Plastic Pollution in the Environment:

Insights from Lake Superior

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ENVIRONMENT AND NATURAL RESOURCES TRUST FUND

DEPARTMENT OF NATURAL RESOURCES

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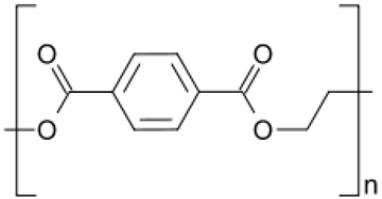
Driven to Discover

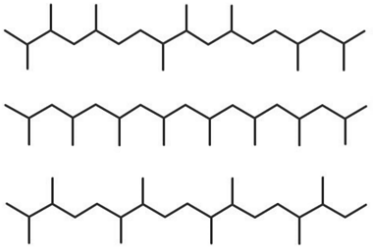
Introduction: some definitions

- Plastic: a synthetic organic polymer that exhibits plasticity (the ability to deform under stress) at some point in its life cycle and that can be molded.
  - Many different polymers fit this definition and they are often mixed with additives to adjust their properties.

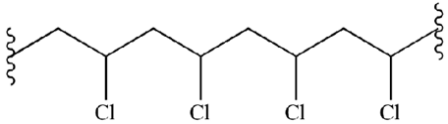
Polyester



Polypropylene



PVC



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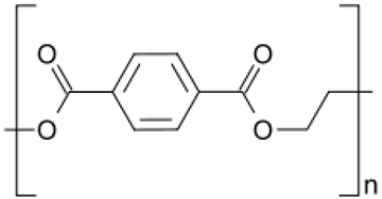
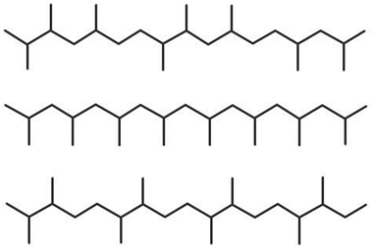
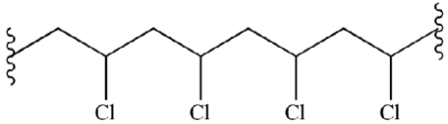


