Understanding the Ecological Consequences of Microplastic Pollution along the Freshwater-marine Continuum

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SEALE Coastal Zone Observatory AT VIRGINIA TECH

NOAA National Oceanic and Atmospheric Administration U.S. Department of Commerce

GLOBAL CHANGE CENTER AT VIRGINIA TECH

Plastic pollution: A pervasive problem

- 121.4 billion pounds of plastic were produced in the US in 2019
  - ~13% increase since 2013
- 80% of plastic in marine and coastal environments are from land-based sources
- Less focus on freshwater ecosystems

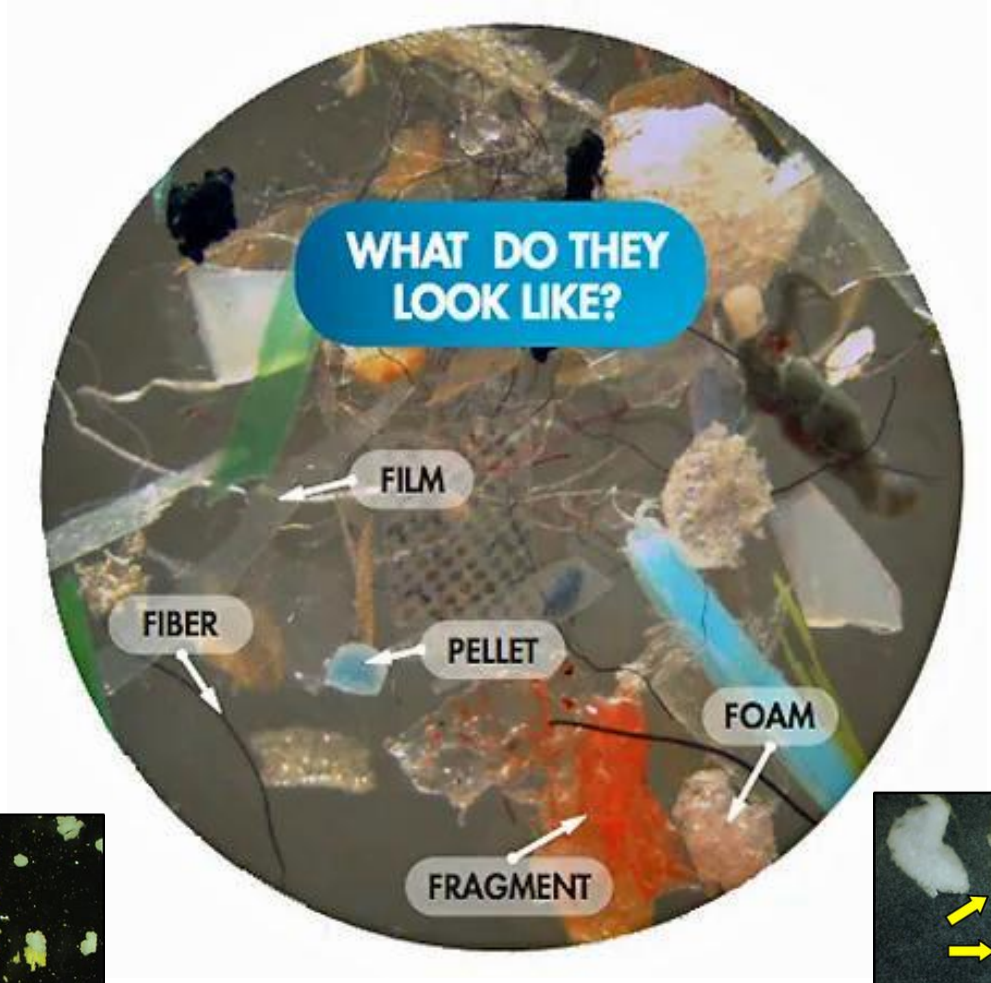
From Plastic to Microplastic

primary microplastics

≈ 19 to 31% of microplastics in the oceans

directly released into nature as small particles

coming mainly from land activities
e.g. cosmetics such as facial scrubs, car tyres or laundering of synthetic clothes



secondary microplastics

≈ 69 to 81% of microplastics in the oceans

originate from large pieces of plastic that fragment into smaller pieces in nature

e.g. bottles, bags or fishing nets

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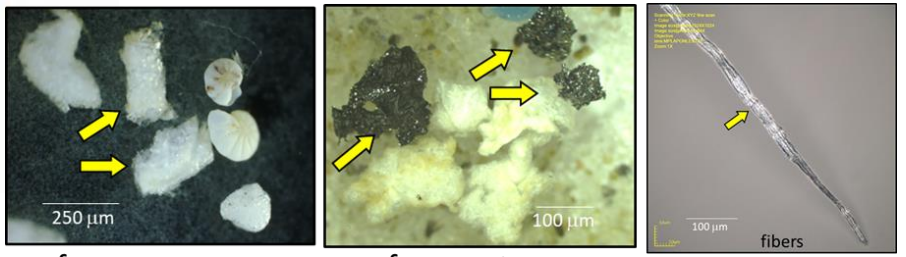
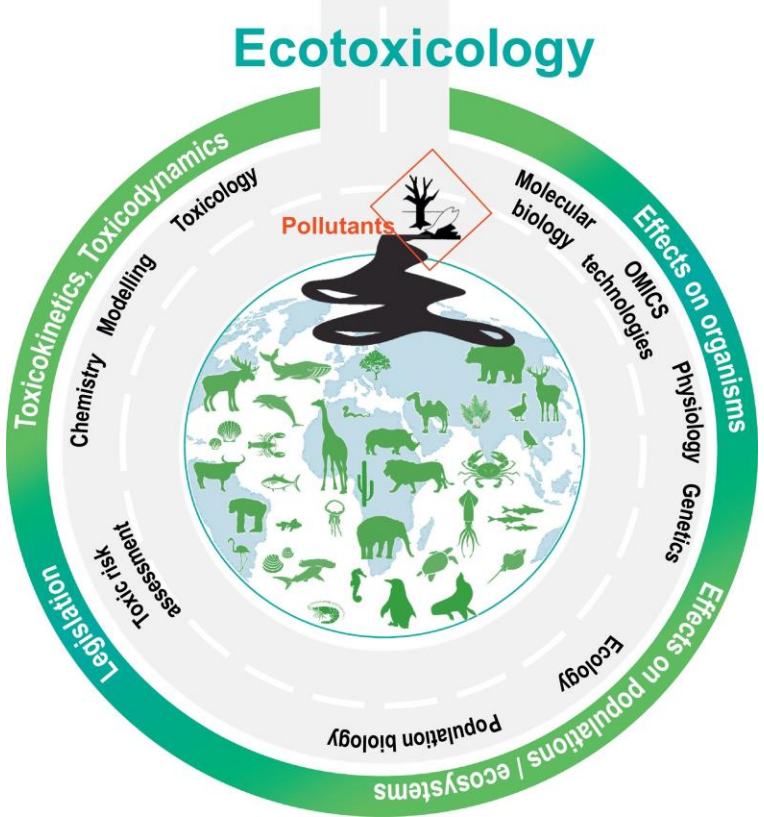


