Microplastics in the Ocean's Interior

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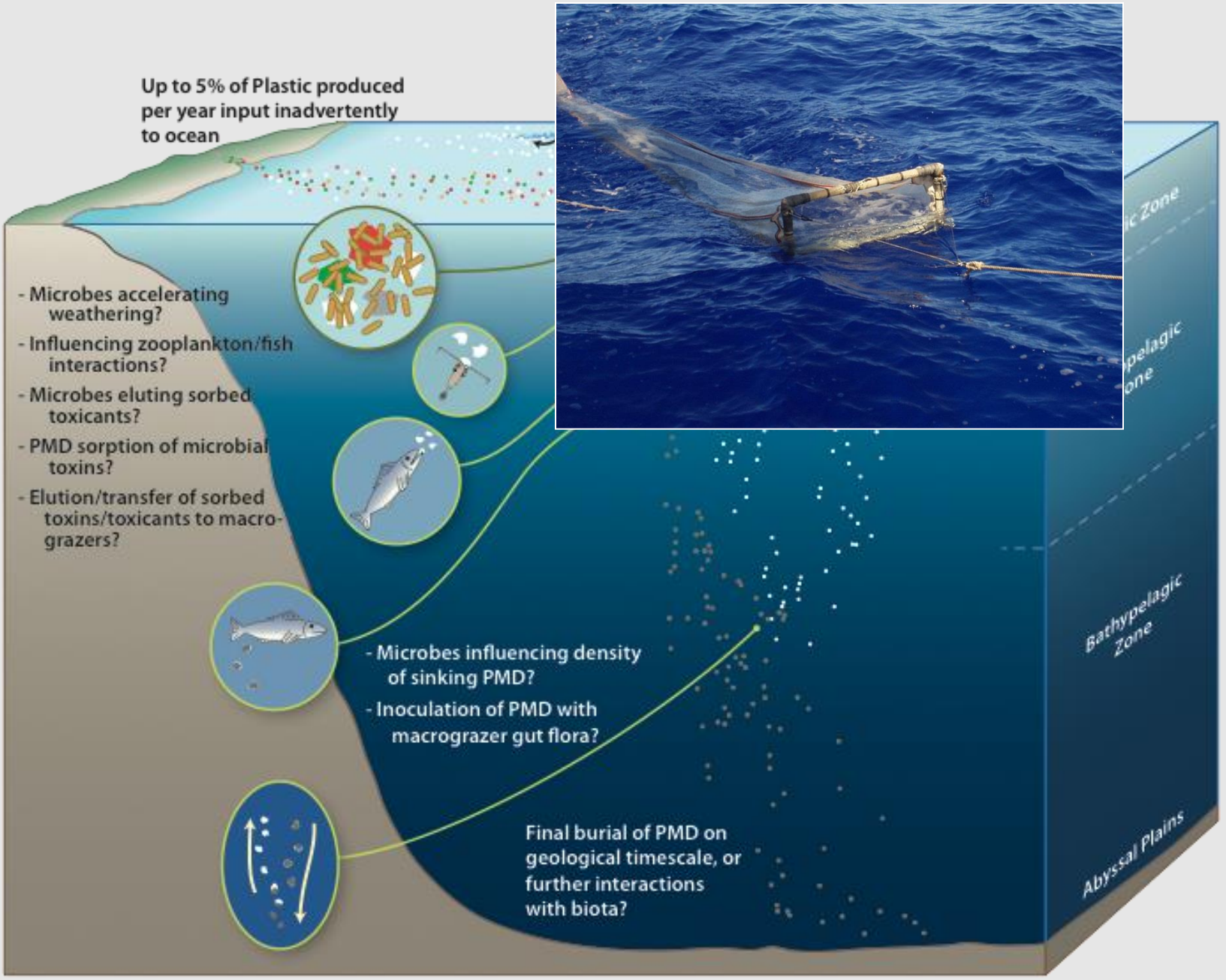

Mincer et al., 2016

Plastic Particles in Surface Waters of the Northwestern Atlantic

The abundance, distribution, source, and significance of various types of plastics are discussed.

John B. Colton, Jr., Frederick D. Knapp, Bruce R. Burns

As early as 1974:

Guidelines for controlling the release of plastic debris in the marine environment

Among the technological developments and methodology needed are:

1) Development of water-soluble and photodegradable polymers for one-time-use and short-time-use plastic products.

2) Development of efficient, nonatmospheric polluting incinerators to replace open dumping and sanitary landfill.

3) Increased effort in the technological development of plastic reclamation systems.

4) Increased efforts in plastic recycling to a level of that in the paper, metal, and glass industries. This will require not only new technological development but also a change in attitude concerning the use of scrap and reprocessed material among resin producers, designers, and buyers of molded products.

Science, New Series, Vol. 185, No. 4150 (Aug. 9, 1974), pp. 491-497

Analytical Methods

ARTICLE

An approach for extraction, characterization and quantitation of microplastic in natural marine snow using Raman microscopy

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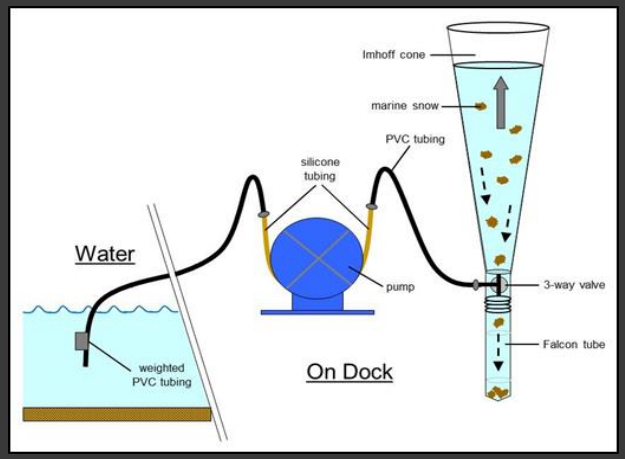
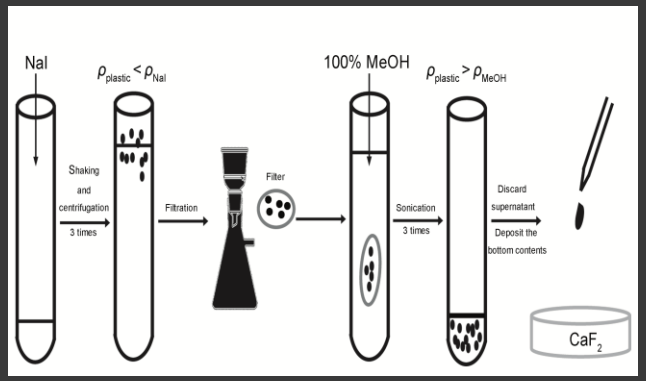
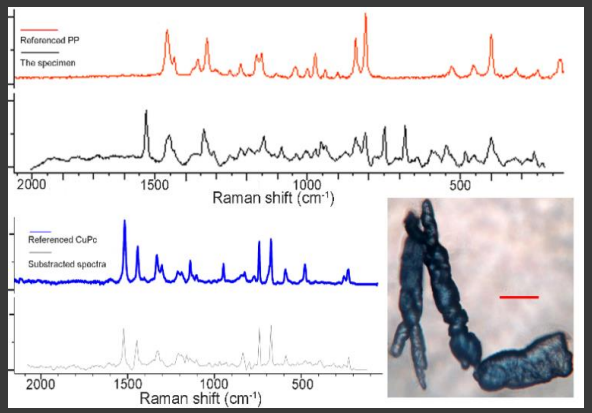
Shiye Y. Zhao,[a b] Meghan Danley,[c] J. Evan Ward,[d] Daoji Li[a] and Tracy J. Mincer*[b]





