TETRA TECH

Chesapeake Bay Program
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Framework for Monitoring Plastic Pollution in the Chesapeake Bay

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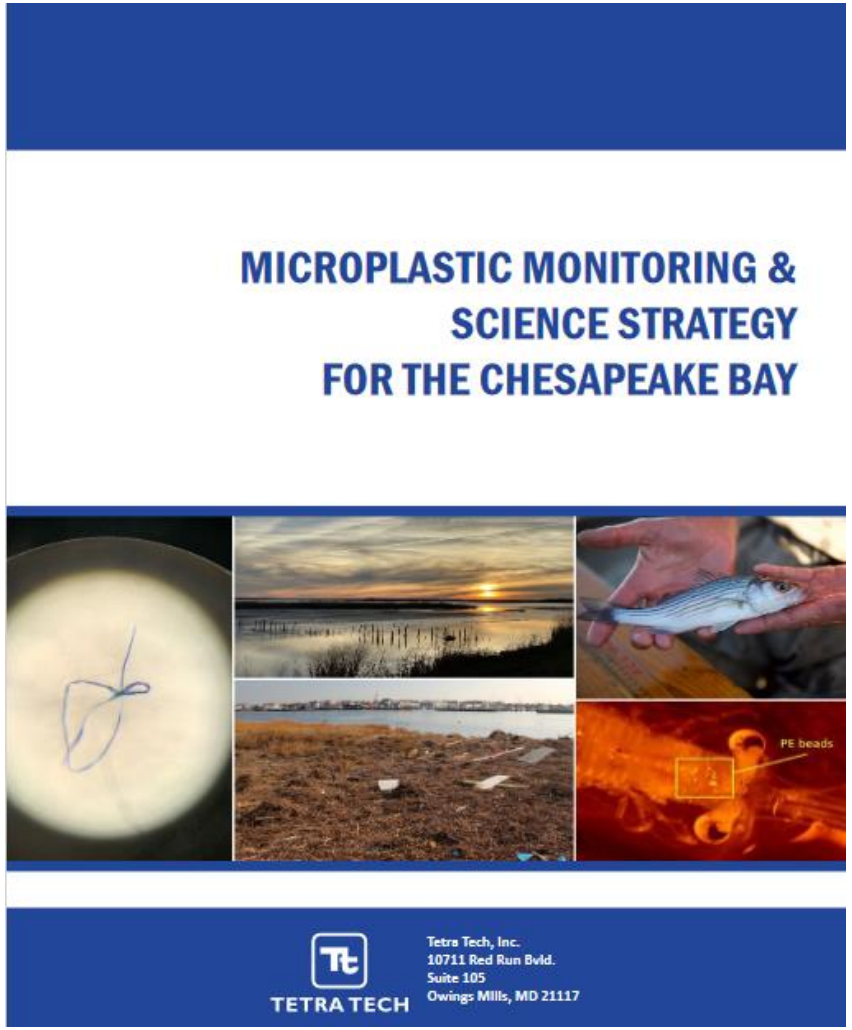
October 29, 2024

Microplastic Monitoring Strategy



The Plastic Pollution Action Team (PPAT) recommends the following priorities for the CBP to undertake:

1. Design and implement a microplastic monitoring program, integrated into the existing Chesapeake Bay watershed monitoring framework

2. Support research to understand microplastic pathways in the Bay, including trophic pathways that may affect living resources such as Striped Bass, Blue Crabs, Oysters, and other species critical to the Bay ecosystem

3. Ensure adequate infrastructure resources are available to process microplastic samples, including analytical equipment

4. Continue to support the PPAT in order to direct research, management, and policy development

Outline

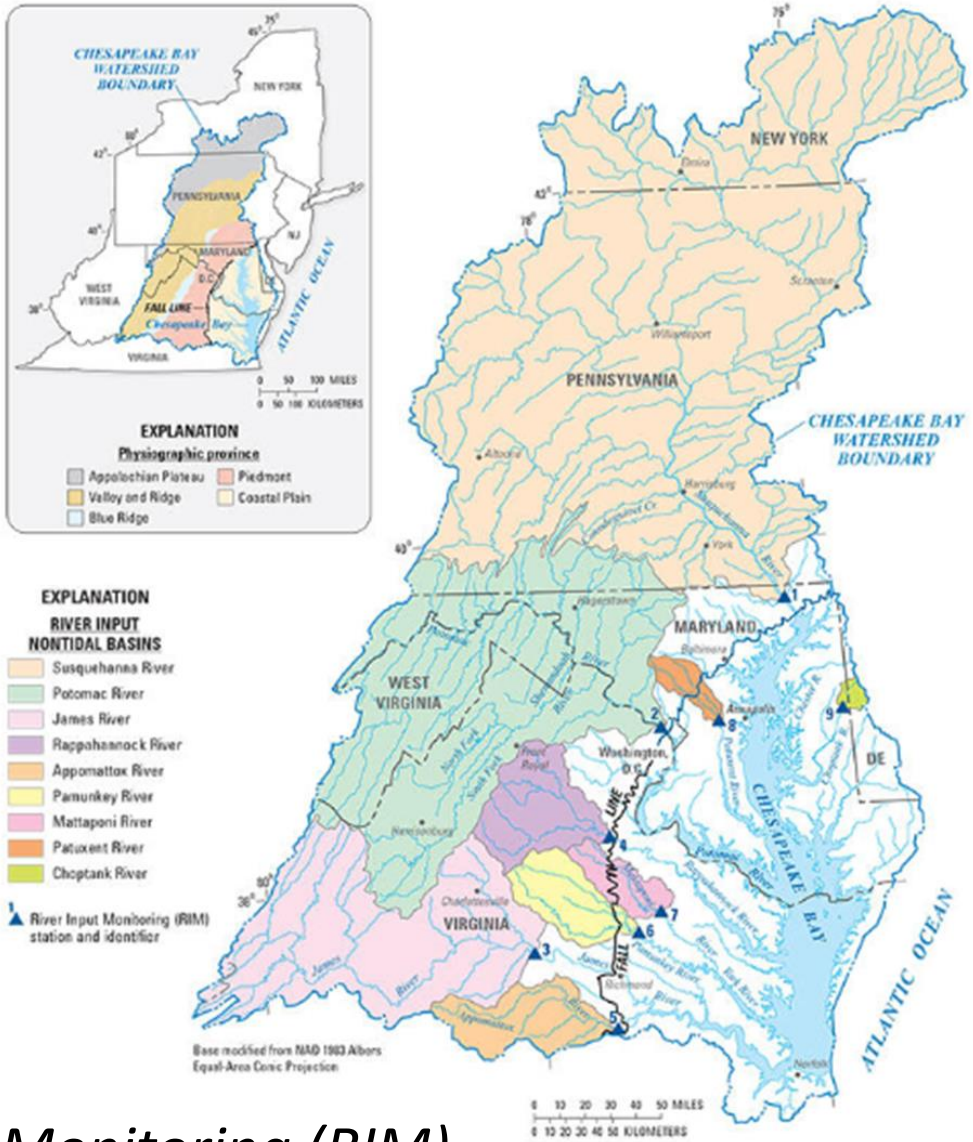
- Goals and Priorities
- Existing Water Quality Programs
- Monitoring Microplastic Concentrations and Trends
- Monitoring for Spatial Distribution of Microplastics at Varying Scales
- Major Exposure Pathways of Microplastics
- Monitoring for Concentrations and Toxicity of Microplastics in Ecological and Human Health Endpoints
- Recommended Near-term and Future-term Priority Actions

