Developing a Preliminary Conceptual Ecological Risk Assessment and Science Strategy for Microplastics in the Potomac River

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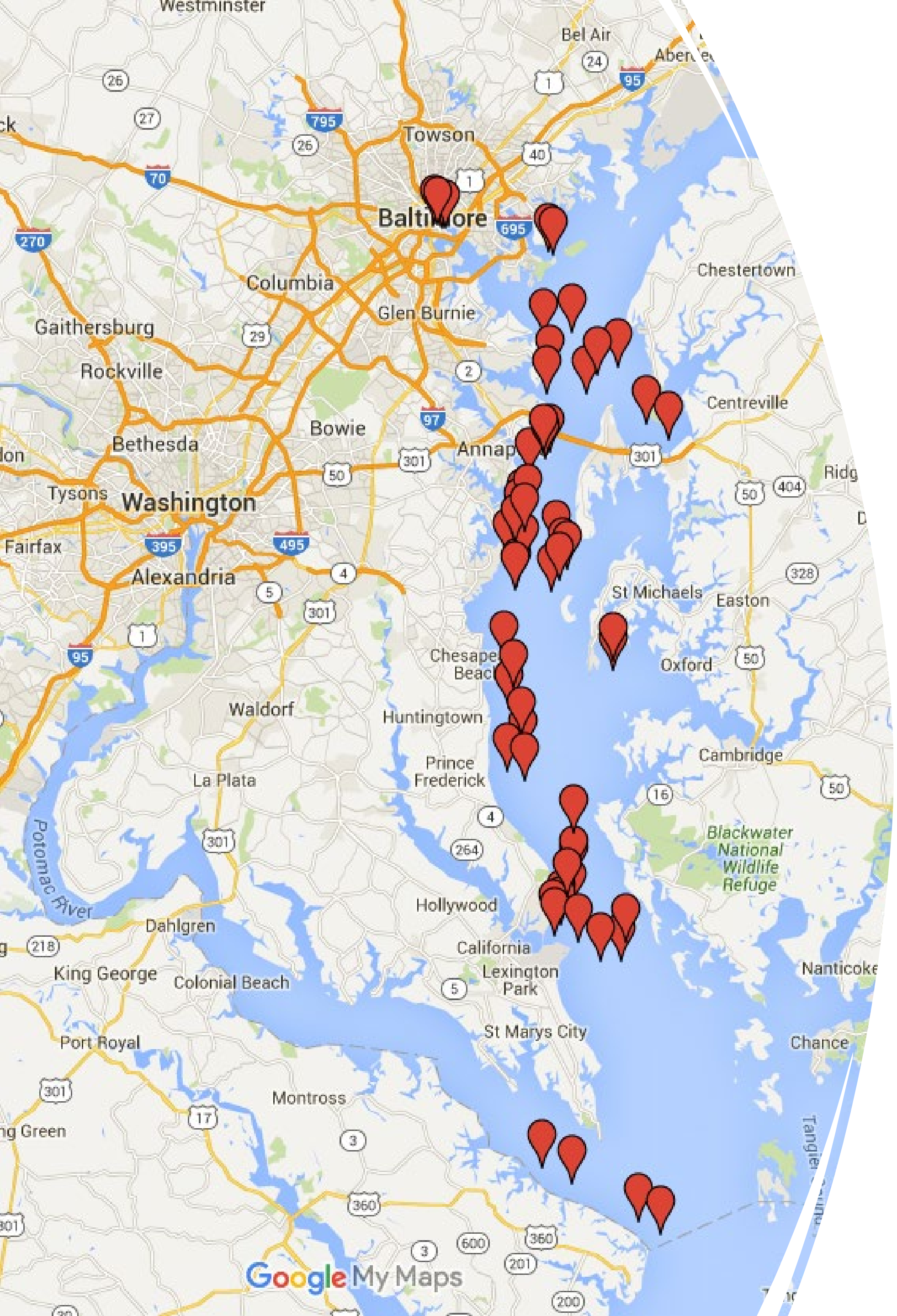
Background and Project Outline

- Microplastics in the Chesapeake Bay
- Assessing the State of Science
- Identifying the Problem and Potential Solutions
- Creating conformity among size and unit terminologies
- Identifying the Risks
- Developing a Strategy



Microplastics are Ubiquitous in Chesapeake Bay

- **Selection of Publications**
  - Yonkos et al. (2014) found microplastics in 59 out of 60 samples in four tidal tributaries to the upper Chesapeake Bay. Concentrations highly correlated with urban/suburban landuse.
  - USGS has found microplastics in every sample taken at five non-tidal stations in the Chesapeake Bay watershed (Fisher, 2019).
  - In 2018, 95% of smallmouth bass (*M. dolomieu*) sampled in the central Susquehanna River had microplastics in their guts (Parks, 2019).
  - Brander (2019) found that juvenile Black Seabass (*Centropristis striata*) fed with fish fed with pre-cleaned microplastics displayed increased oxygen consumption. Juveniles exposed to microfibers in the water column displayed increased oxygen consumption.
  - Knauss (2019) found that Eastern Oyster (*C. virginica*) larvae that ingested polystyrene microbeads displayed a significant increase in algal clearance.
- **2015 Bay Trash Trawl conducted by Trash Free Maryland (sites with red flags)**
  - surveyed 30 sites for microplastics in the Chesapeake Bay mainstem and tidal tributaries.
  - 100% of samples contained microplastics.
  - Highest concentrations found in urban and suburban tributaries.

