Microplastics in the Aquatic Environment: History, Fate and Effects

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Ocean Conservancy

U of T Trash Team

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Altered Oceans Part Four: Plague of Plastic Chokes the Seas

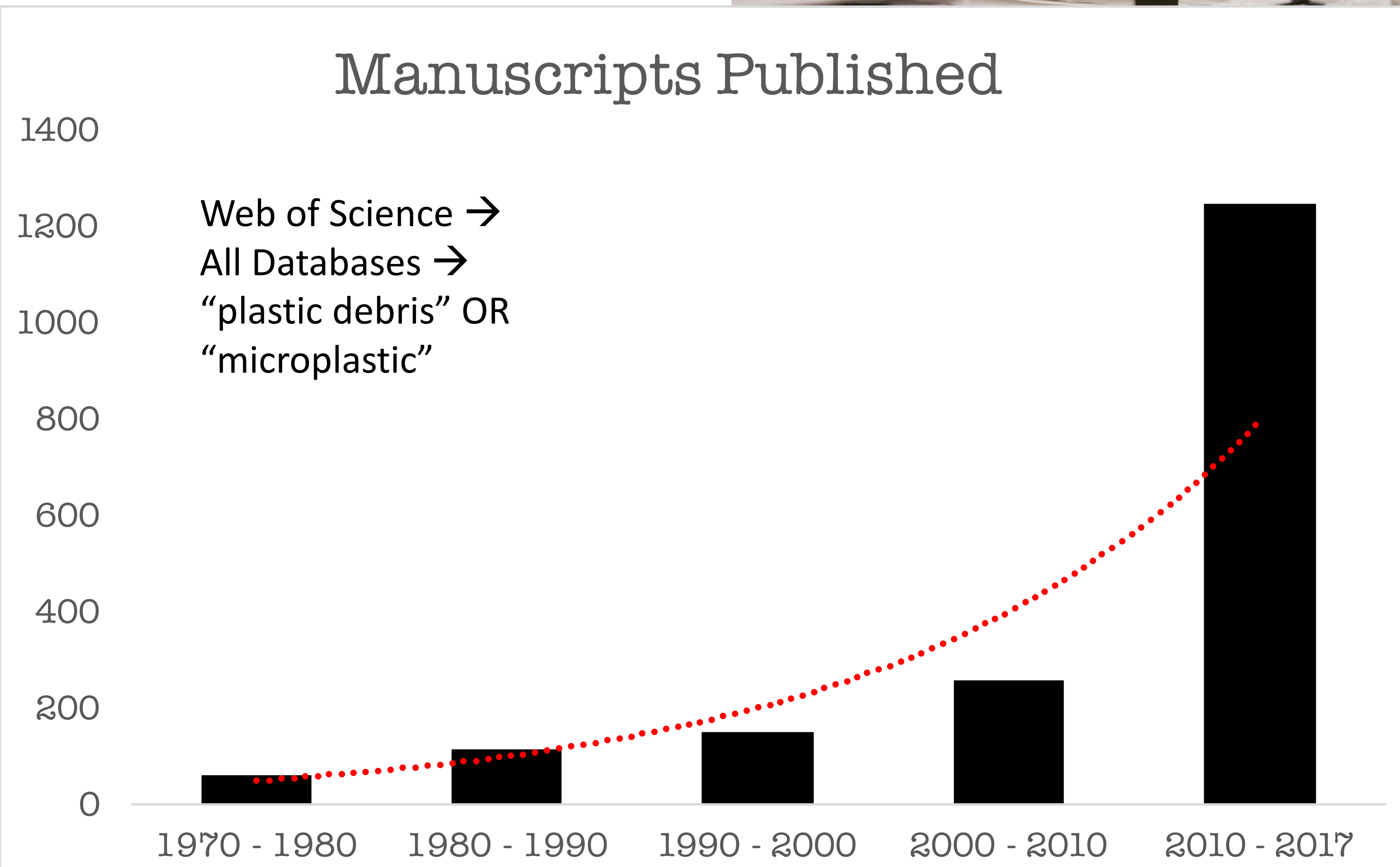
This five-part series on the crisis in the world's oceans was published in July and August of 2006. The series – by reporters Kenneth R. Weiss and Usha Lee McFarling and photographer Rick Loomis – won the 2007 Pulitzer Prize for explanatory reporting.

By **Kenneth R. Weiss**

AUGUST 2, 2006 | REPORTING FROM MIDWAY ATOLL

The albatross chick jumped to its feet, eyes alert and focused. At 5 months, it stood 18 inches tall and was fully feathered except for the fuzz that fringed its head.

All attitude, the chick straightened up and clacked its beak at a visitor, then rocked back and dangled webbed feet in the air to cool them in the afternoon breeze.



Manuscripts Published
Web of Science →
All Databases →
"plastic debris" OR
"microplastic"
1400
1200
1000
800
600
400
200
0
1970 - 1980
1980 - 1990
1990 - 2000
2000 - 2010
2010 - 2017

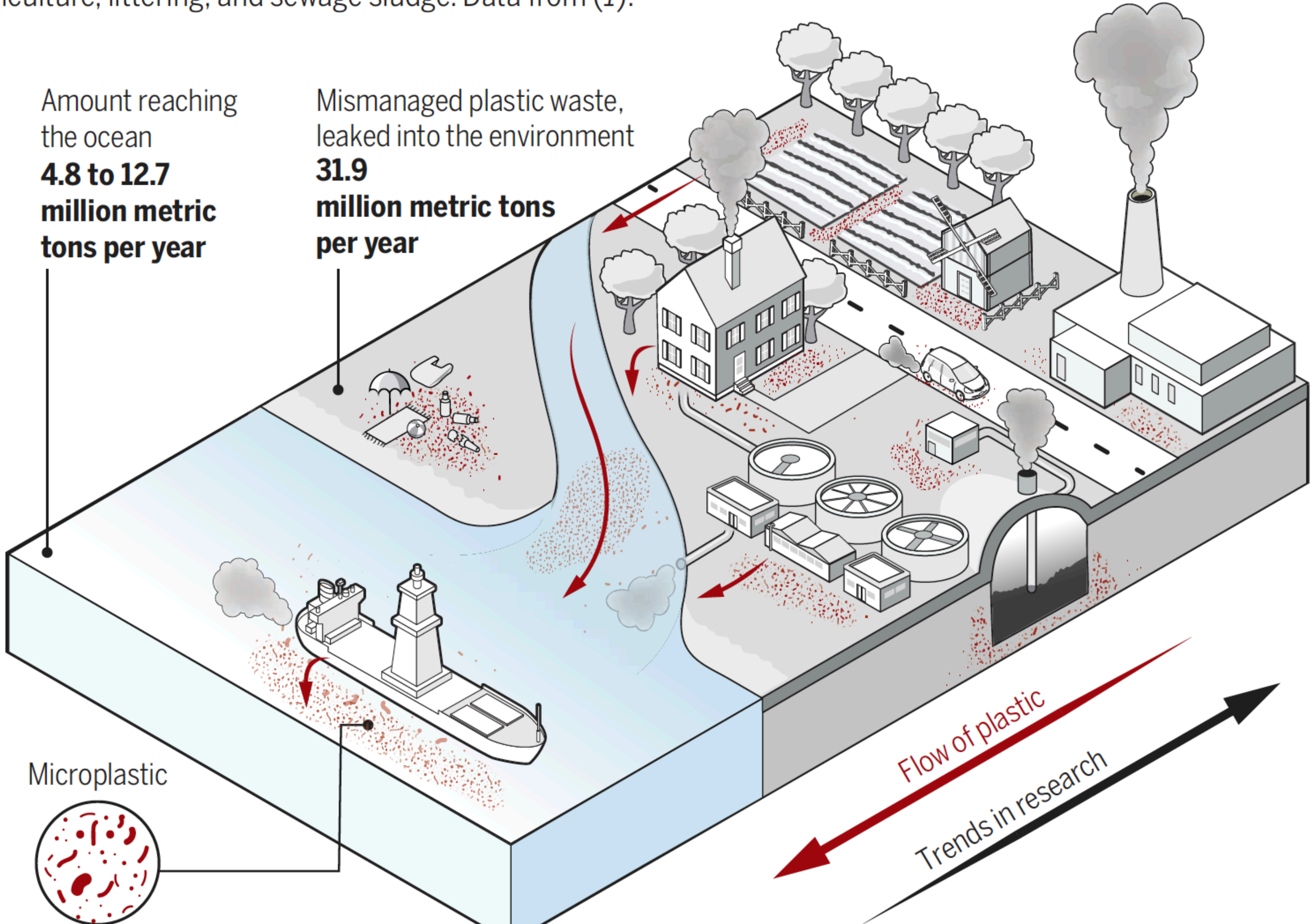
Contamination

Macroplastics (>5 mm)

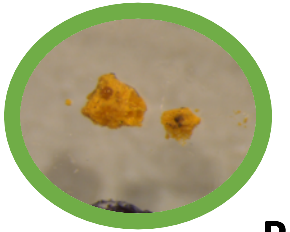
Microplastics (< 5mm)

Microplastics everywhere

High amounts of microplastics have been found not just in the sea and on beaches, but also in rivers and soils around the world, demonstrating how pervasive this modern pollution is. Sources include leakage from landfills, plasticulture, littering, and sewage sludge. Data from (*1*).