Polypropelene

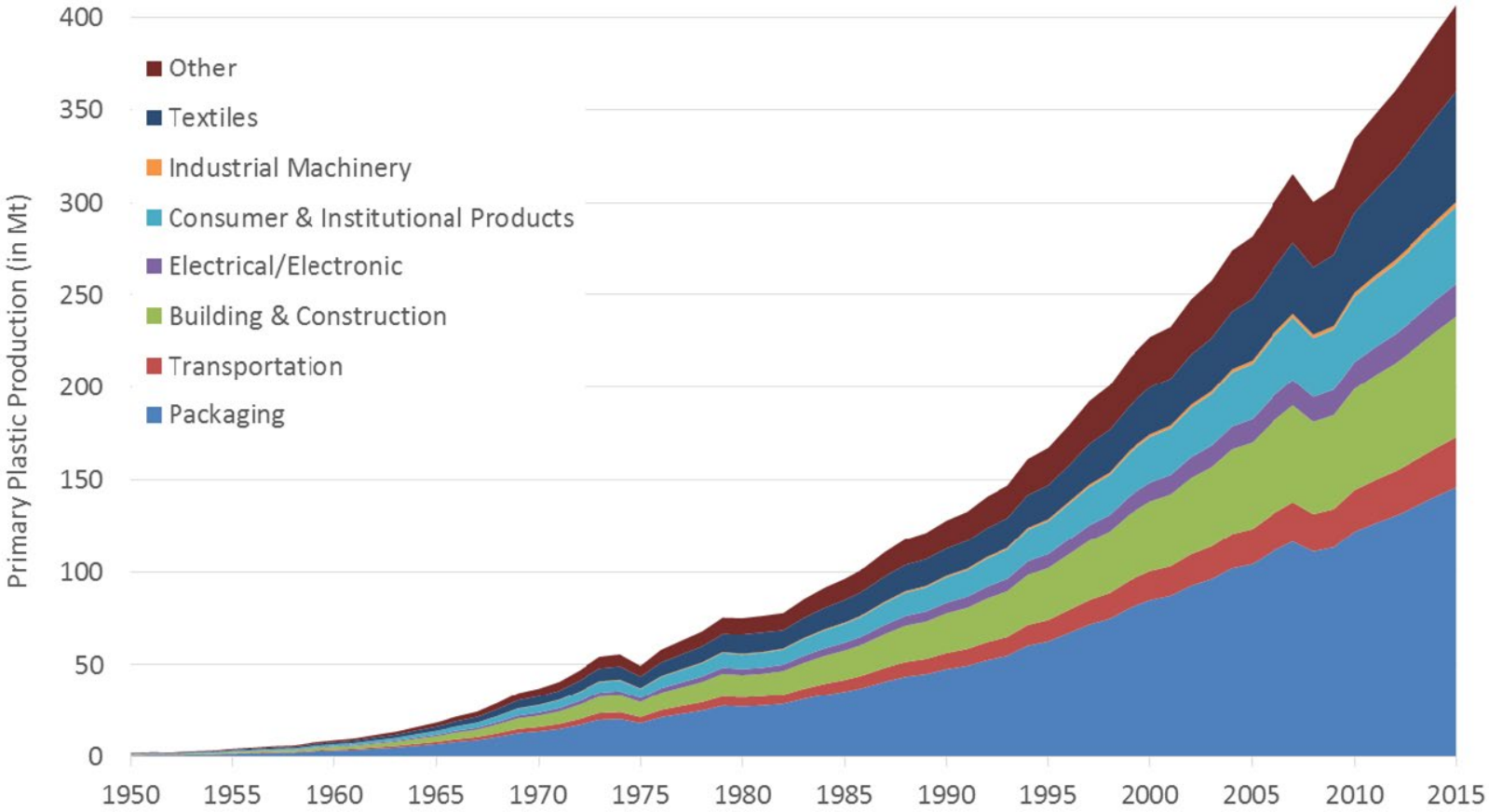


PVC



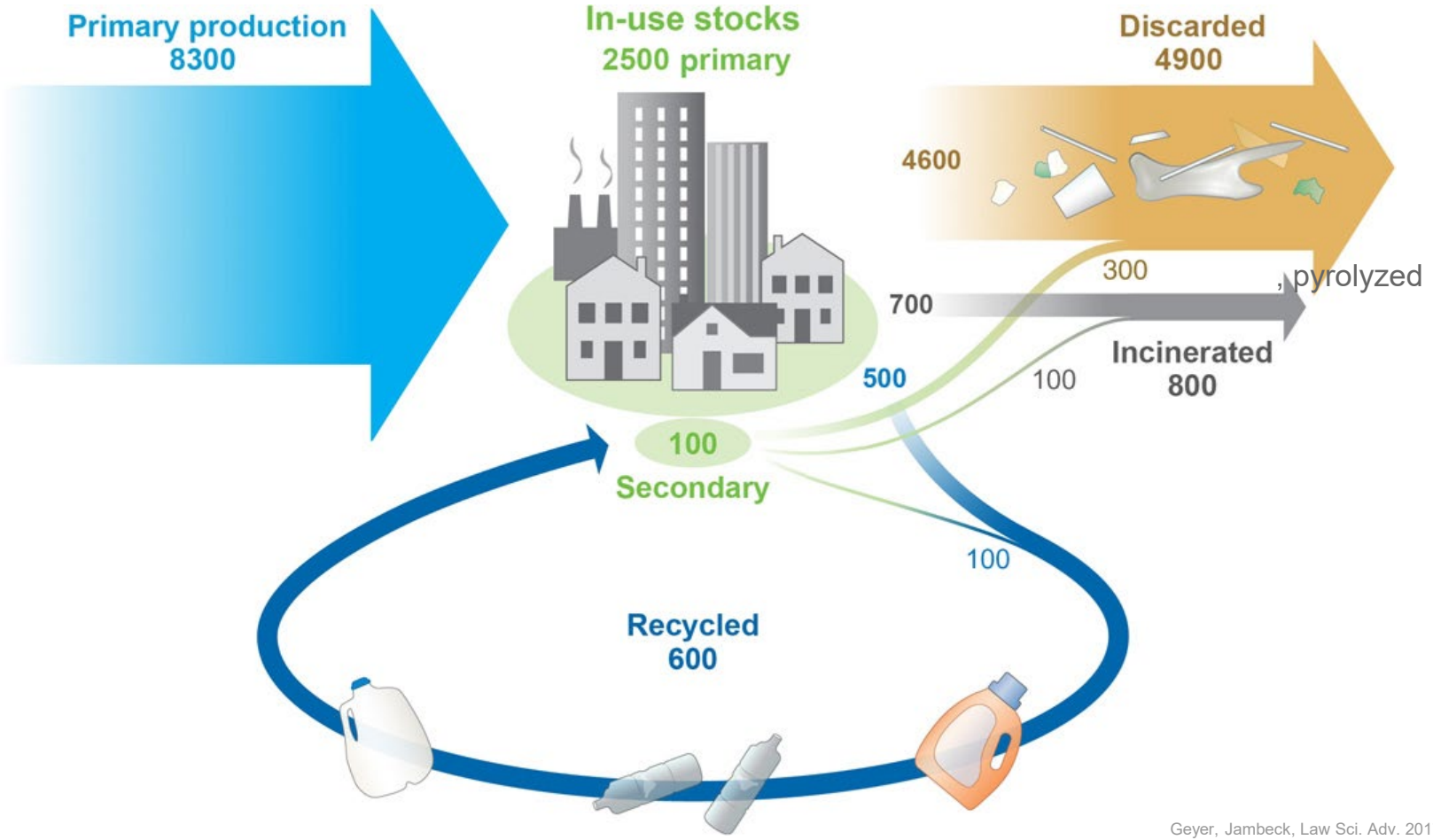
- Plastic size ranges
  - **Microplastics** usually defined as <5 mm in size with lower size cut-off determined by analytical limitations (>300 um usual for microscopy, >20 um for microFTIR - explained later)
  - **Nanoplastics** have a range of definitions, but are generally smaller than microplastics (< 300 um or < 20 um)

Introduction



Geyer, Jambeck, Law Sci. Adv. 2017;3: e1700782

Introduction



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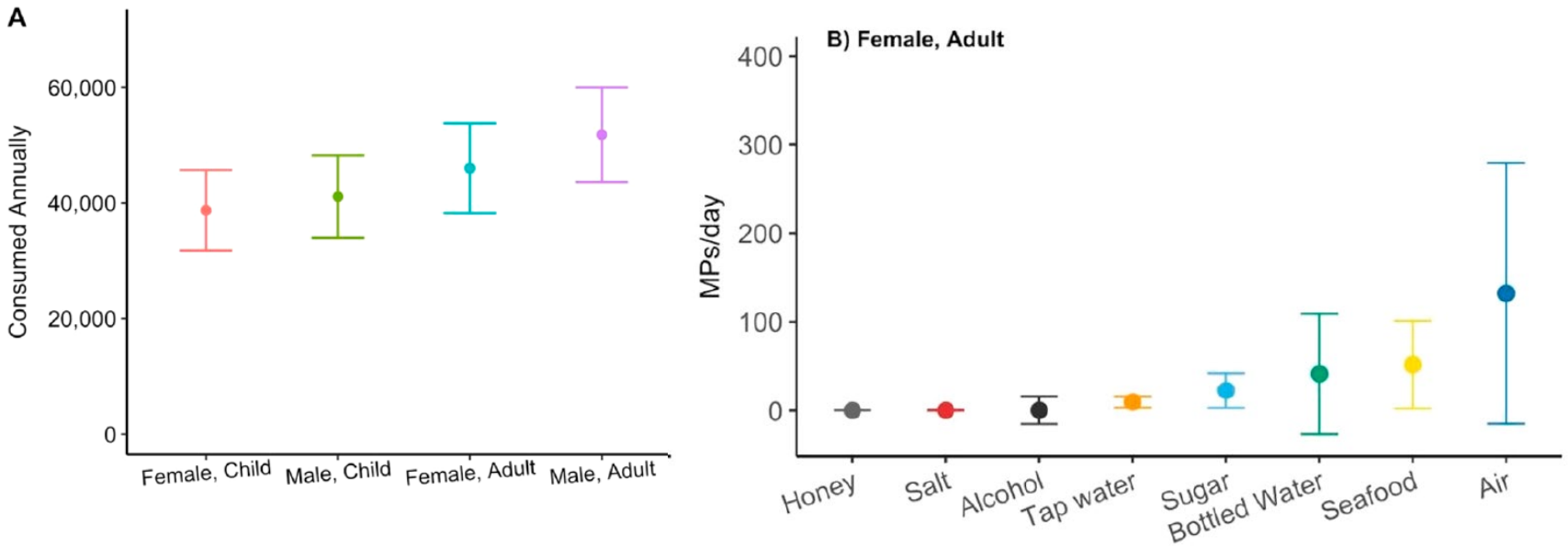


Estimates of microplastic consumption by humans (from Cox et al, 2019). Caveat: based upon 15% of US caloric consumption. No data on fish, chicken, vegetable microplastic contents…

Cox et al, 2019. Environ. Sci. Technol. 53, 7068−7074

But the collection & analysis of environmental microplastics is a science that is still being developed.

