

Artificial Intelligence and Real-World Microplastics: Accelerating Hazard, Exposure, and Decision-Making using Models and Data

September 8, 2026

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OEHHA
California Office of Environmental
Health Hazard Assessment



São Paulo School of
Advanced Science on
MICROPLASTIC



“The interweaving of the synthetic & natural world”
by Elizabeth Ellenwood & Hans Peter Arp



OEHHHA
California Office of Environmental
Health Hazard Assessment



CalEPA
California Environmental
Protection Agency

What I do at OEHHHA:

Assess risks of contaminants and develop
health-protective guidelines in air, water, and
soil to inform regulations by agency partners

Agencies Need Evidence to Make Decisions...

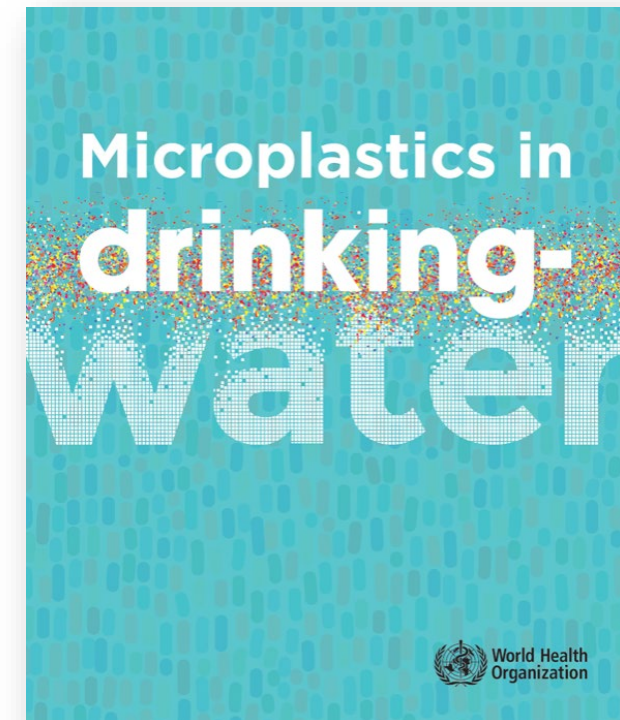
`the **absence of evidence** of microplastics risks currently does not allow one to conclude that risk is either present or absent with sufficient certainty.`

- SAPEA (2019)

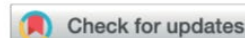


‘humans have ingested microplastics and other particles in the environment for decades with no related indication of adverse health effects’ and that there is ‘**no evidence** to indicate a human health concern.’

- WHO (2019)



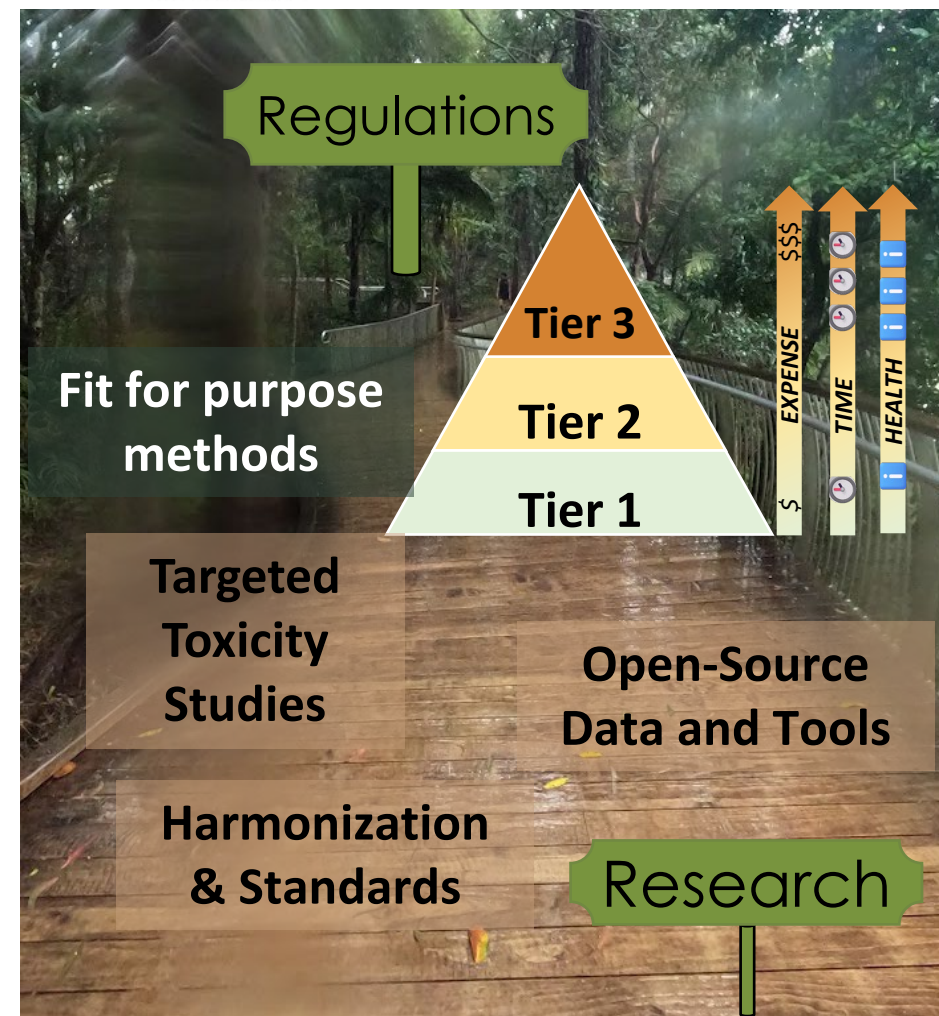
My roadmap from 2021



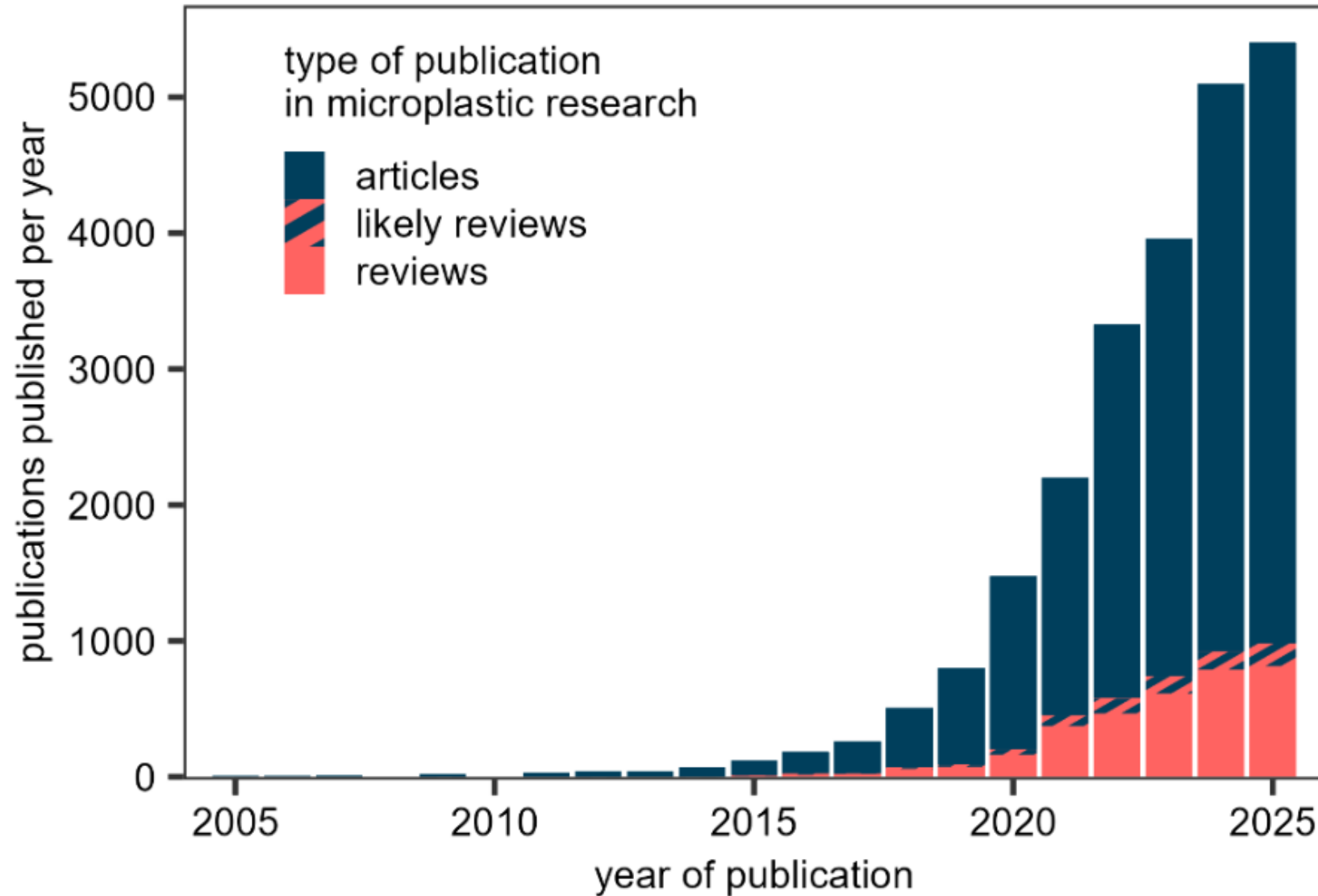
Cite this: *Environ. Sci.: Adv.*, 2023, 2, 356

The emergence of microplastics: charting the path from research to regulations

Scott Coffin *



The Great Pacific Microplastics Publication Gyre



Nanna B. Hartmann; David Mennekes; **Martin Wagner** (2026). “Lost in a Sea of Information: The Microplastics Publication Deluge”
Environmental Science & Technology

More data is great!

...But we have to interpret it in a way that can withstand the legal hurdles that regulatory agencies will face.

The Path Forward:

- Data-driven models;
- Effective & inclusive coordination

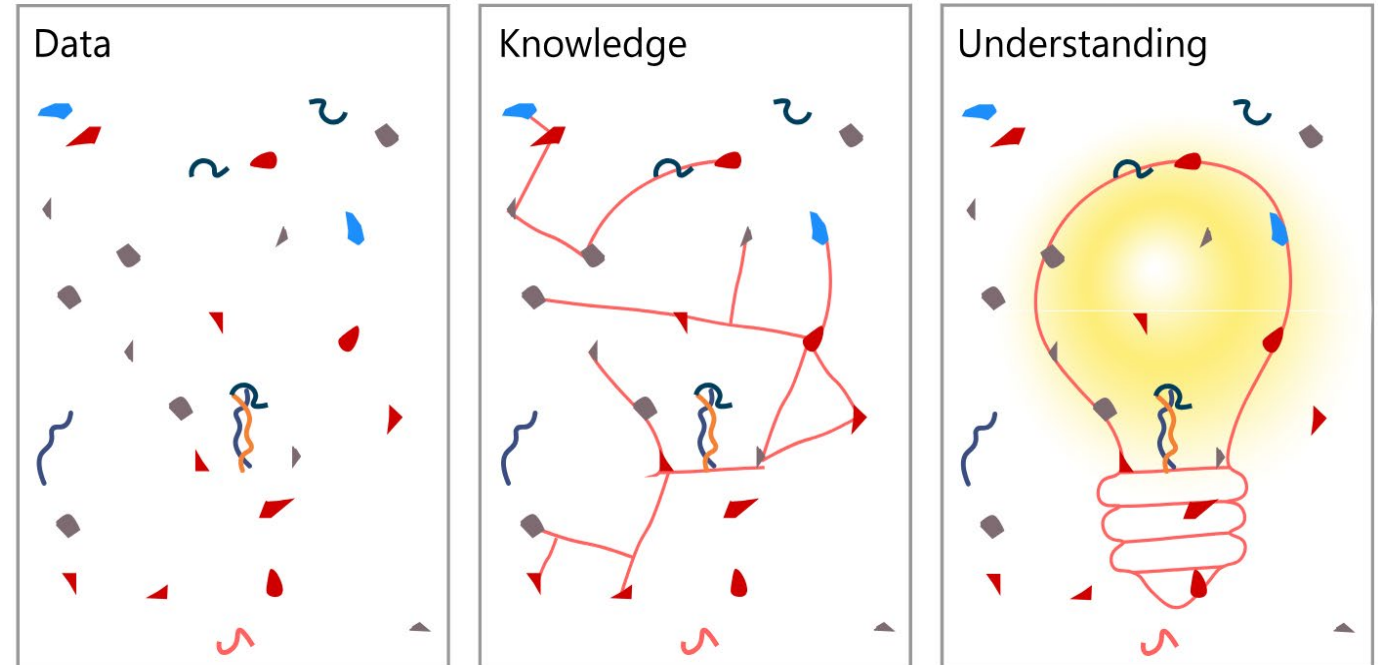
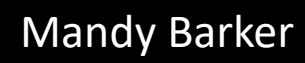


Figure from Nanna B. Hartmann; David Mennekes; Martin Wagner (2026). "Lost in a Sea of Information: The Microplastics Publication Deluge". *Environmental Science & Technology*



California Senate Bill 1263 (2018)

Deadlines

2022

- Initiate Statewide Microplastics Strategy

2026

- **Develop risk assessment framework**
- Develop standardized methods
- Establish baseline occurrence data
- Investigate sources and pathways
- Recommend source reduction strategies

2-Track Statewide Microplastics Strategy

Track 1: Solutions

- **Pollution Prevention**

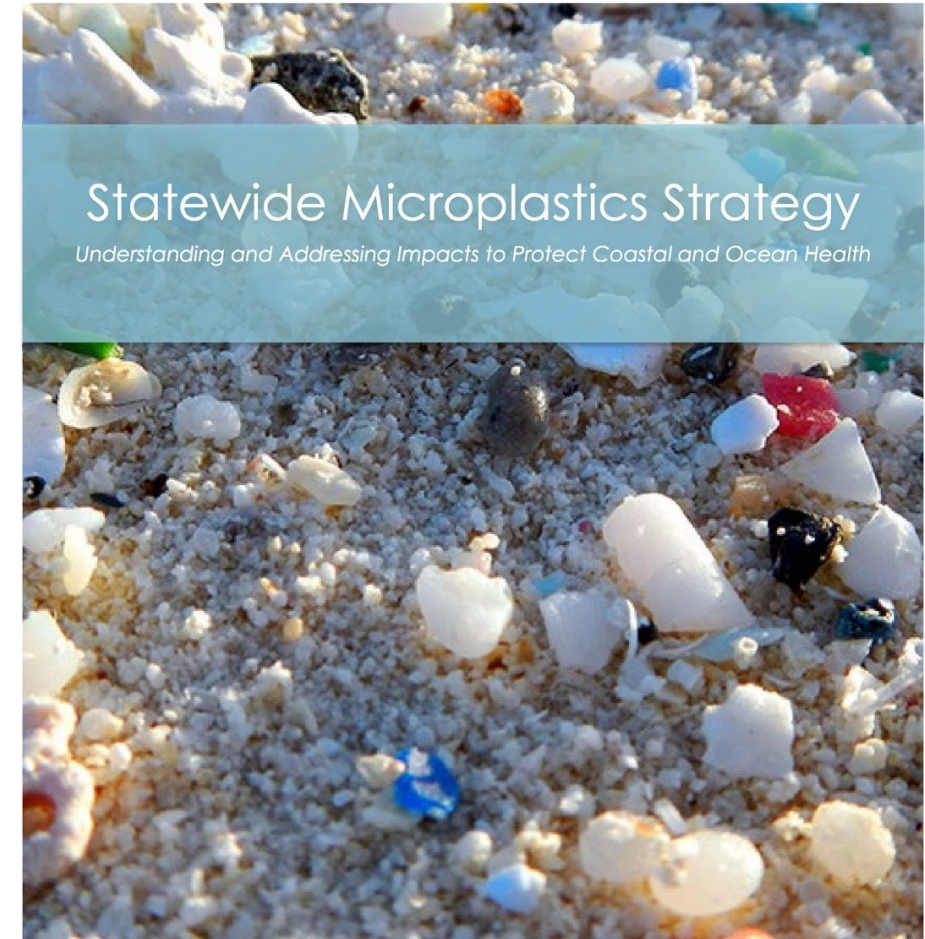
Eliminate plastic waste at the source

- **Pathway Interventions**

Intervene with the mobilization of microplastics into CA waters

- **Outreach & Education**

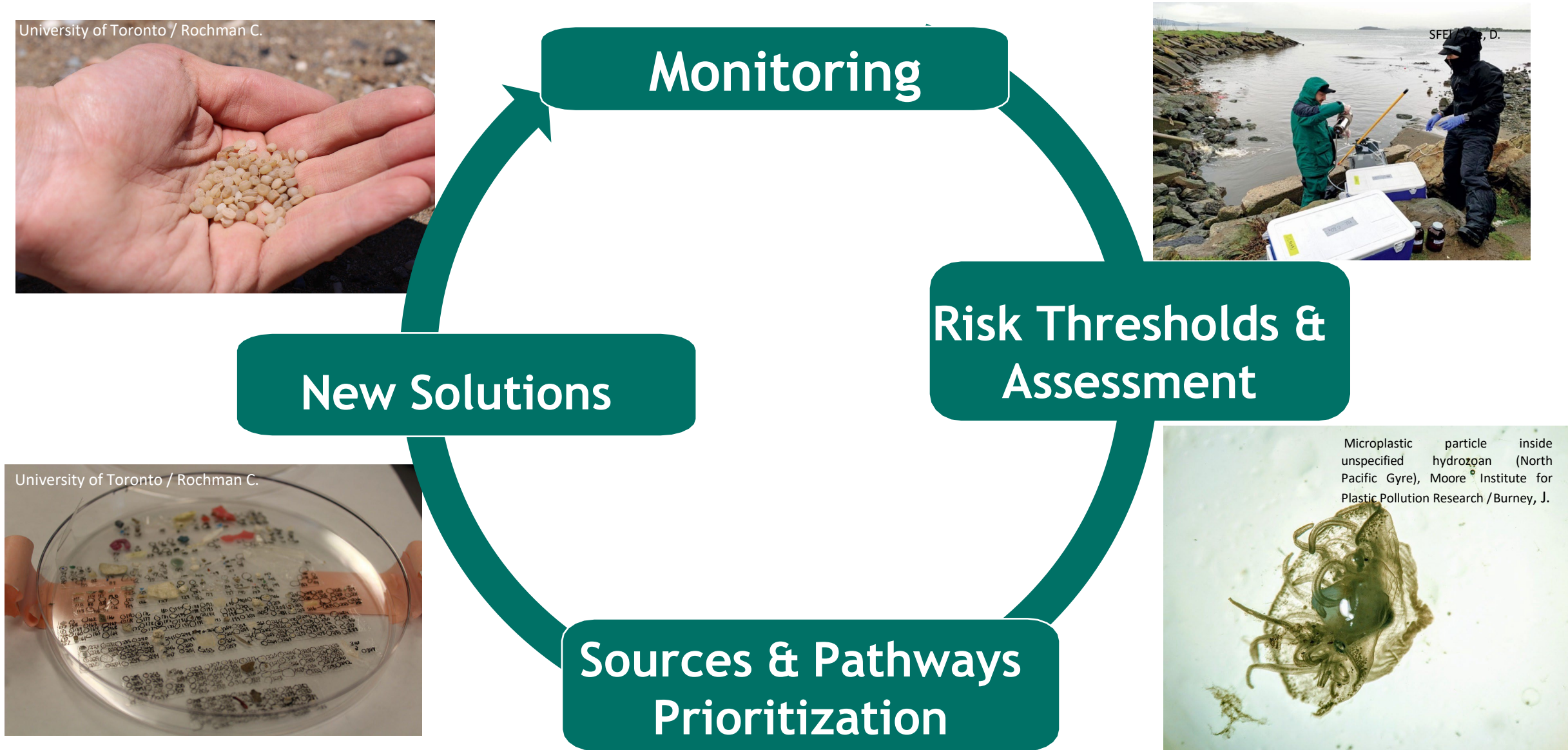
Inform public of microplastics sources, impacts, solutions



February 2022



Track 2: Science to Inform Future Action



California Senate Bill 1422 (2018)

July 1, 2020

- Define 'microplastics'



July 1, 2021

- Standard method
- Accredited laboratories
- Health-based guidance level
- Four years of testing

Deadlines

California Senate Bill 1147 (2024)

Microplastics in Drinking Water and Bottled Water

- OEHHA shall study **health effects of microplastics** in drinking and bottled water
- OEHHA to provide biennial status update reports on findings
- Following OEHHA's report, State Water Resources Control Board may request OEHHA develop a **Public Health Goal** for microplastics in drinking water

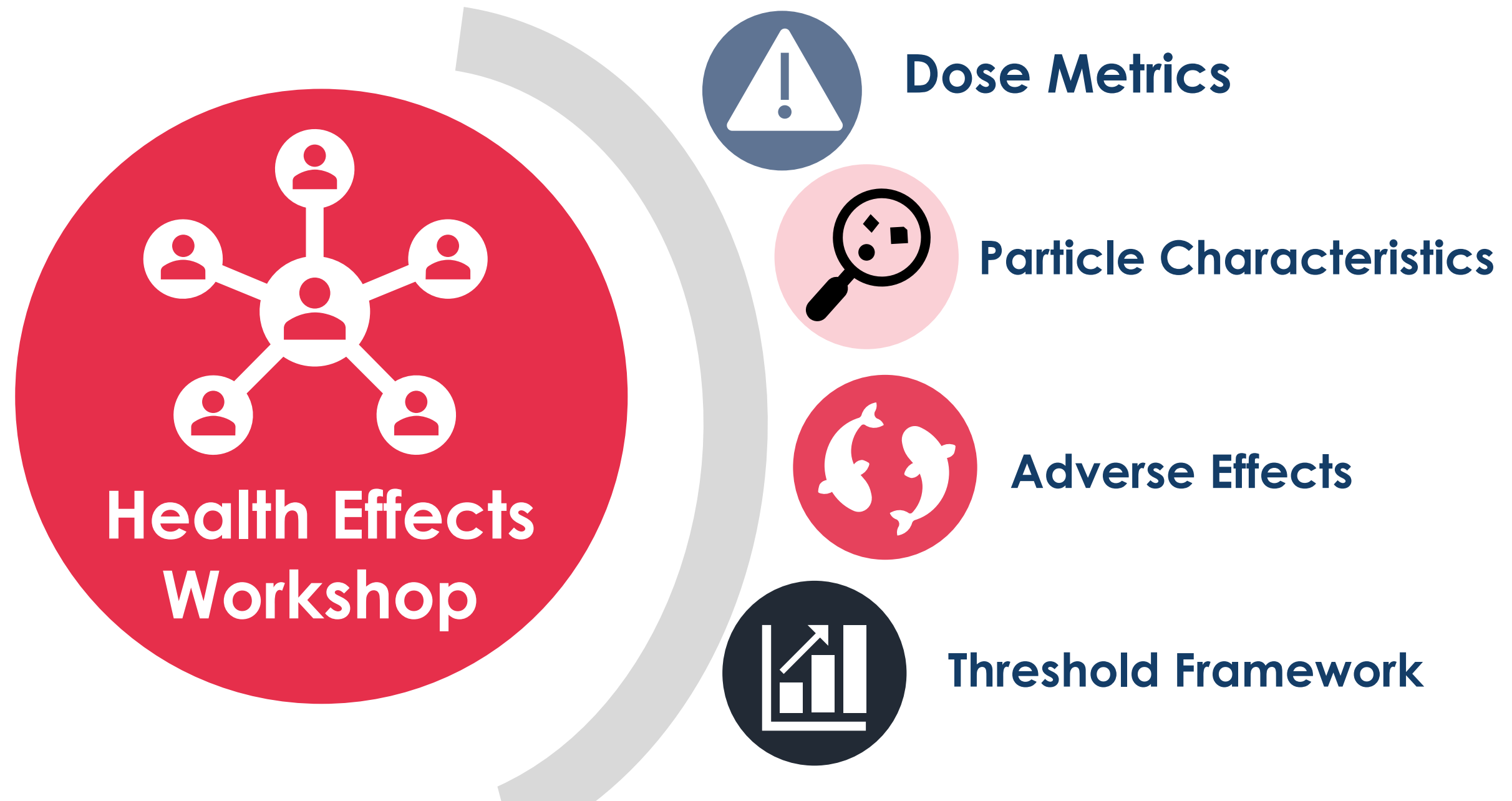
A Public Health Goal is the level of a chemical contaminant in drinking water that does not pose a significant risk to health.



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California Office of Environmental
Health Hazard Assessment

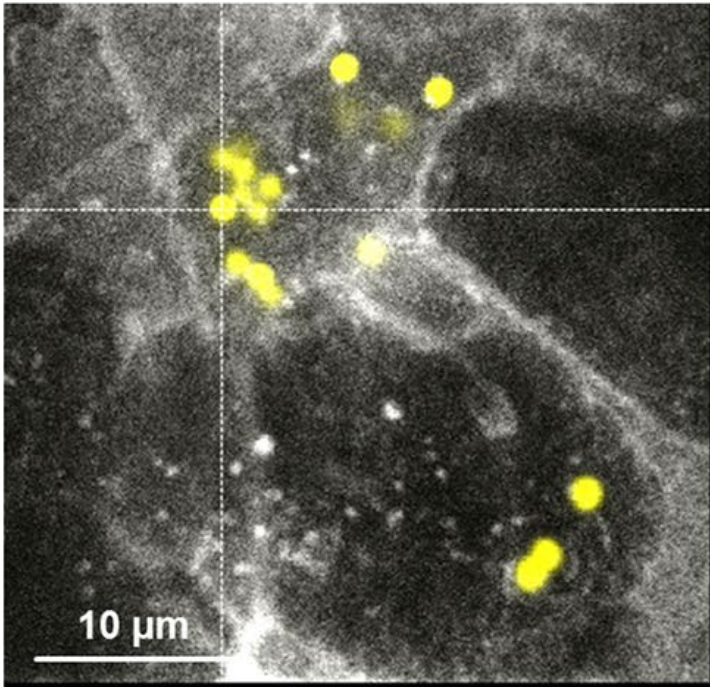


2020 – 2022: Human & Ecological Health Effects Workshop



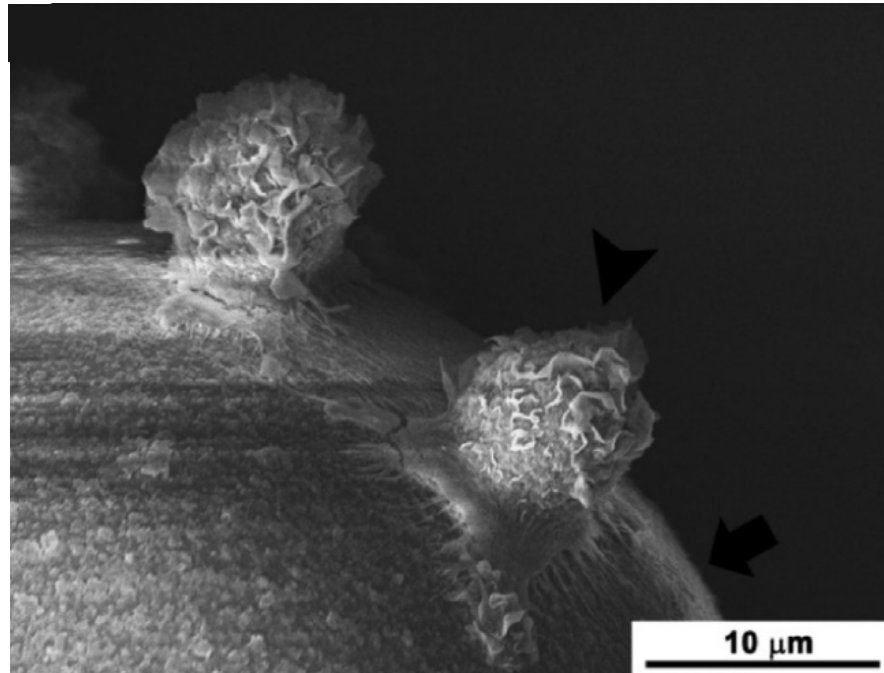
Microplastic Hazards

Particle



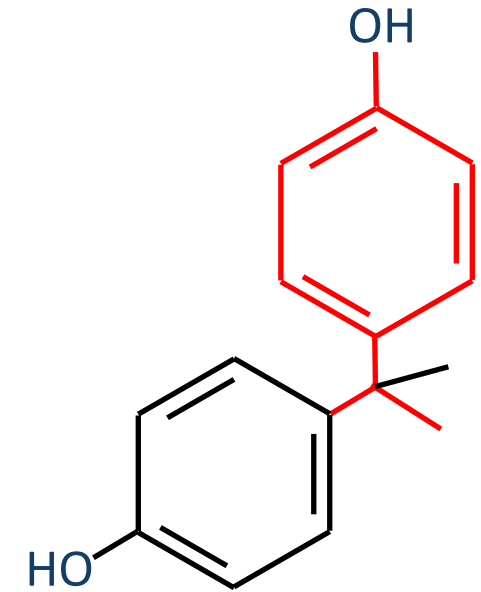
Stock, V. *et al.* (2019) 'Uptake and effects of orally ingested polystyrene microplastic particles in vitro and in vivo', *Archives of Toxicology*.

Biological



Jeon, S. *et al.* (2021) 'The reactive oxygen species as pathogenic factors of fragmented microplastics to macrophages', *Environmental Pollution*.

Chemical



Bisphenol A

Physical Effects of Microplastics

Entanglement



Food Dilution

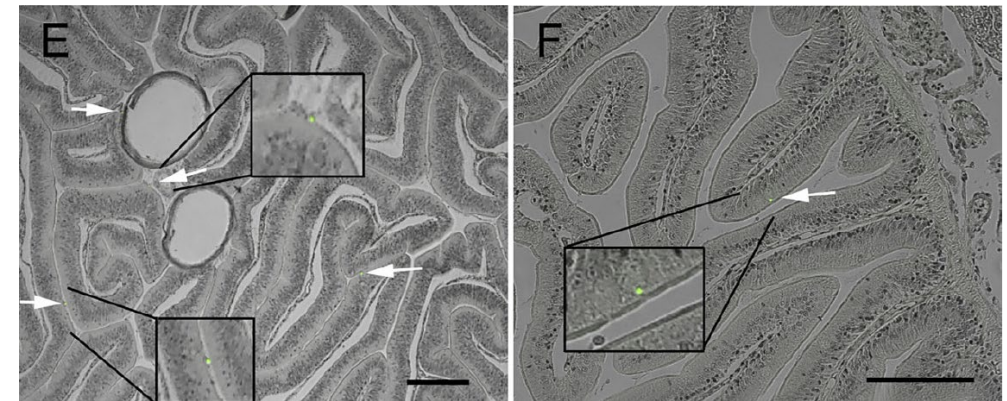


Internal Lacerations



Marcus Eriksen

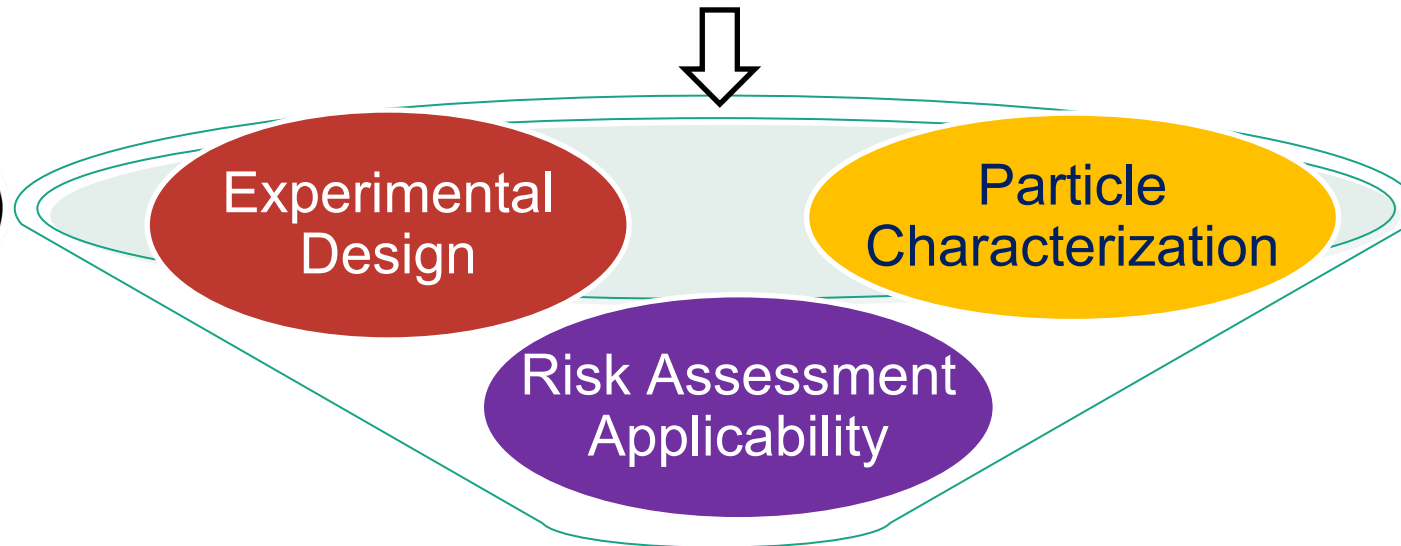
Cellular Toxicity



Mammalian Toxicity Study Screening

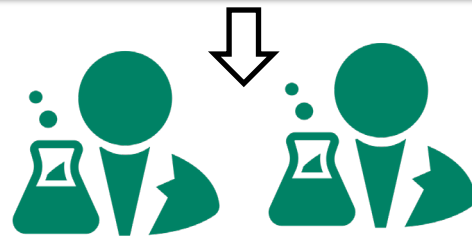
Ingestion-based *in vivo* mammalian microplastics toxicity studies

(n = 29)

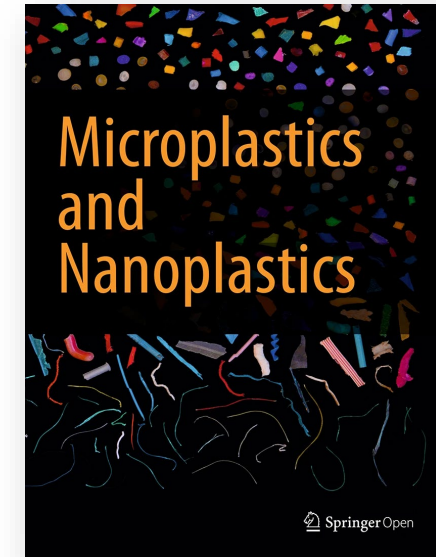


Fit for purpose studies

(n = 12)

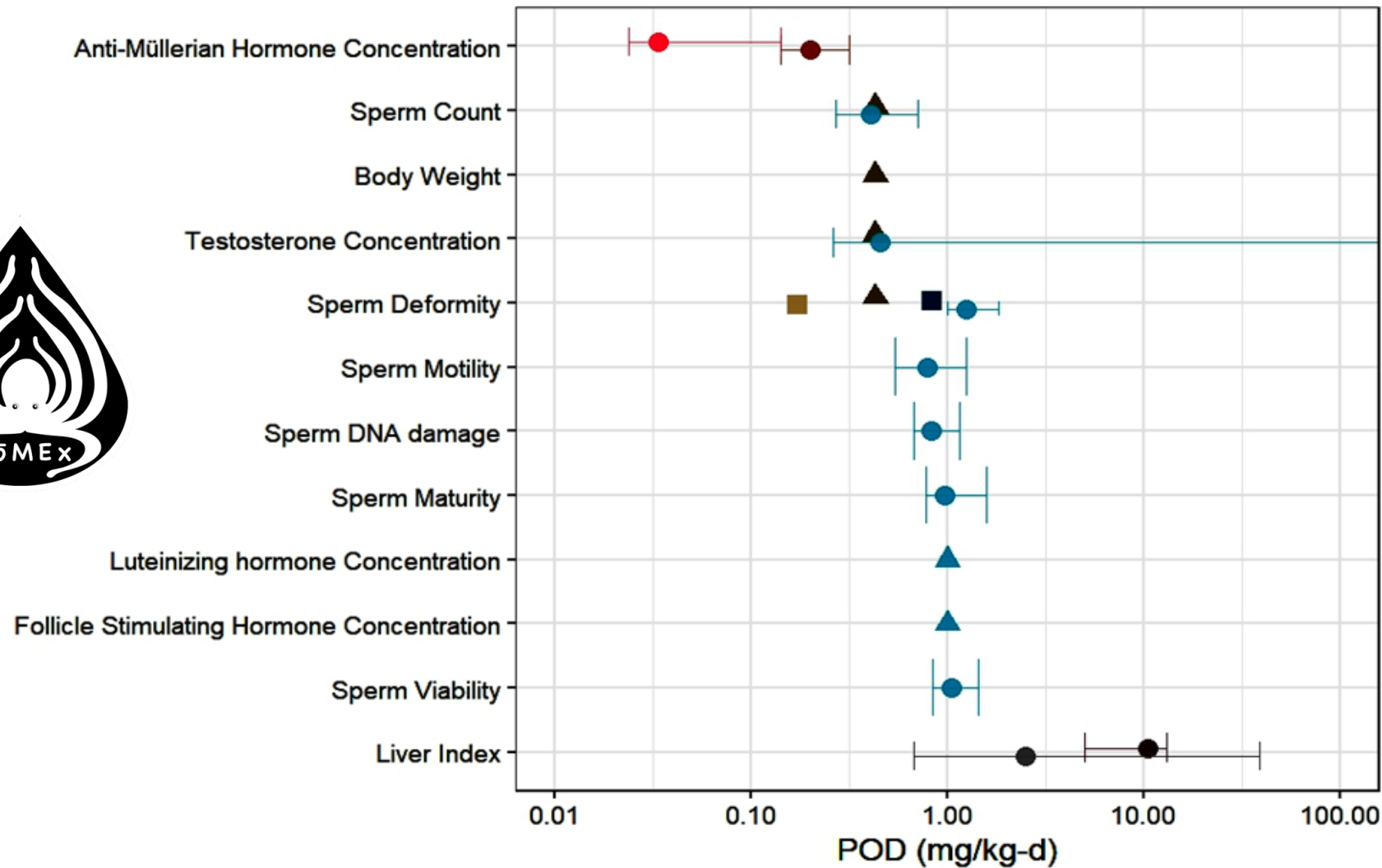


Expert review



Coffin, Bouwmeester, Brander, Damdimopoulou, Gouin, Hermabessiere, Khan, Koelmans, Lemieux, Teerds, **Wagner**, Weisberg, Wright 'Development and application of a health-based framework for informing regulatory action in relation to exposure of microplastic particles in California drinking water', *Microplastics and Nanoplastics* (2022).