Goals and Priorities

- What is the current status (i.e., concentrations and loads) and future trends of plastic pollution in tidal and nontidal waters of Chesapeake Bay and its watershed?
- What is the spatial distribution of plastic pollution in the Chesapeake Bay watershed?
- What are the exposure pathways (i.e., wastewater, stormwater, aerial deposition) of plastics for the bay and its watershed?
- What are the sources (i.e., plastic products and usage) of plastics found in the bay and watershed?
- What is the range of concentrations for plastic pollution within the food web, focusing on species identified in the Chesapeake Bay 2014 Watershed Agreement Goals and Outcomes (e.g., blue crabs, oysters, brook trout, black duck) as well as other species of commercial and/or recreational importance (e.g., striped bass)?
- Are there discernible impacts evident from plastic pollution in the Chesapeake Bay watershed on water quality, living resources, and human wellbeing?
- Are the concentrations and loads of plastic pollution responding to management actions?

Leverage Existing Water Quality Programs

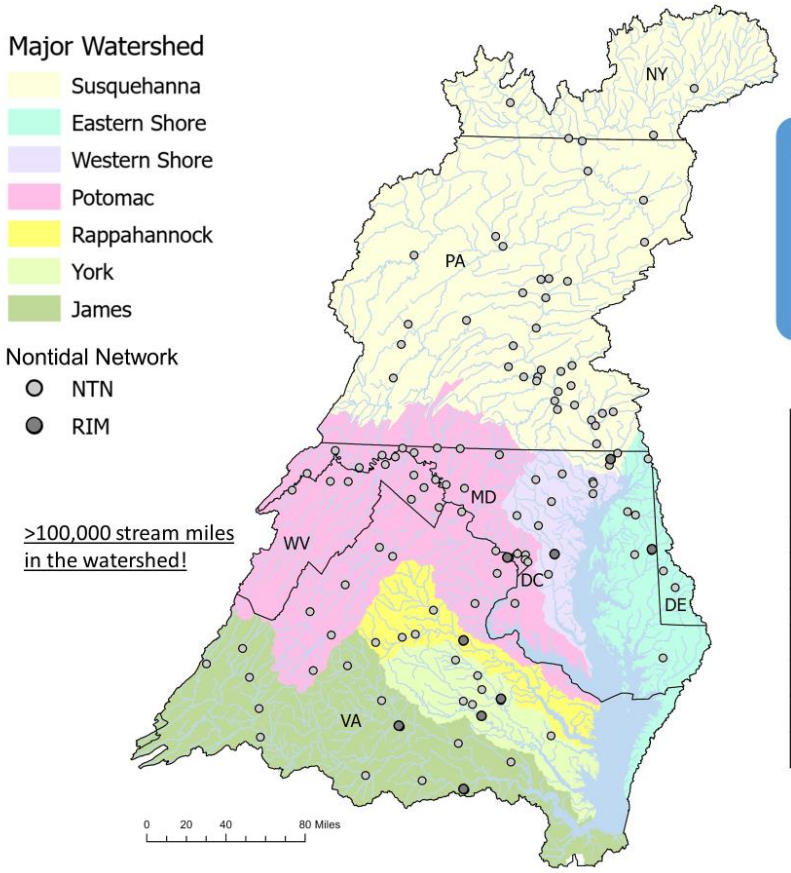
- Chesapeake-wide monitoring
- State-wide and regional monitoring
- Local government monitoring
- Non-Governmental Organization (NGO) monitoring



CBP River Input Monitoring (RIM)

Existing Water Quality Programs

- Chesapeake-wide monitoring
- State-wide and regional monitoring
- Local government monitoring
- Non-Governmental Organization (NGO) monitoring



Nontidal Network

Established in 2004

Some datasets pre-date 1985

123 active stations sampled

9 River Input Monitoring (RIM) sites

RIM = 78% of surface water flow to the Bay

State	Surface Area in CBW (mi^2)	NTN Monitoring Stations (count)
DC	68	3
DE	713	2
MD	11,576	32
NY	6,266	4
PA	22,610	35
VA	23,925	37
WV	3,577	10

CBW = 68,734 mi^2

Many stations monitor catchment areas across multiple jurisdictions.

CBP Nontidal Monitoring Network

Existing Water Quality Programs

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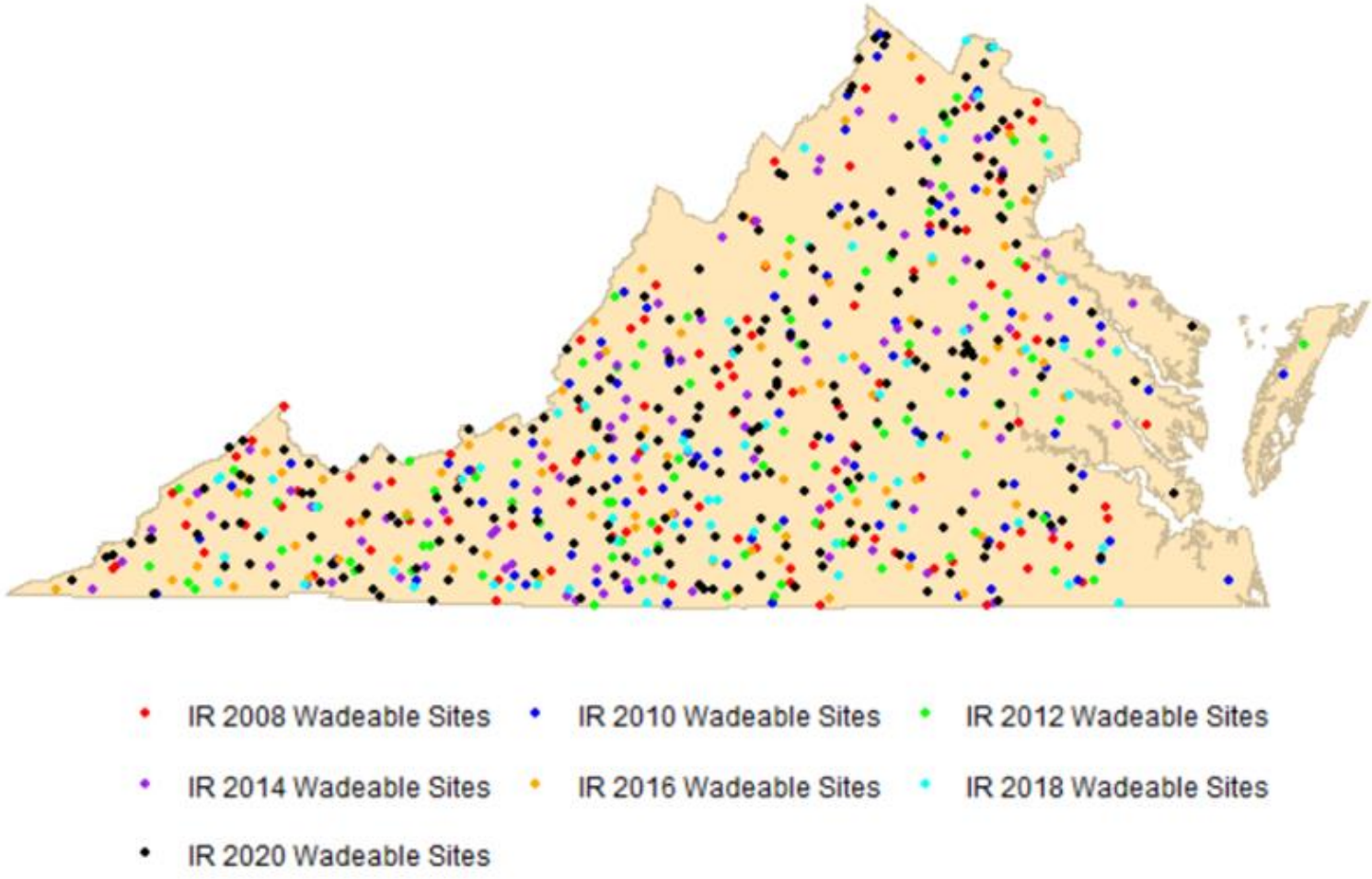