There are many challenges, including:

- Field collection: time intensive and need enough sample for good counting statistics
- Sample preparation: time intensive and requires many human hours
- Sample analysis: difficult and requires specialized equipment

Our studies

Three views of plastics in the environment:

- From water in Lake Superior
- From beach sands in Lake Superior
- From fish from the Texas Gulf Coast

    - Current work investigating water, sediment, and fish in 4 MN lakes.

Sample Collection: Water

Water: Net tows (~30 min): lots of water (one 600 m tow filters ~50,000 L), but nets are larger mesh size (typically 300 um).

For smaller size particles like nanoplastics, which may have more particles/L, 100 to 1000L of water may be enough with an in-situ oceanographic pumped filter system, 1000 L takes ~ 6 hours.

Sample Collection: Sand

- Beach sand: easy to collect (<30 minutes) but time consuming to process

Sample preparation & analysis

1. Sieving/filtering and drying
2. Removal of natural OM if necesssary
3. Density separation
4. Microscopy: melt testing, particle picking
5. Chemical identification (PyGCMS, FTIR, or SEM)
6. Data analysis

Photo: E. Minor

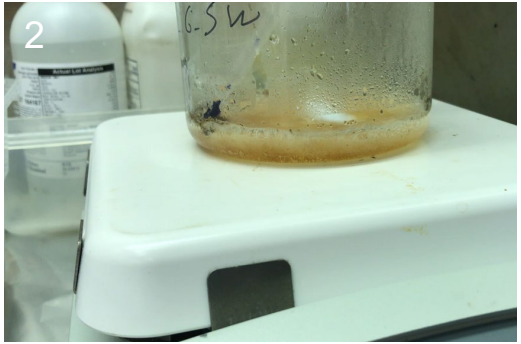
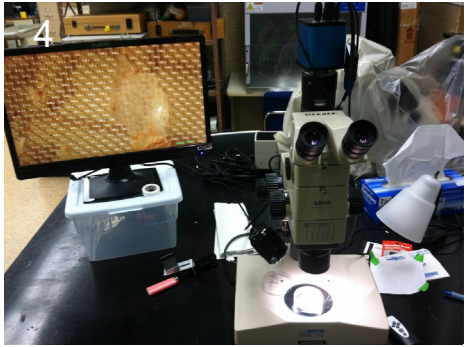


Photo: E. Hendrickson



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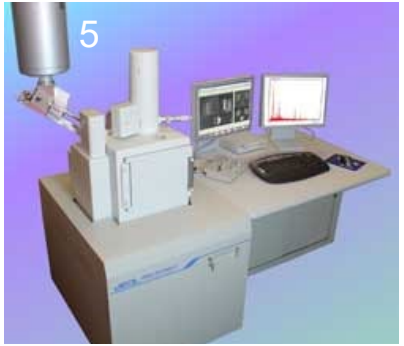


https://www.jeolusa.com/NEWS-EVENTS/Press-Releases/jeol-introduces-new-series-of-scanning-electron-microscopes