foam fragments

Austin Gray

Assistant Professor of Biological Sciences

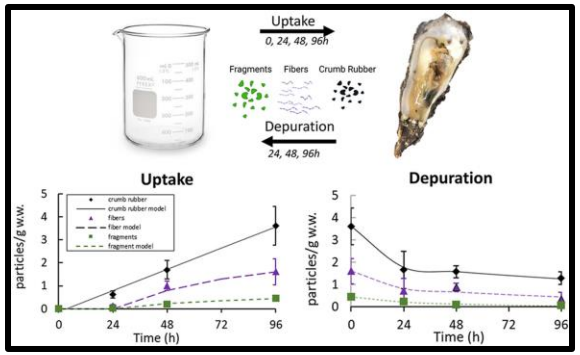


My lab specializes in the occurrence, distribution, fate, and impact of microplastic pollution in aquatic habitats using field and spectroscopy techniques

Gray Lab: Research priorities on MPs

Long-term Monitoring in Bottlenose Dolphins

Toxicokinetic Modeling in Bivalves

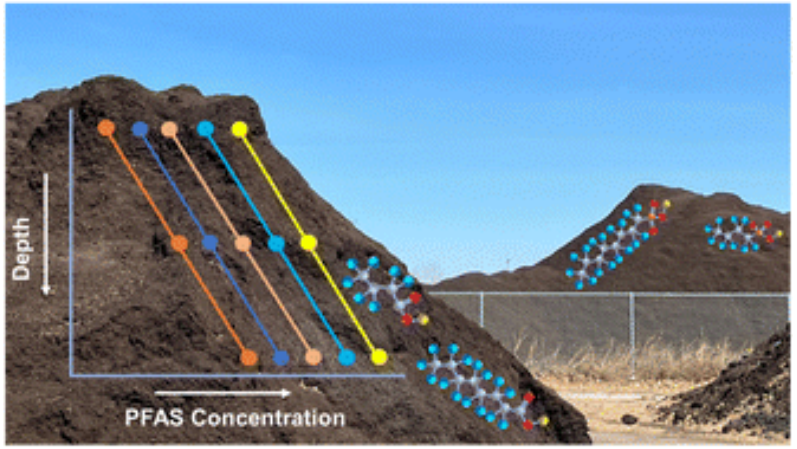


Acute toxicity of tire leachate vs 6PPDQ to aquatic inverts

Impact of MPs on sensitive freshwater taxa

Source, transport rates, and transport dynamics of MPs

MPs and PFAS co-occurrence in compost



Degradation of plastic debris

The Guardian

Microplastics found in every human placenta tested in study

Scientists express concern over health impacts, with another study finding particles in arteries

The Guardian

Microplastics found in human blood for first time

Exclusive: The discovery shows the particles can travel around the body and may lodge in organs

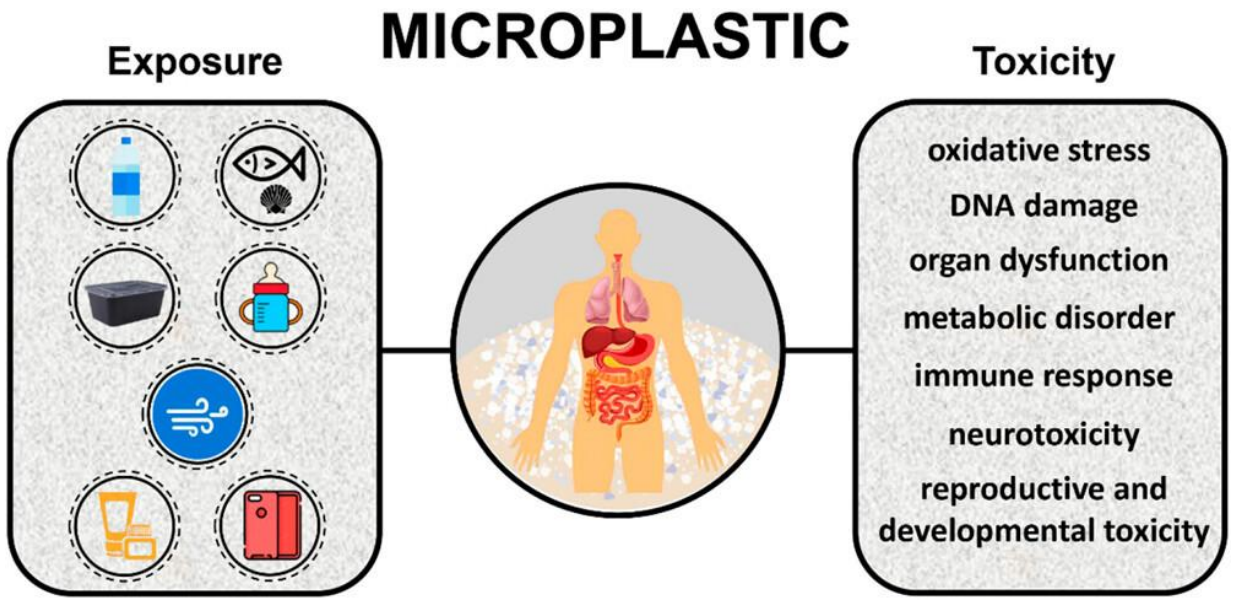
nature

Landmark study links microplastics to serious health problems

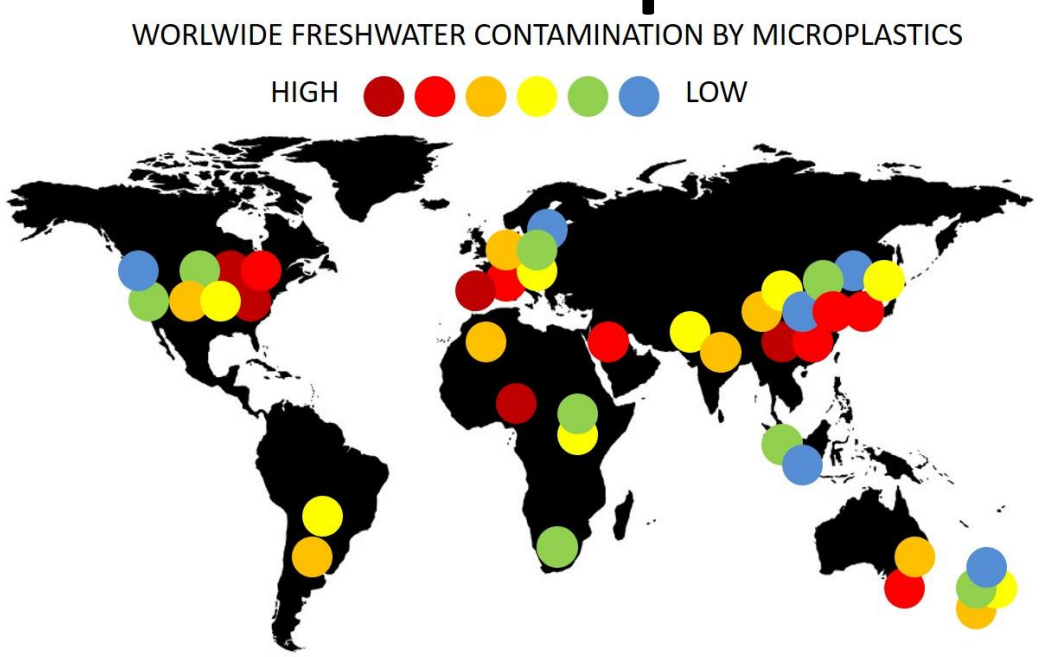
People who had tiny plastic particles lodged in a key blood vessel were more likely to experience heart attack, stroke or death during a three-year study.

