



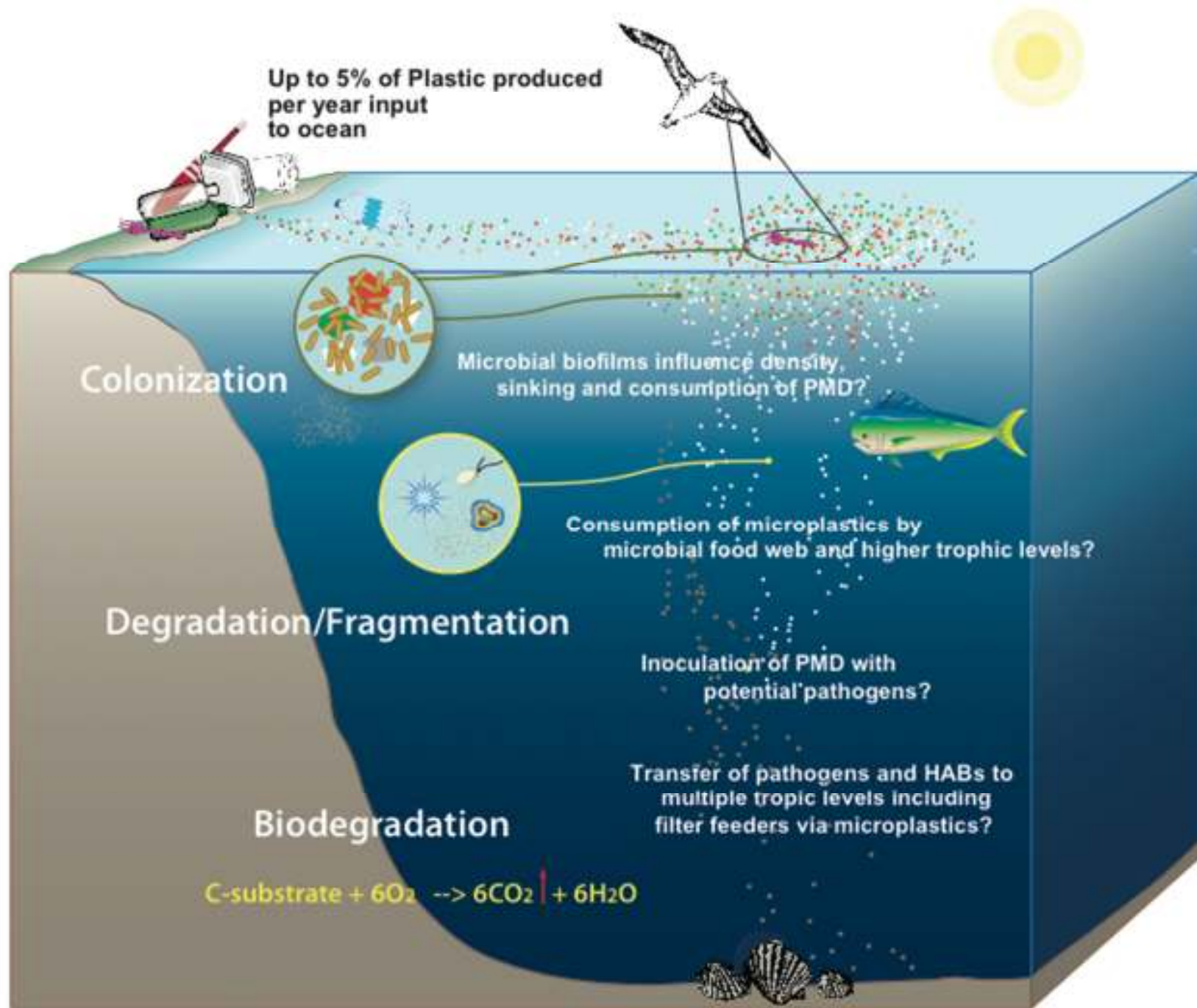
# Assessing the Fate of Plastics: Colonization and density changes

Erik Zettler

Royal Netherlands Institute for Sea Research

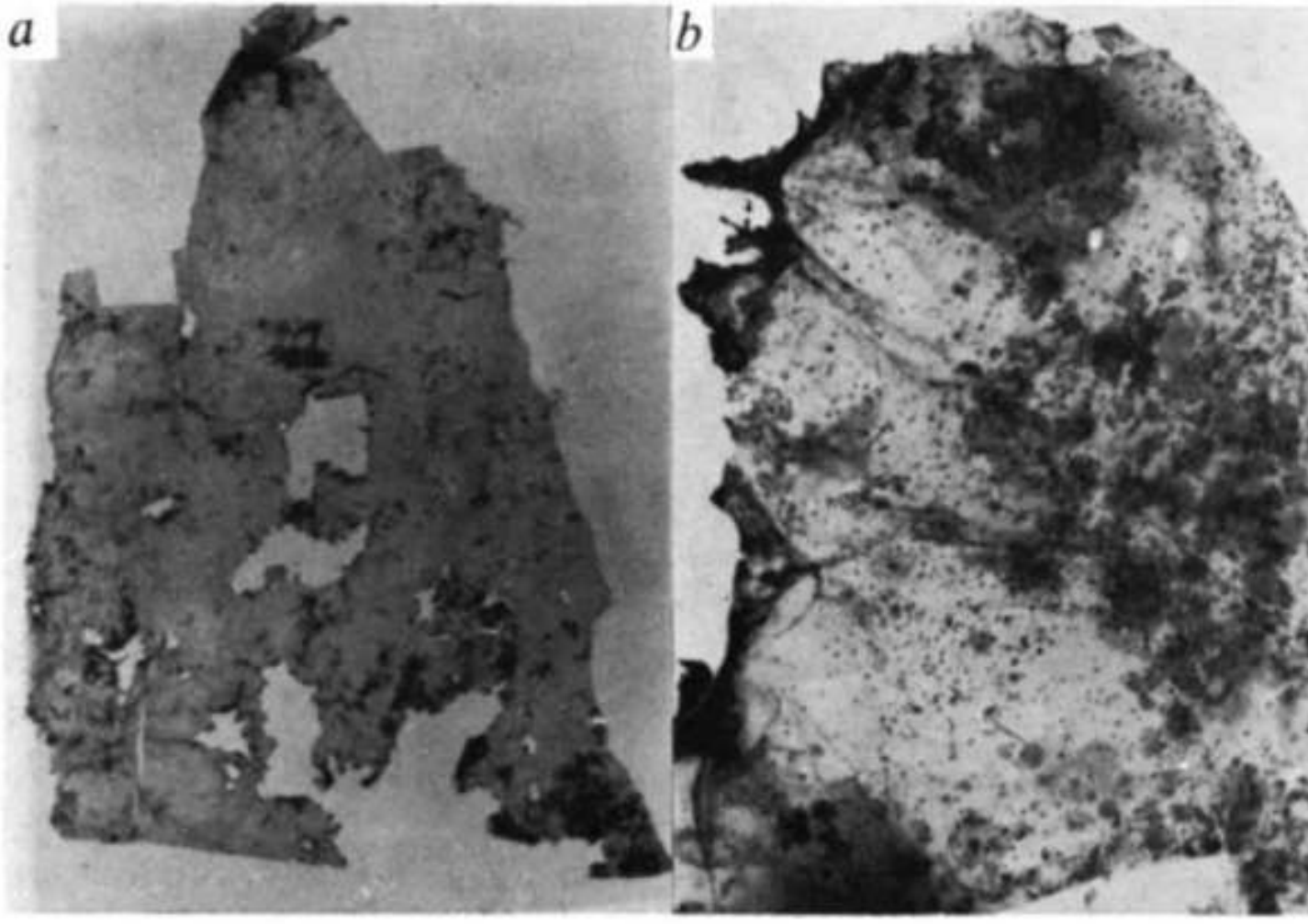
part of the institutes organization of NWO, in cooperation with Utrecht University



