STEEP

Sources, Transport, Exposure & Effects of PFAS

UNIVERSITY OF RHODE ISLAND SUPERFUND RESEARCH PROGRAM

2021-2022 Progress

STEEP at a glance

STEEP Director
Rainer Lohmann, PhD
Graduate School of
Oceanography
University of Rhode Island

STEEP Co-Director
Philippe Grandjean, MD DMSc
University of Rhode Island,
College of Pharmacy

Director Lohmann and Co-Director Grandjean combine complementary expertise in environmental and epidemiological sciences. They brought together a team of individuals that function as an effective and integrated interdisciplinary team, including 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 School of Engineering and Applied Sciences, and the Silent Spring Institute.

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 US, 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 the environmental and public health impacts, thus this contaminant is considered emerging. STEEP (Sources, Transport, Exposure & Effects of PFAS) is committed to researching compelling environmental and human health concerns to inform development of appropriate benchmark dose levels for PFAS. Moreover, STEEP disseminates research results to a variety of stakeholders and train the next generation of scientists essential to the management of these ubiquitous compounds. Within the past few years, a burgeoning awareness of PFAS has exposed its transport through consumer goods and into the food web. From Vermont dairy farms to global applications of thousands of permutations of PFAS, presence of these "forever chemicals" in humans and ecosystems continues to be of concern and under scrutiny.

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 addresses 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.

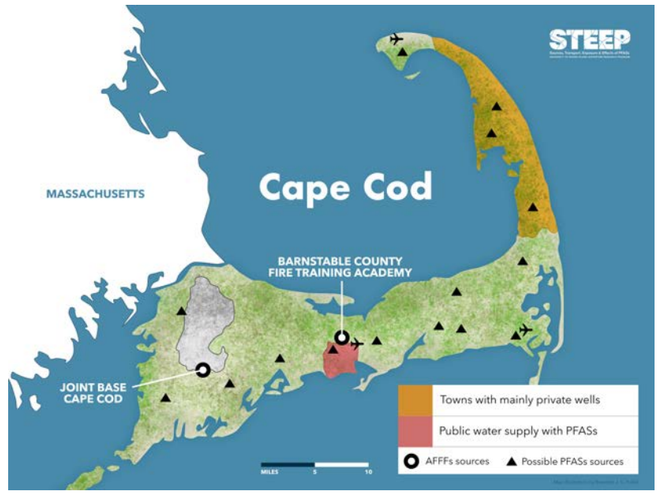
STEEP is focused on two study sites, one on Cape Cod and the other in the Faroe Islands. Barnstable County, MA, is STEEP's primary site for community engagement activities. STEEP partner Silent Spring Institute has conducted community-engaged research and activities focused on water quality and public 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 PFAS 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 PFAS 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 PFAS get into groundwater, they eventually can contaminate both public and private drinking water sources. Given multiple inputs of PFAS 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. 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% GDP, Faroese affluence has promoted 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 PFAS. 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

OVERVIEW:

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

Specific Aims

- Develop a fingerprint for the composition of PFAS in groundwater, drinking water, and fish by measuring and compiling concentrations in the Cape Cod region and identifying statistical clustering among compounds.
- Identify associations among distance of groundwater transport of different PFAS away from point sources, chain length, head group, and geochemical tracers using field measurements.
- Experimentally measure PFAS accumulation in freshwater fish along a hydrological transect away from point sources and assess toxicological biomarkers for responses by using a mobile laboratory to control chronic exposures to contaminated groundwater.

Lead: **Elsie Sunderland,** Harvard John A. Paulson School of Engineering and Applied Sciences (SEAS)

Progress

Between April 2021 and September 2022, the team applied previously developed statistical fingerprinting methods to new measurements of PFAS in coastal watersheds to identify those impacted by Aqueous Film Forming Foam (AFFF) pollution (Ruyle et al., 2021). Field research on Cape Cod, MA showed that downgradient of AFFF-impacted sites, PFAS precursors are rapidly transformed at the surface water/groundwater interface where there are rapid transitions in nutrients and redox chemistry (Tokranov et al., 2021). We further developed a technique for reconstructing the mass budget of PFAS, including diverse precursors, in water and fish using a novel statistical method (Bayesian Inference) combined with the total oxidizable precursor (TOP) assay (Ruyle et al., 2021; Pickard et al., in prep). Code for the oxidizable

PFAS precursor inference calculation is available here: https://github.com/SunderlandLab/oxidizable-pfas-precursor-inference.

Research on PFAS in recreational fish in New Hampshire identified the widespread presence of sulfonamido precursors with high bioaccumulation potential, that are not currently considered as part of fish advisories (Pickard et al., awaiting publication).