Dose-Response Assessment of Reliable Endpoints



Study (particle size)

- Amereh 2020 (0.04µm)
- An 2021 (0.5µm)
- Hou 2021b (0.5µm)
- Hou 2021a (5µm)
- Li 2021b (0.5µm)
- Xie 2020 (5µm)
- Deng 2017 (5µm)
- Deng 2017 (20µm)

POD Derivation Method

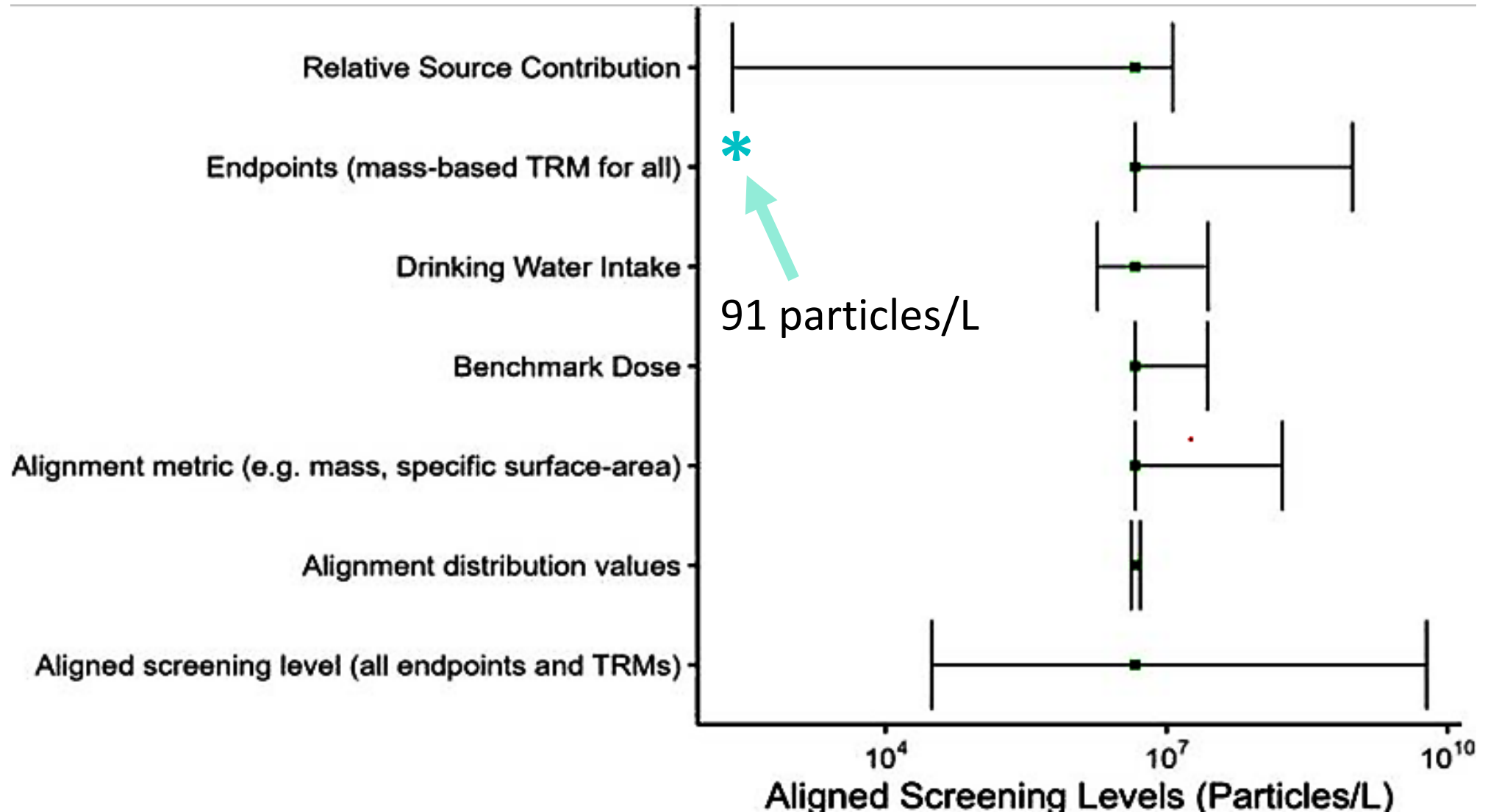
- BMD
- NOAEL
- LOAEL

point of departures (PODs)
derived using EPA's BMDS;
Error bars = 95% CI BMD

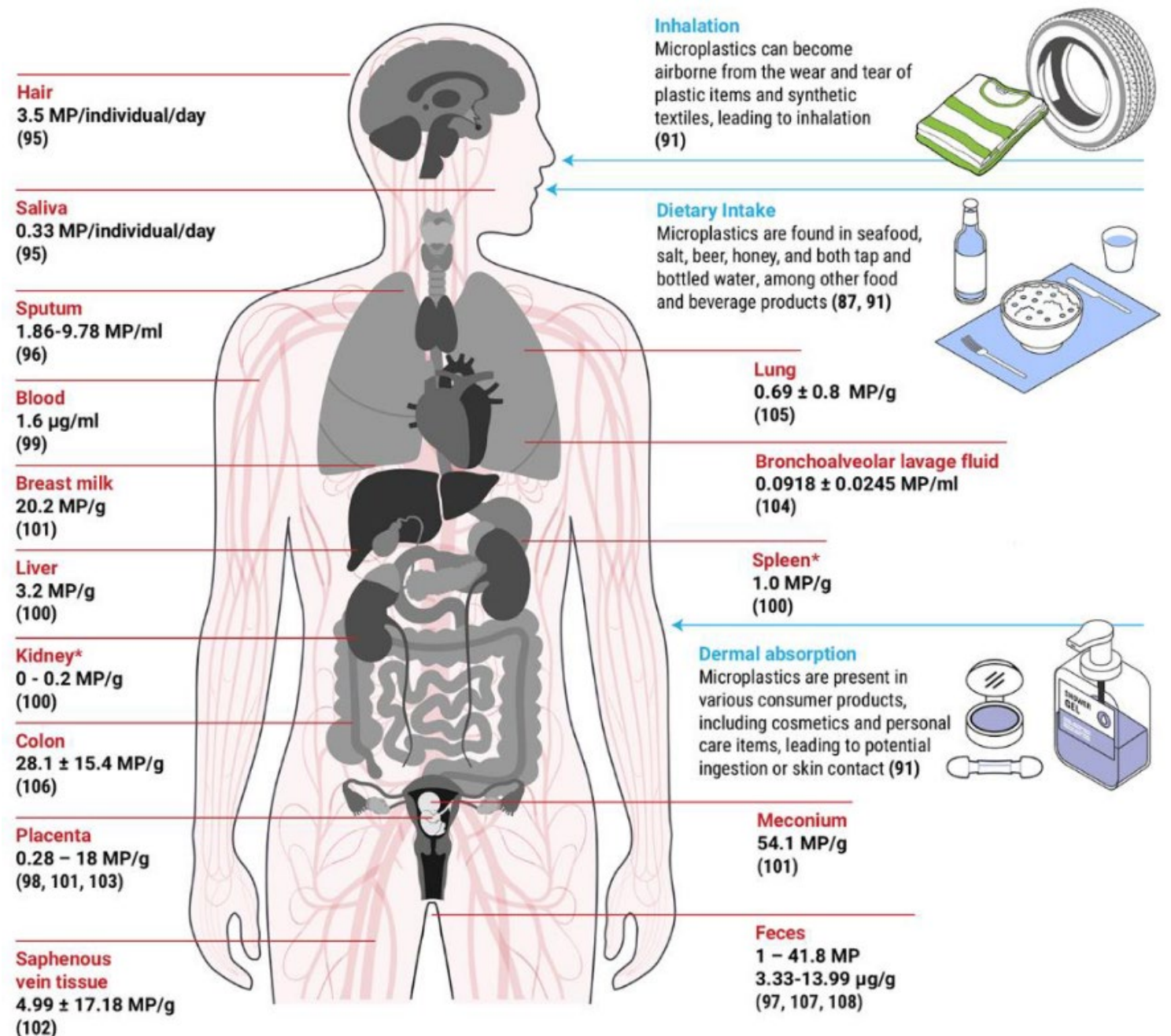
Coffin, Bouwmeester, Brander, Damdimopoulou, Gouin, Hermabessiere, Khan, Koelmans, Lemieux, Teerds, **Wagner**, Weisberg, Wright
'Development and application of a health-based framework for informing regulatory action in relation to exposure of microplastic particles in California drinking water', *Microplastics and Nanoplastics* (2022).

2022: Highly Uncertain Drinking Water Health Thresholds

One-at-a-time sensitivity analysis factor



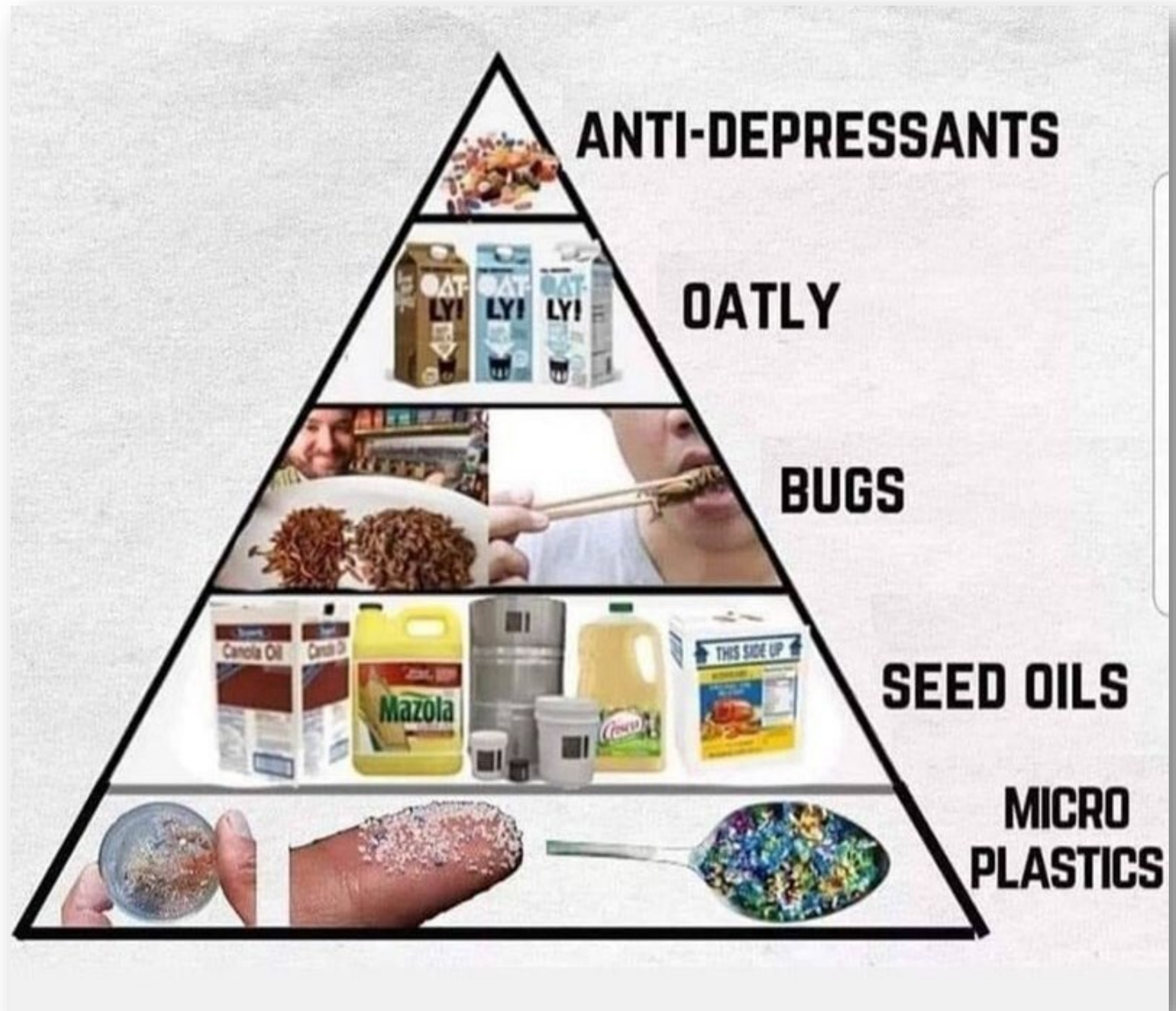
Microplastics Detected in Many Tissues in Human Bodies



Thompson, *et al.* (2024). "Twenty years of microplastics pollution research—what have we learned?" *Science*.

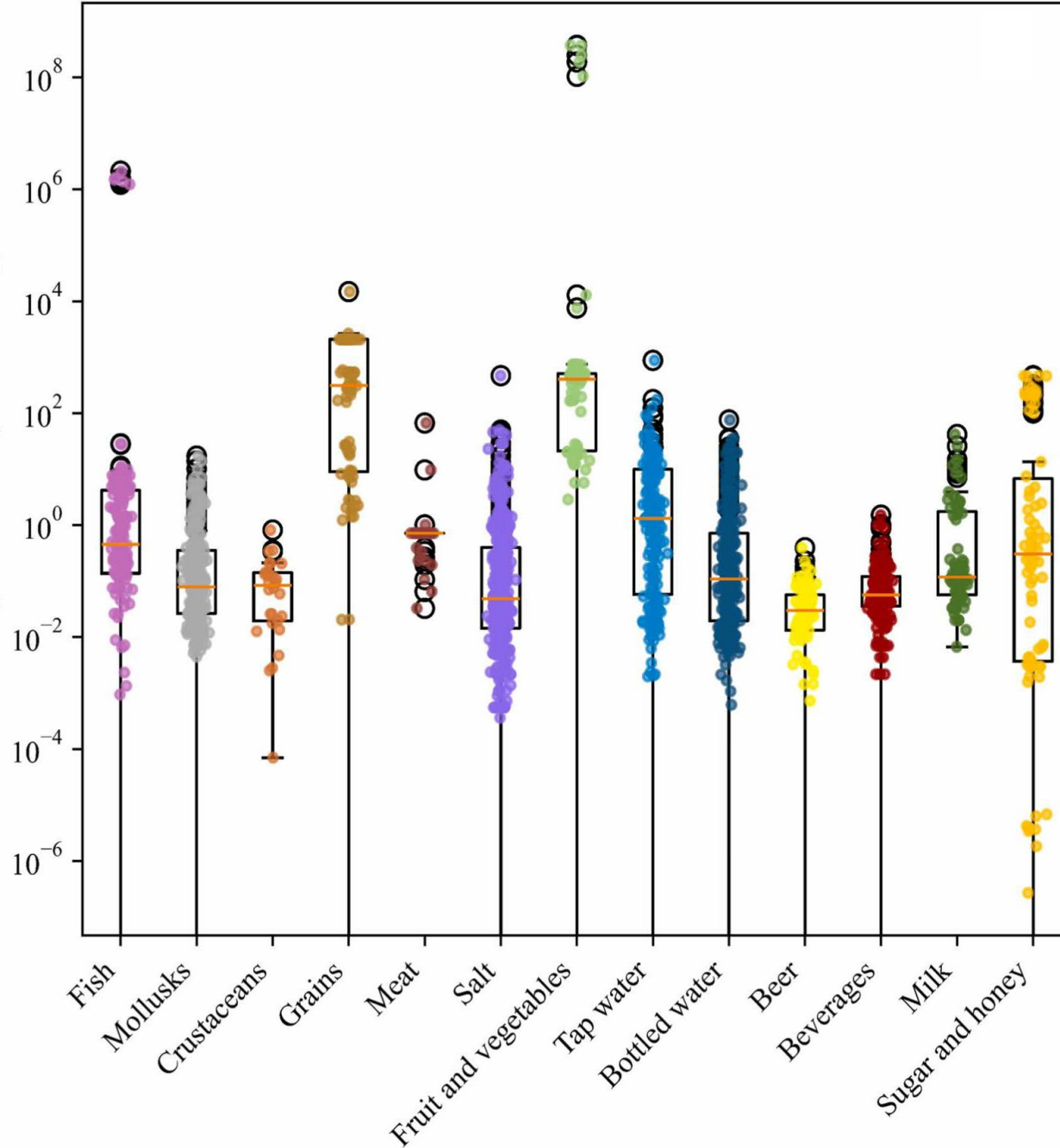


Photo: Reuters (2023)



Official USDA 2026 Food Pyramid?

**Estimated Daily Intake
(particles/kg-bw-day)**



**Wide variability
AND
uncertainties
remain for
human exposure
characterization**

2022: Inadequate Data to Derive Regulatory Levels

Effects database inadequate

- poor particle characterization
- limited polymers, shapes, sizes tested

Uncertain Effect Mechanisms

- necessary for extrapolation to diverse particle types

Incomplete exposure data

- limited food data
- no harmonized drinking water data

Coffin et al (2022), *Microplastics and Nanoplastics*;

State Water Board's policy handbook: waterboards.ca.gov/drinking_water/certlic/drinkingwater/docs/2022/mp-hndbk.pdf

Iterative Monitoring Approach in Drinking Water

Pilot Phase

- Sampling method comparison
- Range-finding
- Sample training

2026

2028

2030

Phase Two

- Additional systems
- Treated waters
- Tiered monitoring

Interim

Interim

2023

Phase One

- Few water systems
- Source waters only
- Surrogate development

California's Inter-Lab Validation Study

Two Methods

26 Laboratories



FTIR
Spectroscopy



Raman
Spectroscopy



Four Matrices



Drinking Water



Ocean Water

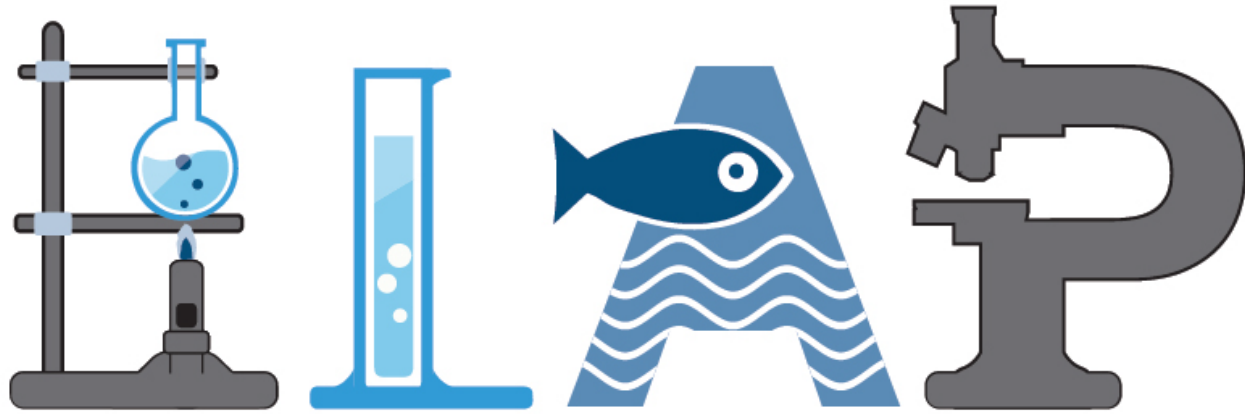


Fish Tissue



Sediment

Standardized Methods Available for Accreditation



Environmental Laboratory Accreditation Program
STATE WATER RESOURCES CONTROL BOARD

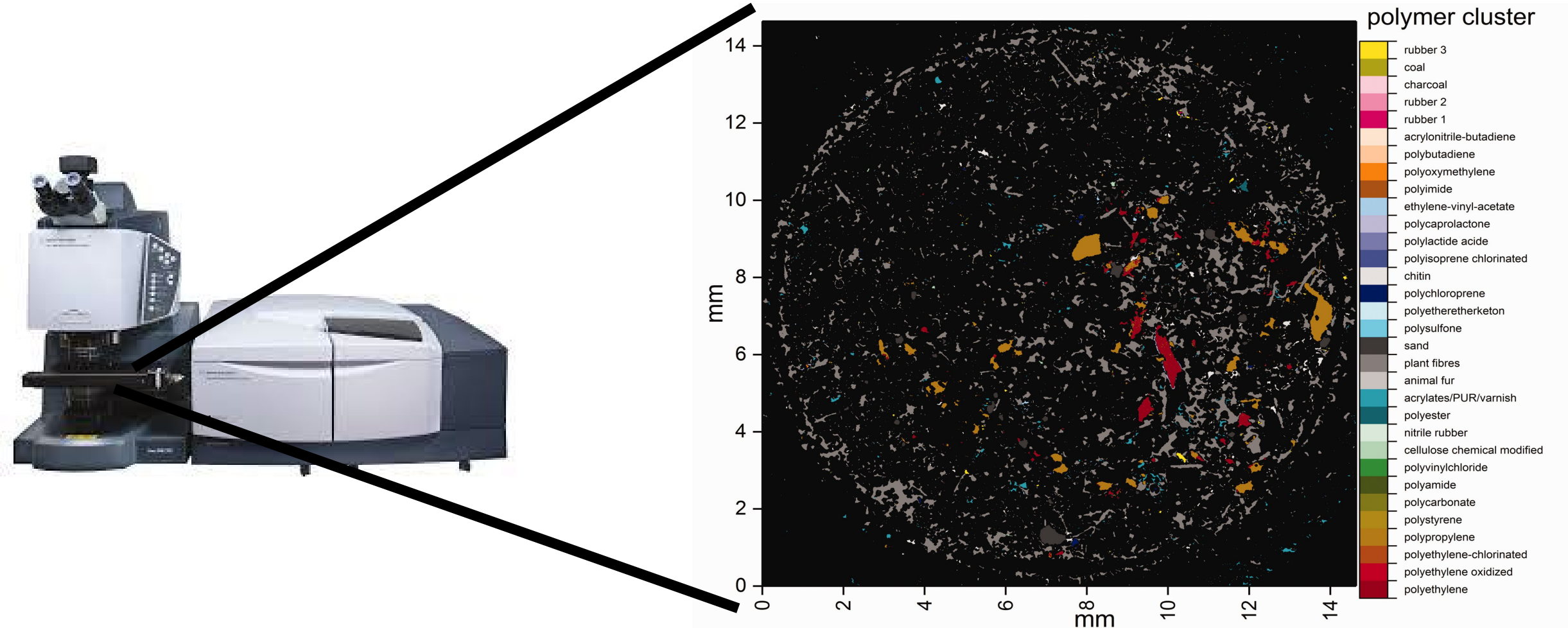
SWB-MP1-Rev1 (FTIR)
SWB-MP2-Rev1 (Raman)

waterboards.ca.gov/drinking_water/certlic/drinkingwater/microplastics



**Accreditor Training at
Moore Institute for Plastic Pollution Research
(April, 2022)**

Regulatory monitoring data must be interoperable... ...but microplastics are very diverse



One4All: An Open-Source Harmonization Portal & Database

Sherrod *et al.* (2024).
Journal of Open Source Software

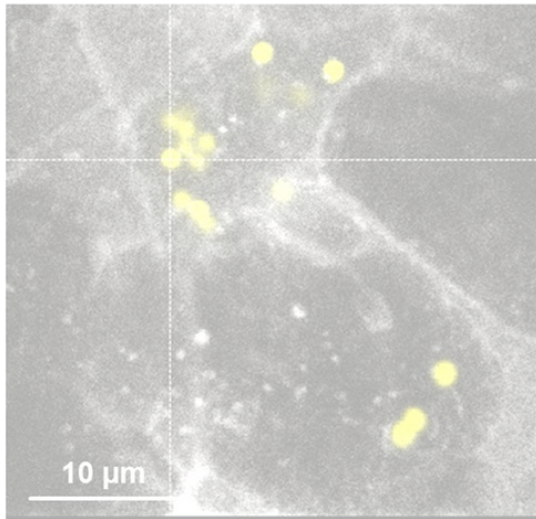


**MOORE
INSTITUTE**
for Plastic Pollution Research

SFEI
SAN FRANCISCO ESTUARY INSTITUTE & THE AQUATIC SCIENCE CENTER

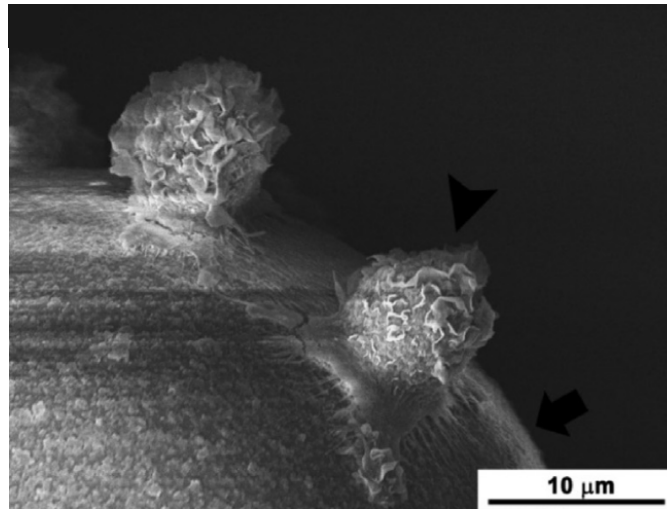
**AQUATIC
SCIENCE
CENTER**

Additional Considerations for Microplastics Risk Assessments



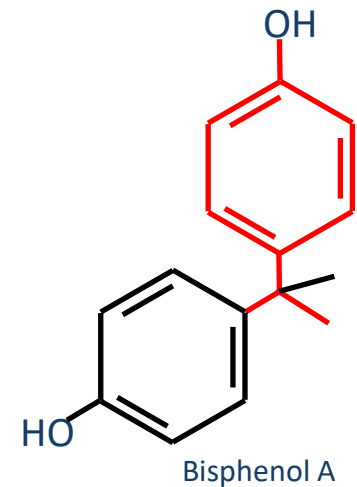
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Particle



Jeon, S. *et al.* (2021) 'The reactive oxygen species as pathogenic factors of fragmented microplastics to macrophages', *Environmental Pollution*.

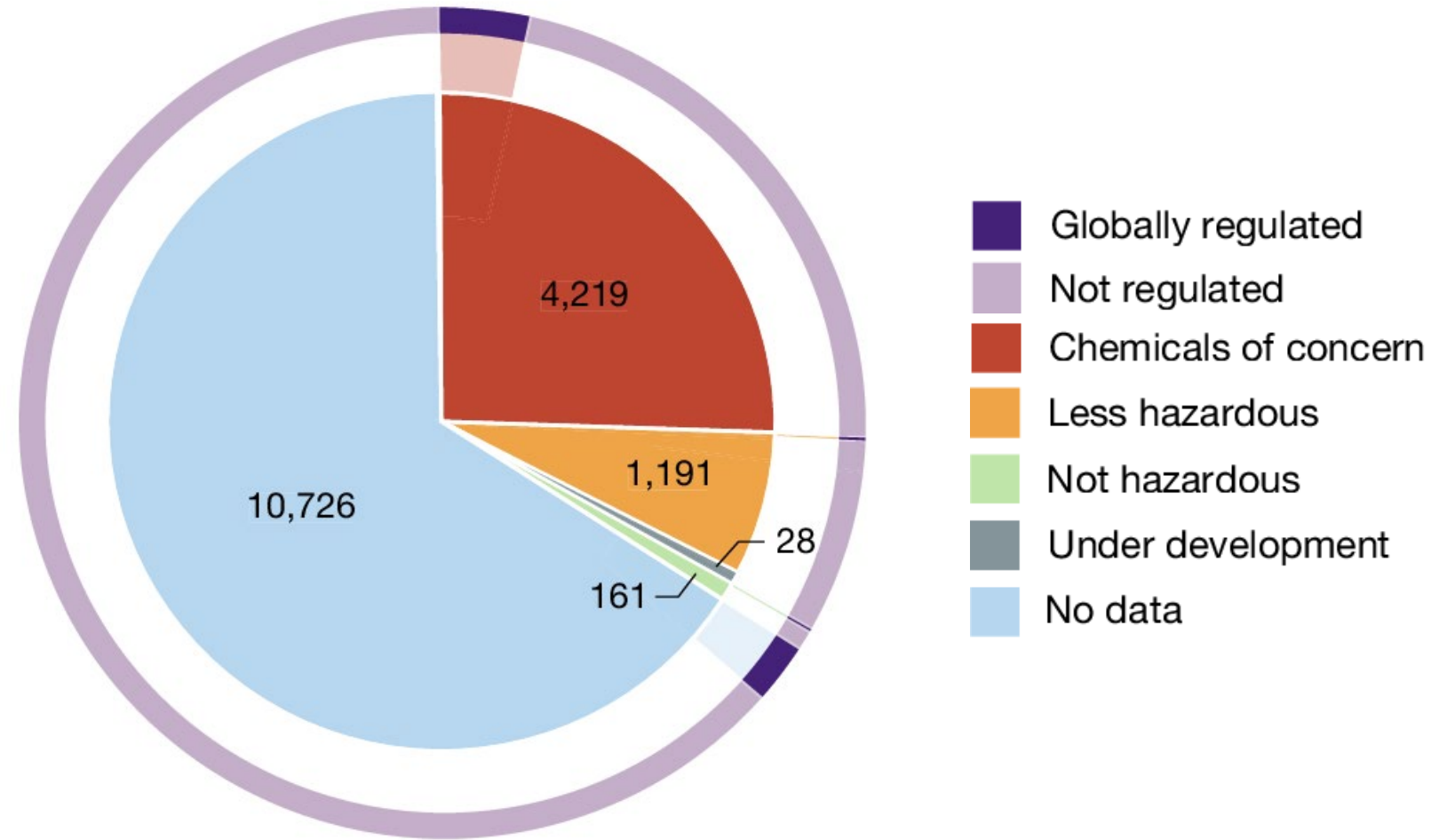
Biological



Chemical

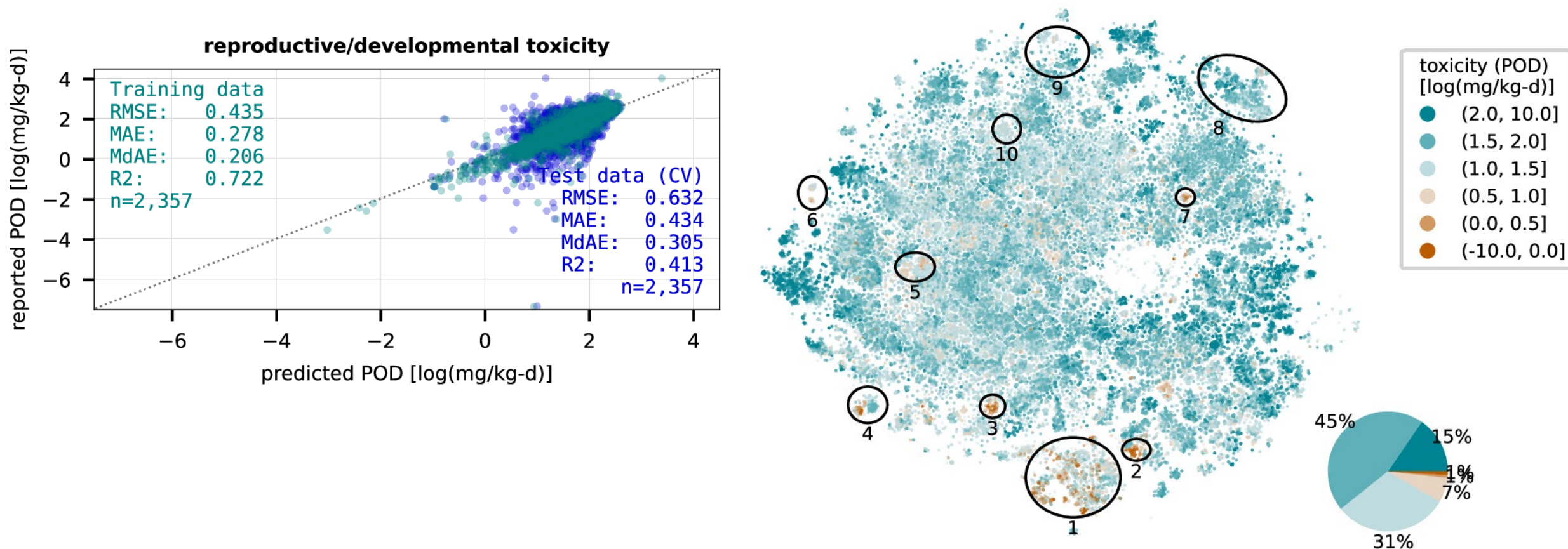
Plastic Contains Many Hazardous Chemicals and Chemicals with *No Toxicity Data*

- >10,000 additives
- **> 4,200 of concern**
- 6% globally regulated



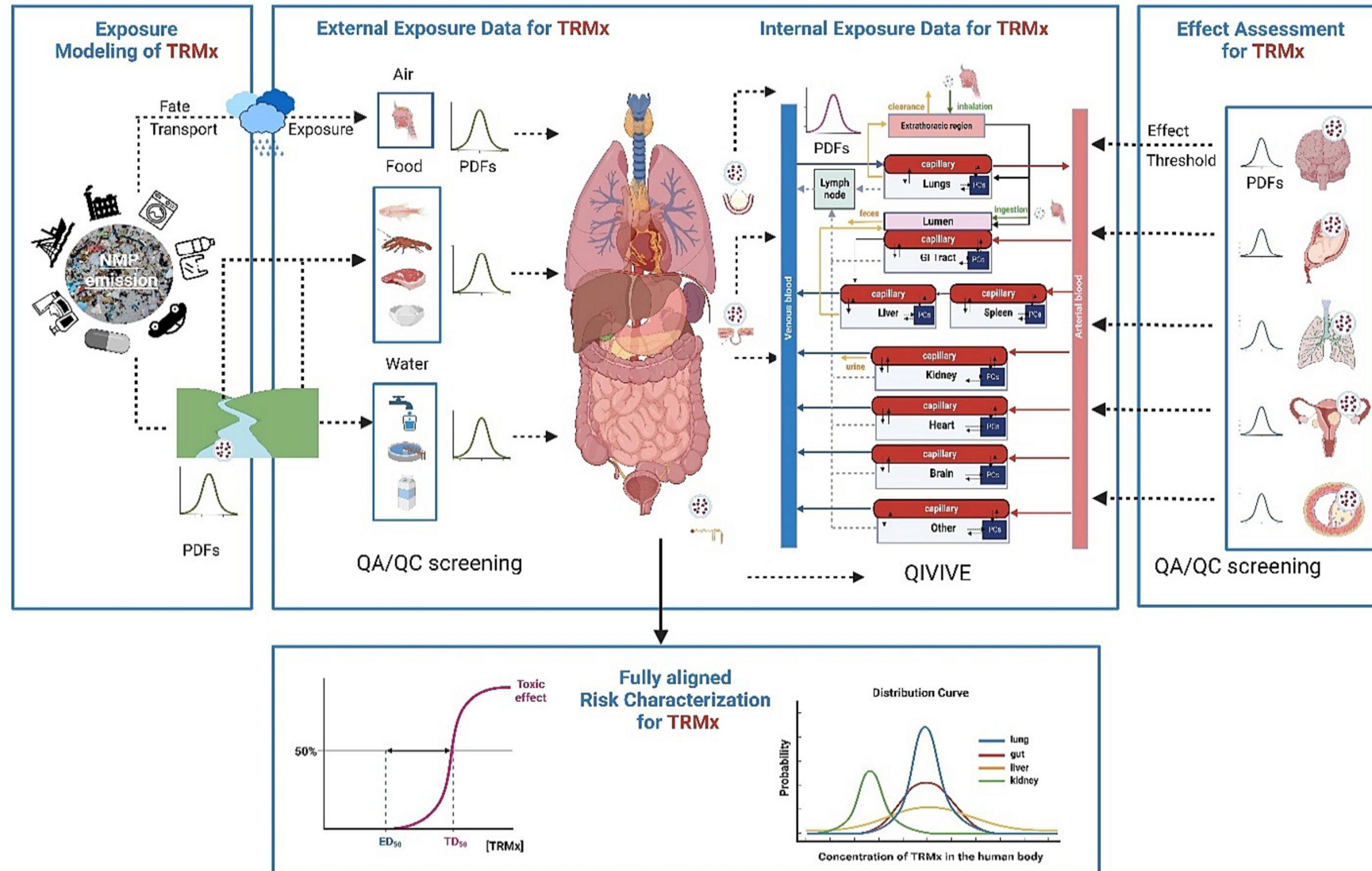
Monclús, Arp, Groh, Faltynkova, Løseth, Muncke, Wang, Wolf, Zimmermann & **Wagner** (2025)
'Mapping the Complexity of Plastics', *Nature*.

2026: Advanced Chemical Toxicity Prediction with Quantitative Structure Activity Response Modelling



Borries *et al.* (2026). "Uncertainty-aware machine learning to predict non-cancer human toxicity for the global chemicals market." *Nature Communications*.

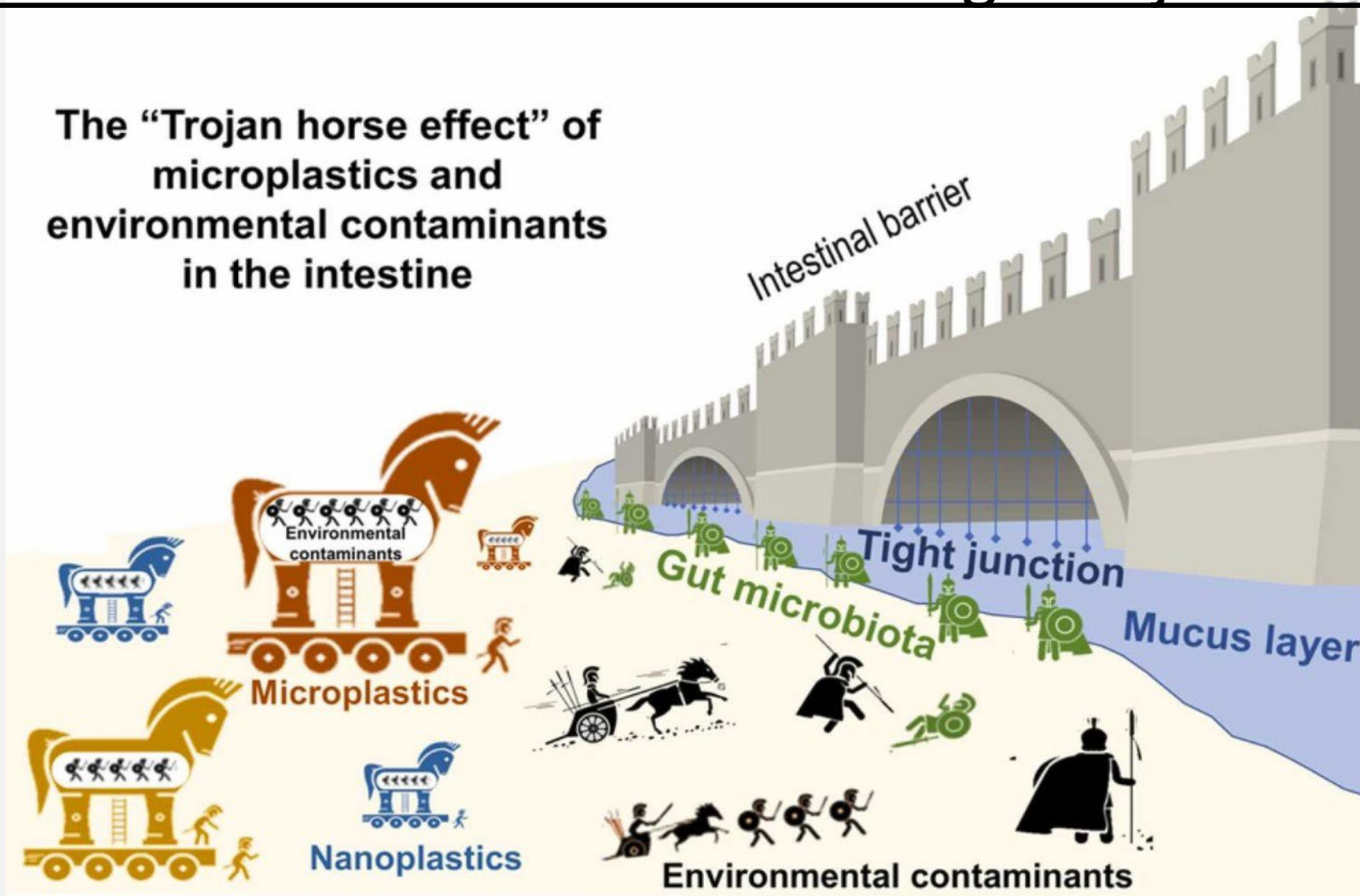
Microplastics + Chemical Toxicokinetic Models Available



Wardani et al. (2024). *Environment International*

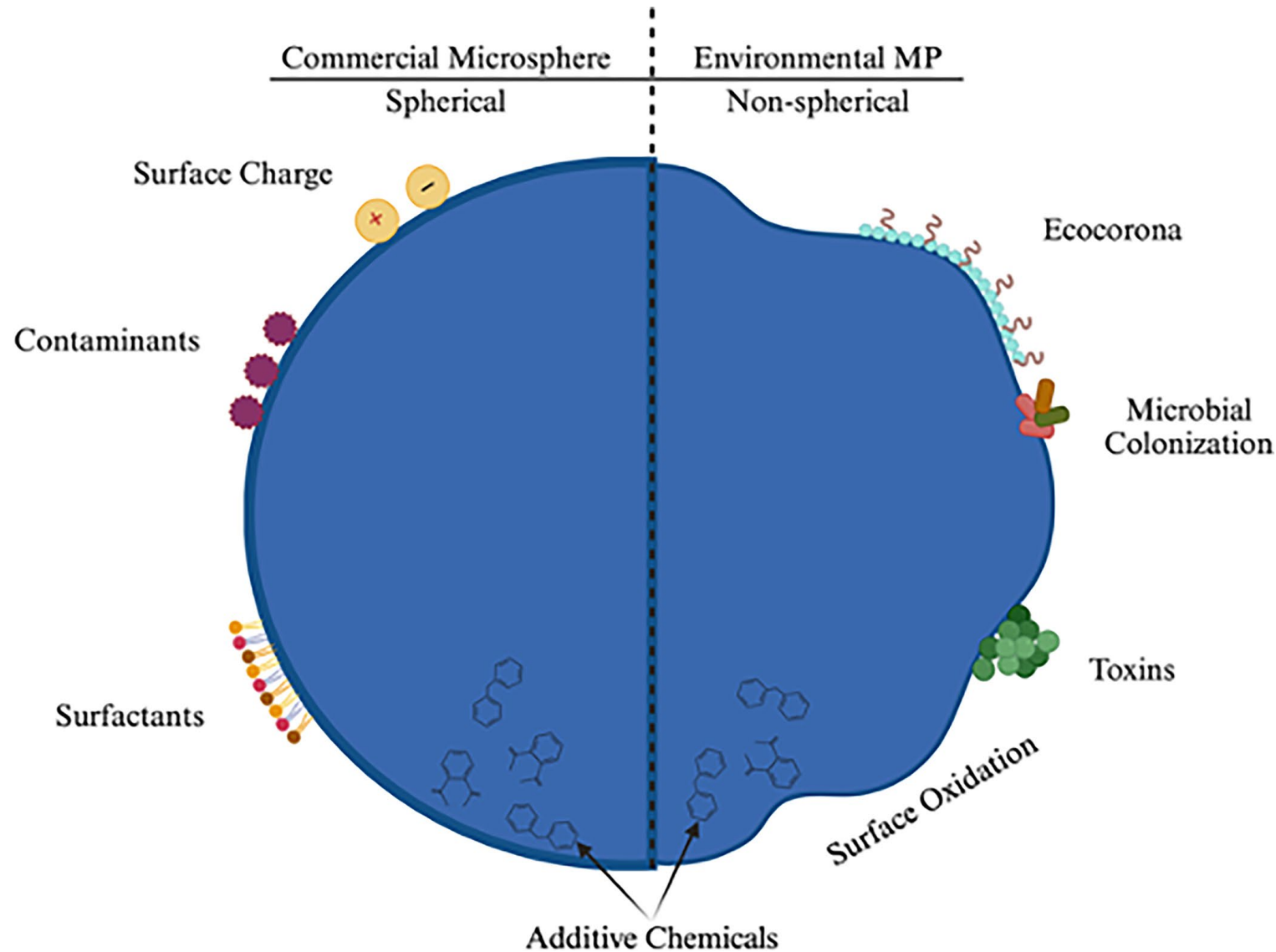
Future Framework:

Cumulative Risk Assessment Considering “Trojan Horse Effect”



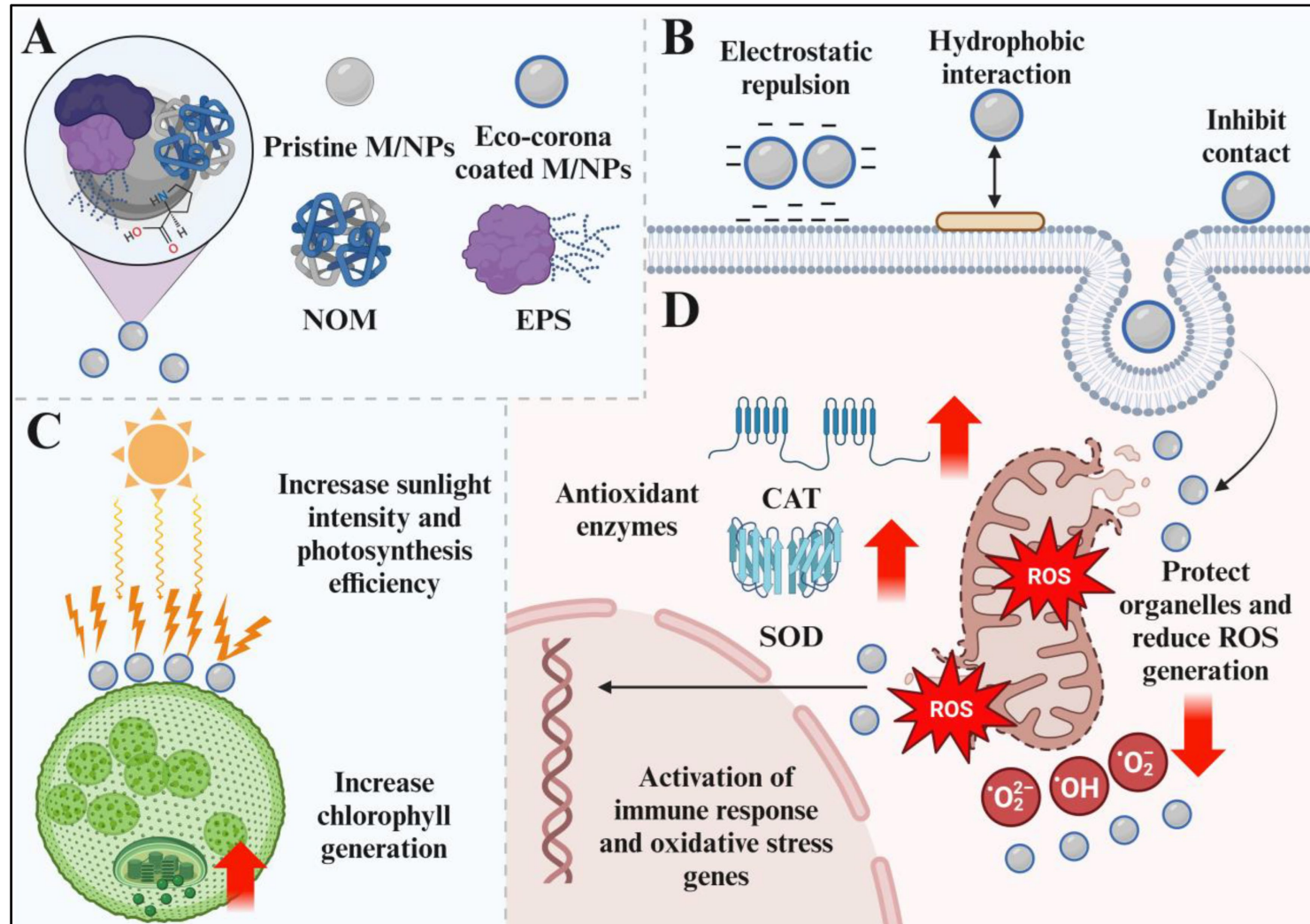
Hu *et al.* (2022). *Journal of Hazardous Materials*

Commercial MP ≠ Environmental MP



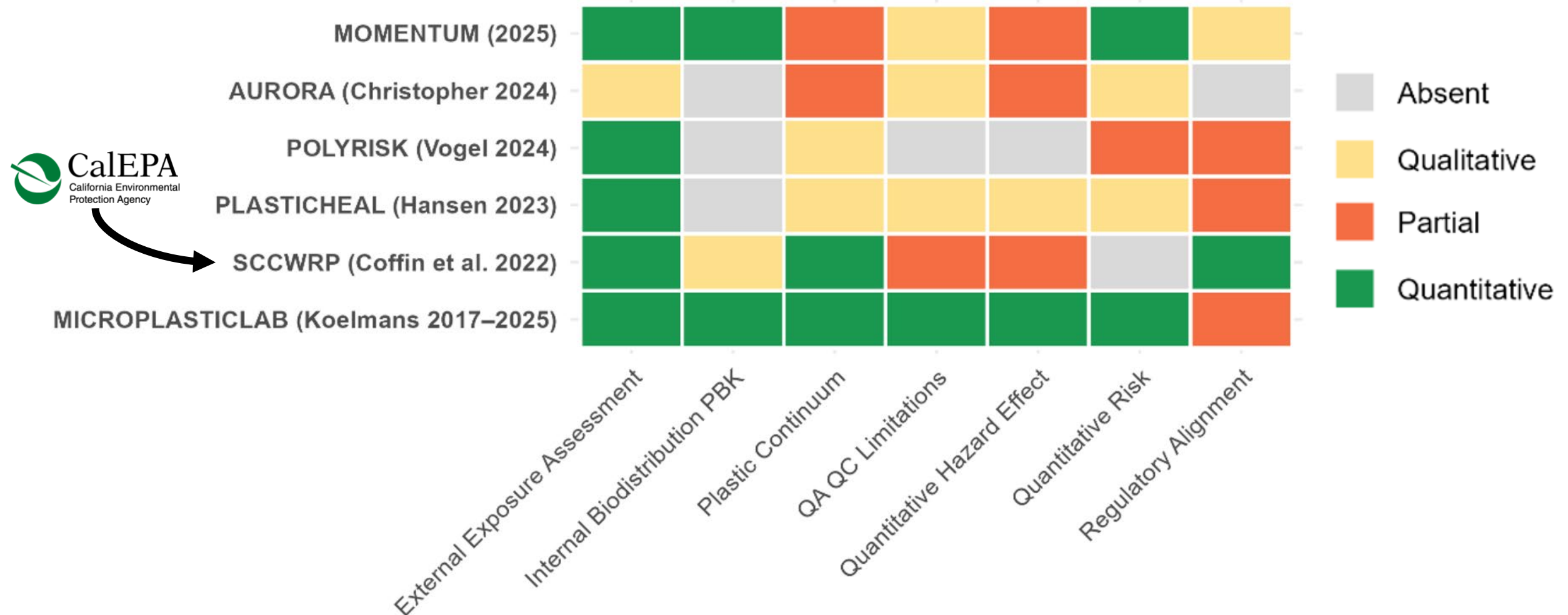
Morgan *et al.* (2025). Understanding Human Health Impacts following Microplastic Exposure Necessitates Standardized Protocols. *Current Protocols*.

