Updates from the Plastic Pollution Action Team

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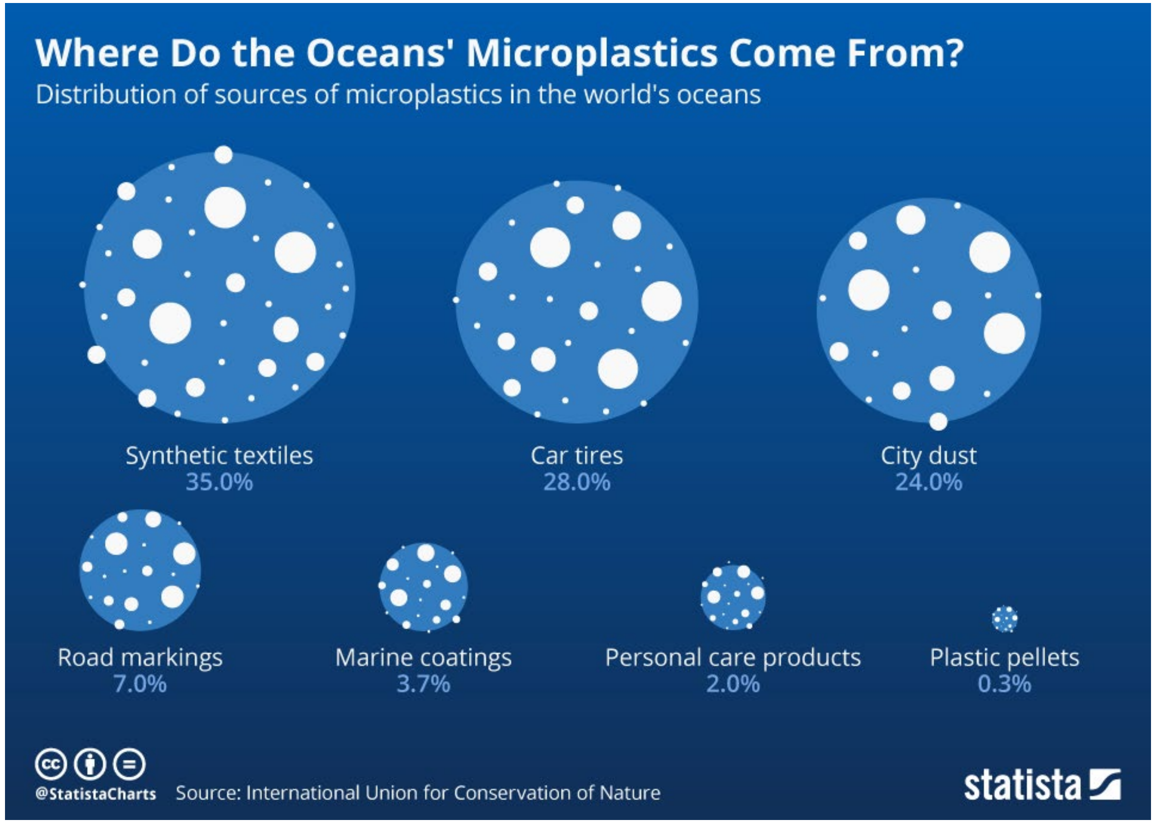
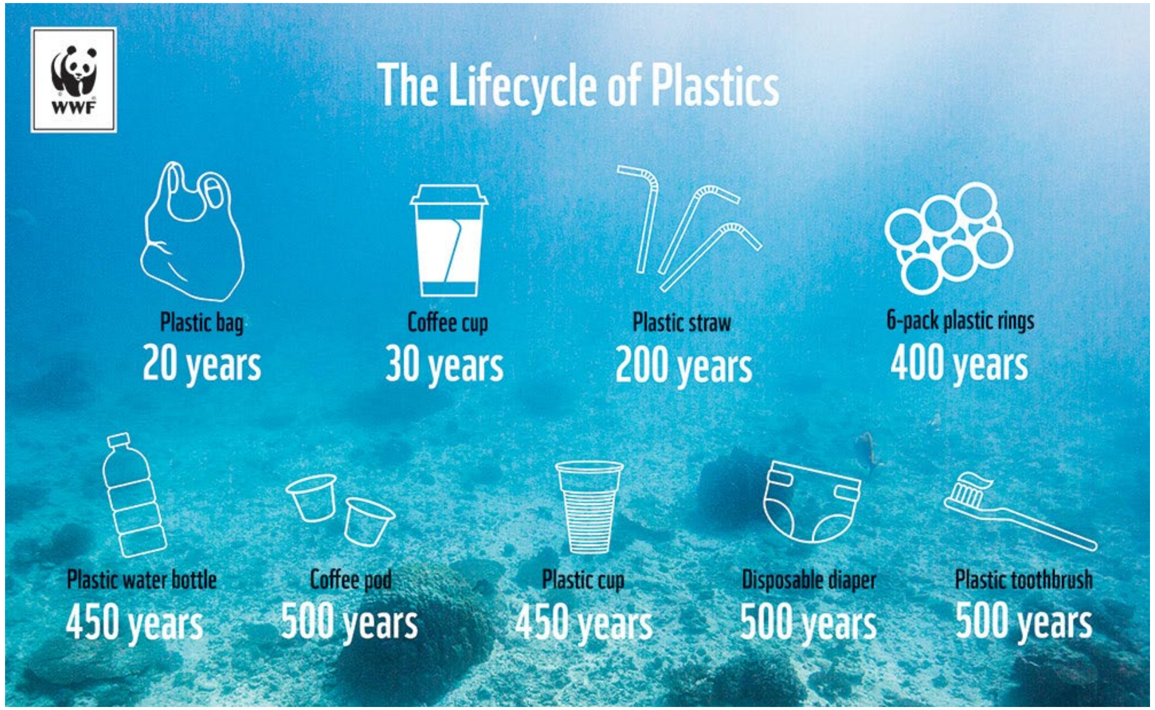
Collaborators: Matt Robinson (EPA), chair; Bob Murphy (Tetra Tech), Justin Shapiro (CRC)

January 13th, 2023

What are Microplastics?





