



Tracking Microplastics in the Great Lakes Region: Advanced Detection and Characterization

Dr. Melissa Duhaime - Associate Professor, Dept Ecology & Evolutionary Biology, Program in the Environment
Dr. Anne McNeil Professor, Dept Chemistry, Program in the Environment, Macromolecular Science & Engineering
Dr. Andy Ault Professor, Dept Chemistry

University of Michigan

The Problem: Great Lakes microplastics data are too sparse and inconsistent to support the risk assessment needed for policy

International Joint Commission—Report of Science Advisory Board on Microplastics

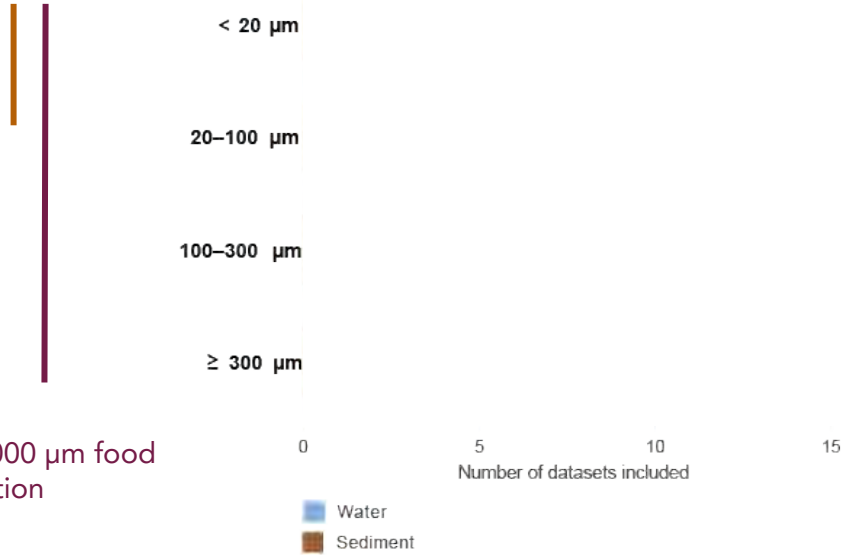


- Microplastics (MPs) are reported in water, sediment, beaches, and biota in every Great Lake; more people → more plastics
- Methods vary too widely to model trends
- No coordinated basin-wide monitoring program
- MPs are reaching people and wildlife
- Some water samples already exceed risk thresholds
- Sediment thresholds can't be set with confidence

McIlwraith et al, 2023: meta-analysis
Hataley et al., 2023: formal risk assessment

How and why does size reporting of microplastics matter?

1-83 µm tissue translocation

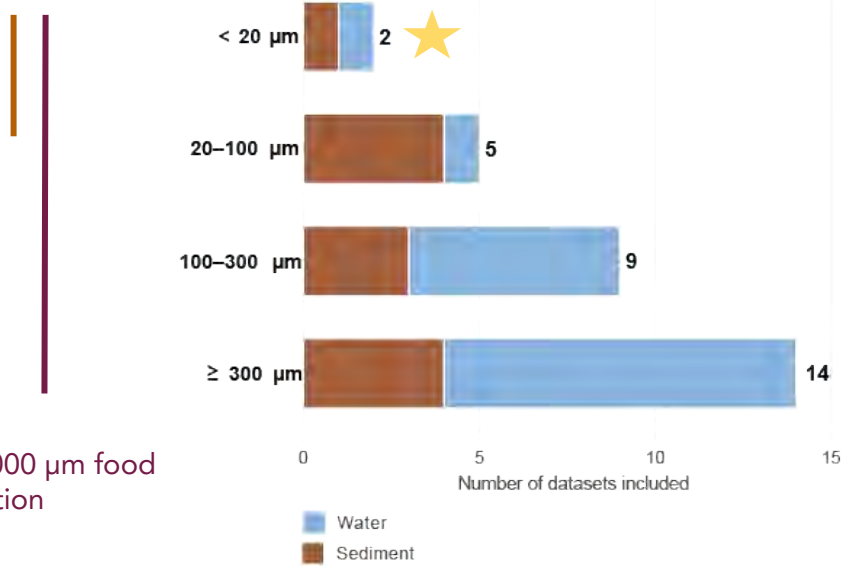


1-5000 µm food dilution

McIlwraith et al, 2023 (GL MPs meta-analysis); Hataley et al., 2023 (risk assessment); Fox et al., 2022 (depth-resolved Lake Superior study); Thomas 2026 (MSc thesis; Lake Superior, depths, water, sediment)

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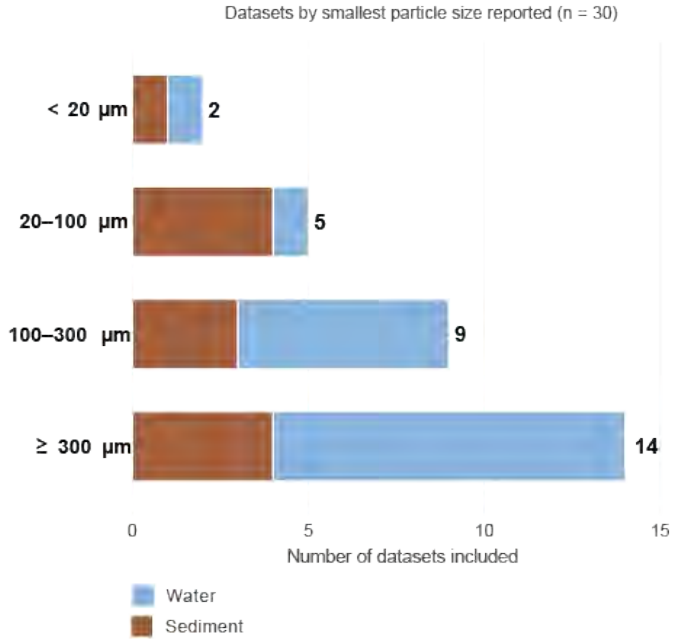
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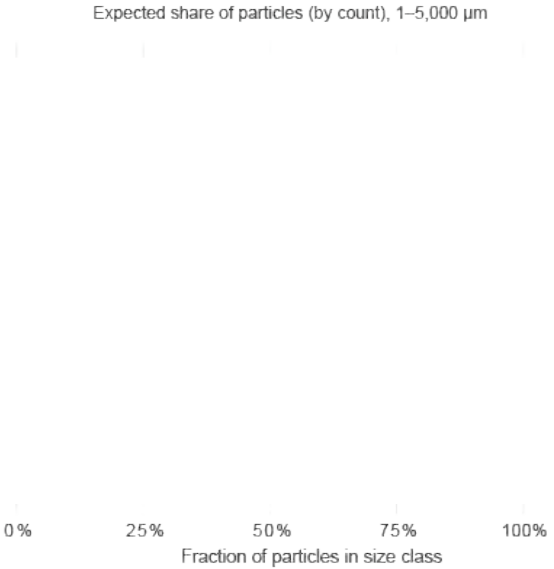
1-83 µm tissue translocation

1-5000 µm food dilution

Counts of Great Lakes Microplastics Datasets



Modeled Distribution of Microplastics



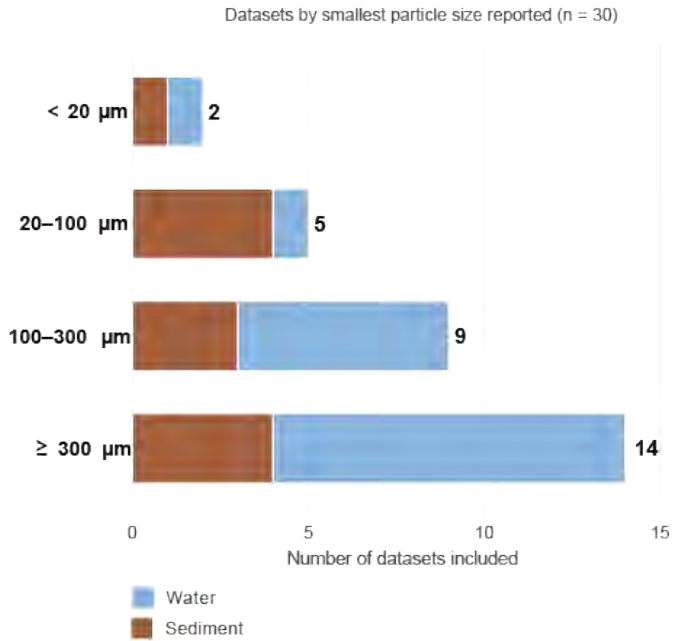
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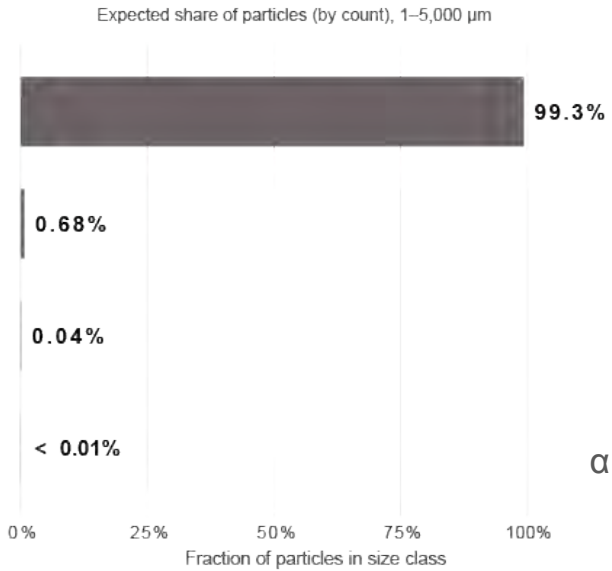
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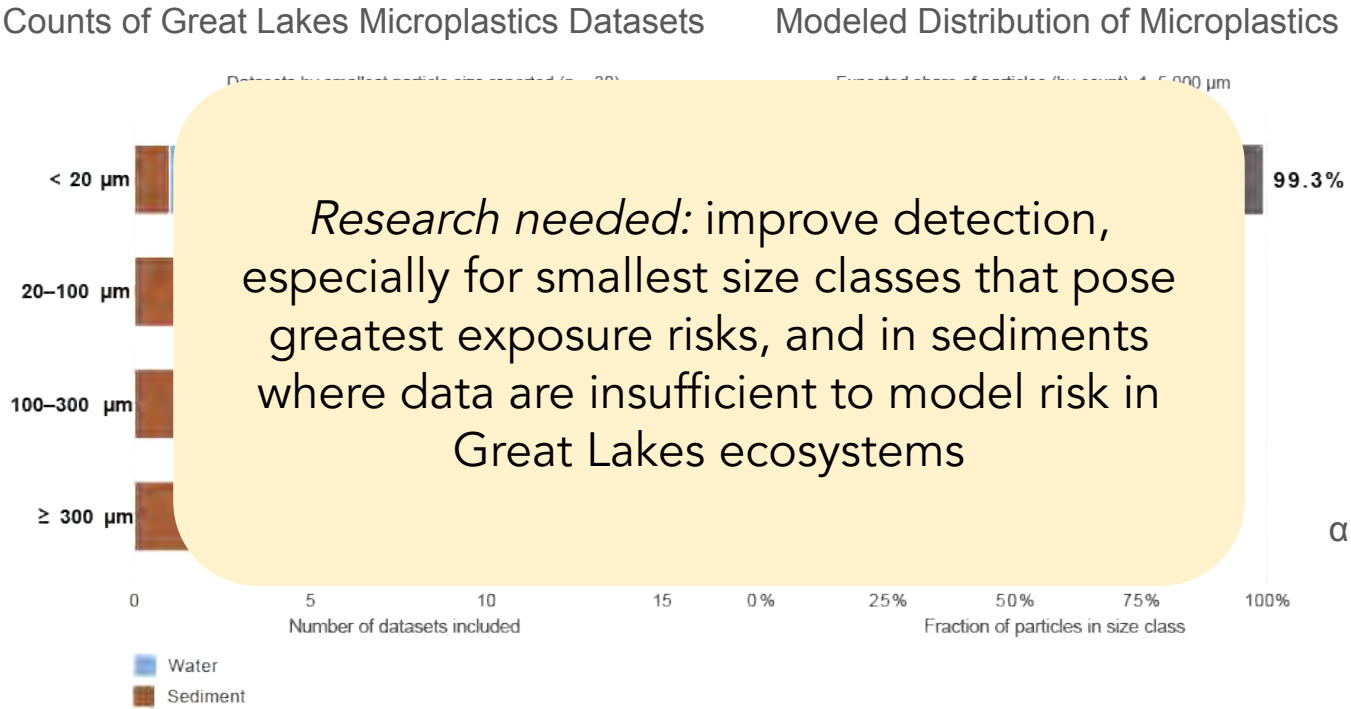
α = 2.64