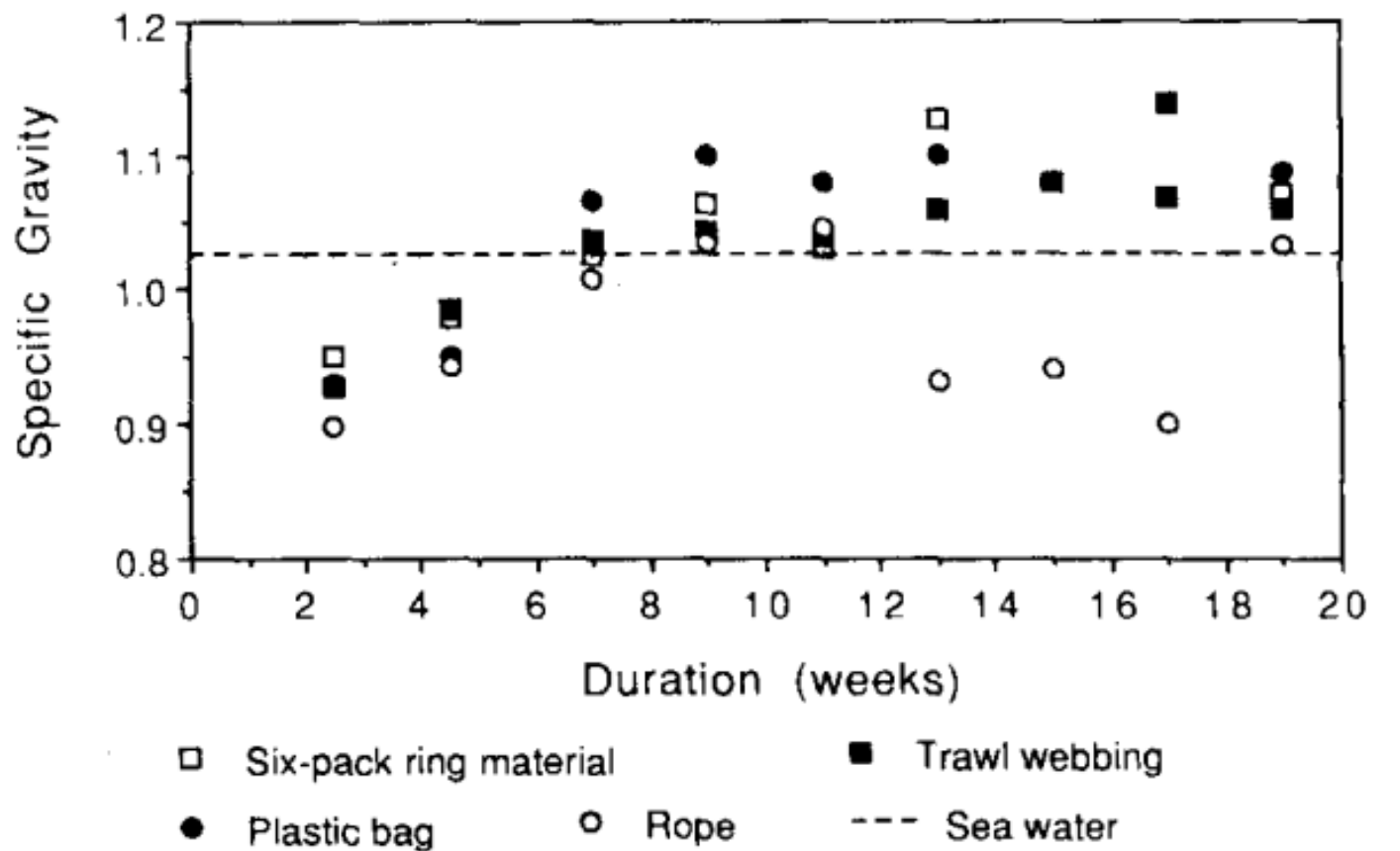


# Plastic reaches the sea floor 20x40cm pieces of LDPE

*Nature Vol. 255 June 19 1975*



# Fouling causes density changes



Ye and Andrady 1991

“Fouling of plastic materials was generally preceded by the formation of a transparent slimy biofilm on the surface.”



# 1972

## Plastics on the Sargasso Sea Surface

EDWARD J. CARPENTER  
K. L. SMITH, JR.

*Woods Hole Oceanographic Institution,  
Woods Hole, Massachusetts 02543*

*Abstract. Plastic particles, in concentrations averaging 3500 pieces and 290 grams per square kilometer, are widespread in the western Sargasso Sea. Pieces are brittle, apparently due to the weathering of the plasticizers, and many are in a pellet shape about 0.25 to 0.5 centimeters in diameter. The particles are surfaces for the attachment of diatoms and hydroids. Increasing production of plastics, combined with present waste-disposal practices, will undoubtedly lead to increases in the concentration of these particles. Plastics could be a source of some of the polychlorinated biphenyls recently observed in oceanic organisms.*

While sampling the pelagic *Sargassum* community in the western Sargasso Sea, we encountered plastic particles in our neuston (surface) nets. The occur-

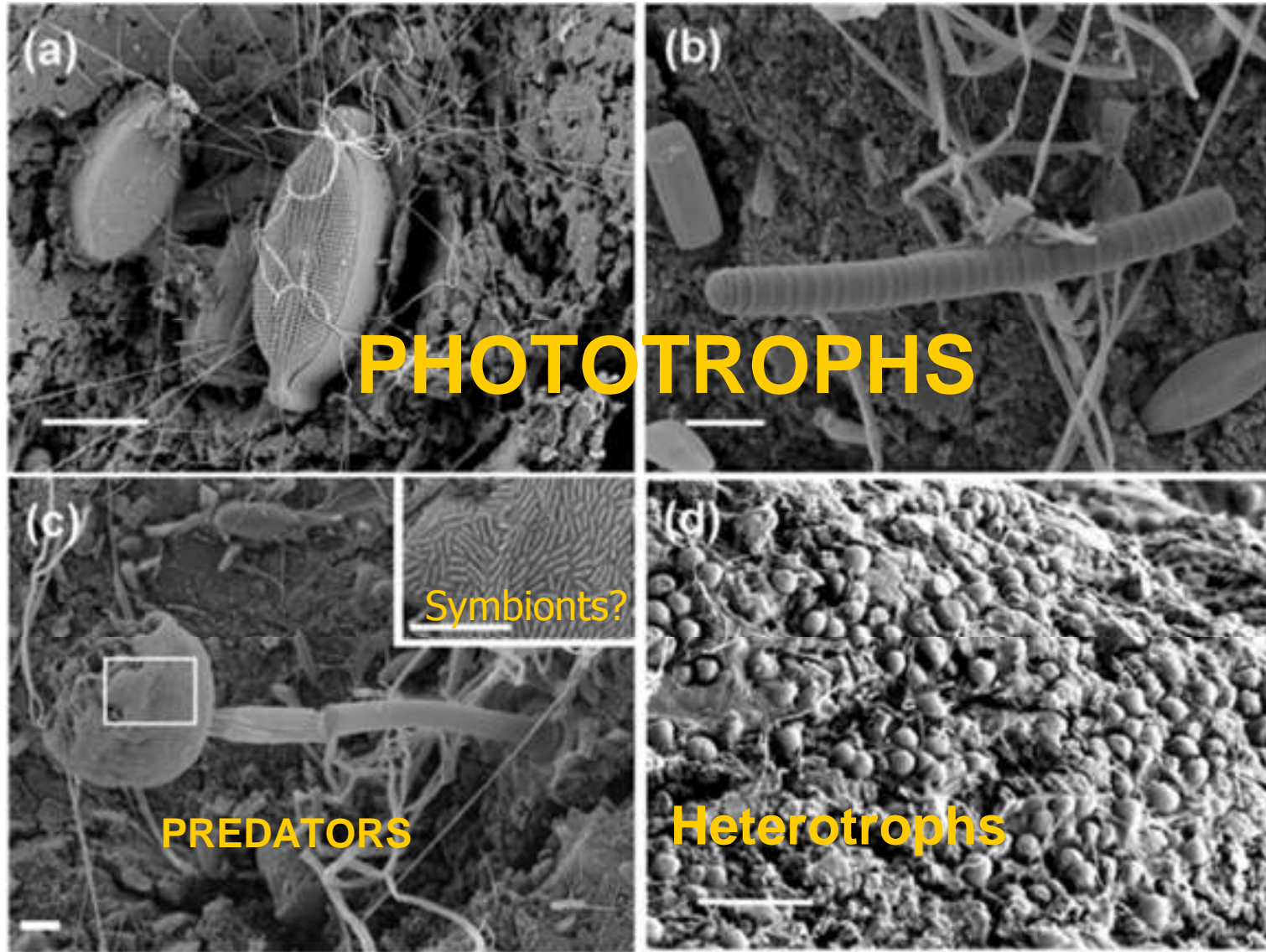
rence of these particles on the sea surface has not yet been noted in the literature [we also collected petroleum lumps, which have received attention (1, 2)].

