Understanding Microplastic Pollution

March 1, 2021, 6:00 – 7:00 pm

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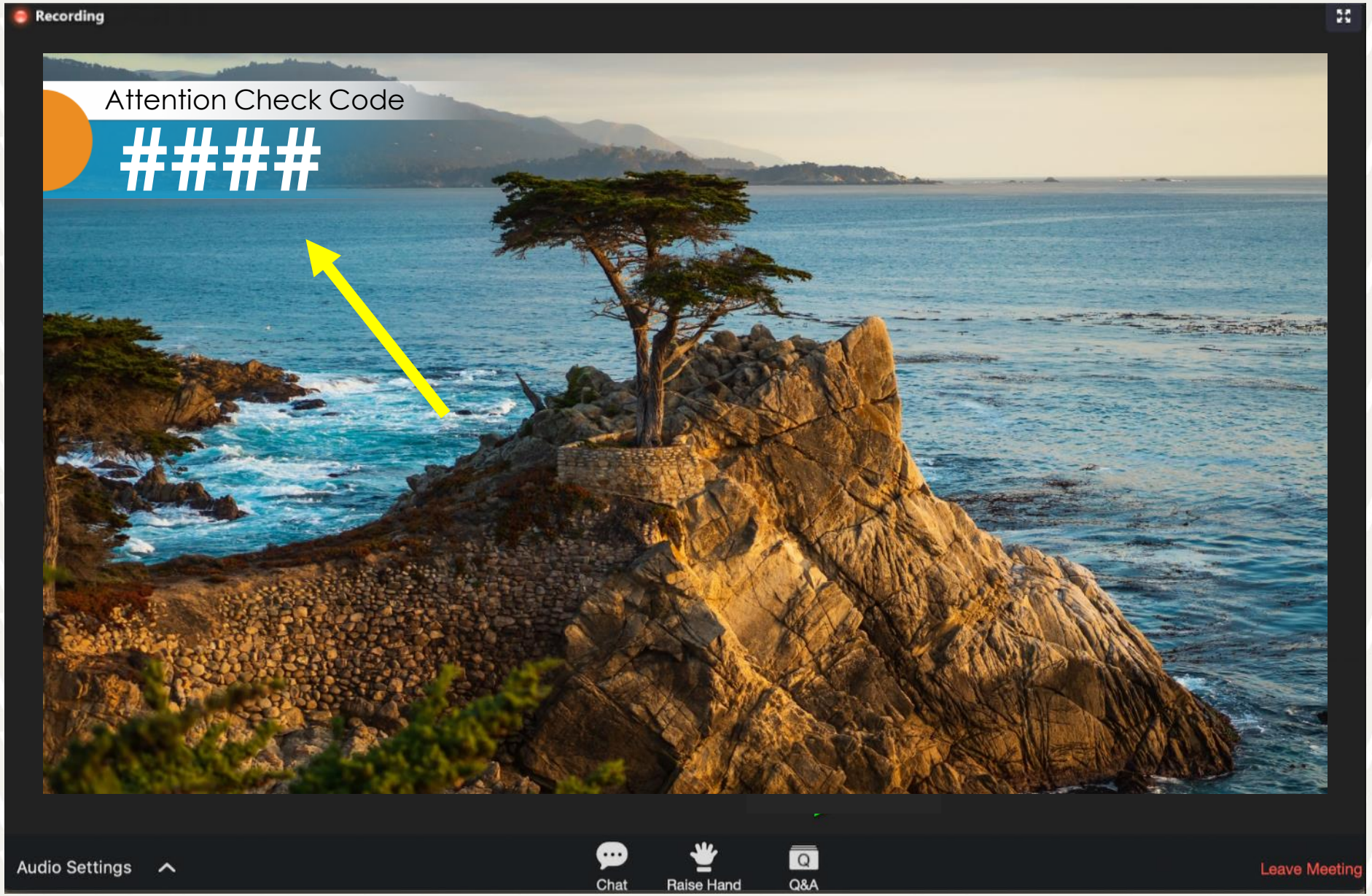

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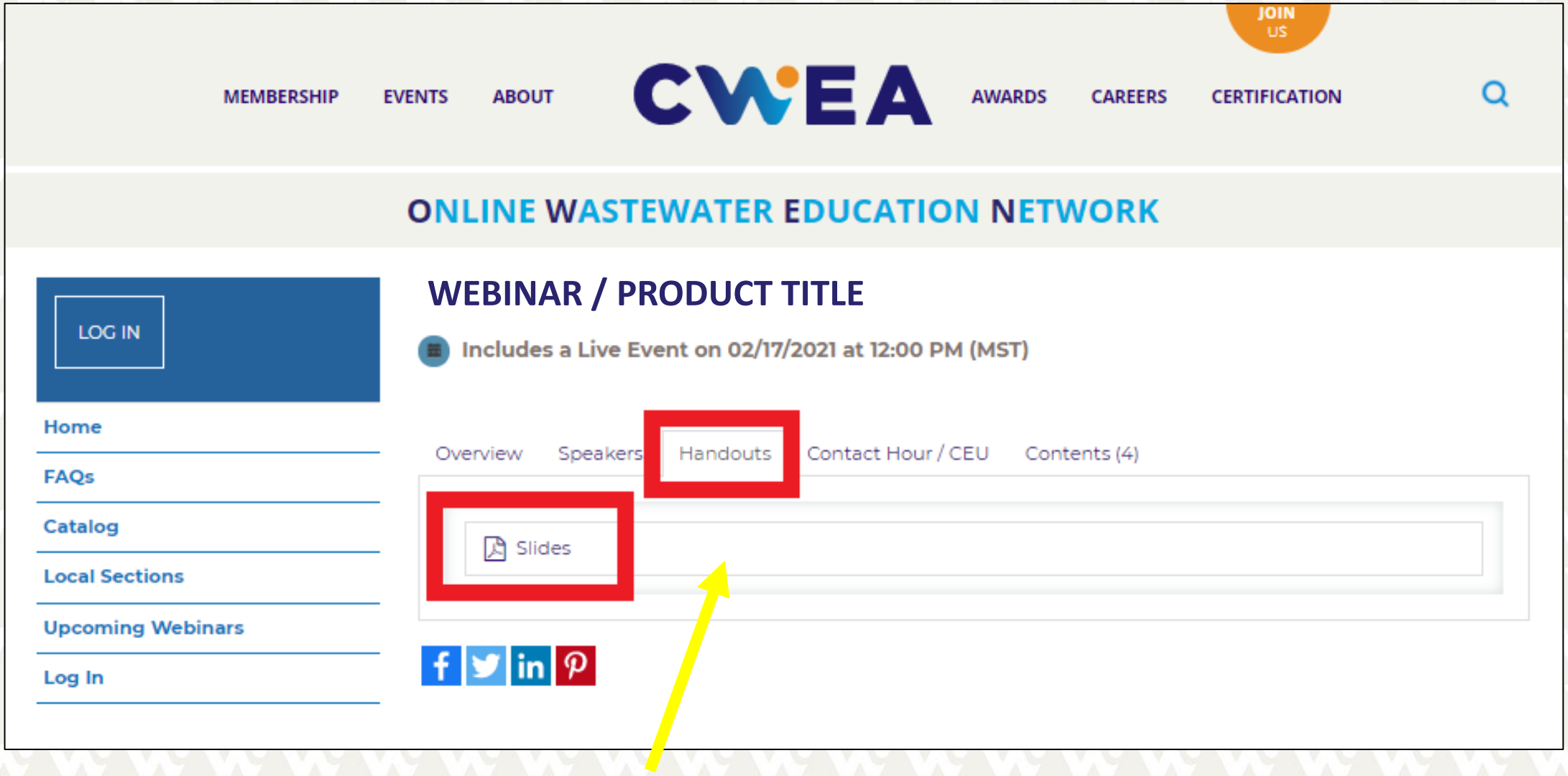

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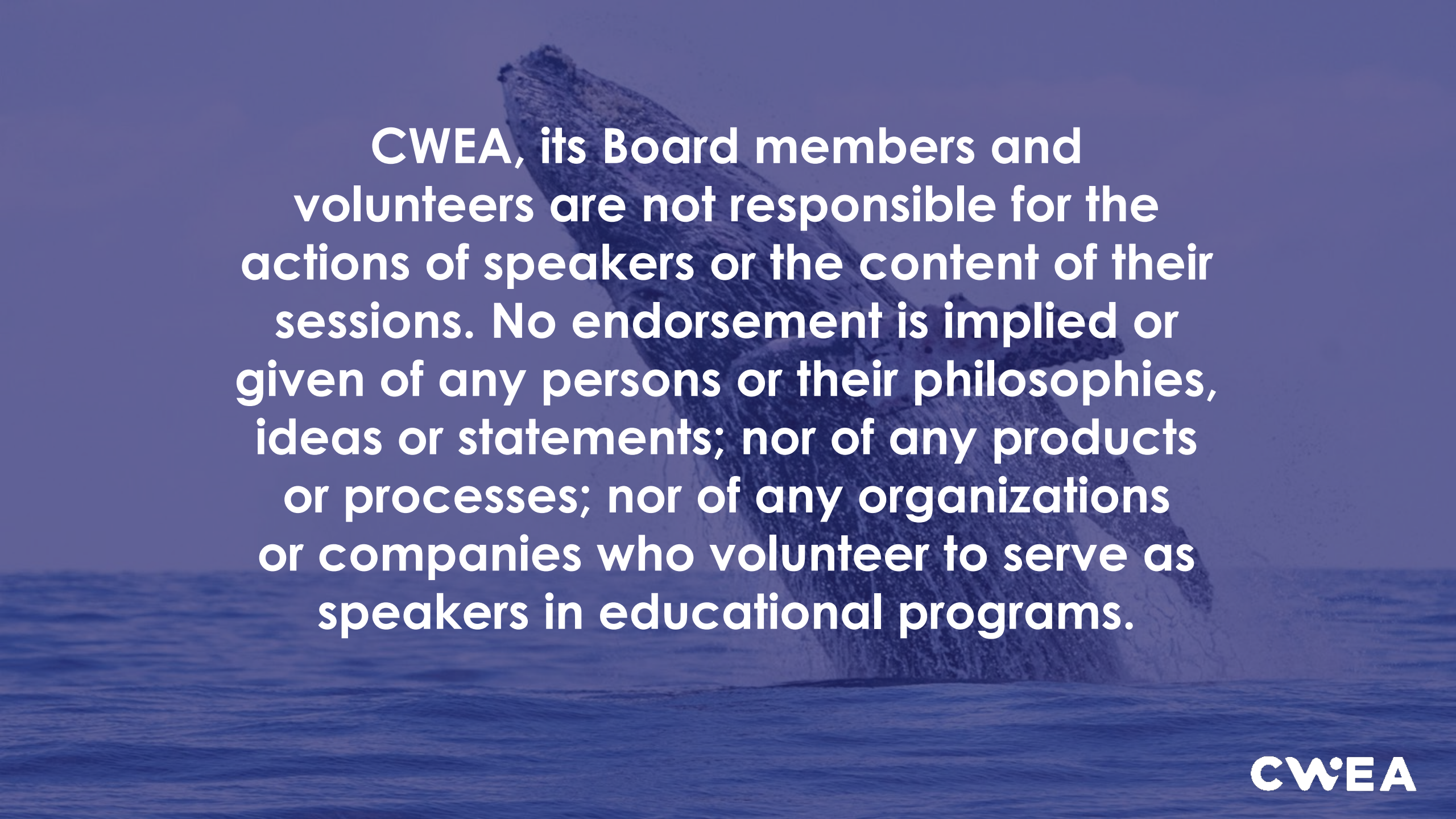

