MICROPLASTICS IN THE ENVIRONMENT, IN HUMANS, AND THE ROLE OF REGULATION IN LIMITING THEM

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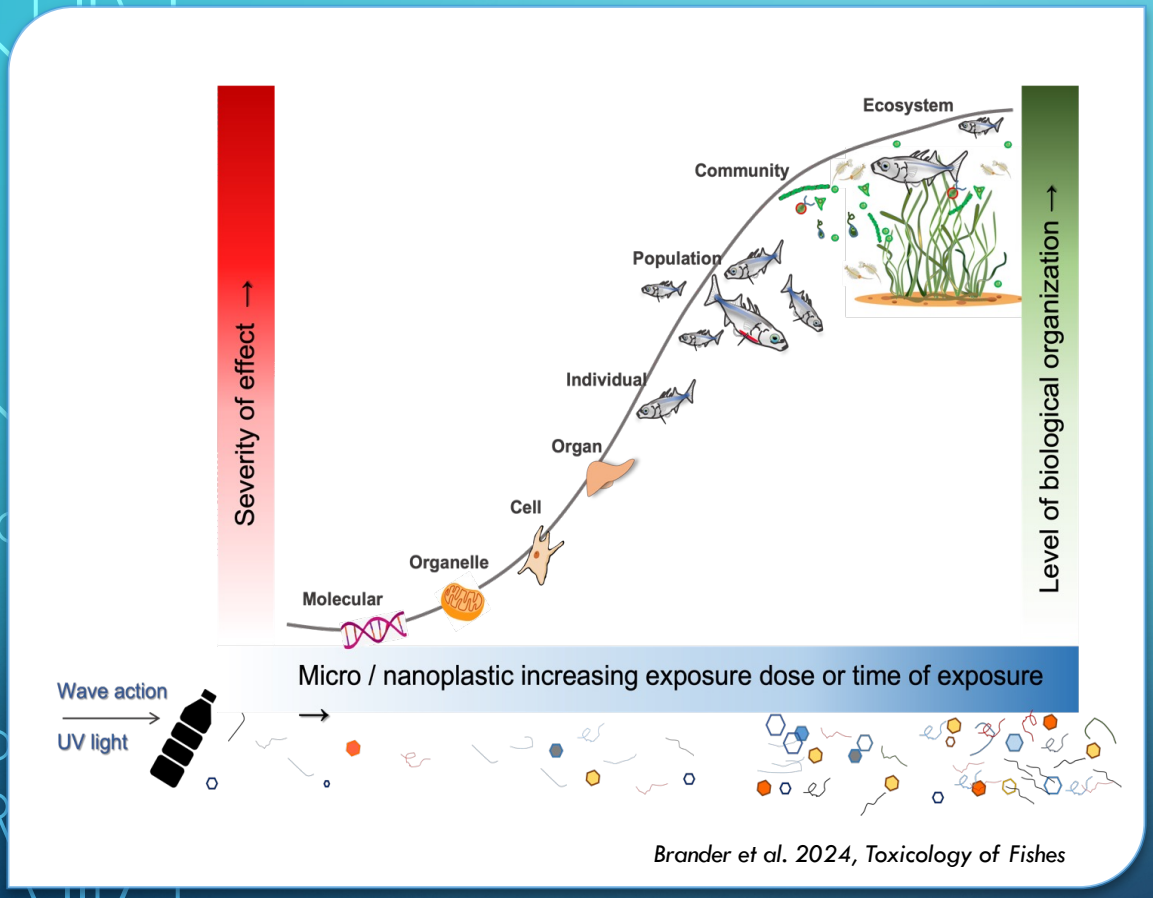
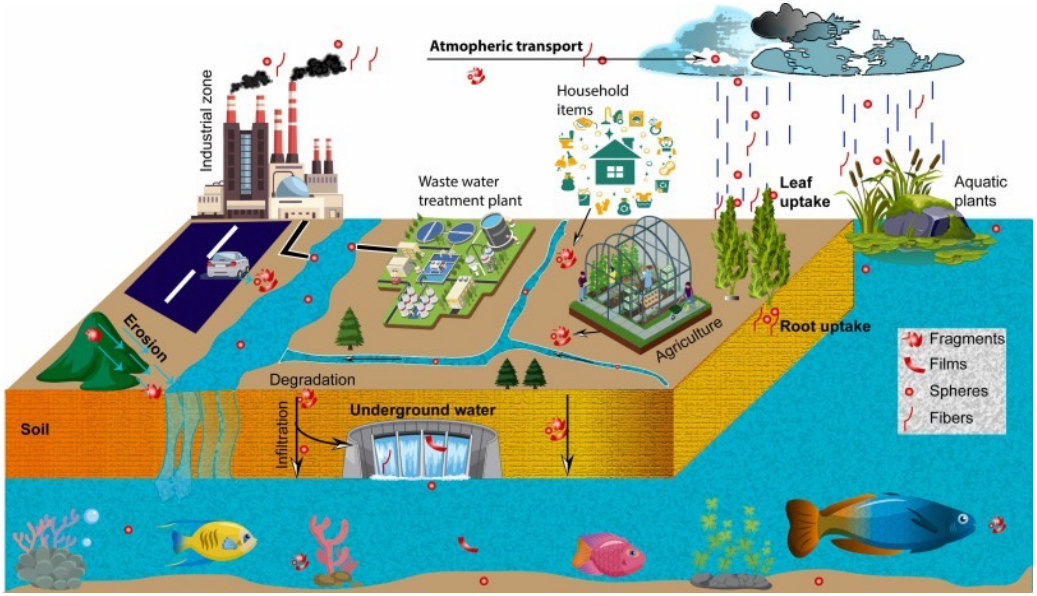


Brander et al. 2024, Toxicology of Fishes

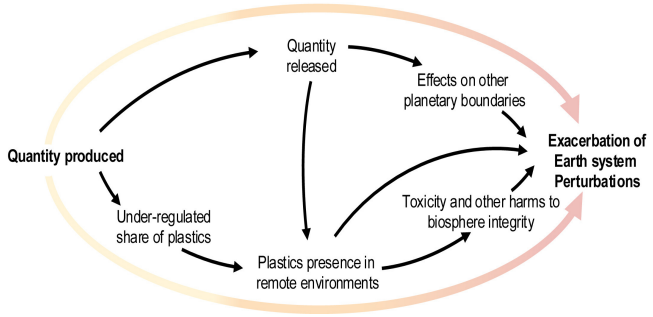
1. BACKGROUND
2. OCCURRENCE IN FOOD WEBS
3. TOXICITY
4. LINKS TO HUMAN HEALTH
5. MITIGATION AND PLASTICS TREATY



Hambumugisha et al. 2024, Ecotox Env Safety

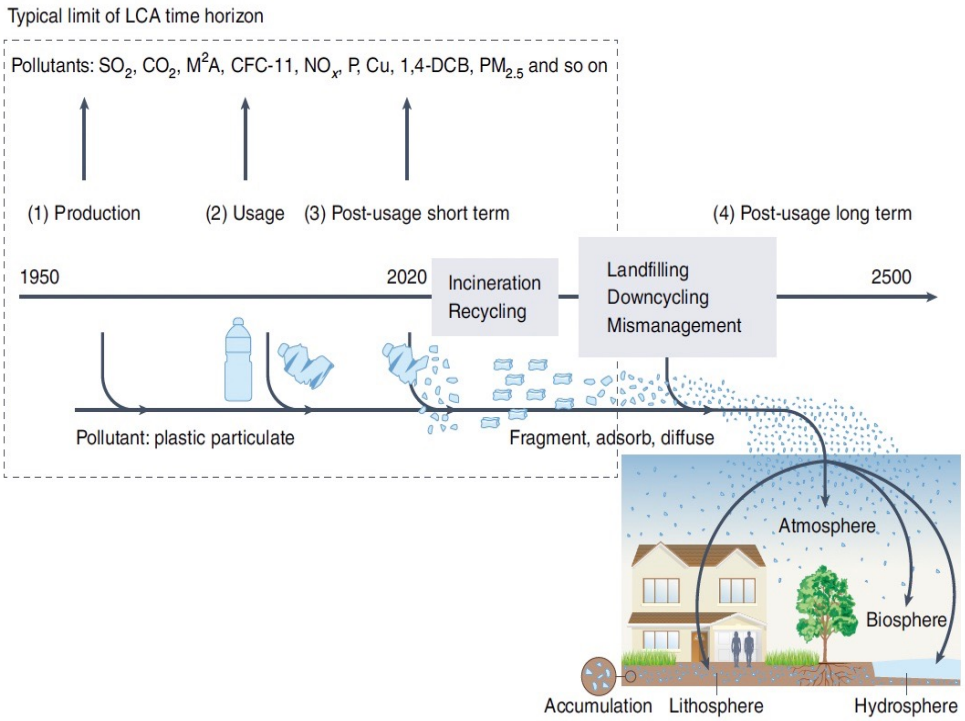
EVERYTHING EVERYWHERE, ALL AT ONCE

Organisms are exposed via a variety of different pathways



Plastics are a major factor contributing to our near exceedance of planetary tolerance for anthropogenic disturbance.

