctane Sulfonate (PFOS) is Associated with Induction of Fatty Acid Uptake Mechanisms in Diet-induced Non-alcoholic Fatty Liver Disease (NAFLD). Poster presentation at the Northeast Society of Toxicology Regional Chapter Meeting, Shrewsbury, MA, October 20, 2017. *Winner of NESOT poster presentation

Invited Presentations

Marques E. and **Slitt A.** PFASs human health effects. Memphremagog Watershed Association, 2019 Annual Meeting: The Science and Monitoring of PFAS/PFOA, Gateway Center, Newport VT, June 21st, 2019.

Marques E., **Pfohl M.**, Wei W., Amaeze O., and **Slitt A.** (2019). Gene expression and lipid accumulation profiles for perfluoroalkyl acids (PFAA) and PFAA mixtures in human hepatocytes. Session Title: Analyzing the Heath Effects of Complex Mixtures of Chemical and Non-Chemical Environmental Stressors. Northeast Superfund Research Program Meeting, Boston, MA, April 4, 2019

Marques E., **Pfohl M.**, Wei W., Amaeze O., and **Slitt A.** (2019) Targeted gene expression assays reveal markedly different gene expression and lipid accumulation profiles for perfluoroalkyl acid (PFAA) mixtures compared to single PFAA treatment in cryopreserved human hepatocytes. Platform Session SPC Highlights Emerging Scientists: Adverse Effects of Perfluorinated Alkyl Substances. The Toxicologist, 1721. Society of Toxicology Annual Meeting, Baltimore, MD, March 23, 2019.

Pfohl M. (2019). An 'omics approach to PFAS induced toxicity. North East Superfund Research Program (NE-SRP). Big Data in Environmental Health: Collection, Synthesis, Analysis and Use (selected session speaker).

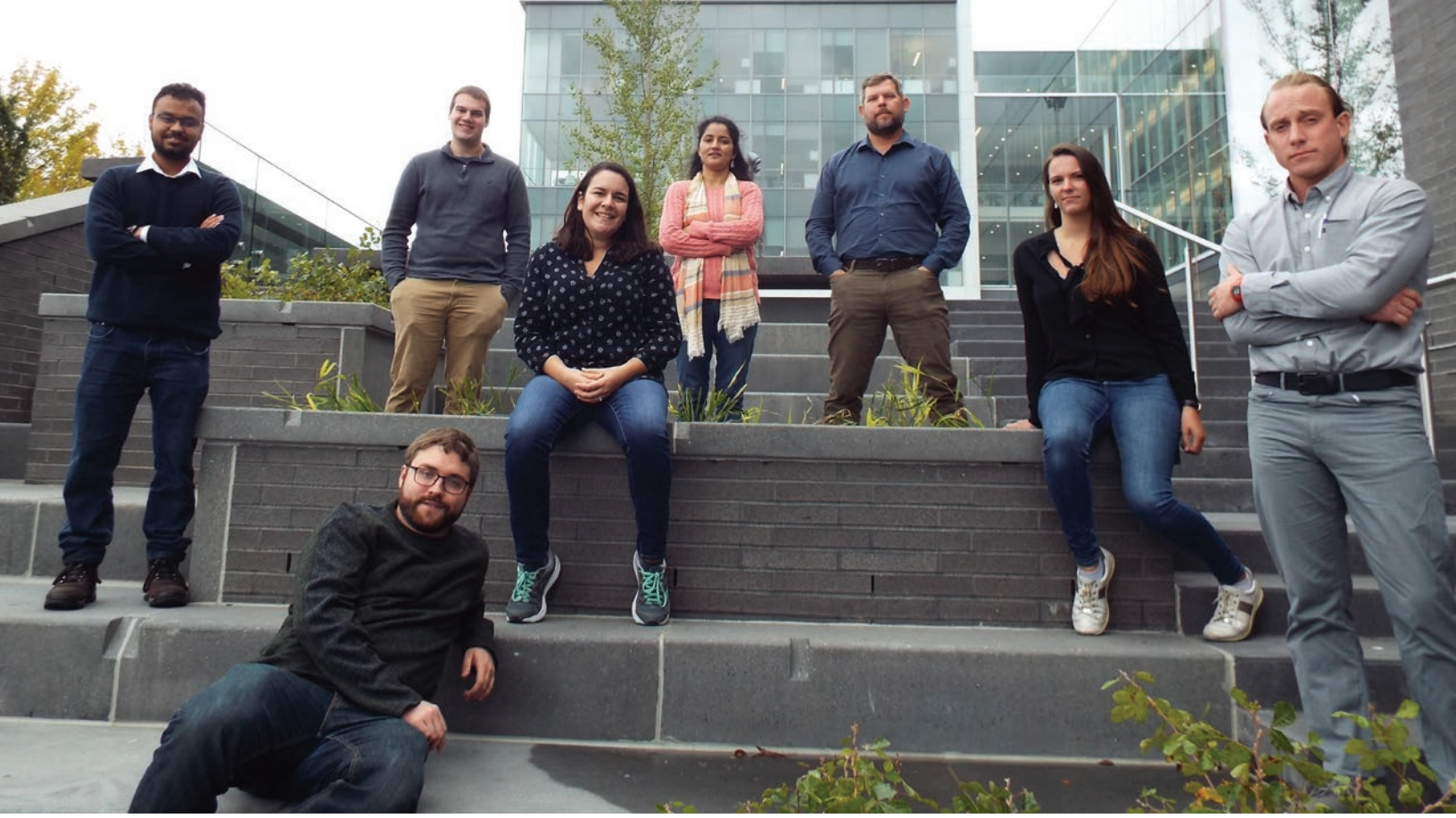
Pfohl M. (2019). An 'omics approach to unraveling the paradoxical effect of diet on PFOS and PFNA induced non-alcoholic fatty liver disease (NAFLD). Society of Toxicology (SOT), Medical Devices and Combination Product Special Section (awardee presentation).

Pfohl M. (2019). An 'omics approach to unraveling the paradoxical effect of diet on PFOS and PFNA induced non-alcoholic fatty liver disease (NAFLD). Society of Toxicology (NESOT), Regional Chapter Student Speaker Session (selected student speaker).

Slitt A. Evaluation of PFAS Interaction with Moderate and High Diet Fats in Mouse Models of Obesity. Oral presentation at Federal Exchange on PFAS, February 2-6, 2018.

Slitt, Angela, Invited speaker, xMAP Connect 2018 in Boston, Use of xMAP Technologies Quantify Gene Expression and Address Potential Cytochrome P450 Inducers, September 2019.

Slitt, Angela, Invited Symposium speaker, Society of Toxicology Annual Meeting, Evaluating Diet-PFAS Interactions in Models of Obesity and NAFLD, March 2019.



Slitt, Angela, Invited speaker, New England Interstate Water Pollution Control Commission (NEIWPCC) Presentation, PFAS Human Health Concerns, January 2019.

Slitt, Angela, Invited speaker, Biology Department, Bates College, Evaluating Perfluoroalkyl substances as disruptors of metabolic homeostasis, February 2019.

Slitt, Angela, Invited speaker, OMICS in Environmental Health Research Symposium, University of Southern California, March 2019.

Slitt, Angela, Invited speaker, PFAS Conference, Boston University, Targeted gene expression assays reveal more potent induction of gene expression and lipid accumulation for newer generation PFASs in cryopreserved human hepatocytes, June 2019.

Slitt, Angela, Invited speaker, Cellular and Molecular Mechanisms of Toxicity, Gordon Research Conference, Evaluating Diet-PFAS Interactions in Models of Obesity and NAFLD, August 2019.

Manuscripts

Salter DM, Wei W, Nahar P, and **Slitt A**. Perfluorooctanesulfonic acid (PFOS) thwarts the beneficial effects of caloric restriction and metformin. Submitted to Toxicological Sciences, August 2018.

Dassuncao, C., **Pickard, H.**, **Pfohl, M.**, **Tokranov, A.K.**, Li, M., Mikkelsen, B., **Slitt, A.**, and **Sunderland, E.M.** (2019). Phospholipid Levels Predict the Tissue Distribution of Poly- and Perfluoroalkyl Substances in a Marine Mammal. Environ. Sci. Technol. Lett. 6, 119-125.

Salter DM, Wei W, Nahar P, and **Slitt A**. Perfluorooctanesulfonic acid (PFOS) thwarts the beneficial effects of caloric restriction and metformin. Re-submitted to Toxicological Sciences.

Marques E, **Pfohl M**, Jamwal R, Barlock BJ, Goedken M, Akhlaghi F, **Slitt A.L.**, Proteomics reveals PFOS induced alterations in lipid utilization and xenobiotic metabolism in a model of PFOS-augmented diet induced fatty liver. Submitted to Toxicological Sciences.