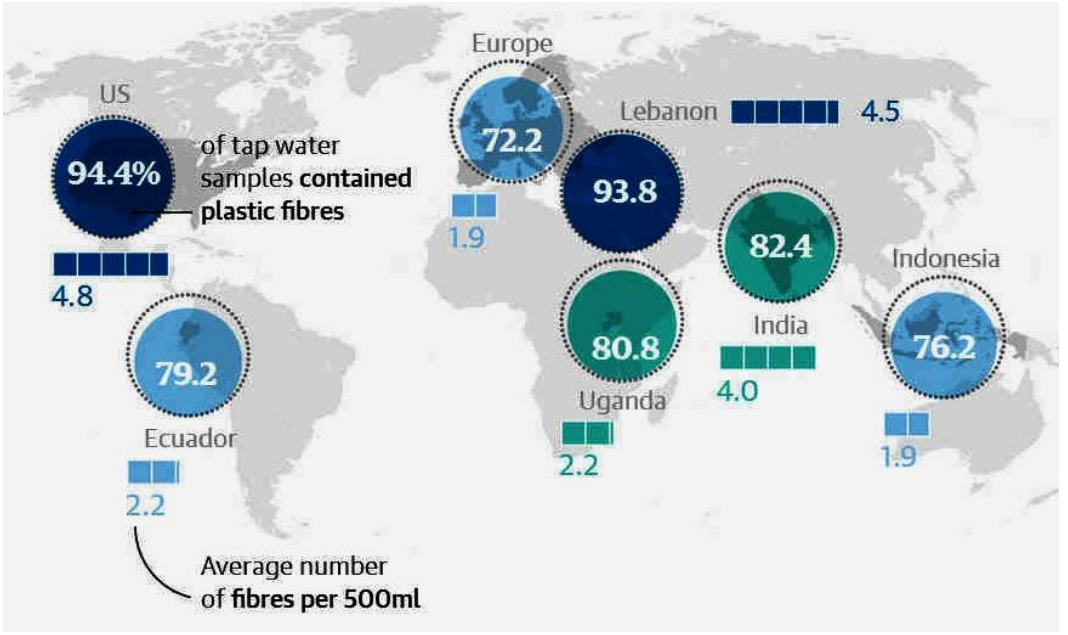
Pressing concerns regarding MPs

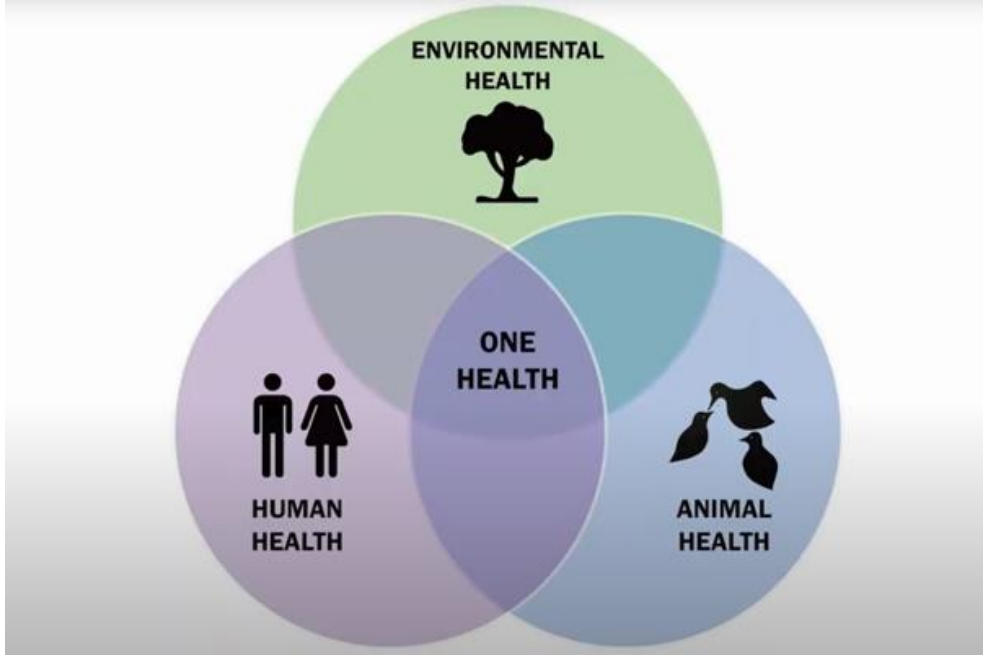
1. Size and shape toxicity to aquatic organisms
2. Developmental alterations
3. **Trojan Horse for other pollutants**
4. **Inhalation and ingestion by humans**
5. **Translocate into cells**
6. **Unknown human health implications**



Microplastics around the World







Because of the connectivity of water and air, MPs can enter every ecosystem

Environmental health and human health are directly linked

History of Microplastic Composition and Concentration in the Chesapeake Bay

In collaboration with Dr. Tina Dura

Made possible by a donation to the Coastal Zone Observatory by the Seales

- Since the rise of plastic production and use in the early 1950s, microplastics (plastics smaller than 5 mm) have been accumulating in onshore and offshore sediment sinks
- Salt marshes and estuaries are a significant sink for microplastics because they are inundated daily by tides and naturally accumulate sediment, and microplastics, through time

Photo: Summer 2022 fieldwork in Savis Marsh, Bayside of Chesapeake, VA

Guiding research questions:

- How has the concentration and composition of microplastics varied through time since the mid-20th Century?
- Does microplastic concentration/composition differ in intertidal environments in the Chesapeake Bay versus Atlantic-facing intertidal systems?
- Relationship of microplastic concentration/composition to frequency of tidal inundation? What can this tell us about sea-level rise?