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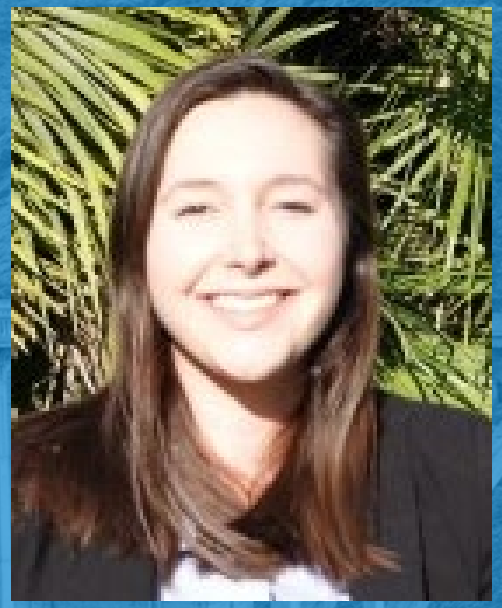

Ashley Thomas

MODERATOR
ENVIRONMENTAL ANALYST
LAWRENCE LIVERMORE NATIONAL LABORATORY

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Harry Allen

SPEAKER
LA TEAM LEAD

US ENVIRONMENTAL PROTECTION AGENCY (EPA)

Understanding Microplastic Pollution

Harry Allen, MS
Superfund Division –
U.S. Environmental Protection Agency Region 9
Allen.HarryL@epa.gov

Occurrence of plastic pollution in the environment

- It is generally accepted that the majority of plastic pollution originates from land-based sources.
- Every piece of “macro” plastic will fragment into smaller particles which will either be ingested by birds, fish and other wildlife, or which will sink to the bottom of the waterbody.
- Samples from all rivers, lakes, harbors, seas, oceans and even the polar ice caps have demonstrated the presence of plastic particles.

What we know:

- ❑ Plastic production continues to increase exponentially, doubling over the next 20 years and almost quadrupling by 2050
- ❑ Recycling rates for plastic over the last forty years remain stagnant at less than 10% globally

Microplastic Sources – conceptual modeling

EVERYWHERE ELSE

How Does Al

OCEAN ... S 2017

1. *A poor waste management/recycling system (or none at all) is the leading cause.*
2. *Plastic garbage from cities and industrial centers flows directly into rivers and seas with untreated wastewater.*
3. *Microplastic used as additives in cosmetic products is not filtered out by water treatment plants.*
4. *Fishing nets and lines lost or intentionally abandoned at sea.*
5. *Lost loads and ship materials.*
6. *Garbage illegally dumped at sea.*
7. *Catastrophic waste: wreckage and garbage swept out to sea by hurricanes, floods, and tsunamis.*

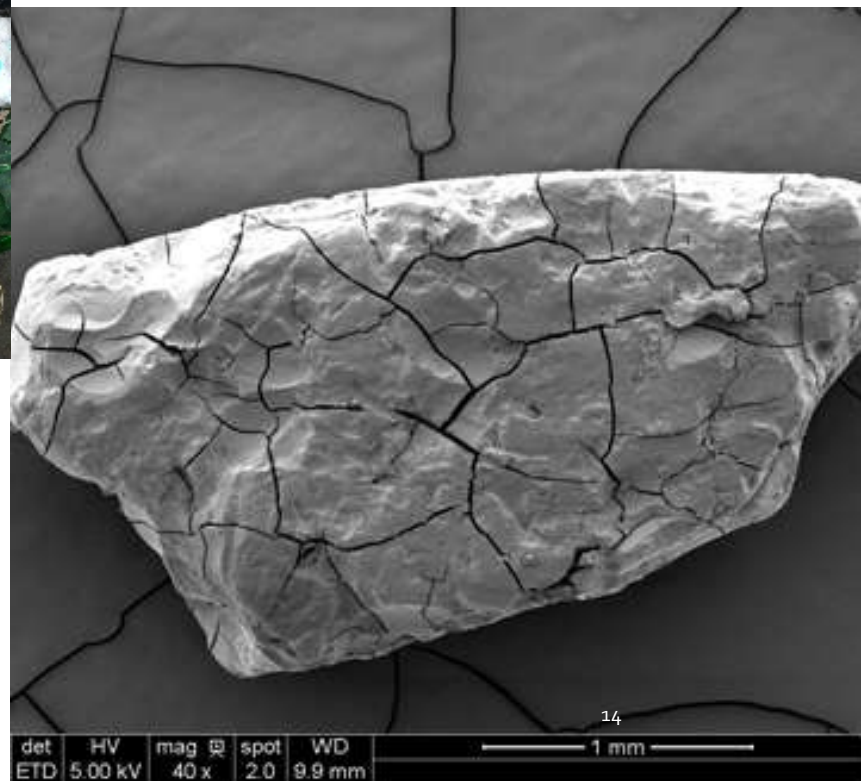
(Heinrich Böll Foundation – Ocean Atlas 2017)

Sources - Microplastic generation

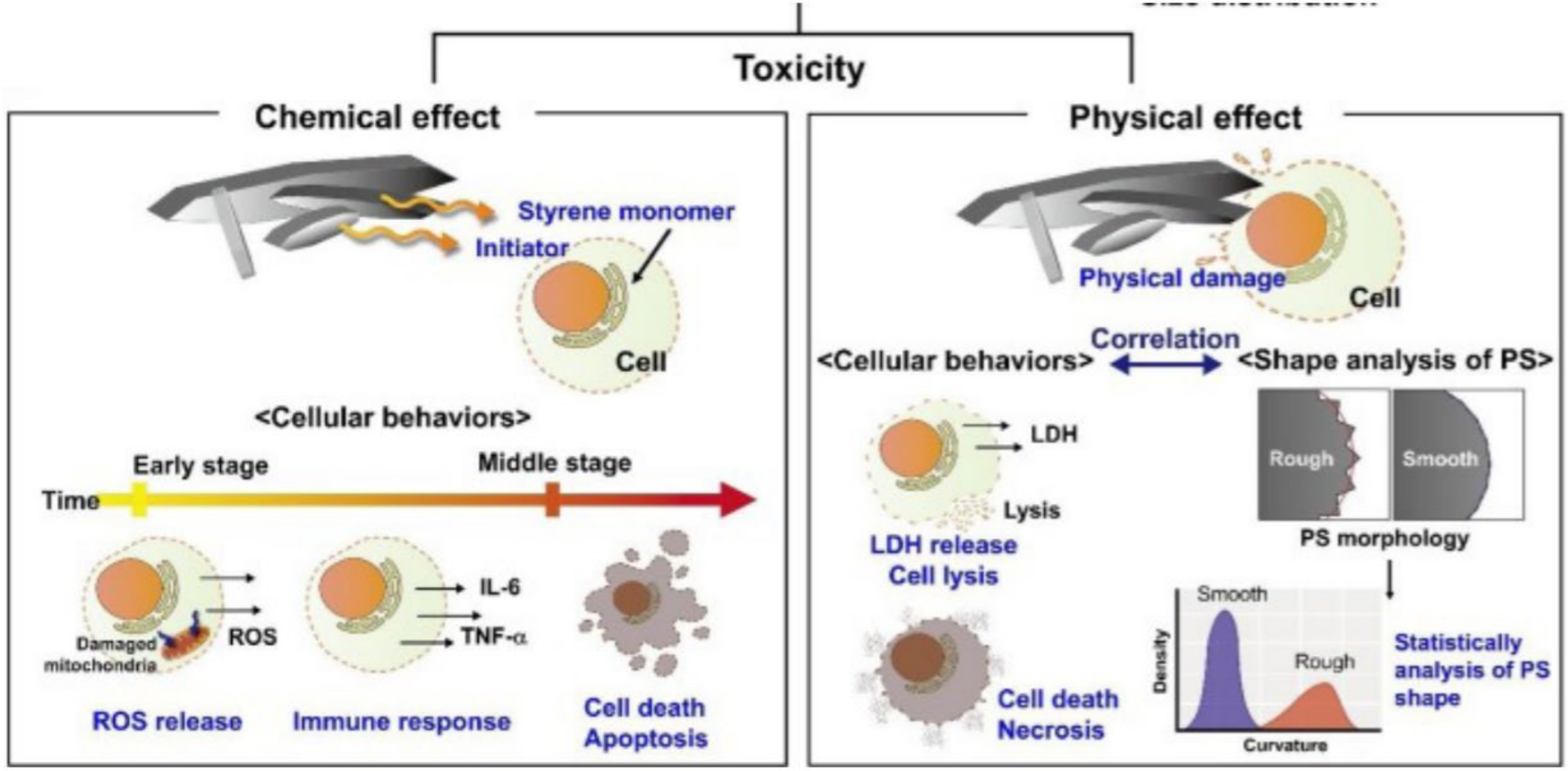
- Plastic feedstock - nurdles
- Plastic as additives - microbeads used in cosmetics
- Weathering of plastics - by far the most significant source (Reference - conceptual model)

Weathering of Plastics

- As plastic particles weather in sun, wind and water they change in size and shape
- These particles migrate to waterways and eventually receiving waters (rivers, lakes, oceans).

