Overview of Select SERDP PFAS Ecotox Projects

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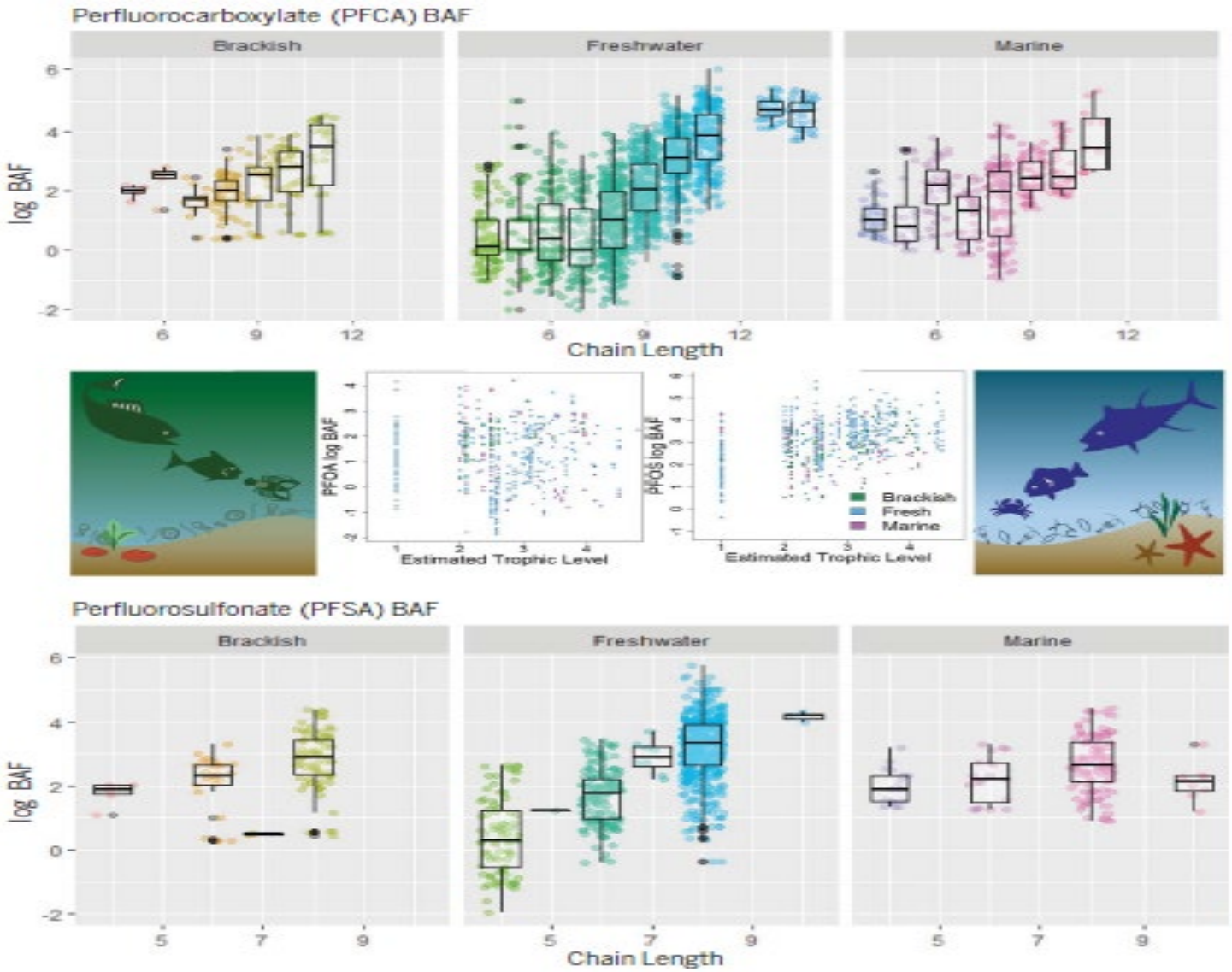
SERDP Research Projects

ESTCP Demonstration Projects

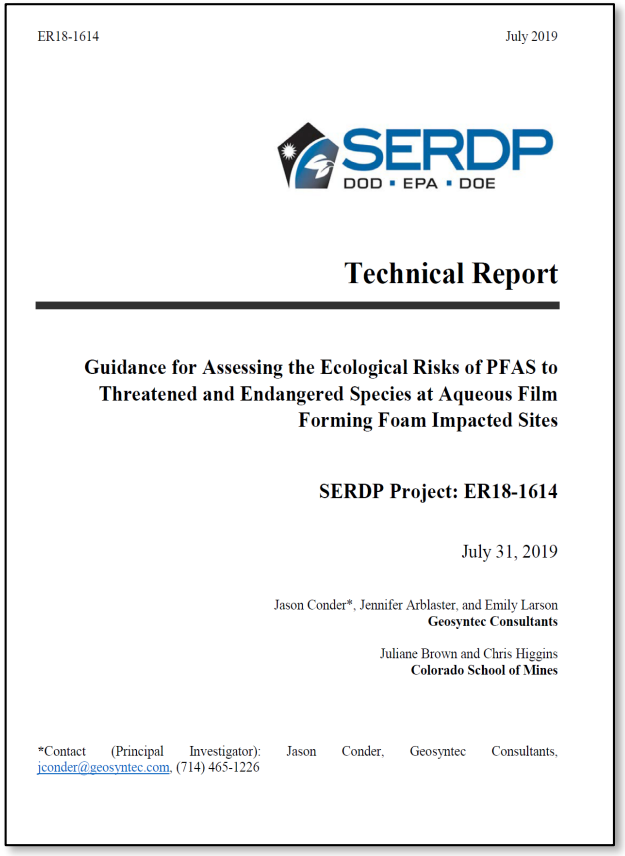
Treatment | Ecotoxicity | Fate, Transport and Characterization | Analytical and Sampling Methods | PFAS-Free AFFF