Microplastics in the Chesapeake Bay

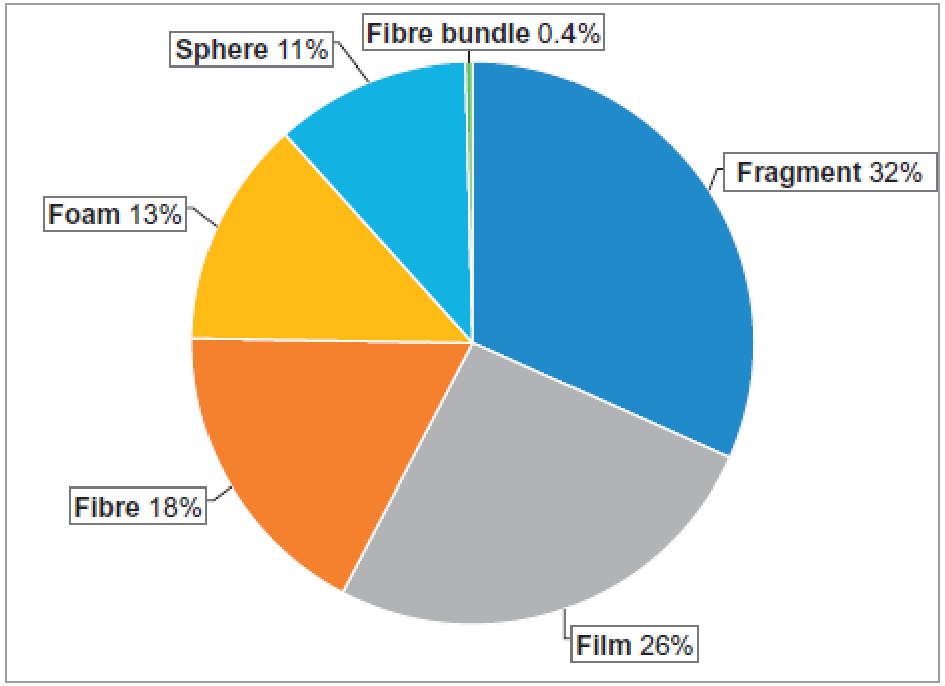
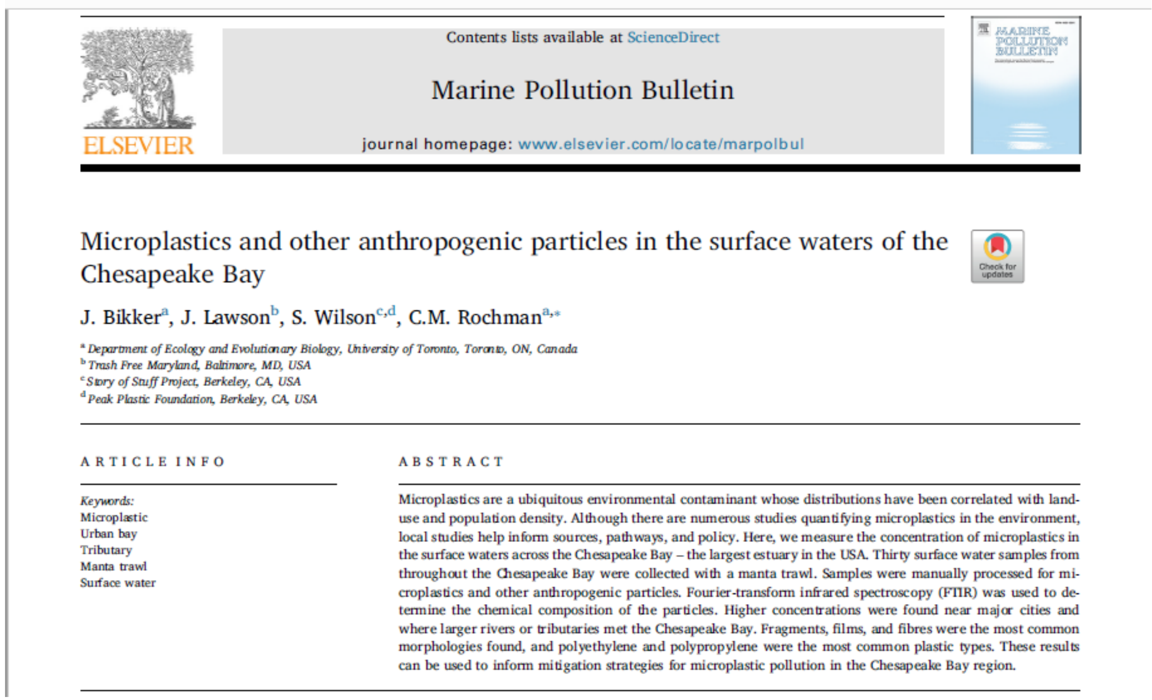


Fig. 3. Morphology of particles from thirty surface water samples (after blank correction) in the Chesapeake Bay.



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Microplastics and other anthropogenic particles in the surface waters of the Chesapeake Bay

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ARTICLE INFO

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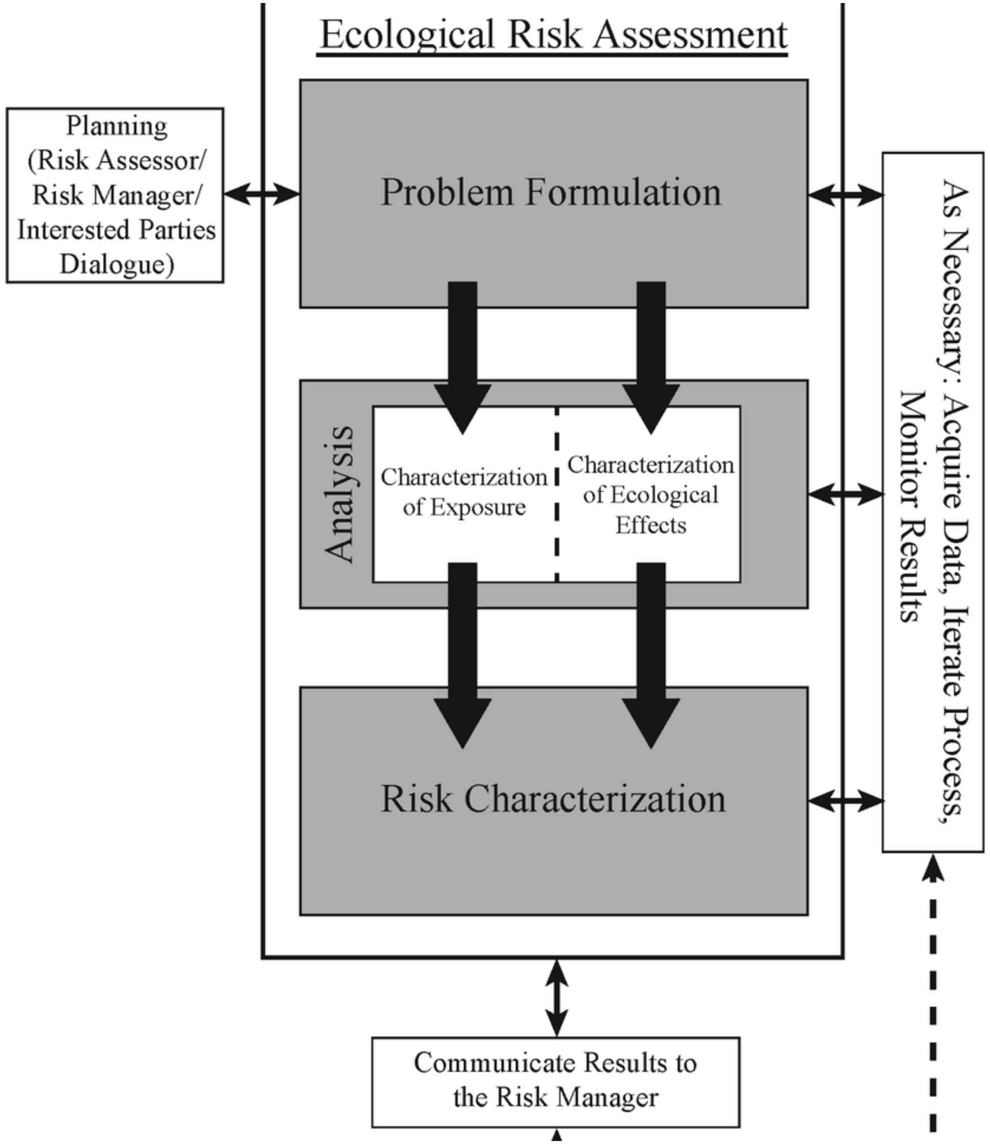
Tributary
Manta trawl
Surface water

ABSTRACT

Microplastics are a ubiquitous environmental contaminant whose distributions have been correlated with land-use and population density. Although there are numerous studies quantifying microplastics in the environment, local studies help inform sources, pathways, and policy. Here, we measure the concentration of microplastics in the surface waters across the Chesapeake Bay – the largest estuary in the USA. Thirty surface water samples from throughout the Chesapeake Bay were collected with a manta trawl. Samples were manually processed for microplastics and other anthropogenic particles. Fourier-transform infrared spectroscopy (FTIR) was used to determine the chemical composition of the particles. Higher concentrations were found near major cities and where larger rivers or tributaries met the Chesapeake Bay. Fragments, films, and fibres were the most common morphologies found, and polyethylene and polypropylene were the most common plastic types. These results can be used to inform mitigation strategies for microplastic pollution in the Chesapeake Bay region.

