Exposure and Effects of PFAS on Birds

Twin Ports Freshwater Folk Meeting - Wednesday February 1st, 2023

What are Per- and polyfluoroalkyl substances (PFAS)?



A prototypical PFAS structure: PFOS=perfluorooctane sulfonate Multi-carbon backbone substituted with fluorine atoms

• C-Fl bond very stable and strong – hard to break

Charged functional group

 Acts as a surfactant – which decreases the surface tension between liquids and other substances

Fully synthetic

- Several thousand structural variants
 - >7800 currently identified by the EPA

A Brief History of PFAS



What items contain PFAS?

PFAS are widespread in many different products that are used in industrial, commercial, and consumer products

Industrial

- Manufacturing and oil industries
- Electronic manufacturing

Commercial

- Fire-fighting foams
- Pesticides
- Fuel additives

Consumer

- Food packaging
- Non-stick products
- Polishes, waxes, paints, cleaning products
- Water and stain repellent coatings and substances





PFAS: A Significant National Impact

PFAS are known as "forever chemicals" that are persistent and break down very slowly over time.

- Bioaccumulation and biomagnification in the environment
- May be linked to harmful health effects
- Present in 98% of human blood samples from 2000-2014.



PFAS: Local Impacts

97% of assessed closed landfills have PFAS contamination



Local impacts of PFAS

- Found in fish such as smelt, creating consumption advisories in Lake Superior
- Contamination found in private wells and in surrounding ground water
- MPCA found high levels of PFAS in closed landfill sites in Minnesota

MPCA rings alarm: Old landfills leaking contaminants in Northland, across state

The "forever chemicals" have been found in high levels at closed landfills in Duluth, Ely and in 96 other sites across the state, said the Minnesota Pollution Control Agency on Thursday.

Written By: Brady Slater | 2:58 pm, Mar. 18, 2021

https://www.pca.state.mn.us/air-water-land-climate/pfas-and-closed-landfills

Avian Field Study Motivating Observations

Laboratory and field studies together suggest that exposure to PFOS (and perhaps other PFAS) may impair avian reproduction

Wetland-associated insectivorous birds may be at particular risk though substantial uncertainties remain, including:

- The specific dietary pathways leading to avian exposure
- The role of bioaccumulation and biomagnification within invertebrate communities leading to avian exposure
- The specific endogenous systems and the toxic mechanisms of PFAS exposure
- The fitness consequences of exposure at realistic environmental concentrations



Study Sites:

Site (established)	Classification
Boulder Lake	Reference
Rice Lake	Impacted
Martin Road	Impacted
Airbase (DANGB)	Impacted
Boy Scout Landing	Impacted
UMD Farm	Experimental
EPA	Experimental

Technical Approach



Study Species

Tree Swallow (Tachycineta bicolor)



- Insectivore
- Feeds while flying
- Strongly associated with aquatic environments

House Wren (Troglodytes aedon)



- Insectivore
- Feeds on ground, shrubs & low trees
- Likes aquatic edges

Black-capped Chickadee (*Poecile atricapillus*)



- Omnivore
- Feeds on mostly insects during breeding season.
- Terrestrial trees & shrubs

More Aquatic

DIET

More Terrestrial

2022 Field Season





Nest Box Monitoring

- May 16th August 10th
- Checked boxes twice a week
- Recorded the following data:
 - Species
 - Number of eggs and nestlings
 - Estimated egg hatch date
 - Age of nestlings
 - Nest failure events

Nest Box Summary

	Boxes per	r TRES HOWR BCCH		Nests per	
	site	occupied	occupied	occupied	site
Rice Lake	40	8	0	0	8
UMD Farm	30	8	10	0	18
Boulder Lake	20	11	0	1	12
Airbase (DANGB)	53	15	0	3	18
DANGB A	23	6	0	1	7
DANGB B	20	6	0	2	8
DANGB C	10	3	0	0	3
Martin Road	35	5	8	0	13
Boy Scout Landing	21	5	7	2	14
GLTED LAB	20	1	4	0	5
TOTAL	219	53	29	6	88

Nest Box Occupancy & Success

Sites	% Occupancy	% Successful Nests*
Rice Lake	20%	88%
UMD Farm	60%	78%
Boulder Lake	60%	83%
Airbase (DANGB)	34%	72%
DANGB A	30%	57%
DANGB B	40%	100%
DANGB C	30%	33%
Martin Road	37%	85%
Boy Scout Landing	67%	93%
GLTED LAB	25%	100%
TOTAL	40%	83%

*Successful Nest = at least one nestling survived to day 12

Eggs

- PFAS analysis
- 1-2 eggs were randomly collected and dissected from each clutch
- Dead eggs were collected opportunistically



Nestlings

- 1-2 nestlings collected per brood
- Nestling exposure and potential PFAS effects
 - Morphology (weight, feather length)
 - Whole carcass (PFAS & legacy contaminants)
 - Plasma (hormone analysis)
 - Liver (RNA analysis)
 - Stomach contents (PFAS & diet)







Fecal sacs

- Collected from nestlings during nest box monitoring
- Dissected fecal sac used for DNA-based assessment of diet composition

Field Respirometry

- Eggs and nestlings
- Does PFAS exposure correspond to changes in metabolism?





