Order for the Day

- Add standards to a jar
- Add Sample to a jar
- Add 200 ml salt water to each jar and set aside
- Introductions
- What are microplastics & how do we collect them
- Filter standard and sample
- Re-add water and set aside
- Potential impacts of plastic
- Filter samples & standard
- Examine sample
- Questions

Microplastics: All around us

Juanita Urban-Rich

School for the Environment

University of Massachusetts Boston

Outline

- What are they?
- How do we collect them?
- Why do we care / what may they do?

What are microplastics (particles & fibers)

- All synthetic polymer particles smaller than 5 mm in their longest dimension (Arthur et al. 2009)

- Microfibers are any natural or artificial fibrous materials of threadlike structure with a diameter less than 50 µm, length ranging from 1 µm to 5 mm, and length to diameter ratio greater than 100 (Liu et al 2019)

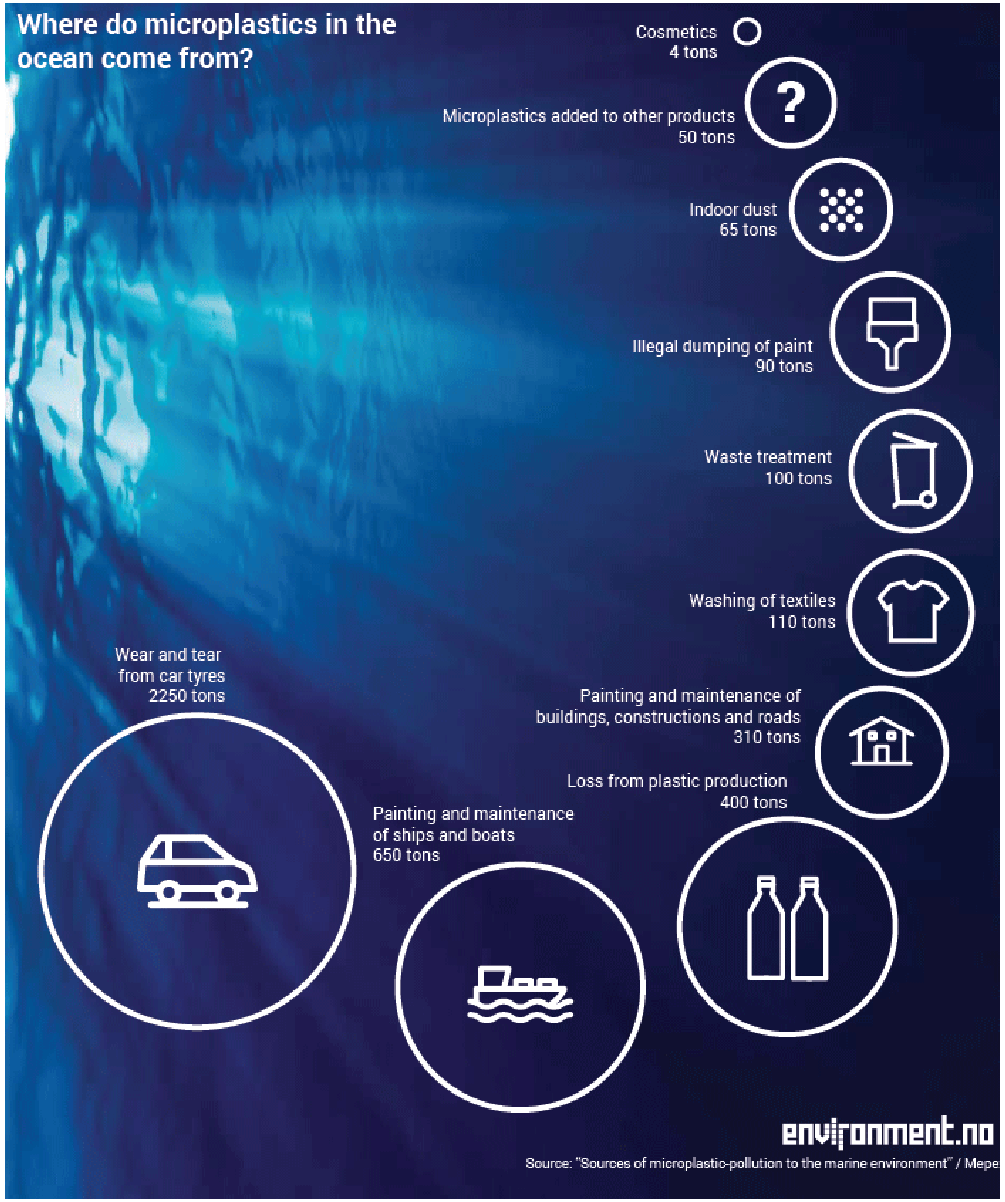



Microplastic Categories: Source

- Primary
  - Created in this size for a purpose or as nurdles that are shipped to factories to be melted into larger plastic items.
- Secondary
  - Formed from the break down of larger plastic items or the shedding from textiles.

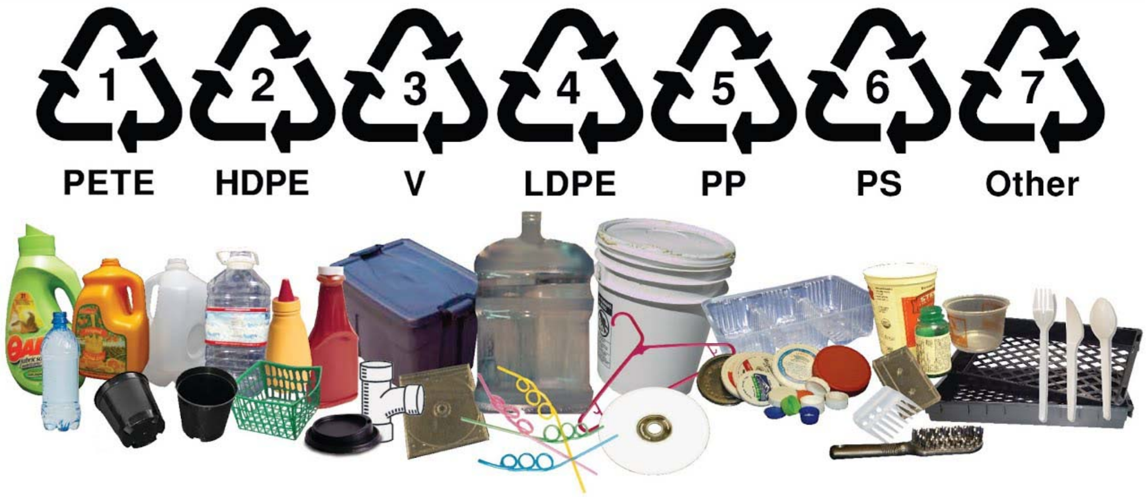
Distribution in the water

- Secondary usually make up 97-99%

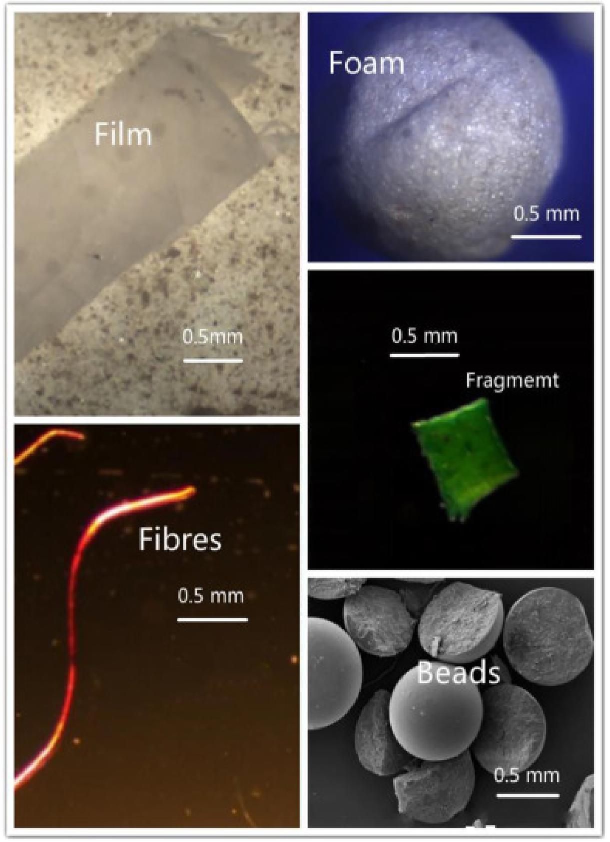


Microplastic Categories: Composition

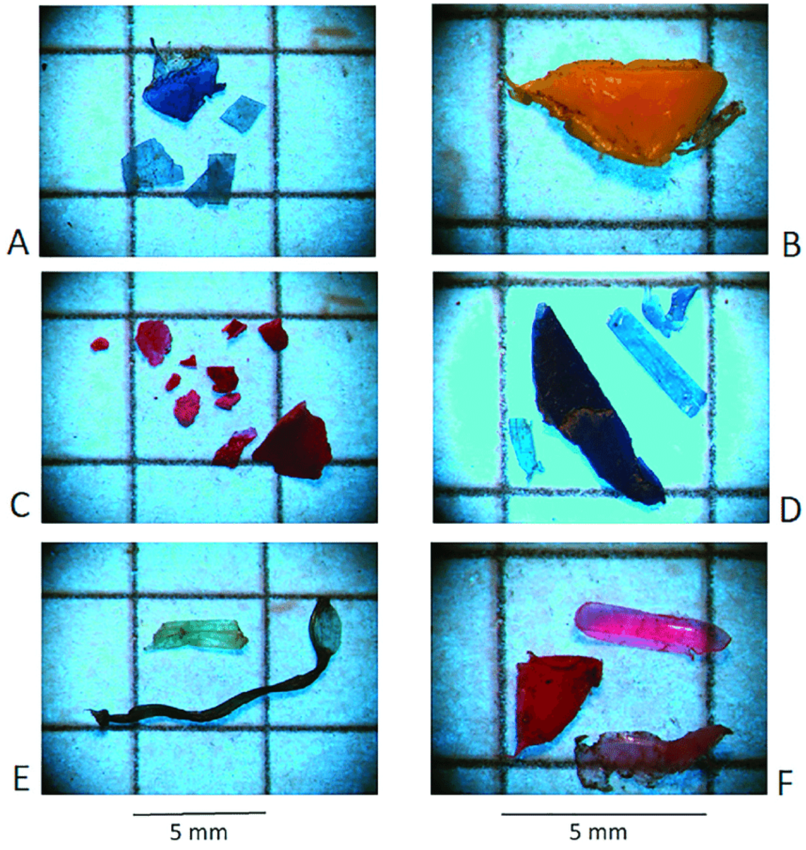
1 PET	Polyester
2 PE-HD	High Density Polythene
3 PVC	PVC
4 LDPE	Low Density Polythene
5 PP	Polypropylene
6 PS	Polystyrene
7 OTHER	Other