McIlwraith et al, 2023 (GL MPs meta-analysis); Hataley et al., 2023 (risk assessment); Fox et al., 2022 (depth-resolved Lake Superior study); Thomas 2026 (MSc thesis; Lake Superior, depths, water, sediment); Kooi et al., 2021 (fit power law to particle length)

How and why does size reporting of microplastics matter?

1-83 µm tissue translocation

1-5000 µm food dilution



Research needed: improve detection, especially for smallest size classes that pose greatest exposure risks, and in sediments where data are insufficient to model risk in Great Lakes ecosystems

α = 2.64

McIlwraith et al, 2023 (GL MPs meta-analysis); Hataley et al., 2023 (risk assessment); Fox et al., 2022 (depth-resolved Lake Superior study); Thomas 2026 (MSc thesis; Lake Superior, depths, water, sediment); Kooi et al., 2021 (fit power law to particle length)

The Problem: Great Lakes microplastics data are too sparse and inconsistent to support the risk assessment needed for policy

This Talk



Detection: How new spectroscopy combined with machine-learning (ML) methods can increase confidence at small particle sizes



Application: Lessons from airborne MPs



Taking this to the Great Lakes: Current efforts towards reliable data for Great Lakes water column and sediments

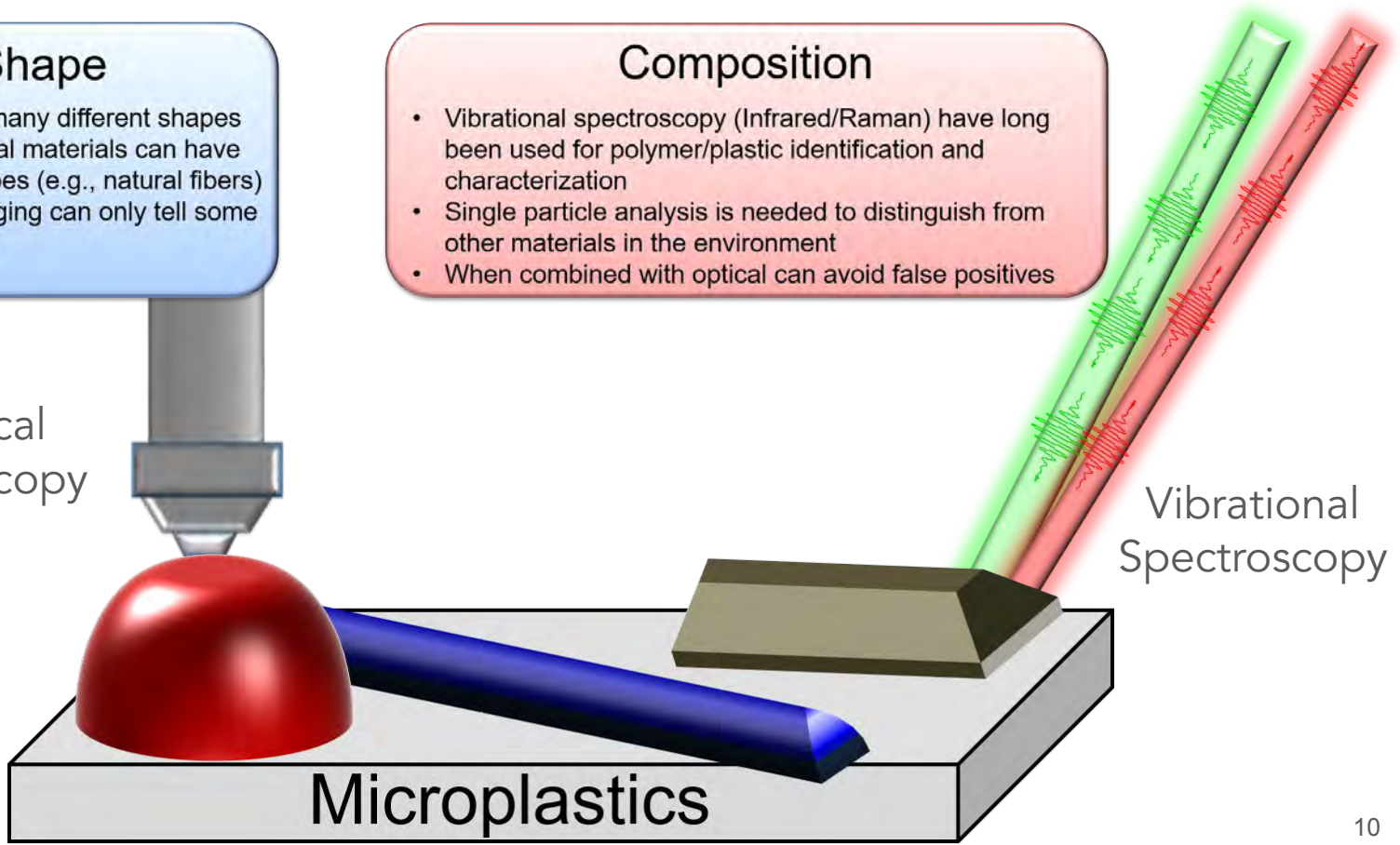
The Challenge of Identifying Microplastics

Shape

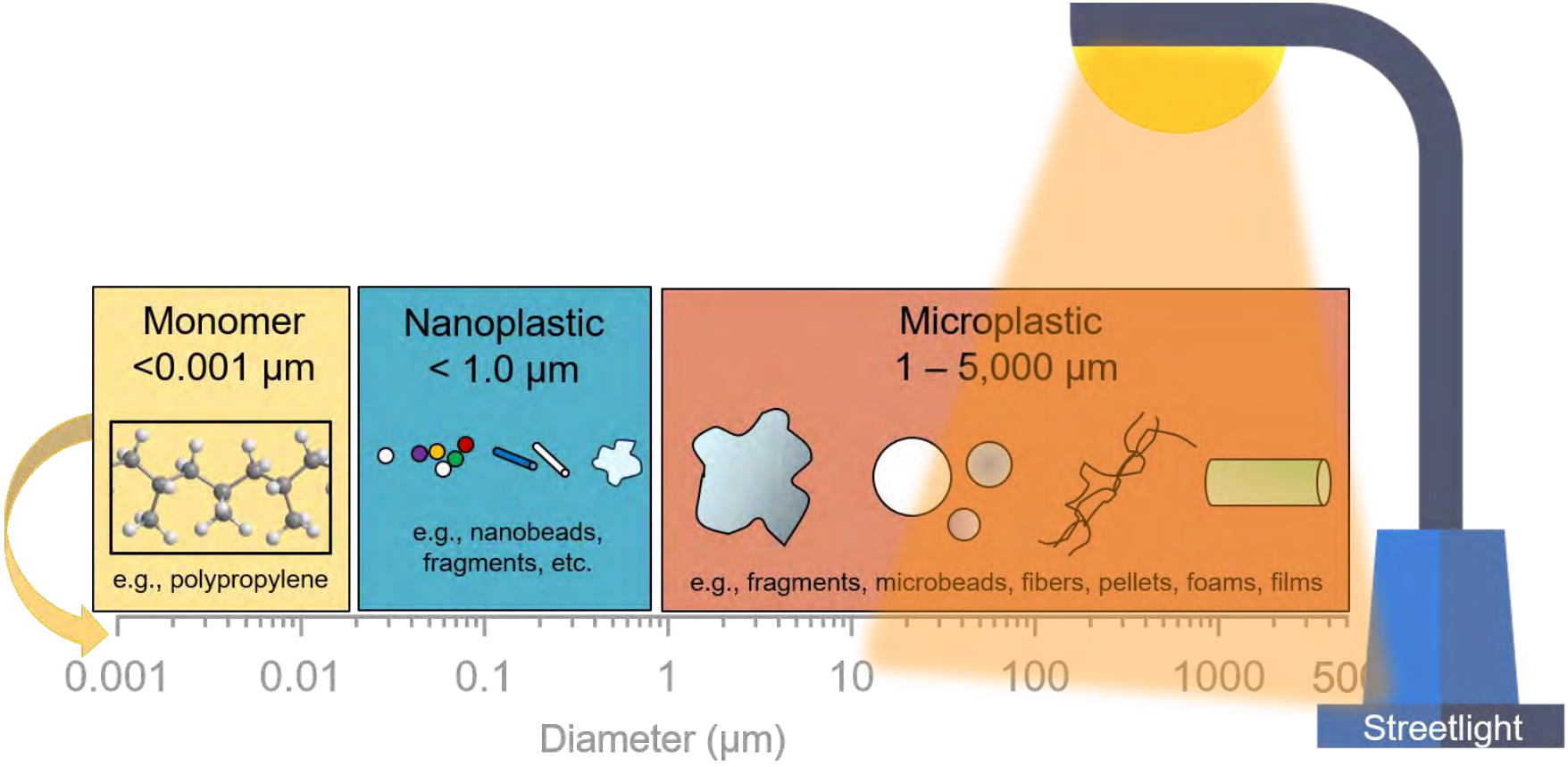
- MPs have many different shapes
- Other natural materials can have similar shapes (e.g., natural fibers)
- Optical imaging can only tell some of the story

