

Quantifying and characterizing plastic pollution in the ocean: a focus on textile sources

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Center for Marine
Debris Research

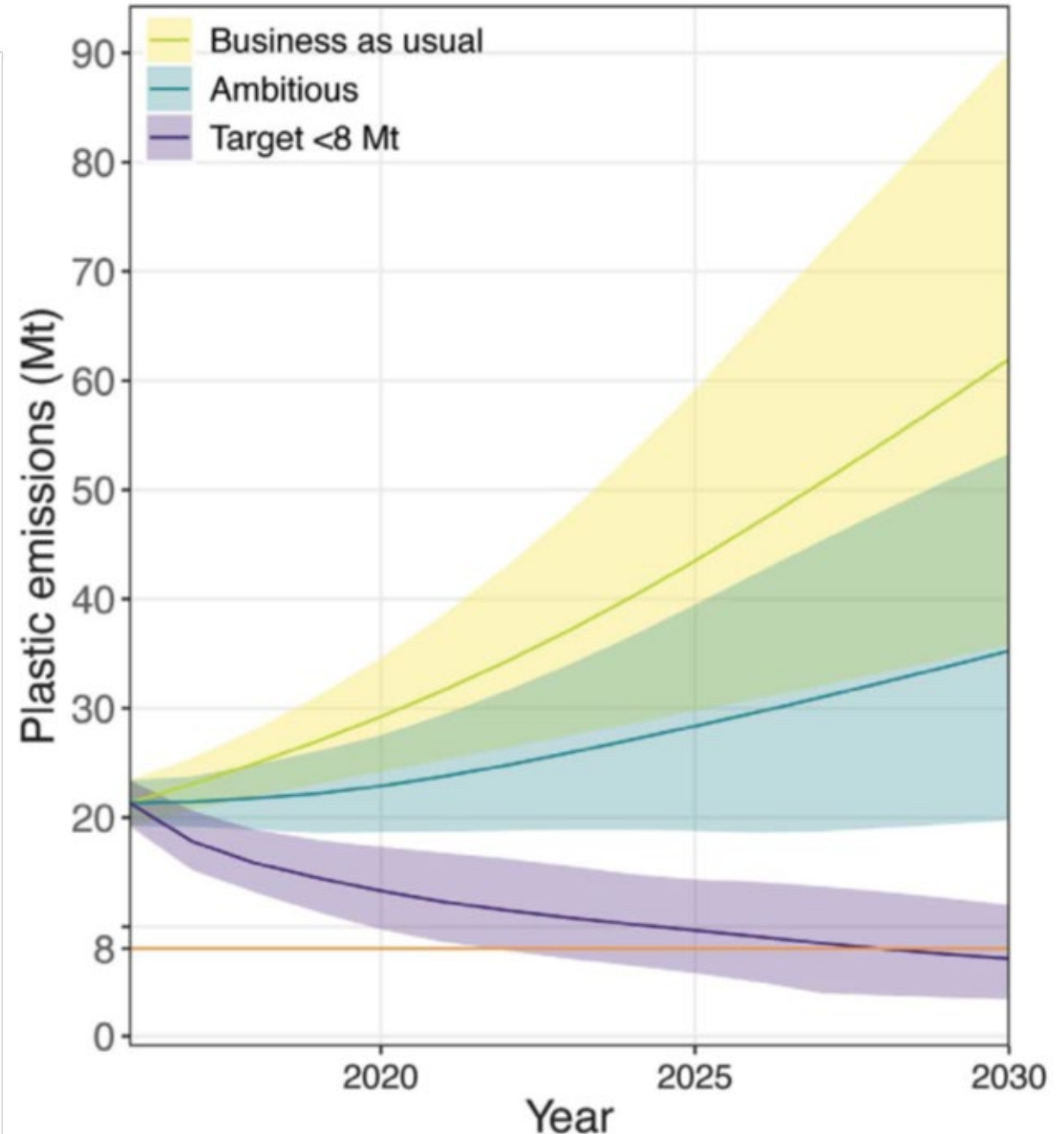
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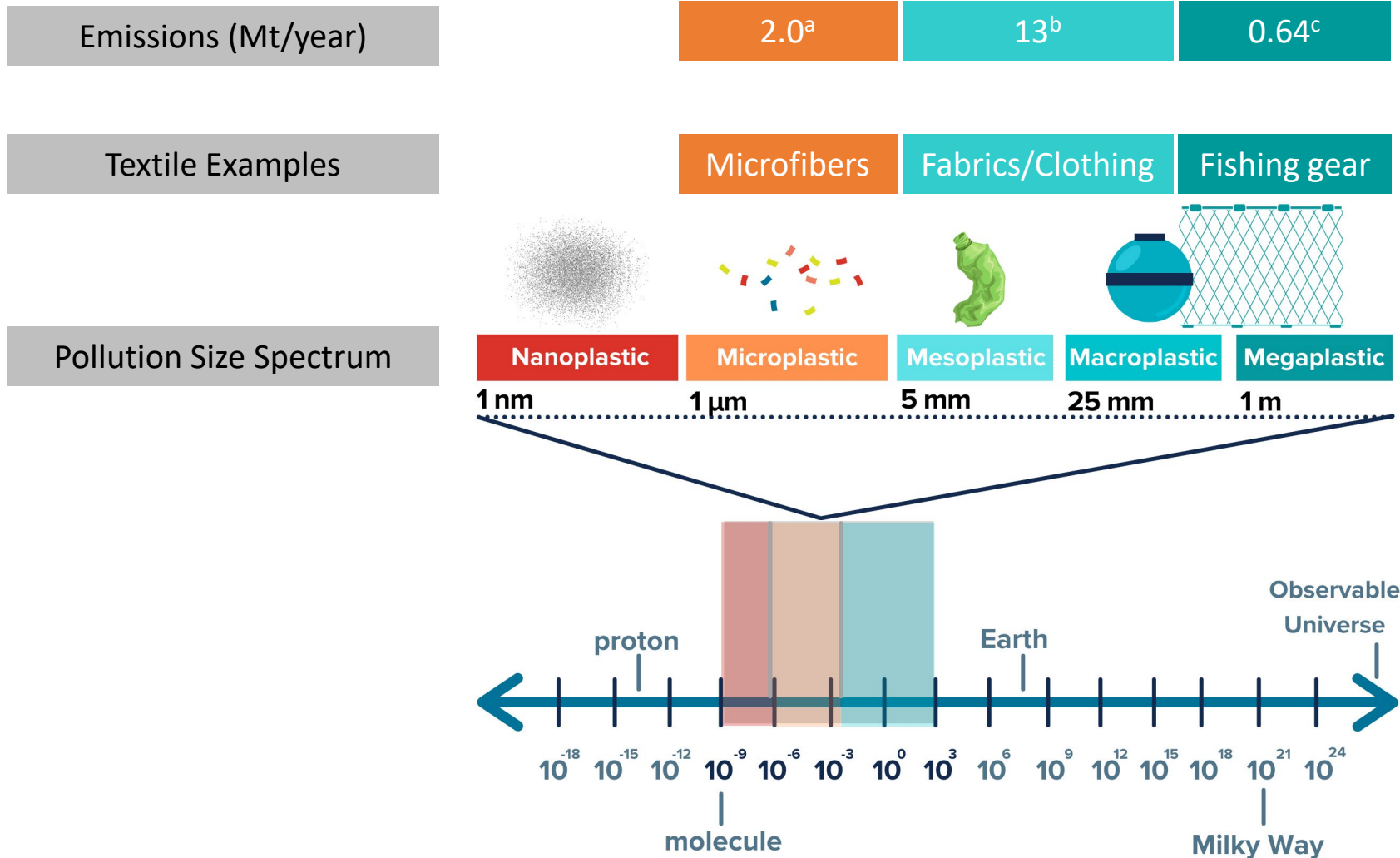
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Plastic Pollution