SCIENCE, VOL. 175

**“At present, the only known biological effect of these particles is that they act as a surface for the growth of hydroids, diatoms, and probably bacteria.”**



# A diverse microbial “reef”

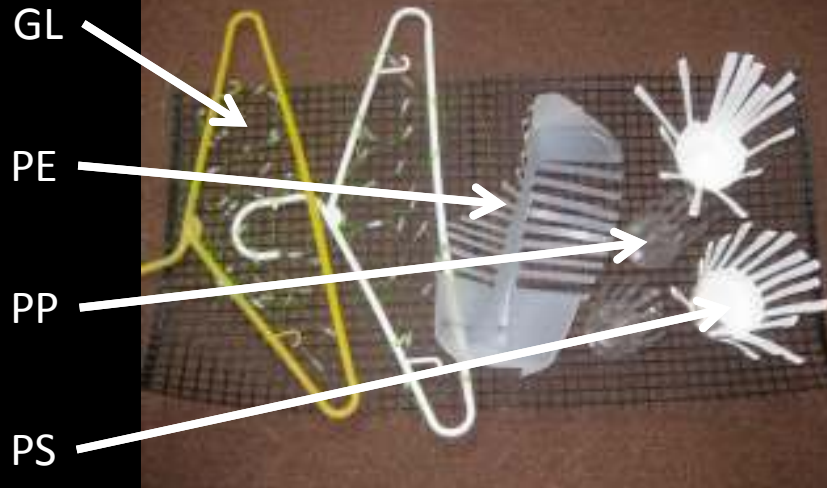


All scale bars = 10µm

Zettler, Mincer, Amaral-Zettler 2013



# Colonization Experiments



Clare Morrall

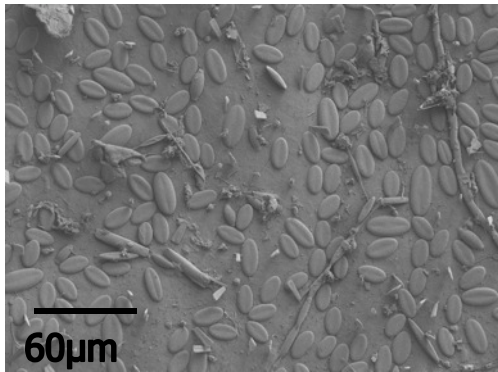


Clare Morrall

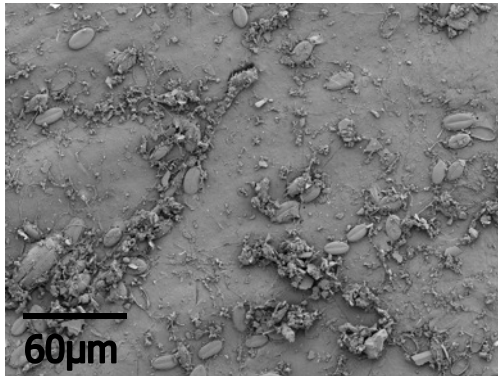


Clare Morrall

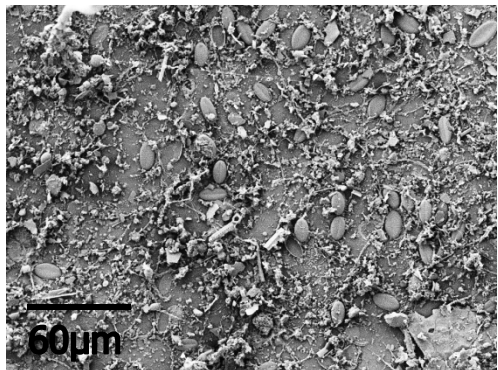
