Plastics in Shoreline and Seabed Sediments of Narragansett Bay

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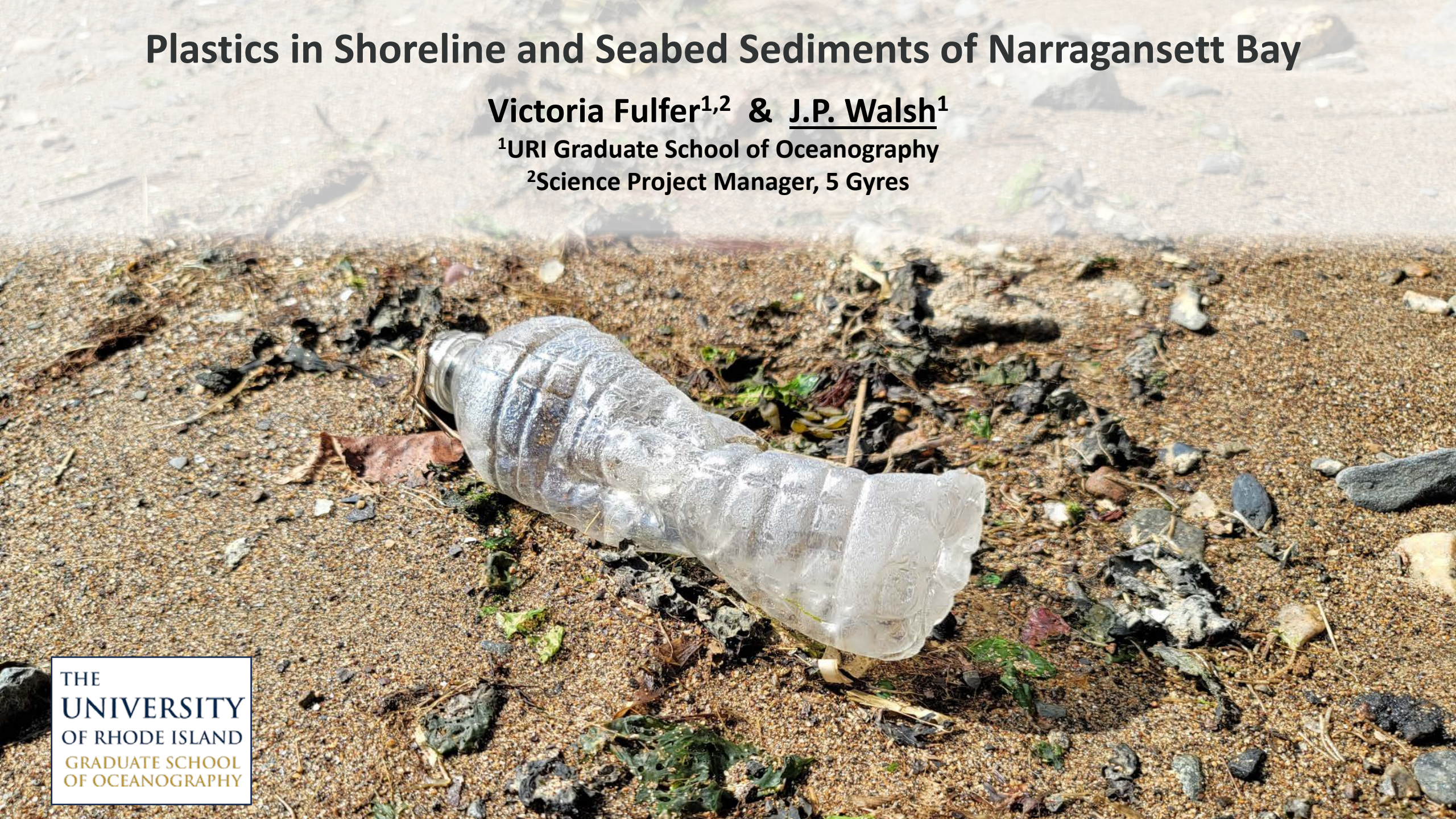
[2]Science Project Manager, 5 Gyres



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A picture says a thousand words…

***The Graduate*, 1967**

Global Plastics Production

Our World in Data

February 6, 1909

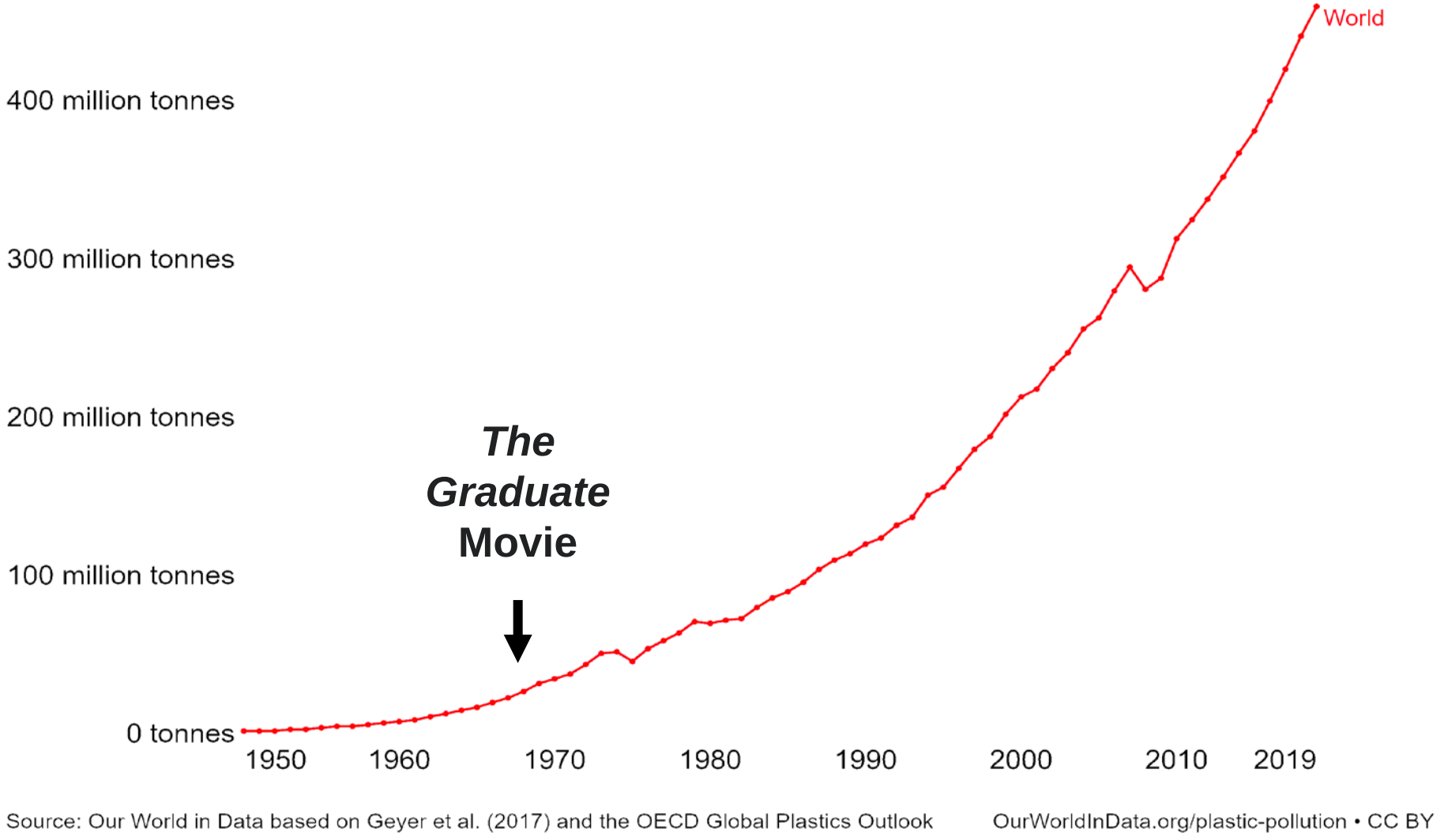
The New York Times

NEW CHEMICAL SUBSTANCE.

Bakelite Is Said to Have the Properties of Amber, Carbon, and Celluloid.

Bakelite

Oxybenzylmethyleneglycolanhydride



Source: Our World in Data based on Geyer et al. (2017) and the OECD Global Plastics Outlook

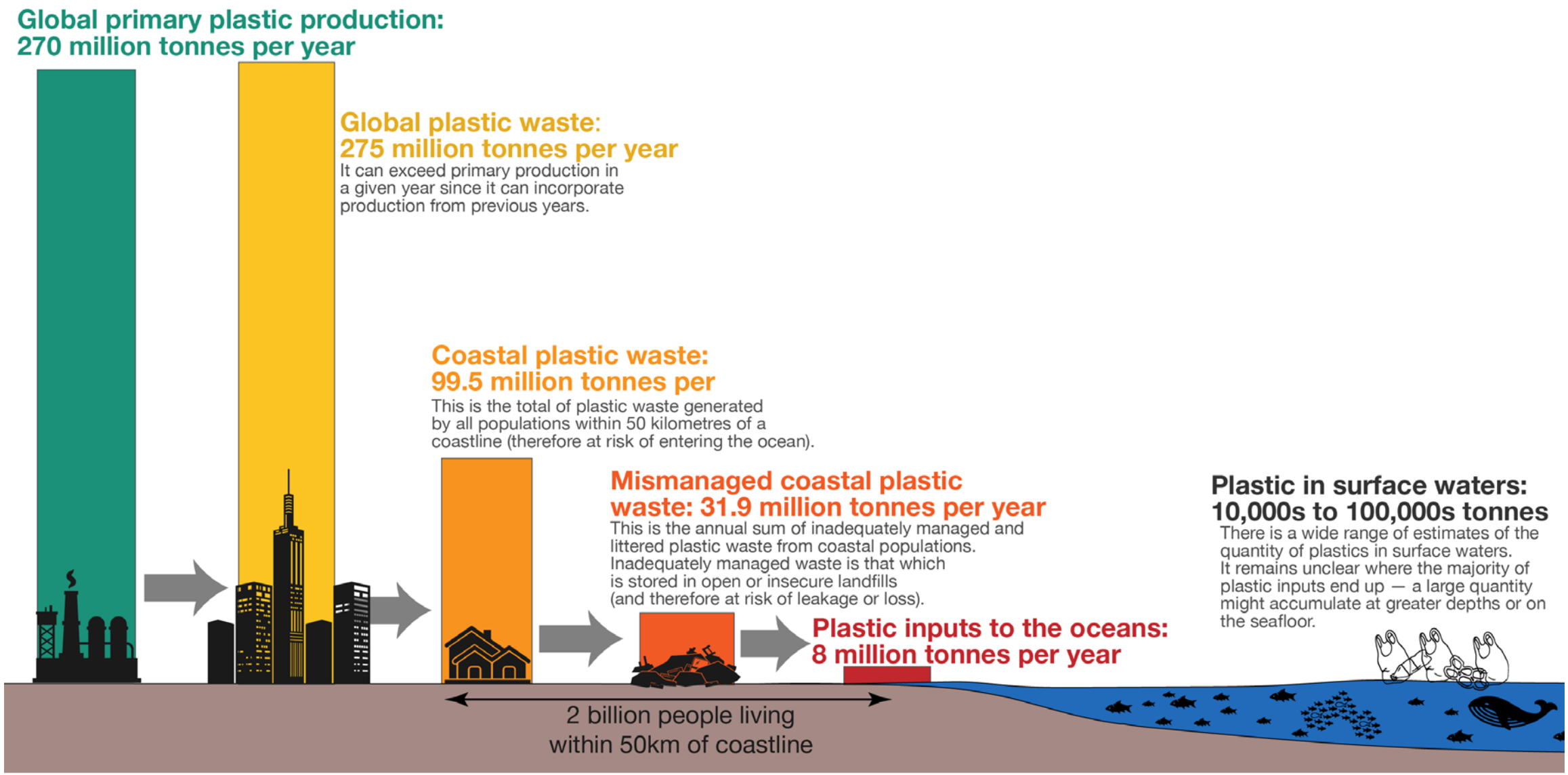
OurWorldInData.org/plastic-pollution • CC BY

Many difficult images.
Is there a bigger concern?

The pathway by which plastic enters the world's oceans

Our World in Data

Estimates of global plastics entering the oceans from land-based sources in 2010 based on the pathway from primary production through to marine plastic inputs.



Source: based on Jambeck et al. (2015) and Eriksen et al. (2014). Icon graphics from Noun Project.
Data is based on global estimates from Jambeck et al. (2015) based on plastic waste generation rates, coastal population sizes, and waste management practices by country

This is a visualization from OurWorldinData.org, where you will find data and research on how the world is changing.

