

PFAS in the Coastal Zone

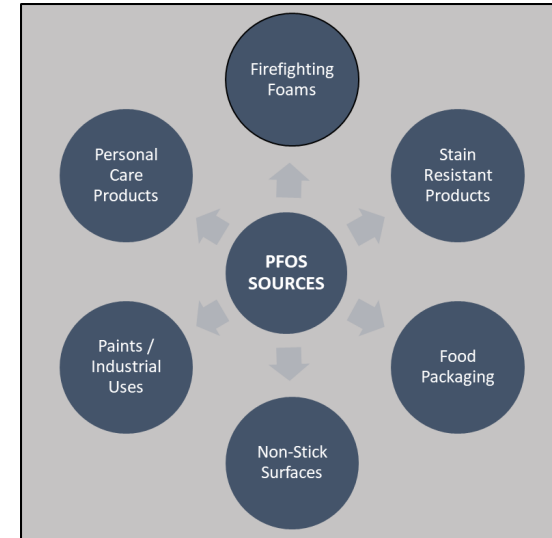
Summary of NOAA/NCCOS Research

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Per- and Polyfluoroalkyl Substances (PFAS)

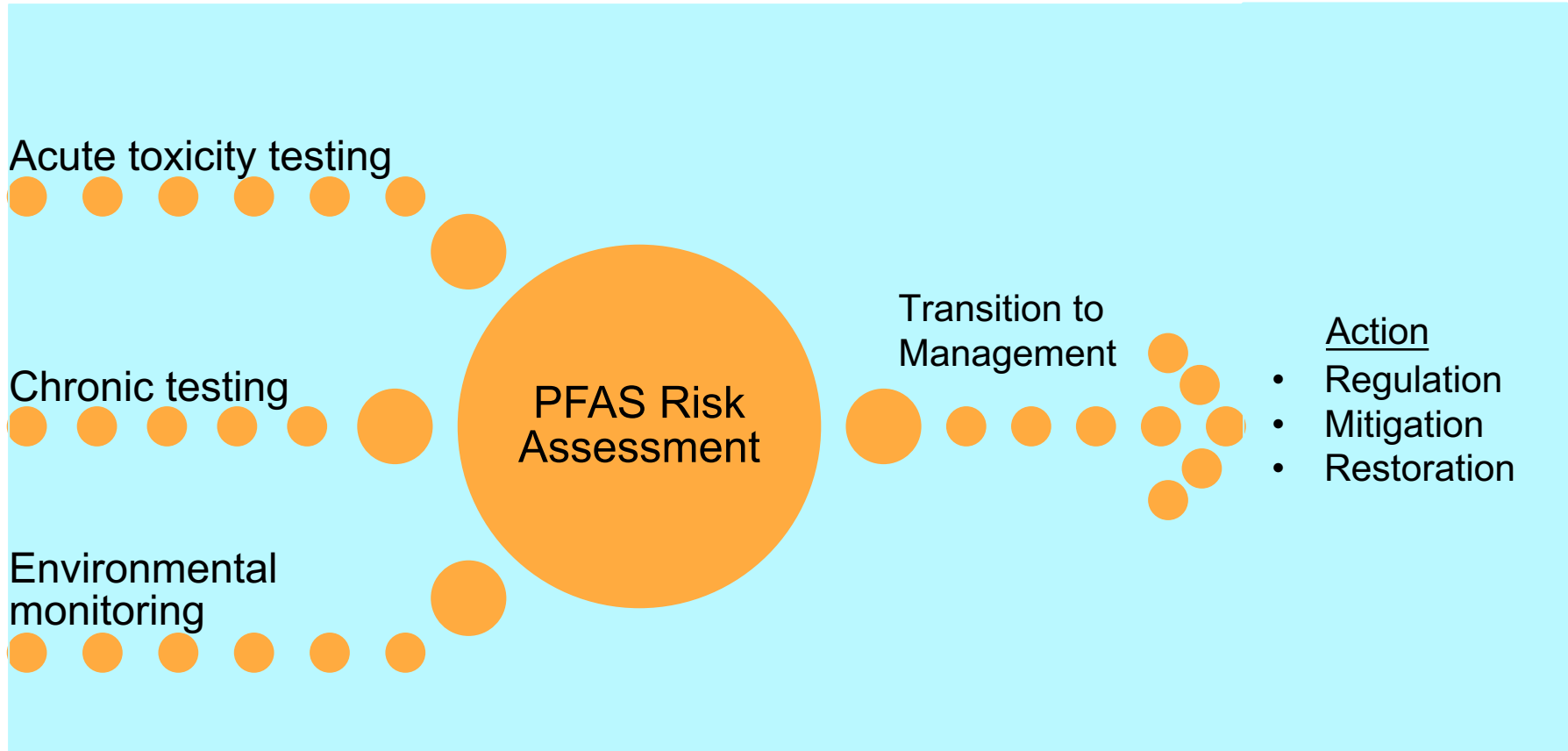
- Broad group of fluorinated chemicals marketed for widespread use since the 1980s. Mobility and persistence within the environment has resulted in ubiquitous PFAS contamination in GW, DW, SW, animal & human tissues / adverse health effects including liver, kidney, thyroid disease/cancer, autoimmune diseases, & developmental and reproductive impairments
- Recent advancements in science, governmental support, and regulations are providing new data to help replace and remediate these enduring legacy chemicals
- PFAS is an additive in Aqueous Film Forming Foams (AFFF) - Critical tools in DOD fire suppression systems and protocols
- PFAS mandated to be phased out of AFFFs by October 2023 - Testing of replacement compounds is needed
- Key data gap: marine organisms, especially marine food species: fish, shrimp and bivalves (oysters, mussels, clams) / presence, persistence and chronic exposure effects