Identifying the Problem: Workshop Goals

- Assess the state of the knowledge on microplastic pollution in the Chesapeake Bay and its tributaries
- Assess possible effects of microplastics on various habitats and associated living resources
- Identify existing policy and management tools being used to address plastic pollution in the watershed and beyond, and their effectiveness
- Identify research gaps moving forward, and develop recommendations for future studies or new tools



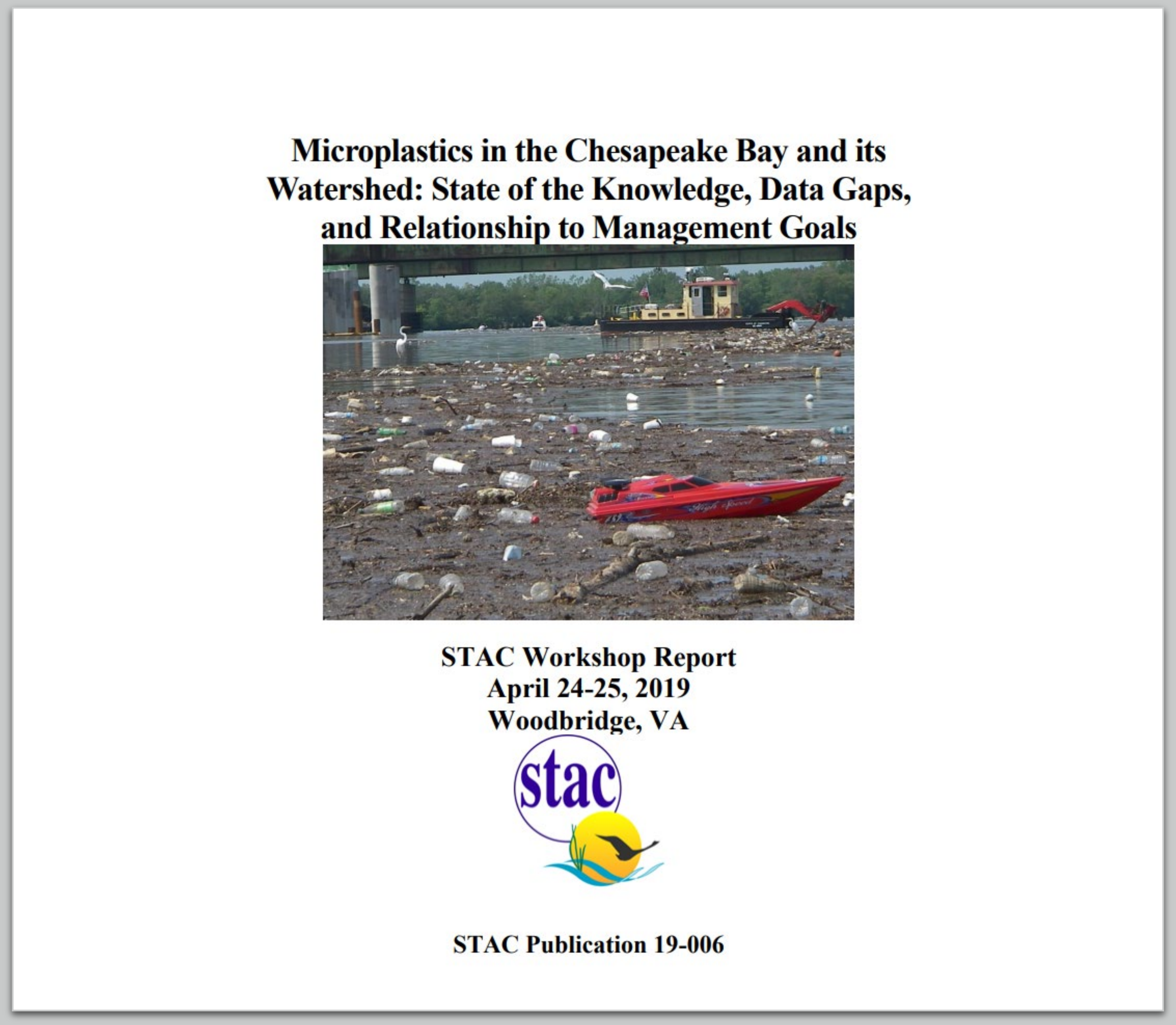
Workshop Format

- Steering committee decided early on that the workshop should be formatted around conducting an **ecological risk assessment (ERA)**

- The Ecological Risk Framework consists of the following components:
  1. **Problem Formulation**: Determine assessment endpoints and measurement endpoints
  2. **Risk Analysis**: Identify testable linkages between sources, stressors and assessment endpoints
  3. **Risk Characterization**: What are the risk and effects? Ex. LC50 – Lethal concentration to kill 50% of a population

Workshop Recommendations

- The CBP should create a cross-GIT Plastic Pollution Action Team to address the growing threat of plastic pollution to the bay and watershed.
- The Scientific, Technical Assessment and Reporting Team should incorporate development of ERAs of microplastics into the CBP strategic science and research framework, and the Plastic Pollution Action Team should oversee the development of the ERAs focused on assessment of microplastic pollution on multiple living resource endpoints.
- STAC should undertake a technical review of terminology used in microplastic research, specifically size classification and concentration units, and recommend uniform terminology for the CBP partners to utilize in monitoring and studies focused on plastic pollution in the bay and watershed.
- The CBP should develop a source reduction strategy to assess and address plastic pollution emanating from point sources, non-point sources, and human behavior.
- The CBP should direct the Plastic Pollution Action Team and STAR Team to collaborate on utilizing the existing bay and watershed monitoring networks to monitor for microplastic pollution.



Microplastics in the Chesapeake Bay and its Watershed: State of the Knowledge, Data Gaps, and Relationship to Management Goals

STAC Workshop Report
April 24-25, 2019
Woodbridge, VA

stac

STAC Publication 19-006

Establishing the Plastic Pollution Action Team

- The Plastic Pollution Action Team is compromised of various stakeholders from Federal, State, Local, NGO and Academia
- The PPAT was given a charge by the CB Management Board
- The PPAT is responsible for guiding the various deliverables in this project and providing expertise.

Project Tasks and Deliverables

01

Develop an ecological risk assessment (ERA) conceptual model looking at the effects of microplastics on various ecological endpoints in the Potomac River.

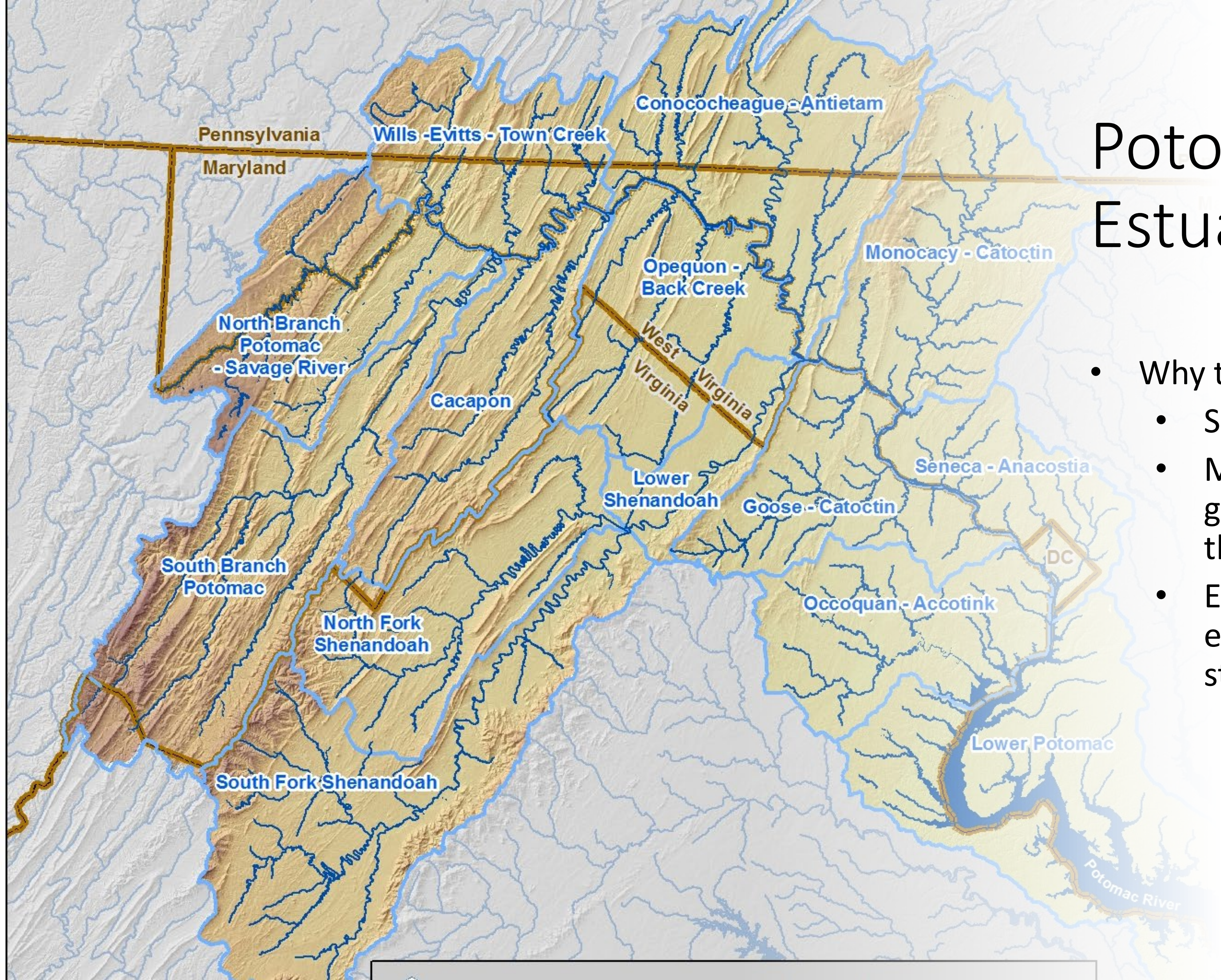
02

Compile the best available science to develop a preliminary ERA using the EPA framework. A gap analysis will be conducted to identify needs for future study.

