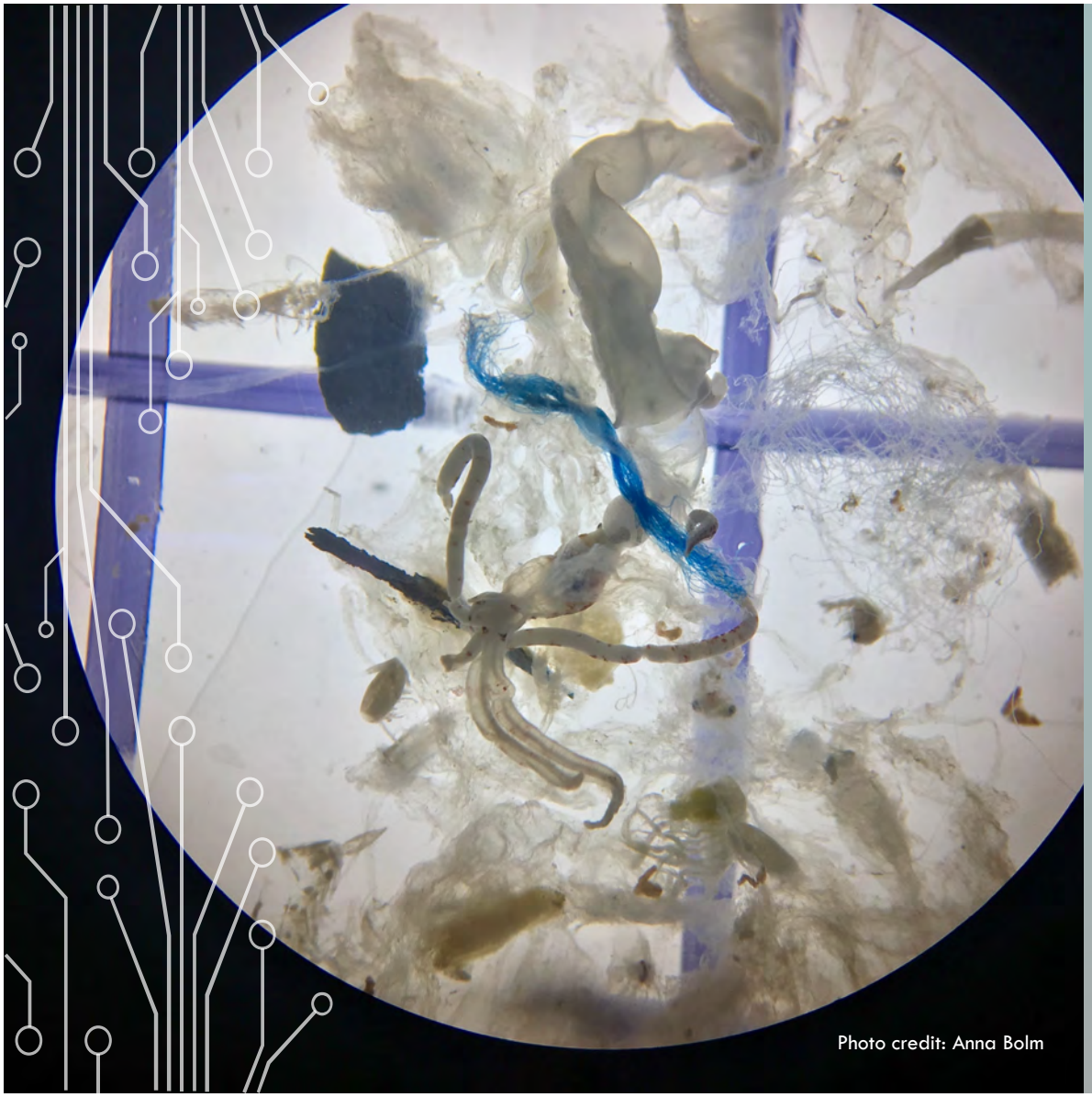


Photo credit: Anna Bolm

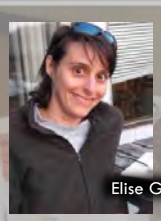
An unexpected snack: micro and nanoplastic occurrence and mechanisms of toxicity

SUSANNE BRANDER, PHD

ASSOCIATE PROFESSOR

OREGON STATE UNIVERSITY

Acknowledgments



Pacific Northwest Consortium on Plastics

NSF

Sea Grant Oregon

Agricultural Research Foundation

National Oceanic and Atmospheric Administration NOAA U.S. Department of Commerce

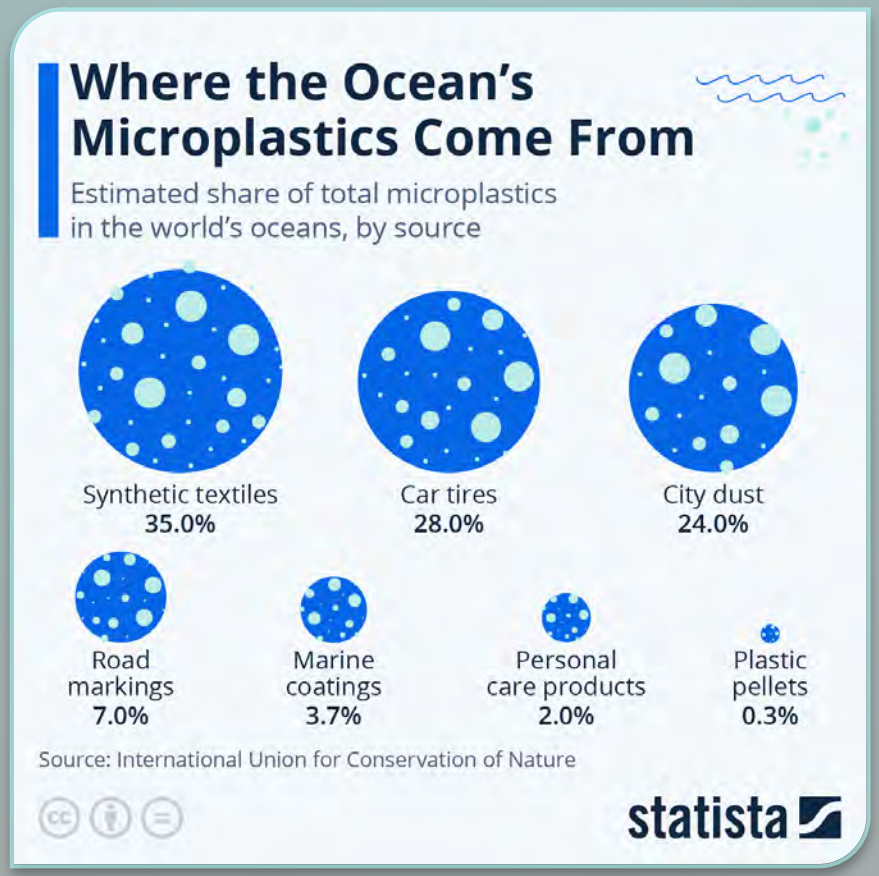
State of Oregon Department of Environmental Quality DEQ

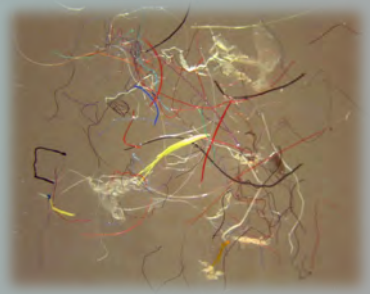
Bluesky: @pnwmicroplastics, @smbrander
Instagram: @pnwmicroplastics
LinkedIn: Pacific Northwest Consortium, Dr. Susanne Brander

