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Microplastics in Estuarine and Coastal Ecosystems: Recent Assessment of the State of Knowledge in the Chesapeake Bay

Presenter: Bob Murphy (Bob.Murphy@TetraTech.com)

Webinar moderator: Bridget John (bridget@iaia.com)

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Microplastics in Estuarine and Coastal Ecosystems: Recent Assessment of the State of Knowledge in the Chesapeake Bay

Presenter:

Bob Murphy

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Microplastics in Estuarine and Coastal Ecosystems: Recent Assessment of the State of Knowledge in the Chesapeake Bay

Bob Murphy, Tetra Tech, Center for Ecological Sciences

Goals

- An understanding of the scope of microplastics in the aquatic environment
- State of the knowledge (using Chesapeake Bay as framework of regional understanding)
- Current efforts
- Future directions in microplastic research and assessment

5 Gyres

NOAA

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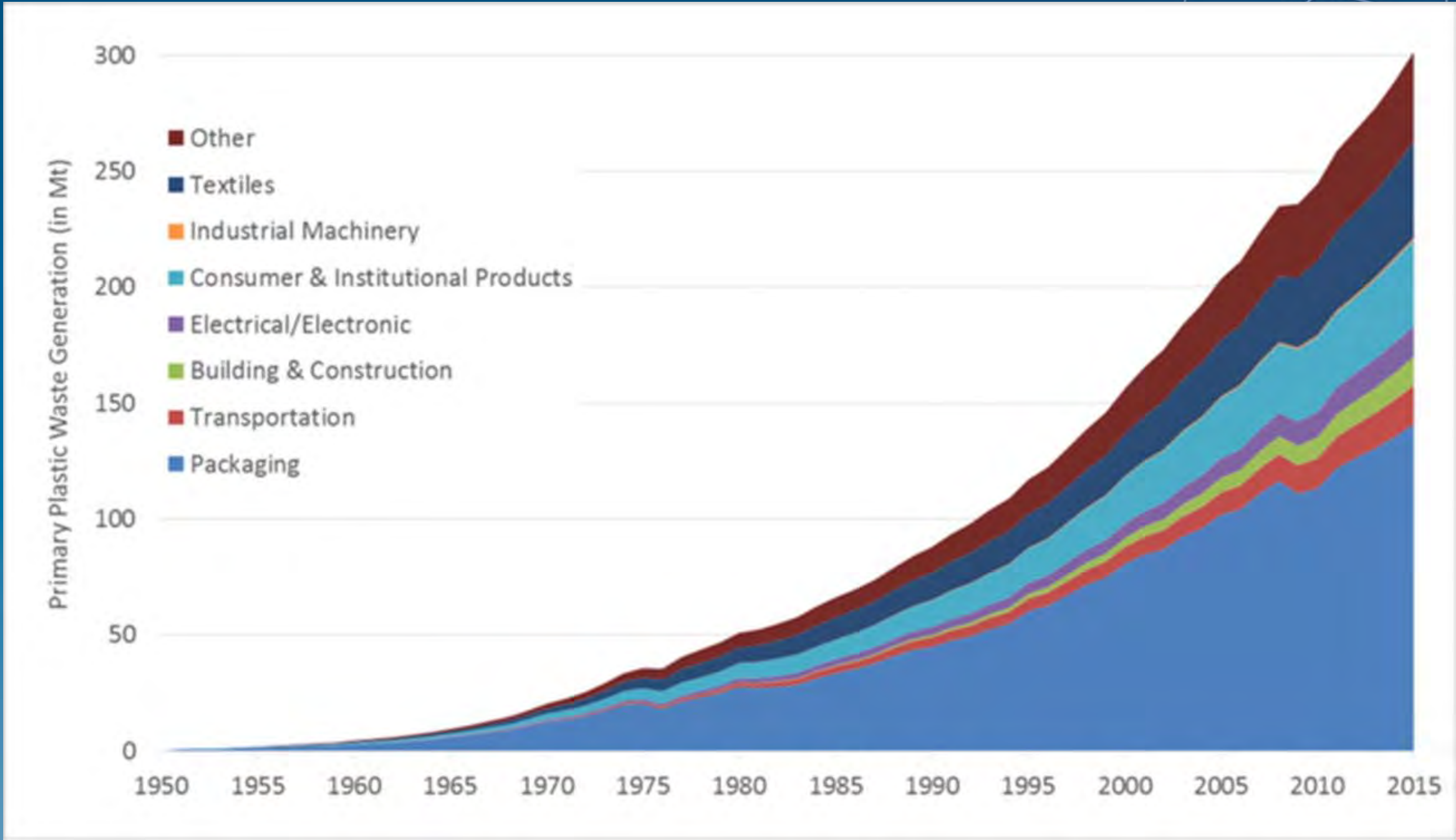
Plastics are a Global Problem



J. Geyer in *Science Advances*. 2017

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Every day in the US, we use 500 million straws.

What is the volume occupied by that many straws?

1 box of 40 straws from Harris Teeter: 3.6 cm X 8.0 cm X 20 cm = 576 cm^3

$$\frac{40 \text{ straws}}{576 \text{ cm}^3} = \frac{500 \times 10^6 \text{ straws/day}}{\text{volume } x}$$

Cross-multiply, solve for *x*, and convert cm^3 to m^3

$x = 7.2 \times 10^9 \text{ cm}^3$

$(1 \text{ m}^3/10^6 \text{ cm}^3) = 7.2 \times 10^3 \text{ m}^3$

A bit more than 7,000 m^3 per day!

Compare that volume with the volume of your office

F. Dobbs, ODU

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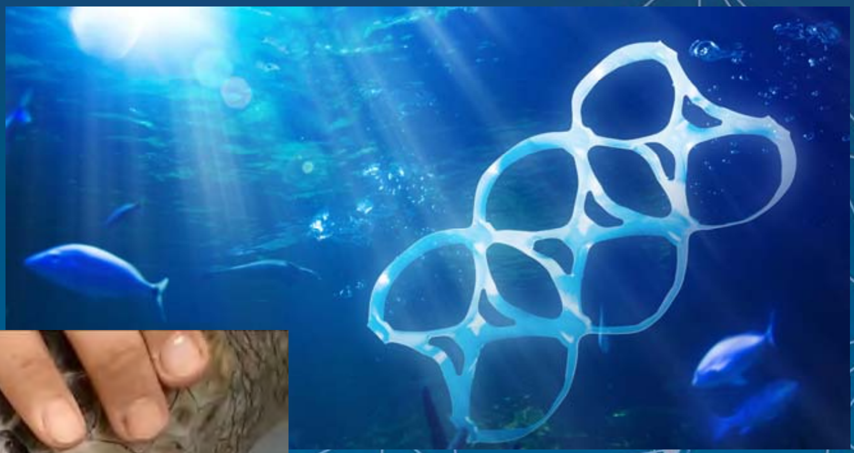
Plastic Pollution - Well documented



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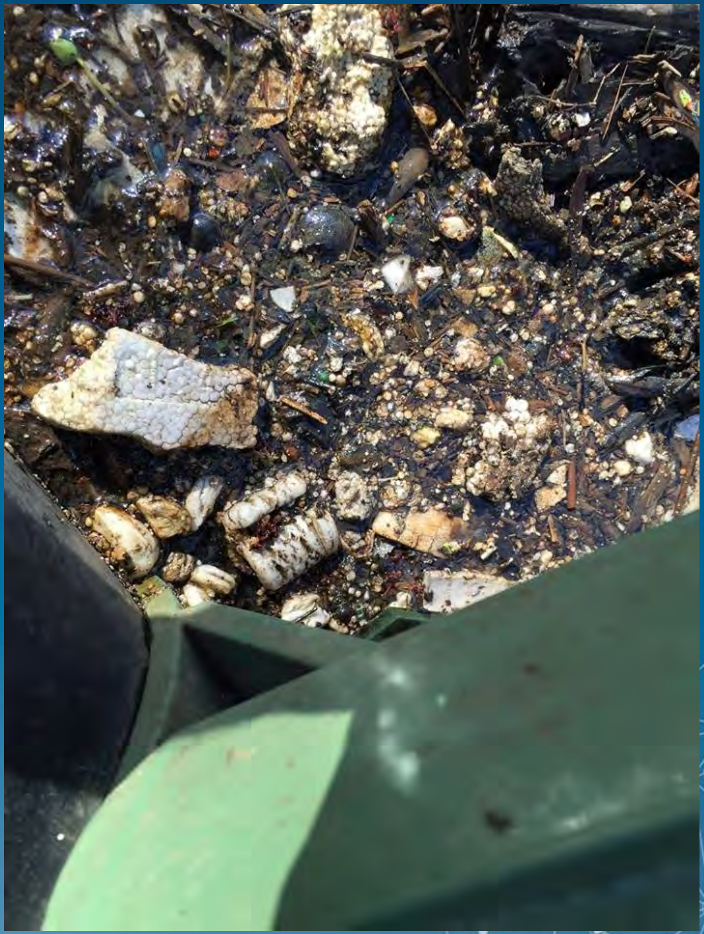
Policy Response

- Washington DC initiates plastic straw ban (Jan. 1, 2019)
- State of Maryland considering banning single use plastic bags
- State of Virginia considering taxing plastic bags
- Maryland bans single use Styrofoam food containers (goes into effect July 1, 2020)

Foam and other plastics start out as this.....