Environmental Science & Technology

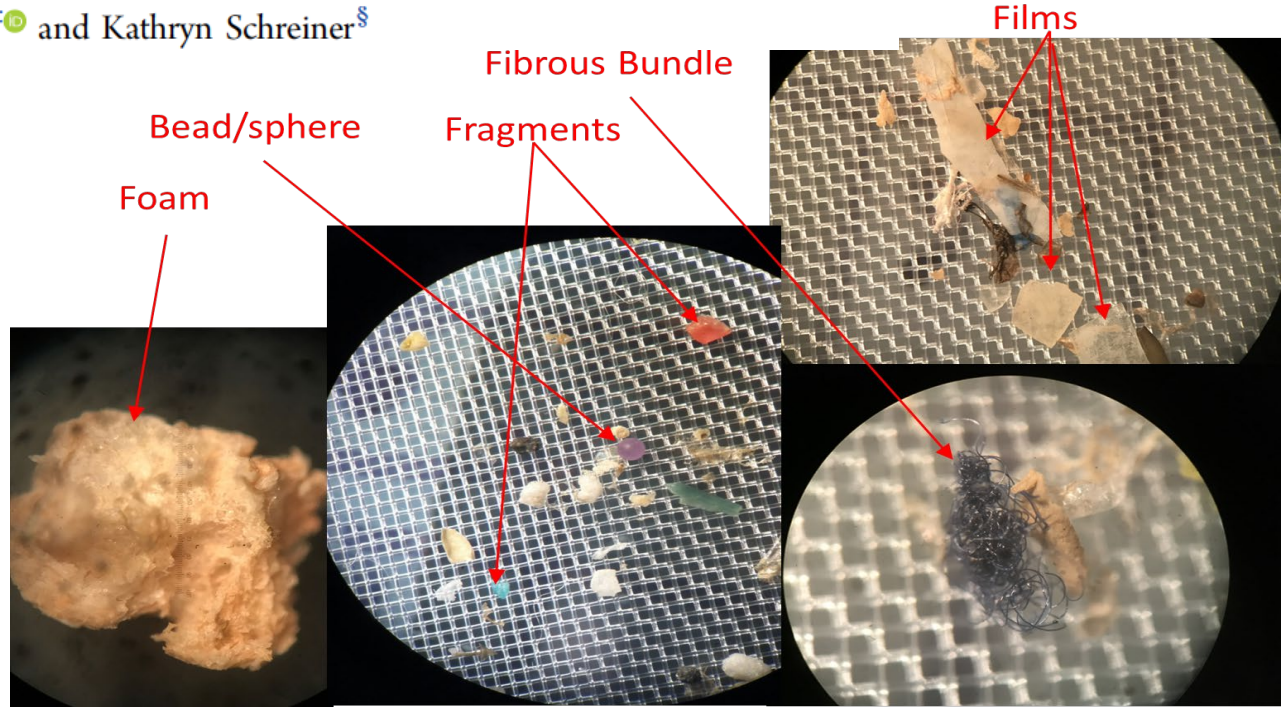
Article

Cite This: Environ. Sci. Technol. 2018, 52, 1787−1796

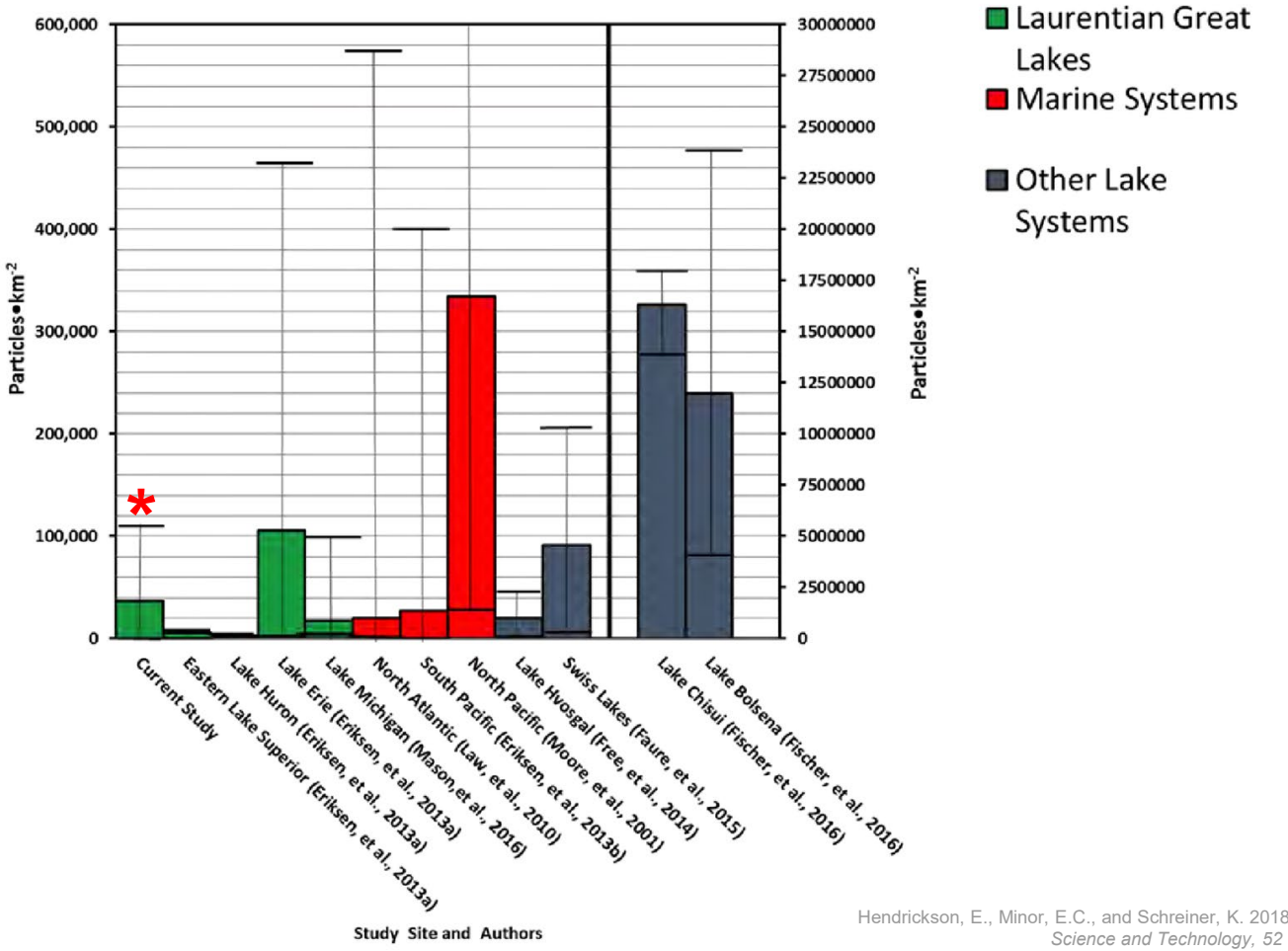
pubs.acs.org/est

Microplastic Abundance and Composition in Western Lake Superior As Determined via Microscopy, Pyr-GC/MS, and FTIR

Erik Hendrickson,[†] Elizabeth C. Minor,[*,‡] and Kathryn Schreiner[§]



Results: Water



Hendrickson, E., Minor, E.C., and Schreiner, K. 2018. *Environmental Science and Technology, 52* (4), 1787–1796.