Rochman, 2018 *Science*



Microplastics

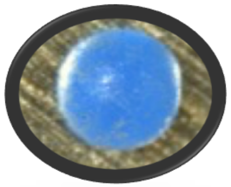
Primary vs. Secondary (broken down bits of larger plastic products)

Categories (shape) – fragments, fibers, foam, sphere, pellet, film

Polymer Type – PP, PE, PVC, PET, PS, acrylic, styrene butadiene, PC, nylon…

Chemical Additives – UV Stabilizers, Flame Retardants, Plasticizers, etc…

Size – nm to µm to mm



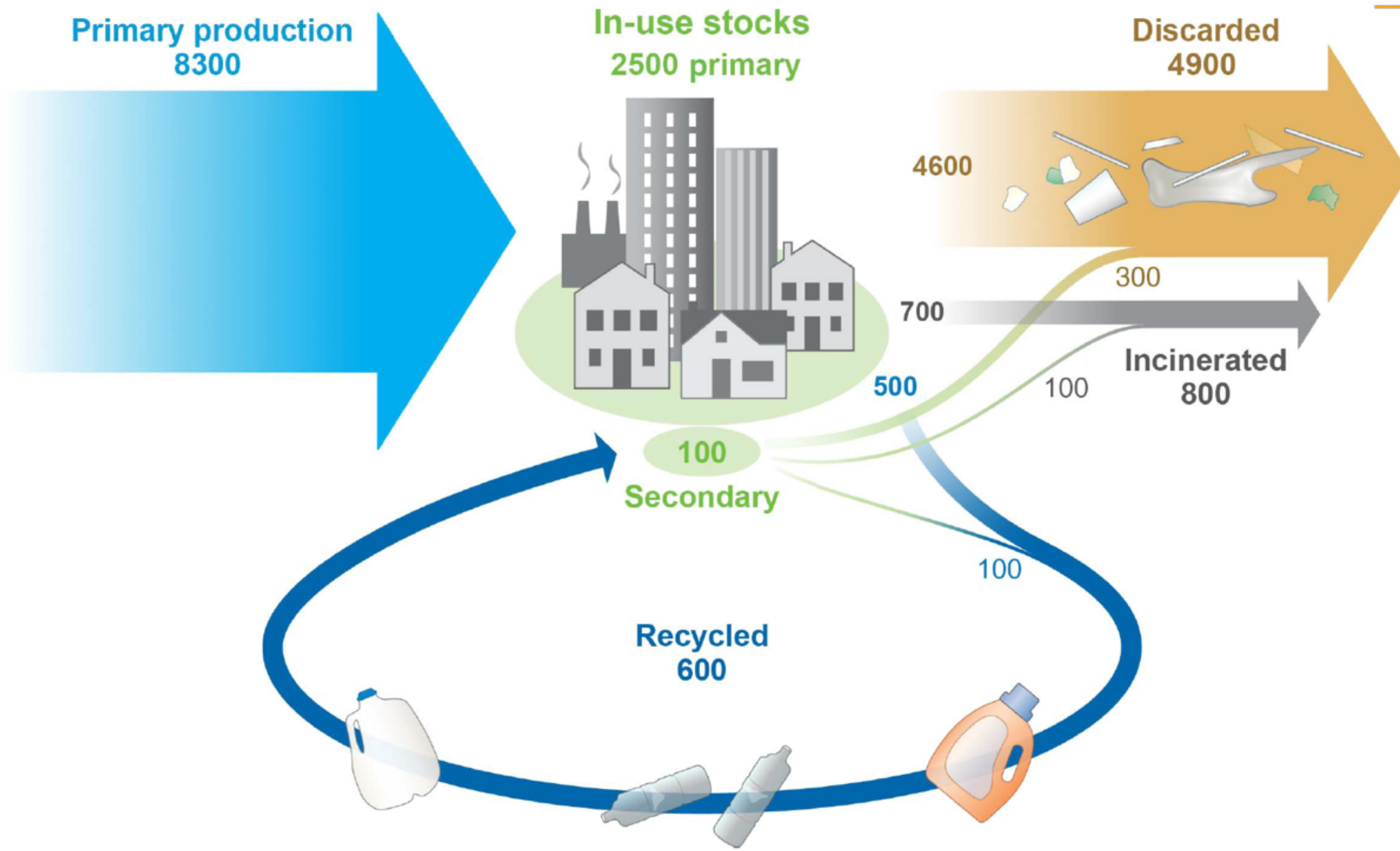


Fig. 2. Global production, use, and fate of polymer resins, synthetic fibers, and additives (1950 to 2015; in million metric tons).