03

Develop uniform size classification and concentration unit terminology that can be adopted for future microplastic research in the Potomac River, and possibly elsewhere in the Mid-Atlantic Region.

Potomac River Estuary



- Why the Potomac River?
  - Scale is appropriate.
  - Many of CBP's restoration goal species are found in the Potomac.
  - ERA development will still engage multiple stakeholders.

Task 1: Uniform Size Classification and Concentration Unit

Classification	Size	Rationale
Microplastic	5 mm - 1000 nm (1µm)	--NOAA and GESAMP precedence --Upper size limit is consistent with previous monitoring studies in Chesapeake Bay and tributaries --Use of 333 µm as a lower bound potentially excludes the inclusion of laboratory or monitoring studies that include data below that value -- The lower size limit is consistent with the SI naming convention.
Nanoplastic	1 nm - <1000 nm (1µm)	--The upper limit is consistent with the SI naming convention. --Limit is inclusive of particles <100 nm as defined for non-polymer nanomaterials in the field of engineered nanoparticles -- The lower size limit is consistent with the SI naming convention.

UNIT CONCENTRATIONS

Media	Description	Units	Info
Water Column	# of particles per volume of water	Number of particles m^{-3}; Number of particles l^{-1}	Quantifies number of plastic particles in water by volume This unit of measurement potentially accounts for particles throughout the water column.
	# of particles per area of water	Number of particles m^{-2}	Quantifies number of plastic particles on the surface area of water. Since water, is more than area (I.e. not two-dimensional), this metric is less informative for understanding the overall amount of microplastics and may exclude particles that are lower density and not at the surface of the water column .
Sediment	# of particles per volume of sediment	Number of particles l^{-1}	Quantifies number of plastic particles in sediment samples and based on a liquid volume of sediment.
		Number of particles kg^{-1} dry weight	Quantifies number of plastic particles in sediment samples and based on dry weight of sediment.
		Number of particles kg^{-1} wet weight	Quantifies number of plastic particles in sediment samples and based on wet weight of sediment.
	# of particles per area of sediment	Number of particles m^{-2} sediment surface	Quantifies number of plastic particles on the surface of a quadrate area of sediment.
		Mass m^{-2} sediment surface	Quantifies mass of plastic particles on the surface of a quadrate area of sediment

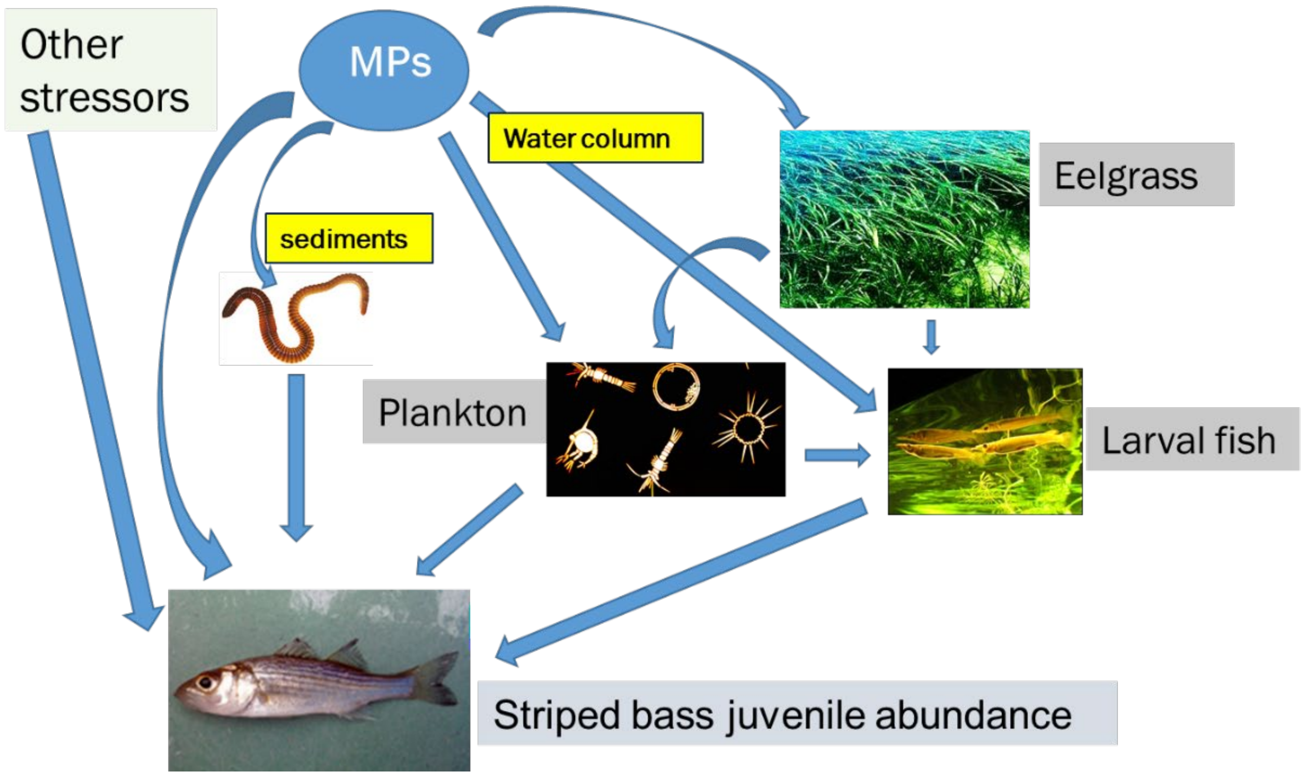
UNIT CONCENTRATIONS

Media	Units	Measurements	Info
Organisms	# of particles per individual	Number of particles/individual	Quantifies abundance of plastic particles within a whole individual
	Mass of plastics per stomach or gastrointestinal tract	Mass of plastics in stomach	Quantifies abundance of plastic particles within stomach contents.
		Mass of plastics in GI tract	Quantifies mass of plastic particles within the entire gastrointestinal tract
	Number of stomachs with particles	Number of organisms within a study in which plastics were found	Quantifies abundance of individual stomachs in which plastic particles were observed. A very useful metric that serves as an index to selectivity of fish (Hyslop 1980, Chesson 1983, Deudero and Morales-Nin 2001, Liao et al. 2001)
	# of particles per wet or dry tissue weight	Number of particles g^{-1} wet weight	Quantifies number of plastic particles in tissue samples and based on wet weight of tissue.
		Number of particles g^{-1} dry weight	Quantifies number of plastic particles in tissue samples and based on dry weight of tissue
	Total mass per unit of tissue	Mass of plastics/g wet weight	Quantifies mass of plastic particles in tissue samples and based on wet weight of tissue.
		Mass of plastics/g dry weight	Quantifies mass of plastic particles in tissue samples and based on dry weight of tissue.
	# of particles in stomach or gastrointestinal tract	Number of particles in stomach	Quantifies the number of plastic particles in the stomach of an animal. This measurement provides insight to available plastics for ingestion and perhaps selectivity of plastic types by fish. However, it may not yield an ideal relative measure of impact given variability in size, whereby total microplastic mass may be more informative.
		Number of particles in GI tract	Quantifies the number of plastic particles in the GI tract of an animal. This measurement shares many of the same issues as those previously described for number of particles in stomach or GI tract.
	# of particles on gill surfaces	Number of particles/gill surface	Quantifies the number of plastic particles on or in the gill surfaces of an animal. This methodology can potentially serve as a proxy for area of gill surface covered (and may be easier to measure than particle area)
	Mass of particles on gill surfaces	Mass of plastics/ gill surface	Quantifies the mass of plastic particles on or in the gill surfaces of an animal. This is biologically informative measurement as gill surface area is critical for sufficient respiration (Avio et al. 2015)