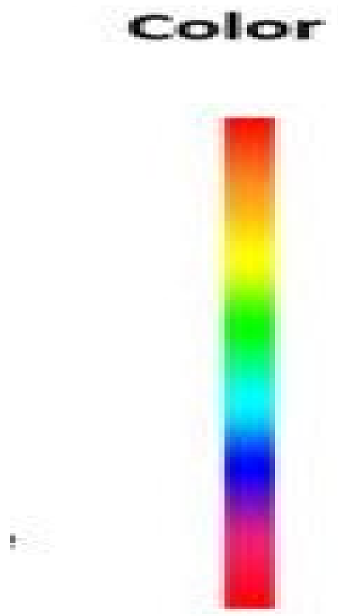


Microplastic Categories: Shape



Microplastic Categories: Color





Characteristics: Density and Surface:Volume

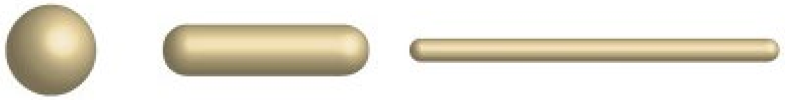
Plastic products	Polymer composition	**Density (kg/L)**	Floats?
Facial cleanser micro-beads	High-density polyethylene	0.92 - 0.97	Yes
Soft drink bottle lid	High-density polyethylene	0.92 – 0.97	Yes
Polystyrene	Polystyrene	1.04 - 1.10	Yes
PVC pipe	Poly(vinyl chloride)	1.16 - 1.58	No
Shopping bag	Polypropylene	0.90 - 0.91	Yes
Take-away food container	Polypropylene	0.90 - 0.91	Yes

Source: [1]Hidalgo-Ruz et al. (2012)

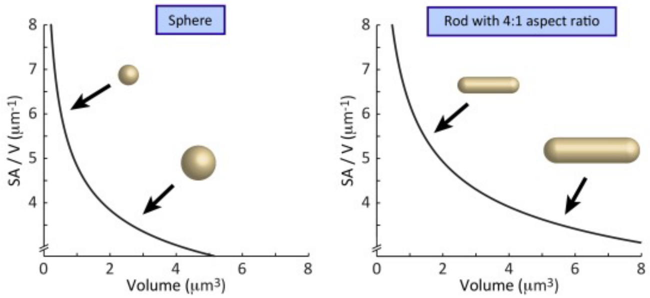
Specific gravity of various plastics

Plastics	Specific gravity
LDPE	0.91~0.93
HDPE	0.94~0.97
PP	0.90~0.91
PS	1.04~1.07
PVC	1.35~1.45
ABS	0.99~1.10
Polyester	1.38~1.39
PC	1.2
Nylon 66	1.13~1.15
Teflon	2.1~2.2

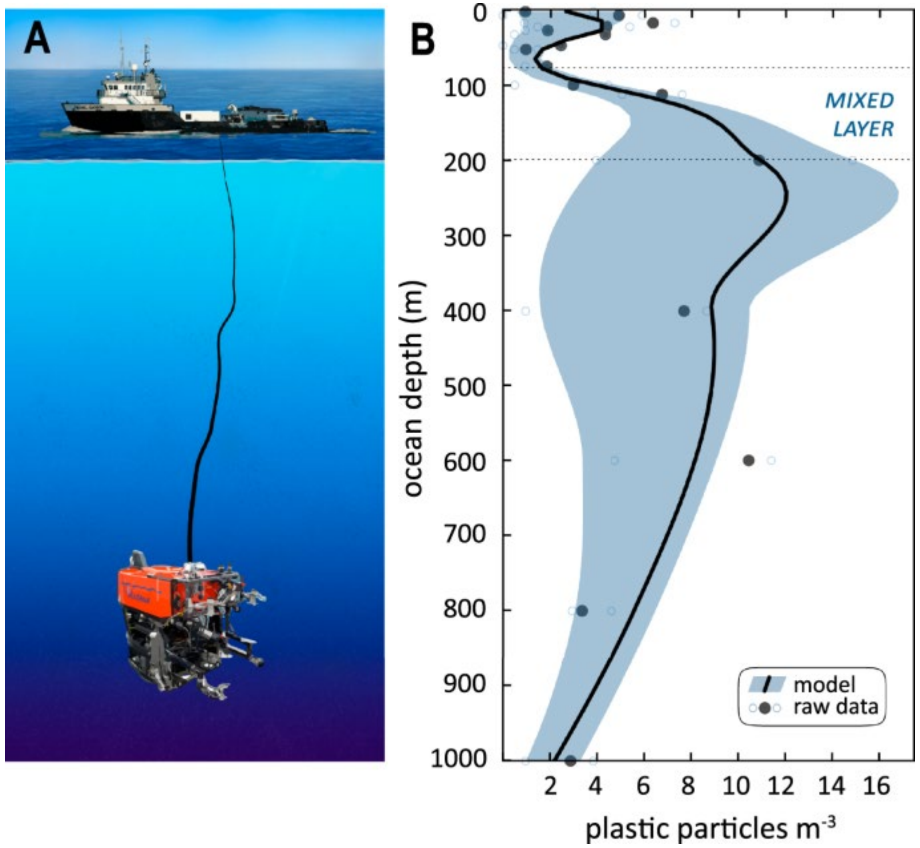
Source: "Polymer dictionary" by Taiseisha Co., Ltd (1970)

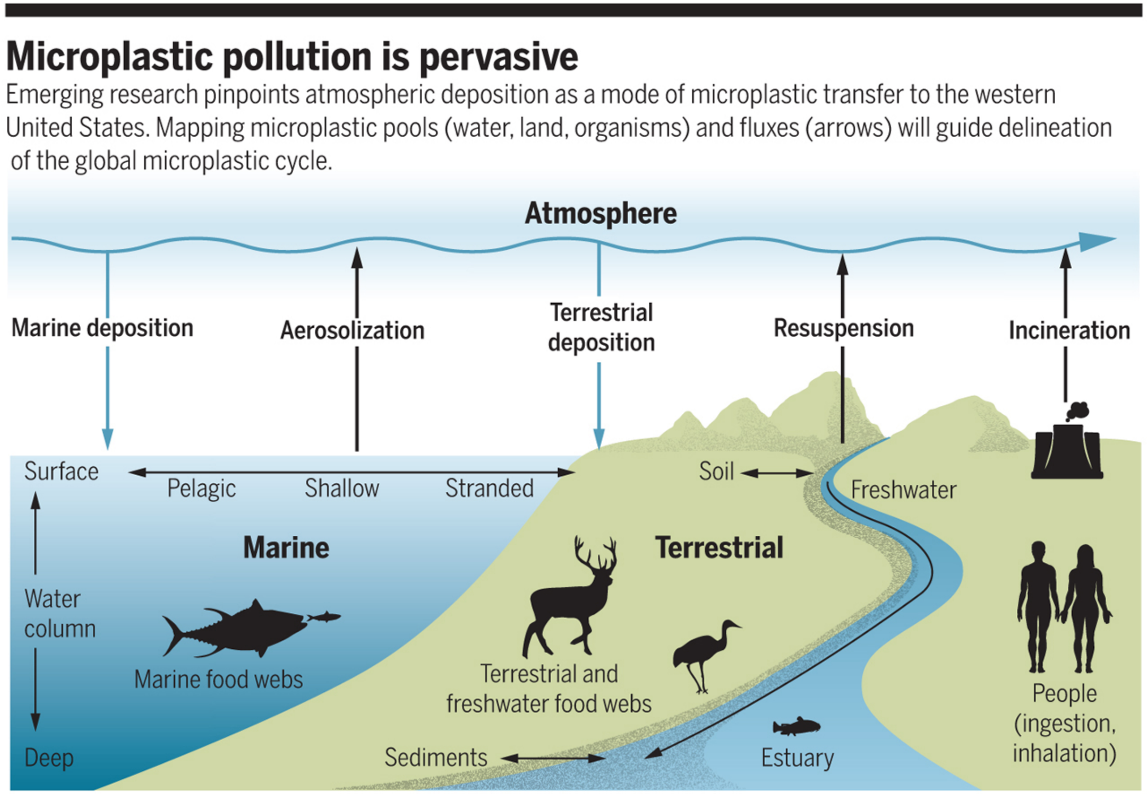


Aspect ratio	1:1	4:1	16:1
Volume	0.5 μm³	0.5 μm³	0.5 μm³
SA / V	6.1 μm⁻¹	7.8 μm⁻¹	16.3 μm⁻¹



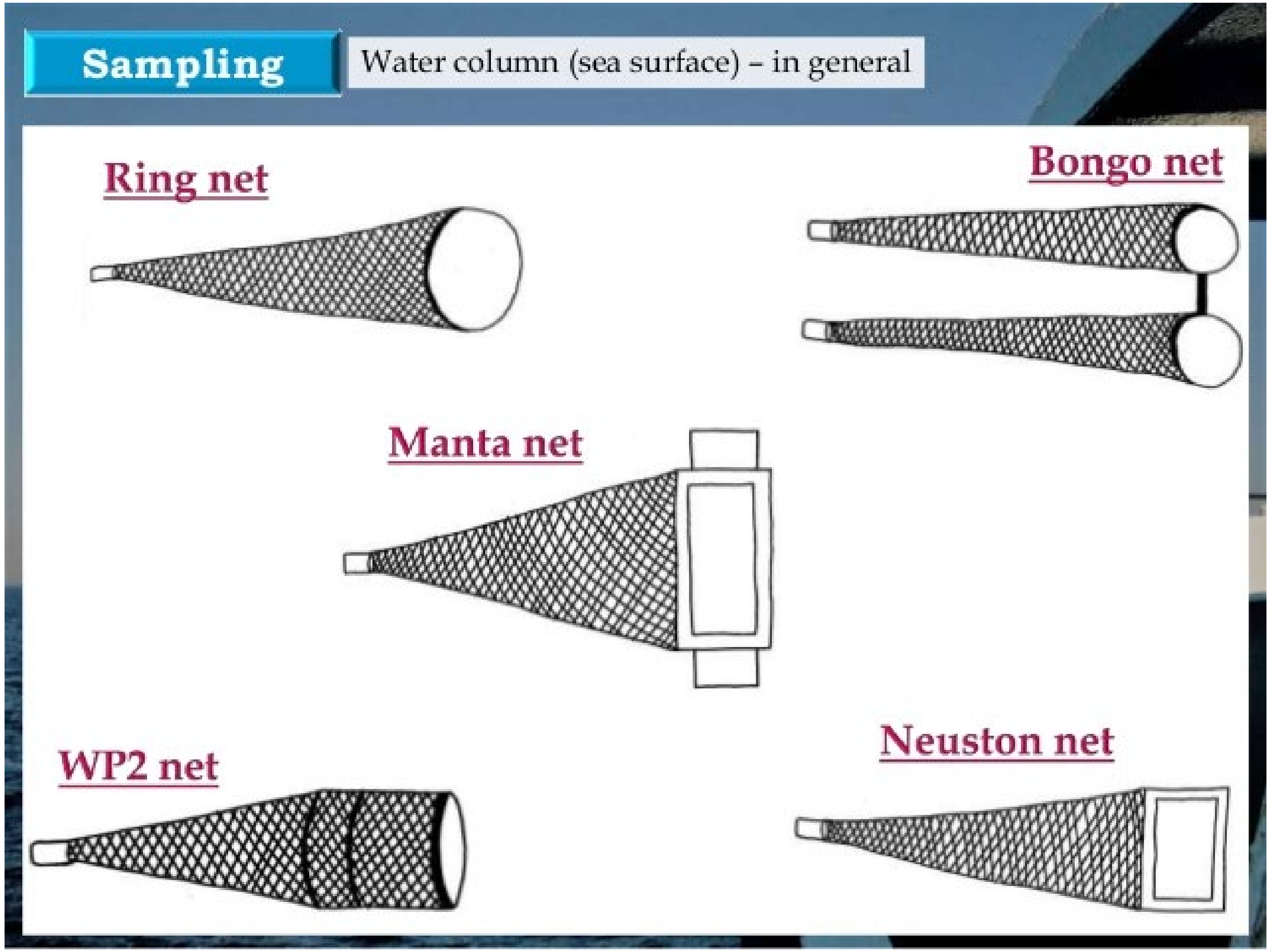
Where are they found?