Geyer et al., 2017 *Science Advances*





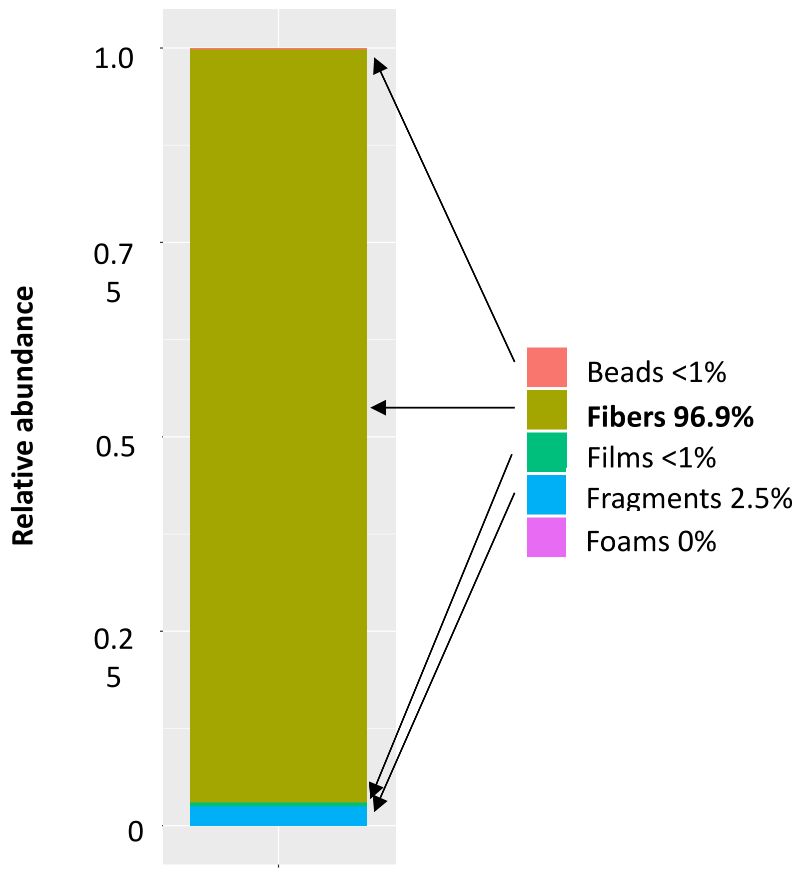



© MBARI

>220 species

FAO Report 2017

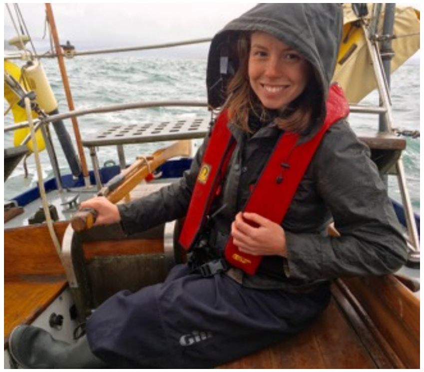
Microplastics in **Great Lakes fish**



- In 100% of fish sampled
- 96.9% of are fibers

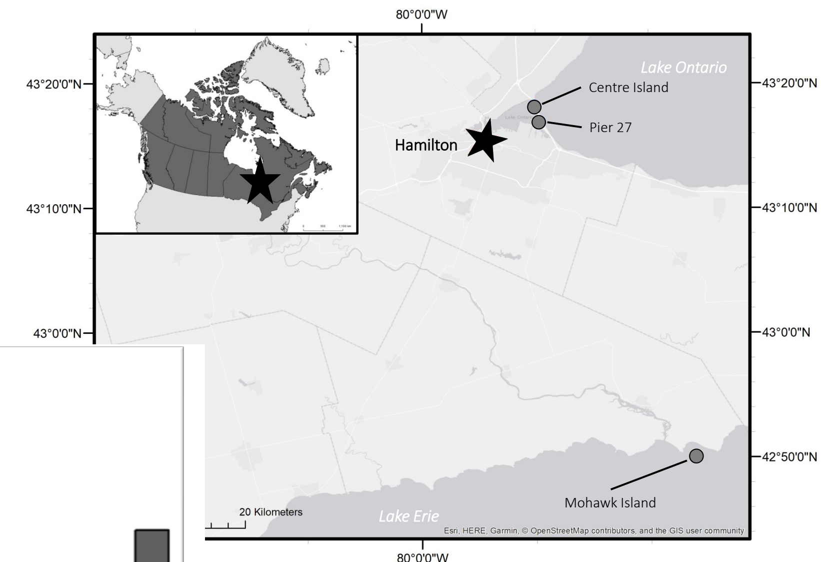
Rainbow smelt
(*Osmerus mordax*)

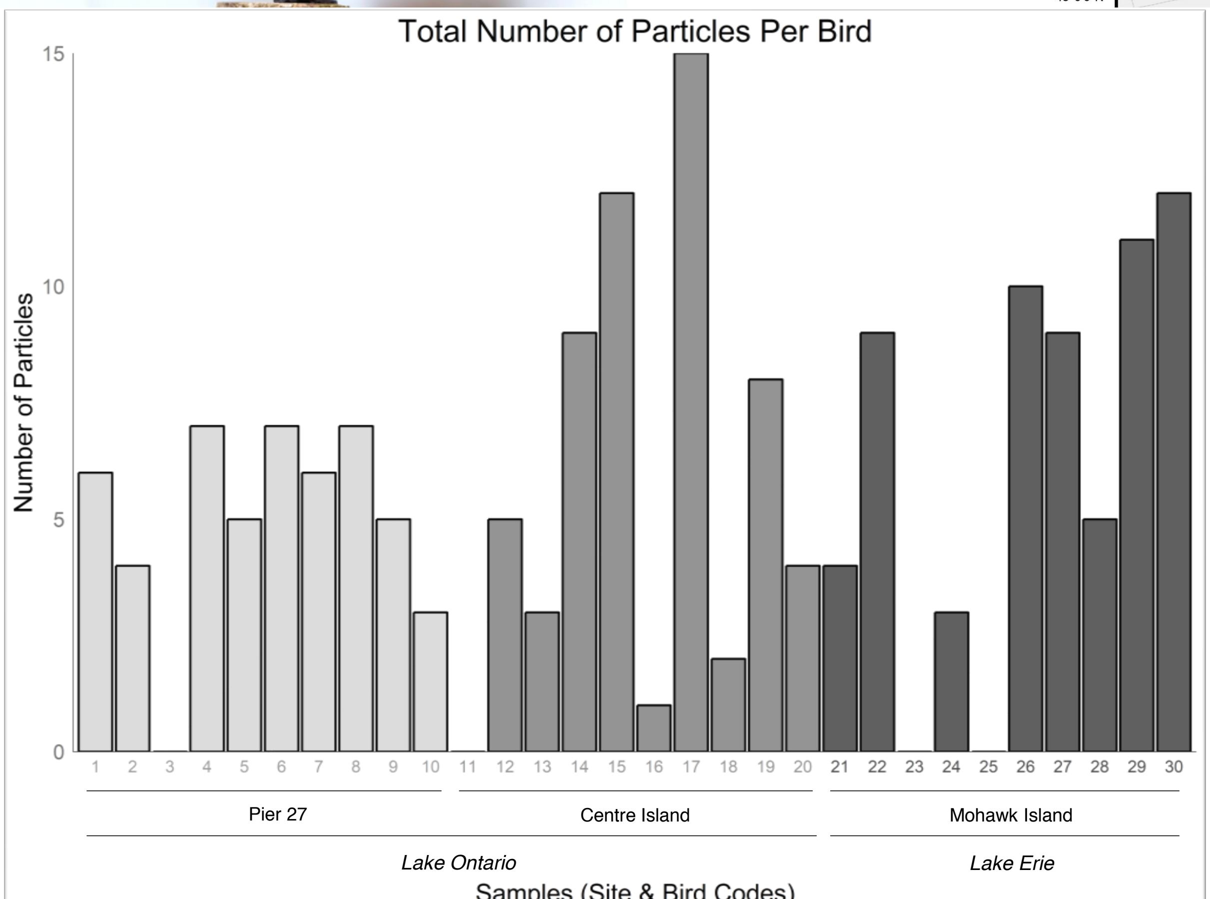
Lake trout
(*Salvelinus namaycush*)



Erdle et al., unpublished data

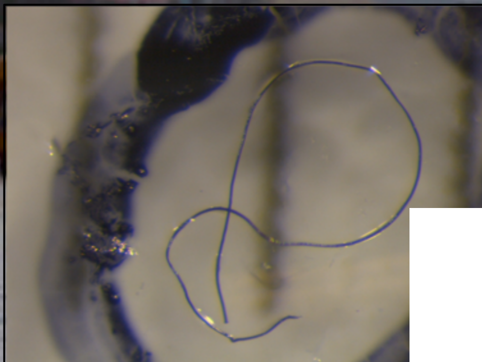
Microplastics in **Great Lakes cormorants**