Rapidly Evolving Science: Evich et al. 2022



ER18-1624

- Guidance* for ERAs
  - 60-pages with 9 tables and 10 figures
  - 5 Appendices (62 pages total)
- Recommended values 18 target PFAS
  - 82 bioaccumulation values for predicting uptake by aquatic biota
  - 35 bioaccumulation values for predicting uptake by terrestrial biota
  - 23 Wildlife Toxicity Reference Values (TRVs)
  - 6 Aquatic Life Criteria
  - 4 plant/invertebrate soil criteria
- Based on a comprehensive review
  - Over 250 studies reviewed
  - Over 200 toxicity values and over 1300 bioaccumulation values considered



ER18-1614 July 2019

SERDP DOD • EPA • DOE

Technical Report

Guidance for Assessing the Ecological Risks of PFAS to Threatened and Endangered Species at Aqueous Film Forming Foam Impacted Sites

SERDP Project: ER18-1614

July 31, 2019

Jason Conder*, Jennifer Arblaster, and Emily Larson
Geosyntec Consultants

Juliane Brown and Chris Higgins
Colorado School of Mines

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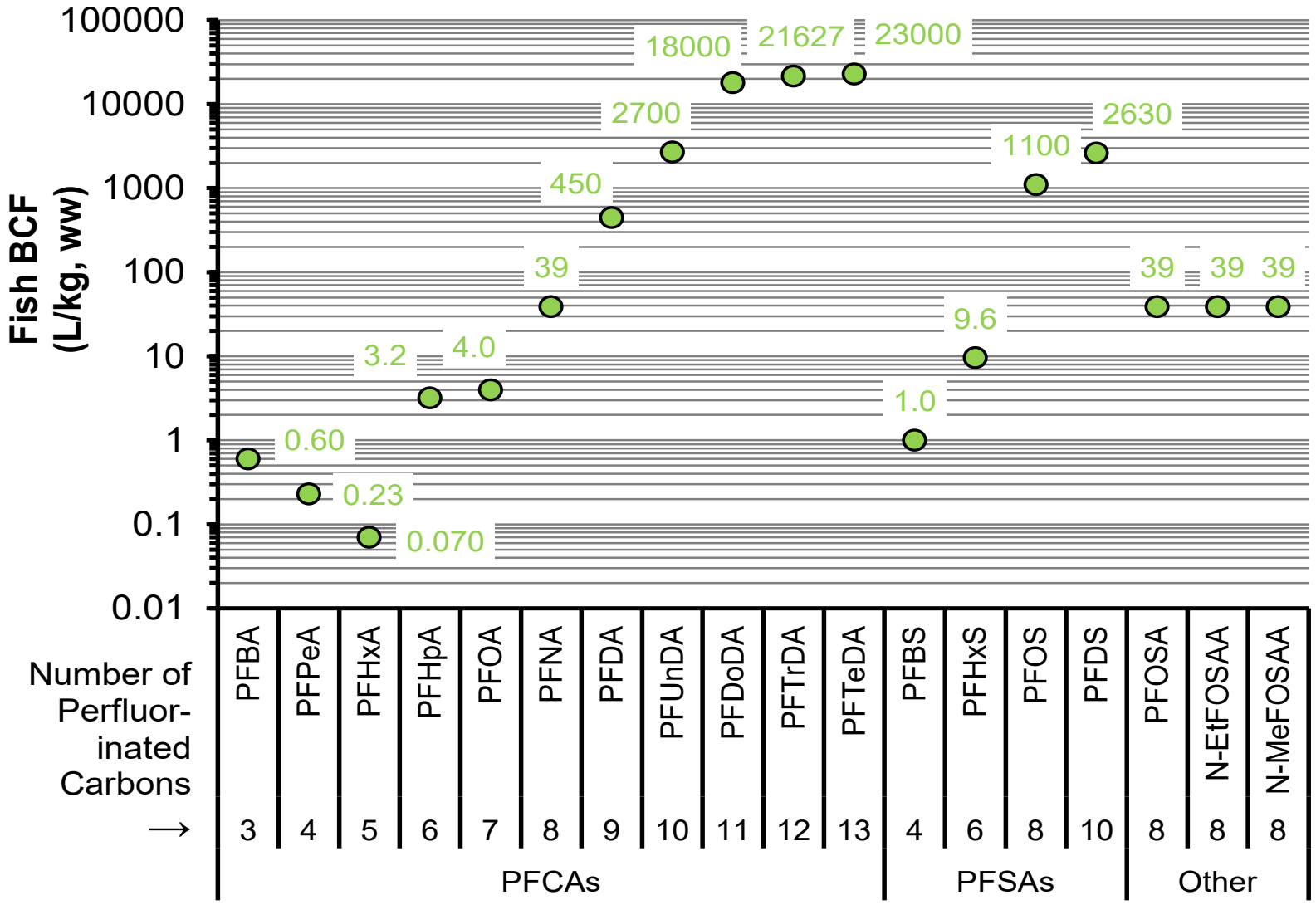
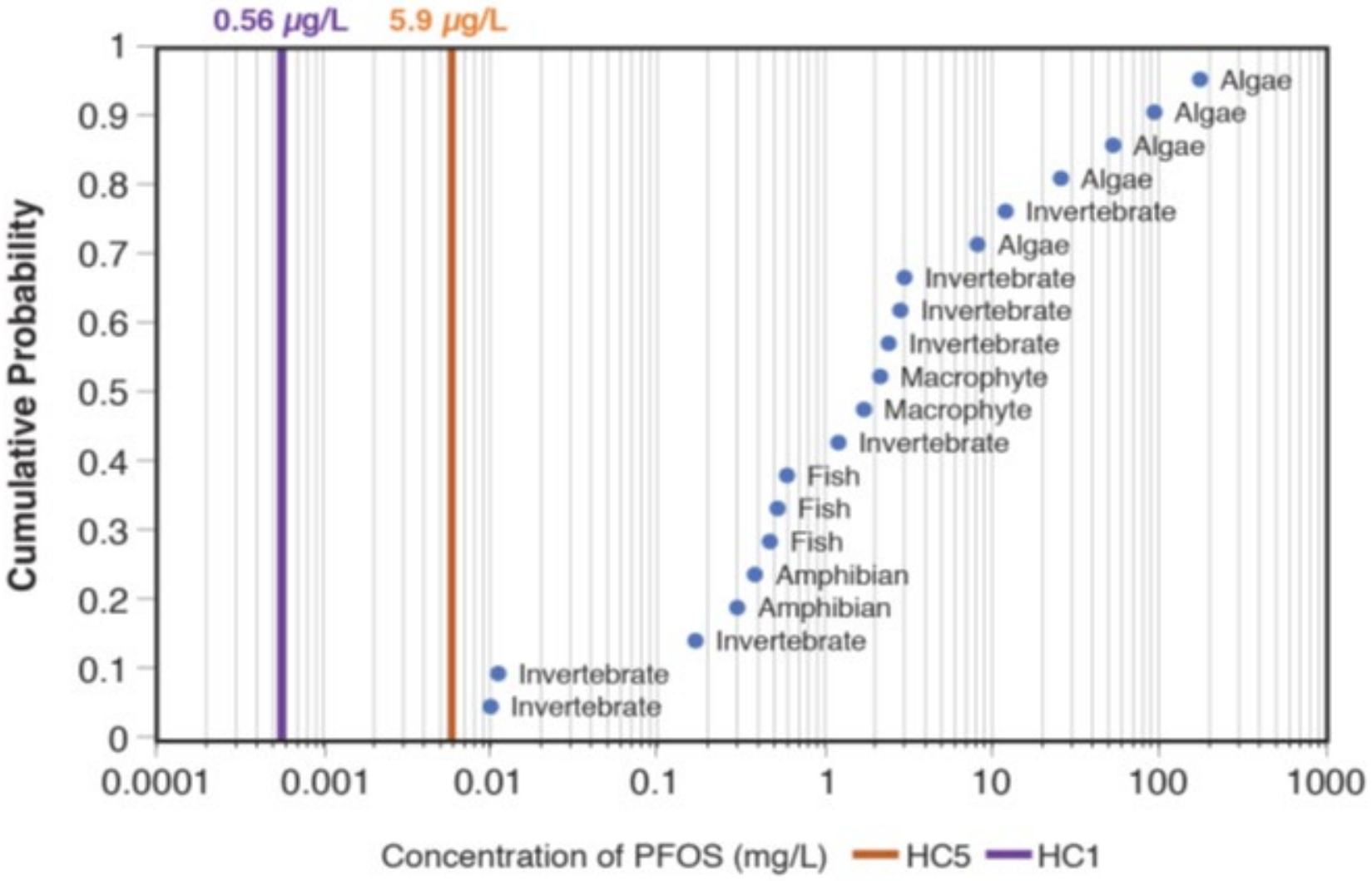
*The term guidance is used within this presentation and final document in a general manner to represent the authors recommendations on best practices; it is not mandatory or a presentation of officially binding rules to be applied by DoD services.