How do we collect them: Water

- Nets
  - PROS: you can sample large volumes of water, skim the surface of water bodies, you can do vertical integrations
  - CONS: you are limited to size studied by mesh size, you can loose particles through mesh (especially fibers), you need to separate the plastics from the biological (problem in coastal or upwelling areas). Hard to do in shallow water. Possible contamination from net.



How do we collect them: Water

- Water Grab
  - PROS: clean samples, whole water, can sample shallow water and places boats can't go
  - CONS: limited sample volume, depth is not clear.

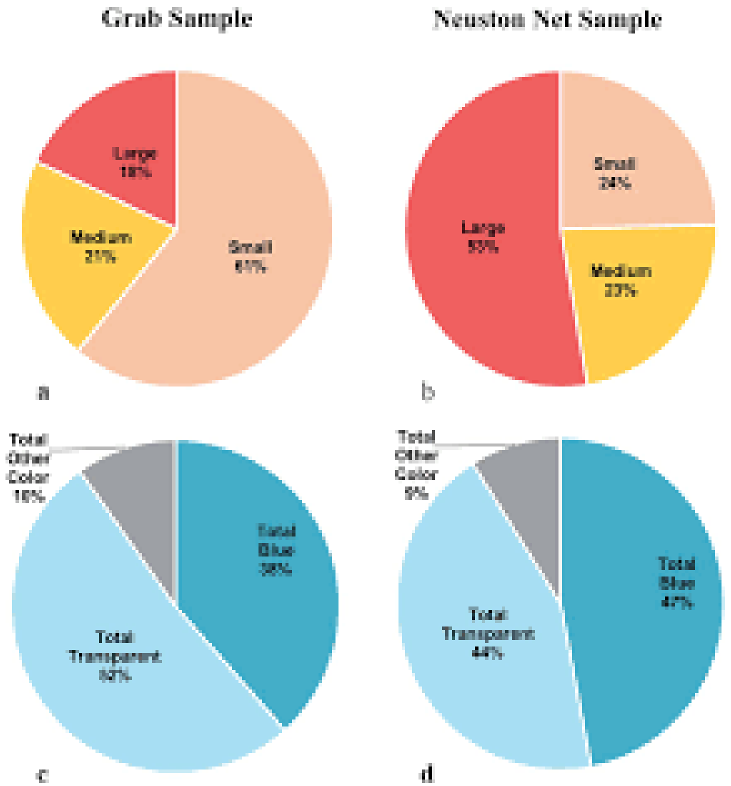
How do we collect them: Water

- Pumps
  - PROS: you sample a large volume of water.
  - CONS: need to filter water through a mesh and at speed- can loose particles. Possible contamination & need for digestion.
- Niskin Bottles
  - PROS: whole water, can collect mid-water depth, know the depth
  - CONS: limited sample volume. Possible contamination from the gear.

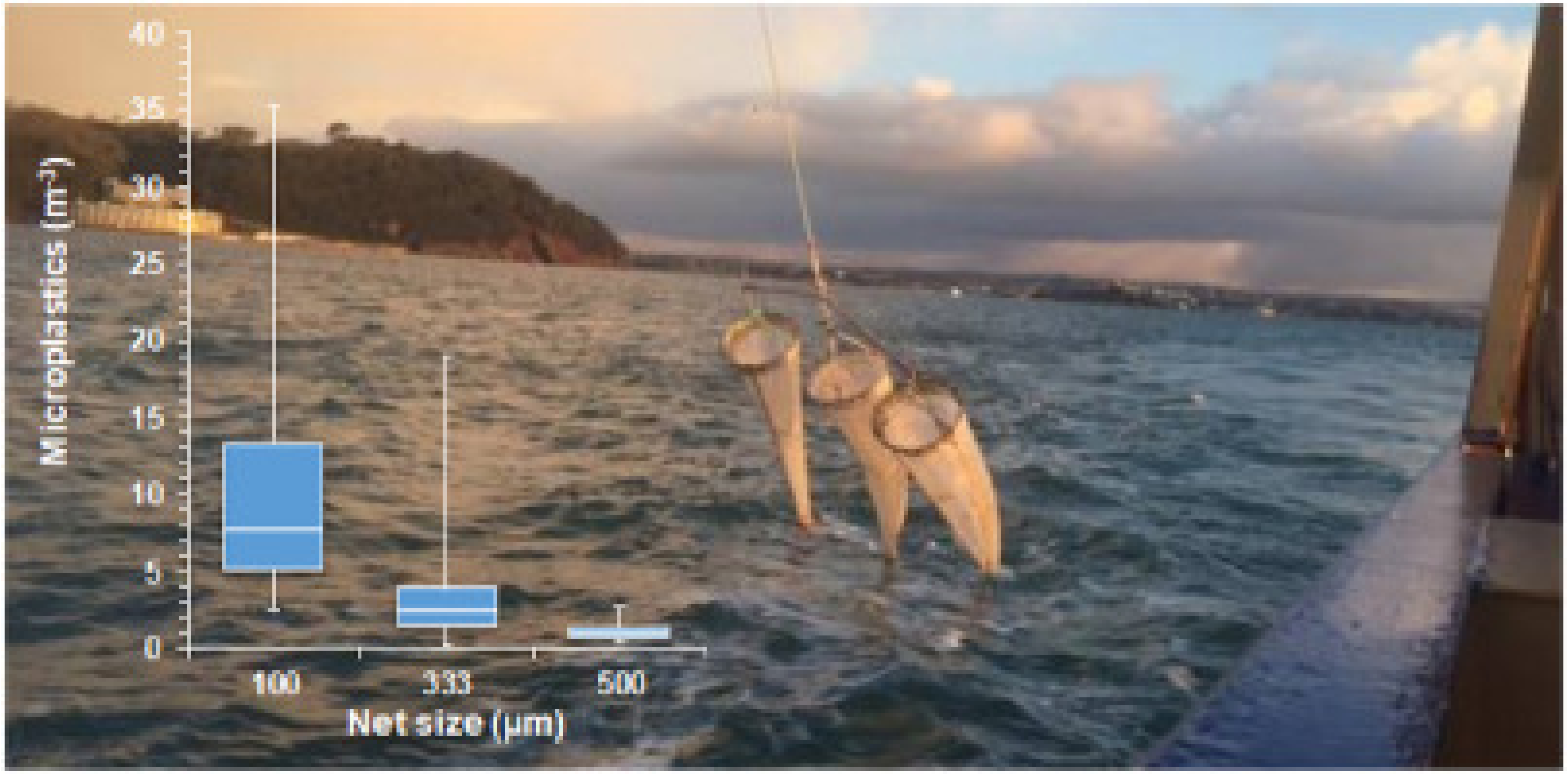
Table 1 Total microplastic pieces per liter (mean ± standard deviation), date and number of samples collected

	Grab sampling		Neuston net sampling	
Date	*N*	Mean ± SD	*N*	Mean ± SD
10/6/14	6	3.4 ± 3.6	2	0.003 ± 0.002
10/13/14	5[a]	10 ± 5.2	2	0.003 ± 0.003
10/28/14	6	4.9 ± 1.1	2	0.008 ± 0.007
Total	**17**	**5.9 ± 4.4**	**6**	**0.005 ± 0.004**

[a] *N* = 5 on 10/13/2014 due to sample loss during laboratory processing.