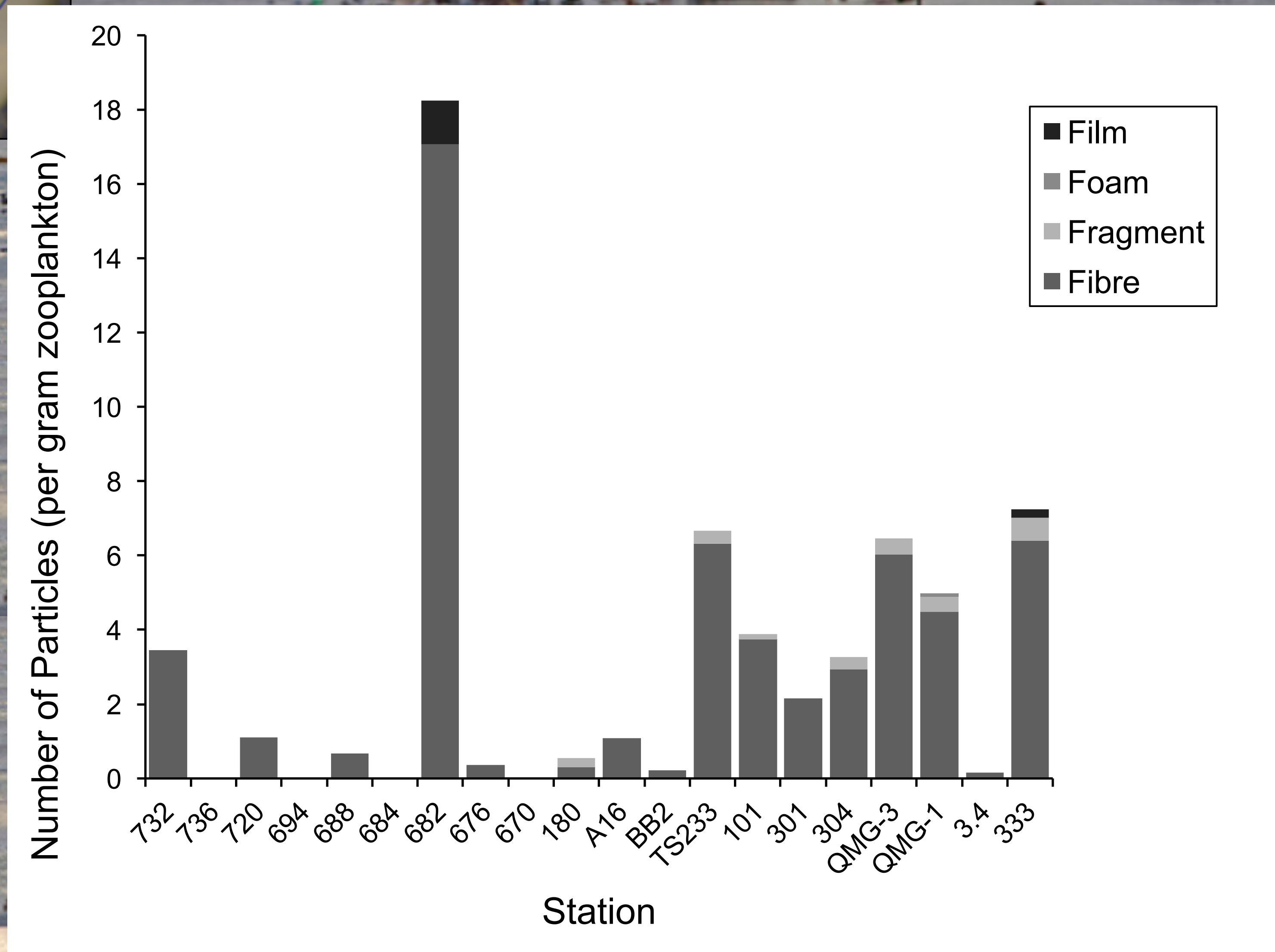




Brookson et al., *in review*

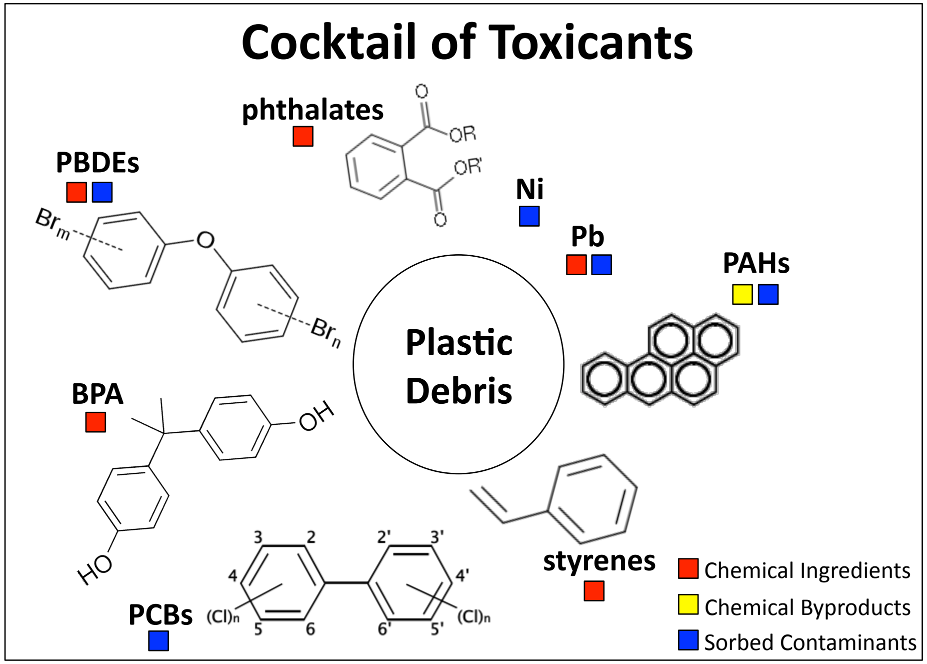
Microplastics in **Arctic zooplankton**





Huntington and Hernandez et al., *Unplublished*

What are the effects?



Rochman 2015 Chapter in *Marine Anthropogenic Litter*

Fate of microplastic and nanoplastics in the body

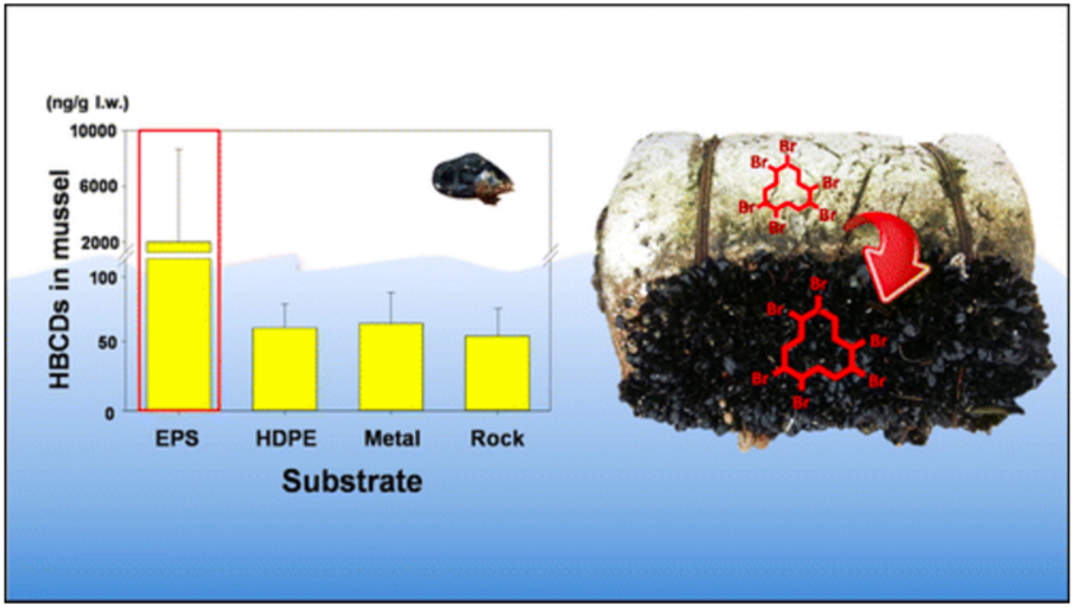
TABLE 6.1

Fate of microplastic and nanoplastics in mammalian bodies as a function of particle size

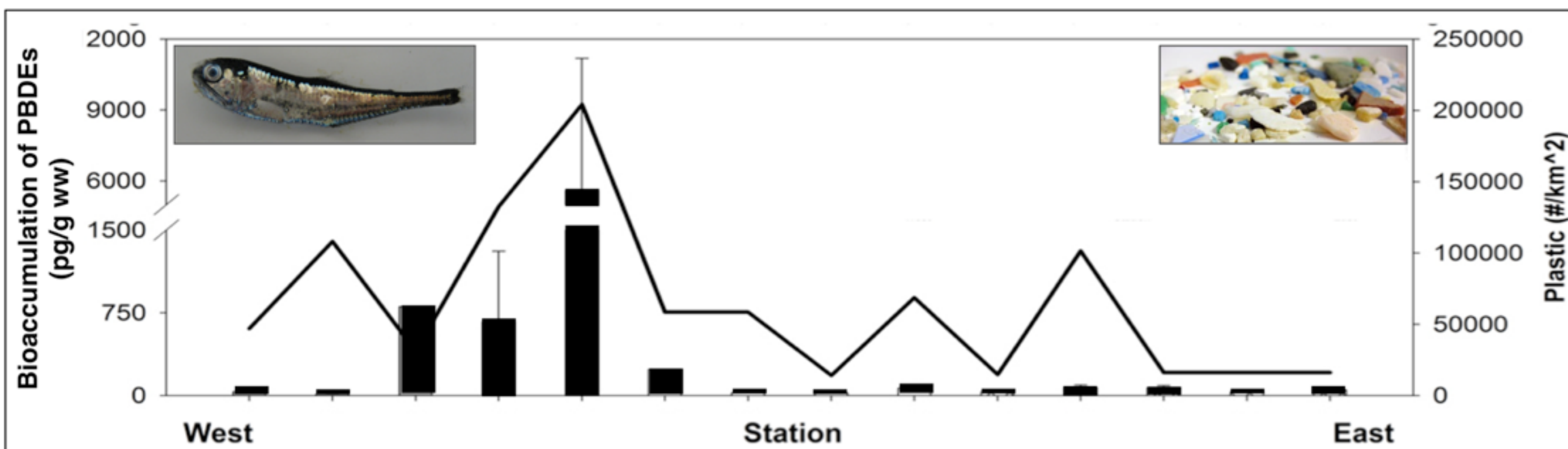
Microplastics (0.1–5000 µm)		**Nanoplastics (1–100 nm)**
> 150 µm	no absorption	
< 150 µm	in lymph absorption ≤ 0.3%	
= 110 µm	in portal vein	
≤ 20 µm (≤20000 nm)	access into organs	
		≤ 100 nm access to all organs, translocation of blood-brain and placental barrier
		Absorption up to 7%

