CALIFORNIA
Water Boards
STATE WATER RESOURCES CONTROL BOARD
REGIONAL WATER QUALITY CONTROL BOARDS

Microplastics in Drinking Water: California's Regulatory Actions

National Environmental Monitoring Conference
August 5, 2020

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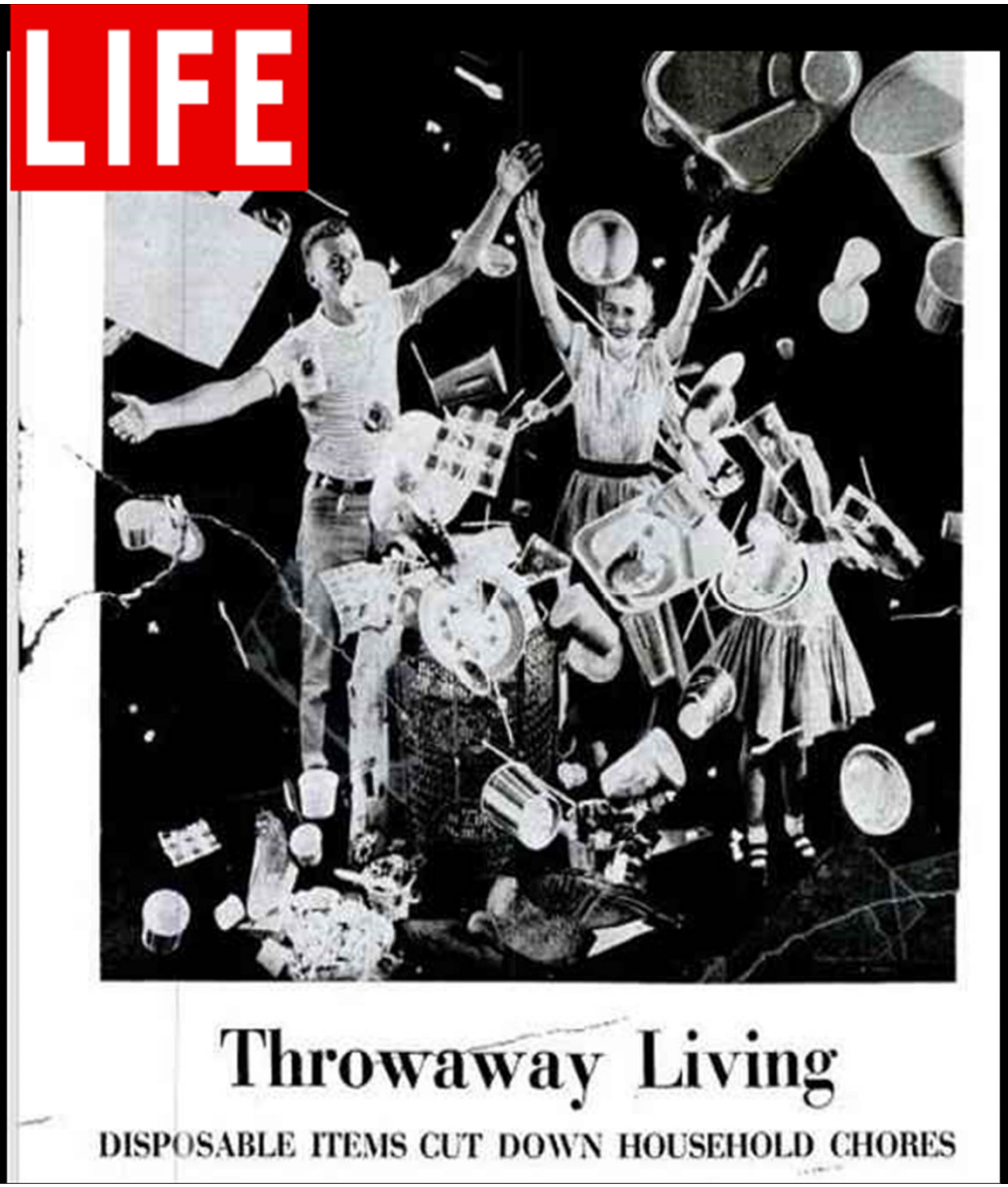
Photo: Mandy Barker


PHOTO BY GREG

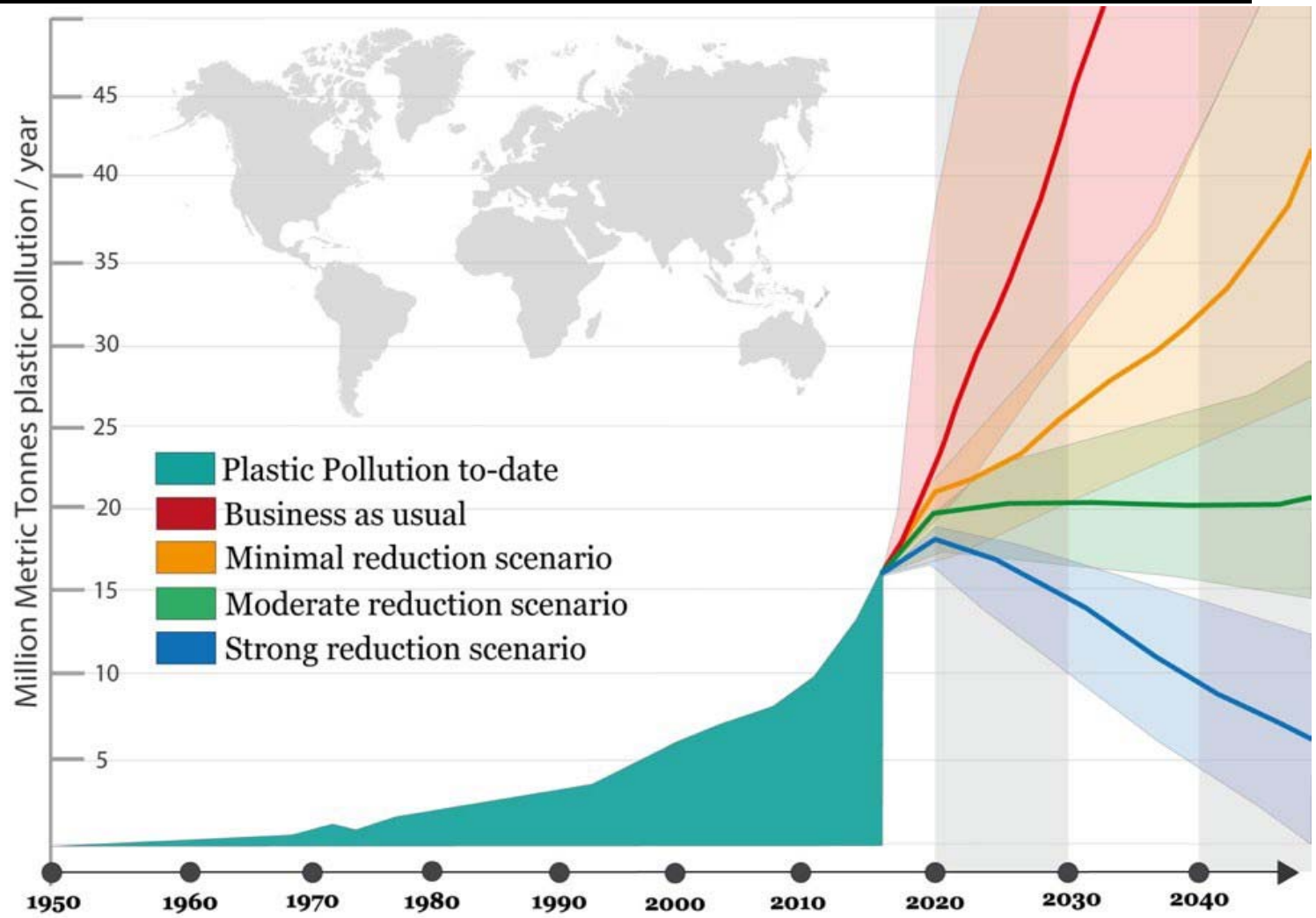
Photo:
LIFE magazine (1955)



Plastic Generation *may* **Double** by 2030

Figure and projections from Lebreton and Andrady (2019), *Palgrave Communications*

Data from Geyer et. al, *Science Advances* 2017



Plastic fragments in environment

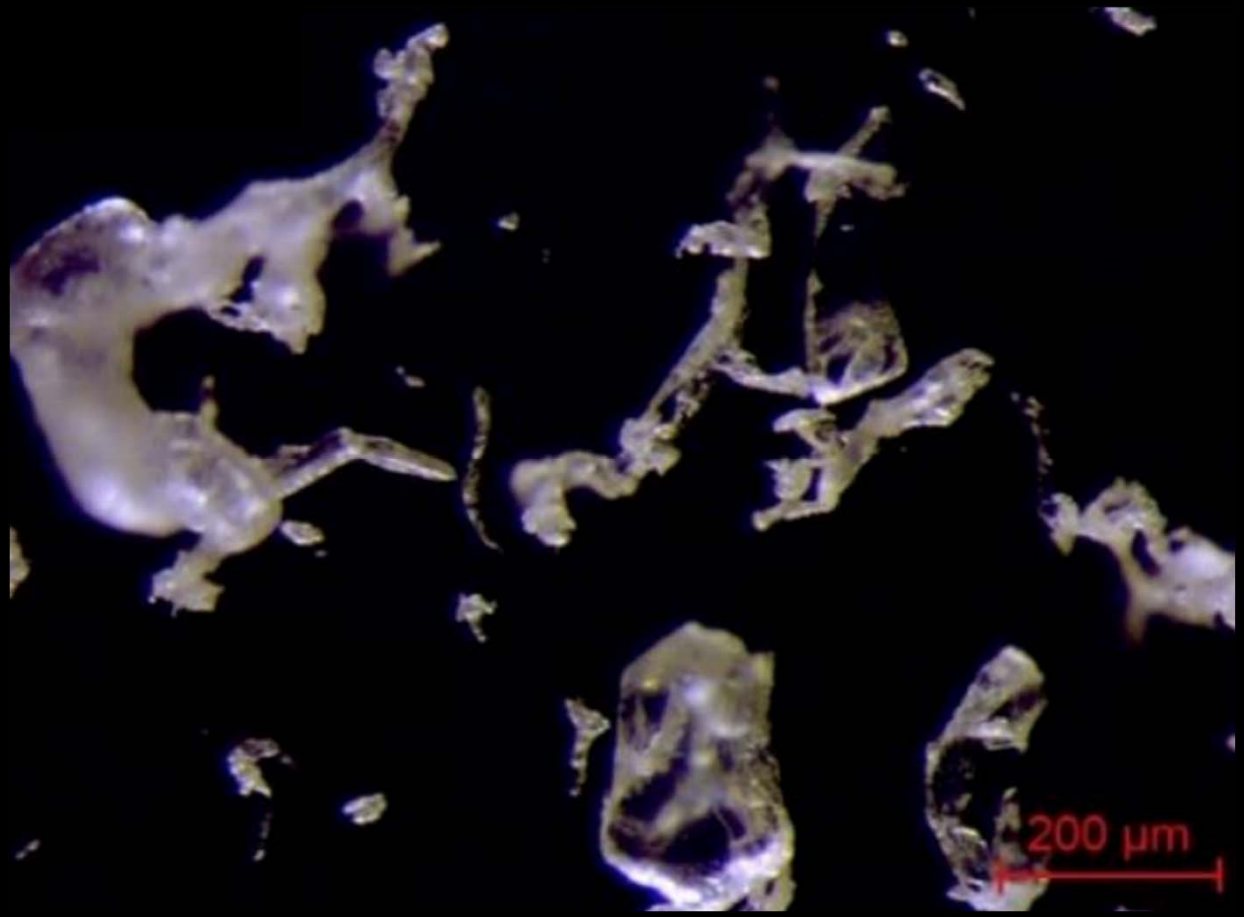


Figure from Hepsø , *Environmental Science & Technology,* 2018.