Villarubia-Gómez et al. 2024, *One Earth*



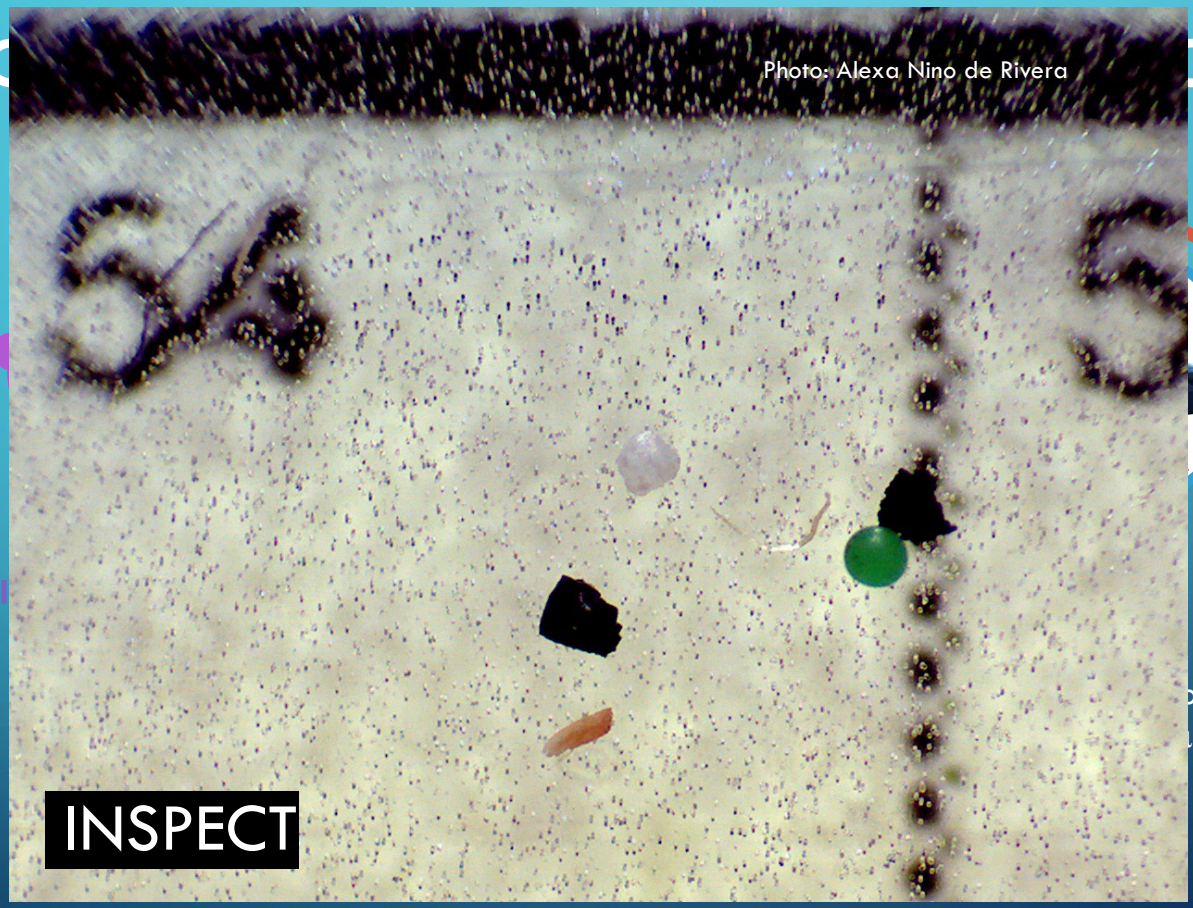
FRAGMENTATION

We don't currently have a good way of estimating the long-term impacts of plastic fragmentation to the environment and health.

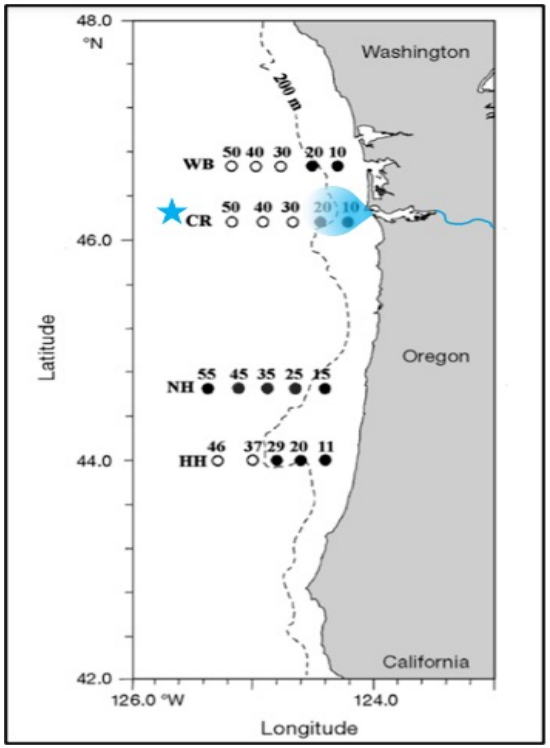
Microplastics and their smaller counterparts, nanoplastics, are toxic due to both physical and chemical properties.

Gontard et al. 2022, Brander et al. 2024

OC LIDS

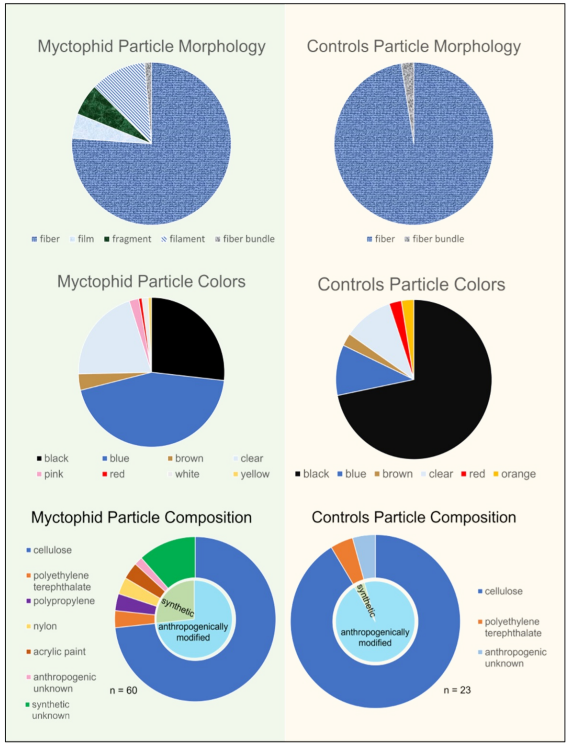


Brander et al. 2020, Cowger et al. 2020, Lasdin et al. 2023, Boisen et al. 2024



SAIP cruise transects

(modified from Suntsov and Brodeur, (2018)



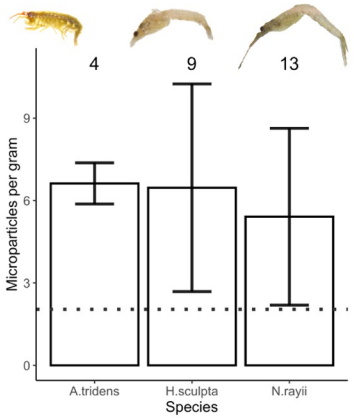
Olivia Boisen, Masters thesis Sept. 2023

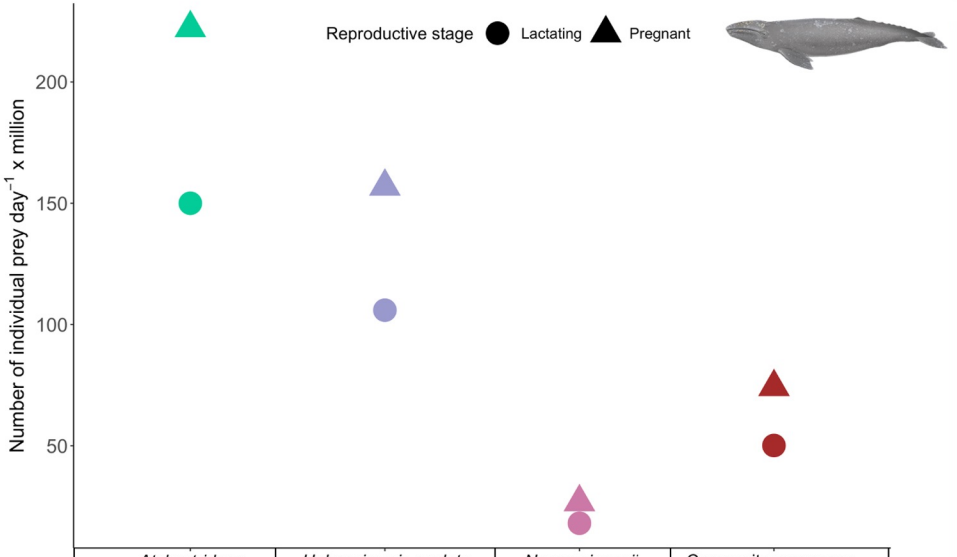
MYCTOPHIDS

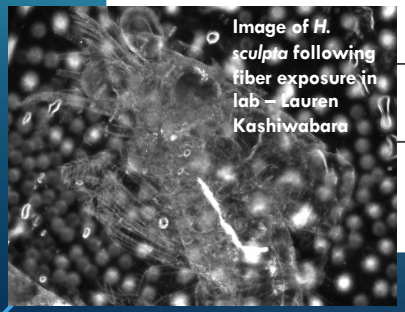
Approximately 34% of fish across three species contained particles (20 fish per station, 340 total). The majority were fibers.