...but turn into this

Microplastics

- **Small plastic fragments, fibers, and granules**
- How small? Usage of the term “microplastic” in the literature varies from 0.1 um to 10mm – a size range of five orders of magnitude!

- **Primary Microplastics** – manufactured products used in:
  - -Facial cleansers and cosmetics (microbeads)
  - -As vectors for drugs
  - -As air-blasting media for removing rust (often contaminated with heavy metals, e.g. cadmium, chromium, lead)
  - -Virgin plastic production pellets – Pellets are convenient to ship and are eventually melted down and molded into manufactured products
- **Secondary Microplastics** – pieces that have broken off larger plastic objects through physical, biological, or chemical processes

Microplastics are Ubiquitous

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RESEARCH ARTICLE

Anthropogenic contamination of tap water, beer, and sea salt

Mary Kosuth[1]*, Sherri A. Mason[2], Elizabeth V. Wattenberg[1]

Original Articles

Synthetic particles as contaminants in German beers

Gerd Liebezeit & Elisabeth Liebezeit

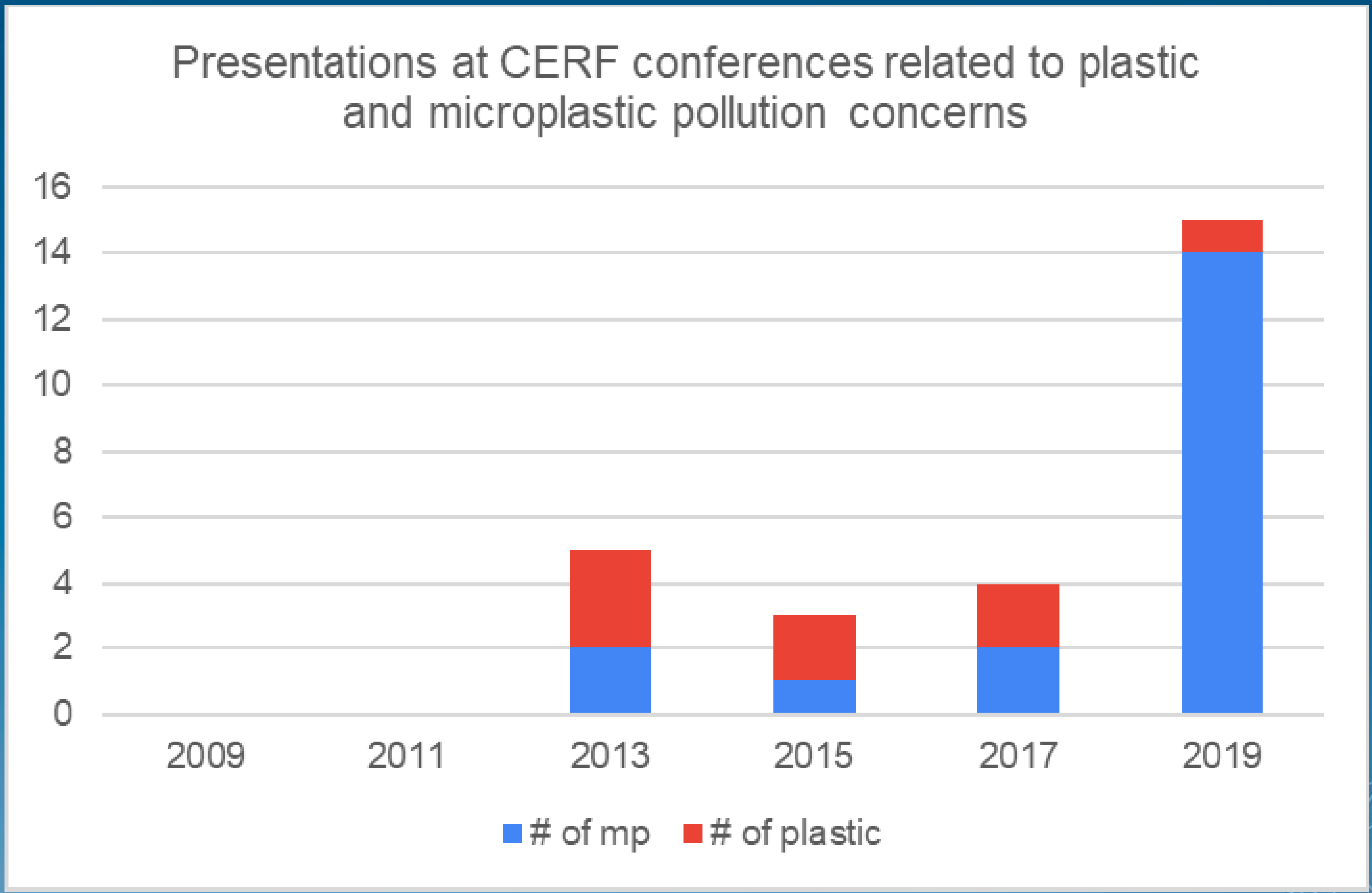
Microplastics in marine sediments near Rothera Research Station, Antarctica

Reed, S

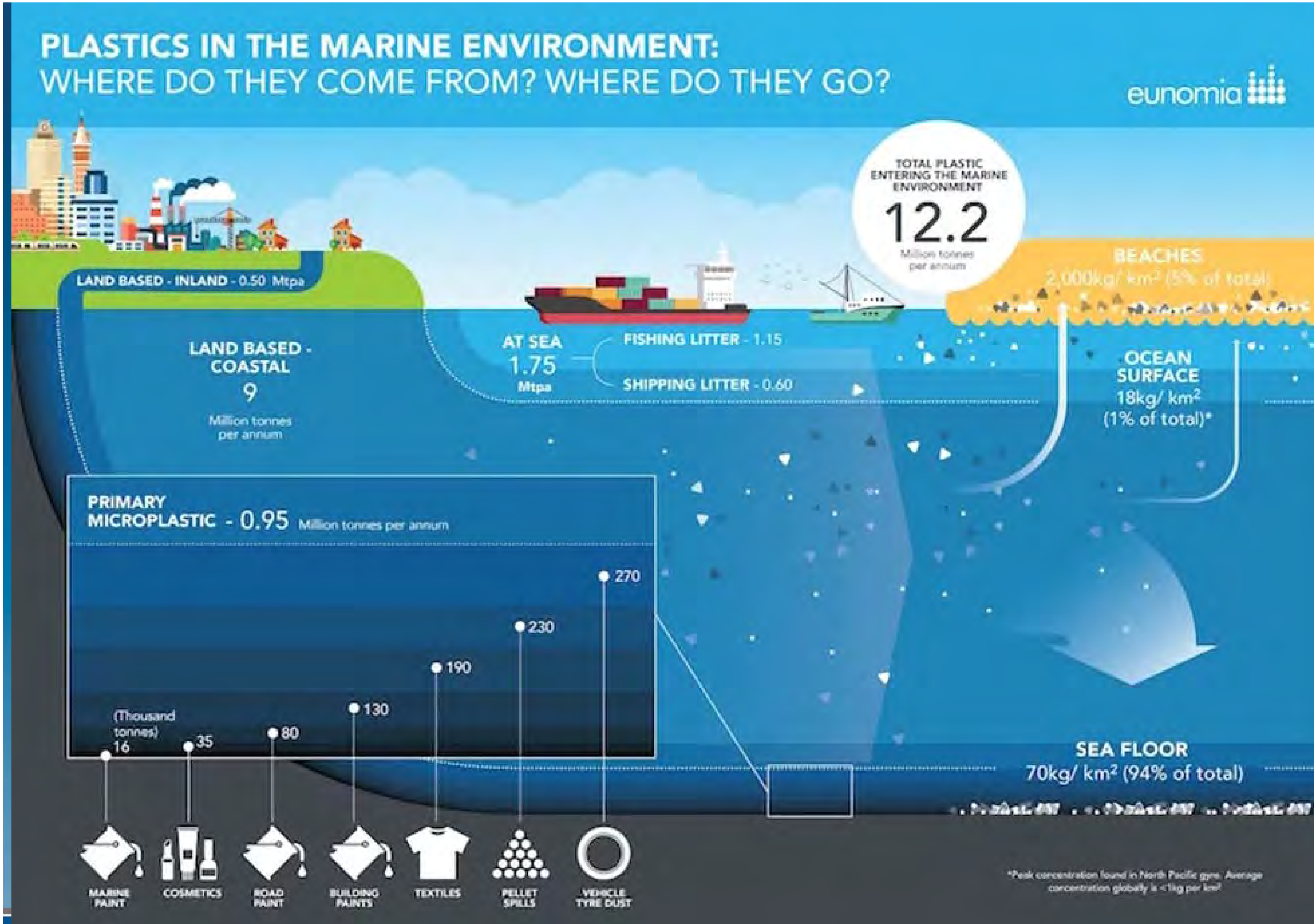
Atmospheric transport and deposition of microplastics in a remote mountain catchment

Steve Allen, Deonie Allen, Vernon R. Phoenix, Gaël Le Roux, Pilar Durántez Jiménez, Anaëlle Simonneau, Stéphane Binet & Didier Galop