Water vs Net



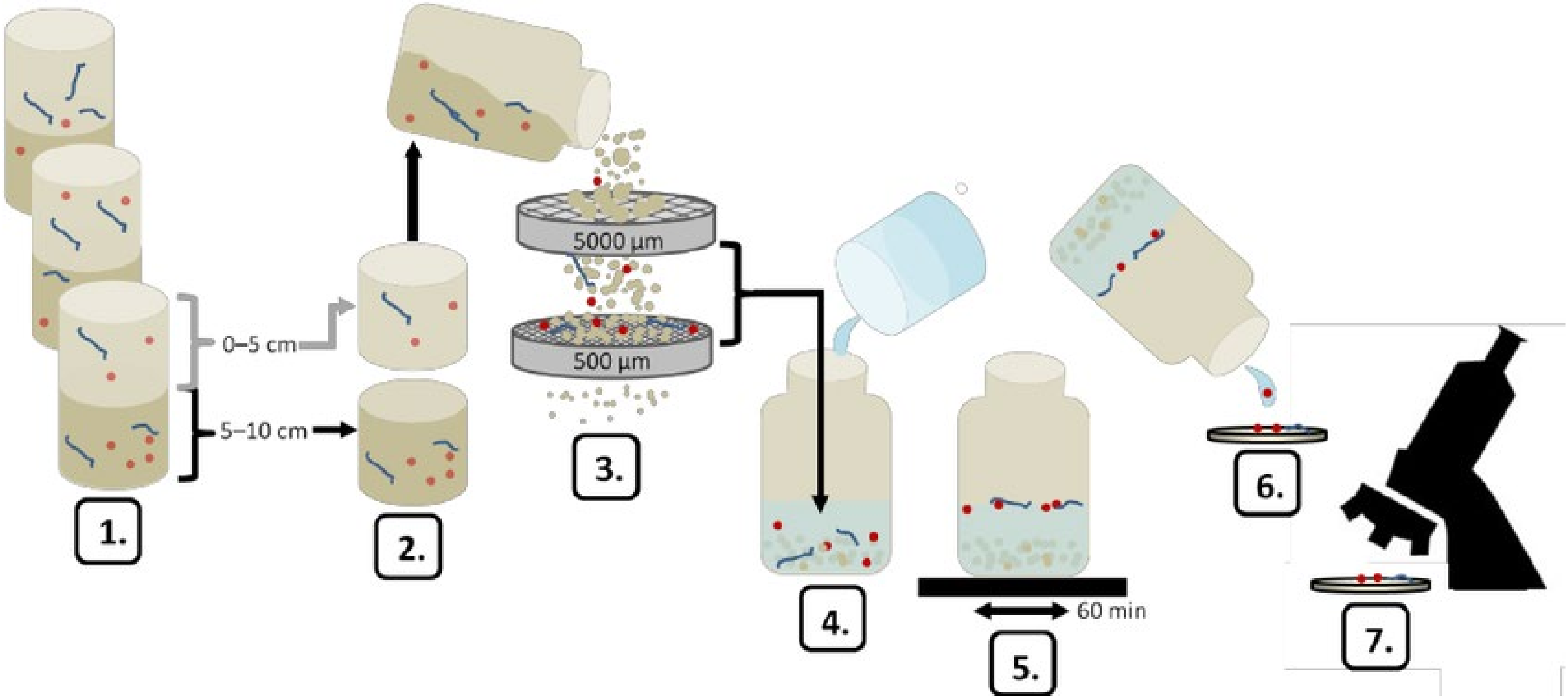
Net Size

How do we collect them: Sediment

- PROS: You get all particle present
- CONS: You need to separate the plastics from all the particles, need to dry the sample.

- **Sieve**
  - Pros: easy, cheap
  - Cons: need to manual separate from other things,
- **Density Gradient**
  - Pros: small subset of the sample
  - Cons: test for recovery, increased chances of contamination, limited by visibility and or the density of the solution, doesn’t remove the inorganics or organic particles that are either the same size or density.