Composition

- Vibrational spectroscopy (Infrared/Raman) have long been used for polymer/plastic identification and characterization
- Single particle analysis is needed to distinguish from other materials in the environment
- When combined with optical can avoid false positives

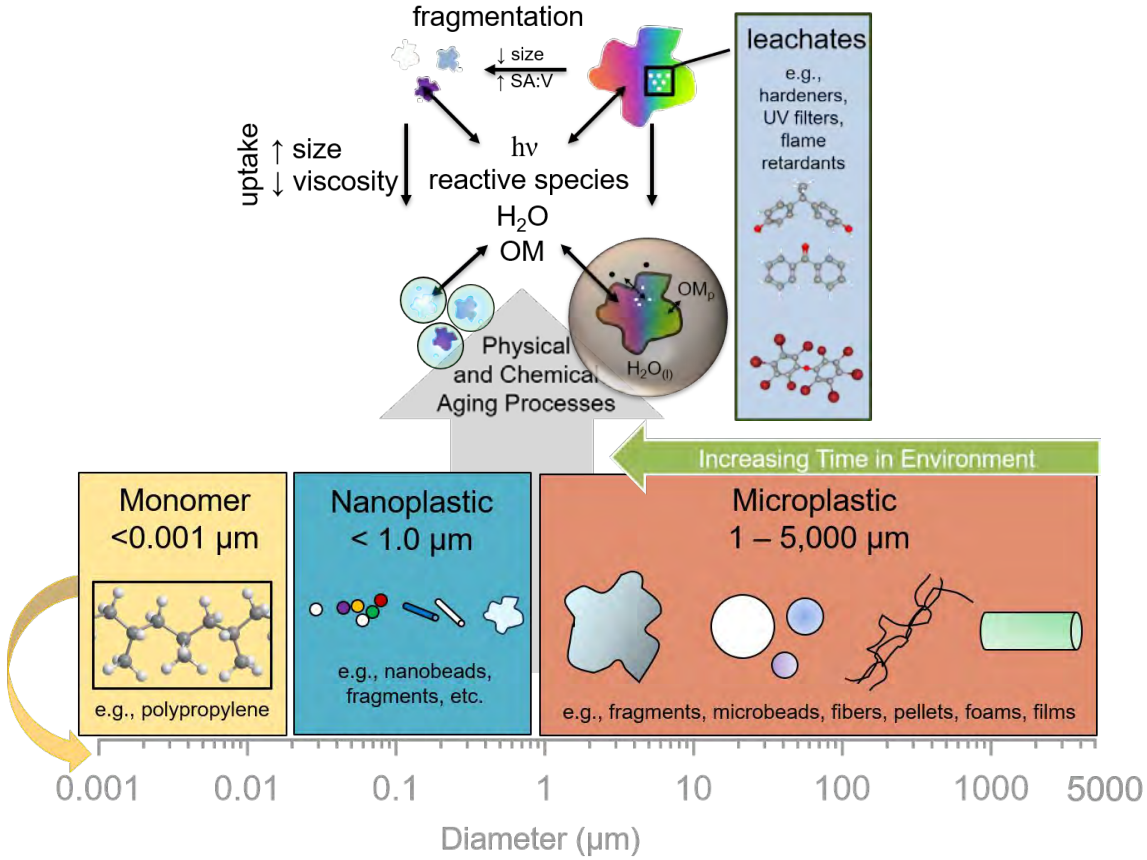


Microplastics Analysis Has Been Limited by the Sizes We Can Measure



Adapted from - Zhang, Y.*; Slade, J. H.*; Ault, A. P.*; Chan, A. W. H.* An Atmospheric Chemistry Perspective on Airborne Micro- and Nanoplastic Particles, Environmental Science and Technology, 2025, 59 (16), 7810-7819.

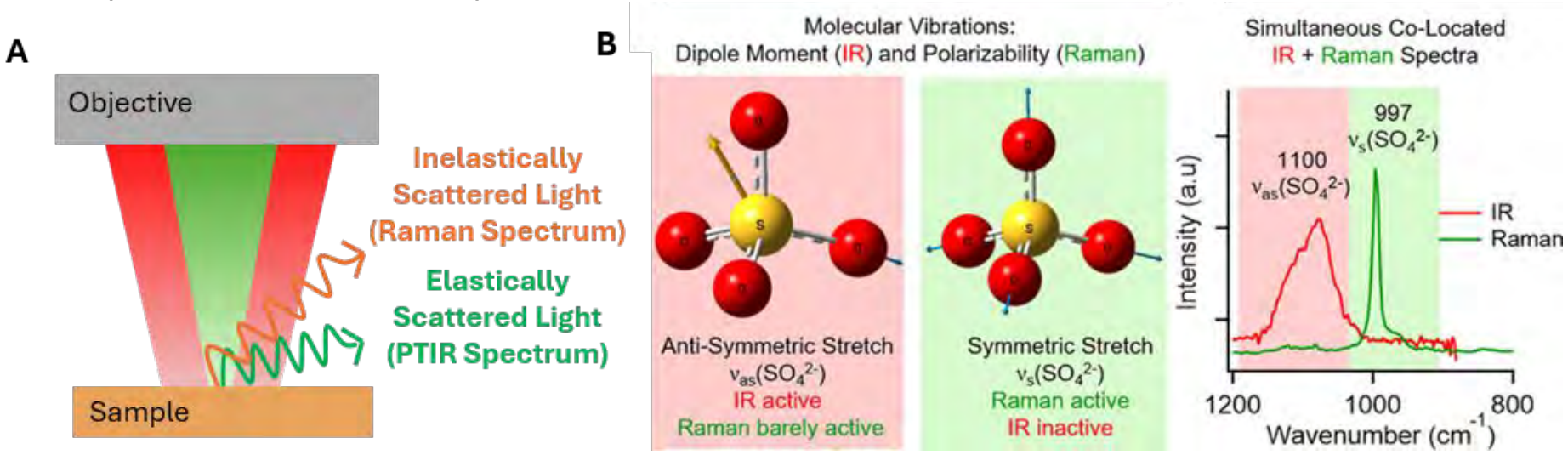
Microplastic Aging Adds a Measurement Challenge



Adapted from - Zhang, Y.*; Slade, J. H.*; Ault, A. P.*; Chan, A. W. H.* An Atmospheric Chemistry Perspective on Airborne Micro- and Nanoplastic Particles, Environmental Science and Technology, 2025, 59 (16), 7810-7819.

Simultaneous Optical Photothermal Infrared (O-PTIR) + Raman Microspectroscopy

Multiple Chemical Fingerprints for Identification



nature reviews methods primers

Ayala, A. M., Smith, J. H.; Lei, Z., and Ault, A. P.* Optical Photothermal Infrared Spectroscopy, *Nature Reviews Methods Primers*, **2026**, 6(1), 71.

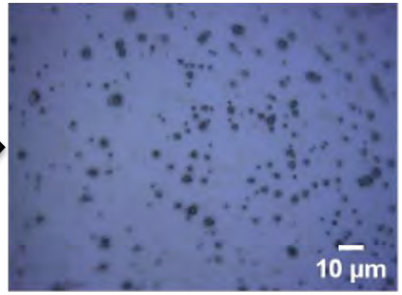
analytical chemistry

Olson, N. E.; Xiao, Y.; Lei, Z.; Ault, A. P.* Simultaneous Optical Photothermal Infrared (O-PTIR) and Raman Spectroscopy of Submicrometer Atmospheric Particles, *Analytical Chemistry*, **2020**, 92(14), 9932–9939.

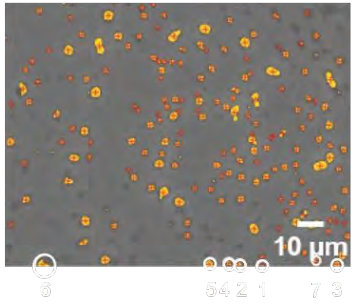
Increasing Throughput: Computer Controlled Analysis (CC-OPTIR+Raman)



Optical Imaging



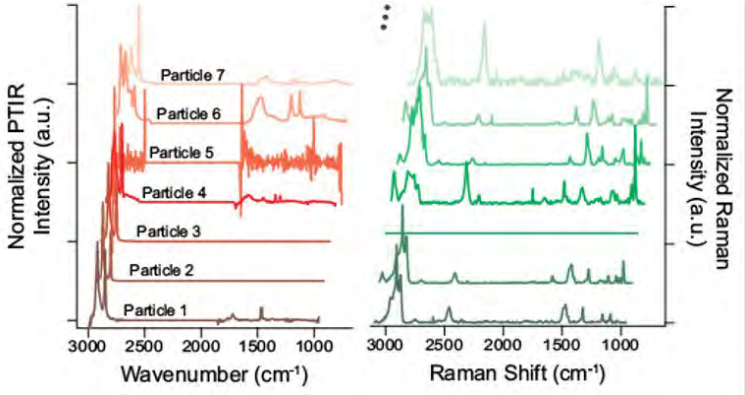
Software Masking

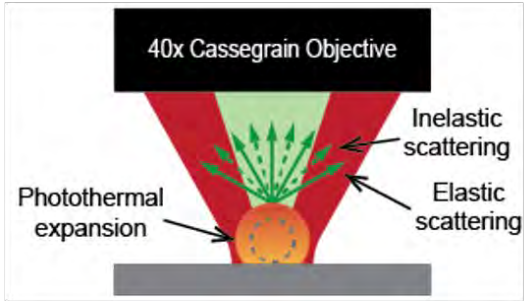


Dr. Rebecca Parham



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Automated Particle Analysis

analytical chemistry

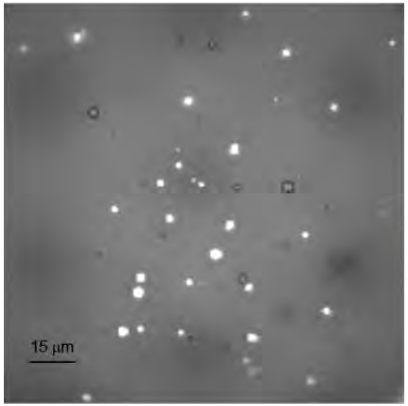
Parham, R. L.; Ayala, A. M.; Meagher, L.; Clough, M. E.; Ochoa Rivera, E.; Shi, J.; Tewari, A.; McNeil, A. J.; Ault, A. P.* Identifying Microplastics in Laboratory and Atmospheric Aerosol Mixtures via Optical Photothermal Infrared and Raman Microspectroscopy, *Analytical Chemistry,* 2025, 97 (33), 18136-18143.