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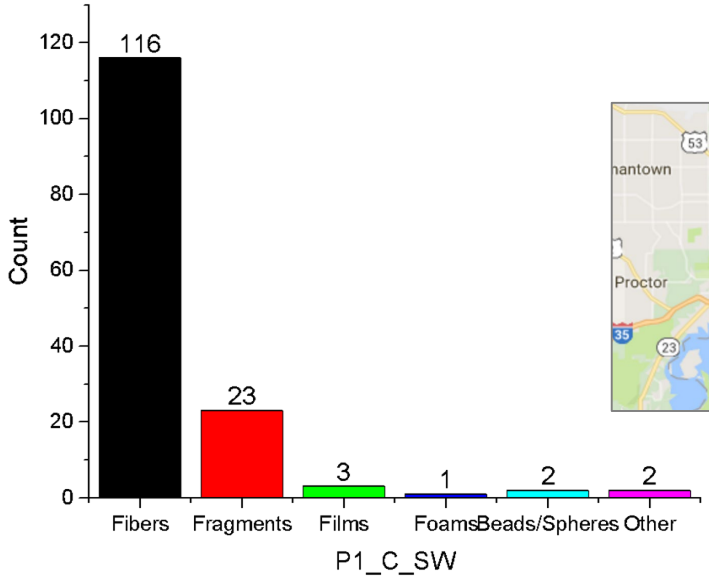
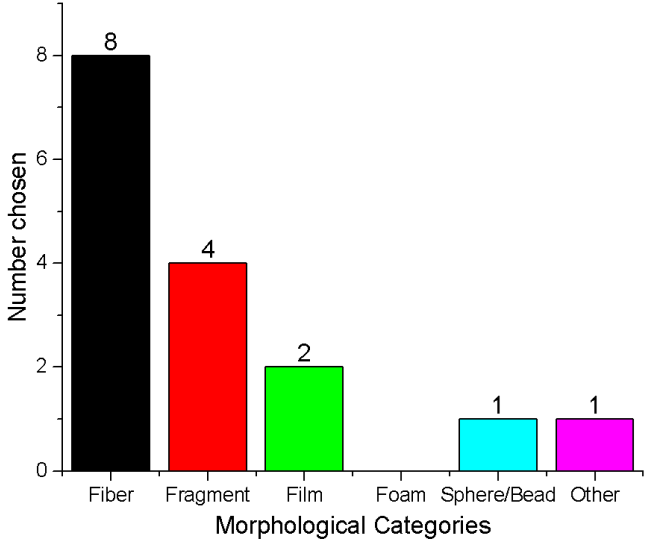
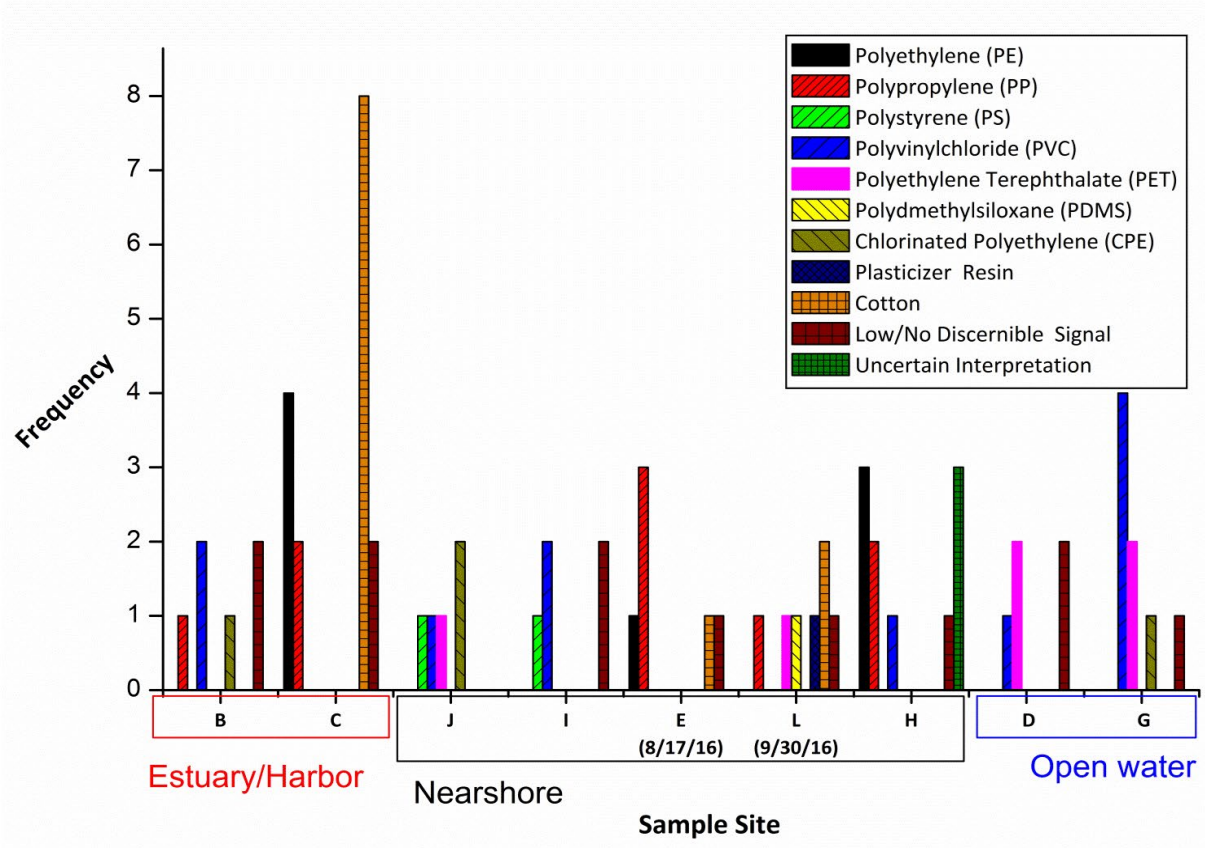




- Particles obtained from site C
- Microscopic identification with pressure test only.

- Particles chosen for chemical analysis.
- Slightly disproportional because:
  - Wanted morphology from at least 1 in all categories.
  - Challenges in identification:
    - E.g., Non-plastic fragments found, analyzed in replicate.

Results: Water (Lake Superior)

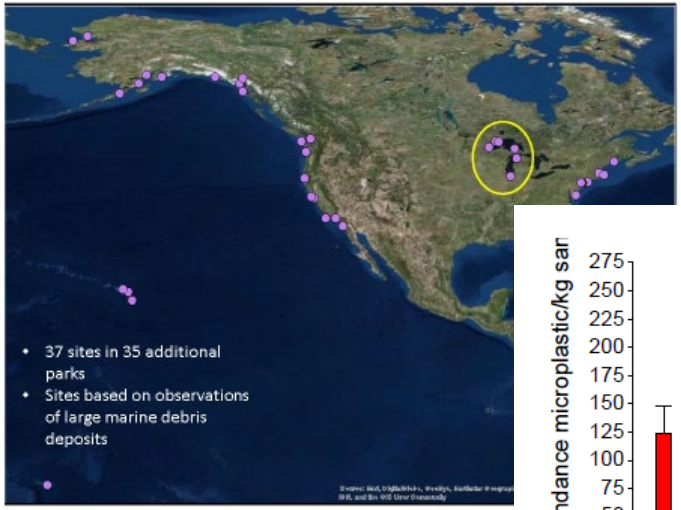


PVC, PP, PE, and PET most dominant plastics identified.

Hendrickson, E., Minor, E.C., and Schreiner, K. 2018. *Environmental Science and Technology, 52* (4), 1787–1796

Beach sand study in national parks (samples collected in 2015, 2016)

Whitmire, S.L., Van Bloem, S.J., Toline, C.A., and McCreedy, C. 2017. Quantification of Microplastics on National Park Beaches. NOAA, 28p.