Photo: View from the tide gauge at Wachapreague, VA

Sediment MPs in the Chesapeake Bay?

- Densely populated area
- Accelerated sea-level rise
- Accelerated erosion
- Abundant sources of microplastics entering the bay

Photo: Storm flooding in Norfolk, VA

Skyler Ballard / Chesapeake Bay Program

Core and sample processing

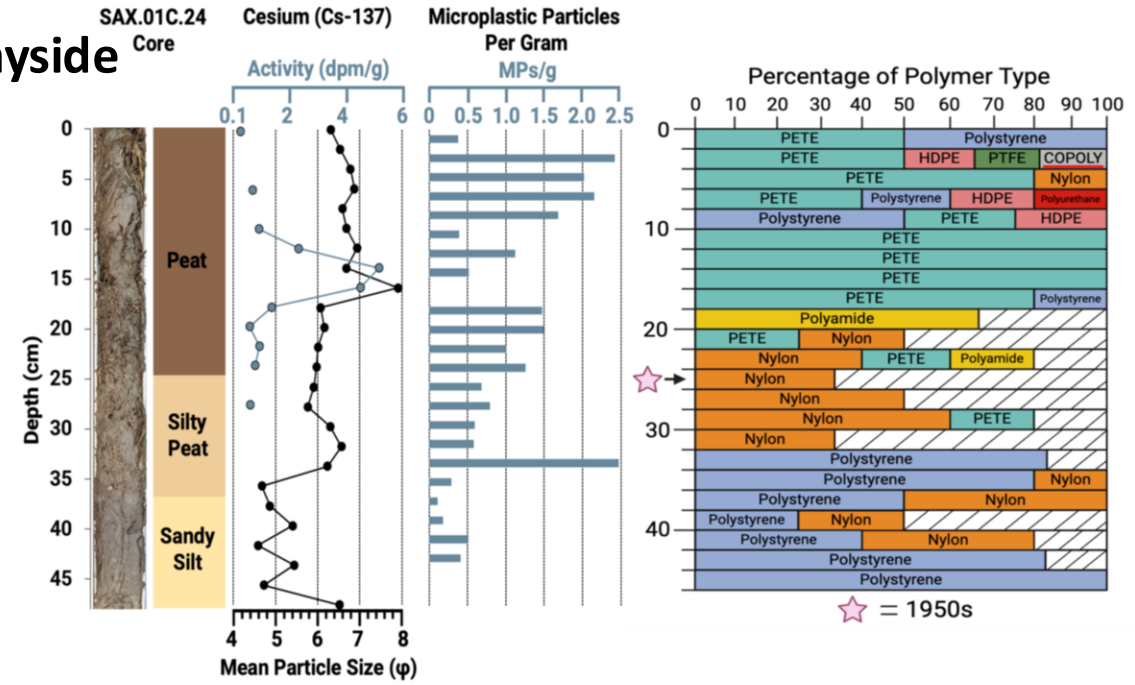
A microplastic!