Models Should Consider Eco-corona Effects on Toxicodynamics & Toxicokinetics



Yang et al. (2025). *Water*

Towards a Regulatory-Ready Microplastics Risk Assessment Framework



Koelmans, Bouwmeester, Christopher, **Coffin**, Haase, Lane, Legler, Vermeulen, Visser, Vogel, Wardani & Zou (2026). Towards regulatory readiness: evaluating frameworks for microplastic health risk assessment. *Microplastics & Nanoplastics*.

OEHHA's Planned Research on Microplastics (2026 to 2028)

- **Drinking & bottled water MNP monitoring**
- **Systematic literature review (tox + exp)**
- **Updated risk assessment framework**
- **Hazard & risk characterization -> thresholds**



Logo created by J.C. Leapman.

Welcome

Overview

Search

Exploration

SSD

Study Screening

Calculators

Predictions

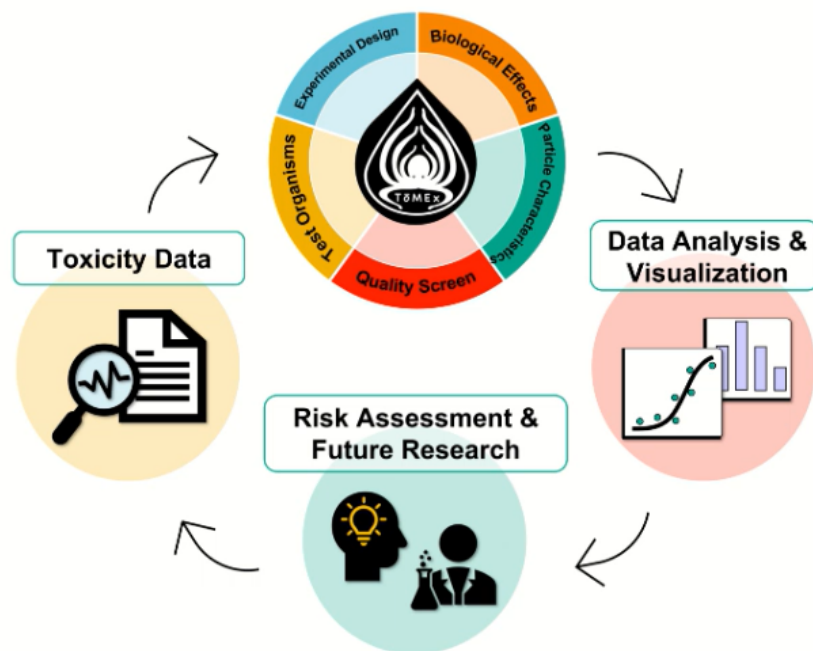
Resources

Data Submission

Contact

Human Health

Welcome to the Toxicity of Microplastics Explorer 2.0, Aquatic Organisms Database!



Toxicity of Microplastics Explorer 2.0

The Toxicity of Microplastics Explorer 2.0 (ToMEx 2.0) is a major expansion of the original ToMEx database coordinated by SCCWRP through a four-part virtual workshop series of more than 60 researchers from 14 different nations.

Disclaimer: When using ToMEx 2.0, it is highly recommended that underlying data are carefully scrutinized before finalizing analyses or drawing major conclusions.

What is the Microplastics Toxicity Database?

This database is a repository for microplastics toxicity data for the California Microplastics Health Effects Workshop.

This web application allows users to explore toxicity data using an intuitive interface while retaining the diversity and complexity inherent to microplastics. Data is extracted from existing, peer-reviewed manuscripts containing toxicity data pertaining to microplastics.

A full length description of the ToMEx 1.0 database and web application is published in [Microplastics and Nanoplastics](#). To access the open access manuscript, [click here](#).

Use the side panel on the left of the page to navigate to each section. Each section provides different information or data visualization options. More specific instructions may be found within each section.

Why was the Microplastics Toxicity Database and Web Application created?

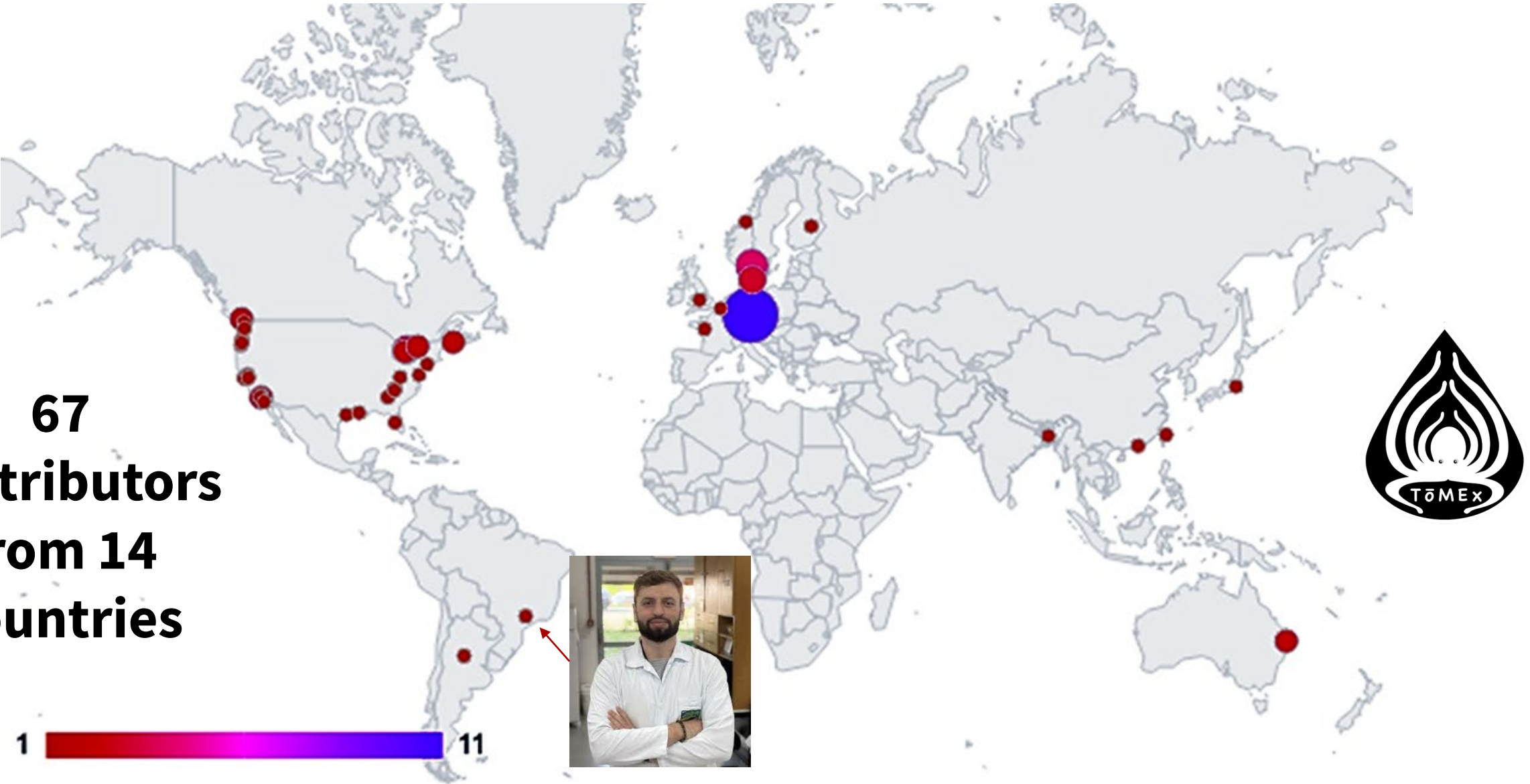
The database and application tools have been created for use by the participants of the [Microplastics Health Effects Workshop](#). The purpose of this workshop is to identify the most sensitive and biologically critical endpoints associated with microplastics exposure, prioritize which microplastics characteristics (e.g., size, shape, polymer) that are of greatest biological concern, and identify critical thresholds for each at which those biological effects become pronounced. Workshop participants will also make recommendations for future research investments. Workshop findings will be published in a special issue of [Microplastics and Nanoplastics](#). These findings will be used directly by the state of California to fulfill [legislative mandates](#) regarding the management of microplastics in drinking water and the aquatic environment.



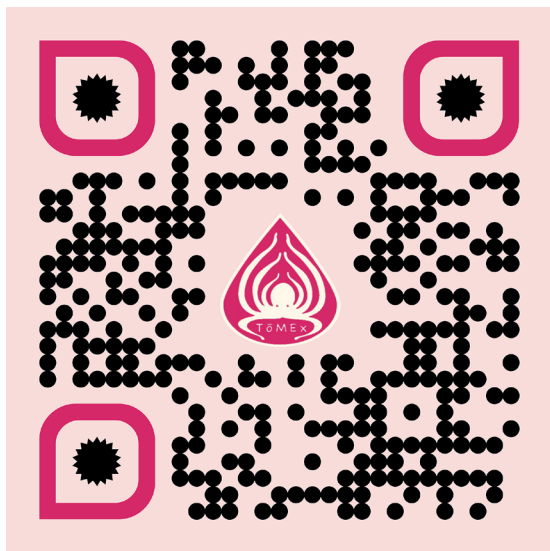
ToMEx is at microplastics.sccwrp.org

Crowd-Sourcing ToMEx 2.0 Update

**67
Contributors
from 14
Countries**

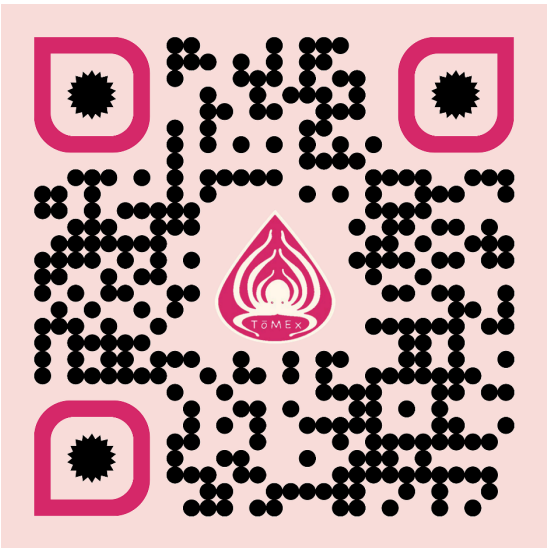


Human Health Hazard Database



	ToMEx 1.0	ToMEx 2.0
Total Number of Publications	55	77
Particle Only	54	76
Chemical Co-Exposure	7	7
Chemical Transfer	-	-
Leachate	-	1
Data Points	3,904	6,977
In vivo data	2,512	4,059
In vitro data	1,392	2,918
Species Represented	6	8

Aquatic Organism Hazard Data



	ToMEx 1.0	ToMEx 2.0
Total Number of Publications	162	287
Particle Only	155	276
Chemical Co-Exposure	12	35
Chemical Transfer	8	18
Leachate	10	13
Data Points	5,871	12,912
Acute data	3,462	8,035
Chronic data	2,409	4,869
In vivo data	5,829	12,436
In vitro data	42	404
Species Represented	109	161
Freshwater species	40	65
Marine species	69	98

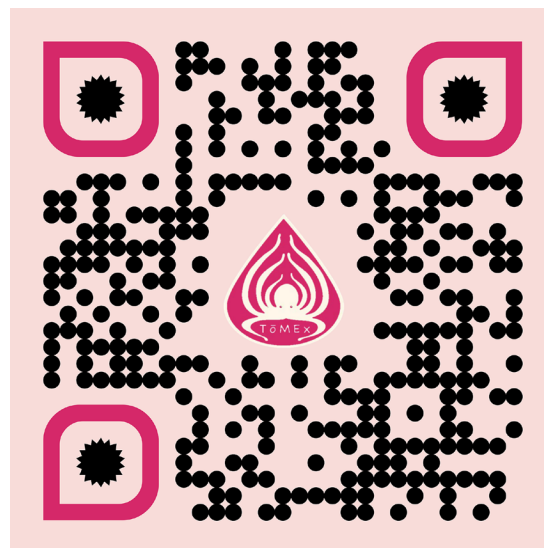
Leah Thornton Hampton
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Darragh Doyle
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Sara J. Hutton
Magdalena M. Mair
Ezra L. Miller
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Jennifer L. Bare
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Travis Cook
Lidwina Bertrand
Virginia Boone
Agathe Bour
Julian Brehm
Victor Carrasco-Navarro
Katherine Berreman
Garth Covernton
Patricia Cubanski
Pedro M.C. Da Silva

Thanks to the ToMEx 2.0 Team

bit.ly/ToMEx20



Natasha Klasios
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Andrew Yeh
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Alvine C. Mehinto
Colleen M Wardlaw



Assessing Ecological Risk of Microplastics



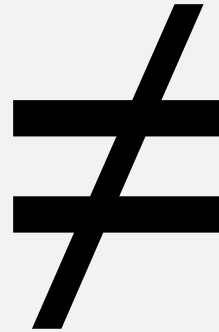
Laboratory Effect Studies

(monodisperse, pristine,
[often] unknown additives)



Environmental Microplastics

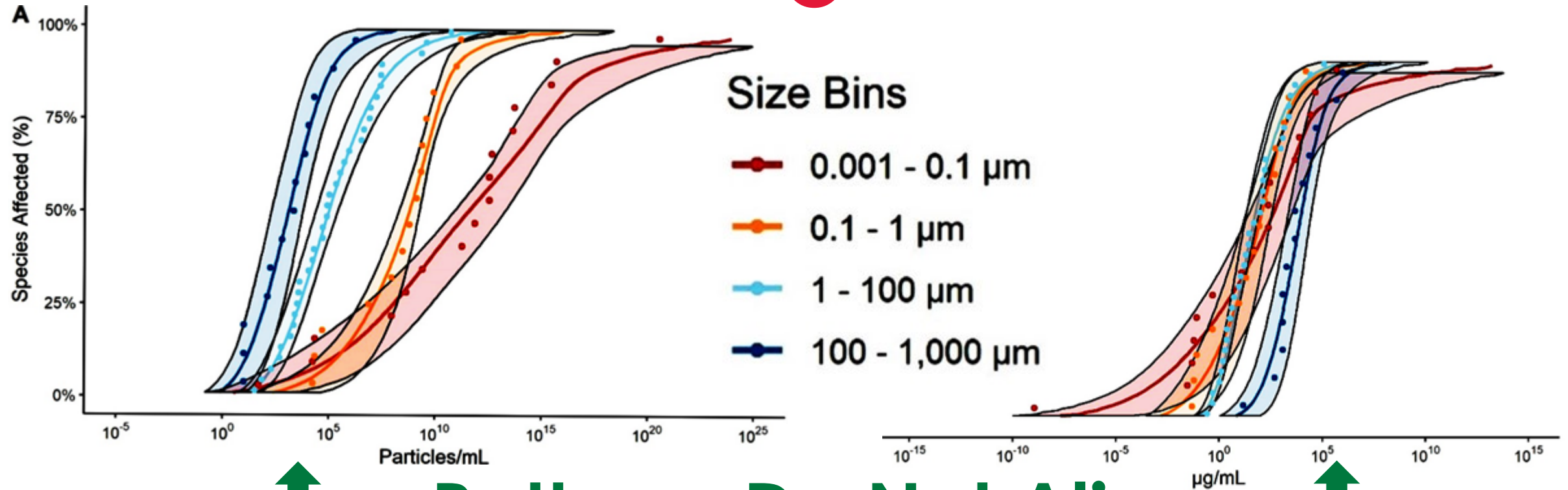
(polydisperse, weathered,
biofilms, contaminants, etc.)



Count
###



Mass



Patterns Do Not Align

Thornton Hampton, *et al.* (2022). "Research recommendations to better understand the potential health impacts of microplastics to humans and aquatic ecosystems." *Microplastics and Nanoplastics*.

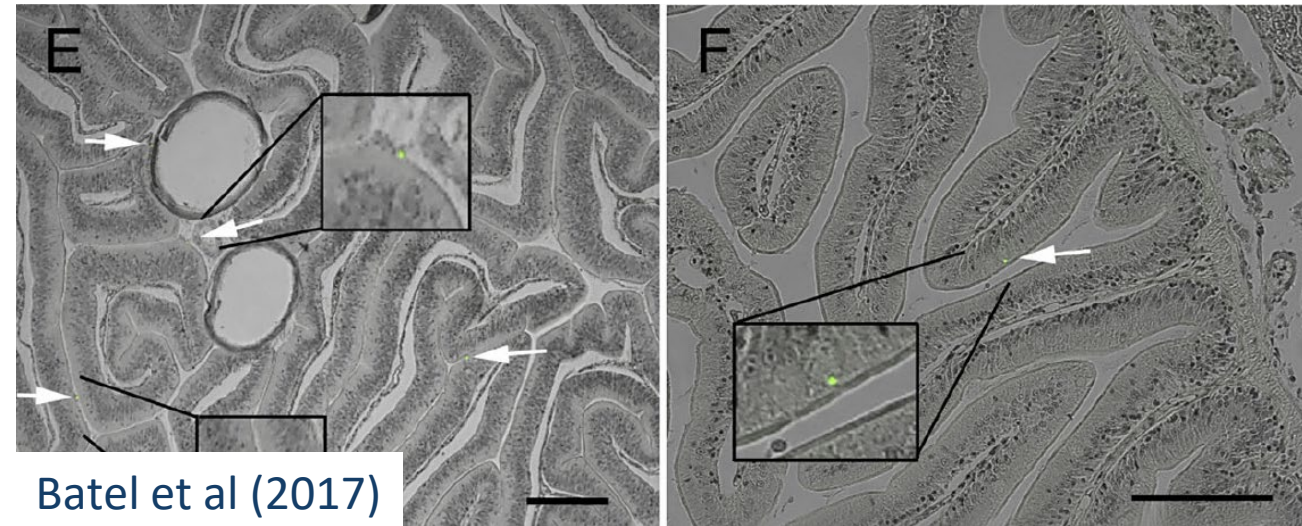
Effect-Based Alignments with Ecologically-Relevant Metrics

Food Dilution



- **Exposure metric:** Volume
- **Bioavailability:** Ingestible sizes

Tissue Translocation

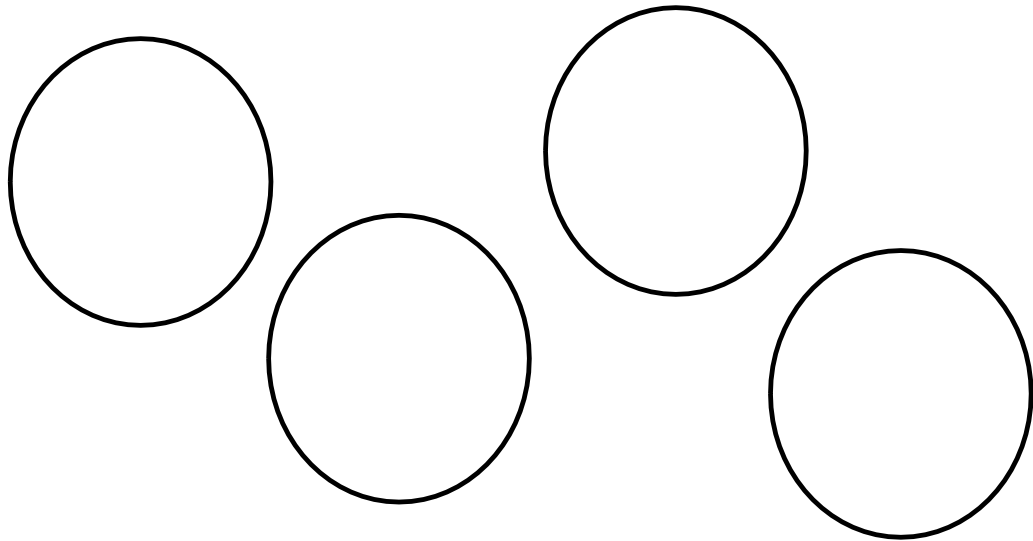


Batel et al (2017)

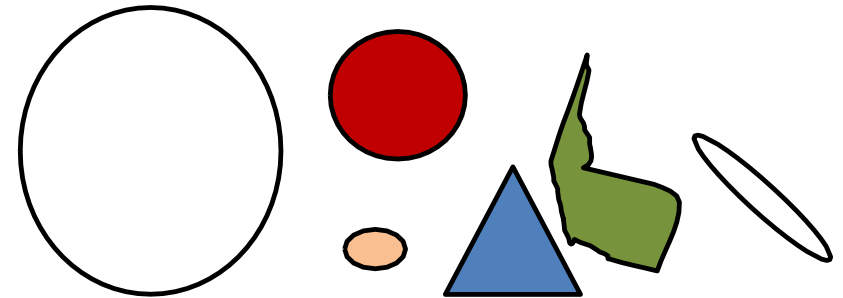
- **Exposure metric:** Surface area
- **Bioavailability:** Translocatable sizes

Aligning Effect Data: In a Nutshell

Imagine an **effect threshold** in the lab of 4 particles/L,
Calculate the ***translocatable*** **surface area** of the 4 particles



Now calculate how many ***translocatable*** **environmental particles** would have that **same surface area**, while that diversity is defined via ***realistic distributions***



Critical Review – High weight of evidence for food dilution causing effects in numerous organism

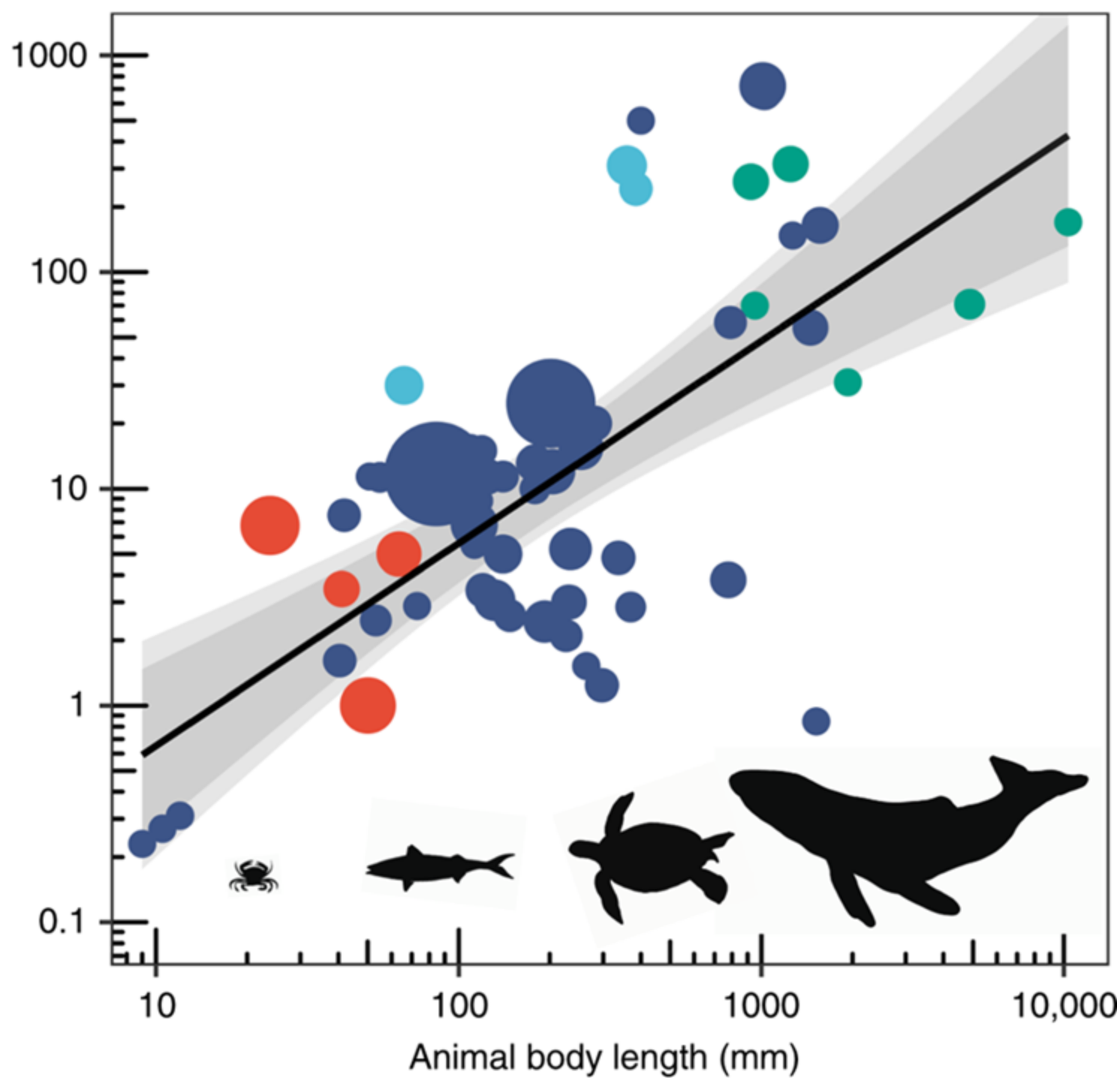
de Ruijter, V.N. et al. (2020) 'Quality criteria for microplastic effect studies in the context of risk assessment: A critical review', *Environmental Science & Technology*.

Plastic found in 90/91 Laysan
Albatross in Hawaii (1969)

Kenyon, and Kridler (1969) 'Laysan Albatrosses Swallow Indigestible Matter', *The Auk*.



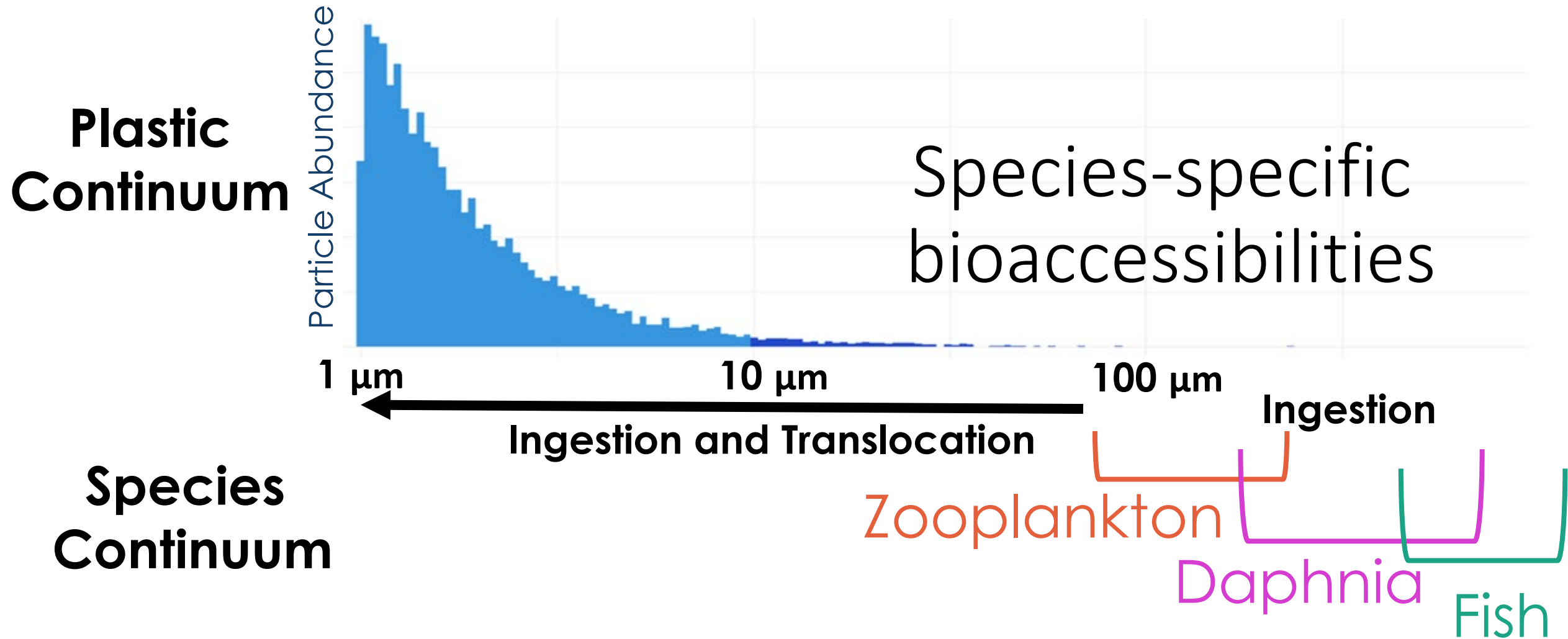
Longest ingested plastic (mm)



Ingestible Plastic Size Predicted by Body Length

Jâms,. et al. (2020) ‘Estimating the size distribution of plastics ingested by animals’, *Nature Communications*.

Restrict Alignment to *Bioaccessible* Particles



Adapted from **Koelmans**, *et al.* (2022) 'Risk assessment of microplastic particles', *Nature Reviews Materials*.

Alignment with Ecologically Relevant Metrics

Environmental Microplastics

polydisperse



$$\begin{aligned} \mu_x &= \frac{x_{UL} - x_{LL}}{\ln\left(\frac{x_{UL}}{x_{LL}}\right)} \\ P(x) &= Cx^{-\alpha} \\ \int_{LL}^{UL} P(x)dx &= 1 \\ \mu_x &= \frac{\ln\left(\frac{x_{UL}}{x_{LL}}\right)}{x_{LL}^{-1} - x_{UL}^{-1}} \\ CF_{meas} &= \frac{L_{UL,D}^{1-\alpha} - L_{LL,D}^{1-\alpha}}{L_{UL,M}^{1-\alpha} - L_{LL,M}^{1-\alpha}} \quad \mu_x = \frac{C}{2-\alpha} (UL^{2-\alpha} - LL^{2-\alpha}) \end{aligned}$$

$$\mu_{x,poly} = \frac{1-\alpha_x}{2-\alpha_x} \times \frac{x_{UL}^{2-\alpha_x} - x_{LL}^{2-\alpha_x}}{x_{UL}^{1-\alpha_x} - x_{LL}^{1-\alpha_x}}$$

$$EC_{poly} \times \mu_{x,poly} = EC_{mono} \times \mu_{x,mono}$$

$$EC_{env} = EC_{poly} \times CF_{bio}$$

Lab Studies

monodisperse



Koelmans, et al. (2020)

'Solving the non-alignment of methods and approaches used in microplastic research in order to consistently characterize risk', *Environmental Science & Technology*.

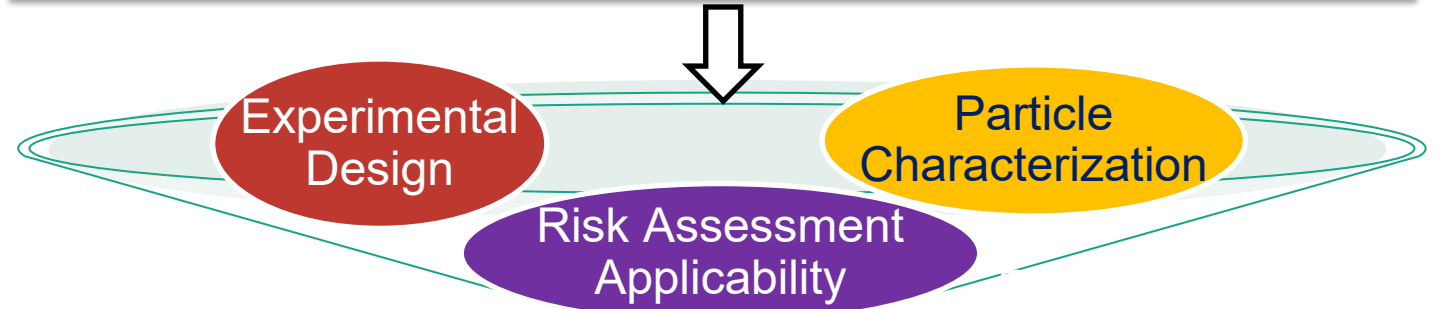
Eco-Toxicity Thresholds Derivation

Coffin et al. (2026).

“A Comprehensive Probabilistic Framework for Deriving Microplastic Hazard Thresholds: Development and Application to Marine and Freshwater Ecosystems with ToMEx 2.0 Data.”
Journal of Hazardous Materials.