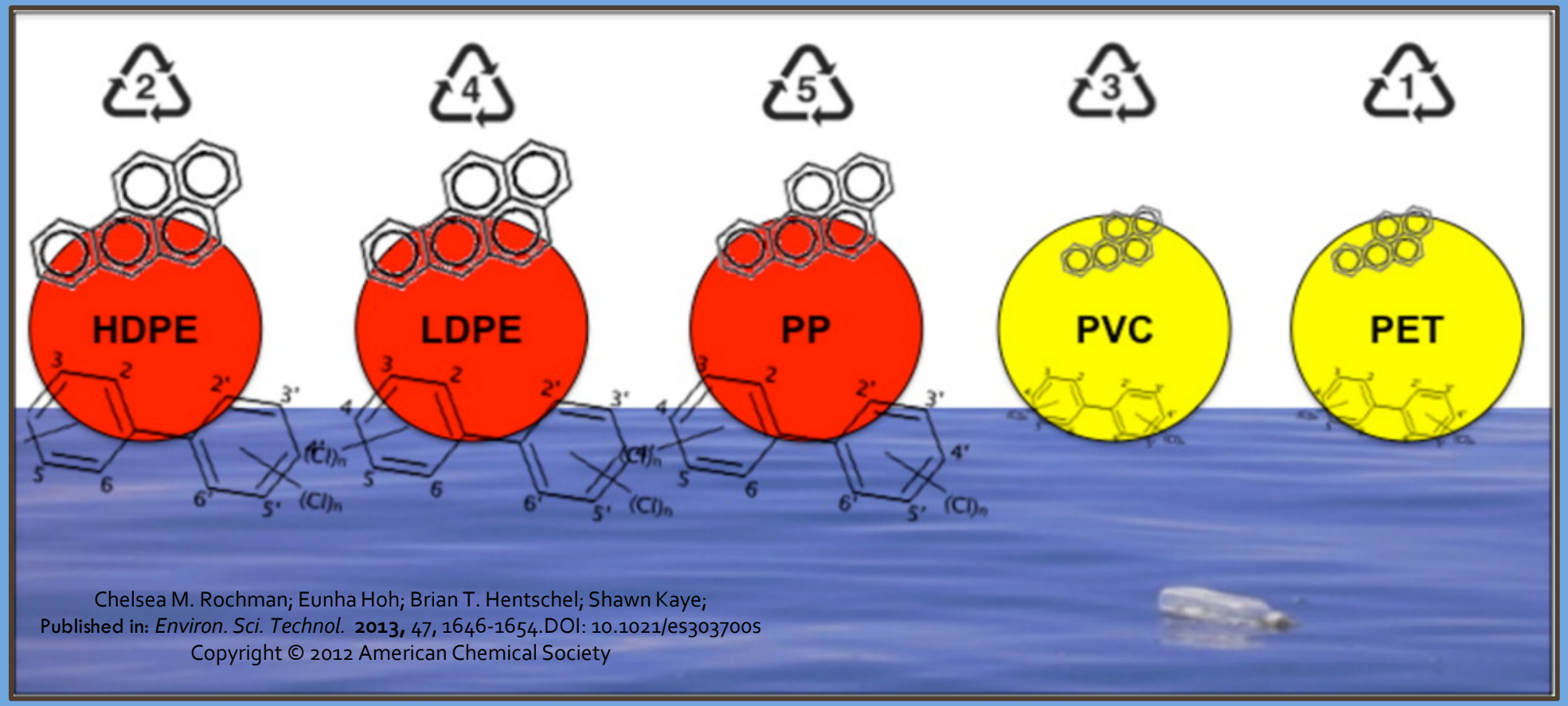


Chemicals or Particles: What Drives Toxicity?



Choi et al. (2020). *Journal of Hazardous Materials*

Courtesy of S. Coffin CA SWRCB



Plastic is not inert: particles readily sorb and hyper-accumulate Persistent Organic Pollutants/Persistent Bioaccumulative Toxic chemicals from the surrounding water environment, concentrating these contaminants by orders of magnitude. Often contaminants are present at levels 1,000 to 1,000,000 times higher than the concentrations of those chemicals in the surrounding water.

A Cause for Concern Environmental Health

- Plastic particles will be widely detected in wildlife - pets?
- Organ toxicity in the lab in fish and in mammals (mouse study)
- Chemical uptake in fish tissue is observed in the field
- Tissue inflammation resulting from exposure is observed in gut (Lu et al. 2018, 2019)

Liver fat composition (Lu et al. 2018, Luo et al. 2019)

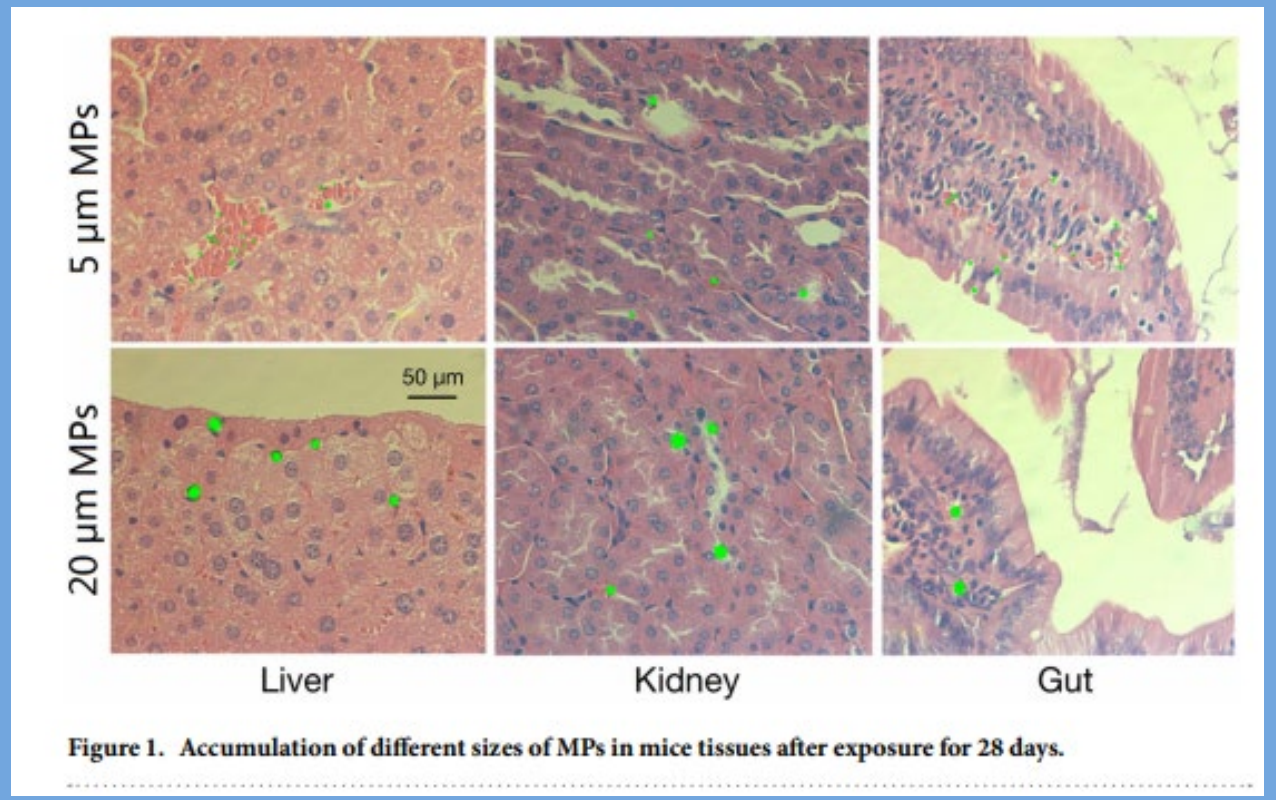
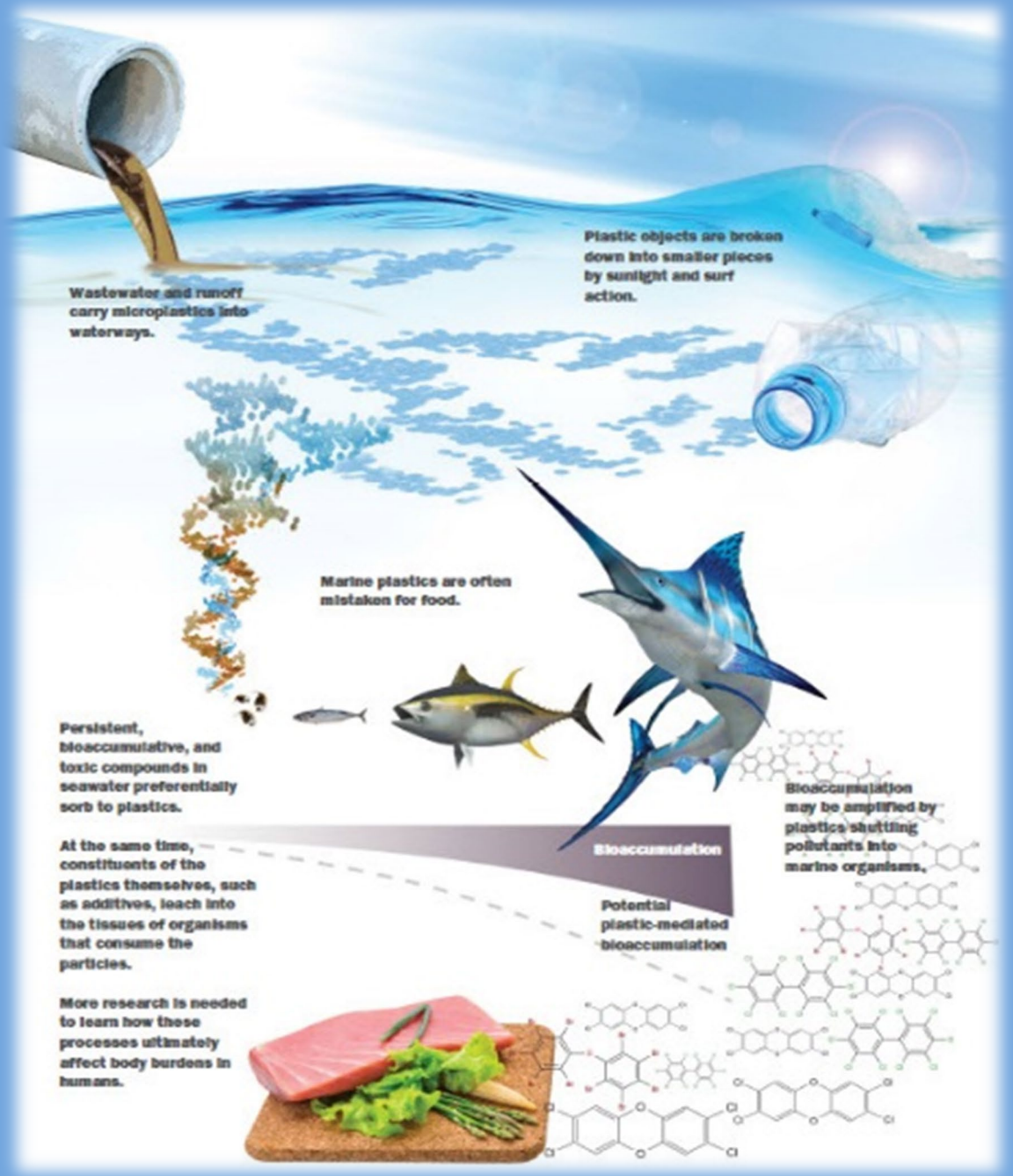