- 20-30 Mt of plastic waste enters waters/year (Borrell et al 2020)
- Add 2 to 2.9 Mt for synthetic microfibers (Gavigan et al 2020; Boucher and Friot 2017)



Plastic Pollution from Textiles



^aBoucher and Friot 2017

^bMishra et al 2019

^cMacfayden et al 2009

Microfiber Magnitude

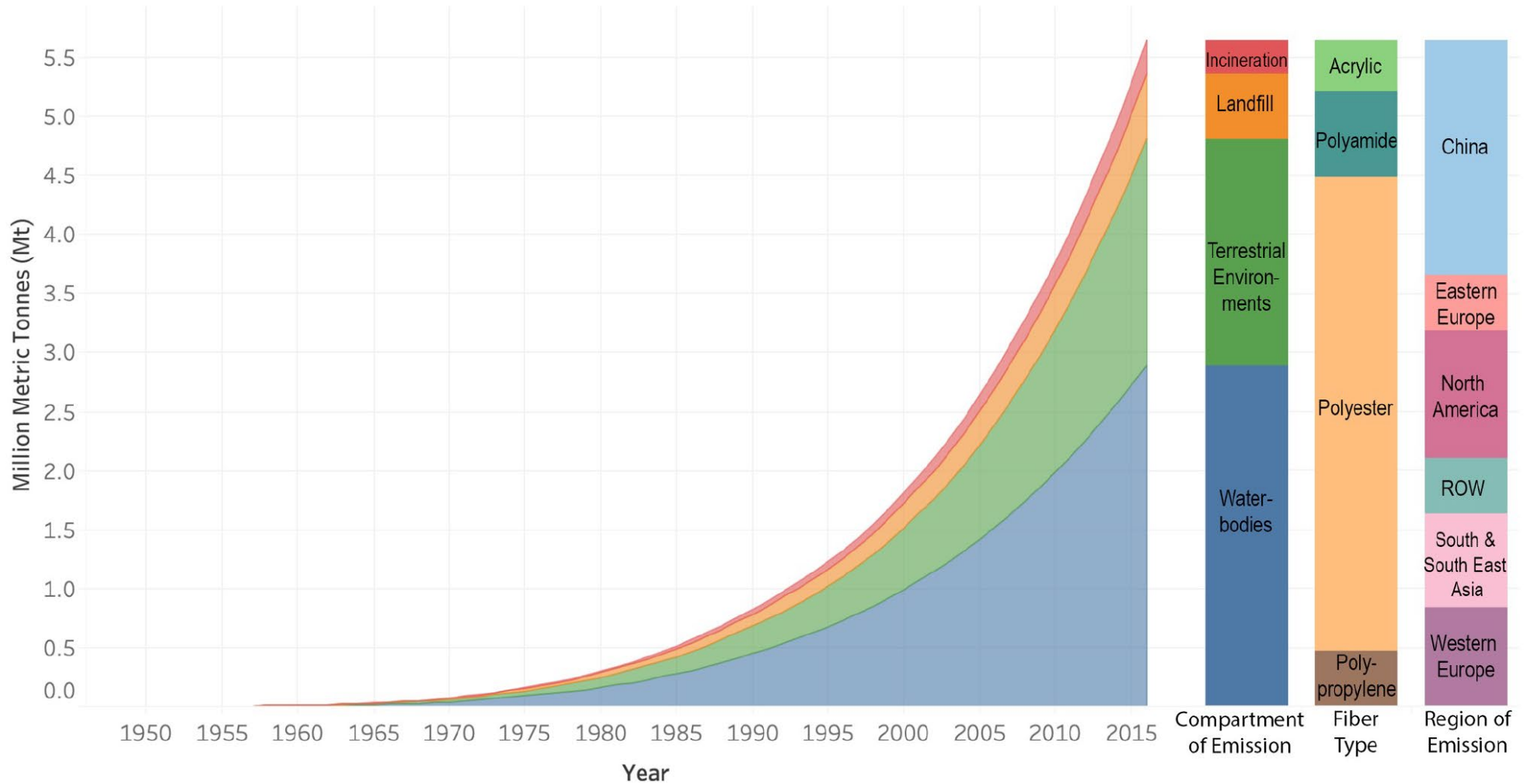
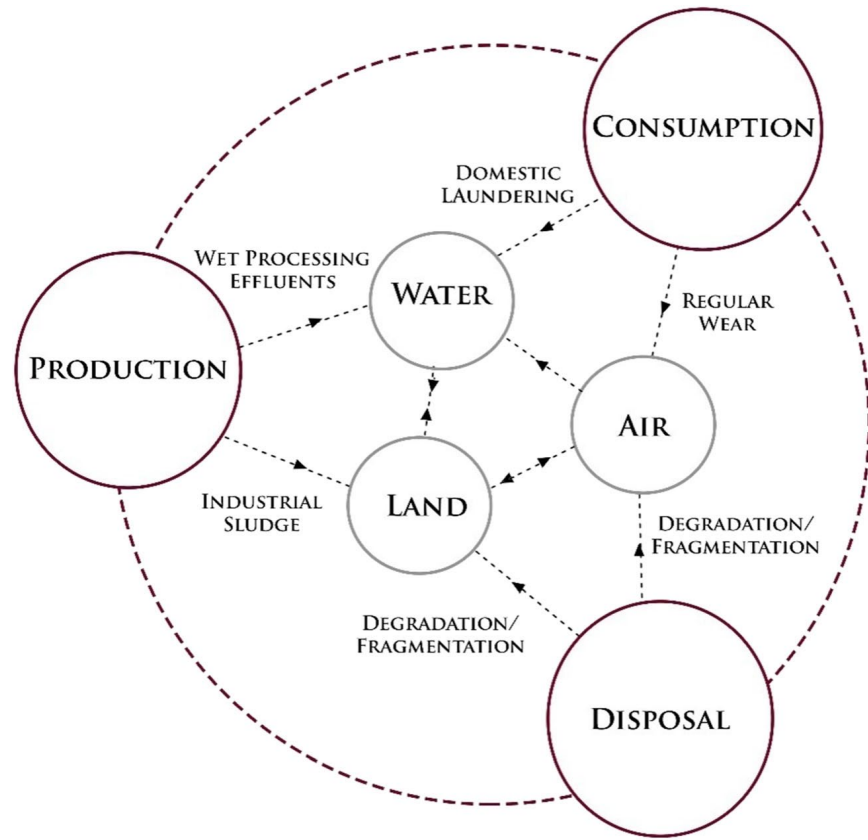