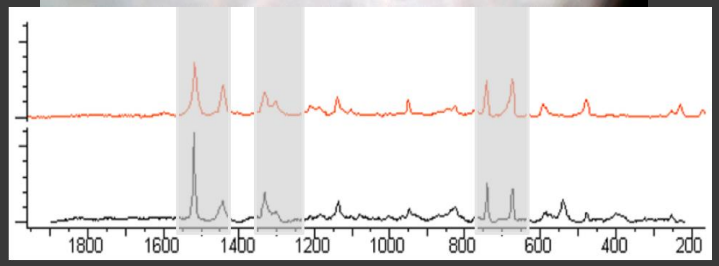


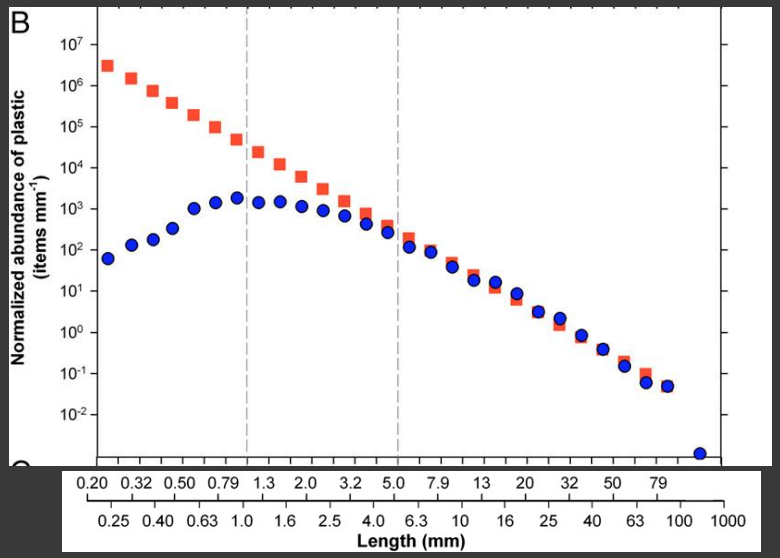
Found clear signal of PMD (< 300 µm) particles in marine aggregates

Surprising finding: PMD of high rugosity (jagged and sharp)

Zhao et al., 2016

Plastic Marine Debris (PMD) in marine aggregates





Organic aggregates termed ‘marine snow’ (one of the most abundant types of particulate carbon in the ocean’s interior) collected from Avery Point, CT

59 polymer particles from eight marine snow samples (48L total volume)

Particle sizes ranged from ~30 µm to 1.6 mm

Part of the ‘missing’ size fraction calculated in Cozar, et al., 2014, PNAS– implying that aggregates are one of the sinks for PMD in this size range.

Environmental Science & Technology

Article

Cite This: *Environ. Sci. Technol.* XXXX, XXX, XXX–XXX

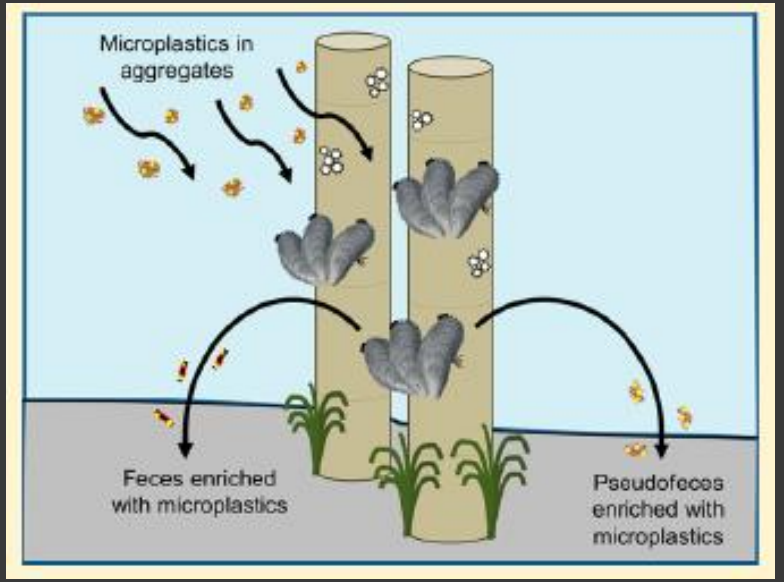
pubs.acs.org/est

Field-Based Evidence for Microplastic in Marine Aggregates and Mussels: Implications for Trophic Transfer