Sediment Analysis



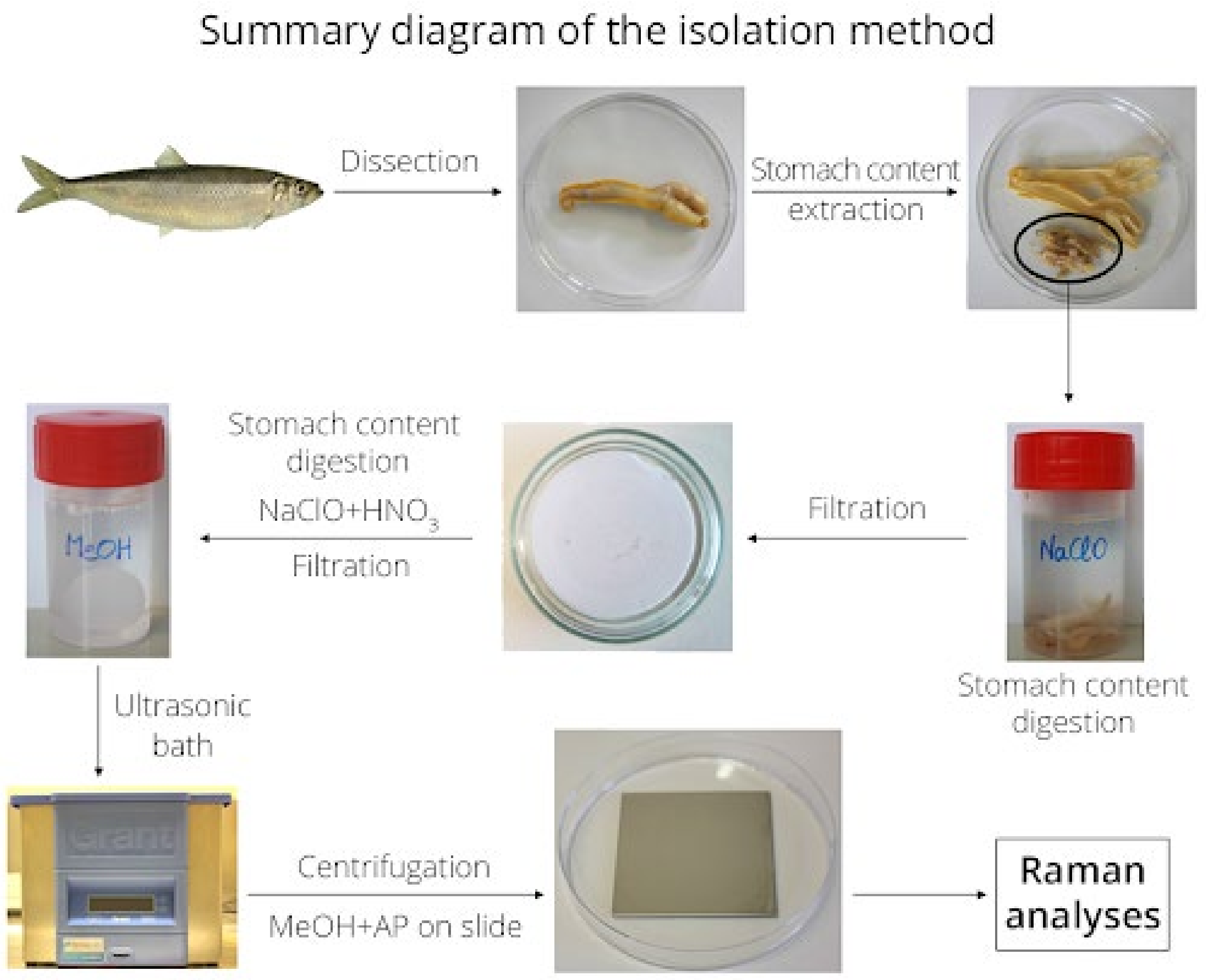
How do we collect them: Biota

Digestion

Enzymes, H_2O_2, Acids

Dissection

Organism, Scat, Organ, Stomach



Identification

Microscopy

- Appearance
- Hot needle

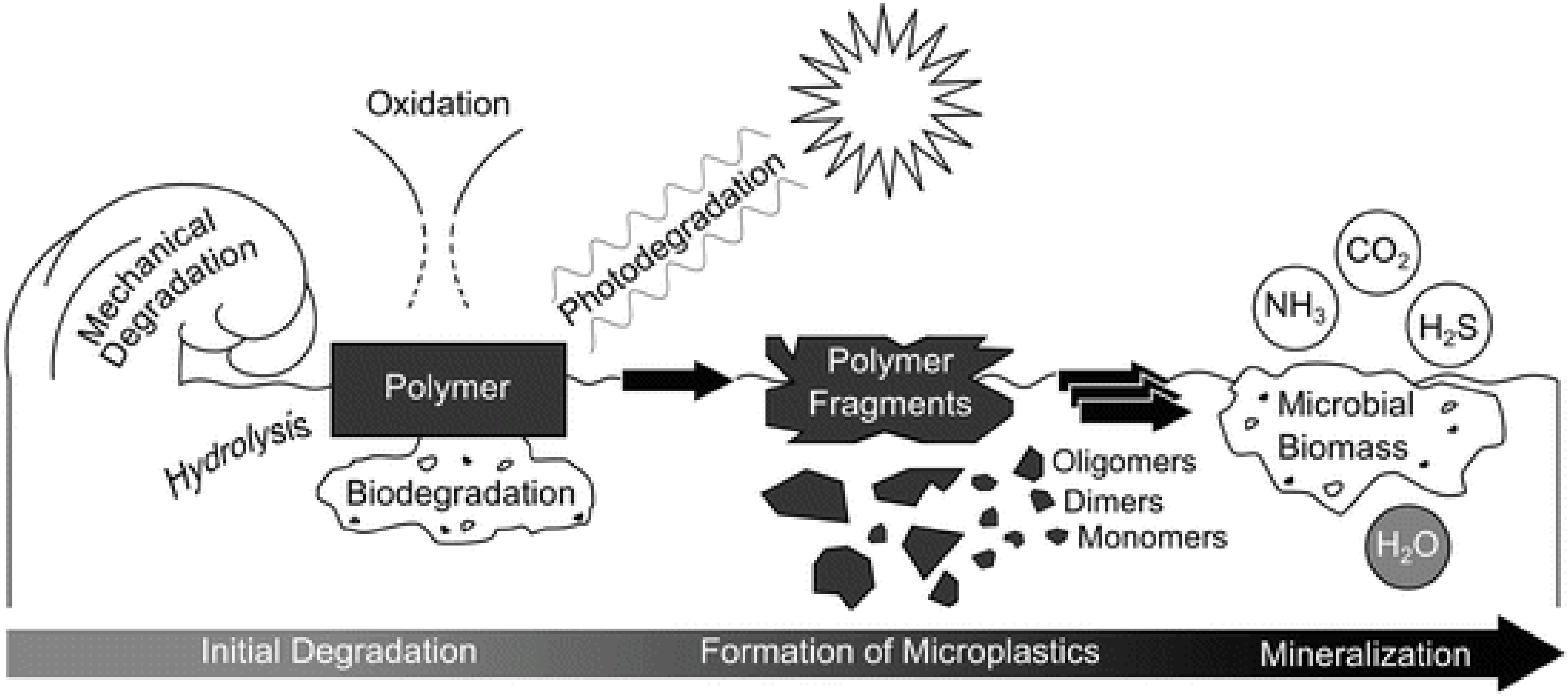
Spectroscopy

- FTIR
- Raman

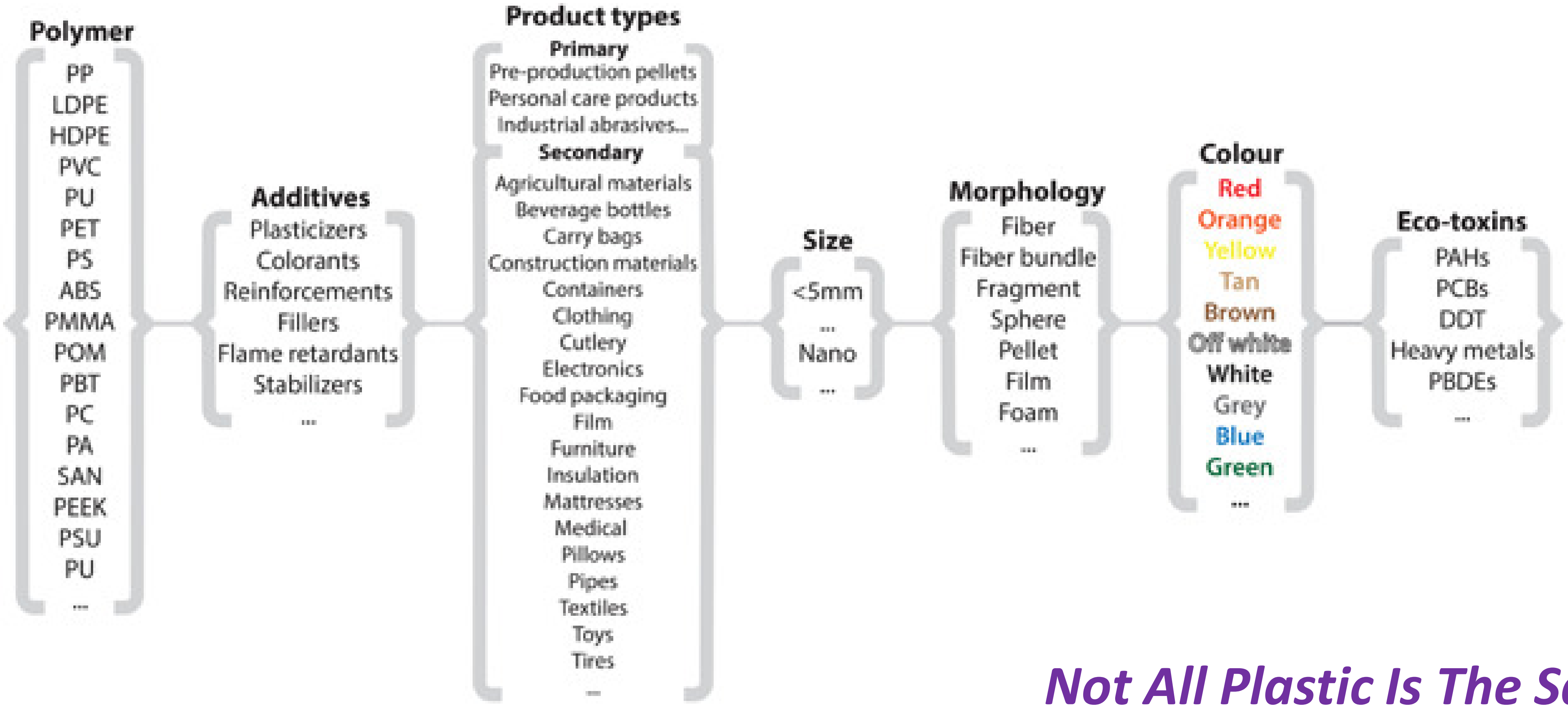
Hot needle example

- https://www.youtube.com/watch?v=PTqHmYSZXYI

Processes that make Secondary Microplastics



Part 2: Why do we care about plastics?



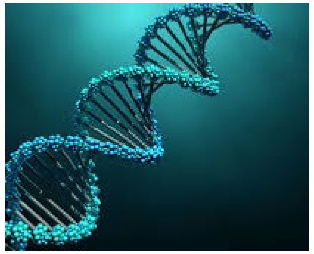
Not All Plastic Is The Same

Environmental Toxicology and Chemistry, Volume: 38, Issue: 4, Pages: 703-711, First published: 25 March 2019, DOI: (10.1002/etc.4371)

Rethinking microplastics as a diverse contaminant suite

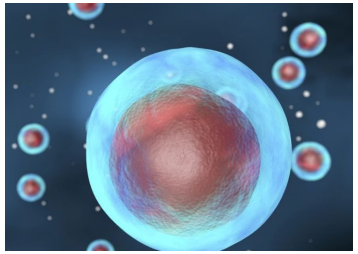
What can ingested microplastics do?

Subcellular



Changes in Gene Expression
-Sex determination
Changes in Enzyme Activity
Oxidative Damage

Cellular



Oxidative Stress
Inflammation

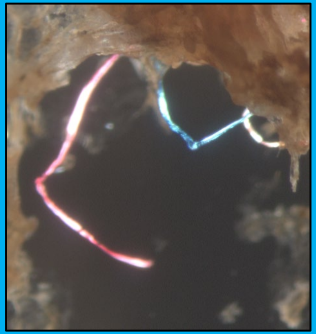
Individual

Reduced fecundity & fertility
Reduced Growth
Altered Energetics & Behavior
Survival
Compromised Immune

Population/Ecosystem

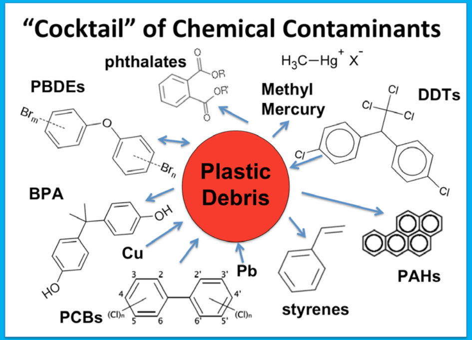
Altered Behaviors
Altered Population Structures
Altered Habitats

Physically



Biologically

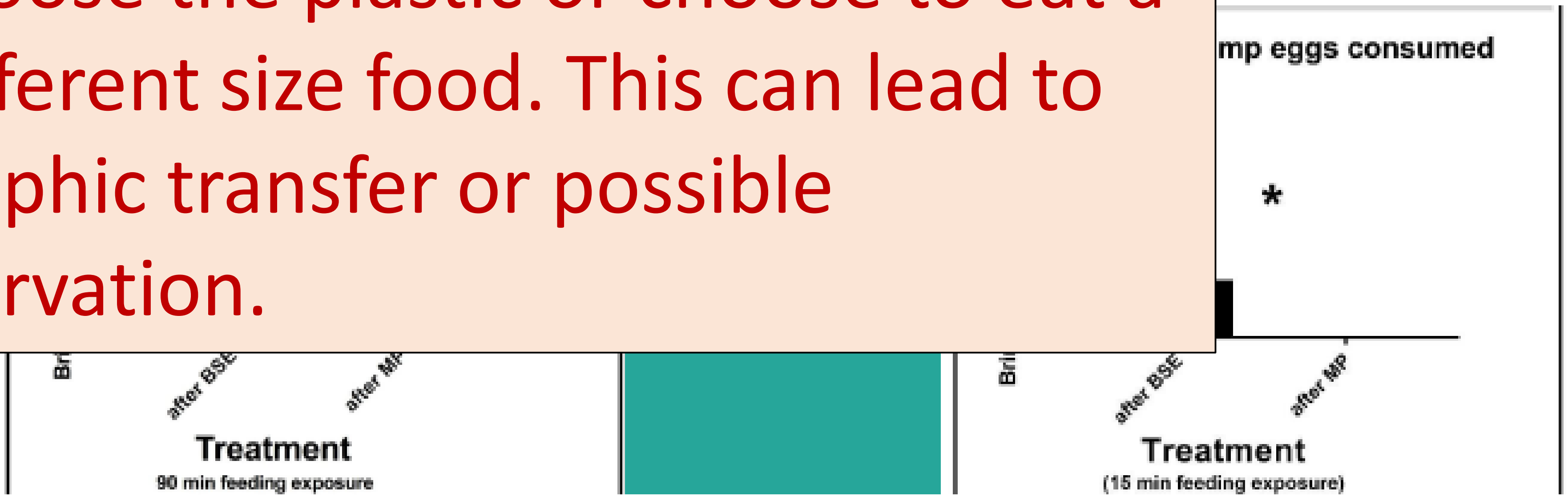
Chemically



Why does it matter?

- "Full" Gut
  - Reduced Feeding
  - Changes

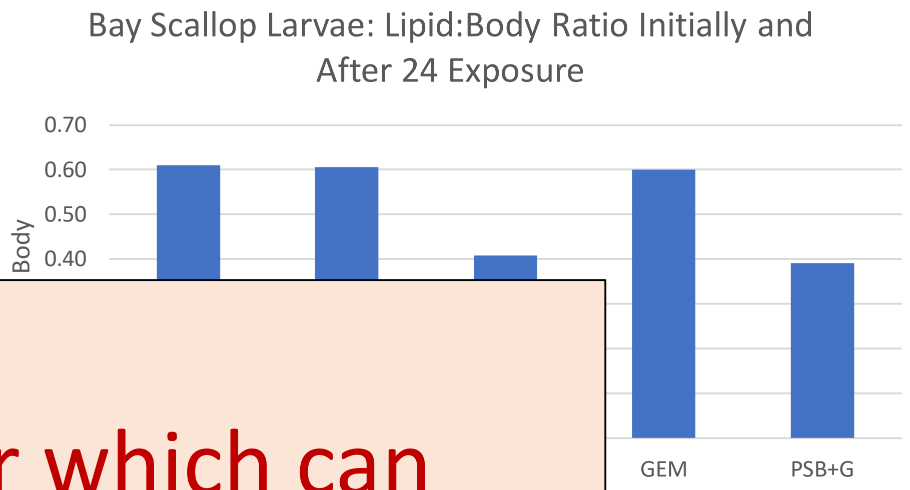
IMPLICATIONS:
- Animals may stop feeding or may choose the plastic or choose to eat a different size food. This can lead to trophic transfer or possible starvation.



Rotjan, et al. 2019

Why does it matter?

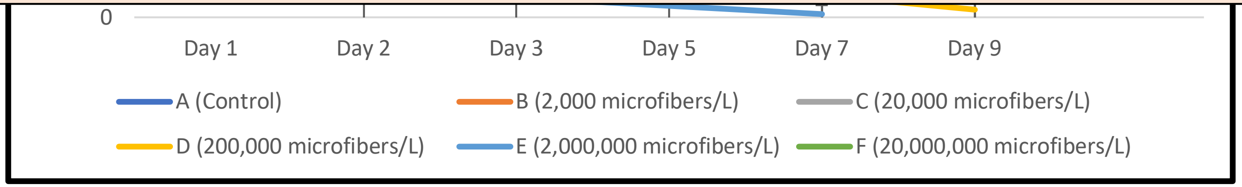
- Physiology
  - Reduced Growth
  - Increase
  - Changes

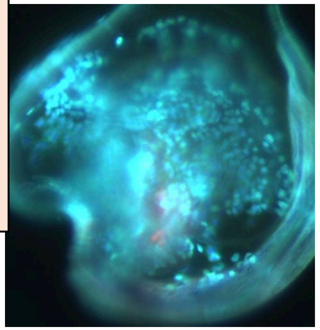


C. Major thesis

IMPLICATIONS:

- Animals may be smaller which can mean they are susceptible to disease and may be smaller as adults so worth less economically. Animals may have development issues.