TROPHIC TRANSFER, FOOD WEB IMPACTS

Zoop to poop





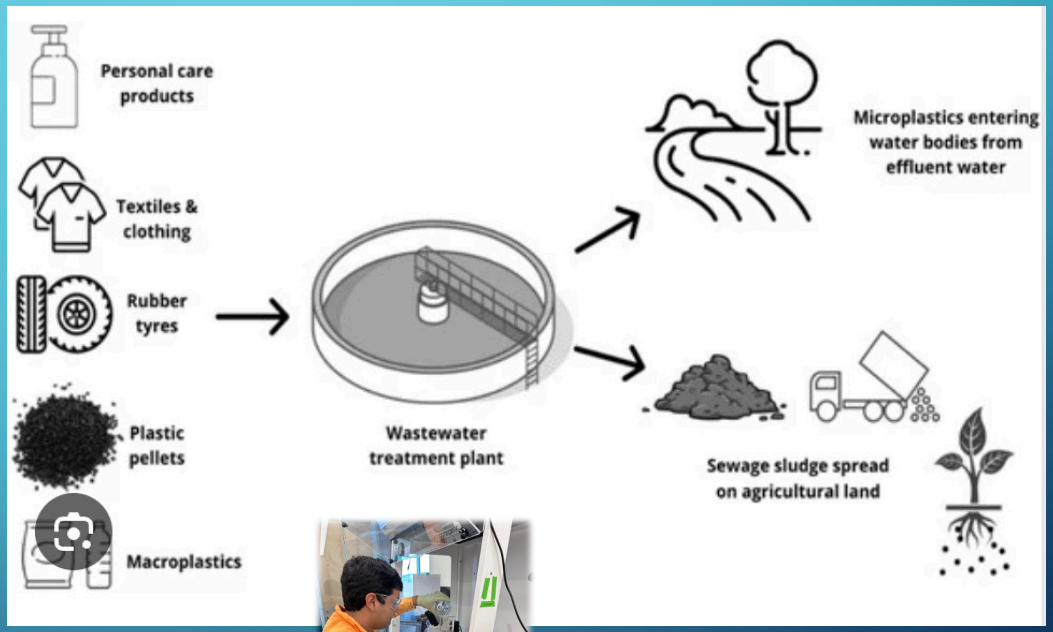


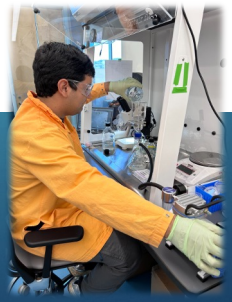
	Atylus tridens	*Holmesimysis sculpta*	*Neomysis rayii*	Composite preyscape
Microparticles per individual prey	0.10	0.09	0.40	0.2
Microparticles ingested by lactating gray whale per day	14.3 million	9.03 million	6.45 million	8.97 million
Microparticles ingested by pregnant gray whale per day	21.2 million	13.4 million	9.55 million	13.3 million

Hildebrand et al. 2021; Torres, Brander et al. 2023

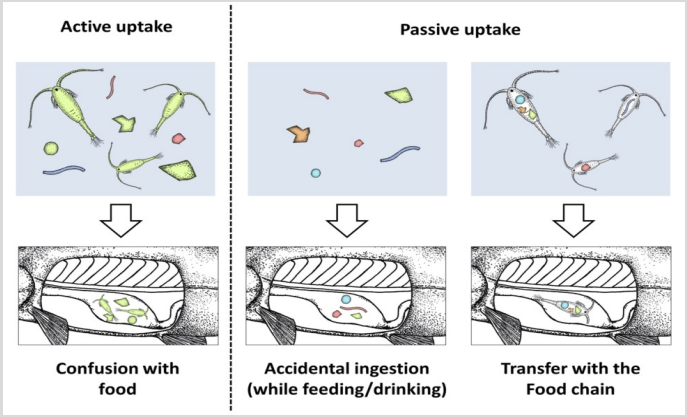
TERRESTRIAL SOURCES OF MPS IN OREGON

- Studying microplastics in biosolids from six regional WWTPs in Oregon
- Also studying fate on a farm that uses biosolids on crops
- So far seeing an average of five particles per 10 grams of dried biosolids, mostly fibers, some plastics such as polypropylene, PETE
- Also evaluating samples from composting and mechanical recycling facilities in collaboration with Oregon DEQ.





Milojevic and Cydzk-Kwiatkowska 2021
Beni et al. 2023
Arriola et al. in prep



Brander et al. 2024, Tox of Fishes

Bucci et al. 2021, Steinbarger et al. 2021, Carney Almroth et al. 2020, Jacob et al. 2020, Bucci et al. 2019, Covernton et al. 2019, Choi et al. 2018, Qiao et al. 2019, Ziajahromi et al 2017, Koelmans et al. 2015, Velzeboer et al. 2014

WHAT WE KNOW ABOUT MP IMPACTS

• • •

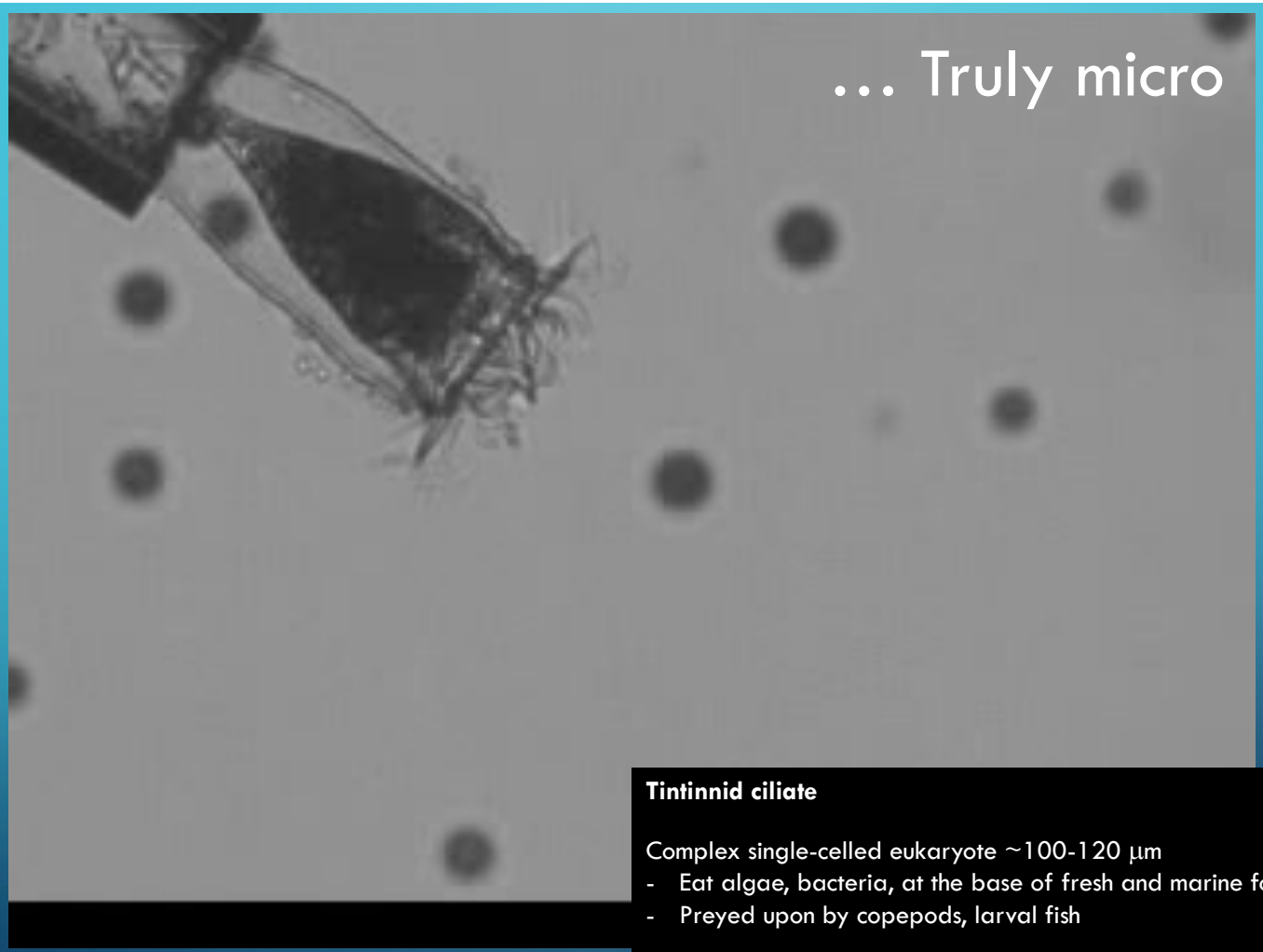
- Size and shape of particles are important, fibers may be more toxic and more easily transported
- Particles cause oxidative stress, changes in behavior
- "Food dilution" is also a big issue for aquatic organisms
- Many studies still use unrealistic particles