Field Respirometer Qubit Qbox RP1LP & RP2LP

Picture source: https://qubitbiology.com/products/respirometry,



Environmental Sampling

- Water, sediment, and soil
- Taken every 2 weeks throughout the field season
- Passive samplers
 - Water and sediment
 - 3 PFAS samplers and a temperature logger on each mooring



Plants

- Stable isotope analysis ($\delta^{15}N$, $\delta^{13}C$)
- Target levels:
 - •overstory
 - •forbs and herbaceous
 - •emergent floating-leaf
 - submerged
 - free-floating
 - adhered substrate
 - •floating algae



Invertebrates

Aquatic Invertebrates

- D-net sampling
- PFAS & stable isotope ($\delta^{15}N$, $\delta^{13}C$) analysis

Spiders

- Night sampling
- Four 50 m transects at two shoreline scenarios: lake and stream
- Target species: Orb-weavers

Fish

- Sampled by electro-fishing and seining
- PFAS & stable isotope ($\delta^{15}N$, $\delta^{13}C$) analysis
- Targeted feeding levels:
 - Benthic (bottom)
 - Pelagic (water column)
 - Piscivorous (carnivorous)



Pilot PFAS Data (2020 & 2021)

Table 1. Sample Size by Site

SiteList	Eggs	Nestlings	Diet
BoyScout	6	6	1
Airbase	5	5	1
MartinRd	3	5	1
RiceLake	3	6	1
Boulder	5	5	0
UMD	2	1	0



Mean PFAS tissue concentrations across all samples

	Compound	N egg	Av egg	Geo egg	N nestling	Av nestling	Geo nestling	N Diet	Av Diet	Geo Diet
16	PFOS	24	411.8	59.6	28	54.0	24.4	4	42.2	27.8
36	7.3.FTCA	15	106.0	23.0	5	18.8	7.4	1	2.9	2.9
35	5.3.FTCA	2	58.2	43.6	1	26.7	26.7	0	NaN	NaN
21	6.2.FTS	10	55.3	3.1	13	1.3	1.1	4	12.0	3.1
14	PFHS	22	33.5	3.7	27	5.0	2.5	4	1.4	1.0
22	8.2.FTS	2	10.1	7.6	1	1.1	1.1	3	0.8	0.8
17	PFNS	3	7.3	1.8	1	0.4	0.4	0	NaN	NaN
5	PFOA	23	6.5	1.0	28	2.1	1.2	4	0.9	0.7
6	PFNA	24	5.8	2.1	28	1.2	1.0	4	0.7	0.6
15	PFHpS	17	5.2	1.0	19	0.5	0.4	1	0.4	0.4
9	PFDoA	24	4.1	1.0	11	0.2	0.1	0	NaN	NaN
29	N.EtFOSE	17	4.0	2.7	4	1.6	1.5	2	1.1	1.1
8	PFUnA	24	3.9	1.7	28	0.3	0.3	1	0.3	0.3
7	PFDA	24	3.7	1.3	27	0.5	0.4	4	0.3	0.3
10	PFTrDA	24	3.2	1.2	21	0.1	0.1	0	NaN	NaN
11	PFTeDA	24	2.1	0.6	3	0.2	0.2	0	NaN	NaN
23	PFOSA	2	2.0	1.8	5	0.5	0.2	1	0.2	0.2
18	PFDS	20	1.8	0.5	5	0.2	0.2	0	NaN	NaN

Table 2 Summary Statistics by Compound in Pilot Data.

Analysis by SGS/Axys using MLA110 (EPA 1633)

PFOS



PFAS Summary

- PFOS is the most abundant PFAS in eggs, nestlings, and diet at our sites
- PFOS concentrations are lowest at Boulder and UMD
- PFOS concentrations are highest at Airbase, Martin Rd, and Rice Lake
- Some evidence for increasing PFOS concentration from Airbase to Martin Rd to Rice Lake

PFAS in Food Web Pathways + Composition and Quality of Diet

TO3. Characterize invertebrate prey diets of breeding birds using \underline{DNA} metabarcoding and $\delta 13C$



PFAS in Food Web Pathways + Composition and Quality of Diet



2022 Invertebrate Samples

Order

Post-season Analyses & New Activities in 2023

<u>Acknowledgements</u>







Chemical Safety for Sustainability (CSS) Research Program

The views expressed in this presentation are those of the authors and do not necessarily represent the views or the policies of the U.S. Environmental Protection Agency.



Questions?

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