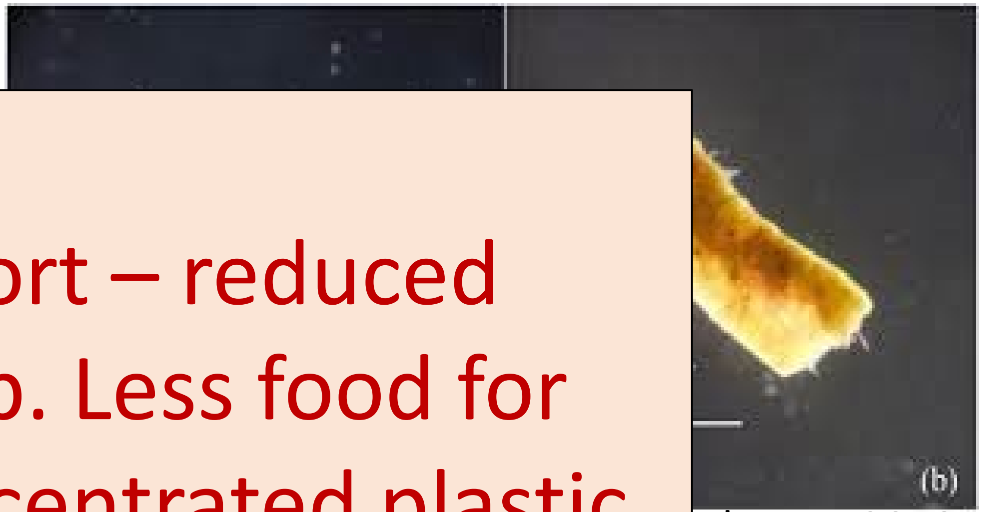
C. Tobin Dissertation

Why does it matter?

- Fecal Pellets / Pseudofeces
  - Decreases Density
  - Incre

IMPLICATIONS:

- Decreased carbon export – reduced biological carbon pump. Less food for deep sea animals. Concentrated plastic for suspension or detritus feeders.

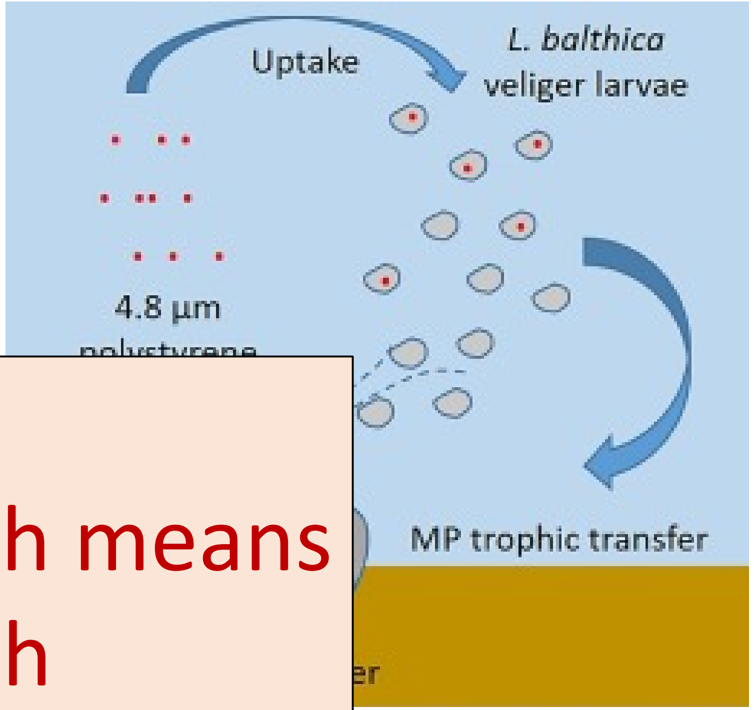


Woods et a. 2018

Coppock et a. 2019

Why does it matter?

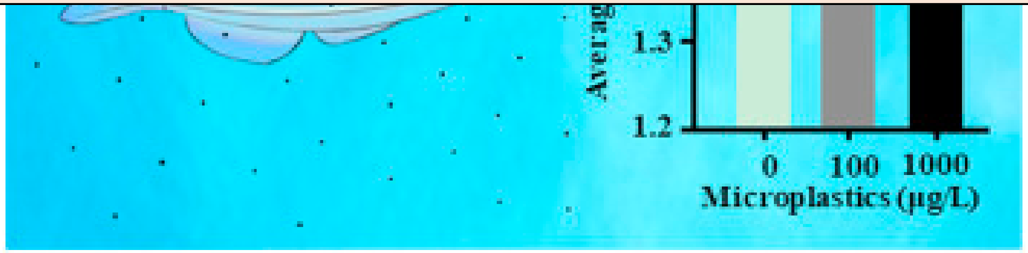
- Behavior
  - Swim
  - Cons



Van Colen et al. 2020

IMPLICATIONS:

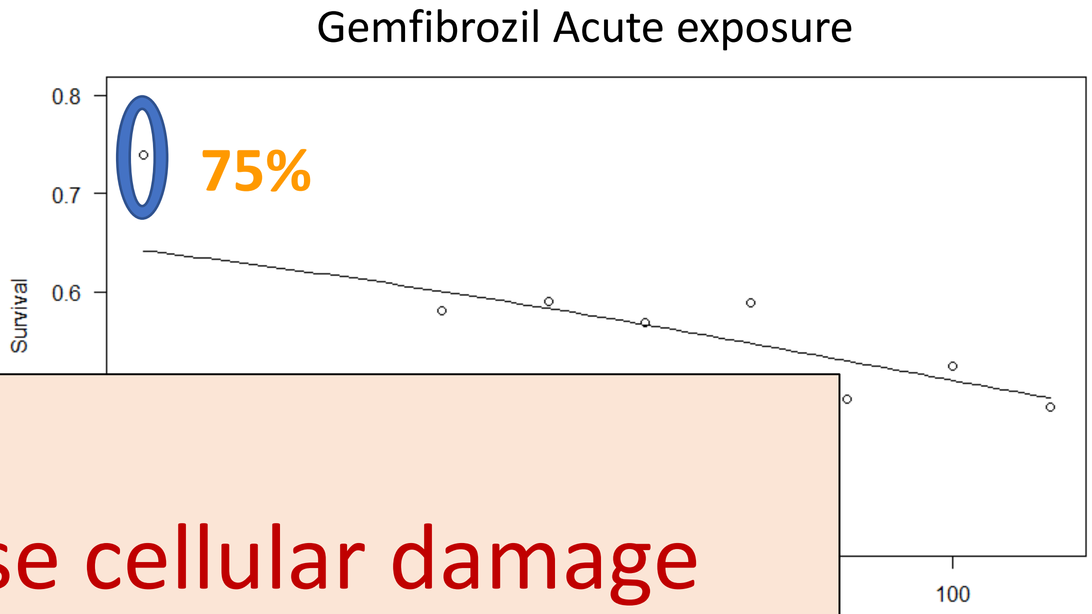
- Juvenile fish swim slower which means they are more vulnerable which increases trophic transfer. Shellfish larvae exhibit constant swimming – lose energy, grow slower.

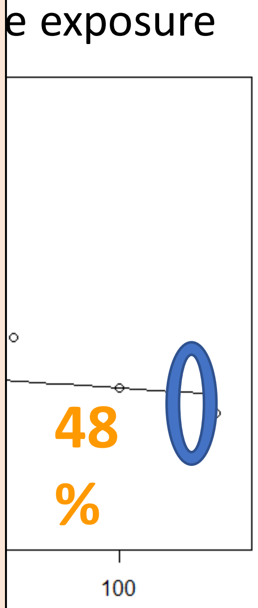


Qiang & Cheng 2019

Why does it matter?

- Chemical Leaching
  - Plasticizers
  - Adso





IMPLICATIONS:

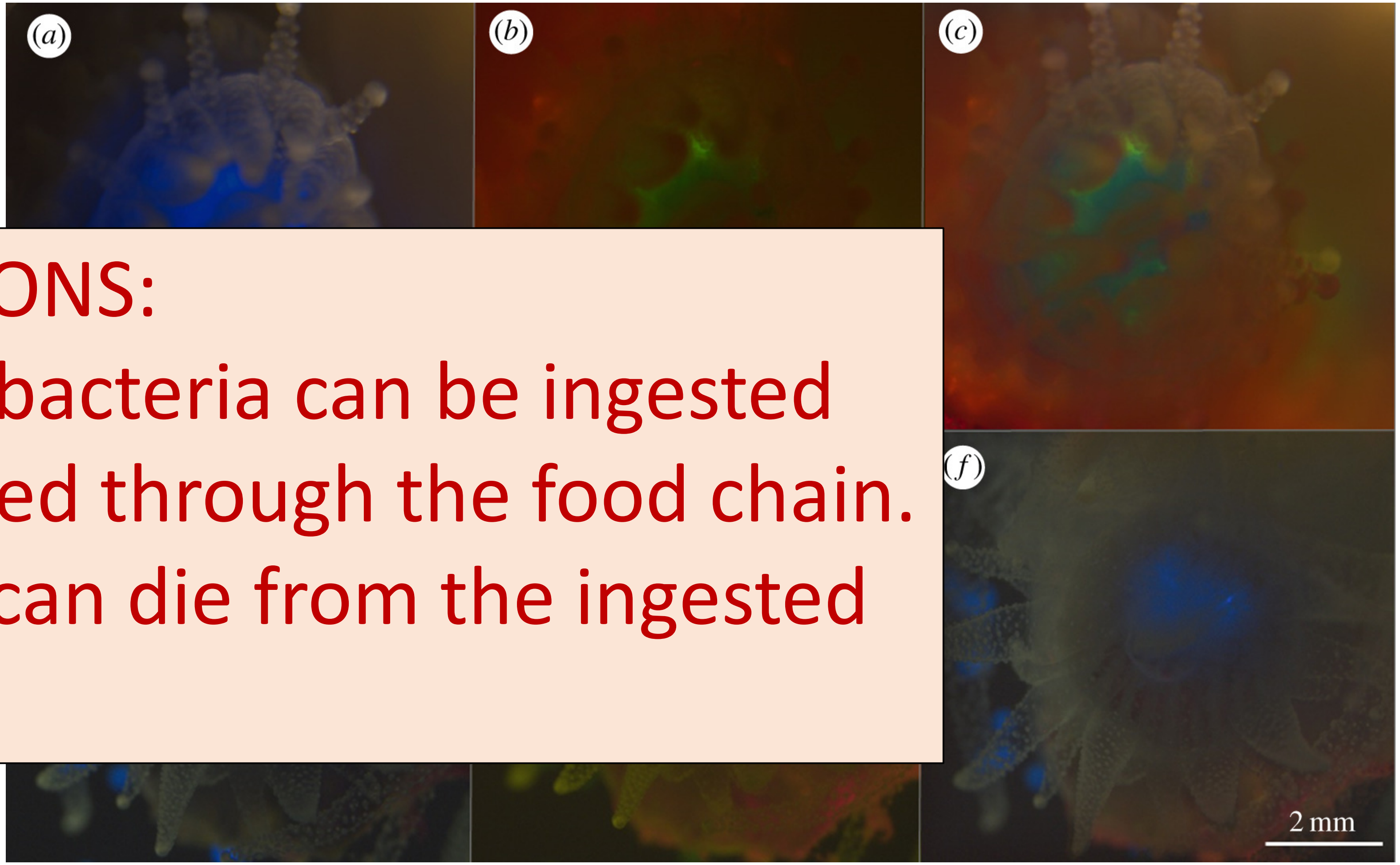
- The leaching can cause cellular damage leading to development issues or sex determination or organism death or slower growth. This could affect the population and its role in the ecosystem. This could also be passed up the food chain.