UNIT CONCENTRATIONS

Media	Units	Measurements	Info
Submerged Aquatic Vegetation	Number of Particles per Area of Blade/volume of plant canopy	Number of particles cm^{-2} of plant surface area	Quantifies the number of particles attached to plant surface. Can be used to assess impacts directly to plant health or as pathway for organisms feeding on plant tissue or surface (Goss et al. 2018)
		Number of particles l^{-1} of samples SAV canopy	If comparing the canopy filtration of particles, then a volumetric approach is more robust as one would be comparing # particles per volume of canopy sampled vs nearby similar volume of unvegetated water column
Shoreline	Number of particles per unit~~y~~ volume of shoreline substrate	Number of particles kg^{-1} dry weight	Quantifies number of plastic particles in beach samples and based on dry weight of sand/substrate
	Number of particles per area of shoreline substrate	Number of particles m^{-2} substrate surface (valid when depth of samples remains constant)	Quantifies number of plastic particles on the surface of a quadrat~~e~~ area of sediment.

Task 2: Develop a Conceptual Preliminary Eco Risk Assessment for MP in the Potomac River



Step 1 Biological endpoints of potential interest

Step 2 Qualitative food web interactions that could lead to microplastic intake by Striped Bass;

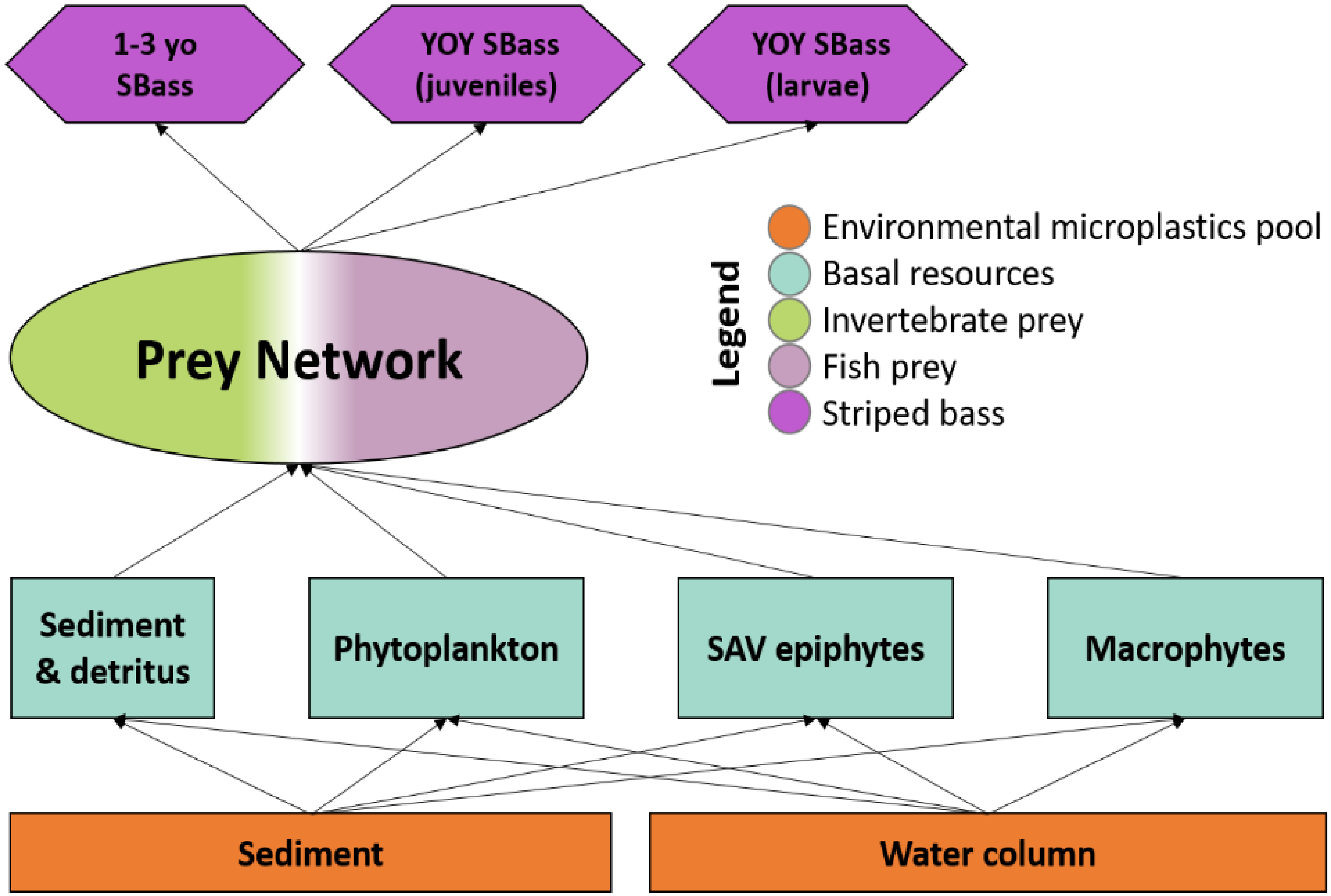
Step 3 Semi-quantitative food web interaction scenarios for Striped Bass living in different salinity regimes.

Model Developed by Bob Murphy, Tetra Tech

Biologic Endpoint Criteria

- Parameters
  - Upper Trophic Level
  - Represented Chesapeake Bay Agreement
  - Data Rich
  - Common
  - Wide Distribution
- Species Discussed
  - Blue Crabs
  - American Shad
  - Forage Gish
  - American Eel
  - Eastern Oysters
  - White Perch
  - **Striped Bass**