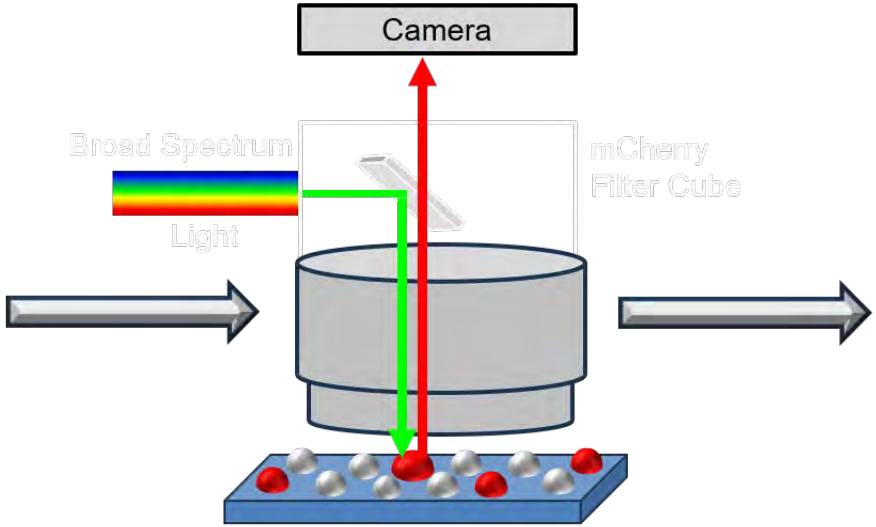
Accelerating Analysis – Fluorescence-Guided OPTIR



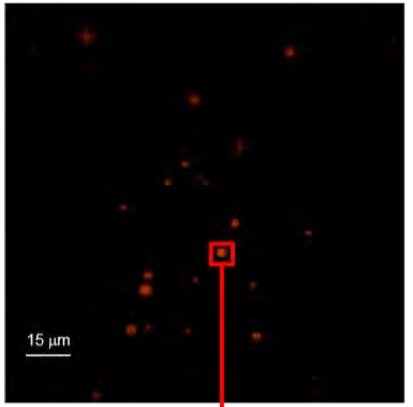
Randi Libin-Straub (Ault Lab)

Brightfield Image

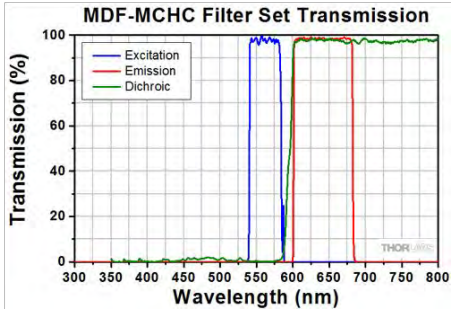


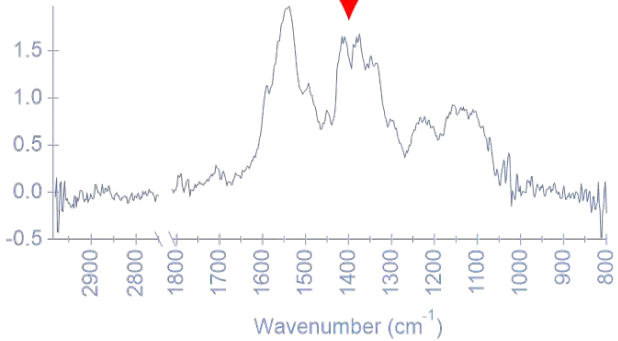


Fluorescence Image



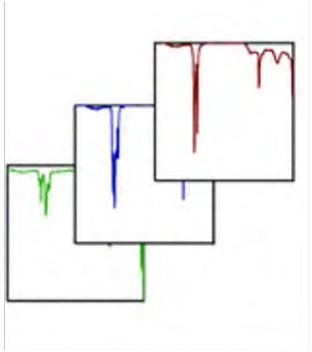
- Using fluorescence to decrease the number of particles analyzed
- With dyes or with autofluorescence





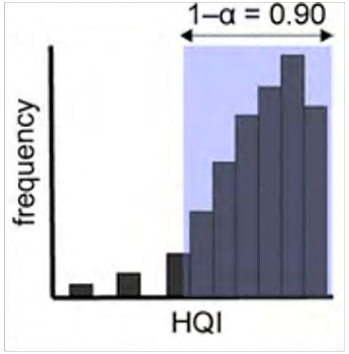
Developed a machine-learning informed protocol for spectral ID

1D (IR or Raman)



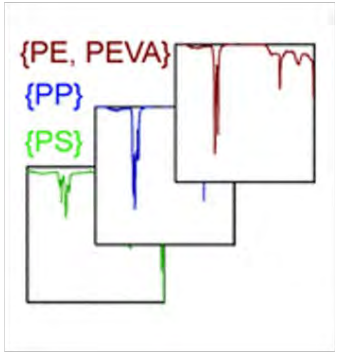
Scores for unknown spectra are compared with threshold.

Input



Calculates threshold based on a known score distribution.

Output



Returned labels carry a *confidence guarantee*.



Prof. Ambuj Tewari (UM Statistics)

Dr. Maddie Clough (McNeil Lab)



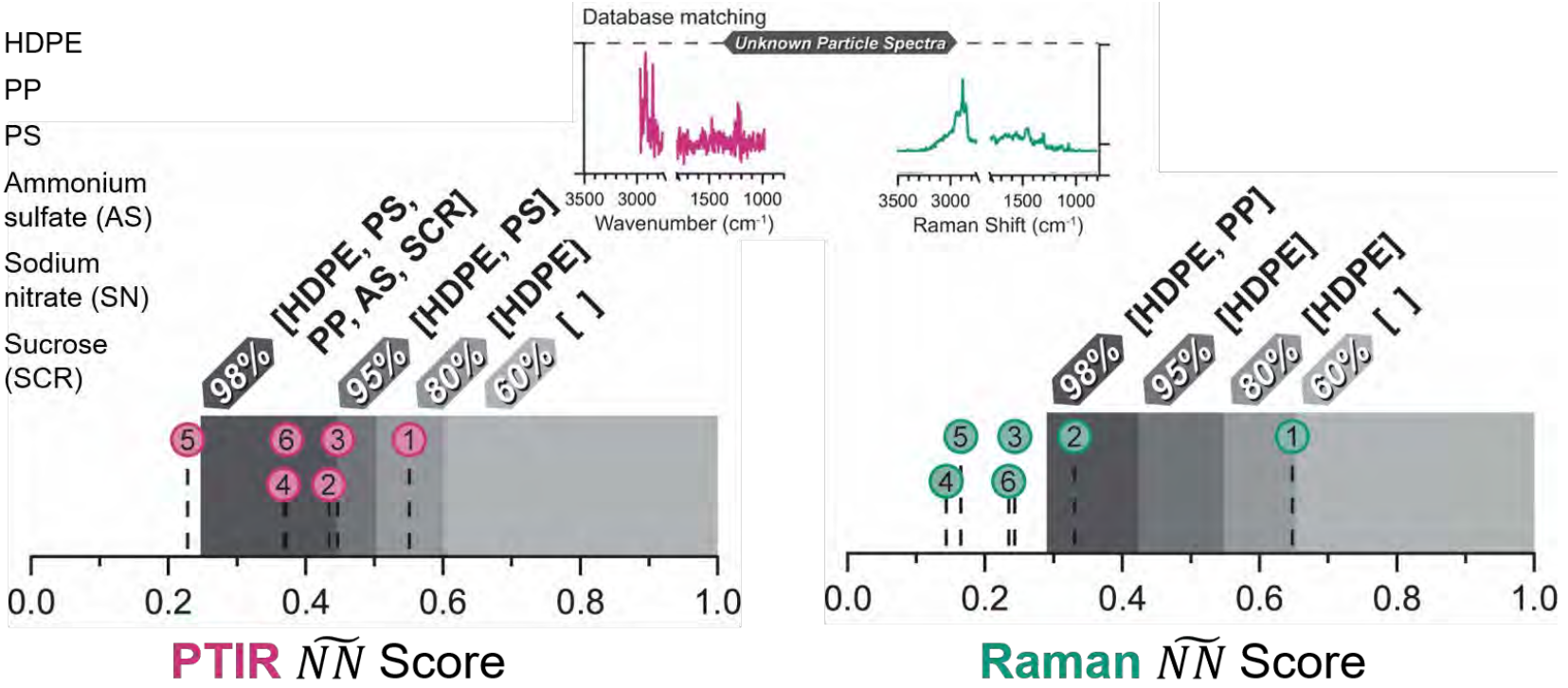
Eduardo Ochoa Rivera (Tewari Lab)



Adapted from Clough, M. E.; Rivera, E. O.; Parham, R. L. G; Ault, A. P.; Zimmerman, P. M.; McNeil, A. J.*; Tewari, A. J.* Enhancing Confidence in Microplastic Spectral Matching via Conformal Prediction, *Environmental Science and Technology*, **2024**, 58, (49), 21740-21749.