Marques ES, **Pfohl M**, Picard C, Jamwal R, Barlock B, and **Slitt AL**. Perfluorooctanesulfonic acid (PFOS) worsens hepatic steatosis in mice fed a high fat diet and alters lipid uptake and metabolism pathways. In Preparation for submission to Toxicological Sciences.

Marques ES, **Pfohl M**, Wei W, Amaeze O, and **Slitt AL**. Targeted gene expression assays and lipid accumulation profiles for perfluoroalkyl acid (PFAA) cryopreserved human hepatocytes. In Preparation for submission to Environmental Science and Technology.

Awards

MDCPSS Student Travel Award, Feb. 2019, SOT Medical Device and Combination Product Specialty Section (**E. Marques**).

Selected as 2019/2020 Graduate Student Representative of the Mechanisms Specialty Section of the Society of Toxicology (**E. Marques**).

Milestones

Marisa Pfohl – approved dissertation proposal, passed comprehensive examination.

Marisa Pfohl will be defending her doctoral dissertation in October 2019. She has taken a postdoctoral position at the Environmental Protection Agency.

Project 4: Detection Tools

Environmental Engineering: Develop passive samplers for the detection and bioaccumulation of PFASs in water and porewater

CENTRAL HYPOTHESIS:

Passive sampling can be used to detect PFAS and their precursors in air, water, and porewater.

Lead: **Rainer Lohmann**, Graduate School of Oceanography, University of Rhode Island (GSO)

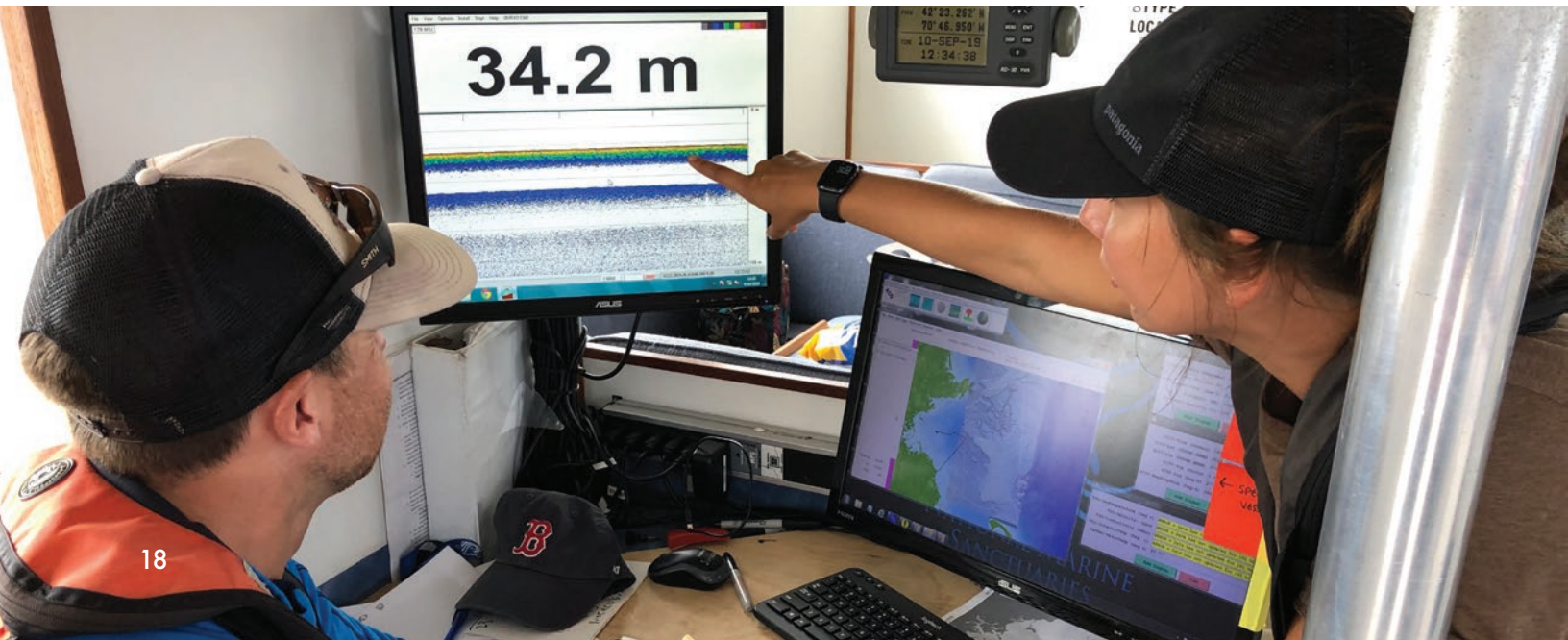
Key Personnel: **Laurel Schaider**, Silent Spring Institute (SSI)

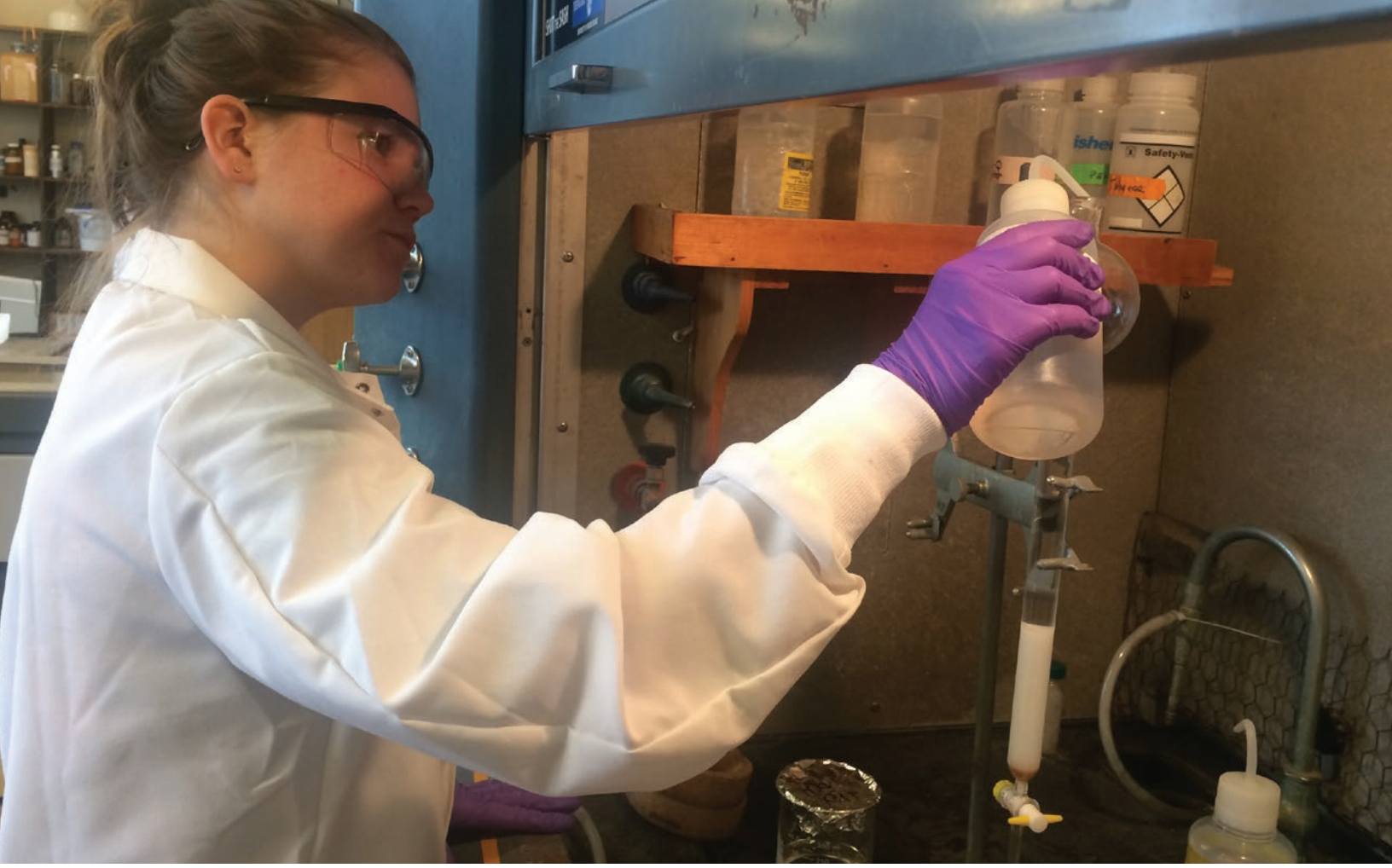
Overview

This project is developing, validating, and deploying novel passive samplers for the detection of poly- and perfluoro-alkyl substances (PFAS) in air, water, and porewater (water in the sediment). At contaminated sites, as the extent of a PFAS plume is investigated, benefits of field-validated passive sampling approaches include ease of handling, shipping, and analysis; reduced potential for contamination; and lower detection limits that will be needed as regulatory agencies adjust their references doses.