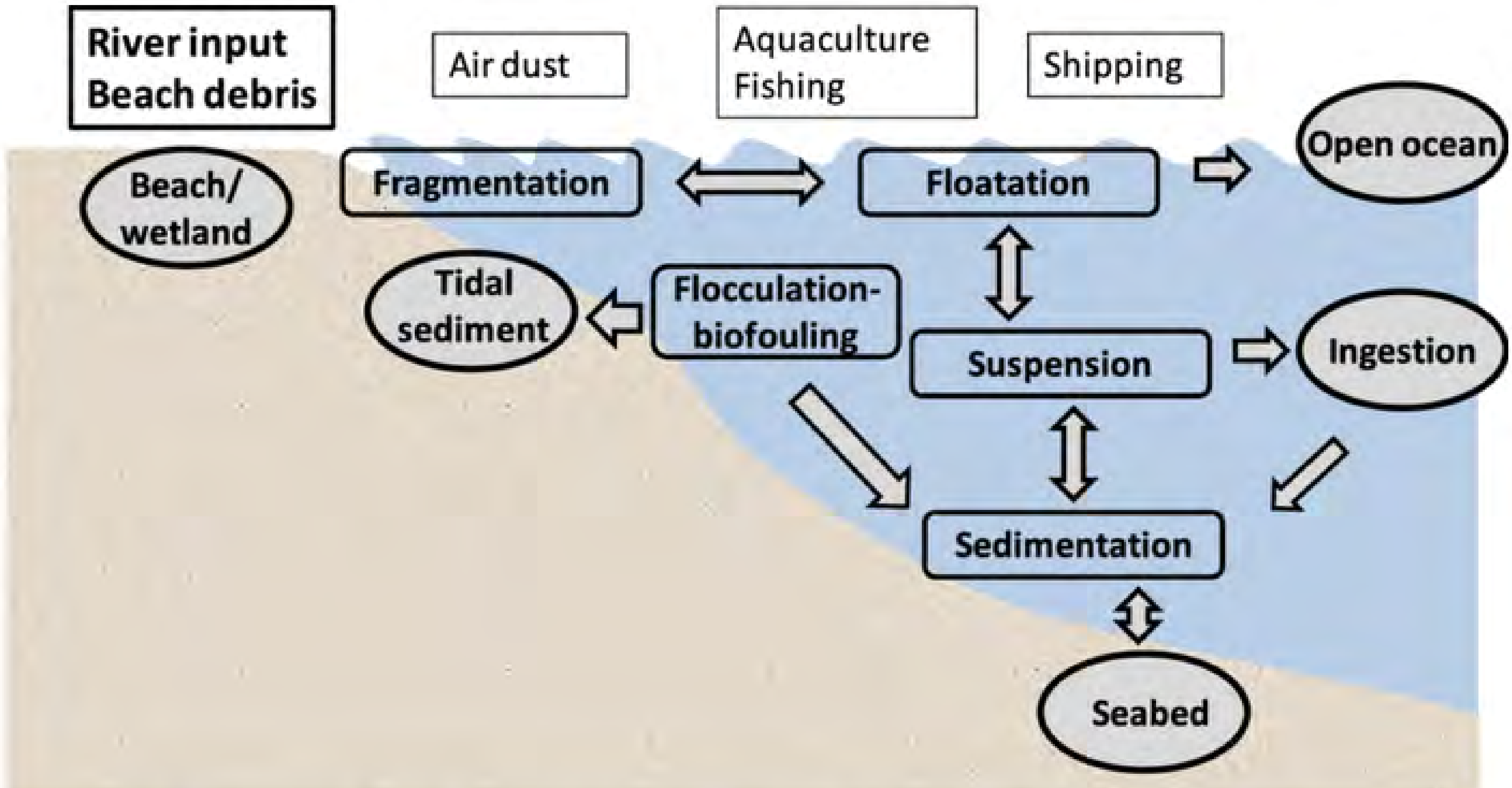
Coastal & Estuarine Research Federation



B. Landry



Ecowatch, 2016



Schematic representation of sources, sinks, and pathways of microplastic transport in the marine environment.

Zhang, 2017

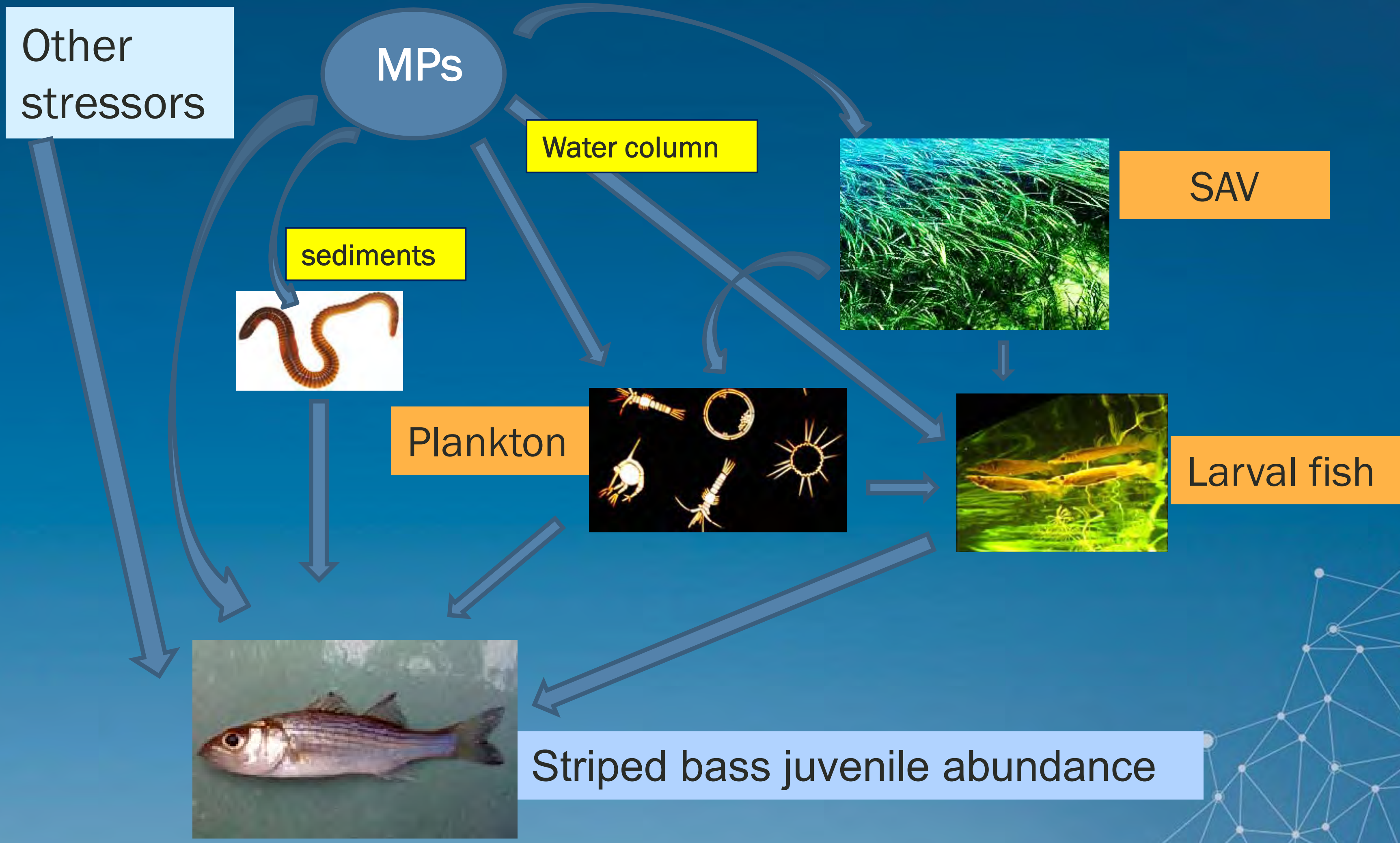
Why Do We Care about Plastics and Microplastics in Coastal Ecosystems?