1 week



2 weeks

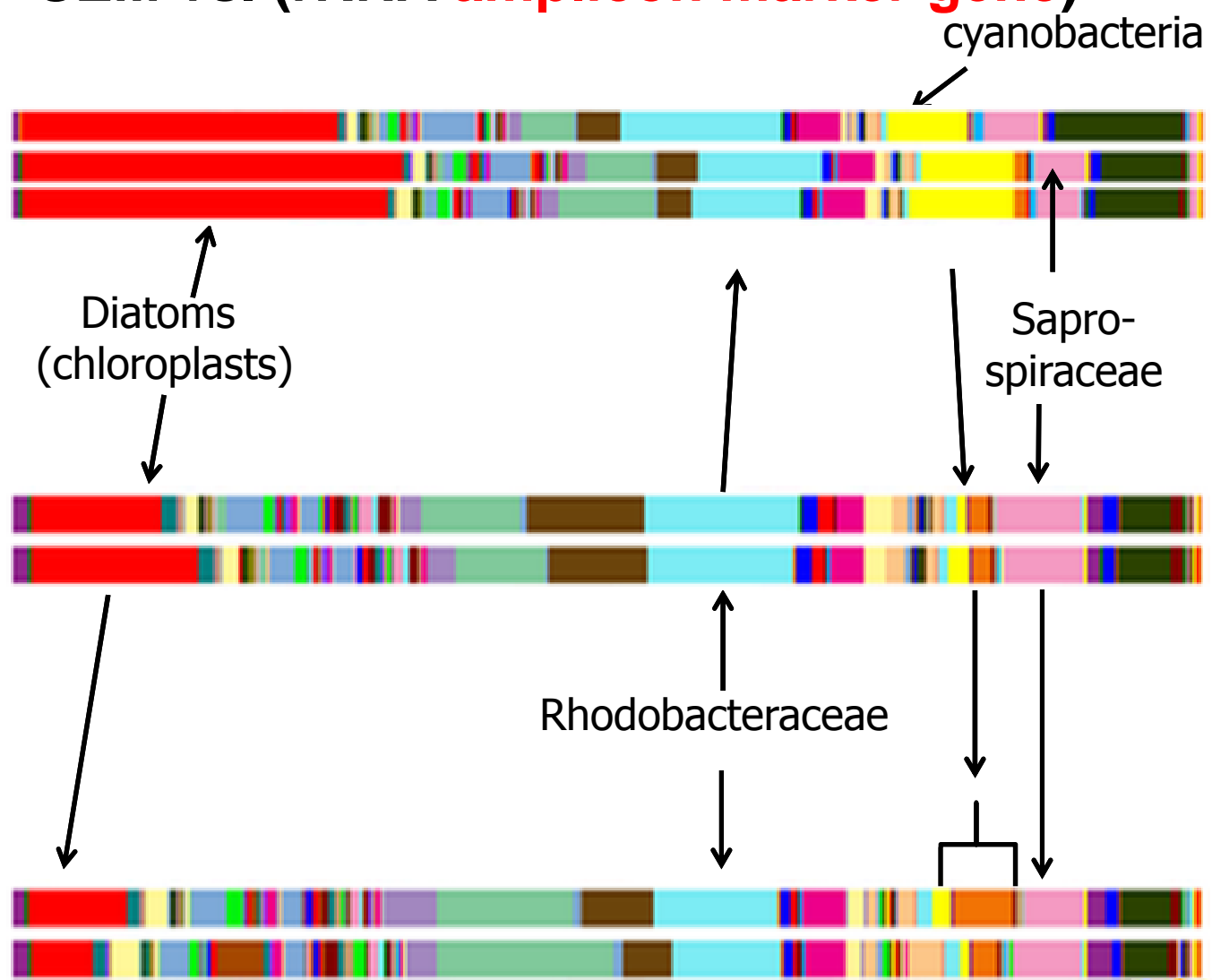


4 weeks



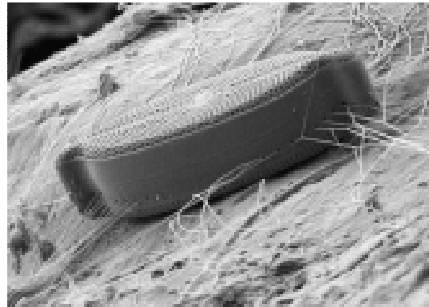
# Bacterial Succession on PE

## SEM vs. (rRNA amplicon marker gene)

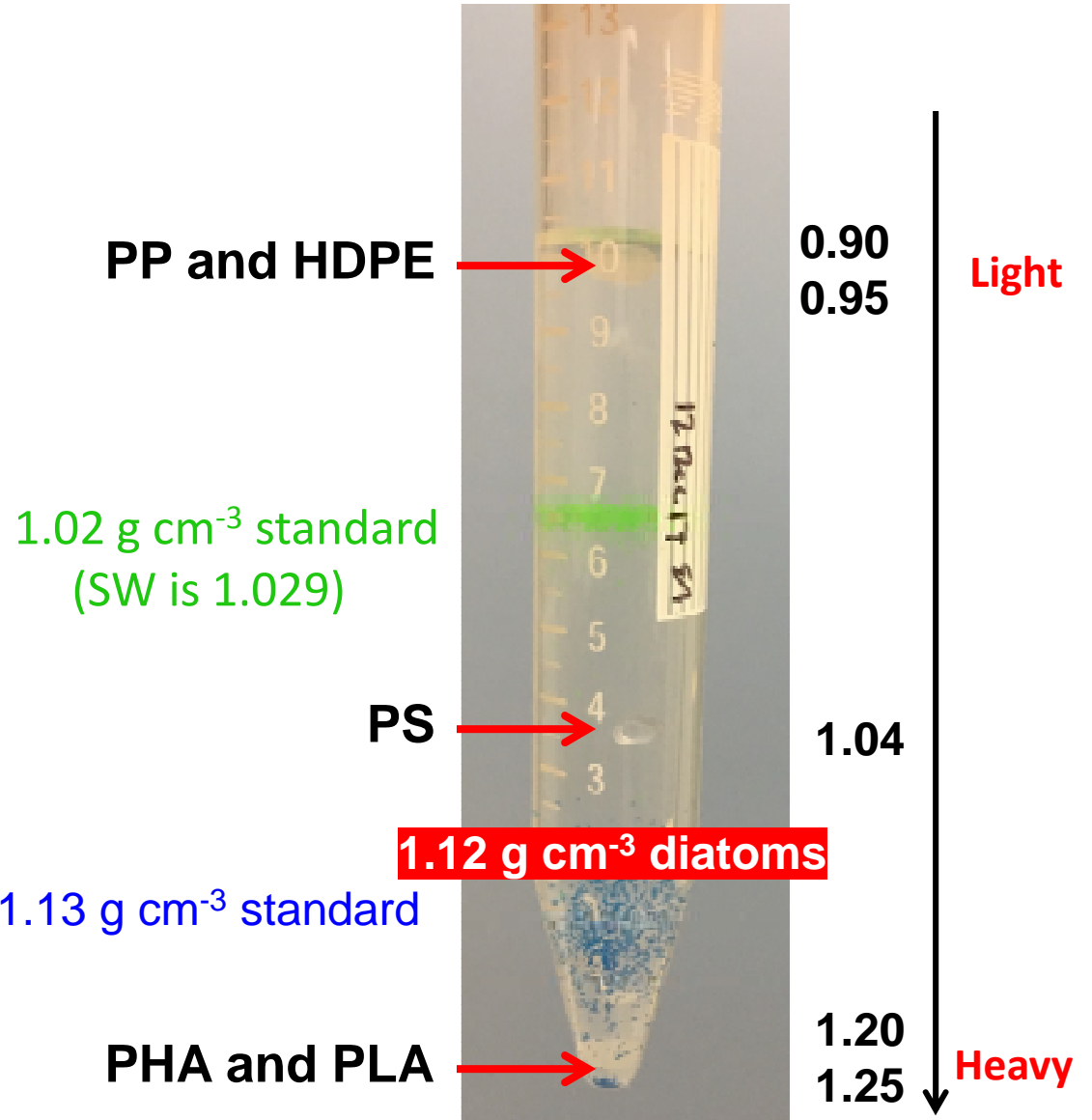




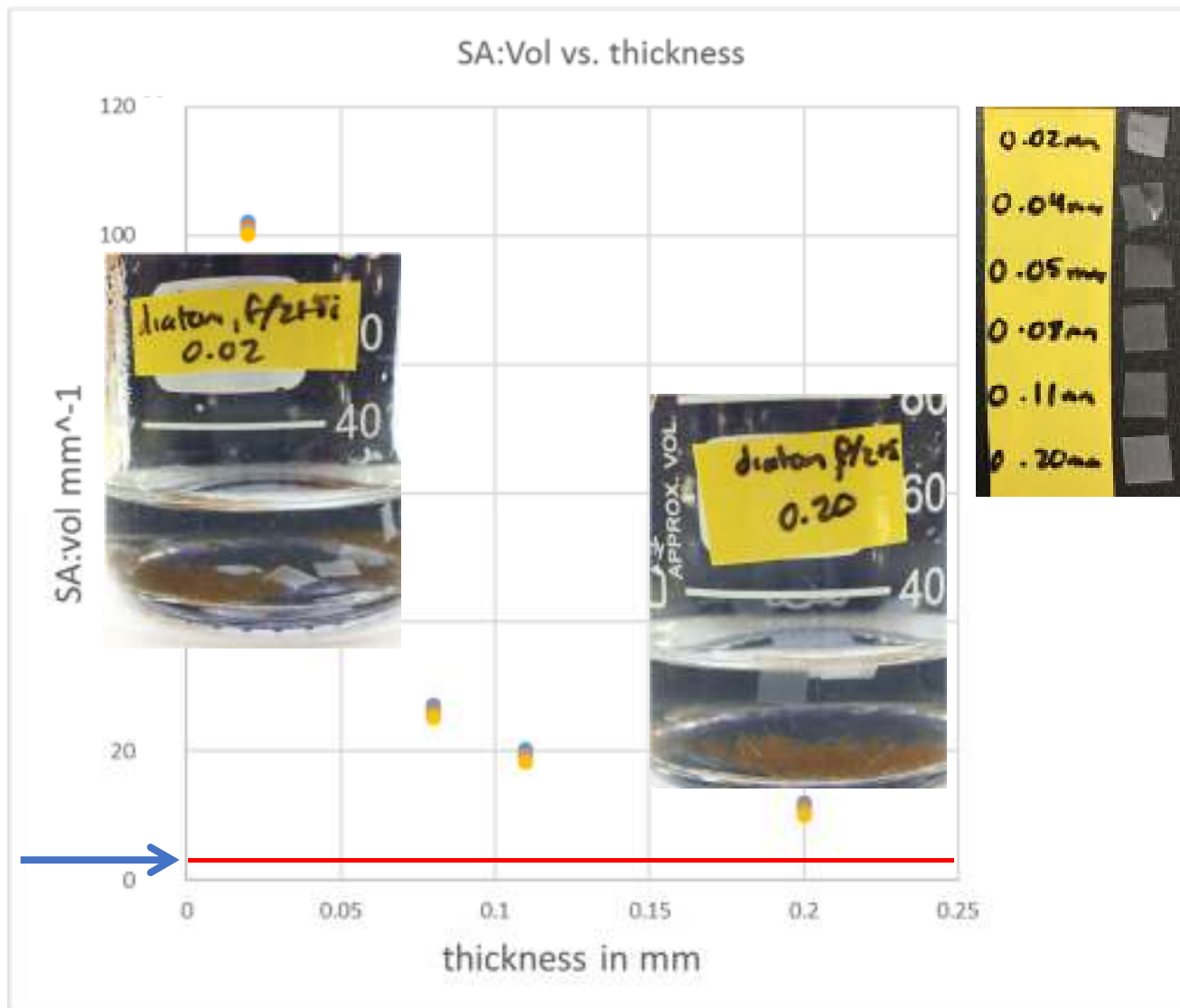
# Exp 1: Diatoms, Pellets, and density gradient



+ Diatom culture isolated from plastic



# Exp 2: Sheets and films have far higher SA:Vol ratios, determined mainly by thickness



Films

Pellets  
SA:Vol  
(~1.7)