Save The Bay's 2023 RI Coastal Cleanup Report

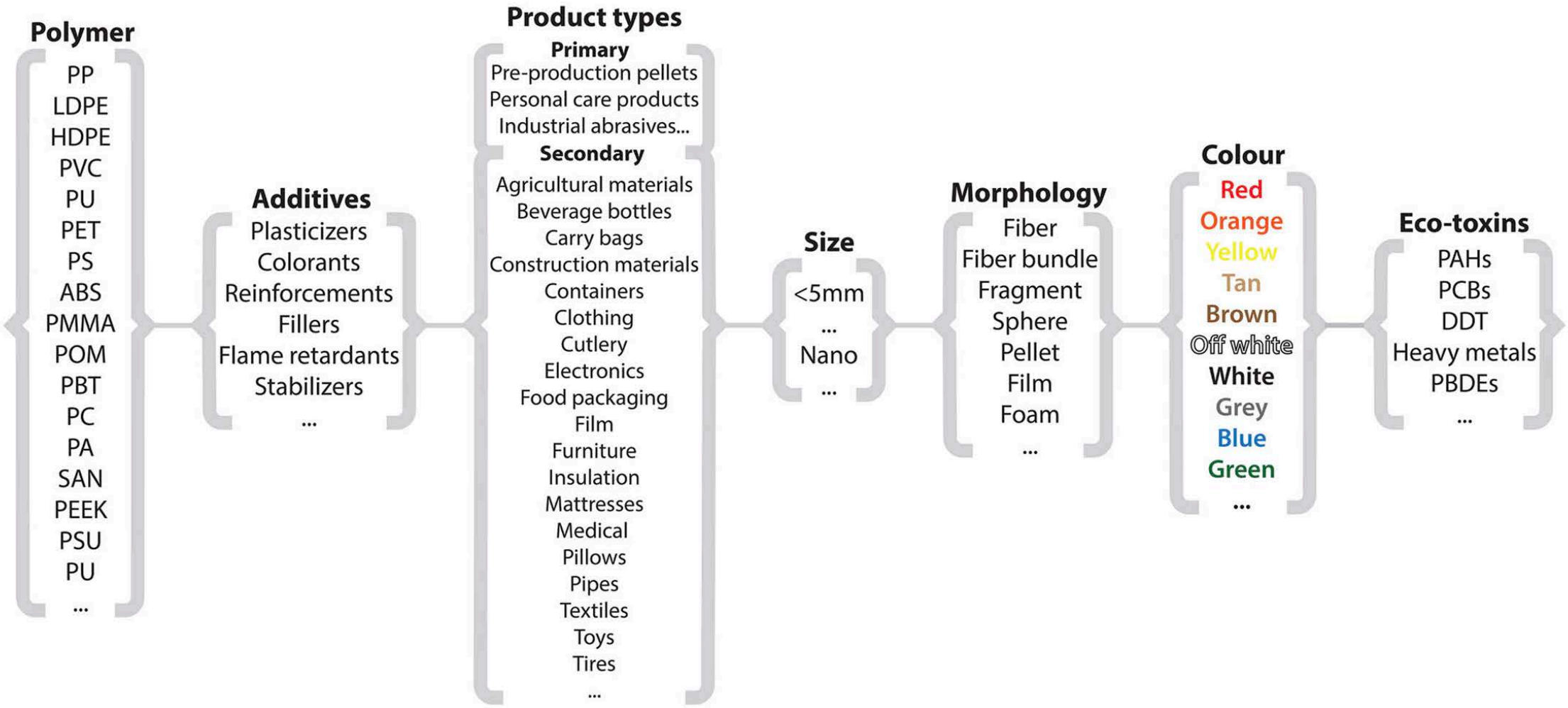
Drinking = #1 Category

43,858 items

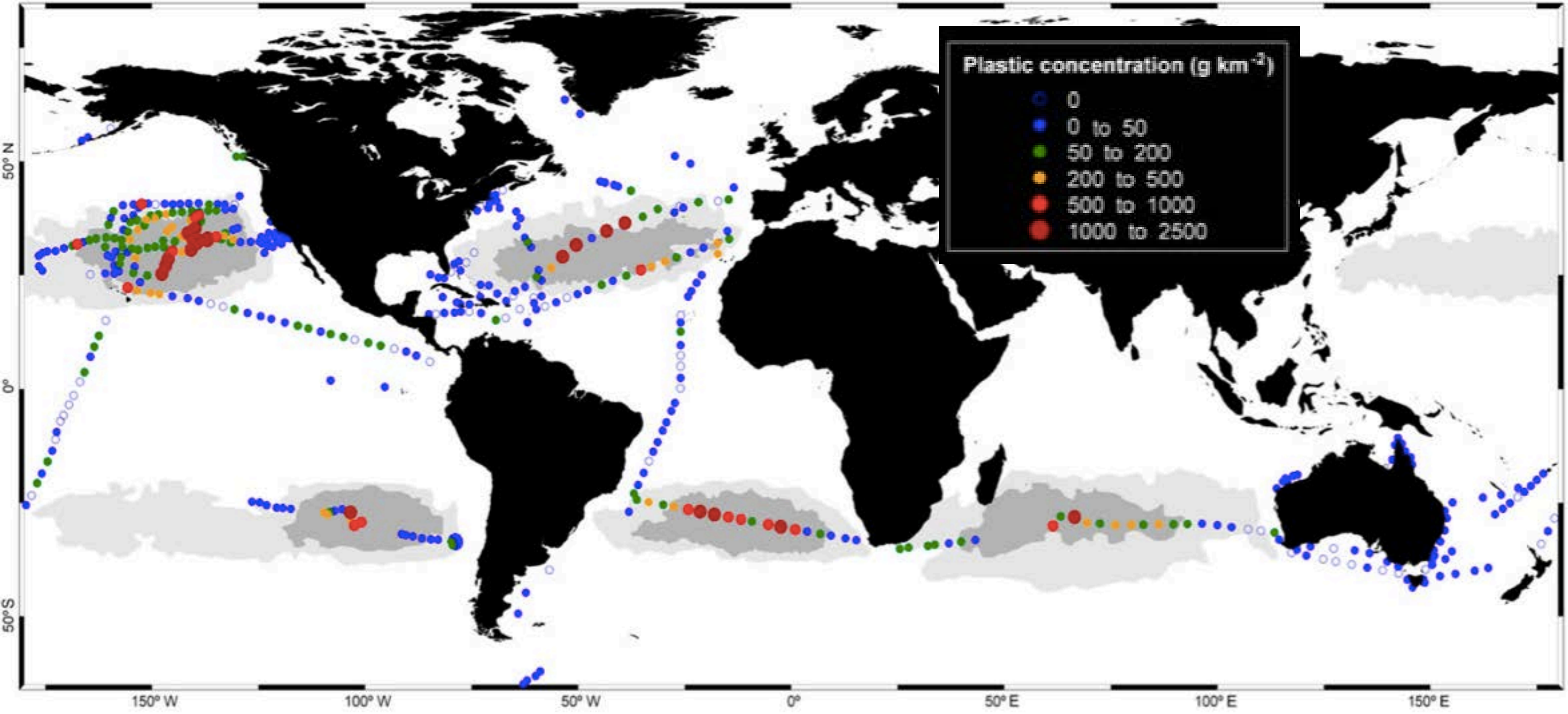
https://savebay.org/wp-content/uploads/ICC-Brochure-2023-for-web-1.17.24.pdf

What are microplastics?

1 nm < plastics particles < 5 mm in size, EPA

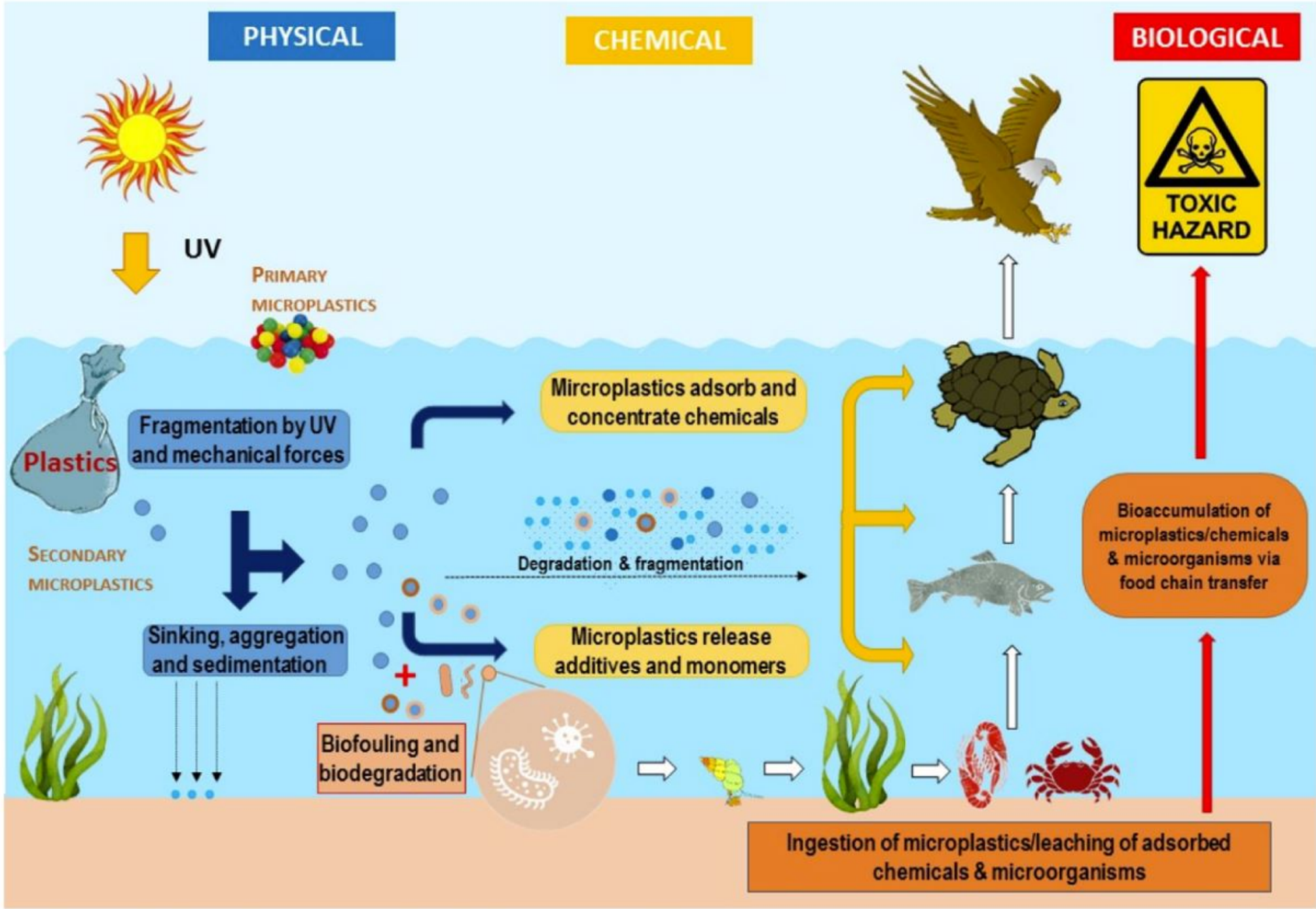


Rochman et al., 2019



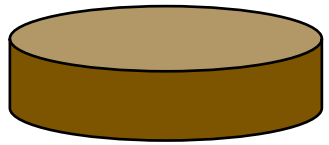
Zones of high concentration in in ocean gyres

~99% Unaccounted For


PHYSICAL
CHEMICAL
BIOLOGICAL
UV
PRIMARY MICROPLASTICS
Plastics
Fragmentation by UV and mechanical forces
SECONDARY MICROPLASTICS
Sinking, aggregation and sedimentation
Mircroplastics adsorb and concentrate chemicals
Degradation & fragmentation
Microplastics release additives and monomers
Biofouling and biodegradation
TOXIC HAZARD
Bioaccumulation of microplastics/chemicals & microorganisms via food chain transfer
Ingestion of microplastics/leaching of adsorbed chemicals & microorganisms

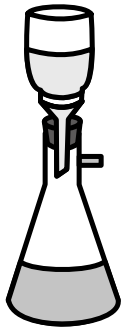
Microplastics Extraction and Analysis

Microplastics
(63 µm – 5 mm)

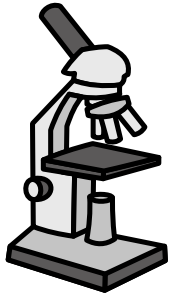


~50 g sediment

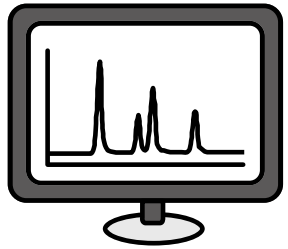
10% H_2O_2 + 10% HCl digestion
NaI density separation