Microplastics analysis

Coastal Hazards Lab

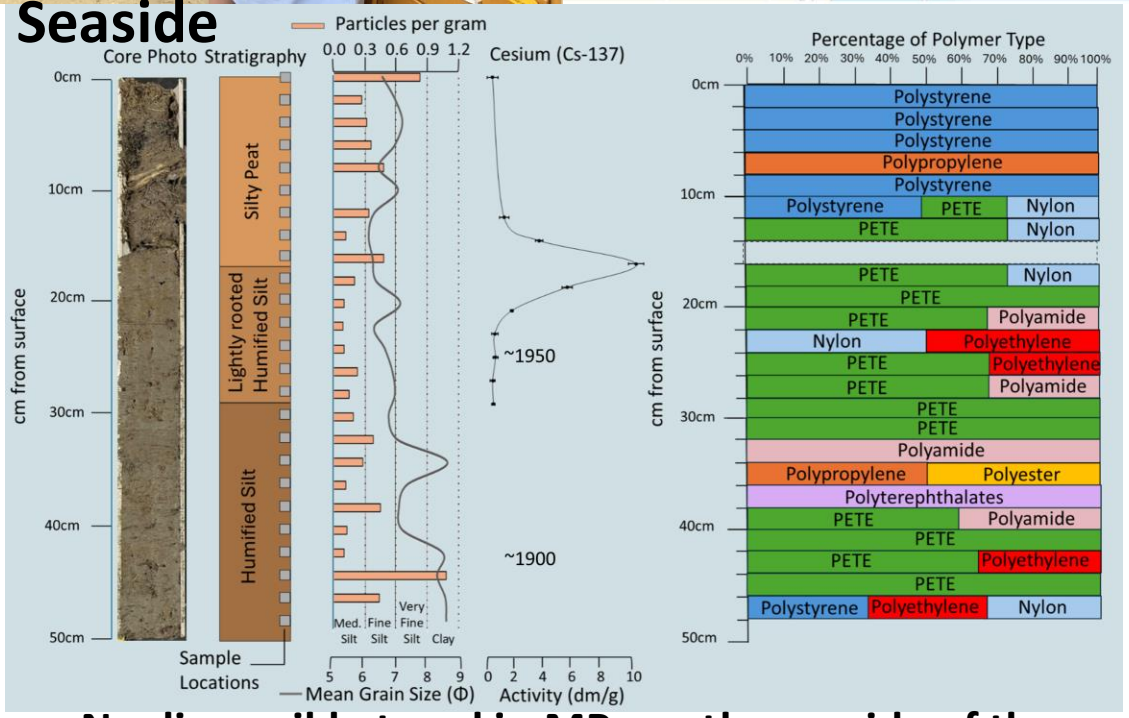
Grain size analysis

Bayside



Over time MPs increase along the bayside in the Chesapeake Bay

Seaside



No discernible trend in MPs on the seaside of the Chesapeake Bay

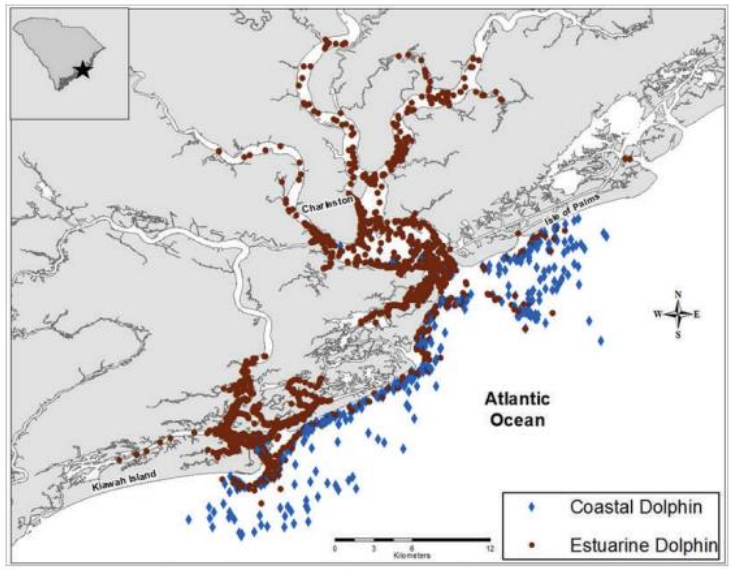
LONG-TERM MONITORING OF MICROPLASTICS IN COASTAL DOLPHINS

This ecosystem toxicologist is tracking microplastic consumption in dolphins

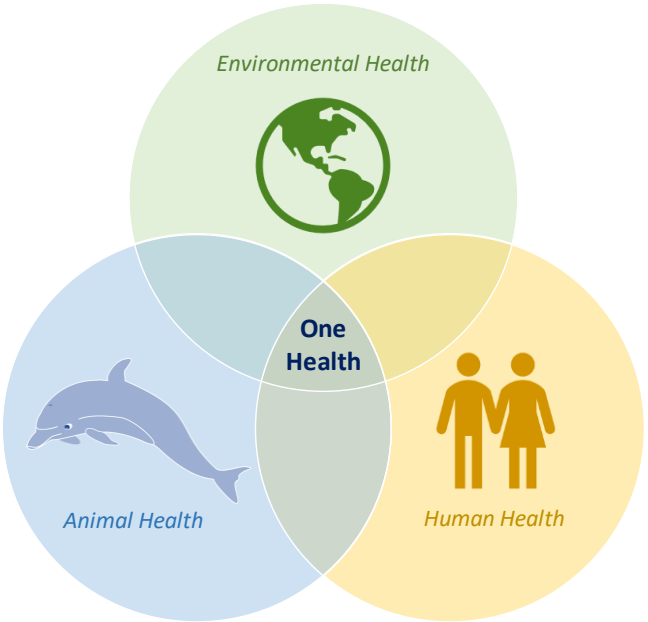
Marine Mammals as Ecosystem Sentinels

- Long-lived apex predators in the coastal environment.
- Dolphins are marine mammals
- Ecosystem sentinels can be monitored to provide an early indication of potential risks to environmental and human health.

The objective of this research is to understand the exposure pathways and biological fate of microplastics in the coastal region by studying local bottlenose dolphins as ecosystem sentinels.

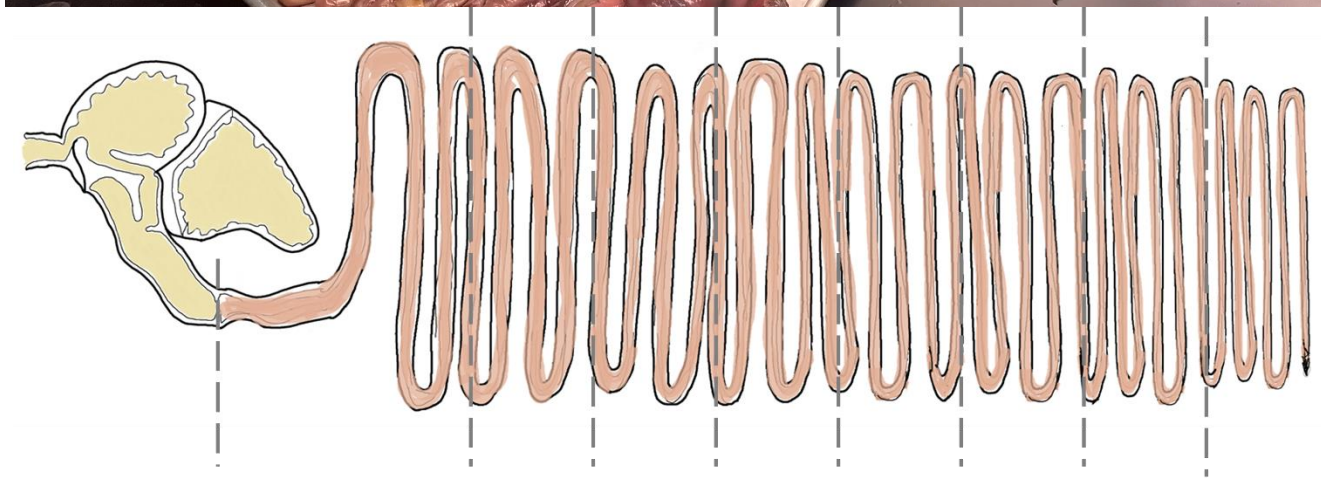


(Laska et al., 2011)



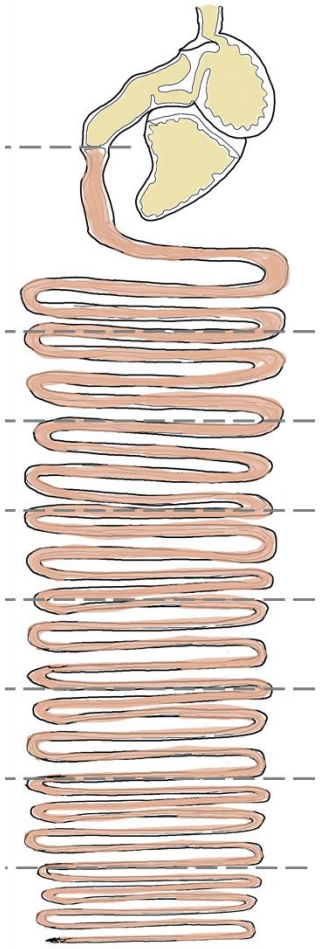
Bonnie Ertel
NOAA Contractor

Sample Collection



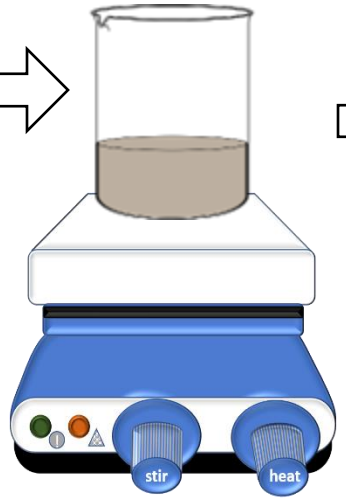
Sample Processing and MP Analysis

Dissect stomach and intestines



Rinse GI contents through sieves >125 µm

Digest biological material with a filtered 10% potassium hydroxide (1.4M) solution at 3x vol for 7 days @60˚C