Fig 1. Cumulative microfiber emissions from 1950 to 2016. The right columns describe compartmental, compositional, and regional characteristics of the cumulative mass of microfiber emitted by 2016.

Sources of Microfibers



Ramasamy and Subramanian 2021



Browne et al 2011



Fishing gear = PE, nylon, PP fibers

Environmental Impact

“Throwaway” Fashion

Fashion is one of the most polluting industries in the world, in terms of both its large production and the nonbiodegradable waste it leaves behind (Brodde 2017).

“Plastic microfibers are considered one of the dominant forms of microplastic pollution (particles < 5 mm) in the world’s oceans... with evidence pointing to textiles as a potentially important source.” Vassilenko et al 2021

5 trillion microfiber particles circulate in marine surface waters (Smith et al 2018)

No location exposed to the Earth's atmosphere or waters has escaped microfiber pollution. Mishra et al 2019

Zooplankton, coral, fish, crabs, mussels, whales, and many others ingest microplastics directly (Cauwenberghe and Janssen, 2014).

Humans may be impacted by inhalation and consumption (25, 26). Microfiber inhalation may cause lung inflammation, but human health impacts are not well understood (27).

Studies observing adverse effects of microfibers are more numerous than studies not showing an effect [4]. Kapp and Miller 2020

“Adverse effects may include entanglement of feeding appendages, gut blockage and malnutrition in zooplankton or lower levels of the food web” Vassilenko et al 2021

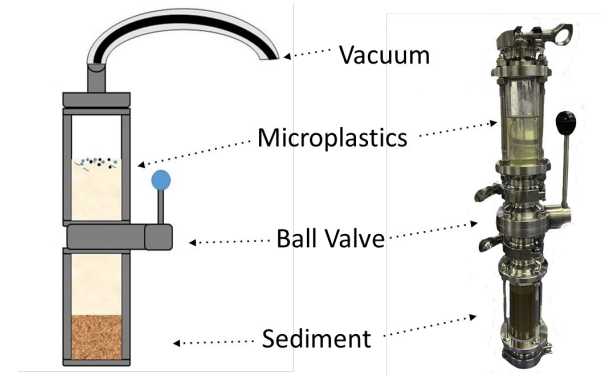
Organisms are harmed through “decreased feeding ability, abnormal reproduction, decreased nutrition, and poorer health. Liver toxicity in fish, decreased reproductive potential in oysters, and decreased survival and predator aversion ability in beach hoppers (Sussarellu et al., 2016;Tosetto et al., 2016).” Mishra et al 2019