# Exp 3: Defined polymers, 6 thicknesses, 5 microbes



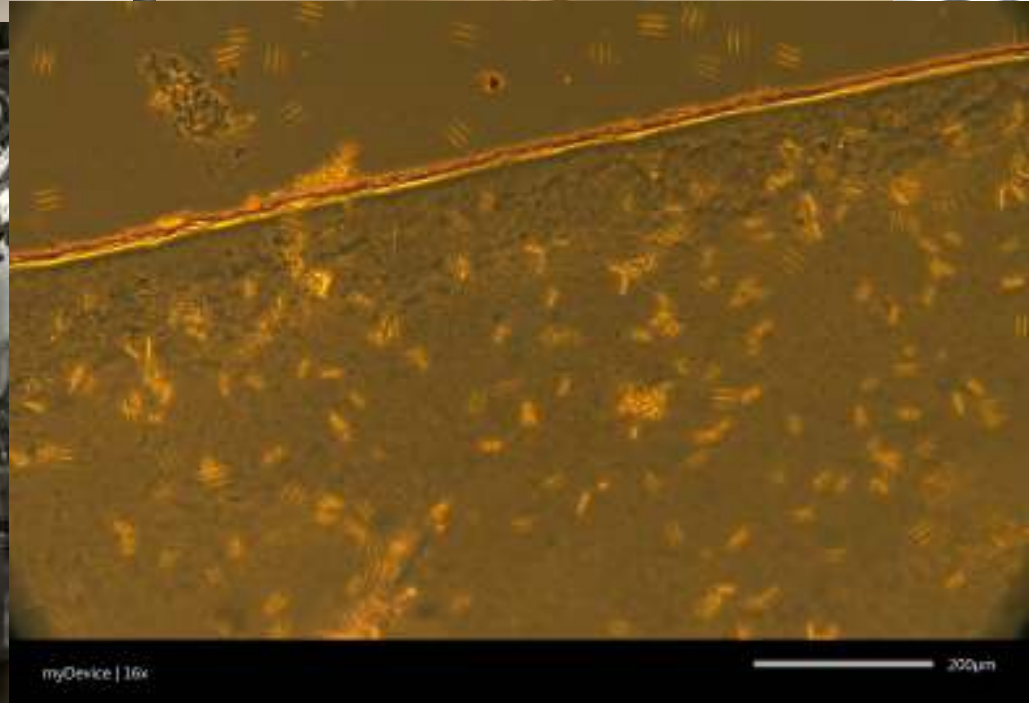
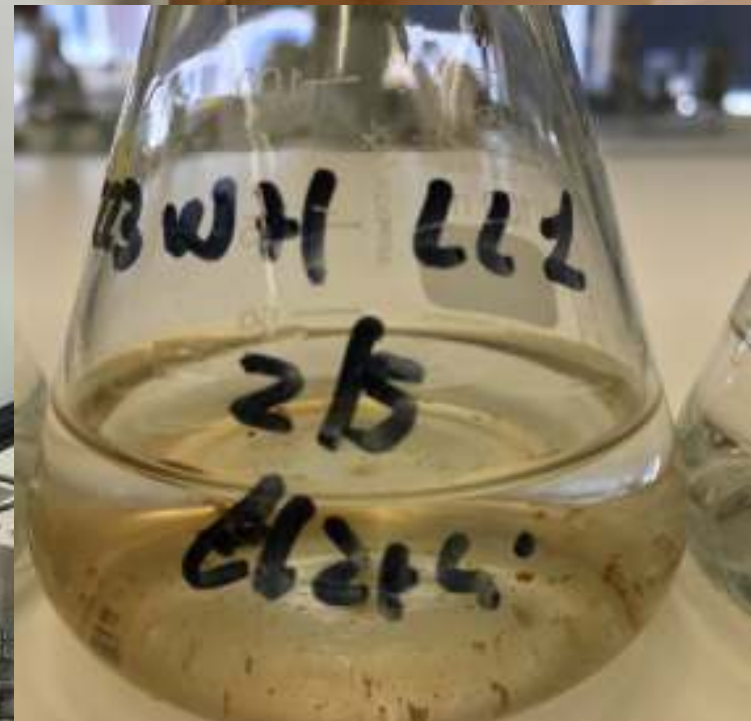
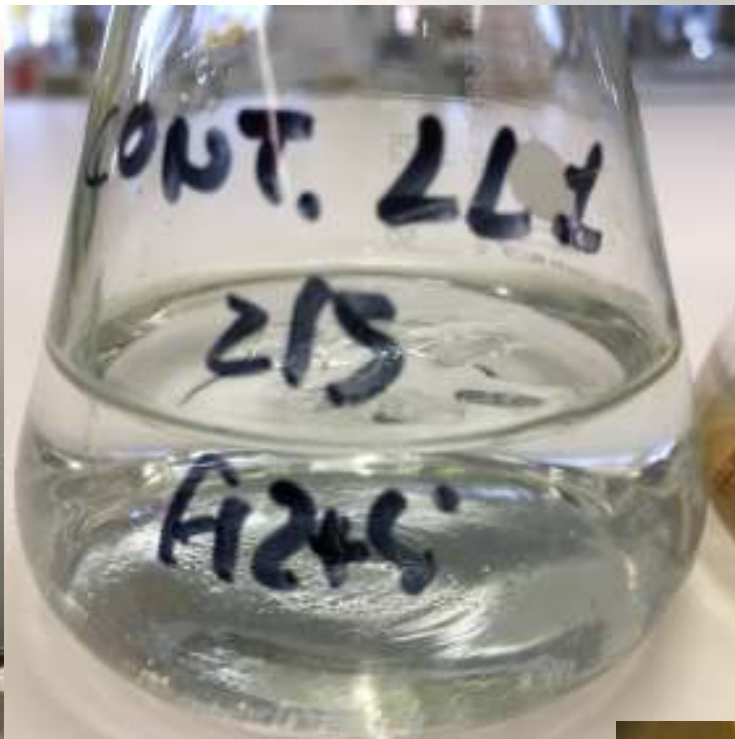
HDPE 0.962 g/cm<sup>3</sup>      LDPE 0.920 g/cm<sup>3</sup>      LLDPE 0.918 g/cm<sup>3</sup>



Thickness in mm  
0.0254  
0.0508  
0.0762  
0.1016  
0.1524  
0.2032

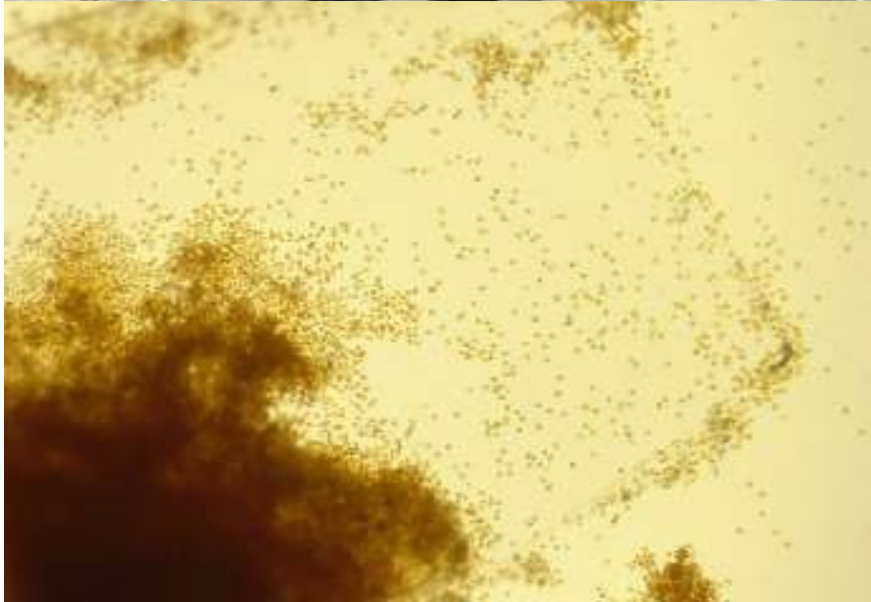


5 cultures:  
2 diatoms  
2 cyanobacteria  
1 dinoflagellate  
Plus a control

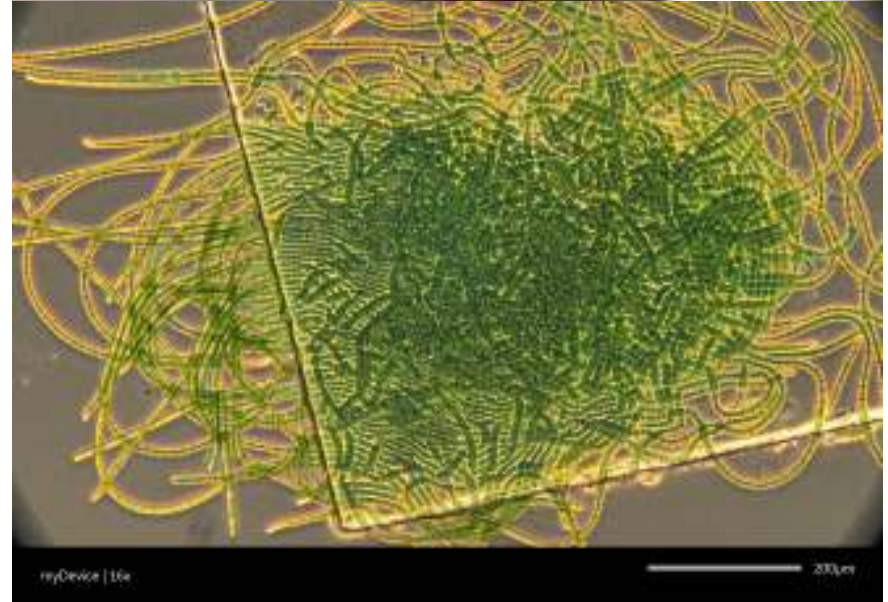




Microbes alone CAN cause sinking, but only with dense growth on pieces with high SA:Vol ratios