FAO Report 2017

Chemicals from microplastics can transfer to wildlife

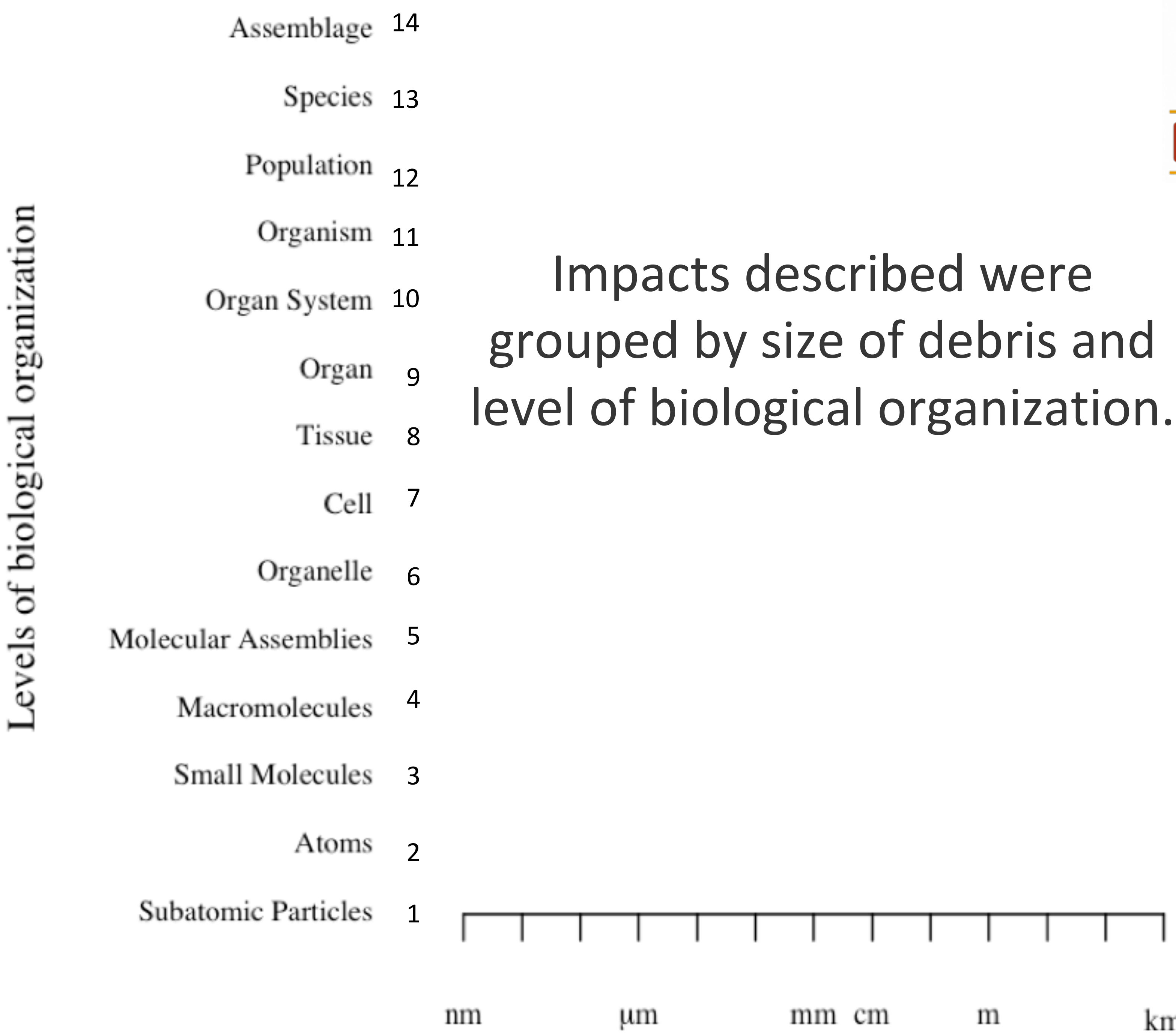


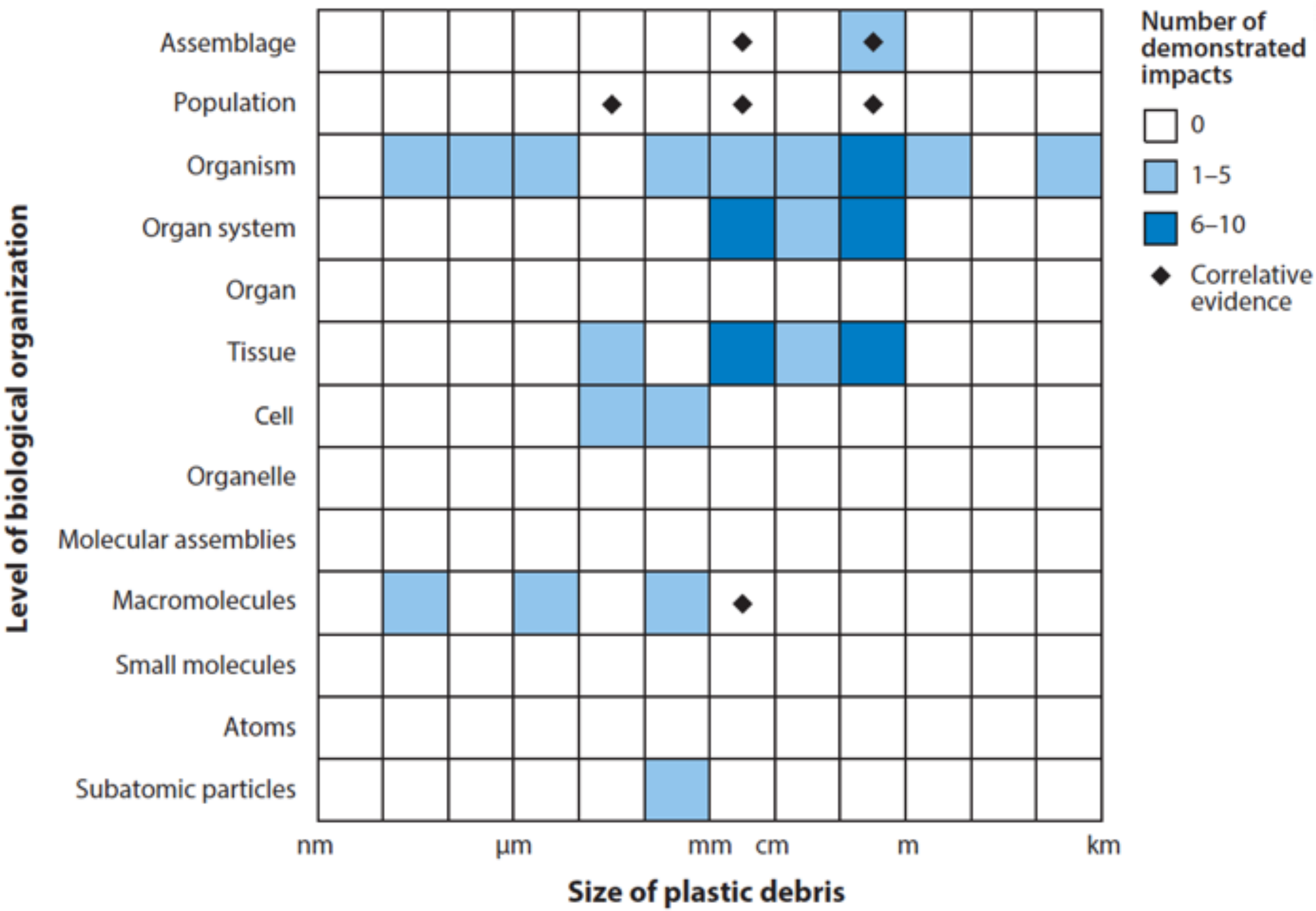
Jang et al., 2016 *ES&T*



Rochman et al., 2014 *Science of the Total Environment*