Microplastics 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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A R T I C L E I N F O

Keywords:
Microplastic
Urban bay
Tributary
Manta trawl
Surface water

A B S T R A C T

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.

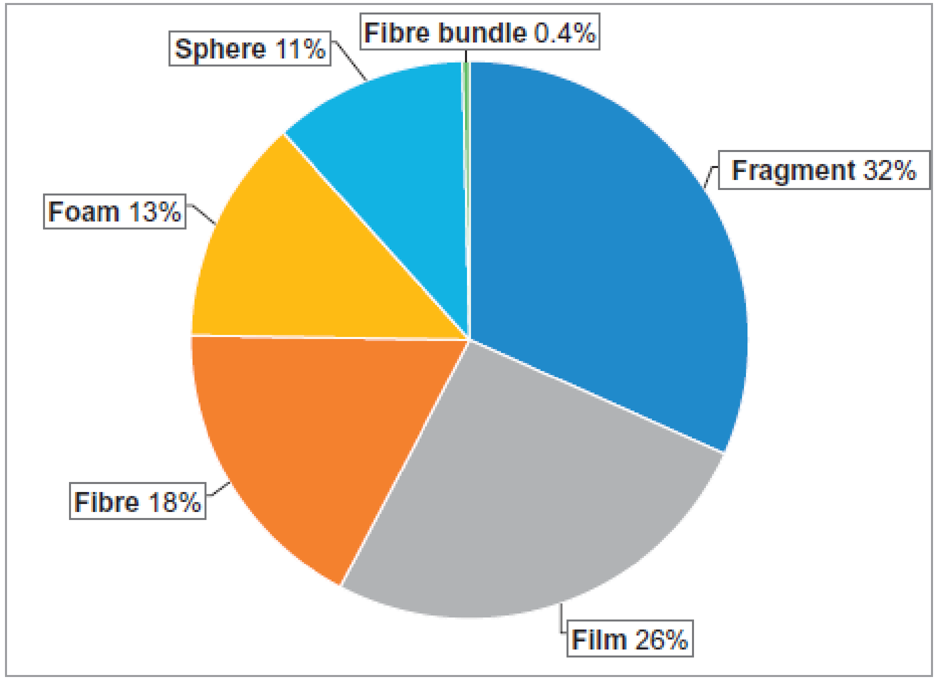
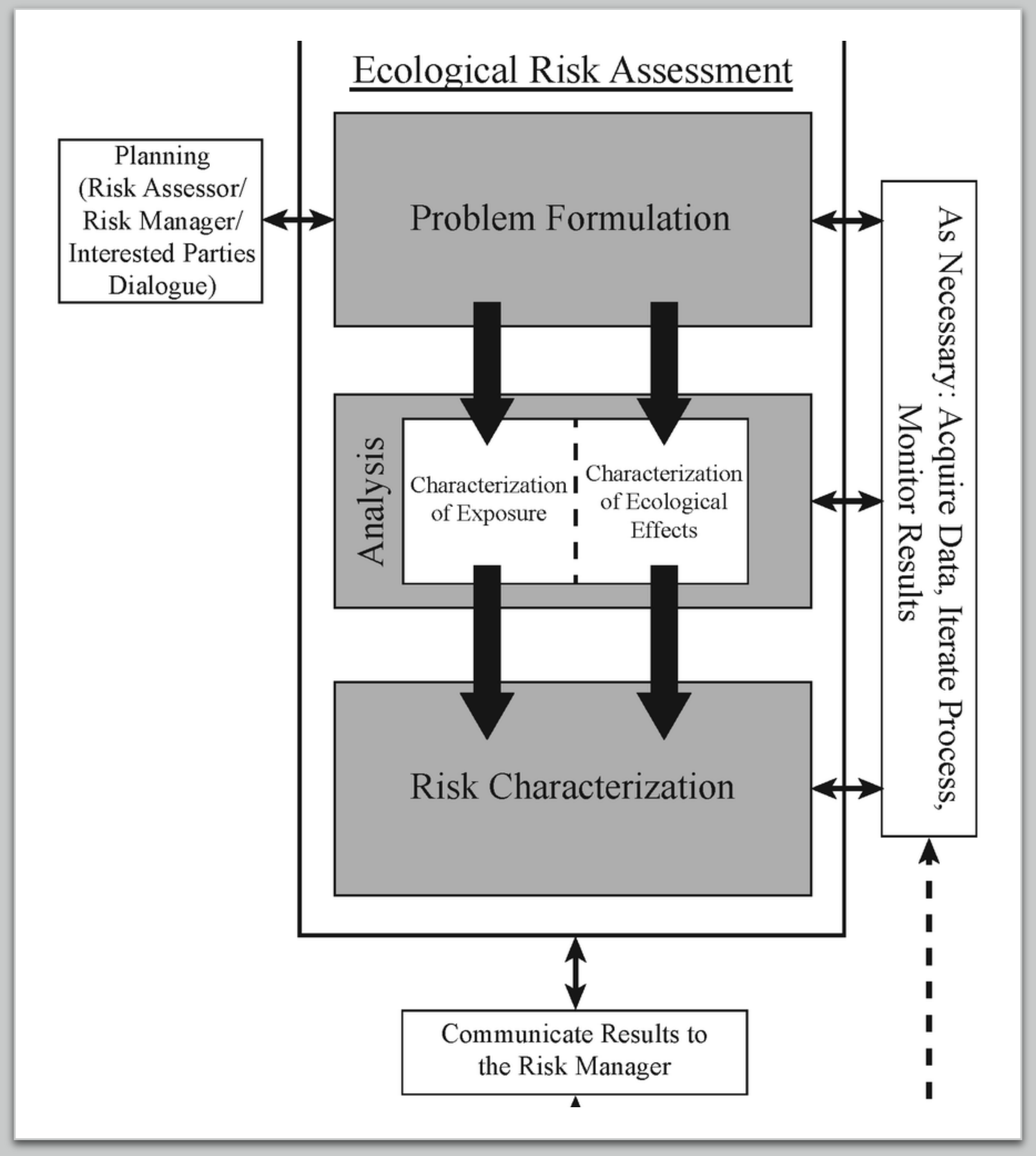