Polyethylene mechanically weathered with sand for 80 days. Optical light microscopy image.

Plastic breaks down and enters surface water

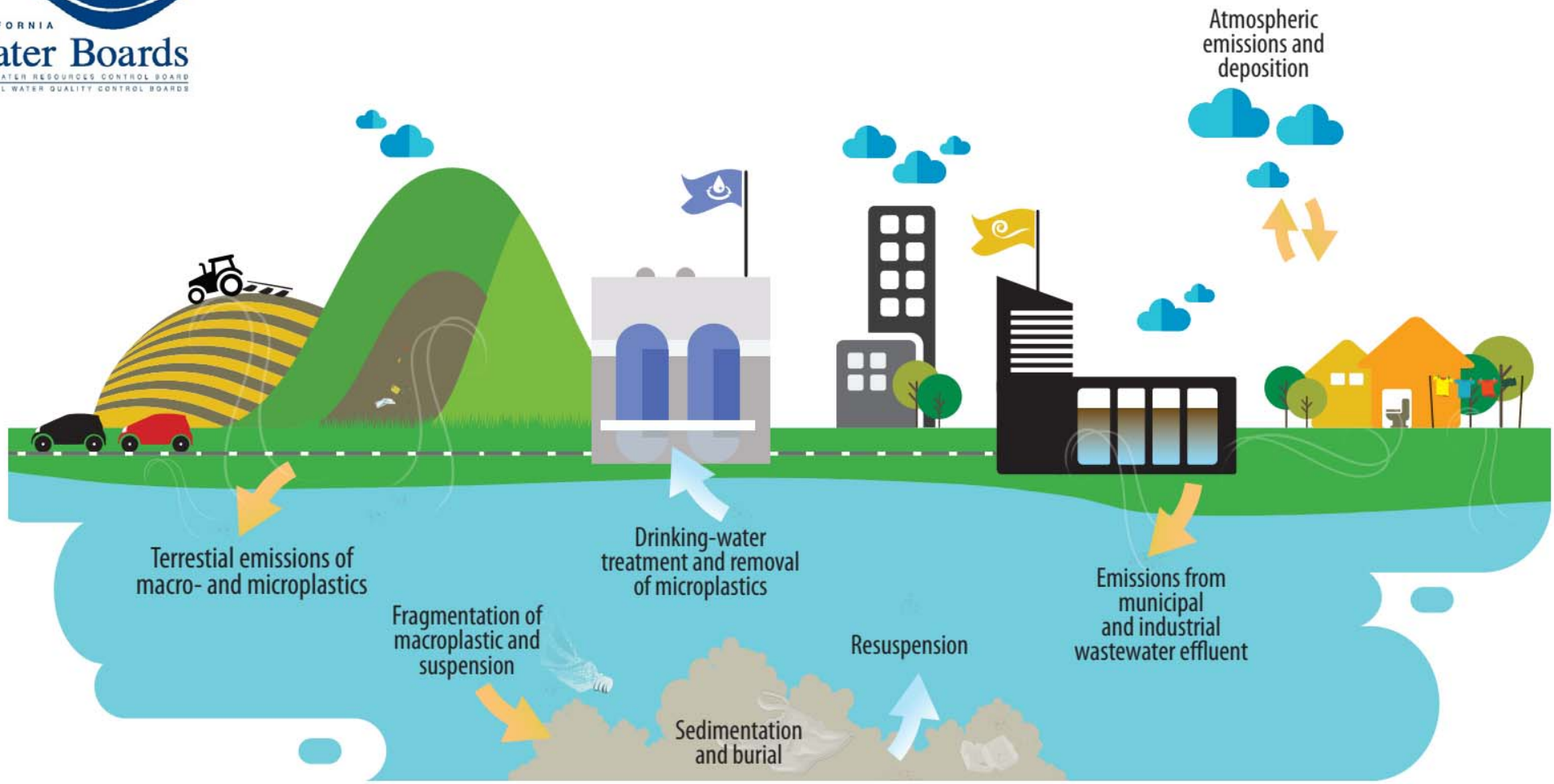


Figure from *World Health Organization* (2019)

Wind and Rain transport Microplastics

- <6 percent of dust in re mote areas are micropl astics
- > 1,000 metric tons are deposited in Western N ational Parks yearly fro m aeolian transport.

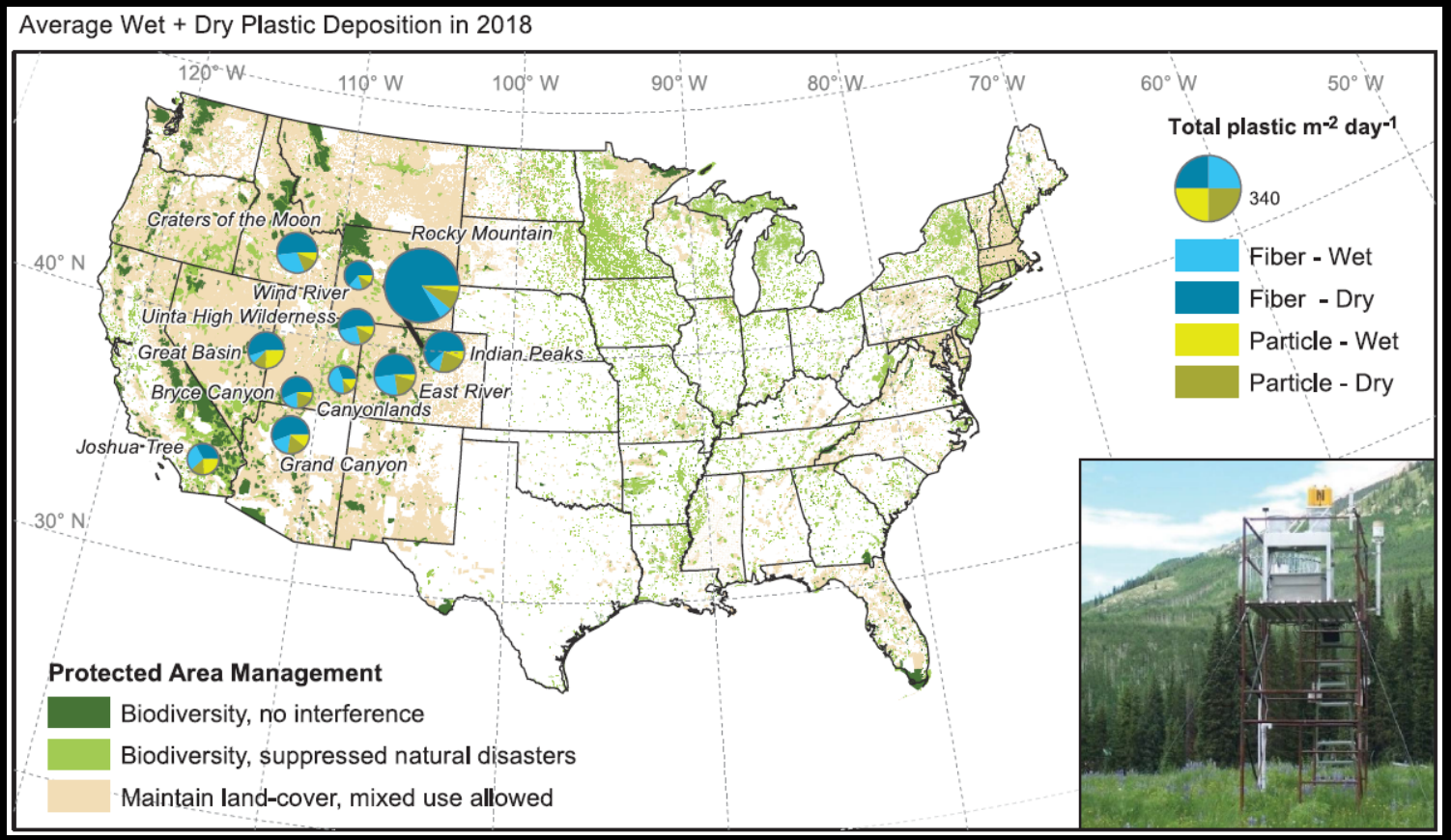


Figure and data from Brahney et al. (2020). *Science*

California Senate Bill 1422 (2018): Microplastics in Drinking Water

CALIFORNIA Water Boards
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Deadlines

July 1,2020

- State Water Board must define ‘micr oplastics in drinking water’

July 1,2021

- Adopt standard analytical method(s)
- Adopt requirements for four years of te sting and public disclosure of results
- Consider issuing a notification level or o ther guidance
- Accredit qualified laboratories (ELAP)

California Senate Bill 1263 (2018): Statewide Microplastics Strategy

Deadlines

December 31, 2021

- Initiate Statewide Microplastics Strategy

December 31, 2025

- Develop **risk assessment** framework
- Develop standardized **methods**
- Establish baseline **occurrence** data
- Investigate **sources** and **pathways**
- Recommend **source reduction** strategies

The Road to Defining 'Microplastics'