ER18-1624: Fish Bioaccumulation



Example: Water to Fish Tissue Bioconcentration Factors

ER18-1624: Aquatic Marine PFOS SSD



ER-2627: PFAS Toxicity to Avian Receptors - 90-day Toxicity Studies

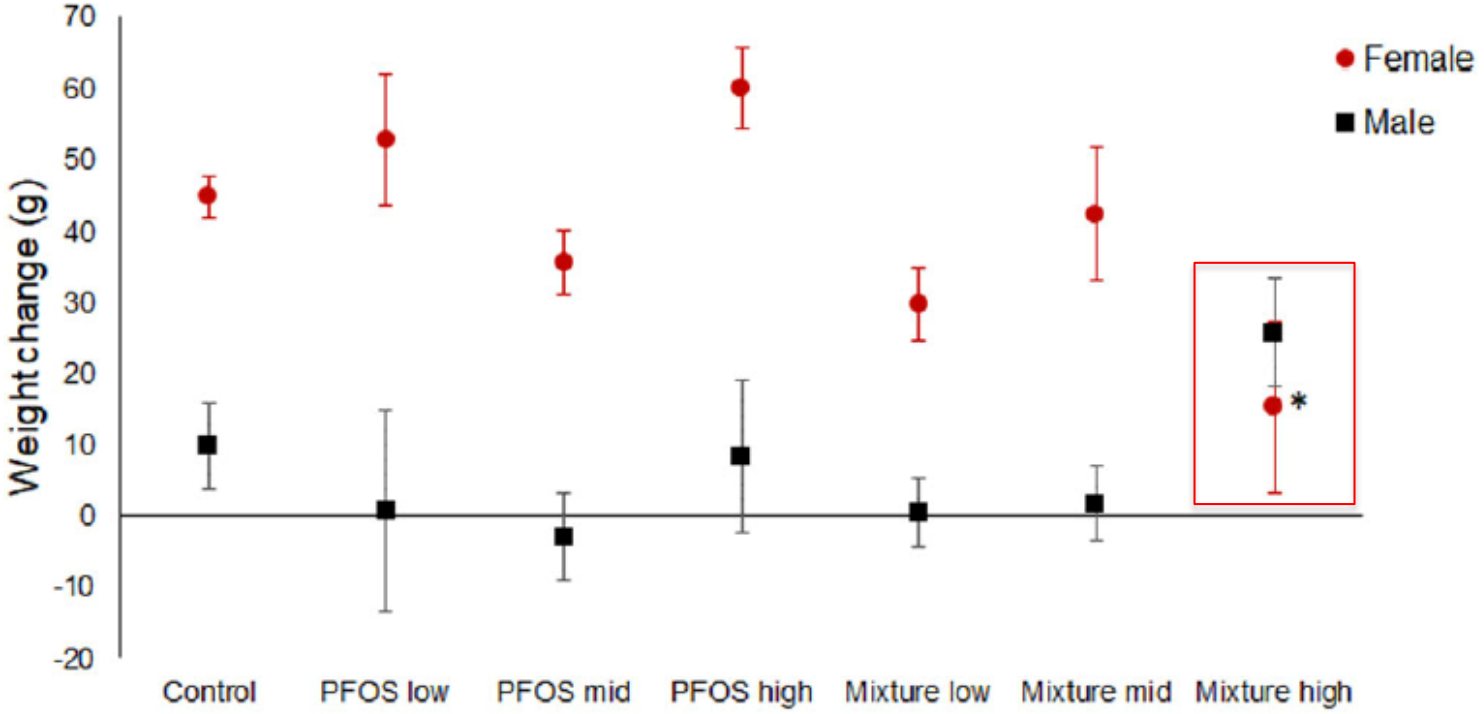
- Dr. Todd Anderson: Quail exposed to PFAS via drinking water
  - PFAS exposure via drinking water (0.1, 1.0, 20 µg/L)
  - Survival, organ mass, reproductive endpoints, hatchling endpoints
  - PFOA, PFHpA, PFHxS, and PFBS
  - PFOS (Dennis et al., 2020)
  - PFHxA (Dennis et al., *in press*)
  - PFOS+PFHxS (Dennis et al., 2020)
  - PFOS+PFHxA (Dennis et al., *in press*)

Avian Toxicity Values (Drinking Water)

PFAS	Toxicity Value (mg/kg/d)	Biological Endpoint
PFOA	1.83 x 10-3	No significant toxicity
PFHpA	1.94 x 10-3	No significant toxicity
PFBS	3.24 x 10-3	No significant toxicity
PFHxS	**1.81 x 10-5**	**LOAEL, egg production**
PFOS	**2.45 x 10-3**	**LOAEL, Eggs hatched, not pipped**
PFHxA	**1.49 x 10-5**	**LOAEL, 21-day chick weight**