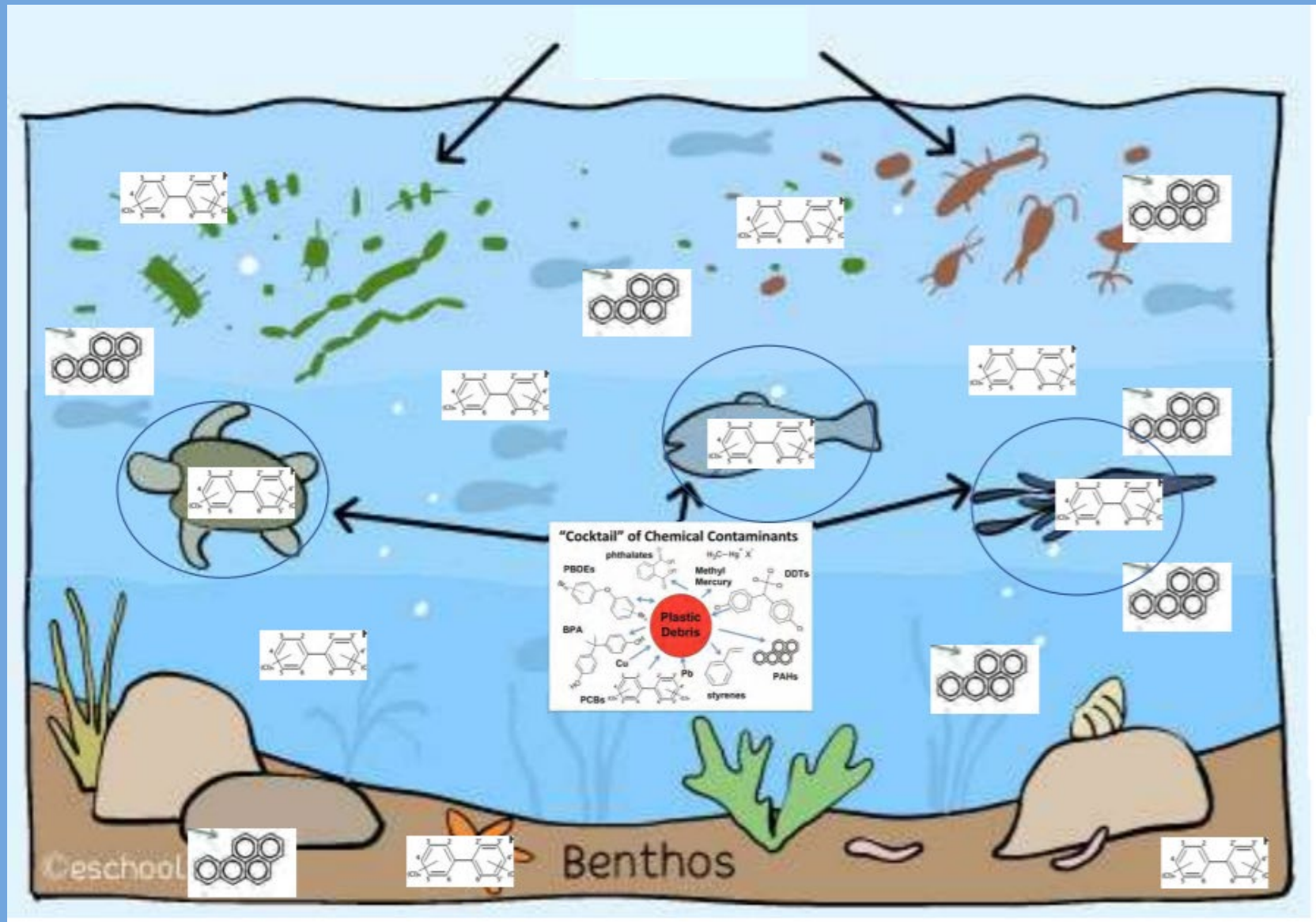
Figure 1. Accumulation of different sizes of MPs in mice tissues after exposure for 28 days.

(Deng et al. Nature Scientific Reports. 2017)

Potential Human Health Concerns

We hypothesize that when microplastic particles are ingested as food by marine organisms, chemical additives and sorbed contaminants bioaccumulate and biomagnify within and up the food chain, resulting in potential impacts to human health.





Plastic is a cocktail of contaminants

versus

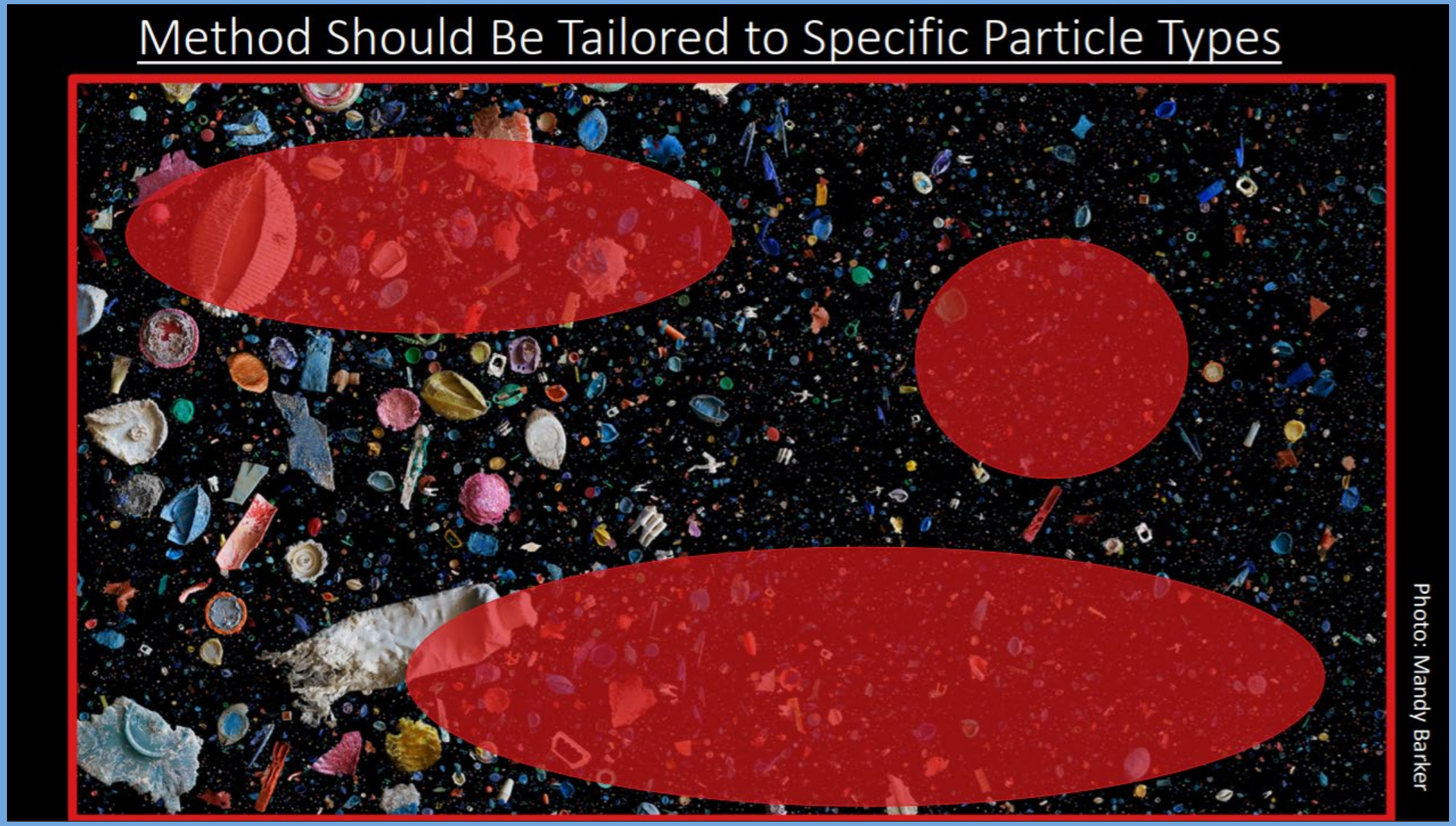
The environment is a cocktail of contaminants

Courtesy of A. Koelmans

POLL QUESTION

- Do you believe microplastics are inert in the environment?
  - Yes
  - No
  - I don't know

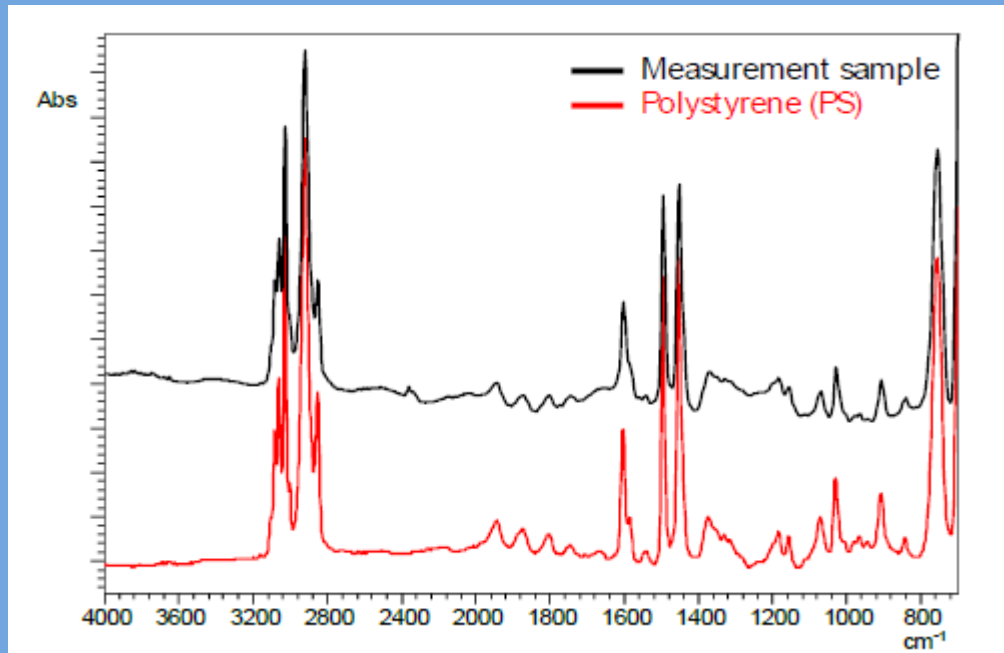
Method Should Be Tailored to Specific Particle Types



