Uncovering the Origin, Fate, and Impact of Plastic and Microplastic Debris in Aquatic Ecosystems

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Virginia Tech, Department of Biological Science

Plastic pollution: An emerging global threat

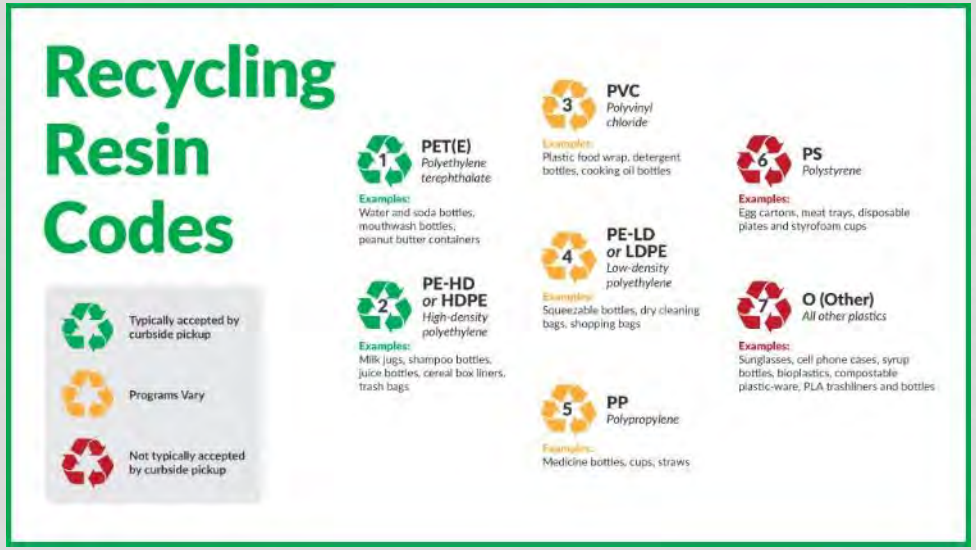
- **Plastic pollution is considered a pressing environmental issue**
- **Plastics can be found in all ecosystems**
- **Even those considered once "pristine"**
- **Pose threats to human, animal, and environmental health**

Plastic pollution: An emerging global threat

- **Plastics are derived from petrochemicals**
- **Used due to:**
  - **Low cost**
  - **Ease of manufacture**
  - **Versatility and durability**
  - **Persistence**
- **Few polymers in use are easily recyclable**

Some common types of plastic:

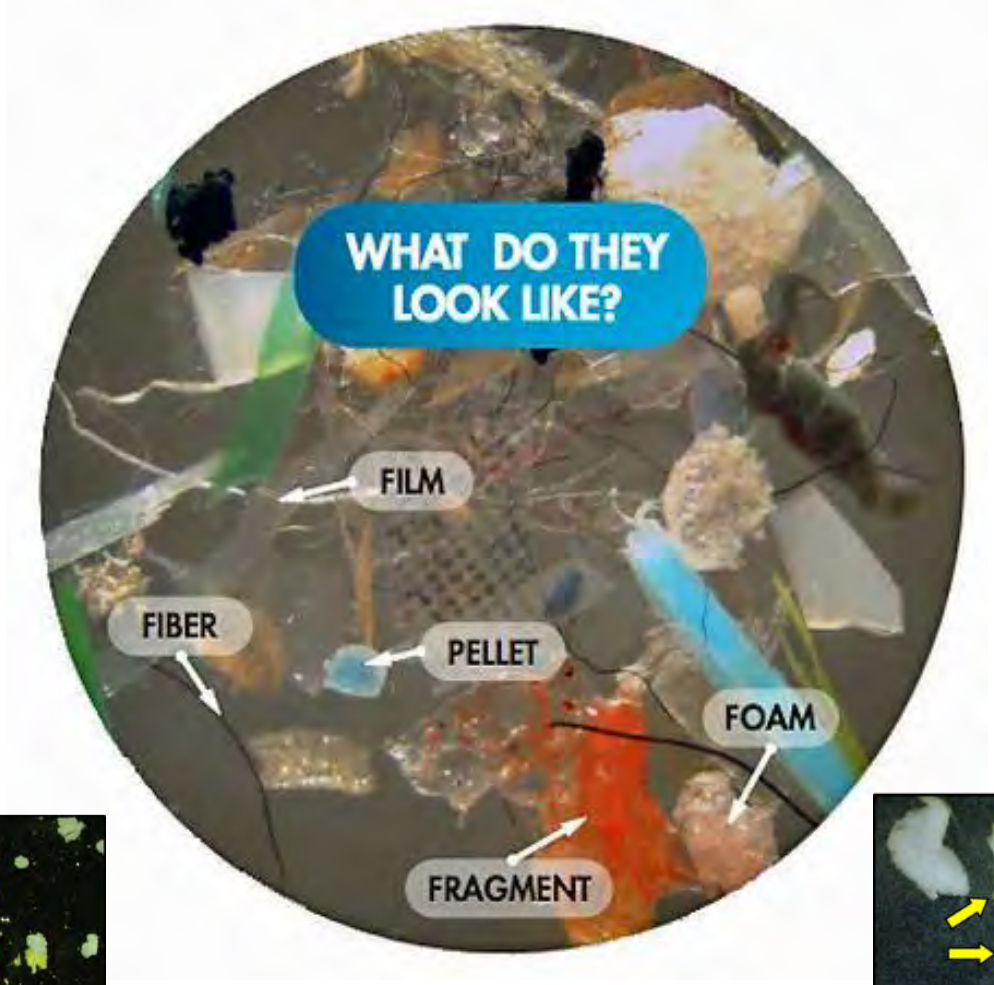
Acronym	Full name	Common Example
PET (PETE)	Polyethylene terephthalate	soda bottles
PES	Polyester (yes, it's actually a plastic!)	polyester clothing
PE	Polyethylene	plastic bags
HDPE	High-density polyethylene	detergent bottles
PVC	Polyvinyl chloride	plumbing pipes
PP	Polypropylene	drinking straws
PA	Polyamide (aka nylon)	toothbrushes
PS	Polystyrene	take-out food containers

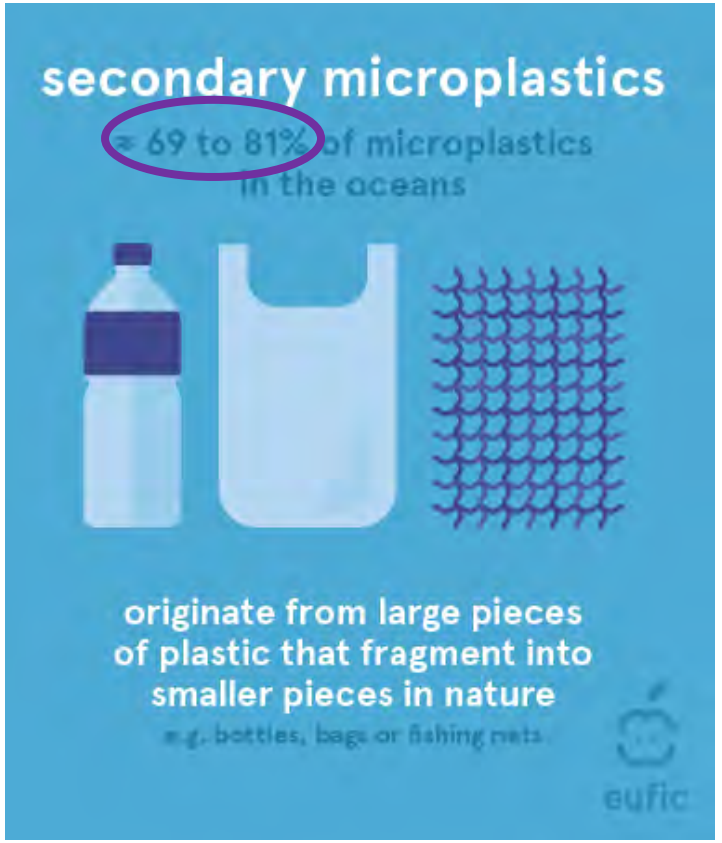


Plastic pollution: A pervasive problem

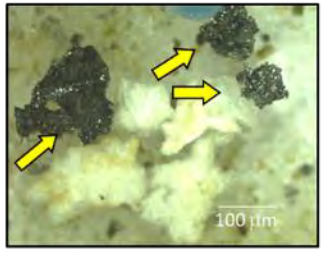
- 121.4 billion pounds of plastic were produced in the US in 2019
  - ~13% increase since 2013
- 80% of plastic in marine and coastal environments are from land-based sources
- Less focus on freshwater ecosystems

Microplastic Debris:
A Growing Environmental Concern

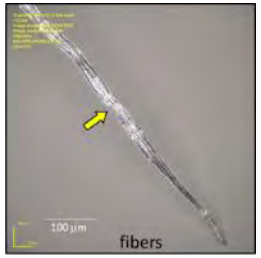




foam

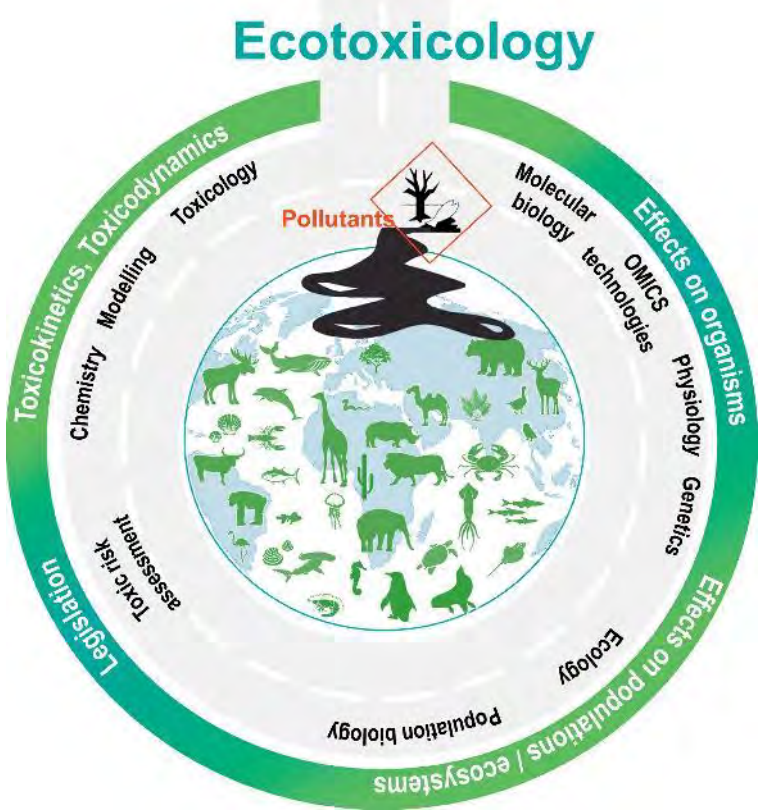


fragments



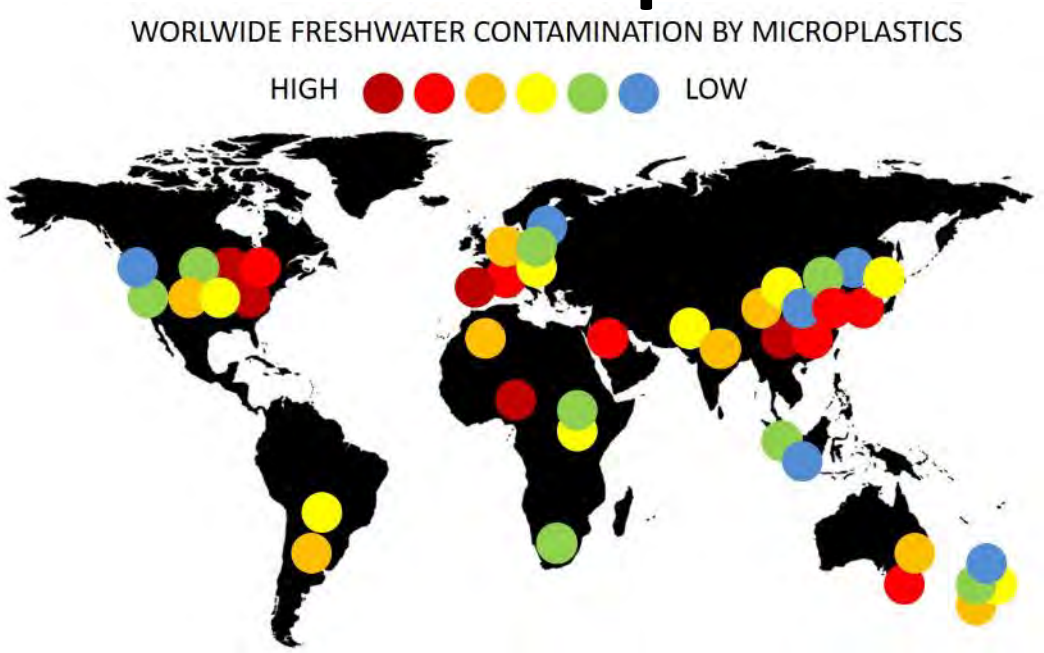
Austin Gray

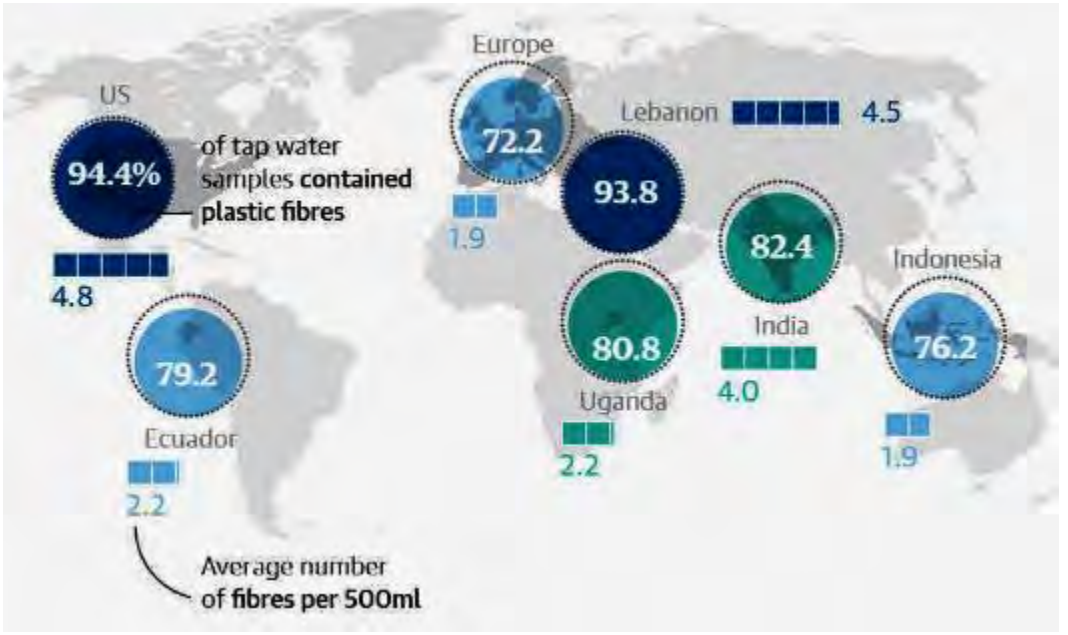
Assistant Professor of Biological Sciences