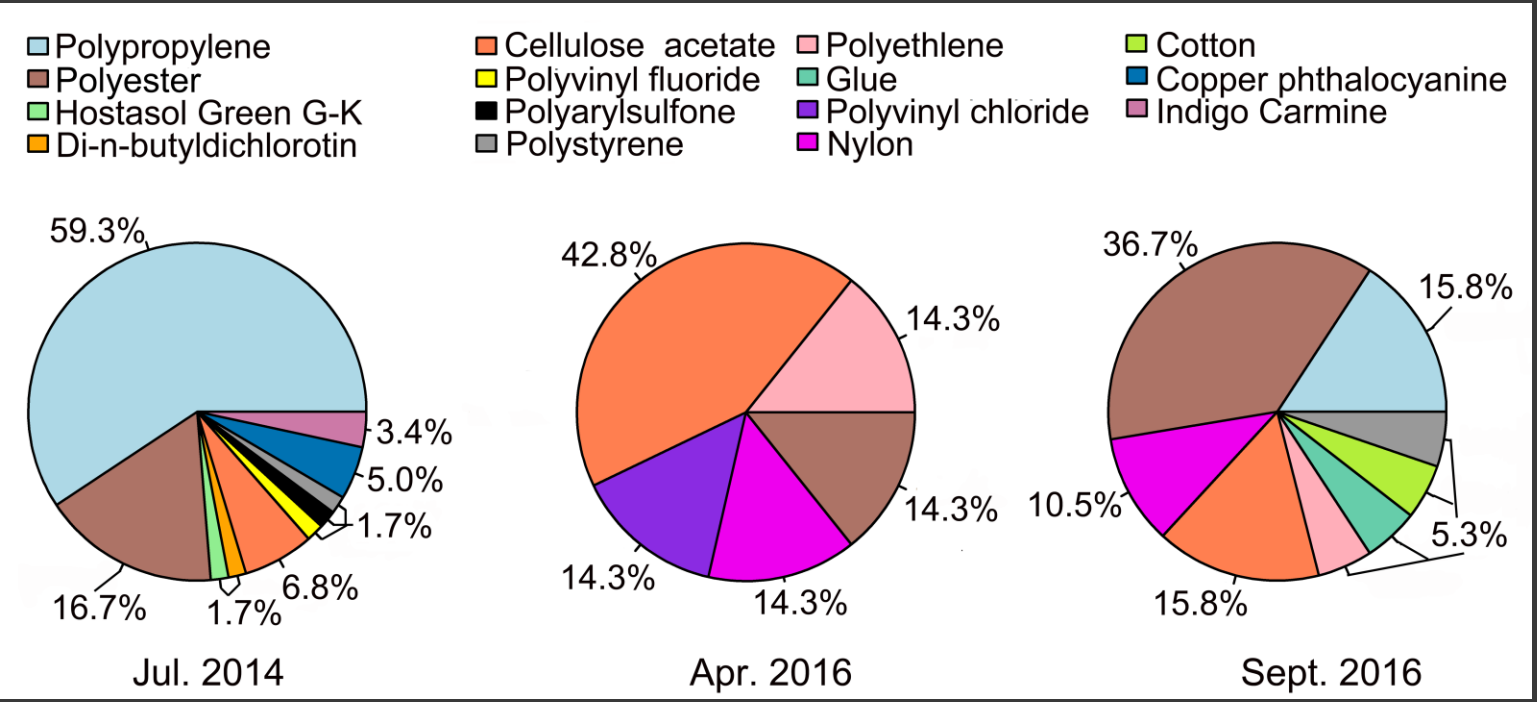
Shiye Zhao,[#,†,‡] J. Evan Ward,[*,§] Meghan Danley,[▽,∥] and Tracy J. Mincer[*,⊥]

Environ. Sci. Technol. 2018, 52, 19, 11038-11048

- Over 90% of plastic/aggregate particles were smaller than 1 mm
- Over 40% of microplastics were deposited as pseudofeces or feces
- Aggregates important in removing microplastic from surface waters