Courtesy of S. Coffin

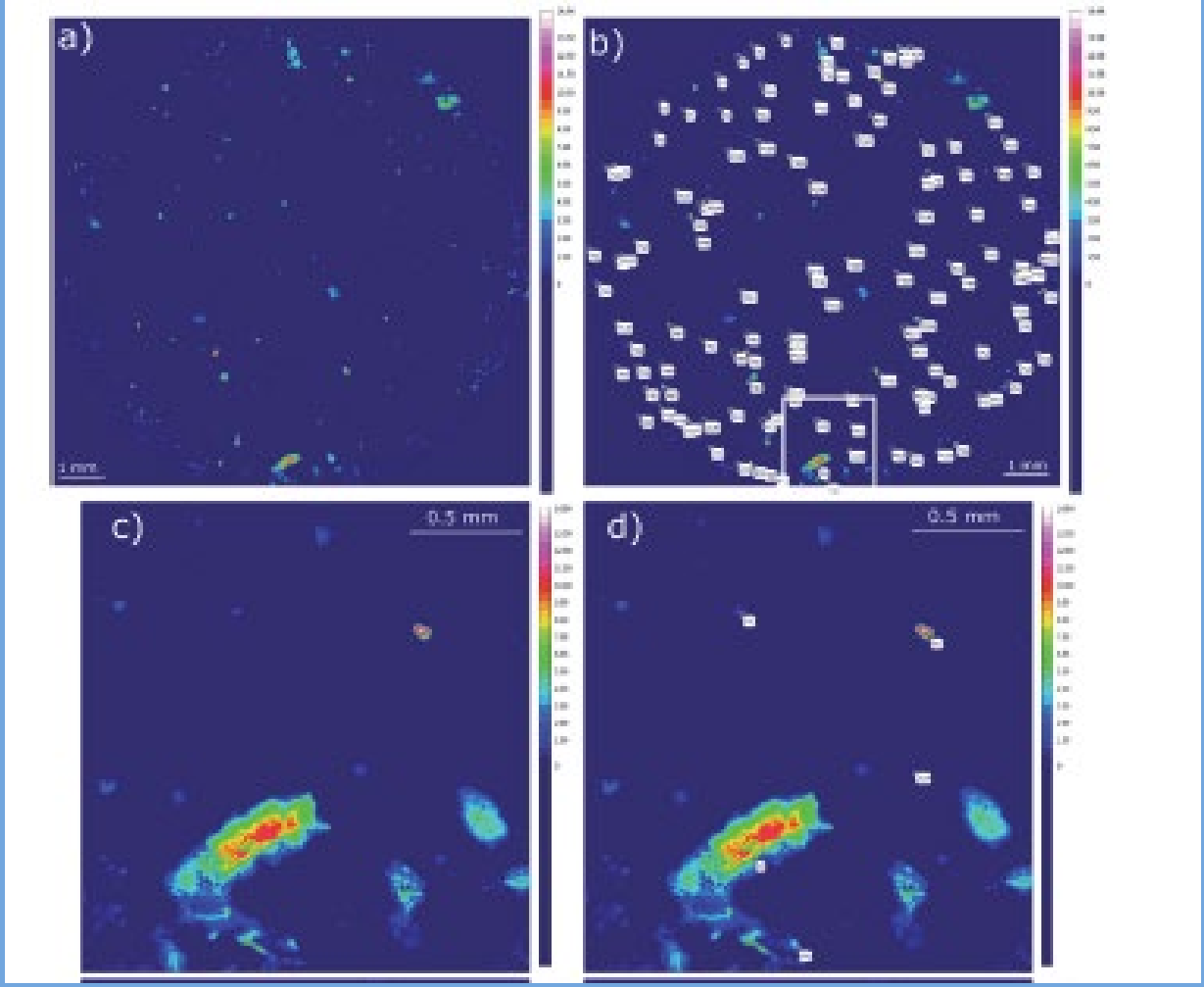
Why the wide discrepancies? Sampling/Extraction/Identification & Analytical methods

- Sampling approach – Neuston nets 333um allowed particles to be missed, also shed particles into the samples
- Extraction challenges – Peroxide (WPO), KOH, enzymatic digestion is time-consuming
- Original approaches (Masura & Baker*), visual, hot needle, Nile Red
- Polymer identification
  - Microspectroscopy (Raman/FTIR)
  - Py-GCMS – emerging technique



(*Masura & Baker NOAA Technical Memorandum NOS-OR&R-48)

Results with FTIR, focal plane array microscopy



(Primpke 2017. Analytical Methods)

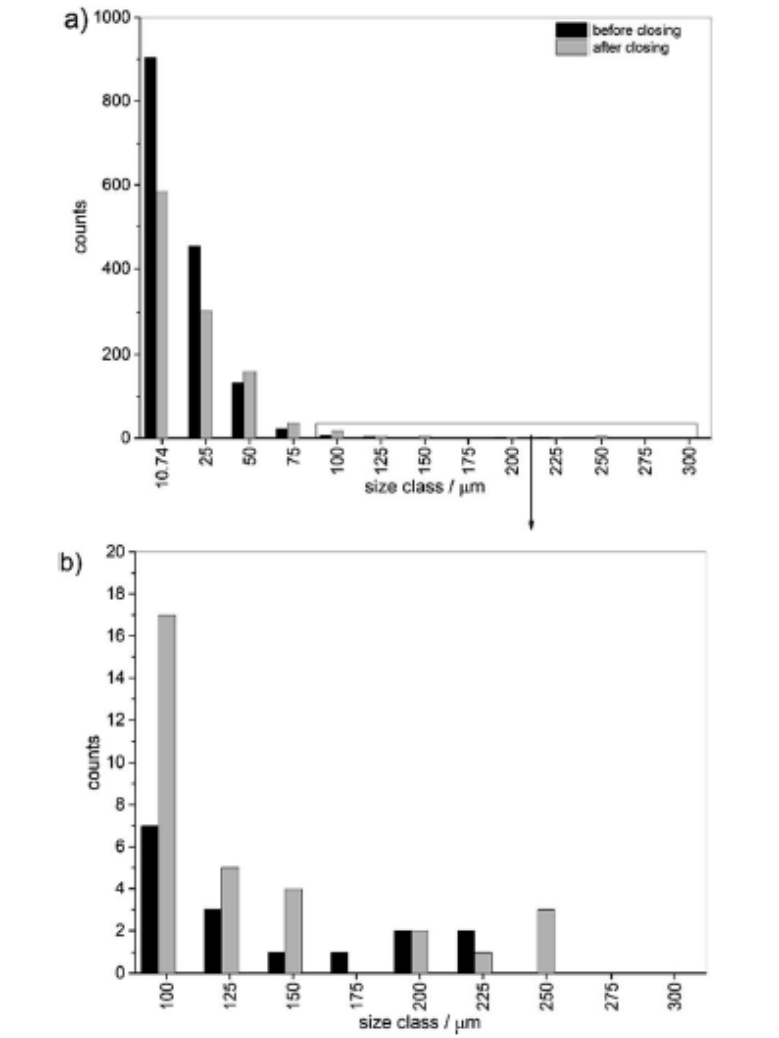


Fig. 5 Overall particle size distribution binned into size classes before and after closing (a) full distribution and (b) zoom into particle bins for classes higher than 75 µm.

Environmental Sampling

Laternfish and sport fish

Wastewater and open water

Sediments and soils

Food - fish also salt

Drinking water

Human environment

CA Department of Public Health

Pima County Wastewater

LA Sanitation

Navy SPAWAR

Adventure Scientists

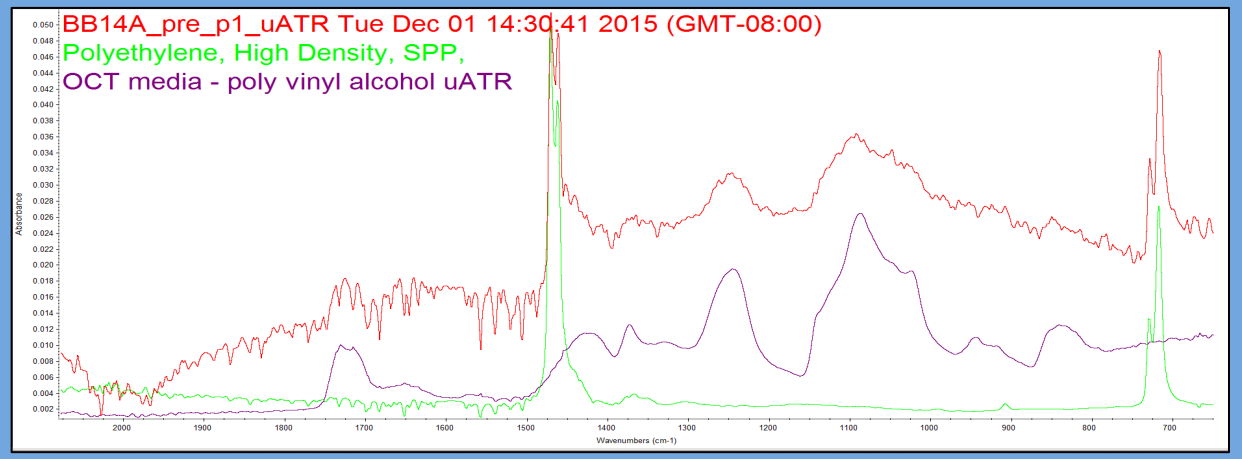
SCRIPPS - MBARI

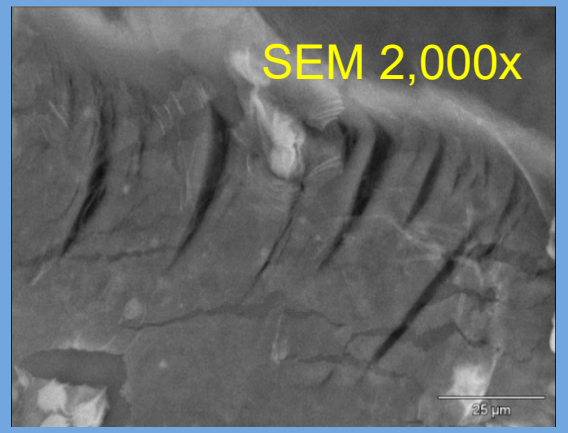
SFEI - SCCWRP

Private Parties

Microplastic fiber identified in the stomach of a Lantern fish (Myctophid) in the South Atlantic Ocean

Stereozoom (STZ), SEM, and FTIR images and spectra of 13 x 0.2 mm PE microplastic fiber extracted from South Atlantic Ocean Myctophid stomach BB14A





Sutapa Ghosal, Jeff Wagner, Zhong-Min Wang, and Stephen Wall
California Department of Public Health

FTIR Identification – fish stomachs

Rapid spectral identification with mapping:

Thermo Scientific Nicolet iN-10MX FTIR Microscope

MCT-A detector used for manual acquisitions

FPA detector used for mapping acquisitions

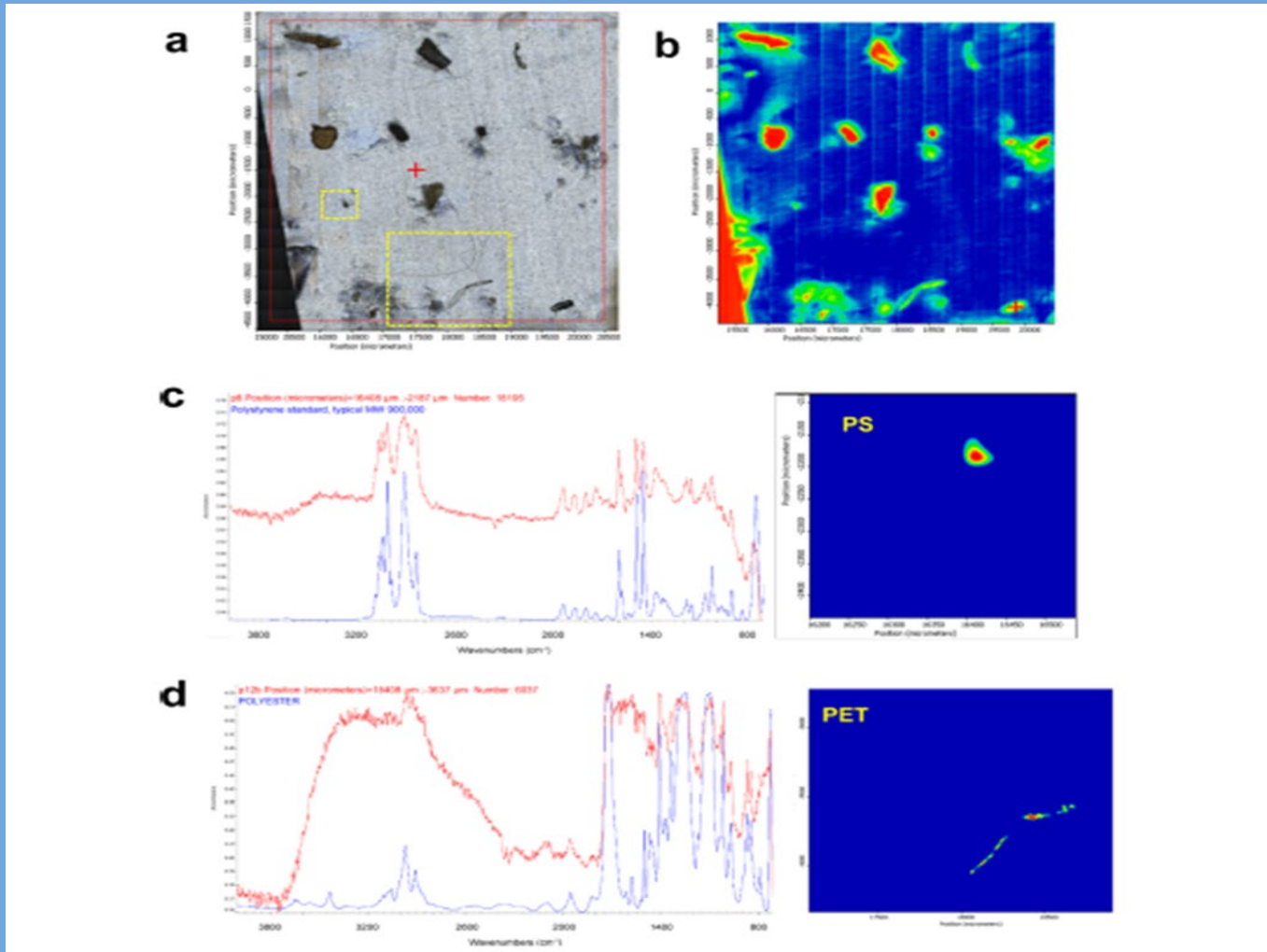


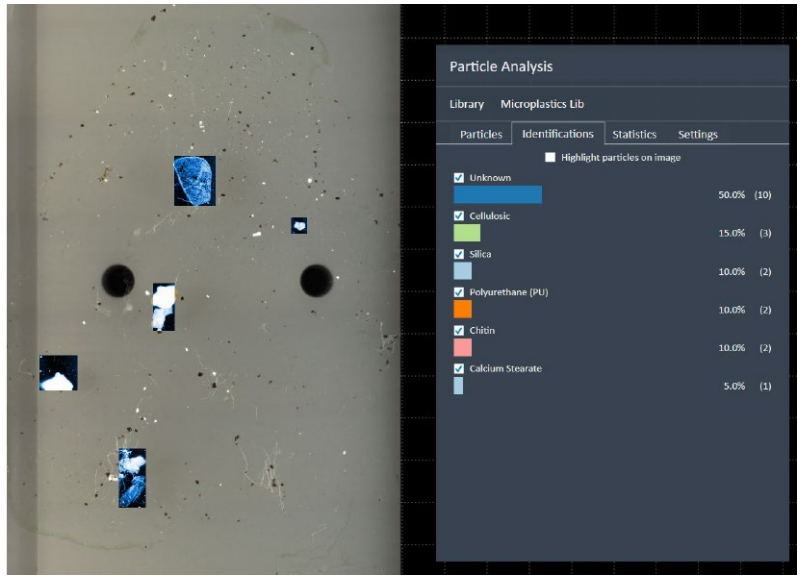
Figure 2. (a) Mosaic of reflected-light images generated from automated FTIR reflection mapping of microplastics extracted from fish stomach L3b. (b) IR intensity map corresponding to (a). (c,d) Details of spectral imaging correlation maps for 75 μm PS and 20 × 700 μm PET fiber, respectively, from areas shown in (a). Manual FITR confirmations are shown next to each.

Wagner et al. 2019. Nondestructive Extraction and Identification of Microplastics from Freshwater Sport Fish Stomachs. ES&T

Wastewater Influent Sample

East Bay MUD, Oakland, CA

~20x magnification

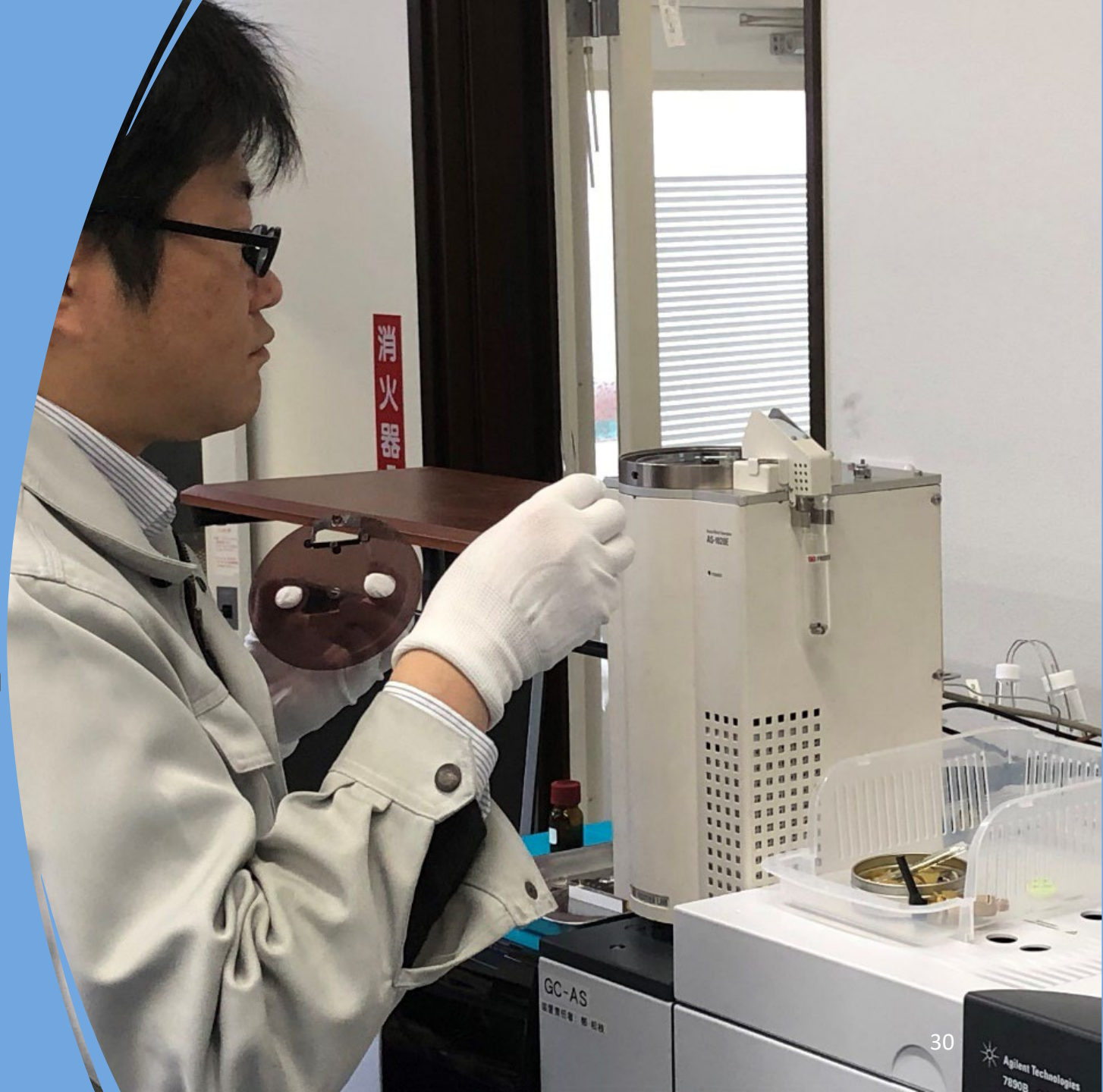


Agilent LDIR

- The Laser Direct Infrared Imaging detector provides compositional analysis of substances using spectral matching
- This helps us get positive plastic counts by polymer type with lots of supporting information.
- Rapid automation – simultaneous analysis

Mass-based Methods – Pyrolysis/GCMS (Frontier Analytical)

- Flash pyrolysis (between 500-600°C) of a sample yields pyrolyzates which evolve into the GC column.
- A mass spectrometer detects the pyrolyzates and produces a pyrogram
- Plastic polymer contents are identified by peak height and retention time and their mass is estimated.