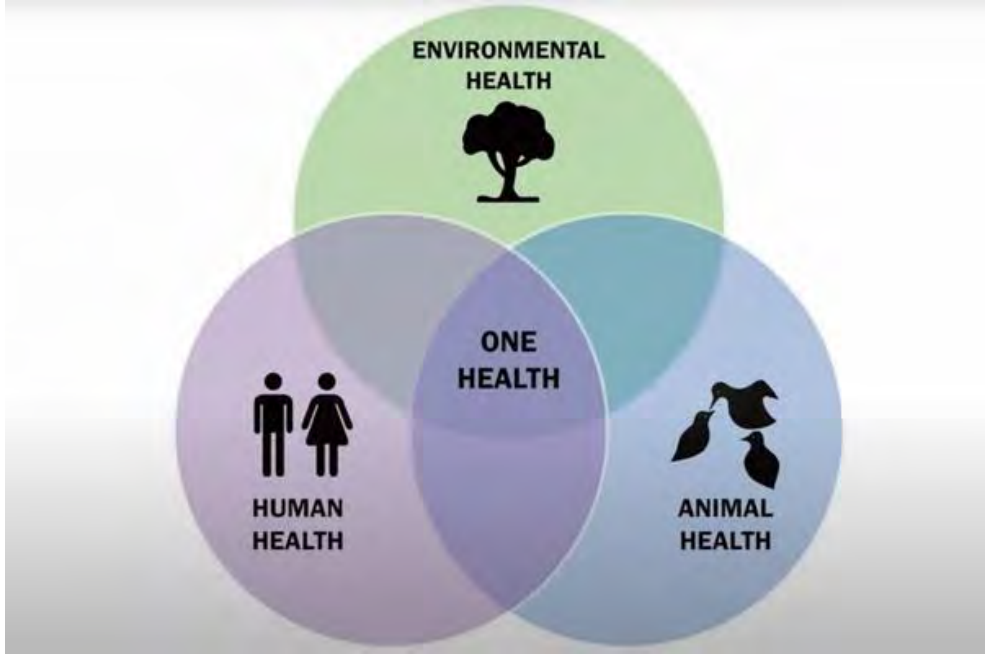


My lab specializes in the occurrence, distribution, fate, and impact of microplastic pollution in aquatic habitats using field and spectroscopy techniques

Microplastics around the World







Because of the connectivity of water and air, MPs can enter every ecosystem

Environmental health and human health are directly linked

Degradation of plastic debris

The Guardian

Microplastics found in every human placenta tested in study

Scientists express concern over health impacts, with another study finding particles in arteries

The Guardian

Microplastics found in human blood for first time

Exclusive: The discovery shows the particles can travel around the body and may lodge in organs

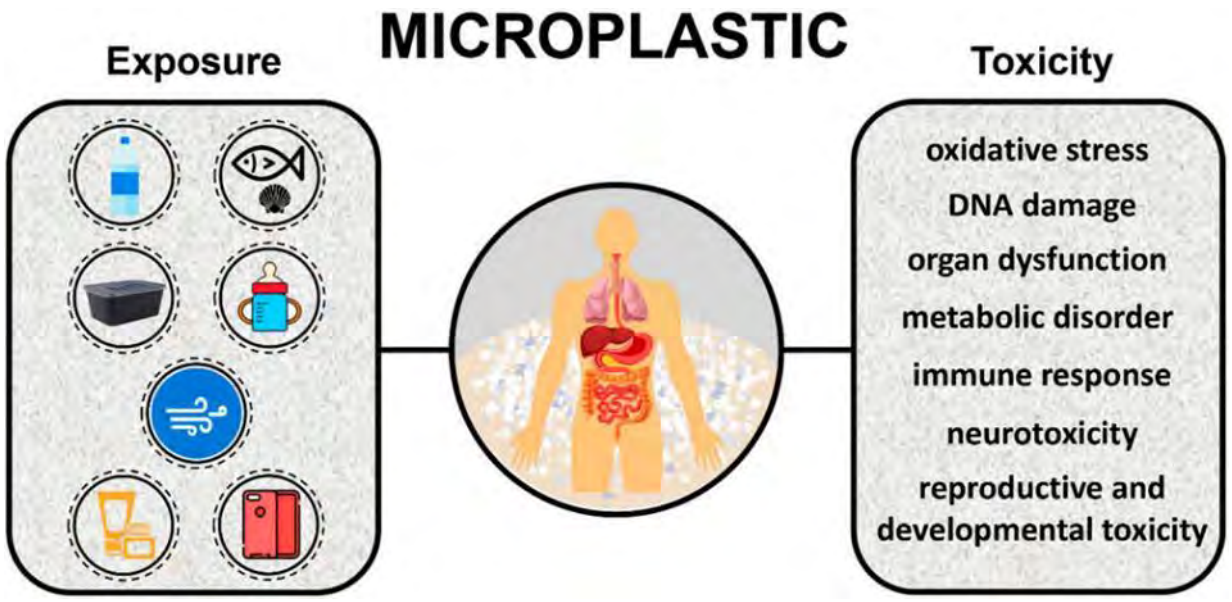
nature

Landmark study links microplastics to serious health problems

People who had tiny plastic particles lodged in a key blood vessel were more likely to experience heart attack, stroke or death during a three-year study.

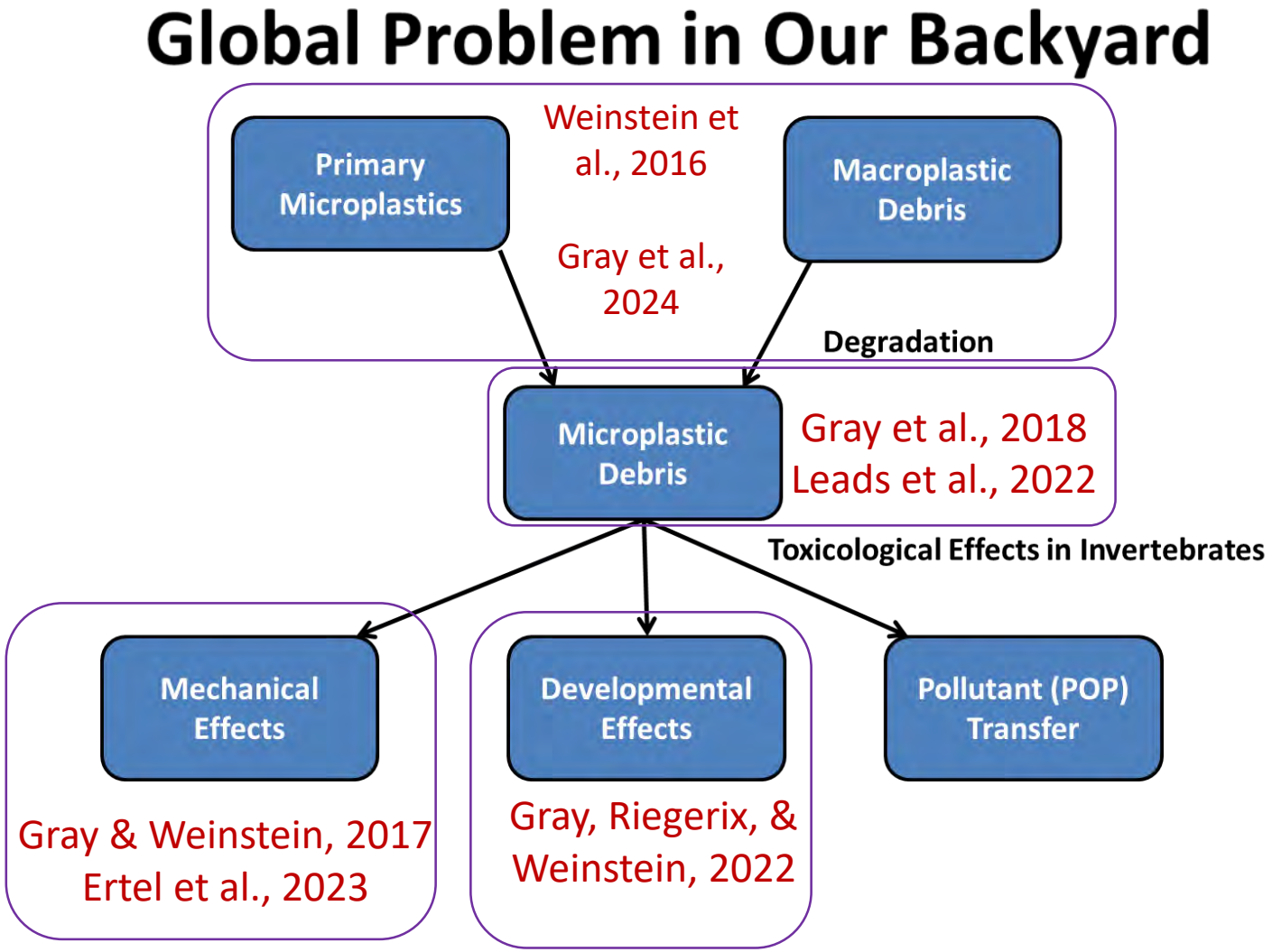
Pressing concerns regarding MPs

1. Size and shape **toxicity** to aquatic **organisms**
2. Developmental alterations
3. **Trojan Horse** for other pollutants
4. Inhalation and ingestion by **humans**
5. **Translocate** into cells
6. Unknown **human health** implications



Microplastic Debris: A Growing Environmental Concern

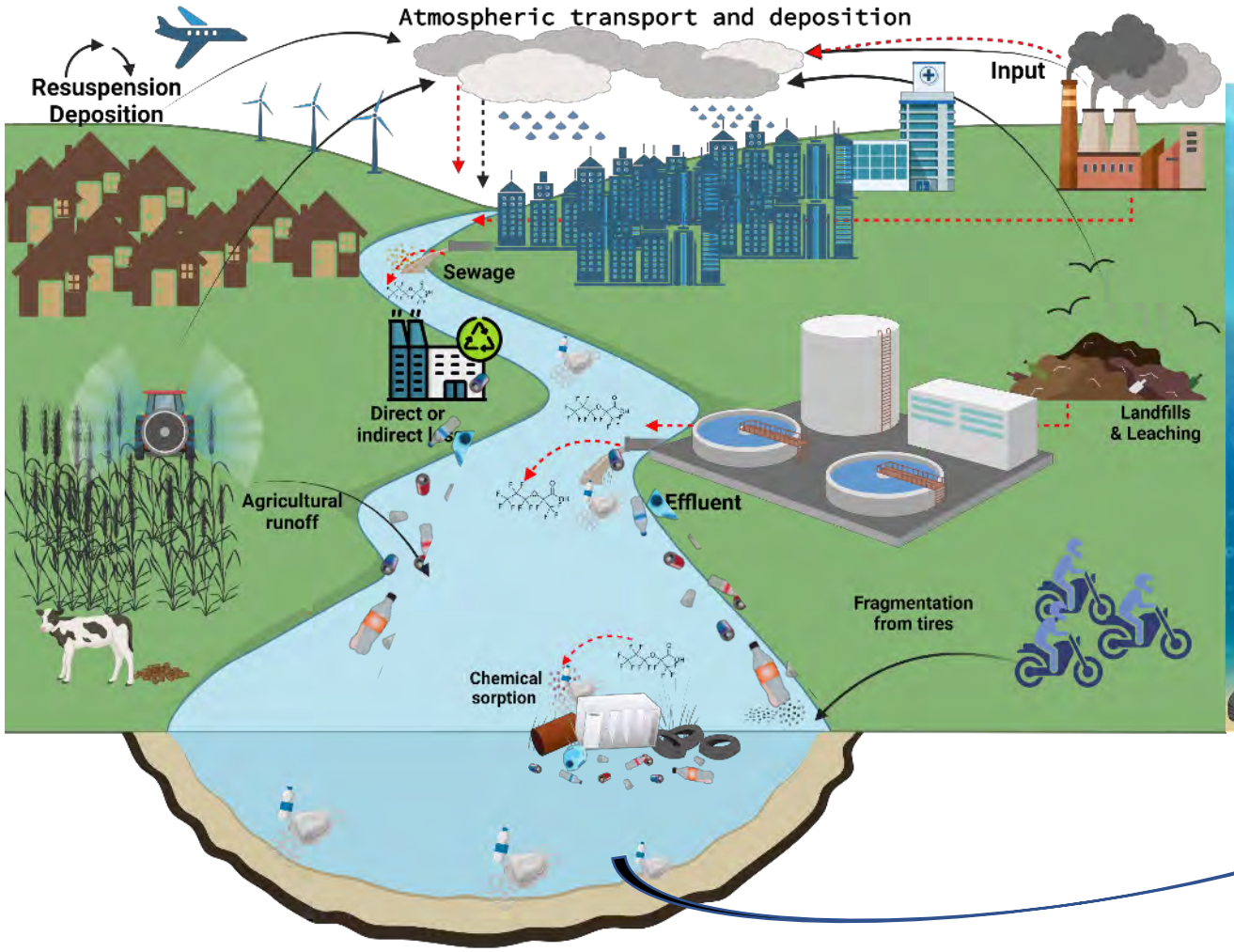
- Documented globally
- Abundance is increasing
- Same size range as food
- Toxicological concerns include:
  - Ingestion by wildlife
  - Developmental effects
  - Transfer of persistent organic pollutants (POPs)