This project is:

- Developing a porewater fiber for measuring PFAS concentrations.
- Collaborating with U.S. Environmental Protection Agency to determine PFAS accumulation in bivalves (e.g., mussels and oysters), and comparing these results to the novel passive samplers.
- Validating PFAS passive sampling tools.





Sites for field validation and application are located on Cape Cod, MA, including in ponds near Joint Base Cape Cod, where groundwater is contaminated by aqueous film forming foams (AFFF). Researchers are engaging residents and stakeholders to address concerns about long-range PFAS transport and characterizing the extent of impacted ponds, creeks, and estuaries.

Progress to date

- Performed the first laboratory experiments on how to sample PFAS with thin fibers, and first tests linked to measuring the bioavailability of PFAS in controlled lab experiments (Jitka Becanova, trainee).
- Field-tested passive sampling tubes for PFAS in Narragansett Bay and two local wastewater treatment plants to derive sampling rates (Christine Gardiner, former trainee).
- Analyzed coastal and offshore seabirds for legacy and novel PFAS in wildlife, including Nafion byproducts (Anna Robuck, trainee).
- Prepared passive sampling tubes for deployment in streams on Cape Cod, rivers in CT and RI (Matt Dunn, trainee).
- Tested polyethylene sheets indoors to detect precursor PFAS (Maya Morales McDevitt, trainee).

Plans for upcoming year

- Assess the distribution of legacy and emerging PFAS in different bird tissues from coastal and offshore seabirds from the US East Coast in collaboration with U.S. EPA (Anna Robuck, trainee).
- In collaboration with STEEP Project 1, field-test passive samplers for PFAS in a stream on Cape Cod next to a USGS gauge to evaluate their performance under a range of field conditions (Matt Dunn, trainee).
- Collect water samples from additional ponds and estuaries throughout Cape Cod to identify future sampling sites.
- Collect shellfish from Cape Cod embayment with upwelling of AFFF-impacted groundwater.

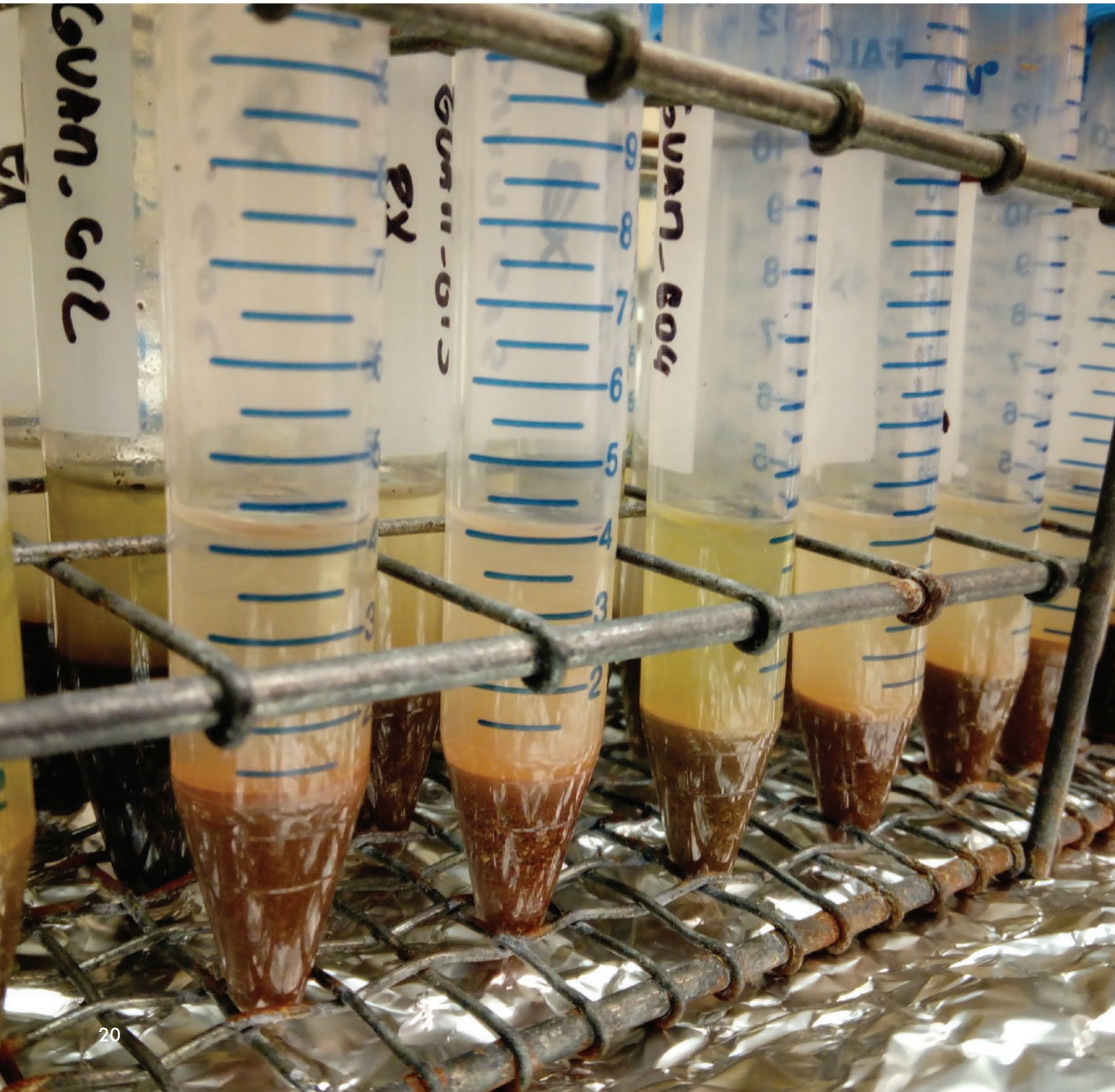
- Validate PE sheets as indoor air passive samplers (Maya Morales-McDevitt, trainee).
- Continue collaboration with Brown University (Dr. Hurt) on testing nanographites as potential sampling tools for PFAS (Jitka Becanova, trainee).
- Continue field-testing passive samplers on Guam to identify PFAS sources to groundwater (Jitka Becanova, trainee).

PROJECT 4 TRAINEES

Jitka Becanova, Postdoctoral Researcher, GSO URI
Matt Dunn, PhD Student, GSO URI
Maya Morales-McDevitt, PhD Student, GSO URI
Anna Robuck, PhD Candidate, GSO URI

PROJECT 4 GRADUATES

Christine Gardiner, Masters Student, GSO URI
Erik Dixon-Anderson, Masters Student, GSO URI



SELECTED ACCOMPLISHMENTS

Mohammed A. Khairy, Gregory O. Noonan, and **Rainer Lohmann**. Contrasting Uptake and Bioaccumulation of legacy and emerging contaminants in the Aquatic Food Web of the Lower Passaic River: OCPs, PBDEs and PFAAs. Environ Tox Chem 2019, 38, 872–882. Doi: 10.1002/etc.4354.

Ian T. Cousins, Gretta Goldenman, Dorte Herzke, Andrew B. Lindström, **Rainer Lohmann**, Mark Miller, Carla A. Ng, Sharyle Patton, Martin Scheringer, Xenia Trier, Lena Vierke, Zhanyun Wang, Jamie C. DeWitt. The concept of essential use for determining when uses of PFAS can be phased out. Environ Sci: Processes& Impact 2019, accepted.

Lohmann, R. Environmental sources, fate, transport, and monitoring of PFAS. SciLine Online Media Briefing on PFAS Contamination in U.S. Communities, Nov. 2018.

Rainer Lohmann, Panelist: "Understanding PFAS Exposure", as part of Understanding, Controlling, and preventing exposure to PFAS. A workshop of the Environmental Health Matters Initiative, National Academy of Science, Washington (DC), Sept'2019.

Rainer Lohmann: Global presence and fate of PFAS precursors. Toxics Use Reduction Agency (TURA) Science Advisory Board meeting, Boston (MA), Sept 2019.

Rainer Lohmann, Mohammed Khairy, **Anna Robuck**: EXPOSURE PATHWAYS FOR PFAS AND OTHER PERSISTENT CHEMICALS IN BIOTA, 8th International Clean-Up Conference, KEYNOTE Adelaide (AUS), Sept 2019.

Rainer Lohmann: Passive Samplers for PFAS in Surface Water and Air; Presentation at day-long course on PFAS Sampling for Environmental Professionals by the Rhode Island Society of Environmental Professionals on June 17, 2019, Providence (RI).