Fig. 3. Morphology of particles from thirty surface water samples (after blank correction) in the Chesapeake Bay.

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

1. The CBP should create a cross-GIT Plastic Pollution Action Team to address the growing threat of plastic pollution to the bay and watershed.
2. 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.
3. 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.
4. The CBP should develop a source reduction strategy to assess and address plastic pollution emanating from point sources, non-point sources, and human behavior.
5. 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.

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

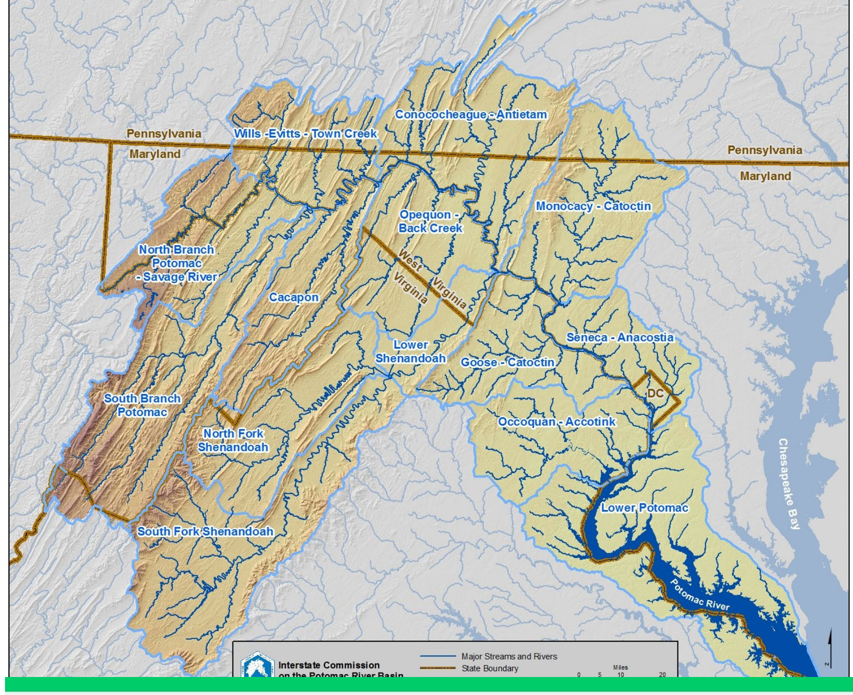
Compile the best available science to develop a preliminary ERA using the EPA framework. A gap analysis will be conducted to identify needs for future study.