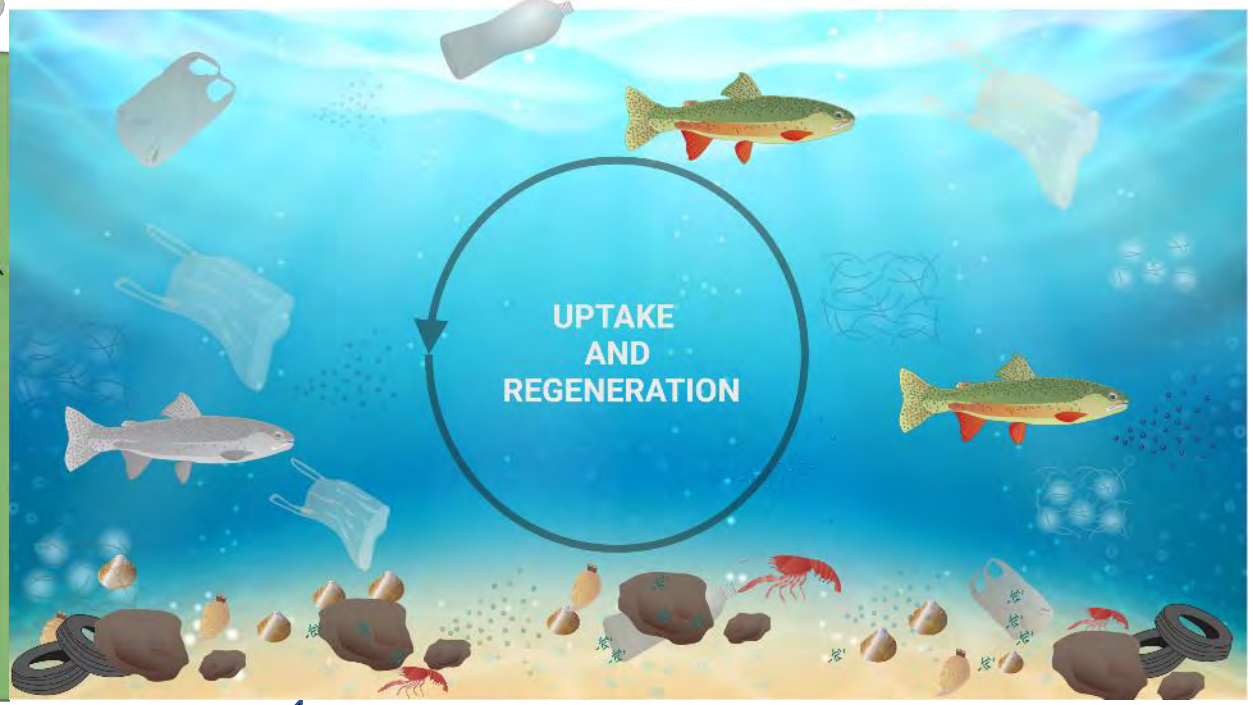


Degradation of macroplastics in stream habitats

80% of plastic pollution in oceans comes from riverine systems

Small streams >70 % of the total stream length in the continental US



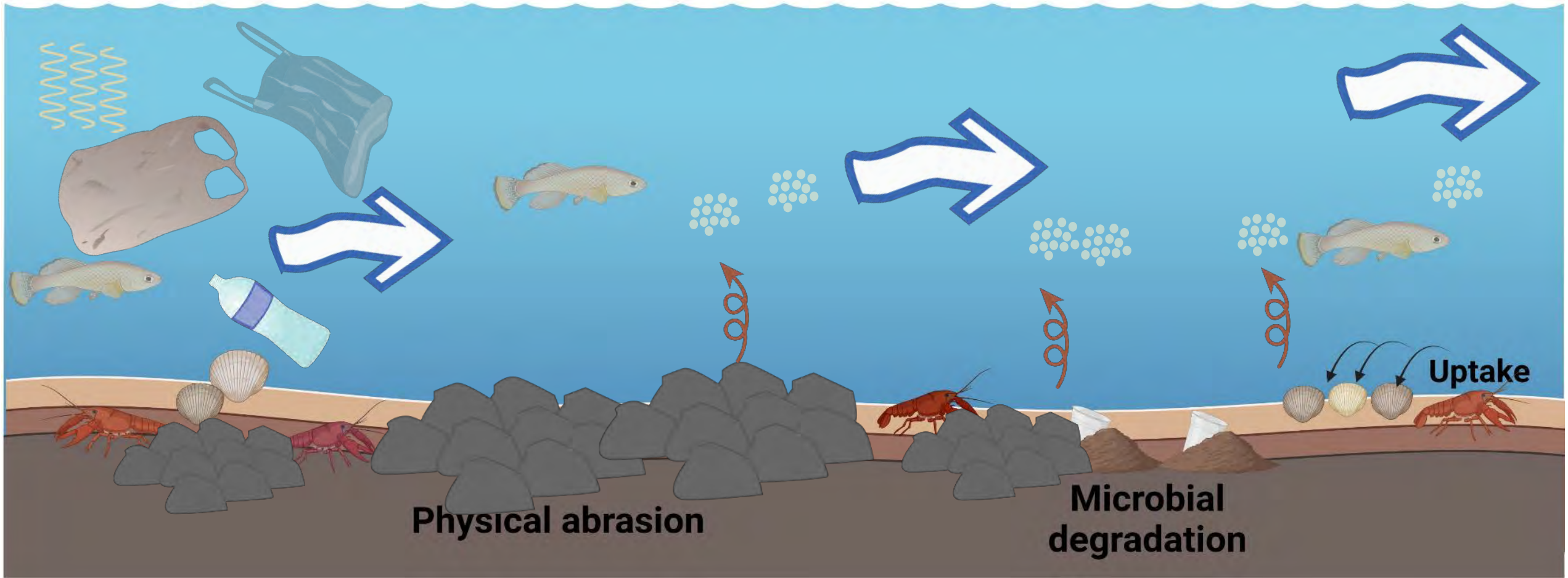


Gray et al., 2024 (Under Review)

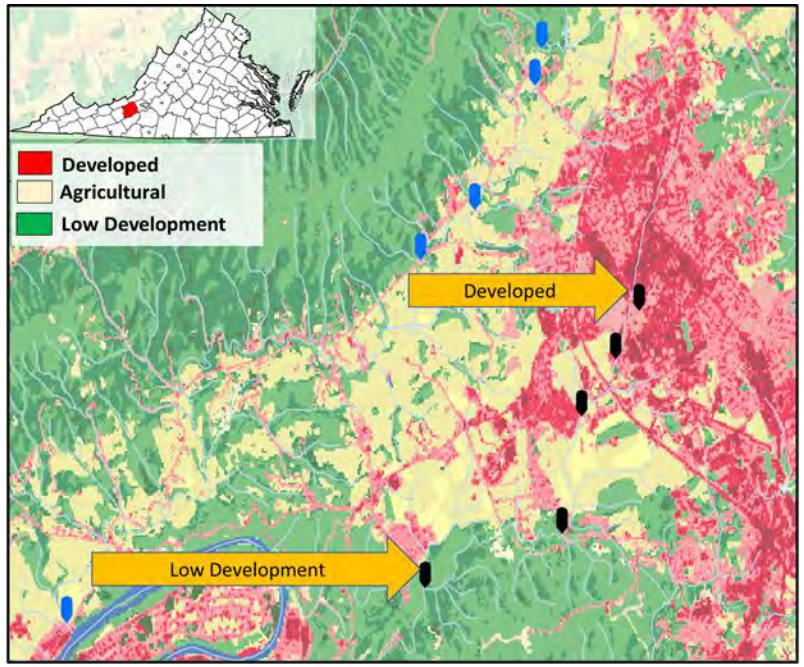
Macroplastic Degradation in Stream Habitats

Research Questions

1. How long does it take for MPs to be produced from plastic debris in stream habitats?
2. Does fragmentation differ between stream habitats?



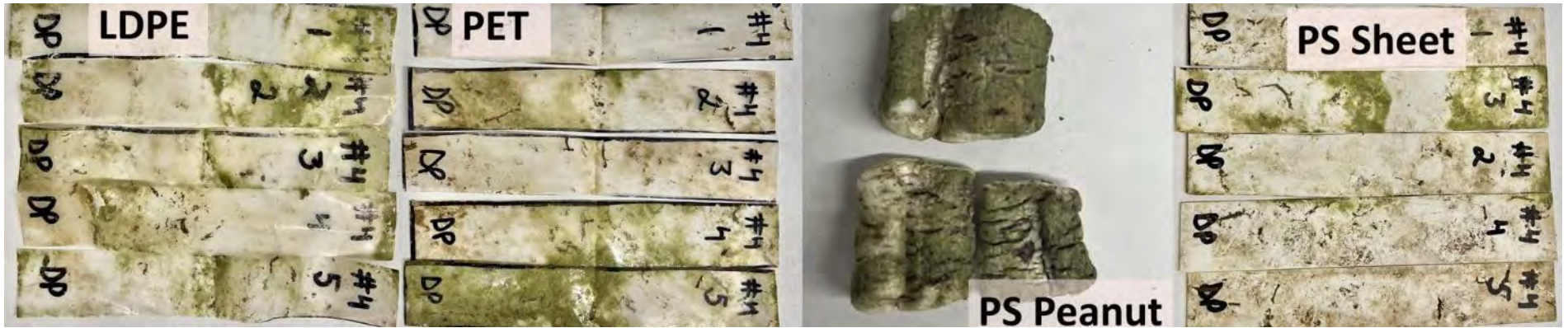
Degradation of macroplastics in stream habitats



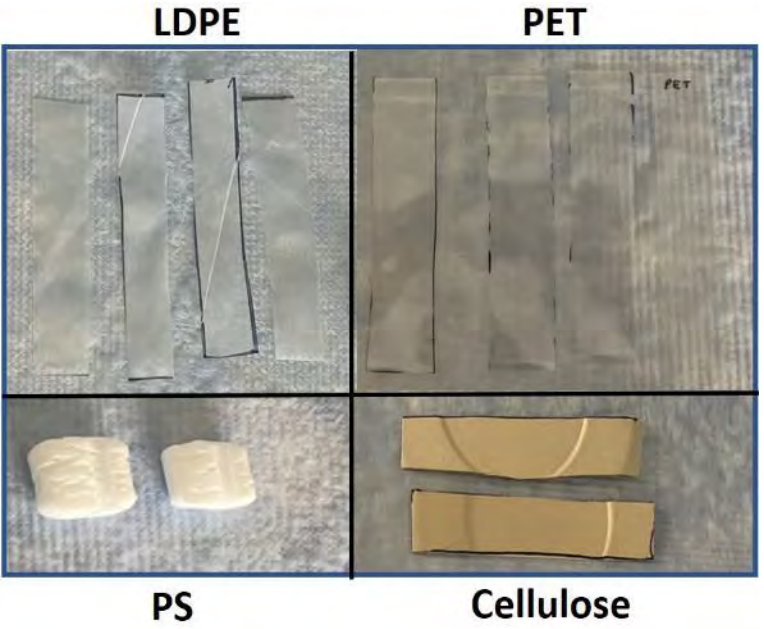
Site Map showing locations where bags were placed for the study