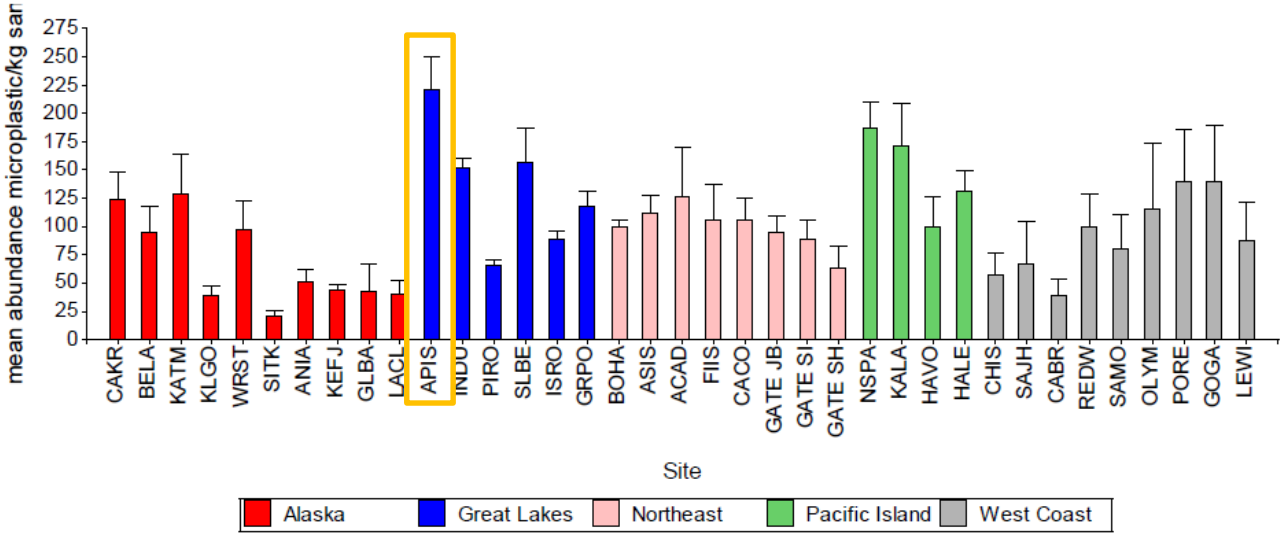


Figure 2: Mean abundance of microplastics per kg of sand for thirty-seven NPS units sampled during 2015 and 2016. Colors represent the region the park is located. Error bars represent standard error.

- APIS: 221 ± 29 microplastic particles/kg (all fibers)…

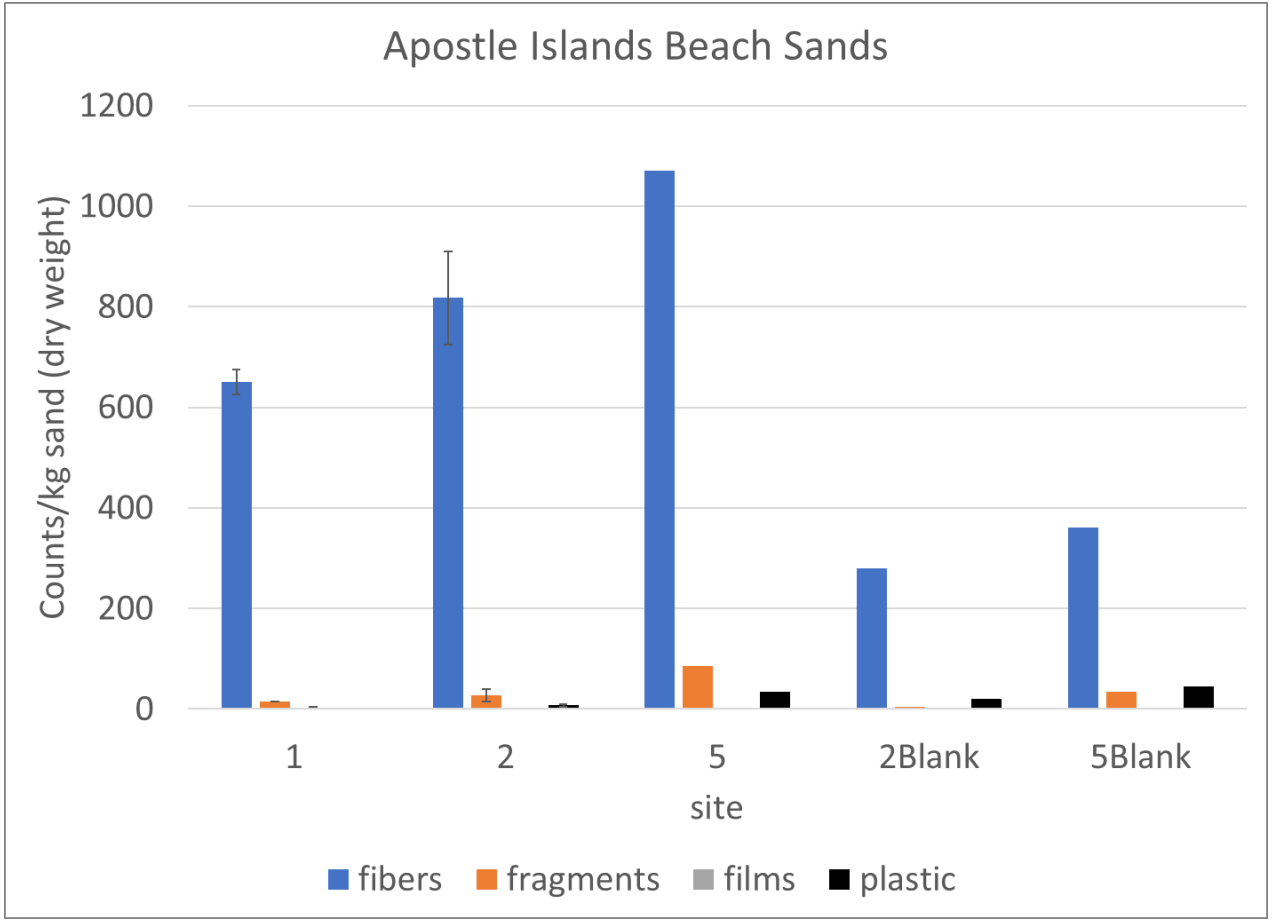
Results: Beach sand

- We even more fibers 330/kg (blank corrected)
- But via melt test: 0 to 35 plastic particles/kg
- blank-corrected values have **no measurable plastics**