- **November, 2019- February, 2020:** Definition drafting
- **February, 2020**: Independent expert peer review
- **March 24 - April 24:** 30-day Public Comment Period
- **April 7, 2020:** Staff Workshop at State Water Board
- **June 16, 2020:** State Water Board Adopts Definition

Microplastics is a *Diverse* Contaminant Suite

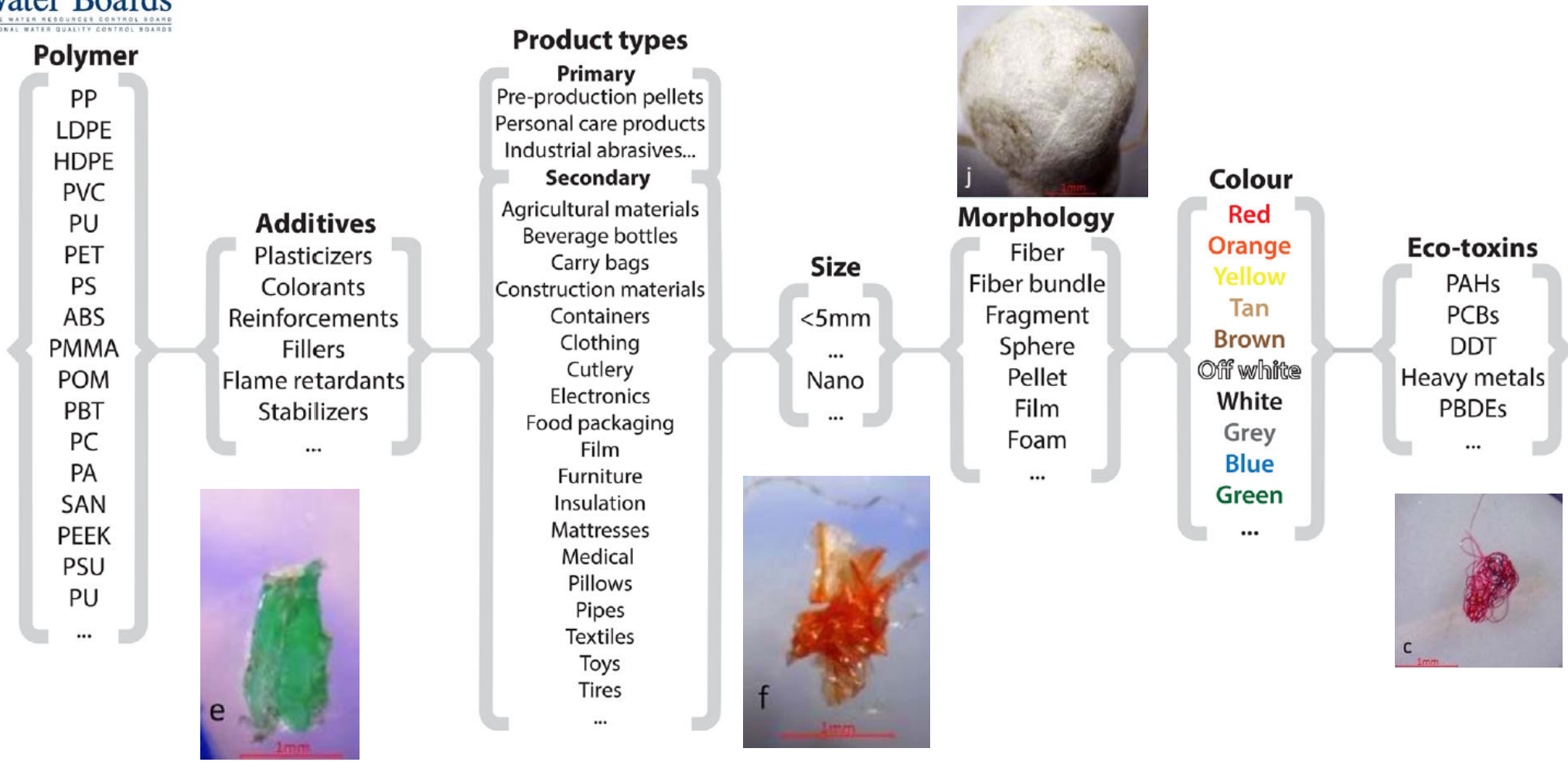


Figure from Rochman, et al. *Environmental toxicology and chemistry* (2019)

Towards a Consensus on Size

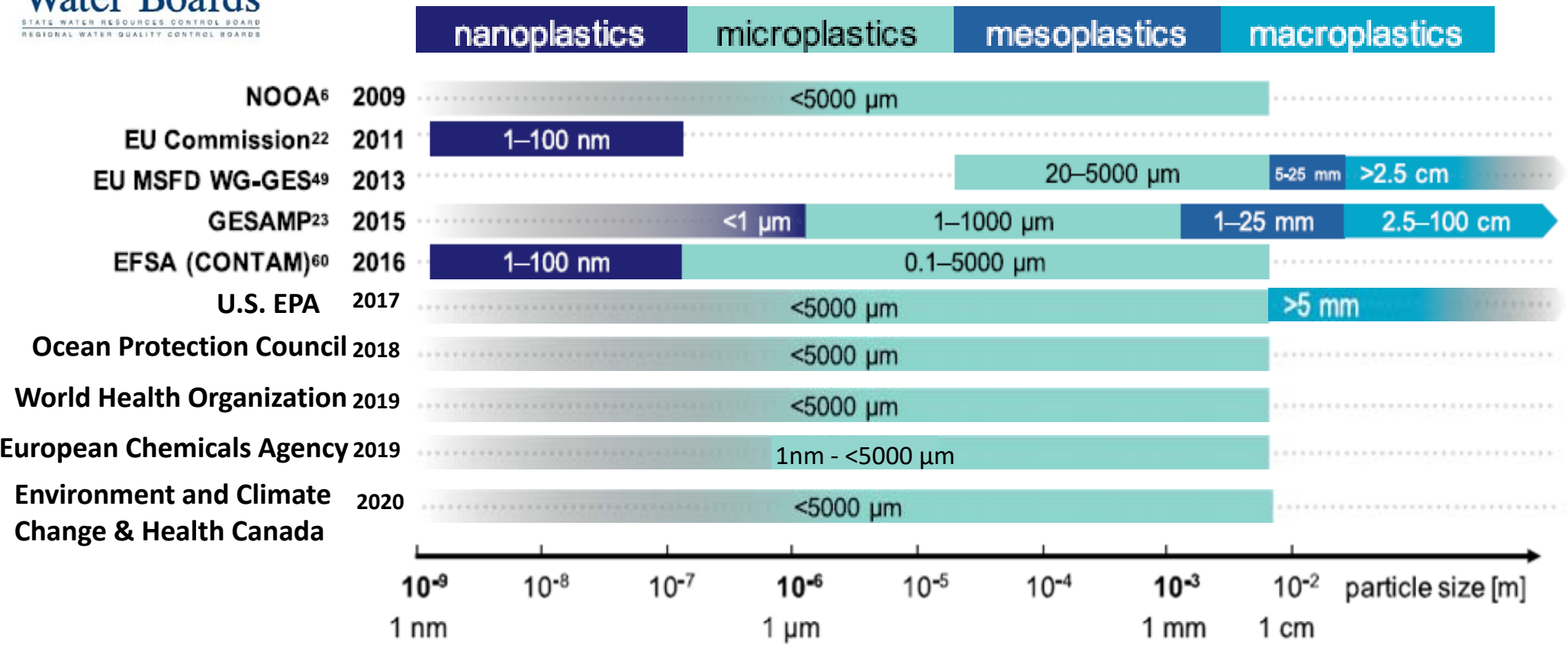


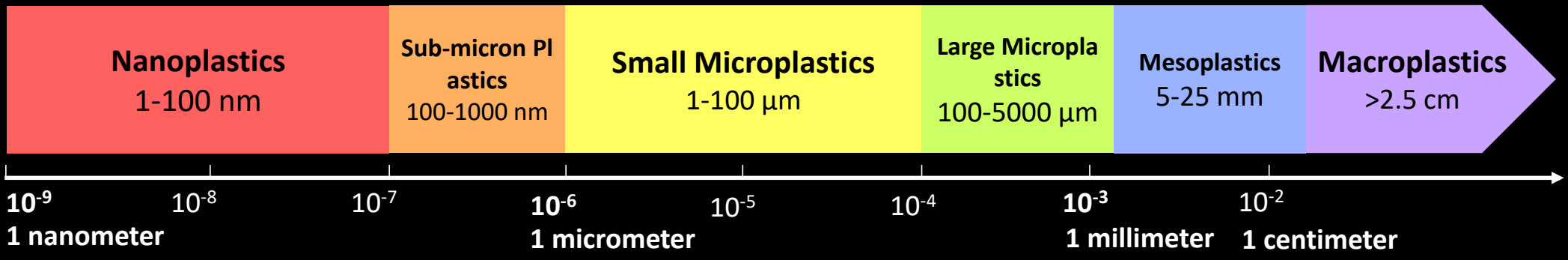
Figure adapted from Hartmann et al. (2019), *ES&T*

Official Adopted definition (June 6, 2020) 'Microplastics in Drinking Water'

'solid polymeric materials to which chemical additives or other substances may have been added, which are particles which have at least three dimensions that are greater than 1 nanometer and less than 5,000 micrometers.

Polymers that are derived in nature that have not been chemically modified (other than by hydrolysis) are excluded.'