Acknowledging many colleagues who are currently furloughed

STAND UP FOR SCIENCE 2025

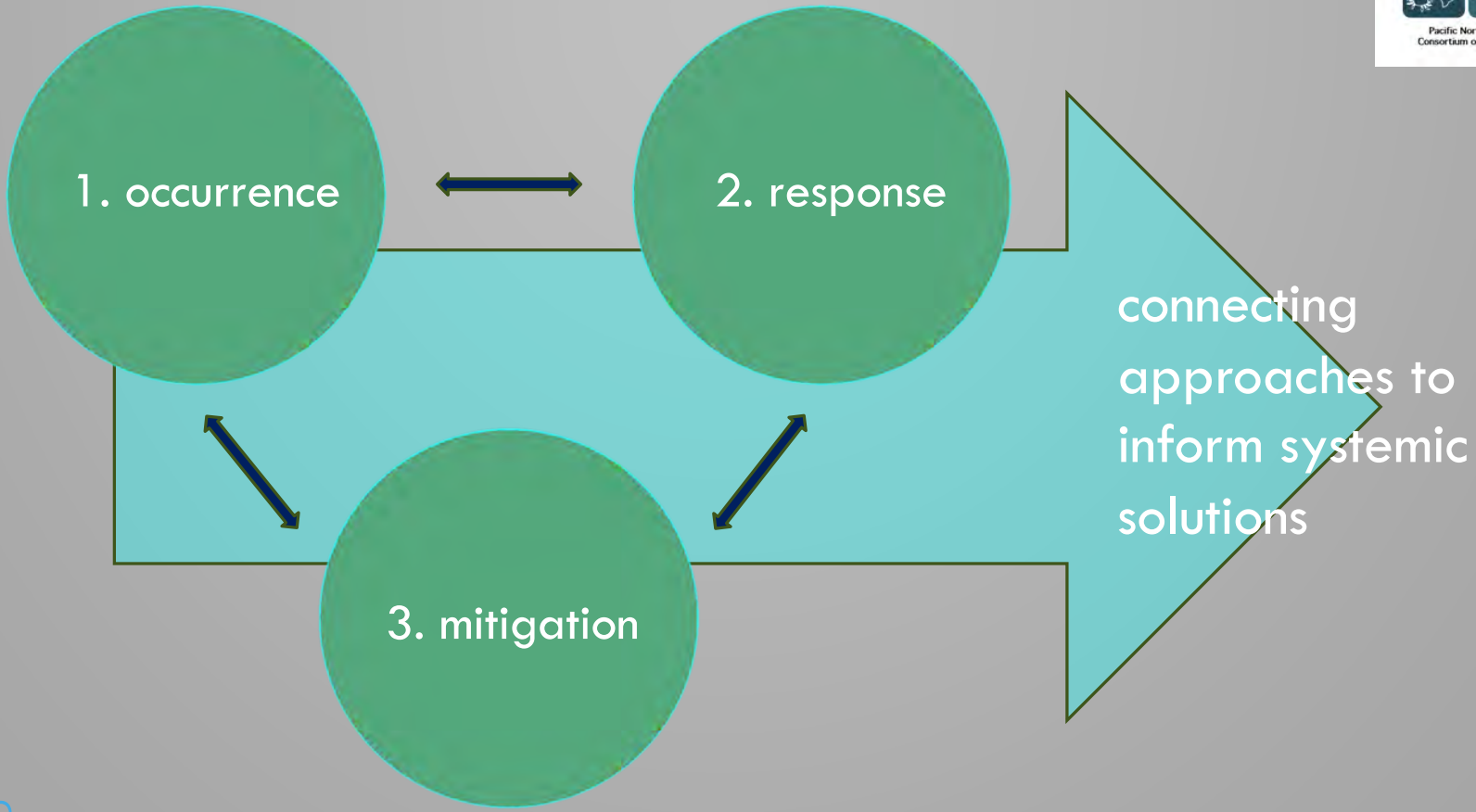
TEXTILES AND TIRES ARE THE MOST OFTEN DETECTED



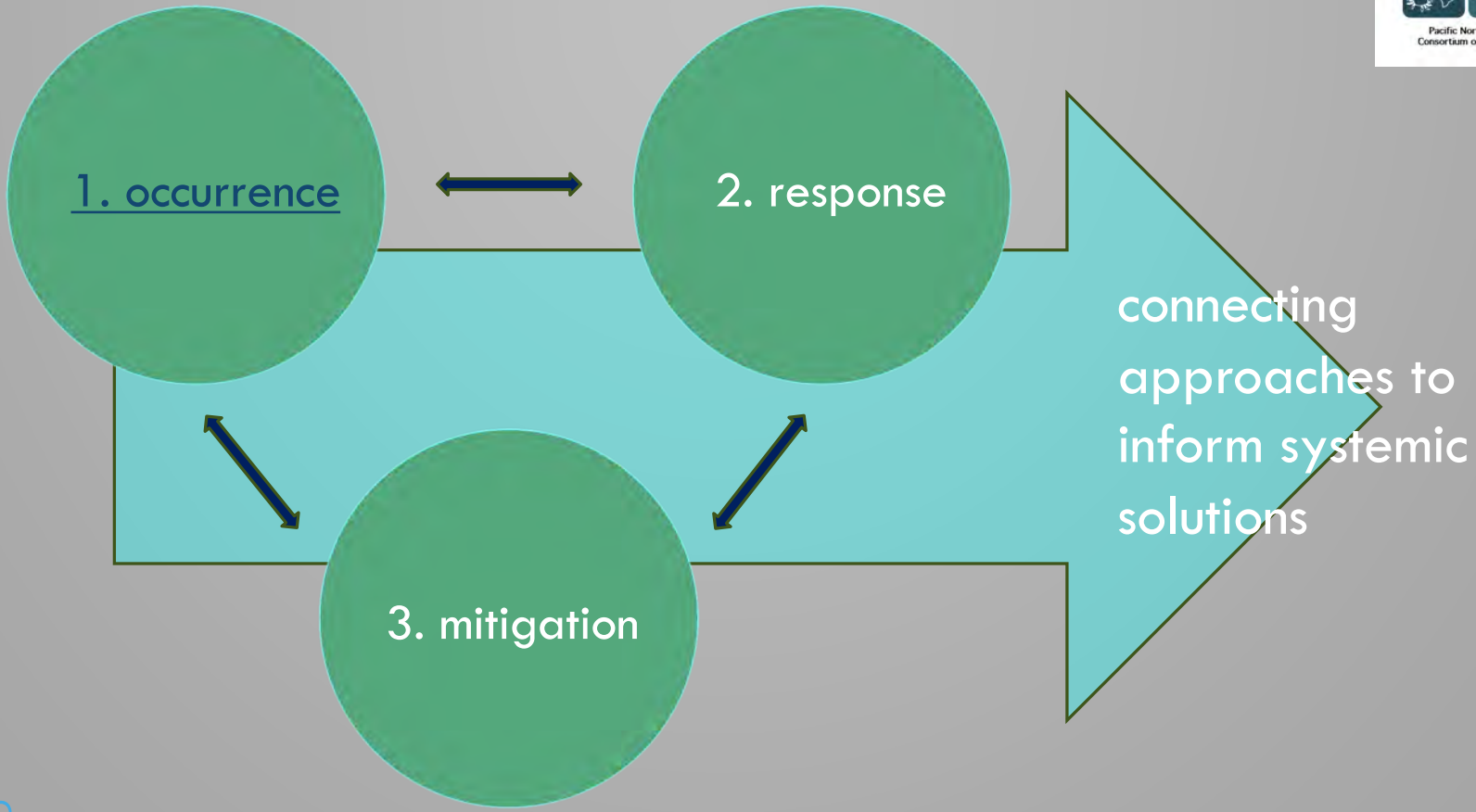


Granek et al. 2022, Mayer et al. 2024

OUTLINE


1. occurrence
2. response
3. mitigation
connecting approaches to inform systemic solutions

OUTLINE


1. occurrence
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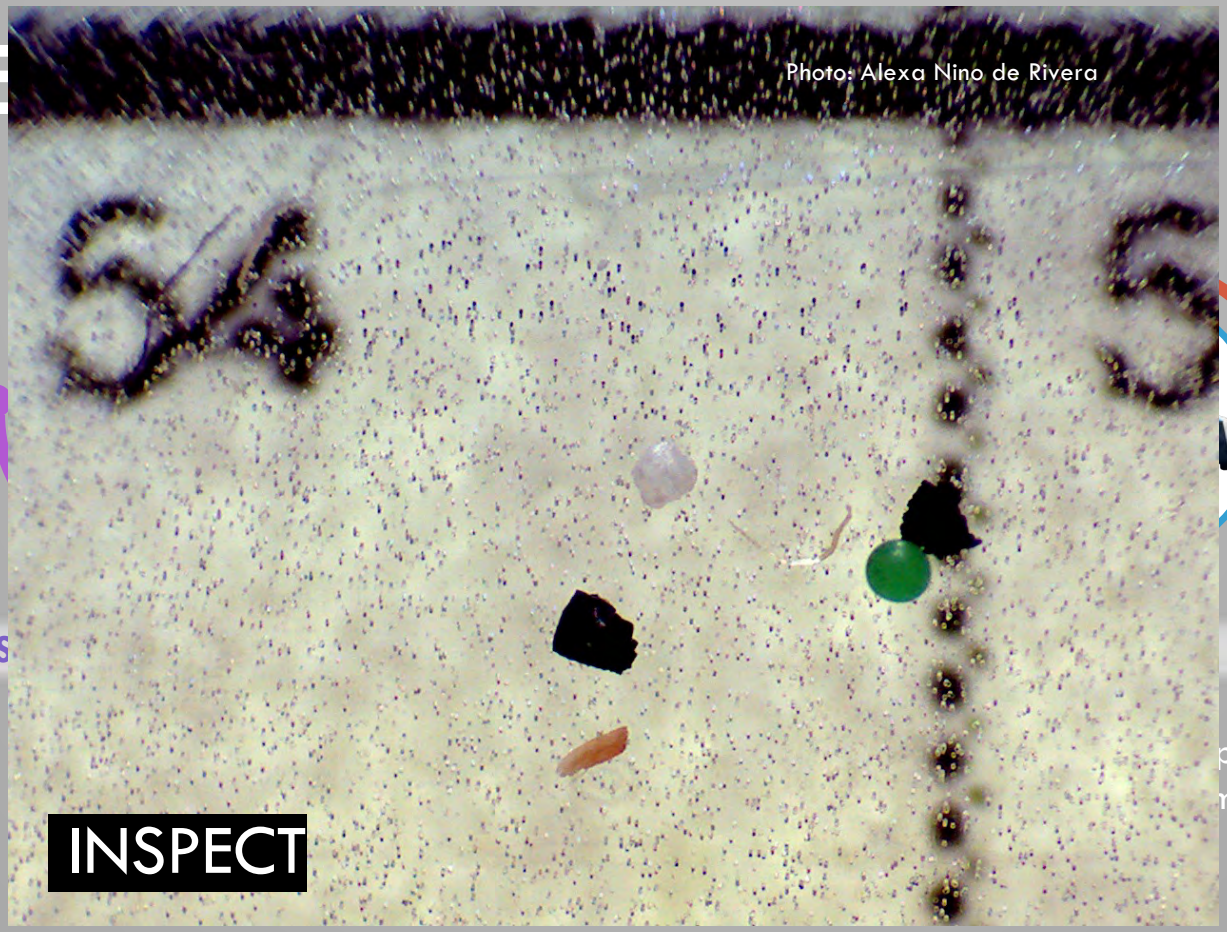