***in vivo* aquatic microplastics toxicity studies**
(n = 287 studies; 168 species; 12,878 data points)

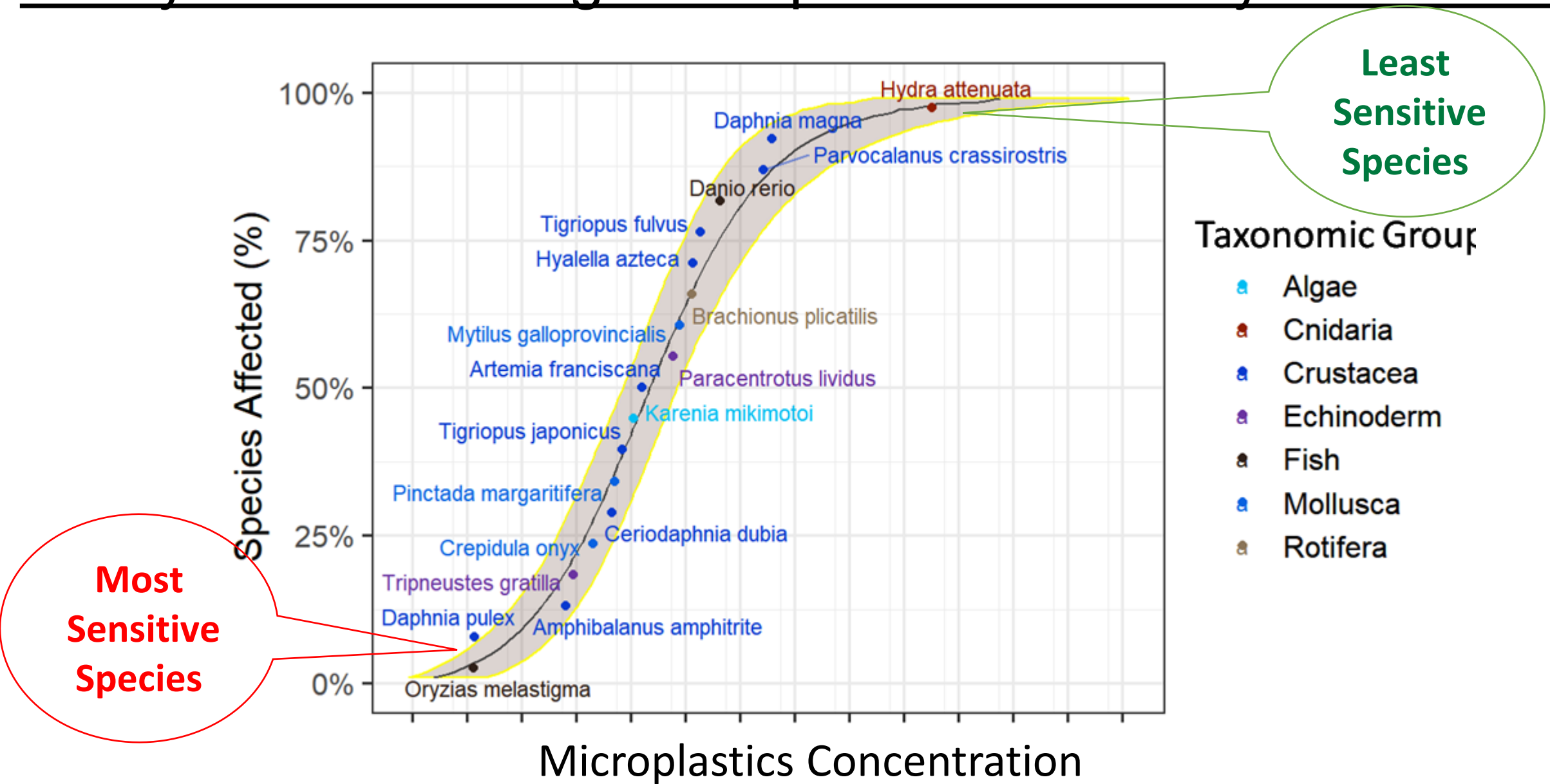


Fit for purpose studies
(n = 58 studies; 44 species; 398 data points)

Alignment (Food Dilution, Tissue Translocation)

**Probabilistic Species sensitivity
distribution modelling**

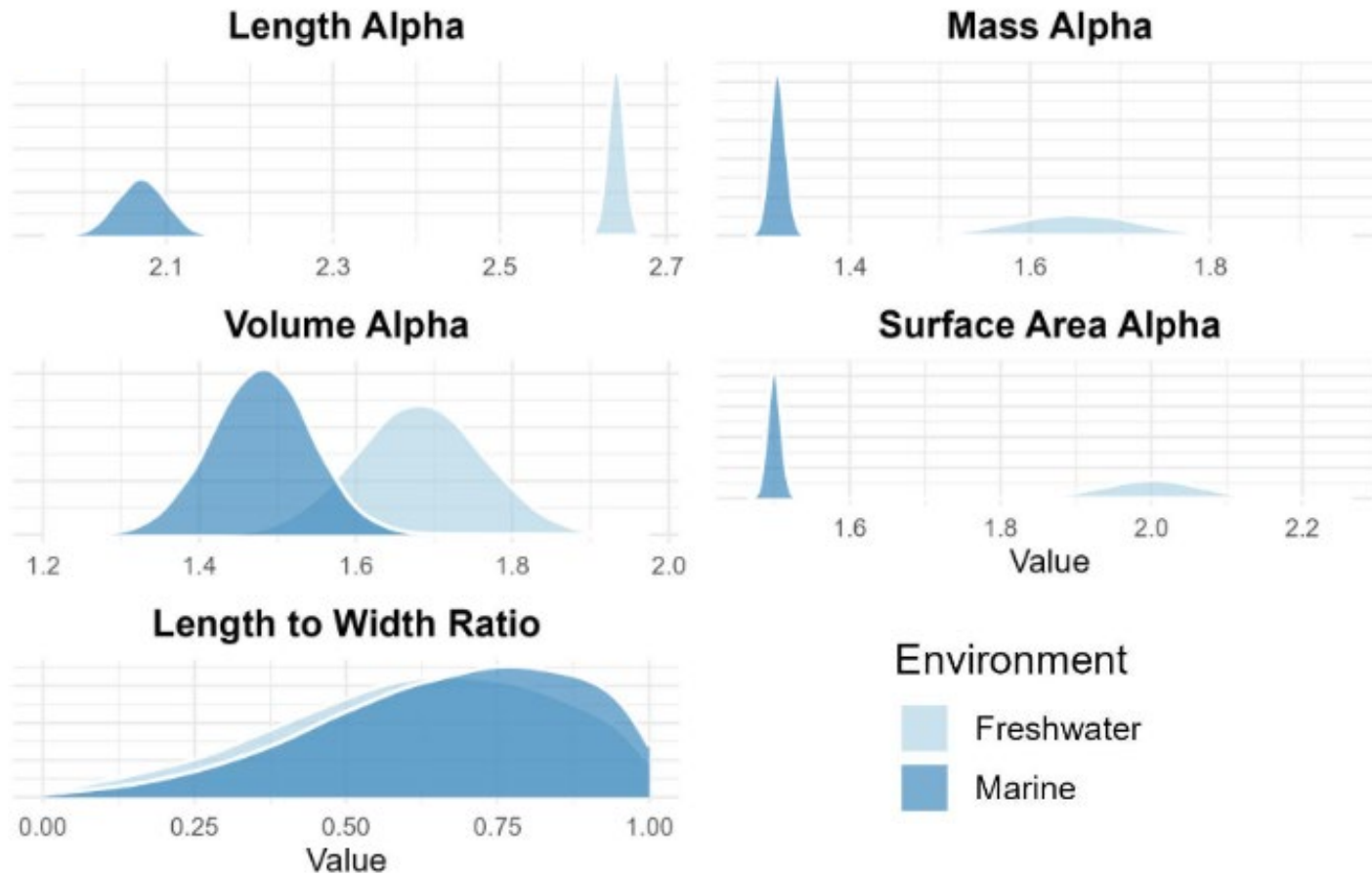
Ecosystem Modelling with Species Sensitivity Distributions



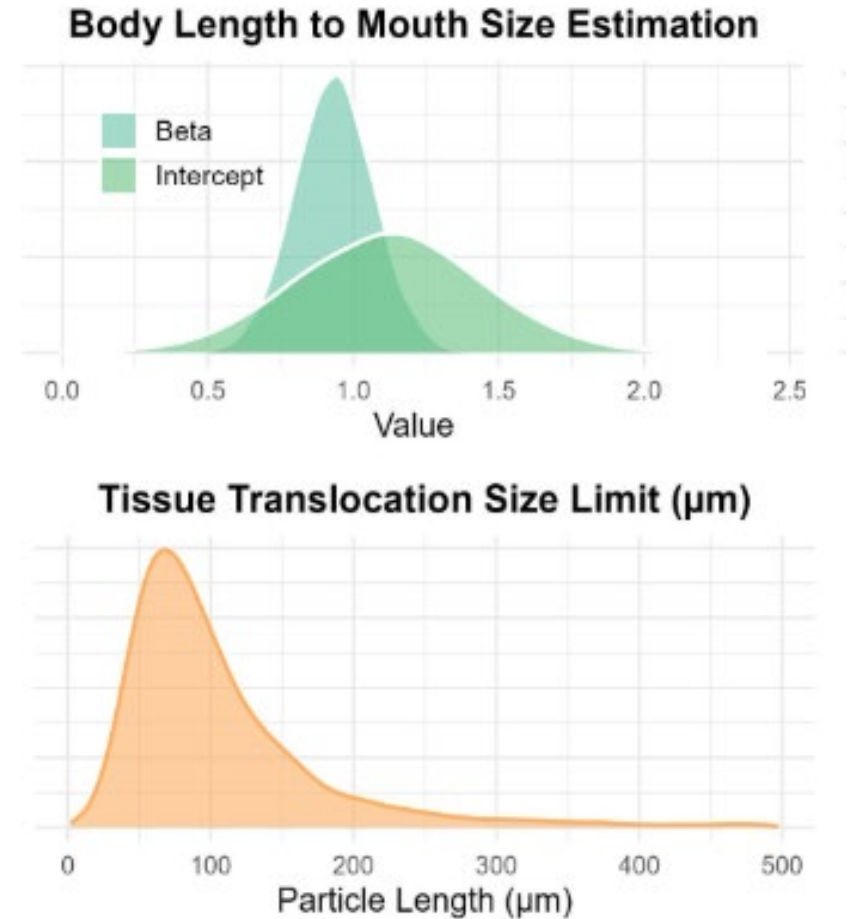
Mehinto, **Coffin**, Koelmans, Brander, **Wagner**, Thornton Hampton, Burton, Miller, Gouin, Weisberg & Rochman. 'Risk-based management framework for microplastics in aquatic ecosystems', *Microplastics and Nanoplastics* (2022)

Probabilistic Alignments with Monte-Carlo

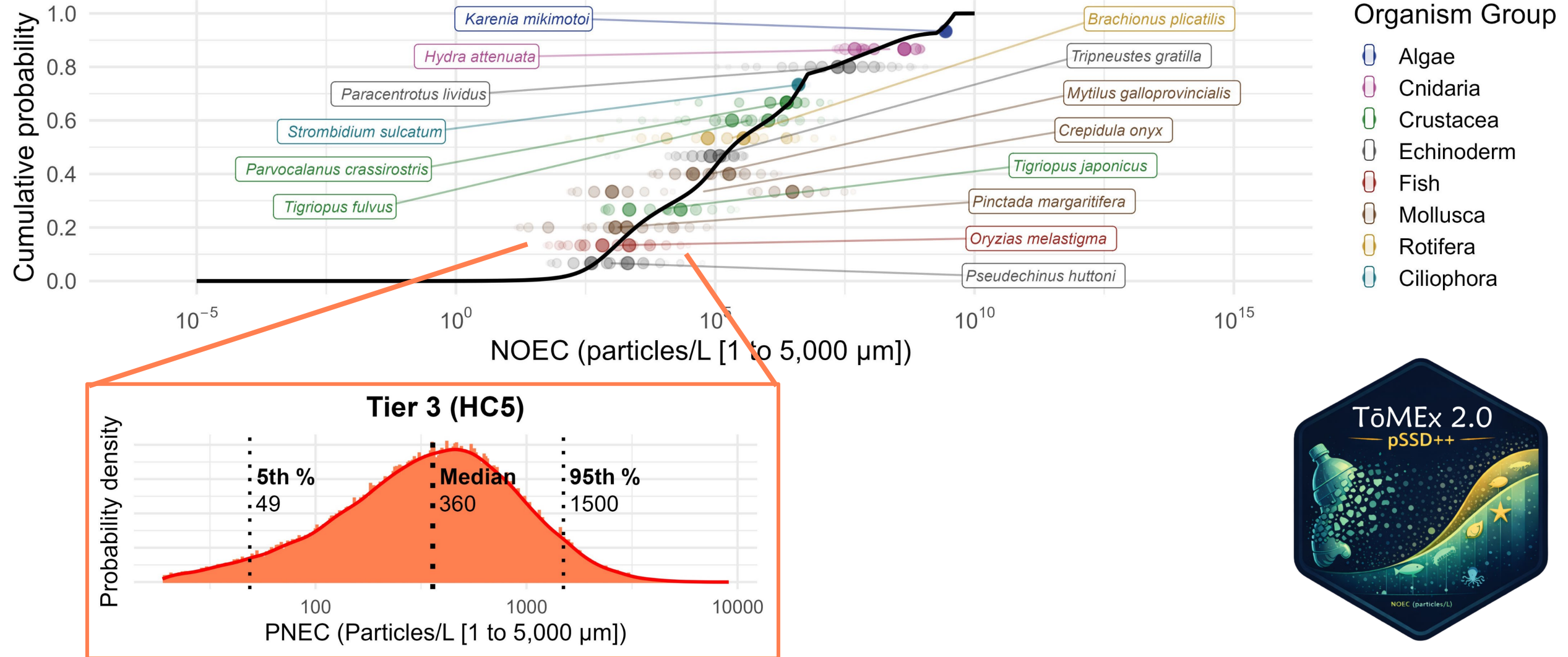
Compartment-Specific Particle Characteristics



Organism Characteristics



“Probabilistic Species Sensitivity Distribution ++”



Coffin, Bertrand, Ahmed, de Souza Leite, Cowger, Siña, Barrick, Kukkola, Carney Almroth, Miller, Yeh, Kennedy, Mair. “A Comprehensive Probabilistic Framework for Deriving Microplastic Hazard Thresholds: Development and Application to Marine and Freshwater Ecosystems with ToMEx 2.0 Data.” *Microplastics & Nanoplastics* (2026).

PSSD++ Accounts for Variabilities & Uncertainties

Tissue Translocation

Marine

Freshwater

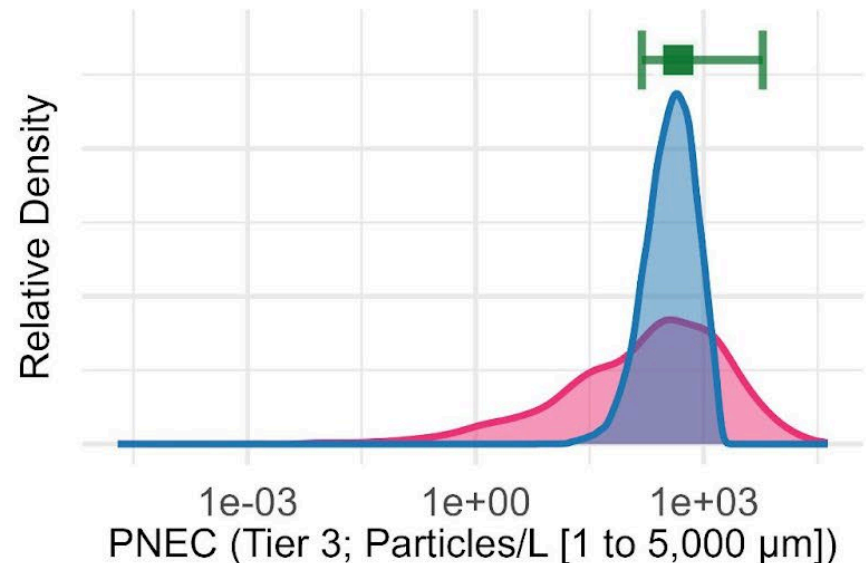
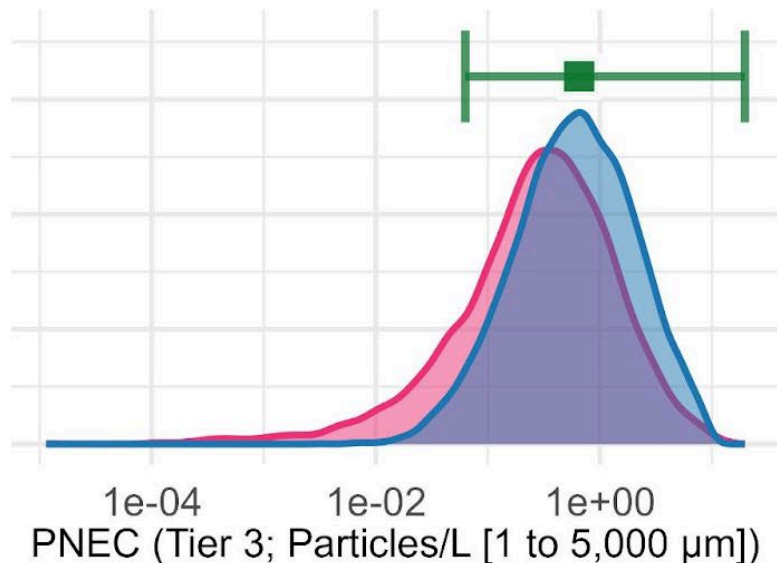
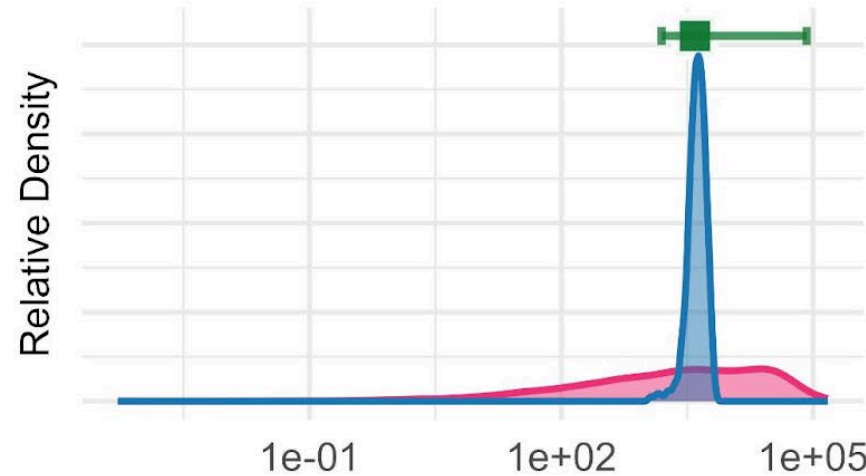
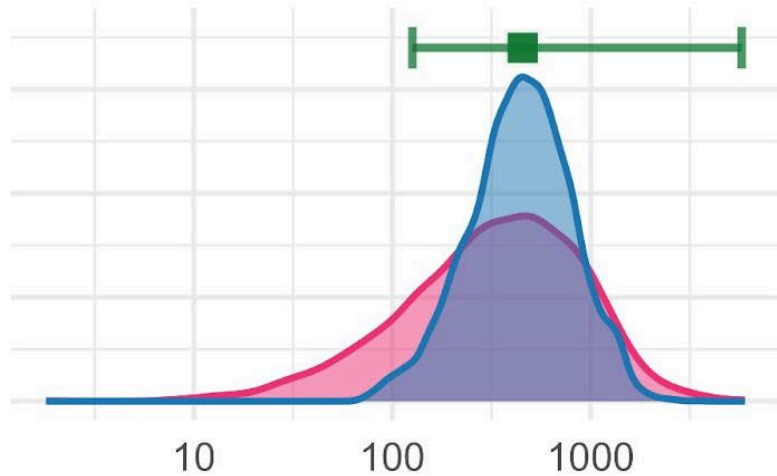
Method

Species Sensitivity Distribution

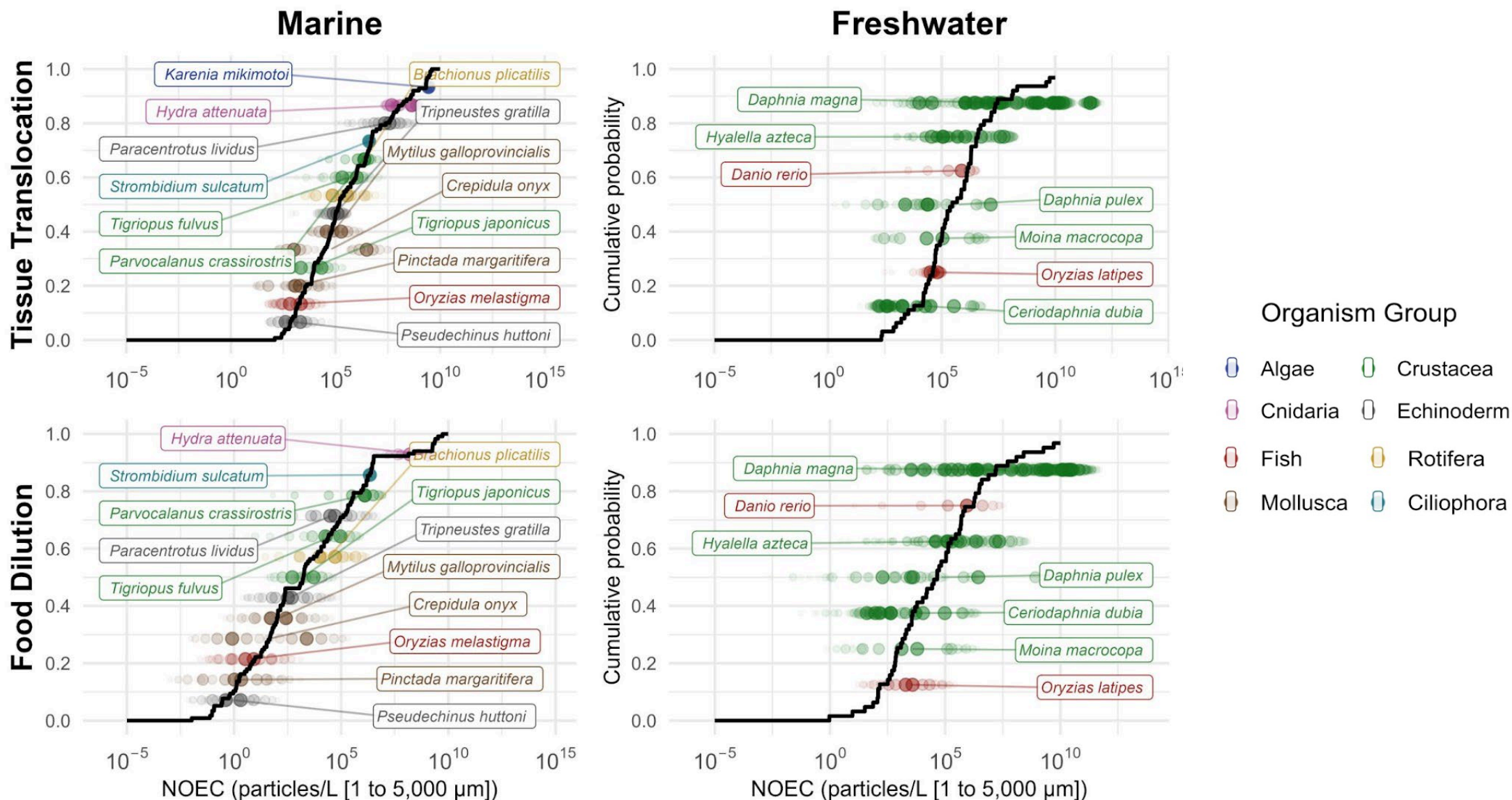
10,000 SSDs (MC-aligned ERM)

PSSD++

Food Dilution



pSSD++s for Marine & Freshwater x ERM



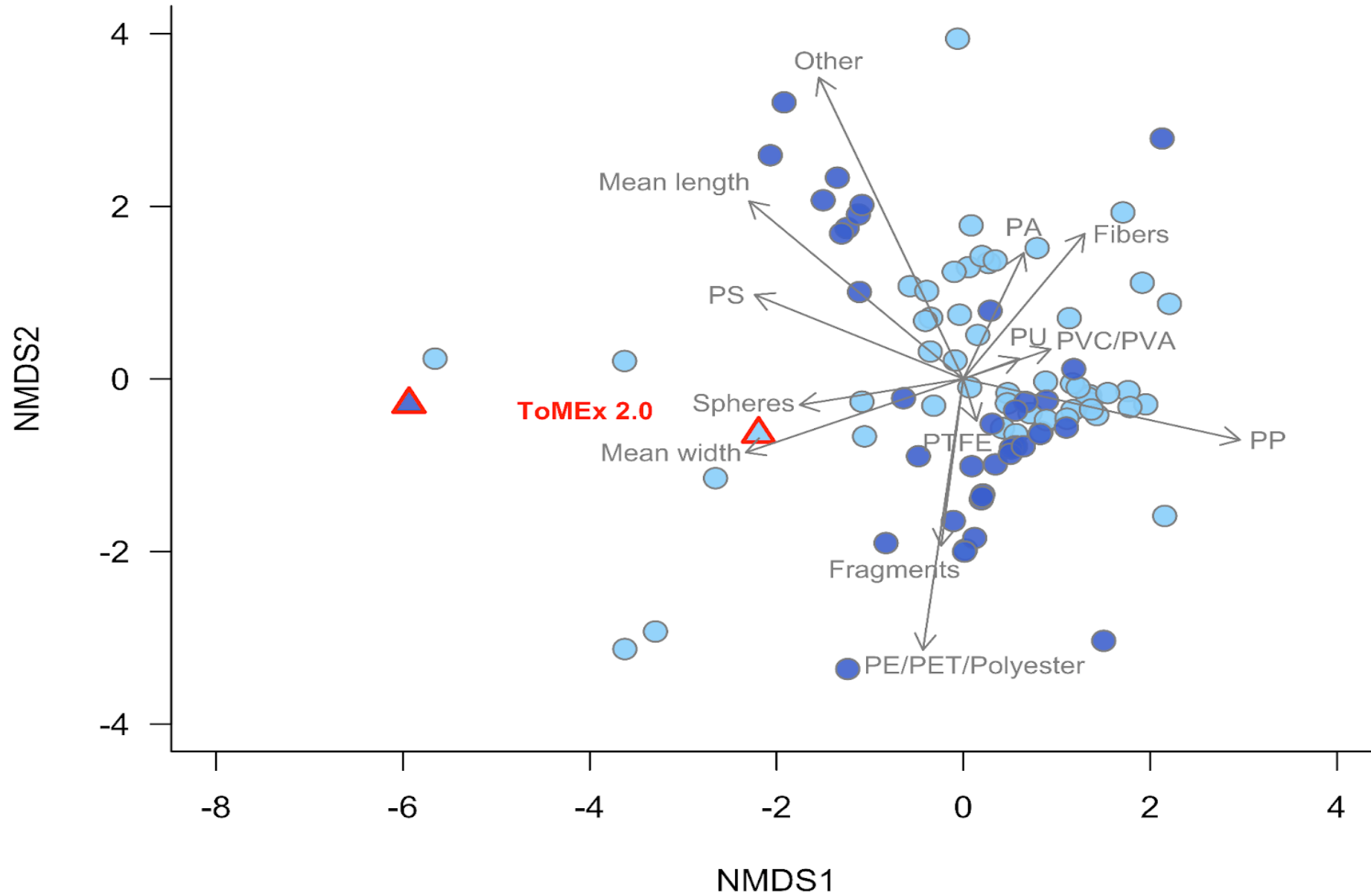
pSSD++ Available as an R Package on Github





Additional Research Needed to Assess Microplastics Hazards

Particles used in Tox Studies Very Different than in the Environment



Ecological Risk Assessment: Room for Improvement

- Account for additional **physicochemical particle features** that influence toxicity (e.g., fibrous shape, biofouling, eco-corona, zeta potential, etc.)
- Integrate **chemical-** and **pathogen-induced risks**
- Account for differences in **water column species <-> particle interactions**
- **Environmentally-realistic** particle exposures needed
- Account for **entanglement, lacerations**

Plymouth
Marine
Laboratory



Characterizing Ecological Risks in San Francisco Bay, California

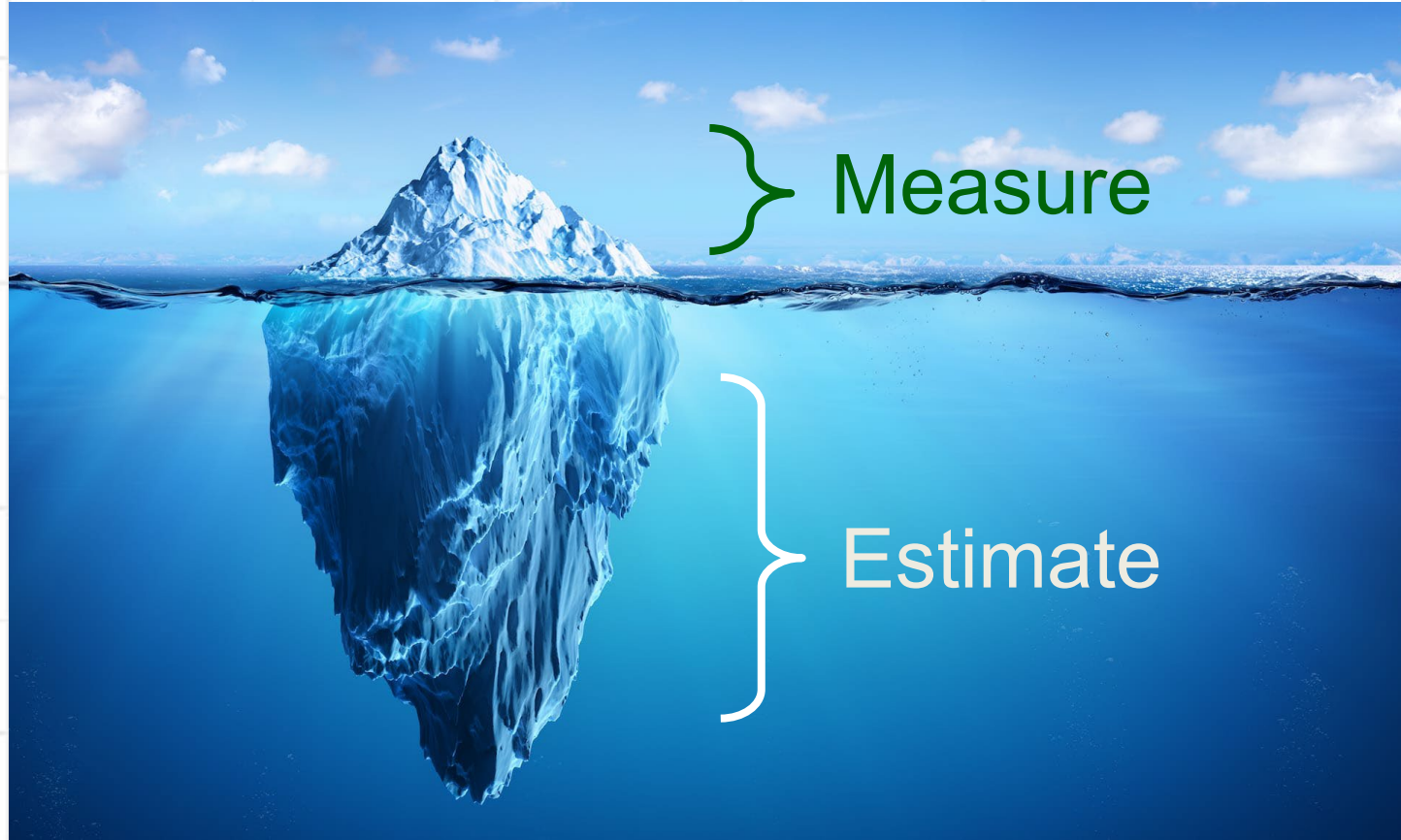
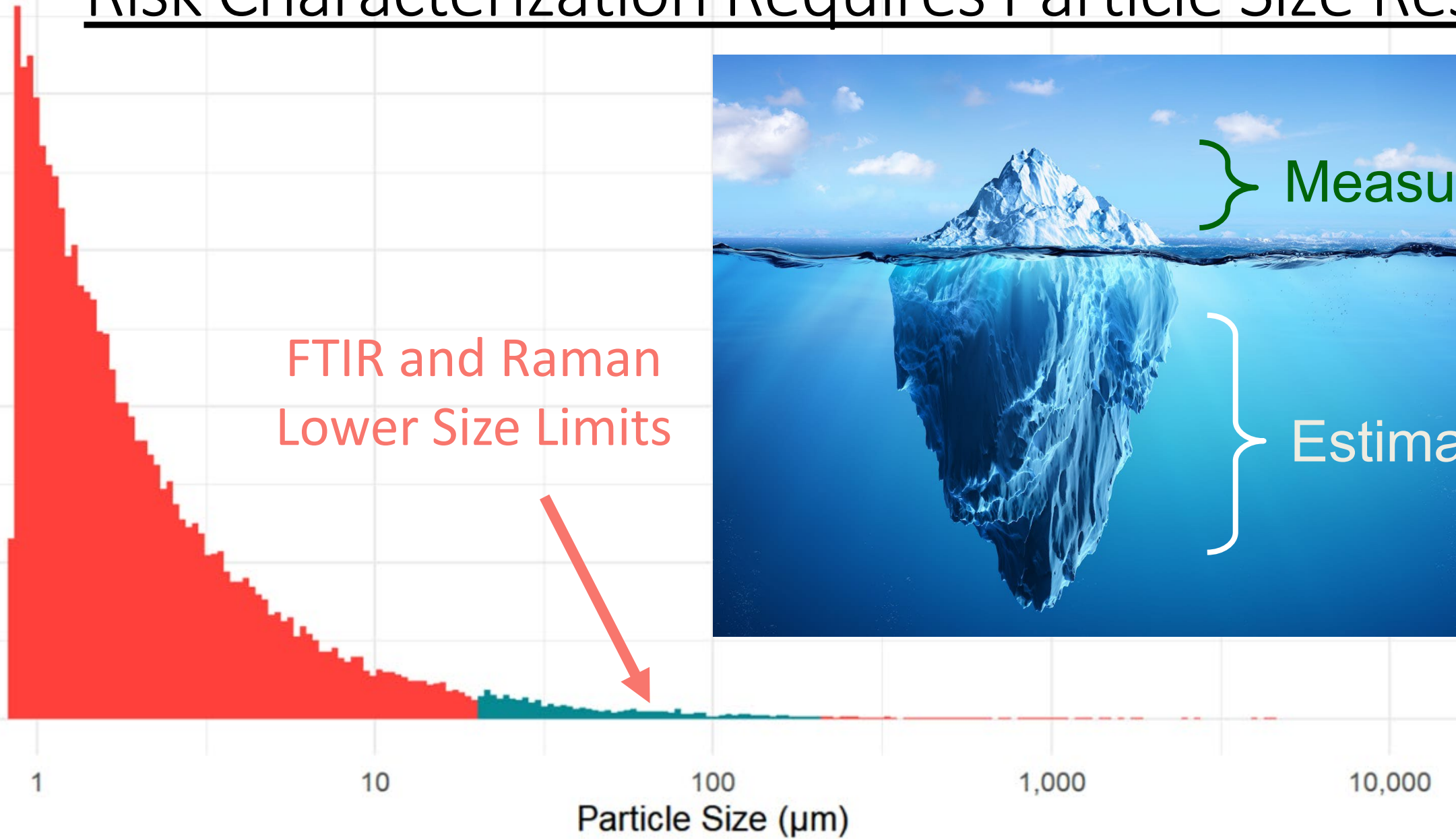


Photos: Erika Delemarre



Risk Characterization Requires Particle Size Rescaling

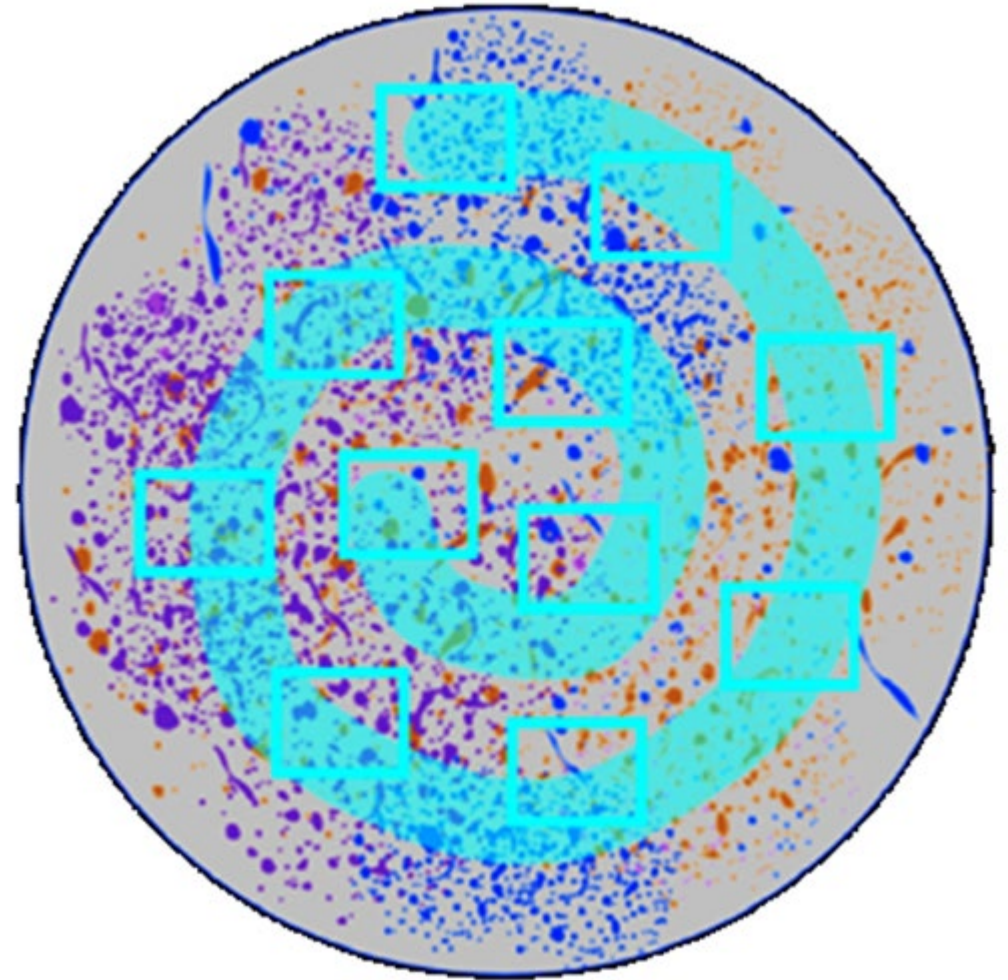
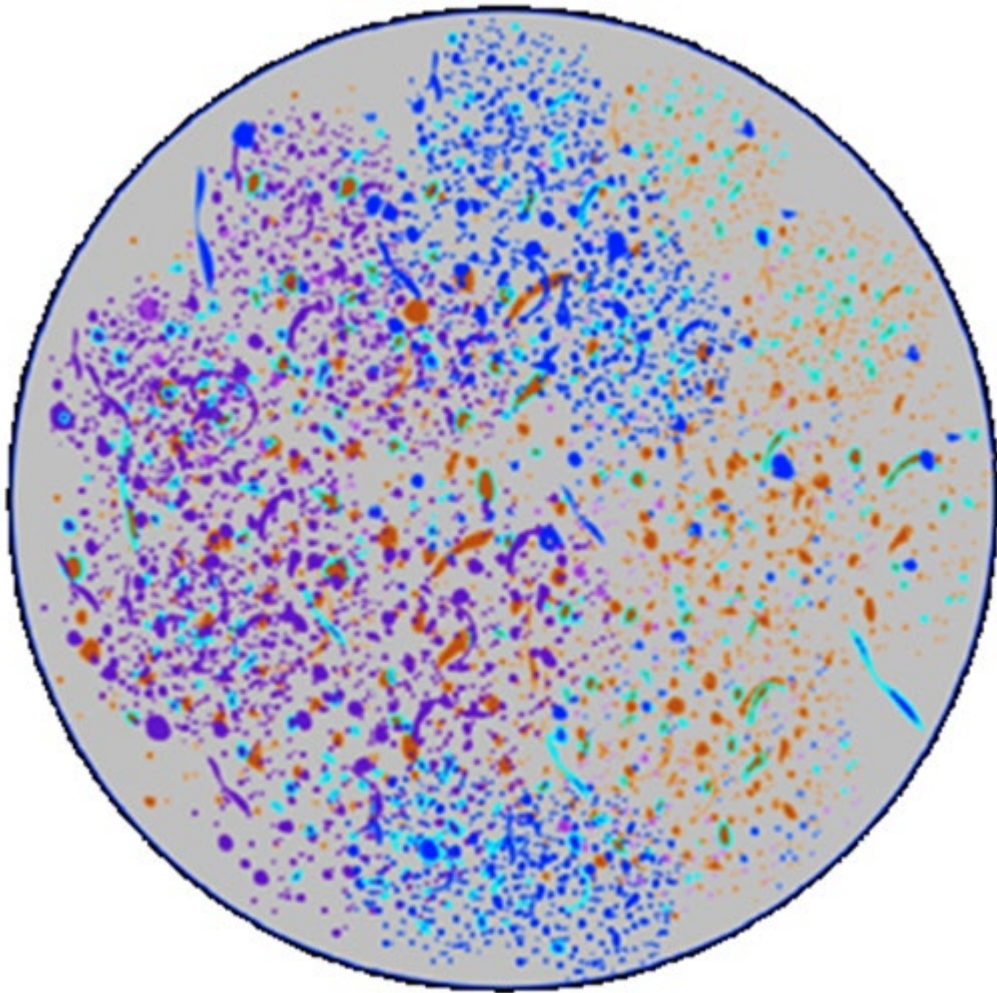
FTIR and Raman
Lower Size Limits



Microplastics Analysis (was / can still be) Extremely Time-Consuming



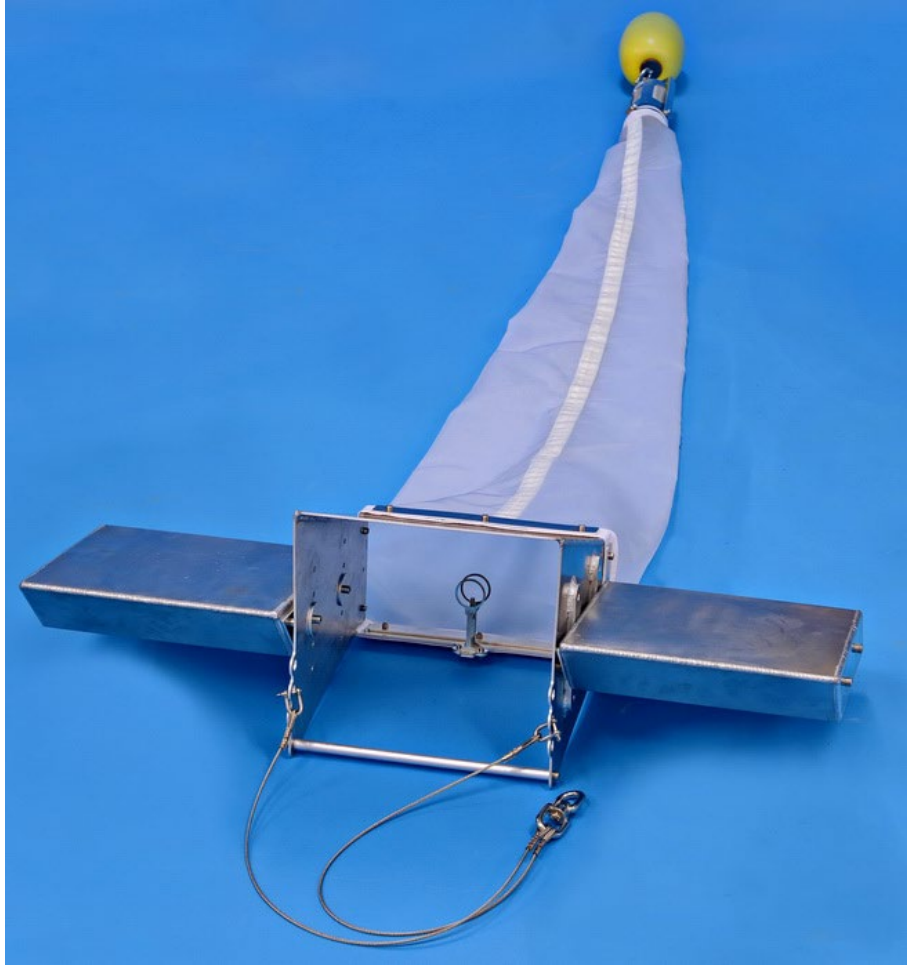
Spectroscopic Subsampling Used to Confirm Plastic



SF Bay Monitoring Data from Zhu, X. *et al.* (2021) 'Holistic Assessment of Microplastics and Other Anthropogenic Microdebris in an Urban Bay Sheds Light on Their Sources and Fate', *ACS ES&T Water*.