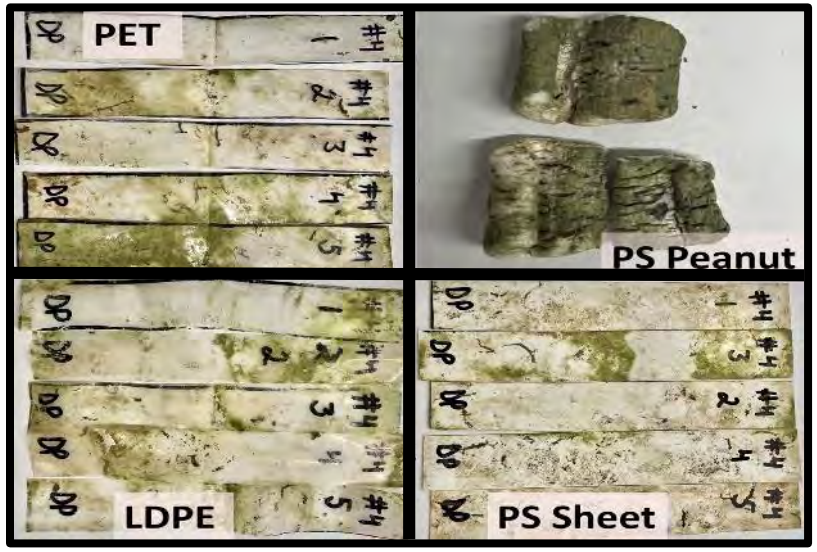
Summary of Polymer Types
Polymer Types:
Polyethylene terephthalate (PET)
Low-density polyethylene (LDPE)
Polystyrene (PS) Sheet or Peanut
Cellulose

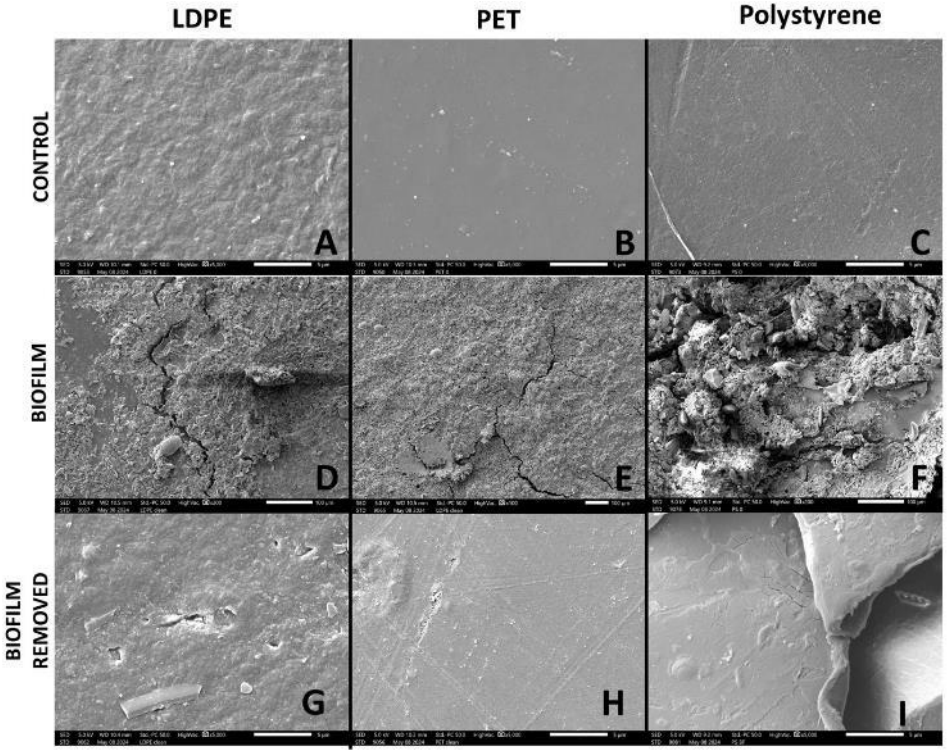
Field plastics collected at 8 months

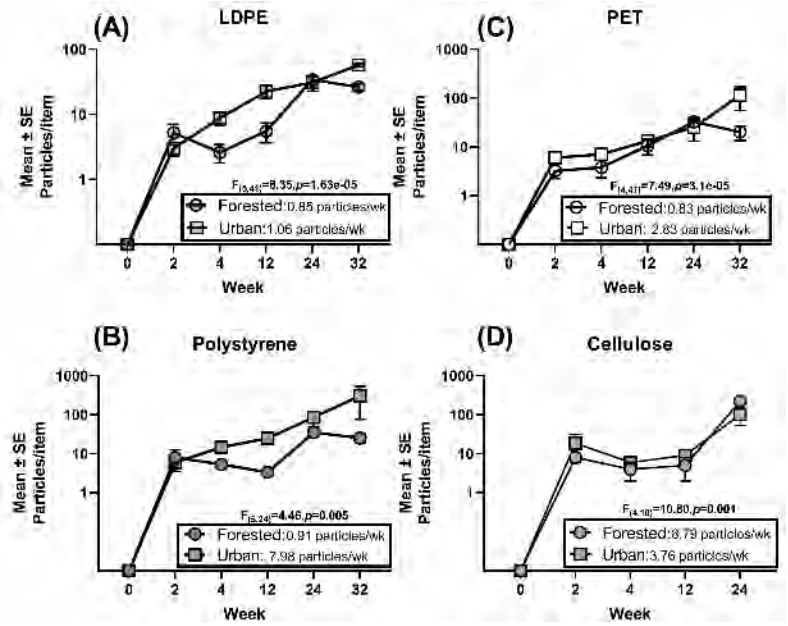


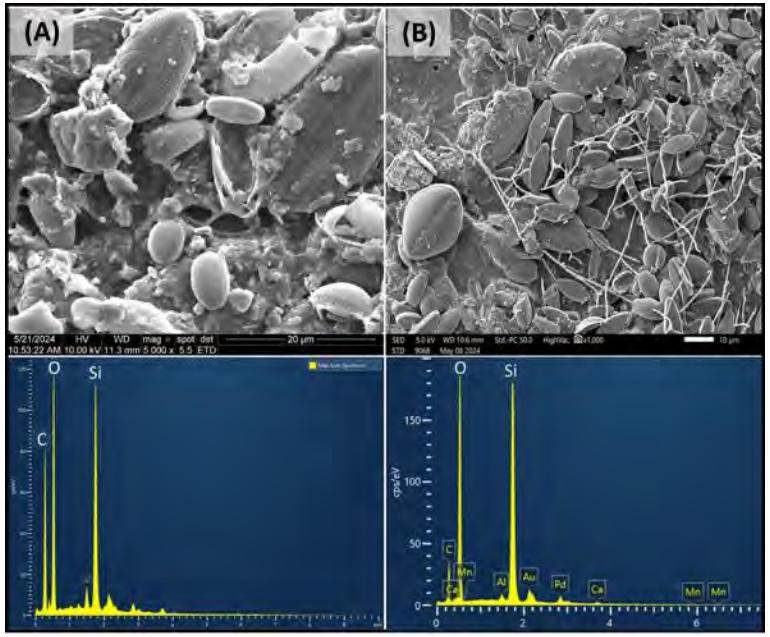
Degradation of MPs in streams





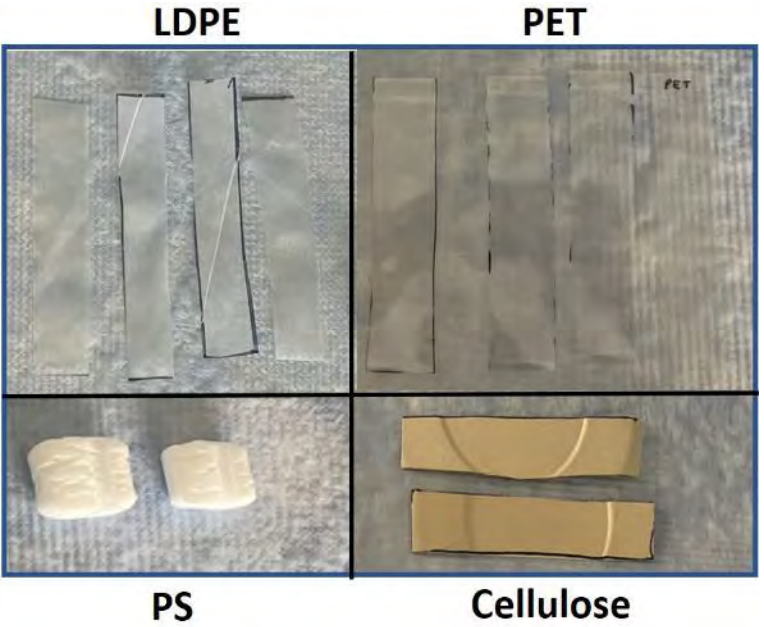


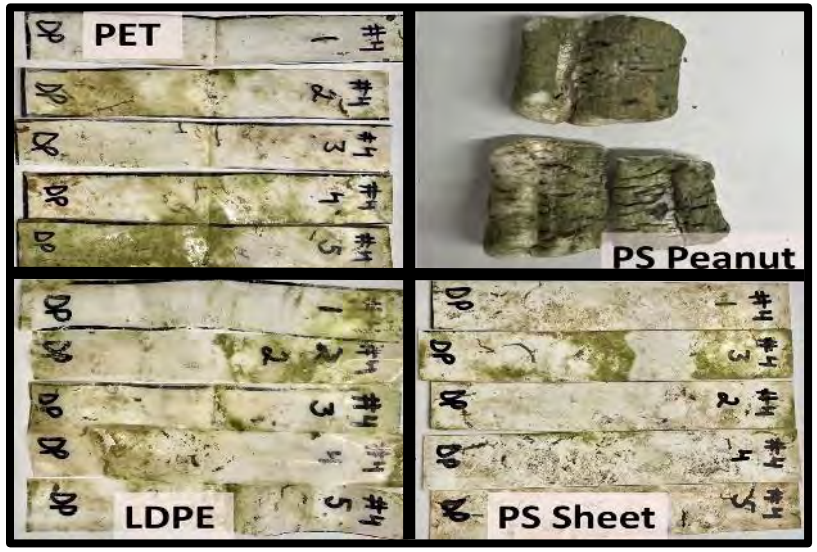


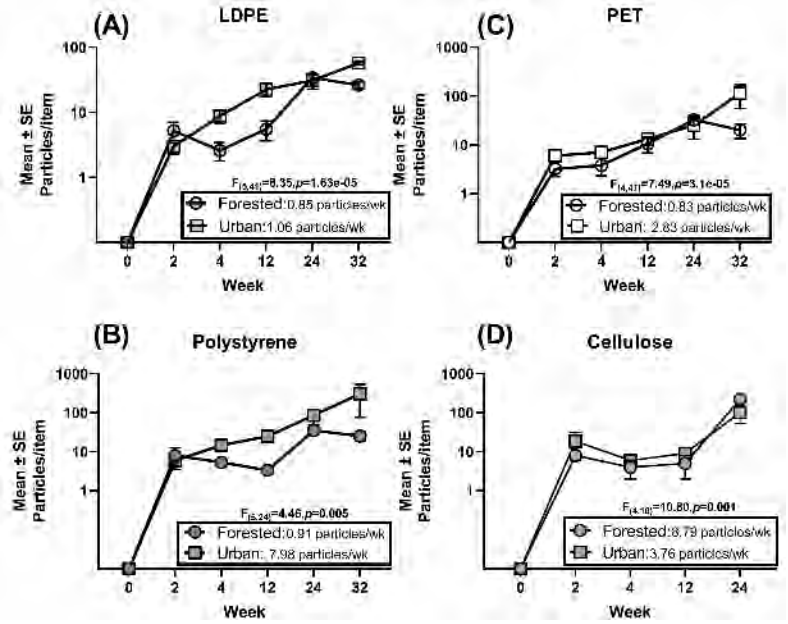


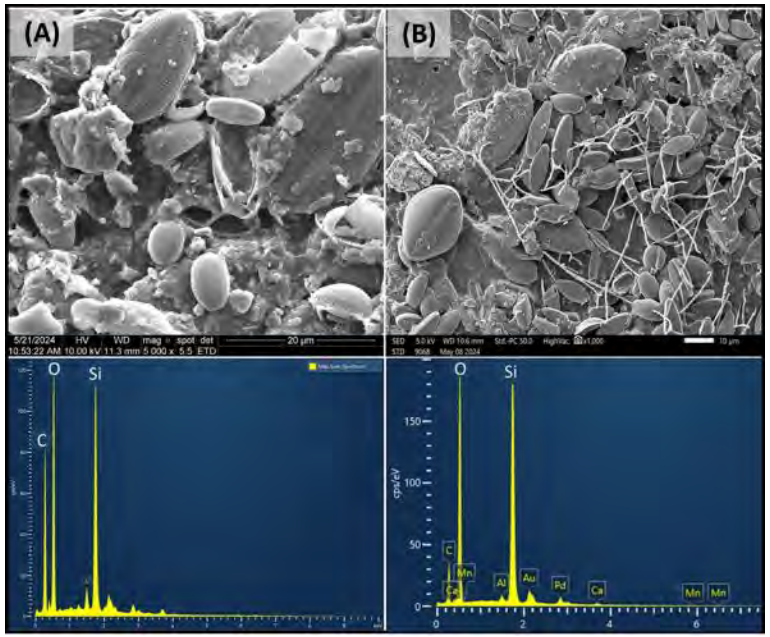
Gray et al., 2024 (Under Review)