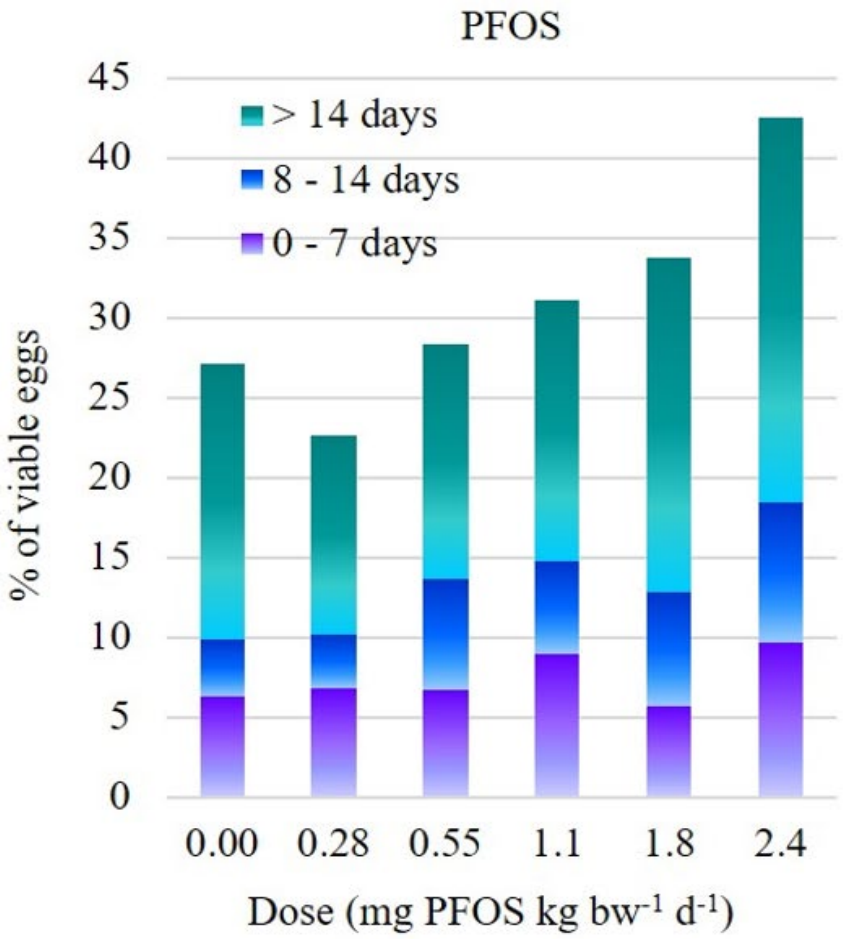
Avian Toxicity: Mixture Effects

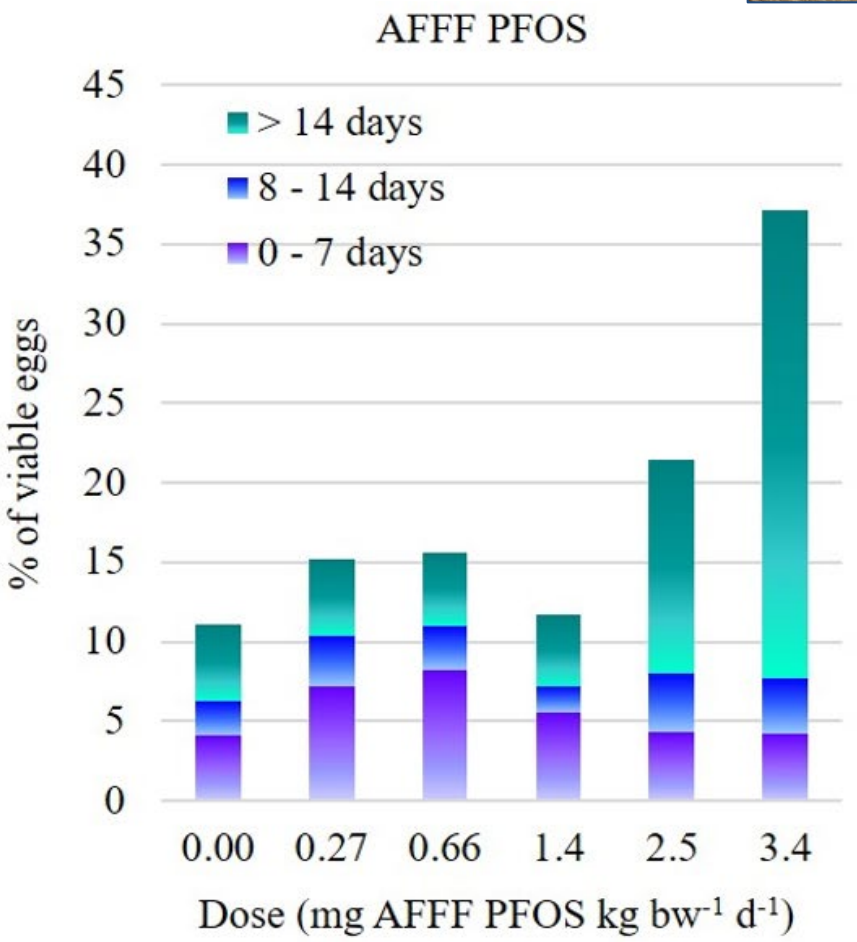
- PFOS + PFHxS mixture as ~ 2:1 PFOS:PFHxS
- Negative effects on female weight gain at highest mixture concentration



ER-2624 (Prof Matt Simcik)