Size-Based Classification



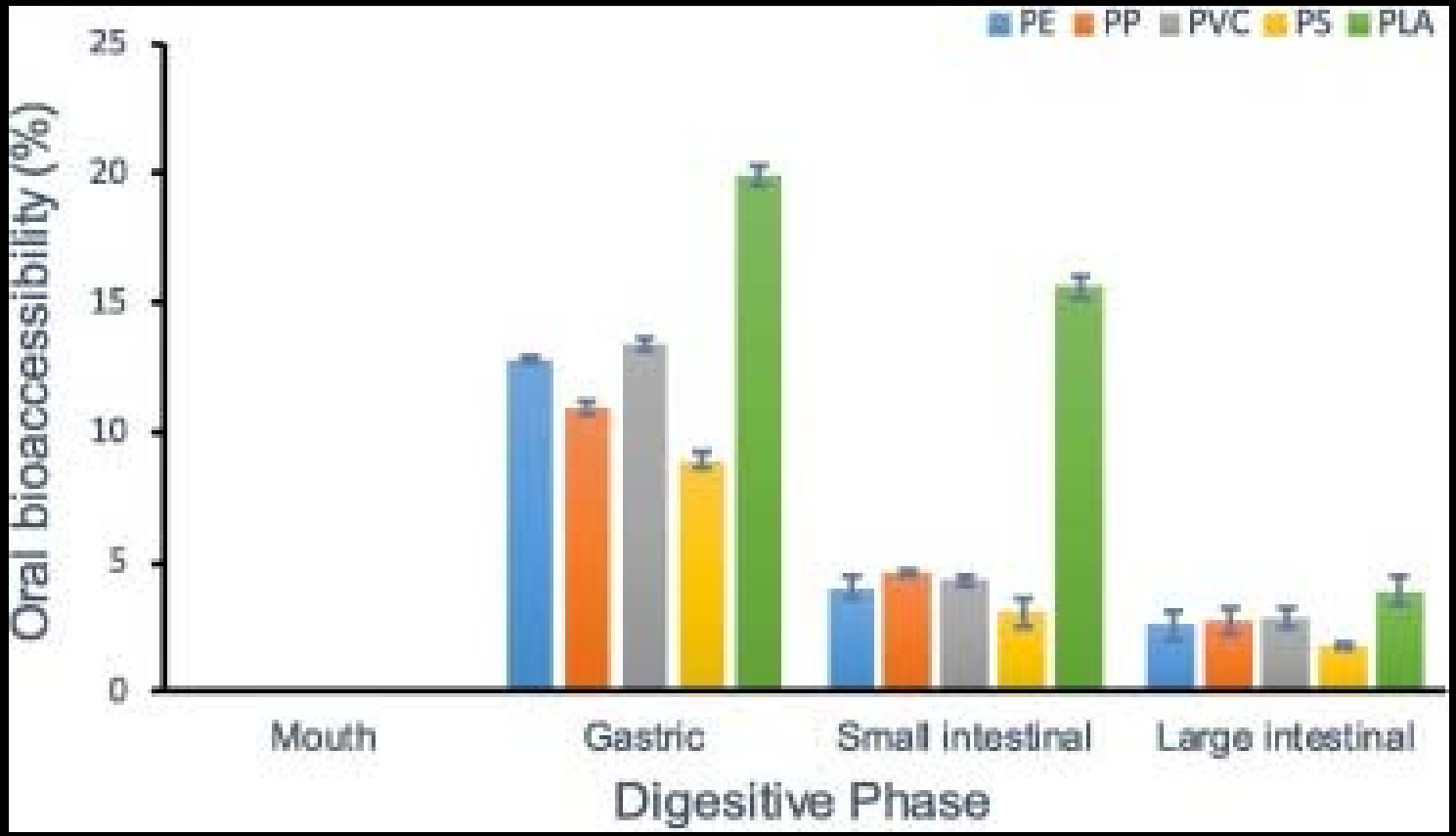
European Definition: Excludes Biodegradables

'solid polymeric materials to which chemical additives or other substances may have been added, which are particles which have at least three dimensions that are greater than 1 nanometer and less than 5,000 micrometers.

Polymers that are derived in nature that have not been chemically modified (other than by hydrolysis) are excluded, as are polymers that are (bio)degradable."[1]

[1]European Chemicals Agency (2019). "Annex XV Restriction Report Proposal for a Restriction: Intentionally Added Microplastics. Version 1.2

Biodegradable Microplastics: No Evidence of Safety



Liao and Yang (2020), *Science of the Total Environment*

PLA (Polylactic Acid)

Hexavalent chromium **more bioaccessible** from **biodegradable polymer polylactic acid (PLA)** in simulated human gut than 'traditional' polymers (polyethylene, polypropylene, polyvinyl chloride, polystyrene) [1]

Polymers included in Adopted Definition 'Microplastics in Drinking Water'

Derived monomer or physical constituent	Examples
Petroleum-derived	**polyethylene**, polypropylene, polyurethane, polyethylene terephthalate, polystyrene, polyvinyl chloride (PVC), polyester
Non-petroleum biologically derived chemicals	**bio-polyethylene terephthalate**, bio-polyethylene, polylactic acid, polyhydroxyalkanoates
Inorganic or inorganic-organic hybrid polymers	elastomers such as **silicone**
Chemically modified natural polymers	Polymer-grafted cotton/wool, **cellulose acetate**
Chemically modified natural rubber	**Tire wear particles**
Chemically modified cellulose	**cellophane**
Copolymers	**acrylonitrile-butadiene-styrene [ABS]**, ethylene-vinyl acetate [EVA], styrene-butadiene rubber [SBR]
Polymer composites	**nylon**, glass fiber-reinforced polyester, graphite reinforced epoxy, cotton/wool-polyester **textile blends**

Method Development and Standardization

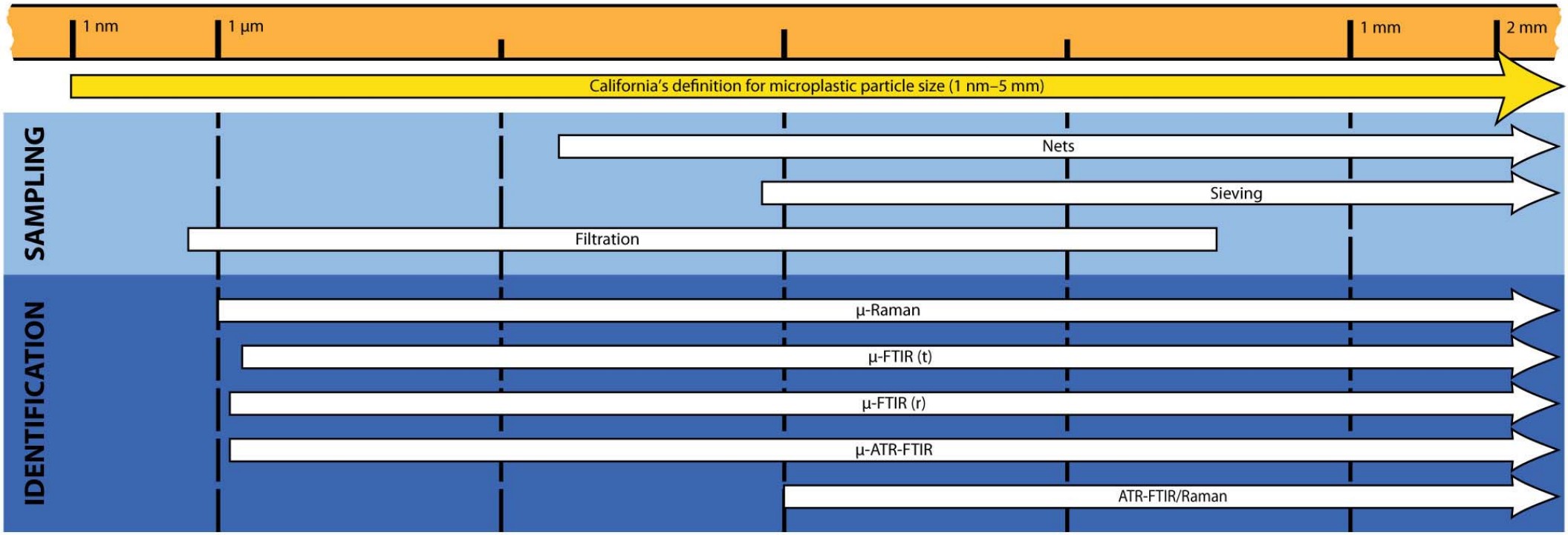
- >35 laboratory participants in 7 countries
- Workshop Report-Out**: October 6, 2020 (afternoon)**
- The Southern California Coastal Water Research Project (SCCWRP)

- **Matrices**: Drinking water, 'dirty water,' fish tissue, sediment





Method Development: Sizes and Instruments



LEGEND

µ-Raman	Raman microscopy
µ-FTIR (t)	Fourier-transform infrared spectroscopy microscopy in transmission mode
µ-FTIR (r)	Fourier-transform infrared spectroscopy microscopy in reflection mode
µ ATR-FTIR	Micro attenuated total reflection Fourier transformation infrared spectroscopy
ATR-FTIR/Ramen	Attenuated total reflection Fourier-transform infrared spectroscopy

Smaller Sizes More Difficult to Measure

Lower detection size limit for most labs: **20-100 µm** (µ FTIR)

Majority of labs use ATR-FTIR lower detection size limit: 330-333 **µm**

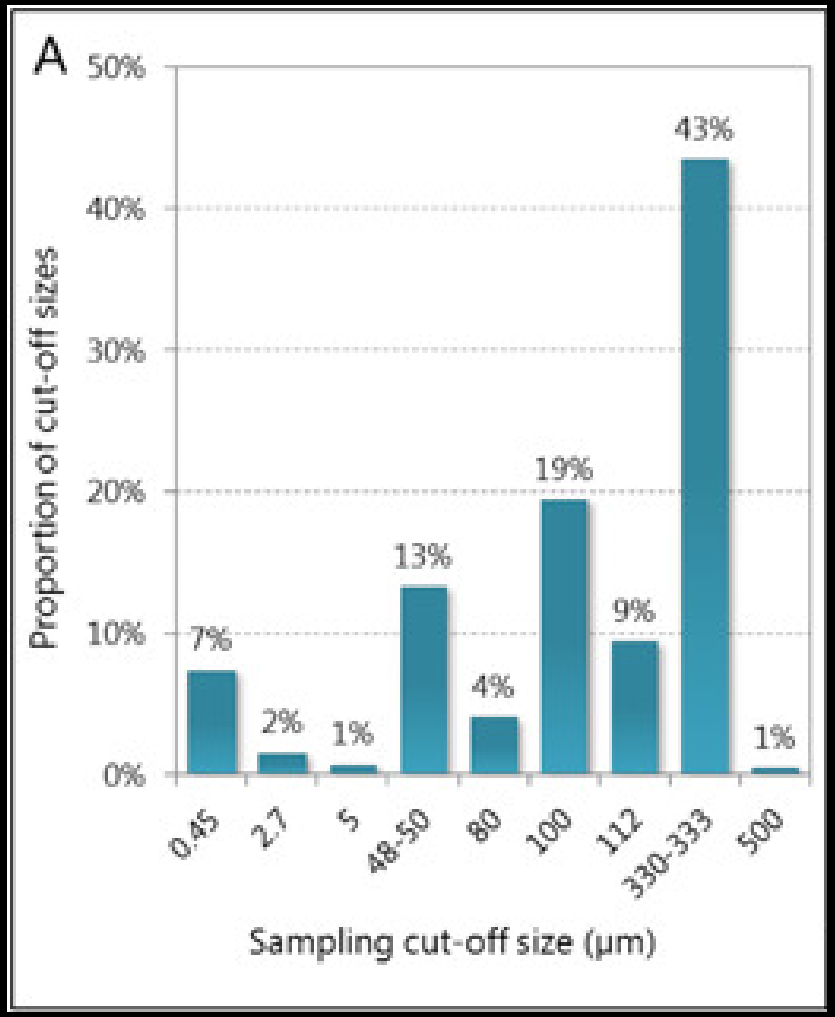


Figure and Data from Adam et al. (2018). *Environmental Toxicology and Chemistry*