Degradation of MPs in streams





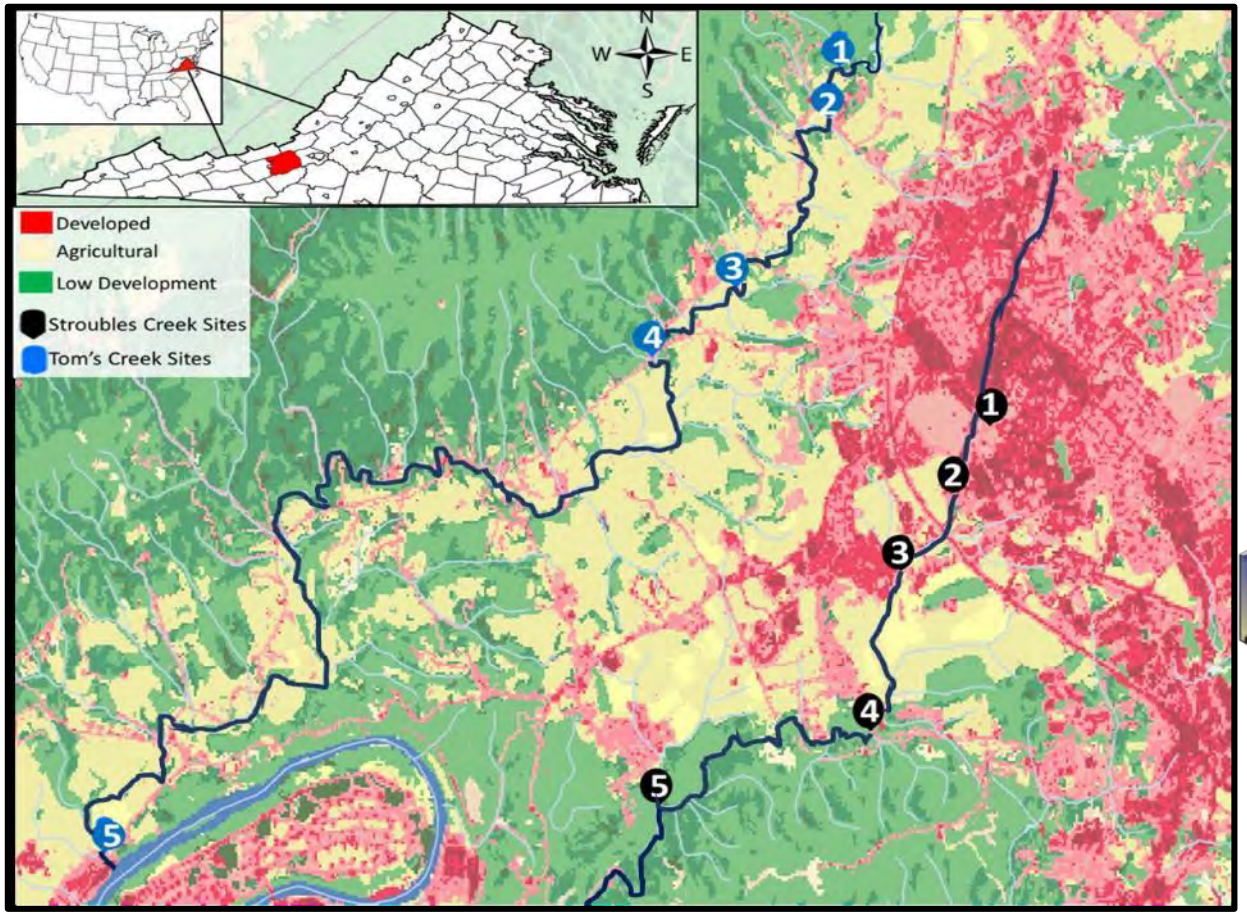


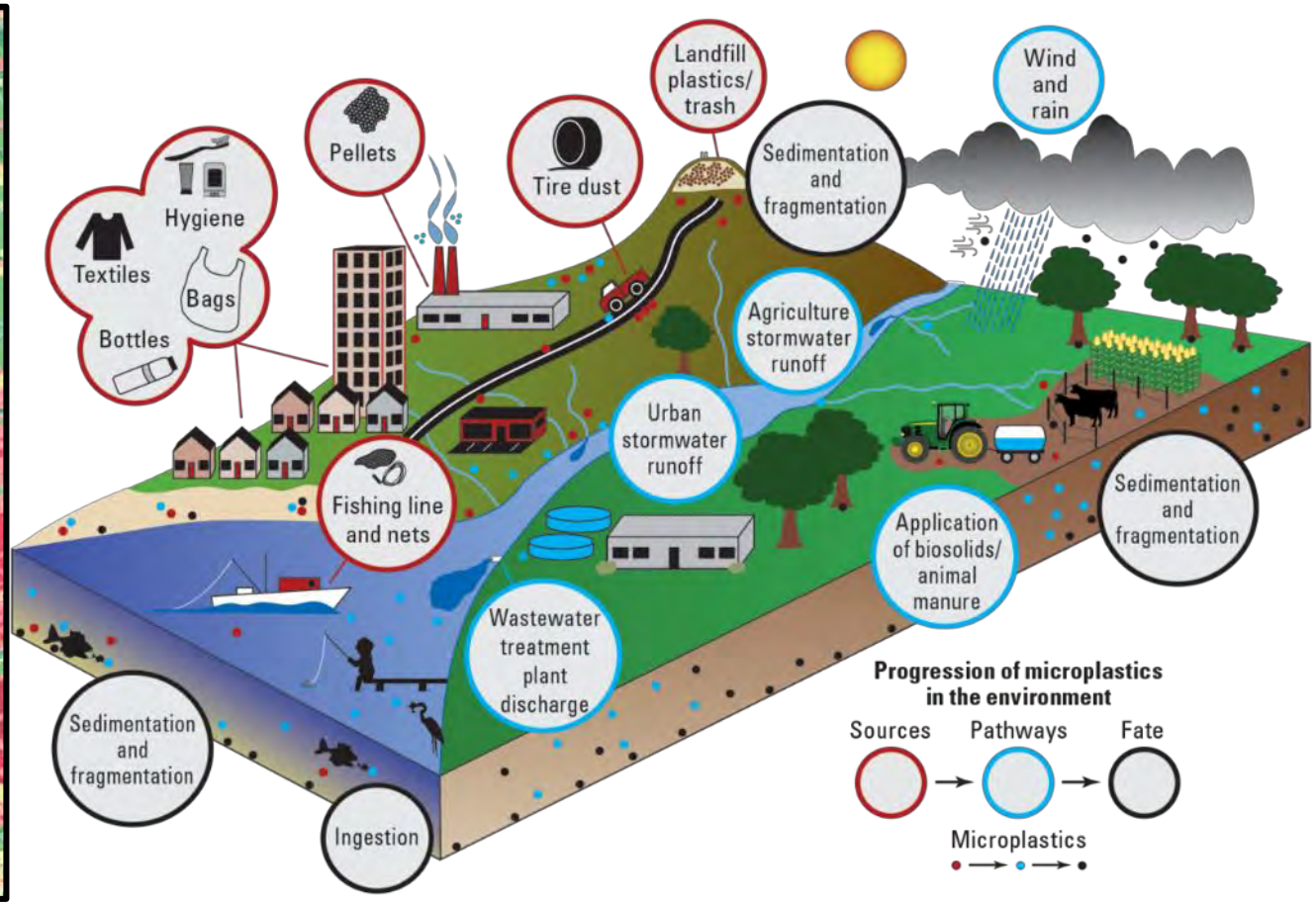


- MPs were produced across both sites in as little as 2 weeks
- Urban streams had a higher rate of fragmentation
- Degradation and fragmentation are influenced by various factors and not UV solely

Gray et al., 2024 (Under Review)

MP Body Burden in Native and Non-Native Crayfish

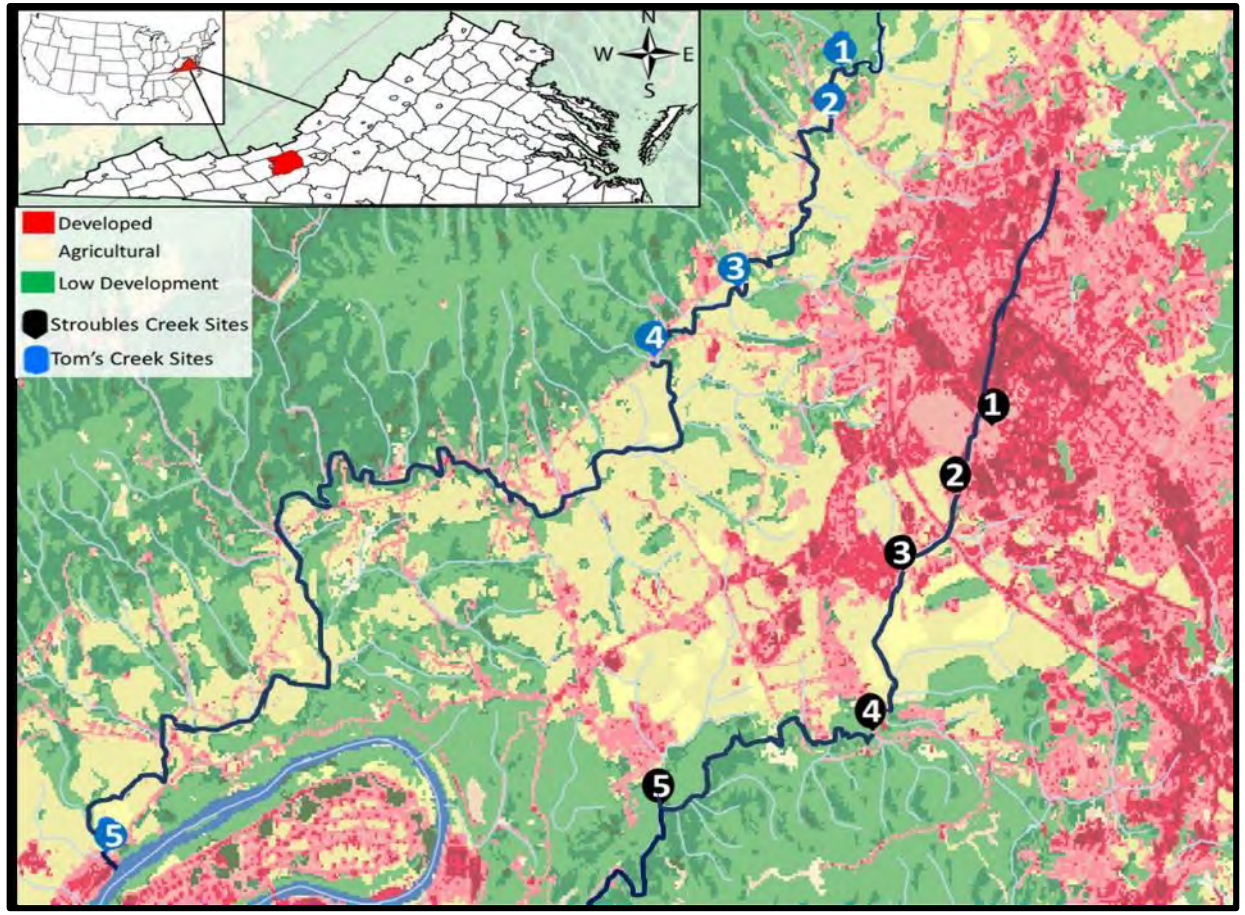


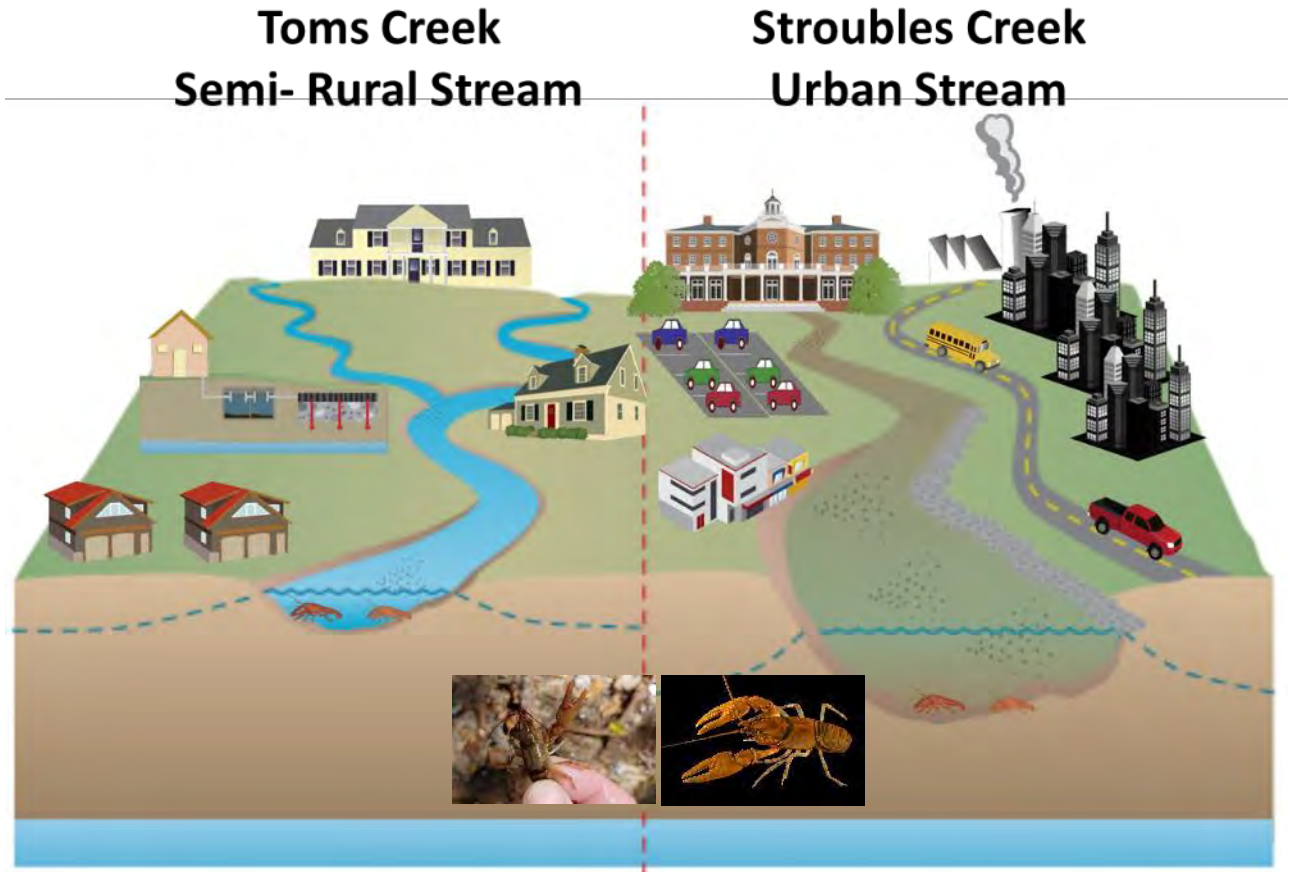


MPs have entered every ecosystem due to various pathways of entry, including atmospheric deposition