Combining individual particle IR and Raman for identification

1. HDPE
2. PP
3. PS
4. Ammonium sulfate (AS)
5. Sodium nitrate (SN)
6. Sucrose (SCR)



Dr. Rebecca Parham



Recent Ault Lab Graduate

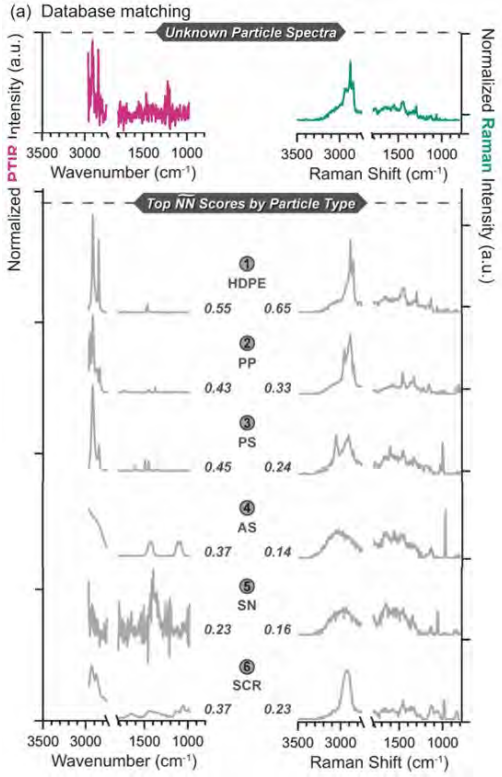
Dr. Eduardo Ochoa Rivera (Tewari Lab)

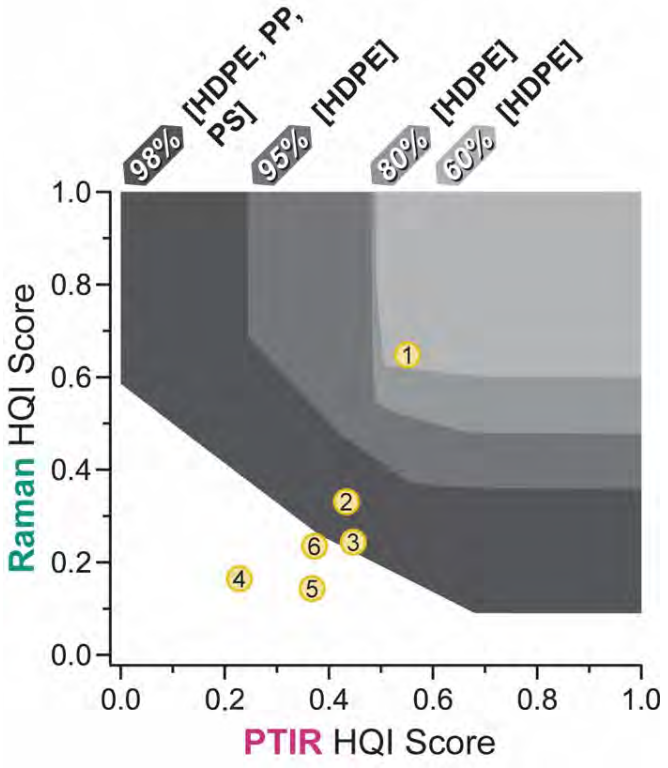


ACS MEASUREMENT SCIENCE Au
AN OPEN ACCESS JOURNAL OF THE AMERICAN CHEMICAL SOCIETY

Parham, R. L.; Ochoa, E. R.; Ayala, A. M.; Clough, M. E.; Patel, Y.; McNeil, A. J.; Tewari, A.*; Ault, A. P.* Improved Microplastic Identification from Simultaneously-Collected Photothermal Infrared and Raman Spectra using Multiview Conformal Prediction, *ACS Measurement Science: Au,* **2026**.

Multiview conformal prediction (MVCP)
Using PTIR and Raman together to Identify Microplastics





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Recent Ault Lab Graduate

Dr. Eduardo Ochoa Rivera (Tewari Lab)



ACS MEASUREMENT SCIENCE Au
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Applying these methods to airborne microplastics sampling

how many microplastics are we breathing in?

what are the common sources of microplastics in our air?



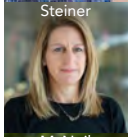
does where we live matter?

M4AM











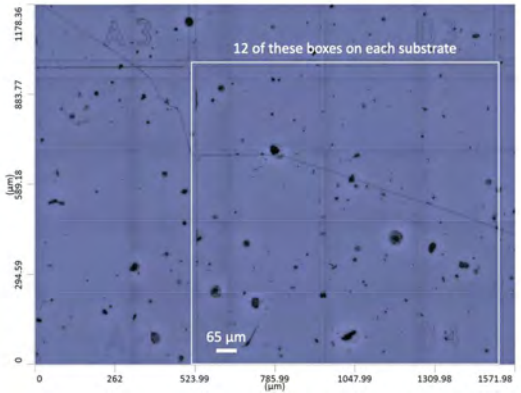
Performed both active and passive air sampling at four schools





across 10 months

gridded silicon substrates

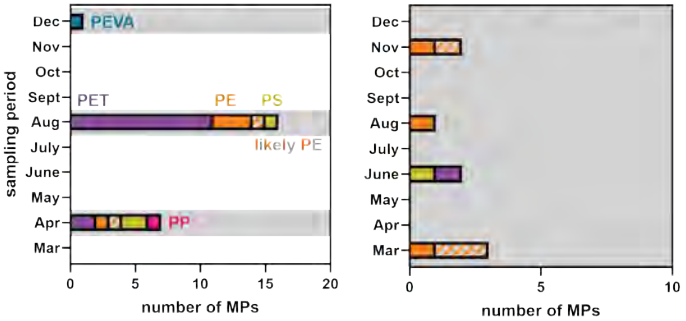


Few plastics found overall, and mostly in nanoplastic size range

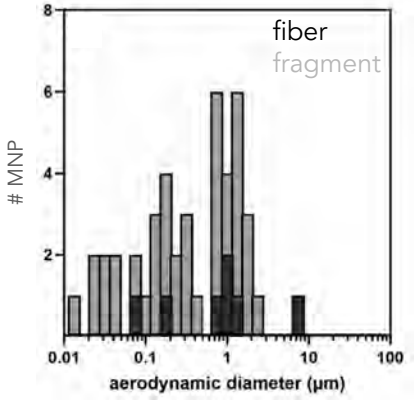


~1% of <u>all</u> particles were plastic (number proportion)
~0.80% were tires and ~0.25% were other plastic (PE, PP, PS, PET, PEVA)
>60% were in nanoplastic size range (by aerodynamic diameter)
fragments were most common shape

Washtenaw data
dry-deposited non-tire MPs
(active & passive)



all dry-deposited non-tire MPs

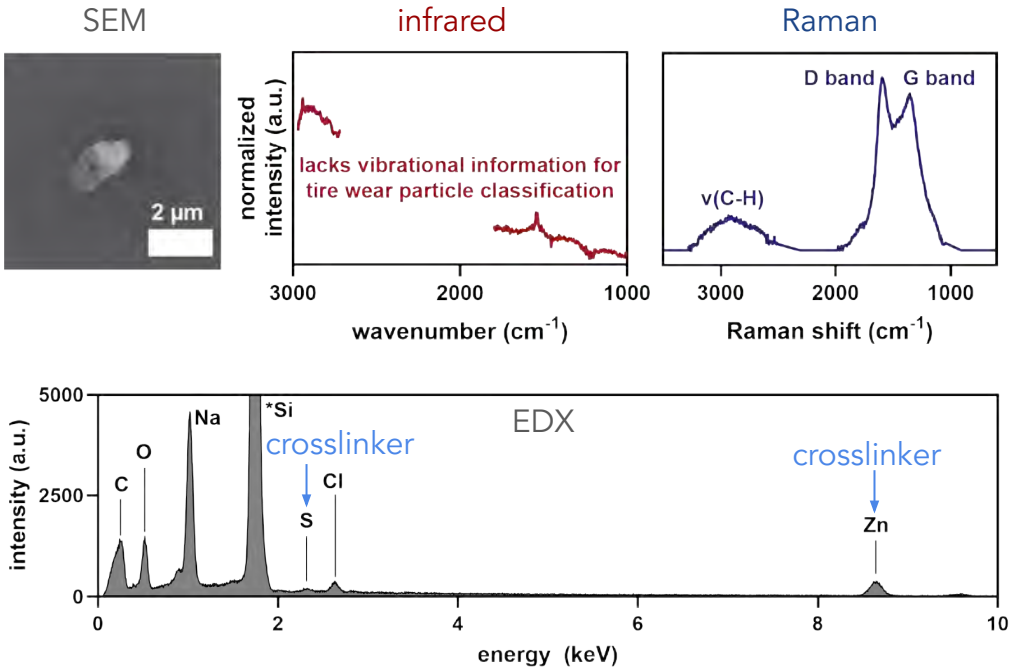


ES&T Air **2026**, in press.

Rubber particles outnumber non-rubber particles



looked for elemental markers consistent with vulcanization
only 24% of vibrationally suspected TWP were confirmed



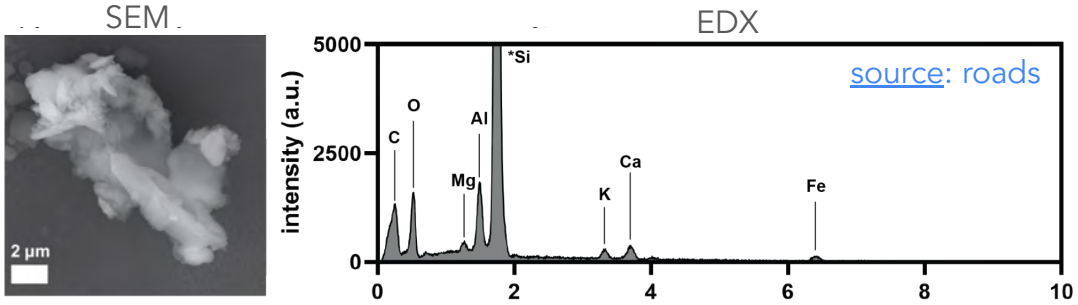
ES&T Air **2026**, in press.