Filtration



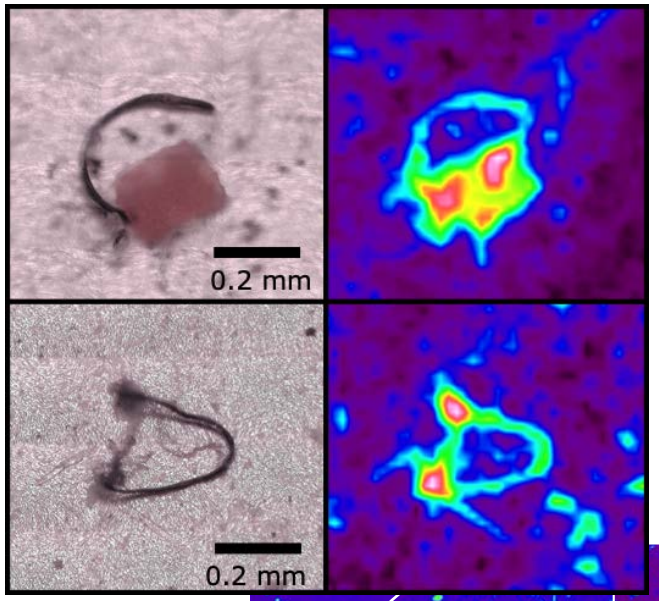
Count (particles / kg DW)
Color
Size
Morphology