Mysid


Silverside


Daphnia

… Truly micro



Tintinnid ciliate

Complex single-celled eukaryote ~100-120 µm
- Eat algae, bacteria, at the base of fresh and marine food webs
- Preyed upon by copepods, larval fish

Widely distributed in marine and freshwater

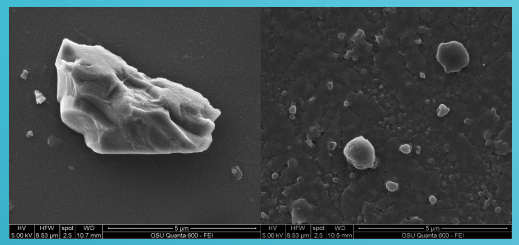
Use cilia to create a current when randomly encountering food items

Athey et al. 2020, *Limno Ocean Letters*
Echevarria et al., 2014, *FEMS Microbiology, Ecology*

MILLED PLASTICS (MICROSCALE VS NANOSCALE)

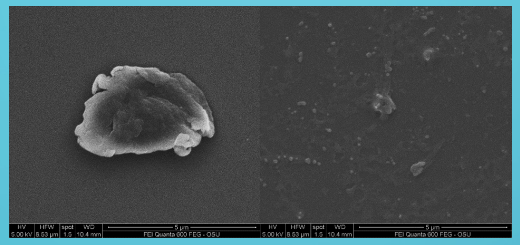
Pacific Northwest Consortium on Plastics

Tire wear



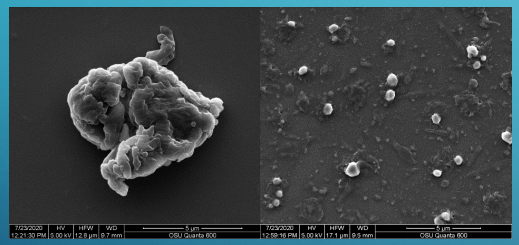
1–20 µm <1 µm

Polyethylene Terephthalate



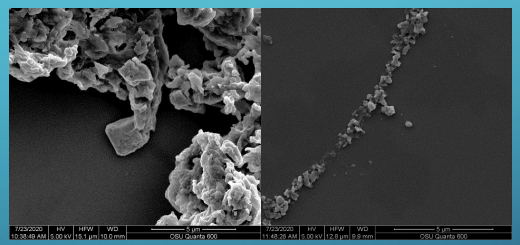
1–20 µm <1 µm

Polypropylene



1–20 µm <1 µm

Polylactic Acid



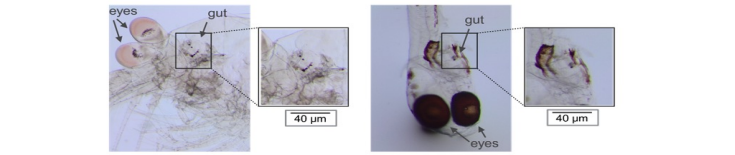
1–20 µm <1 µm

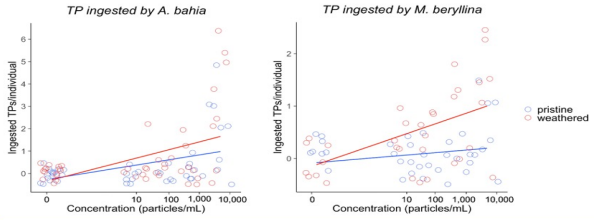
Polyester Fiber

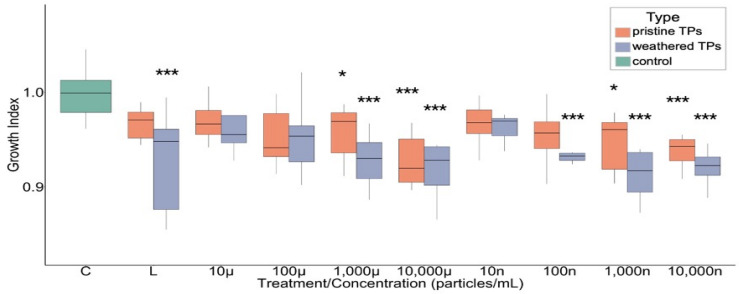
Examples of milled plastics at micro and nanoscale (SEM), aiming to mimic complexity of MNPs in environment

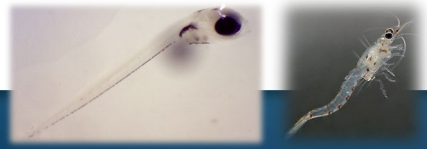
Have generated and tested fibers, tire wear, PLA, PP, PET, etc.

Expose early life stages of fish and invertebrates to particles made in house.









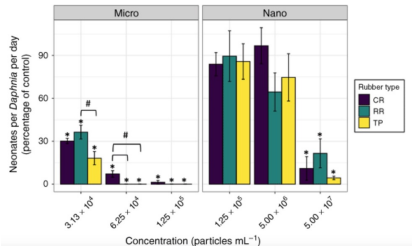
TIRE WEAR MIXTURES
WEATHERED VS. NEW

- By the time organisms are exposed to tire particles, they are likely highly weathered, here we compared new to weathered particles from the same CMTT mixture.
- Weathered particles were more readily ingested and had a greater impact on growth.

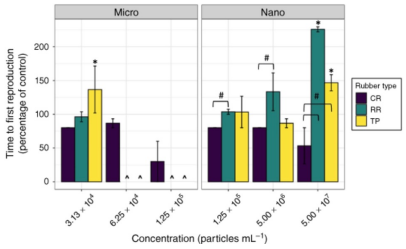
Raguso et al. in review, *Jr. Haz. Mat.*

RUBBER TYPES, EFFECTS ON REPRODUCTION

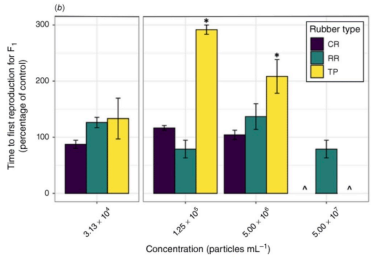
Neonates per day



Time to 1st repro F0



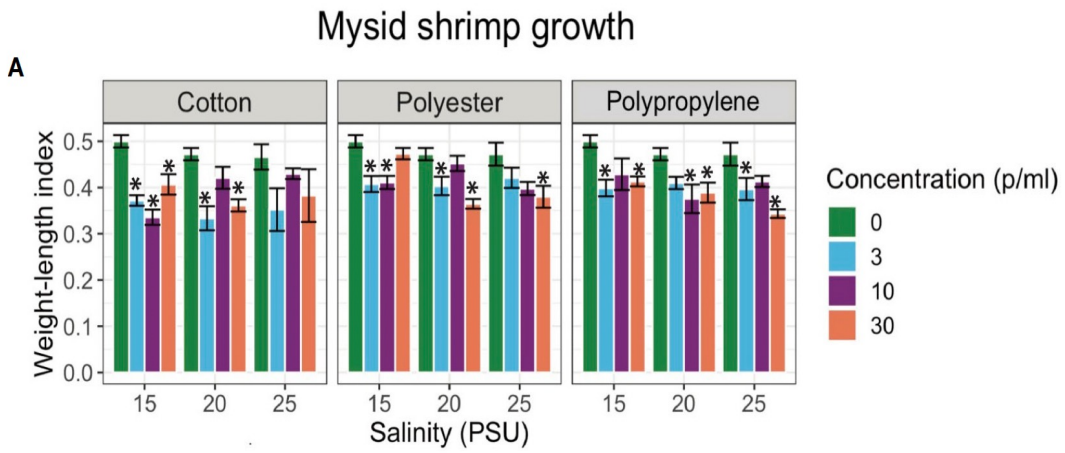
Time to 1st repro F1



CUNNINGHAM ET AL., 2024, *ENV CHEMISTRY*

- Reproduction was affected by exposure to sublethal concentrations of all three rubber types. Reproductive output was assessed as the number of neonates produced per *Daphnia* per day and as time to reproduction.
- All concentrations of micro-sized rubber particles caused significant decreases in neonate production in comparison to the controls. Offspring from exposed nano-TP parents took longer to start reproducing.