Filter retained particles onto a 0.45 µm nitrocellulose gridded filter

Analyze particles using visual microscopy and Raman spectroscopy

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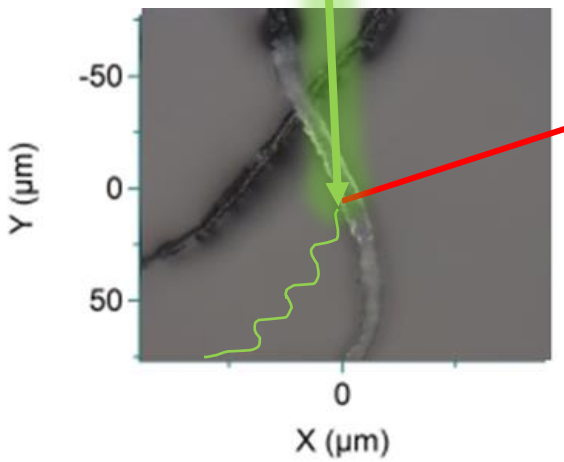
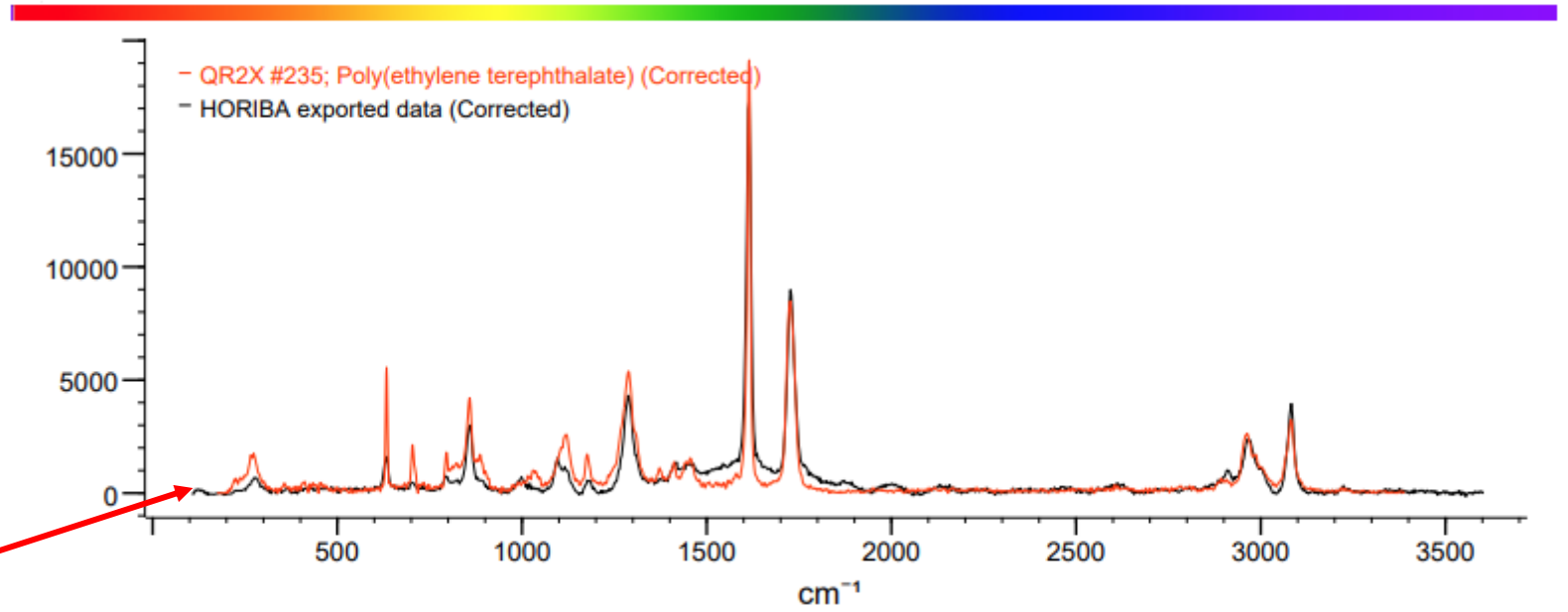
methods from Battaglia et al., 2020