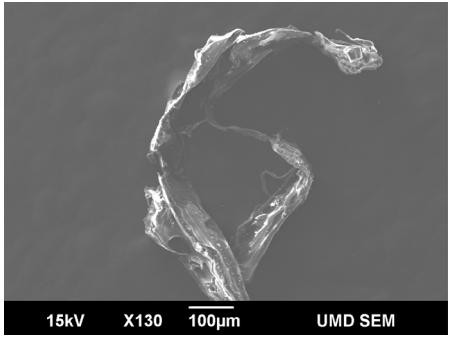
What are these fibers that don't melt (either burn or are inert to flame)?

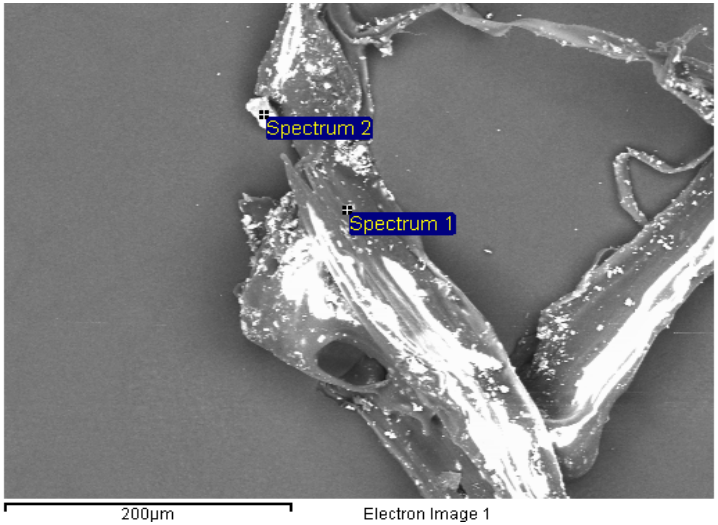
No signal via pyGCMs.

Tried scanning electron microscopy instead…



Results: Beach sand





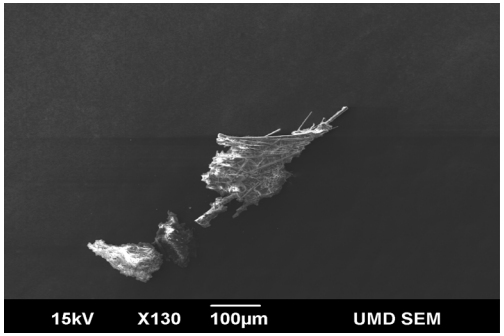
SEM data

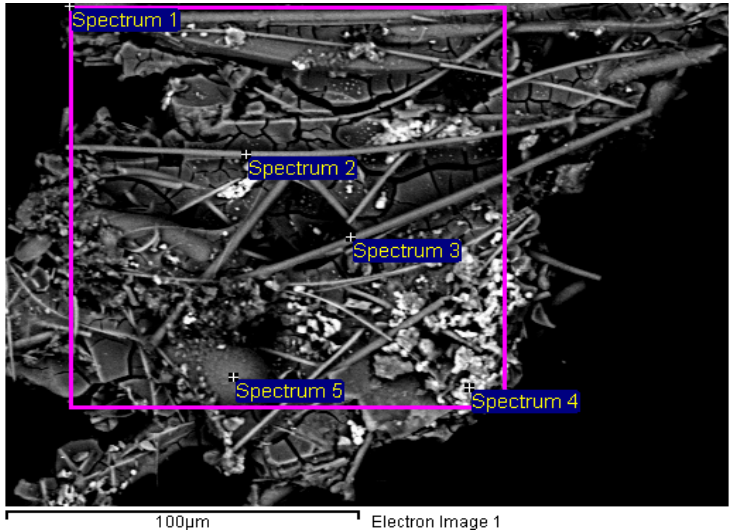
Al1_2a (plastics) > 0.45µm Location 1

Spectrum	In stats.	C	O	Al	Si	Total
Spectrum 1	Yes	85.56	12.99	0.38	1.07	100.00
Spectrum 2	Yes	33.34	3.38		63.28	100.00

Particle is C rich but doesn't have much O, organic?