FIBERS



Siddiqui et al. 2023

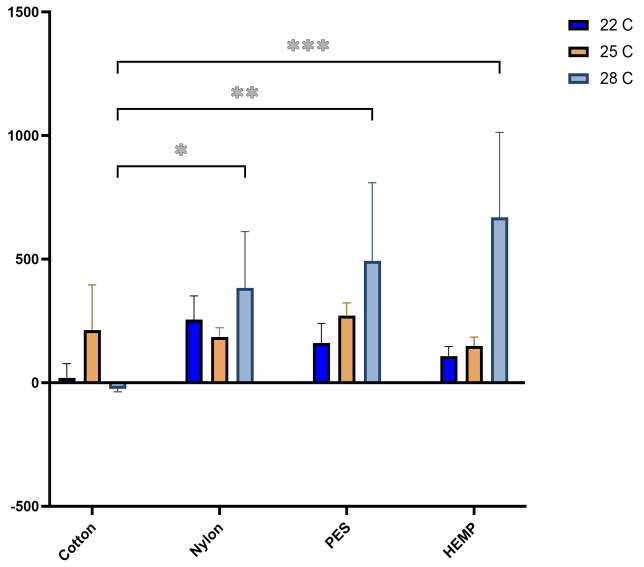
TEXTILES ARE ALSO A CHALLENGE

Cotton caused similar decreases in growth for mysid shrimp in comparison to polyester and polypropylene fibers. Silverside growth was not impacted by cotton (data not shown).

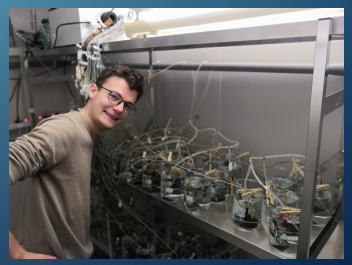
FIBERS

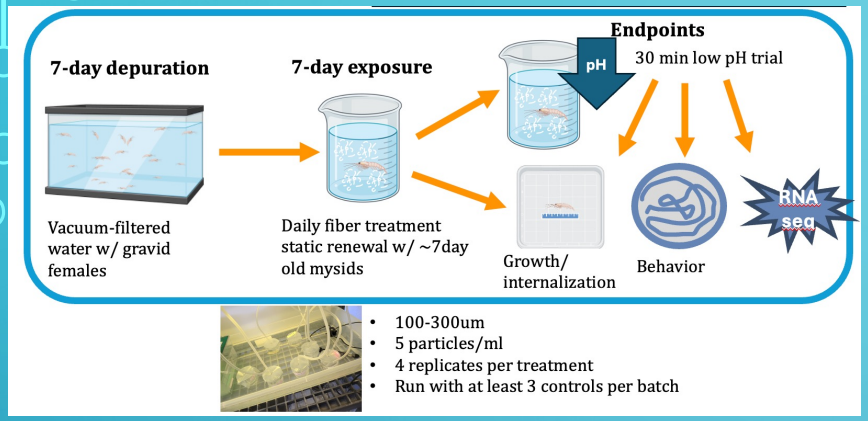
Biefel et al. in 2024

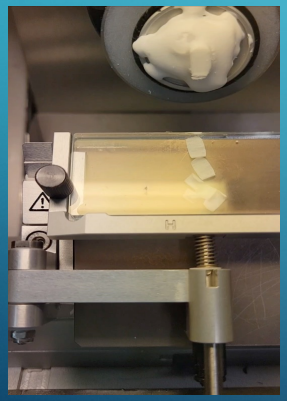
Reactive Oxygen Species

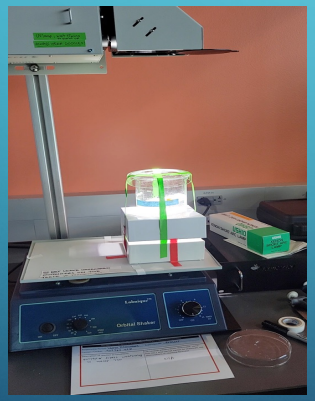


NATURAL IS USUALLY BETTER, BUT TEXTURE AND TEMP MATTER TOO.







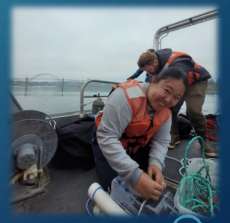


Kashiwabara in prep.

EXAMINING MICROFIBER IMPACTS ON COASTAL FOOD WEBS

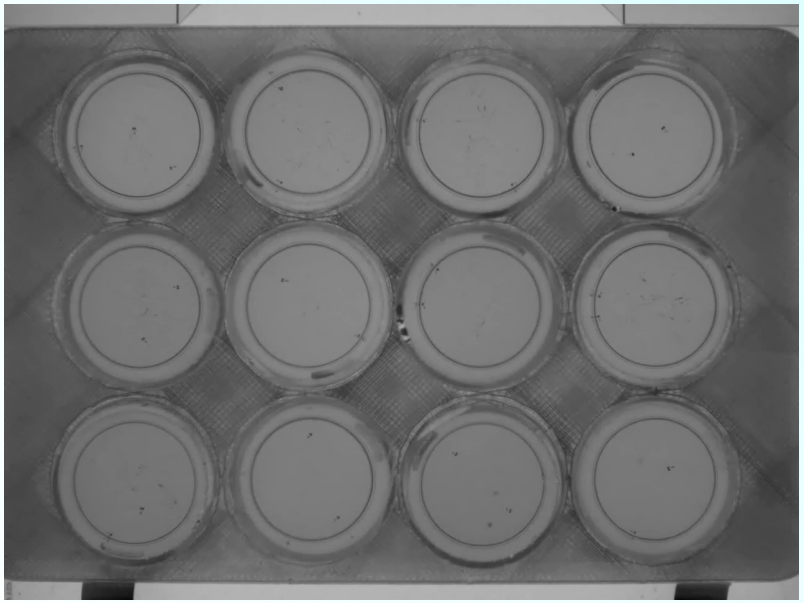
Image of *H. sculpta* following fiber exposure in lab – Lauren Kashiwabara

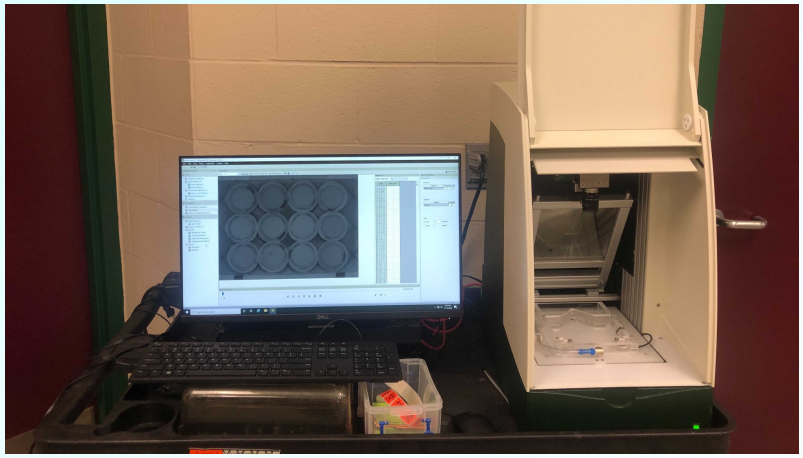
Native and lab-reared mysids are being exposed to textiles obtained from a denim factory at different treatment stages (griege, ozonated, chemically treated).



Preliminary results indicate that chemically treated fibers may have a larger impact on behavior, and that native mysids may be more sensitive.

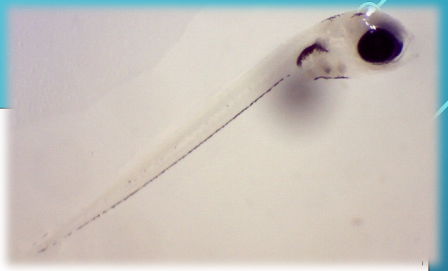
BEHAVIORAL RESPONSES



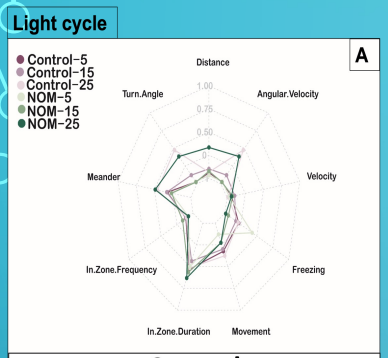


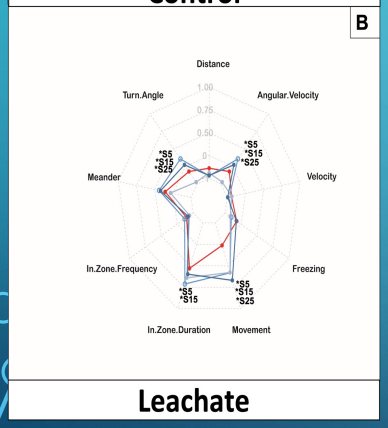
Sara J Button

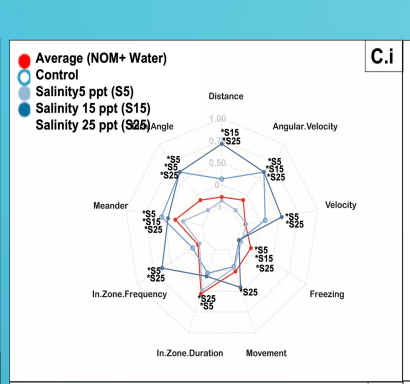
Noldus ethovision autorecords animal activity and movement, can measure small changes in a variety of behavioral responses.