*Prorocentrum lima*



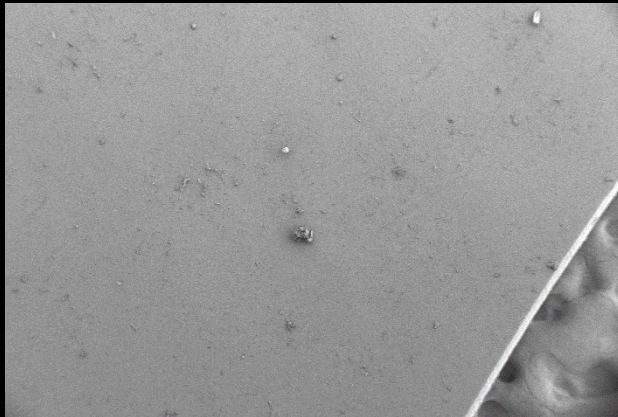
*Phormidium sp.*

# Impact of whole colonizing community in natural settings?

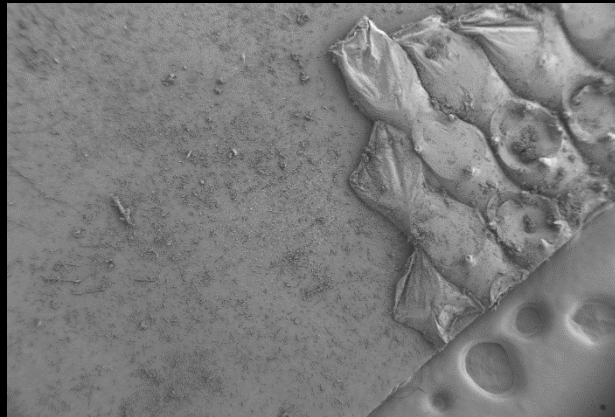




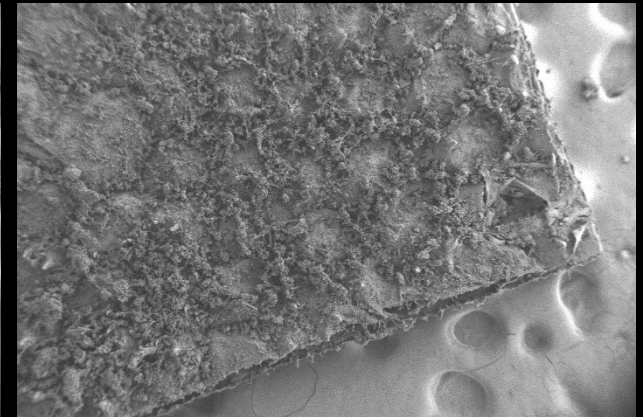
# HDPE 0.1mm thick



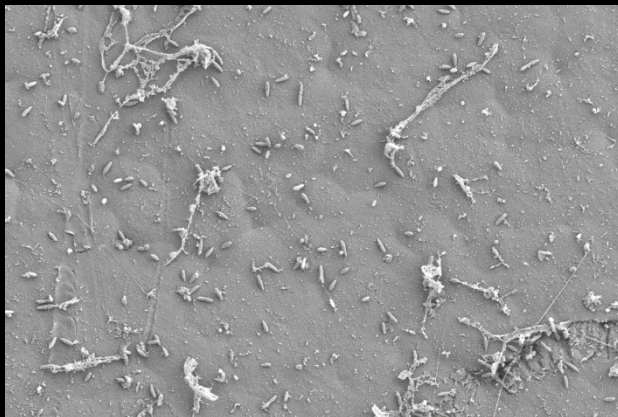
100  $\mu$ m EHT = 3.00 kV Signal A = SE2 15 Oct 2019 Mag = 100 X  
WD = 8.3 mm Width = 3.010 mm File Name = J3-2-11-HDPE4-022.tif MBL Biological Discovery in Woods Hole



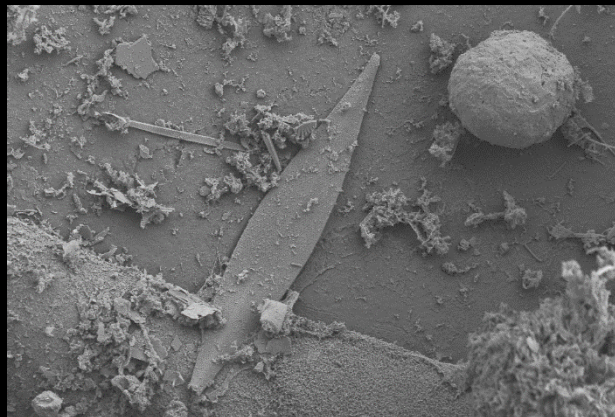
100  $\mu$ m EHT = 3.00 kV Signal A = SE2 15 Oct 2019 Mag = 100 X  
WD = 8.1 mm Width = 3.010 mm File Name = J3-2-12-HDPE4-059.tif MBL Biological Discovery in Woods Hole



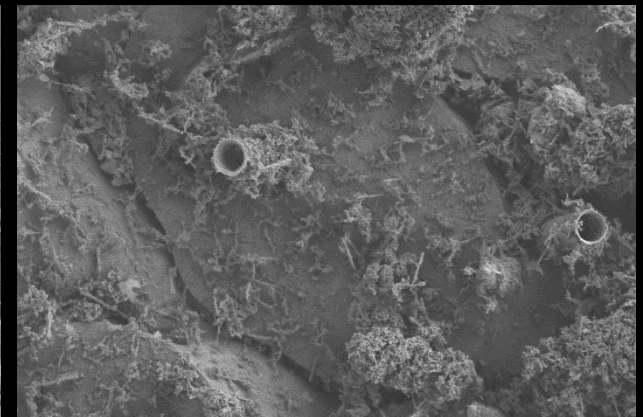
100  $\mu$ m EHT = 3.00 kV Signal A = SE2 15 Oct 2019 Mag = 100 X  
WD = 8.0 mm Width = 3.010 mm File Name = J3-2-13-HDPE4-075.tif MBL Biological Discovery in Woods Hole



2  $\mu$ m EHT = 3.00 kV Signal A = SE2 15 Oct 2019 Mag = 5.04 K X  
WD = 8.2 mm Width = 59.68  $\mu$ m File Name = J3-2-11-HDPE4-030.tif MBL Biological Discovery in Woods Hole



10  $\mu$ m EHT = 3.00 kV Signal A = SE2 15 Oct 2019 Mag = 2.71 K X  
WD = 8.1 mm Width = 111.1  $\mu$ m File Name = J3-2-12-HDPE4-067.tif MBL Biological Discovery in Woods Hole

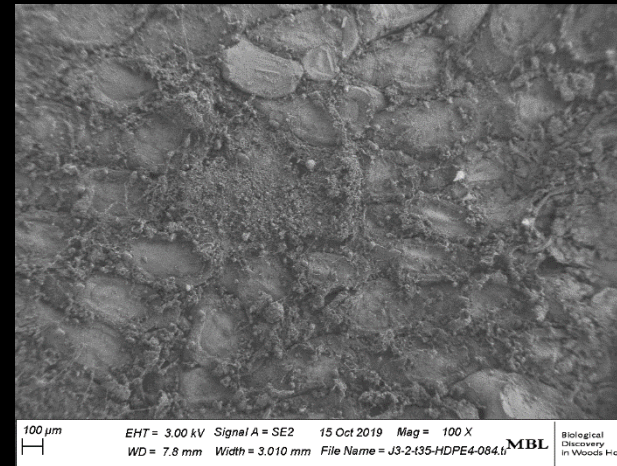
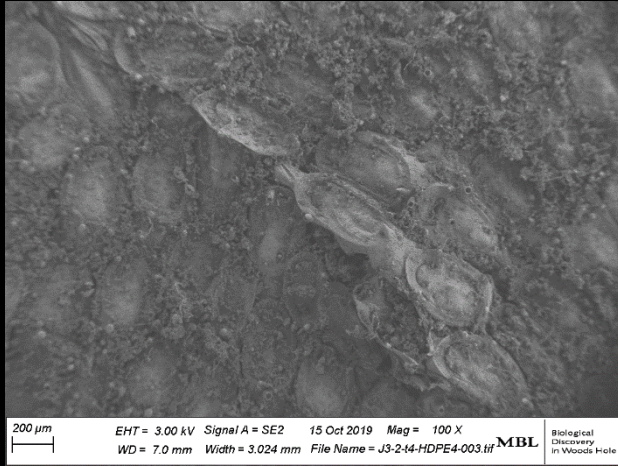