In March 2019, Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO) estimated 95% of all seabird species will ingest some form of plastic by 2050

World Economic Forum projects more plastic in the ocean than fish by 2050

Photo by Masaya Maeda, Anacostia Watershed Society

Fate of Microplastics

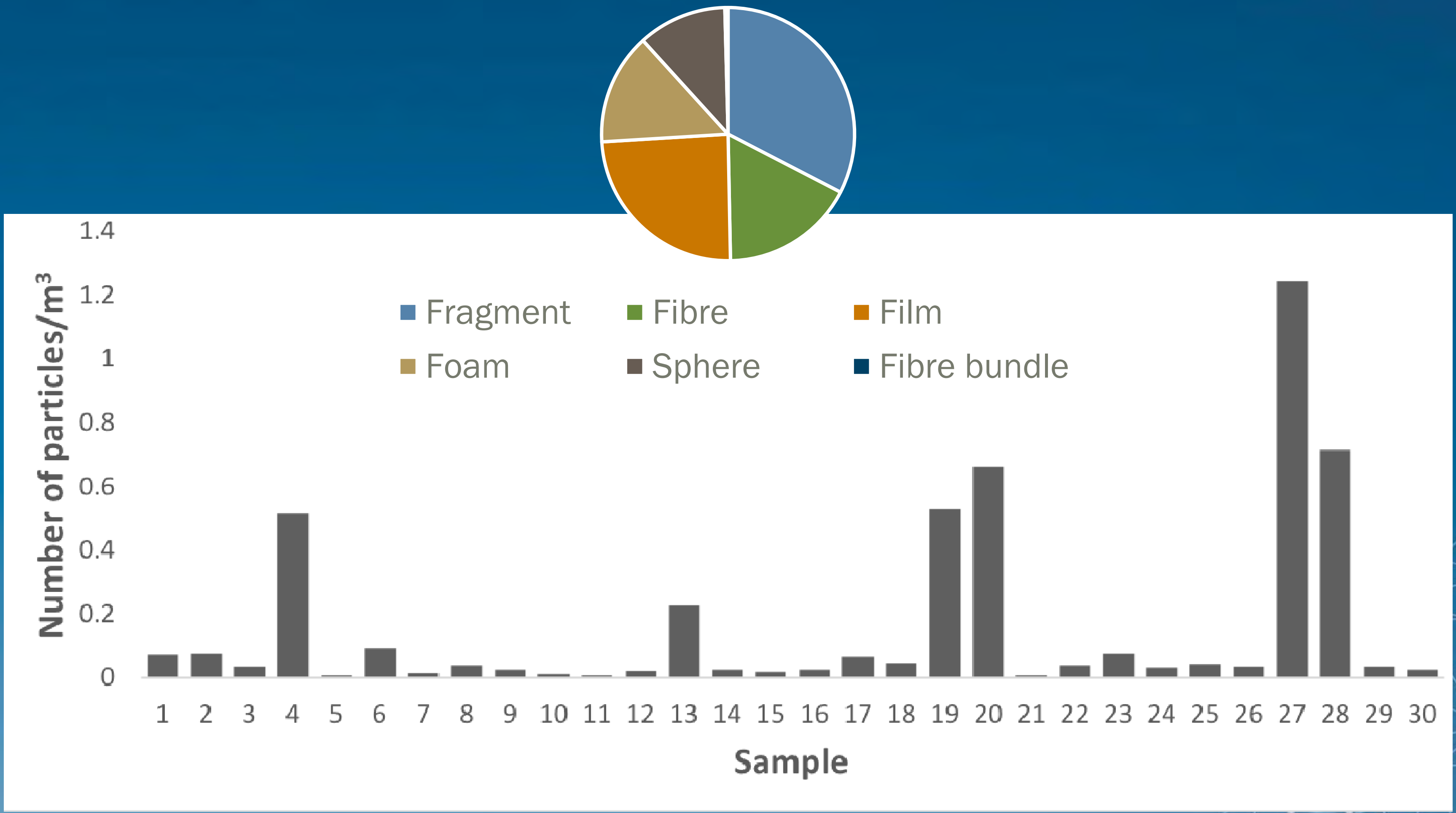


Evidence of Microplastics in the Bay and Watershed

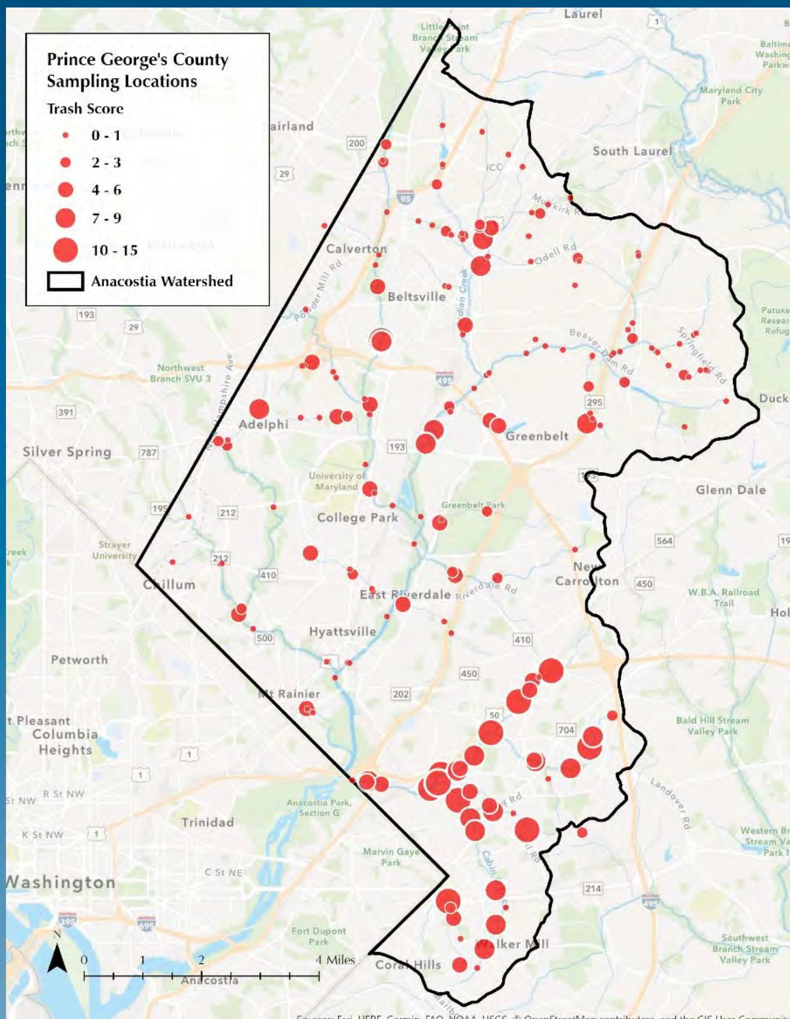
Photos by Masaya Maeda, Anacostia Watershed Society, 2017

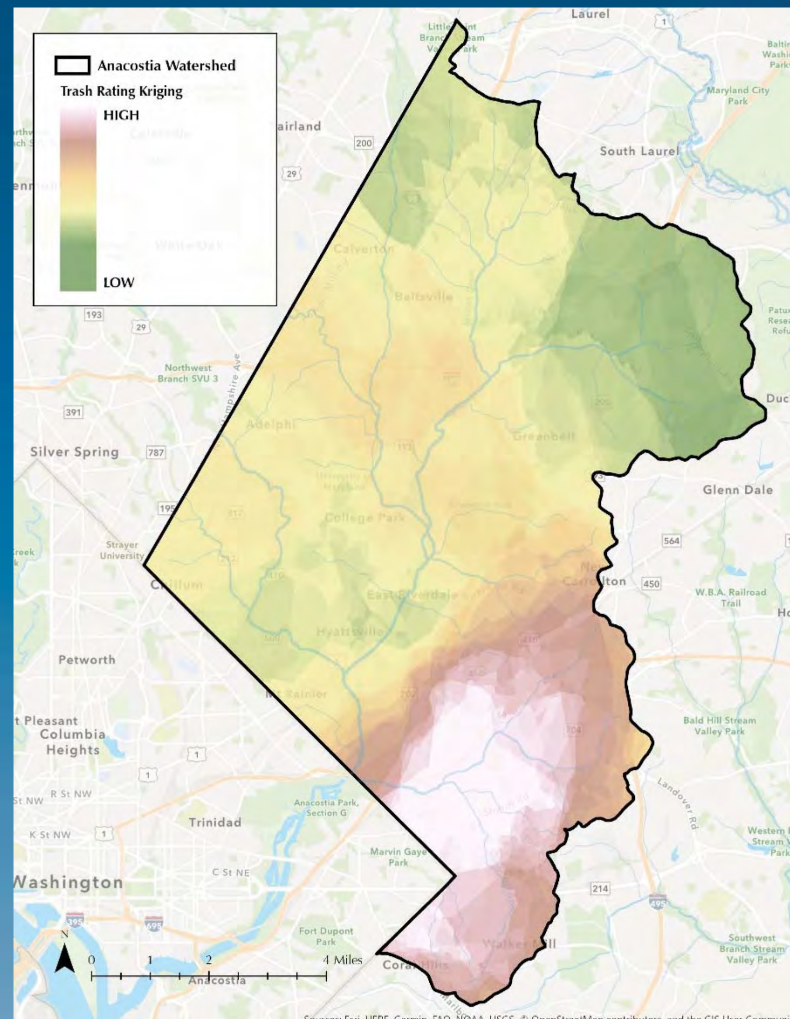
Trash Free Maryland: Trash Trawl Surface Water Manta Trawl Across the Bay
(Courtesy DNR, TFM, Univ Toronto)

Trash Trawl Results (courtesy DNR, TFM, Univ. Toronto)



Trash Data from Prince Georges County-Anacostia River Watershed





Data courtesy Prince Georges County, Maryland

Where are those Microplastics likely to accumulate?

- 2000% increase in submerged aquatic vegetation (SAV) in DC between 2009 and 2017
- Surpassed Chesapeake Bay Program goals for SAV restoration
- SAV also habitat for larvae of DC state fish, American Shad (*A. sapidissima*)
- Question: could SAV beds be capturing microplastics?