Virginia probabilistic monitoring wadeable locations

Existing Water Quality Programs

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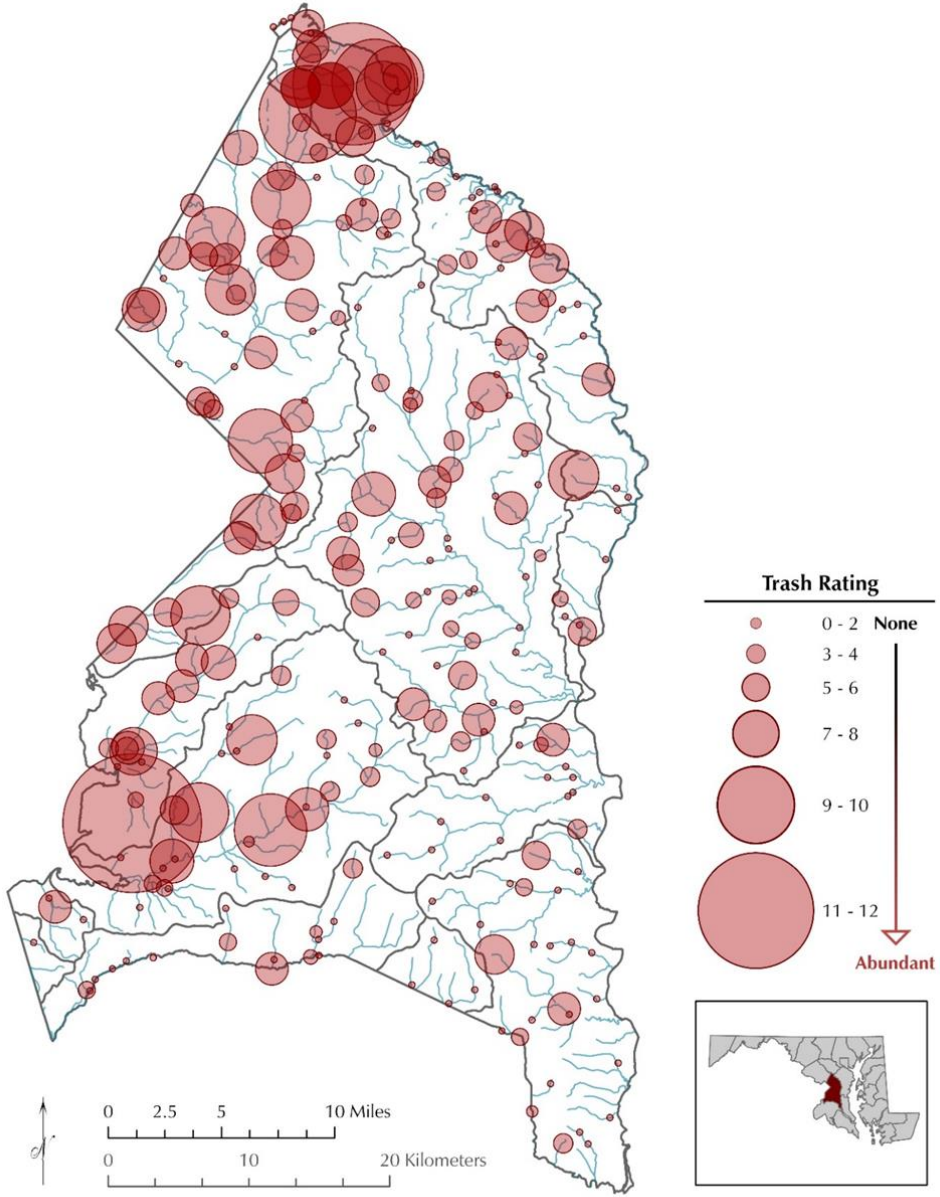