Rainer Lohmann, **Angela Slitt**, **Philippe Grandjean**. PFAS Immunotoxicity and Risk. PFAS Experts Symposium at the 8th International Clean-Up Conference, Adelaide (AUS), Sept'2019.

Lohmann, R. et al. Novel detection tools to assess the sources, transport & bioaccumulation of PFAS. Seminar, ATSDR, Atlanta (GA) May 2019.

Lohmann, R. et al. PFAS across our State's waters. NEIWPCC PFAS Surface Water Science Coordination, Providence (RI) May 2019.

R Lohmann appointed to RI Dept of Health's PFAS Drinking Water Technical Advisory Group

Cordner, Alissa, Vanessa Y. De La Rosa, **Laurel A. Schaider**, Ruthann A. Rudel, Lauren Richter, Phil Brown. Guideline levels for PFOA and PFOS in drinking water: the role of scientific uncertainty, risk assessment decisions, and social factors. J Exp Sci Environ Epidemiol 2019, 29,157-171. doi: 10.1038/s41370-018-0099-9.

DeWitt, Jamie C., Sarah J. Blossom, and **Laurel A. Schaider**. Exposure to perfluoroalkyl and polyfluoroalkyl substances leads to immunotoxicity: epidemiological and toxicological evidence. J Exp Sci Environ Epidemiol 2019, 29, 148-156. doi: 10.1038/s41370-018-0097-y

Susmann, Herbert P., **Schaider Laurel A.**, Rodgers Kathryn M., Rudel, Ruthann A. Dietary Habits Related to Food Packaging and Population Exposure to PFAS. Environ Health Perspect 2019, in press. doi: 10.1289/EHP4092.

Schaider, Laurel. Why do PFAS drinking water guidelines in the U.S. vary so widely? Oral presentation. International Society of Environmental Epidemiology Annual Meeting, Utrecht, Netherlands, August 2019.

Laurel Schaider, Panelist: "Understanding PFAS Exposure," as part of Understanding, Controlling, and Preventing Exposure to PFAS, a workshop of the Environmental Health Matters Initiative, National Academy of Science, Washington (DC), September 2019.

Schaider, L, Costa, A., **Lohmann, R.**, **Becanova, J.**, **Gardiner, C.**, **Robuck, A.**, Phillips, P., Kolpin, S., Furlong, E., Alvarez, A., **Tokranov, A**. PFAS in Cape Cod Bay Estuaries: Associations with conventional water quality parameters, land use, and organic wastewater compounds. NIEHS SRP annual meeting, Sacramento (CA), November 2018.

Schaider L. A. Per- and polyfluoroalkyl substances (PFAS): Characteristics, challenges, and concerns. KEYNOTE. New England Water Environment Association PFAS and Biosolids Conference, Lowell (MA), October 2018.

Administrative Core

Director: **Rainer Lohmann**, Graduate School of Oceanography, University of Rhode Island (GSO)

Co-director: **Philippe Grandjean**, Harvard T.H. Chan School of Public Health, Department of Environmental Health (HSPH)

Project Coordinator: **Wendy Lucht**, Graduate School of Oceanography, University of Rhode Island (GSO)

Overview

The Administrative Core (AC) is the central hub of STEEP, responsible for oversight and management of the Superfund Research Program (SRP). Its main role is to ensure the efficacy of STEEP's activities — producing integrated science, training next generation scientists, communicating research findings for multiple audiences, and engaging a broad swath of researchers and study sites for the benefit of the Superfund Research Program and stakeholders. The AC provides financial management and is integrated with the rest of the Center through the Director's and Co-Director's leadership and role in active STEEP project research, communication, and outreach. The AC, supported by the Coordinator, works closely with the STEEP Internal Advisory Committee (IAC), and the External Advisory Committee (EAC).

This core:

- Ensures successful integration of research projects and cores through regular meetings and evaluations from internal and external advisory committees.
- Provides relevant operational insights and tools for stakeholders and communities.
- Oversees the STEEP SRP that responds in a timely fashion to evaluations, opportunities, and challenges.

Completed and ongoing activities

- Administer the grant and subcontracts serving as the liaison between the University of Rhode Island, Harvard T.H. Chan School of Public Health, Silent Spring Institute, and the National Institute of Environmental Health Studies.
- Provide financial oversight and support to each project and core.
- Manage reporting to NIEHS: Research Performance Progress Report (RPPR), Annual Update, fiscal reporting, and SRP Data Collection Tool.
- Manage the STEEP team calendar.
- Coordinate STEEP-wide interaction with federal and state agencies and stakeholders; support AC leads in maintaining comprehensive interactions with national and international leaders in the field. Highlights from the STEEP leadership include:
  - » Rainer Lohmann appointed to U.S. EPA's Board of Scientific Counselors.
  - » Conference calls with stakeholders and state agencies on current and future PFAS needs (RIDEM, RIDOH, MassDEP, NHDES, Toxics Action Network; New England Biosolids and Residuals Association).

- » Presentation at the New England meeting of the American Ground Water Trust, Westford, MA, September 18, 2019.
- » Submission of STEEP written comments and oral testimony in MA, NH in support of establishing MCLs for PFAS in drinking water.
- » Meeting with Senator Jack Reed (RI, D) on PFAS and DoD concerns, Sept 2019.
- » Representing STEEP at Senator Sheldon Whitehouse's Annual Energy and Environment Leaders Day.
- » Submission of supplemental SRP grants linked to Data Science, Alzheimer's research and new instrumentation.
- » Preparation in progress for FLUOROS 2020 symposium in Providence, RI, October 2020.

- Ensure contributions to peer SRPs including:
  - » Co-organized the 2nd National PFAS conference, Northeastern University, May 2019.
  - » Planning of Administrators' Session at National SRP meeting, Seattle, WA.
  - » Ongoing corresponding with RI Congressional Delegation regarding NIEHS budget and federal legislation language under consideration.
  - » Session planning for the 2020 Northeast Superfund Research Program meeting, Providence, RI.

National and International Collaborations

Center lead Rainer Lohmann and co-lead Philippe Grandjean are engaging in high-level meetings at both the national and international level as well as meeting with Congressional staff, serving as expert witnesses, and penning incisive editorials addressing threats to public health. This provides STEEP with an important voice in the international emerging contaminants community, most specifically with regard to PFAS and next generation chemicals. Their work also ensures that STEEP is on the cutting edge of discovery and subsequent regulatory action.

- Philippe Grandjean previously served as a medical expert for the State of Minnesota in a lawsuit against the company 3M for environmental PFAS pollution, a case that was settled in February 2018 on the eve of trial. He has since advised on water pollution problems in New Hampshire, Vermont, and Michigan.

- Rainer Lohmann was co-author on the manuscript "The concept of essential use for determining when uses of PFASs can be phased out" by the Global PFAS Science Panel (in press). The paper has been widely discussed and was part of a webinar by Drs Lohmann (URI) and DeWitt (ECU) in September 2019.
- Rainer Lohmann provided expert testimony at RI House Environment and Natural Resources Committee on PFAS in drinking and surface waters.
- The URI STEEP Center hosted Senator Reed (RI, D) at the URI Bay Campus and discussed STEEP's activities and the progress of proposed legislation to reduce adverse effects of PFAS across the US (Sept 2019).
- Rainer Lohmann was an invited panelist for the session "Understanding PFAS Exposure" as part of Understanding, Controlling, and Preventing Exposure to PFAS, a workshop of the Environmental Health Matters Initiative, National Academy of Science, Washington (DC), September 2019.

Internal Advisory Committee (IAC)

- Rainer Lohmann, SRP Director, University of Rhode Island (ex officio)
- Philippe Grandjean, SRP Co-Director, Harvard University
- Judith Swift, Research Translation Core, University of Rhode Island
- Peter Snyder, Vice-President for Research, University of Rhode Island (ex officio)
- Art Gold, Natural Resource Sciences, University of Rhode Island
- Bongsup Cho, Pharmacy, University of Rhode Island
- Wendy Lucht, GSO, University of Rhode Island (ex officio)

Recent IAC activity includes establishing a proper reporting structure for the SRP within the University of Rhode Island, which now reports to Vice President P. Snyder directly. Further IAC initiatives fostered the interaction of STEEP with new colleagues within URI, including the URI Health Collaborative, the URI College of Business Textiles, Fashion, and Design Department, URI Harrington School of Communication and Media, URI Business Engagement Center, and Library Services. Harrison Dekker, Professor of Library Science, will be leading the Data Science activities based on a recent supplemental funding from NIEHS.