Sample Processing: Raman Spectroscopy

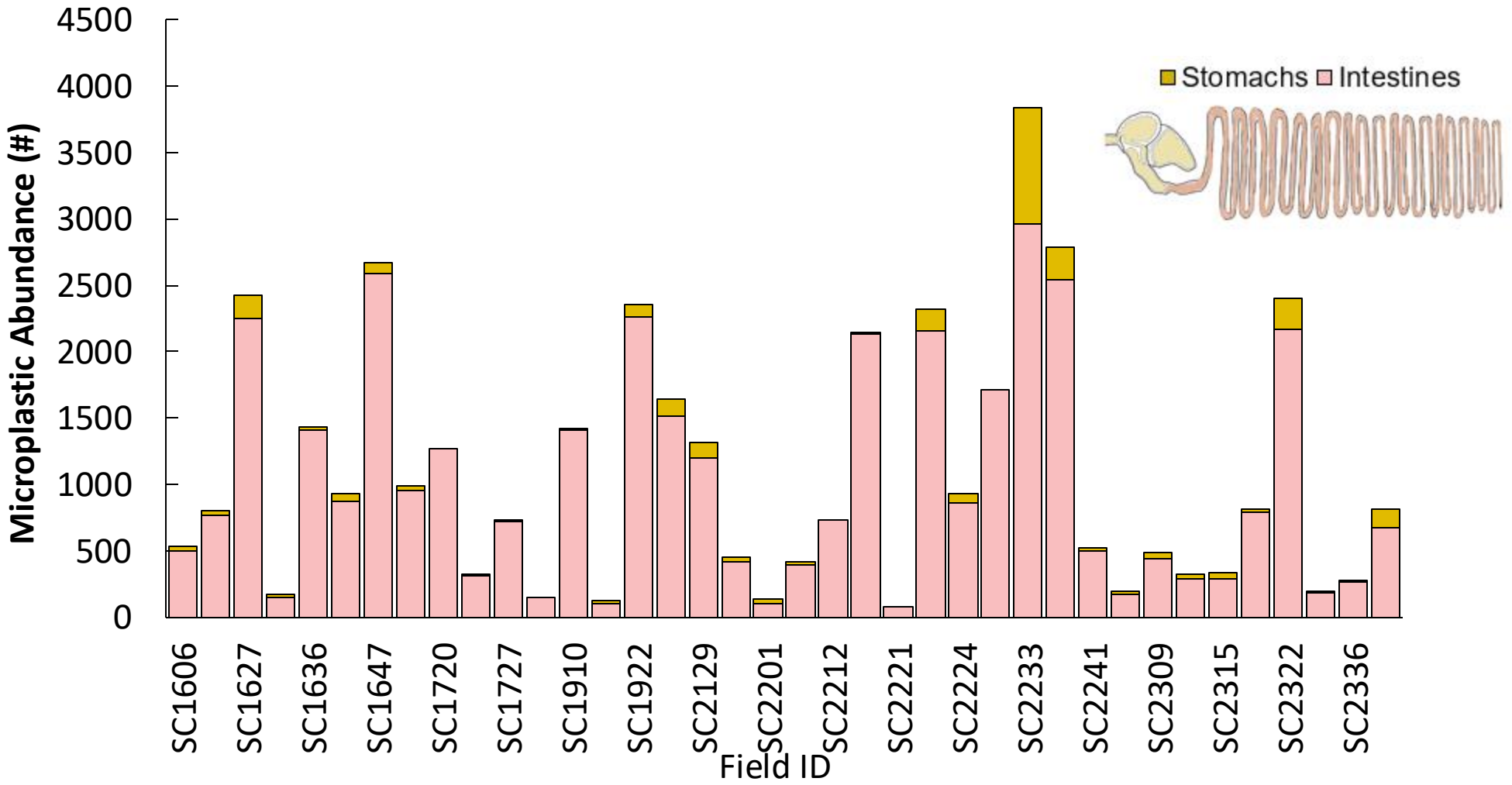
535nm
laser





Raman spectroscopy allows us to identify the chemical composition of a particle

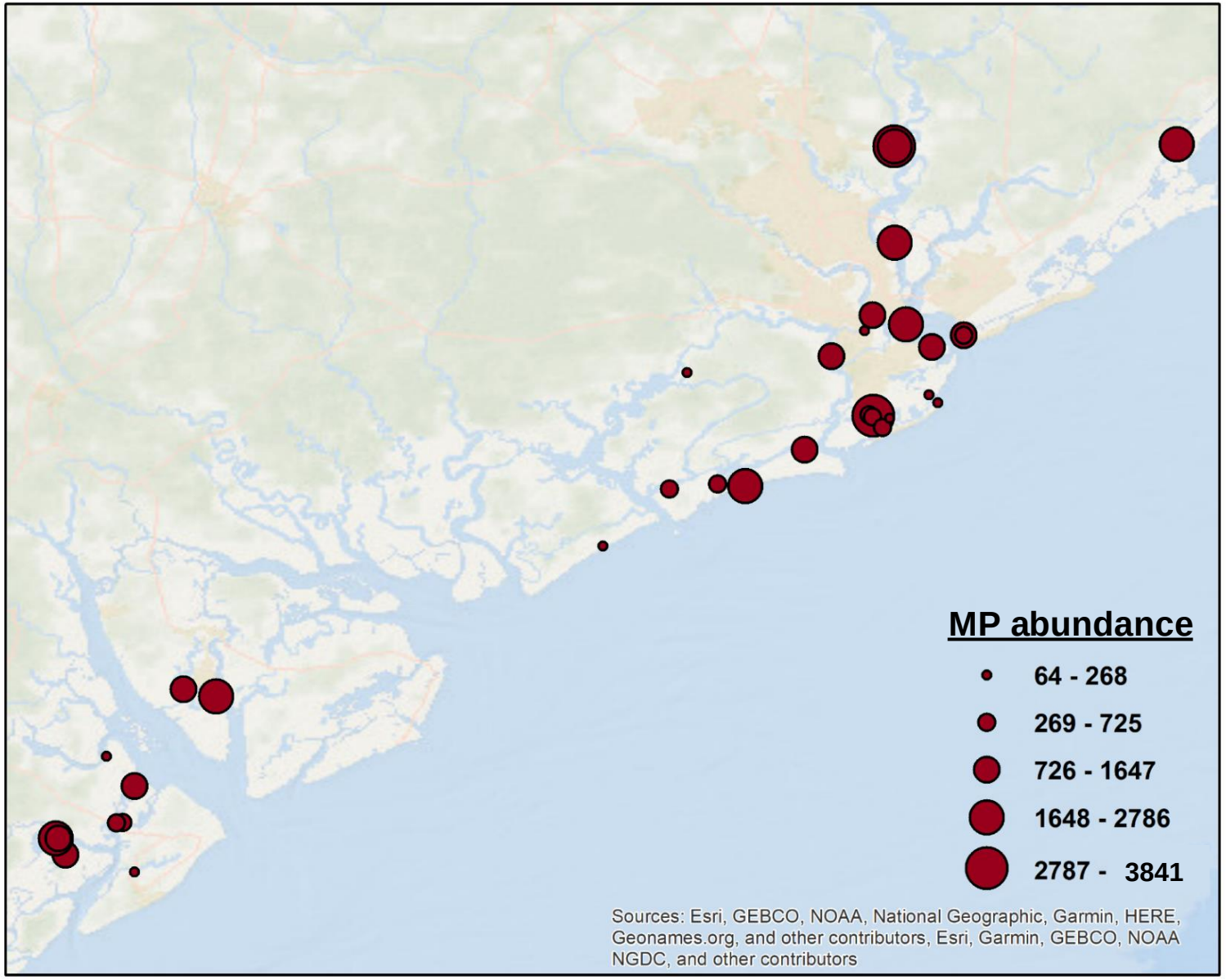
Year 1-3 Results: MP Abundance



MPs identified in all dolphins' GIT, with more in their intestines (1039 ± 151 MP) **than stomachs** (89 ± 27 MP)

($p<0.0001$)

Year 1-3 Results: MP Abundance

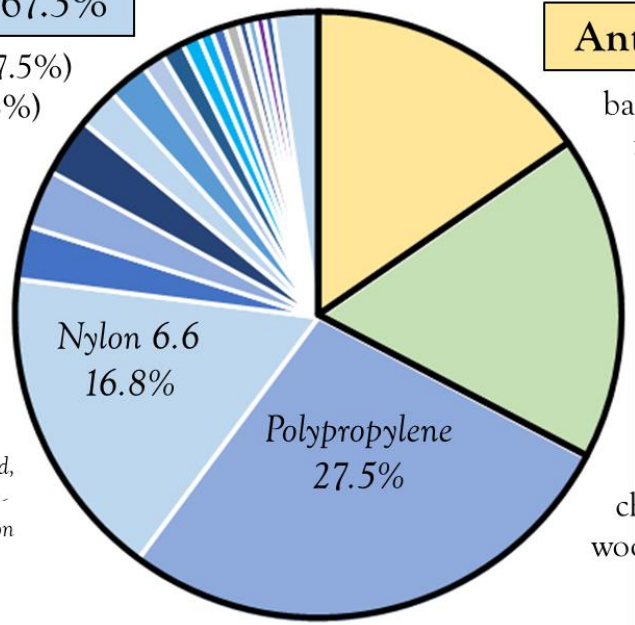


Year 1-3 Results: MP Abundance

Polymers: 67.3%

polypropylene (27.5%)
nylon 6.6 (16.8%)
copolymer blend (3.1%)
polyvinyl chloride (3.1%)
polyethylene terephthalate (2.8%)
polyethylene (2.1%)
poly(methyl methacrylate) (12.1%)
polyamide (1.2%)
nylon 12 (1.2%)
Other polymers (<1%)

polyurethane, polybutadiene, polyacrylic acid, LDPE, MDPE, HDPE, polyisoprene, PE1-octene copolymer, PVA, nitrile, acrylic, nylon 11, polyester epoxy, ethylene ethyl acrylate, polynbutyl methacrylate, polyvinyl formyl, polycarbonate, polyoxymethylene