Polymer compositions in marine aggregates

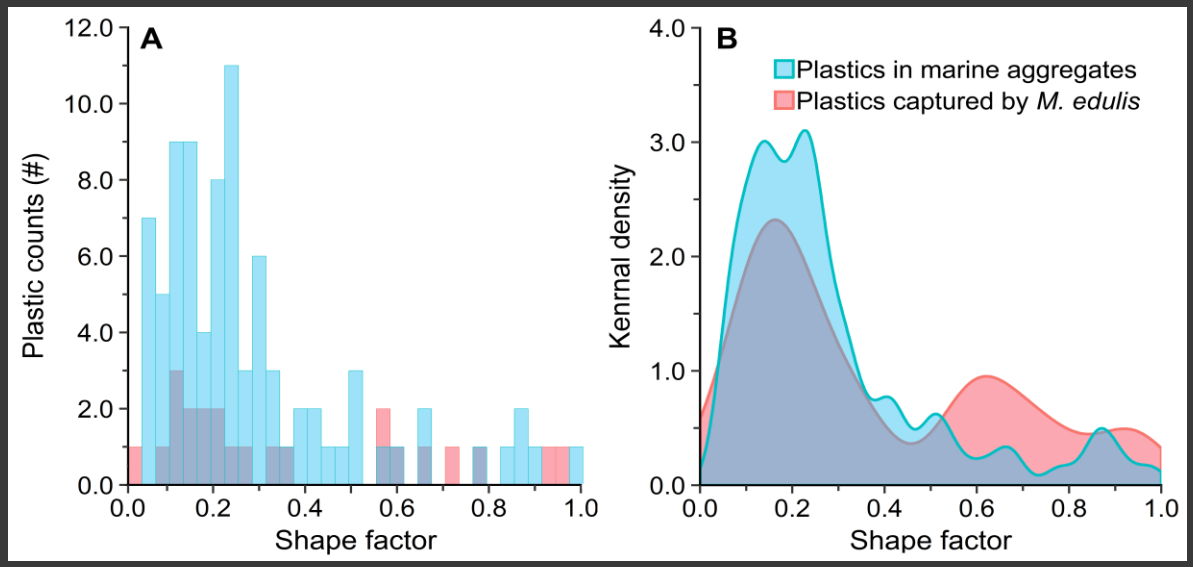


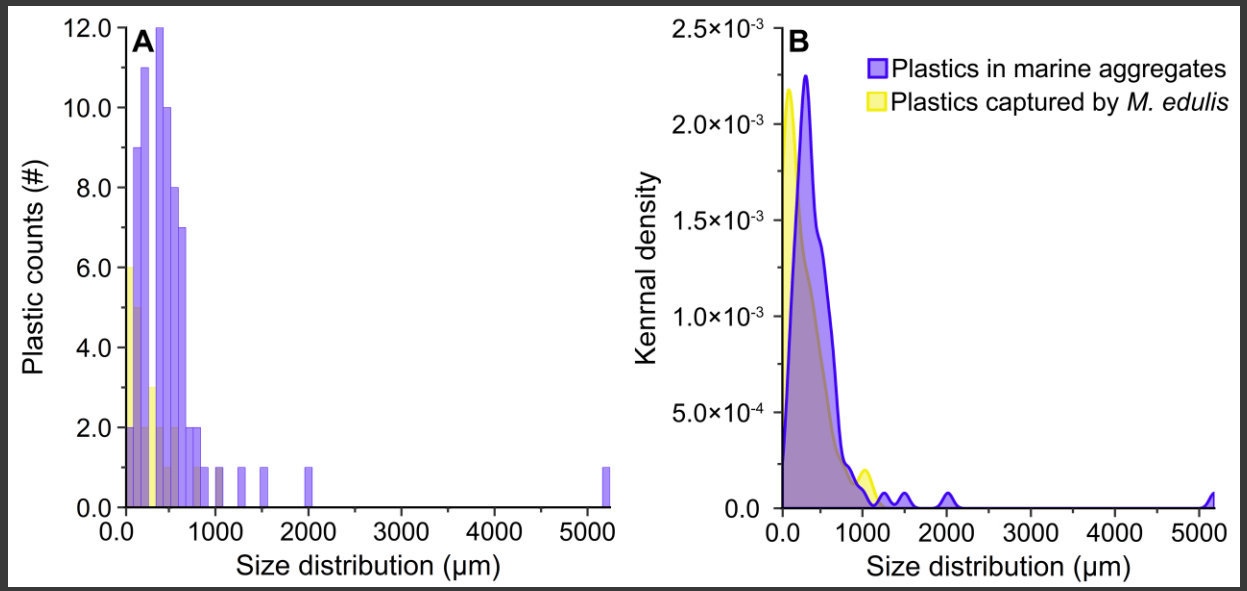
Microplastics were detected in 19 of the 26 (73.1%) samples of marine aggregates

A total of 85 microplastic particles confirmed by spectrometric analysis

Zhao et al., *Environ. Sci. Technol. 2018, 52, 19, 11038-11048*

Aggregate plastic particle sizes match mussel feeding preferences

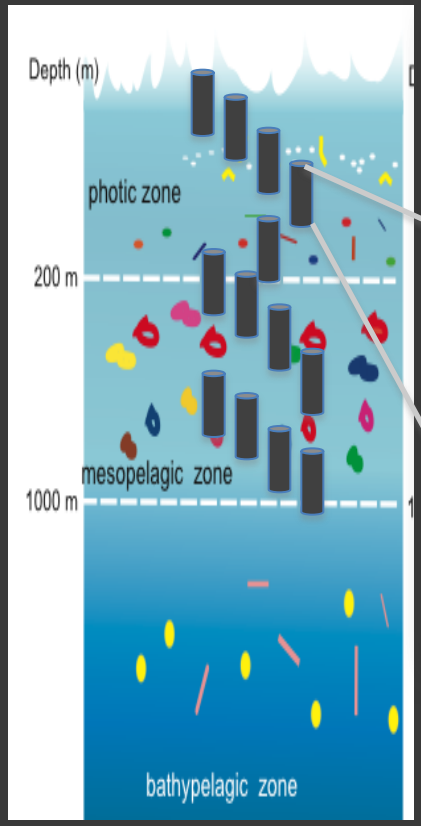




Zhao et al., *Environ. Sci. Technol. 2018, 52, 19, 11038-11048*

Samples of opportunity VERTIGO Station K2

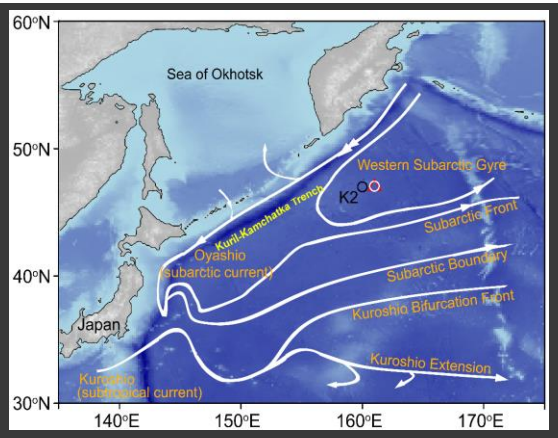
13 high volume pumps arrayed from surface to 900m deployed

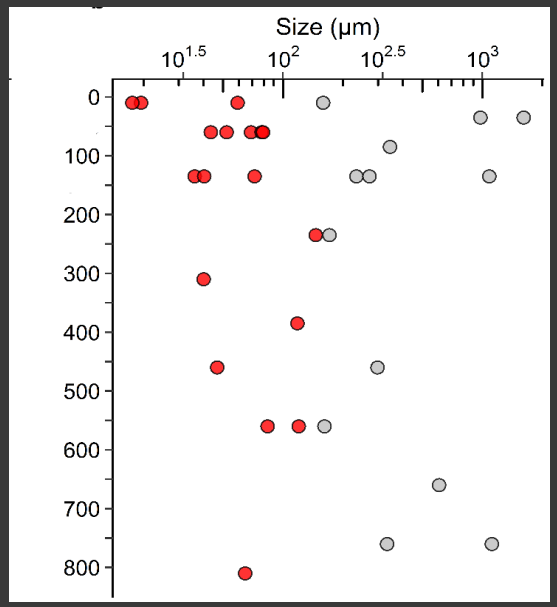


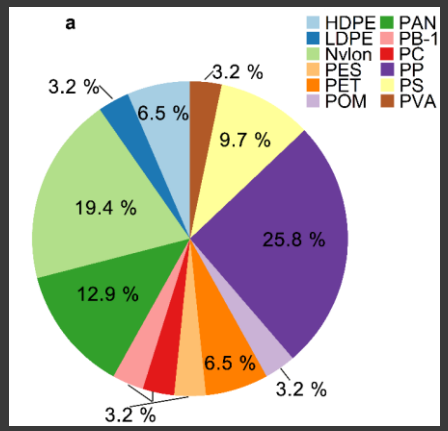
Revisiting Carbon Flux Through the Ocean's Twilight Zone

Ken O. Buesseler[1,*], Carl H. Lamborg[1], Philip W. Boyd[2], Phoebe J. Lam[1], Thomas W. Trull[3], Robert R. Bidigare[4], James K. B. Bishop[5,6], Karen L. Casciotti[1], Frank Dehairs[7], Marc Elskens[7], Makio Honda[8], David M. Karl[4], David A. Siegel[9], Mary W. Silver[10], Deborah K. Steinberg[11], Jim Valdes[12], Benjamin Van Mooy[1], Stephanie Wilson[11]