External Advisory Committee (EAC)

- Kim Boekelheide, MD, PhD, Brown University, Associate Director of Superfund Research
- Jane Crowley, RS, MS, Eastham Health Agent, Director of Health and Environment
- Chris Higgins, PhD, Colorado School of Mines, Associate Professor Civil and Environmental Engineering
- Gary Ginsberg, PhD, New York State Department of Health, Director, Center for Environmental Health
- Marc A. Mills, PhD, United States Environmental Protection Agency, Office of Research and Development

The primary goals of the EAC are to provide guidance, feedback, and resources to STEEP with a focus on the scientific merit of the research; the relevance and importance of the individual components to the goals of the SRP; the integration of research across disciplines; the effectiveness of research translation activities in linking projects and stakeholders; and the appropriateness of community engagement and training activities. STEEP year 2 evaluation will take place at the EAC meeting in October 2019.

Research Translation Core

Core Lead: **Judith Swift**,
Coastal Institute at URI

Co-lead: **Nathan Vinhateiro**,
Coastal Institute at URI

Co-lead: **Amber Neville**,
Coastal Institute at URI

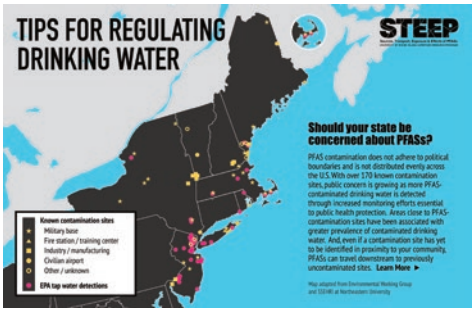
Overview

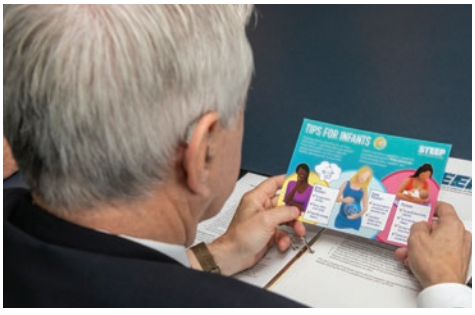
The Research Translation Core (RTC) is leveraging and building upon already existing relationships and communication networks to disseminate information to its stakeholders on PFAS, their adverse human health impacts, and STEEP's scientific accomplishments. The RTC is making STEEP's research results and the implications of these findings readily accessible to stakeholders to assist them in understanding the effects and characterizing the risk of PFAS exposure. As part of the iterative process, RTC is embedding opportunities in the overall communication strategy for stakeholders to provide feedback to SRP researchers at regular intervals, complemented by a clear timeline for researchers to provide updates in response to community concerns. As this iterative process continues, stakeholders and researchers will continue to narrow in on scientific questions and research strategies that are essential to management and regulatory applications.

To accomplish this overarching goal, RTC is developing targeted messages for: 1) researchers within STEEP and the broader SRP network; 2) state and federal agencies including the National Institute of Environmental Health Sciences, U.S. EPA, Agency for Toxic Substances and Disease Registry (ATSDR), and Tribal Councils; 3) other end-users with a focus on communities on Cape Cod, MA, and the Faroe Islands; and 4) additional groups as identified.

This core:

- Ensures STEEP's results are widely disseminated guided by principles of the Transtheoretical Model of behavior change (TTM).





- Provides information to state and federal regulators as well as industry leaders to influence the mitigation of PFAS use to protect human health.
- Facilitates technology transfer where appropriate.
- Synergizes relationship with Community Engagement Core (CEC) to ensure wide dissemination of information to affected communities, and improve communication techniques of STEEP trainees, scientists, and researchers.
- Coordinates broad-spectrum outreach and communication efforts in partnership with CEC and Training Core (TC).

RTC is adapting the message complexity to suit individual target audiences without jeopardizing the scientific rigor demanded by the investigation of emerging contaminants.

Progress to date

- Supported PI Lohmann until Program Coordinator was hired and coordinated the STEEP press conference and community kick-off event on December 4, 2017.
- Developed, launched, and consistently update website—www.uri.edu/steep—including conceptual design of infographics, illustrations, and mixed-use communication tools to stimulate intellectual and emotional response to engage affected communities. Continue to use social media as a means to drive Gen Zs and millennials to the website.
- Developed 8 short videos (3-7 mins): (1) exploring the dynamic between a researcher's role as scientist and humanist and the ongoing conflict between objectivity and outrage; (2) observing the passion that drives a researcher in his/her quest for remediation of PFAS impact on children, their development, and the legacy created for their future health; (3) storytelling that captures the unfolding of the dangers of GenX and its newly recognized impact on human and ecosystem health.
- Organized meeting series to foster dialogue between STEEP scientists and local government agencies and NGOs, e.g., RI Department of Health, EPA ORD (Region 1), RI Department of Environmental Management, Conservation Law Foundation, Narragansett Bay Estuary Program, New England Interstate Water Pollution Control Commission.
- Developed outreach events to complement CEC study site community engagement, focusing on a range of audiences including other SRPs, government agencies, the university communities, and environmental groups with which the Coastal Institute partners on a regular basis:
- Robert Bilott, attorney, public lecture on DuPont environmental suit in WV.
- Devil We Know - two public film screenings.
- Pál Weihe, Clinical Lead, Faroe Islands study, Coastal Institute Nixon lecture (~100 attendees); arranged colloquium talk for STEEP trainees.
- Continued to enhance STEEP branding with use of logo, partner, and funding agency on bookmarks, letterhead, folders, business cards, notepads, PowerPoint template, t-shirts, one-pager, visual placards, hashtags, etc.

- Presented on RTC/CEC monthly webinar hosted by NIEHS SRP.
- Assumed responsibility for STEEP newsletter which will be broadly distributed twice annually with email and website presence.
- Developed a library of resource materials focusing on STEEP research and PFAS information: Tips for Well Owners, Tips for Regulating Drinking Water, Table Tips: Food for Thought, Tips for Families, Tips for Infants, Tips before Taps — Reduce Your PFAS Exposure, Preliminary findings of quality of Cape Cod drinking water, Medical monitoring of PFAS adverse health effects, and Information for private well study volunteers.
- Worked with trainees to develop protocol for colloquia: assisted with development of new trainee orientation packet and offered face-to-face coaching (hosting etiquette – from small talk to dinner conversation, promotional activities, utilizing social media channels, engaging with elected officials, letters of appreciation, etc.).
- Assisted trainees with preparation for fellowship applications and interviews.
- Developed promotional and informational materials for STEEP Science Day 2019.

Plans for upcoming year

- Develop additional tip cards on the continued use or disposal of PFAS-laden products, medical monitoring, and adverse health effects of PFAS exposure.
- Update and expand website through continued rotation of featured landing page stories, current news stories, and addition of videos and podcasts.
- Develop additional videos to be promoted through social media and viewable on both the STEEP website and YouTube.
- Continue organization, maintenance, and expansion of STEEP photo gallery, to extend access to NIEHS.
- Provide periodic updates to NIEHS on RTC/CEC activities.
- Develop three 10-minute podcasts focused on the history of PFAS, the health risk of PFAS, and the regulation and remediation of PFAS. Each will feature interviews with STEEP researchers and other experts as well as professional recording, editing, and underscoring designed to attract and hold listeners' attention.
- Continue to work with CEC to promote their current efforts and as possible, RTC will develop additional programming to reach target groups with specific interests and concerns, including "translated" PFAS information to include in report backs to volunteers in the private well testing program as well as associated media reports.

SOCIAL MEDIA OUTREACH

Twitter stats:
19.5K impressions in last quarter

Nature Article with STEEP scientists input
2,406 impressions, 87 engagements

STEEP PFAS Regulator's Tip Card:
2,132 Impressions, 45 engagements

Trainee Anna Robuck article on Attorney Rob Bilott:
1,894 impressions, 67 engagements

SELECTED ACCOMPLISHMENTS

Lohmann R, **Grandjean P**, **Bothun G**, **Cho B**, **McCann A**, **Neville A**, **Rohr NE***, **Schaider L**, **Slitt A**, **Sunderland EM**, **Swift J** (authors in alphabetical order, *presenting author). Introduction to Sources, Transport, Exposure & Effects of PFASs: University of Rhode Island Superfund Research Program. Poster presentation at 2017 NIEHS Superfund Research Program Annual Meeting, Philadelphia, PA, December 6-8, 2017.

Neville, A., **McCann, A.**, **Schaider, L.** Promoting private well water testing and PFAS education through traditional and social media outreach. Poster presentation at 2018 NIEHS Superfund Research Program Annual Meeting, Sacramento, CA, November 28-30, 2018.