Submerged Aquatic Vegetation (SAV)

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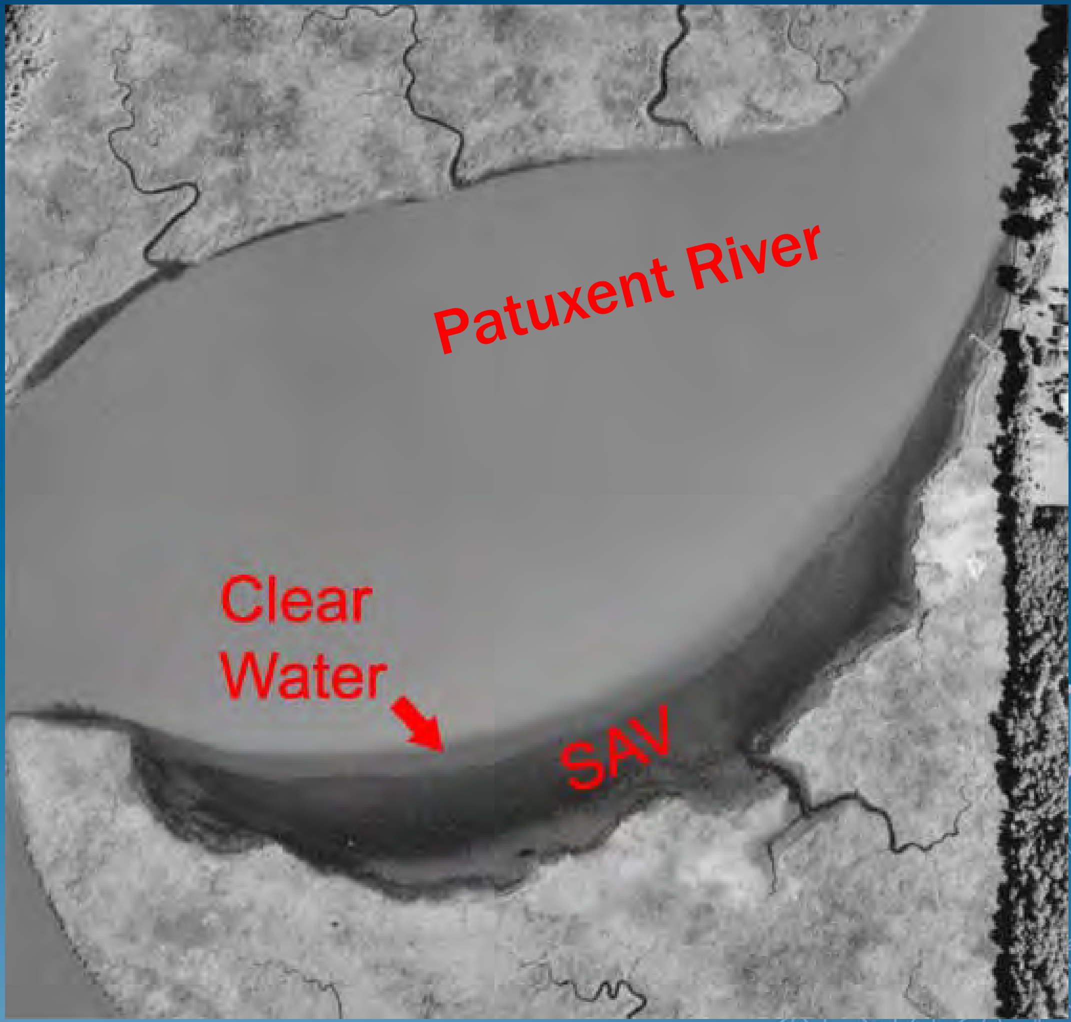
- Underwater grasses are a critical part of coastal ecosystems because they provide food and habitat for countless species.
- SAV helps keep the water clear by absorbing nutrients, trapping sediments, reducing erosion and adding oxygen.
- Fish, crabs and other animals exploit grass beds to seek out food and find shelter from larger predators.
- Underwater grasses are also an important source of food for waterfowl such as ducks and geese.

SAV beds serve as natural filters (think sediments)

- Slow water flow
- Physically filter particles from water column

"Underwater Grasses
Underwater grasses grow in the shallow waters of the Bay and its streams. They provide food and habitat to wildlife, add oxygen to the water and *trap sediment and nutrient pollution*." –CBP website 12/19



VIMS, 2006

SAV beds slowing flow

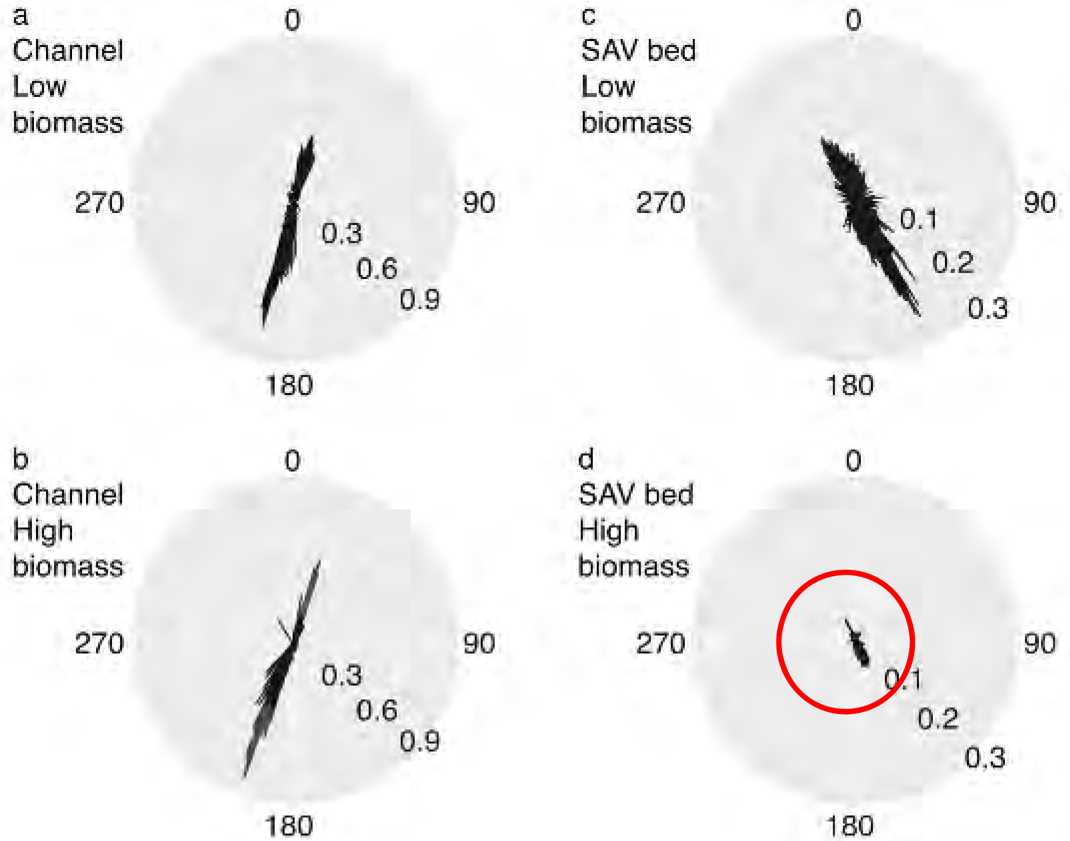


Fig. 7 Flow velocity measured during high SAV biomass (June) and low SAV biomass (August). *Concentric circles* represent current speed ($m\ s^{-1}$) and *radial lines* represent compass direction (degrees). Note that the scale for current speed is different across sites but the same across seasons