µFT-IR Spectroscopy
Polymer Type

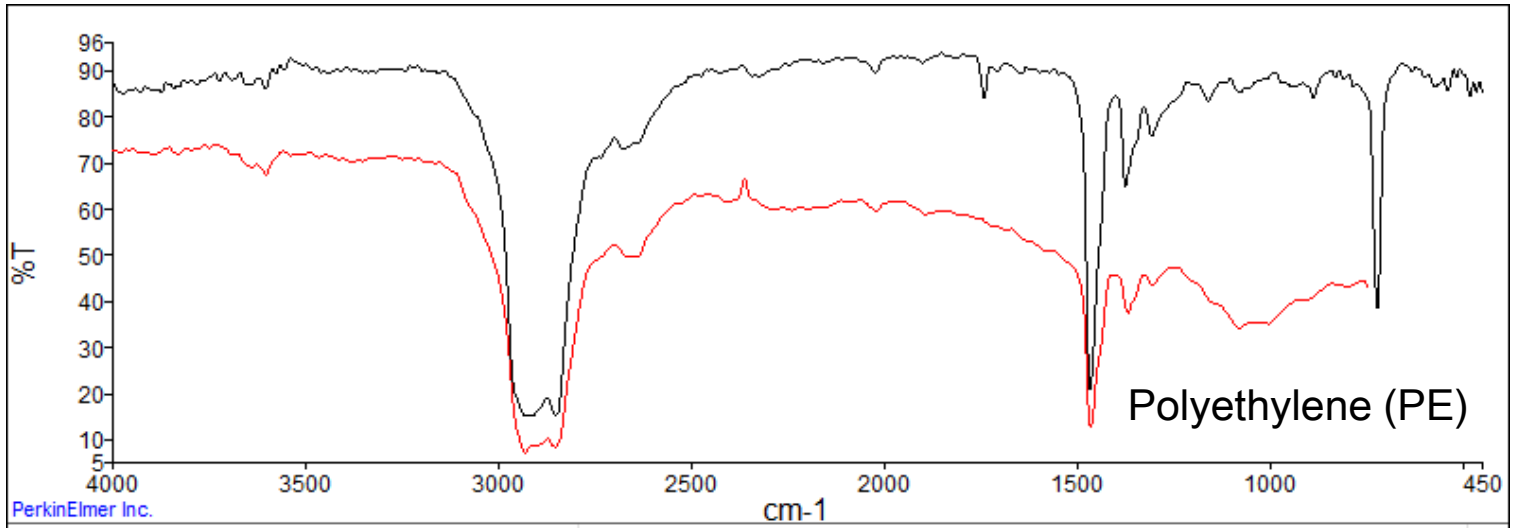
PerkinElmer
For the Better

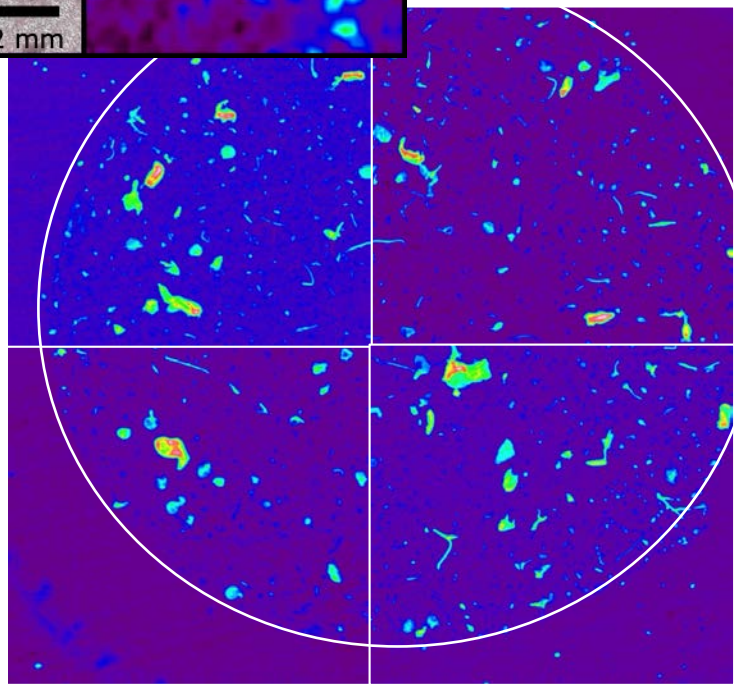
Microplastics Polymer Analysis µFT-IR



PerkinElmer
For the Better

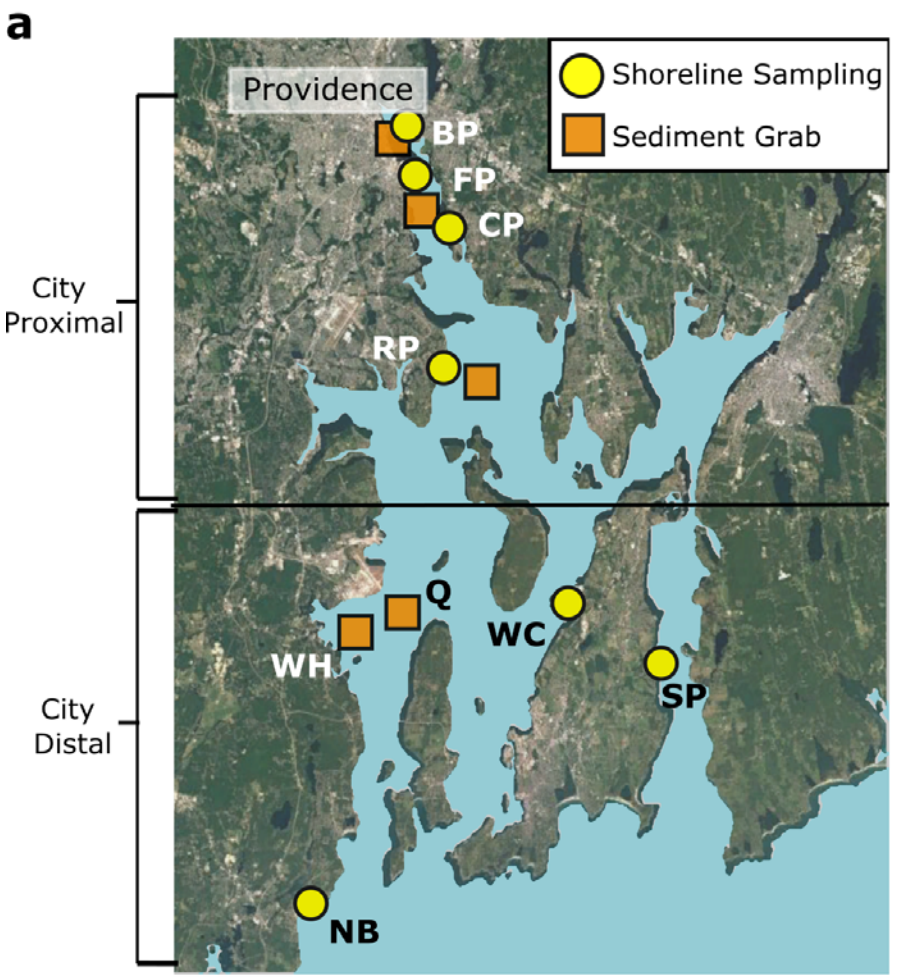
Reference spectra
Sampled spectra

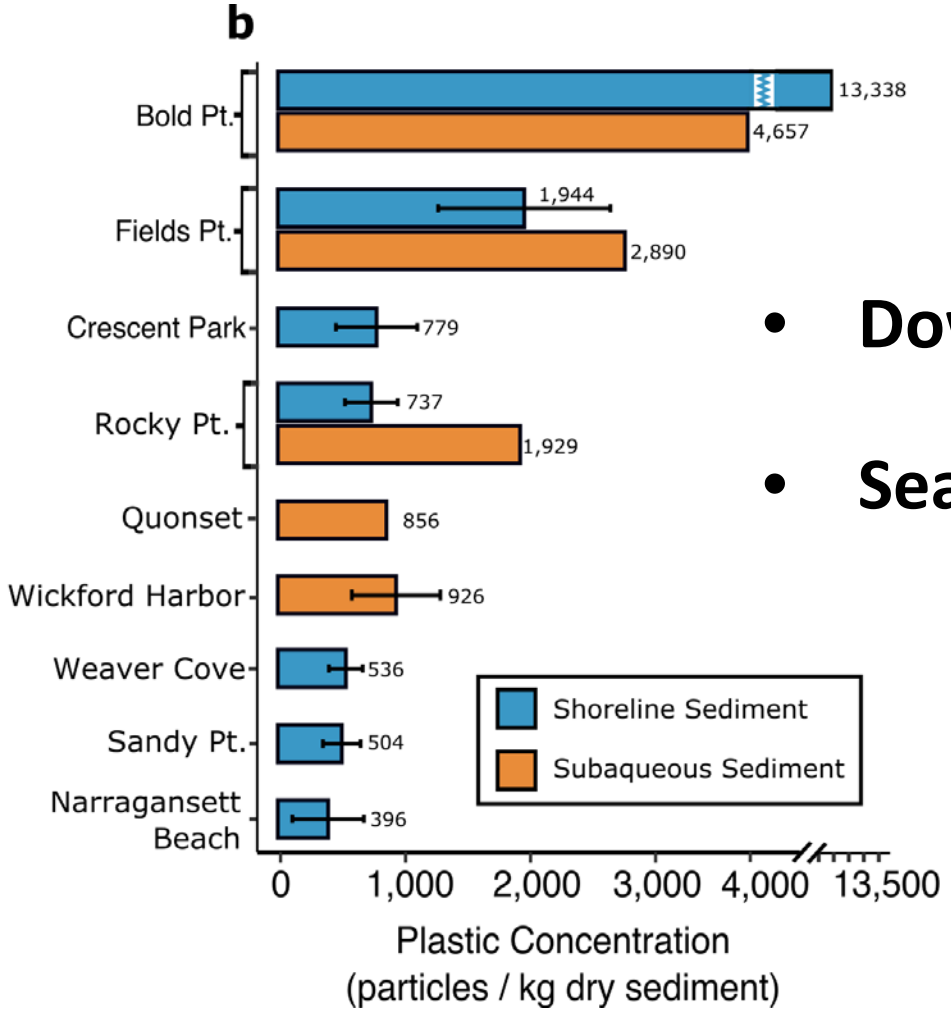




Perkin Elmer Spotlight 400 µFT-IR Imaging System

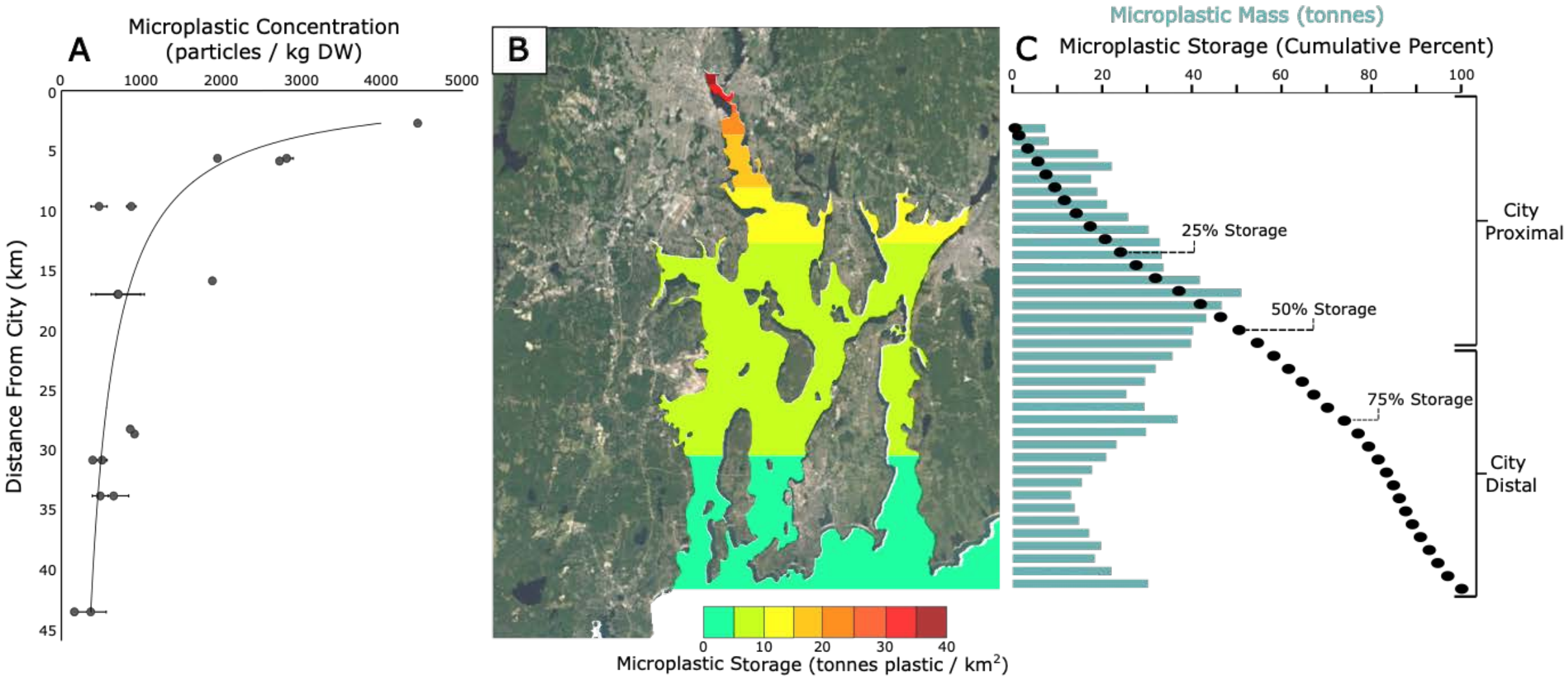
Microplastics abundant in shoreline and seabed sediments





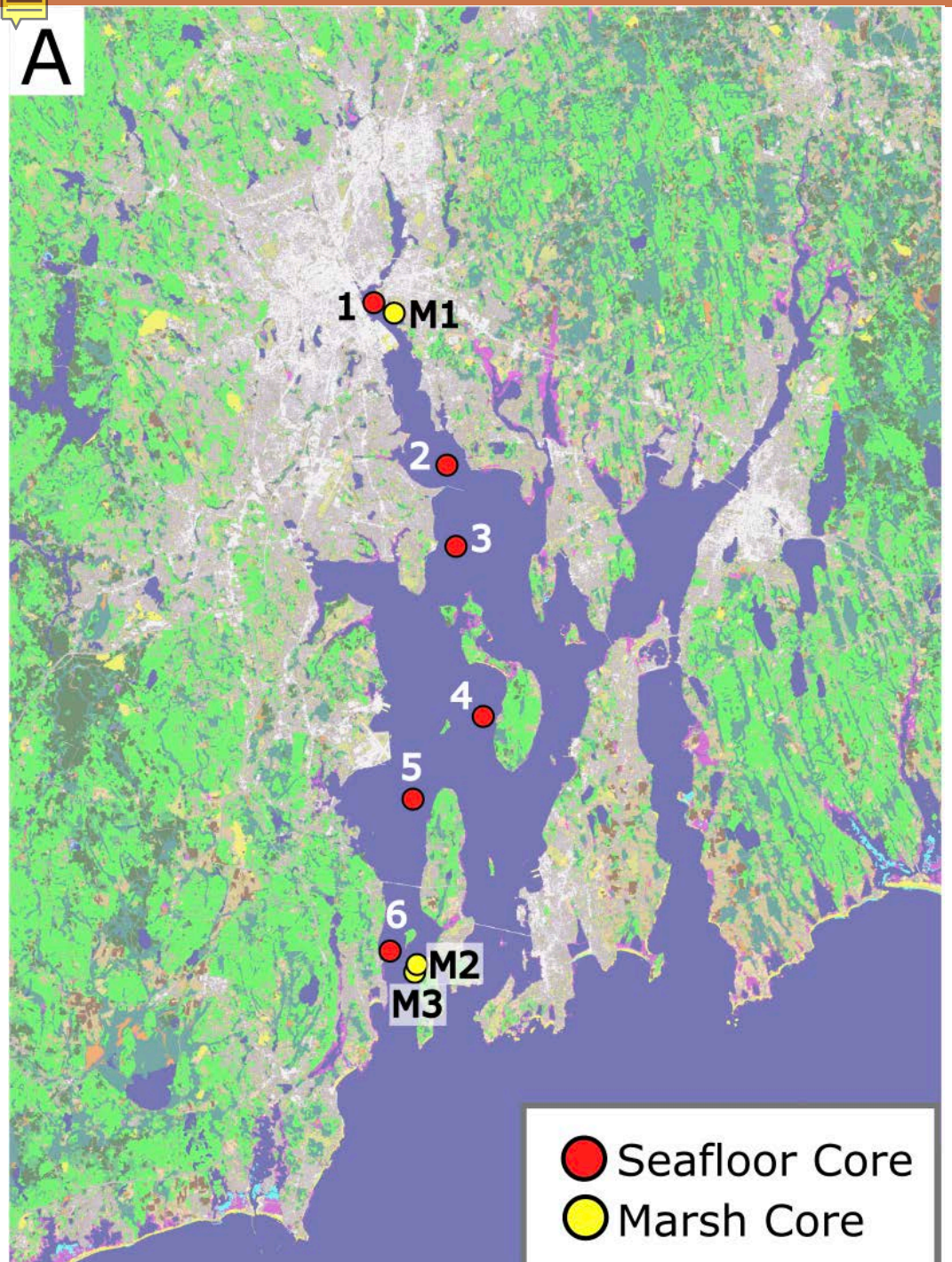
- **Down-system gradient**
- **Seabed > Shoreline**

Fulfer and Walsh, *Scientific Reports*, 2023



Fulfer and Walsh, *Scientific Reports*, 2023

- **~1000 tonnes in the upper 5cm**
- **50% of plastic mass is trapped in the upper estuary**



What is the history (and future) of microplastics along the RI coast?