Swift, J., **Lohman, R.**, **Rohr, N.**, Parmenter, A., Gray, T., **Neville, A.** Update on Ubiquitous Contaminant–PFASs. Land & Water Conservation Summit. University of Rhode Island, March 9, 2019.

Swift, J. Talking Science to Lay People. 2019 RI IDeA Symposium. Alpert Medical School of Brown University, Providence, RI. June 7, 2019.

Outreach resources:
https://web.uri.edu/steep/resources/outreach/

Promotional social media placards:
https://web.uri.edu/steep/science-day/

Community Engagement Core

Co-lead: **Alyson McCann**, College of the Environment and Life Sciences, University of Rhode Island (CELS)

Co-lead: **Laurel Schaider**, Silent Spring Institute (SSI)

Overview

Community Engagement Core (CEC) activities are centered on Cape Cod, MA, a region where groundwater and drinking water have been impacted by poly- and perfluoroalkyl substances (PFAS). The CEC is engaging with residents, local officials, non-profit organizations, and regulators to protect human health and support local water quality protection.

This core is:

- Developing a PFAS testing and report-back program for private well owners on Cape Cod.
- Hosting an annual STEEP Science Day on Cape Cod for researchers and trainees to share research findings and for stakeholders and community members to ask questions and inform research and engagement activities.
- Participating in community events and be responsive to the community's needs by providing scientific expertise in response to local questions and concerns.
- Promoting and implementing prevention and intervention strategies to reduce exposures to PFAS.

The CEC is collaborating with community partners such as the Massachusetts Breast Cancer Coalition and the Sierra Club Cape Cod Group to expand community outreach by engaging a broader base of each community partners' constituents. The CEC's activities on Cape Cod are connected to STEEP research projects. Private well testing results will inform chemical "fingerprinting" as part of the Environmental Fate & Transport research, and input from Cape residents and stakeholders will inform site selection as part of the Detection Tools research.

Progress to date

WELL WATER TESTING

The CEC is conducting a private well testing program to evaluate PFAS exposures from drinking water, report results back to individual participants, and identify sources of PFAS contamination to groundwater. The CEC will complete testing of a total of 250 wells over the course of the five-year study. CEC worked with RTC to prepare recruitment materials, and in April 2018 received approval from the URI IRB for recruitment and sample collection protocols. To date, 185 volunteers from 13 towns throughout Cape Cod have volunteered for the study. The locations of volunteer wells and potential PFAS sources have been mapped using GIS.

In summer and fall of 2018, CEC collected samples from 101 wells in 12 Cape Cod towns. These wells were selected on the basis of volunteers who were available to have their well tested during field sampling trips. At each home, samples were collected to be analyzed for PFAS, nitrate, and trace elements (including boron). Field blanks and field duplicates were collected as part of the QA/QC protocols. PFAS and trace element analyses were conducted by the Sunderland Lab at Harvard University and nitrate analyses were conducted by the Barnstable County Water Quality Laboratory.

Customized, online reports were prepared for each participant using Silent Spring Institute's Digital Exposure Report-Back Interface (DERBI). These reports included high-level summaries, as well as chemical-specific graphs that showed participants how their levels compared to other wells in the study, as well as to state and federal guidelines. These reports also contained a summary of overall preliminary findings and information about health effects, water treatment, and exposure reduction tips. RTC provided input during the development of these reports, and usability testing was conducted among participants and other Cape residents.

CEC also worked with RTC to create a one-page overview of study findings, which was distributed at the STEEP Science Day on October 2, 2019. The first round of data has shown that wells with higher levels of nitrate—a marker of septic system impact—tended to have higher PFAS concentrations. PFAS detection frequencies were higher in the upper and mid Cape compared to the lower and outer Cape.

STEEP SCIENCE DAY

CEC coordinated an all-day series of events on October 2, 2019. The event included:

- A 90-minute session for high school students held at Barnstable Town Hall. The session included presentations by STEEP Director Rainer Lohmann, CEC co-lead Laurel Schaider, and URI trainee Alicia Crisalli. Also included was a presentation by a member of the Cape Cod Community Advisory Committee, Hans Keijser, the superintendent of the Hyannis Water System, and a presentation by Rose Forbes and Doug Karson of Joint Base Cape Cod, which featured a demonstration of groundwater flow. 83 students and teachers from five local high schools attended this event.
- A tour of the Hyannis Water System for high school students.
- Two sessions for the general public, each two hours in length, held sequentially at the Barnstable Town Hall and at the Yarmouth Senior Center. These sessions included presentations from STEEP researchers and a Q&A period, as well as informal mingling time where residents could talk with STEEP researchers and view posters prepared by STEEP trainees. A total of 59 people attended these events.

The session for high school students and one of the sessions for the general public were recorded and re-broadcast on local access TV and are available online.

COLLABORATION WITH COMMUNITY GROUPS AND ATTENDANCE AT COMMUNITY EVENTS

STEEP Cape Cod Advisory Committee (CCAC) was consulted and informed regarding the private well studies, community events, and STEEP research. CEC held a workshop, hosted by the Barnstable County Department of Health and Environment Director, with town health officials and staff at the Barnstable County Water Quality laboratory to inform health officials of STEEP's private well testing results prior to their release at Science Day.

In April 2019, STEEP partnered with Sustainable Practices, MBCC, and Pleasant Bay Community Boating to co-host a screening of the film, The Devil We Know, at the Chatham Orpheum Theater.

STEEP trainees, CEC, and RTC met with residents and distributed informational materials at community events, including:

- Cape Cod Moms Parent Resource Fair, Barnstable, MA, Jan. 26, 2019
- Hyannis Open Streets, Barnstable, MA, May 19, 2019
- Celebrate Our Waters, Orleans, MA, Sept 21, 2019

CEC co-lead Laurel Schaider presented on PFAS and water quality at community events, including:

- Cape Cod Community College Nursing Program, 2/25/19
- Hyannis Rotary Club, 4/25/19
- Greater Hyannis Civic Association PFAS meeting, 6/3/19
- Cape Cod Hospital Pediatricians monthly meeting, 6/19/19

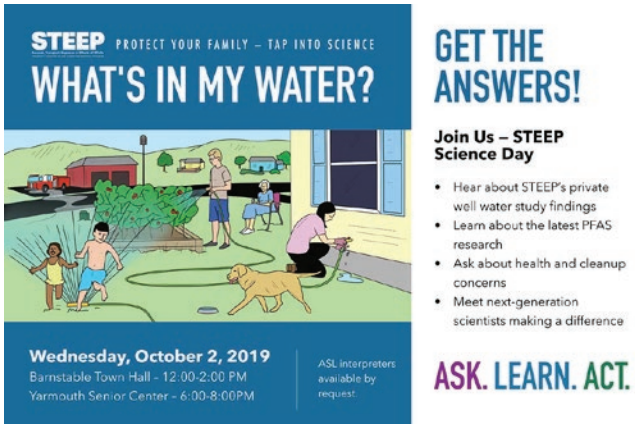
CEC team members provided oral comments at community meetings: Barnstable County Fire Training Academy and Municipal Airport; Hyannis Water Board; Greater Hyannis Civic Assoc.

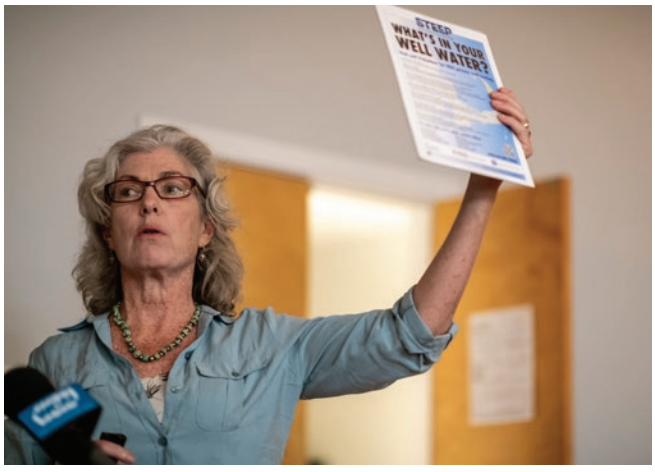
Plan for upcoming year

- Follow-up with First Round Private Well Owners. CEC will conduct follow-up interviews with a subset of participants to gain feedback on DERBI reports, learn about reactions to well water test results, and planned actions in response to results.
- Second Round of Private Well Testing and Report-Back. CEC will continue well water sample collection from the remaining 150 private wells on Cape Cod before the end of 2020. Samples will be analyzed using the same protocol as the initial 101

wells. Spatial analyses will be conducted to investigate relationships between PFAS concentrations and proximity to potential sources — landfills, fire stations, and car washes.