C. Major Thesis

Why does it matter?

INGESTION

- Biofilms
  - Diseas
  - Gut M



IMPLICATIONS:

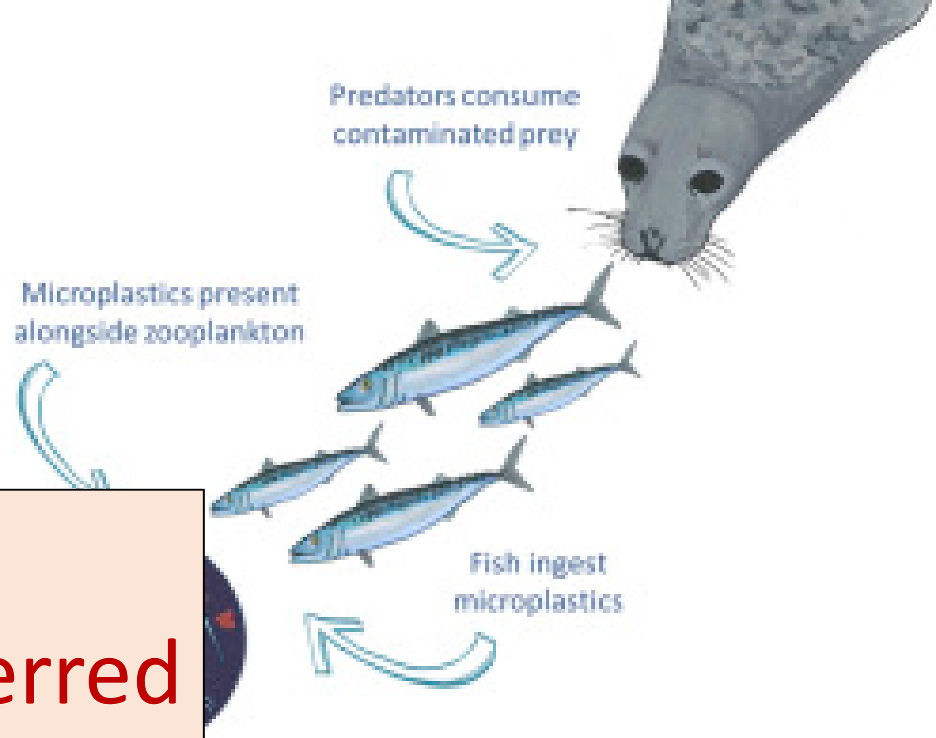
- Harmful bacteria can be ingested and passed through the food chain. Animals can die from the ingested bacteria.

Rotjan et al. 2019

Why does it matter?

TROPHIC TRANSFERS

❖ Bioaccumulation



IMPLICATIONS:

- Plastic is potentially transferred up the food chain, possibly all the way to humans. Chemicals can also be passed along.

Potential Risk is related to exposure

Zoom out (Ctrl+Minus)

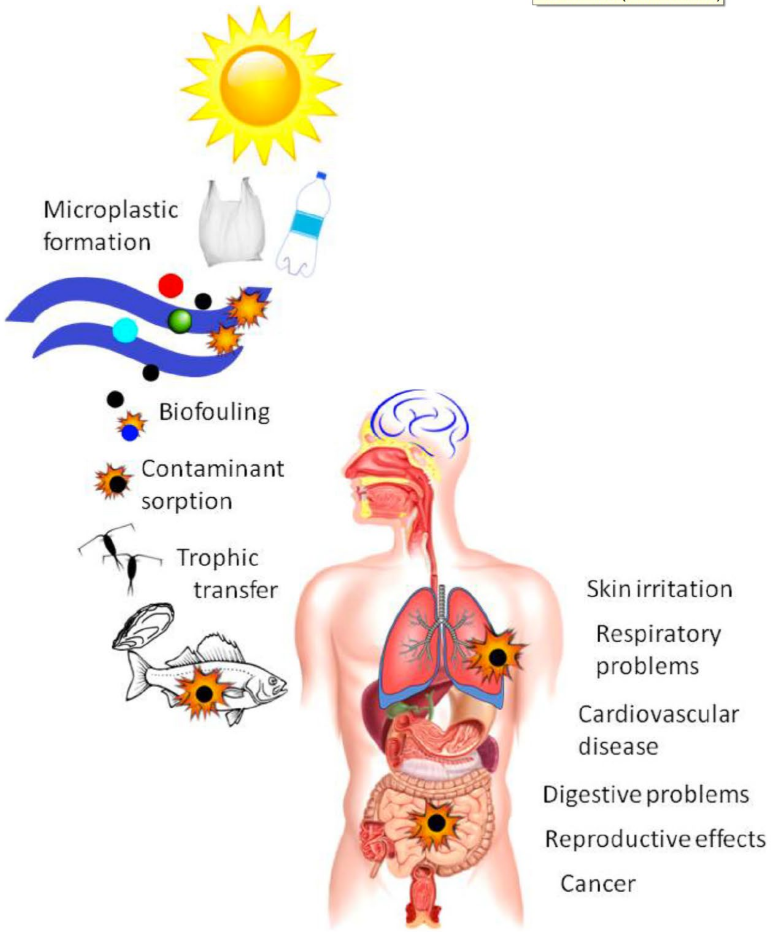


Fig. 3. Potential health effects resulting from the bioaccumulation and biomagnification of microplastics and chemical contaminants in the human body.

Carbery, et al. 2018 https://doi.org/10.1016/j.envint.2018.03.007

Risk Assessment

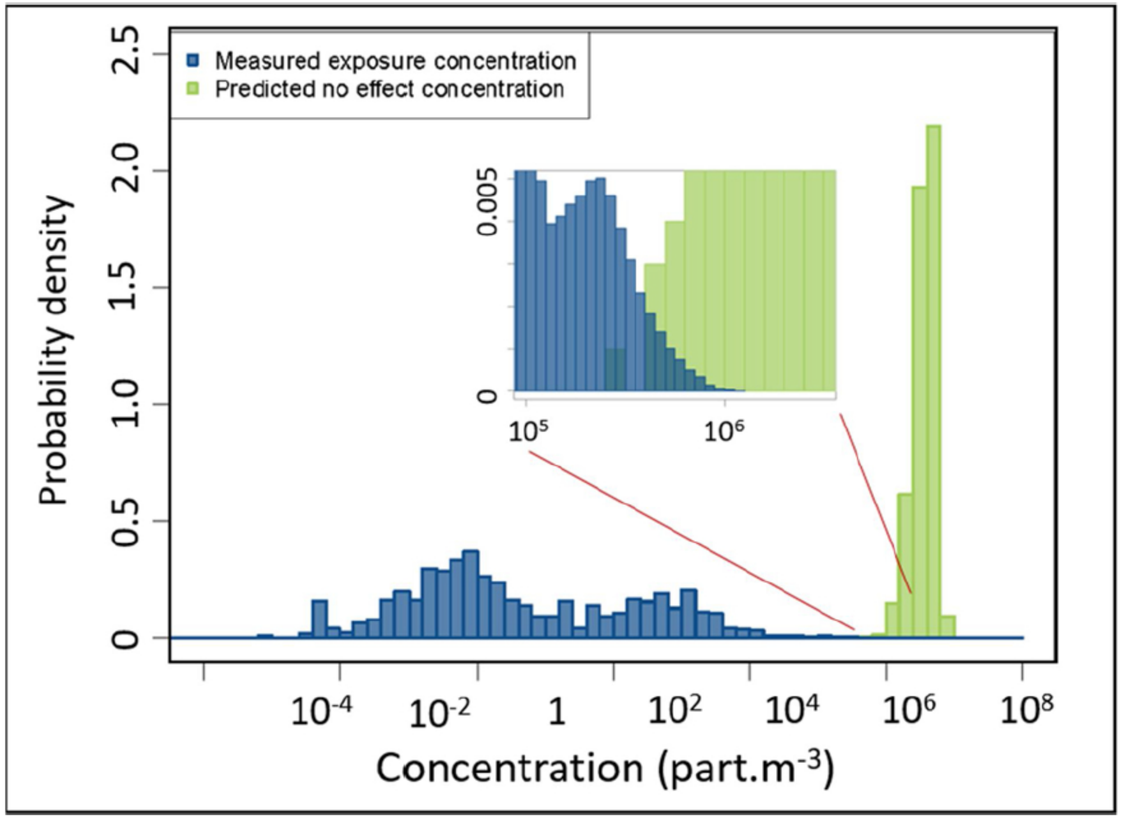


Fig. 3. Worldwide measured environmental concentration (MEC) and predicted no-effect concentration (PNEC) distributions in part m^{-3} for marine habitats.