Trainee Jennifer Sun developed a new bioaccumulation model for PFAS in aquatic food webs including both legacy and emerging PFAS (https://github.com/SunderlandLab/fish_foodweb_pfas_model) (Sun et al., 2022). Results from the mobile fish lab PFAS exposure experiment in collaboration with USGS were submitted for publication (Barber et al., 2023). Former trainee Cindy Hu led the development of a machine learning model for identifying private wells vulnerable to PFAS pollution (Hu et al., 2021). KC Donnelly fellow Bridger Ruyle collaborated with NIH on a project with Dr. Suzanne E. Fenton, Reproductive Endocrinology Group leader at the National Toxicology Program to apply analytical methods developed in his dissertation to study the toxicokinetics of AFFF mixtures (Mauge-Lewis et al., in prep.).

PROJECT 1 TRAINEES

Fabian Fischer, Postdoctoral Researcher, Harvard SEAS
Jahred Liddie, Ph.D. Student, Harvard SEAS
Heidi Pickard, Ph.D. Student, Harvard SEAS
Jennifer Sun, Ph.D. Student, Harvard SEAS

PROJECT 1 GRADUATES

Bridger Ruyle, Ph.D., Postdoctoral Fellow, Harvard SEAS
Lara Schultes, Postdoctoral Fellow, Harvard SEAS

PUBLICATIONS

Barber LB, Pickard HM, Alvarez DA, Becanova J, Keefe SH, LeBlanc DR, Lohmann R, Steevens JA, Vajda AM. Uptake of Per- and Polyfluoroalkyl Substances by Fish, Mussel, and Passive Samplers in Mobile-Laboratory Exposures Using Groundwater from a Contamination Plume at a Historical Fire Training Area, Cape Cod, Massachusetts. Environ Sci Technol. 2023 Apr 11;57(14):5544-5557. doi: 10.1021/acs.est.2c06500. Epub 2023 Mar 27. PMID: 36972291; PMCID: PMC10116195.

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Sun JM, Kelly BC, Gobas FAPC, Sunderland EM. A food web bioaccumulation model for the accumulation of per- and polyfluoroalkyl substances (PFAS) in fish: how important is renal elimination? Environ Sci Process Impacts. 2022 Aug 17;24(8):1152-1164. doi: 10.1039/d2em00047d.

Project 2: Childhood Risk

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

OVERVIEW:

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.

Specific Aims

- To examine exposure associations with measures of immune dysfunction and metabolic abnormalities.
- To determine associations of early-life exposures with measures of metabolic and inflammatory serum markers.
- To assess whether exposure associations with metabolic abnormalities in late childhood are modified by or mediated via changes in the metabolic and inflammatory markers at younger ages.

Lead: **Philippe Grandjean**, University of Rhode Island, College of Pharmacy

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

Key Personnel: **Flemming Nielsen**, Senior Scientist, University of Southern Denmark

Key Personnel: **Esben Budtz-Jørgensen**, Biostatistician, University of Copenhagen

Progress

Poly- and perfluoroalkyl substances (PFAS) continue to be widely used industrial chemicals, and current exposures appear to cause adverse effects on the immune system and other sensitive tissues and organs, particularly in regard to early-life exposures.

These concerns were examined in a birth cohort at the Faroe Islands already established with NIEHS support.. Advantages include the homogeneity of the Faroese population, the wide range of exposures, and the high participation rates in clinical follow-up. The cohort was generated from consecutive births and is the largest and most thoroughly examined group of PFAS-exposed children followed since birth, now numbered at nearly 3,000 children. Clinical exams at age 9 years were completed.

In addition, specialized examinations, such as dual x-ray absorptiometry (DEXA) scans to measure bone density, were completed. Concurrently, PFAS analytical methods were upgraded and optimized on a new and more sensitive system. All clinical data were entered into the database along with results of blood tests and PFAS analyses to allow advanced statistical analyses of exposure associations with vaccine antibodies and metabolic biomarkers.

PUBLICATIONS

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Wu Q, Coumoul X, Grandjean P, Barouki R, Audouze K. Endocrine disrupting chemicals and COVID-19 relationships: A computational systems biology approach. Environ Int. 2021 Dec;157:106232. doi: 10.1016/j.envint.2020.106232. Epub 2020 Oct 30. PMID: 33223326; PMCID: PMC7831776.

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)

Specific Aims

- Evaluate the relative potency of PFAS and Cape Cod samples to impact steatosis, adipogenesis and adipokine secretion.
- Determine the effect of PFAS exposure during postnatal and adult windows of age as a risk factor to diet-induced fatty liver and inflammation in adulthood.
- Determine the physicochemical properties of PFAS and their partitioning behavior to fat and in protein phases.