Prince George's County MD trash ratings at biological monitoring sites

Existing Water Quality Programs

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- State-wide and regional monitoring
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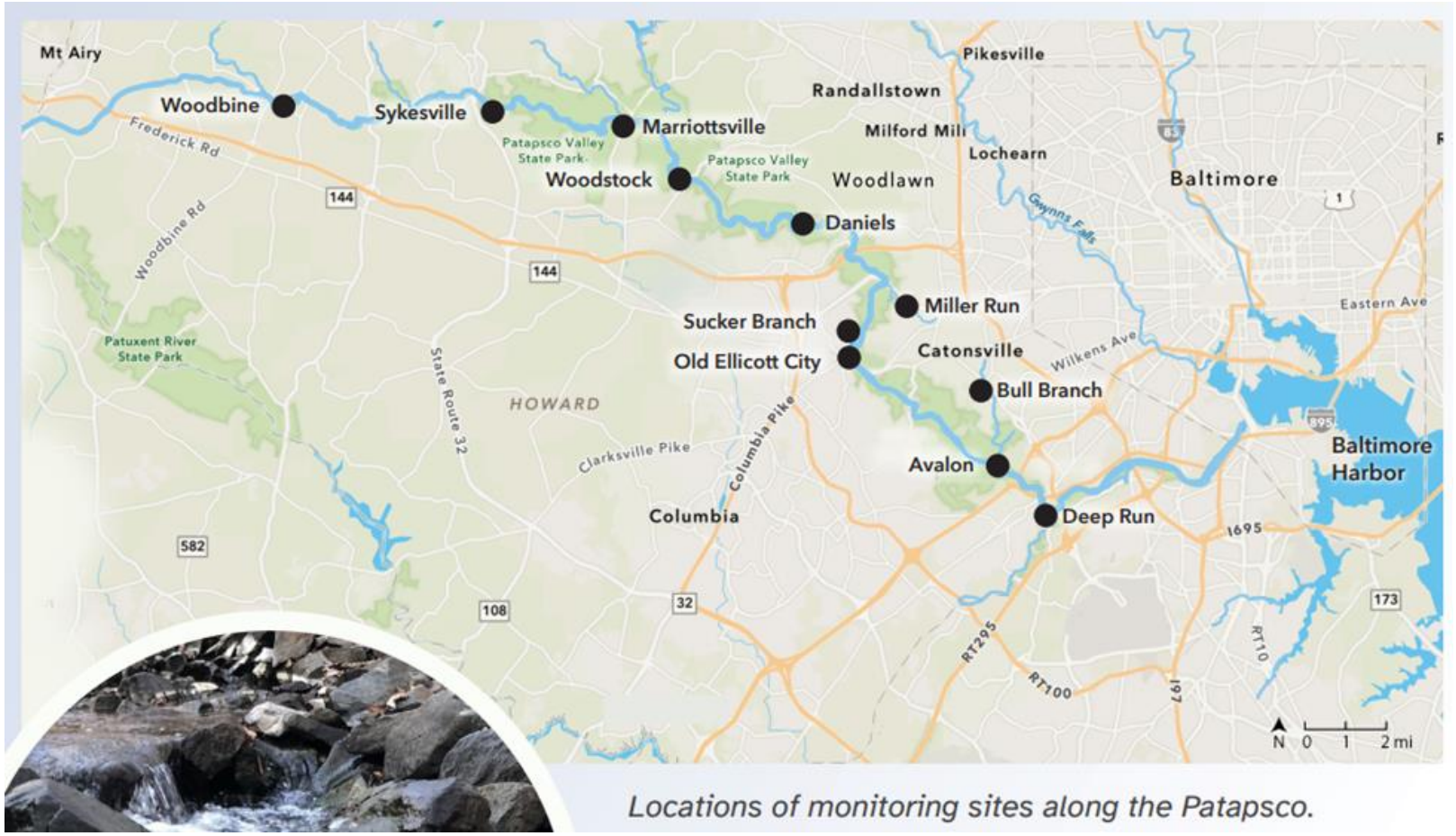
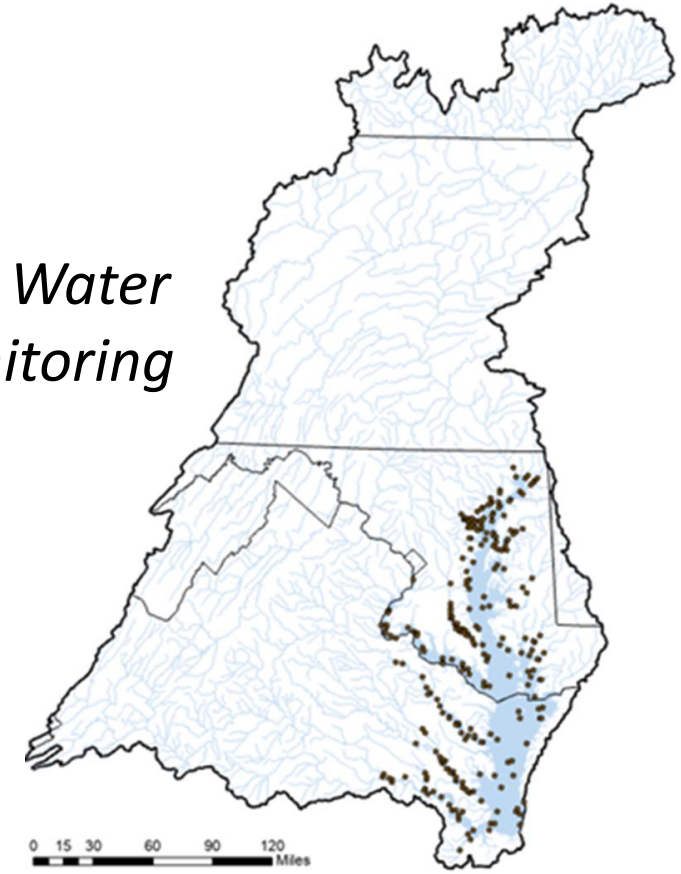


Patapsco Heritage Greenway (PHG) volunteer monitoring sites

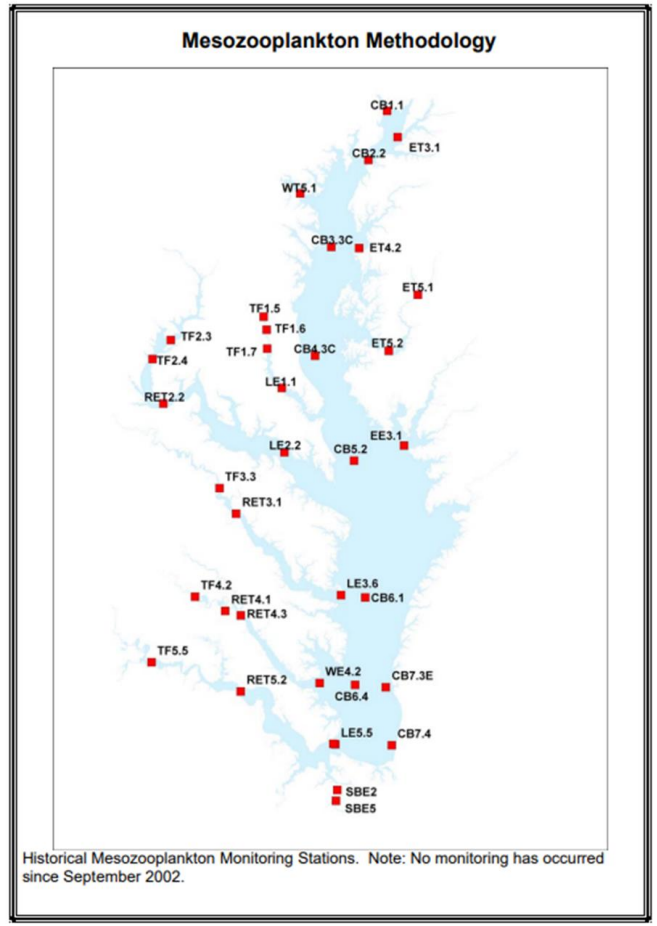
Monitoring Microplastic Concentrations and Trends

- Chesapeake Bay Loadings from Tributaries (RIM)
- Chesapeake Bay Tidal Water Quality Monitoring