Science 27 Apr 2007:
Vol. 316, Issue 5824, pp. 567-570







Raman Spectroscopy and FT-IR Identification

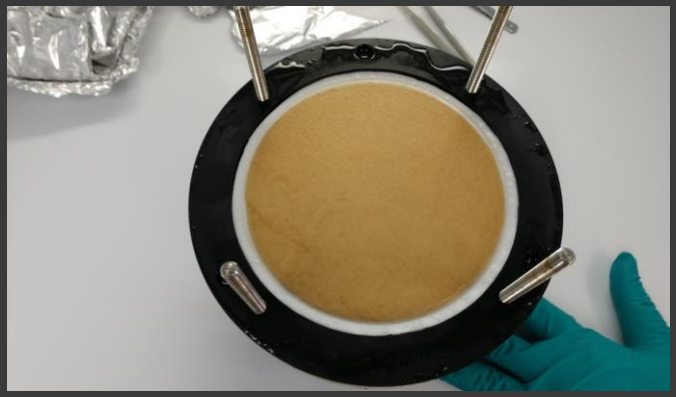
P-POC : POC 0.01- 0.001%

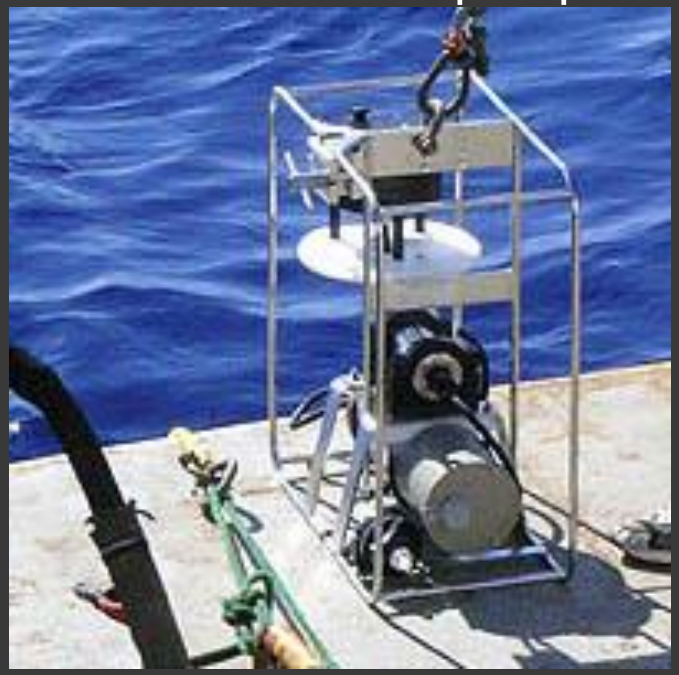
~40 plastic particles/1000 L

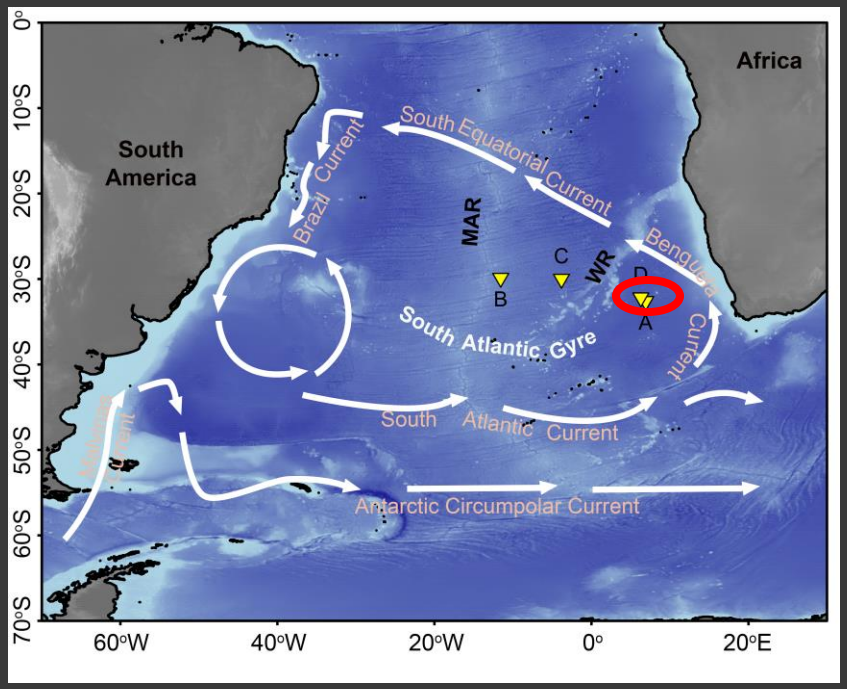
Problem: backing filter showed plastic contamination in 3/9 filters

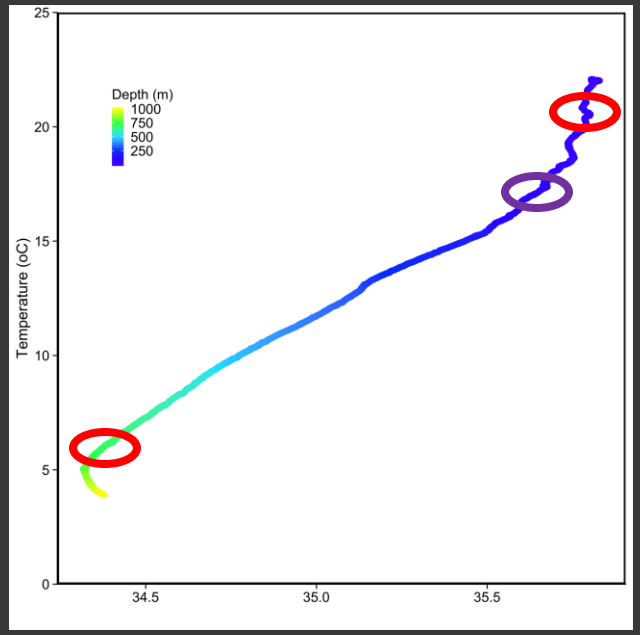
R/V Pelagia PE-448

- January 2019, total cruise track 3978 nautical miles
- 5 days sampling in South Atlantic Gyre
- Study included 4 stations of high volume seawater samples ranging from 400-1100 liters of seawater
- Ship outfitted with HEPA cleanroom
- 4 McLane pumps