Note, the down-system gradients in population, urbanization & pollution sources

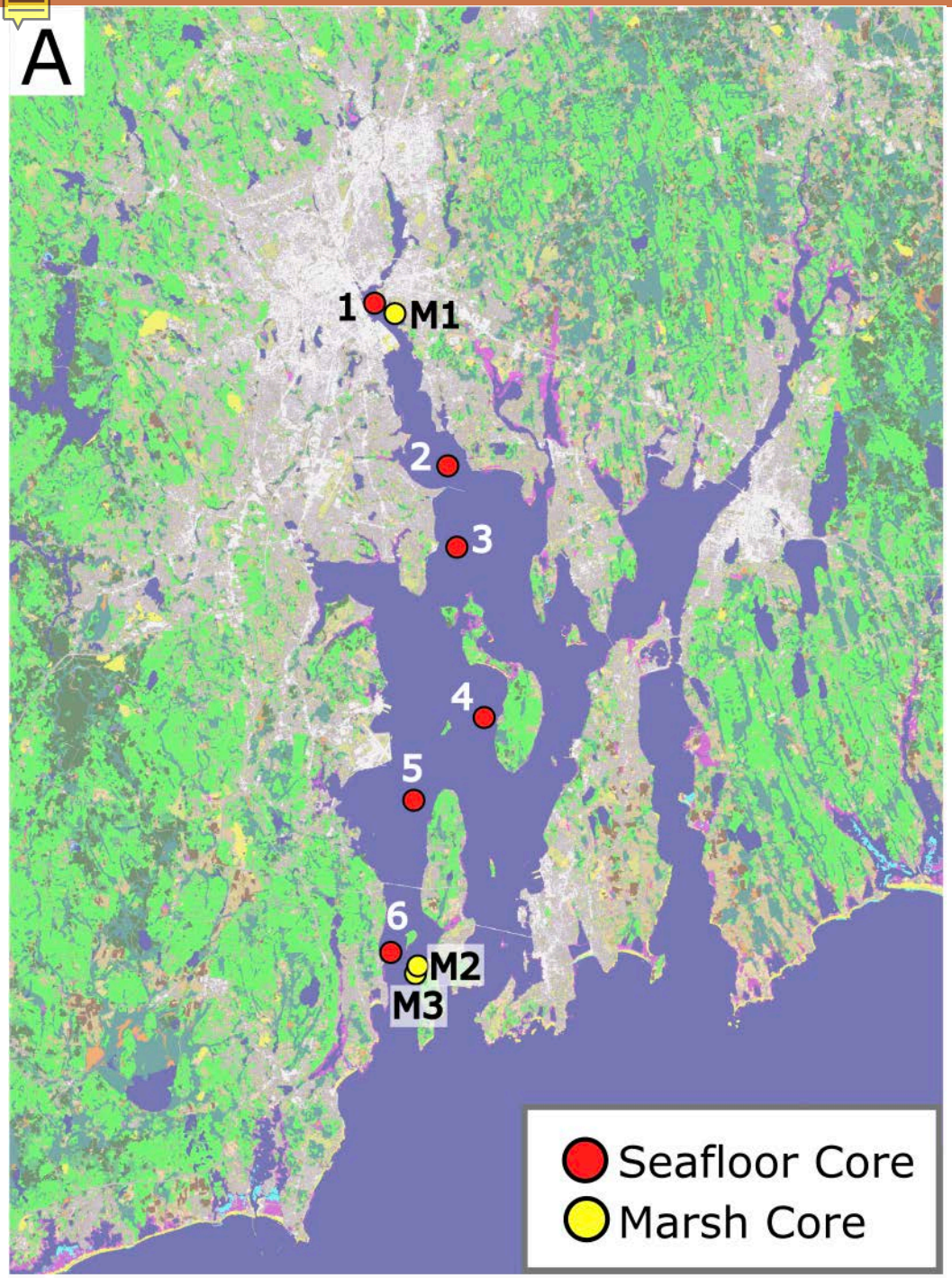
Land Use

Impervious Surface / Urbanized

Natural Surface

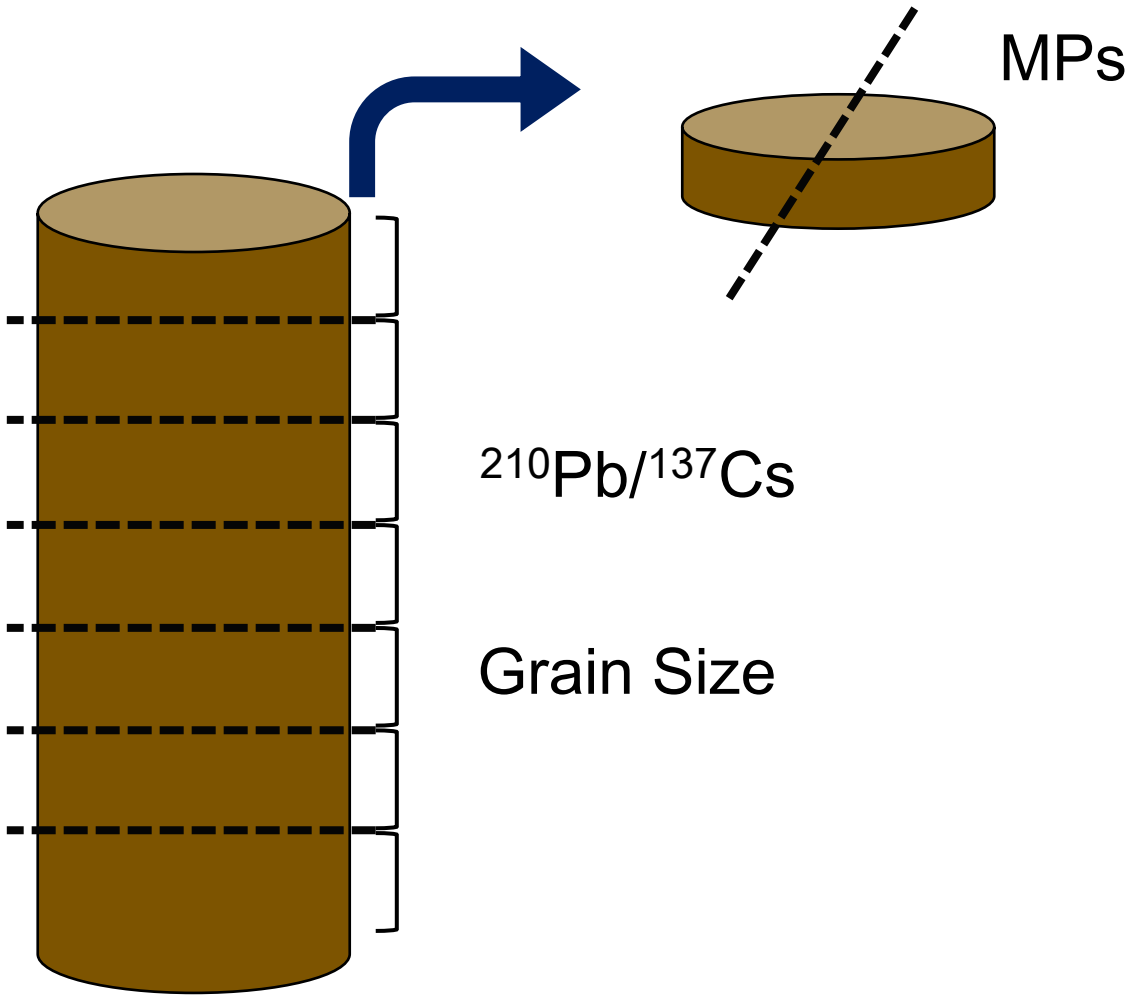
Agriculture

Water

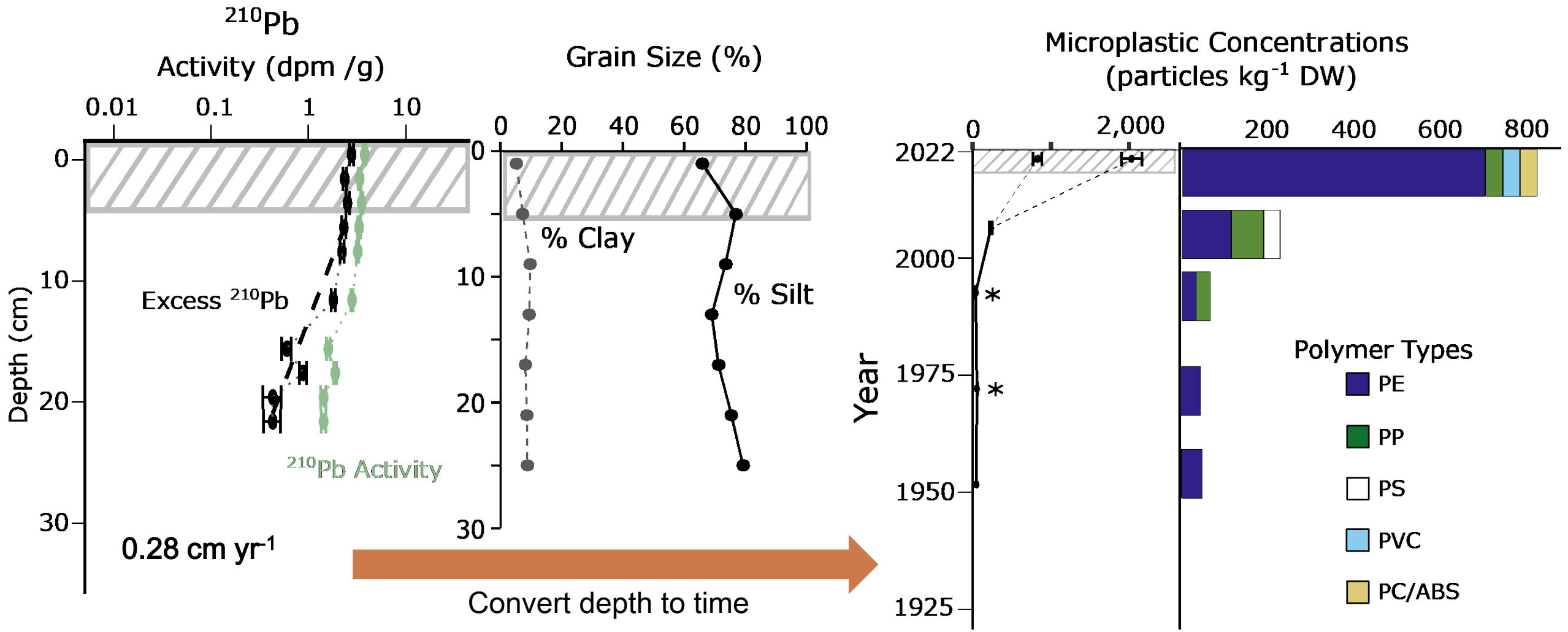


Studying the History in Sediments

- 6 Bay cores
- 3 marsh cores

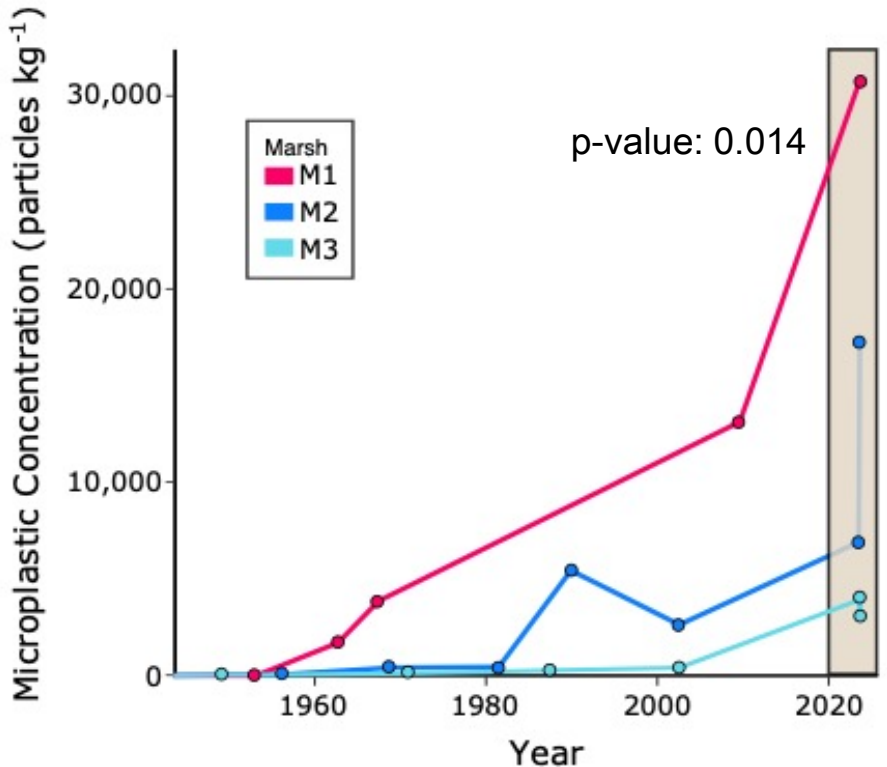


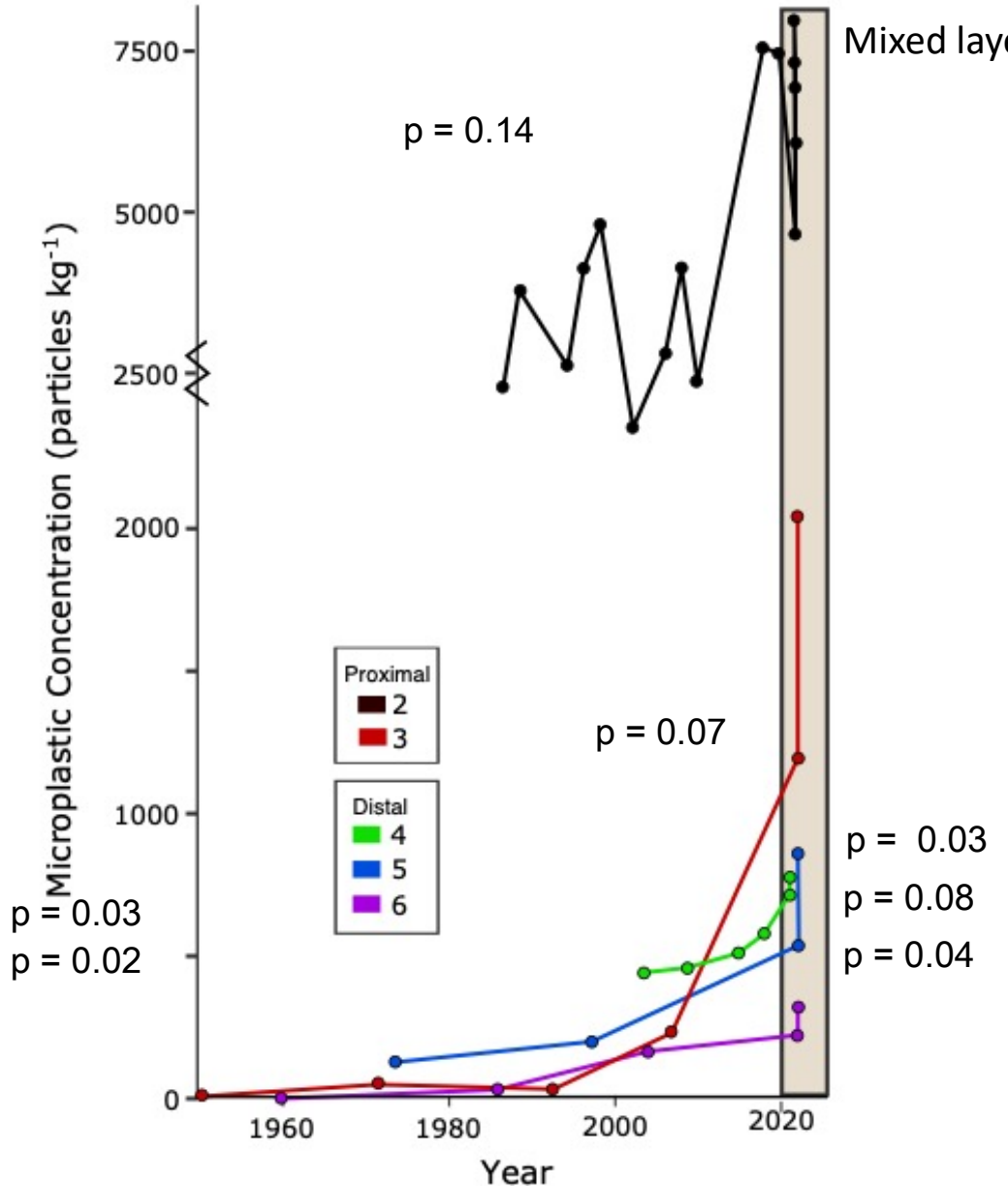
Reconstructing the Sedimentary History of Plastic Pollution