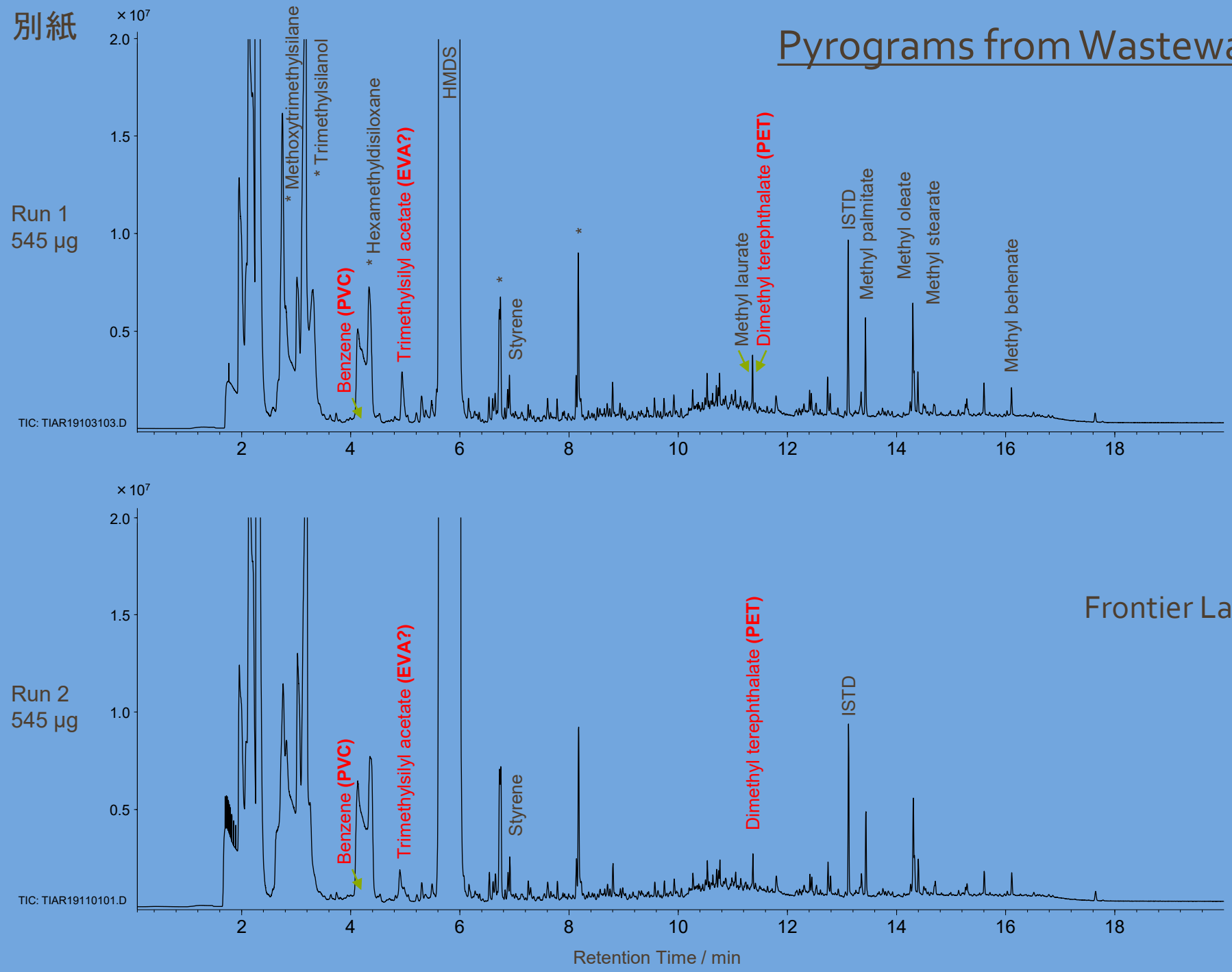


別紙

Pyrograms from Wastewater Sample

* HMDS副生成物

下水堆積物



Frontier Lab, 2020

EPA Region 9 & ASTM International D19

- Began a microplastics method development in "all waters" and funded significant research (June 2016).
- Multiple partner organization to develop standardized methods and practices for identifying microplastics in water.
  - Published methods for collection and sample preparation
  - Pending: reference sample preparation, analysis with Pyrolysis-GCMS and FTIR microspectroscopy.
  - Partners include: CA Department of Public Health, Pima County Wastewater, Agilent Technologies, Shimadzu Corp., Easy Bay MUD, LA County Sanitation and Frontier Analytical (Japan)

Using data to mitigate microplastic pollution

- Integrating plastic particle analysis with water monitoring
  - Oceans and estuaries, rivers, lakes and source waters
  - Includes point-source and non-point source monitoring
  - Repeatable and of high quality
- SFEI SF Bay 2018-19
- SCCWRP-UCR SoCal Bight 2020-21

Control Strategies – Stormwater management

- Litter control and collection
- Stormwater engineering collection and filtration
- Improving wastewater treatment

Reduction Strategies – What works best?

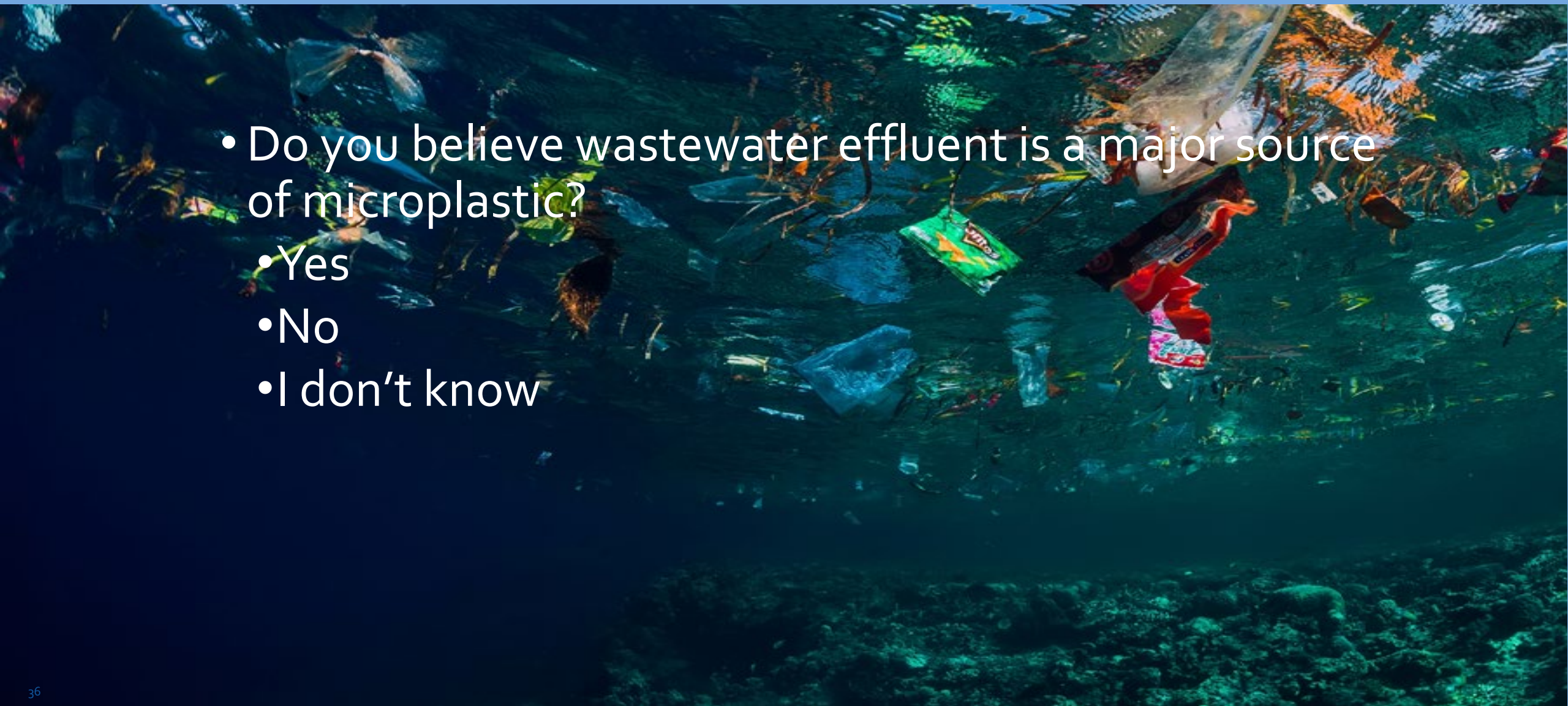
MP Management strategy recommendations (SFEI 2019)

1. Reduce single use through consumer education
2. Stormwater pathways and sources,
   - 300 times more plastic particles in stormwater than in wastewater
3. Green stormwater infrastructure, rain gardens retain particles (Gilbreath 2019)
4. Can we identify intervention points for fiber removal in wastewater?
5. How can Macroplastic monitoring be tied to Microplastic?

Scientific recommendations:

- Further evaluate fish/plastic/chemical transfer (evaluate impacts to the foodweb)
- Conduct monitoring alongside policy implementation, emphasize siting and monitoring filtration effectiveness
- Evaluate airborne pathways

POLL QUESTION



- Do you believe wastewater effluent is a major source of microplastic?
  - Yes
  - No
  - I don’t know

Control Strategies: Trash Capture

Trash capture devices, traps and booms in storm-water catchment basins, creeks and rivers prevent the escape of plastic trash to the oceans and its subsequent fragmentation into billions of microplastic particles.

LA Rain Garden – will capture MP and filter stormwater

State of CA Policy Direction on Microplastics

In July 2020, the State Water Board adopted a definition of microplastics in drinking water pursuant to section 116376 to the Health and Safety Code (as directed in Senate Bill No. 1422).

The law requires the State to adopt a standard methodology for the testing of drinking water for microplastics and requirements for four years of testing and reporting of microplastics in drinking water.

•On or before July 1, 2021:

- Adopt a standard methodology for testing of microplastics in drinking water;
- Adopt requirements for four years of testing and reporting of microplastics in drinking water, including public disclosure of those results;
- Consider issuing quantitative guidelines (e.g., notification level) to aid consumer interpretations of the testing results, if appropriate;
- Accredit qualified laboratories in California to analyze microplastics in drinking water.

CA Microplastics – Ocean Protection Council

- California Ocean Litter Prevention Strategy and by Senate Bill 1263, which requires OPC to develop and submit a statewide Microplastics Strategy to the legislature by the end of 2021
  - Develop a Risk Assessment Framework impacts on microplastics to the ocean
  - https://opc.ca.gov/webmaster/ftp/pdf/agenda_items/20200619/Item9_MicroplasticsProjects_FINAL.pdf
- SFEI and SCCWRP each have embarked on microplastic research studies using State funding.
  - SFEI's plastic study was far reaching though suffered from significant technical challenges. SCCWRP expected to follow (H. Allen Pers. Communication).