Progress

In Year 5, the team focused on completing the proposed aims and publishing our research findings. We finalized hepatocyte and adipocyte work proposed in our specific aims. Work was performed in collaboration with the three other Projects and the Community Engagement Core to identify and test PFAS detected in the environmental samples, mobile fish lab, private well water, and human blood samples, with an emphasis on how PFAS affect gene and protein expression. This resulted in two publications (Marques et al., 2022; Modaresi et al., 2022) that illustrated the PFDA shifts the proteome of adipocytes and that numerous replacement PFAS can induce gene expression signatures in human hepatocytes similar to PFOS, PFOA, and PFHxS. Two publications addressing the second aim, which showed interactions between maternal diet and PFAS exposure on liver and brain outcomes in pups (Marques et al., 2021; Basaly et al., 2021). Additionally, we have completed proposed outcomes for that study and have manuscripts in preparation that describe additional findings for liver, brain, and lung. With regard to the third aim, we completed PFAS protein binding studies to albumin proteins using complementary biophysical techniques that provide new mechanistic insight into the binding event (Fedorenko et al., 2020). In collaboration with Project 4, we have been studying how serum and liver lipid profiles change in response to PFAS exposure. Our work resulted in three peer-reviewed publications, with an additional two manuscripts pending revisions.

PROJECT 3 TRAINEES

Juliana Agudelo, PhD Student, URI Pharmacy
Alicia Crisalli, PhD Student, URI Pharmacy
Emily Kaye, PhD Student, URI Pharmacy
Sadegh Modaresi, PhD Student, URI Pharmacy
Sangwoo Ryu, PhD Student, URI Pharmacy and Pfizer Global Research
Olga Skende, MS Student, URI Pharmacy

PROJECT 3 GRADUATES

Jessica Alesio (formerly Orr), PhD, URI Engineering

PUBLICATIONS

Alesio JL, Slitt A, Bothun GD. Critical new insights into the binding of poly- and perfluoroalkyl substances (PFAS) to albumin protein. Chemosphere. 2022 Jan;287(Pt 1):131979. doi: 10.1016/j.chemosphere.2021.131979. Epub 2021 Aug 21. PMID: 34450368; PMCID: PMC8612954.

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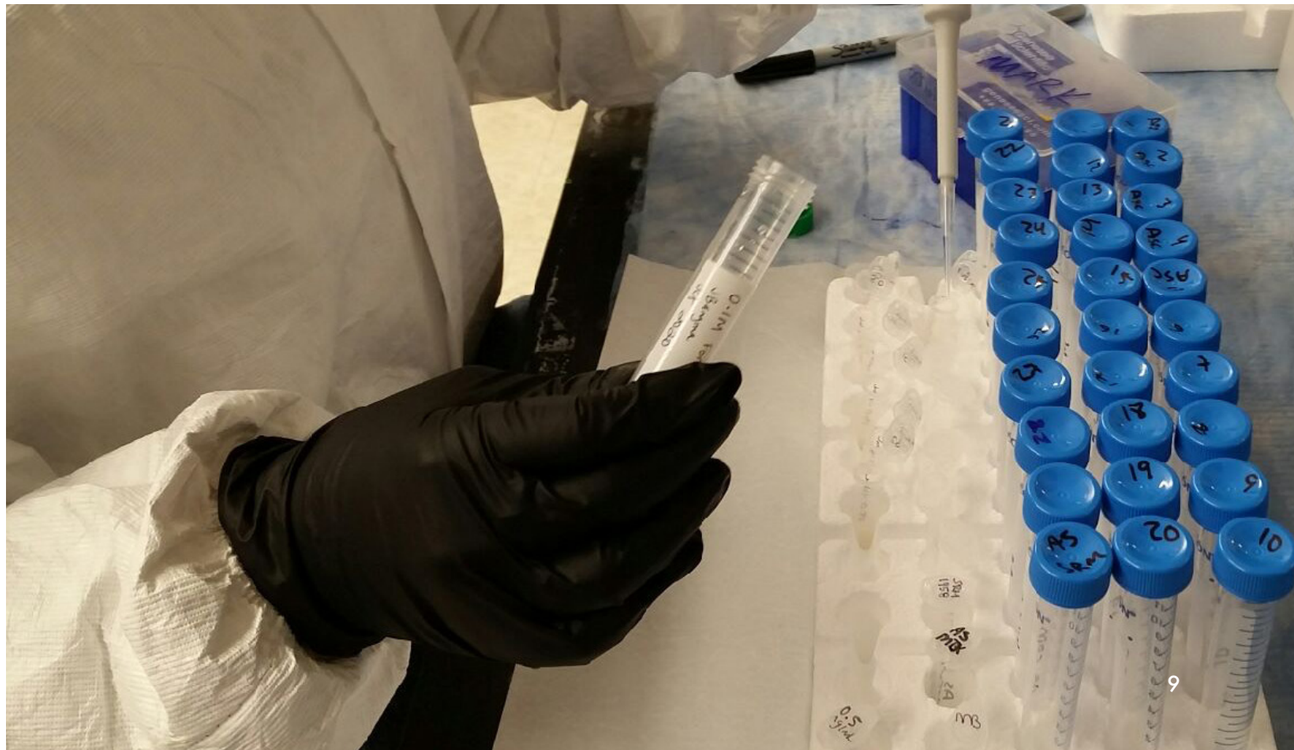

Project 4: Detection Tools

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

OVERVIEW

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)

Specific Aims

- Develop passive samplers to determine partitioning and bioavailability of PFAS in sediment, soil, water and porewater.
- Validate and field-test PFAS sampling tube in water.
- Validate passive polyethylene PFAS precursor samplers in air and water.