Images from Schymanski, D. *et al.* (2021) 'Analysis of microplastics in drinking water and other clean water samples with micro-Raman and micro-infrared spectroscopy: minimum requirements and best practice guidelines', *Analytical and Bioanalytical Chemistry*

Fibers May Slip Through Nets



Data Cleanup and Systematic Bias Corrections



Zhu et al. (2021)

Mehinto *et al.* (2022)

Coffin *et al.* (2022)

Environmental
monitoring data

Field and lab blanks

Blank-corrected
“anthropogenic particle”
concentrations

Manta Trawl Fiber Bias
Correction Factor
(particle counts)

Size-based Rescaling
(measured lengths)

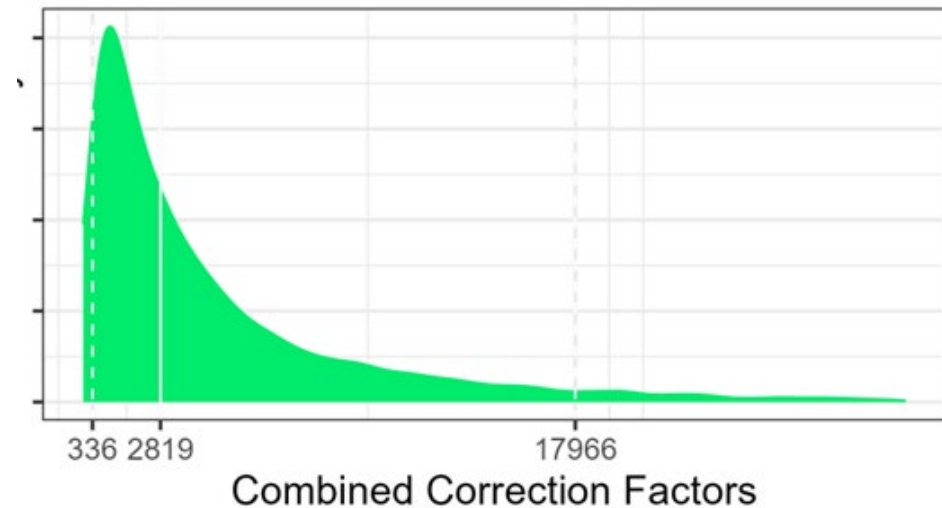
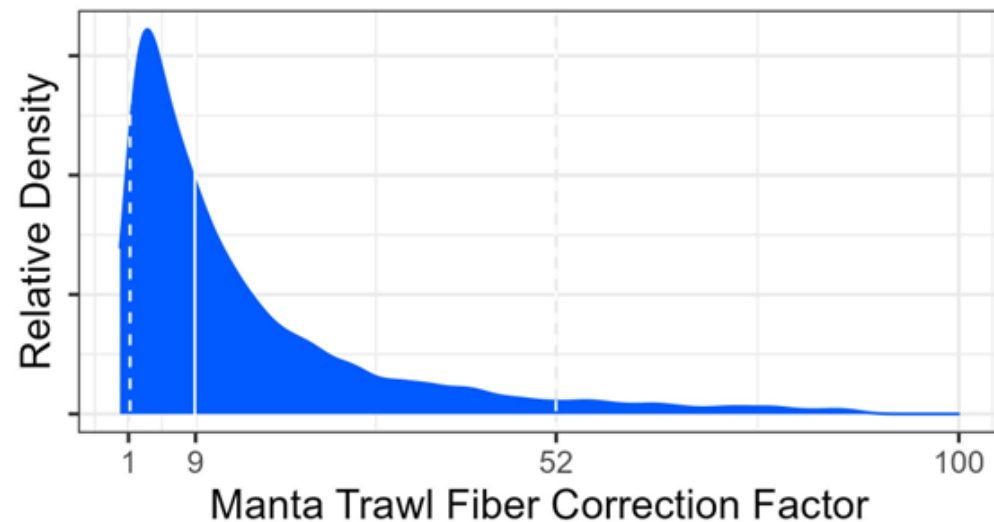
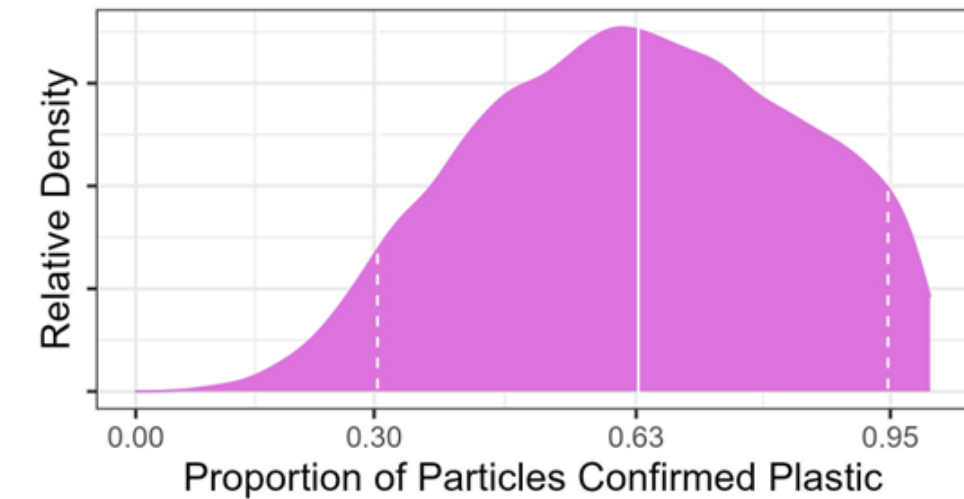
Plastic Subsampling
Fraction
(spectroscopy)

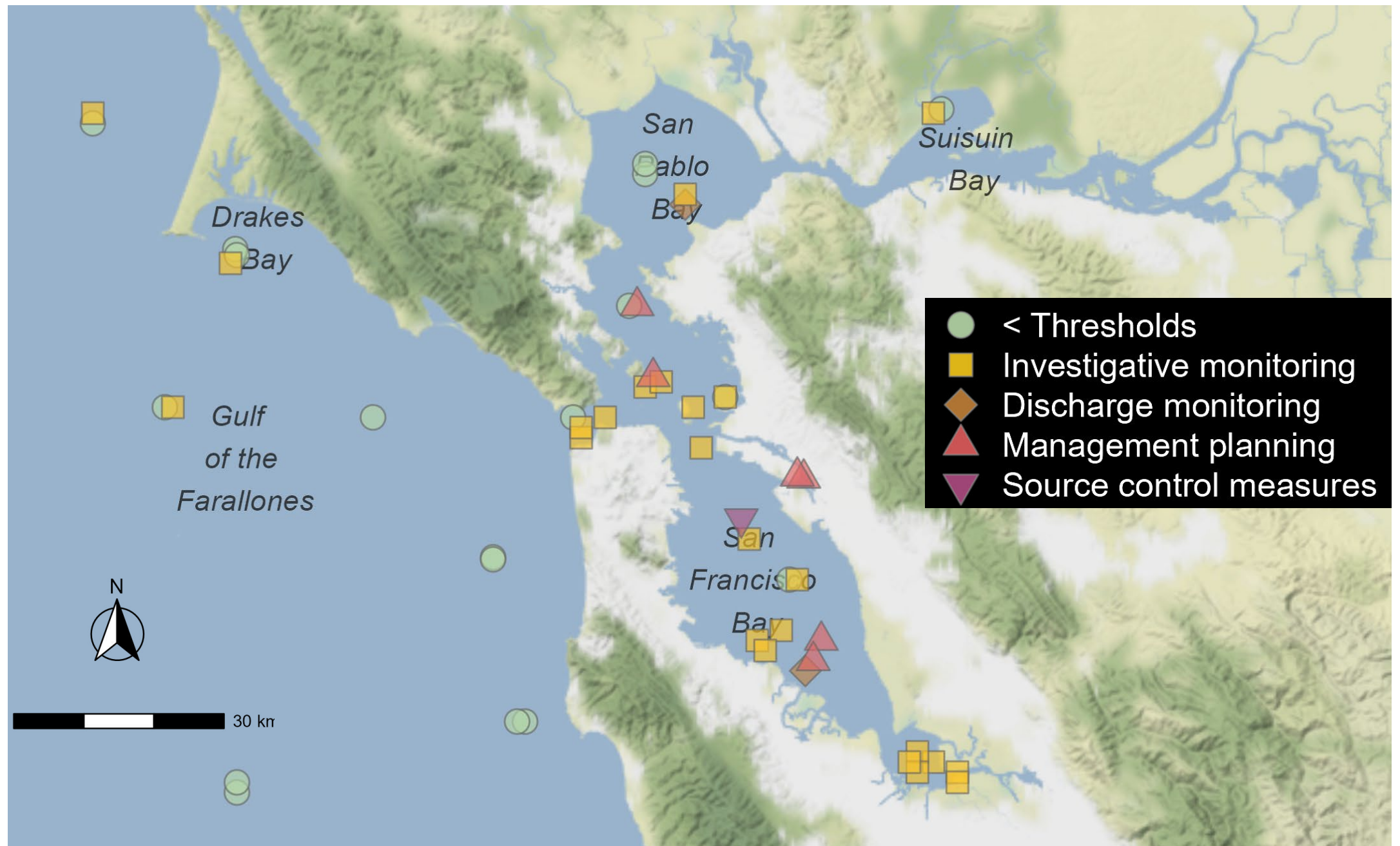
Corrected- and Aligned-
Microplastics concentrations

Aligned microplastics
hazard thresholds

Risk exceedances

Systematic Biases Adjusted with Probability Distributions



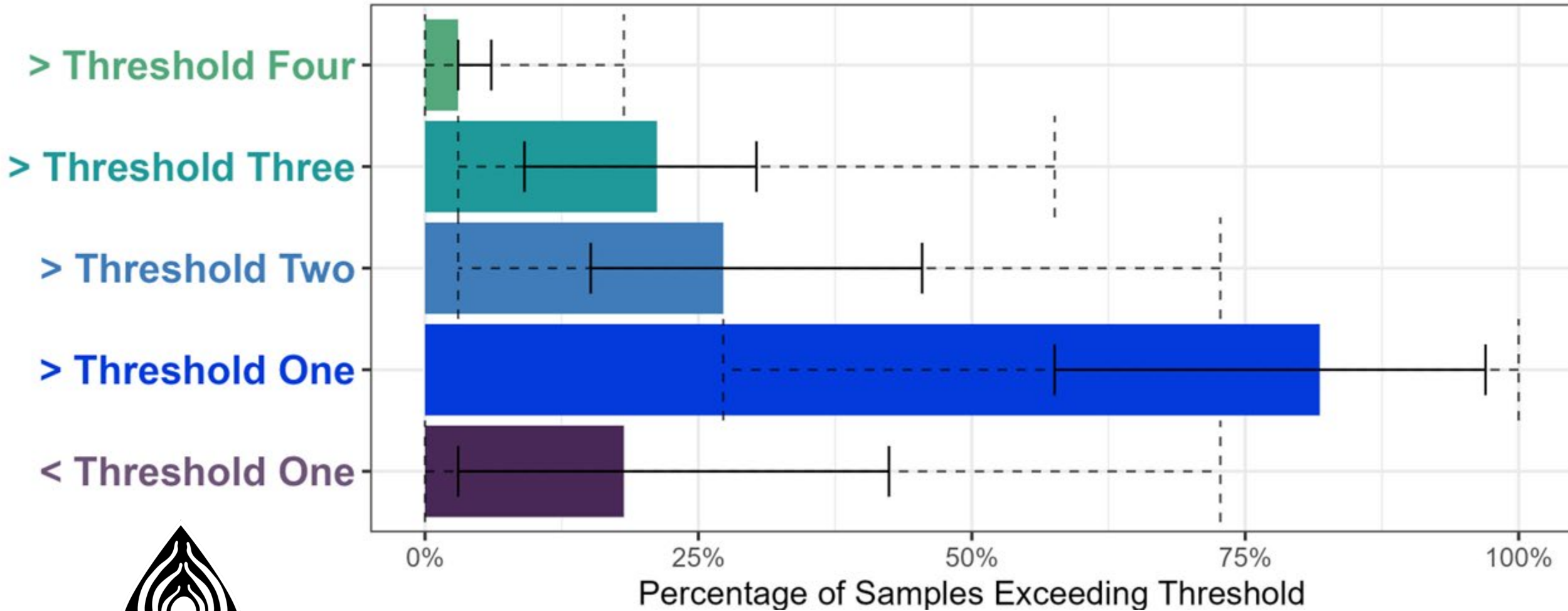


Coffin, et al. (2022) 'Risk characterization of microplastics in San Francisco Bay, California', *Microplastics and Nanoplastics*.

Microplastics Particle Simulations in SF Bay



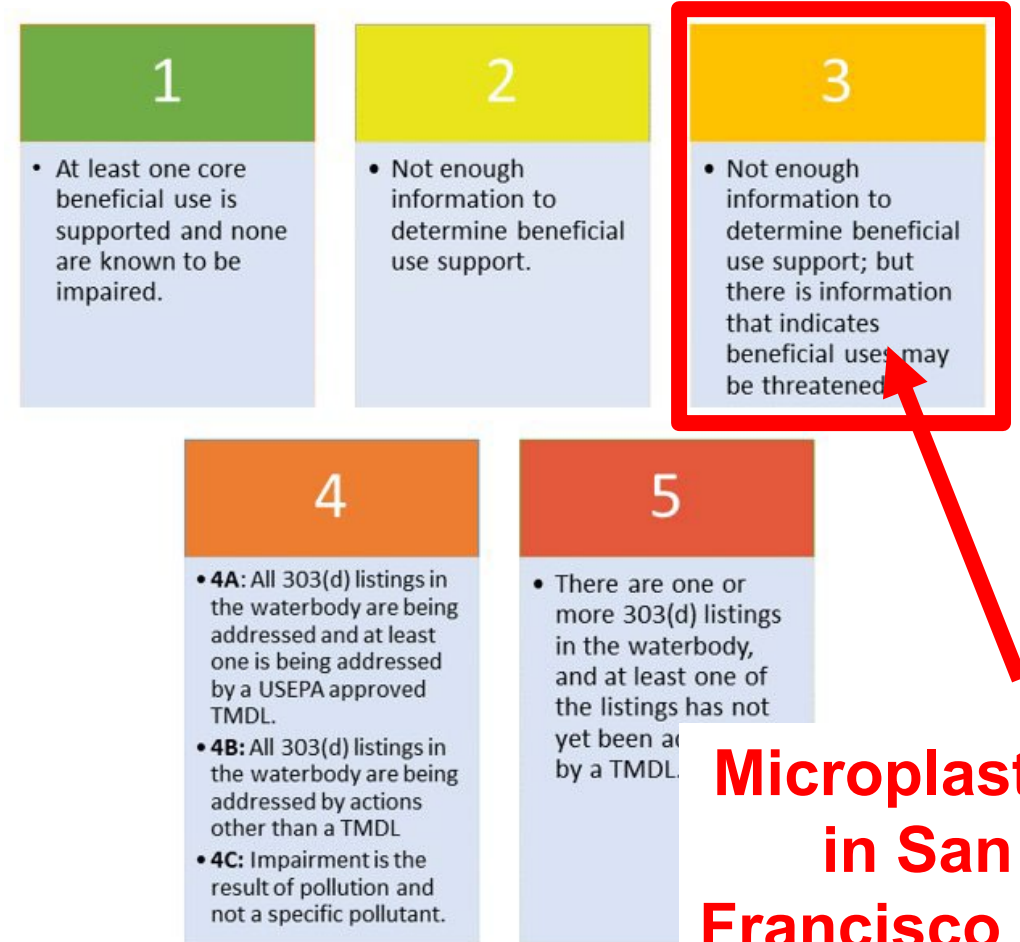
Probabilistic Risk Characterization of San Francisco Bay



Some San Francisco Waterbodies Determined to be Potentially Impaired under Clean Water Act

The 303(d) List

- Impaired waterbodies that do not meet water quality standards
- Informs remediation, e.g. - total maximum daily loads (TMDLs)

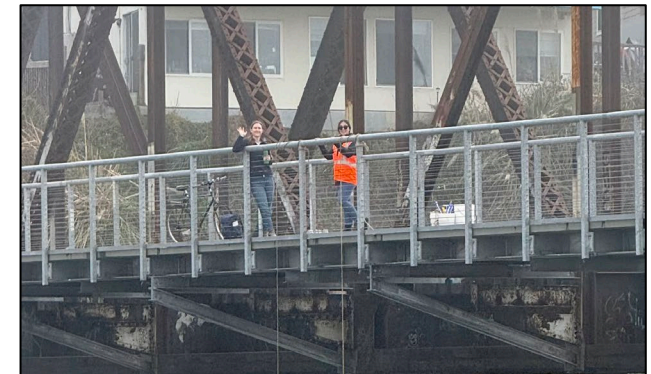
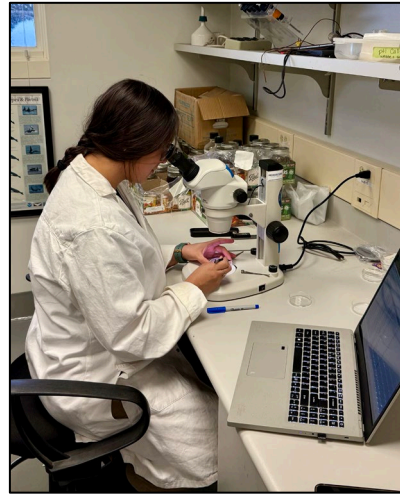


State Water Resources Control Board. 'California Integrated Report: Surface Water Quality Assessments to Comply with Clean Water Act Sections 303(d) and 305(b).' (2024)

**Microplastics
in San
Francisco Bay**

From Watershed to Whales:

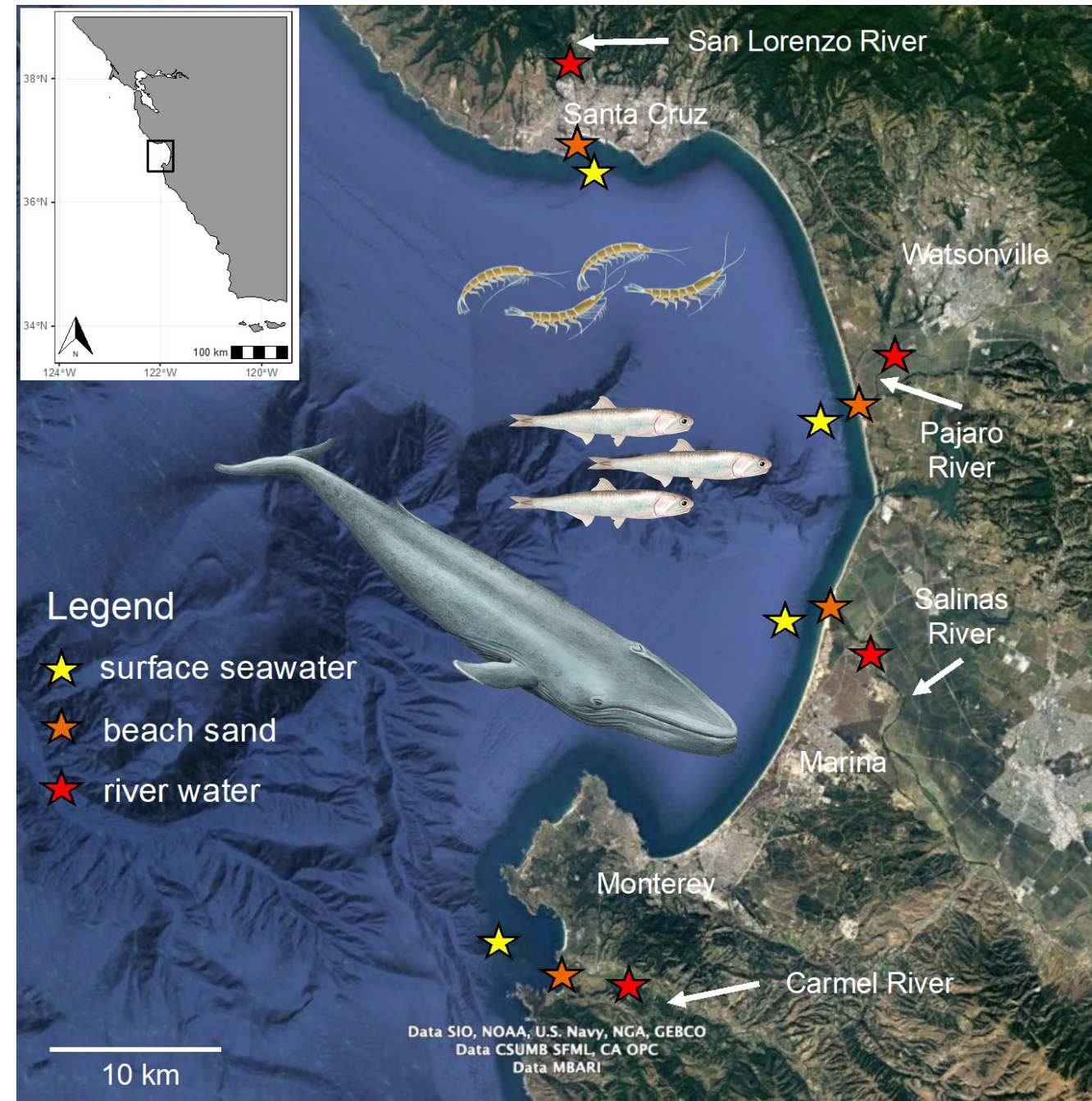
Tracking the source and transport of microplastics in the greater Monterey Bay region to inform risk assessments



Principal Investigator: Dr. Matt Savoca (Hopkins Marine Station of Stanford University)

Project Objectives

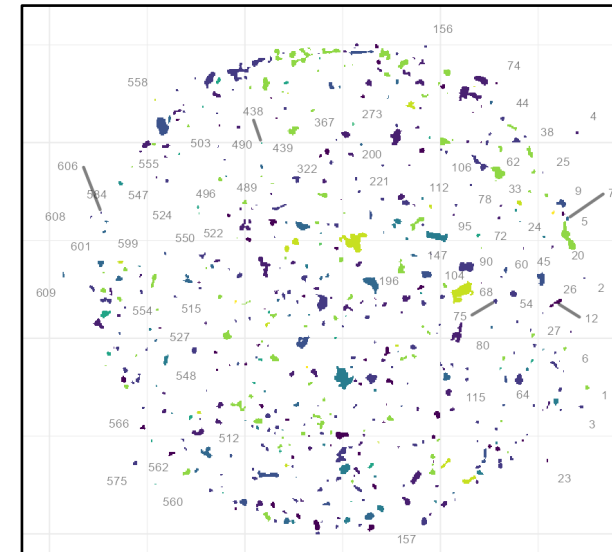
1. Quantify MP flux between the rivers, beach, ocean, and biota in the greater Monterey Bay region
2. Determine sources of MPs to Monterey Bay
3. Develop citizen science to gather plastics data on Monterey Bay beaches
4. Develop a mass balance framework to inform ecological risk assessments



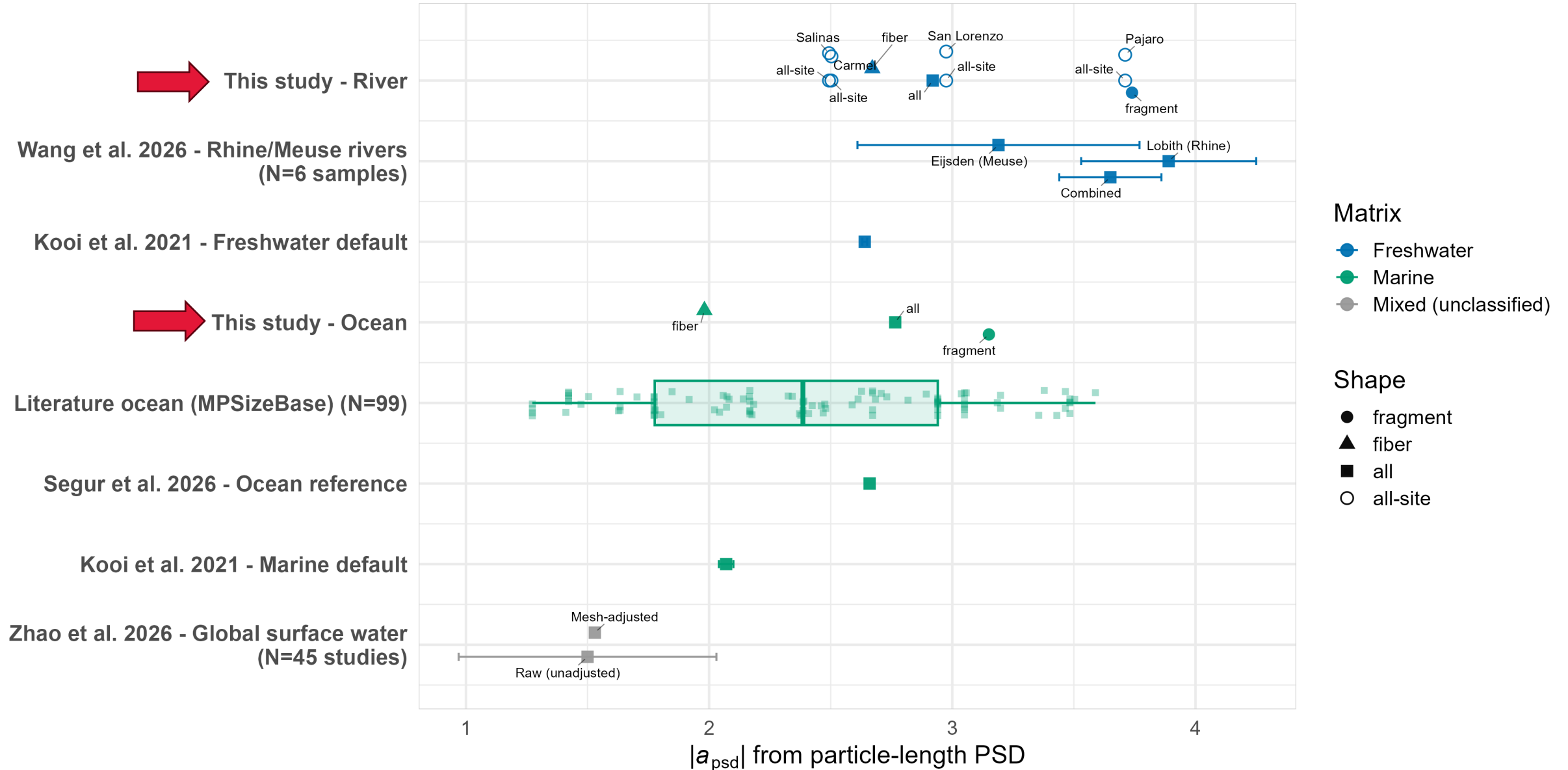
Small size class (50-500μm)

n = 22,932 microplastics identified

	sample_type	MP_mean_SE_SampleSize	MP_per_L
➡	beach sand	751.1 ± 166.1 (n=44)	31.29
	river water	205.2 ± 37.5 (n=59)	1.03
	ocean water	236.9 ± 104.2 (n=10)	1.18
	lab blank	48.7 ± 43.7 (n=6)	NA
	field blank	32.5 ± 15.6 (n=8)	NA

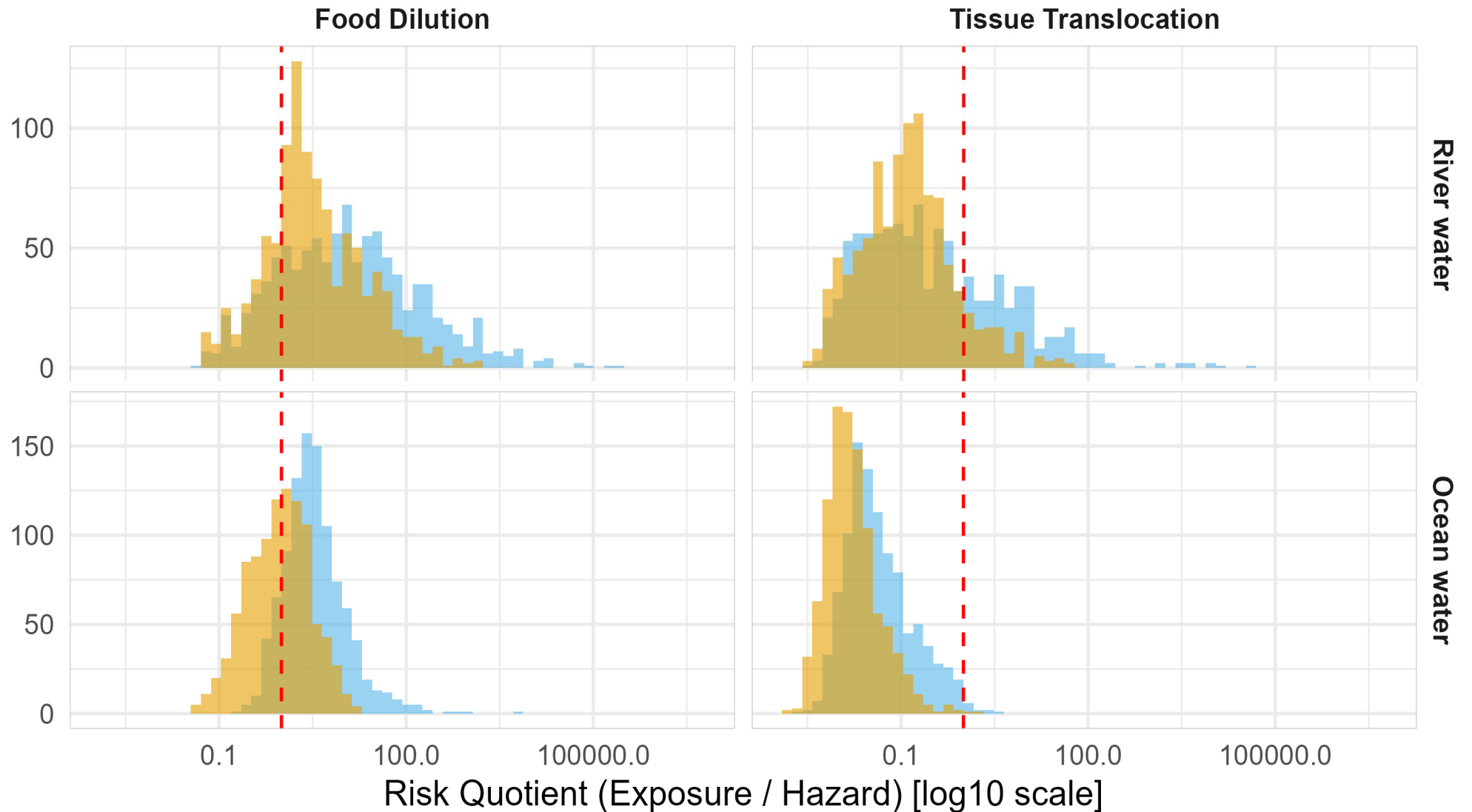
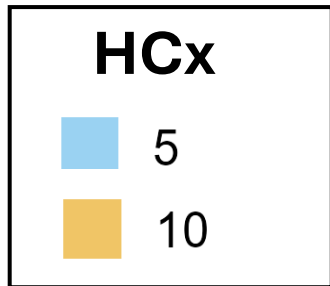


Power Law Distributions Comparable to Other Studies



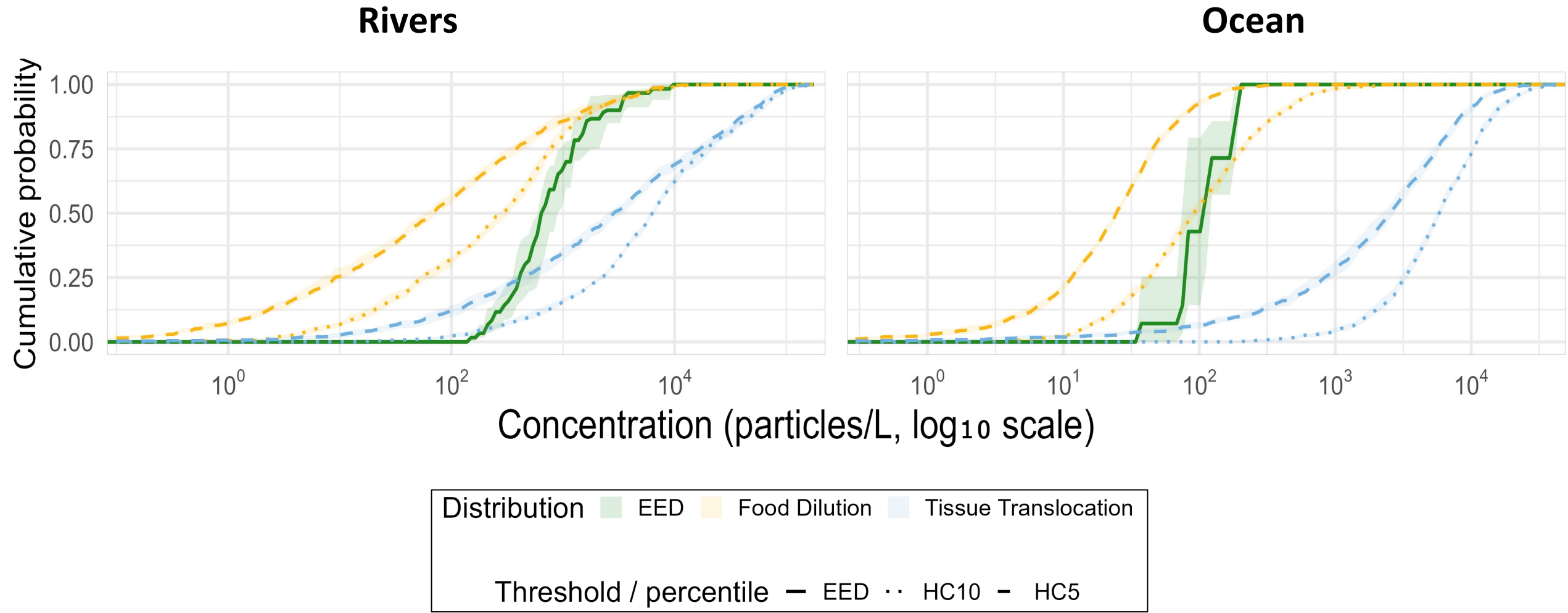
Coffin (*In Progress*). “Risk Characterization of Microplastics in the Monterey Bay Region.”

Food Dilution Risk Dominant; Rivers > Ocean



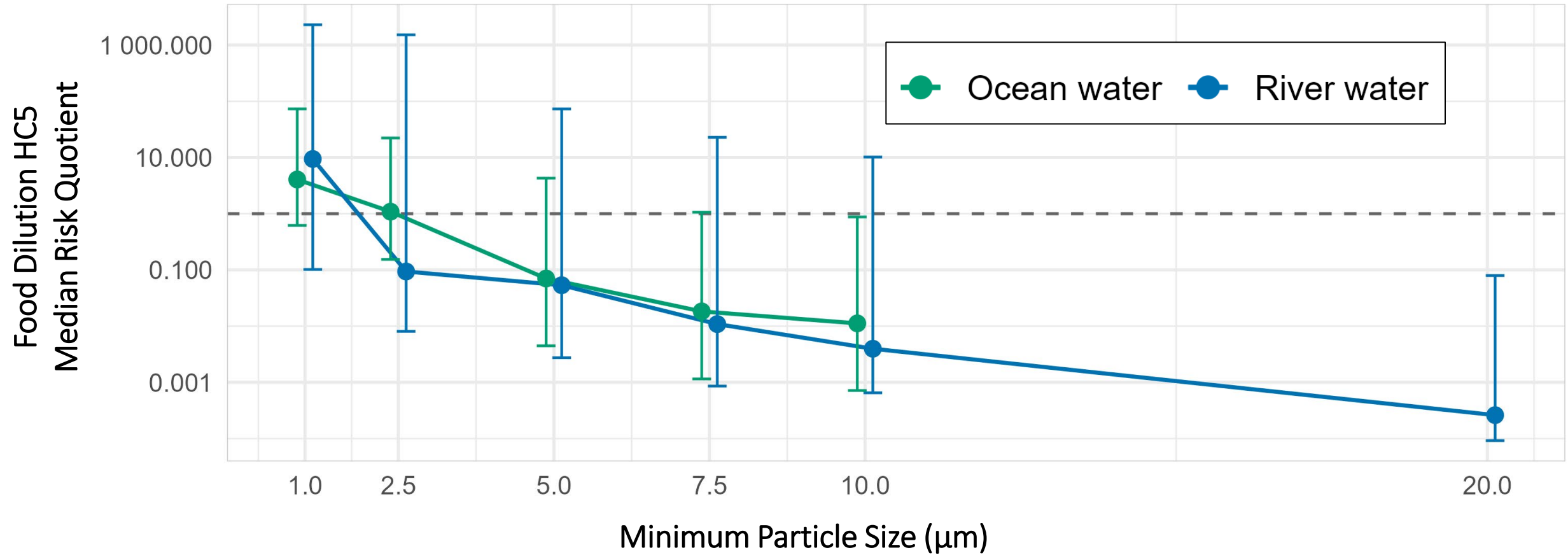
Coffin (*In Progress*). “Risk Characterization of Microplastics in the Monterey Bay Region.”

Exposure Distribution more uncertain than hazard thresholds



Coffin (*In Progress*). "Risk Characterization of Microplastics in the Monterey Bay Region."

Risk Depends on Minimum Particle Size of Operational Definition



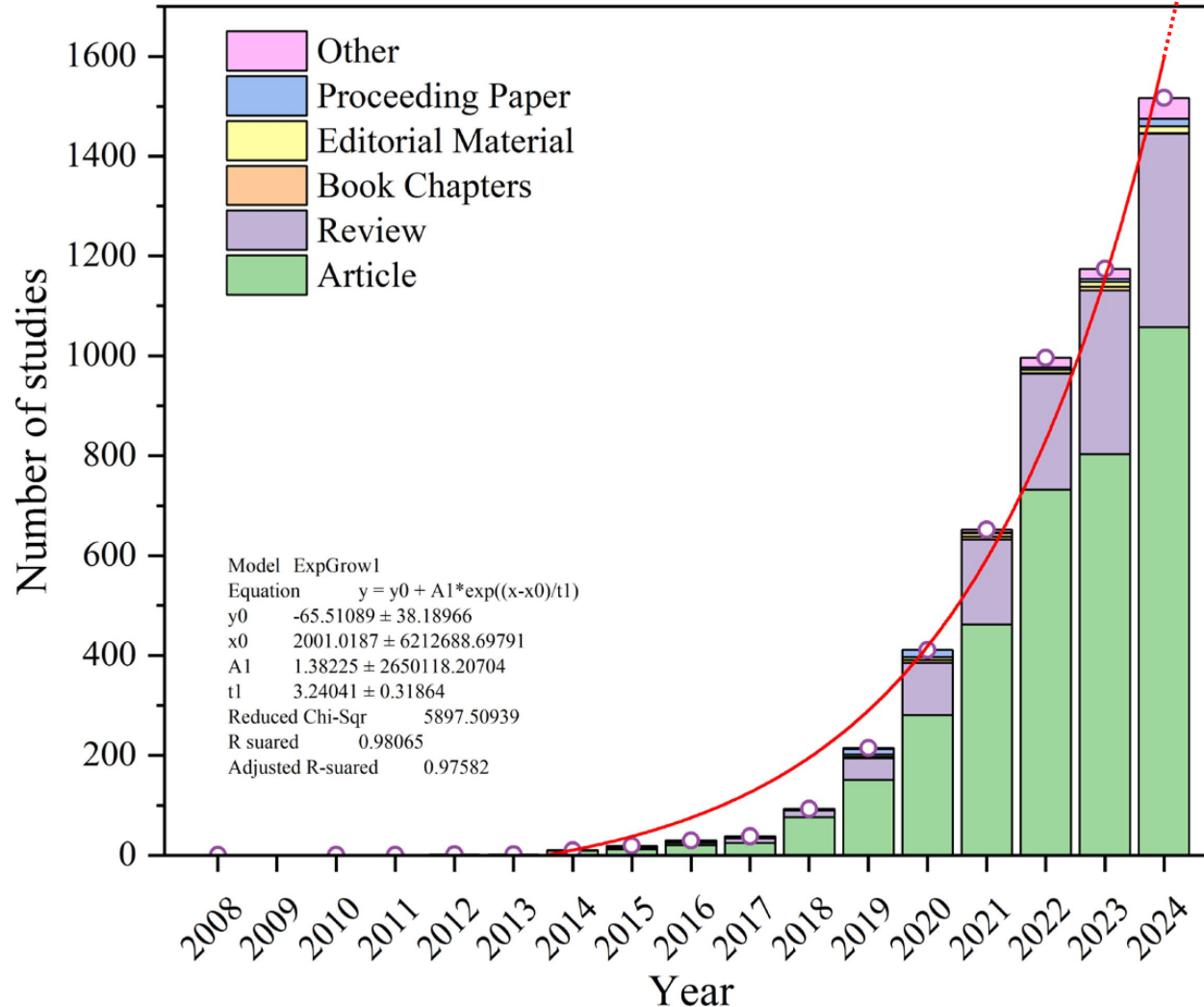
Coffin (*In Progress*). "Risk Characterization of Microplastics in the Monterey Bay Region."

Monterey Bay Risk Characterization Conclusions

- First ever *fully probabilistic* microplastics risk characterization
- Exposure rescaling to $<10\ \mu\text{m}$ particles is **uncertain**
- Risk exceedance of **rivers** for food-dilution **cannot be excluded**
- **Need:** reliable monitoring of $<10\ \mu\text{m}$ particles

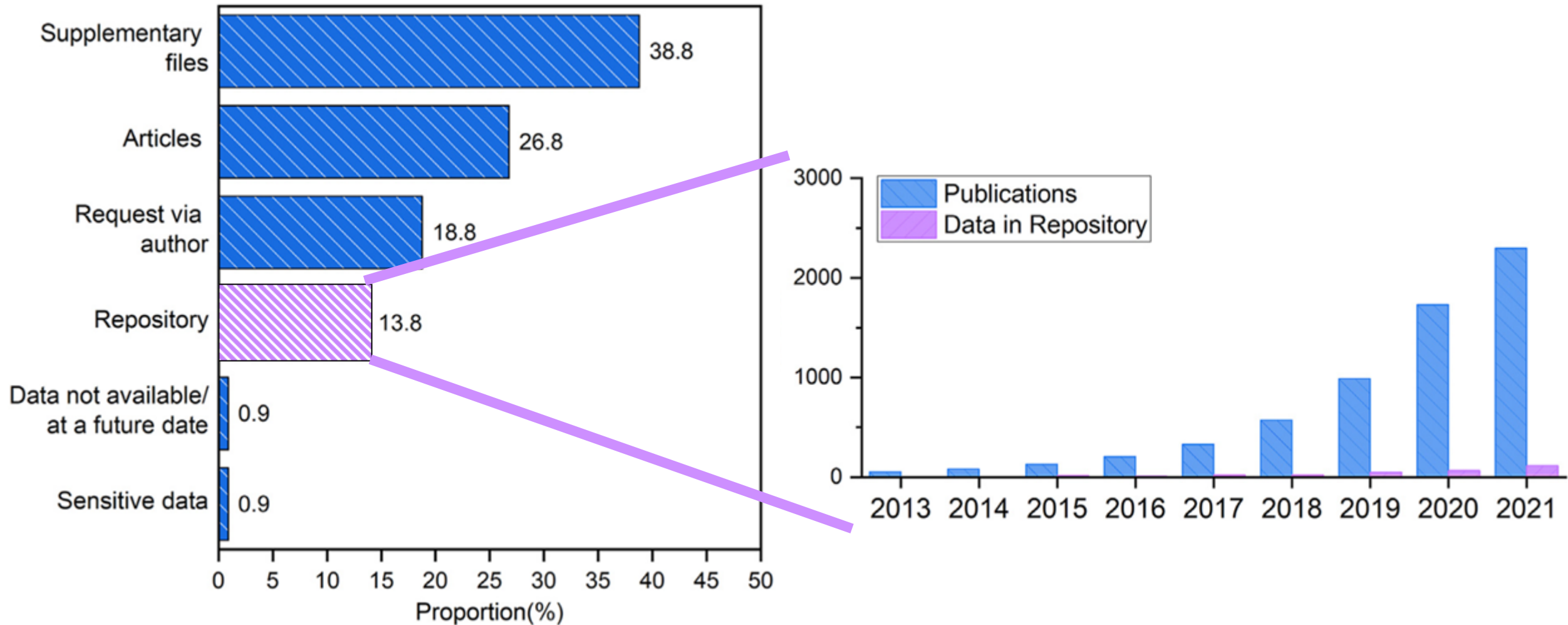


2026?



**~3,000 new
microplastics
studies anticipated
in 2026**

Microplastics Data is Rarely Structured or in Repositories



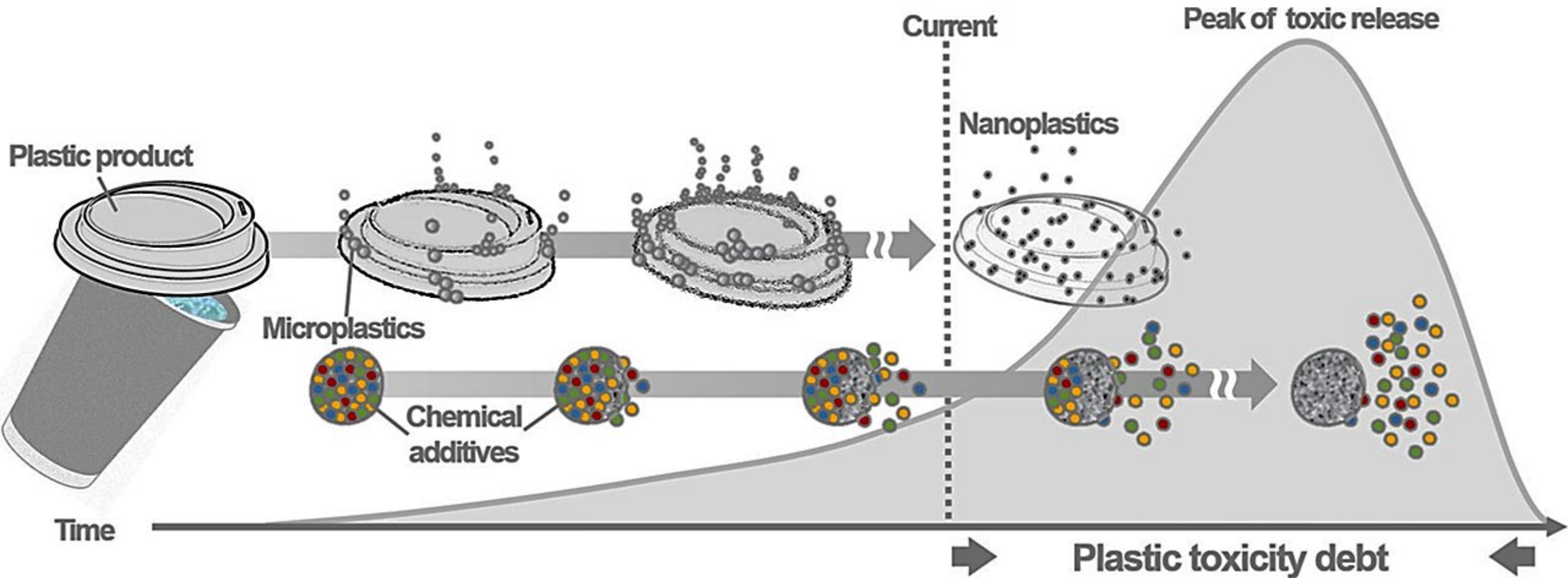
Jenkins, *et al.* (2022). "Current State of Microplastic Pollution Research Data: Trends in Availability and Sources of Open Data." *Frontiers in Environmental Science*.