Gray et al., 2024 (Env. Research)

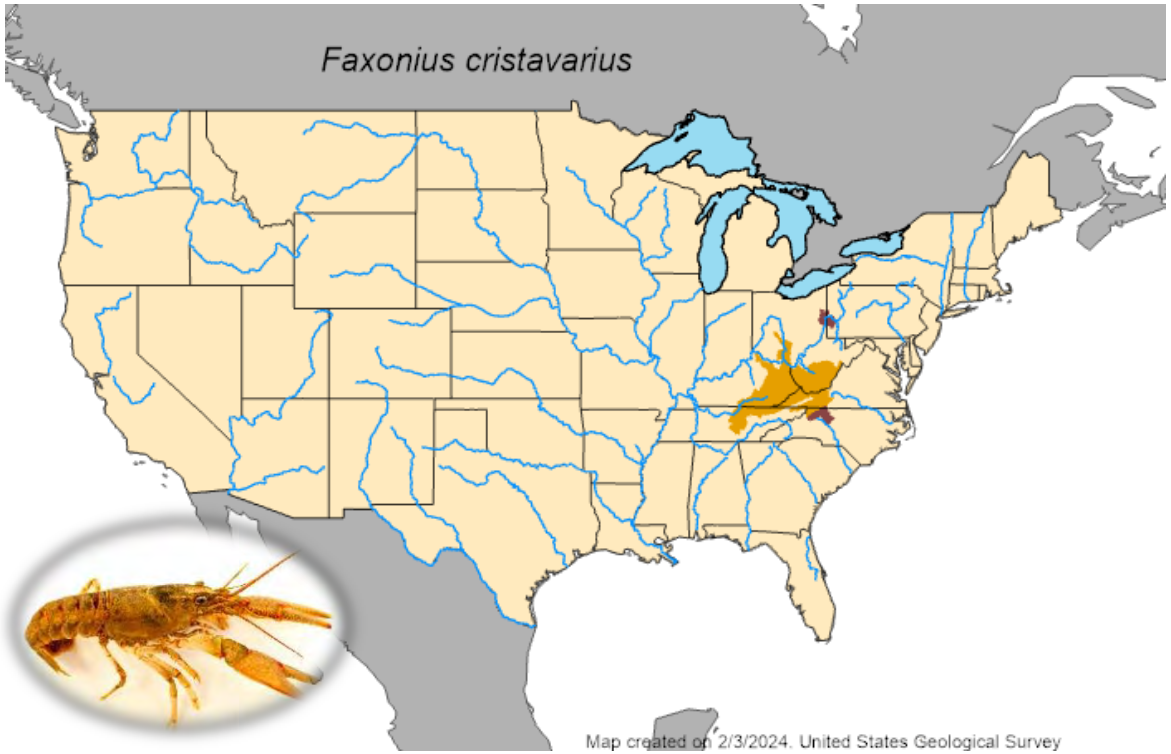
MP Body Burden in Native and Non-Native Crayfish





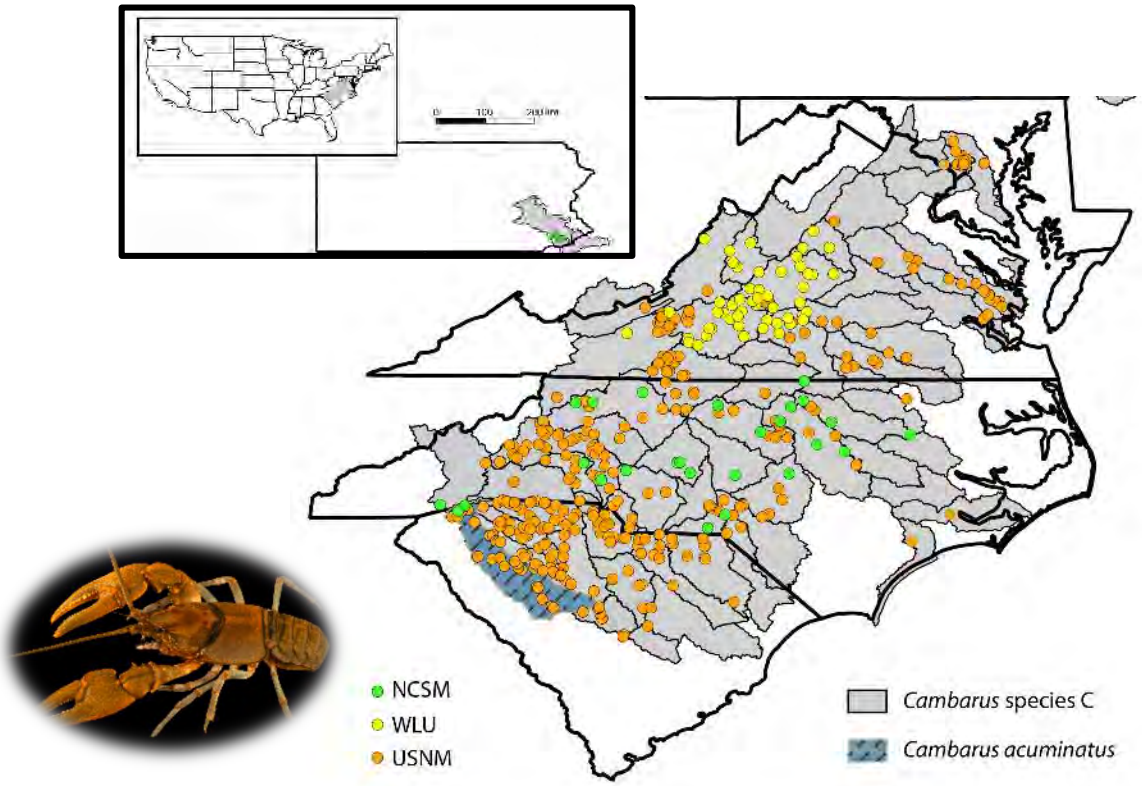
The concept of a pristine system is not realistic when considering microplastic pollution

Spiny stream crayfish (*Faxonius cristavarius*)



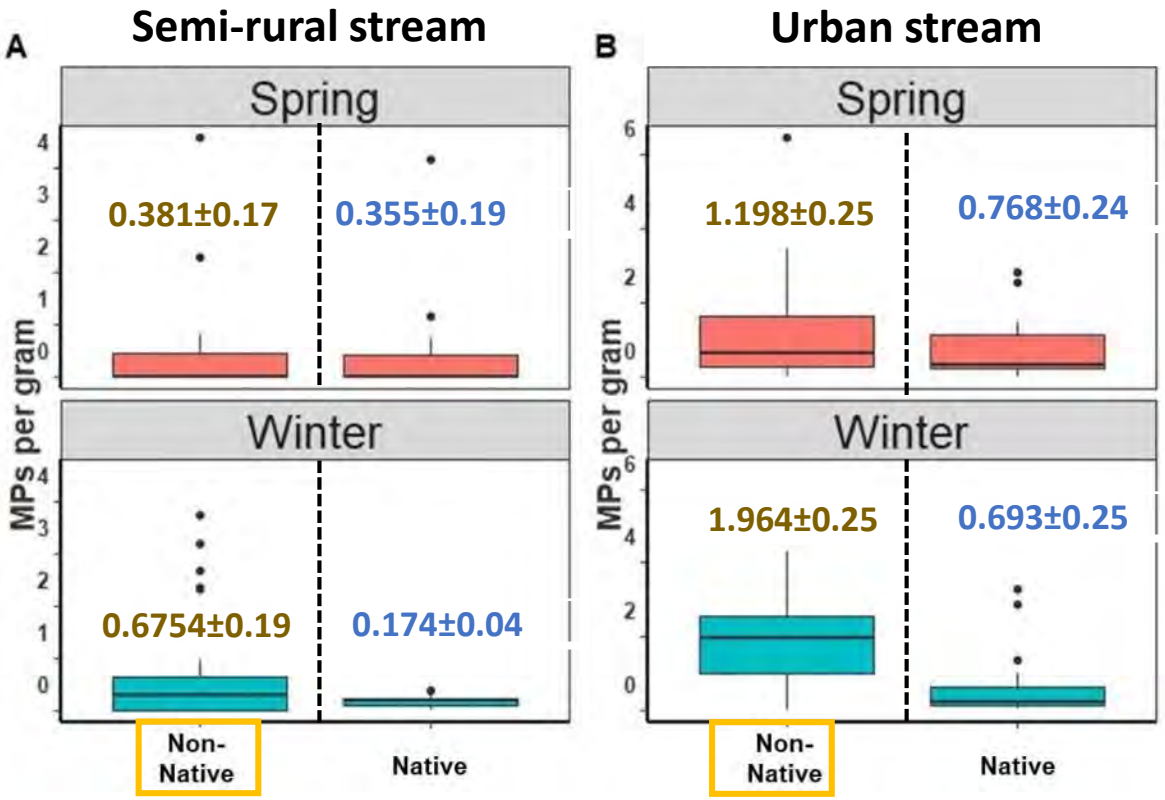
Non-native species that can dominate populations in stream habitats, outgrowing and competing native crayfish

Stream-dwelling crayfish (*Cambarus appalachiensis*)

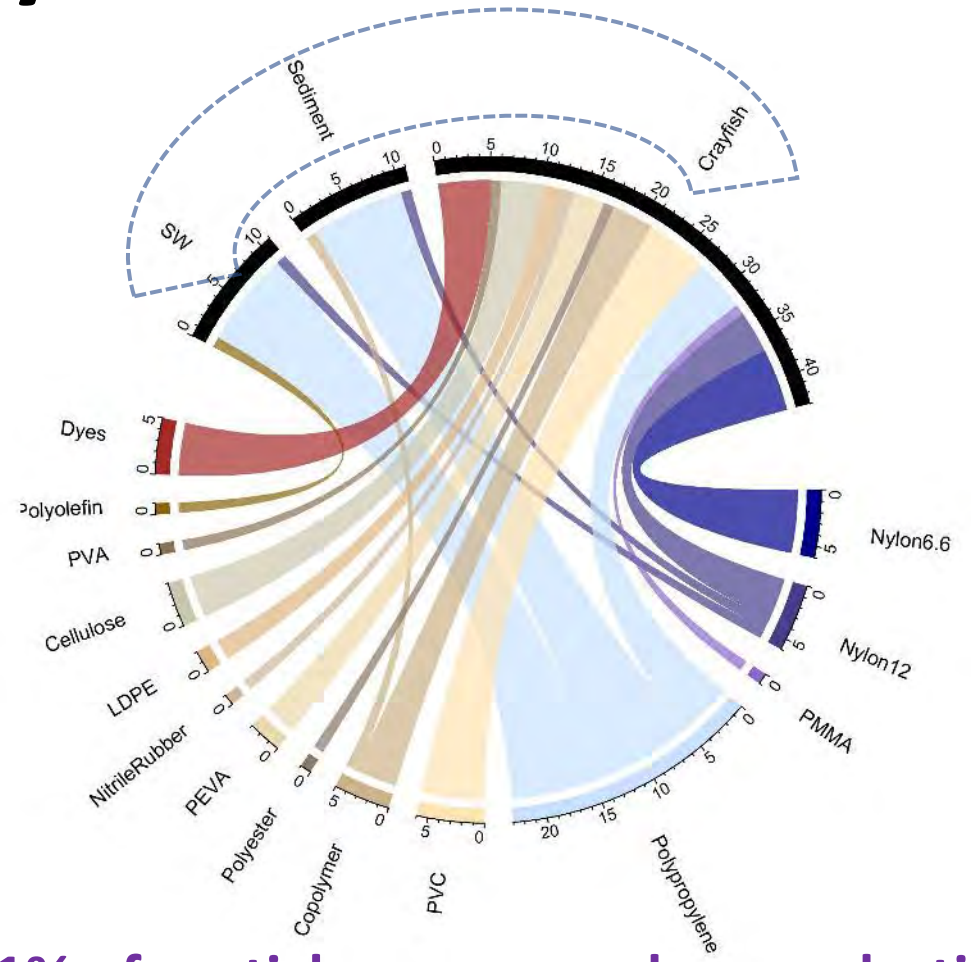


Newer species endemic to the greater New River basins of Virginia and West Virginia