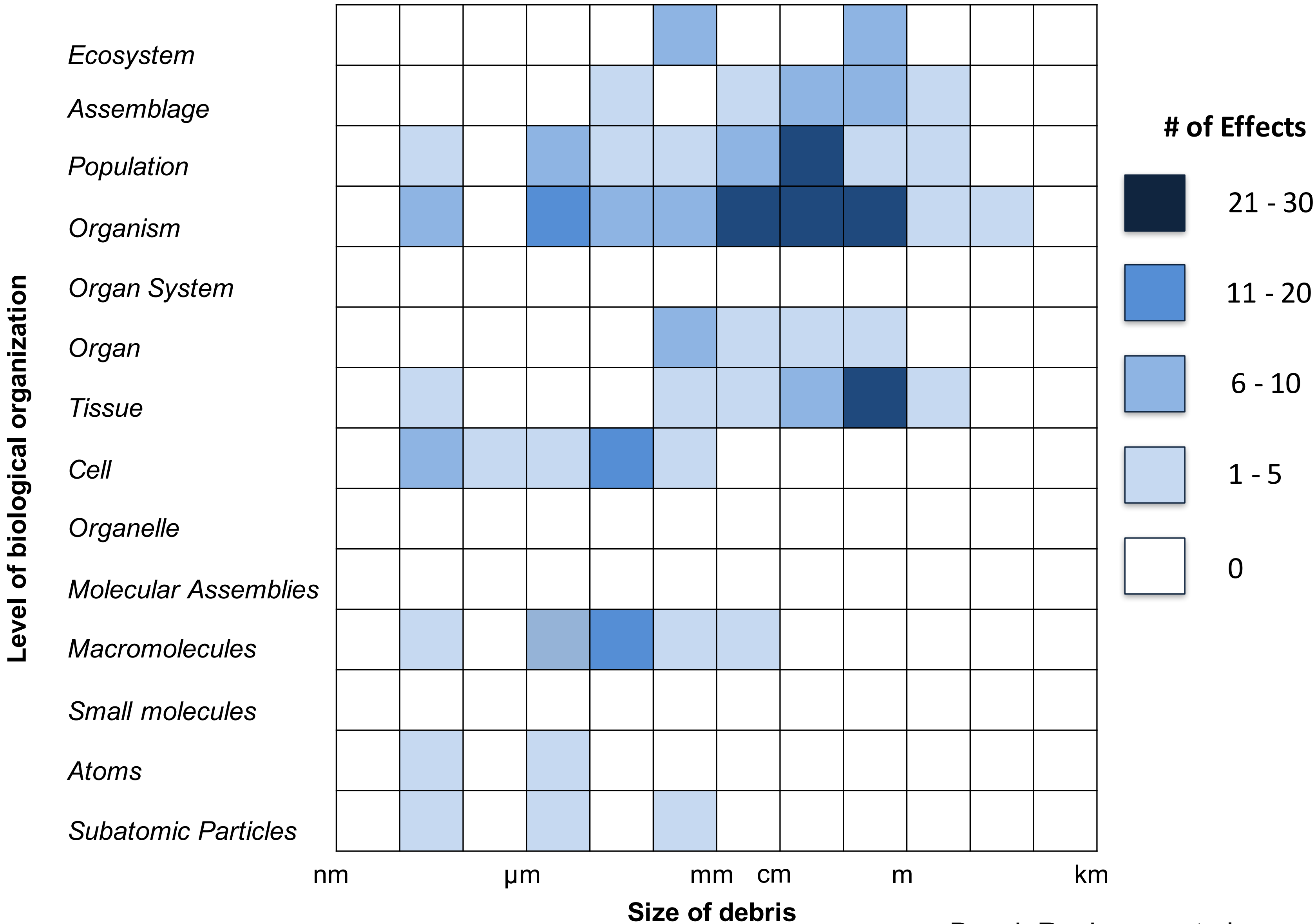
Impacts described were grouped by size of debris and level of biological organization.





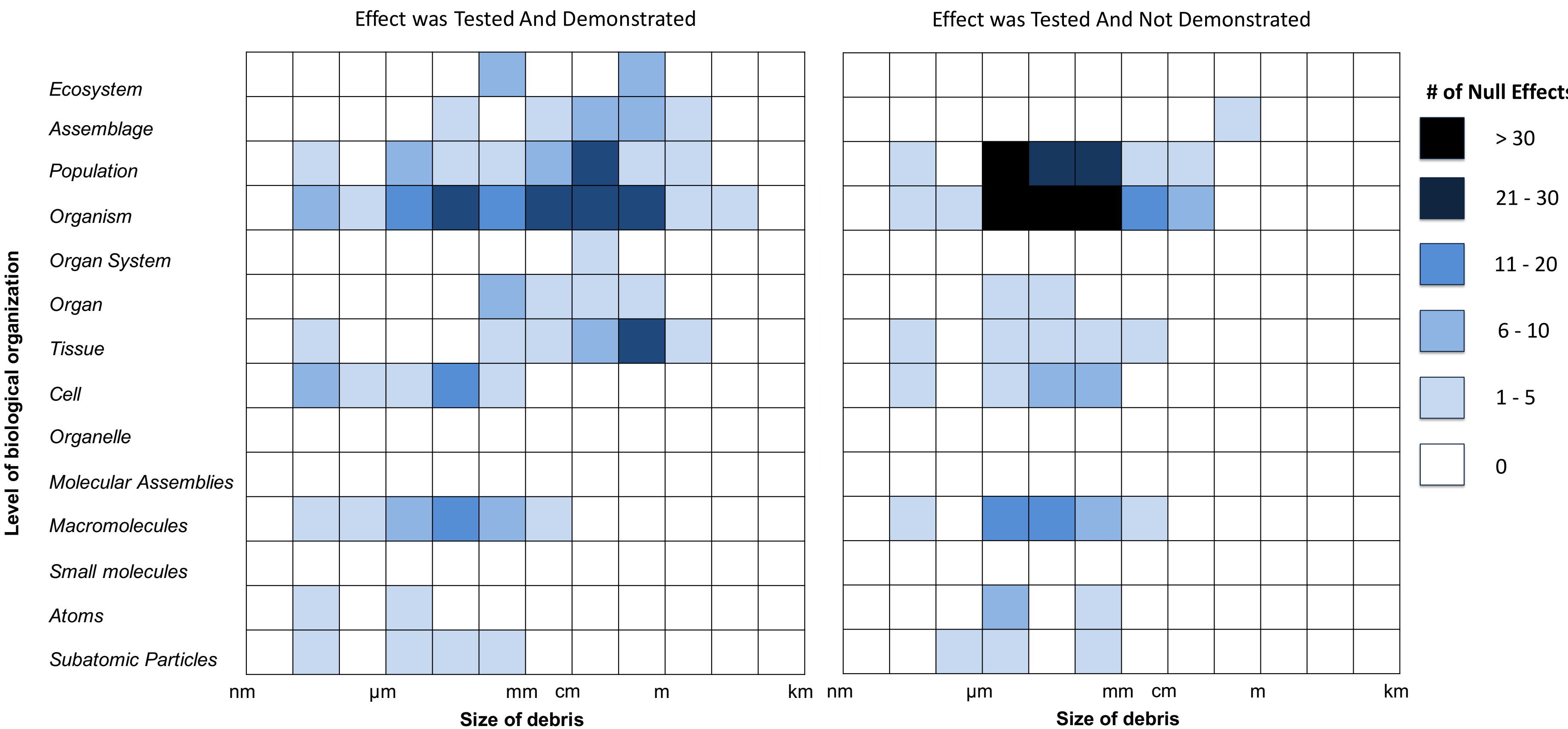
Law, *Ann. Rev. Mar. Sci.* 2017,
adapted from Rochman et al. *Ecology* 2015