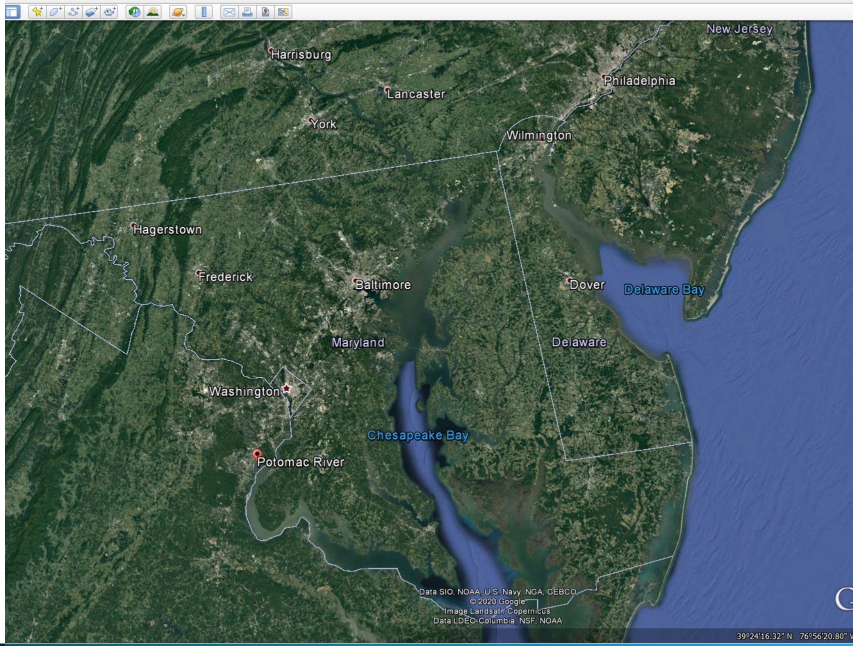
03

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.





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.

Task 1: Uniform Size Classification and Concentration Unit Terminology

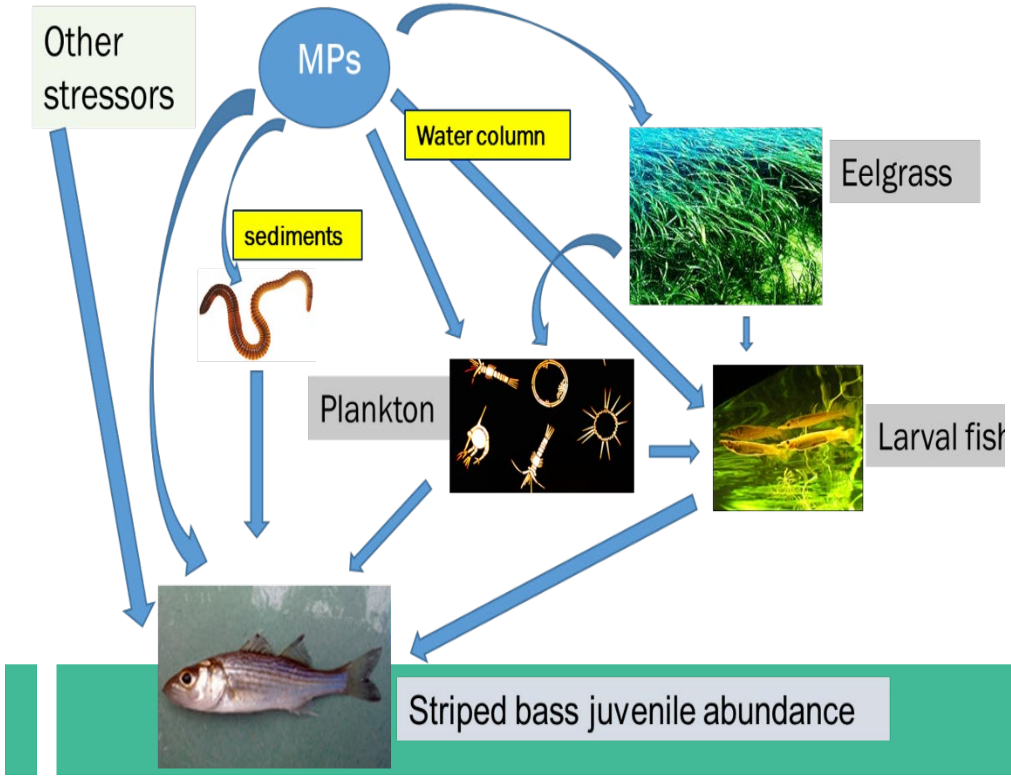
Classification	Size	Rationale
Microplastic	5 mm - 1000 nm (1µm)	--NOAA and GESAMP precedence --Upper size limit is consistent with previous monitoring studies in Chesapeake Bay and tributaries --Use of 333 µm as a lower bound potentially excludes the inclusion of laboratory or monitoring studies that 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.

Concentration Units Guidelines

- Established across common sampling media
  - Water Column
  - Sediment
  - Organisms
  - Submerged Aquatic Vegetation
  - Shoreline

Here, a sample of ocean microplastics is displayed during a 2015 trash trawl survey on the Chesapeake Bay. (Photo by Will Parson/Chesapeake Bay Program)