- Private Well Owner Focus Groups. CEC will conduct focus groups in 2020 with private well owners / community leaders to identify barriers to private well water testing and treatment. Protocol will be submitted to IRB for review.
- Cape Cod Community Advisory Committee. CEC will continue to build the CCAC and will hold two in-person meetings and two conference calls annually.
- Community events. The annual Cape Cod STEEP Science Day will be held in 2020 to provide continued updates. CEC will work with our community partners to organize and participate in community events, e.g. the Unitarian Universalist Fellowship of Falmouth, presentations at Nauset Regional High School.





SELECTED ACCOMPLISHMENTS

CEC team members participated in interviews and outreach with local Cape Cod media to promote STEEP events and the private wells study:

Media Coverage

STEEP Science Day sessions available online and local access TV:
http://streaming85.townofbarnstable.us/CablecastPublicSite/search?channel=1&query=steep%202019

Town of Barnstable Weekly Newsletter, 10/4/19
https://www.town.barnstable.ma.us/TownManager/newsletter-files/FridayOctober042019.pdf

Cape Media News, 10/4/19
STEEP Science Day

Cape Cod Times, 10/3/19
Nearly half of private wells sampled on Cape have PFAS

Barnstable Patriot, 10/3/19
Testing for PFAS on Cape Cod: STEEP Team visits Barnstable, Yarmouth

WCAI-NPR for Cape, Coast & Islands, 10/2/19
Study Finds Nearly Half of Private Wells Tested Positive for PFAS

Patch.com
STEEP Science Day: Get the facts on PFAS

Barnstable Patriot, 9/30/19
STEEP scientists to release private well study findings

Cape Cod Times, 9/28/19
2 Cape forums to provide public with information on PFAS

Barnstable Patriot, 9/26/19
BARNSTABLE TOWN NOTES - News

NewsRadio 95, WXTK, 9/25/19
STEEP Science Day

Barnstable Patriot, 9/11/19
What's in your water? - News

Orleans Pond Coalition
What's in my Water – STEEP Science Day

Barnstable Patriot, 8/7/19
$12 million water plant build gets underway in Hyannis

Cape Cod Times, 6/4/19
Hyannis forum seeks balance between PFAS, fire training issues

Barnstable Patriot, 6/4/19
Firefighter training imperative for public safety, but PFAS problem's deep, Yunits says

Training Core: Next Generation

Lead: **Bongsup Cho**, College of Pharmacy, University of Rhode Island (Pharm)

TC Coordinator: **Alicia Crisalli**, PhD Student, Pharm URI, TC Trainee

Assessment Coordinator: **John Stevenson**, Professor Emeritus of Psychology, University of Rhode Island (PSY)

Overview

The STEEP Training Core (TC) is responsible for shaping the next generation of environmental health scientists into well-rounded researchers with an interdisciplinary approach and the professional skills necessary to succeed after graduate school. The TC will provide pre- and post-doctoral level STEEP trainees with additional resources and opportunities to become skilled scientists and engineers. They will be able to address various aspects of emerging contaminants, specifically empirical research, practical remediation, community engagement, and research translation facets of PFAS.

The primary goals of the Training Core are to:

- Promote and coordinate inter- and intra-institutional as well as interdisciplinary cross-training experiences.

- Provide professional development opportunities to enhance leadership, peer-to-peer mentoring, outreach, and communication skills.
- Collaborate with Research Translation and Community Engagement Cores to provide skills often not addressed in traditional PhD programs.
- Connect trainees through social media to create a cohesive and integrated team.
- Support intra-STEEP lab exchanges and participation in professional conferences.

The TC is capitalizing on STEEP's multi-institutional strength by focusing on innovative and interdisciplinary training activities. The TC supports three distinct groups of research trainees over the entire five-year grant cycle: fully supported pre-doctoral trainees, fully supported post-doctoral trainees, and partially STEEP-funded graduate students and post-doctoral fellows. In addition, two STEEP fellowships for students from underrepresented minority groups are being supported through the URI Graduate School Diversity Program. All graduate trainees will be fully immersed in their rigorous interdisciplinary training activities.

Progress to date

- The TC organized and completed a full two-year cycle of STEEP's Colloquium on PFAS during the 2018 and 2019 Spring semesters (PFAS Colloquium 1 and 2, respectively). The main objective of the PFAS Colloquium was to provide trainees unique opportunities to explore all aspects of PFAS in one course sequence. The PFAS Colloquium 1 focused on sharing PFAS knowledge and research including physicochemical properties, detection and remediation, toxicology, and other scientific findings. Additional focus included community engagement, communicating science to affected communities, social justice, and public policy. Speakers included STEEP program faculty and core leads, as well as invited guests from the PFAS community. PFAS Colloquium 2 was established as a 2-credit course (PHC/CHE/OSG 579X) in the colleges of Pharmacy, Engineering, and the Graduate School of Oceanography at URI. Course content included expert guest speakers, professional development and responsible conduct of research (RCR) workshops by URI faculty, and trainee presentations on individual research progress. All lectures were broadcast live via WebEx conferencing to include trainees from Harvard.
- Trainees coordinated the visits of colloquium and other guest speakers, including inviting the speakers, developing the agenda, and day of visit logistics.
- Trainees rated each of the Spring 2019 colloquia on eight structured items for guest presenters and two additional items on the presentation process for trainee presentations representing the training outcome objectives specified in the grant proposal with responses from strongly disagree to strongly agree.
- Trainee Anna Robuck completed the first STEEP lab rotation with the US EPA National Exposure Research Lab (NERL) studying emerging PFAS, such as GenX, in birds procured from the Cape Fear River Estuary, Massachusetts Bay, and Narragansett Bay.
- Trainees responded to end of year surveys for years 1 & 2; suggestions for improvement were considered by the TC and qualitative comments showed trainees felt their contributions were appreciated and concerns were addressed.
- TC's activities occurred mostly in the spring semester (e.g., PFAS Colloquium); however, trainees have engaged year-round in various group meetings, community engagement activities, special seminars, and local and national meetings.

Plan for upcoming year

- Continue to improve upon the Colloquium, including how to reduce redundancy for senior trainees while brining new trainees up to speed.
- Integrating how to handle big data (e.g., Big Data Supplement).
- Encourage small expertise group meetings among STEEP trainees.
- Support and encourage trainee engagement in the STEEP Lab Rotation program.

SELECTED ACCOMPLISHMENTS

Jitka Becanova, a 2018 KC Donnelly Awardee, presented her research at the 2018 NIEHS Superfund Research Program Annual Meeting in Sacramento, CA.

Anna Robuck was named a 2019 Switzer Environmental Leadership Fellow and traveled to South Africa to carry out lab and field work with the Shearwater research team at Stellwagen Bank National Marine Sanctuary to better understand the bioaccumulation of PFAS in wildlife. She also received URI GSO Corless/Kester Marine Chemistry Prize, NOAA National Seabird Program, and Ada Sawyer Prize

Trainee Christine Gardiner successfully defended her Master's Thesis in June 2019. Marisa Pfohl will be defending her Doctoral Dissertation in October 2019.

STEEP gained four new trainees; three in Dr. Angela Slitt's lab and one in Dr. Elsie Sunderland's lab.

Eight trainees represented STEEP and presented posters at the Regional SRP Meeting in Boston, MA, held April 3-4, 2019. Emily Marques and Marisa Pfohl were selected to give oral presentations on their research.

Several trainees attended the 2018 and 2019 Society of Environmental Toxicology and Chemistry conferences.

Several trainees presented posters at the 2nd National Conference on PFAS held at Northeastern University in June 2019.

Alicia Crisalli, Heidi Pickard, and Matt Dunn gave oral presentations and presented posters to high school students and community members at STEEP Science Day in Hyannis, MA on October 2, 2019.

Jessica Alesio (Orr), Alicia Crisalli, and undergraduate Rachel Carley will attend the NIEHS Superfund Research Program Annual Meeting, including the Trainee Program, in Seattle, WA being held November 18-20, 2019. Jessica will give an oral presentation, Alicia and Rachel will present a poster.

Marisa Pfohl was awarded a travel Award to present her research titled "An 'omics approach to unraveling the paradoxical effect of diet on PFOS and PFNA induced non-alcoholic fatty liver disease (NAFLD)" at the 2019 Society of Toxicology (SOT), Medical Devices and Combination Product Special Section.

Marisa Pfohl received an offer for a postdoctoral position in the Homeland Security Research Program of the EPA pending the successful completion of her degree.

Trainee Presentations (Posters)

ME Morales-McDevitt, S Vojta, **R Lohmann**. Testing of Polyethylene Sheets as Passive Samplers for Volatile PFAS in Indoor Air. Presented at 2019 NE SRP Meeting.