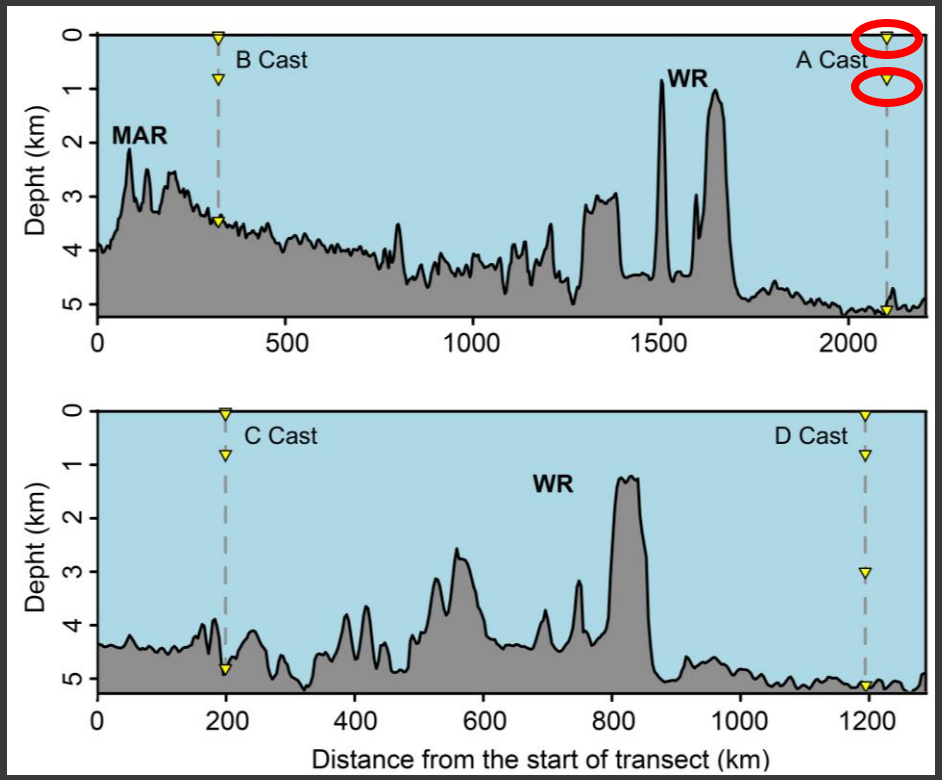








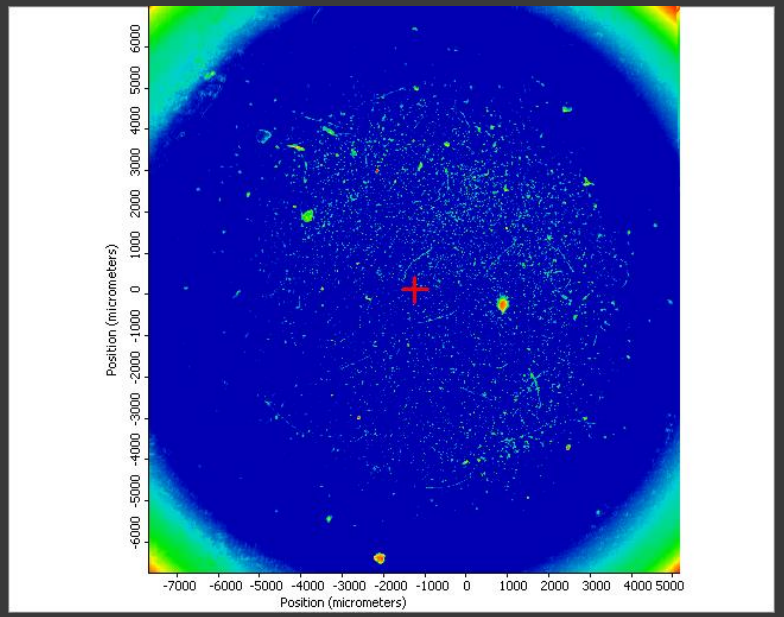
Sampling scheme:
Station A
10m, 100m, 800m, 5000m
= FT-IR processed
= FT-IR underway