Progress

In Year 5, the team further assessed different PFAS sampling tools. Polyacrylate coated solid phase microextraction (SPME) fibers were used as rapid passive samplers for PFAS in collaboration with the U.S. EPA. PFAS concentrations in exposed fish embryos and co-exposed SPMEs were highly correlated (Becanova et al, in prep). Seabirds collected downstream from a major fluoropolymer production site contained the highest concentrations of legacy and novel PFAS, with blood, liver, kidney, and lungs being the primary reservoirs of PFAS in seabirds.

Novel perfluoroalkylether acids were detected in brain tissue, indicating these compounds are capable of passing the highly selective blood-brain barrier in vertebrate wildlife (Robuck et al., 2020; 2021). Based on her KC Donnelly externship, trainee Becanova collaborated with the Brown SRP on the synthesis, chemical functionalization, and characterization of a new graphene-based hydrogel monolith as a PFAS equilibrium passive sampler. Modifying the surface of the nanographenes improved the accumulation of all ionic PFAS by at least ten-fold (Becanova et al, 2021). Polyethylene tube samplers were validated as passive samplers for PFAS in surface waters (Gardiner et al., 2021). Polyethelene (PE) sheet deployments in indoor air demonstrated that neutral PFAS concentrations in indoor air are strongly correlated to those in dust and carpet, indicating that fluorotelomer alcohols (FTOHs, used

in the production of PFAS) are likely originating from carpets, and that PFAS in air and dust are both potential exposure pathways indoors (Morales-McDevitt et al., 2021). PE sheets also enabled the detection of FTOHs in air and water of Dhaka, Bangladesh (Morales-McDevitt et al., 2022).

PROJECT 4 TRAINEES

Matthew Dunn, PhD Student, GSO URI
Asta Zerue Habtemichael, PhD Student, GSO URI
Jarod Snook, PhD Student, GSO URI
Erasme Uyizeye, Postdoctoral Researcher, GSO URI
Melissa Woodward, PhD Student, GSO URI
Tatyana Yanishevsky, MS Student, GSO URI

PROJECT 4 GRADUATES

Jitka Becanova, Postdoctoral Researcher, GSO URI
Nicholas Izak Hill, MS student, GSO URI

PUBLICATIONS

Cousins IT , De Witt JC , Glüge J , Goldenman G , Herzke D , Lohmann R , Miller M , Ng CA , Patton S , Scheringer M , Trier X, Wang Z . Finding essentiality feasible: common questions and misinterpretations concerning the "essential-use" concept. Environ Sci Process Impacts. 2021 Aug 1;23(8):1079-1087. doi: 10.1039/d1em00180a. Epub 2021 Jun 30. PMID: 34190275; PMCID: PMC8372848.

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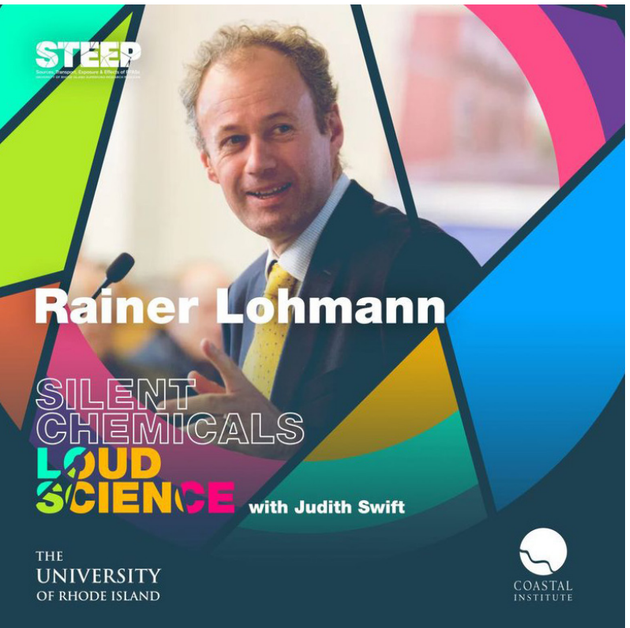
Research Translation Core

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

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

Specific Aims

- Facilitate and enhance exchange of information between and among stakeholders.
- Provide information and support to stakeholder groups with capacity to control use of emerging contaminants.
- Coordinate technology transfer with URI technology transfer office.
- Develop and implement opportunities to enhance and improve overall communication techniques within STEEP.
- Initiate and lead broad-spectrum outreach and communication efforts.