Zooplankton Water Column Monitoring

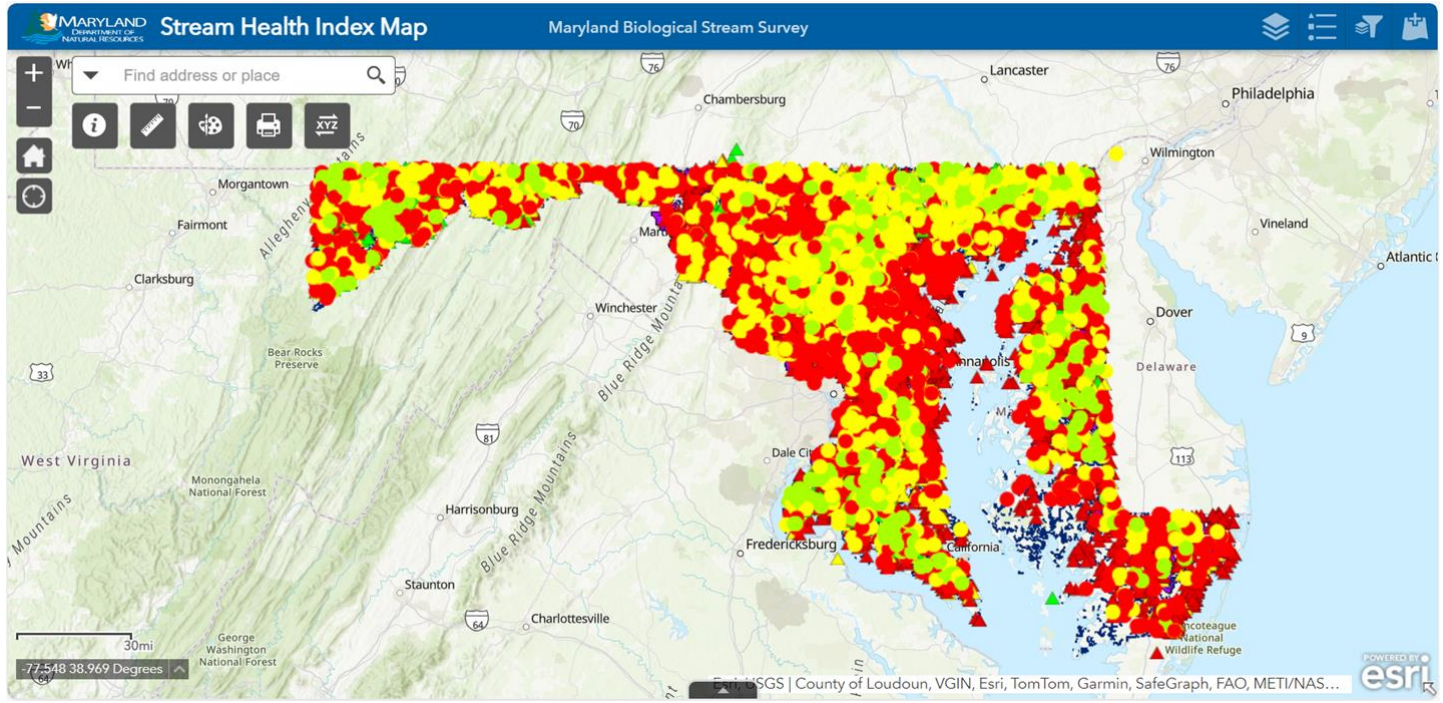


Long-Term Benthic (LTB) Sediment Monitoring

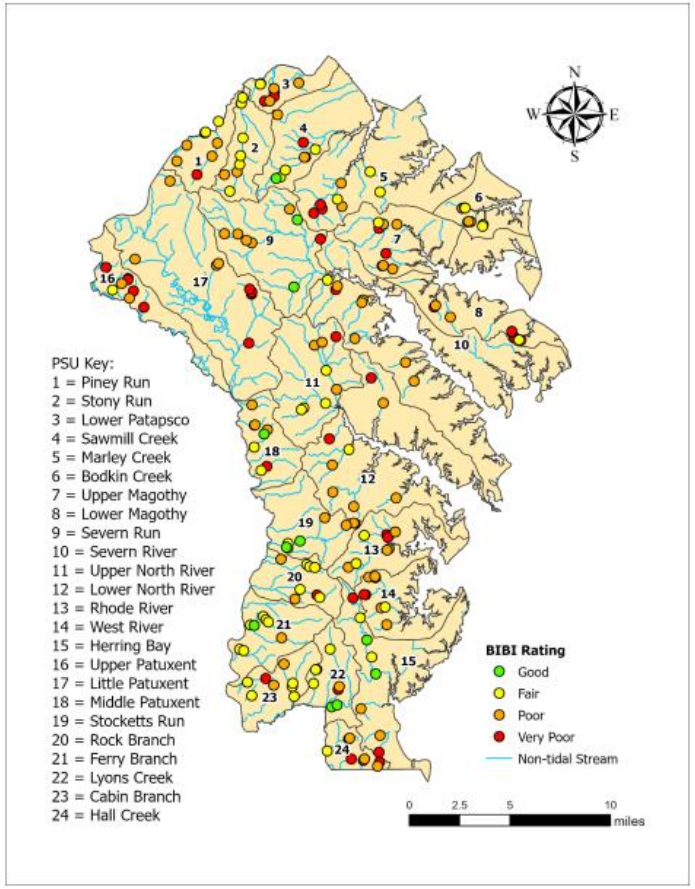


Monitoring for Spatial Distribution of Microplastics at Varying Scales

- Probabilistic Sampling of Non-tidal Streams



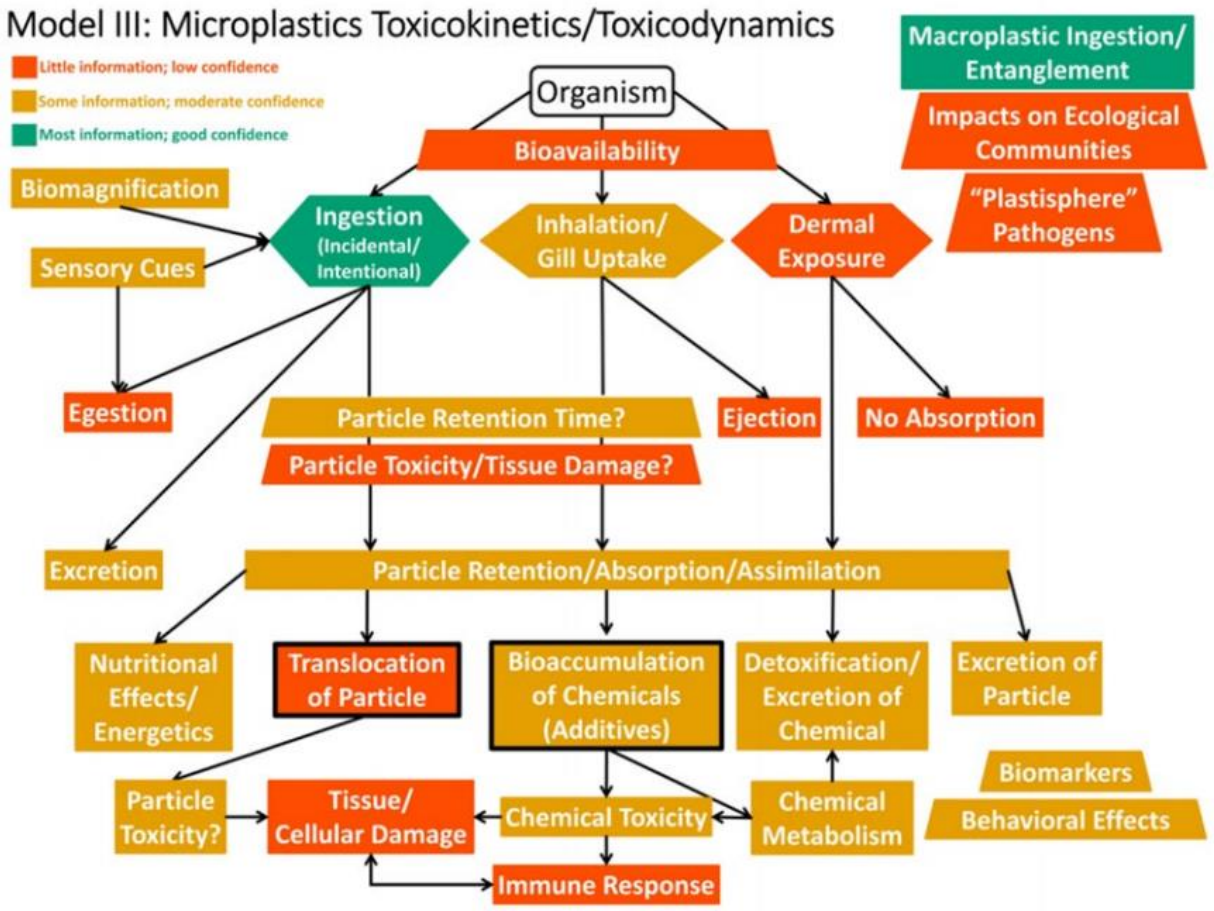
Maryland Biological Stream Survey (MBSS)