Food Web Interactions



Food Web Model Developed by Tetra Tech

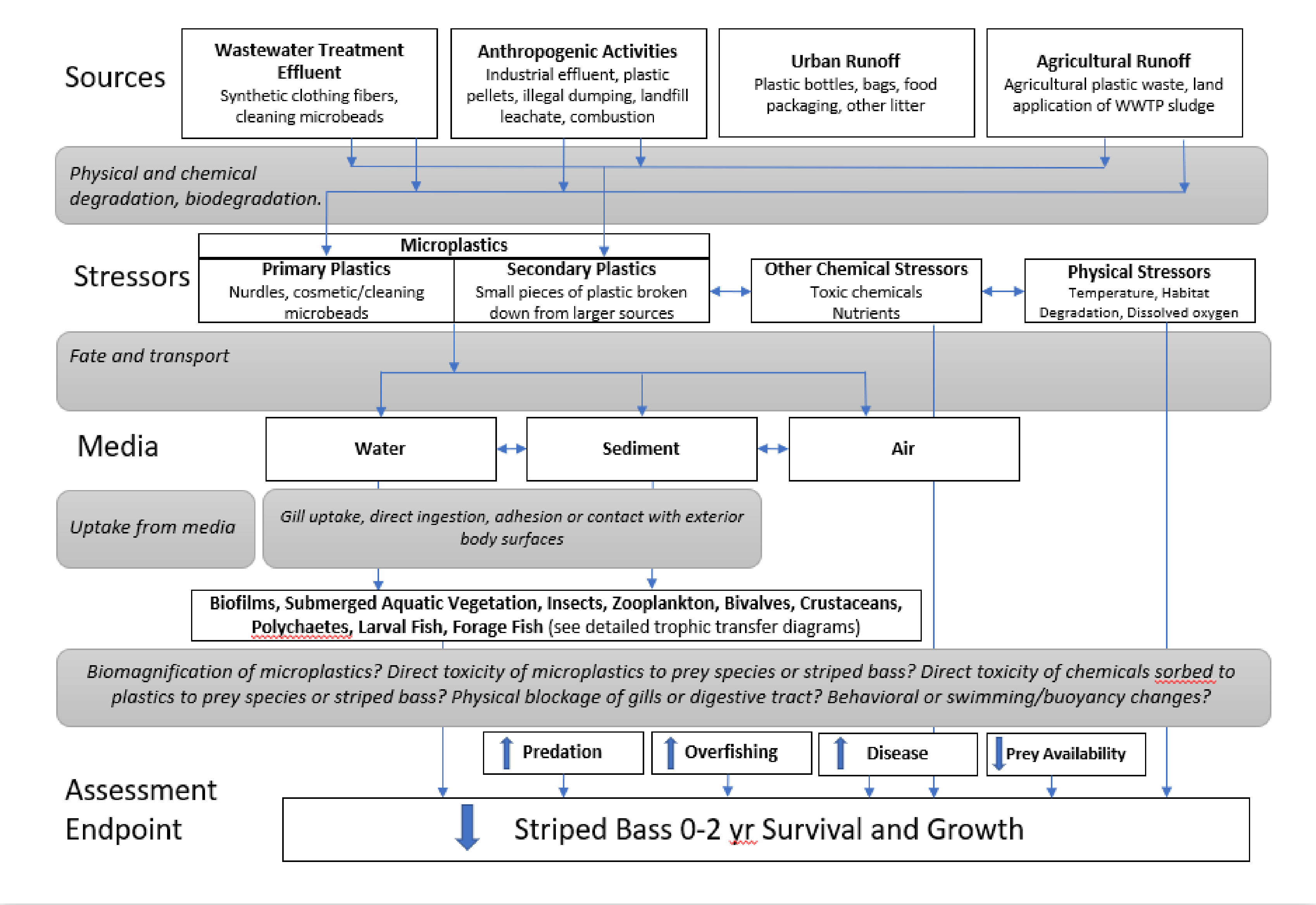
Potential Assessment Endpoints

Individual Assessment Endpoints

- Growth rates
- Fecundity
- Predator susceptibility
- Direct mortality
- Physiological condition
- Behavior change

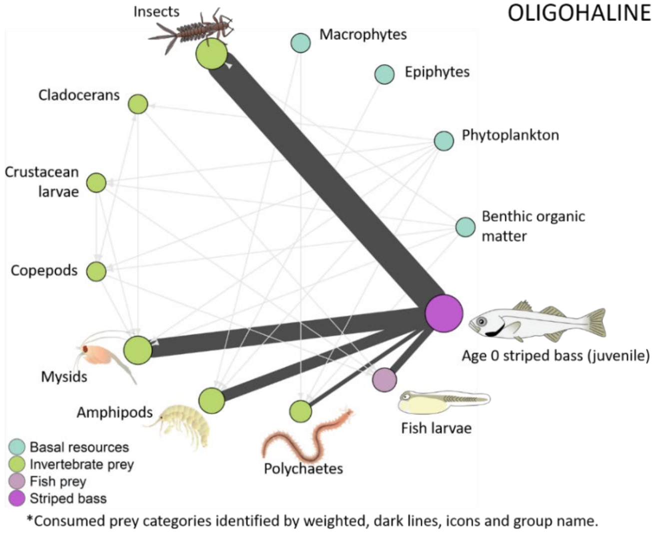
Population Assessment Endpoints

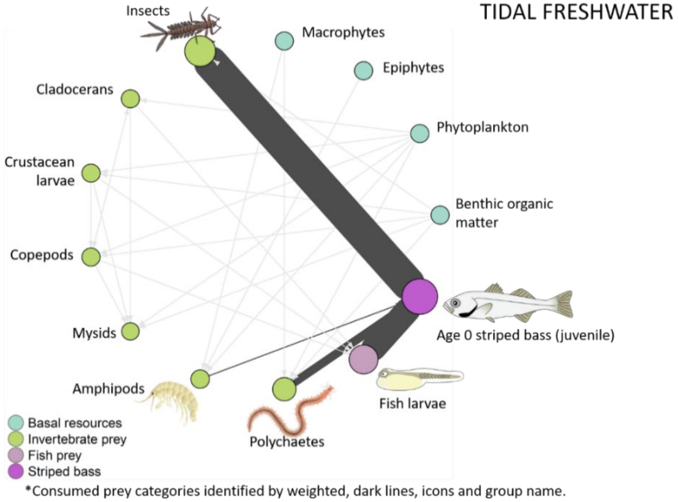
- Catch-per-unit-effort
- Size-at-age
- Age-structure
- Mortality
- Spawning stock biomass

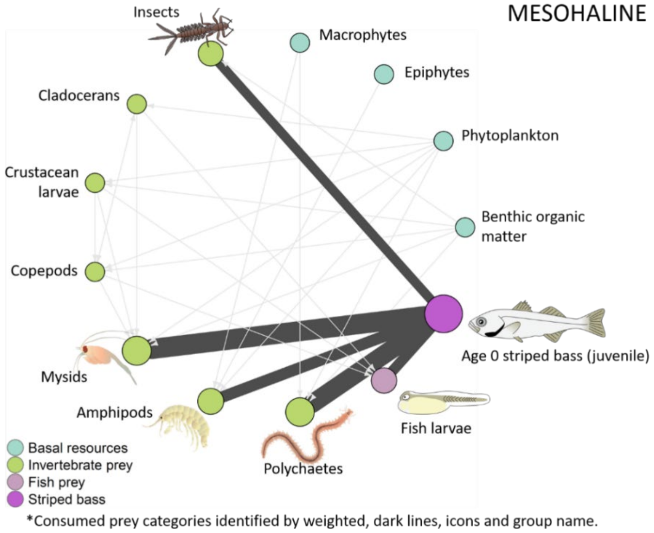


Conceptual Model

Conceptual Model Developed by Tetra Tech







Semi Quantitative Results

Food Webs Developed by Tetra Tech

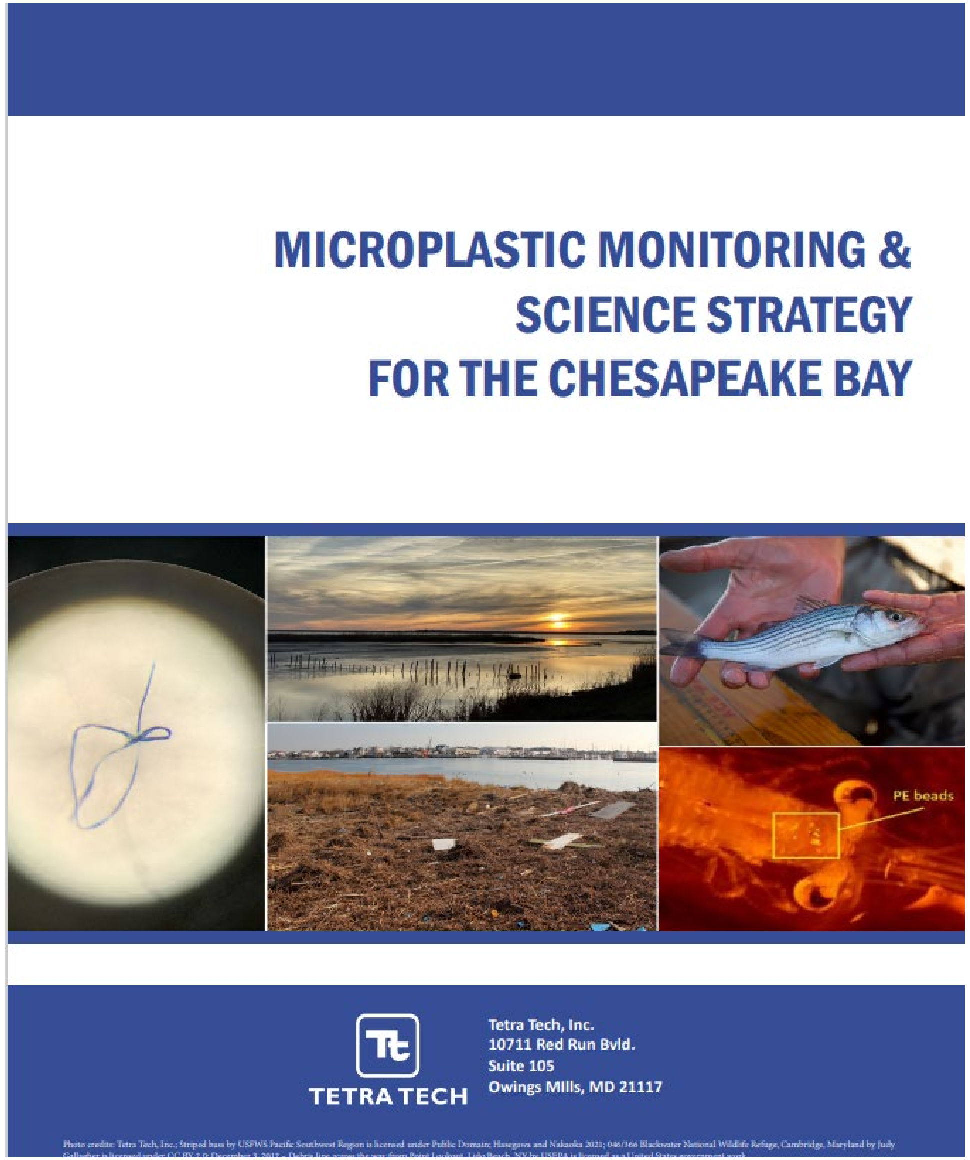
Semi Quantitative Results

- It is hypothesized the MP may contributed to degreased growth and survival by several mechanisms:
  - Physical blockage of guts resulting in reduced feeding
  - Behavioral changes such as swimming behavior increasing predation risk
  - Toxicity to striped bass because organic contaminants adhere to plastics