Senate Bill 1422 (2018): Microplastics in Drinking Water

Deadline

July 1,2021

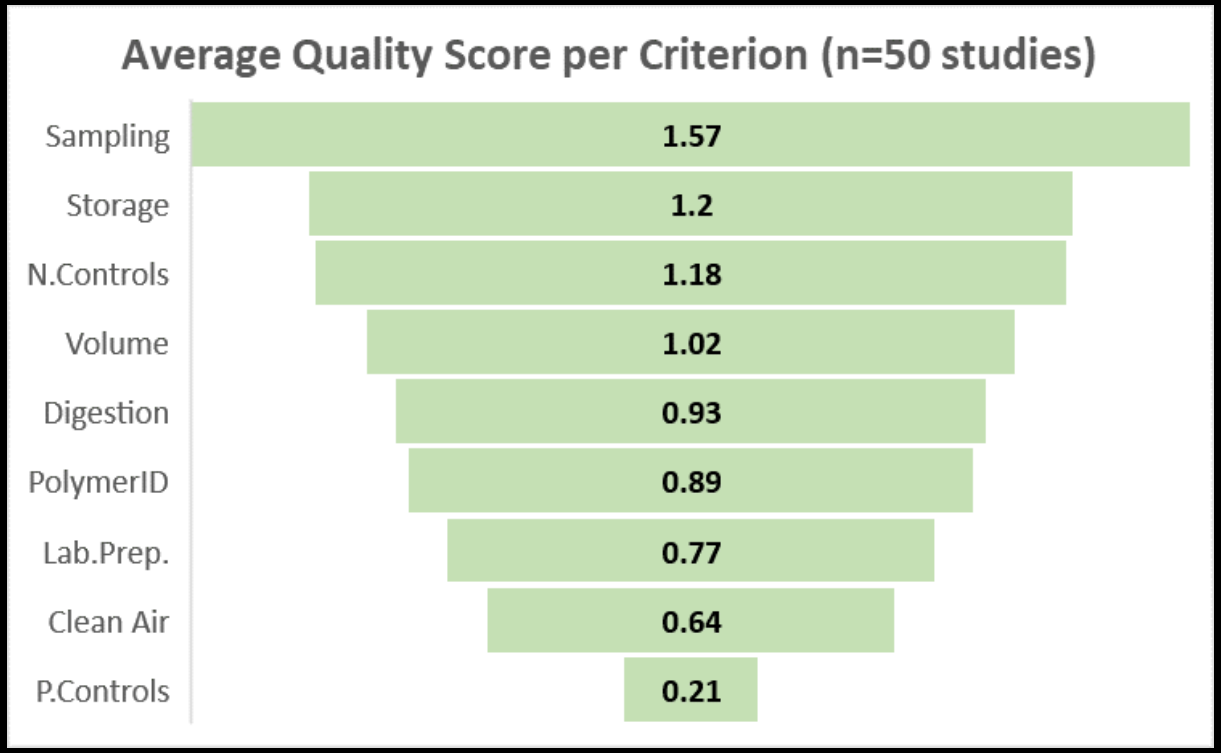
- **Provide accreditation for** qualified laboratories

- Available to commercial labs everywhere
- **Quality Assurance** will be critically assessed (i.e. clean labs)
- **Proficiency Testing (PT)** samples will be utilized (still looking for vendors)

Drinking Water Microplastics Studies Vary in Quality

Quality of Drinking Water Monit oring Studies assessed for World Health Organization (2019)

- Based on lit. review “best practices”
- Studies quantitatively assessed base d on set criteria (2, 1, 0 points)



Koelmans et al. (2019), *Water Research*.

Senate Bill 1422 (2018): Microplastics in Drinking Water

Deadline
July 1,2021

- Consider issuing a **notification level** or other health-based guidance level

Notification level = health-based advisory level established by the State Water Board for chemicals in drinking water that lack maximum contaminant levels (MCLs). Requires timely notification if exceeded.


Are humans
at risk of
from
microplastic?

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Hazard ✕ **Exposure** = **Risk**