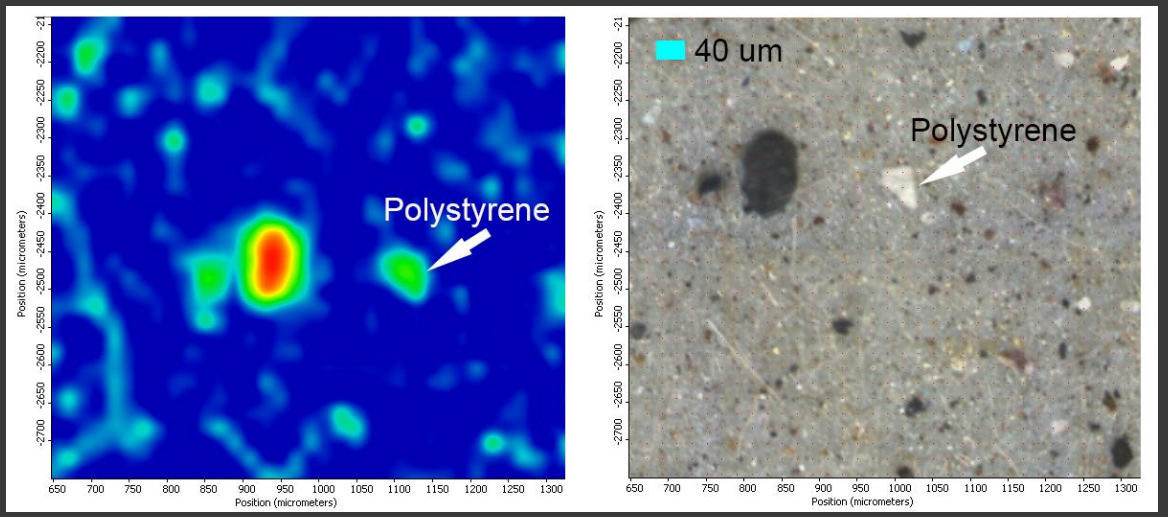


Workflow: QMA (0.7µm) filters with 150µm stainless prefilter

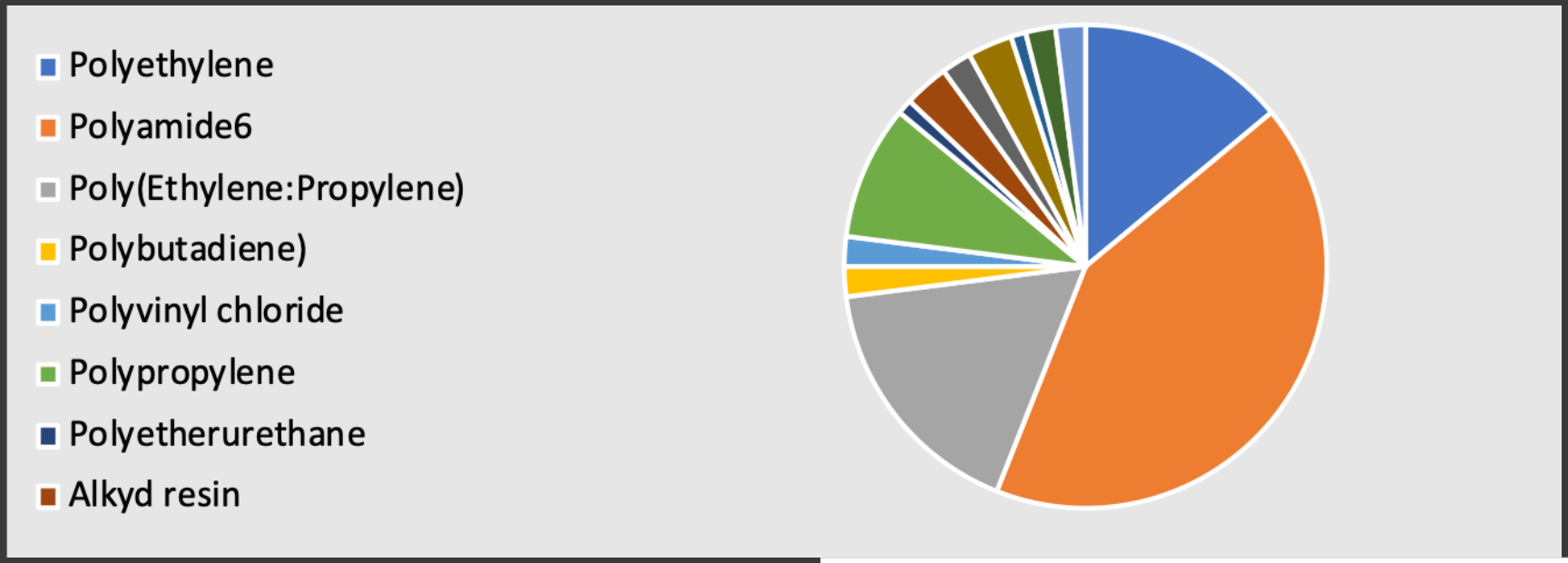
- Minimization of plastic in workflow
- 25 mm punch to equivalent of ~100 L
- Triplicate samples per depth
- Density separation in NaI solution, sonication
- Centrifuge 500 x g 10 min
- Pull plastic off top layer with combusted Pasteur pipet
- Repeat 3X
- Pull down plastic enriched fractions onto 0.2 um Anodisc
- FT-IR scan parameters

Mode: Transmission
Spectra: 3600-1250 cm-1
Aperture: 25 x 25 µm
Step size: 20 micron
Hit Quality: >80%





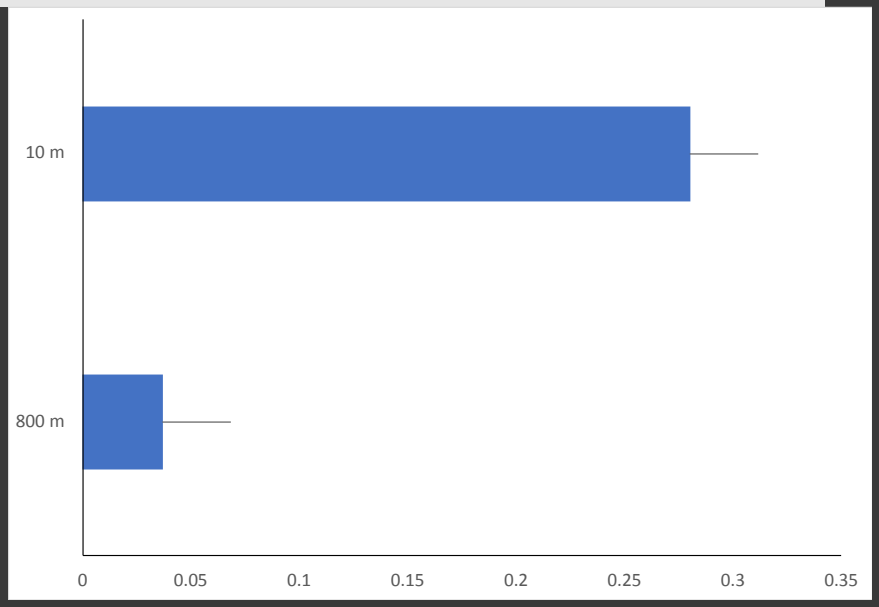
Nylon highly abundant at 10 meters depth



Particles per cubic meter:

10 meters:
280/1000L (+/- 31)

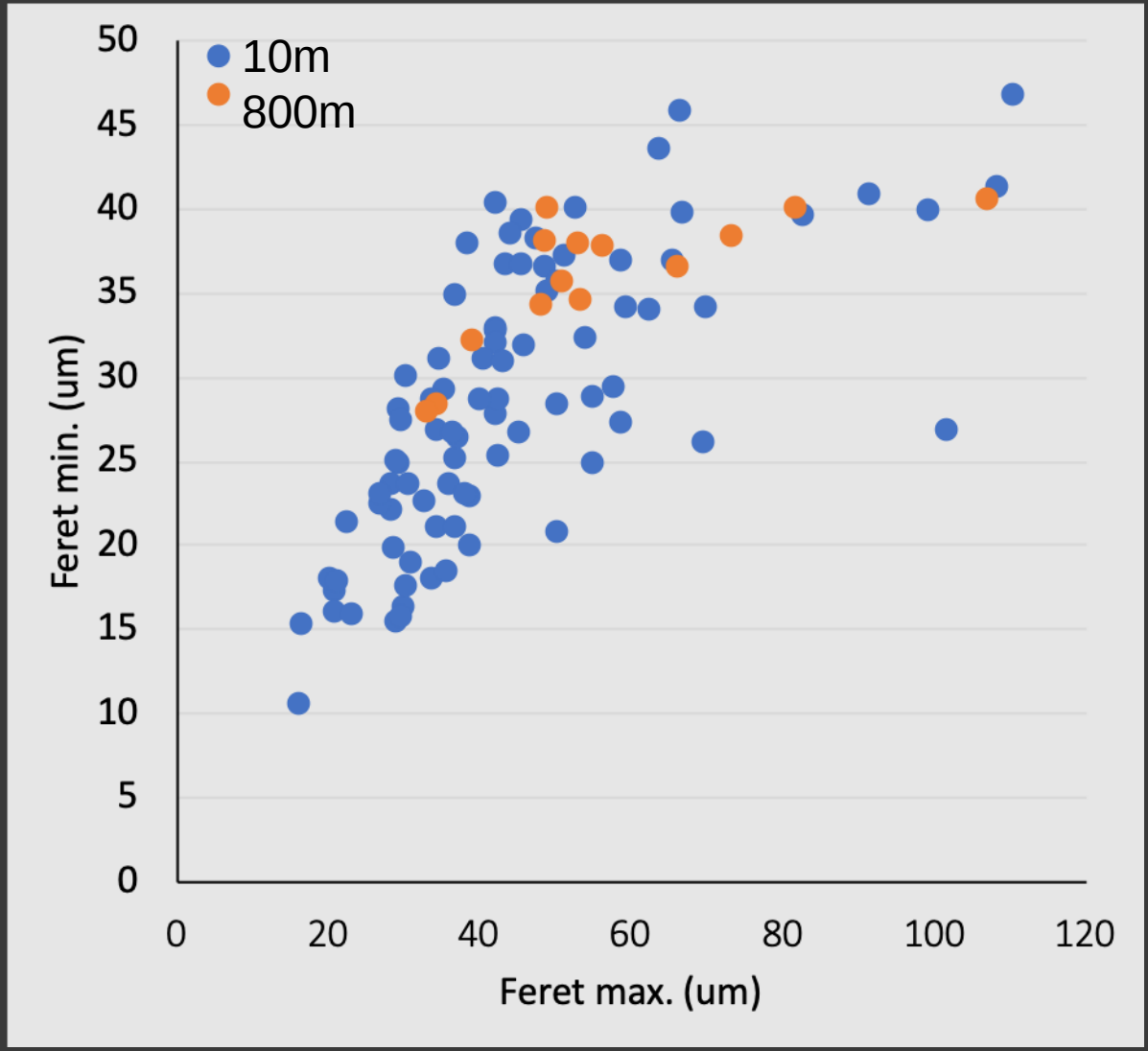
800 meters:
39.7/ 1000L (+/- 38)