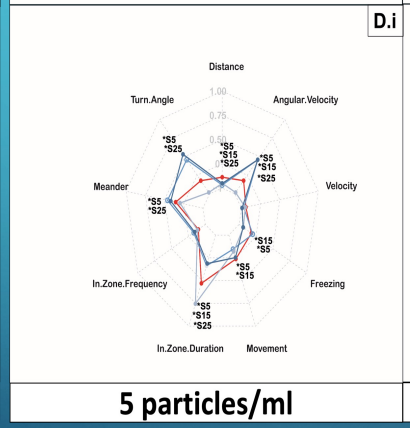


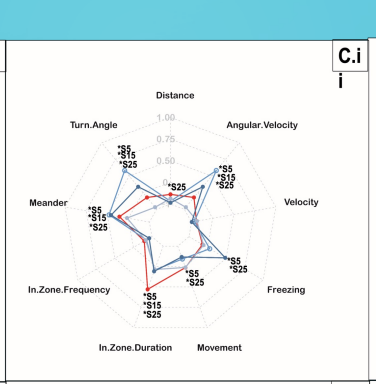
Hutton et al. in prep

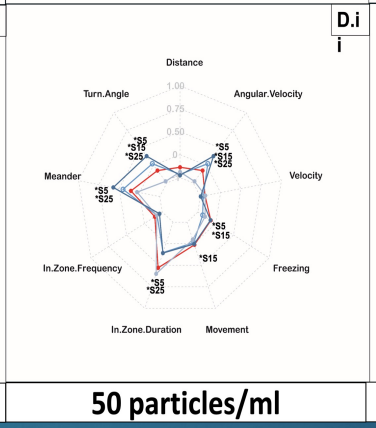






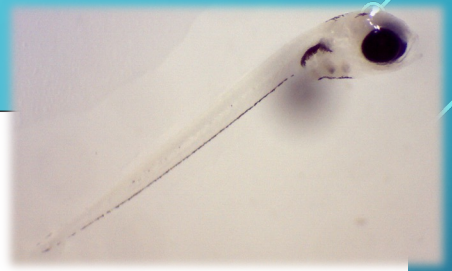






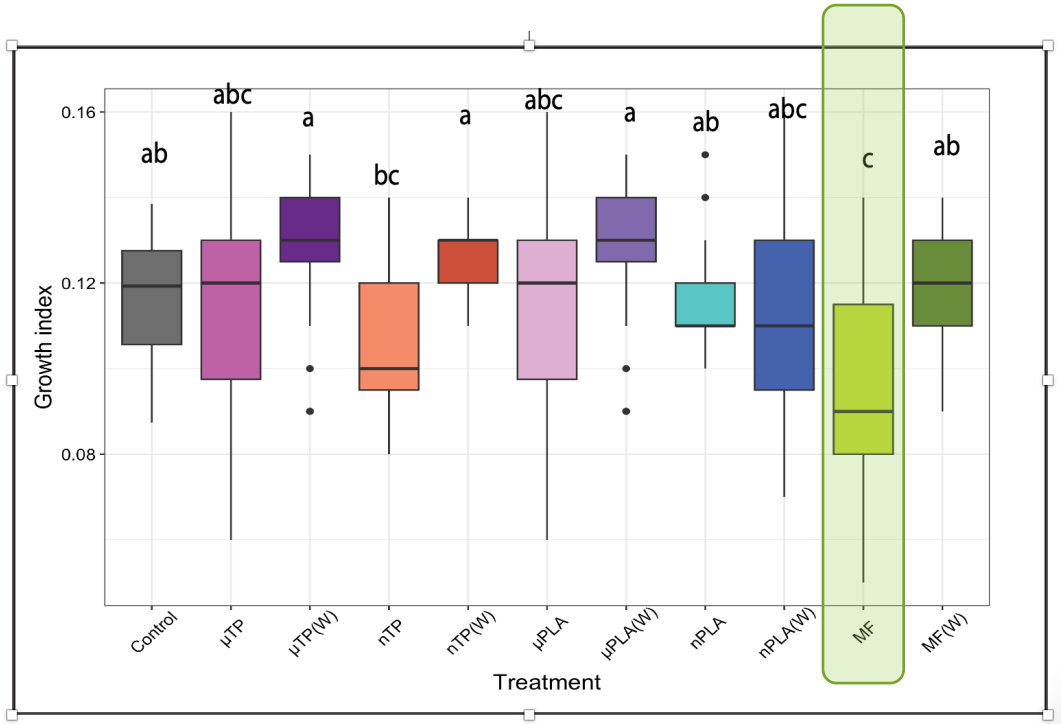
micro

nano



Polylactic Acid

BEHAVIOR IS ALSO SIMILARLY ALTERED

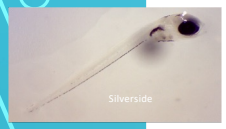


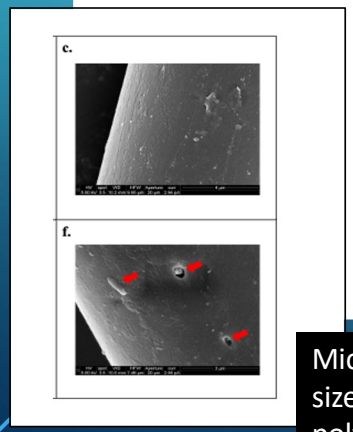
Hutton et al. 2024

ACROSS PARTICLE TYPES

New microfibers significantly reduce growth over 21 days in larval fish, some PLA treatments overlap with MFs and TP.

Weathered microfiber activated gene pathways similar weathered nano polylactic acid (bio-based)





Microscope image showing nano-sized particles breaking off from polyester fibers (Kashiwabara)

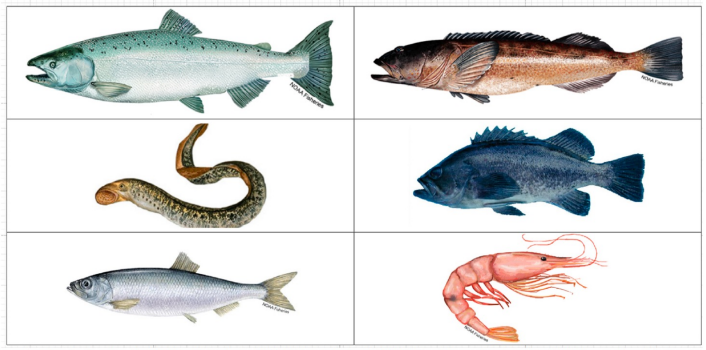
Top 15 upregulated pathways

Hutton et al. 2024, Frontiers in Tox

COMMERCIAL FISHERY SPECIES

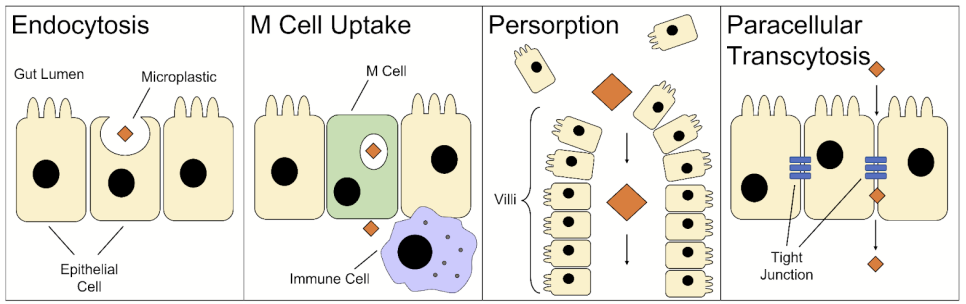
TABLE 3 Breakdown of material color, shape, length, and material categories identified via FTIR

	Color				Type			L
	White/clear	Black	Blue	Other	Fiber	Film	Fragment	< x size
Retail								
Pink shrimp	271	80	19	3	361	2	11	1.024
Black rockfish	134	81	81	2	245	1	54	3.795
Lingcod	155	23	50	4	185		45	1.625
Vessel								
Pink shrimp	321	24	12		357	4	24	0.477
Pacific herring	115	8	22		134		11	3.89
Lingcod	18	21	5	3	40		8	7.15
Riverine juvenile Pacific lamprey	116	1	6		62	1	62	7.73