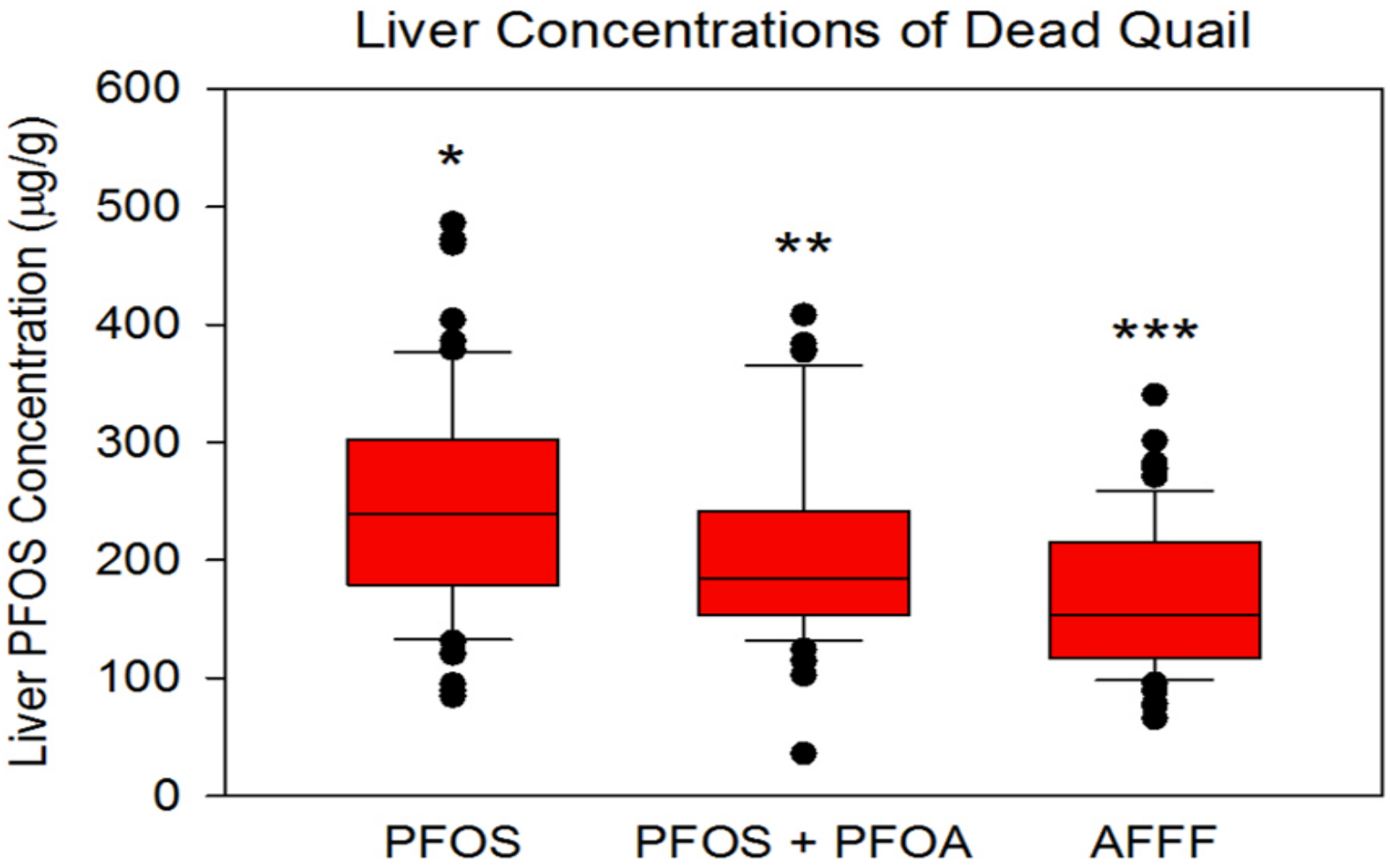
- Greater toxicity from mixture





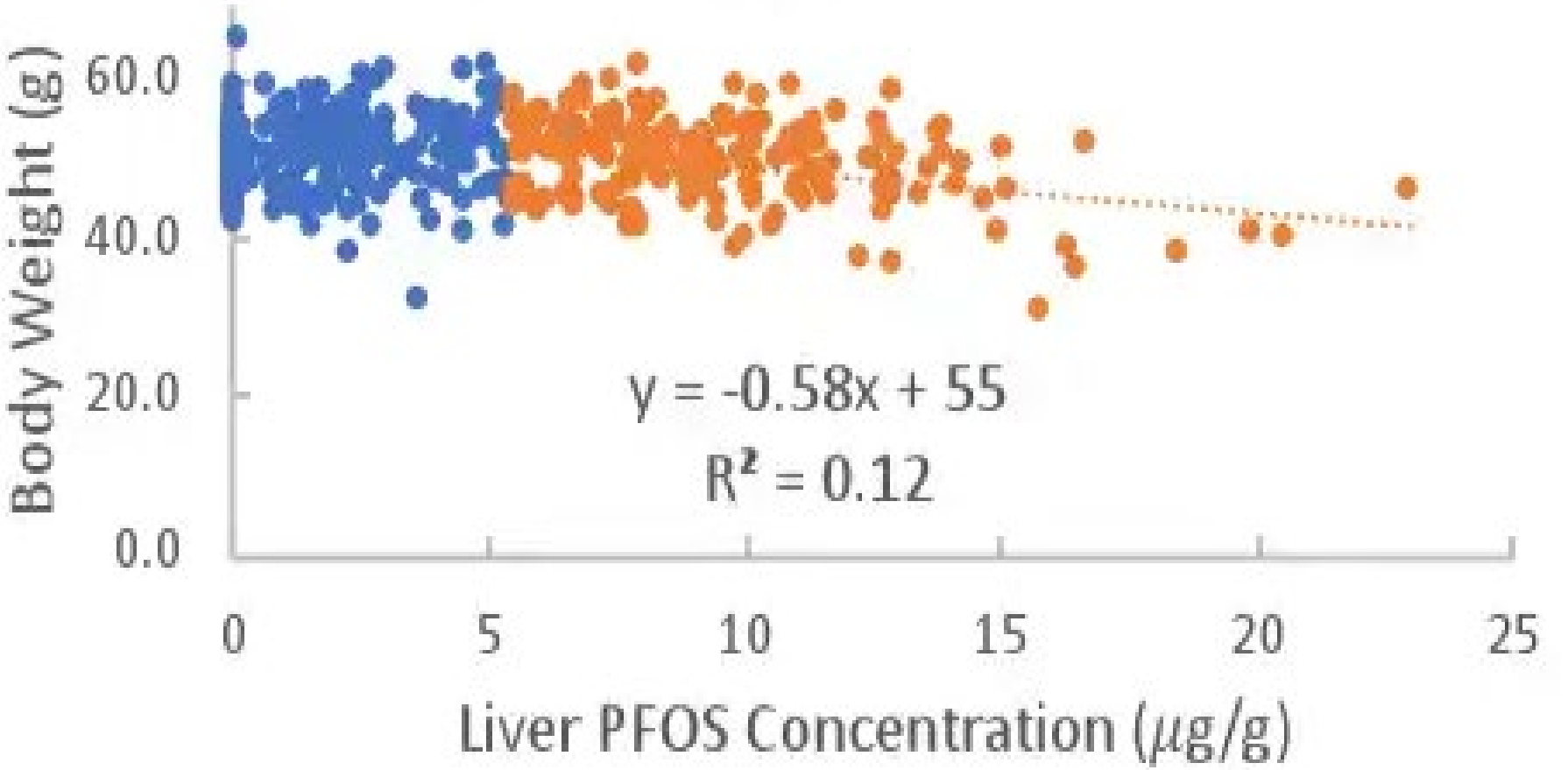
ER-2624

- PFOS only PFAS bioacummulated



ER-2624

- PFOS critical body residue: 5.5 µg/g in liver



ER-2627: PFAS Toxicity to Reptiles

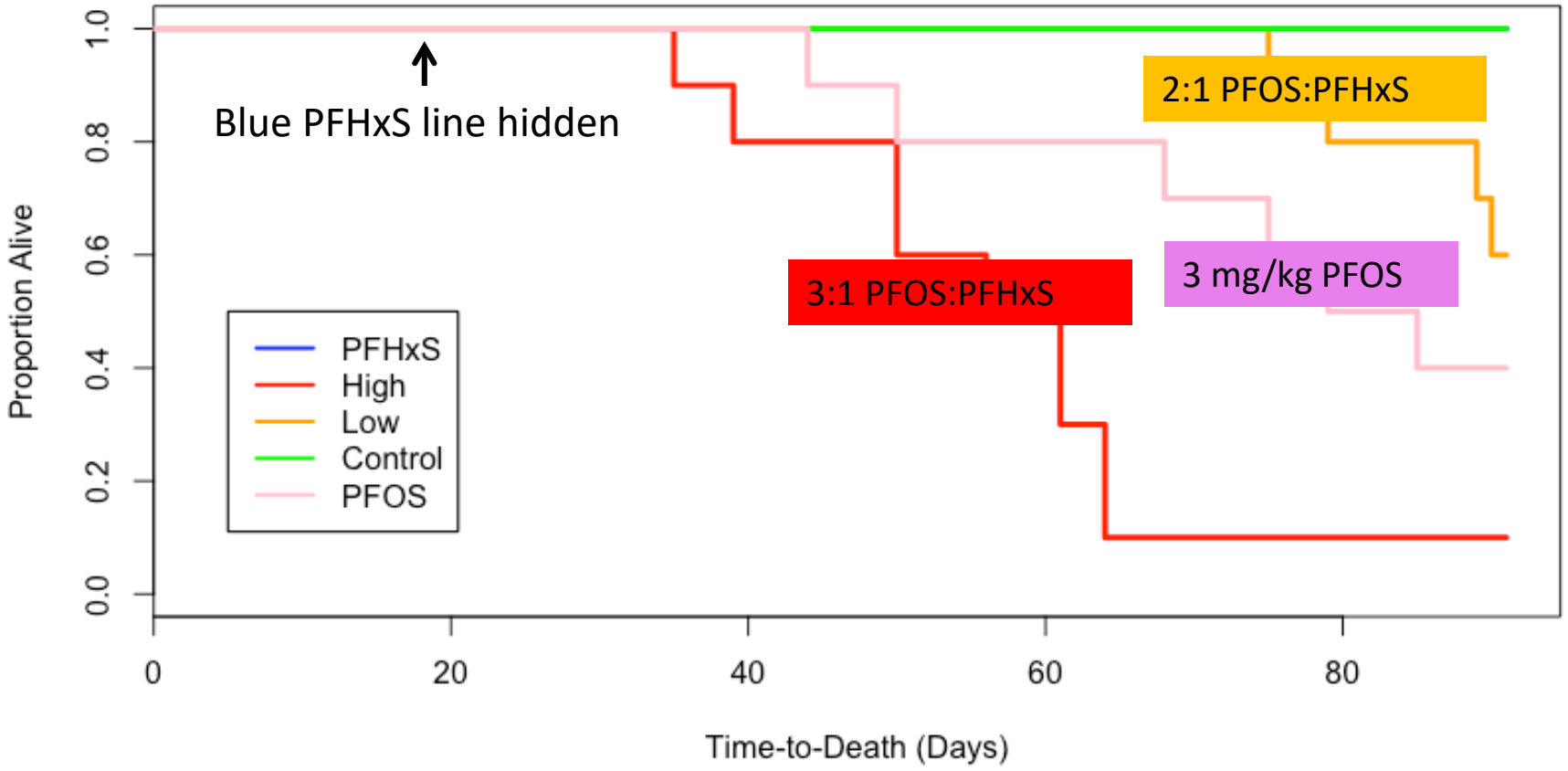
- Towson University developed *Anolis sagrei* for reptilian toxicity testing
- Brown anoles as laboratory models:
  - Invasive in U.S.
  - Readily available
  - Amenable to laboratory study
- Studies:
  - Pilot studies to develop *A. sagrei*
  - PFOS 35-day and 90-day exposures, males only
  - PFHxS 60-day exposure, both sexes/reproductive
  - PFAS 60-day Screening Study for PFOA, PFNA
  - PFOS 90-day reproductive study
  - PFOS + PFHxS 90-day study, males only
  - Established breeding colony
  - Several egg studies