NOAA's role in PFAS

- NOAA's role in PFAS is to provide the science to help managers detect PFAS in coastal, marine, and Great Lakes environments, to understand its biological effects, and to mitigate its impacts.
- Our key tools are environmental sampling, laboratory toxicity testing, field and mesocosm studies, and ecological forecasts. These measurements and predictions allow better decisions affecting health and seafood safety by local, regional, and upstream managers.
- We work closely with federal and state agencies to translate our data into technological solutions and management actions that mitigate pollution impacts and protect sustainable use of coastal resources.

Research Plan



EPA Proposed PFOA & PFOS Freshwater Aquatic Life Criteria

Chemical	DRAFT Acute Water Column Criteria (CMC)
PFOA	49 mg/L
PFOS	3.0 mg/L
Chemical	DRAFT Chronic Water Column Criteria (CCC)
PFOA	0.094 mg/L
PFOS	0.0084 mg/L

* Limited data did not allow for the derivation of estuarine/marine criteria

EPA Proposed PFOA & PFOS Saltwater Benchmarks

Chemical	DRAFT Acute Water Column Benchmark
PFOA	7.0 mg/L
PFOS	0.55 mg/L

Ecotoxicology Efforts

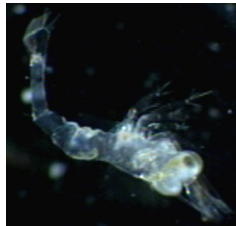
- The NCCOS Ecotoxicology Branch is establishing acute toxicity thresholds for larval estuarine fish and invertebrates for PFAS and alternative PFAS-free aqueous fire-fighting foam products. Our preliminary results indicate the most sensitive species to be larval mud snails, followed by sheepshead minnows, grass shrimp and oysters. We are also examining climate interactions (temperature, salinity, UV light) with PFAS toxicity.
- Research with the PFAS alternative fire fighting foam products is funded by DoD/SERDP and is in collaboration with NIST and the Army Corps of Engineers ERDC. ERDC is establishing toxicity thresholds for the same PFAS-free products using freshwater organisms.
- These studies will rank the PFAS alternative products based on ecotoxicity and the DoD can use that information, along with efficacy and human safety data in selecting products for future use.