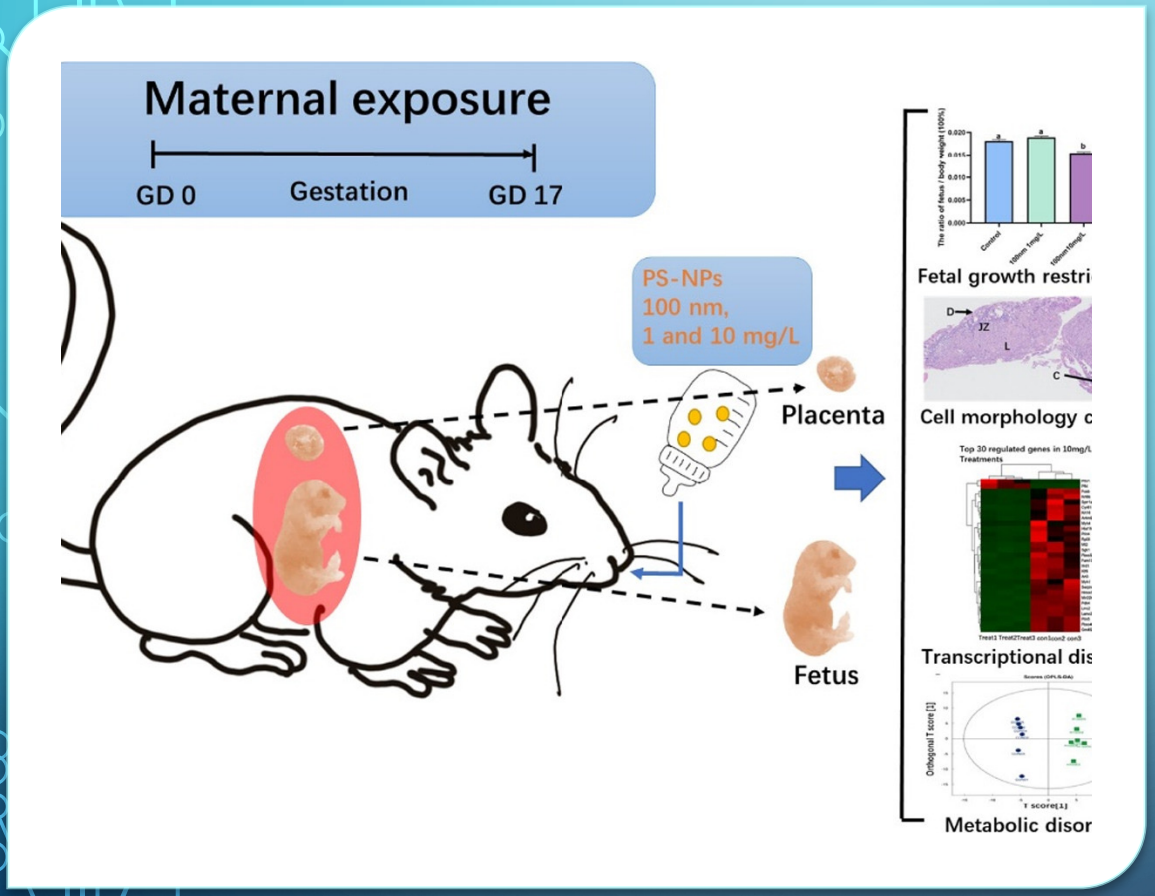


oto credits: Chinook salmon, lingcod, pink shrimp, Pacific herring (NOAA Fisheries), black rockfish (ODFW), and lamprey (North Carolina Wildlife Resource Commission).

astics and fibers were all
d in fillets (edible muscle tissue).



Traylor et al. in 2024, Lasdin et al. 2023
Brander et al. 2024



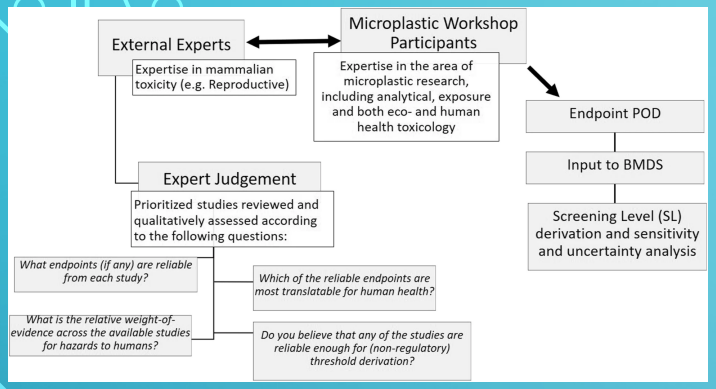
Chen et al. 2023

Maternal PS-NP exposure caused fetal growth restriction in mice.

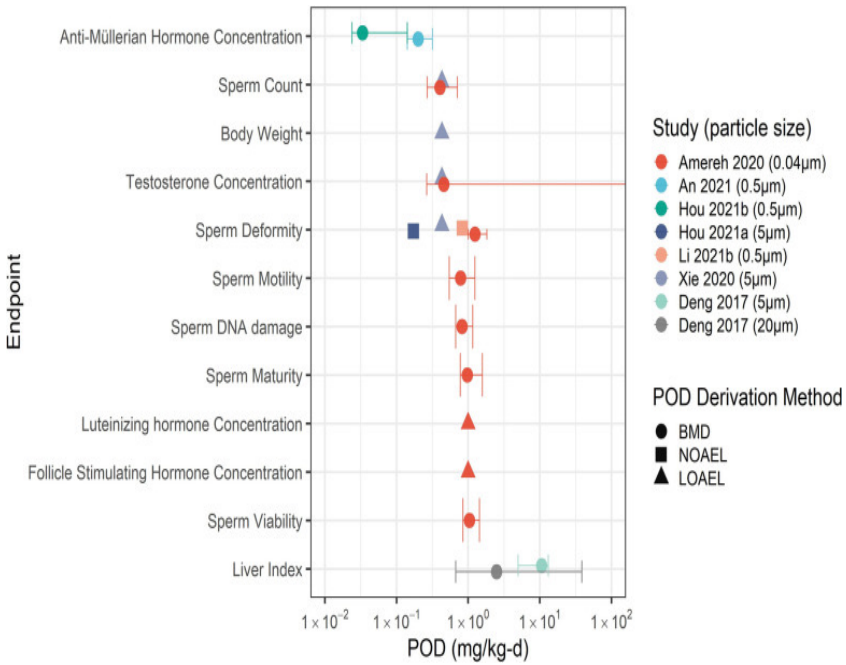
•Multiomics were used to reveal the reproductive toxicity mechanism of PS-NP to mice.

•PS-NP generated abnormal cholesterol metabolism and nutrient balance in placenta.

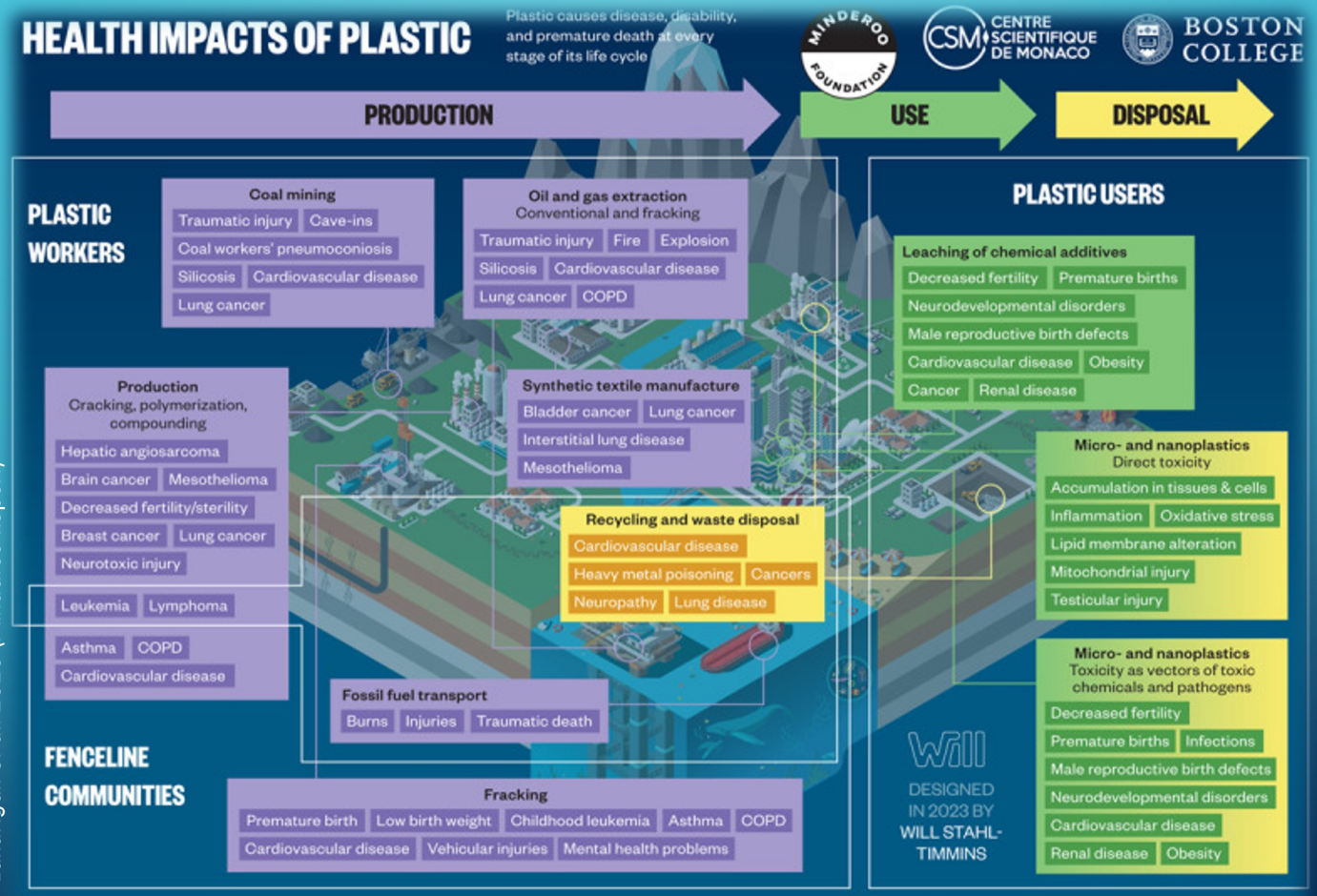
•PS-NP mainly affected fetus by disturbing muscle system and lipid metabolism.