Progress

A comprehensive STEEP website (www.uri.edu/steep) is complete and continues to grow with a mindful commitment to the use of a consistent design palette that incorporates engaging and original infographics, icons, and photos while employing succinct plain language. Visuals echo our social media platforms as a means to drive younger generations to the content-rich website and encourage bidirectional and intergenerational communication. Sections of each project and core focus on the relevant aims and aspirations.

STEEP social media platforms also continue to grow and rely heavily on the use of images, as current research supports imagery enhancing interest by as much as 40%.

We launched *Silent Chemicals, Loud Science*, a podcast series designed for PFAS concerns of people of all backgrounds and educational levels. Intimate conversations with our experts, Rainer Lohmann, Laurel Schaider, and Philippe Grandjean, lead listeners though the world cycling of PFAS, and how these chemicals impact every part of our lives.

Working with an award-winning videographer, a series of eight short videos were developed featuring the research of two project leaders and a series focused on a STEEP trainee.

Research Translation Core played a key role in promoting, marketing, and hosting FLUOROS 2021: "An International Symposium on Fluorinated Compounds and Their Impacts on Human and Environmental Health". We launched an impactful event, drawing attendees from diverse backgrounds and affiliations, designing an electronic program guide, creating an engaging social media conversation, and helping to disseminate key findings with stakeholders, affected communities, and regulators.

Community Engagement Core

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

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

Senior investigator: **Emily Diamond**,
Communication Studies/Marine Affairs, University of Rhode Island

Specific Aims

- Strengthen and develop collaborative, sustainable partnerships with local, state, and federal government agencies and environmental, health, and other community organizations.
- Develop a private well testing program on Cape Cod.
- Engage and educate local, regional and national audiences about PFAS.
- Provide training in community engagement best practices to STEEP trainees.

Progress

In Year 5, the Community Engagement Core completed collection of samples for our private well study.

For our second round of sampling in 2021, we adapted our sample collection protocols to allow participants to collect their own samples, based on COVID-19 precautions. We strengthened our partnership with the Mashpee Wampanoag Tribe by conducting focus groups with tribal members and facilitating analysis of shellfish samples for PFAS and report-back of results to tribal members and town officials. We extended our four-part webinar series, "Let's Talk About PFAS," which featured local officials and residents from Cape Cod as well as members of the STEEP research team to engage community members on Cape Cod and beyond. We continued to be a resource for decision makers on Cape Cod who were addressing PFAS drinking water contamination in their communities, and contributed to regional and national conferences focused on PFAS and the needs of PFAS-impacted communities. We supported the professional development of trainees through involvement with STEEP activities on Cape Cod and through a workshop on PFAS communications.

Training Core: Next Generation

Lead: **Angela Slitt**, URI College of Pharmacy (Pharm)

Co-lead: **Elsie Sunderland,** Harvard John A. Paulson School of Engineering and Applied Sciences (SEAS)

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

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

Specific Aims

- Promote and coordinate interdisciplinary cross-training by taking advantage of the unique, diverse, and collaborative academic environment offered by the STEEP program faculty. Specifically, our trainees will attain: (1) knowledge of and respect for how other disciplines add to understanding and problem-solving in research on emerging contaminants, (2) ability to combine scientific knowledge across disciplines to address environmental issues specifically relating to PFAS, and (3) ability to collaborate with peers and professionals across disciplines.
- Professional development for outstanding career contributions. Provide our trainees with opportunities to enhance: (1) leadership and mentoring skills, (2) ability to communicate to diverse audiences both orally and in writing, and (3) knowledge of and respect for Responsible Conduct of Research.
- Immersion in application of scientific expertise for public benefit and environmental policy decisions. Enhance the ability of our trainees to (1) generate and apply scientific knowledge in ways that effectively engage communities, and (2) develop translational research, and translate scientific knowledge for application to policy-making for public benefit.

Progress

Training Core had a busy year and deliverables still had to be adjusted to meet COVID-19 restrictions. Throughout the year, trainees participated in monthly virtual meetings and had an opportunity to present research findings and host guest speakers to discuss PFAS-related research and career paths. Additionally, trainees hosted two joint laboratory meetings with North Carolina State University Superfund Center Trainees. Trainees presented posters and had oral presentations at Society of Environmental Toxicology and Chemistry, Society of Toxicology, and the Annual Superfund Research Program, as well as regional meetings. STEEP trainees are also meeting program milestones, with five trainees passing written doctoral comprehensive examinations, one Master and two Doctoral degrees granted. There were 18 publications (first or co-author) from STEEP trainees during the funding period. Six STEEP graduates have been recently employed, with four attaining positions at the EPA and others being employed in the private sector or academia.