1. PFOS toxicity and bioaccumulation

Results – Larval Grass Shrimp

Treatments	96-h LC50 [mg/L] (95% C.I.)
25°C and 20 ppt	5.04 (4.38, 5.73)
32°C and 20 ppt	3.23* (2.66, 3.91)
25°C and 10 ppt	1.78* (0.91, 3.08)
32°C and 10 ppt	0.72* (0.26, 1.19)

* Significantly different from standard laboratory protocol



Results – Larval Sheephead Minnow

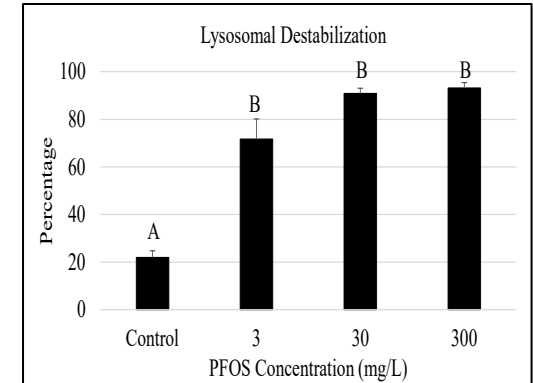
Treatments	96-h LC50 [mg/L] (95% C.I.)
25°C and 20 ppt	1.85 (0.99, 3.40)
32°C and 20 ppt	0.53* (0.39, 0.64)
25°C and 10 ppt	3.05 (2.39, 4.65)
32°C and 10 ppt	0.85 (0.70, 1.05)

* Significantly different from standard laboratory protocol



1. PFOS toxicity and bioaccumulation

- We determined cellular effects, bio-uptake and depuration in adult oysters.
- Biomarker analysis revealed that 48 h PFOS exposures had a significant effect on lysosomal destabilization. The three exposure concentrations had percentages of destabilized (damaged) cells over 60%.
- In a 7d exposure, oysters bioaccumulated PFOS in tissue up to 84 fold. Up to 96% of PFOS eliminated after 2 d in clean seawater, but levels remained high (over 10 ppm), indicating longer depuration times may be needed for seafood consumption.
- Uptake and Biological Effects of Perfluorooctane Sulfonate Exposure in the Adult Eastern Oyster *Crassostrea virginica*. [Allisan A. Aquilina-Beck](#), [Jessica L. Reiner](#), [Katy W. Chung](#), [Meaghan J. DeLise](#), [Peter B. Key](#) & [Marie E. DeLorenzo](#). [Archives of Environmental Contamination and Toxicology](#) volume 79, 2020



2. Ecotoxicity of Fluorine-Free Firefighting Foams

Objective #1

Determine the **acute toxicities** of the selected FF-AFFF alternatives to representative **freshwater and marine taxa**

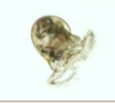




Objective #2

Does toxicity **persist** over time (i.e. to account for the effects of transformation and degradation of the selected FF-AFFF alternatives)

Objective #3

Determine the **chronic, sublethal toxicity** (e.g. growth and reproduction) of the selected FF-AFFF to standard, representative and sensitive **freshwater and marine taxa**

2. AFFF Acute Toxicity - Objective #1

AFFF Formulation	LC50 (mg/L) (95% CI) (48h)	LC50 (mg/L) (95% CI) (48h)	EC50 growth (mg/L) (95% CI) (72h)	LC50 (mg/L) (95% CI) (96h)	LC50 (mg/L) (95% CI) (48h)
					
	<i>Tritia obsoleta</i>	<i>Cyprinodon variegatus</i>	<i>Phaeodactylum tricornutum</i>	<i>Americamysis bahia</i>	<i>Arcartia tonsa</i>
Solberg RF	1.84 (0.96, 2.56)	9.06 (4.54, 11.88)	2.99 (1.28, 3.44)	126.89 (109.55, 149.34)	10.08 (7.72, 13.84)
Buckeye AFFF	19.95 (17.09, 22.72)	125.97 (72.81, 169.26)	5.18 (3.96, 6.79)		12.02 (8.18, 21.58)
AVIO Green	4.81 (4.33, 5.32)	5.93 (4.96, 7.48)	0.15 (0.02, 0.99)	16.39 (12.83, 20.73)	10.09 (8.07, 12.94)
Bio-ex ECOPOL	1.31 (0.86, 1.75)	14.70 (12.42, 16.64)	0.41 (0.24, 0.70)		13.90 (9.94, 23.02)
Fomtec ENVIRO USP	2.85 (2.30, 3.34)	9.45 (7.26, 11.32)	2.68 (1.35, 5.33)	71.46 (63.53, 80.22)	8.79 (6.77, 10.94)
NFD 20-391	1.80 (1.49, 2.09)	10.74 (8.08, 13.61)	3.08 (1.69, 5.60)		13.75 (10.58, 19.37)
NRL 502W	5.32 (3.98, 6.97)	31.72 (8.61, 54.49)	0.67 (0.49, 0.92)		8.18 (5.83, 12.09)