2026: Lost in a sea of information?

Image generated using ChatGPT 4 (OpenAI 2023)



Microplastic Pollution will Increase Long After Releases Stop

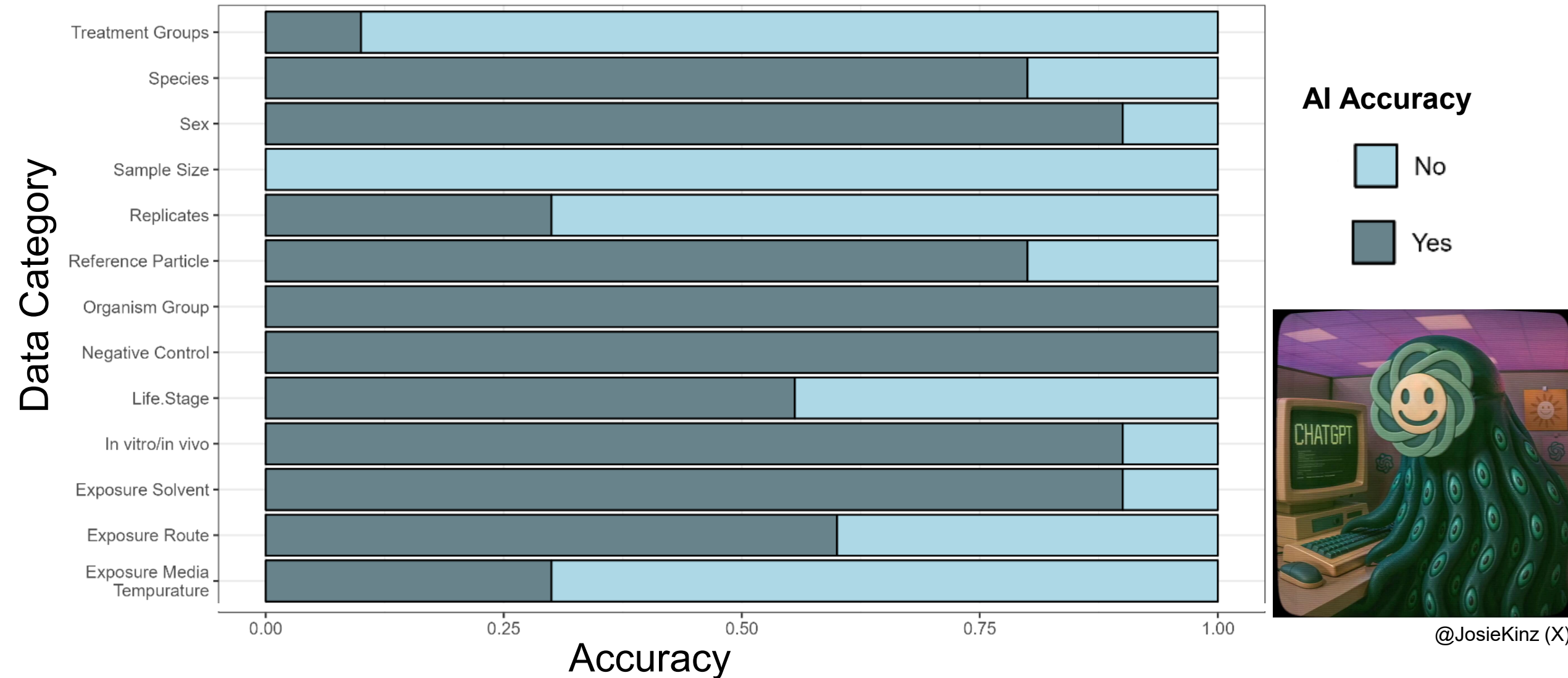


Rillig *et al*, 2021 (*ES&T*)

(Effective) use of AI can accelerate progress!



Pilot Study: Automating Data Extraction w/ChatGPT (3.5)



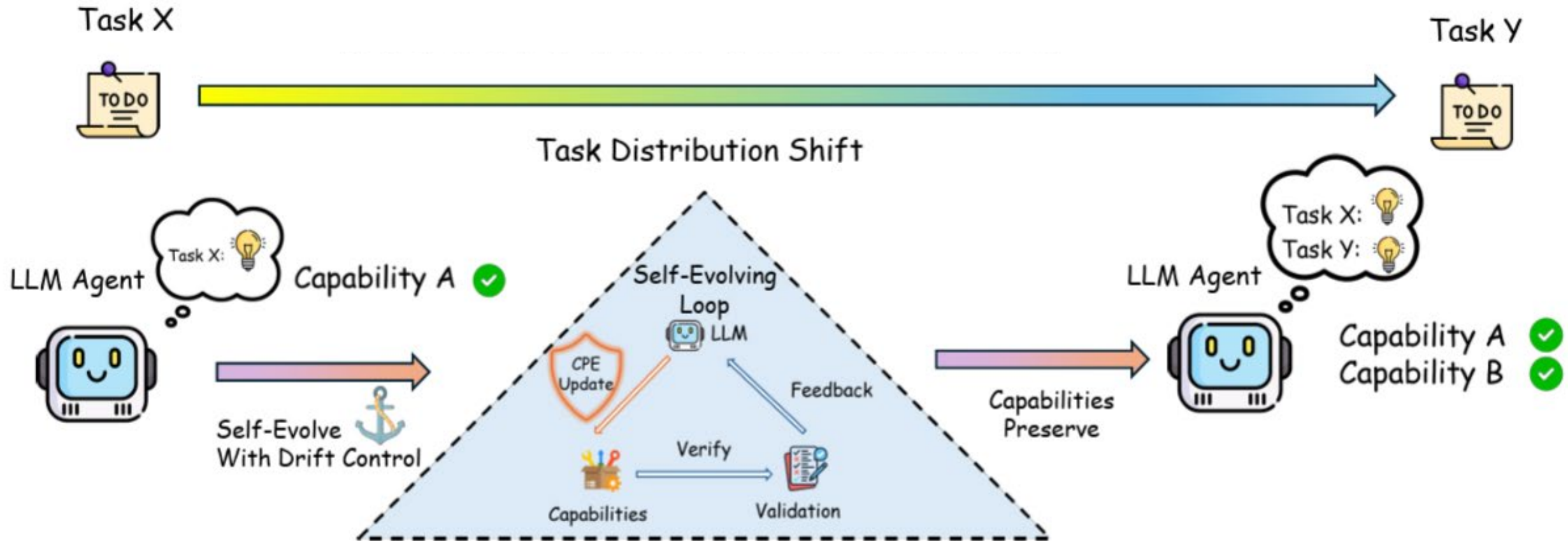
Thornton-Hampton *et al.* (2025) “The Toxicity of Microplastics Explorer (ToMEx) 2.0”. *Microplastics and Nanoplastics*.

ToMEx 3.0 - Agentic Pipeline Workflow



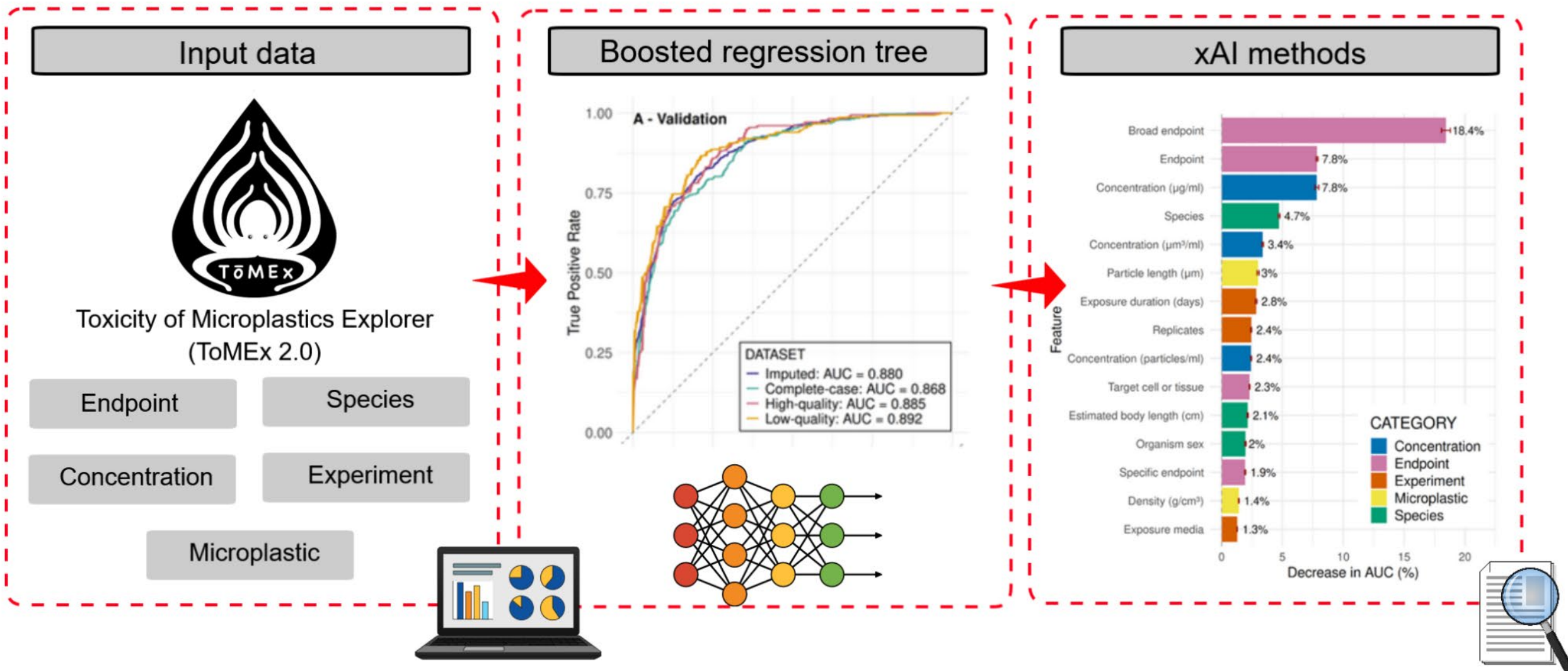


ToMEx 3.0 – Self-Evolving Agentic Loop



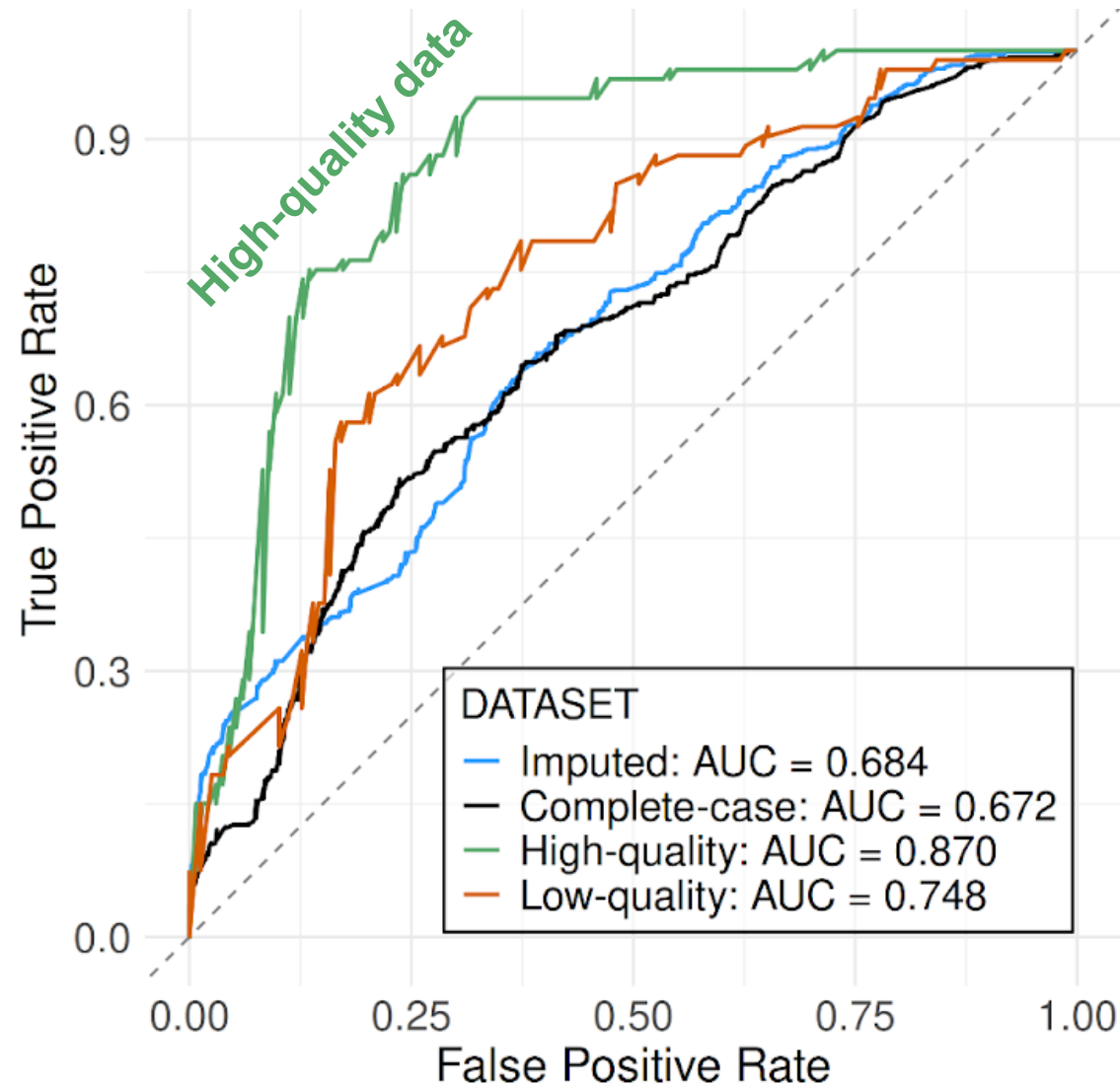
Angosteng Bayitaa, Maaïke Vercauteren, Scott Coffin, Leah Thornton Hampton, Martin Wagner, Jacob Chen, Huazheng Wang.
"Automated Microplastics Toxicity Data Extraction - ToMEx 3.0." (In Progress)

Predicting (Binary) Microplastic Toxicity for Aquatic Organisms

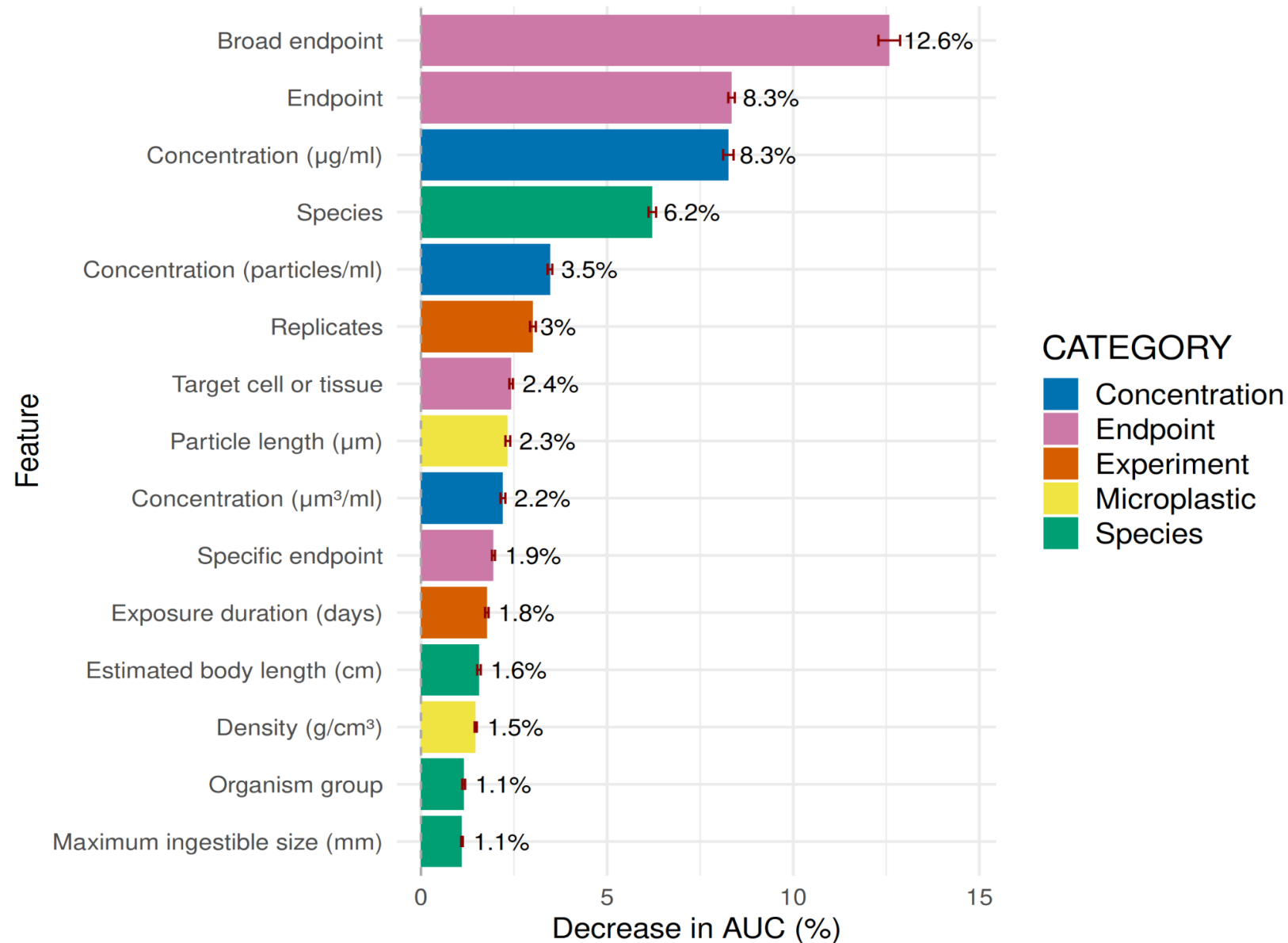


High Model Performance Achieved with Quality-Screened Data

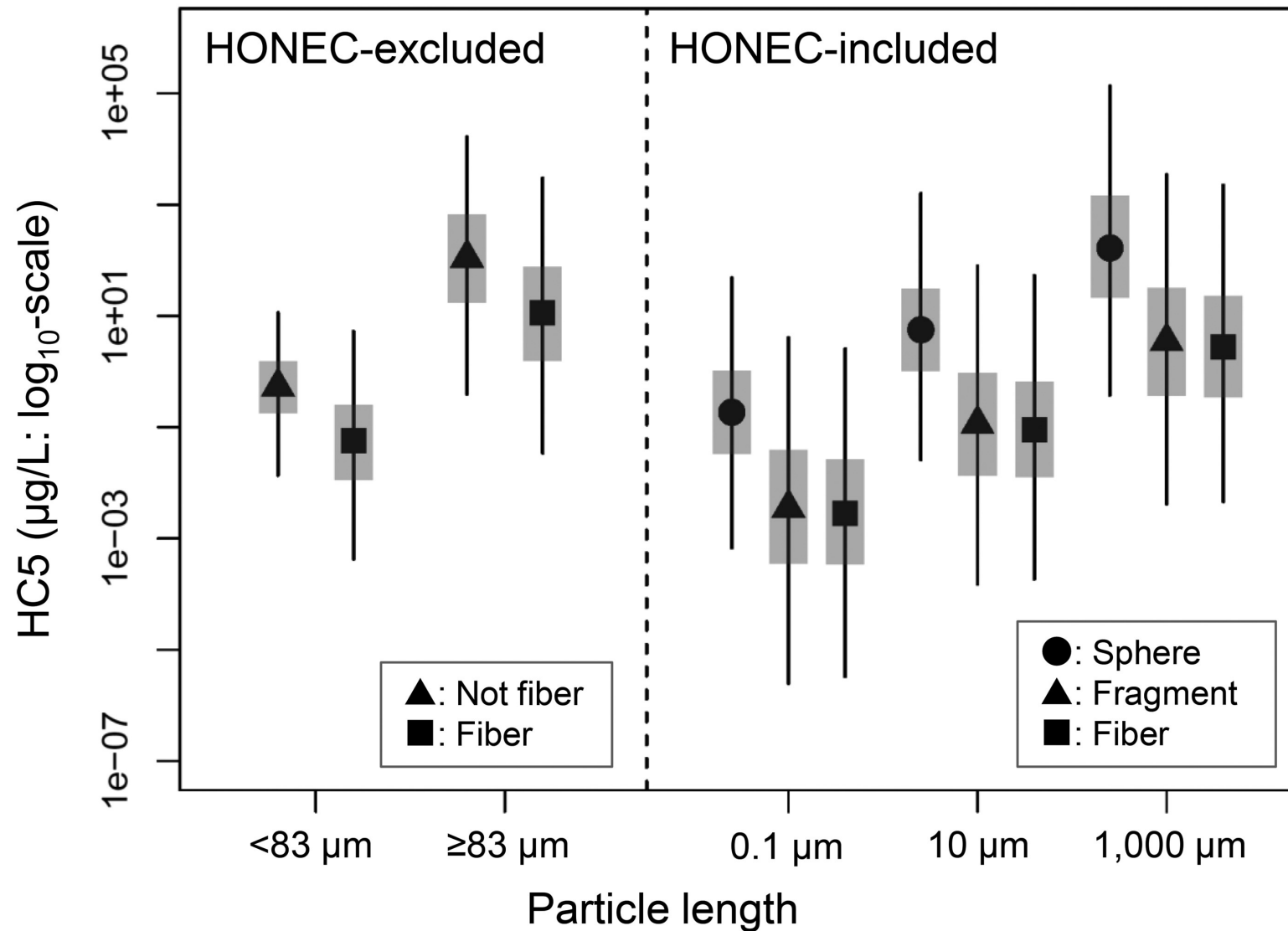
Blocked Cross-Validation



Endpoints, Dosage, & Species Drive Toxicity over Particle Traits



Meta-Analysis: Fibers more toxic than spheres or fragments

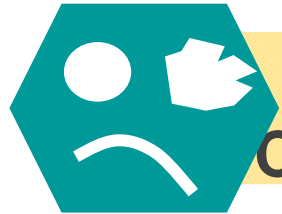


Iwasaki *et al.* (2026). “Bayesian species sensitivity distribution modeling for microplastic particles: Integrating particle characteristics and intraspecies variation.” *ET&C*

Predicting Quantitative MP Toxicity with Machine Learning



Data



**Particle
Characteristics**



**Test
Parameters**



**Organismal
Characteristics**



Effects

Machine Learning

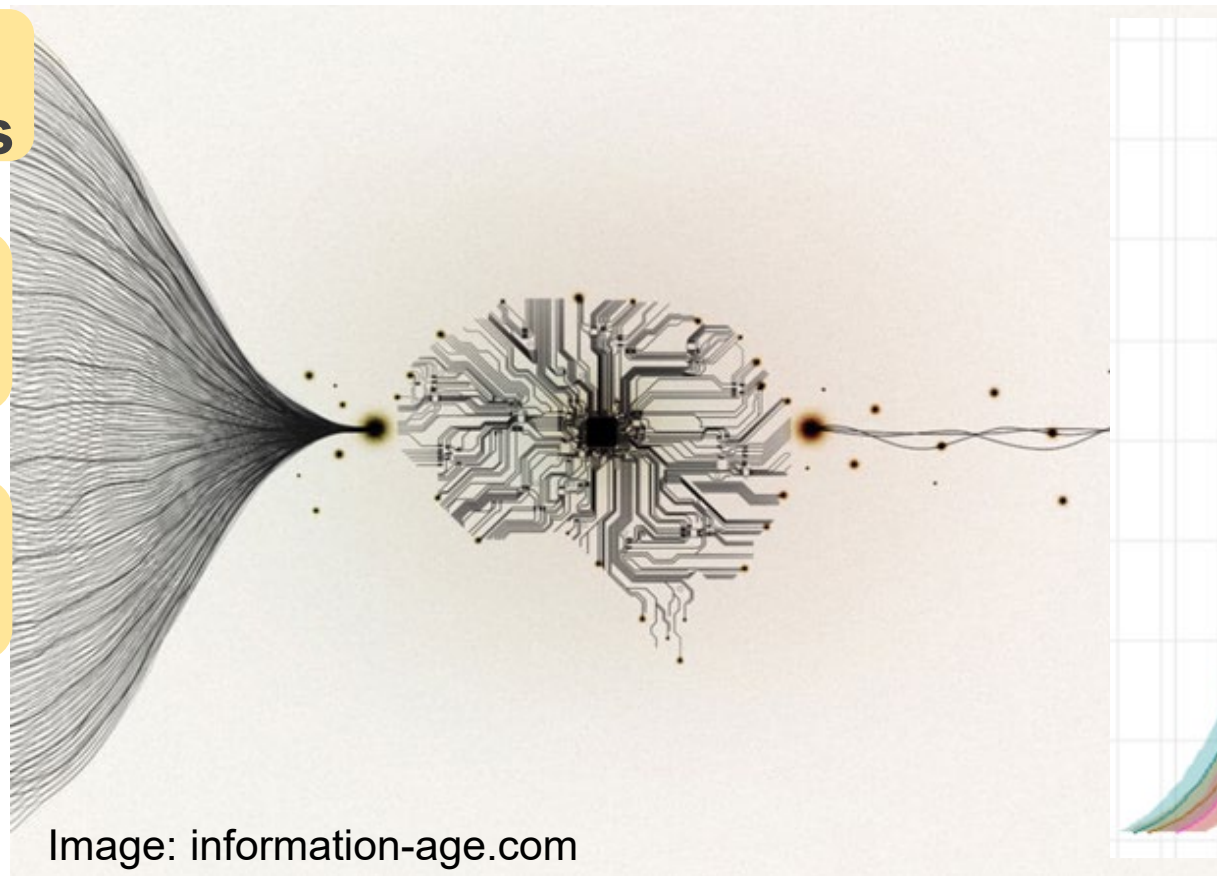
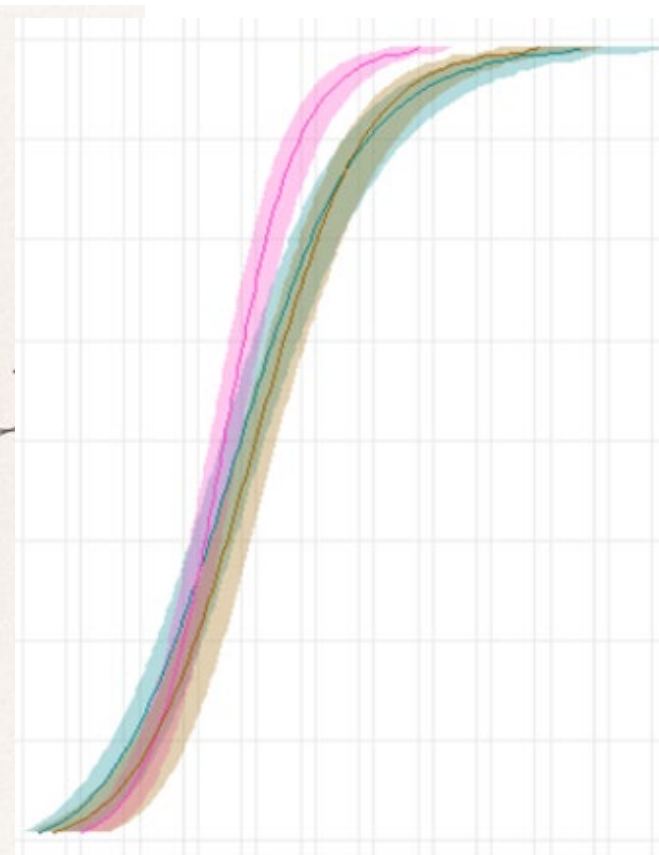
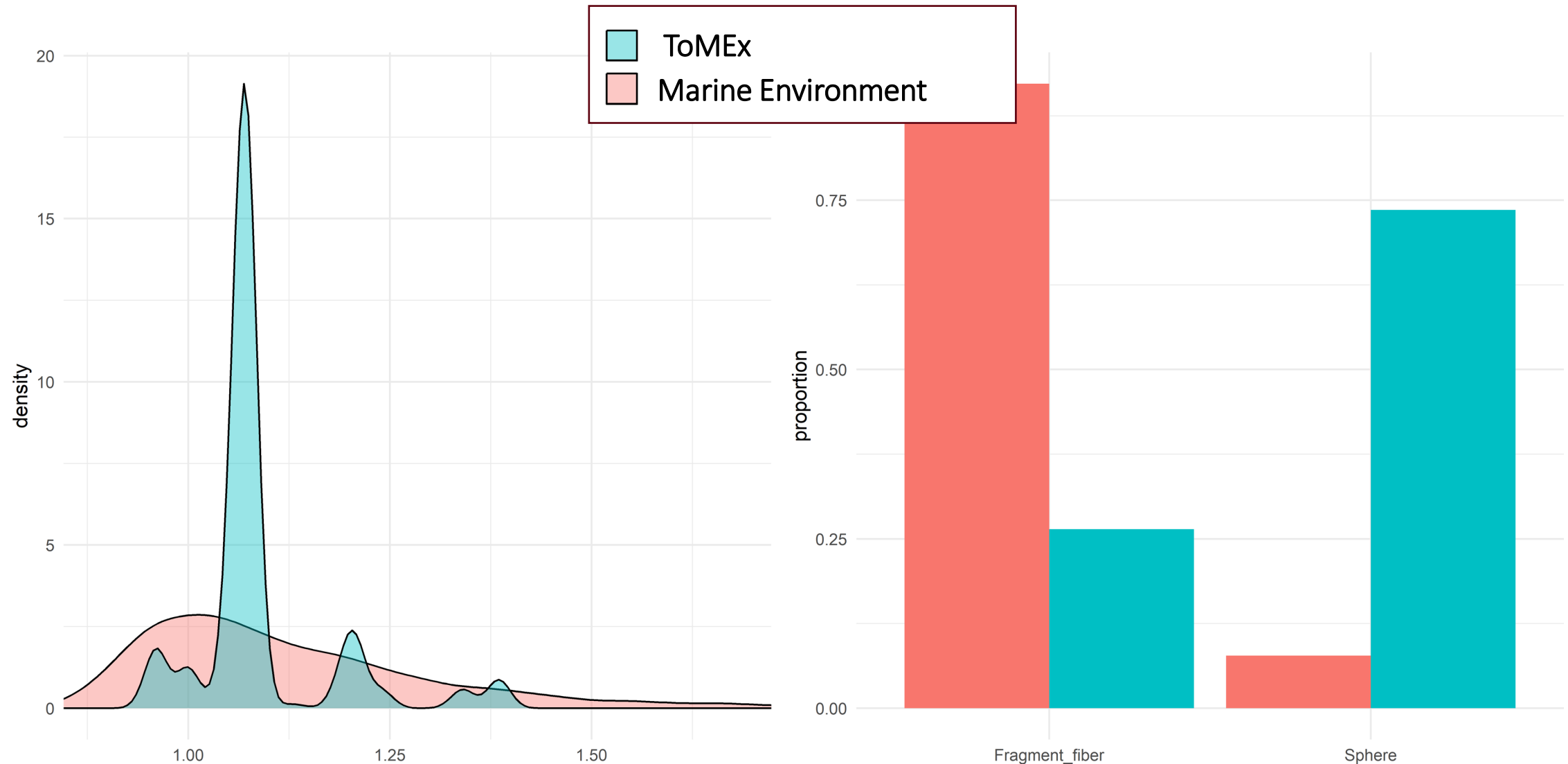


Image: information-age.com

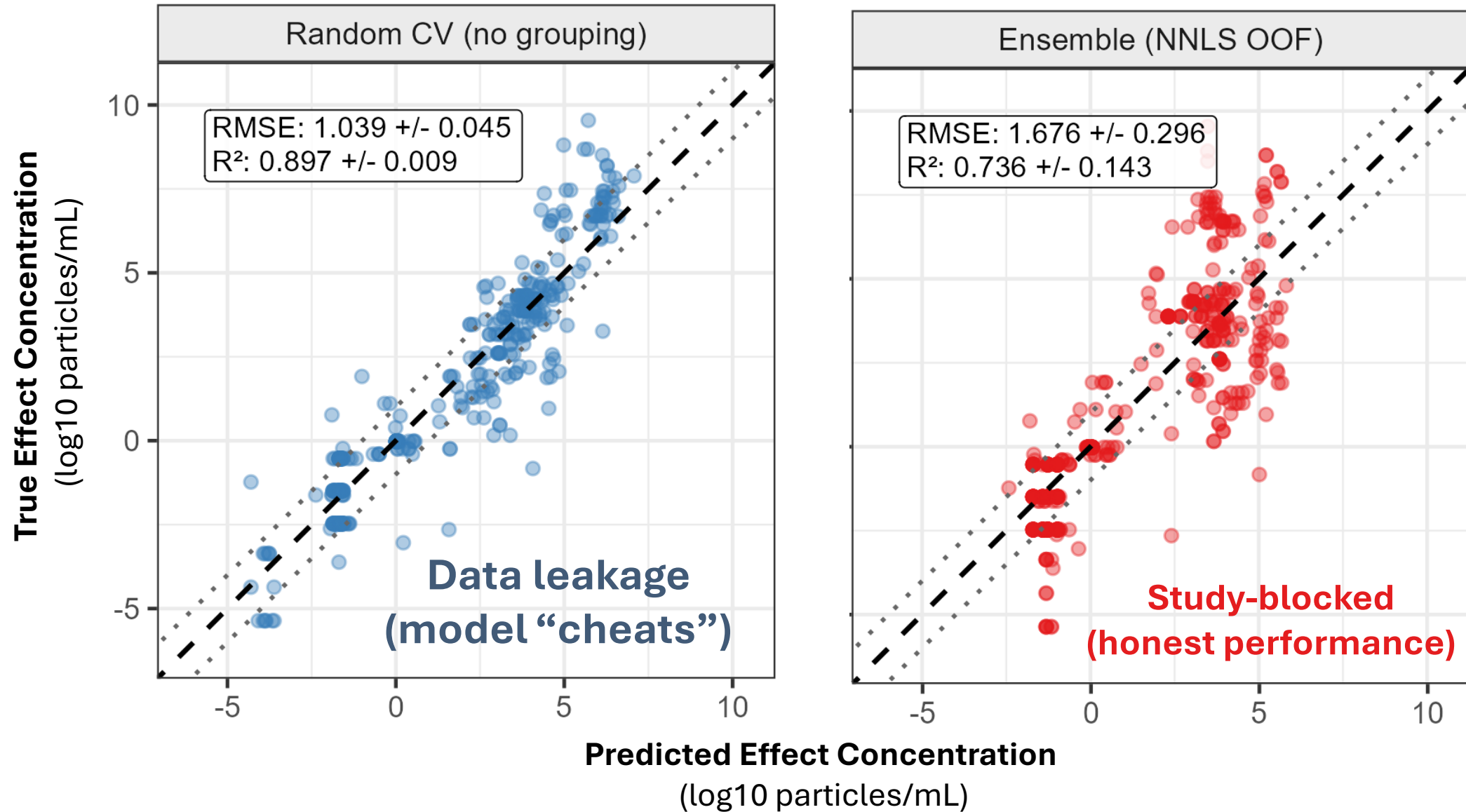
**Quantitative
Predictions**



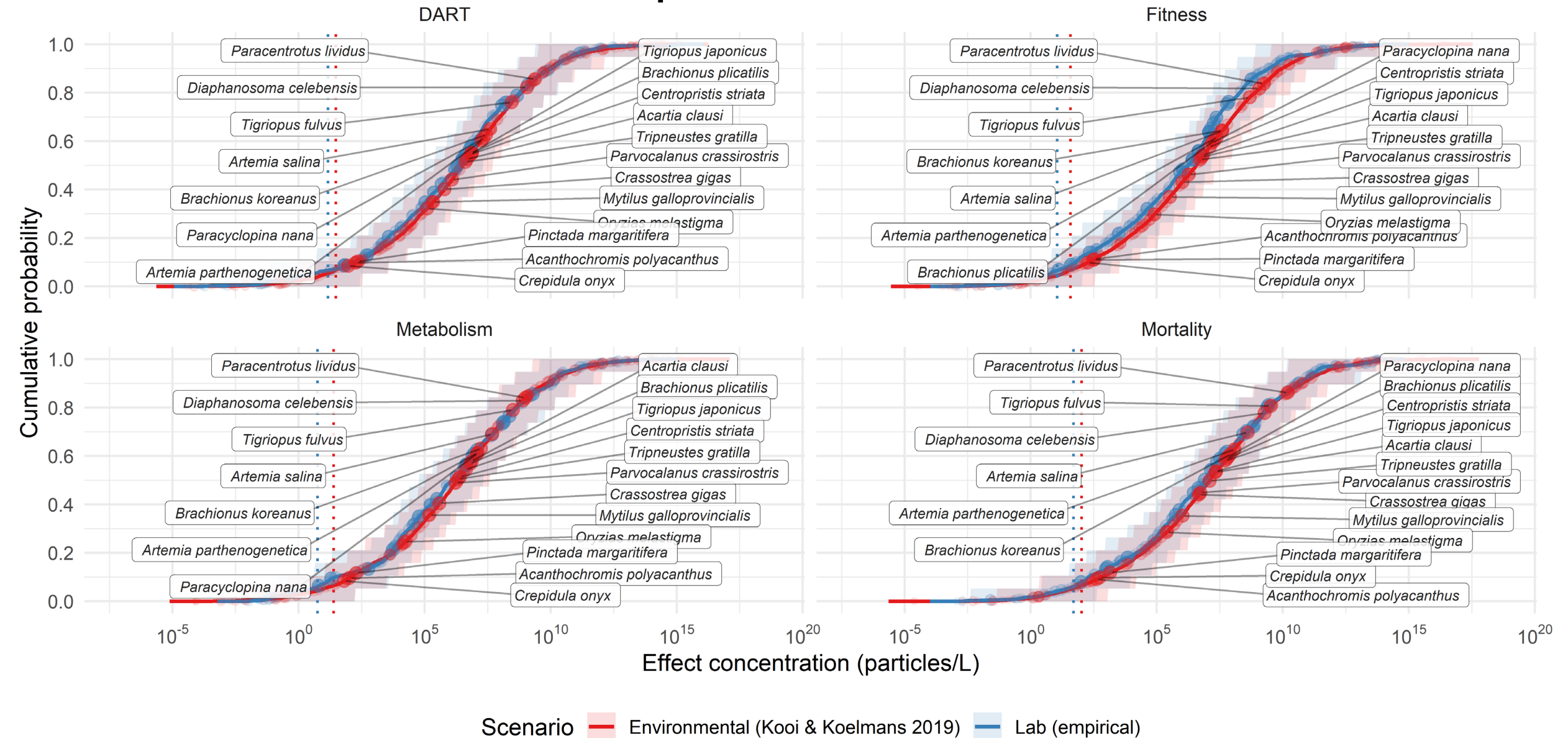
Polystyrene/Spheres Significantly *Over-Represented* in ToMEx

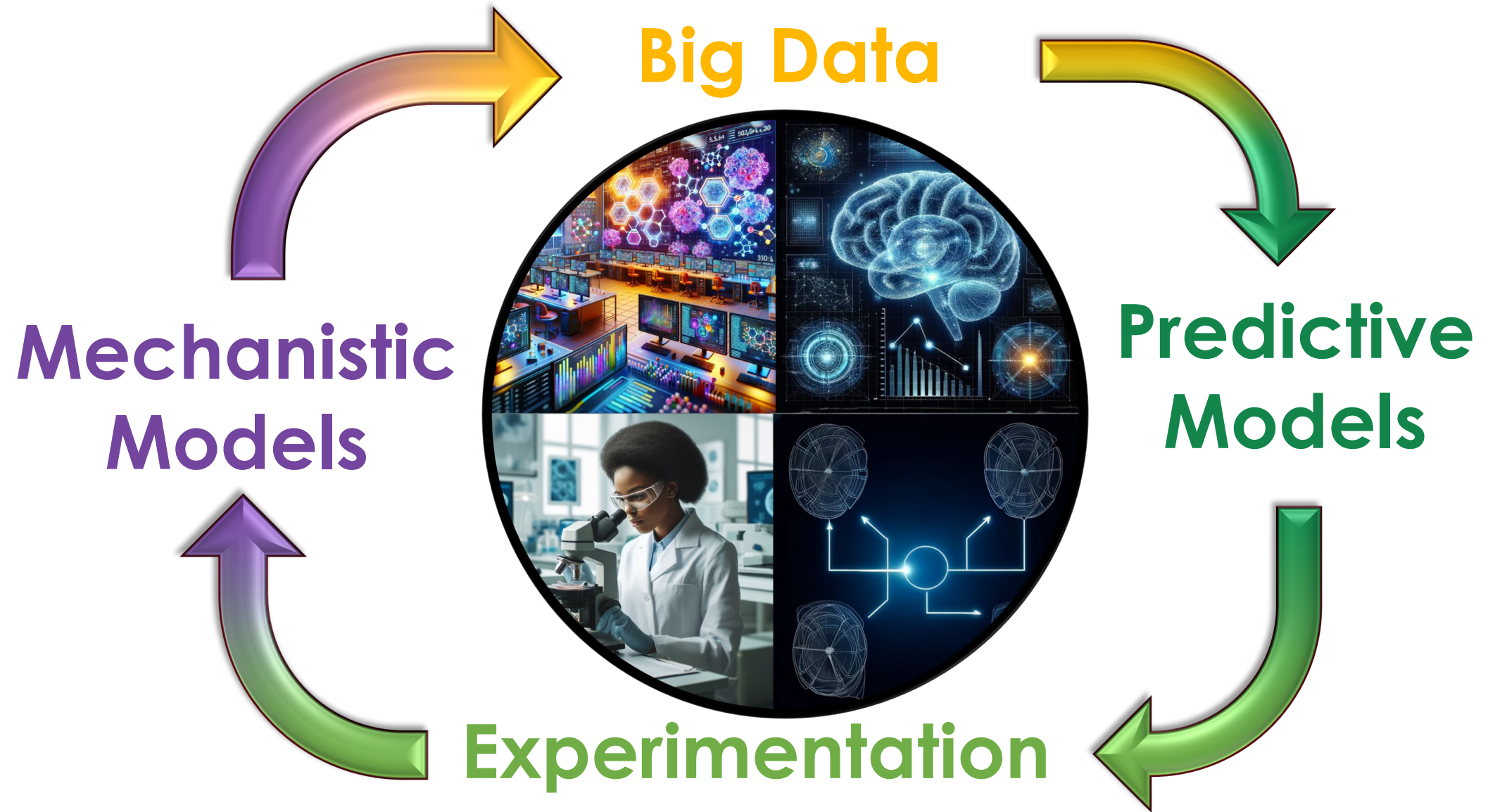


Model Performance Strongly Depends on Data Splitting



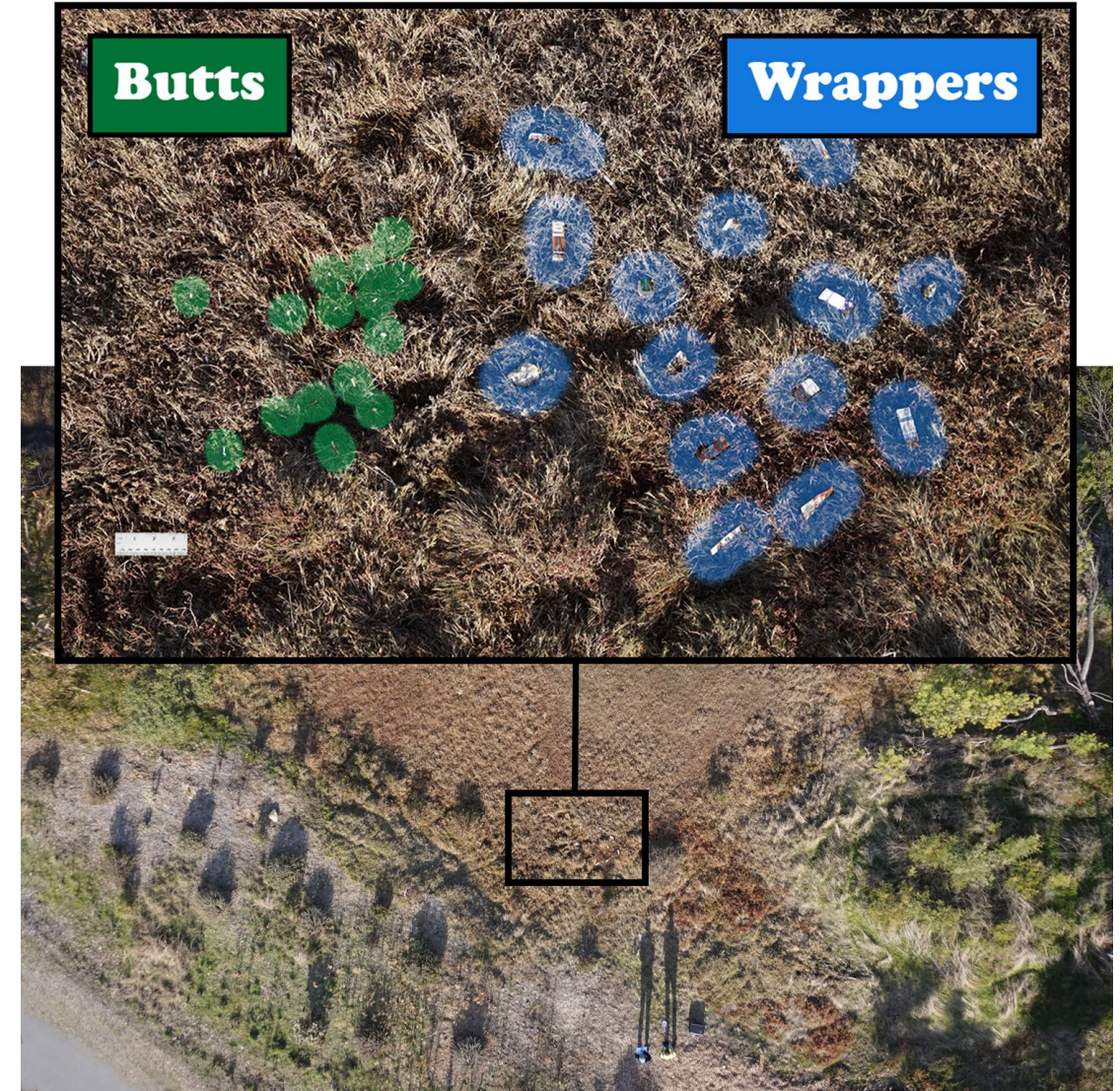
Predict pSSD+'s with ML Model





Coffin (In Preparation). "Regression-Based Toxicity Predictions of Microplastics in Aquatic Organisms Using Machine Learning."