Brander et al. 2020, Cowger et al. 2020, Lasdin et al. 2023, Boisen et al. 2024

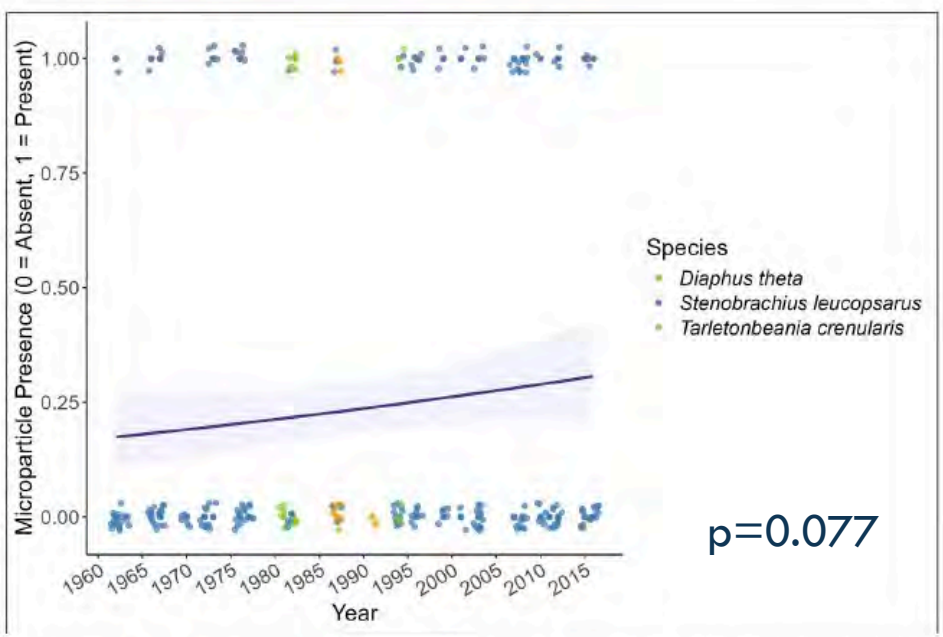


Fig. 5. Results from the generalized linear model in which year of capture best predicts of microparticle ingestion.

SAIP cruise transects

(modified from Suntsov and Brodeur, (2018)

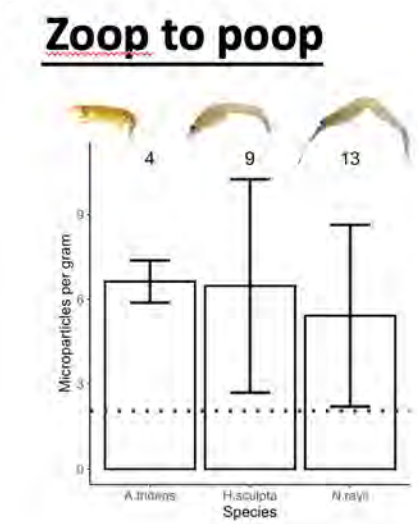
Boisen et al. 2024a,b

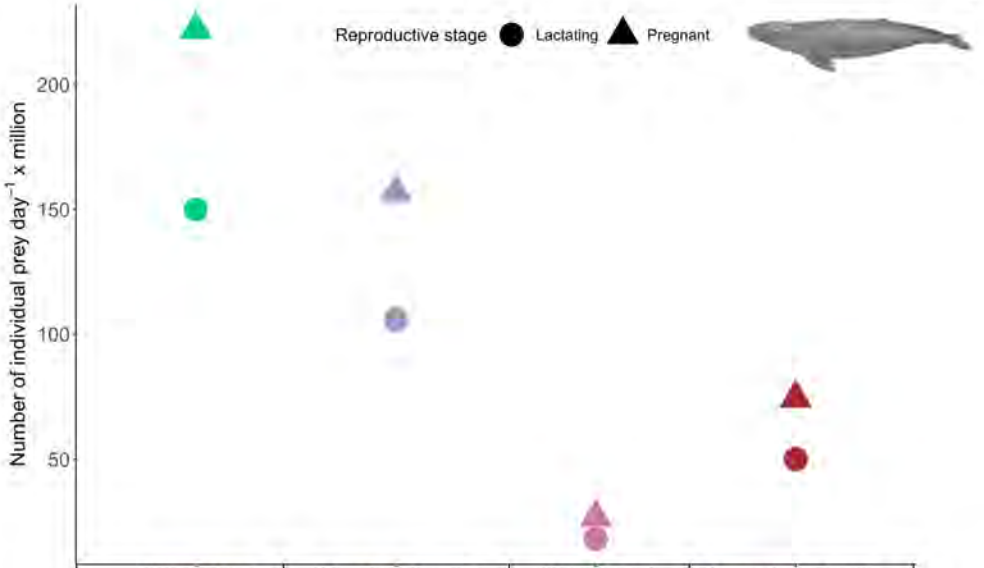
MYCTOPHIDS

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

Important prey for larger fishes and squid.

TROPHIC TRANSFER, FOOD WEB IMPACTS





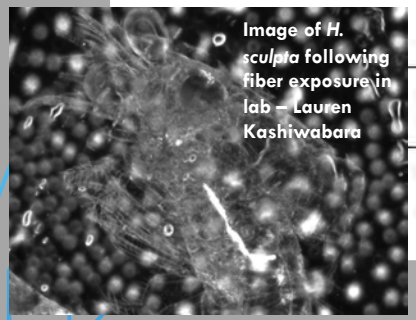


Image of *H. sculpta* following fiber exposure in lab – Lauren Kashiwabara

	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

COMMERCIAL FISHERY SPECIES

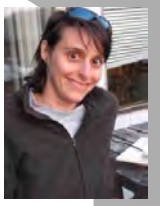
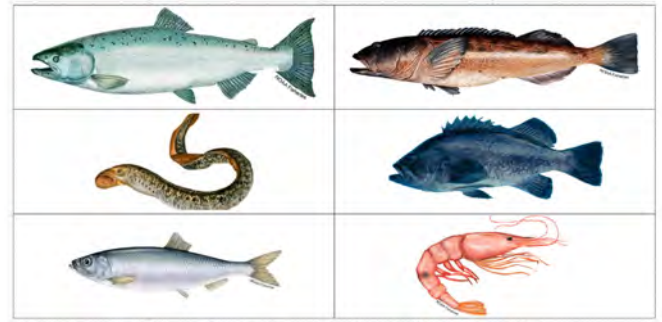


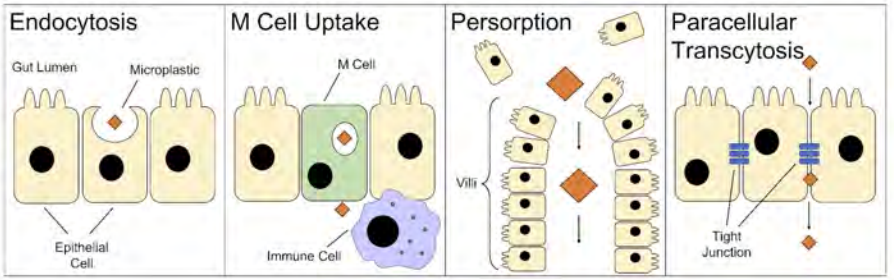
TABLE 3 Breakdown of material color, shape, length, and material categories identified via FTIR