ME Morales-McDevitt, S Vojta, **R Lohmann**. Testing of Polyethylene Sheets as Passive Samplers for Volatile PFAS in Indoor Air. 2019 Northeastern PFAS 2019 Conference.

Robuck, A.R., McCord, J.P., Strynar, M.J., **Lohmann, R.** Tissue-specific distribution of legacy and emerging per- and polyfluoroalkyl substances (PFASs) in seabirds from Atlantic offshore and coastal environments. Society of Environmental Toxicology and Chemistry, Aug 2019, Durham, NC.

Robuck, A.R., McCord, J.P., Strynar, M.J., **Lohmann, R.** Tissue-specific distribution of legacy and emerging per- and polyfluoroalkyl substances (PFASs) in seabirds from Atlantic offshore and coastal environments. Per- and Polyfluoroalkyl Substances 2019, June 2019, Boston, MA

Jitka Becanova, **Rainer Lohmann**. Fiber passive sampler - a promising tool for PFAS detection at AFFF impacted area. 2018 NE SRP meeting.

Jitka Becanova and **Rainer Lohmann** - PFAS detection at AFFF impacted sites using a fiber passive sampler. 2018 SETAC.

Jitka Becanova, Zachary Saleeba, Robert Hurt, **Rainer Lohmann**. Testing nanographites as passive samplers for PFAS in the aquatic environment. 2018 SRP meeting.

Jitka Becanova and **Rainer Lohmann**. Characterization of a fiber passive sampler for PFAS detection at AFFF impacted sites. 2019 - PFAS 2nd National Conference on PFAS.

Jitka Becanova, Christine Gardiner, Matthew Dunn and **Rainer Lohmann**. In situ and laboratory characterization of two novel

passive samplers for PFAS detection. 2019 - SETAC PFAS.

Pfohl M. An omic's approach to PFAS induced toxicity. 2019 North East Superfund Research Program (NE-SRP). Big Data in Environmental Health: Collection, Synthesis, Analysis and Use (selected session speaker).

Pfohl M. An 'omics approach to unraveling the paradoxical effect of diet on PFOS and PFNA induced non-alcoholic fatty liver disease (NAFLD). 2019 Society of Toxicology (SOT), Medical Devices and Combination Product Special Section (awardee presentation).

B. Ruyle, **A.K. Tokranov**, **H.M. Pickard**, **E.M. Sunderland**. A mass budget for PFAS subsurface and riverine transport and retention in a coastal groundwater and surface water system. 256th ACS National Meeting. Boston, MA, August 19-23, 2018.

B. Ruyle, **A.K. Tokranov**, **H.M. Pickard**, **E.M. Sunderland**. A mass budget for PFAS subsurface and riverine transport and retention in a coastal groundwater and surface water system. 5th Northeast Graduate Student Water Symposium (NEGSWS), UMass, Amherst, September 7-9, 2018.

Trainee Presentations (Oral)

Jessica Alesio (Orr). Protein Pairing and Lipid Linking: Mechanistic Studies Reveal the Effects of Environmental Conditions and PFAS Mixtures. 2019 Spring ACS National Meeting in Orlando, FL.

Lohmann, R., **Becanova, J.B.**, **Gardiner, C.L.**, **Dunn, M.**, **Morales-McDevitt, M.E.**, **Robuck, A.R.** New sampling strategies for detection of PFASs in the environment. Per- and Polyfluoroalkyl Substances 2019, June 2019, Boston, MA.

Robuck, A.R., Cantwell, M.A., **Gardiner, C.L.**, **Lohmann, R.** Legacy and emerging poly- and perfluoroalkyl substances (PFASs) in seabirds from Atlantic offshore and coastal environments. Society of Environmental Toxicology and Chemistry, Nov 2018, Sacramento, CA.

B. Ruyle. Assessing per- and ployfluoroalkyl substances (PFAS) sources, transport and health risks. the USGS Minnesota Water Science Center, Mounds View, MN, August 16, 2018.

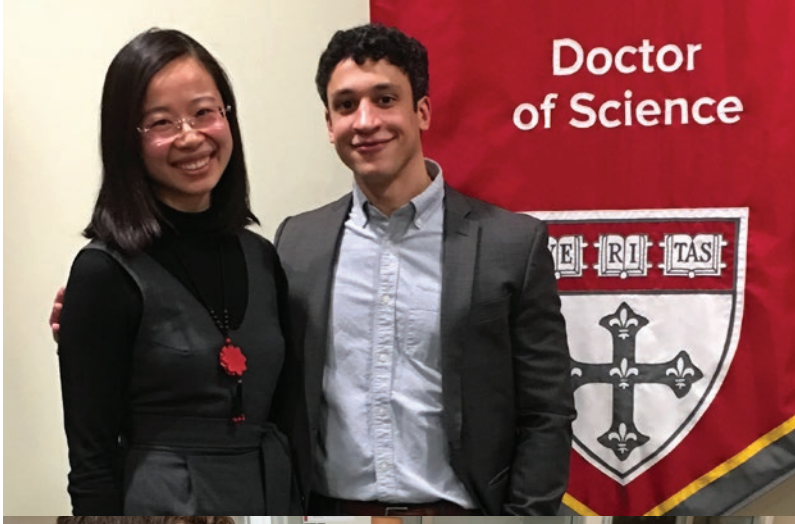
Trainee Publications

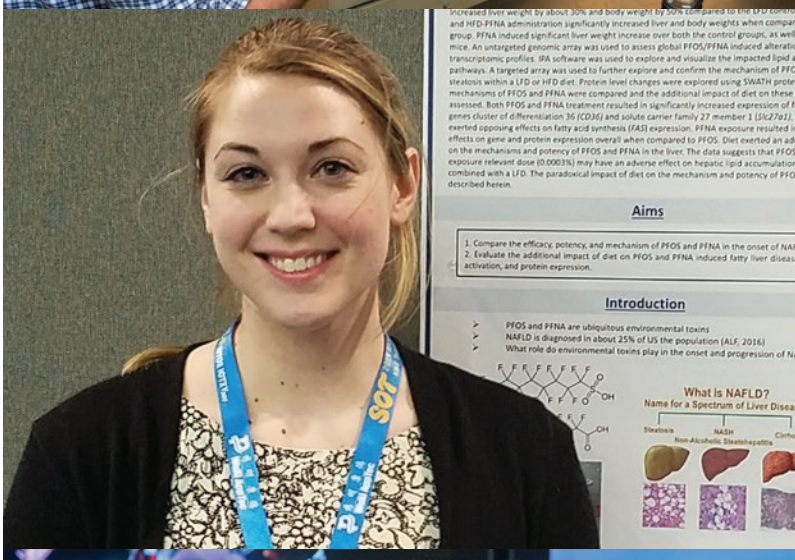
Audy, O., Melymuk, L., Venier, M., Vojta, S., **Becanova, J.**, Romanak, K., et al. (2018). PCBs and organochlorine pesticides in indoor environments - A comparison of indoor contamination in Canada and Czech Republic. Chemosphere, 206.

Dassuncao, C., **Pickard, H.**, **Pfohl, M.**, **Tokranov, A.K.**, Li, M., Mikkelsen, B., **Slitt, A.**, and **Sunderland, E.M.** (2019). Phospholipid Levels Predict the Tissue Distribution of Poly- and Perfluoroalkyl Substances in a Marine Mammal. Environ. Sci. Technol. Lett.

Sharma, B. M., **Bečanová, J.**, Scheringer, M., Sharma, A., Bharat, G. K., Whitehead, P. G., et al. (2019). Health and ecological risk assessment of emerging contaminants (pharmaceuticals, personal care products, and artificial sweeteners) in surface and groundwater (drinking water) in the Ganges River Basin, India. Science of The Total Environment, 646, 1459-1467.

Shelly C, **Grandjean P**, Oulhote Y, Plomgaard P, Frikke-Schmidt R, Nielsen F, Zmirou-Navier D, **Weihe P**, **Valvi D** (2019) Early Life Exposures to Perfluoroalkyl Substances in Relation to Adipokine Hormone Levels at Birth and During Childhood. J Clin Endocrinol Metab.,104:5338-5348. doi: 10.1210/jc.2019-00385





Trainees

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Slitt Lab

Jessica Alesio
PhD Student
College of Engineering, URI
Bothun Lab

Jitka Becanova
Postdoctoral Researcher
Graduate School of Oceanography, URI
Lohmann Lab

Alicia Crisalli
PhD Student
College of Pharmacy, URI
Cho Lab/TC Grad Assistant

Matt Dunn
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Heidi Pickard
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Sunderland Lab

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Lohmann Lab

Bridger Ruyle
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Sunderland Lab

Tatyana Yanishevsky
Affiliate
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Lohmann Lab/Boving Lab

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

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Superfund Research Program

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