Methods to Quantify & Characterize

1. Larval Fish Guts



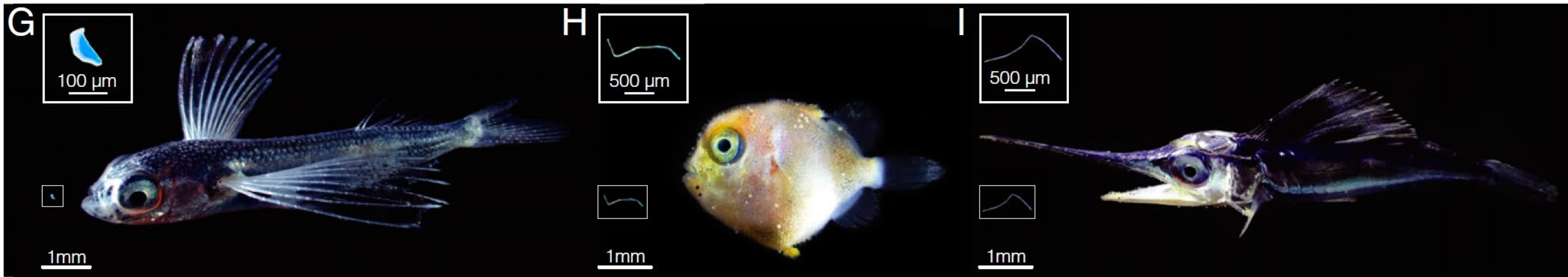
2. Deep-Sea Sediment



3. Mega-sized Derelict Fishing Gear



Larval Fish Guts

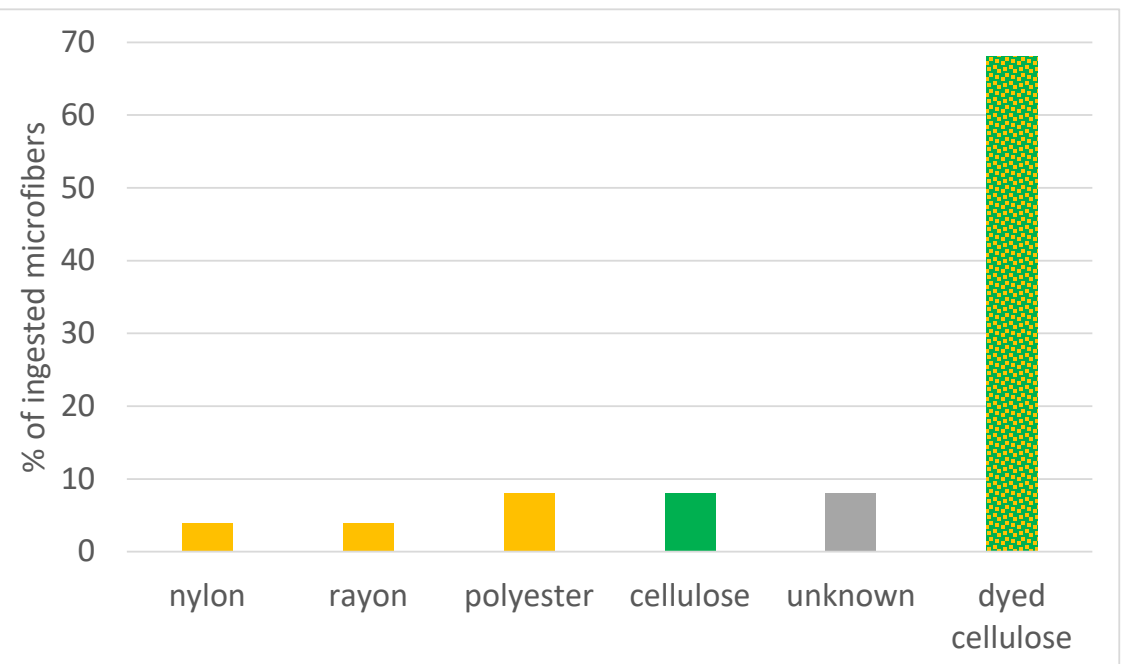


- 658 micro-dissections – 6.3 % had ingested polymers
- 42 pieces – 93% were microfibers
- 25 microfibers analyzed by ATR FT-IR and/or Raman microscopy