Highlights

Sadegh Modaresi published his research findings that are related to Project 3 in the journal Toxicology entitled “Per- and polyfluoroalkyl substances (PFAS) augment adipogenesis and shift the proteome in murine 3T3-L1 adipocytes” in January 2022. The results of the work showed that in general, every PFAS investigated in our study has the potential to induce the 3T3-L1 differentiation to adipocytes in the presence of rosiglitazone, a drug FDA approved for the treatment of type 2 diabetes mellitus. Proteomics analysis revealed specific markers regarding to adipogenesis upregulated upon exposure to each of the ten PFAS. Modaresi also had his research presented in three conferences. Preliminary data on the role of liver fatty acid binding protein on the PFOS absorption and distribution was presented at the Fluoros Global, 2021; 2022 Society of Toxicology Annual meeting, in San Diego CA; and the annual 2022 Northeast Society of Toxicology Regional Chapter meeting, in Boston, MA.

Anna Robuck, a NOAA Nancy Foster scholar, Switzer and KC Donnelly fellow and STEEP alumna has joined the US EPA as a research chemist. At EPA Office of Research and Development, her research focuses on the identification and understanding of novel or understudied PFAS in the environment. Prior to joining the EPA, Robuck was a research fellow in the Department of Environmental Medicine and Public Health at the Icahn School of Medicine at Mount Sinai. Her work there focused on relating markers of disease to plastic and chemical exposure in diverse human populations using high resolution mass spectrometry and exposomic data handling techniques. As an indication of her on-going productivity, her PhD work has so far resulted in eight publications (three first publications, five co-authored).

Nicholas Izak Hill graduated from URI with a MS in Oceanography in 2022. He has since joined the US EPA as an ORISE fellow, continuing his research into the bioaccumulation and effects of PFAS in aquatic organisms. First results from his MS research, an improved method to detect PFAS in cow’s milk, was published recently (Hill et al., 2022). His other research was a collaboration with Project 1, USGS and the University of Denver; it focused on the bioaccumulation of PFAS in fathead minnows as part of the mobile laboratory experiments on Cape Cod. Results highlight the importance of bioaccumulation of PFAS beyond the few target compounds; the corresponding manuscript, “Bioconcentration of PFAS from AFFF environmental exposure: Evidence of precursor bioaccumulation in fathead minnows”, is close to submission.

This year, Matthew Dunn attended four conferences, presenting posters at the Gordon Research Conference for Environmental Sciences: Water and annual Strategic Environmental Research and Development Program (SERDP), displaying research from his first dissertation chapter, which is the pre-publication process at the time of this writing. Dunn also attended the New England Estuarine Research Society in fall of 2022 to present on his work in Rhode Island’s surface waters; he was awarded Ketchum Prize for best graduate student oral presentation. In December 2022, Dunn presented to the SRP conference in Raleigh, North Carolina on the results of his KC Donnelly award.

Other notable achievements include winning the James Corless prize for best chemical oceanography seminar from the Graduate School of Oceanography at URI and completing the school’s badge program in diversity and inclusion studies.

Trainee Asta Habtemichael was awarded the prestigious Switzer Fellowship in 2022 for his combination of social science and natural science research methods to study the effects of contaminants of emerging concern in the environment and public health. Habtemichael’s research focuses on sources, fates and pathways of PFAS and Organophosphate esters (OPEs). He also passed his comprehensive exams in 2022, and was inducted in the Association of American Colleges and Universities Future Leaders Society. Habtemichael was awarded the Donald H. Wulff Diversity Fellowship from the Professional Organization and Development Network, and he was selected by AGU LANDInG Program to serve as an ambassador for Community of Practice.

Trainees

Juliana Agudelo
PhD Student
College of Pharmacy, URI
Slitt Lab

Jessica Alesio (formerly Orr)
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

Matthew Dunn
PhD Student
Graduate School of Oceanography, URI
Lohmann Lab

Fabian Fischer
Postdoctoral Researcher
School of Engineering and Applied Sciences, Harvard
Sunderland Lab

Nicholas Izak Hill
MS Student
Graduate School of Oceanography, URI
Lohmann Lab

Emily Kaye
PhD Student
College of Pharmacy, URI
Slitt Lab

Jahred Liddie
PhD Student
School of Engineering and Applied Sciences, Harvard
Sunderland Lab

Sadegh Modaresi
PhD Student
College of Pharmacy, URI
Slitt Lab

Heidi Pickard
PhD Student
School of Engineering and Applied Sciences, Harvard
Sunderland Lab

Bridger Ruyle
PhD Student, Postdoctoral Fellow
School of Engineering and Applied Sciences, Harvard
Sunderland Lab