Watershed assessment sampling by counties

Major Exposure Pathways of Microplastics

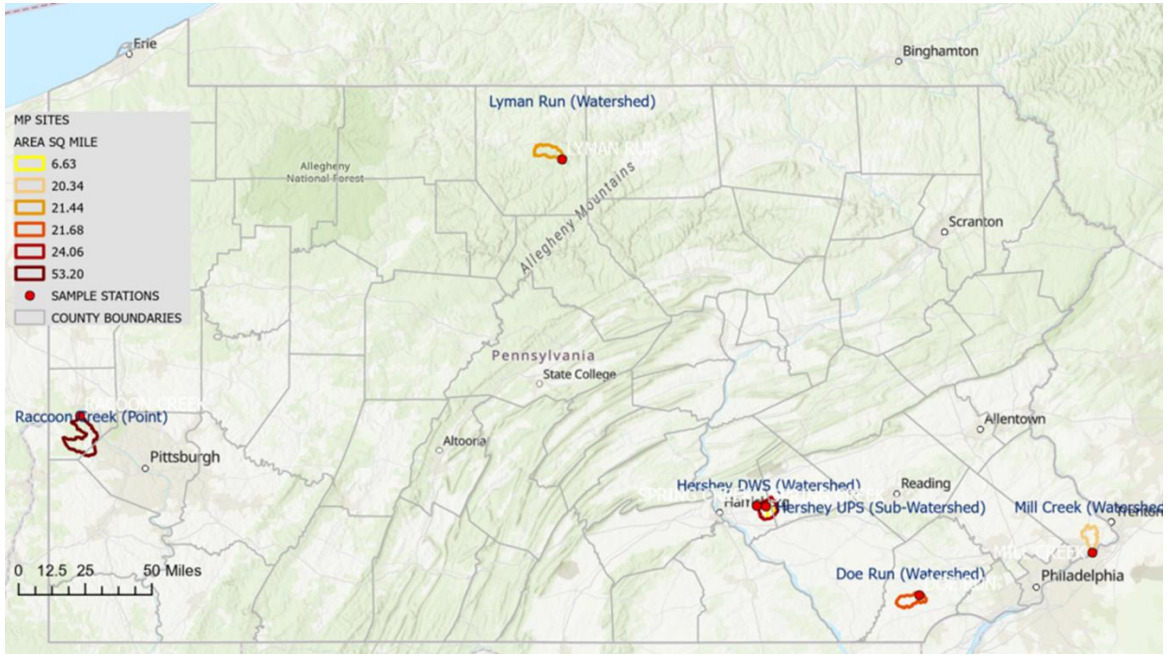
- Needed to reduce risk to human and natural environment
- Exposure pathways from sources to endpoints is critical to effective reduction strategies
- Conceptual model of the sources, fate, transport, and ultimate destination of microplastics
- Trophic studies such as water to mysids to striped bass



EPA conceptual model of pathways for plastic pollution (2017)

Pollution Monitoring for Sources, Types, and Transformation of Microplastics Pollution

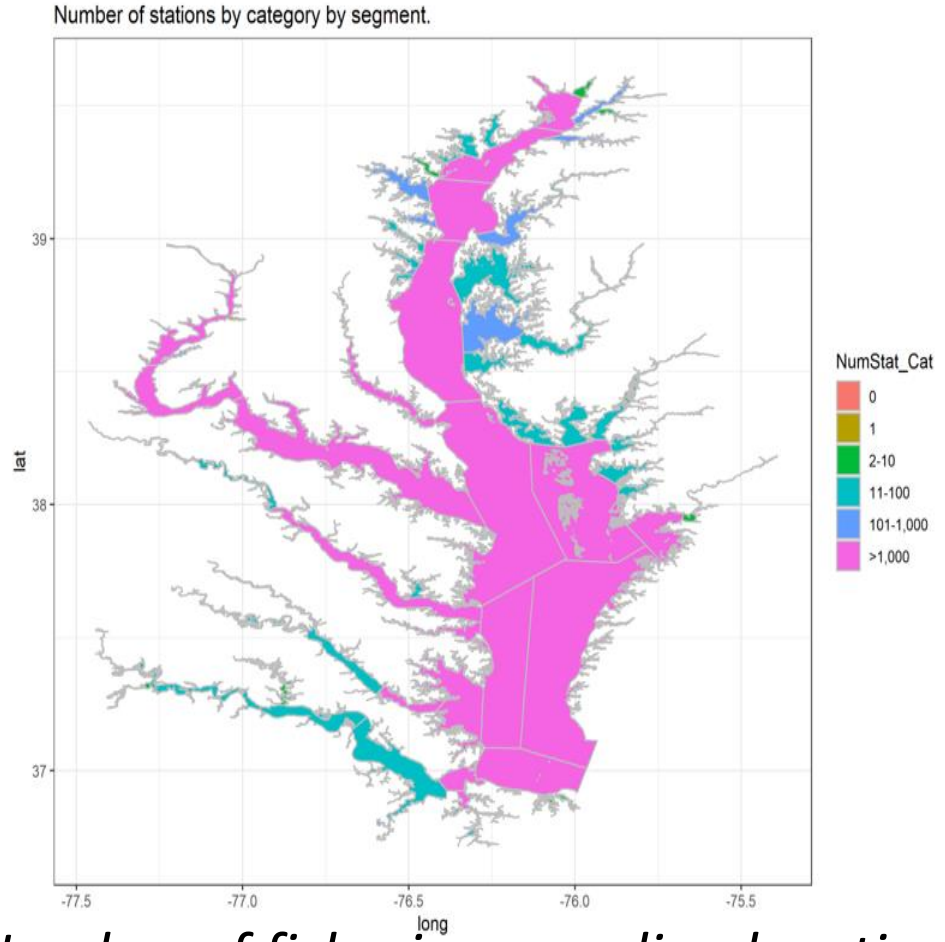
- All locations not practical, so focus on types (shape and composition) of that can be linked to potential sources
- Proximal sources like plastic bags, soda bottles, coated paper, and plastic fibers from tires and clothing
- Ultimate sources of urban land, agriculture, landfills, wastewater treatment plant discharges and sludge application, residential washing machines, and litter zones
- Systematic polymer and fiber analyses on representative samples from other monitoring programs
- Tying hotspots to types and sources is most promising method of local pollution reduction



Pennsylvania sample sites for microplastics pilot study

Monitoring for Concentrations and Toxicity of Microplastics in Ecological and Human Health Endpoints