Some source attribution possible

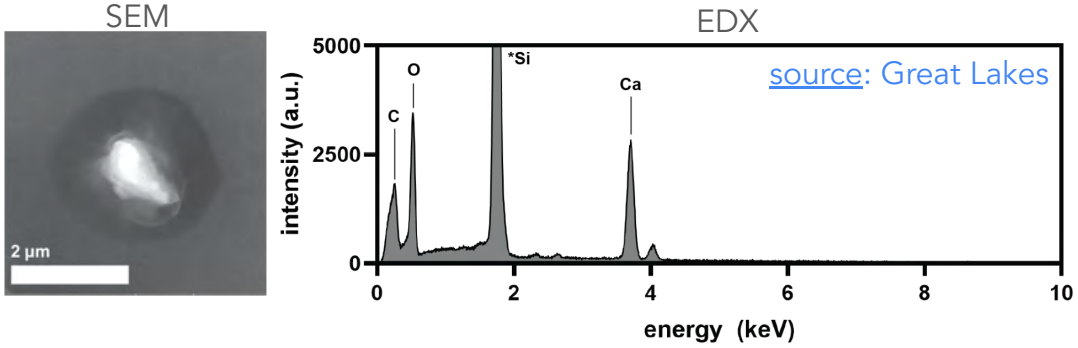


elemental markers consistent with generation from roads & great lakes

PE
passive
(Washtenaw, Nov 24)



PE
active
(Washtenaw, Aug 24)

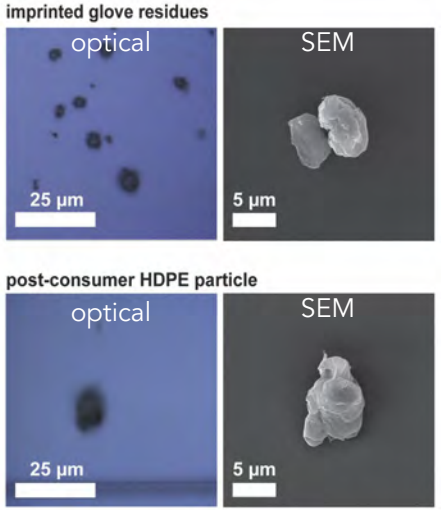


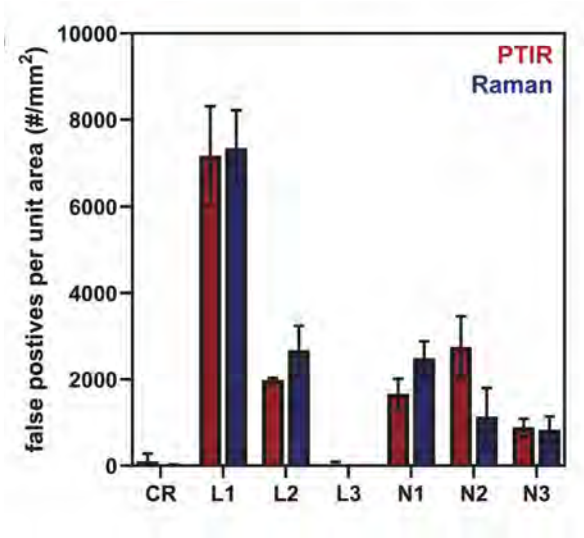
ES&T Air **2026**, in press.

Beware of contamination from dry contact with lab gloves



80% of QA/QC papers recommend glove use
most gloves are contaminated with stearate particles
standard library matching (esp. Raman) label as PE











Anal. Methods **2026**, *18*, 2914–2926.

These methods can be applied to (many) other environmental matrices

biosolids
(Delhi township)



soil
(Delhi township)



groundwater
(Delhi township)



compost
(UM Campus Farm)



Fate and Transport

Quantifying microplastic contamination in Michigan's groundwater

Thu Oct 8, 2026 9:55 AM – 10:40 AM

Speaker: Malavika Ramkumar

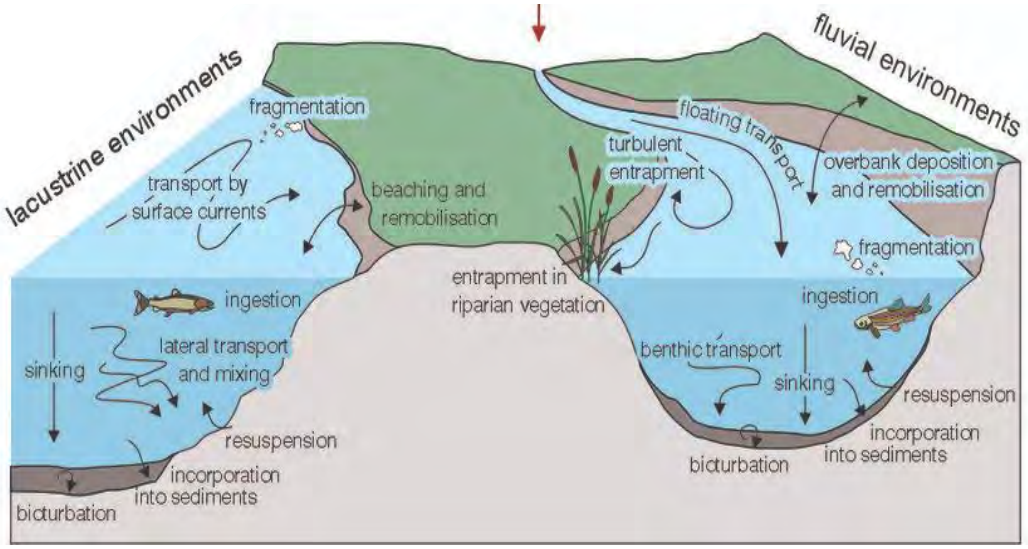
Building the baseline for Great Lakes monitoring

Building the baseline for Great Lakes monitoring

Where do microplastics go when they enter a lake?

Building the baseline for Great Lakes monitoring

Where do microplastics go when they enter a lake?

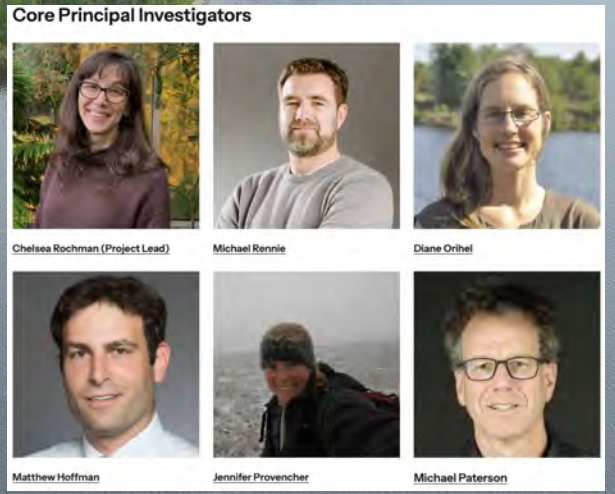


Kallenbach et al, 2021

PelaSTIC

led by Chelsea Rochman,
University of Toronto
IISD Experimental Lakes
Area (Ontario)

Understanding the fate and effects of microplastics in aquatic ecosystems



"When one tugs at a single thing in nature, he finds it attached to the rest of the world."

– John Muir



Determining ecosystem impacts of:

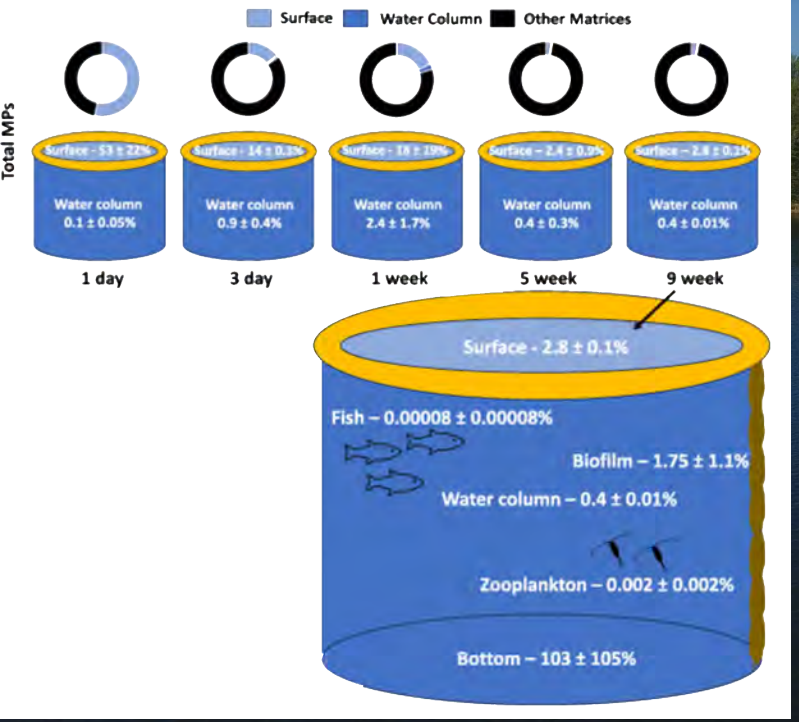
- plastic concentration
- plastic chemical formulation and additives



Rachel Cable
Graduate Student
Duhaime Lab

Determining ecosystem impacts of:

- plastic concentration
- plastic chemical formulation and additives
- impacts on microbial communities and functions—base of the foodweb





Most microplastics leave the surface and water column within days (85%) to weeks (97%)

Rochman et al, *ES&T*. 59:9768 2025

Taking these lessons to the Great Lakes

Taking these lessons to the Great Lakes

- Sample below the surface
- Sample the sediment
- Sample enough volume to account for variability
- Avoid contamination by lab gloves
- Sample for collection of small particle size analyses

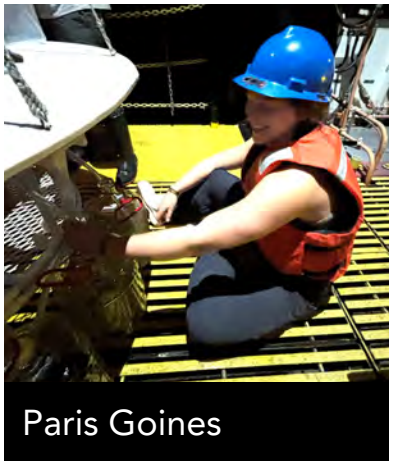
2026 Basin-wide Surveys, plus Georgian Bay