Sangwoo Ryu
PhD Student
College of Pharmacy, URI
Slitt Lab and Pfizer Global Research

Justin Sankey
PhD Student
Graduate School of Oceanography, URI
Lohmann Lab

Lara Schultes
Postdoctoral Fellow
School of Engineering and Applied Sciences, Harvard
Sunderland Lab

Olga Skende
PhD Student
College of Pharmacy, URI
Slitt Lab

Jarod Snook
PhD Student
Graduate School of Oceanography, URI
Lohmann Lab

Jennifer Sun
PhD Student
School of Engineering and Applied Sciences, Harvard
Sunderland Lab

Erasme Uyizeye
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Graduate School of Oceanography, URI
Lohmann Lab

Melissa Woodward
PhD Student
Graduate School of Oceanography, URI
Lohmann Lab

Tatyana Yanishevsky
Affiliate
Graduate School of Oceanography, URI
Lohmann Lab/Boving Lab

Administrative Core

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

Co-Director: **Philippe Grandjean**, University of Rhode Island, College of Pharmacy

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

Specific Aims

- Provide leadership on STEEP's mission and goals and ensure the efficient integration of the center.
- Establish mechanisms to ensure the integration of research projects and cores.
- Ensure STEEP provides relevant and operational insights and tools for stakeholders and communities.

Progress

In its fifth year, the Adminstrative Core (AC) strived for efficient operations and integrated communications for the STEEP SRP Center on PFAS. STEEP continued its bi-weekly team conference calls so that projects and cores could update each other and discuss important topics and urgent details. The AC also organized STEEP's External Advisory Committee (EAC) and Internal Advisory Committee (IAC) meetings, and helped STEEP submit successful applications for K.C. Donnelly externships (Matthew Dunn, Project 4 and Bridger Ruyle, Project 2) and a NIEHS Diversity Supplement (Erasme Uyizeye, PhD, Project 4) in 2021.

STEEP's EAC reviewed our progress in September 2021. In their review letter, the EAC stated that "STEEP has done an outstanding job in the 5 years since its inception inbuilding a highly productive, integrated, and impactful Center." STEEP held two full team strategic planning sessions in Providence, Rhode Island. These meetings focused on delving into each project and core's aims, and how to improve interactions between each project and core. Trainees were integral in the planning and communication during these strategic sessions.

STEEP organized "FLUOROS Global" in October 2021. Leading experts from around the world came together recently to share their latest findings and progress on science-based solutions for PFAS.

STEEP AC conducted special data management activities. STEEP Data Management focused primarily on identifying practices and tools that we can train our researchers to adopt as well as exploring which standards for machine actionable data and metadata to adopt and how to implement them.

FLUOROS Global 2021

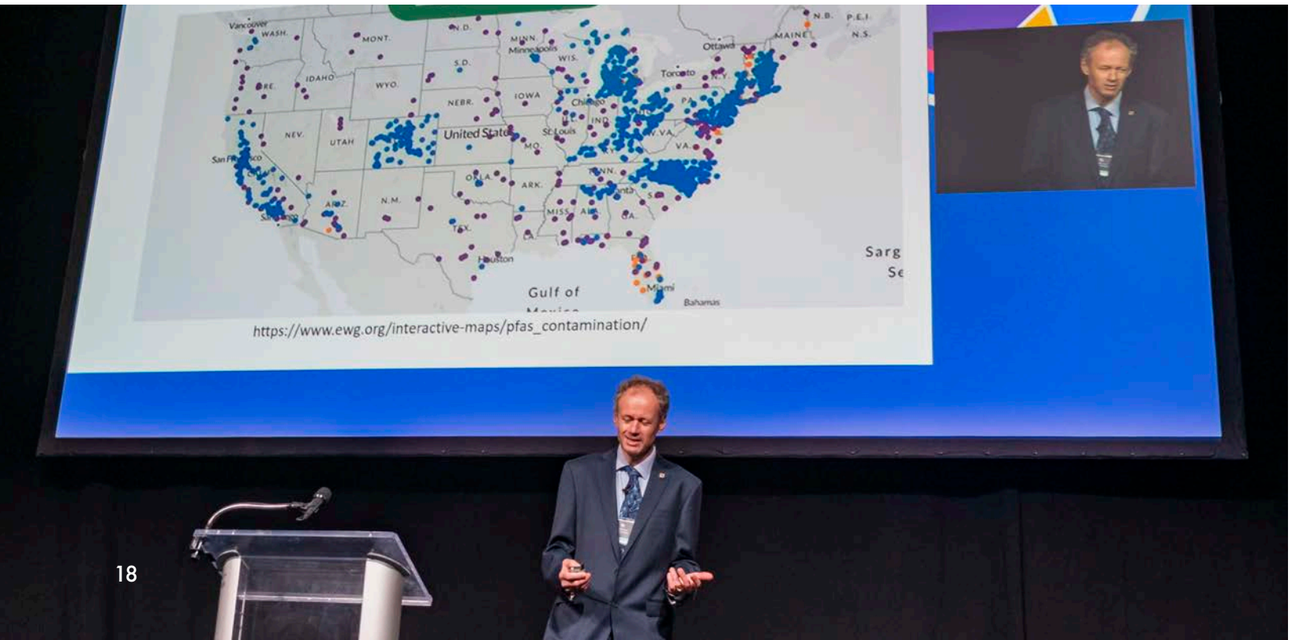
Worldwide Gathering of PFAS Community Examined Science Solutions for "Forever" Chemicals