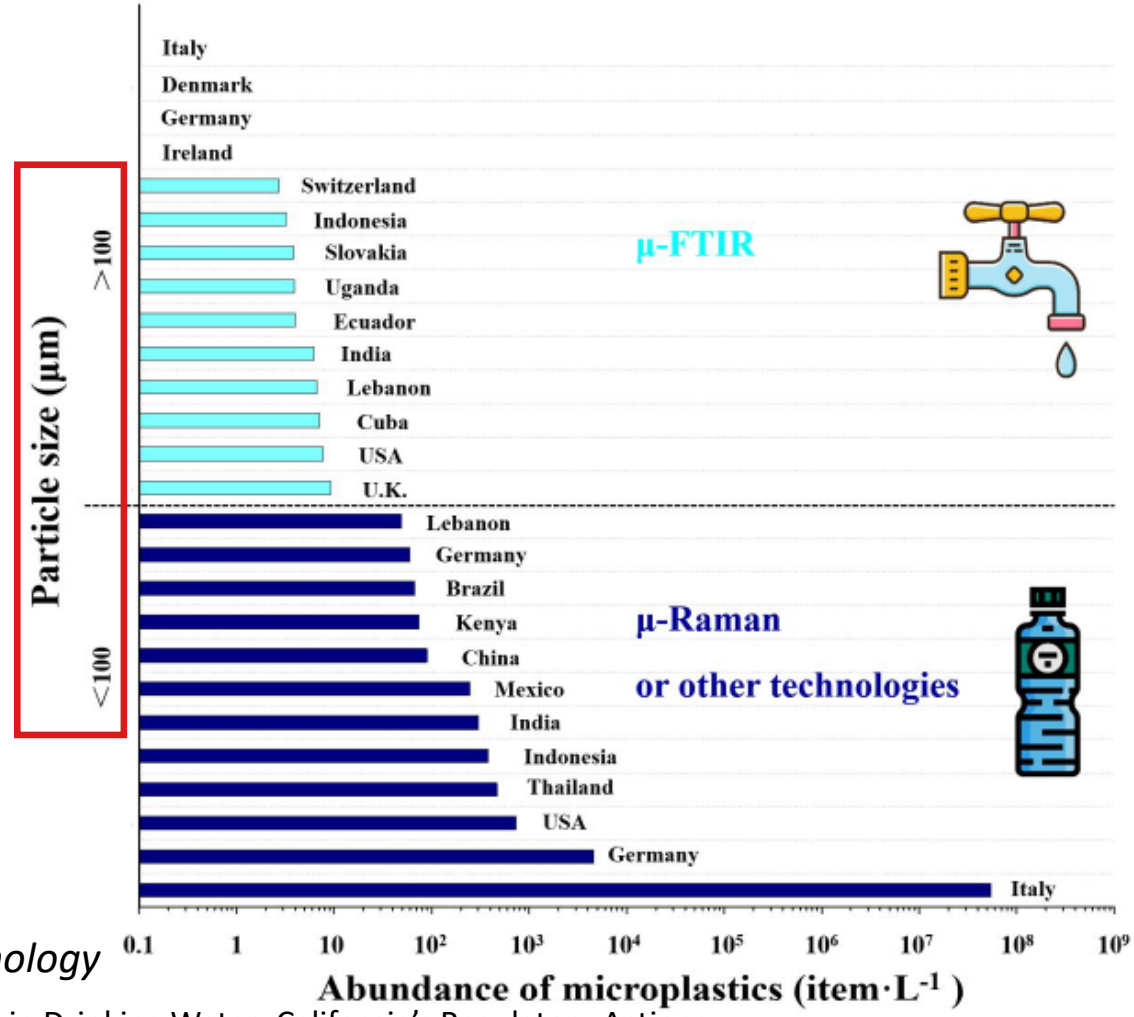
Potential to cause harm

Probability to cause harm

Exposure: Microplastics Abundant in Water

Tap Water: 0-1,000 microplastics/ liter

Bottled water: 10- 1,000,000 microplastics/liter



Data and Figure from
Zhang et al. (2020), *Environmental Science & Technology*

Drinking Water ~1% of Total Microplastic Exposure

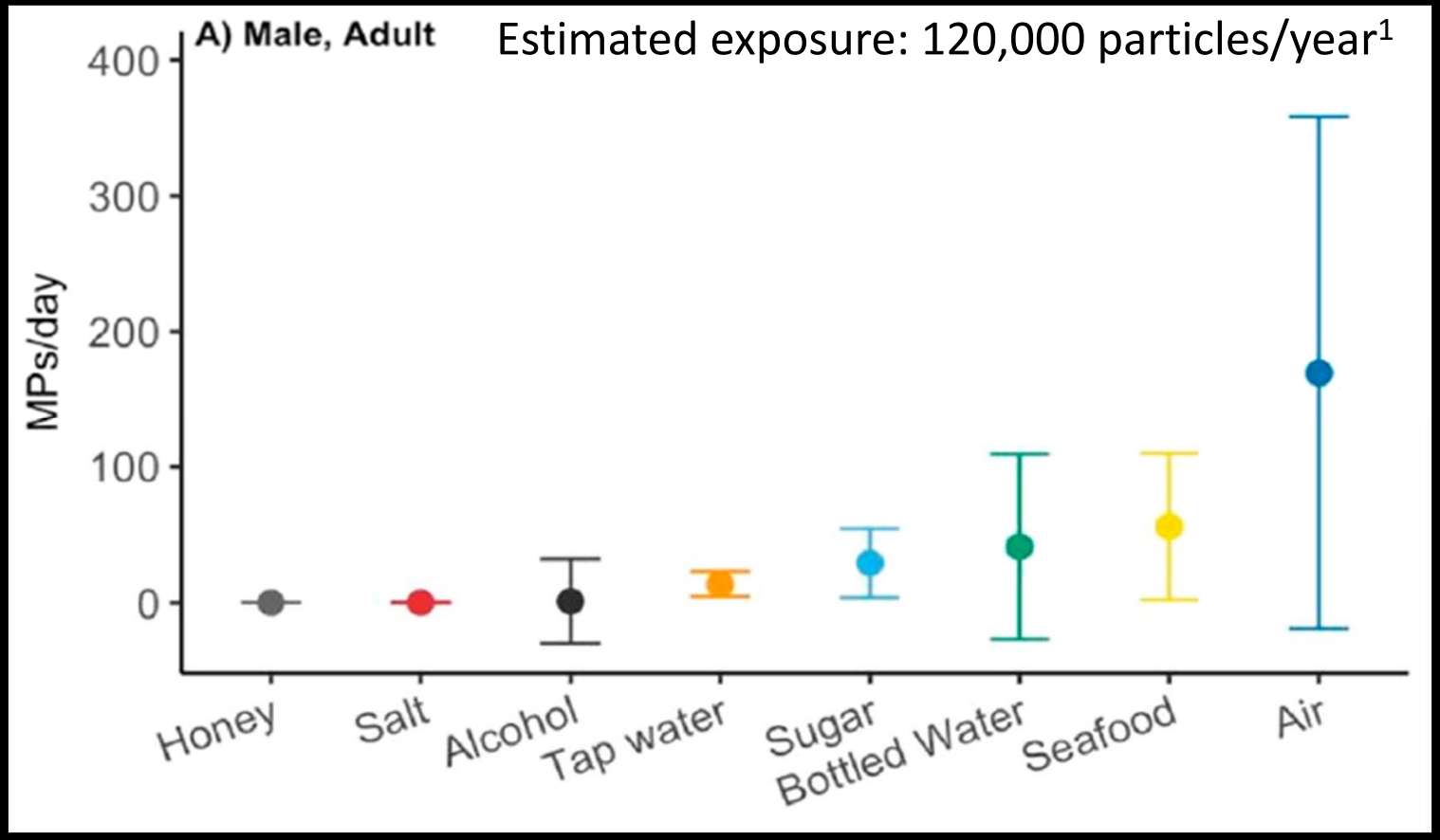


Figure and data from Cox, *et al, Environmental Science & Technology*, 2019

Exposure: Plastic Packaging Releases Microplastics

Opening a plastic water bottle releases **14-2,400** microplastic particles

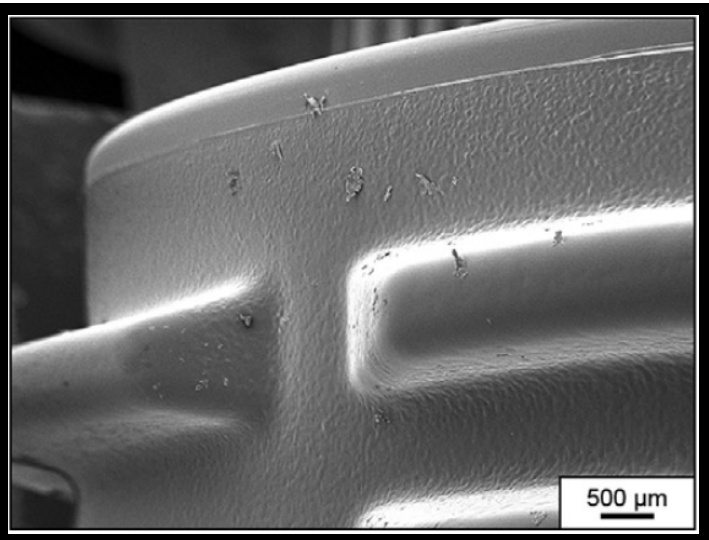


Figure from Winkler, *et al. Water Research* (2020).

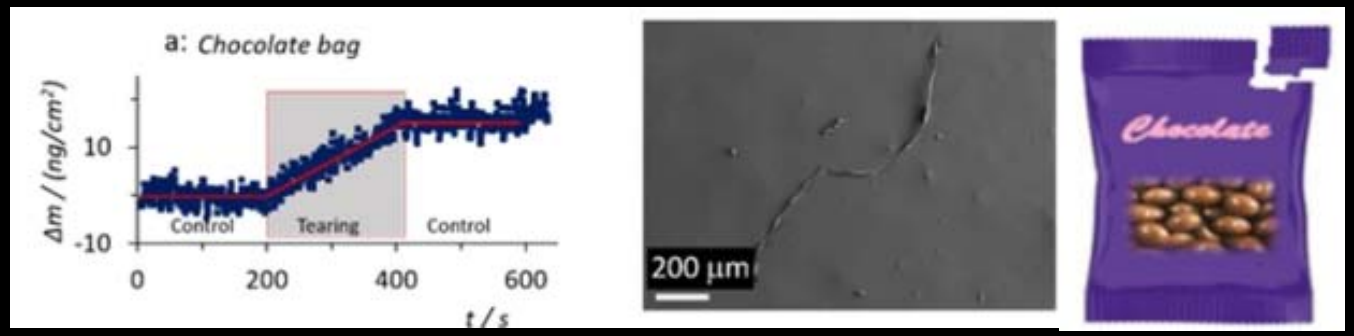
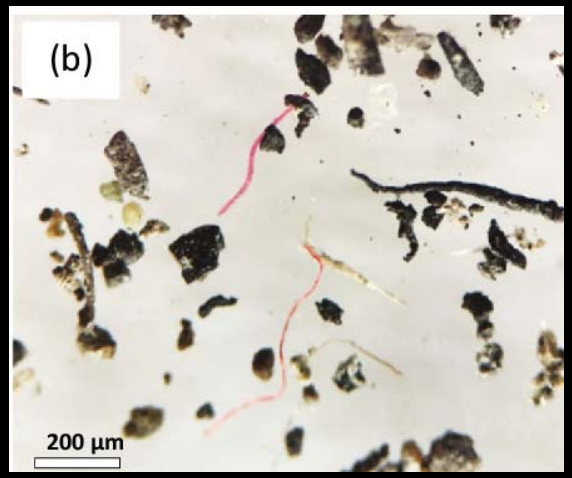


Figure from Sobhani, *et al. Sci Rep* (2020).

Opening a plastic snack bag releases **14,000-75,000** microplastic particles

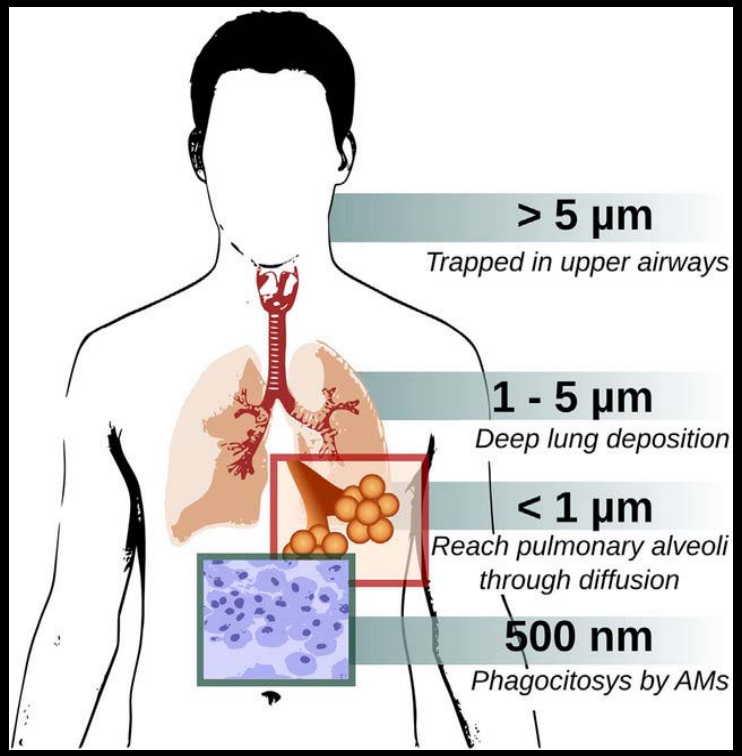
Exposure: Microplastics abundant in dust

- **Household dust** is 2.6% microplastic (range: 1.5-13%) [1]
- **Indoor** (23 g/kg) > outdoor (1.6 g/kg)[1]
- **Fibers** dominate (~88%)[1]



Microfiber in dust[2]

Image: @HaggardHawks



figure[1]

[1]C. Liu et al, *Environment International* 2019
[2]Dehgani et al., *Environmental Science and Pollution Research* 2017

Hazard: Plastic Contains many *Unknown* Chemicals

- Plastic products (food-contact materials) contain ~40-1,000 added chemicals[1]
- **~80% of chemicals** in plastic cannot be identified (Confidential Business Info)[1]
- >350,000 approved for use in commerce[2]
- >75,000 **unique polymers** in commerce[2]
- >120,000 chemicals *unknown*

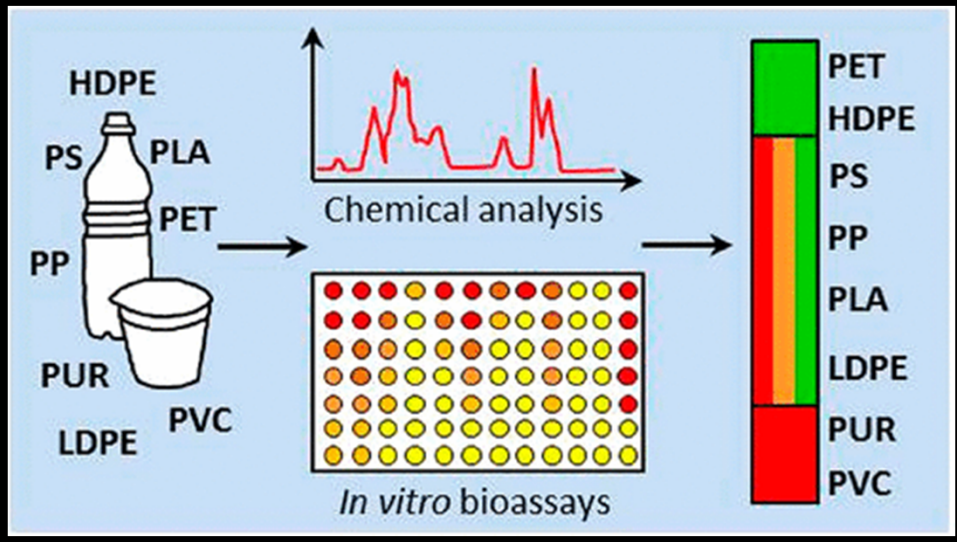


Figure from Zimmerman et. Al (2019). *ES&T.*

[1]Zimmerman et. Al (2019). *ES&T.*

[2]Wang et. Al (2020). *ES&T.*

Hazard: Plastic Acts as Vector for Pathogens

- Microplastics accelerate **biological invasion**[1]
- Microplastics transfer **pathogenic** and **antibiotic resistant** genes[2]
- Coronavirus viable on **plastic** up to 3 days[3]