Task 2: Preliminary Eco Risk Assessment Process



Model Developed by Bob Murphy, Tetra Tech

Biological endpoints of potential interest

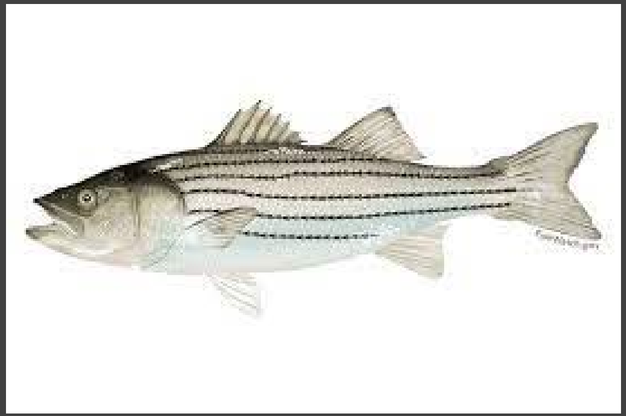
↓

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

↓

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

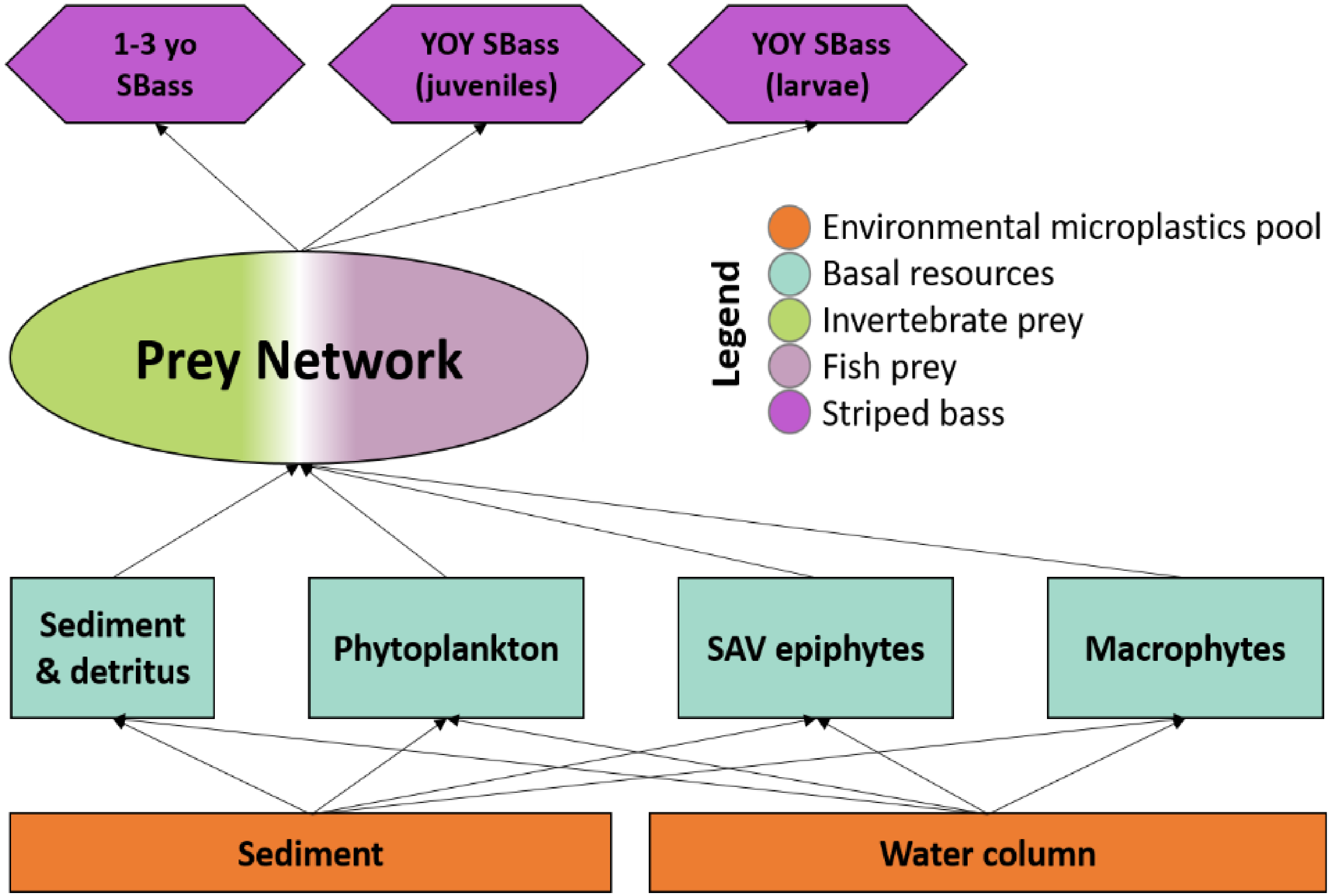
Biologic Endpoint Criteria



- 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**