Gurbisz et al 2017

Microplastics in submerged vegetation beds

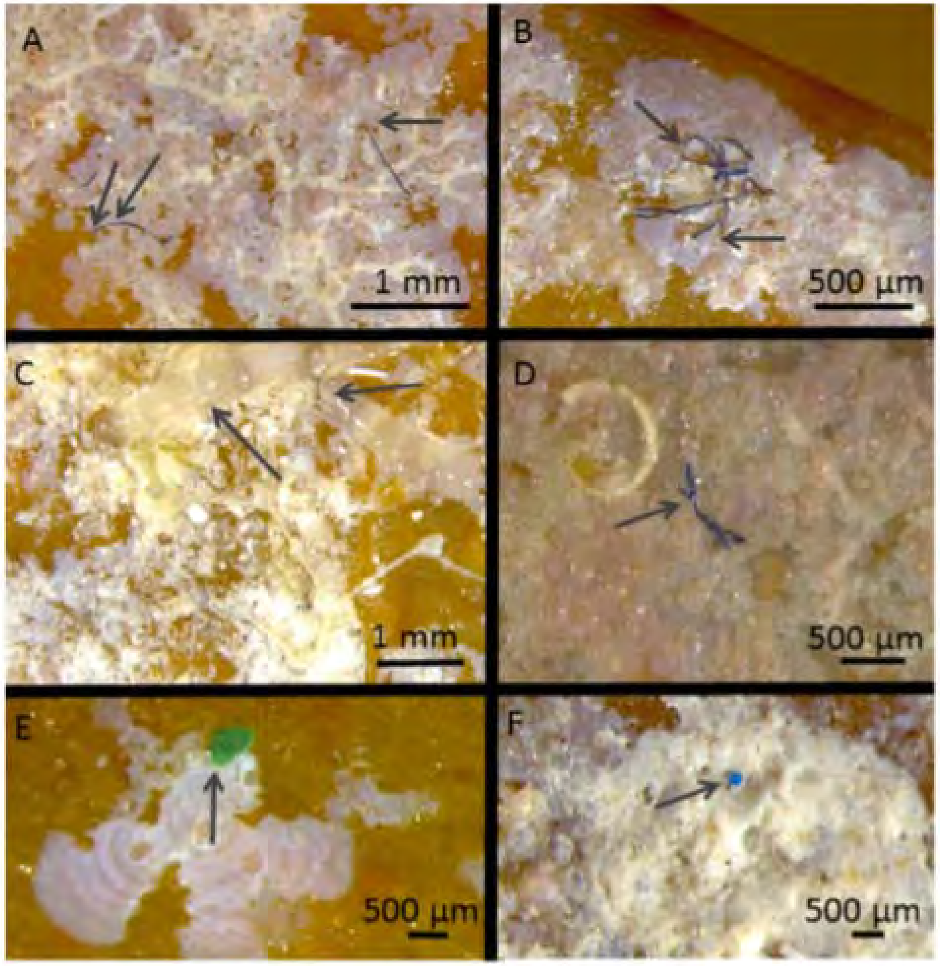


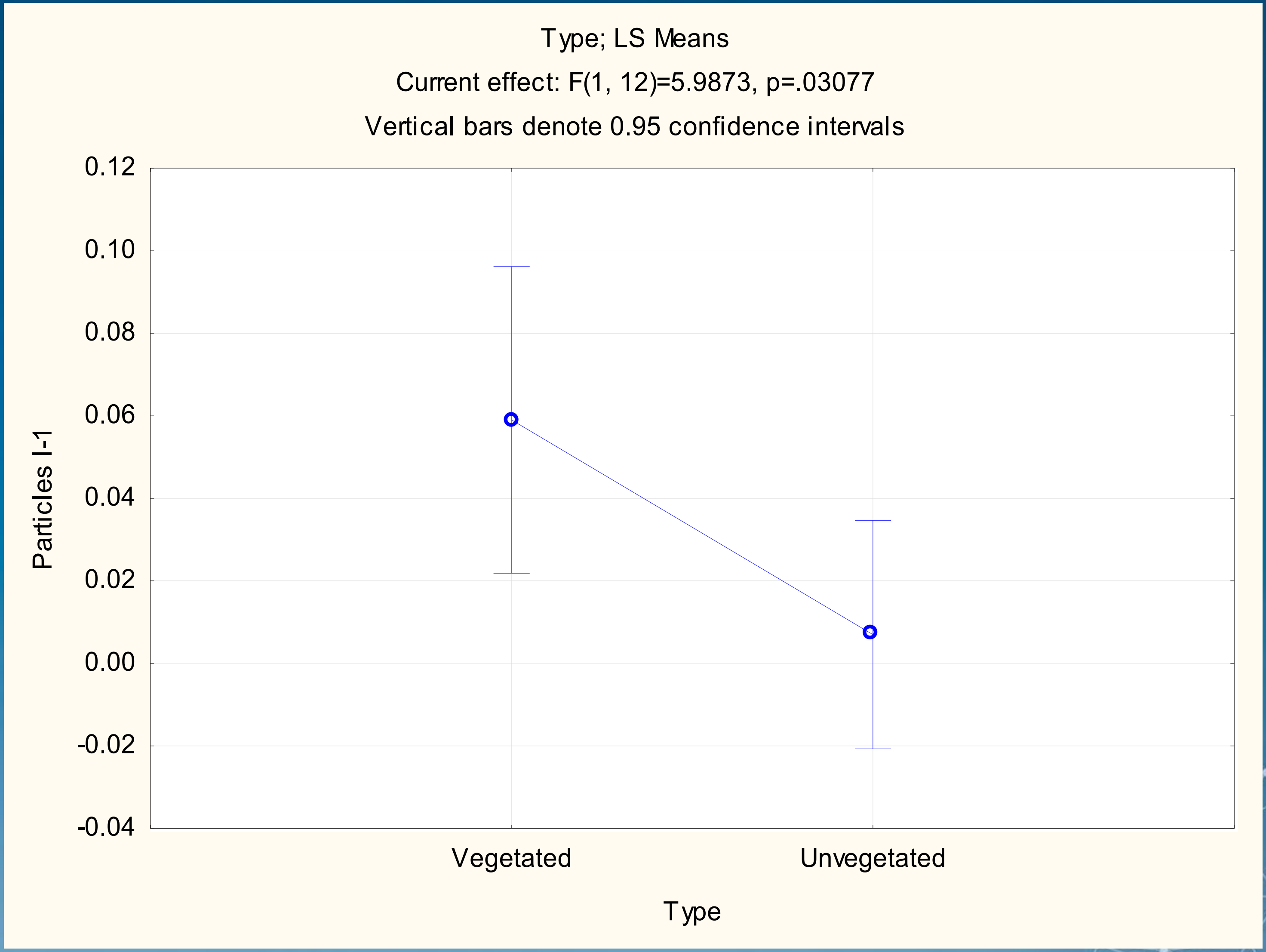
Fig. 2. A–D Microfibers embedded within epibiont communities. Arrows indicate where crustose coralline algae (CCA), gelatinous epibionts, or other epibiotic organisms have begun to grow over fibers. E, F Non-fiber (Chip: E, Bead: F) microplastics found on epibiont communities on *Thalassia testudinum*.

Goss et al 2018

Microplastics in SAV beds –Potomac River, Washington DC

- 500 µm net removed from weighted ring;
- Cinched closed with zip tie
- Placed in cooler with water
- Transported back to lab, kept in water
- Vegetative samples removed, back rinsed Nitex netting, dried in oven 48h
- Visually screened for microplastics

Results


Type; LS Means
Current effect: F(1, 12)=5.9873, p=.03077
Vertical bars denote 0.95 confidence intervals
0.12
0.10
0.08
0.06
0.04
0.02
0.00
-0.02
-0.04
Particles l-1
Vegetated
Unvegetated
Type

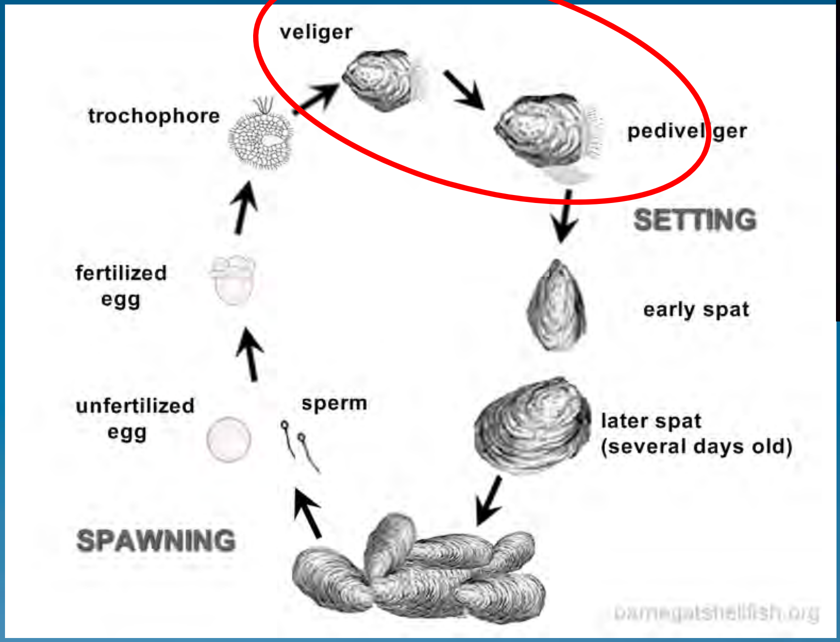
Plastic Types

Habitat type	Particle Type		
	Fiber	Foam (Styrene)	Misc *
Vegetated	13	1	5
Unvegetated	2	0	5

* Included small black, blue, and white plastic pieces

The case of Oysters

- Eastern oyster *(Crassostrea virginica)* larvae
  - Very important ecologically, economically, culturally
  - Population in Bay is <1%
  - Massive effort to restore the population
  - Larvae most sensitive life stage
  - Larvae are free swimming