CA Uses Drones + Deep-learning to Monitor Plastic

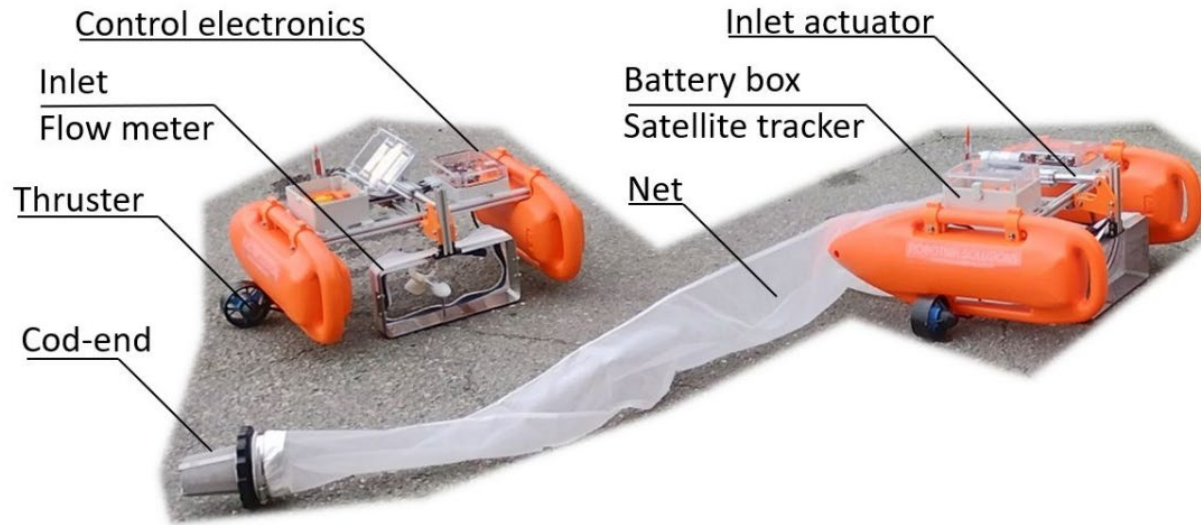


OIMA's Trash Tracker: A.I. on a street sweeper



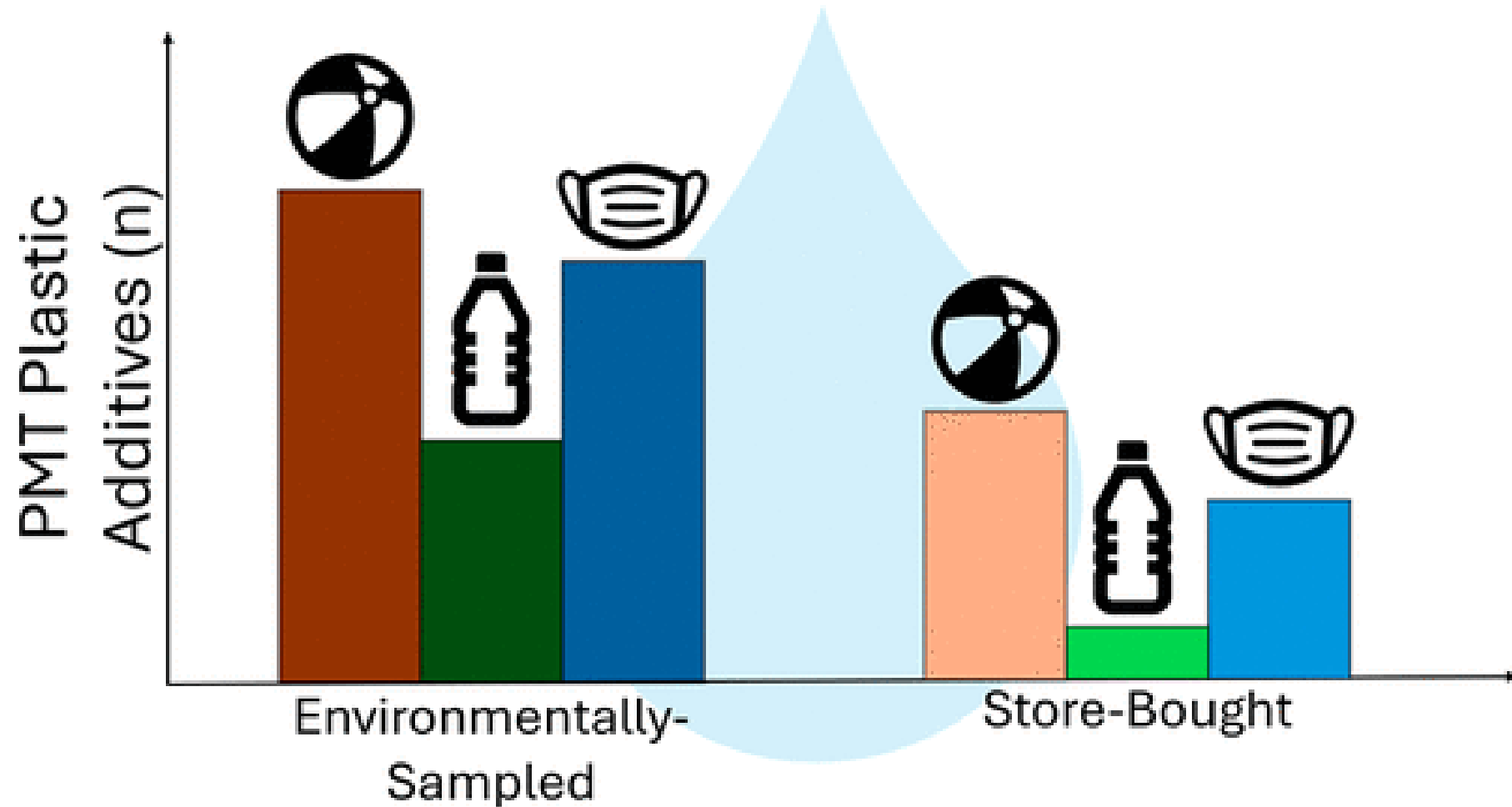
Open Source at github.com/CAWaterBoardDataCenter/Trash-Tracker

Uncrewed microplastics sampling portable catamaran drone – Open Schematic!



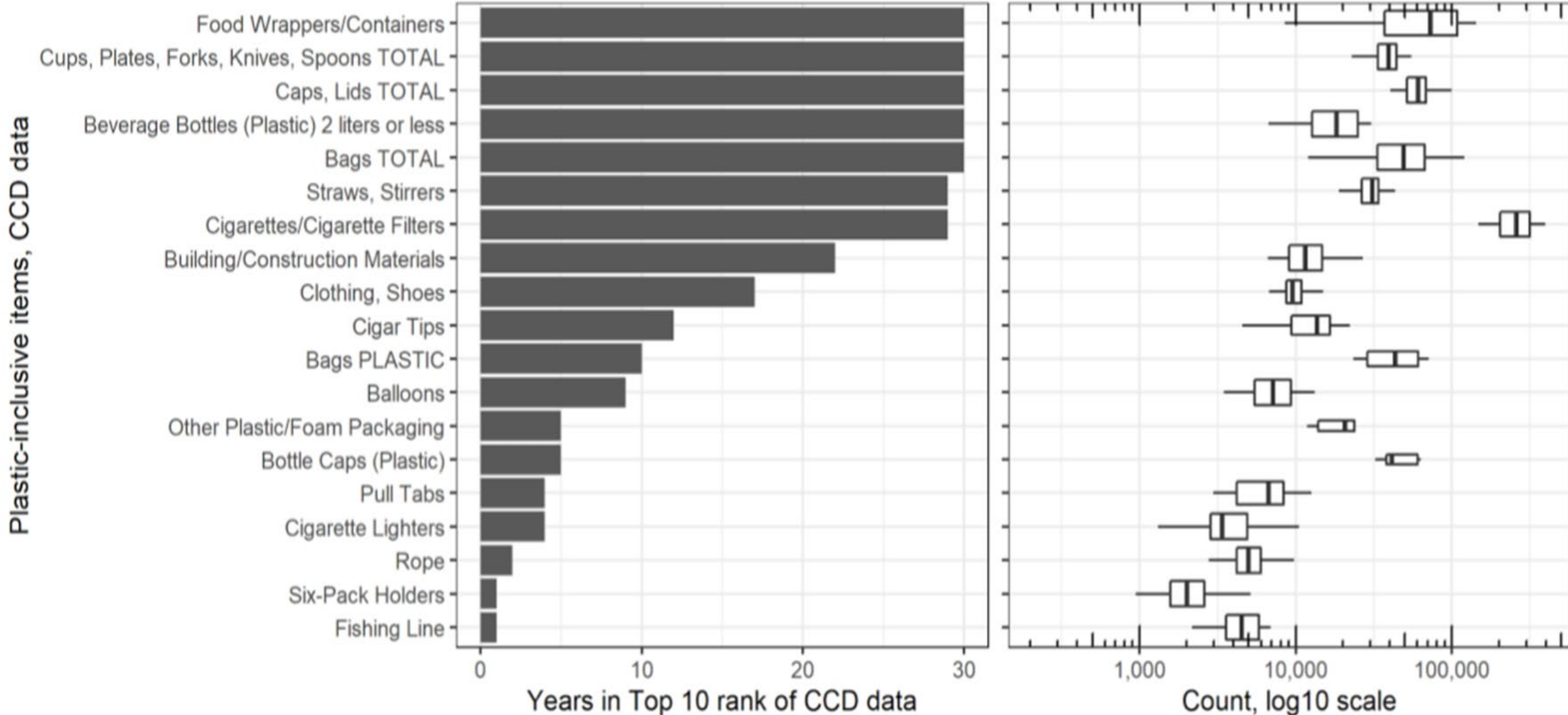
Andrea Faltynkova

Identifying Microplastic Sources Using Chemical Fingerprints + AI



Fries *et al.* (2025). "The Ones that Get Away: Investigating the Leaching of Persistent, Mobile, and Toxic Plastic Additives from New and Environmentally-Sampled Plastic Items." *Environmental Science & Technology*.

California Beach Cleanup Data (1988 – 2021)



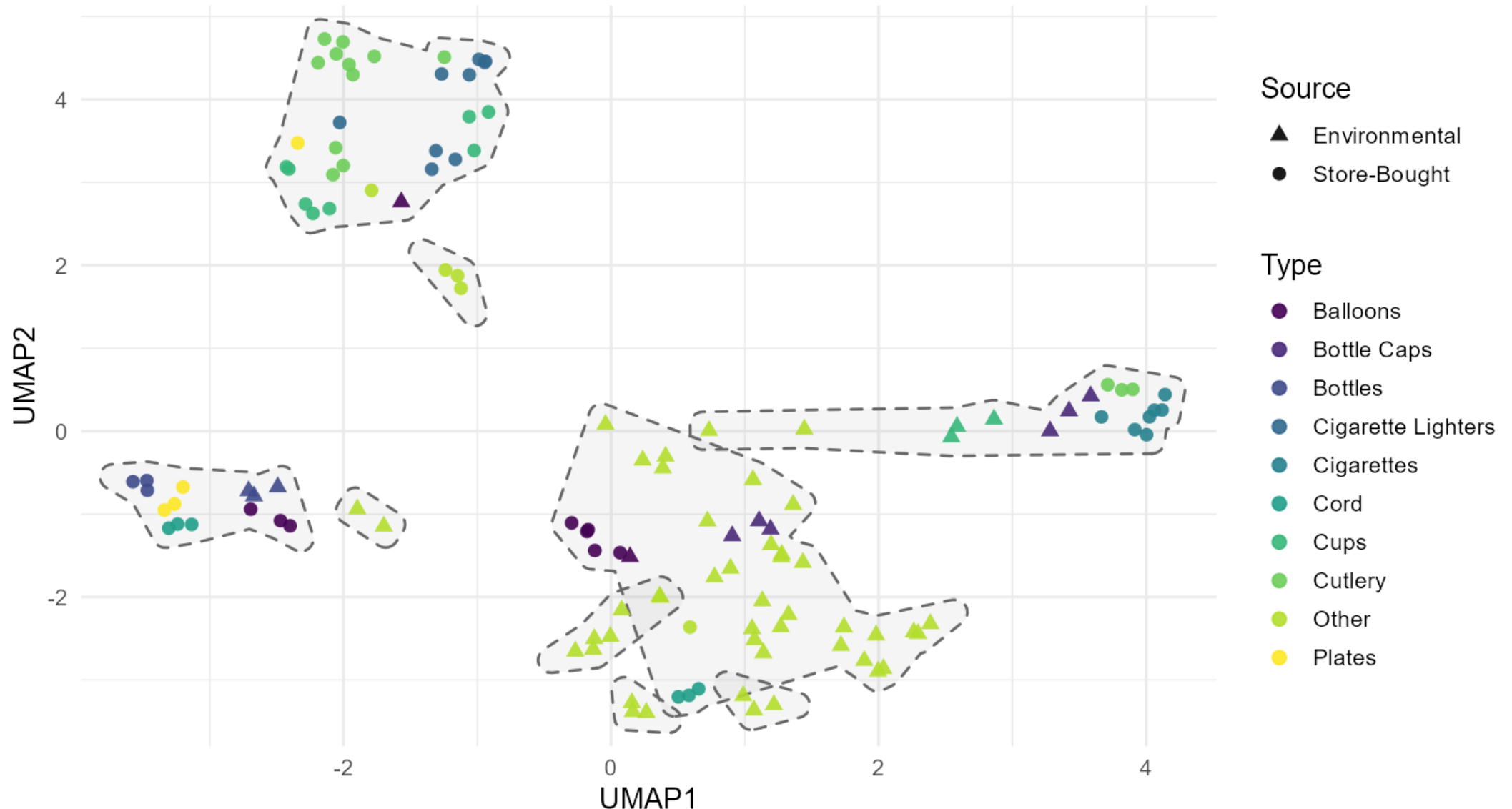
Nguyen; Fries; Jones; Megson; Zonderman; Hildebrandt; **Coffin**; Pröfrock; Sühling. ES&T (2026).

“Chemical Fingerprints of New vs. Weathered Plastics: A Machine Learning Approach.”



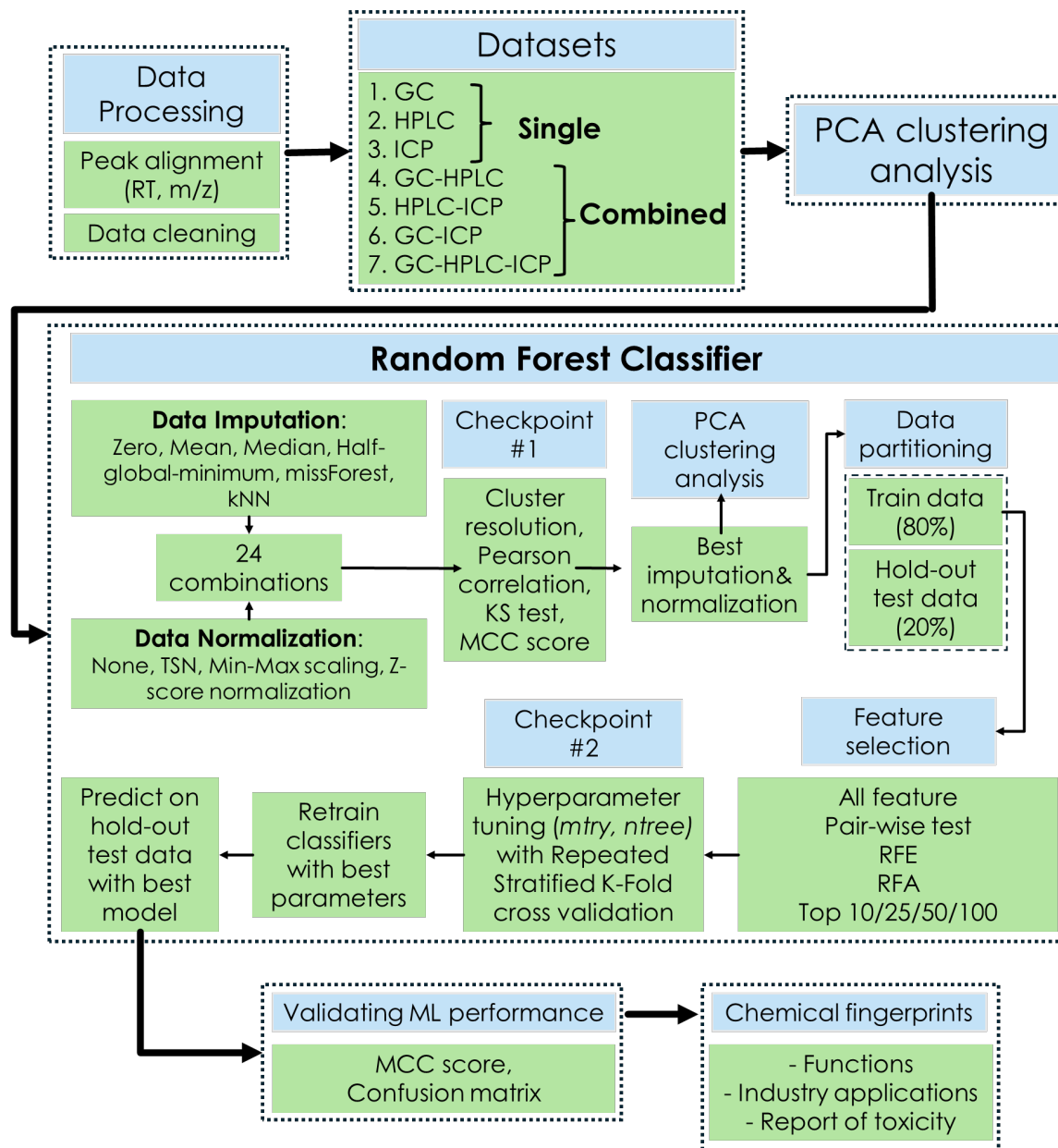
Nguyen; Fries; Jones; Megson; Zonderman; Hildebrandt; **Coffin**; Pröfrock; Sühning. “Chemical Fingerprints of New vs. Weathered Plastics: A Machine Learning Approach.” Environmental Science & Technology (2026).

Plastics have Unique Chemical Fingerprints!



Nguyen; Fries; Jones; Megson; Zonderman; Hildebrandt; **Coffin**; Pröfrock; Sühling. "Chemical Fingerprints of New vs. Weathered Plastics: A Machine Learning Approach." Environmental Science & Technology (2026).

Identifying Microplastic Sources Using Chemical Fingerprints + AI

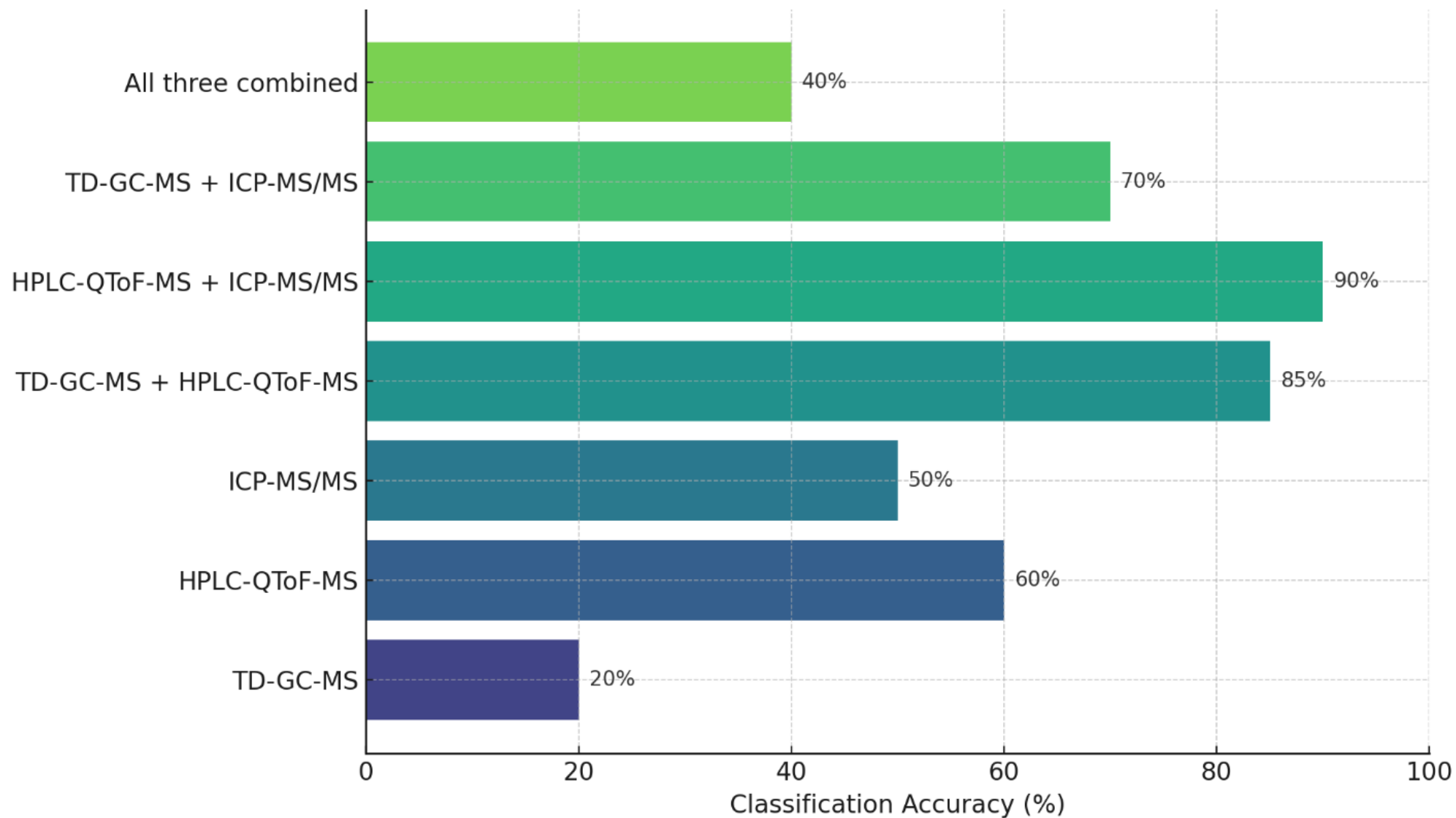


Acronyms:

- **RT**: retention time
- **m/z**: mass-to-charge
- **PCA**: Principal Component Analysis
- **kNN**: k-Nearest Neighbour
- **RFA**: Recursive Feature Addition
- **MCC score**: Matthews Correlation Coefficient
- **KS test**: Kolmogorov-Smirnov Tests
- **TSN**: Total Sum Normalization
- **RFE**: Recursive Feature Elimination
- **missForest**: Missing Value Imputation using Random Forest

Nguyen; Fries; Jones; Megson; Zonderman; Hildebrandt; **Coffin**; Pröfrock; Sühling. "Chemical Fingerprints of New vs. Weathered Plastics: A Machine Learning Approach." Environmental Science & Technology (2026).

90% Classification Accuracy with Best Instrument Combination



Nguyen; Fries; Jones; Megson; Zonderman; Hildebrandt; **Coffin**; Pröfrock; Sühling. “Chemical Fingerprints of New vs. Weathered Plastics: A Machine Learning Approach.” Environmental Science & Technology (2026).

Microplastic Fingerprinting Enables Corporate Accountability through Litigation



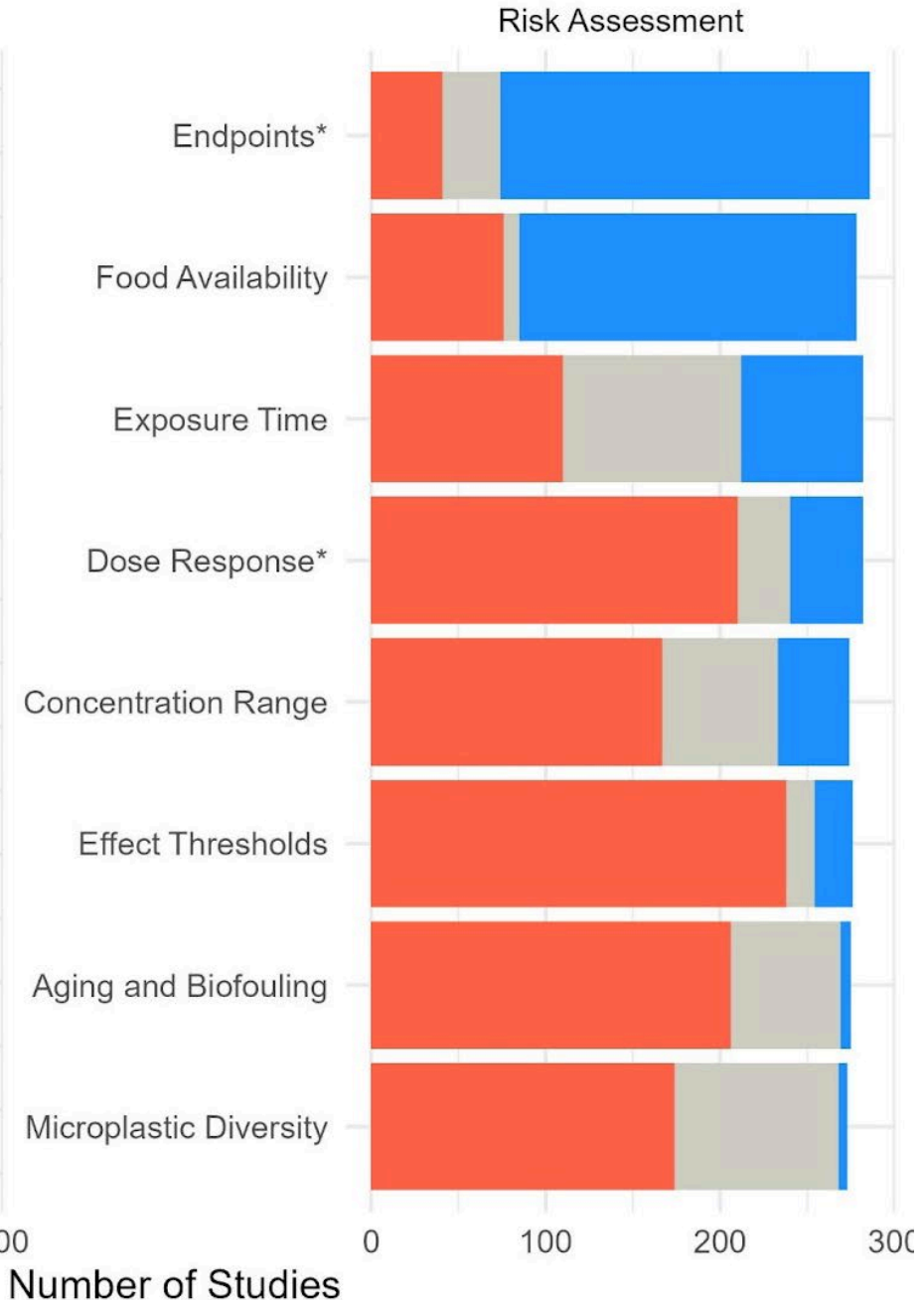
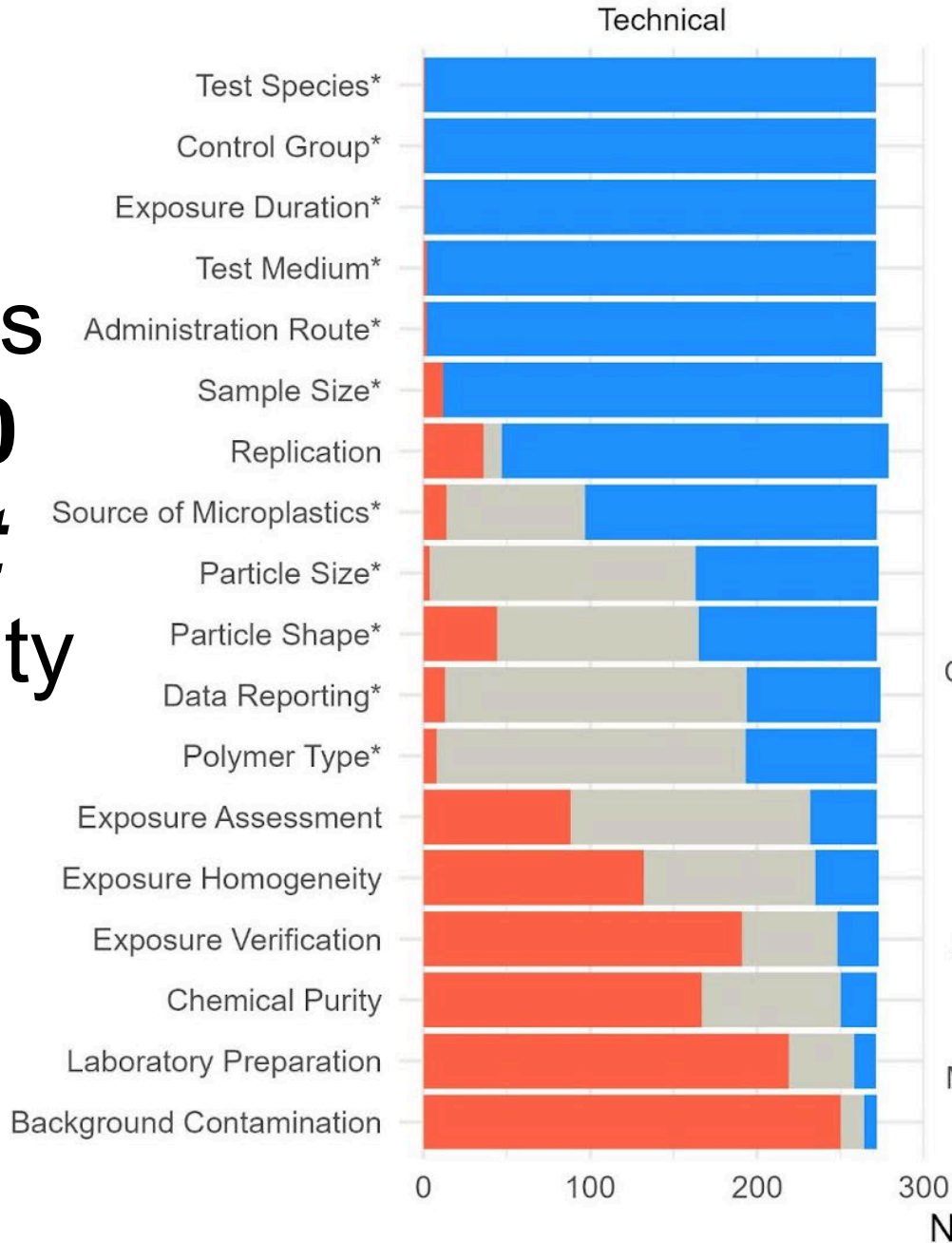


**80% of studies
in ToMEx 2.0
do not meet
minimum quality
criteria**

 Adequate

 Adequate with Restrictions

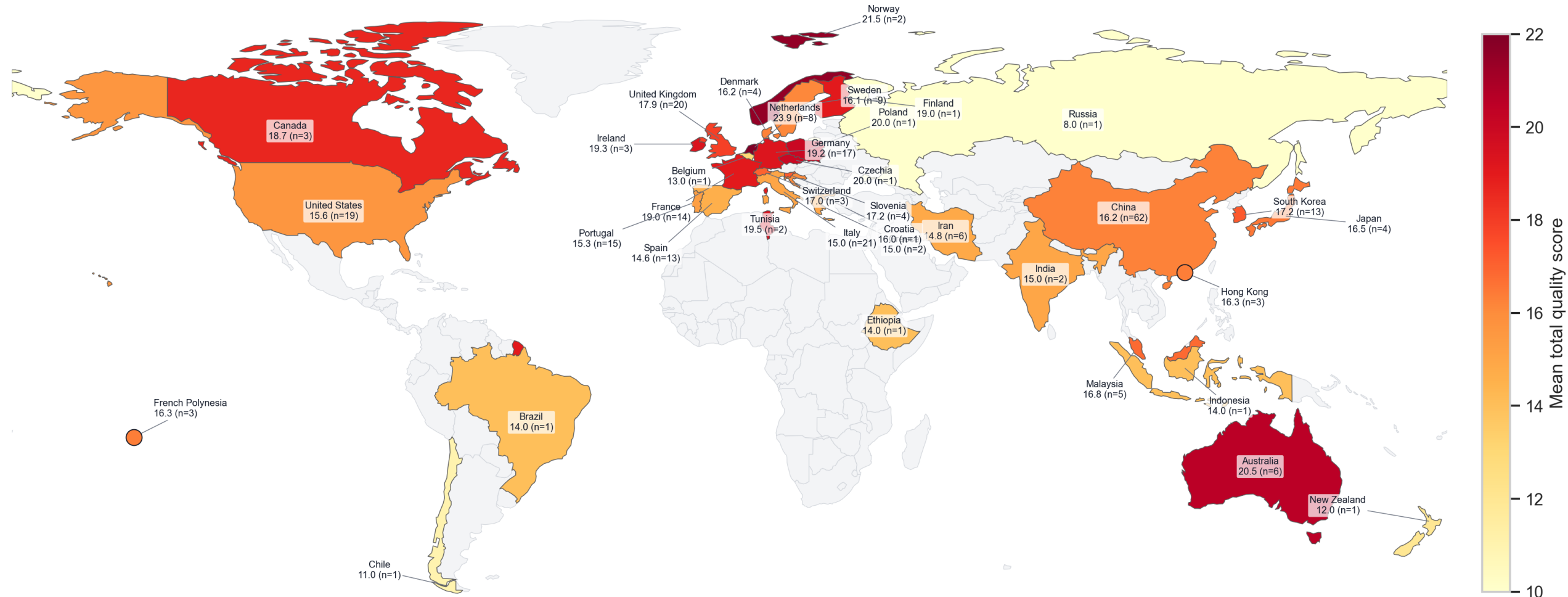
 Inadequate



Kennedy et al. (2026). "Trends in Quality and Risk Assessment Applicability of Microplastic Ecotoxicity Studies." *Journal of Hazardous Materials Advances*.

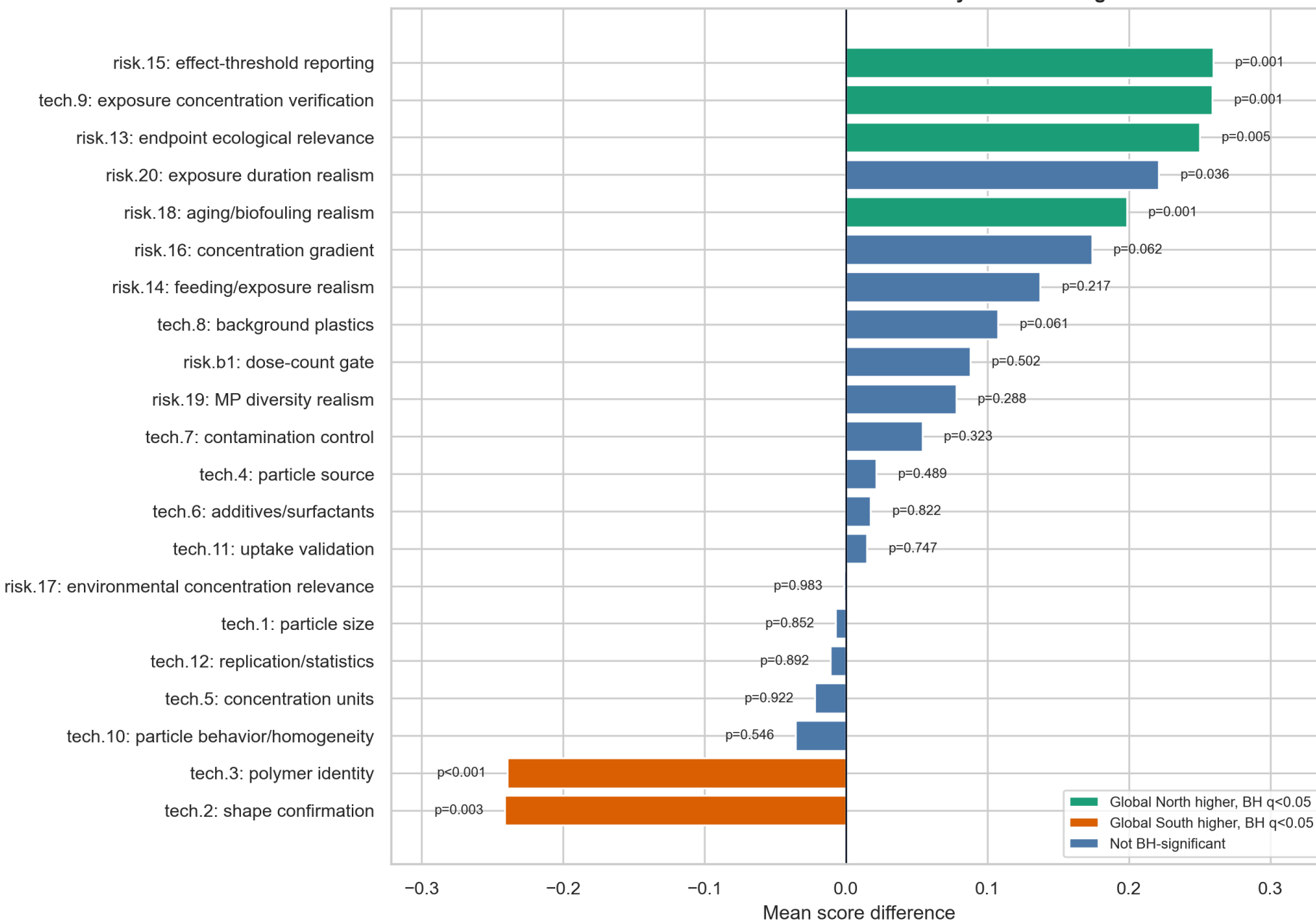
Global Differences in Studies Meeting Toxicity Screening Criteria

Mean ToMEx Total Quality Score by First-Author Country
274 scored papers across 37 countries



Coffin (Unpublished).