Reptilian TRVs (Pseudo-Gavage)

PFAS	Toxicity Value (mg/kg/d)	Biological Endpoint
PFOS	**0.25 mg/kg/d** **0.73 mg/kg/d** **0.21 mg/kg/d**	**EC10 growth, juveniles** **EC20 growth, juveniles** **NOAEL growth, juveniles**
PFOS	**0.05 mg/kg/d** **0.17 mg/kd/d**	**NOAEL, growth, adult females** **LOAEL, growth, adult females**
PFNA	2 mg/kg/d LOAEL	Size, adult males Screening study, single data point
PFHxS	> 3 mg/kg/d	NOAEL, highest dose
PFHpA	> 2 mg/kg/d	NOAEL, highest dose
PFOA	> 2 mg/kg/d	NOAEL, highest dose

PFOS + PFHxS Appear to Show Synergistic Mixture Effects in Reptiles

- PFHxS contributes to toxicity only in presence of PFOS



ER-2626 (Prof Marisol Sepulveda)

PFOA (C8) **PFOS (C8)**
PFHxS (C6) **6:2 FTS (C6)**

48 h → 150 days

Tadpoles

Subadults

Gills, Dermal, Oral

Water | Sediment | Moss | Diet

Bioaccumulation | Survival | Growth | Development

ER-2626

- Larvae exposed via water and sediment
- Metamorphs (juveniles) exposed dermally and orally

Aqueous exposures

Spiking sediments

Dermal exposure

Oral exposures

Frogs

PFAS	LC50	LOEC	NOEC	BCF	References
PFOS	100,000	10-100		20-150	Hoover 17 Abercrombie 19 Flynn 21a Flynn 22 Tornabene 21
PFOA	752,000	100	1,000	< 1	
PFHxS		10		< 1	
6:2 TFS			1,000	< 1	

Salamanders

PFAS	LC50	LOEC	NOEC	BCF	References
PFOS	73,000	10-1,000		230	Flynn 22 Abercrombie 19 Flynn 21b Tornabene 21
PFOA	711,000	10		2.5	
PFHxS		10		<1	
6:2 TFS		10-100		<1	

Toads

PFAS	LC50	LOEC	NOEC	BCF	References
PFOS	84,000		1000	65	Flynn 22 Abercrombie 19 Tornabene 21
PFOA	752,000	10		<1	
PFHxS		10		<1	
6:2 TFS		10		<1	

ER-2626: Major Findings

- PFOS only PFAS that bioaccumulated and the precursor 6:2 FTS metabolized quickly within animals
- Responses varied by species, but overall, toads were the least sensitive, followed by salamanders and frogs
- LOECs for effects on growth, development, and condition factor ranged between 10 – 1000 ppb
- Preliminary mixtures studies resulted in highly variable and inconsistent results with some non-monotonic dose-response

Fundamental Conclusions to Date

- PFOS (and maybe PFHxS) drives risk at least from legacy AFFF-impacted sites
  - Largely driven by biomagnification of PFOS to upper trophic levels including predatory birds and mammals
- BAFs and TRVs are available for an ever increasing number of PFAS and receptors
- Mixture effects observed thus far are highly variable and inconsistent across species, endpoints, age groups, sex, etc.

Other Select Active EcoTox Projects Related To Legacy AFFF and PFAS

ER19-1032: Uptake and Bioaccumulation/Biomagnification of Subsurface-Derived PFAS by Lotic, Warm Water Food Webs	Marie Kurz Drexel University
ER19-1041: Determination of Biomagnification Potentials for Per/Polyfluoroalkyl Substances in Terrestrial Food-webs.	Roman Kuperman U.S. Army CCDC
ER19-1193: Physiological, Ecological and Environmental Determinants of PFAS Accumulation in Fish: Towards an Improved Bioaccumulation Model	Christopher Salice Towson University
ER18-1502: A Framework for Assessing Bioaccumulation and Exposure Risks of PFAS in Threatened and Endangered Species on AFFF-Impacted Sites	Frank Gobas Simon Fraser University
ER21-3464: Tree Swallows as Indicators of PFAS Exposure and Effects at Selected DoD Sites in the Mid-Atlantic Region, USA	Christine Custer USGS
ER20-1542: Multi-Generational PFOS Exposure in Zebrafish	David Moore U.S. Army ERDC

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