MP accumulation and polymer characterization



- First comparative study of MPs in native and non-native crayfish
- Significant interactive effect of season, site, and nativity (p=0.004)
- Concentrations greatest in our urban stream
- Non-native crayfish had higher MPs conc. versus native, regardless of the season

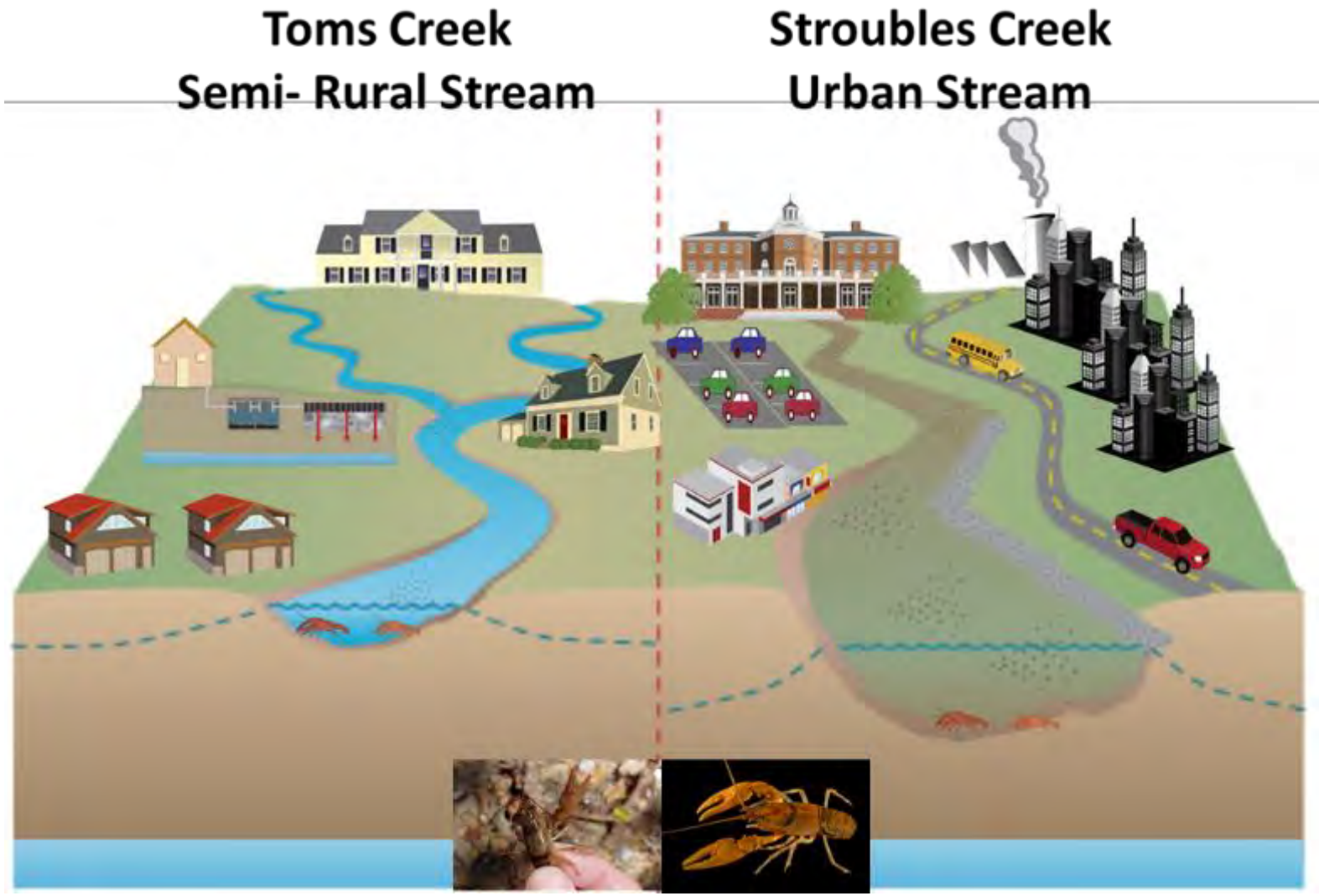


- 81% of particles recovered were plastic
  - 10% were rubber (TRWPs potentially)
- Polypropylene was the common polymer among all compartments
  - Greater MP polymer diversity in crayfish

Gray et al., 2024 (Env. Research)

Conclusions

- Pollution in urban streams corresponds to higher accumulation
- Keystone species introduce MPs to higher trophic level organisms
- Unknown toxicological implications of MP-associated additives
- Important to monitor to understand and preserve freshwater biodiversity



History of Microplastic Composition and Concentration in the Chesapeake Bay

In collaboration with Dr. Tina Dura

Made possible by a donation to the Coastal Zone Observatory by the Seales

- Since the rise of plastic production and use in the early 1950s, microplastics (plastics smaller than 5 mm) have been accumulating in onshore and offshore sediment sinks
- Salt marshes and estuaries are a significant sink for microplastics because they are inundated daily by tides and naturally accumulate sediment, and microplastics, through time

Photo: Summer 2023 fieldwork in Saxis Marsh, Bayside of Chesapeake, VA

Guiding research questions:

- How has the concentration and composition of microplastics varied through time since the mid-20th Century?
- Does microplastic concentration/composition differ in intertidal environments in the Chesapeake Bay versus Atlantic-facing intertidal systems?
- Relationship of microplastic concentration/composition to frequency of tidal inundation? What can this tell us about sea-level rise?

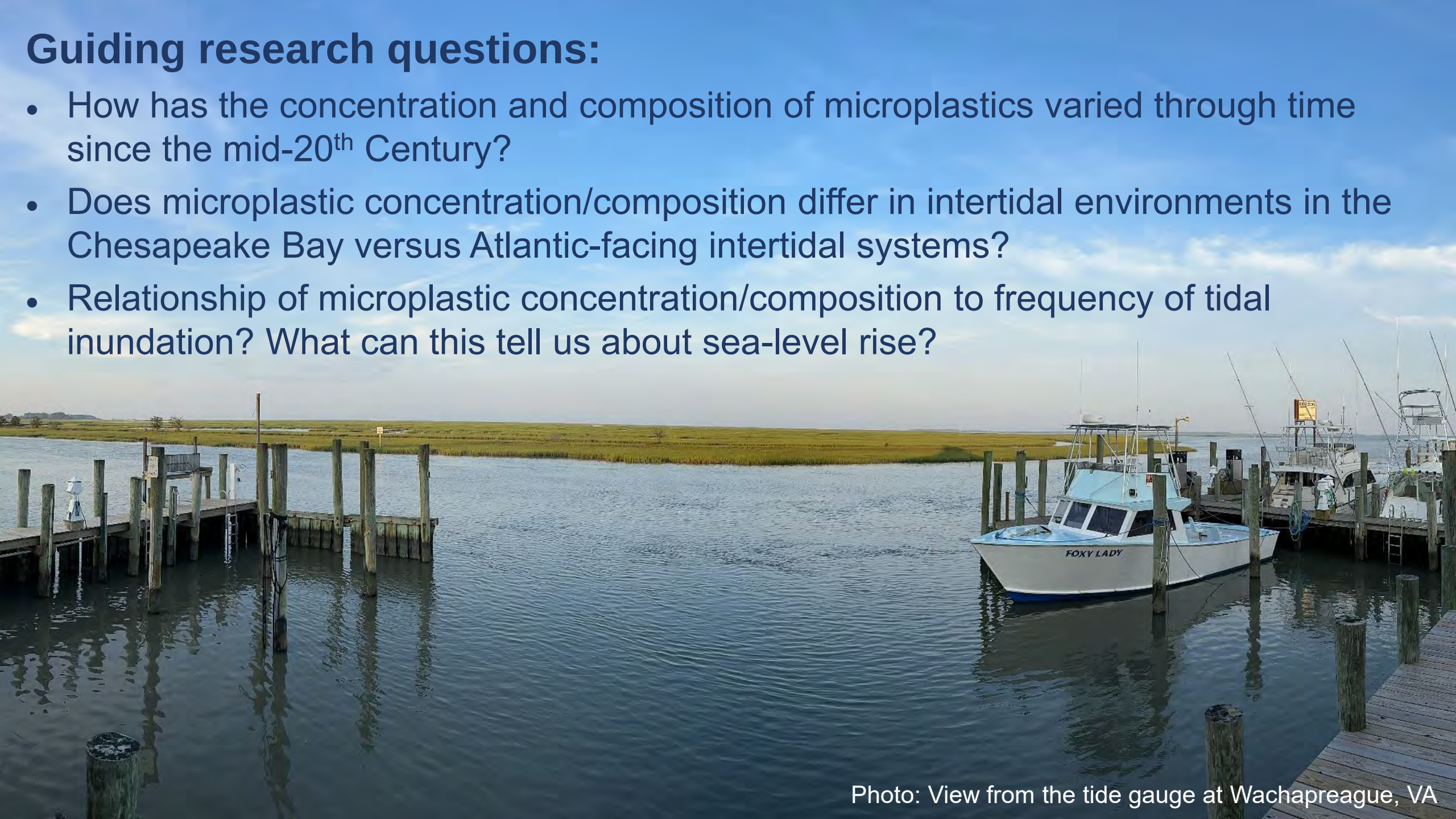


Photo: View from the tide gauge at Wachapreague, VA

Sediment MPs in the Chesapeake Bay?

- Densely populated area
- Accelerated sea-level rise
- Accelerated erosion
- Abundant sources of microplastics entering the bay

Photo: Storm flooding in Norfolk, VA

Skyler Ballard / Chesapeake Bay Program

PAUL HORN / Inside Climate News

Core and sample processing

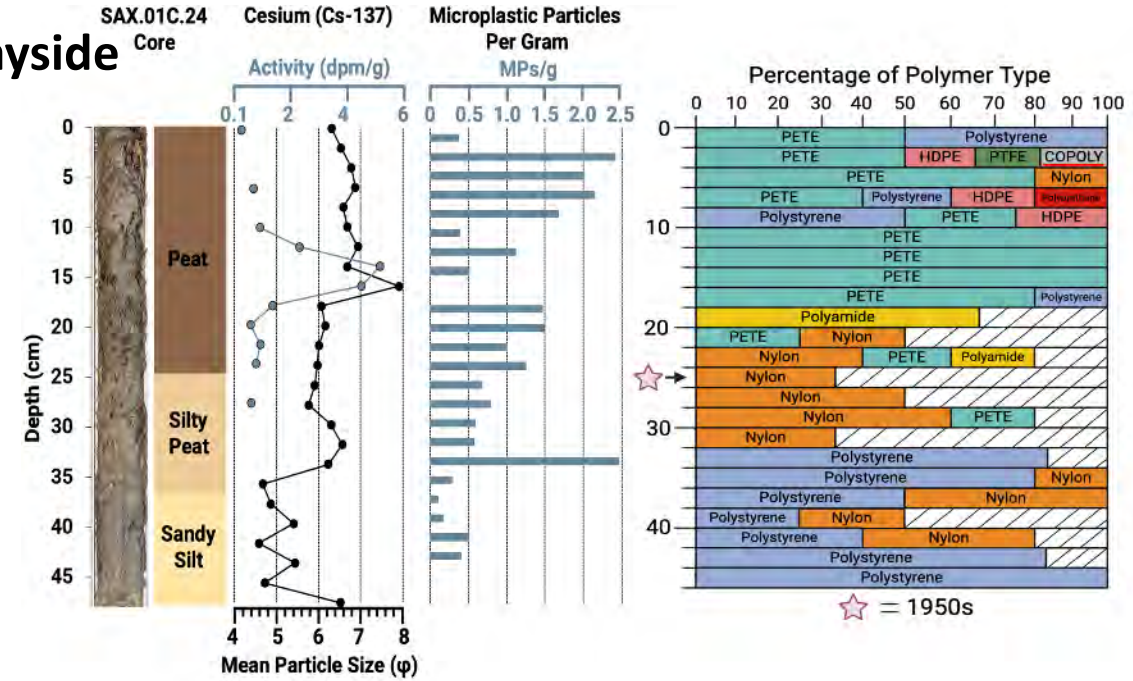
A microplastic!