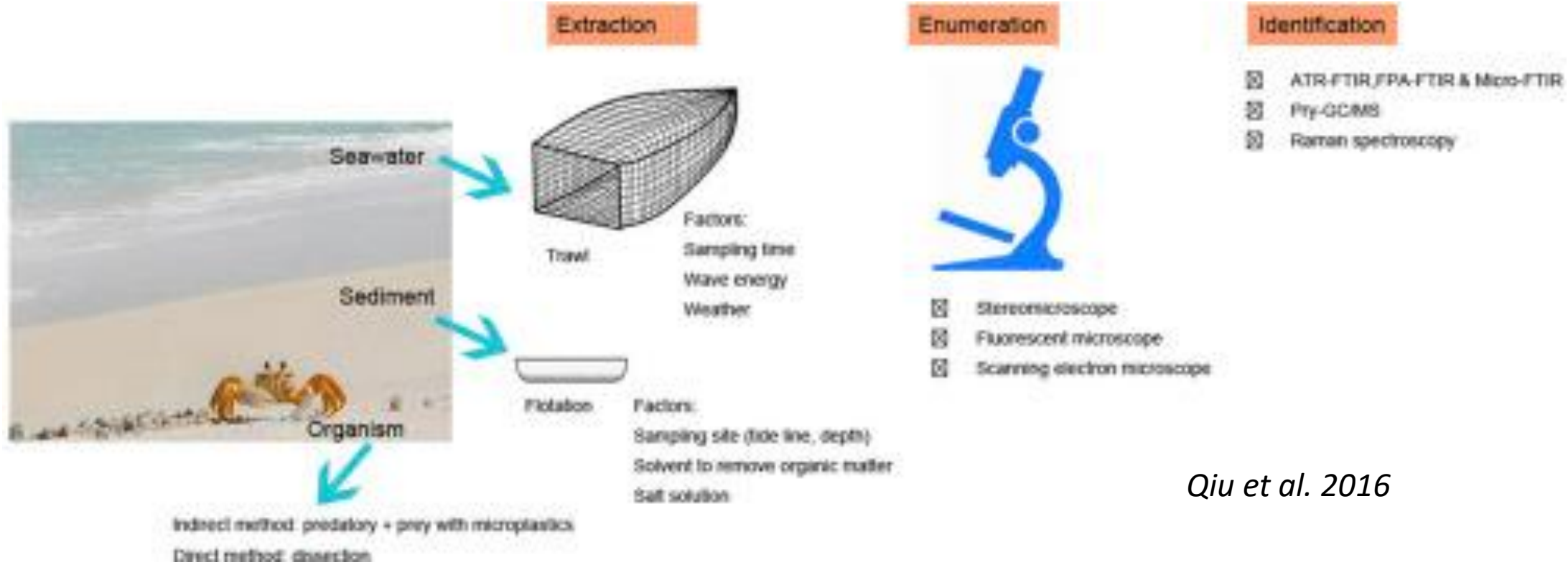
- Living resources—brook trout, striped bass, blue crabs, oysters
- Bioaccumulation, degradation and transformation
- Stomach content analyses (e.g., VIMS' ChesMMAP)
- Some state and local governments routinely sample fish and benthic macroinvertebrate that could be subsampled for laboratory analyses
- Laboratory studies of toxicity to determine potential human health and environmental impacts and inform management strategies.



Number of fisheries sampling locations within Bay segments

Monitoring Reference Guides

- Best professional practices such as “Uniform Size Classification and Concentration Unit Terminology for Broad Application in the Chesapeake Bay Watershed” Example: number of particles per sediment volume (not per surface area)
- Expectation that new research may update/refine methodologies



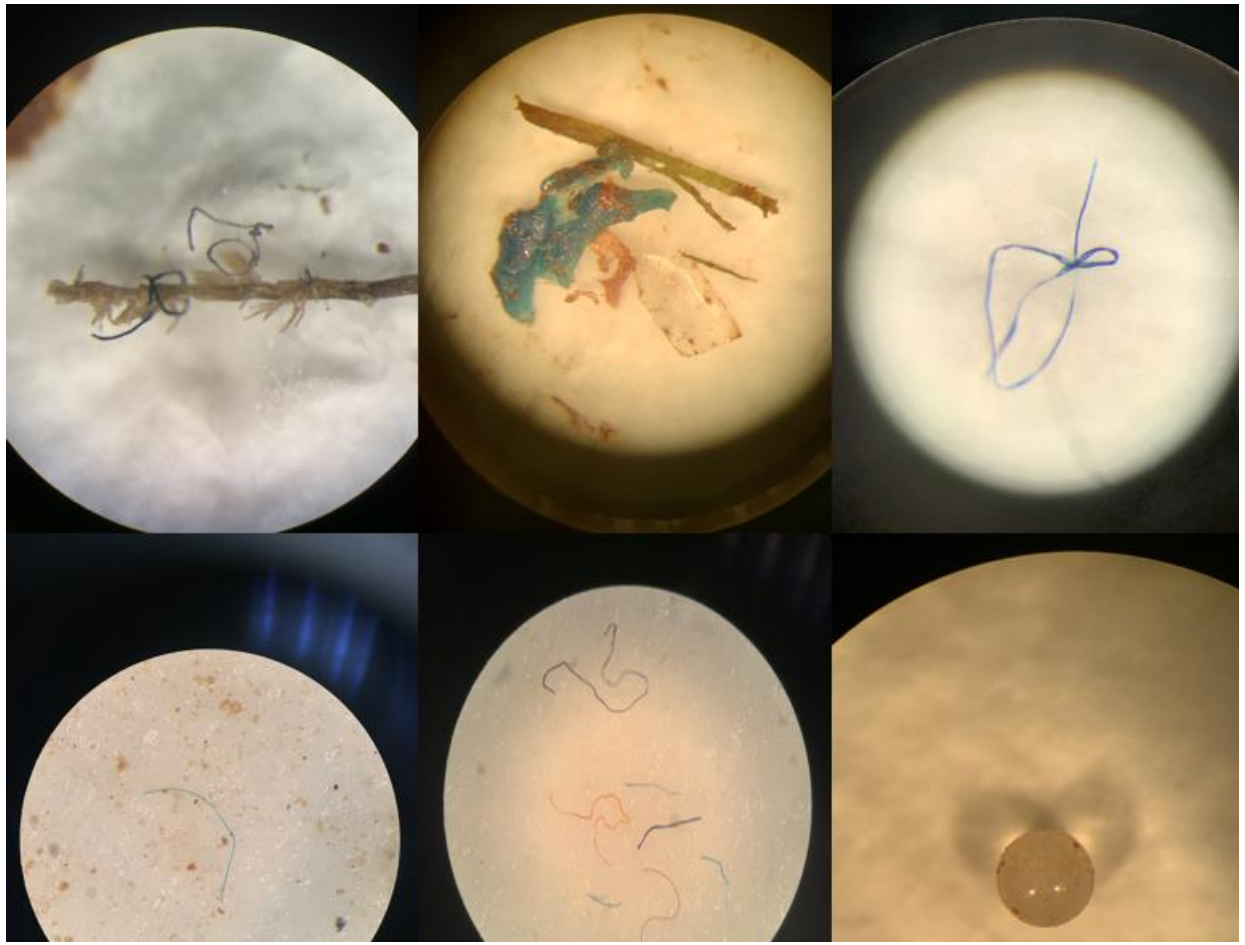
Qiu et al. 2016

Field Sampling Reference Guide

- Literature review
- Survey design
- Methods for sampling different media
  - Water (grab, trawl, composite, stationary net)
  - Sediment (grab, core, transects)
  - Biota (fish, other)
- Waterbody types (lakes/ponds, rivers/streams, wetlands, estuaries/open ocean)
- Sediment types (beach/shoreline, benthic environments)
- Biota types (fish, other)