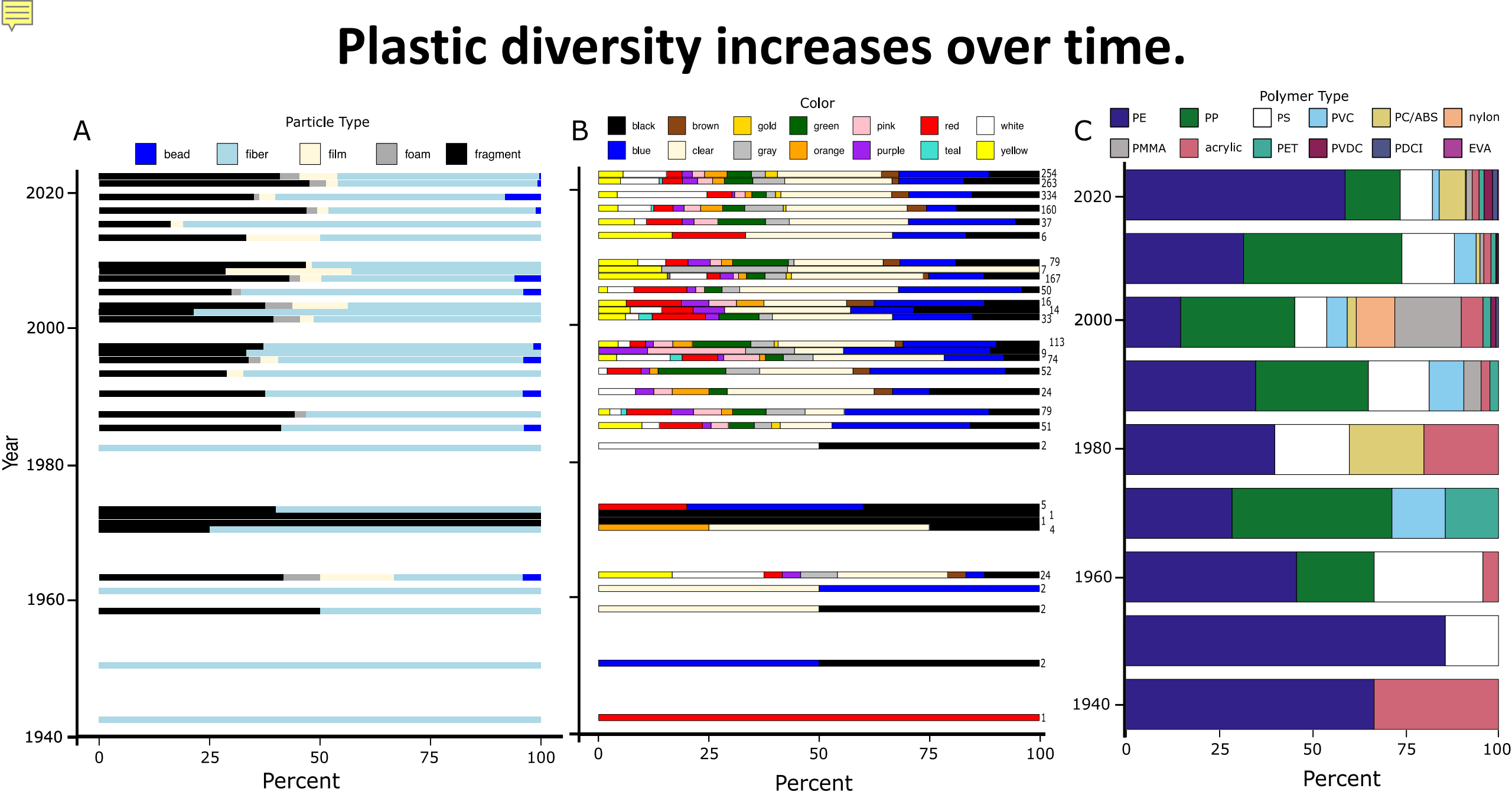
Microplastic pollution is increasing exponentially.

- **Sites show exponential increase**
- **Plastic concentrations are higher in the Proximal Zone**
- **Marshes trap 10 – 50x more MPs than the nearby seabed**

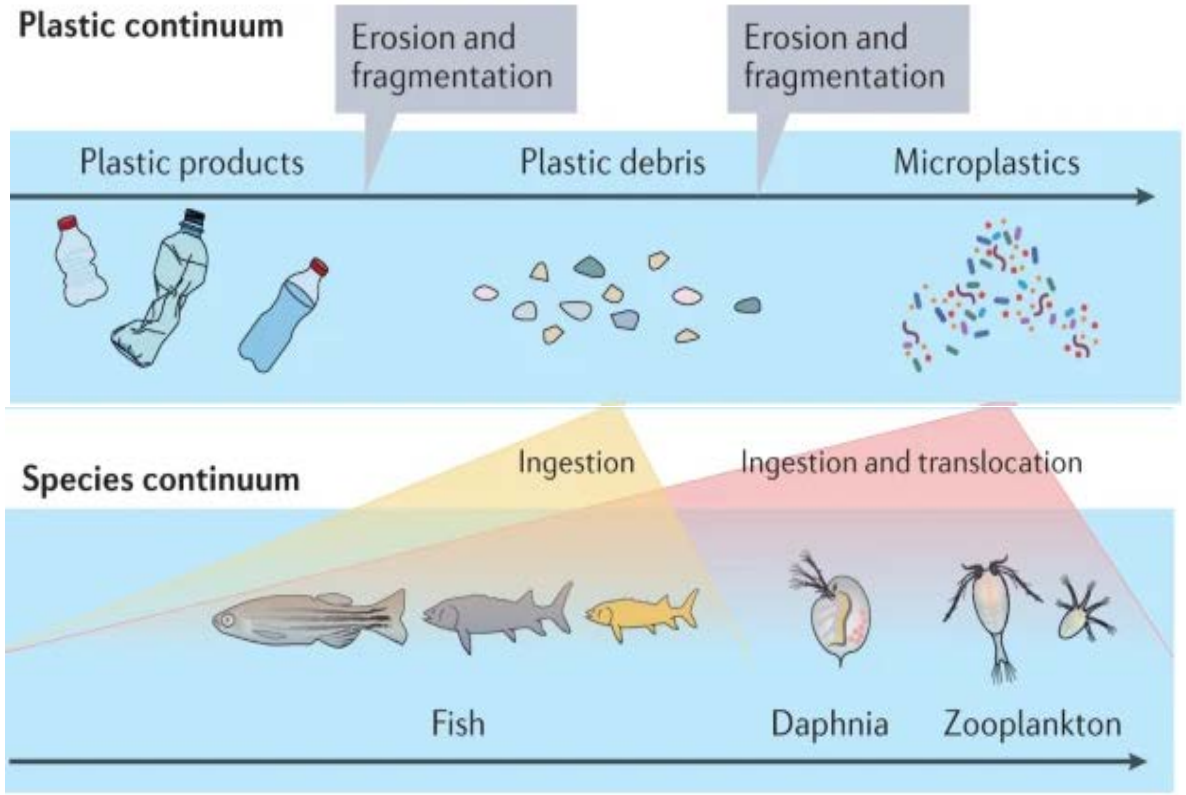




Plastic diversity increases over time.

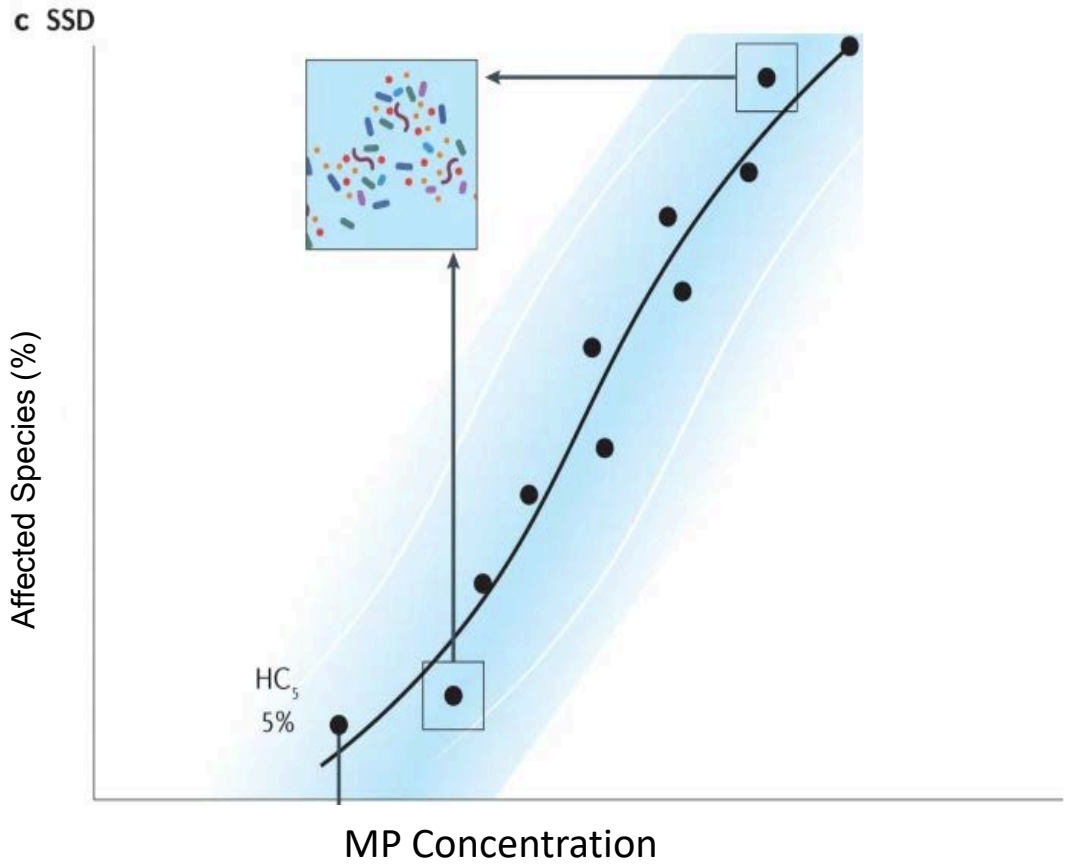


What are the consequences of microplastic pollution in estuarine sediments?



Koelmans et al., 2022

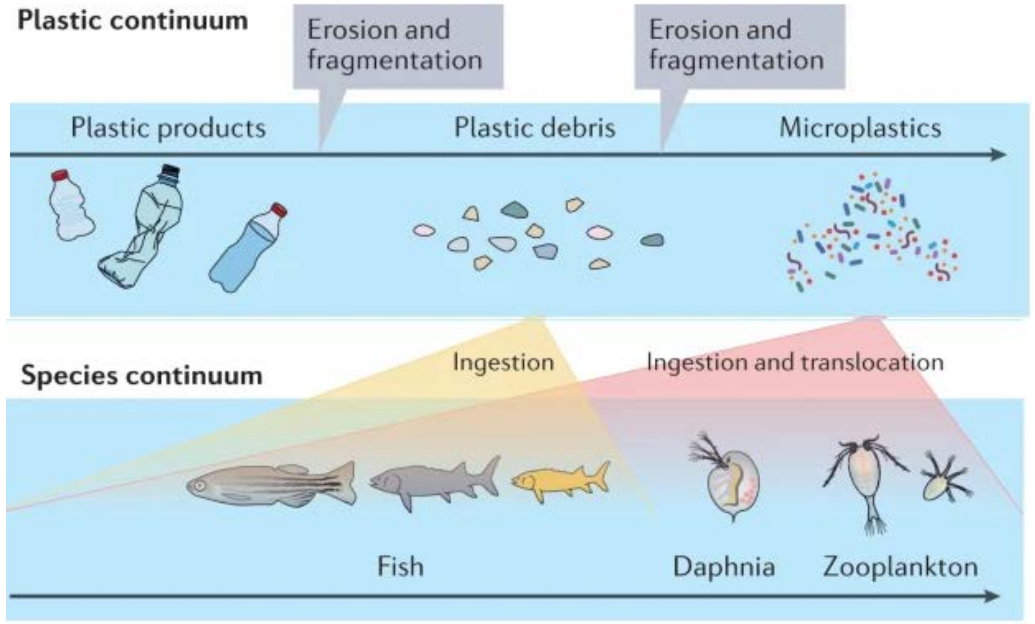
Species Sensitivity Distribution



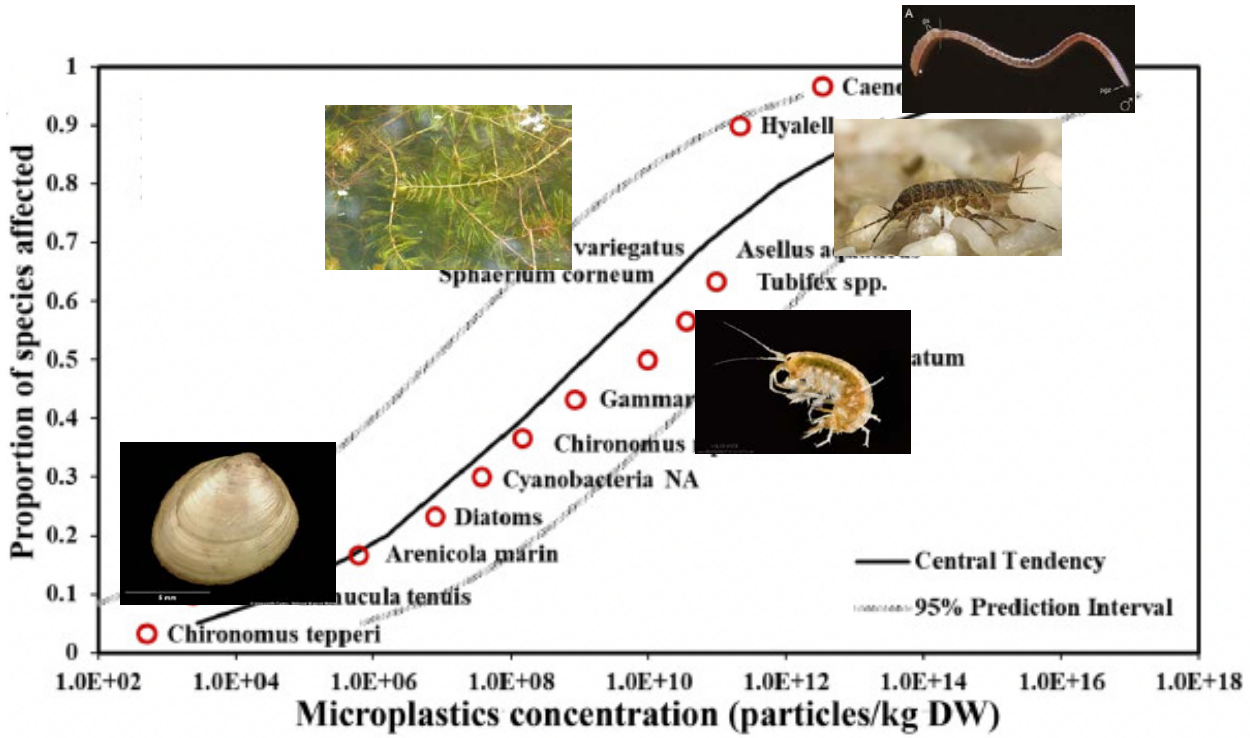
Ecotoxicology studies are completed on different organisms across a range of concentrations

HC_5 = hazard concentration
At this concentration, 5% of species will be impacted

What are the consequences of microplastic pollution in estuarine sediments?