20  $\mu$ m EHT = 3.00 kV Signal A = SE2 15 Oct 2019 Mag = 500 X  
WD = 7.8 mm Width = 602.0  $\mu$ m File Name = J3-2-13-HDPE4-079.tif MBL Biological Discovery in Woods Hole

2 weeks

4 weeks

6 weeks



2 months

5 months



**6 weeks**

**0.102mm →**

**0.076mm →**

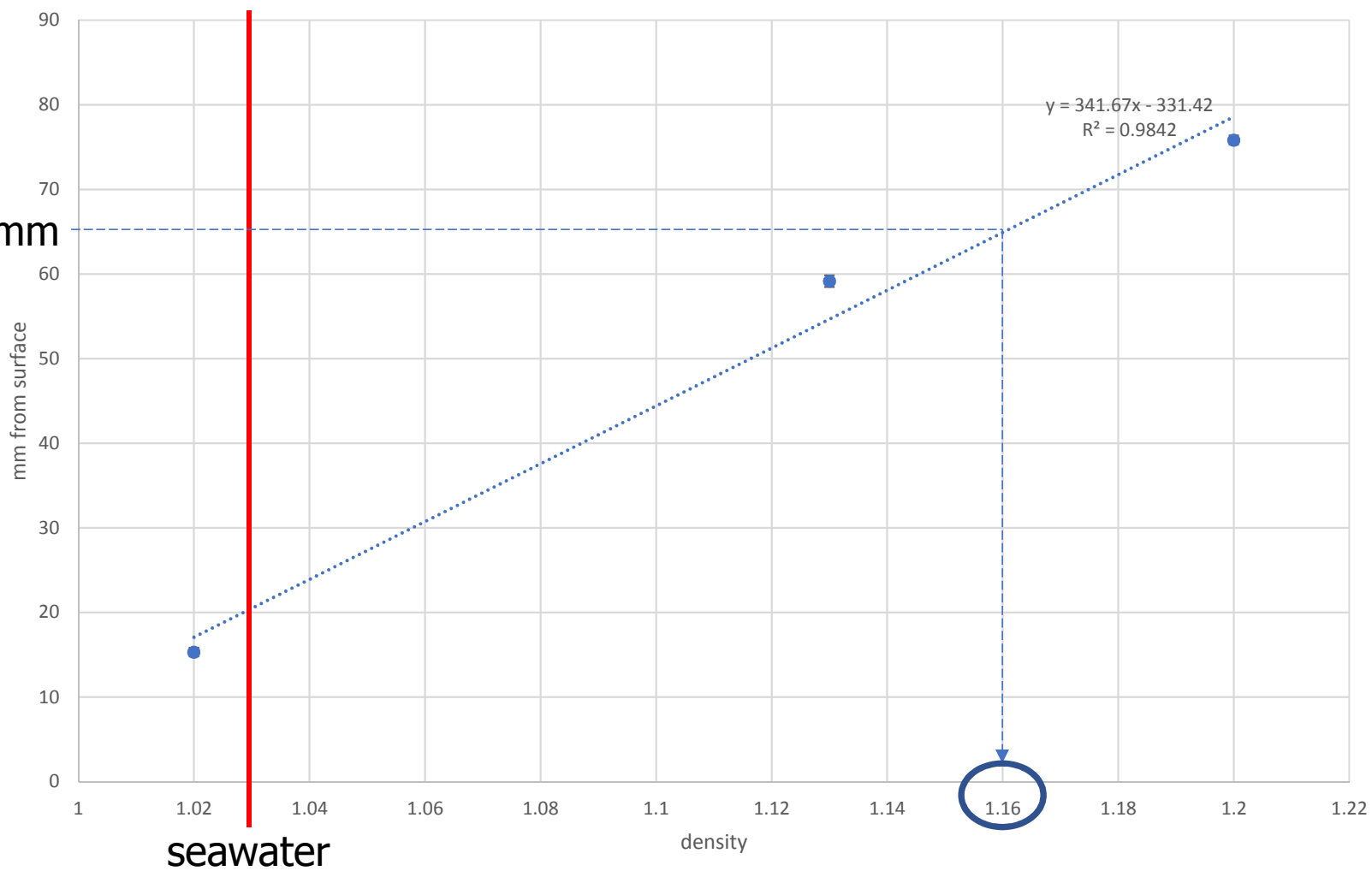
**0.051mm →**

**0.025mm →**

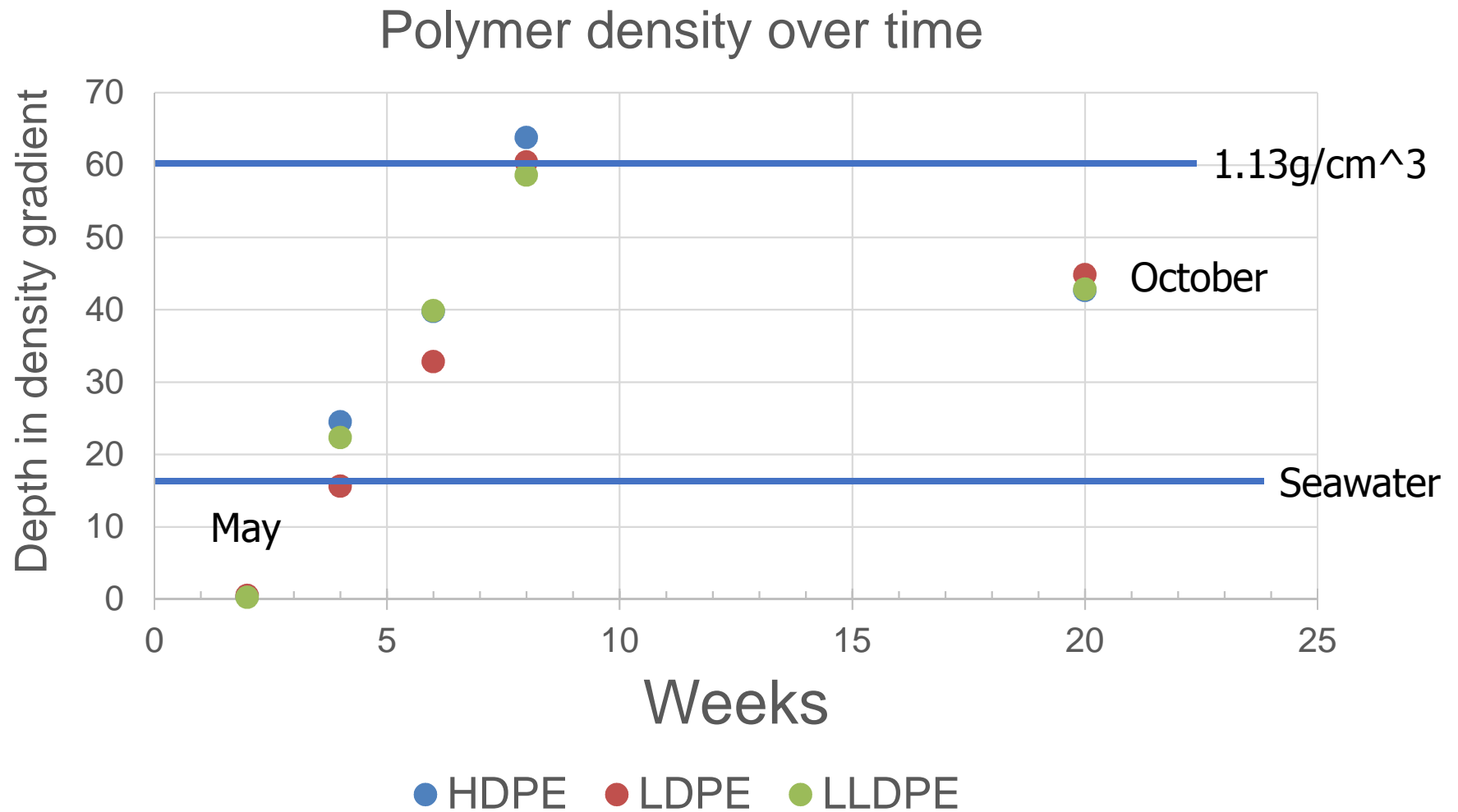


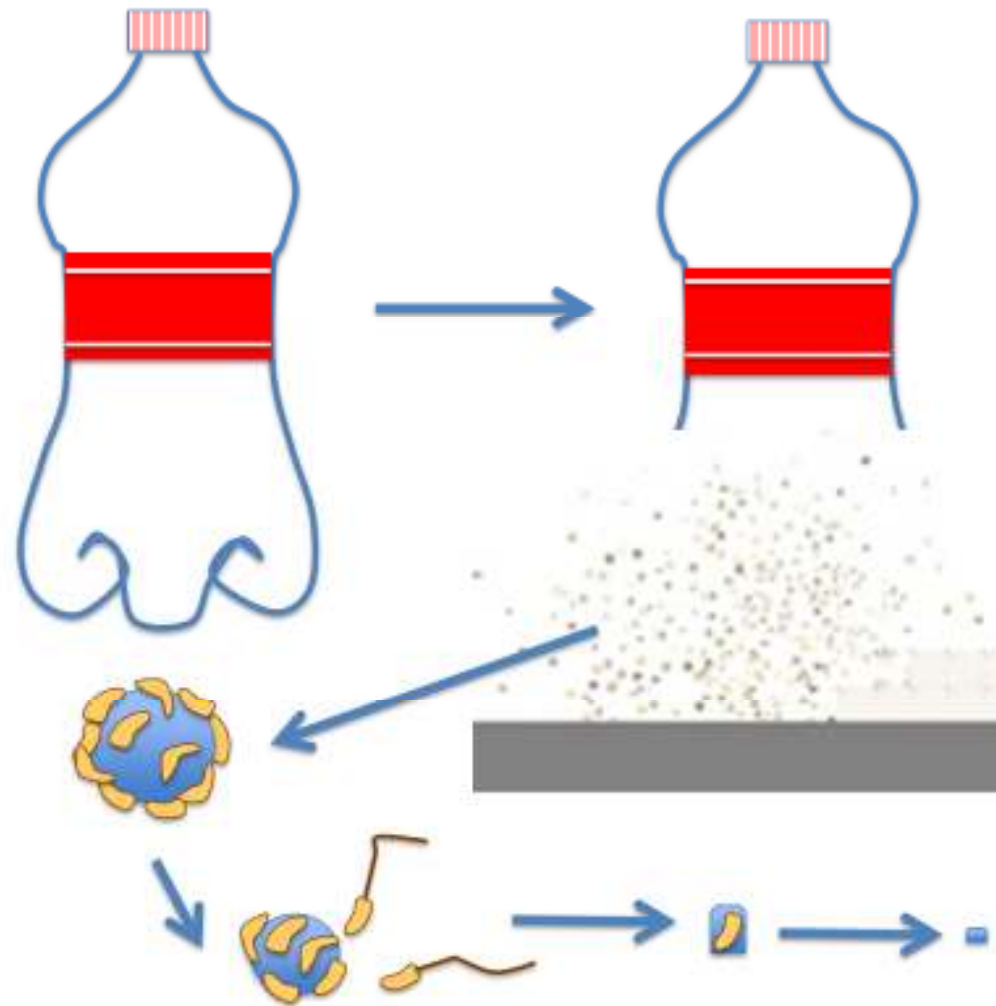
density calibration 2019-10-08

HDPE  
0.051mm



# Comparison of average density 3 polymers



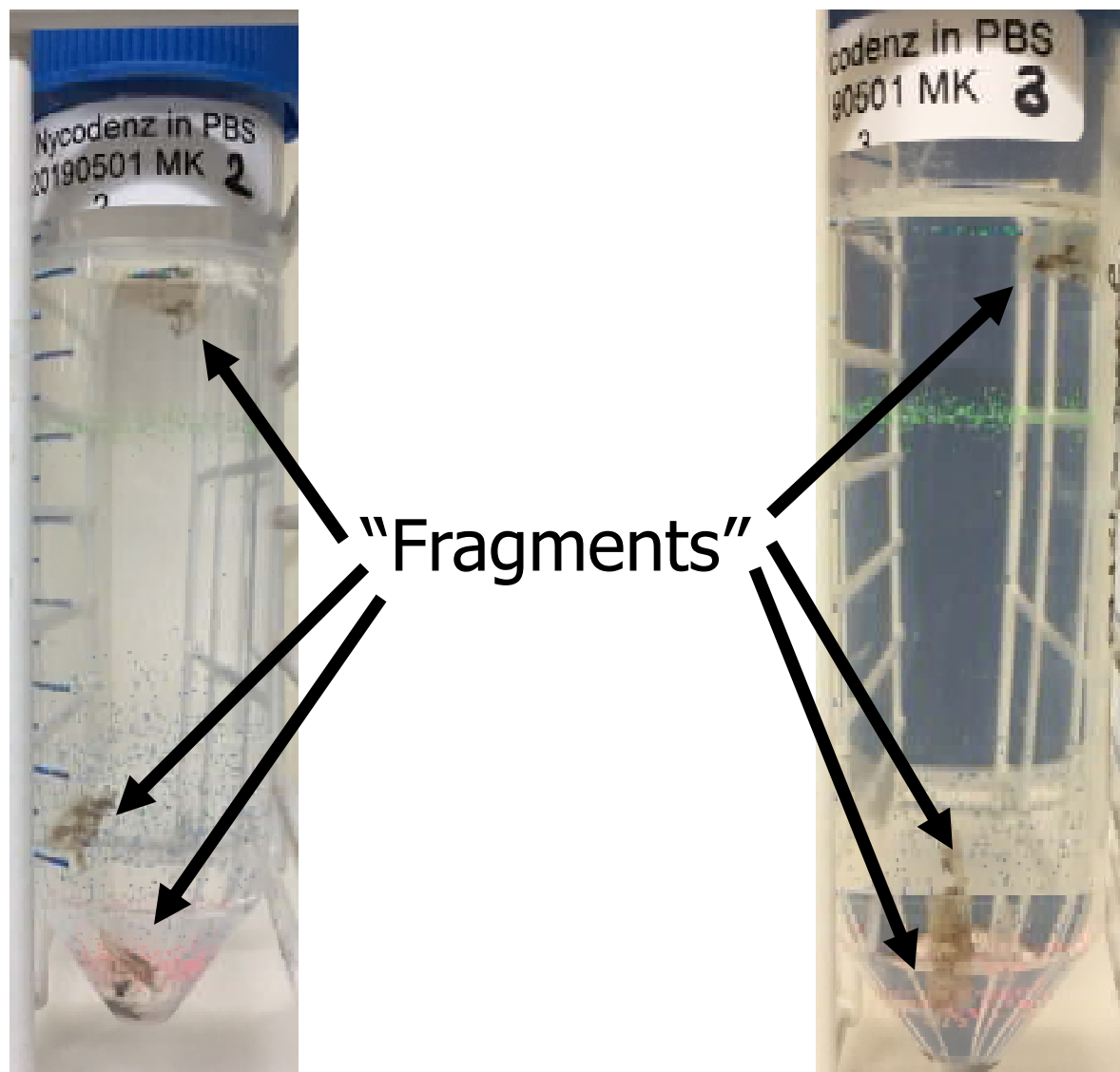


Fragmentation leads to an increase in SA:Vol,  
but also influences who can colonize



So, there is more to sinking than just SA:vol...





“Fragmentation” leads to range of densities  
Large pieces support larger, dispersed colonizers

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**WE OFFER 3 KINDS OF SERVICES**

**GOOD-CHEAP-FAST**

**BUT YOU CAN PICK ONLY TWO**

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**GOOD & CHEAP** WON'T BE **FAST**

---

**FAST & GOOD** WON'T BE **CHEAP**

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**CHEAP & FAST** WON'T BE **GOOD**

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Provide at least ranges of densities that will be helpful to modelers

## In progress:

- Quantify the influence of fragment size on density
- Calibrate live vs. fixed density, allowing us to compare different areas, seasons using archived samples
- Sequencing, including eukaryotes to move beyond descriptive list of groups, and to examine relationships between microbes and metazoans





# Conclusions



- **Microbial populations colonize plastic marine debris quickly**
- **Microbes alone can in some cases cause sinking of plastics with high SA:Vol ratios**
- **The biofilm can also influence sinking due to:**
  - **Colonization by invertebrates**
  - **Ingestion of plastic and incorporation into fecal pellets**
- **Fragmentation results in higher SA:Vol ratios, but due to uneven colonization by larger/denser organisms, this does not always result in increases in density**
- **Changes in microbial and metazoan colonization regionally and seasonally may result in periodic pulses of plastic from the surface into the sediments**

# Thanks to:

- Collaborators Linda Amaral-Zettler (MBL/NIOZ);
- Tracy Mincer (FAU); Scott Gallager (WHOI);
- Michiel Klaassen, Michele Grego,
- Ilsa Posthuma (NIOZ)
- American Chemistry Council
- Marine Biological Lab

[erik.zettler@nioz.nl](mailto:erik.zettler@nioz.nl)