	Color				Type			
	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



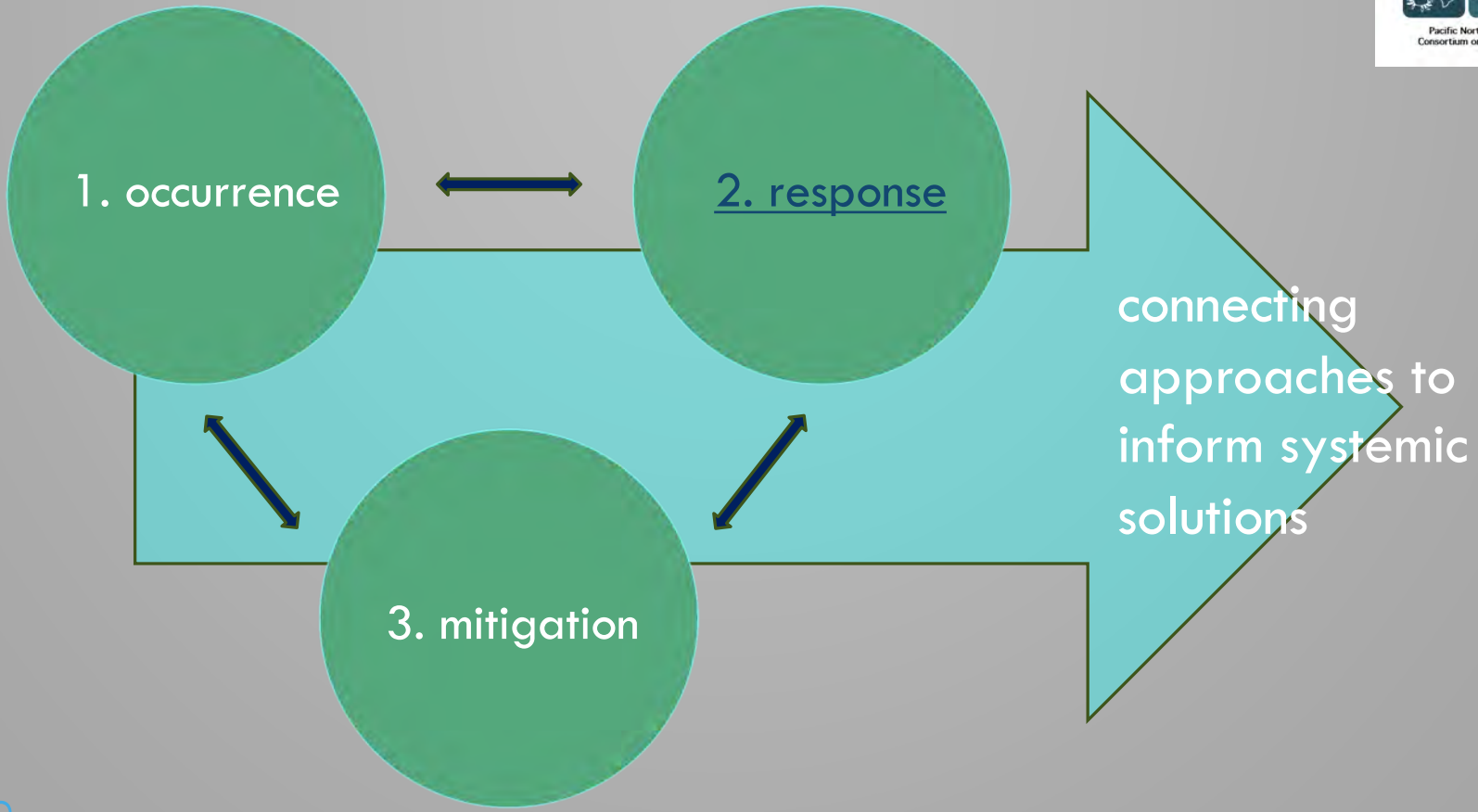
...to credits: Chinook salmon, lingcod, pink shrimp, Pacific herring (NOAA Fisheries), black rockfish (ODFW), and lamprey (North Carolina Wildlife Resource Commission).

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



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

OUTLINE


1. occurrence
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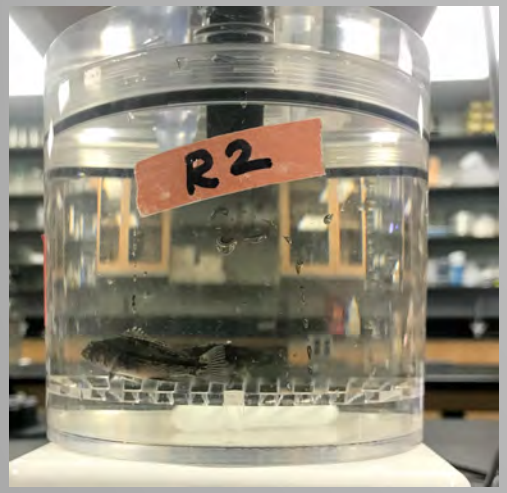
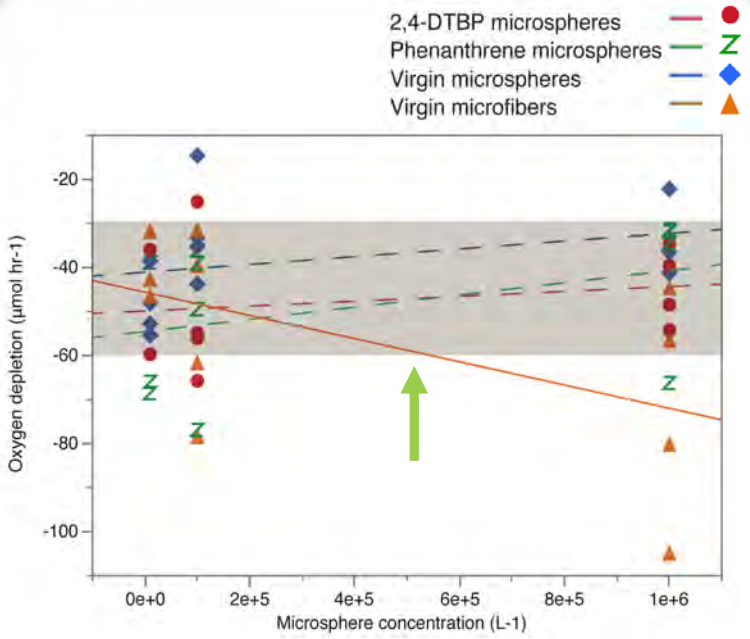
connecting approaches to inform systemic solutions

DIFFERENCES IN RESPONSE BETWEEN PARTICLE TYPES



Following a 4-day microplastic exposure:

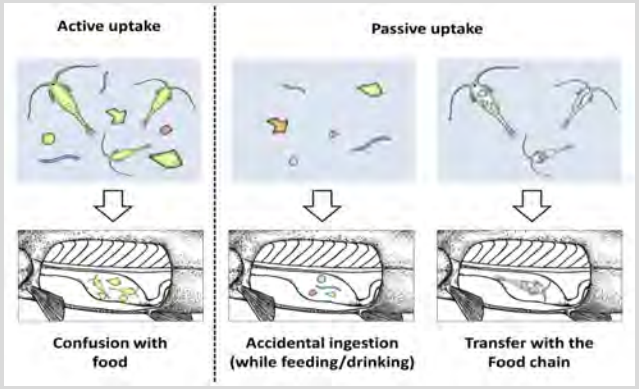
- Measured rates of oxygen consumption
- Closed-system respirometry
  - Combined 2 fish per replicate (n=4)
  - Normalized to body mass
  - 10 min acclimation & 10 min data collection
  - Resp. stress with fibers, not spheres



C. *striata* exposed to virgin microfibers exhibited a significant increase in O2 consumption.

Steinbarger et al. 2021

Dr, Stacey Harper



Brander et al. 2024, Tox of Fishes

- Size and shape of particles likely important
- Sublethal effects are critical for other pollutants – growth, gene expression, development, reproduction, behavior
- Need to test a diversity of polymer types, weathering
- Across several model species we saw food dilution, behavioral change, altered gene expression, ROS, and reproductive impacts.