Prey-size plastics are invading larval fish nurseries

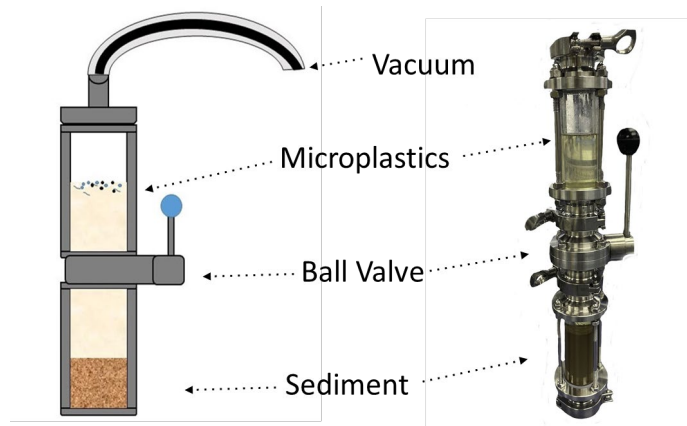
Jamison M. Gove^{a,1,2}, Jonathan L. Whitney^{a,b,2}, Margaret A. McManus^c, Joey Lecky^{a,d}, Felipe C. Carvalho^a, Jennifer M. Lynch^{e,f}, Jiwei Li^g, Philipp Neubauer^h, Katharine A. Smith^{b,c}, Jana E. Phipps^{a,b}, Donald R. Kobayashi^a, Karla B. Balagso^a, Emily A. Contreras^{a,b}, Mark E. Manuel^{i,j}, Mark A. Merrifield^k, Jeffrey J. Polovina^a, Gregory P. Asner^g, Jeffrey A. Maynard^l, and Gareth J. Williams^m

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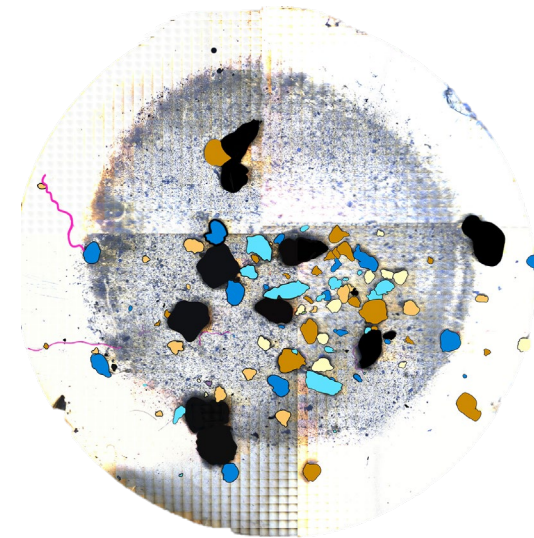