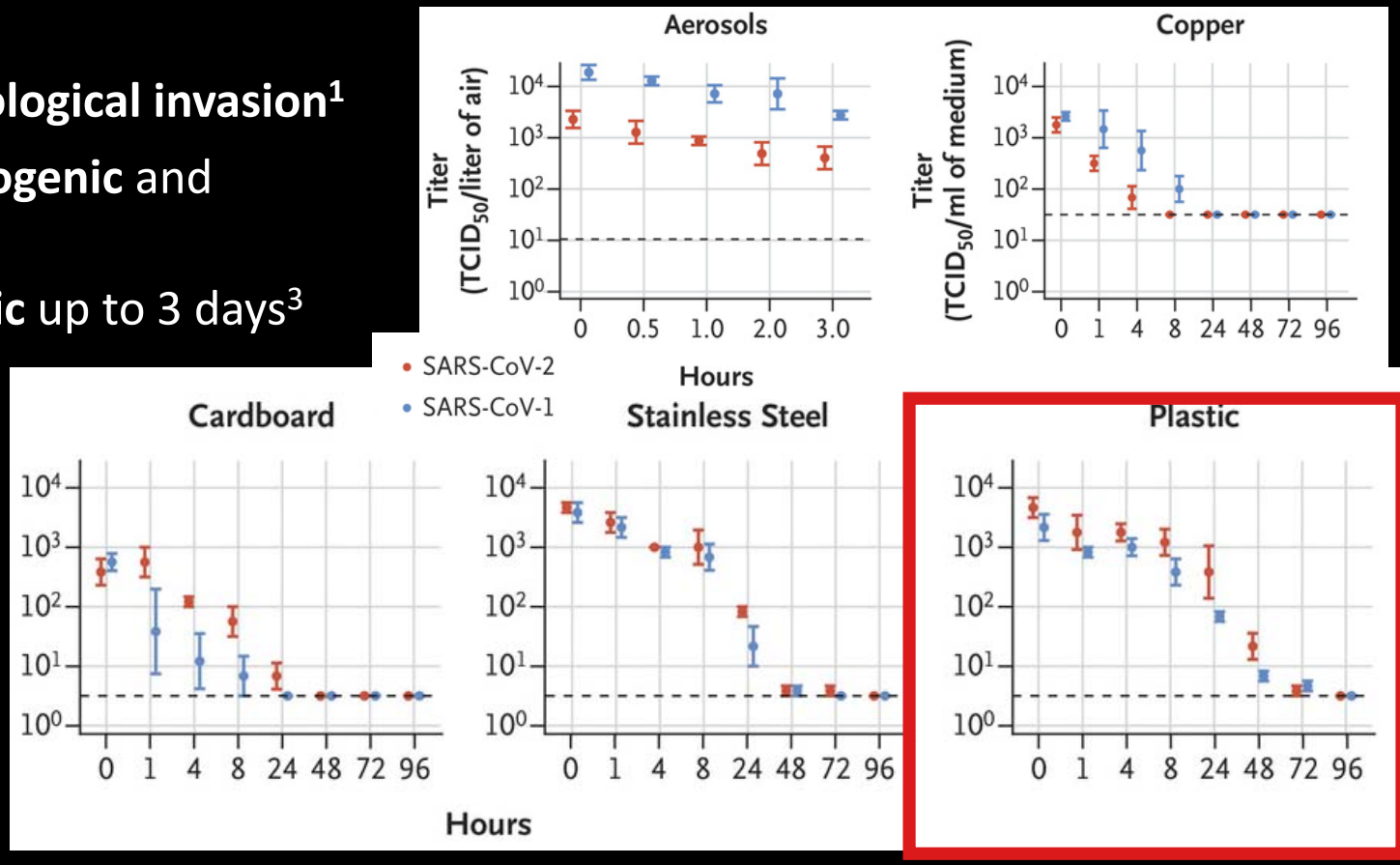


Figure from Doremalen, et al. (2020). *New England Journal of Medicine.*

[1]McCormick et al., (2014) *Environmental Science & Technology*

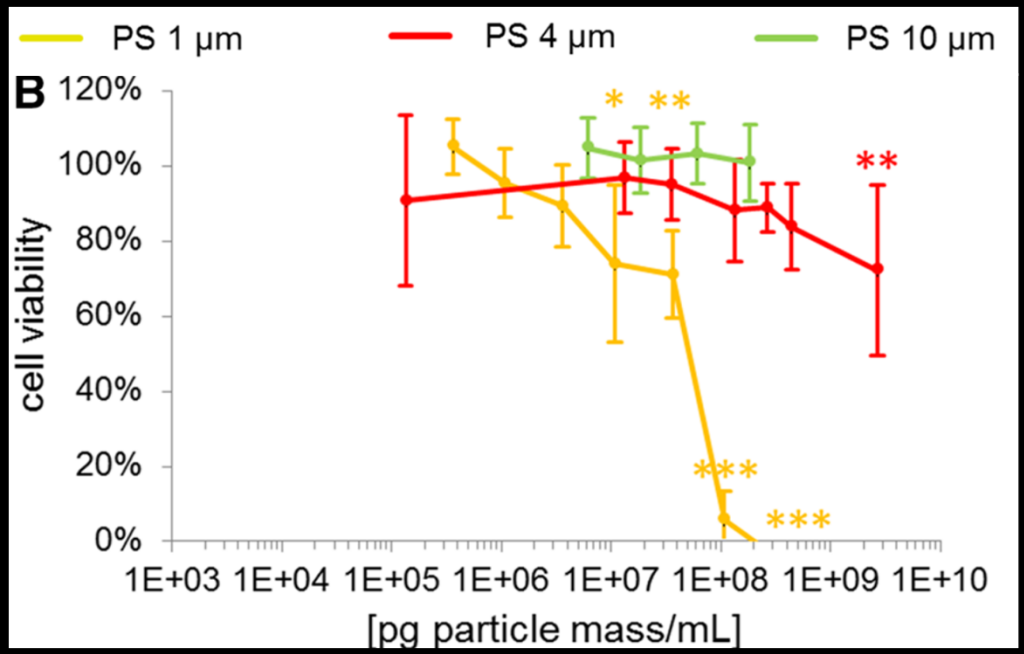
[2]Zettler et al., (2013) *Environmental Science & Technology*

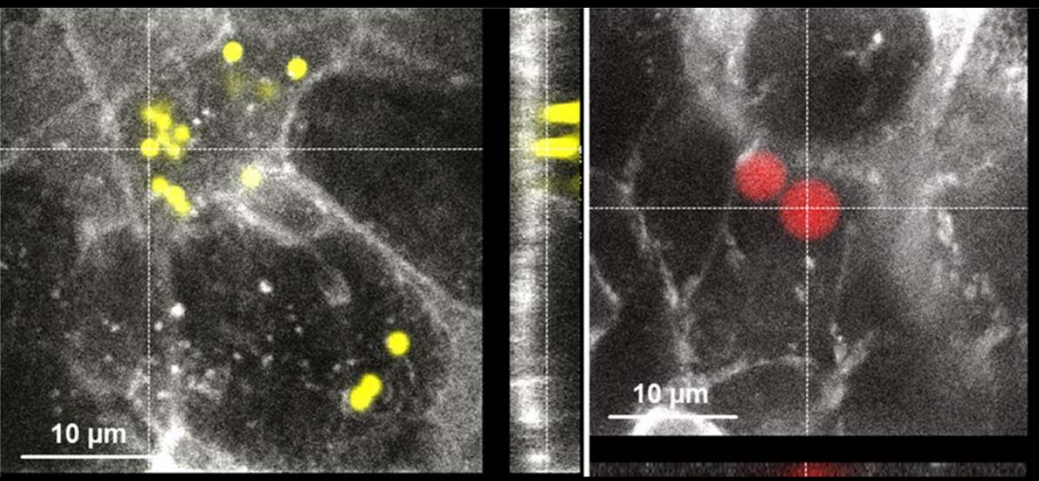
[3]Doremalen, et al. (2020). *New England Journal of Medicine*, March.

Hazard: Smaller Plastic Particle are More Toxic

1 µm polystyrene particles demonstrated **cytotoxicity** in a human monoculture cell (Caco-2), while 4 µm and 10 µm particles were not cytotoxic.

Stock et al. (2019). *Archives of Toxicology*





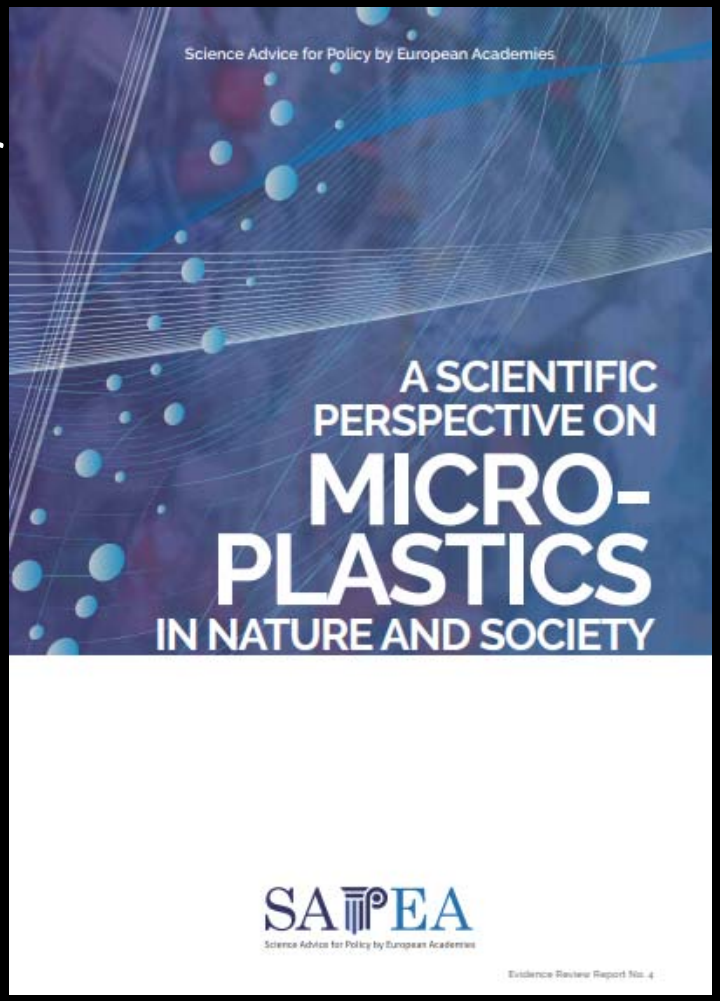
Human macrophages **uptake polystyrene particles** up to 10 µm in size.