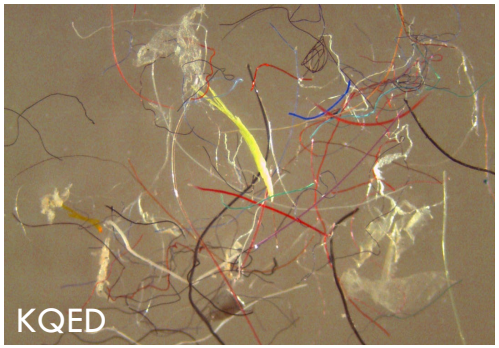
A meta-analysis conducted to determine the potential for MNP impacts from drinking water exposure was conducted in the state of California in 2020-2022, studies that passed QA/QC saw impacts on male and female reproductive endpoints.

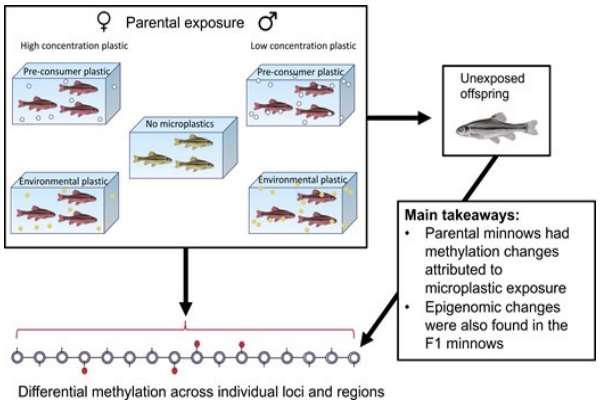


Coffin et al. 2022



Landrigan et al. 2023 (Minderoo Report)





Wade et al. 2025, Jrnl Heredity

SUMMARY AND FUTURE NEEDS

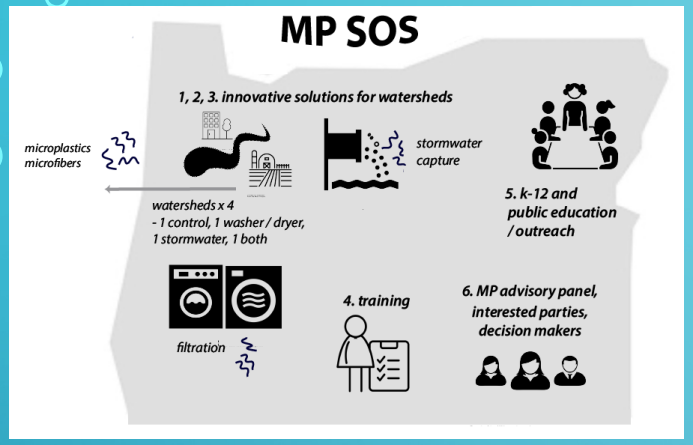
Particles appear to become more toxic as they decrease in size, and fibers may be more problematic than other morphologies. Growth, reproduction, behavior, and gene expression are impacted across taxa.

Translocation is a major concern, more work is needed to understand the implications of particles becoming entrapped in tissues or cells

Future research needs include:

1. Standardized bioassays, and a better understanding of longer-term impacts, many studies are acute or shorter chronic studies.
2. More multigenerational studies are needed as are studies that span environmental and human health.
3. Analytical approaches to track and detect nano-sized particles in tissues and to understand how associated chemicals may increase toxicity.
4. Better understanding of how weathering and biofilm growth influence toxicity for common particle types.
5. Strategies for avoiding regrettable substitutions, bio-based plastics are not necessarily safer.
6. Mitigation approaches are needed downstream in the short term (filtration), and upstream over the longer term (reduced production).

EXPLORING MITIGATION APPROACHES IN OREGON AND WASHINGTON



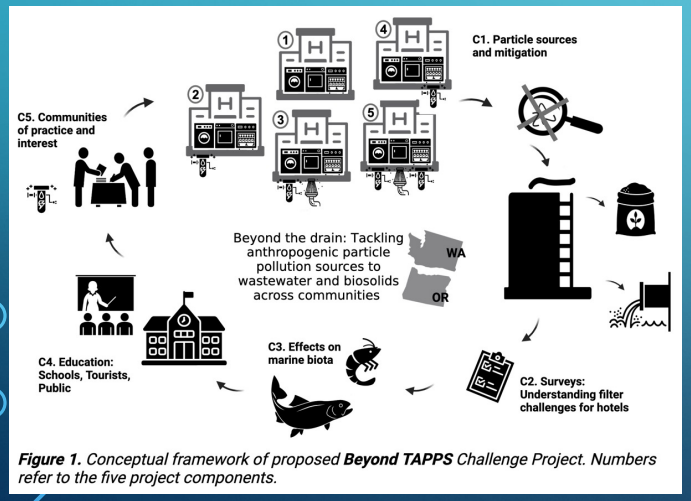
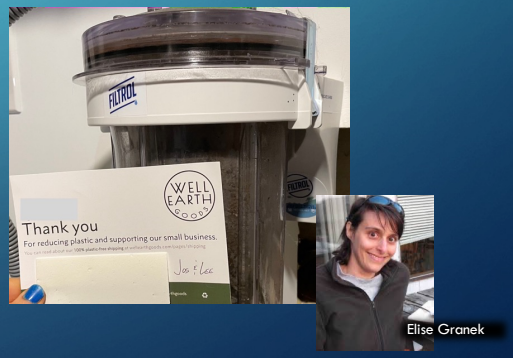


Figure 1. *Conceptual framework of proposed* ***Beyond TAPPS*** *Challenge Project. Numbers refer to the five project components.*

Sampling stormwater in Depoe Bay

Filter outreach at Bigfoot's



Elise Granek

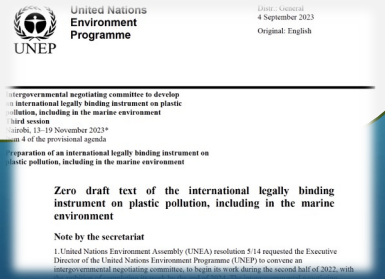
GLOBAL POLICY

Scientists' Coalition for an Effective Plastics Treaty

The Scientists' Coalition for an Effective Plastics Treaty is a network of independent scientific and technical experts contributing summaries and interpretations of scientific knowledge to decision makers and the public involved in the negotiations towards a global plastics treaty.

The Coalition was formed in 2022, following the decision of the United Nations Environment Assembly to start negotiations.

Scientists' Coalition for an Effective Plastics Treaty



United Nations Environment Programme

UNEP

4 September 2023

Original: English

Zero draft text of the international legally binding instrument on plastic pollution, including in the marine environment

Note by the secretariat

1. United Nations Environment Assembly (UNEA) resolution 5/14 requested the Executive Director of the United Nations Environment Programme (UNEP) to convene an intergovernmental negotiating committee, to begin its work during the second half of 2022, with

Objectives

I. To mobilize a diverse, international and transdisciplinary network of scientific experts to engage with and provide scientific evidence, evaluations, and guidance to government delegations and the wider public throughout treaty negotiations.

II. To identify and address biases, misunderstandings or misrepresentations of scientific data to enable an informed negotiation process.

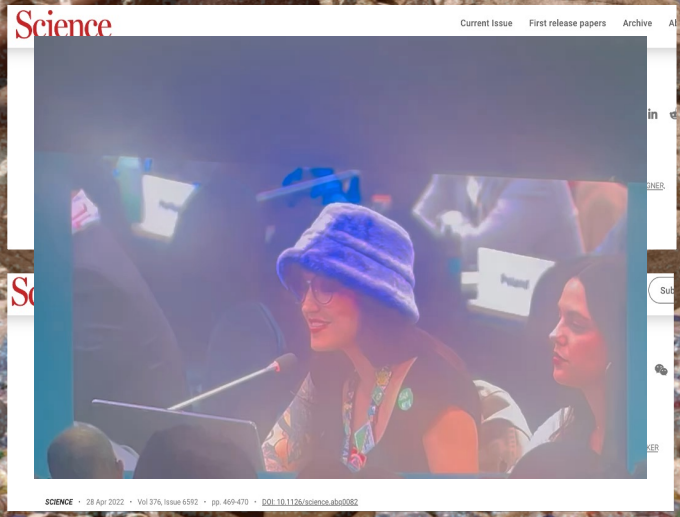
Brander et al. 2024

GLOBAL POLICY

United Nations Environment Programme

Distr.: General
4 September 2023

Original: English



Next negotiations in spring 2025, location TBD

https://www.dailysabah.com/world/africa/uns-new-task-save-africa-from-becoming-worlds-plastic-dustbin?gallery_image=undefined#big

The PNW Consortium on Plastics is dedicated to conducting reliable, science-based research to uncover the risks associated with micro and nanoplastic particles from land to sea.

Webinar on 4/23 on human health and MPs

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