Mysid

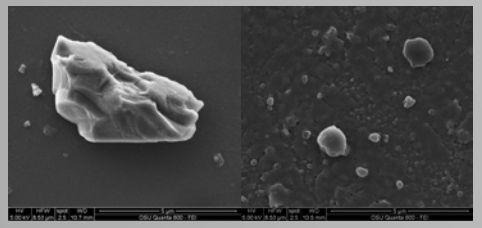

Silverside


Daphnia

Bucci et al. 2021, Steinbarger et al. 2021, Corney 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

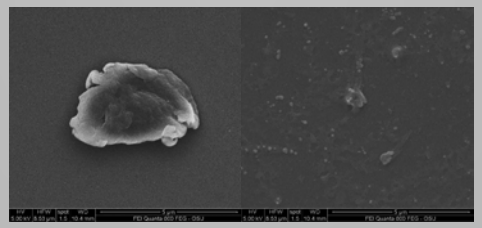
MILLED PLASTICS (MICROSCALE VS NANOSCALE)

Tire wear



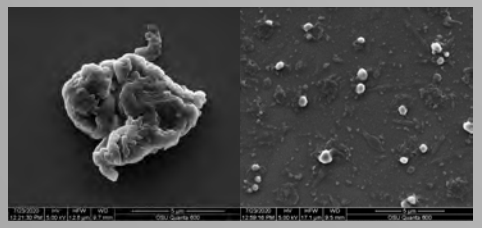
1–20 µm <1 µm

Polyethylene Terephthalate



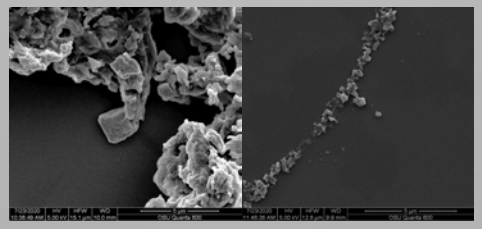
1–20 µm <1 µm

Polypropylene



1–20 µm <1 µm

Polylactic Acid



1–20 µm <1 µm

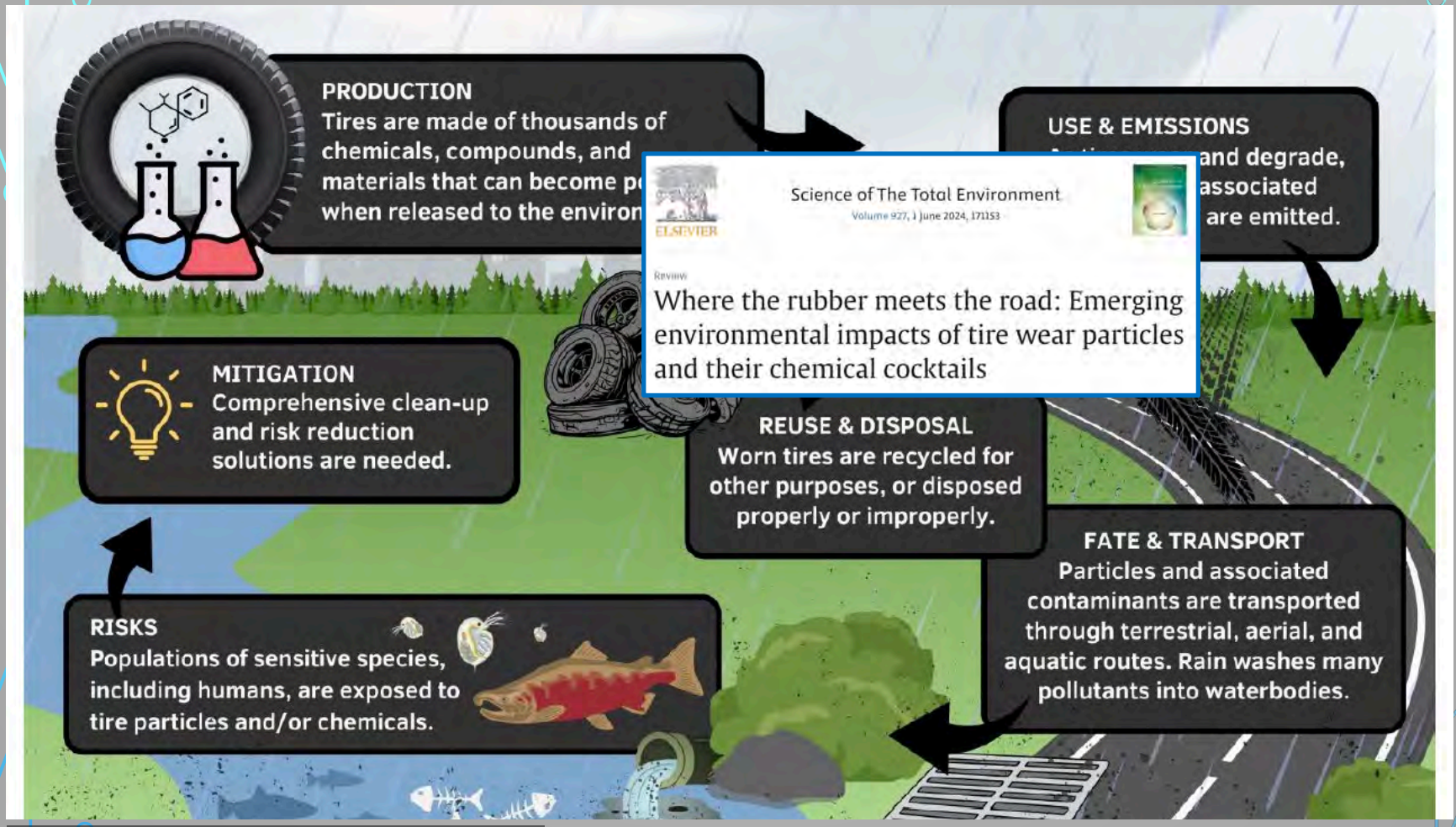
Polyester Fiber

Pacific Northwest Consortium on Plastics

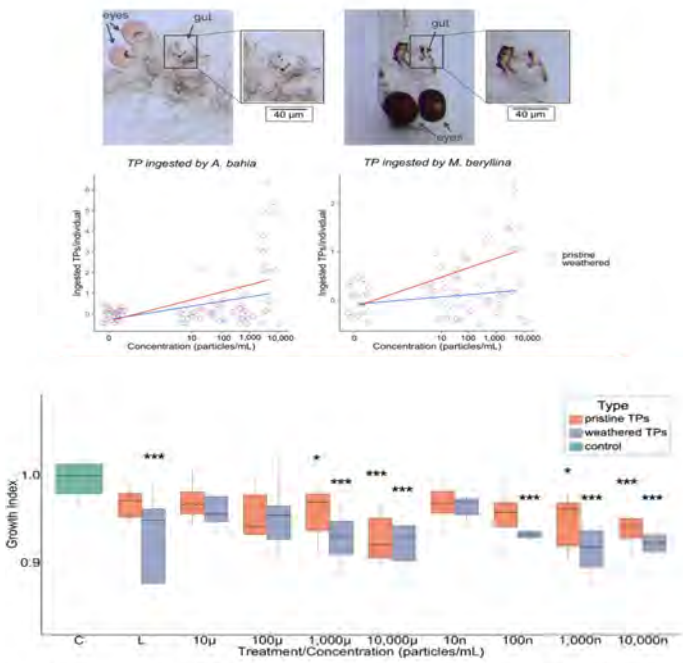
Examples of milled plastics at micro and nanoscale (SEM), aiming to mimic complexity of MNPs in environment

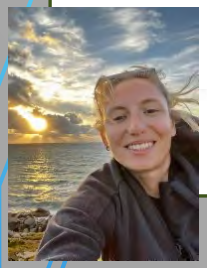
Have generated and tested, tire wear, PLA, PP, PET, etc. (Harper lab OSU), create microfibers in Brander lab. Particles are weathered under a solar simulator.