Eric Osantowski, Scientist, U.S. EPA
Crew of the *Lake Guardian* R/V
Great Lakes National Program



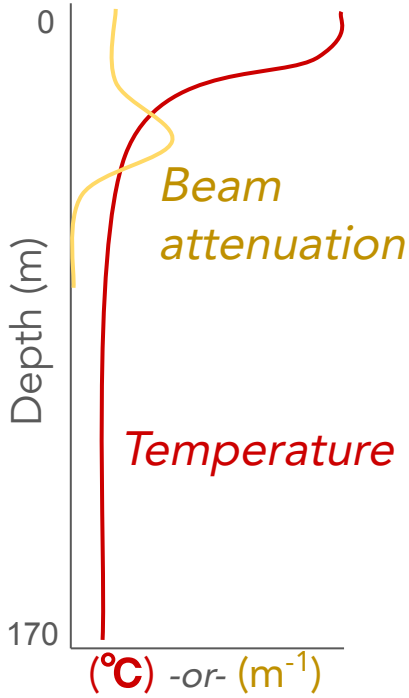






Depth-Resolved Water Sampling

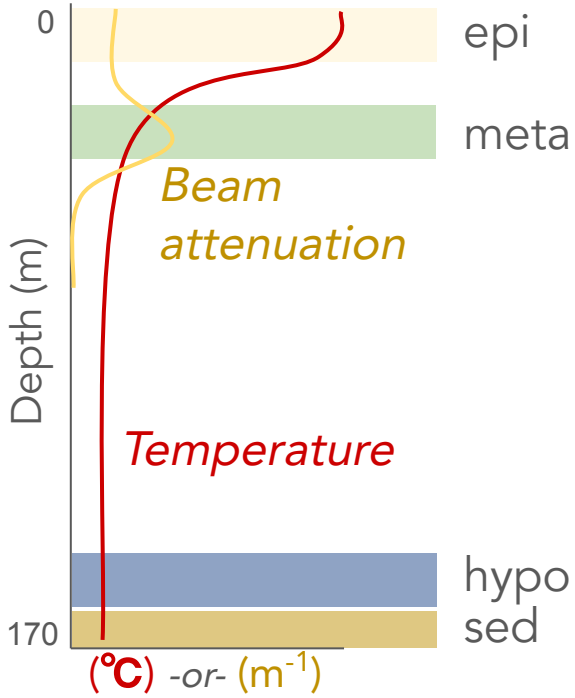






Depth-Resolved Water Sampling



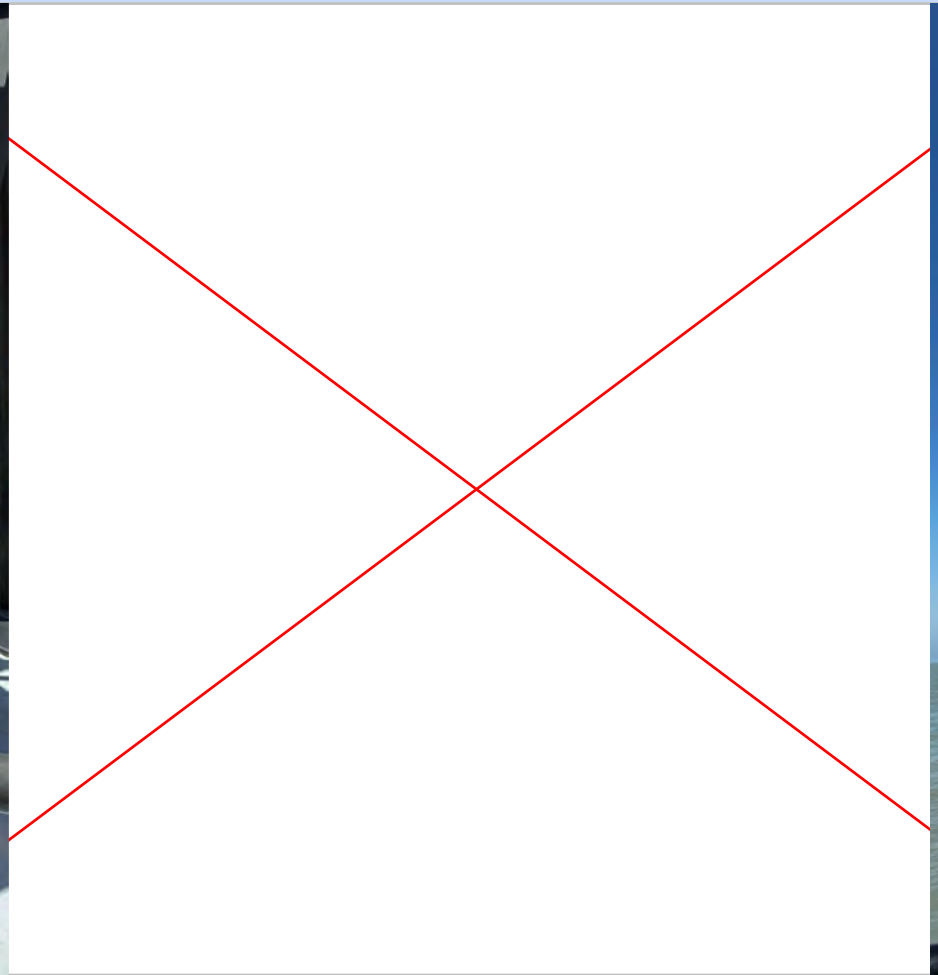






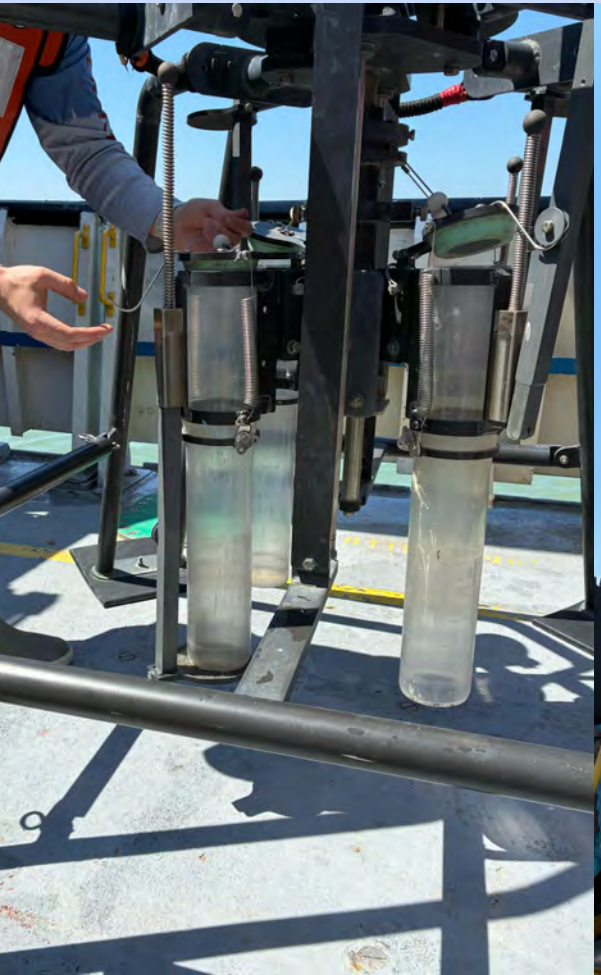
Depth-Resolved Water Sampling…and Sediment