Biological Endpoints



Food Web Model Developed by Tetra Tech

Potential Assessment Endpoints

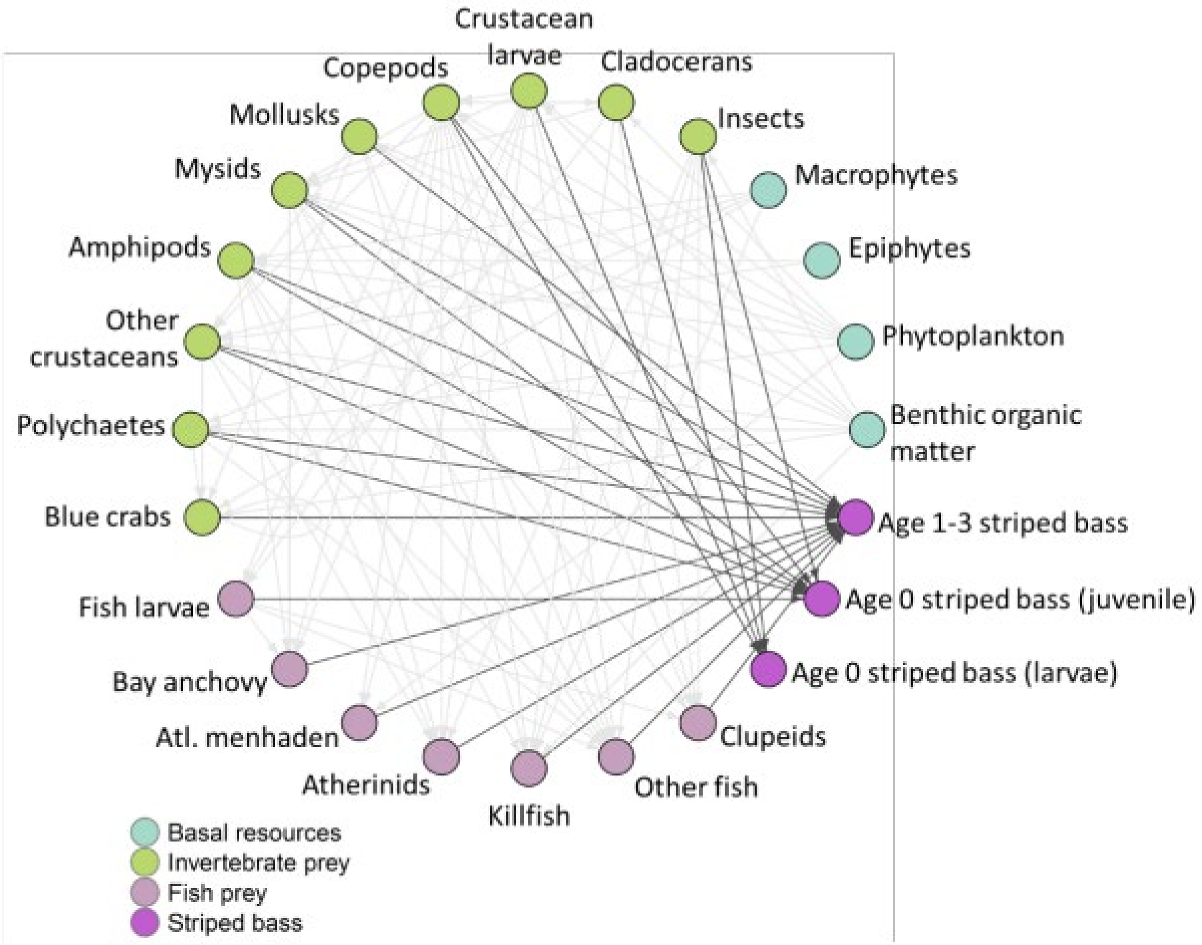
Individual Assessment Endpoints

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

Population Assessment Endpoints

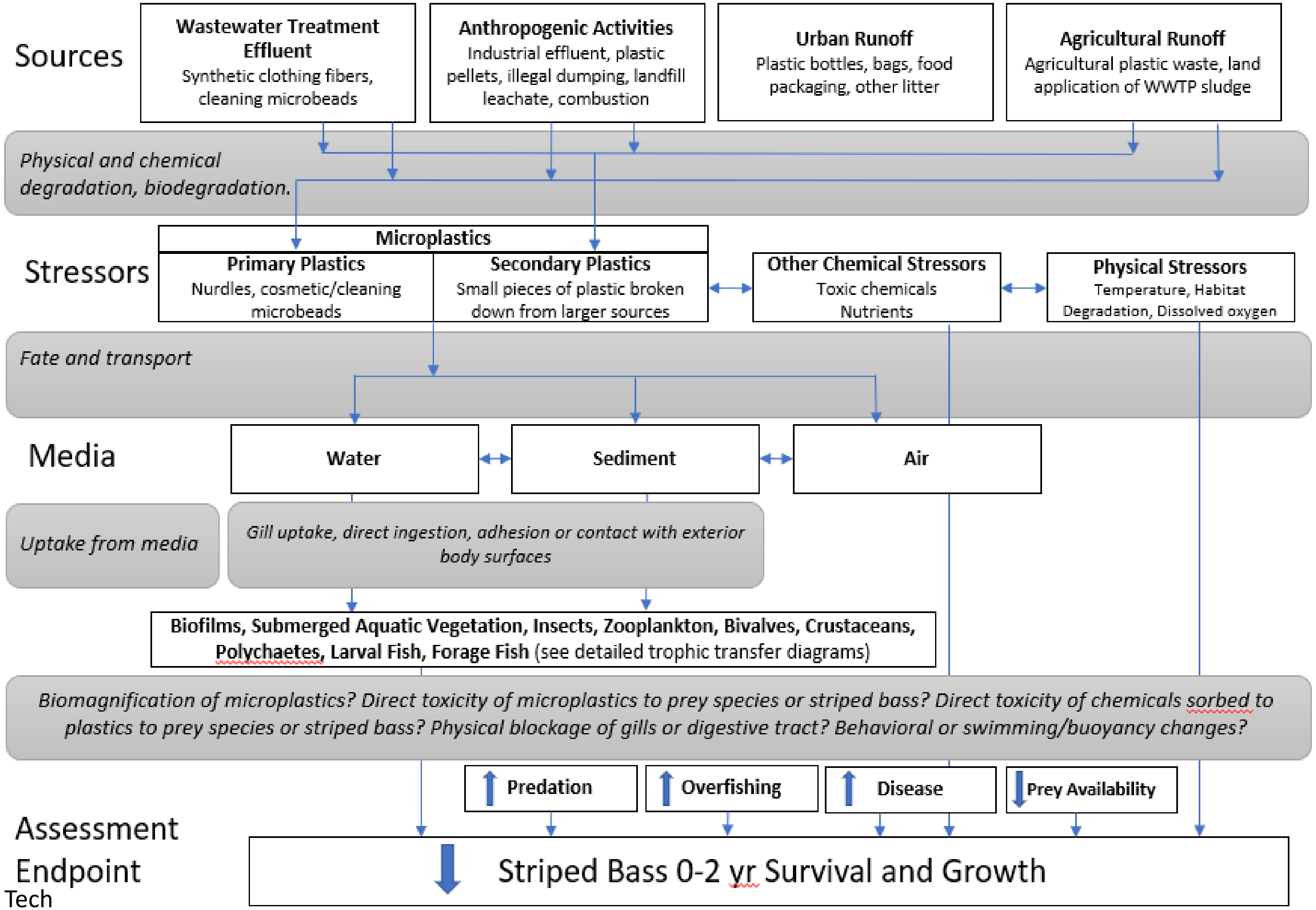
- Catch-per-unit-effort
- Size-at-age
- Age-structure
- Mortality
- Spawning stock biomass