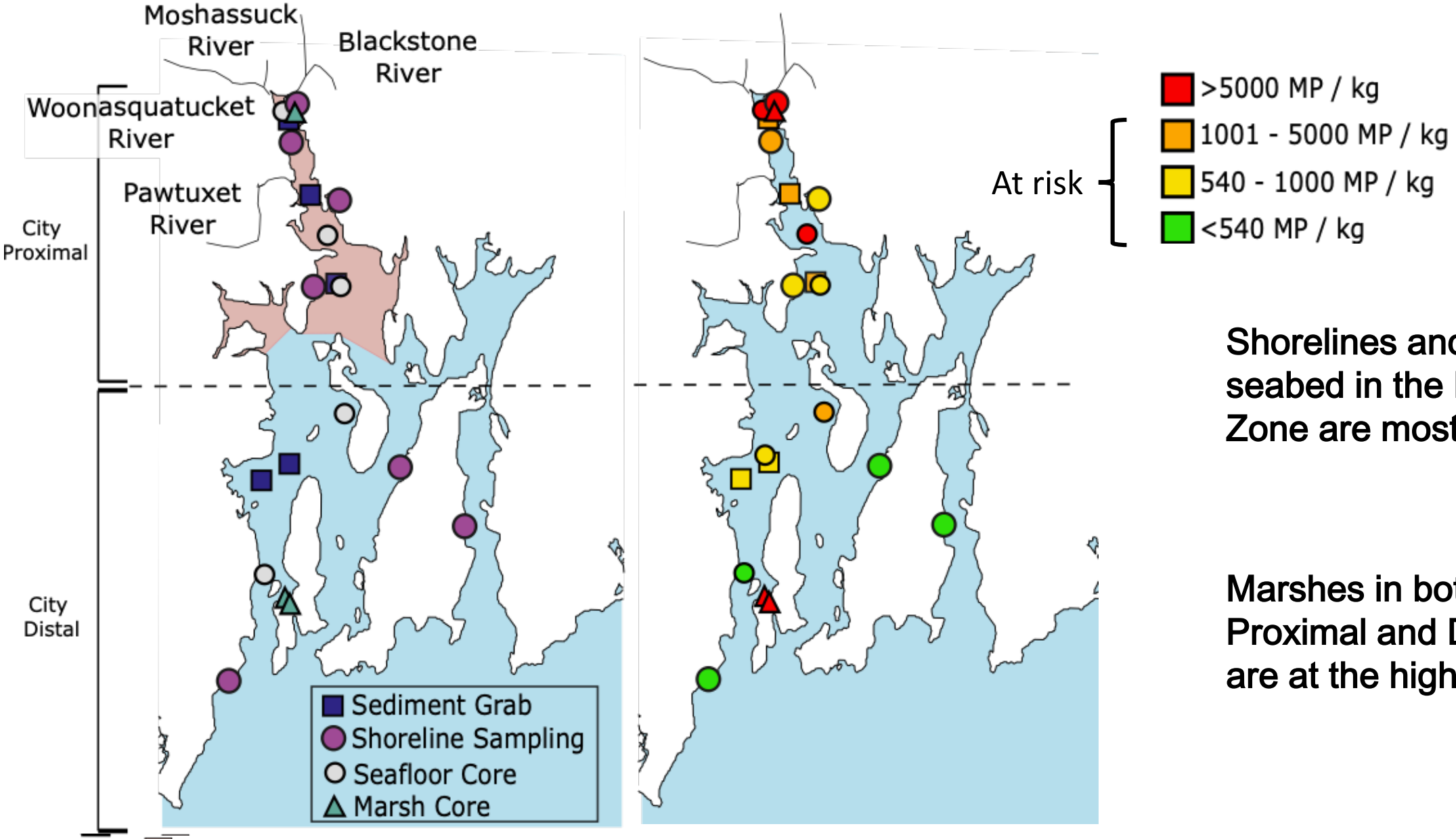


Koelmans et al., 2022



Threshold for harm:
540 MP particles kg^{-1}
(Yang et al., 2023; Koelmans et al., 2022; Everaert et al., 2018; 2022)

Microplastic pollution in Narragansett Bay is widespread

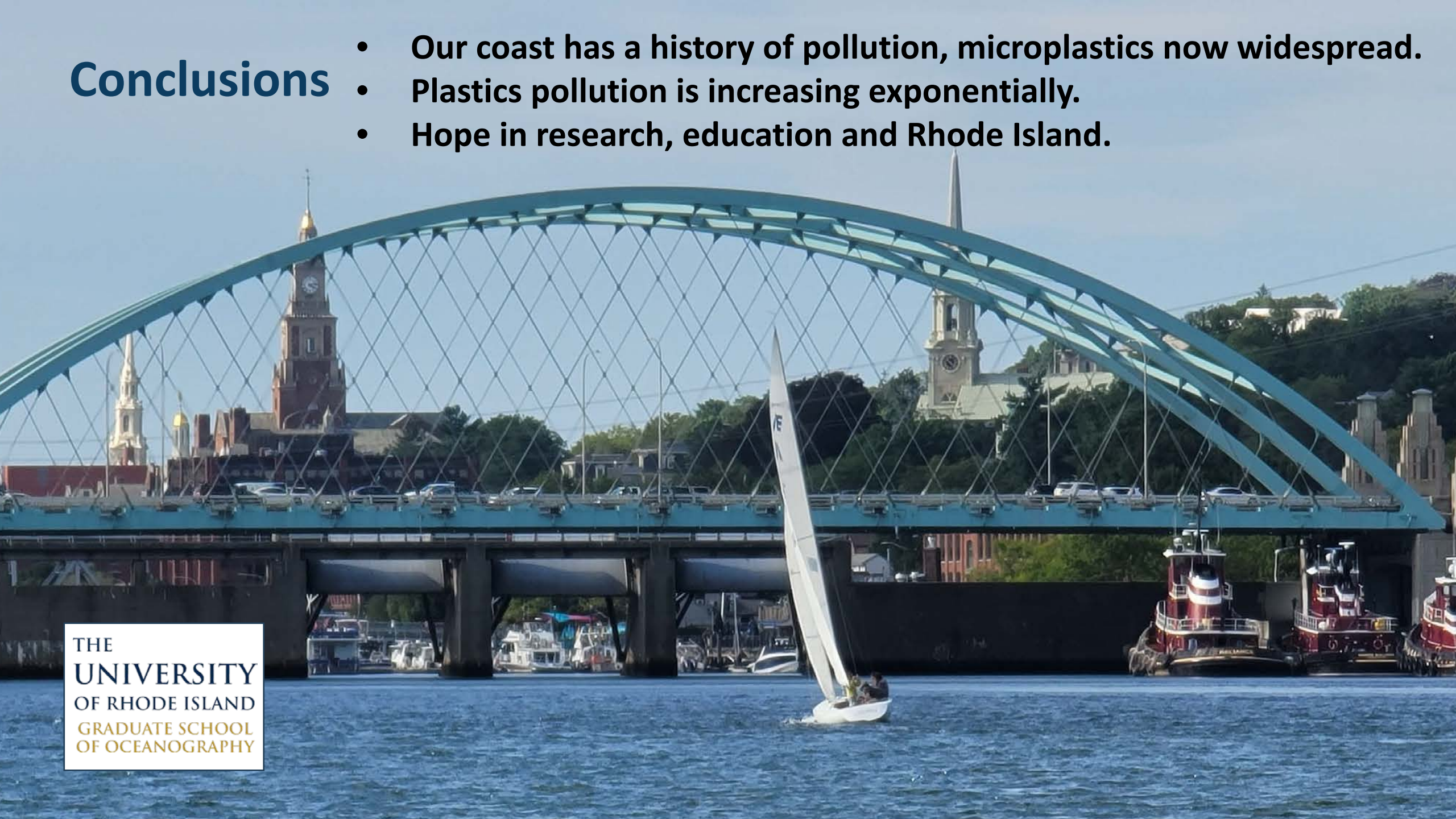


Shorelines and the seabed in the Proximal Zone are most at risk

Marshes in both the Proximal and Distal Zones are at the highest risk.

Conclusions

- Our coast has a history of pollution, microplastics now widespread.
- Plastics pollution is increasing exponentially.
- Hope in research, education and Rhode Island.