	Age-0				Age-1	Age-2	
	Larval	Juvenile			SA	SA	
Prey category	**OLIGO**	**TF**	**OLIGO**	**MESO**	**MAIN**	**MAIN**	**Priority-level**
Insects		47.5	40	12.5			
Cladocerans	26.2						
Larval zooplankton	1						
Adult copepods	40.3						
Bivalves					0.9	1.2	
Mysids		0	24.5	27	4.5	21	
Amphipods		1.5	15	15.5	1.9	5	
Other crustaceans					2.8	4	
Polychaetes		12	5.5	25	4.4	9.4	
Bay Anchovy					57.8	15.6	
Fish larvae		35.5	10	14			
Atl. Menhaden					1.9	17.9	
Other fish					7.6	8	

Task 3: Monitoring and Science Strategy

- Modeled after San Francisco Bay's Microplastic Strategy
- This strategy document provides an overview of management needs regarding implementing policies to reduce plastic pollution, which would result in reduction in microplastics.
- This strategy is intended to be a starting point to develop research priorities, monitoring efforts, and policy development.
- It is expected to be updated in the future as more work and research is completed



Management Questions Posed to the PPAT

How can government and resource managers develop sound policies to reduce [micro]plastic pollution and assessing the economic impacts?

What health risks are posed by microplastics?

What are the sources, pathways, composition, and fate of microplastic loadings into the Chesapeake Bay?

What management actions or policies may be effective in reducing microplastic pollution?

Identified Data Gaps

01

Lack of observational and experimental data on the types, sources, and fates of microplastics in the ecosystem

02

Need more understanding on trophic transfer

03

Need more direct studies on the prevalence, intensity and efforts of microplastics contamination on focal species, their prey and the environment

Conclusions

Studies have shown microplastics are ubiquitous throughout the bay and its tributaries. They have been found in both tidal (Yonkos, 2014; Rochman, 2019) and non-tidal waters (Fisher, 2019).

There is general agreement that plastics represent a widespread, but largely *unquantified*, threat to the Chesapeake Bay ecosystem.

There are a number of piecemeal efforts to monitor plastics in the Bay, but no systematic effort and no organized effort directed at researching plastic pollution.

The ERA reveals there could be significant impacts on a valuable Chesapeake resource, Striped Bass (e.g. 14 prey taxa…). Further refinement of the ERA is needed to provide more accurate estimate of the effects to the resource.

Implementation of the science strategy will put us on a path for understanding the impacts of plastic pollution on Striped Bass and other ecosystem endpoints

Slide courtesy of Bob Murphy, Tetra Tech

2022 Update to the ERA

- Focus on Mysids, Amphipods, and Bay Anchovy
- Include research on similar taxa from elsewhere around the globe
- Investigate potential plankton regime shifts

Slide courtesy of Bob Murphy, Tetra Tech

Priority Prey Items

Prey category	OLIGO	TF	OLIGO	MESO	MAIN	MAIN	Priority-level
Insects		47.5	40	12.5			
Cladocerans	26.2						
Larval zooplankton	1						
Adult copepods	40.3						
Bivalves					0.9	1.2	
Mysids		0	24.5	27	4.5	21	
Amphipods		1.5	15	15.5	1.9	5	
Other crustaceans					2.8	4	
Polychaetes		12	5.5	25	4.4	9.4	
Bay Anchovy					57.8	15.6	
Fish larvae		35.5	10	14			
Atl. Menhaden					1.9	17.9	
Other fish					7.6	8	