Deep-Sea Sediment

Novel Density Separation Device



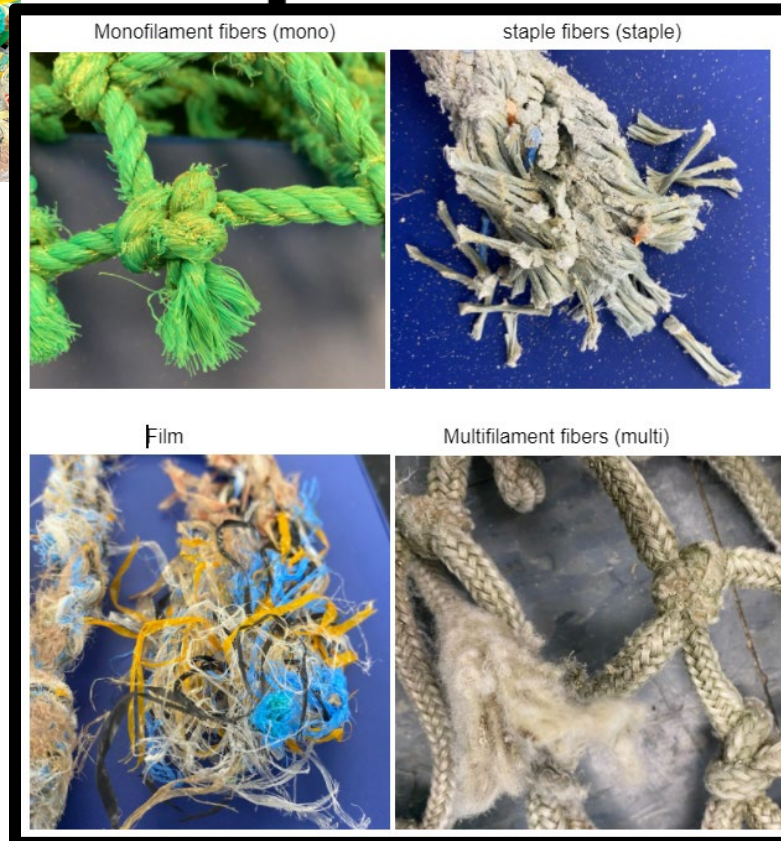
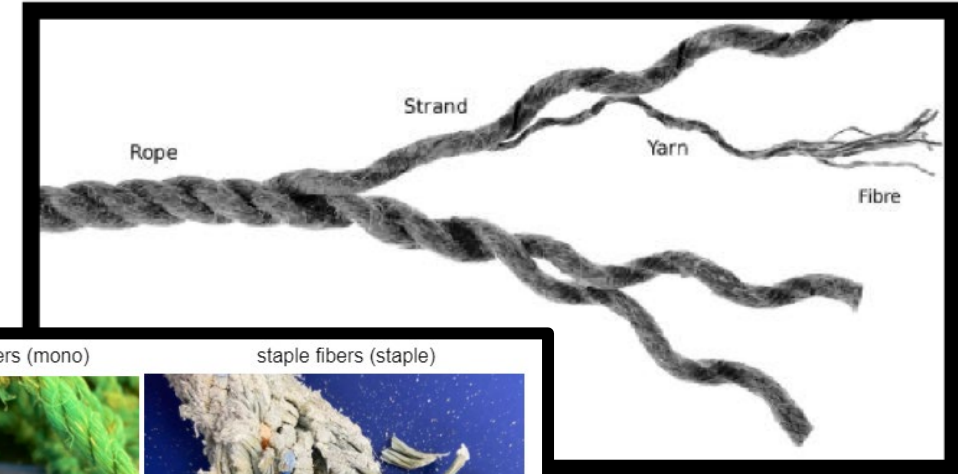
Automated micro-FTIR