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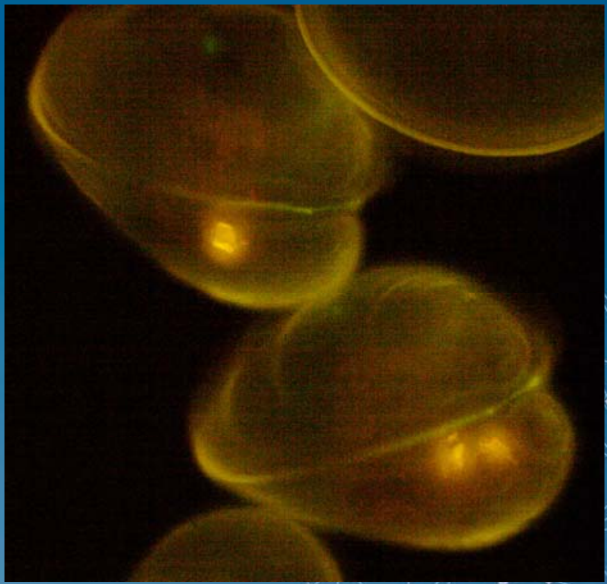
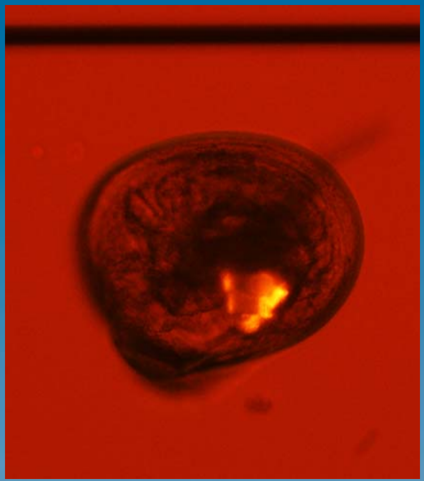
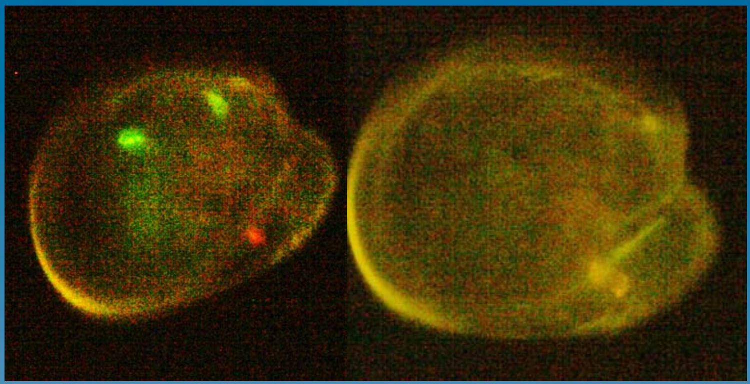
Oysters

- Oyster larvae fed microplastics are clearing more water and assimilating more carbon but using that carbon in the same proportion. No net gain/loss;
- Larval settlement (from the water column) is delayed by up to 6 days — increased predation potential (Sussarellu et al 2016)

14 x 14 µm
PET







14 x 28 µm
PET

cknauss@umces.edu

Implications

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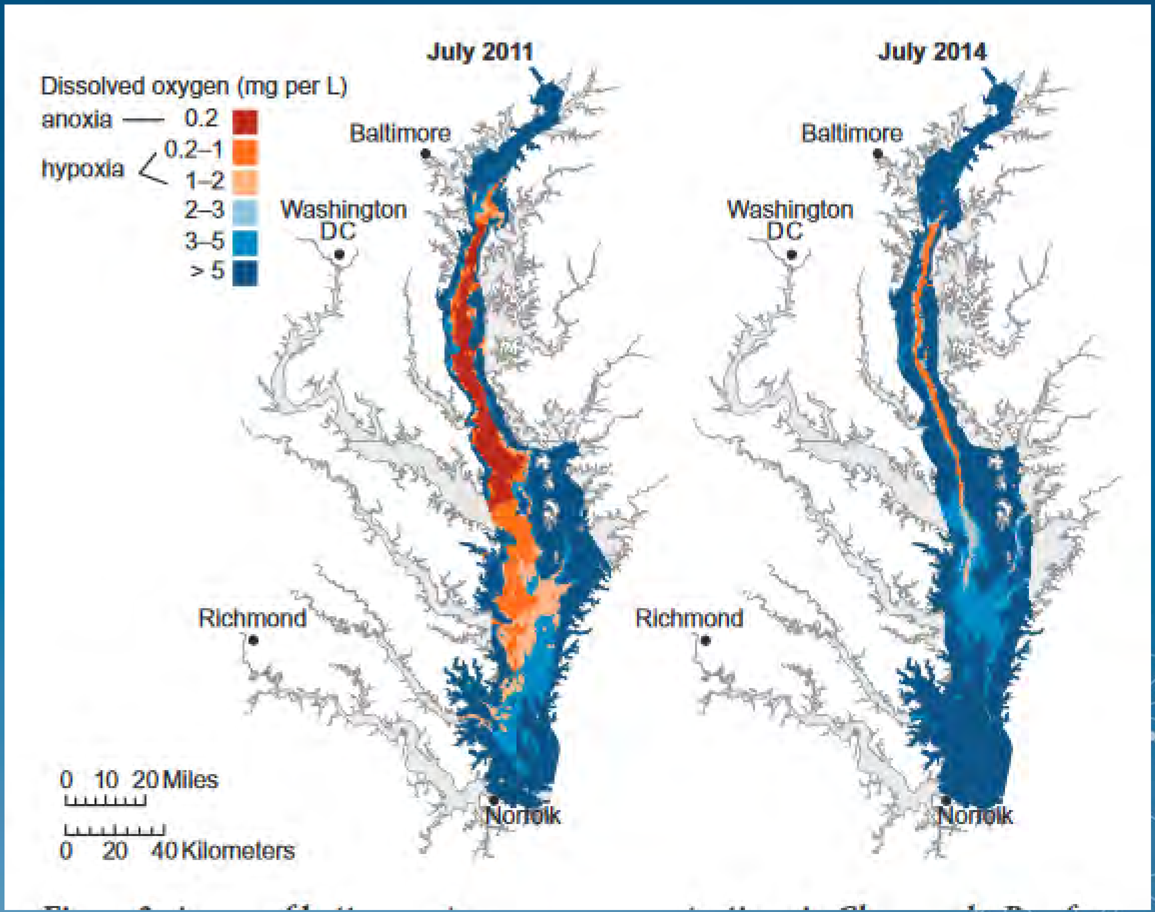
- SAV and oyster reefs serve as critical coastal habitats… this function may now become compromised
- Reduction in oyster recruitment
- Chemical adherence – mortality or…
- Condition effects
- Population level effects
- Human health

Chesapeake Bay

- Largest estuary in North America
- Watershed: 64,000 mi.^{2} (165759 km^2)
- 11,684 miles (18,803 km) of shoreline
- 150 major rivers & streams
- >18 million residents

Chesapeake Bay Program

- Regional federal-state partnership that has led and directed the restoration of the Chesapeake Bay since 1983;
- Set policy (non-regulatory) and restoration goals
  - E.g.- Nitrogen and Phosphorous reductions