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



Mayer, Moran, Miller, Brander, Thornton Hampton, et al. 2024



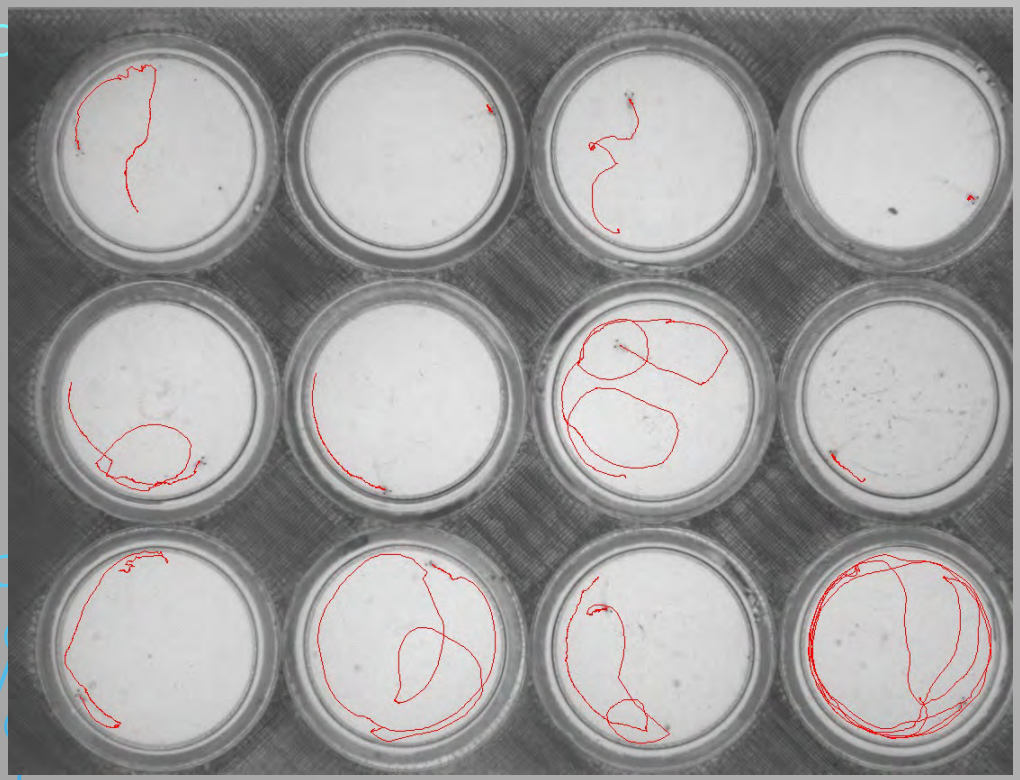


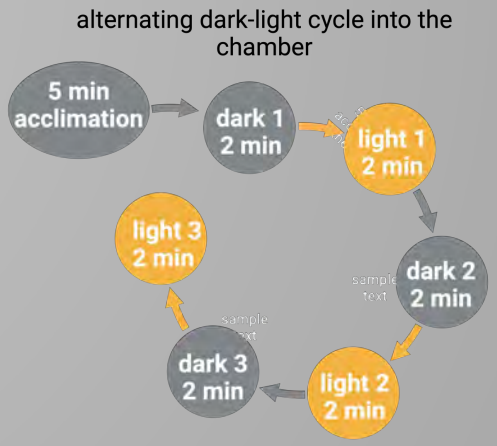
TIRE WEAR MIXTURES
WEATHERED VS. NEW

- By the time organisms are exposed to tire particles, they are likely highly weathered, here we compared new to weathered particles from a mixture of different tire types from the US tire manufacturers assoc.
- Weathered particles were more readily ingested and had a greater impact on growth, especially in shrimp.

Impact of tire particles on coastal species

Behavioral assays





Behavioral endpoints:

- Time spent bursting (speed > 20 cm/s)
- Cruising (speed > 0.5 cm/s and < 20 cm/s)
- Freezing (speed < 0.5 cm/s)
- Velocity (cm/s)
- Thigmotaxis (s)
- Total distance moved (cm)

Impact of tire particles on coastal species

Behavior in M. beryillina and A. bahia

- All six behavioral endpoints examined were significantly affected, in some cases weathering vs. new caused differences in response

	A. bahia					
Endpoints	Pristine Micro-TPs	Pristine Nano-TPs	Weathered Micro-TPs	Weathered Nano-TPs	Pristine TP Leachate	Weathered TP Leachate
Cruising	✕	✓	✓	✓	✓	✓
Freezing	✕	✓	✓	✓	✓	✓
Bursting	✓	✓	✓	✓	✓	✕
Velocity	✕	✓	✓	✓	✓	✓
Thigmotaxis	✓	✓	✓	✓	✕	✓
Total distance moved	✕	✓	✓	✓	✓	✓
	33.3%	100%	100%	100%	83.3%	83.3%

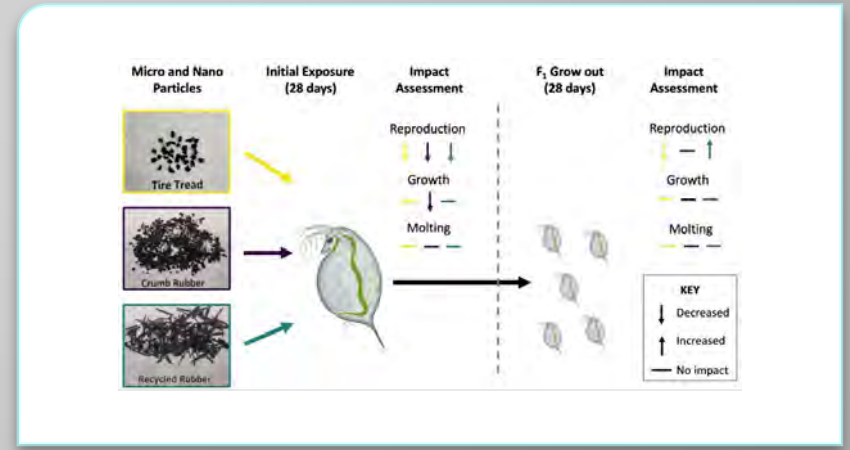
	M. beryillina					
Endpoints	Pristine Micro-TPs	Pristine Nano-TPs	Weathered Micro-TPs	Weathered Nano-TPs	Pristine TP Leachate	Weathered TP Leachate
Cruising	✓	✓	✕	✓	✓	✕
Freezing	✓	✓	✕	✓	✓	✕
Bursting	✓	✓	✓	✕	✓	✓
Velocity	✓	✓	✕	✓	✓	✓
Thigmotaxis	✓	✓	✓	✓	✓	✓
Total distance moved	✓	✓	✕	✓	✓	✓
	100%	100%	33.3%	83.3%	100%	66.7%

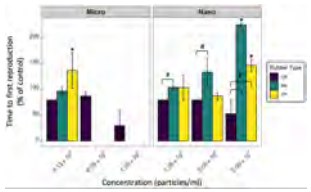
- The differential effects of TPs and their leachate observed between *M. beryllina* and *A. bahia* highlight species-specific sensitivities.

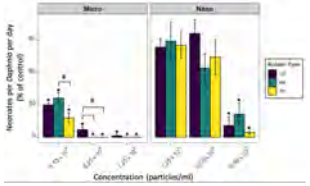
REPRODUCTION IN DAPHNIA

Chronic exposure to the micro rubber particles delayed, decreased and eliminated reproduction starting at $6.25x10^5$ particles/ml.

Chronic exposure to the nano rubber particles had less severe impacts, but delayed and decreased reproduction at the highest exposure level, $5.00x10^7$ particles/ml. Exposure to nano rubber in the parental generation had impacts on reproduction in the F_1 generation.







Cunningham et al. in 2024

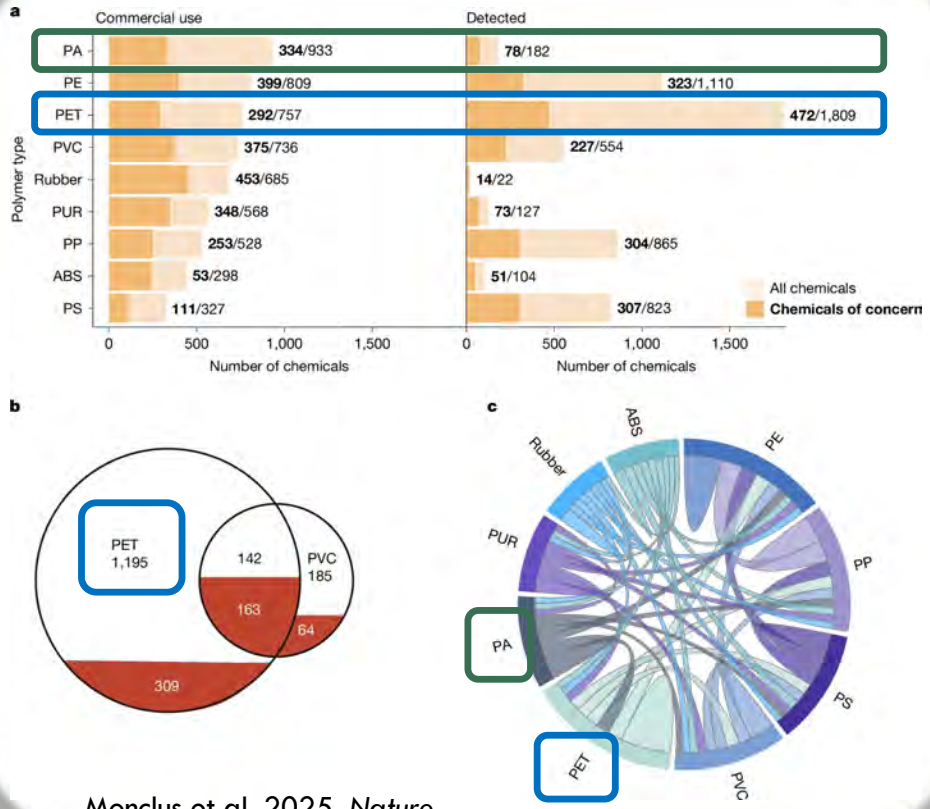
Dr, Stacey Harper

MICROFIBERS

- Global consumption of synthetic fibers increased from a few thousand tons in 1940 to 67 million in 2022.
- Defined as having a length of between 0.3 um and 15 mm, length to width ratio of >3.
- Fibers are found in air, soil, food, and water and are easily transported across large distances. We can also inhale them.