Qualitative food web interactions

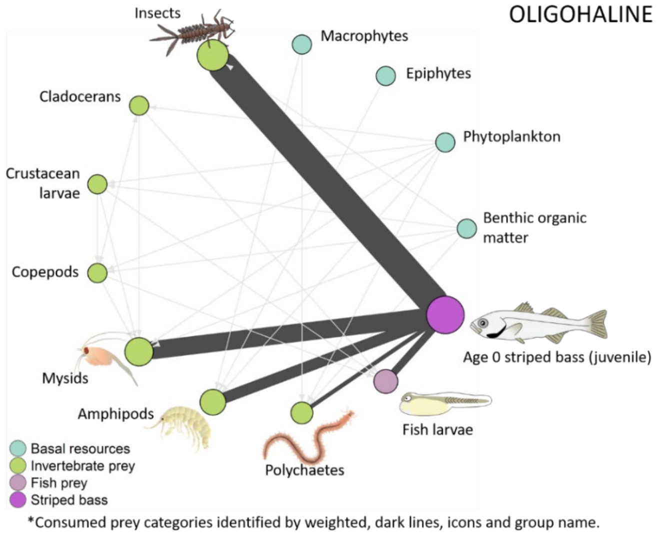


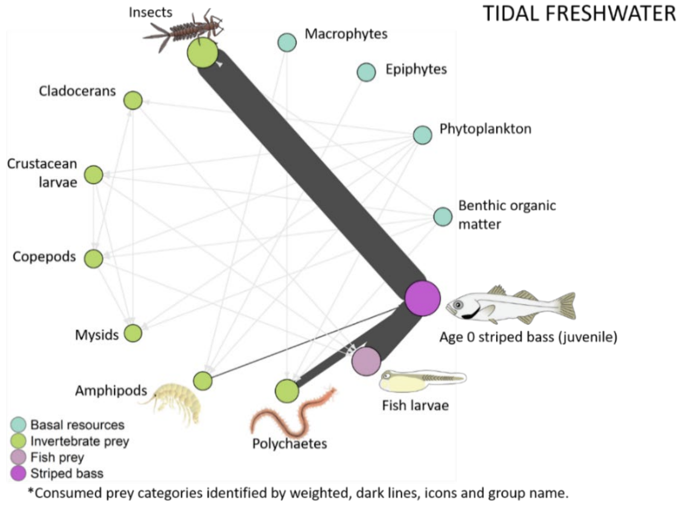
Food Web Models Developed by Tetra Tech

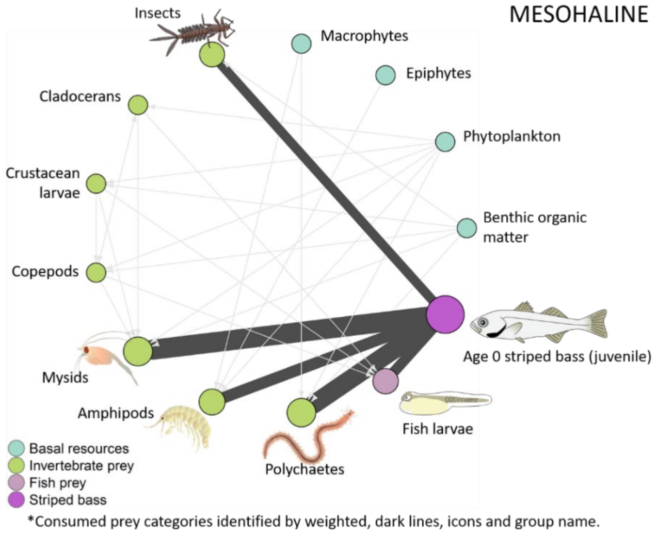
Conceptual Model



Conceptual Model Developed by Tetra Tech







Semi Quantitative Results

Food Web Models Developed by Tetra Tech

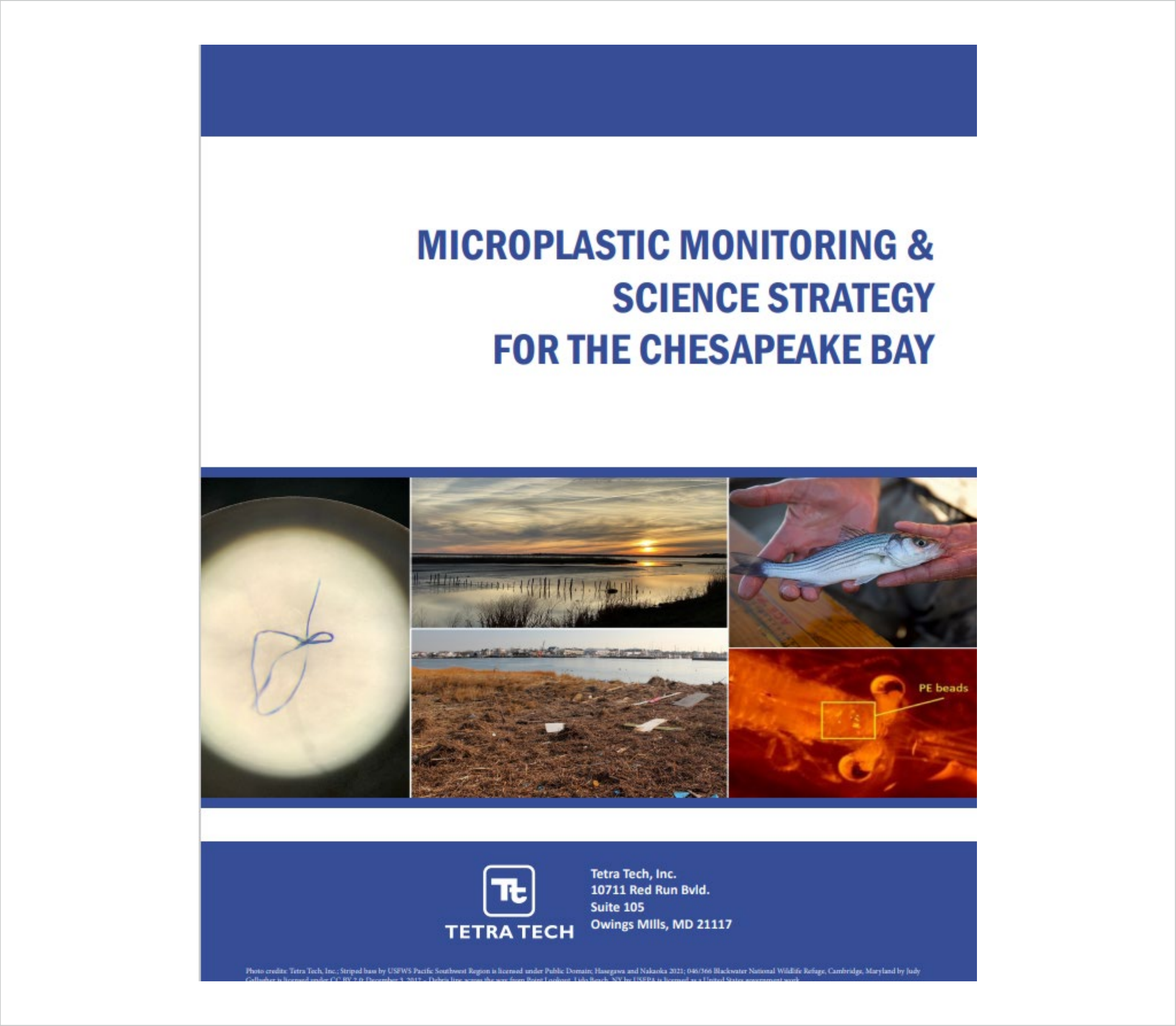
Semi Quantitative Results

- 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

- Lack of observational and experimental data on the types, sources, and fates of microplastics in the ecosystem
- Need more understanding on trophic transfer
- Need more direct studies on the prevalence, intensity and efforts of microplastics contamination on focal species, their pray and the environment

Recommendations

- Design and implement a microplastic monitoring program, integrated into the existing Chesapeake Bay watershed monitoring framework;
- 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;
- Ensure adequate infrastructure resources are available to process microplastic samples, including analytical equipment; and
- Continue to support the PPAT in order to direct research, management, and policy development;

Conclusions

Studies have shown microplastics are fairly 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

Thank you!

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https://www.bayjournal.com/news/pollution/picture-of-chesapeake-microplastics-grows-clearer/article_87bd3606-c3e1-11eb-bdc4-4f1a3864c6f9.html#comments