Results: Beach sand





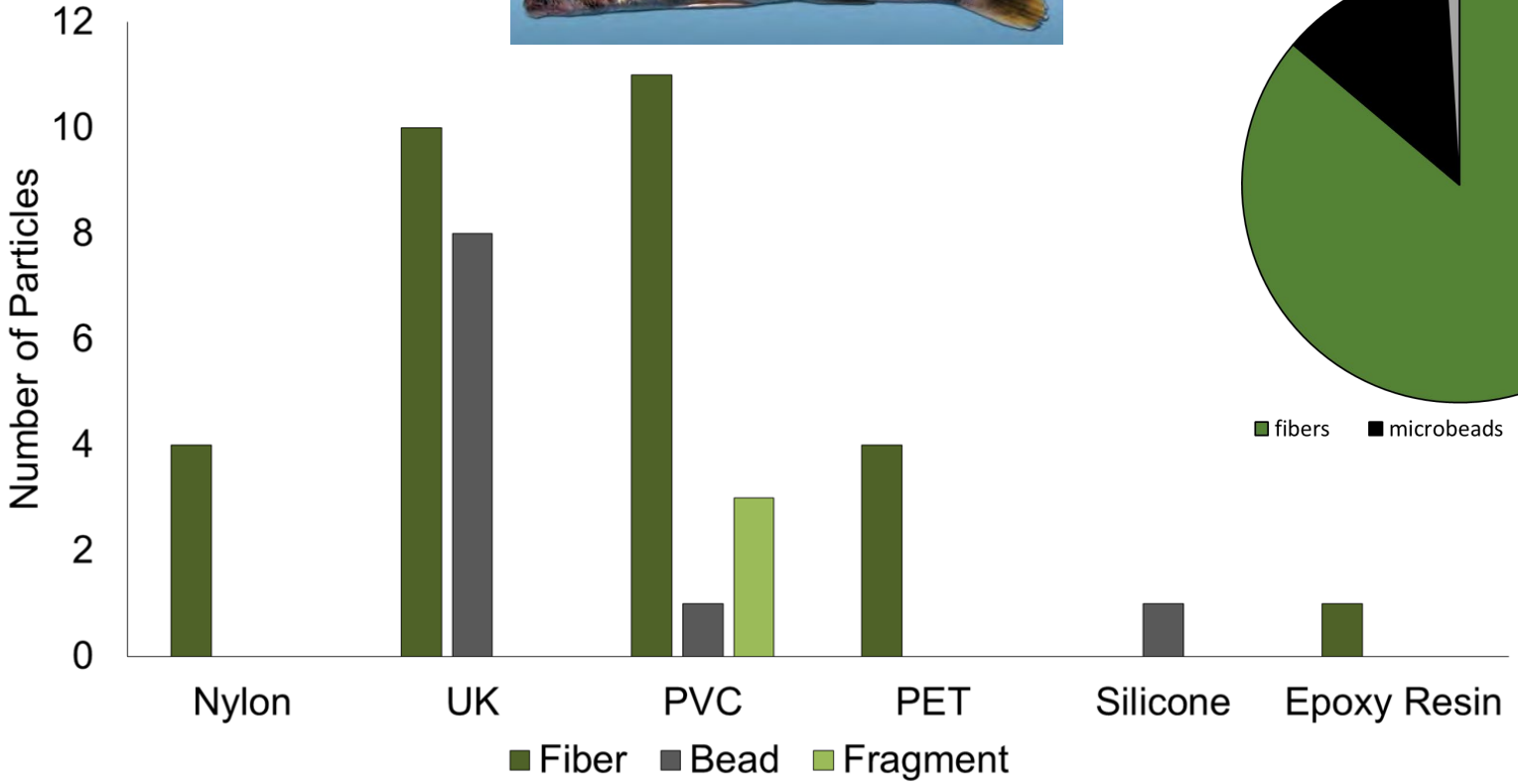
SEM data

AI1_5c Non Plastic Location 2

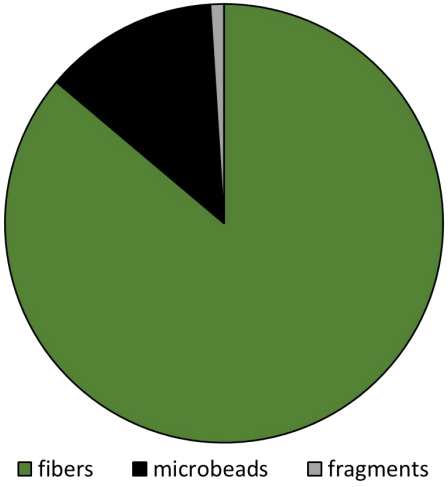
Spectrum	In stats.	O	Na	Al	Si	Cl	K	Br	Total
Spectrum 1	Yes	46.61	4.24	9.46	32.80	6.56	0.33		100.00
Spectrum 2	Yes	55.47	0.65	20.93	22.65	0.30			100.00
Spectrum 3	Yes	56.34	0.62	20.64	22.16	0.23			100.00
Spectrum 4	Yes	12.28	26.87		2.90	56.65		1.30	100.00
Spectrum 5	Yes	52.52	1.01	24.18	21.91	0.38			100.00

Particle floated in density separation, did not melt, appears mineral (high Si, Al, and O levels) via SEM. Aluminosilicate (natural or fiberglass?)

Results: Fish (Gulf Coast)



Ingested microplastics by morphology (from Peters et al., 2017)



Current work

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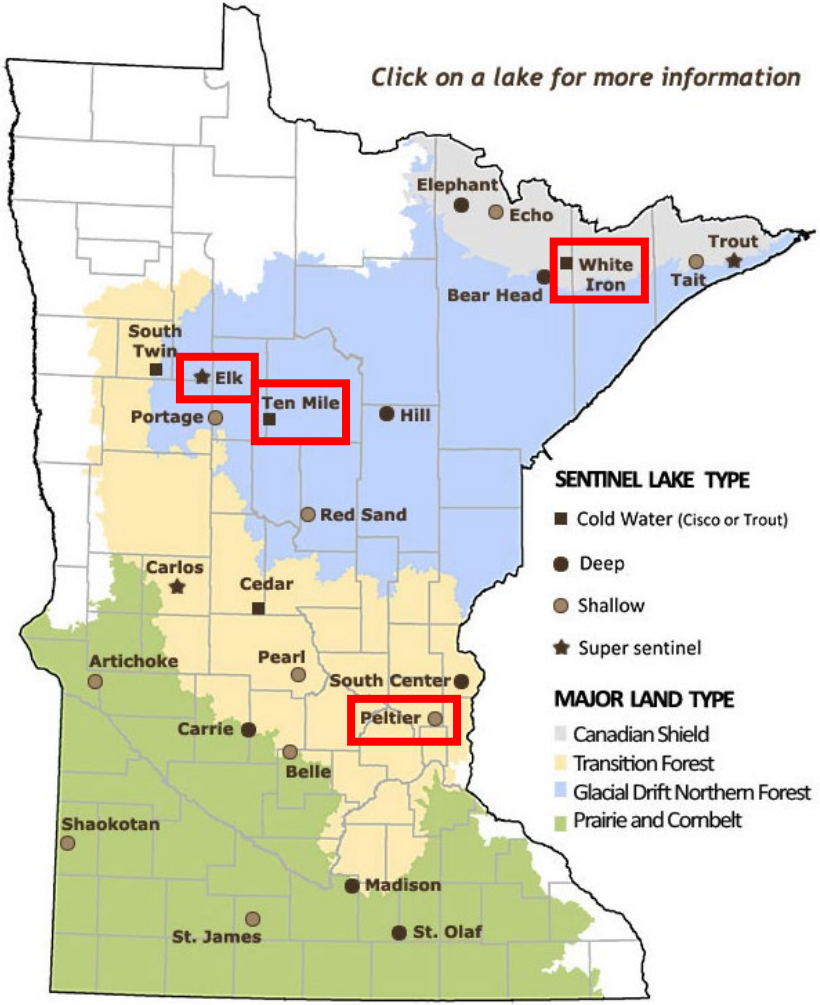
water

sediment

fish

Sentinel lakes



Questions?

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