Brander et al. 2024, https://ikhapp.org/wp-content/uploads/2024/09/Brander-et-al.-2024.-Microfibres-from-textiles-a-key-source-of-microplastics-to-the-environment-fate-effects-and-mitigation-strategies.pdf

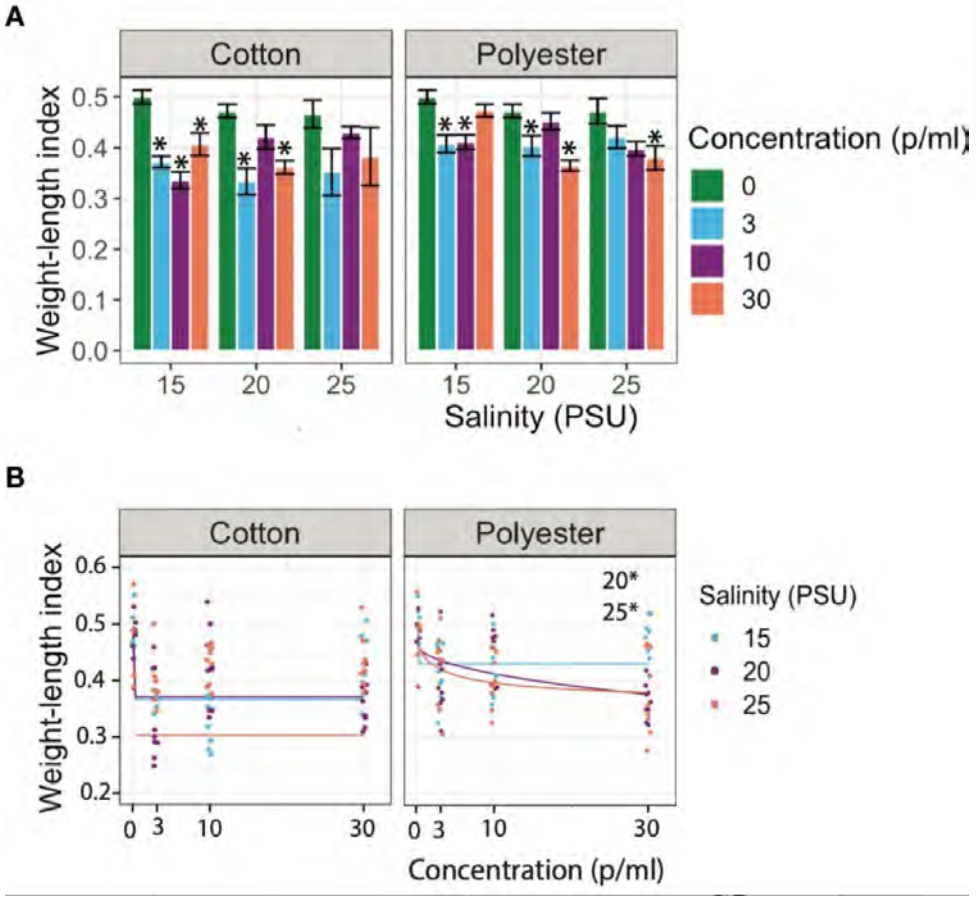
WHAT IS IN SYNTHETIC FABRICS?



Monclus et al. 2025, *Nature*

- *PA = polyamide, nylon is a type of PA*
- *PET = polyethylene terephthalate, polyester is a type of PET*
- Hundreds of chemicals are present in both, some non-intentionally added

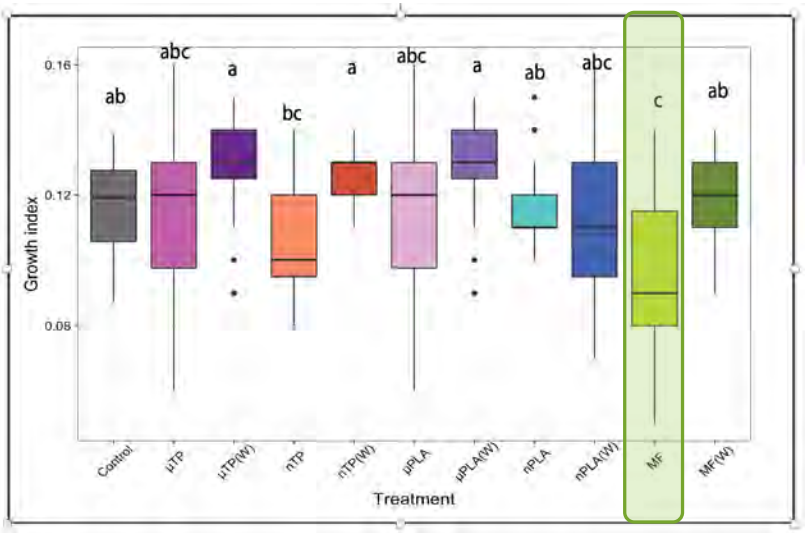
MICROFIBER IMPACTS



Polyester and polypropylene fibers decreased growth over 4-7 days in fish and shrimp. Cotton also decreased shrimp growth. Silverside growth was not impacted by cotton (data not shown).

Siddiqui et al. 2023

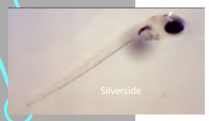
ACROSS PARTICLE TYPES

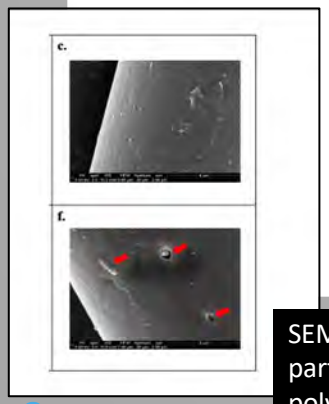


New microfibers significantly reduce growth over 21 days in larval fish, some PLA treatments overlap with MFs and TP.

Hutton et al. 2024

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

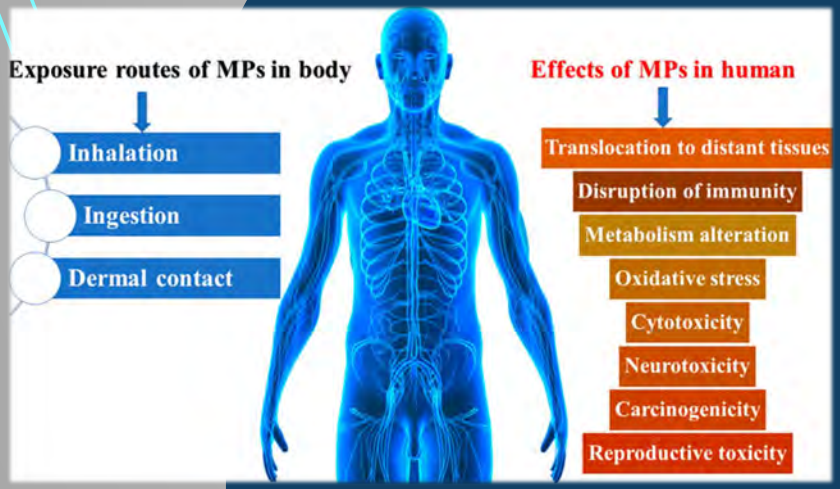


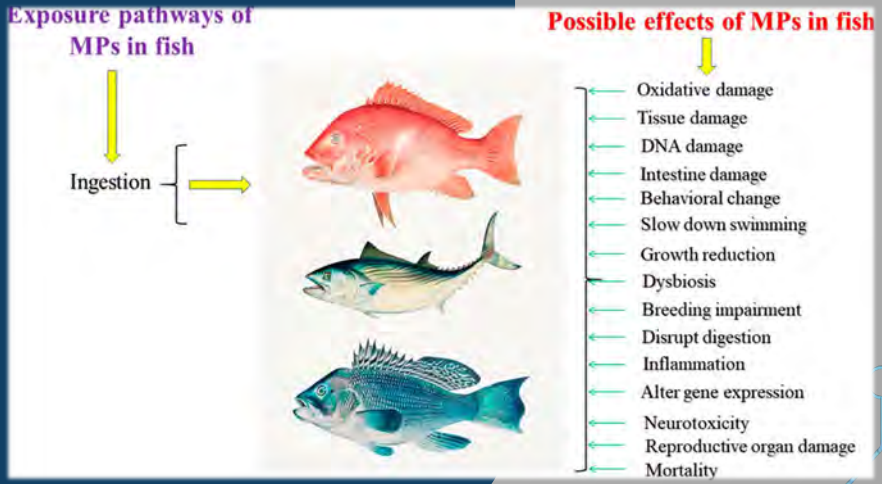


SEM image showing nano-sized particles breaking off from polyester fibers (Kashiwabara)