Leading experts from around the world came together recently to share their latest findings and progress on science-based solutions for a specific kind of chemical pollution – PFAS. FLUOROS GLOBAL 2021, an annual gathering for scientists to join with community members in dialogue on PFAS issues, drew more than 335 attendees from at least 18 countries and Puerto Rico to its hybrid (in-person and virtual) symposium.

Held October 3 – 7, 2021 at the WaterFire Arts Center in Providence, the symposium emphasized the dissemination of knowledge and resources concerning biomedical and environmental research advances regarding PFAS, as well as information for minimizing human exposure and environmental effects. PFAS, or per- and polyfluorinated alkylate substances, are a family of colorless and odorless manmade chemicals which are used in a wide array of household and commercial settings. PFAS uses are many; for example, they are used to retard fire, so are present within extinguishing foams, and they coat pizza boxes and popcorn bags, to keep them from getting soggy with grease. They are also prevalent in coatings used in outerwear, furniture, and carpeting to make them stain and water resistant.

These chemicals are now known to pose harm to human health and the environment – the chemicals disrupt hormones in people and animals, and are carcinogenic, or linked to cancer – and are especially pernicious once dispersed in drinking water sources. "PFAS has turned out to be a much greater health hazard than we thought," says Dr. Philippe Grandjean, STEEP (University of Rhode Island [URI] Sources, Transport, Exposure & Effects of PFAS Superfund Research Program) co-lead.

FLUOROS Global 2021 addressed the rapidly evolving landscape of detection, health effects, regulation, remediation, and community response to PFAS contamination. National and international PFAS experts discussed state-of-the-art research and put forth their insights on advances in the field to the benefit of consumers, manufacturers, oversight and environmental agencies, and global health specialists. Participants included established and early career scientists, government officials (international, federal, state, and local), impacted community members, journalists, environmental NGOs, and PFAS-linked product manufacturers.



Highlights

- Keynote Speaker Elsie Sunderland, a STEEP scientist with STEEP partner Harvard University and a leading PFAS researcher discussed PFAS in the context of food webs impacting human consumers in case studies spanning from the remote Faroe Islands to communities in the Northeast of the United States.

- Panel sessions, such as one on PFAS impacts in the Arctic ecosystem, including discussion of the health and well-being of native and local communities, and potential steps for remediation.

- State-of-the-science talks, such as one on the detection, identification, and toxicology of novel PFAS; other talks focused on issues such as human biomonitoring programs and efforts underway to better understand the extent of impacts in varied environments.

"There is no way to put the genie of PFAS contamination back in a bottle, so countries will have to invest heavily to protect drinking water resources from PFAS, and find novel ways of curtailing further production and use," said Rainer Lohmann, a lead STEEP researcher and chemical oceanographer associated with the URI Graduate School of Oceanography. Scientists the world over now study the problem, working to ensure that the best science informs practical answers to protect human and ecosystem health at the community level.

"A focus on innovation has also informed conference structure and content," said Judith Swift, a STEEP lead, who serves as Director of the URI Coastal Institute. "FLUOROS Global demonstrates that in times of COVID, we can come together even when a classical in-person meeting is not feasible," she says. "The problem of PFAS contamination knows no boundaries and is of pressing concern everywhere. This event provides the arena and sharing spaces we need to coalesce answers and strategies."

The conference, funded in part by the National Institute of Environmental Health Sciences in coordination with partners from the Harvard T.H. Chan School of Public Health and Silent Spring Institute, is also considered of special interest to Superfund Research Program (SRP) trainees. These emerging leaders comprise the critical voice of the next generation of scientists, and they enthusiastically supported the concept of a global FLUOROS. In fact, many SRP trainees ensured the success of the event through their tireless work behind the scenes.

Funding for this conference was made possible, in part, by the National Institute of Environmental Health Sciences under award number R13 ES031852-01. STEEP is a partnership of the University of Rhode Island, Harvard University, and Silent Spring Institute, with funding provided under grant P42ES027706.

THE UNIVERSITY OF RHODE ISLAND

Harvard John A. Paulson School of Engineering and Applied Sciences

SILENT SPRING INSTITUTE
Researching the Environment and Women's Health

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Superfund Research Program

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