Global North - Global South Mean Difference by Score-Bearing Criterion



Global North
Beats Global
South on some
screening
criteria and
visa versa!

Reporting Standards & Guidance are Available

Applied
Spectroscopy



www.s-a-s.org

Reporting Guidelines to Increase the Reproducibility and Comparability of Research on Microplastics

Win Cowger¹ , Andy M. Booth², Bonnie M. Hamilton³, Clara Thaysen³, Sebastian Primpke⁴ , Keenan Munno³, Amy L. Lusher⁵ , Alexandre Dehaut⁶, Vitor P. Vaz⁷, Max Liboiron⁸, Lisa I. Devriese⁹, Ludovic Hermabessiere³ , Chelsea Rochman³, Samantha N. Athey³, Jennifer M. Lynch^{10,11}, Hannah De Frond³, Andrew Gray¹, Oliver A.H. Jones¹², Susanne Brander¹³ , Clare Steele¹⁴ , Shelly Moore¹⁵, Alterra Sanchez¹⁶, and Holly Nel¹⁷

ENVIRONMENTAL
Science & Technology

pubs.acs.org/est

Critical Review

Quality Criteria for Microplastic Effect Studies in the Context of Risk Assessment: A Critical Review

Vera N. de Ruijter,^{*,§} Paula E. Redondo-Hasselerharm,[§] Todd Gouin, and Albert A. Koelmans

Applied
Spectroscopy



www.s-a-s.org

Sampling and Quality Assurance and Quality Control: A Guide for Scientists Investigating the Occurrence of Microplastics Across Matrices

Susanne M. Brander¹ , Violet C. Renick² , Melissa M. Foley³, Clare Steele⁴ , Mary Woo⁴, Amy Lusher⁵ , Steve Carr⁶, Paul Helm⁷,Carolynn Box⁸, Sam Cherniak⁹ , Robert C. Andrews⁹, and Chelsea M. Rochman¹⁰

Learning from history instead of reinventing the wheel: A resource for coordinating microplastics research, reporting, and publication criteria across disciplines

Submitted (August 30, 2026)

*Granek, Elise F.; **Coffin, Scott**; Brander, Susanne M.;
Seeley, Meredith Evans; Thornton Hampton, Leah M.;
El Hayek, Eliane; Walker, Vickie R.; **Wagner, Martin**;
Gouin, Todd; Gray, Andrew B.; Harper, Stacey L.;
Rooney, Andrew A.*



Matrix

Drinking Water	T1	T1	T1	T2	T1	T1
Surface Water	T1	T2	T2	T2	T2	T2
Wastewater	T1	T2	T2	T2	T3	T3
Biosolids	T4	T4	T4	T4	T3	T3
Sediment	T1	T1	T2	T3	T1	T2
Biota / Tissue	T1	T1	T2	T3	T1	T2
Air / Atmospheric	T3	T3	T2	T4	T3	T3
Food / Dietary	T4	T4	T4	T4	T3	T3
Human Tissue	T4	T4	T4	T4	T3	T3
Soil / Terrestrial	T4	T3	T3	T4	T3	T3
	Sampling	Extraction	Analysis	Material Standards	QA/QC	Reporting

Best Available Authority Tier



Tier 1: Normative/
Binding



Tier 2: Authoritative/
Institutional



Tier 3: Interlab Tested/
Critical Guidance



Tier 4: Supporting/
Contextual

Workflow Stage

Granek *et al.* (submitted). “Learning from history instead of reinventing the wheel: A call for coordinating microplastics research, reporting, and publication criteria across disciplines.”

Find the right papers/standards for your project!

MNP Compass

Interactive decision tree for planning microplastics monitoring and toxicology studies.

Select your study type, matrix, and workflow step to find the best available methods ranked by authority tier — Tier 1 (Normative/Binding) to Tier 4 (Supporting/Contextual); see the About tab for the full framework.



[Decision Tree](#) [Crosswalk](#) [Search All References](#) [Glossary](#) [About](#)

Study Design Workflow

Follow the linear workflow below. **Core steps** (solid lines) proceed sequentially. **Auxiliary supports** (dashed lines) apply across the workflow.

Study type

Monitoring



Matrix

 Drinking Water



Particle/polymer type

Choose options



Open source!  <https://mnp-compass.streamlit.app/>

Comprehensive Packaging Extended Producer Responsibility Bill Signed June 30, 2022

Recycling/compostable:

30% by 2028

65% 2032

Creates Independent Producer Responsibility Organization

Plastic Pollution Mitigation Fund:

\$5 bill over 10 yrs from industry to mitigate impacts



Gov. Gavin Newsom (seated) signs SB 54 on June 30, 2022. State Sen. Ben Allen far left. Assemblywoman Luz Rivas to Newsom's right.
Courtesy of State Sen. Ben Allen

US Exports ~1.4 MT/yr of plastic to Global South



Bourtsalas et al. (2023). "U.S. plastic waste exports: A state-by-state analysis pre- and post-China import ban" Journal of Environmental Management.

MAX LIBOIRON



"Pollution is not just an unfortunate byproduct of industrialization; it is a method of creating and maintaining social and geographical order".
-Max Liboiron

2021: California Takes Major Step to Address Waste Colonialism



California passes legislation designed to address mixed plastic exports

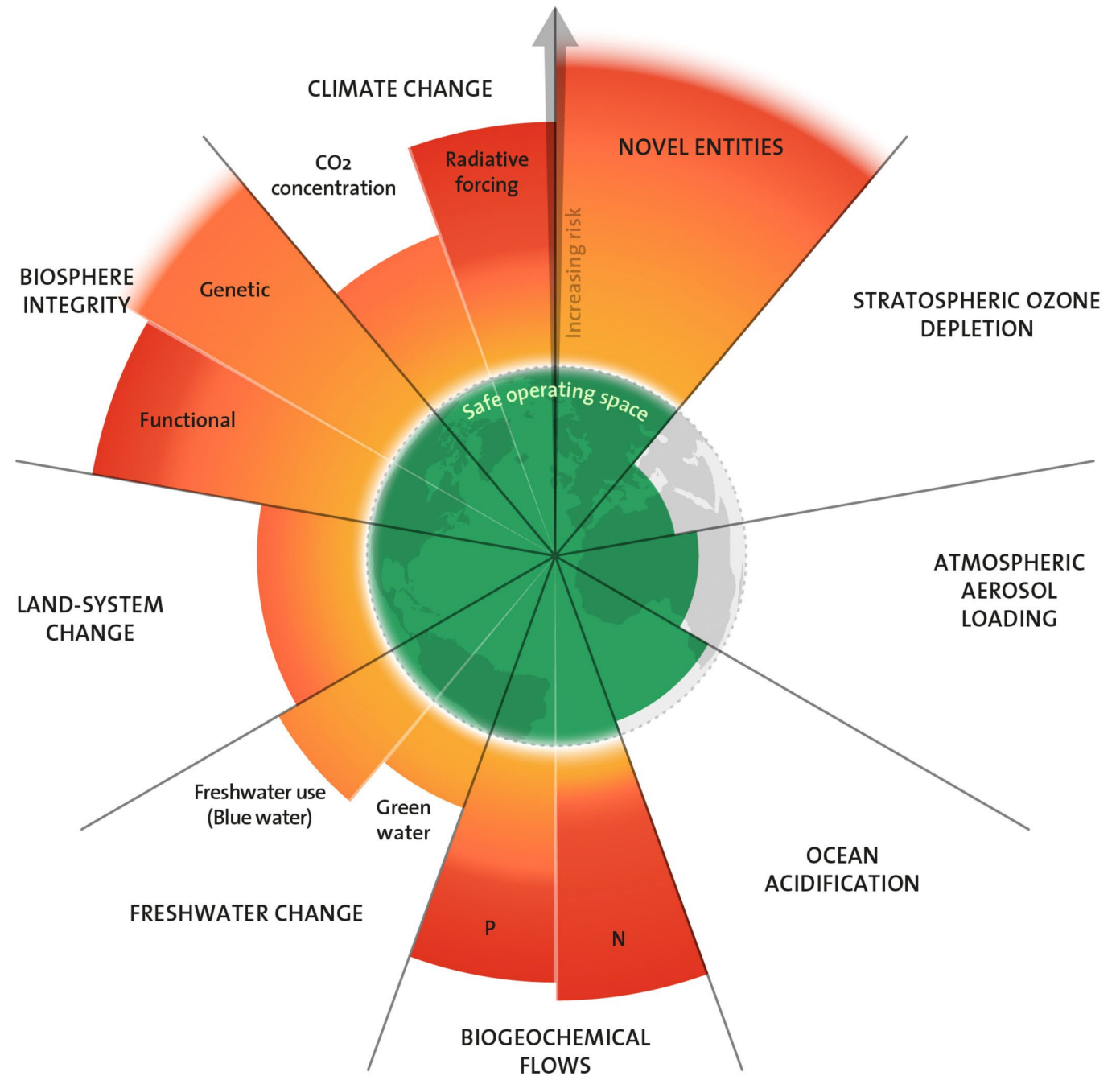


Exported bales of a single type of plastic would not be targeted by California's AB 881.

California's Circular Materials Economy will Increase Bioplastics Usage



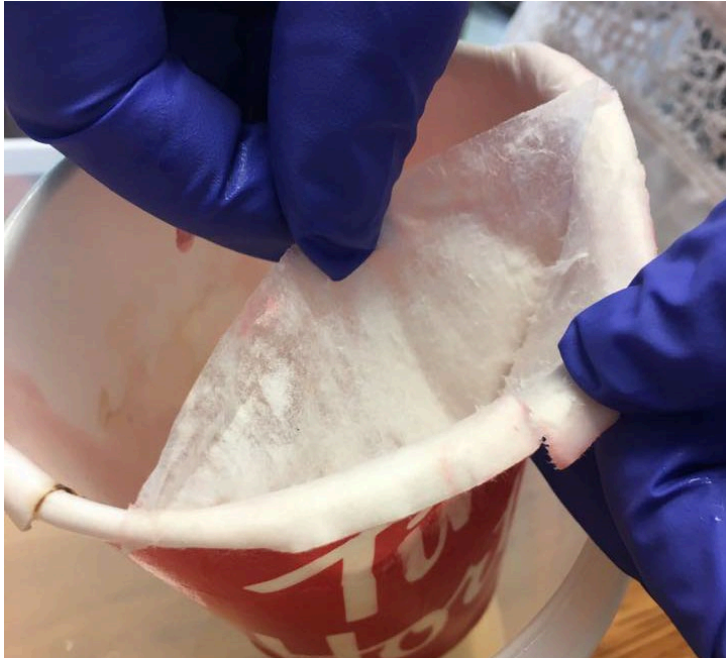
Outside Safe Operating Space of the Planetary Boundaries for **Biogeochemical Flows** and **Novel Entities**



Persson *et al.* (2022), *Environmental Science & Technology*

Nanoplastics used as Replacement for PFAS and Plastic Films

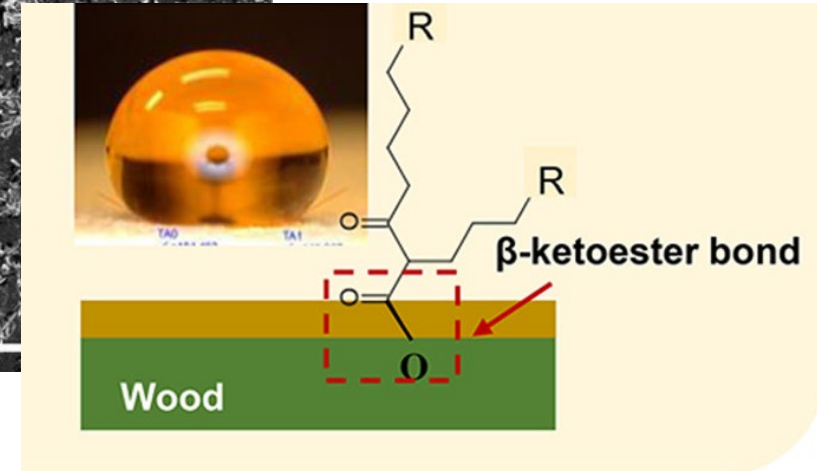
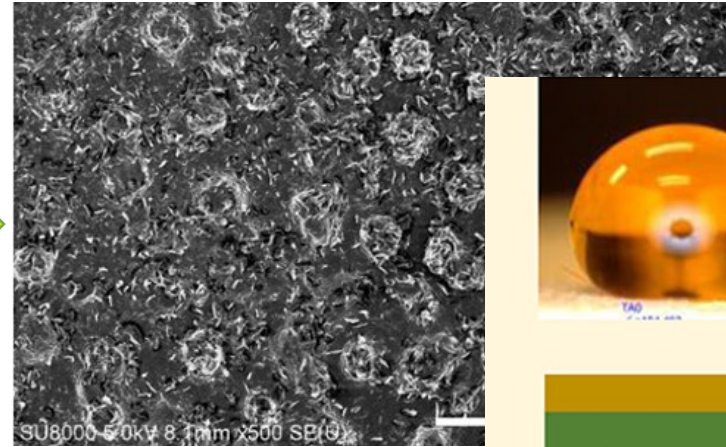
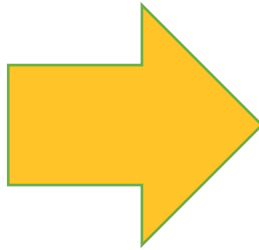
Traditional plastic film



Fundy Regional Service Commission

- Water and oil resistant
- *Not recyclable*
- *Not compostable*

Regrettable Substitution nanoplastics



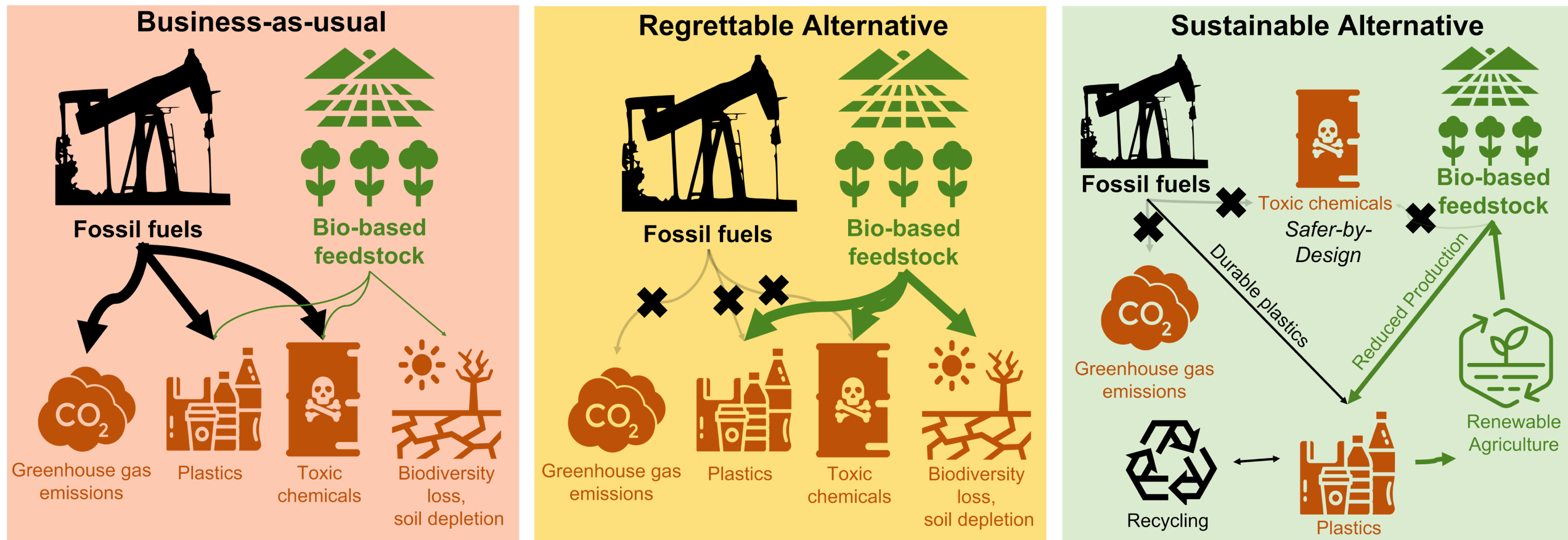
Kaewsaneha et al. "Preparation of Water-Based Alkyl Ketene Dimer (AKD) Nanoparticles and Their Use in Superhydrophobic Treatments of Value-Added Teakwood Products" (2022). ACS Omega

- Water and oil resistant
- Recyclable?
- Compostable?



Maybe,
but nanoplastics have
to go somewhere...

Vision For a Greener Future



Bălan, van Bergen, Blake, Buck, **Coffin**, DeWitt, Goldenman, von Hippel von Hippel, Leonetti, Rist, Scheringer, Trier (2025). "Confronting the interconnection of chemical pollution and climate change."
Environmental Innovation and Societal Transitions

California's Green Chemistry Regulatory Framework: *Safer Consumer Products* adding Microplastics to Candidate Chemicals List



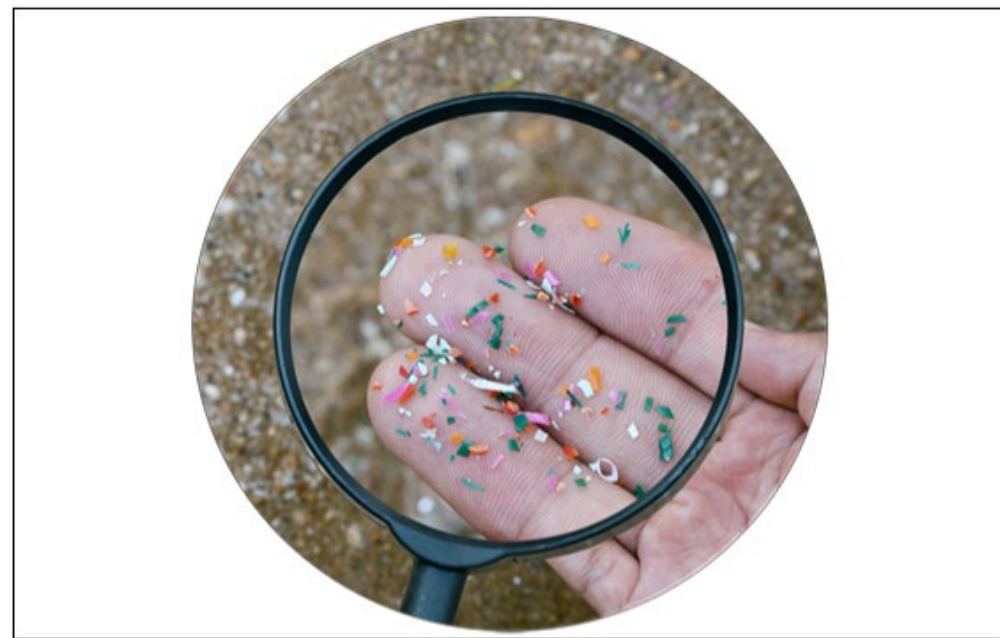
June 20, 2025

Release of Proposed Regulation
for Public Comment



October 01, 2026

Effective Date of Final
Regulation



Background Document on DTSC's Microplastics in Consumer Products Research

November 2025

Prepared by

Department of Toxic Substances Control

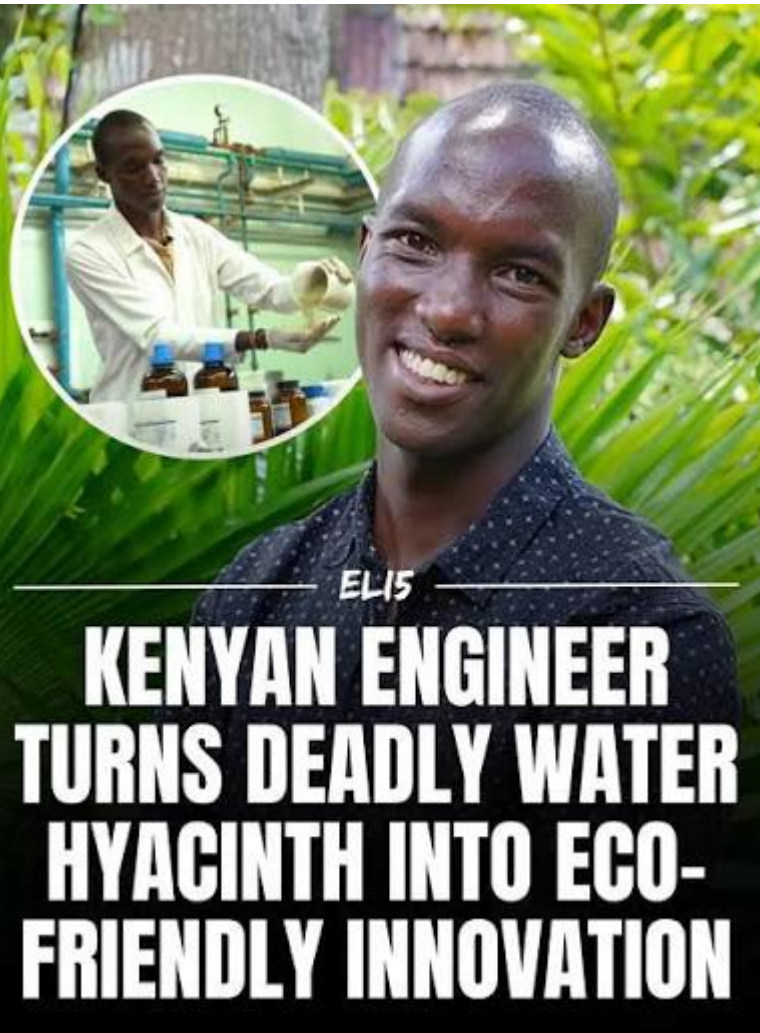
Safer Consumer Products Program

California Environmental Protection Agency



Email updates: dtsc.ca.gov/dtsc-e-lists/

Safe and Sustainable Bio-Based Material Innovation Needed



Professor Zhanyun Zhao's lab
turns fruit pulp and pomace
into edible food packaging

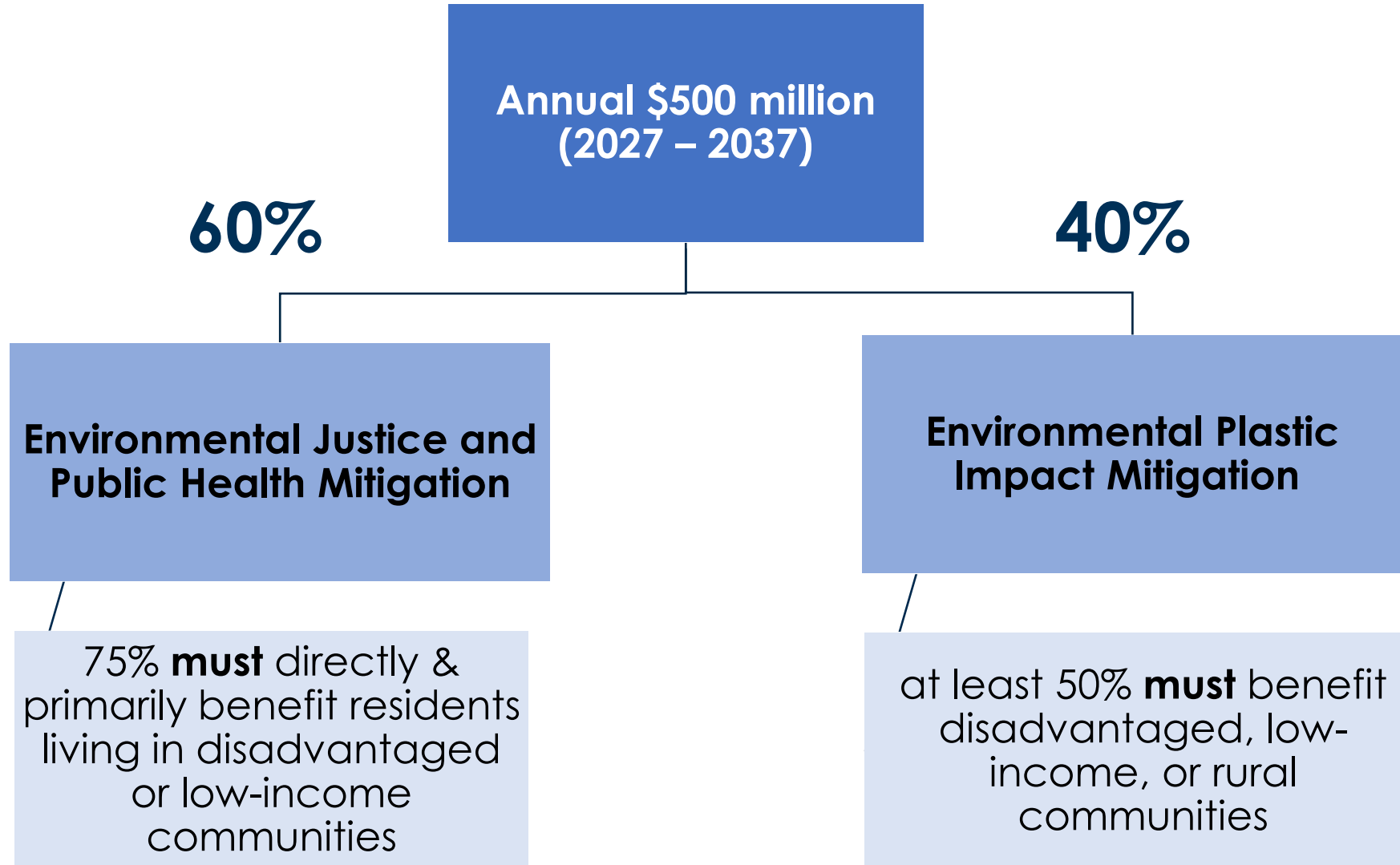


Non-plastic alternatives: coconut shells as plant pots,
Uganda



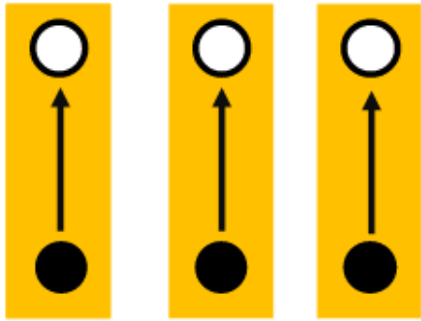
California - Producers PAY for their damages to our health

Plastic Pollution Mitigation Fund

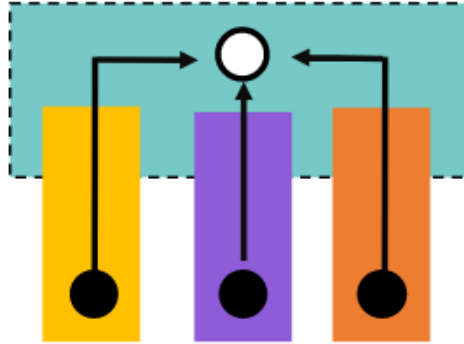


Plastic Problems Require Breakthroughs at Different Levels

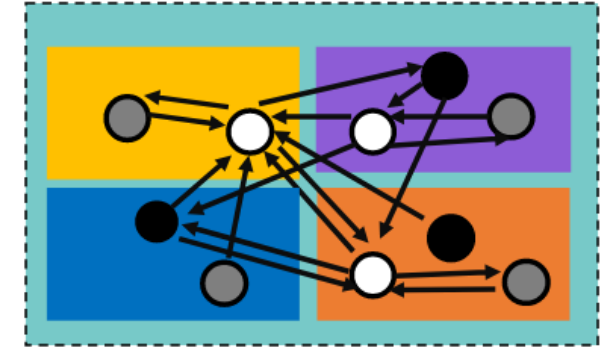
Disciplinary



Interdisciplinary



Transdisciplinary



Examples in Plastic Pollution Research

- Monitoring data
- Analytical method
- Hazard study

- Multi-dimensional risk assessment applied to site

- Risk assessment paired with risk management, community engagement, & policy

Mitrano et al. (2023). “Training the next generation of plastics pollution researchers: tools, skills and career perspectives in an interdisciplinary and transdisciplinary field”, *Microplastics & Nanoplastics*.

Inter-sector Collaboration Needed!

1.6 kilotons/yr of microfibers applied to
California land via biosolids¹



¹Geyer et al. (2022). *Environmental Pollution*.

Open Science Attracts a Diverse Set of Researchers

*The best way to include a diverse group of stakeholders is to **remove existing barriers**, and **design for inclusion**.*

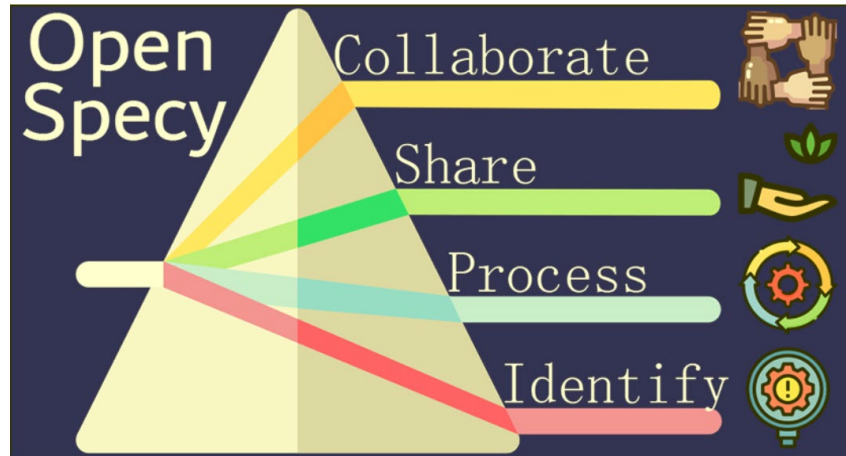


Urbina-Blanco, *et al.* (2020). "A diverse view of science to catalyse change." *Nature Chemistry*.



scientificinfographic
s.com/21-towards-
an-open-science

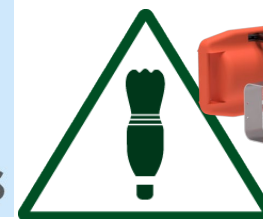
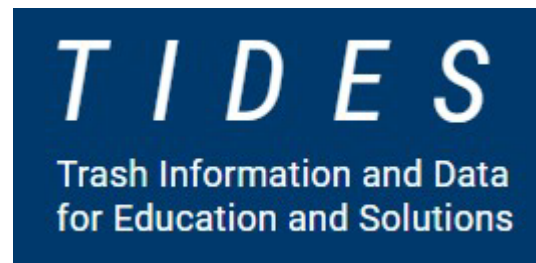
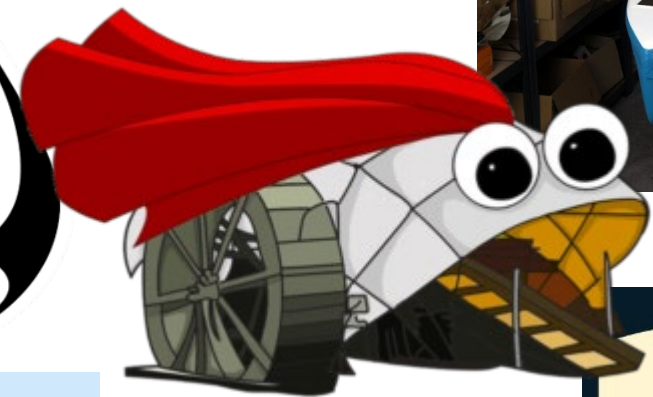
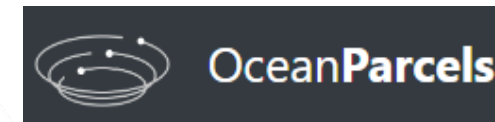
>225 Open Science Tools Available for Plastics Research!



#OpenLitterMap



TACO



Removing barriers on plastic research



Plastiverse.org

Plastiverse.org is an information- and resource-sharing website that is not affiliated with any state agency, and that no one receives monetary benefits from.

Open Centralized Living Resource Hub



PLASTIVERSE

Reducing barriers to plastics research

[Tools & Resources](#)

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PLASTICS RESEARCH TOOLS & RESOURCES

Plastiverse offers a **curated and evolving directory of plastics research tools & resources** – from open-access datasets and sampling/analysis protocols to remediation devices, policy frameworks, citizen science platforms, and much, much more! We pull the diamonds 💎 out of the rough to enable more *rapid progress* on addressing impacts of **microplastics pollution** 🌊. Whether you study microplastics in water 🌊, track macroplastic waste 🗑️, design cleanup strategies 🧹, or shape plastic-policy 🏛️, this page provides a one-stop reference to the tools, methods, data, and guidance currently available worldwide.

If you are aware of something missing or incorrectly described, please -> **let us know** <-

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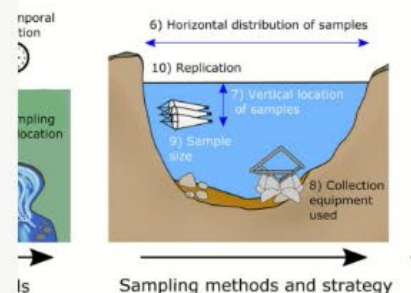
☐ Air (2)

☐ Aquatic (107)



GLOVE: Global Plastic Ingestion Initiative

An open-access dashboard database providing science-



Riverine Microplastics Sampling Quality Criteria

Meta-analysis of 36 river microplastic studies with quality



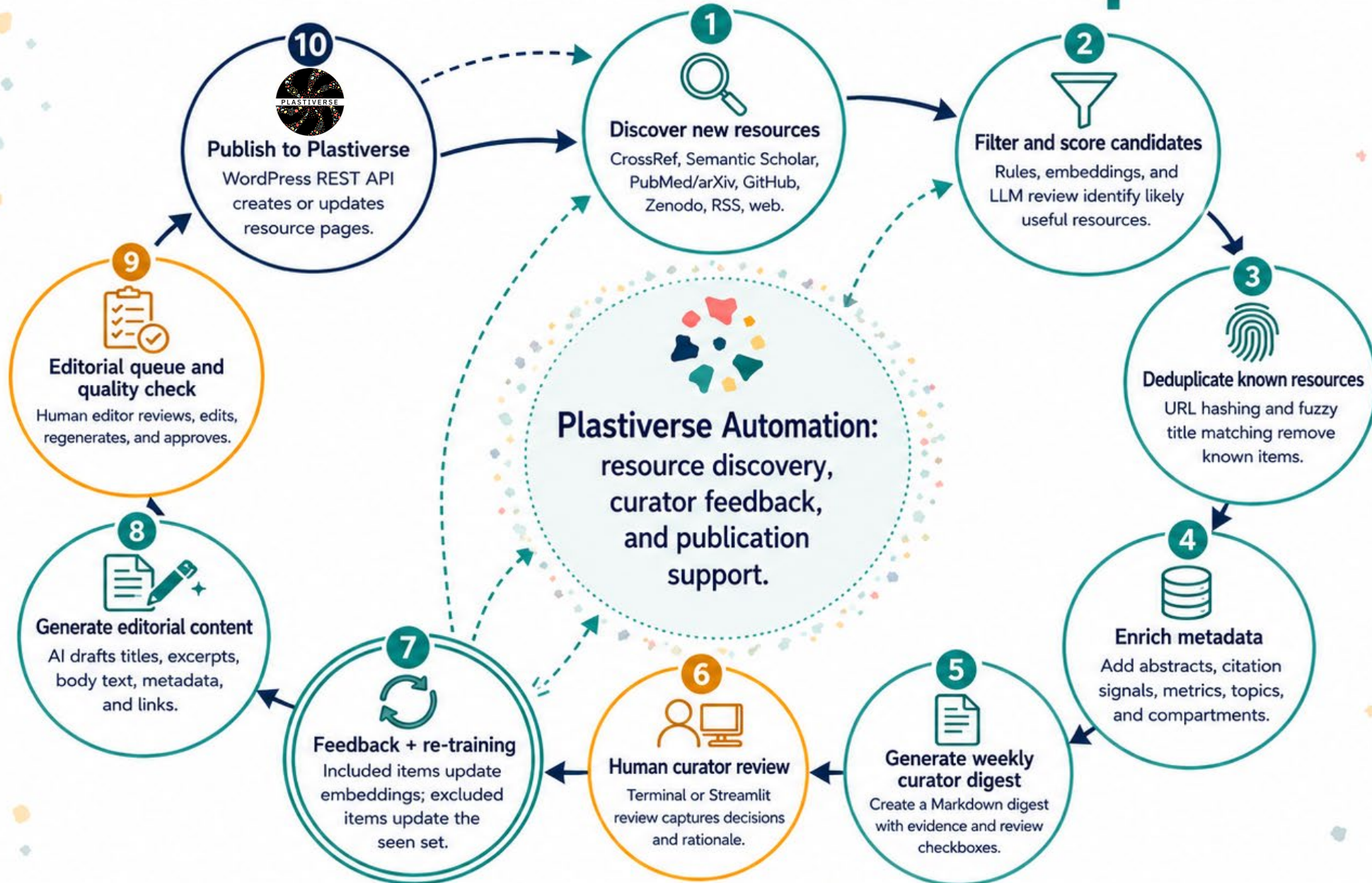
PlasticHealers — Classroom Tool for Micro- and Nanoplastics

Interactive educational

Improving Access Through Making Data Findable

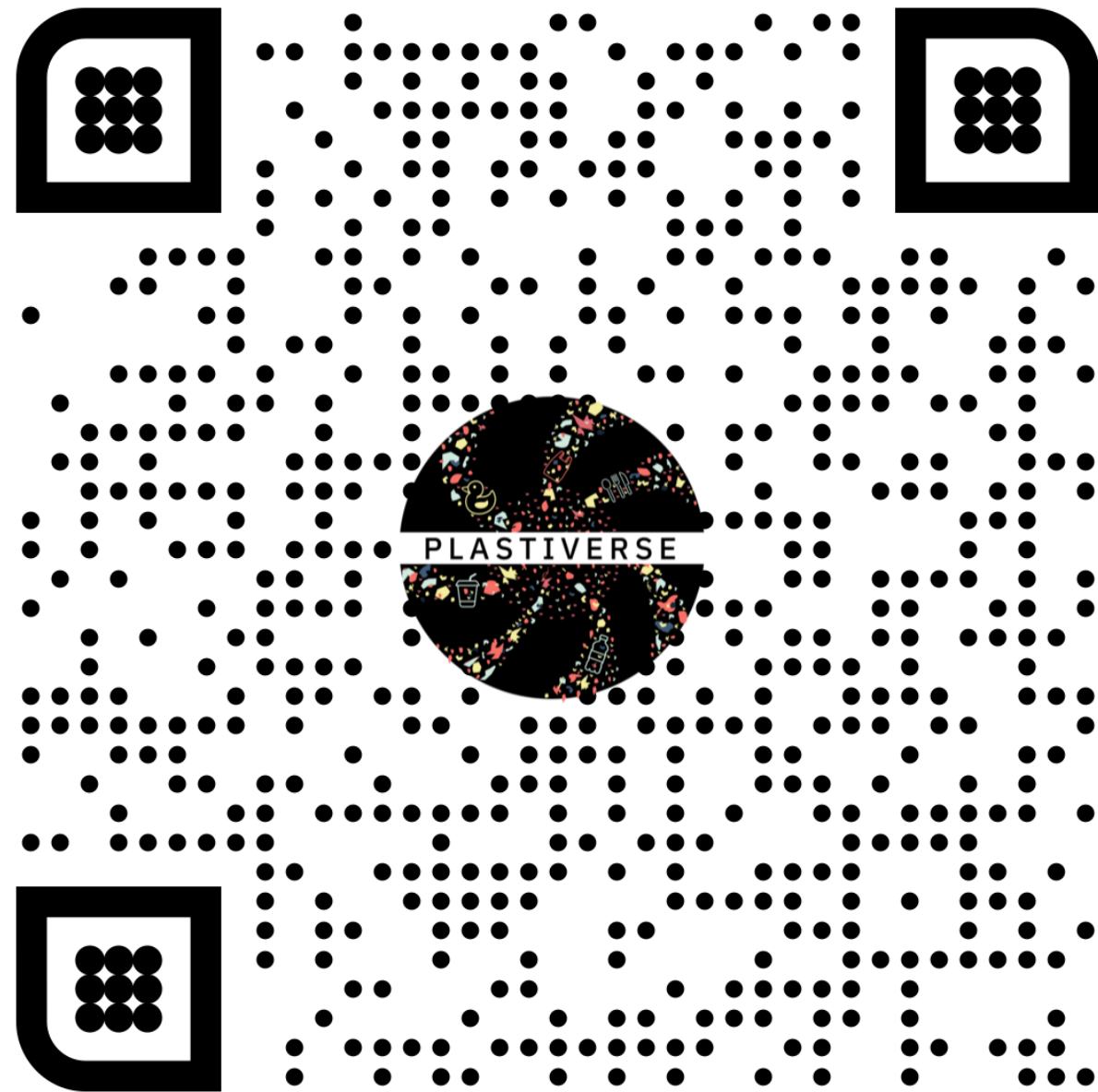


Plastiverse Automation Pipeline



Automated discovery narrows the search space; curator feedback improves the next cycle.

Share **your tools,**
databases, art,
protocols, etc. on
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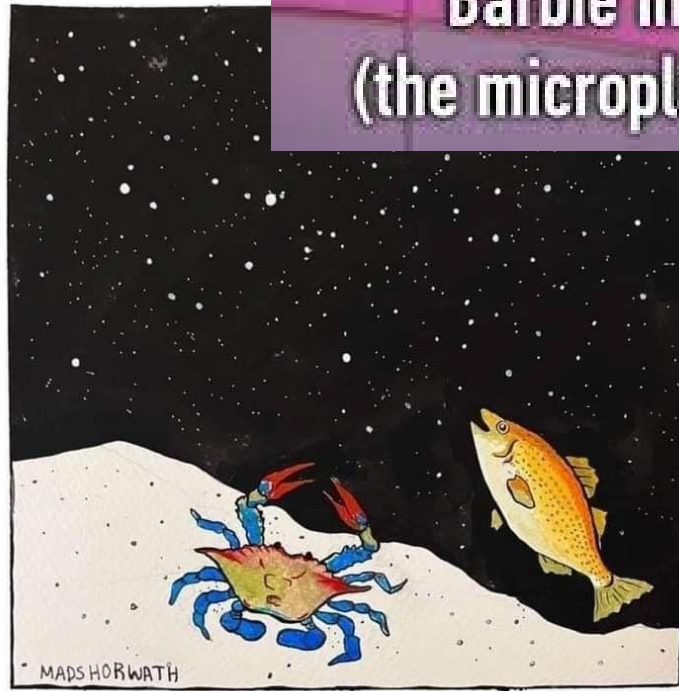




Obrigado!

Scott.coffin@oehha.ca.gov

<https://Scottcoff.in>



"WOW. THE MICROPLASTICS TONIGHT CAN REALLY MAKE YOU FEEL INSIGNIFICANT."