Laboratory Reference Guide

- Literature Review
- Common Analytical Methods
  - Digestion
  - Density Separation
  - Filtration
  - Identification
- Common Analytical Methods Based on Sample Media
  - Water
  - Sediment
  - Biota
- Quality Control
  - Sample spikes and blanks



Monitoring Framework Recommendations

- Consider adding the goal of no net increase in MP pollution to the Bay Agreement
- Institute & implement a monitoring program to measure attainment of goal and support related goals
- Add MP sampling and analysis of water & sediment to existing or new CBP monitoring networks
- Estimate bay loads of MP to Bay tributaries for annual status & trends reporting
- Facilitate incorporation of MP sampling into state & local monitoring programs
- Conduct focused sampling of known MP sources (ie wastewater)
- Monitor plastic type in 20% of samples to understand plastic products and sources
- Determine MP concentrations in select species of ecological and human health importance
- Conduct focused food web studies to better understand trophic pathways
- Undertake scientific studies of the degradation of plastics and their role as a vector of toxicity

Recommended Priority Actions

Recommendation	Near-term Actions	Future-term Actions	Potential Program Partners
1. **Consider adding the goal of no net increase in microplastic pollution to the Bay Agreement**	• Work with partners including identifying a champion jurisdiction to justify the no net increase goal in response to the Beyond 2025 effort and present to Management Board	• Garner full support of CBP to achieve no net increase in microplastic pollution using this monitoring framework as a baseline	• CBP Management • PPAT • GITs • WGs • Champion jurisdiction
2. **Institute and implement a monitoring program to measure attainment of this no net increase goal and support related goals, such as identifying controllable sources of microplastics**	• Ensure that adequate capacity and resources are available for field sampling, laboratory analysis, and data management of a robust monitoring program	• Continue providing resources needed to answer long-term questions	• EPA CBPO • PPAT
3. **Add microplastics sampling and analysis of water and sediment to existing or new CBP monitoring networks**	• Add microplastic collections and analysis of 12 monthly water column samples and 8 storm-event samples annually at 9 RIM stations • Add microplastics analysis of sediment collected by LTB program at its 48 fixed sites annually • Identify one or more institutions that will receive microplastic samples for analysis or archiving • Identify a central repository for microplastic	• Work with CB WQ monitoring network partners to sample about half of 126 stations for microplastics, evenly divided between bay and tidal tributaries • Add microplastics analysis to sediment collected by LTB at spatially balanced 40 of 166 random sites • Consider reinstating zooplankton monitoring program with microplastics sampling • Consider creating a bay-wide beach monitoring program for microplastics	• CB WQ monitoring network participants • EPA CBPO and MD and VA agencies conducting LTB and potentially zooplankton monitoring • ChesMMAP • NCEI

Recommended Priority Actions

Recommendation	Near-term Actions	Future-term Actions	Potential Program Partners
	data or submit data to National Centers for Environmental Information (NCEI) repository for multiple datasets of marine microplastics		
4. **Estimate bay loads of microplastics from each of the major Bay tributaries for annual status and future trends reporting**	• Estimate annual loadings of microplastics using the CBP and USGS methods developed for existing nutrient and sediment loadings calculations	• As years of monitoring accumulate, the trends estimation methods used for nutrients and sediment can also be applied to microplastics results	• EPA CBPO • USGS
5. **Facilitate incorporation of microplastic sampling into state and local monitoring programs wherever possible to build an increasingly complete picture of the spatial distribution of microplastics status and trends**		• Ask each state with a probabilistic non-tidal stream survey (e.g., MBSS) to collect a minimum of 40 water samples (and benthic macroinvertebrate samples if desired) from a spatially balanced random subset of sites. Future sampling designs will lessen sampling in areas of homogenous results and address apparent hotspots • Ask each state with long-term fixed site network to collect a minimum of 20 water samples annually for future trends analysis	• WV DEP • MD DNR • VECOS • VA DEQ • State regulatory agencies • DWSPP • DC DOEE • MS4s • NGOs within CMC
6. **Conduct focused sampling of known proximal (i.e., wastewater, stormwater, aerial deposition) and ultimate (e.g., land uses) microplastic sources in sufficient numbers to characterize variation across the Bay watershed**	• Support the Pennsylvania pilot study designed to sample (1) known microplastics sources, (2) upstream-downstream contributions, and (3) contributions from forest, urban, and agriculture land uses	• Develop systematic monitoring of microplastics in wastewater, stormwater, and aerial deposition at 40 locations (or 10 locations as a pilot) each within the Chesapeake Bay watershed • Work with local governments that monitor catchments of dominant land use to expand on the Pennsylvania pilot.	• EPA CBPO • PA DEP • MS4s • State health departments • State agencies regulating wastewater treatment facilities

Recommended Priority Actions

Recommendation	Near-term Actions	Future-term Actions	Potential Program Partners
		• Ask state regulatory agencies to require wastewater treatment facilities to add microplastics sampling and analysis to their monitoring	
7. **Implement plastic type (shape and composition) identification in 20% of randomly selected samples to develop an accurate picture of plastic products and ultimate sources leading to microplastic pollution, where possible**	• Expand on trash monitoring for local TMDLs (e.g., Anacostia) by adding microplastic sampling to these efforts as an opportunity to match trash types and microplastic amounts for a better understanding of plastic product sources.	• Use consistent existing methods (see Appendix B Laboratory Reference Guide) or develop new comparable diagnostic polymer and fiber analyses to evaluate representative samples from the spatially extensive monitoring programs • Use reference sites as measures of background microplastics in the environment (e.g., MBSS sentinel and local reference sites) • NGOs may have specific designs to meet specific goals that can be related to microplastics for source identification • When possible, incorporate microplastic type identification into extensive non-tidal stream sampling programs to identify specific microplastic pollution hotspots to be controlled	• CBP and academia • State agencies and local governments • NGOs
8. **Determine microplastics concentrations in select species of ecological and human health importance in sufficient numbers to characterize variation across the Bay watershed**	• Add microplastics analysis to existing Chesapeake Bay fish monitoring programs (e.g., VIMS' ChesMMAP) that collect stomachs	• Extend fish stomach collections and analysis for microplastics analysis to state and local governments that sample fish throughout their non-tidal streams • Work with state and local governments to collect a subsample of the fish and invertebrates for microplastics	• EPA CBPO • VIMS ChesMMAP • State agencies and local governments • NGOs

Recommended Priority Actions

Recommendation	Near-term Actions	Future-term Actions	Potential Program Partners
		analysis from regular non-tidal monitoring • As a first step to address human exposure, work with local governments and NGOs to add microplastics to regular or volunteer monitoring for bacteria at beach sites	
9. **Conduct focused food web studies to better understand the trophic pathways leading to microplastics concentrations in these species**	• Conduct targeted sampling of selected species to identify presence of microplastics (e.g., brook trout, striped bass, blue crabs, oysters, and black duck)	• Conduct systematic studies on the trophic pathways of microplastics through the food web, focusing on brook trout, striped bass, blue crabs, oysters, and black duck	• CBP and academia
10. **Undertake scientific studies of the degradation of plastics and their role as a vector of toxicity and other risk factors affecting the ecosystem and human health**		• Conduct laboratory studies of toxicity of microplastics and associated substances on brook trout, striped bass, blue crabs, and oysters. • Expand on VIMS study of impacts of microplastics on bacterial communities and the nitrification/denitrification process • Implement degradation studies and source-sink models for the Bay.	• CBP and academia