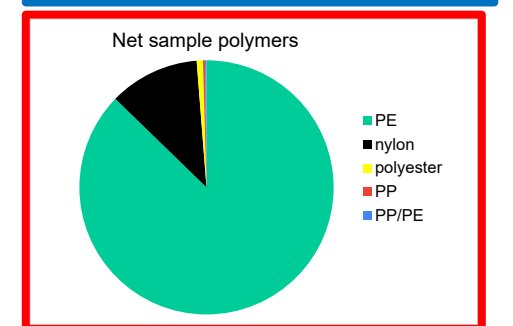
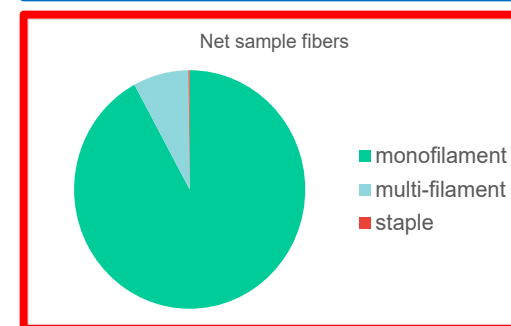
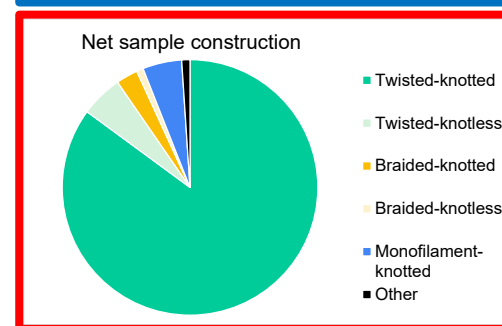
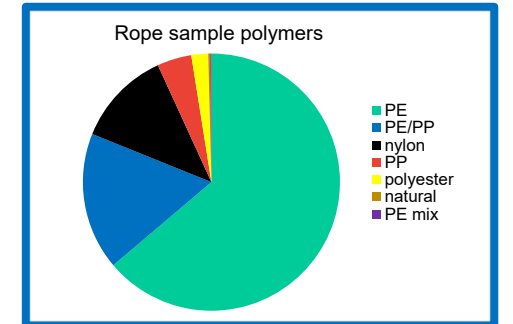
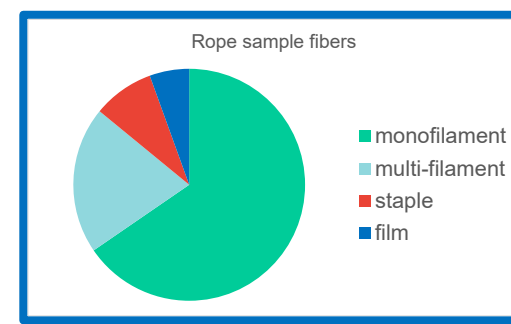
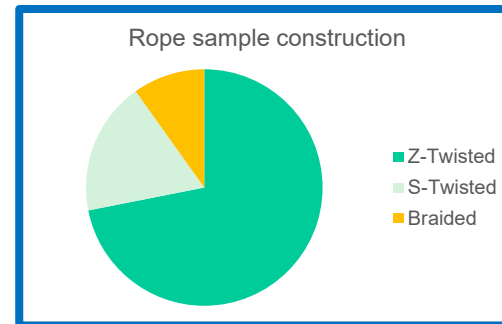
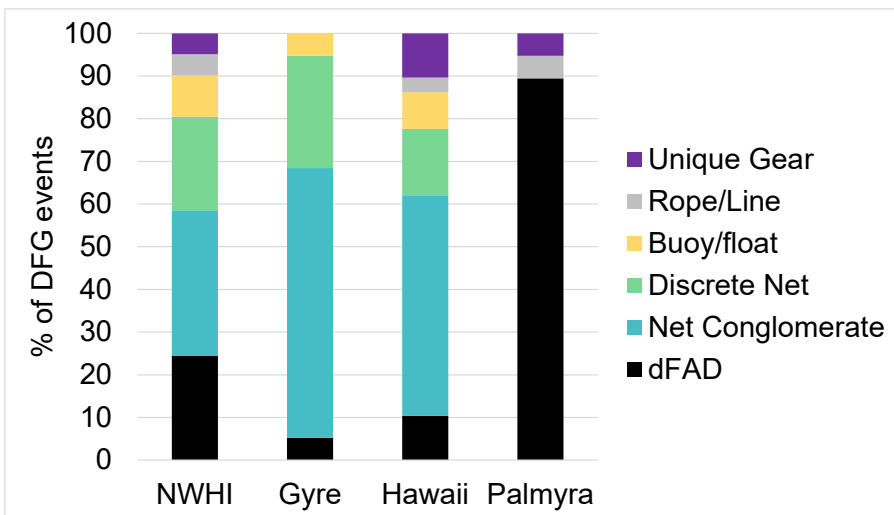
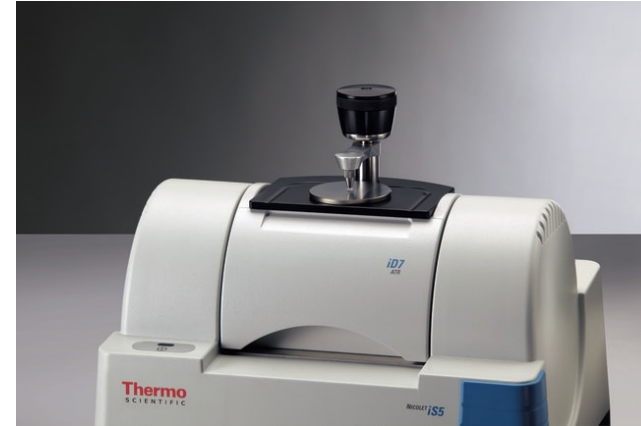
- Polyester
- PVC
- HDPE
- Polystyrene
- Polypropylene
- Nylon
- Crumb Rubber
- Cellulose Acetate

Polymer	% Recovery	
	Shaw et al. in prep.	Cashman et al. 2020 (silt)
PP	84 ± 23 %	40 ± 29 %
HDPE	95 ± 14 %	34 ± 29 %
Cellulose Acetate	34 ± 8 %	-
Polyester	66 ± 45 %	23 ± 25 %

Derelict Fishing Gear



Derelict Fishing Gear



Conclusions

- Textiles are a major source of microfibers to the environment
- Anthropogenic microfibers contaminate the entire globe, including our air, water, food, and bodies
- Testing standards are missing for microfiber pollution
- Environmental monitoring may detect the successes or failures of societal changes



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