Depth-Resolved Water Sampling…and Sediment

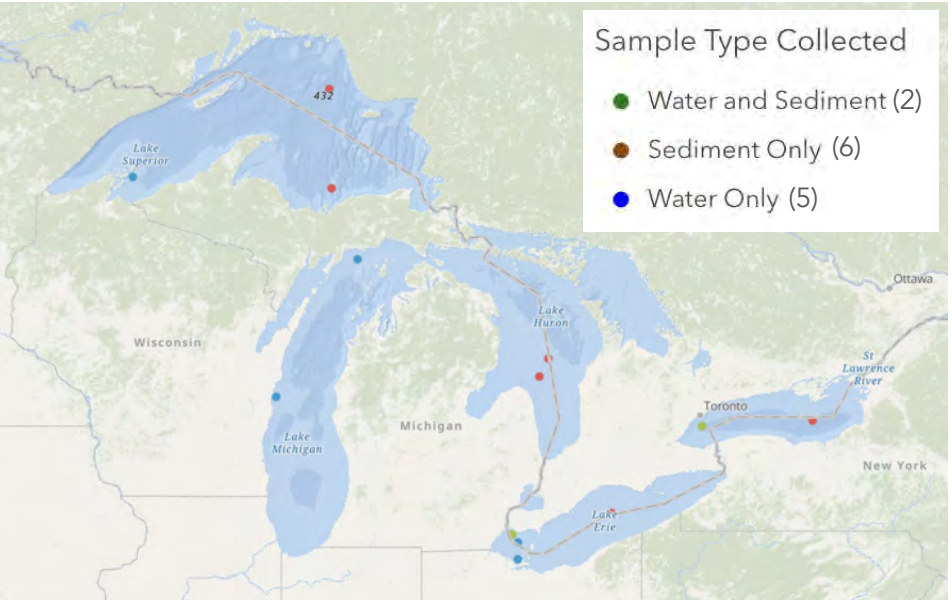




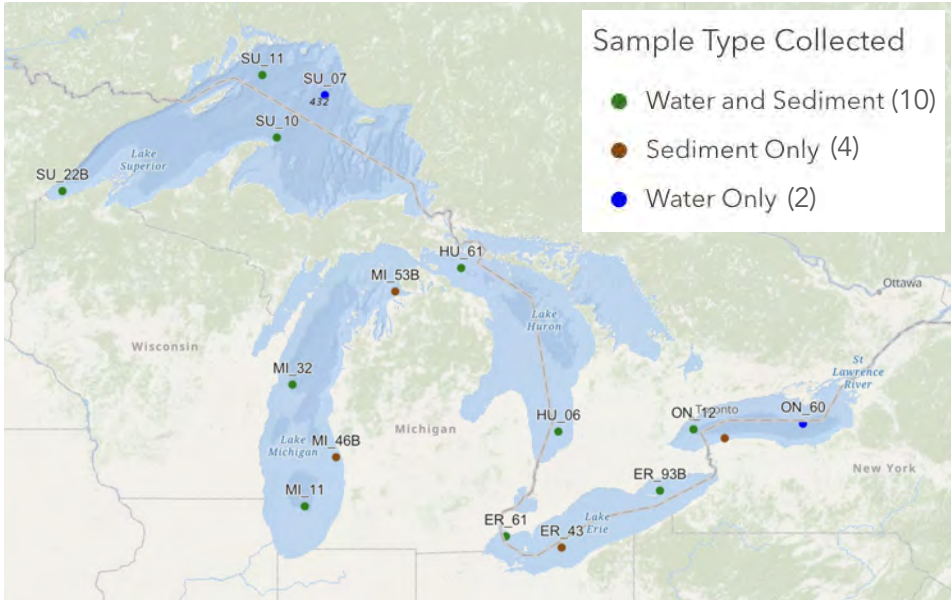


Basin-wide Surveys, plus Georgian Bay

2026 Spring Survey (April)



2026 Summer Survey (August)

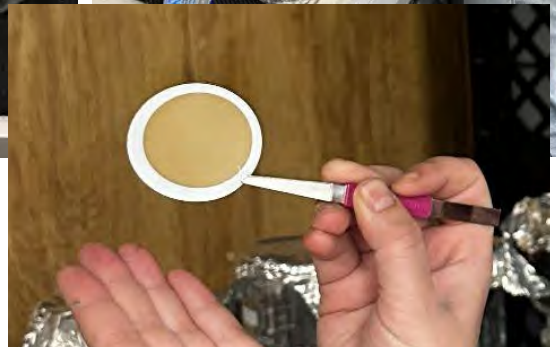


Station depths ranged 10-230 m
29 water stations; 3 depths; high (50 L) + low (8 L) volume samples (*RSVP*, Cross et al., 2025)
22 sediment stations

Sequential Size-Fractionation





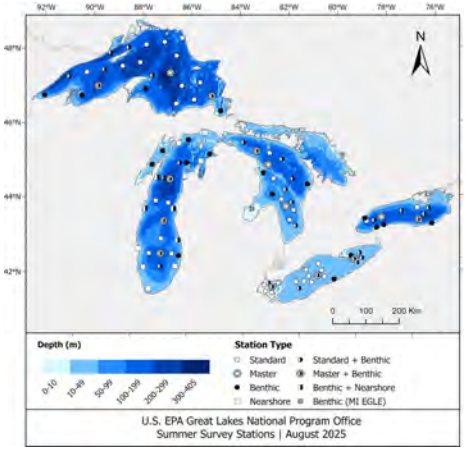


100 µm → 20 µm → 0.45 µm

To the lab for sonication, digestion and on to spectroscopy

Combined for a 5-lake, multi-instrument, multi-team study

Quantify exposure

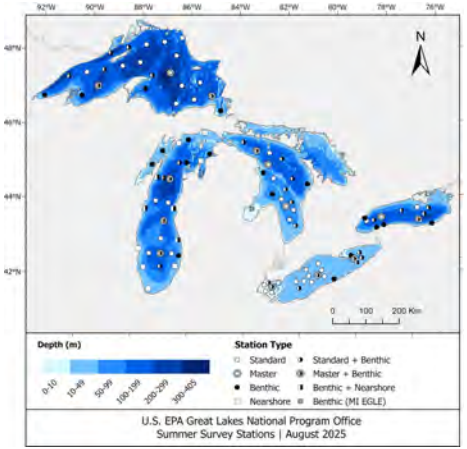




Eric Osantowski, Scientist, U.S. EPA
Great Lakes National Program

Combined for a 5-lake, multi-instrument, multi-team study

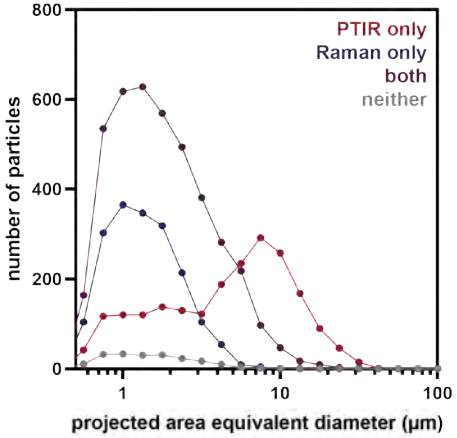
Quantify exposure





Eric Osantowski, Scientist, U.S. EPA
Great Lakes National Program

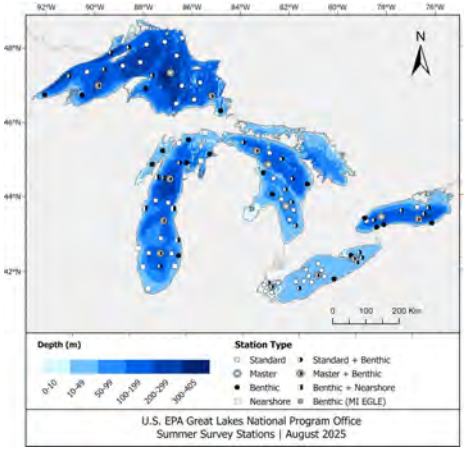
New analytical detection capacity and error modeling



McNeil Lab

Combined for a 5-lake, multi-instrument, multi-team study

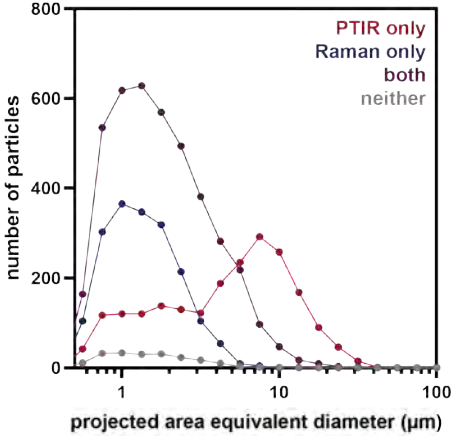
Quantify exposure





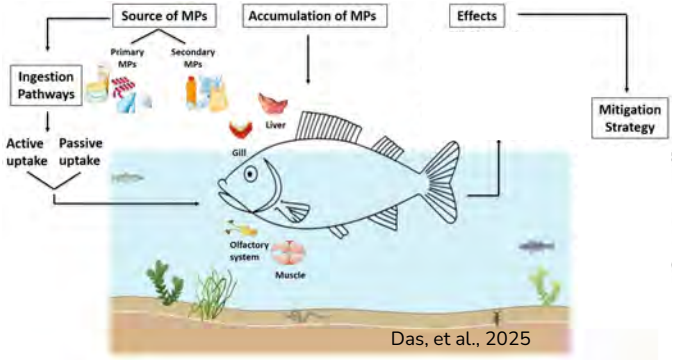
Eric Osantowski, Scientist, U.S. EPA
Great Lakes National Program

New analytical detection capacity and error modeling



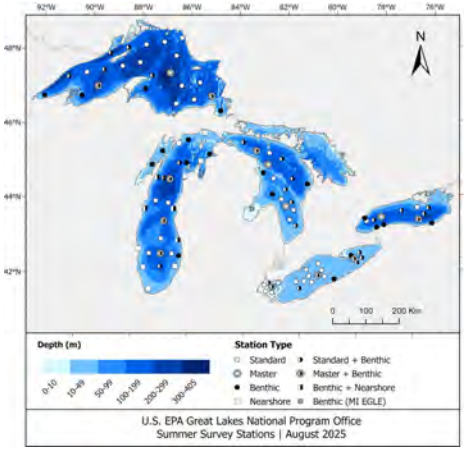
McNeil Lab

Food-web impacts and ecotoxicology



Combined for a 5-lake, multi-instrument, multi-team study

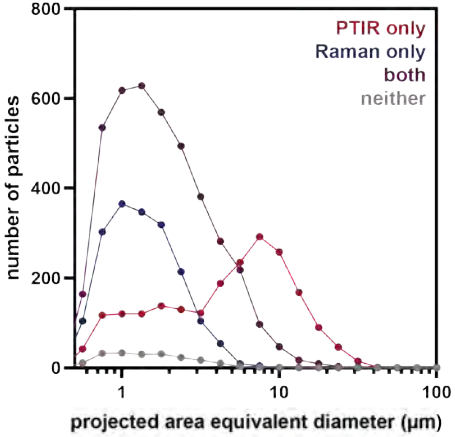
Quantify exposure





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Great Lakes National Program

New analytical detection capacity and error modeling



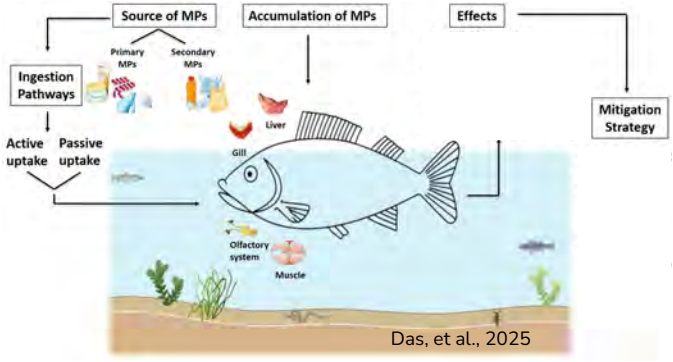
McNeil Lab

RIT

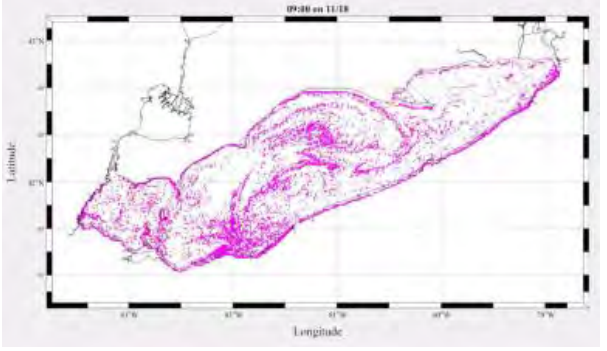
Dr. Matthew Hoffman



Food-web impacts and ecotoxicology



New transport models



Thank you

Estate of Camille P. Hodgson

Duhaime Lab

McNeil Lab

Ault Lab

Matt Hoffman (RIT)

IISD-ELA / Chelsea Rochman and the pELAstics Team

GEORGIAN BAY FOREVER

Cooperative Institute for Great Lakes Research
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