Top 15 upregulated pathways

Hutton et al. 2024, Frontiers in Tox





SIMILARITIES ACROSS VERTEBRATES

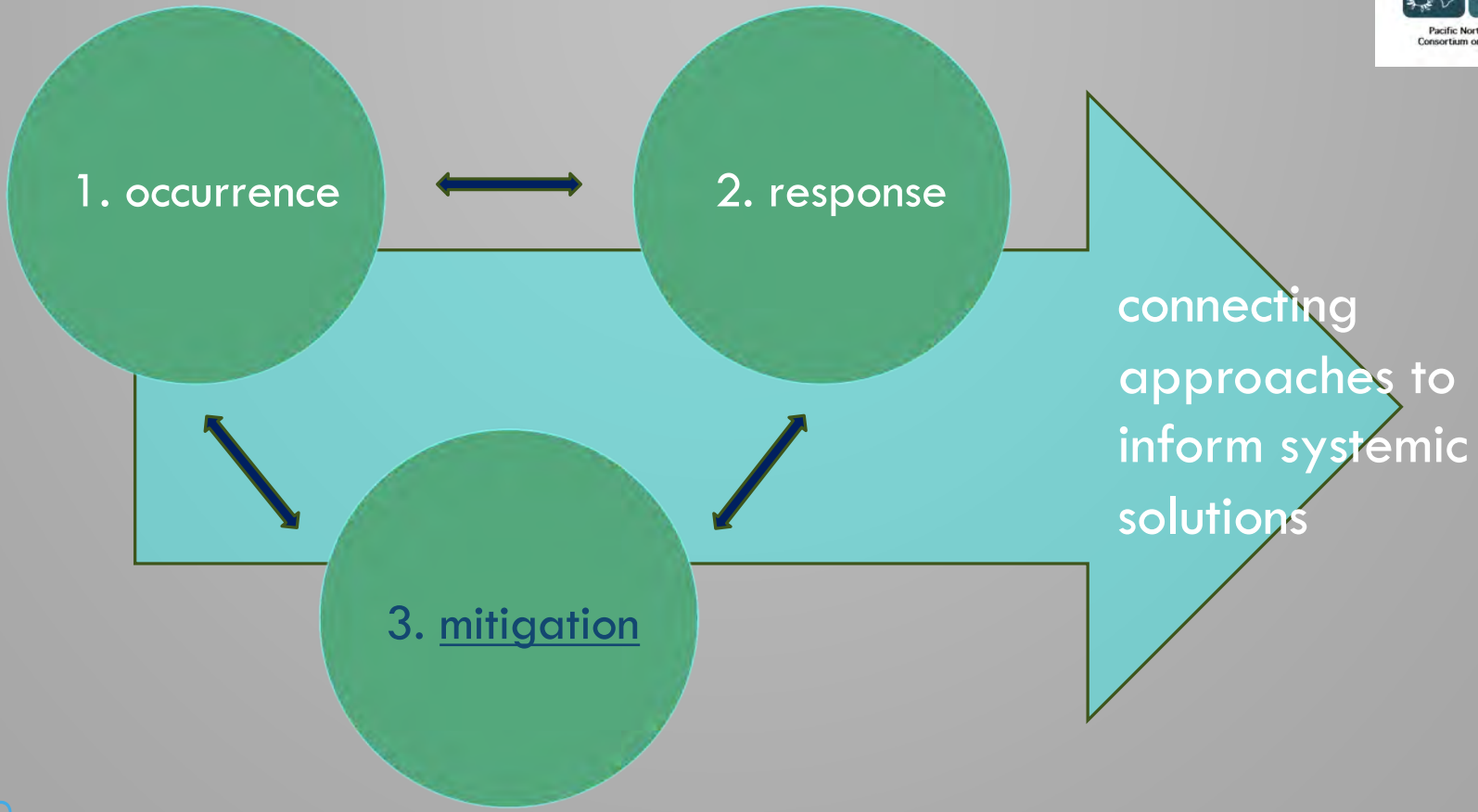
BHUYAN ET AL. 2022, FRONTIERS IN ENVIRONMENTAL SCIENCE; NIHART ET AL. 2025, NATURE MEDICINE

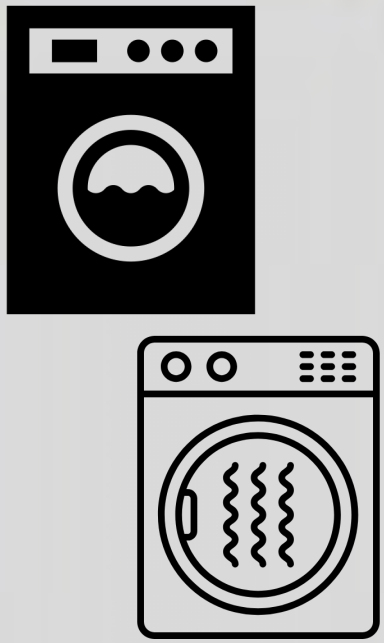
Taxonomic group	Environmental Stressor	Adverse Outcome: Fertility or Fecundity Impact *(colors matched across similar outcomes)*
 Invertebrates	Tributyltin Phthalates Micro/Nanoplastics Ethinylestradiol Ketoconazole Temperature	Imposex, masculinization ↓Mating, ↓ Sperm morphology Altered Gonad development, ↓Fertilization, ↓Juveniles Sex reversal in males Sex reversal in females ↓Fertilization, Altered sperm velocity / longevity
 Fishes	Pyrethroids Bisphenol S Micro/Nanoplastics Ethinylestradiol Temperature	↓Egg production, Modeled population decline ↓Spawning capacity females, ↓Fertility rate males ↓Fertilization, ↓Spawning, ↓Hatching success Sex reversal in males, population decline Sex reversal alone or in combination with EDCs
 Birds	Pyrethroids Organochlorines PFAS Temperature	↓Fledgling success ↑Abnormal testes/feminization of male gonads, ↓Egg survival, ↓Reproduction, Population decline ↑Abnormal sperm ↑Levels of organochlorines, leading to above effects
 Reptiles	Organochlorines Metals Estrogens, Anti-androgens Temperature	↓Penis size, ↑Abnormal ovaries, Altered sex ratio Altered sex ratio in combination with metal exposure Altered sex ratio in combination with EDC exposure Male biased sex ratio, Female biased sex ratio
 Frogs	Phthalates / BPA Micro/Nanoplastics Temperature	↓Repro success, Altered sex ratio, Altered spermatogenesis ↓Hatching rate ↑Male sex ratio, ↓Female body size
 Marine Mammals	Organochlorines Cyanotoxins Temperature	↑Uterine pathologies, ↓Pregnancy rate, Population Decline ↑Abortion, ↑Preterm birth, ↓Pup survival ↑Abortion, ↑Preterm birth, ↓Pup survival
 Humans	PFAS Phthalates Micro/Nanoplastics Temperature	↓Sperm motility, ↓Fertility in couples Male gonad malformations, ↓Sperm count ↓Sperm count, motility ↓Semen volume, total sperm count, sperm motility, Altered morphology

Brander, Swan et al. in review, *Nature emerging contaminants*

Comparable responses between taxonomic groups are common amongst classes of pollutants, micro and nanoplastics are not an exception.

OUTLINE


1. occurrence
2. response
3. mitigation
connecting approaches to inform systemic solutions



Created by beachouse
from Noun Project

Erdle and Athey 2021; Ross et al. 2021, Granek et al. 2022

FIBER SOURCES

- One load of wash can generate up to 9 million microfibers
- Study from Canada shows that installing filters on washers significantly reduces MF loading into waterways
- Dryers, especially in North America, may be a larger source of fibers than washing machines
- Bills have been proposed in several U.S. States to add filters to washers, including Oregon, law enacted in France.

EXPLORING MITIGATION APPROACHES IN OREGON AND WASHINGTON

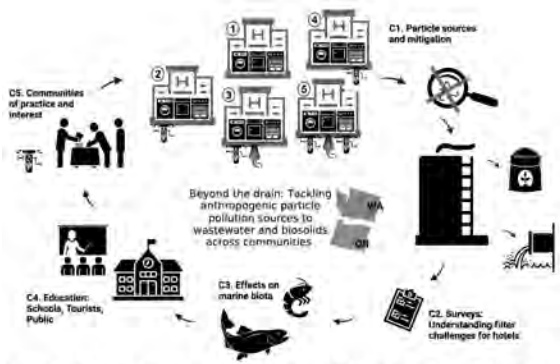


Figure 1. *Conceptual framework of proposed* ***Beyond TAPPS*** *Challenge Project. Numbers refer to the five project components.*

Sampling stormwater in Depoe Bay

Filter outreach at Bigfoot's

Elise Granek

SUMMARY AND FUTURE NEEDS

Particles become more toxic as they decrease in size, and fibers seem more problematic than other morphologies. Growth, reproduction, behavior, and gene expression are impacted across taxa, *species sensitivity can differ but there are broad trends*.

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, longer term studies.
2. Multigenerational studies, linking across taxa.
3. Accessible analytical approaches to better track and detect nano-sized particles.
4. Better understanding of how weathering influences toxicity, chemistry.
5. Strategies for avoiding regrettable substitutions.
6. Mitigation approaches are needed downstream in the short term, and upstream (global ideally) over the longer term.


QUESTIONS?