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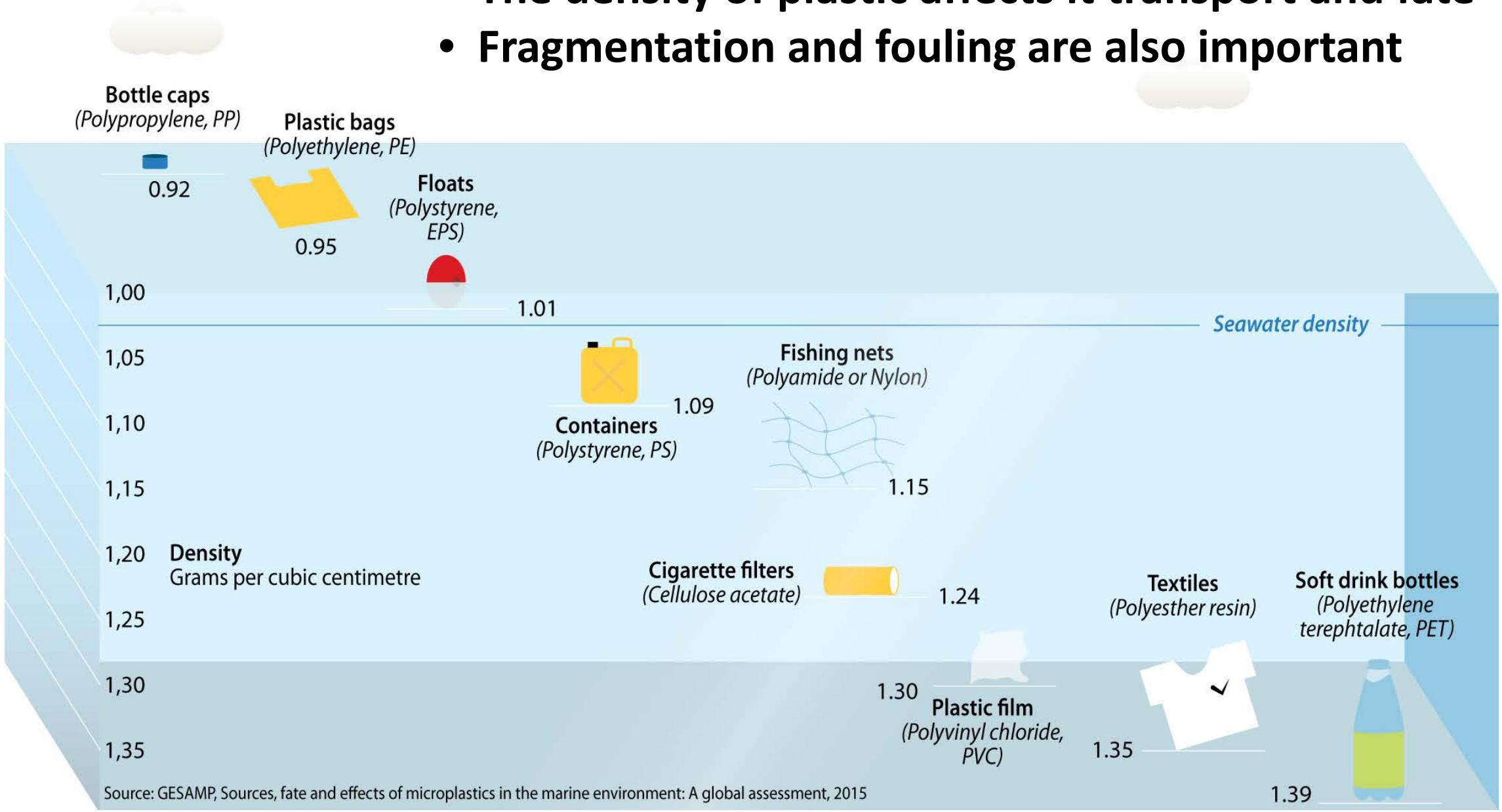
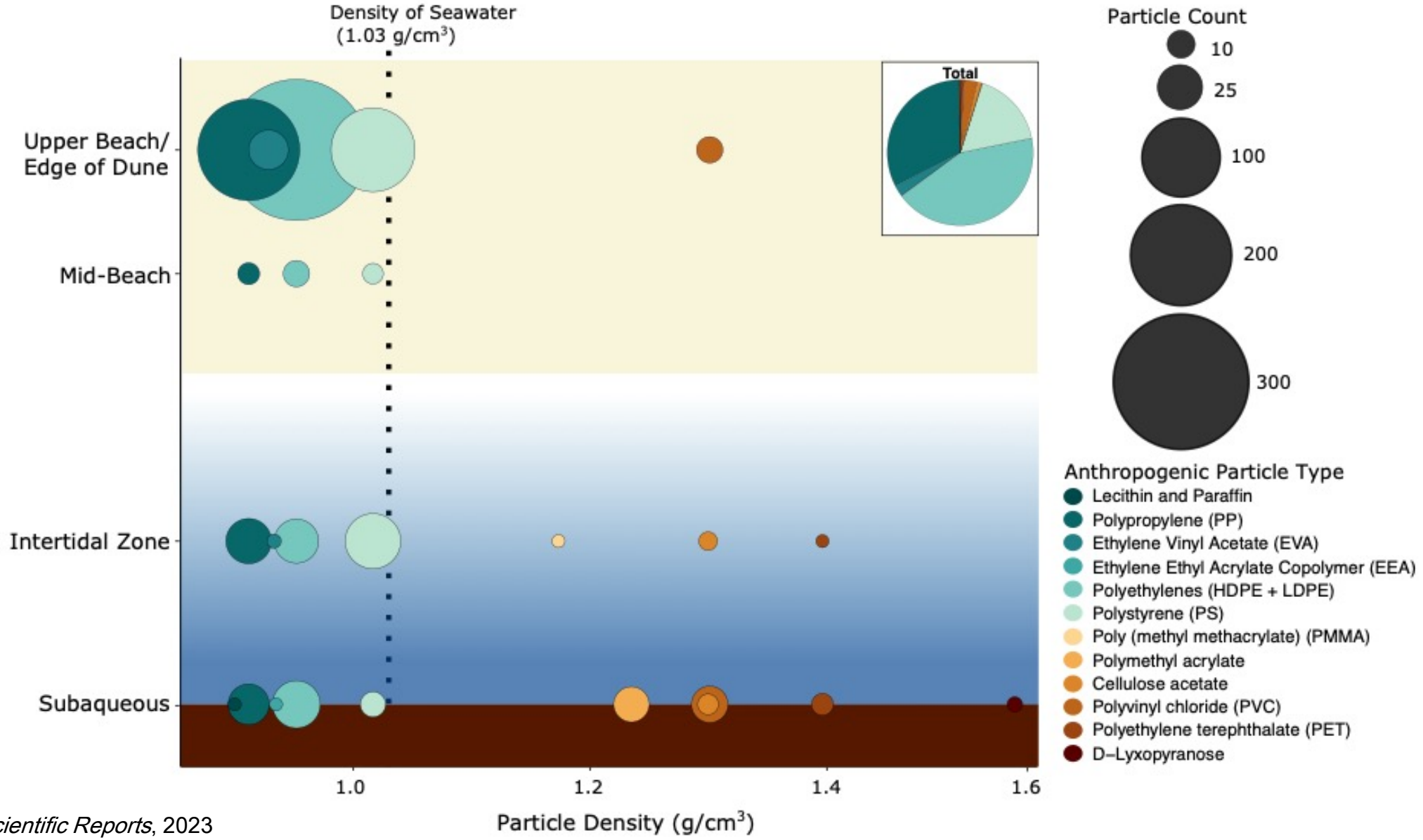
Thank you!

- **The density of plastic affects it transport and fate**
- **Fragmentation and fouling are also important**

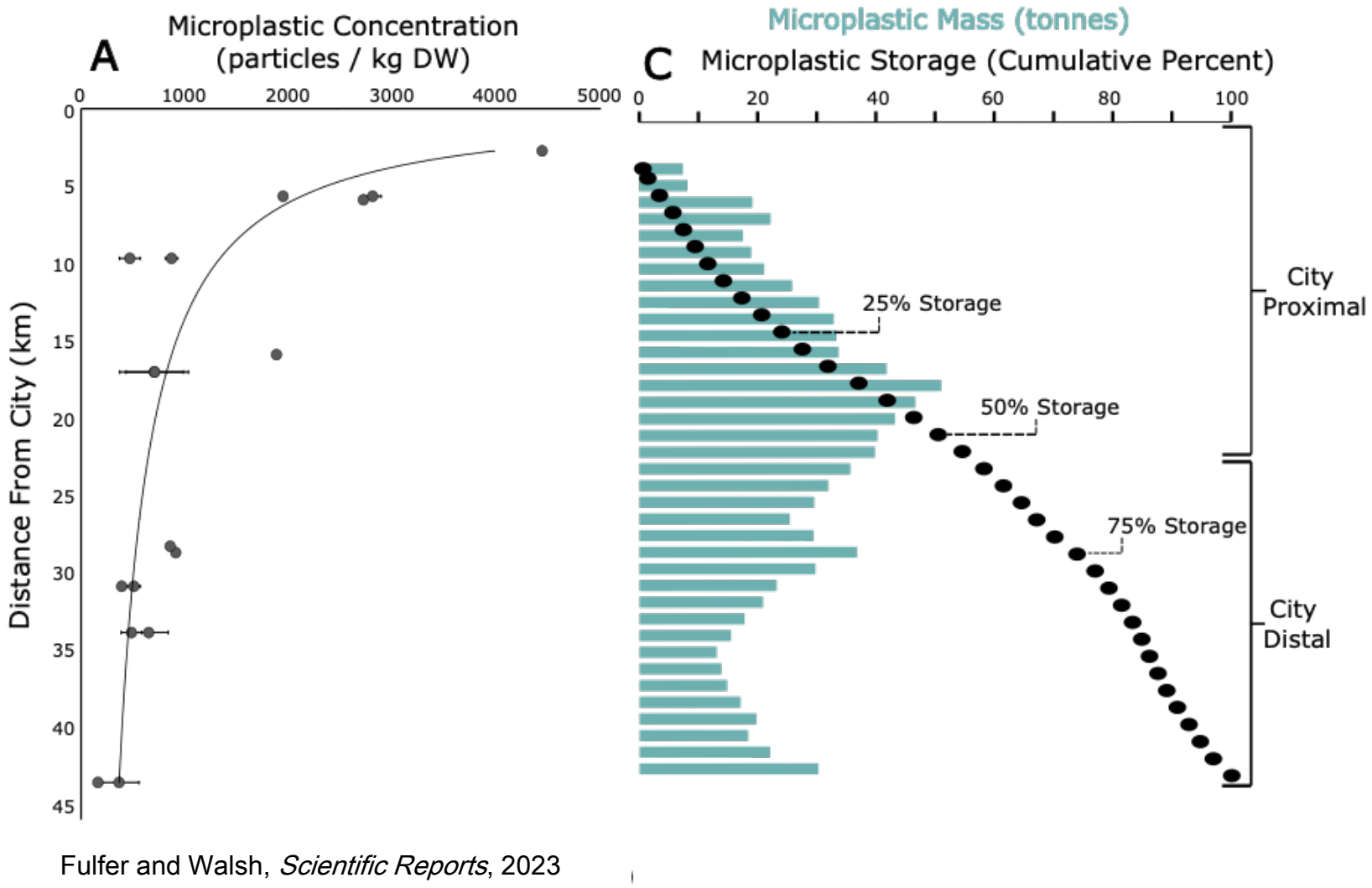


Particle density impacts transport and fate



Fulfer and Walsh, *Scientific Reports*, 2023

Significant estuarine storage of microplastics



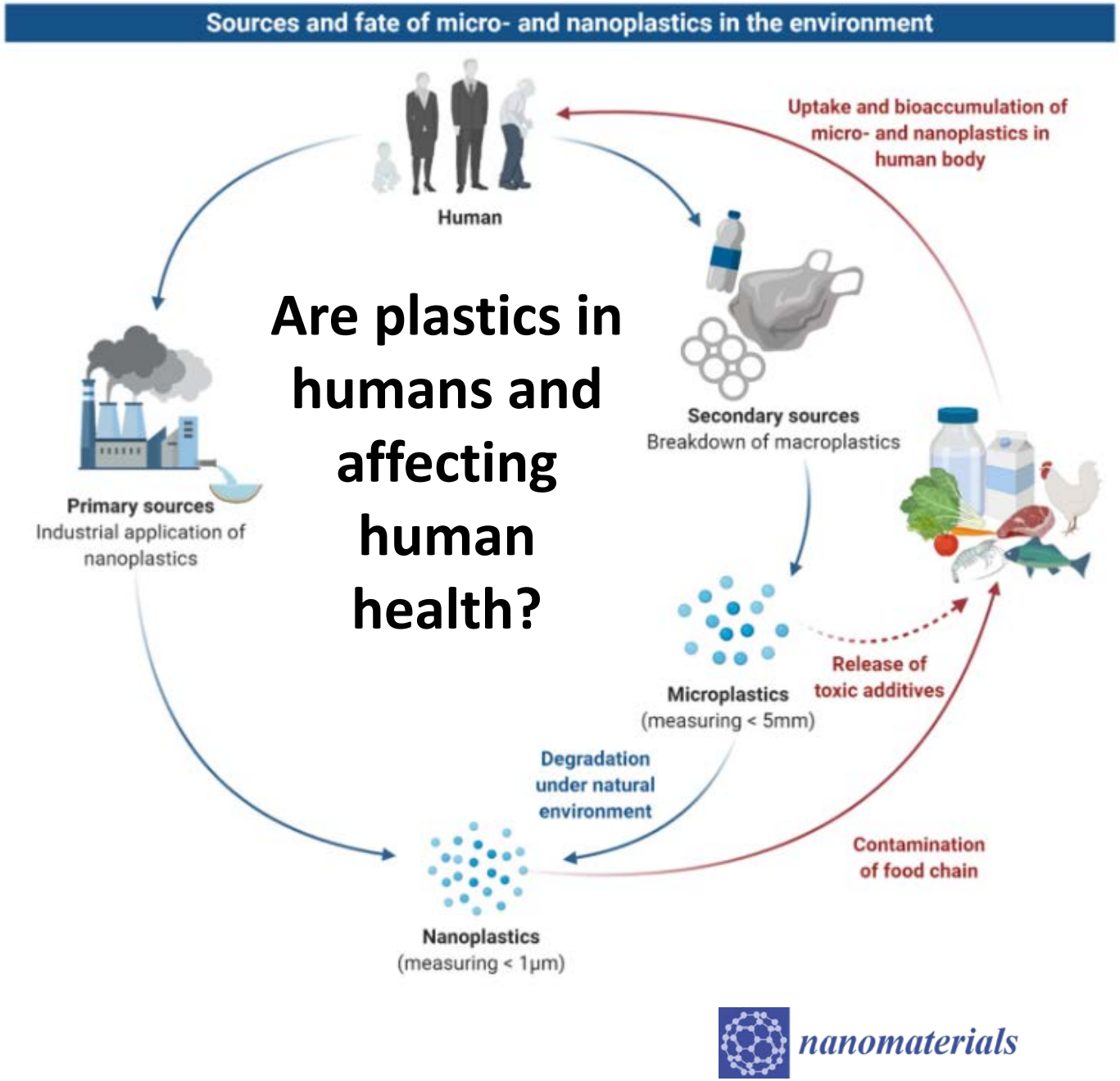
Fulfer and Walsh, *Scientific Reports*, 2023

The top 5 cm of Narragansett Bay contain

$9.76*10^5$ kg MP

or

976 tonnes MP



nanomaterials

Open Access Review

Impact of Microplastics and Nanoplastics on Human Health

by Maxine Swee-Li Yee [1,*], Ling-Wei Hii [2,3,4], Chin King Looi [2,3], Wei-Meng Lim [2,4], Shew-Fung Wong [5,6], Yih-Yih Kok [5,7], Boon-Keat Tan [5,6], Chiew-Yen Wong [5,7] and Chee-Onn Leong [2,4,*]