Figure from Bruinink et al. (2015). *Archives of Toxicology.*

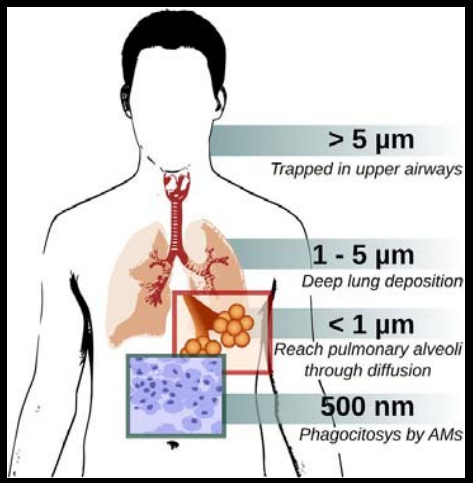
Human Health of Microplastics: No Evidence of Safety

"The absence of evidence of microplastics risks currently does not allow one to conclude that risk is either present or absent with sufficient certainty'"

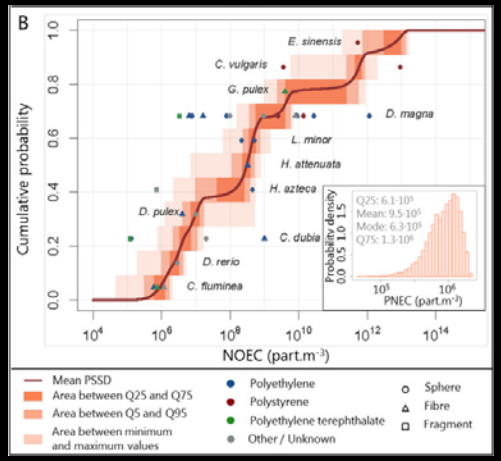
-SAPEA (2019)



Health Effects of Microplastics Symposium



Human Health



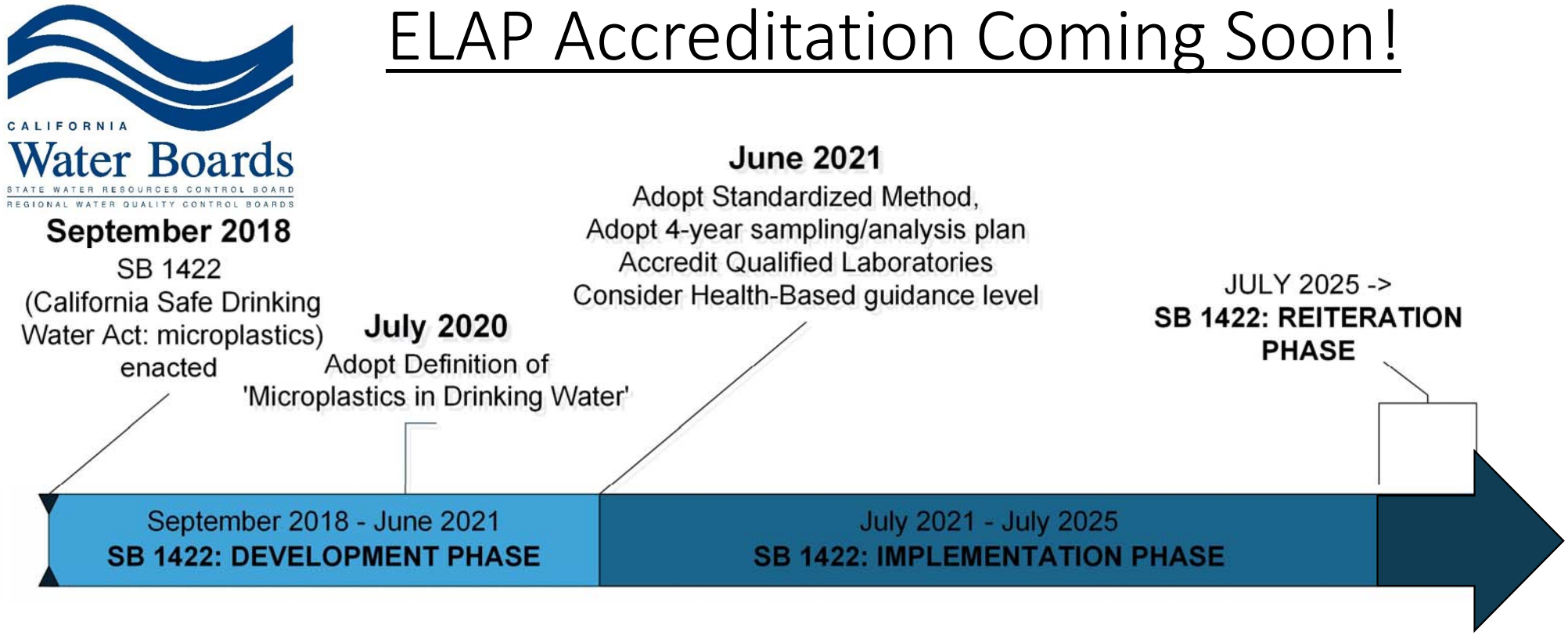
Ecological Health

Public Workshop
October 7, 2020

Invited Experts

- Dr. Susanne Brander (Oregon State University)
- Dr. Matthew Cole (Plymouth Marine Laboratory)
- Dr. Bart Koelmans (Wageningen University)
- Dr. Chelsea Rochman (University of Toronto)
- Dr. Martin Wagner (Norwegian University of Science and Technology)
- Valerie Stock (German Federal Institute for Risk Assessment)

ELAP Accreditation Coming Soon!



- June 31, 2021: ELAP will provide accreditation to qualified laboratories
- June 31, 2021: Standardized method(s) will be adopted
- Vendors for proficiency testing samples still needed…

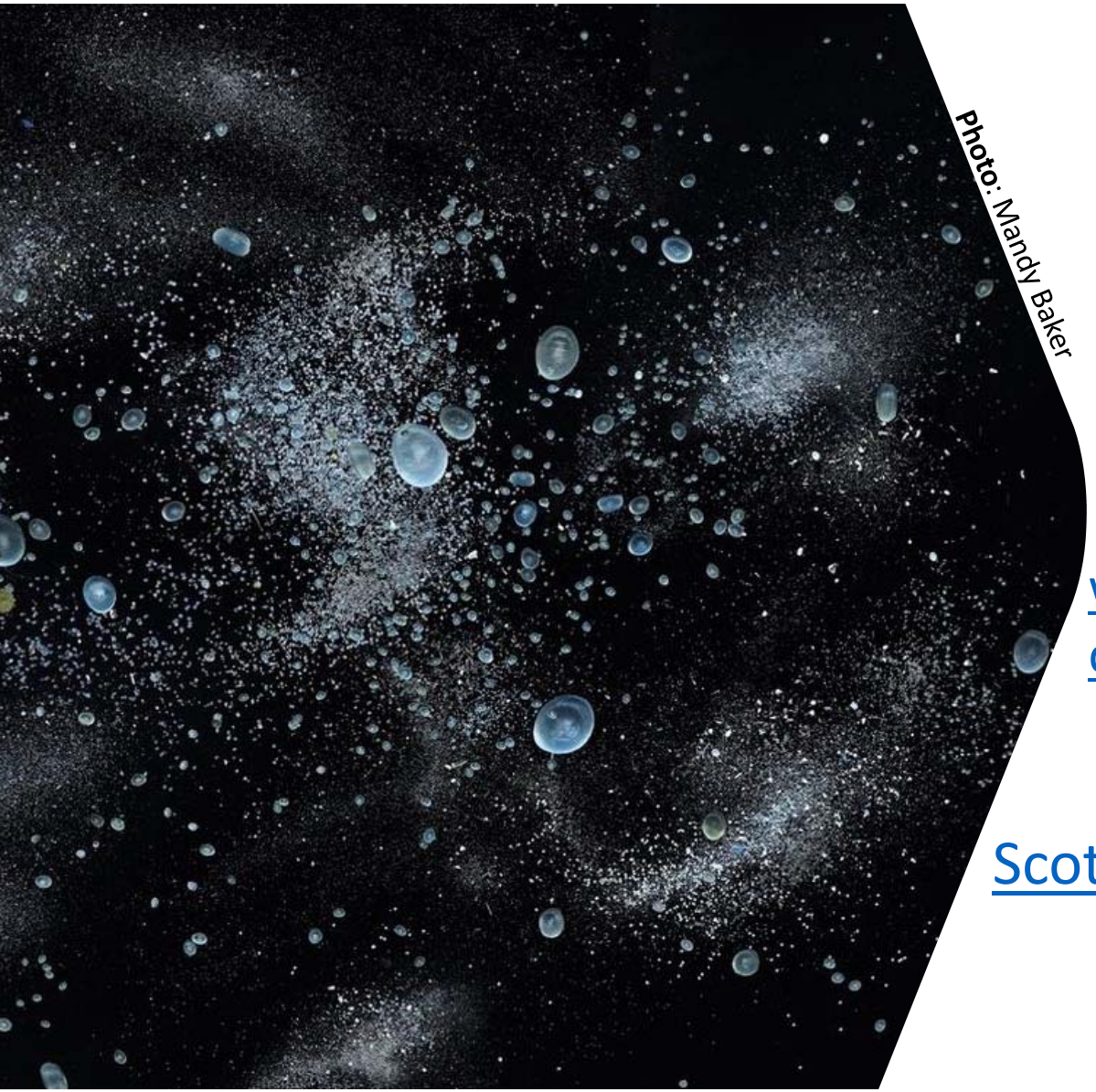


Photo: Mandy Baker

Thank you!

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More Information:

waterboards.ca.gov/drinking_water/certlic/drinkingwater/microplastics

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Defining Microplastics: An Interagency Effort