Testa et al 2017

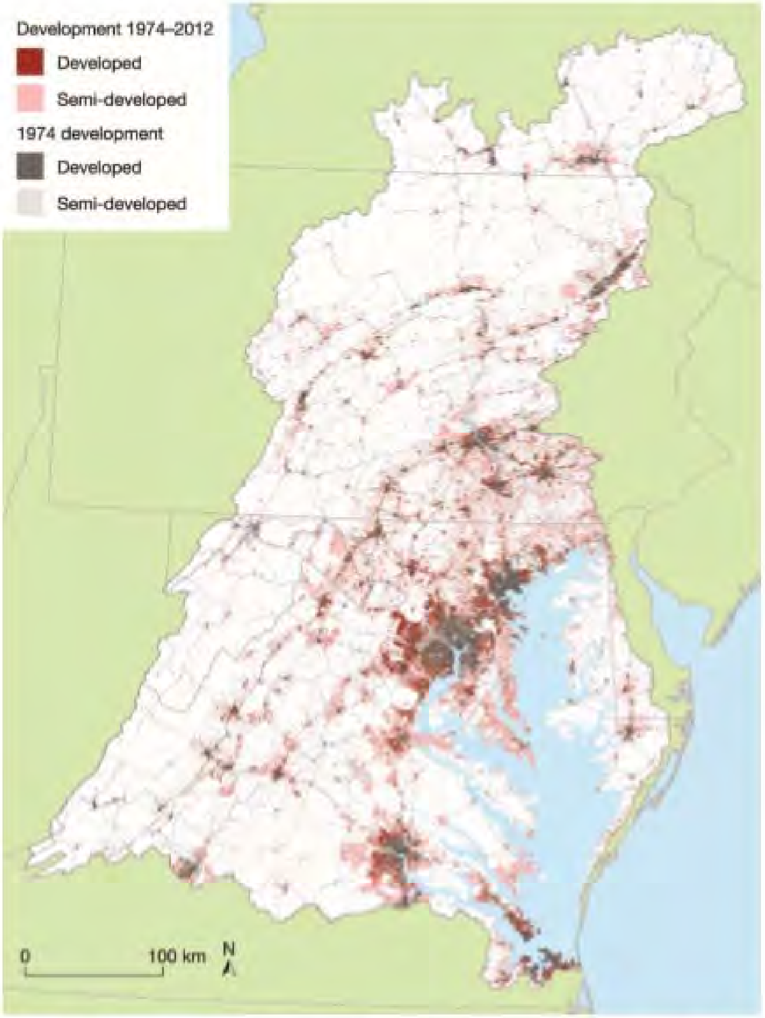
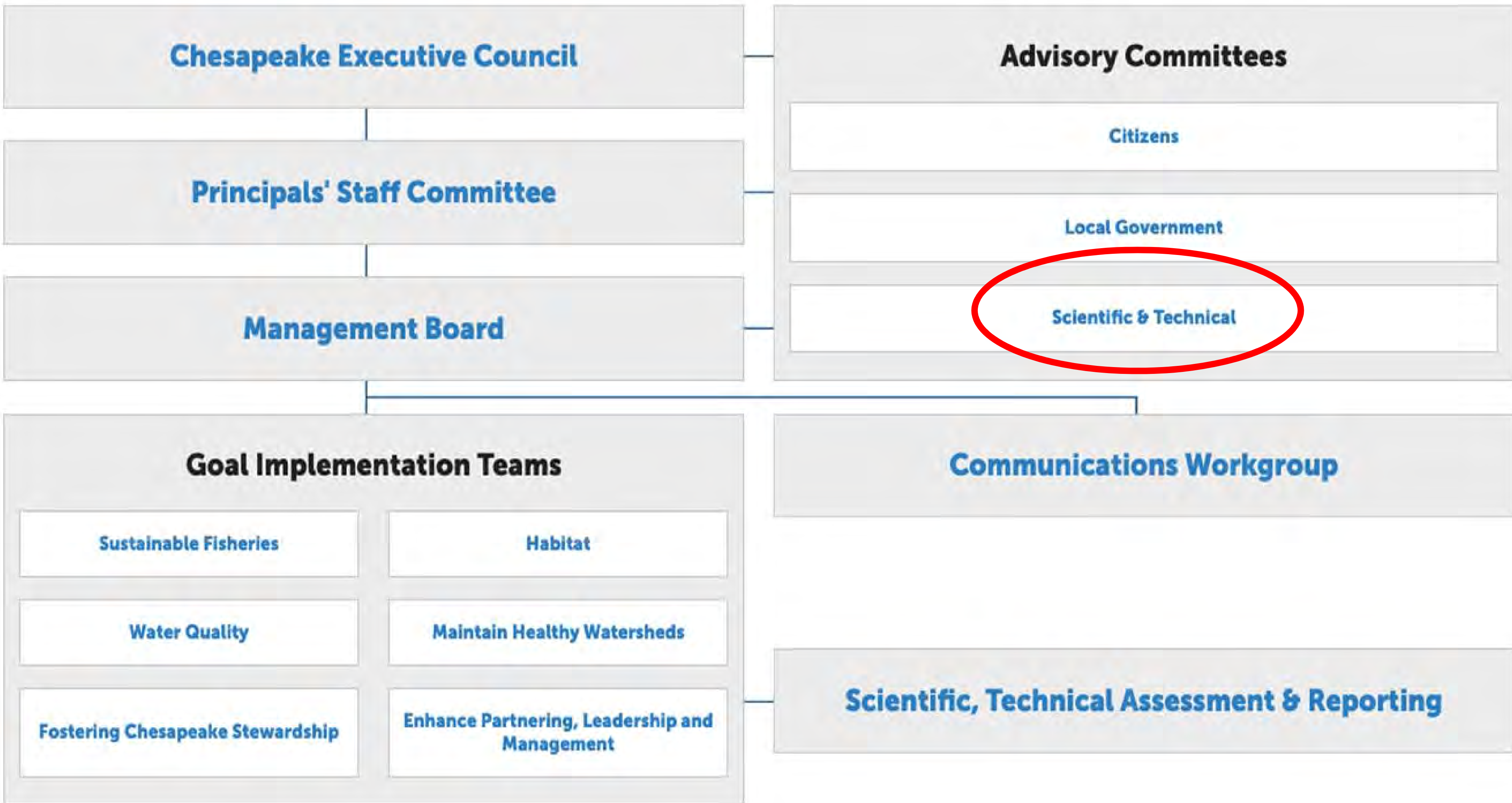


Figure 8. The expansion of developed land in the Chesapeake Bay watershed from 1974 to 2012. The shades of gray show land already developed in 1974, and the shades of red show land developed between 1974 and 2012 by conversion of agricultural land, forests, and wetlands. The developed and semideveloped categories are from aggregating seven developed land subclasses and three semideveloped subclasses (data extracted and synthesized from Falcone 2015). Abbreviaion: km, kilometers.

- Urbanization is a threat to most coastal ecosystems
- Loss of habitat though development
- Water quality issues (impervious surface
- Trash

Orth et al 2017)

Chesapeake Bay Program - Structure



Scientific & Technical Advisory Committee Workshop

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

Report available here:
https://www.chesapeake.org/stac/document-library/microplastics-in-the-chesapeake-bay-and-its-watershed-state-of-the-knowledge-data-gaps-and-relationship-to-management-goals/

Identified Needs

1. The CBP should create a 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 ecological risk assessment of microplastics into the CBP strategic science and research framework
3. STAC should undertake a technical review of terminology used in microplastic research, specifically size classification and concentration units, and recommend uniform terminology 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.

Ecological Impact

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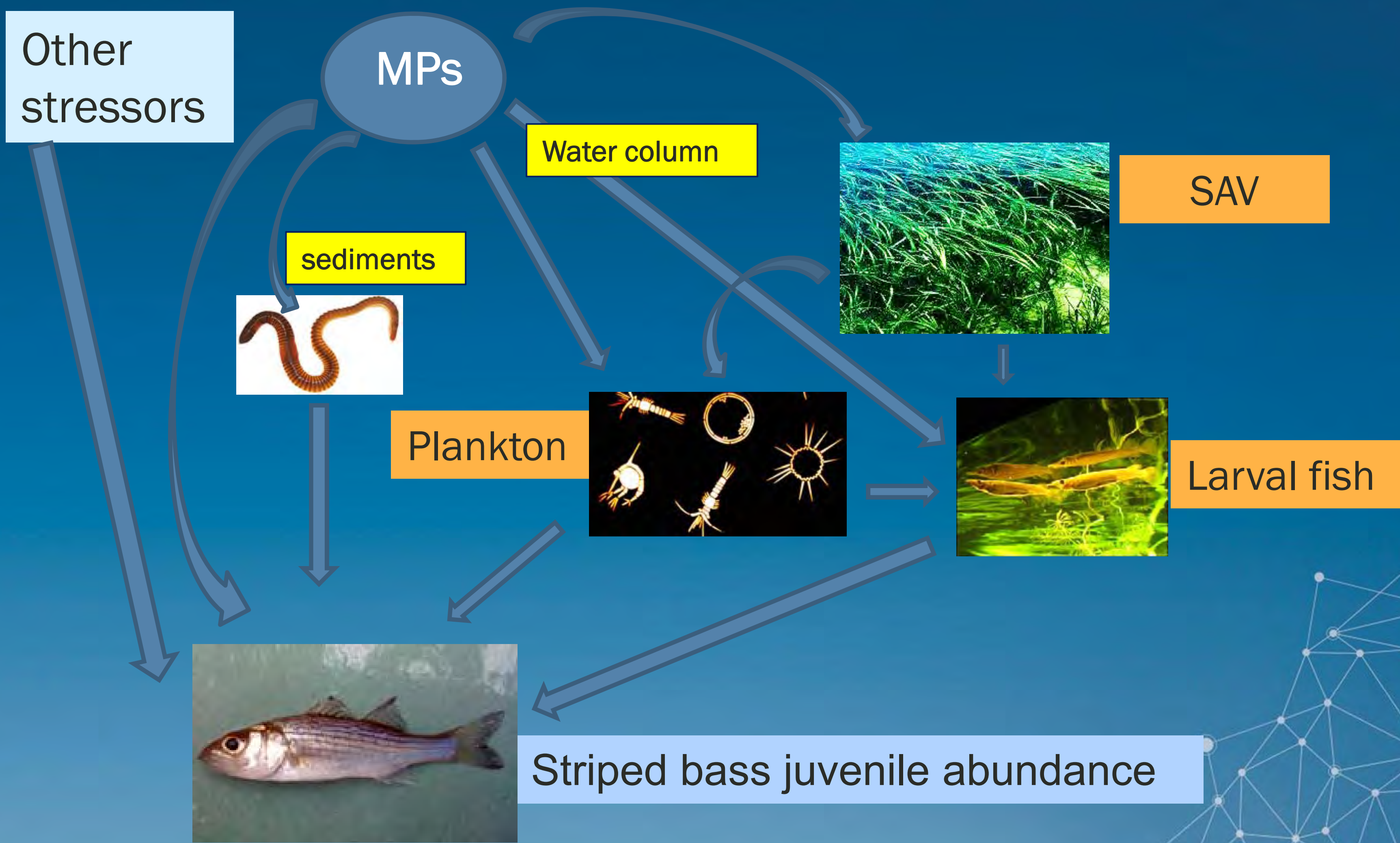
- Long-term environmental stressor – Reduction in physical condition – increased mortality

- Delayed ontogenetic development – increased likelihood of predation (e.g. oysters)

- Trophic transfer of chemical contaminants

- Increased rates of infection (e.g. *Vibrio*)

Ecological Risk Assessment



Future Efforts

- Further evaluation/assessment of SAV beds
- Fish stomach analyses 2020
- Development of full ecological risk assessment (Potomac River, Chesapeake Bay)

Special thanks:

- Matt Robinson, DC Dept. of Energy & Environment
- Brooke Landry, MD Dept. of natural resources
- John Roberts, Tetra Tech
- Chris Wharton, Tetra Tech
- Chad Barbour, Tetra Tech
- Jerry Diamond, Tetra Tech
- Kelly Somers, USEPA Region III

Questions?

Bob Murphy, Tetra Tech, Center for Ecological Sciences

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