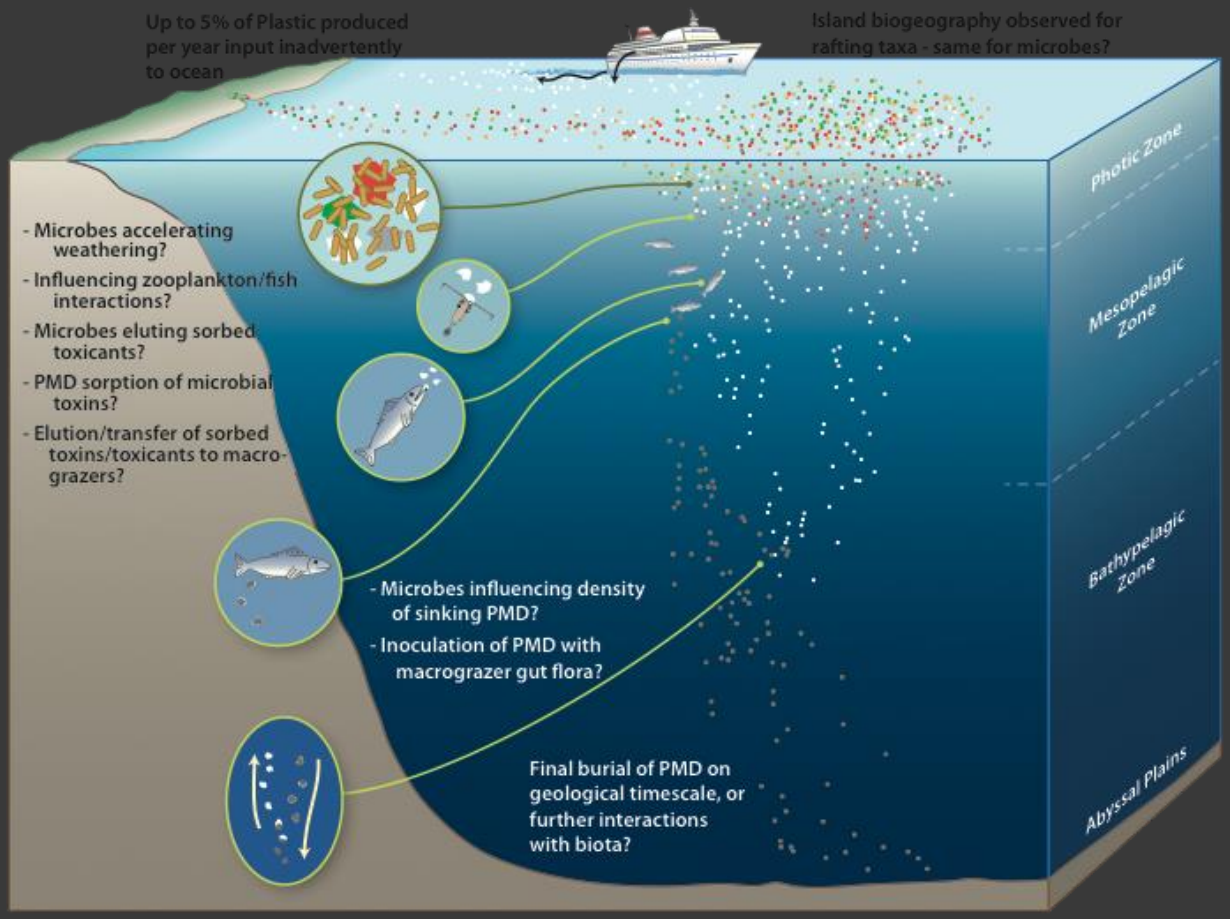
Particles per liter

Plastic particle size distributions

Note aspect ratio tends towards unity at both depths for particles 50 micron and smaller



Plastic appears to working its way into the biological pump



Mincer et al., 2016

Future research questions:

What is the overall fate of this debris? Does it keep getting smaller?

Big Data: How do subsurface plastic compositions vary along transect and depth? Ocean basins?

What is the residence time of these plastic particles?

Redfield's constant = 106:16:1:0.005 (C:N:P:Fe)
Nylon 6 ~ 106:16 (C:N)

Innovative solutions to keep plastic out of marine systems

Mr. Trashwheel, Baltimore Harbor MD, PBS News Hour

“We’ve picked up 16 dumpsters of trash during a single rainstorm”
-Adam Lindquist, director of the Healthy Harbor Initiative

Thank you!

- Dr. Shiye Zhao, Ryan Bos and my new colleagues at FAU

Collaborators:
Linda Amaral-Zettler (NIOZ), Erik Zettler (NIOZ), J. Evan Ward (UCONN-Avery Point), Ken O. Buesseler (WHOI), James L.B. Bishop (Lawrence Berkeley National Laboratory)

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