Microplastics analysis

Coastal Hazards Lab

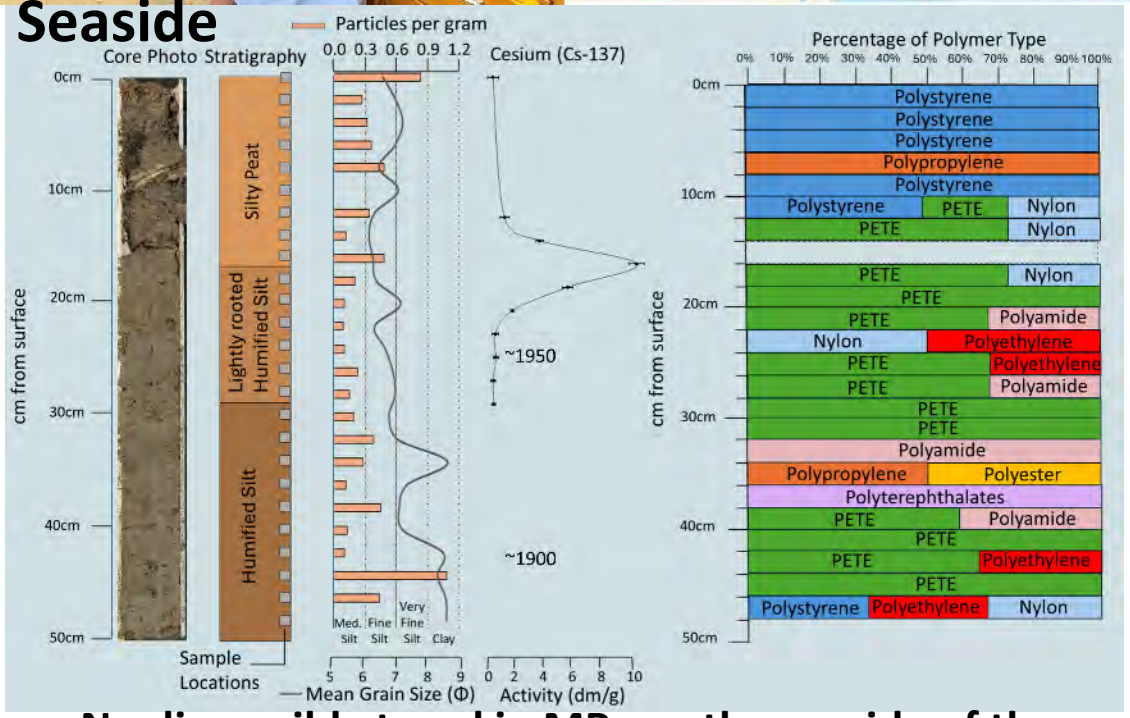
Grain size analysis

Bayside



Over time MPs increase along the bayside in the Chesapeake Bay

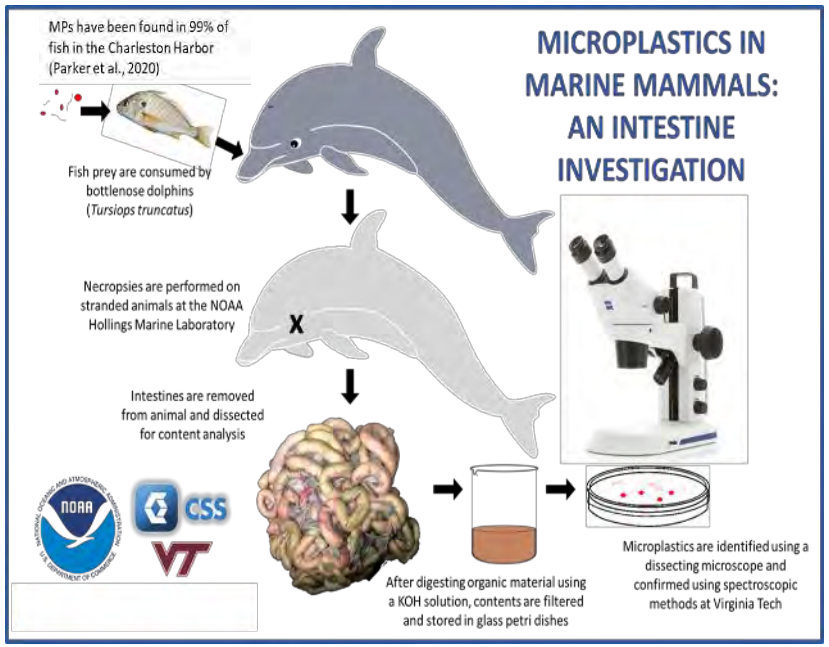
Seaside

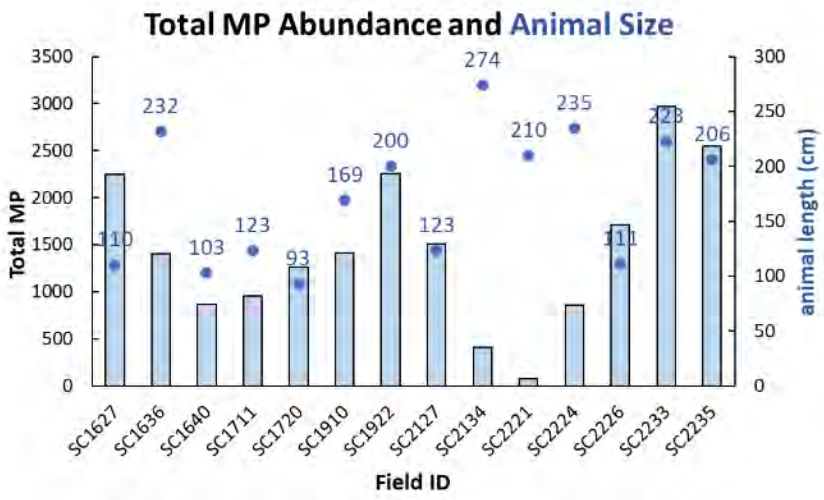


No discernible trend in MPs on the seaside of the Chesapeake Bay

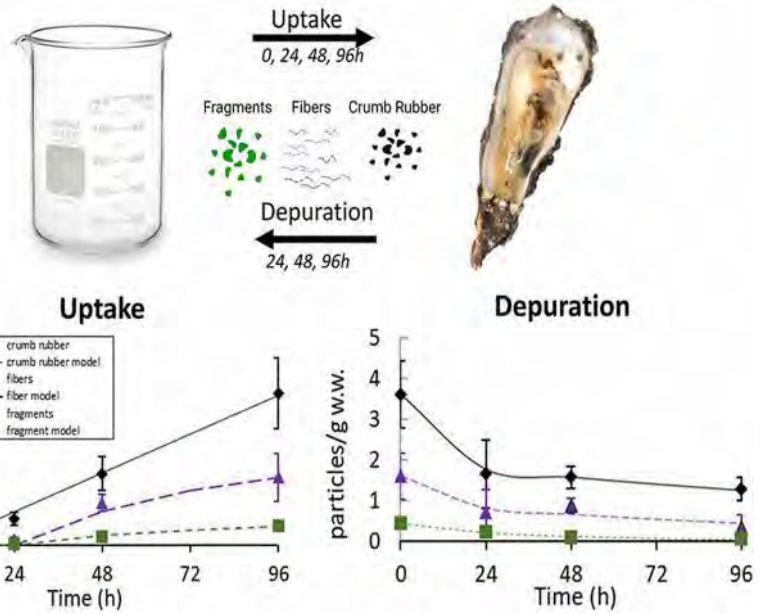
Gray Lab: Research priorities on MPs

Long-term Monitoring in Bottlenose Dolphins



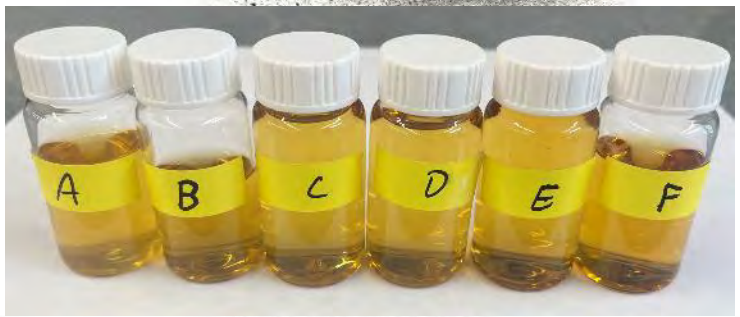


Accumulation in commercial seafood

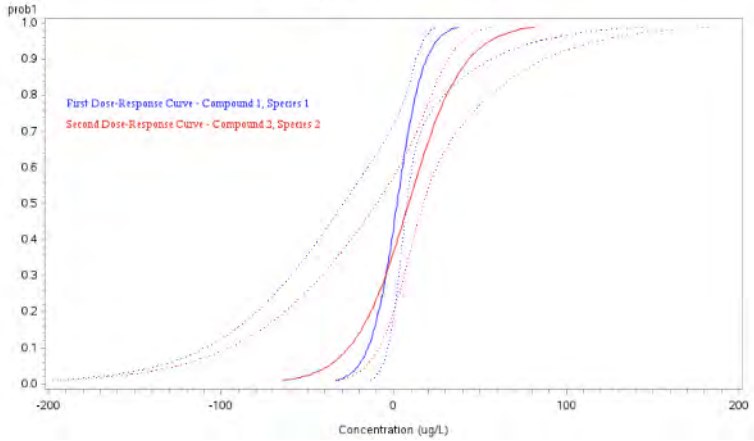


MP type	k_u (mL/g w.w.*h)	k_d (h^{-1})	BAF	$t_{1/2}$ (h)	C_{ss} (MP/g w.w.)
Crumb Rubber	0.0077	0.0048	1.604	144.4	8.02
Fibers	0.0084	0.0084	1.000	82.5	5.00
Fragments	0.0025	0.0205	0.1220	33.8	0.610

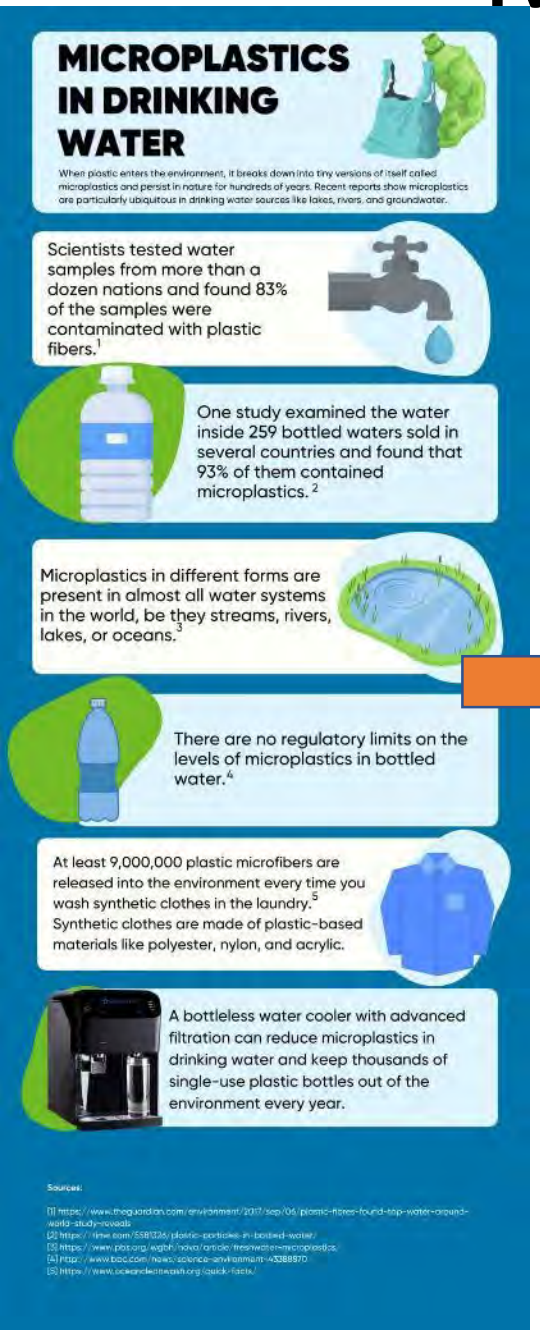
Acute toxicity of plastic leachate and additives



Dose-Response Curves with 95% C.I.



MP research priority for Virginia



HB 33 Public drinking water; Commissioner of Health's work group to study occurrence of microplastics.

Introduced by: **Nadarius E. Clark | all patrons** ... **notes | add to my profiles**

SUMMARY AS INTRODUCED:

Commissioner of Health; work group to study the occurrence of microplastics in the Commonwealth's public drinking water; report. Directs the Commissioner of Health to convene a work group to study the occurrence of microplastics in the Commonwealth's public drinking water and develop recommendations for the reduction of microplastics in the Commonwealth's public drinking water. The bill requires the work group to report its findings and recommendations to the Governor and the Chairmen of the House Committees on Agriculture, Chesapeake and Natural Resources and Health, Welfare and Institutions and the Senate Committees on Agriculture, Conservation and Natural Resources and Education and Health by December 1, 2024.

FULL TEXT

12/18/23 House: Prefiled and ordered printed; offered 01/10/24 24101241D pdf | impact statement

HISTORY

12/18/23 House: Prefiled and ordered printed; offered 01/10/24 24101241D

12/18/23 House: Referred to Committee on Rules

01/25/24 House: Assigned Rules sub: Studies Subcommittee

01/29/24 House: Subcommittee recommends continuing to 2025 by voice vote

02/01/24 House: Continued to 2025 in Rules by voice vote

CALIFORNIA
Water Boards
STATE WATER RESOURCES CONTROL BOARD
REGIONAL WATER QUALITY CONTROL BOARDS

POLICY HANDBOOK ESTABLISHING A STANDARD METHOD OF TESTING AND REPORTING OF MICROPLASTICS IN DRINKING WATER

August 9, 2022

Prepared by:
THE DIVISION OF DRINKING WATER
STATE WATER RESOURCES CONTROL BOARD
STATE OF CALIFORNIA

Austin_doug13

QUESTIONS?