Adam et al. 2021, Aquatic Toxicology 230: https://doi.org/10.1016/j.aquatox.2020.105689

Exposure vs Risk

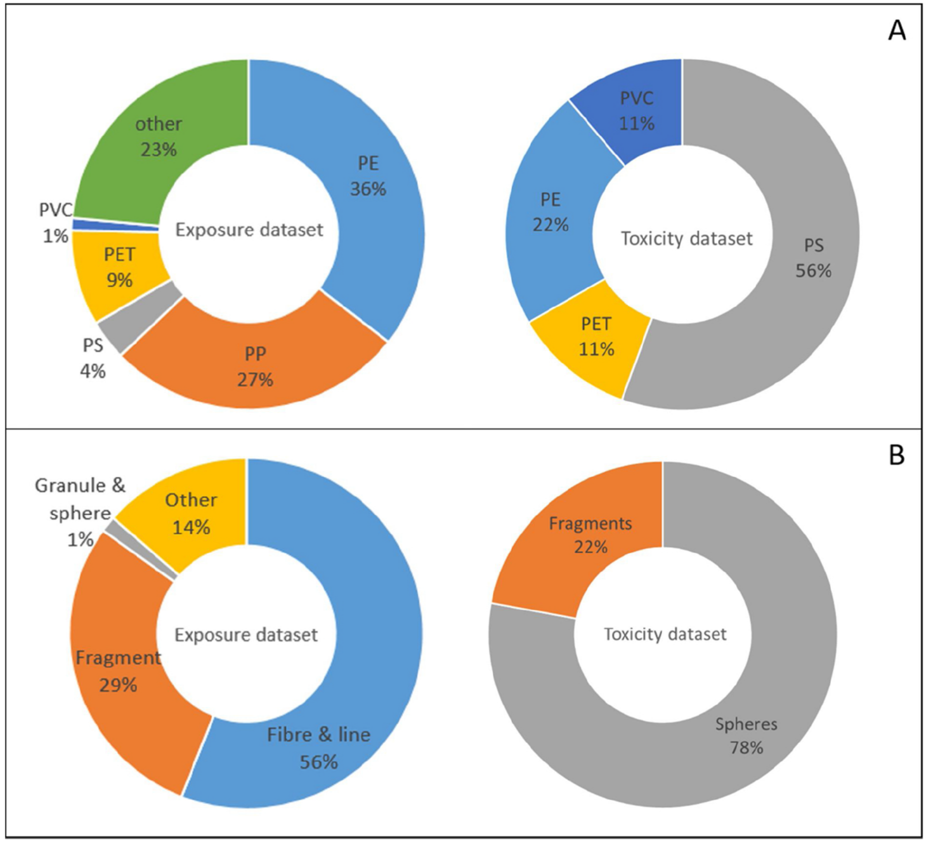
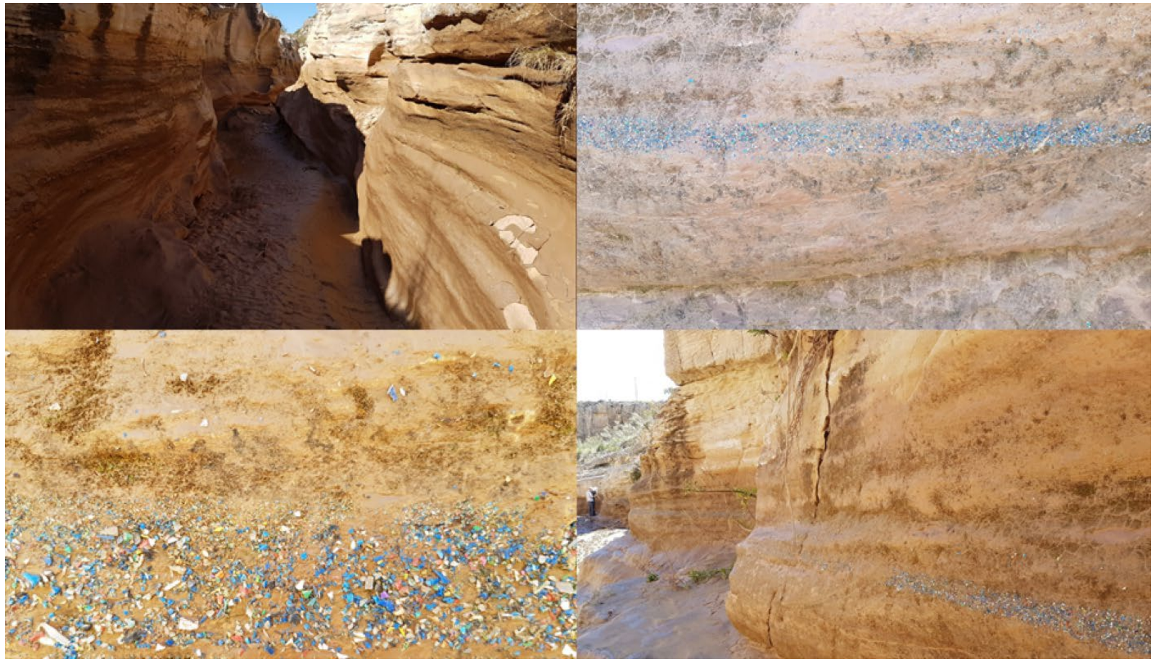


Fig. 6. A: Comparison of polymers found in the environment (exposure dataset) and polymers used in ecotoxicity assays (toxicity dataset). B: Comparison of MP shapes found in environmental samples (exposure dataset) and used in ecotoxicity assays (ecotoxicity dataset). PE: polyethylene, PP: polypropylene, PS: polystyrene, PET: polyethylene terephthalate, PVC: polyvinyl chloride.

Adam et al. 2021, Aquatic Toxicology 230: https://doi.org/10.1016/j.aquatox.2020.105689

Anthropocene



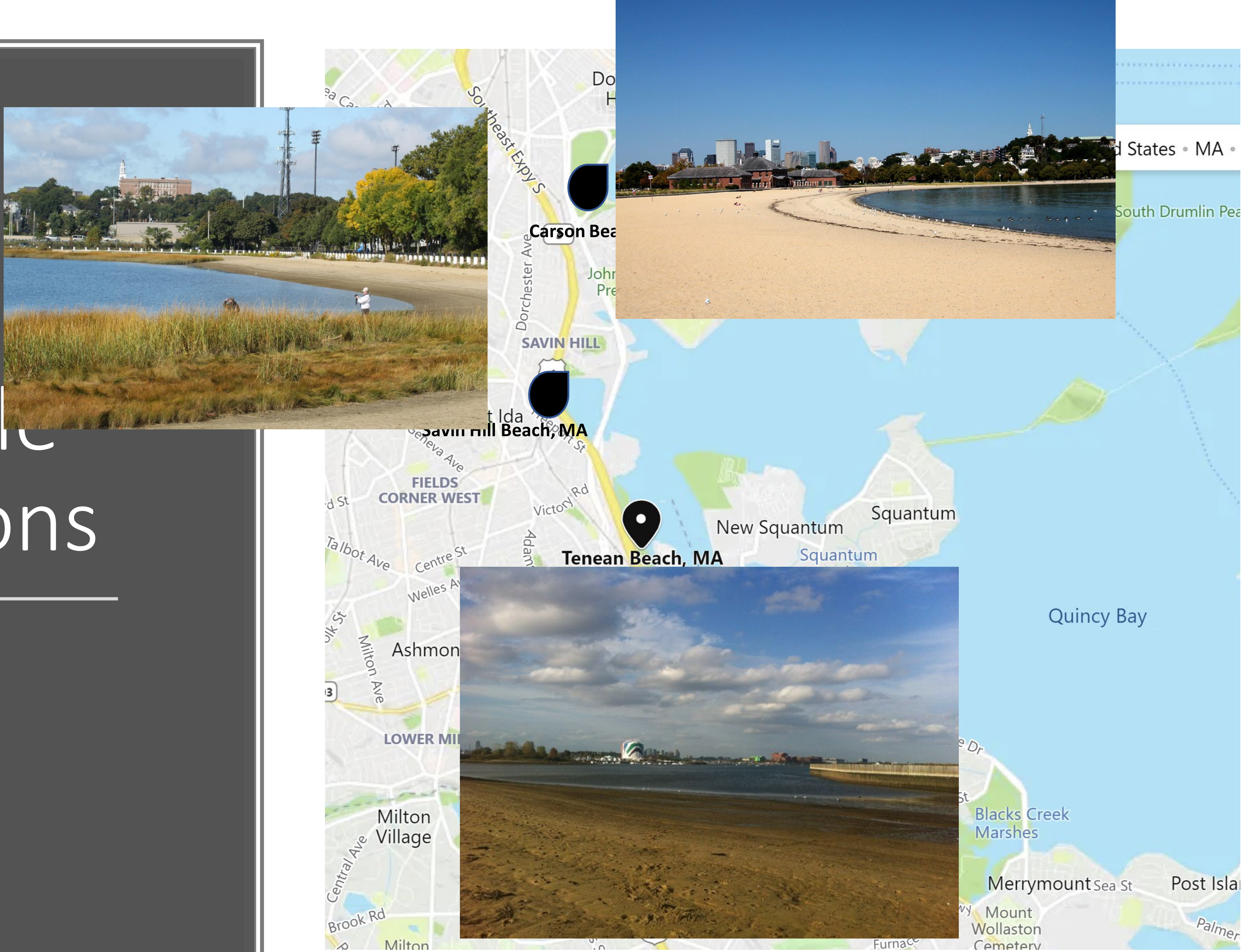
Acknowledgments

Students: Tyler O'Conner, Charles Major, Catie Tobin, Lee Mabry, Shannon Hogan, Jack Barkowski

Colleagues: Yvonne Vaillancourt, Graeme Durovich, Stephanie Wood, Randi Rotjan, Koty Sharp, Jessica Carille, Justin Bemont, Helen Poynton

Funding: UMASS Boston Healey Grant, Crowd Source Funding, ReMain Nantucket

Sample Locations



Reference Resources

- Harris, Leigh & Theriot, Julie. (2018). Trends in Microbiology. 26. 10.1016/j.tim.2018.04.008.
- Carbery, et al. 2018 Env International, 115 pp 400-409, https://doi.org/10.1016/j.envint.2018.03.007.
- Choy, *et al. 2019 Sci Rep* **9,** 7843 https://doi.org/10.1038/s41598-019-44117-2
- Nelms, S. et al. 2019 Env Poll, 238, pp 999-1007, https://doi.org/10.1016/j.envpol.2018.02.016
- *Barrows, A., et al. Anal. Methods*, 2017,9, 1446-1453 https://doi.org/10.1039/C6AY02387H
- Arthur, et al. 2009. *NOAA Technical Memorandum NOS-OR&R30*.
- Rotjan, et al. 2019 *Proc Natl AcadSci* https://doi.org/10.6084/m9.figshare.c.4548467.v1
- Penelope et al. 2020 Environmental Pollution, 265, https://doi.org/10.1016/j.envpol.2020.114721
- Choy et al. 2018. Scientific Reports
- Rochmann et al. 2019. Env Tox Chem
- Adams et a. 2021 Aquatic Tox. https://doi.org/10.1016/j.aquatox.2020.105689
- Van Colen et al. 2020 https://doi.org/10.1016/j.envpol.2019.113479
- Qiang & Cheng 2019 DOI:10.1016/j.ecoenv.2019.03.088
- Cole et al. 2016 https://doi.org/10.1021/acs.est.5b05905
- Coppock et al. 2019 https://doi.org/10.1016/j.scitotenv.2019.06.009