- Acute testing ongoing with mysids, oyster, grass shrimp
- ERDC testing FW species: fathead minnow, rainbow trout, amphipod, chironomid, ceriodaphnia
- Chronic testing next (Obj. #3)

Acute toxicity of 8 aqueous film-forming foams to 13 aquatic species. D. Jones, K. Quinlin, M. Wigren, Y. Choi, M. Sepulveda, L. Lee, D. Haskins, G. Lotufo, A. Kennedy, L. May, A. Harmon, T. Biber, N. Melby, M. Chanov, M. Hudson, **P. Key, K. Chung**, D. Moore, J. Suski, **E. Wirth**, J. Hoverman. *Environmental Science & Technology* 23, 2022

3. Chronic & Mixture Toxicity Testing

- Chronic toxicity bioassays with larval sheepshead minnows and grass shrimp will be conducted to determine any effects on growth, molting, and changes in swimming or feeding behavior.
- Acute toxicity tests with PFAS mixtures with larval sheepshead minnows and juvenile red drum (most sensitive life stages).
- Mixture studies will include compounds most commonly measured in estuarine systems including PFOS, PFOA, and PFHxS.
- Analytical chemistry will be done in collaboration with J. Reiner (NIST).
- Will submit toxicity threshold values to the Chemical Aquatic Fate and Effects (CAFÉ) database.
- Consult with EPA to include our data in setting marine WQC.

4. Bioaccumulation and Ecotoxicity of Representative PFAS in Model Estuarine Species

- This work will quantify ecotoxicity and bioaccumulation of select, DoD relevant PFAS substances in ten model marine and estuarine organisms for derivation of toxicity reference values (TRVs) to support ecological risk assessments.
- Specific objectives include:
 - Develop acute toxicity endpoints for ten marine species and up to 6 different PFAS;
 - Develop chronic toxicity endpoints (e.g., survival, growth, and reproduction) for the most sensitive of the benthic, epibenthic, and pelagic species evaluated;
 - Derive exposure-based TRVs and establish relative toxicity for the test species and PFAS evaluated;
 - Derive residue-based TRVs and establish relative potency (based on internal dose) for those species on which tissue residue analysis is performed;
 - Develop bio-uptake data (bioaccumulation and bioconcentration factors for sediment and water, respectively) to facilitate risk assessment and support future food web modeling efforts.

Environmental Monitoring

- NCCOS' Mussel Watch program conducts regional monitoring of 28 PFAS compounds in sediment and bivalve shellfish including blue mussels and oysters.
- Contributes to building a national scale database that provides coastal resources managers with baseline information of the magnitude and distribution of PFAS in their managed areas, as well as a national perspective of PFAS contamination in the nation's coastal environments.
- Current projects including, assessment of magnitude and distribution of PFAS: oysters from the Southeast (SC to FL coast), blue mussels and oysters from the Mid-Atlantic (MA to NC), oysters from the GOM.
- NCCOS investments in new LC/MS instrumentation, along with new SERDP funding will enable analysis of PFAS compounds by Ecotoxicology Branch.



NCCOS Involvement in PFAS Policy

- White House Council on Environmental Quality Interagency Policy Committee on PFAS
- EPA launching new PFAS Roadmap
- DOD conducting PFAS clean up assessments at ~700 locations
- FDA & USDA expanding testing of food supply and addressing contamination
- NOAA, NIST, CDC, etc. critical research studies
- JSC EIPH PFAS Strategy Team (Marie NOAA rep)
 - The newly-formed Interagency Policy Committee on PFAS will work to coordinate and help develop new policy strategies to support research, remediation, and removal of PFAS in communities across the country.
- Briefing on PFAS Ecotox R&D to Strategy Team
- Report to Congress (Marie and Emily Pisarski on Writing Team) – draft 6/2022