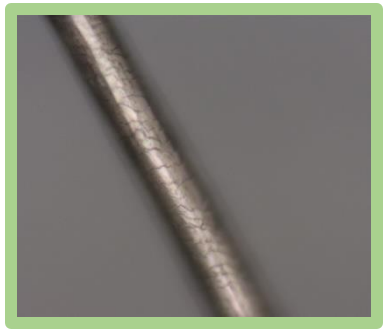


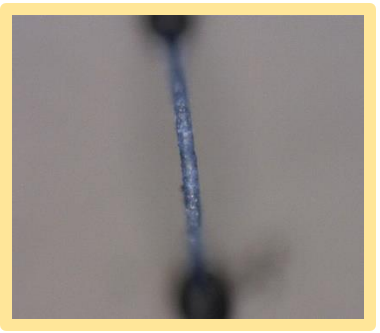
Anthropogenic: 15.4%

based on additives, melting, or burning

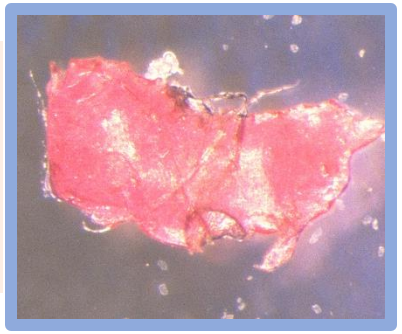
Natural: 17.3%

cellulose
viscose
cotton
chitin
wool



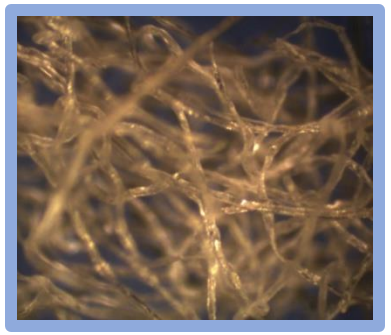


The most abundant polymers are polypropylene and nylon 6,6

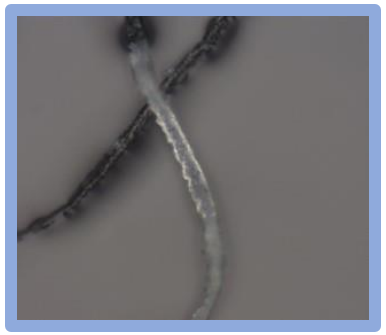


HDPE fragment

Polypropylene fiber

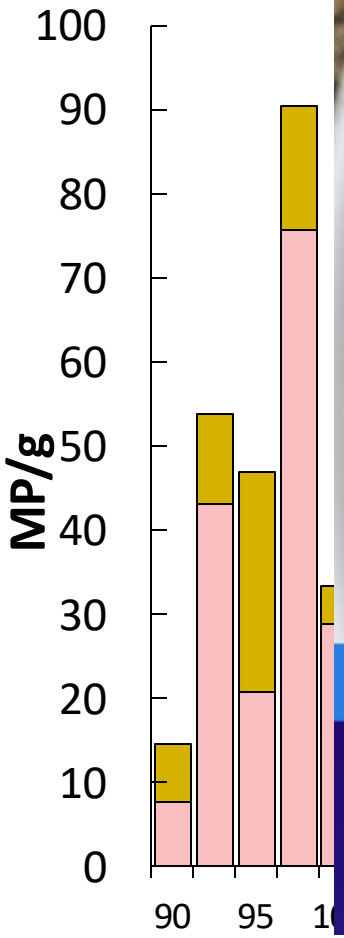


Nylon fiber



Polyester fiber

Year 1-3 Results: Per Gram GI Content

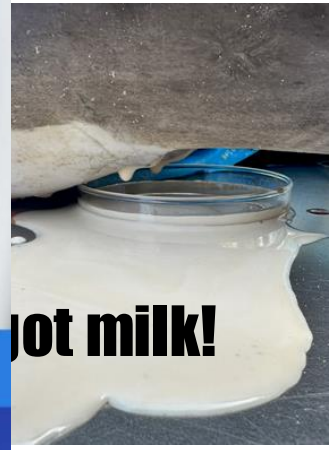


Animal Length (cm)

higher MP

ncentrations had

um in their colon



New discovery: First Evidence of Microplastic Inhalation Among Free-Ranging Small Cetaceans

Todd Speakman/ National Marine Mammal Foundation

CNN Science Space Life Unearthed Watch Liste

Science / Life

Wild dolphins off US Southeast coast found with microplastics in their breath, study says

By Taylor Nicioli, CNN

4 minute read · Updated 5:05 PM EDT, Thu October 17, 2024

The New York Times · 11d

These Scientists Tested Dolphin Breath. They Found Plastic.

Their analysis detected microplastic particles in the breath of all the dolphins they tested. The particles included several ...

Smithsonian MAGAZINE

Scientists Have Found Microplastics in Dolphin Breath for the First Time

Each of the 11 dolphins sampled exhaled at least one suspected particle of microplastic, which researchers say "highlights how extensive environmental microplastic pollution is"

PLOS ONE

First evidence of microplastic inhalation among free-ranging small cetaceans

Miranda K. Dziobak[1,2], Andreas Fahlman[3,4,5], Randall S. Wells[6], Ryan Takeshita[7], Cynthia Smith[7], Austin Gray[8], John Weinstein[9], Leslie B. Hart[1]*

1 Department of Health and Human Performance, School of Health Sciences, College of Charleston, Charleston, SC, United States of America, **2** Department of Environmental Health Sciences, Arnold School of Public Health, University of South Carolina, Columbia, SC, United States of America, **3** Fundacion Oceanografic, Valencia, Spain, **4** Global Diving Research, Sanlucar de Barrameda, Spain, **5** IFM, Linkoping University, Linkoping, Sweden, **6** Chicago Zoological Society's Sarasota Dolphin Research Program, % Mote Marine Laboratory, Sarasota, FL, United States of America, **7** National Marine Mammal Foundation, San Diego, CA, United States of America, **8** Department of Biological Sciences, Virginia Tech, Blacksburg, VA, United States of America, **9** Department of Biology, The Citadel, Charleston, SC, United States of America

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THE CONVERSATION

Academic rigor, journalistic flair

Microplastic pollution is everywhere, even in the exhaled breath of dolphins – new research

Published: October 16, 2024 2:01pm EDT

Hart et al., 2024 PlosOne

Austin_doug13

QUESTIONS?