POLL QUESTION

- Do you believe there is adequate scientific information to make good policy decisions (for example) in California?
  - Yes
  - No
  - I don't know

US EPA Region 9 - TMDL

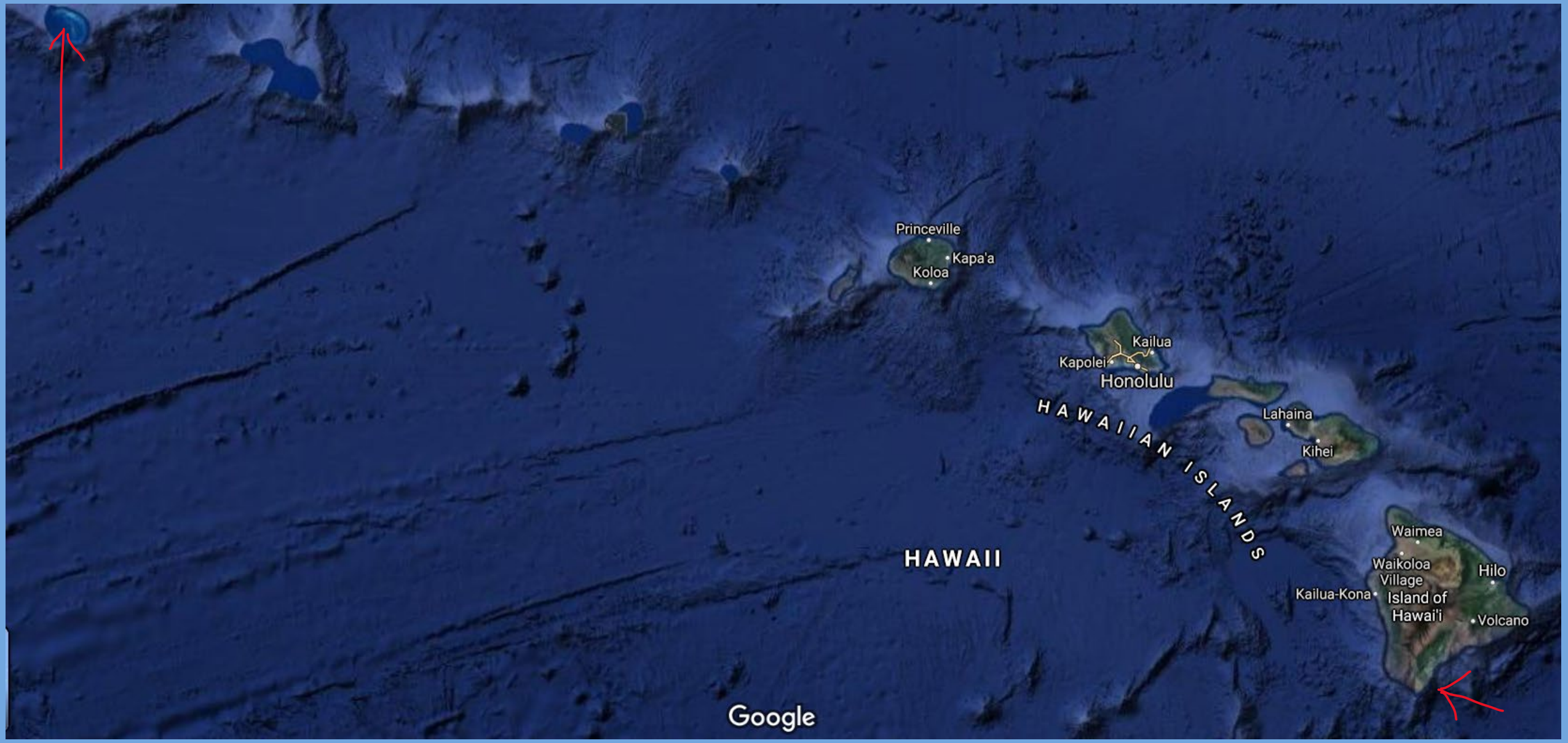
EPA identified two waterbodies that were not included in Hawaii's 303(d) List.

EPA has identified Kamilo Beach and Tern Island waterbodies as impaired by trash and as requiring Total Maximum Daily Loads (TMDLs) under Clean Water Act, Section 303(d).

The Islands Of Hawaii Hold One Of The Dirtiest Places In The World

Kamilo Point shows just how dire the world's plastic pollution problem really is.

https://www.huffpost.com/entry/kamilo-beach-hawaii-dirtiest-beach-america_n_58e99a38e4b05413bfe3792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Kihei
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Hilo
Kailua-Kona
Island of Hawai'i
Volcano
HAWAII
Google

EPA Region 9 & ASTM International D19

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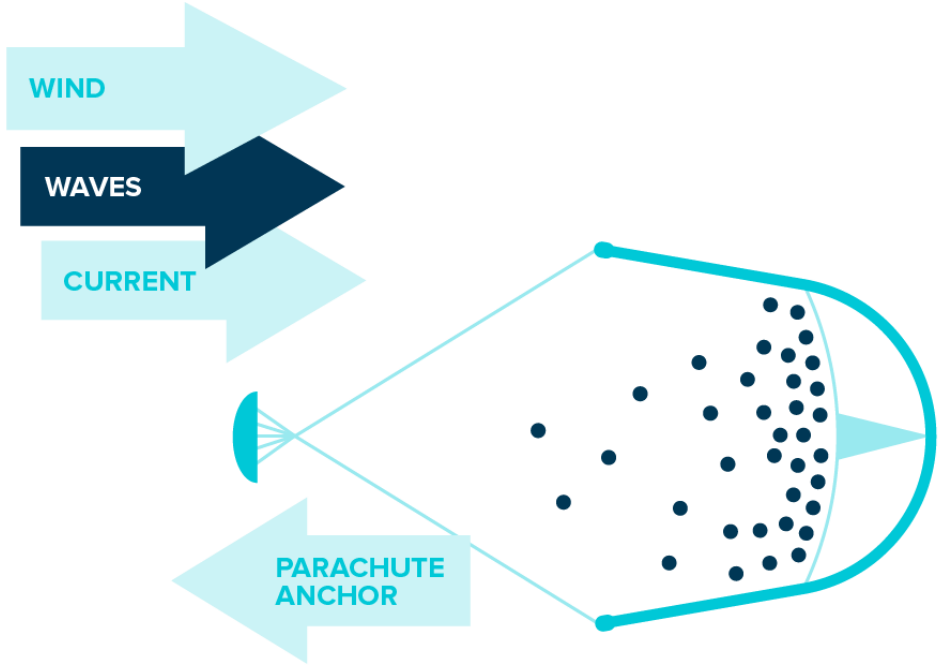
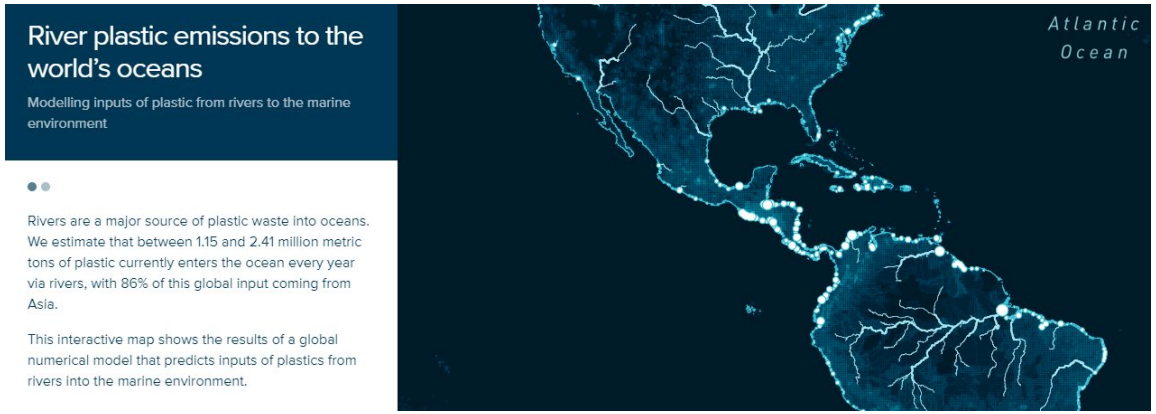
Tern Island

Stormwater discharge, Los Angeles, CA

The Ocean Cleanup





https://theoceancleanup.com/sources/

Microplastic Fallout in Different Indoor Environments

Qun Zhang, Yaping Zhao, Fangni Du, Huiwen Cai, Gehui Wang, and Huahong Shi*

Cite This: *Environ. Sci. Technol.* 2020, 54, 6530–6539

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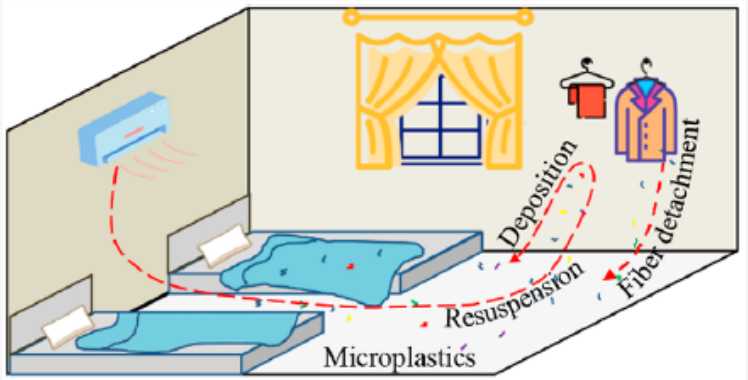
ABSTRACT: Microplastics in the air have gradually attracted our attention in recent years; however, temporal and spatial trends of microplastics in indoor air are rarely discussed. In the present study, we tracked microplastic fallout in a dormitory, an office, and a corridor on both workdays and weekends for three months. In addition, an air conditioner was used to understand airflow influence on microplastic resuspension in the dorm. Among the three sampling sites, the highest average microplastic abundance appeared in the dormitory (9.9×10^3 MPs/m^2/d), followed by the office (1.8×10^3 MPs/m^2/d) and the corridor (1.5×10^3 MPs/m^2/d). In the dormitory, the average MP abundance on weekends (1.4×10^4 MPs/m^2/d) was approximately three times of that on weekdays (5.8×10^3 MPs/m^2/d). In the office; however, the abundance on weekends (1.2×10^3 MPs/m^2/d) was 50% of that on weekdays (2.4×10^3 MPs/m^2/d). Microplastic fallout existed mostly in the form of fibers and showed similar polymer compositions to the textile products used in indoor environments. The airflow tests using an air conditioner suggested that airflow turbulence increased resuspension of microplastics. Taken together, we conclude that indoor environments are prone to serious microplastic pollution, but microplastic level varies greatly due to different characteristics of indoor setting. Our results also indicate that textile quantity is one of the main factors affecting microplastic abundance in indoor air, whereas air conditioner-induced airflow turbulence can cause microplastic migration in indoor environments.



Web Resources

- Opportunity Project StoryMap: https://storymaps.arcgis.com/stories/df9267f53b284f138cacdb6b9db8038d
- Draper Microplastics: https://www.draper.com/business-areas/global-challenges/planet/microplastics
- "Plastic Wars" PBS Frontline https://www.pbs.org/wgbh/frontline/film/plastic-wars/
- Microplastics Health Effects Webinars: https://www.sccwrp.org/about/research-areas/additional-research-areas/trash-pollution/microplastics-health-effects-webinar-series/


Q&A
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