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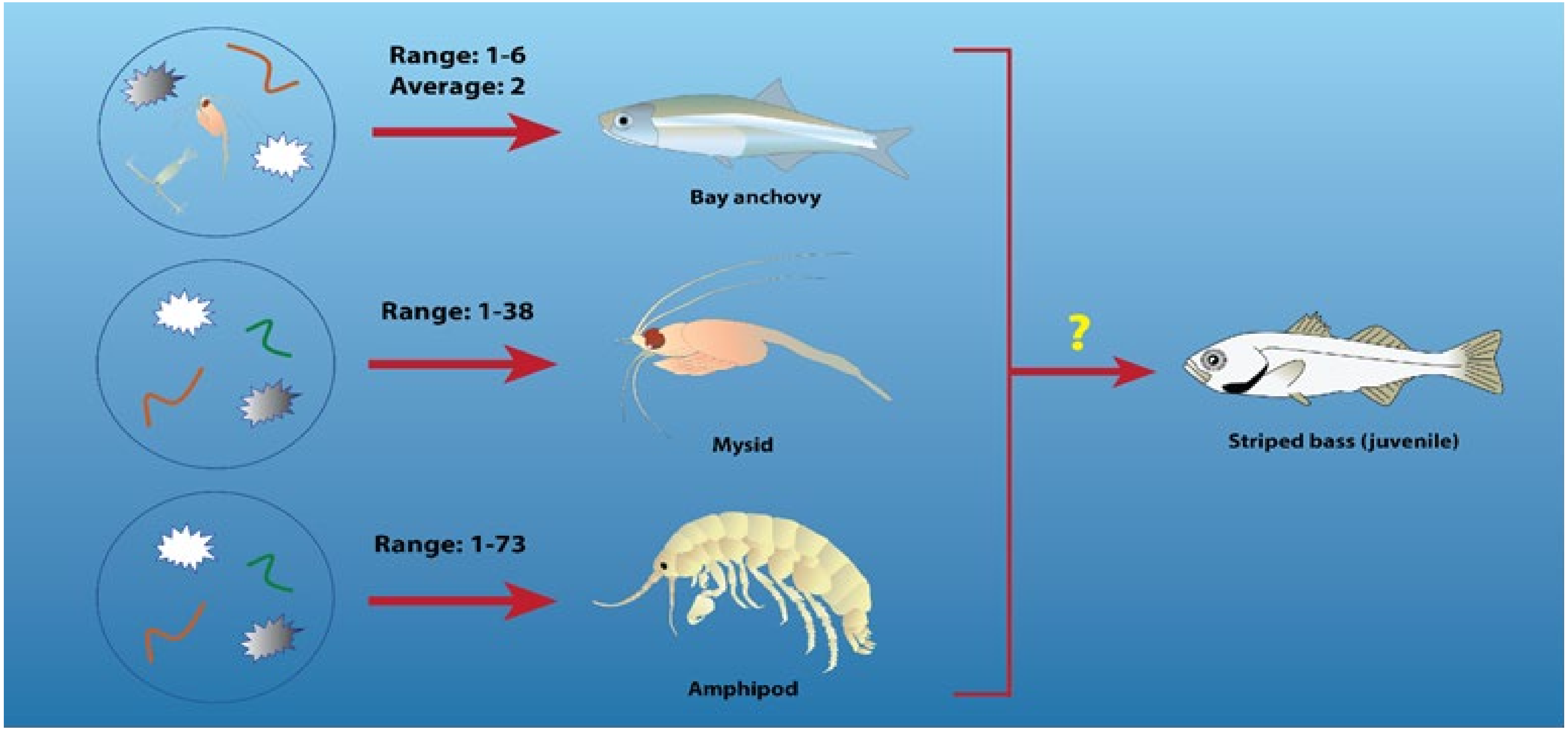
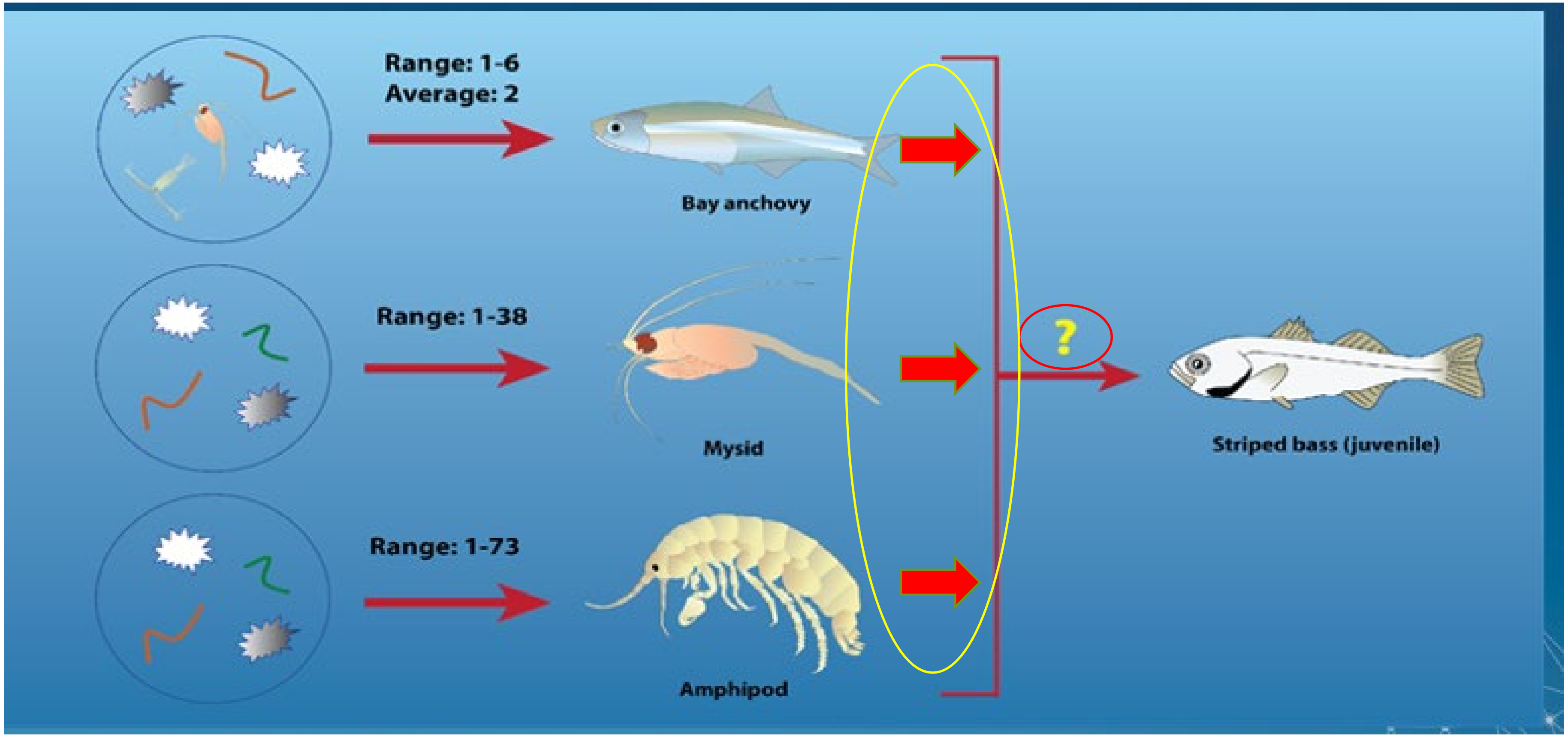


Figure 1. Estimated potential quantities of microplastic particles per individual for each of three common taxa (Bay Anchovy, Mysid, Amphipoda) reaching an individual feeding juvenile striped bass. Sources of microplastics for each taxa are displayed on the left, with most of it free-floating plastic particles, with the exception of mysid shrimp in bay anchovy diet (described in the text).

Slide courtesy of Bob Murphy, Tetra Tech

Trophic Transfer



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Recommended Next Steps from 2022 ERA Update

Combination field and laboratory studies that will:

- Assess the loadings of microplastics within the prey community;
- Measure uptake of microplastics in these taxa;
- Conduct behavioral studies of prey taxa after microplastic consumption;
- Assess trophic transfer to YOY striped bass.

Slide courtesy of Bob Murphy, Tetra Tech

Upcoming Projects for 2023: Microplastics Source Tracking in the Chesapeake Bay

- In order to identify potential risks microplastics may be having on valuable and vulnerable resources in the Chesapeake Bay watershed, specific data on the size, shape, composition, and conveyances are needed. These specific measures will support fully developed ecological risk assessments and better target potential management and policy actions.
- Understanding the sources, transport mechanisms and composition of plastics in the watershed will require sampling at various landscapes.
- This project proposes to collect plastic samples at several conveyance types including agriculture, wastewater, stormwater, urban, suburban and wetlands in the Potomac River Watershed along a gradient from tidal headwaters toward the confluence with the Bay at two time series (baseflow and stormflow).
- The contractor will be responsible for selecting the sampling locations and collecting the water samples. In addition, the contractor will isolate and extract the microplastics from the water samples. Further analysis by U.S. EPA ORD will use Raman spectroscopy for polymer identification. That dataset will be used by the contractor to identify potential sources of plastics entering the watershed.

Upcoming Projects for 2023: Develop a Monitoring and Analytical Reference Guide and Monitoring Framework for Plastic Pollution in the Chesapeake Bay Watershed

- Research efforts will continue to gather critical information needed to model potential impacts to living resources and restoration efforts. Developing a monitoring reference guide and framework is the logical next step in order to implement a full plastic pollution monitoring program.
- A monitoring program will establish baselines to inform environmental concentrations, monitor trends and potential hot spots, and inform decision makers and researchers on best management practices to prevent and reduce plastic pollution in the Chesapeake Bay and its watershed.
- The contractor will collaborate with the PPAT and build upon the foundational work that has been completed by the PPAT's monitoring subcommittee where objectives and priorities have been established.
- The framework will include details on approach, methods, frequency, scale, etc. in collaboration with the PPAT. The contractor will include the Sampling Reference Guide and Analytical Reference Guide as appendices in the final document.
- The final deliverables for this project will be a Framework for Monitoring Plastic Pollution in the Chesapeake Bay watershed and include a sampling reference guide and an analytical reference guide as appendices

DRAFT PROPOSED Project for 2023: Assessing Biological Effects of Plastic Pollution Exposure on Young-of-Year Striped Bass (Morone saxatilis) in Chesapeake Bay and its tributaries

In order to develop a complete ERA, the PPAT requires additional data on:

1. Presence of microplastic contamination in mysid shrimp collected in the Chesapeake Bay and its tributaries. Quantitative food web analysis previously conducted for the preliminary ERA has shown that mysids are a very important prey item for striped bass.
2. Biological impacts on YOY striped bass fed with mysid shrimp contaminated with microplastics. Examples of biological impacts include, but are not limited to, hepatosomatic ratio, growth, stress response, and mortality.

Assessing Microplastics in Various Trophic Level Fish in the tidal Potomac and Anacostia Rivers

- Microplastic pollution in the aquatic environment has been a growing concern for the past two decades. The primary findings of this study include:
  - Microplastic fragments were found in all trophic levels examined in this study, demonstrating the ubiquity of particles in the aquatic environment.
  - 23% of fish collected in the Washington, DC, region contained microplastics in their stomachs.
  - More microplastics and higher frequency of occurrence in higher trophic positions (planktivores lowest, invertivores most).
  - Regional differences only present in smallest, least mobile taxa (planktivores).
  - Seasonal differences important for planktivores and piscivores.
  - Increasing number of microplastics with increasing body size among piscivores only.
  - >25% occurrence of microplastics in young-of-year Striped Bass.

Authors: Bob Murphy, Tetra Tech and Ryan Woodland, UMCES

Slide courtesy of Bob Murphy, Tetra Tech

Questions for the PPAT?

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