The Evidence Demonstrating Impacts to aquatic biota is Growing



Bucci, Rochman, et al. unpublished

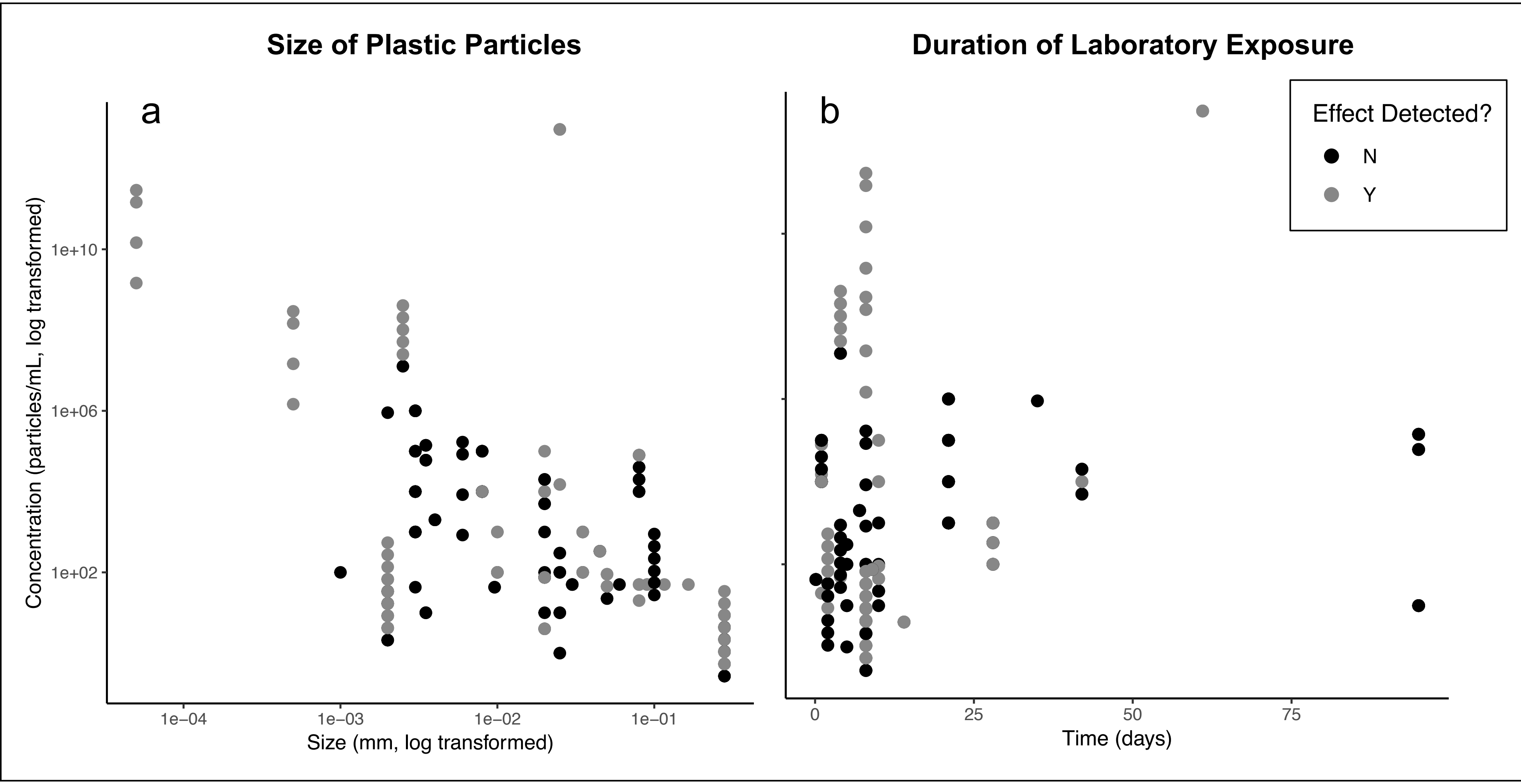
Effect Detected vs Not Detected



Bucci, Rochman, et al. unpublished

What makes an effect detected vs not detected?

- type of microplastic
- size of microplastic
- shape of microplastic
- taxa
- dose of microplastic
- length of exposure



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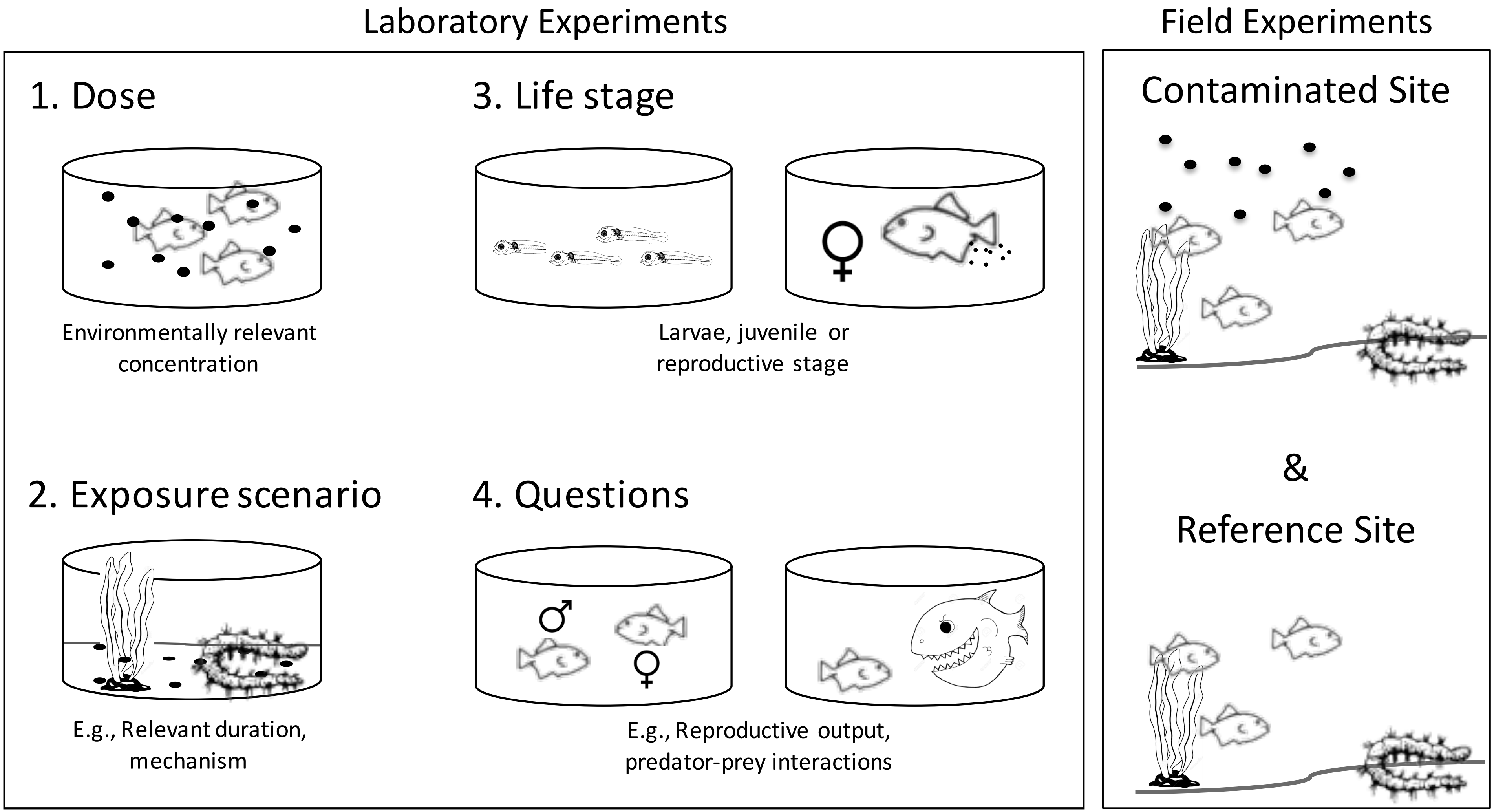
Laboratory Experiments
Field Experiments
1. Dose
Environmentally relevant concentration
3. Life stage
Larvae, juvenile or reproductive stage
2. Exposure scenario
E.g., Relevant duration, mechanism
4. Questions
E.g., Reproductive output, predator-prey interactions
Contaminated Site
&
Reference Site

Next Big Questions and Research Needs for Microplastics:

- Identify local entry points for microplastics into the environment

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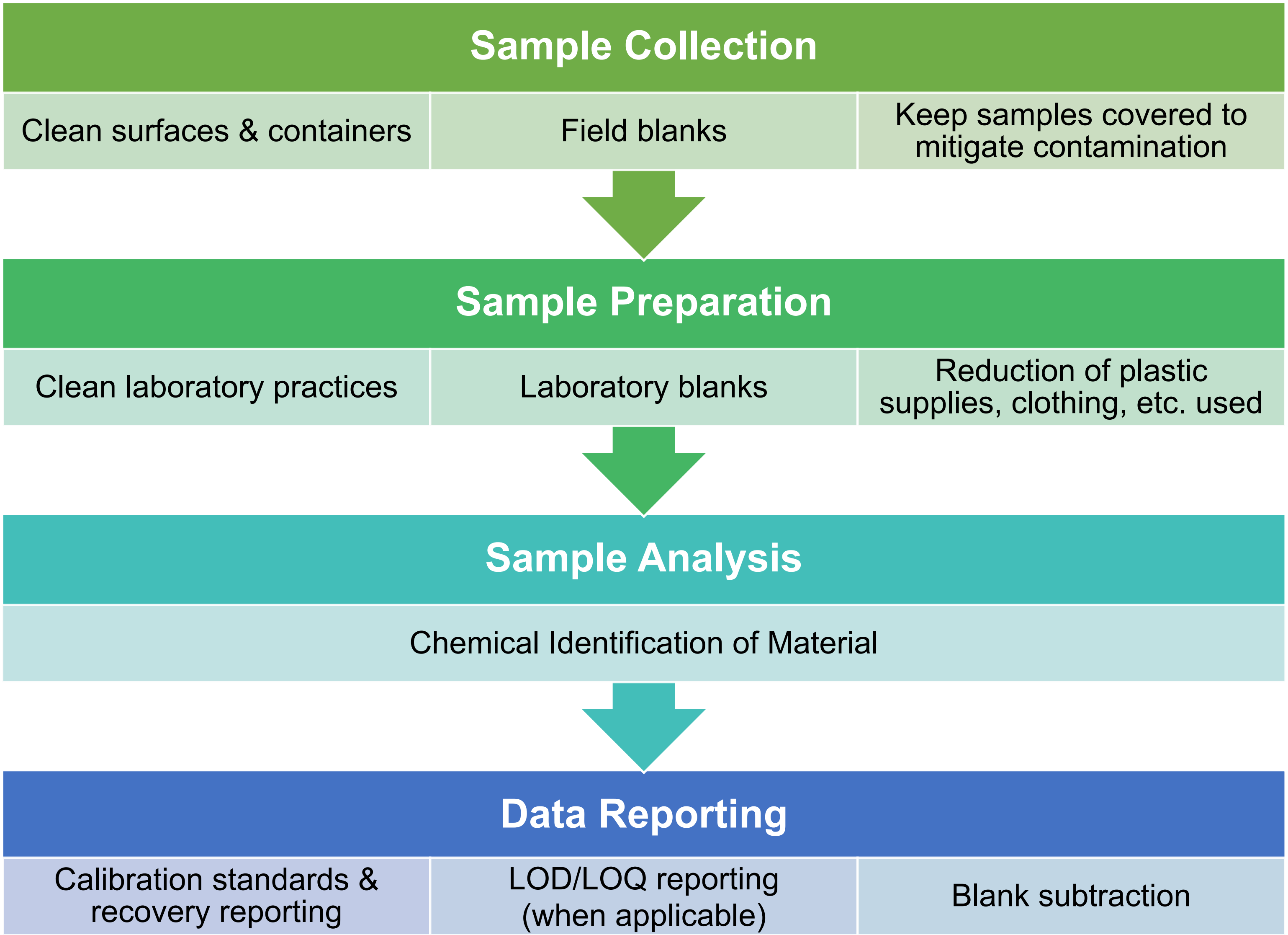
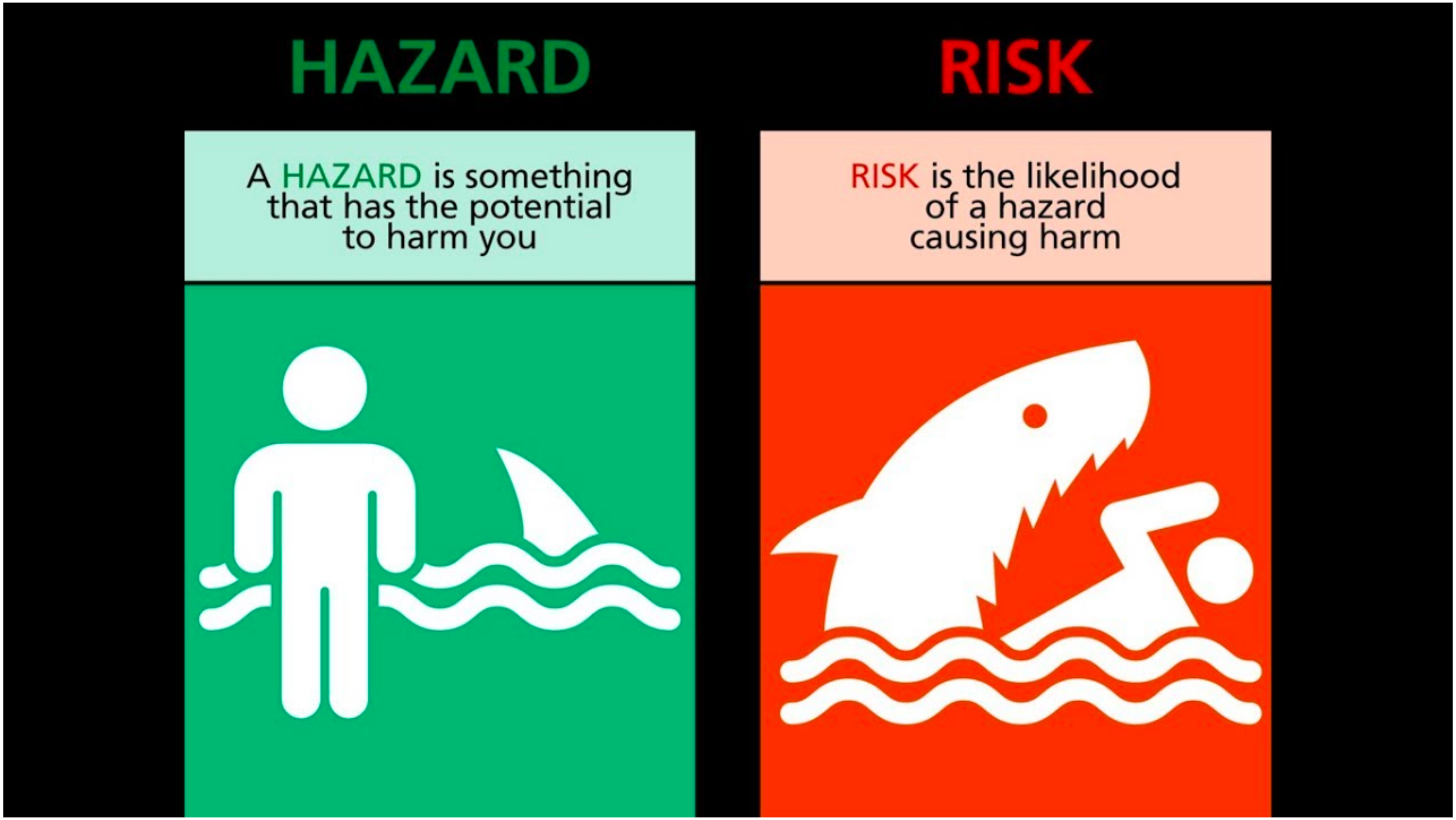
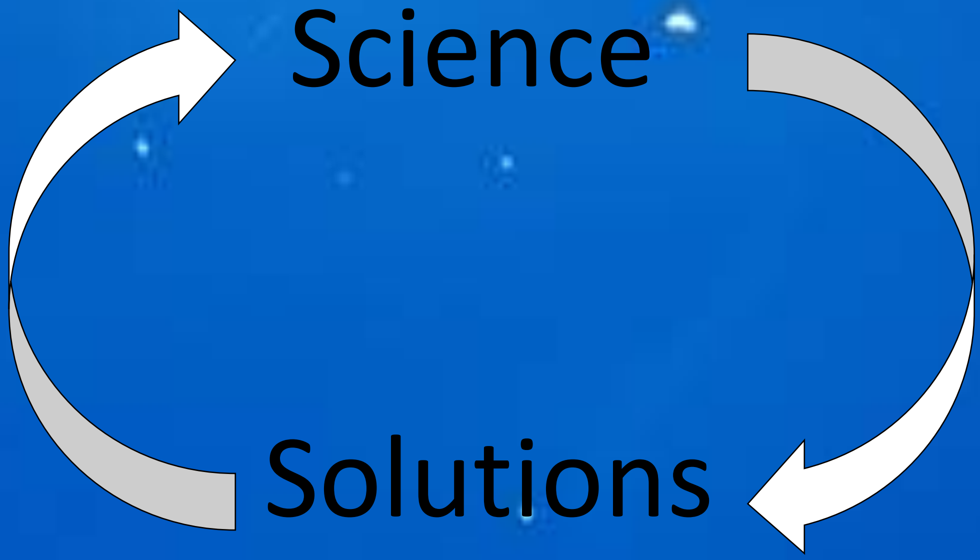
- **Improve methods for quantifying and characterizing microplastics in complex matrices.**


Sample Collection
Clean surfaces & containers
Field blanks
Keep samples covered to mitigate contamination
Sample Preparation
Clean laboratory practices
Laboratory blanks
Reduction of plastic supplies, clothing, etc. used
Sample Analysis
Chemical Identification of Material
Data Reporting
Calibration standards & recovery reporting
LOD/LOQ reporting (when applicable)
Blank subtraction

How can we measure risk if we cannot measure contamination?



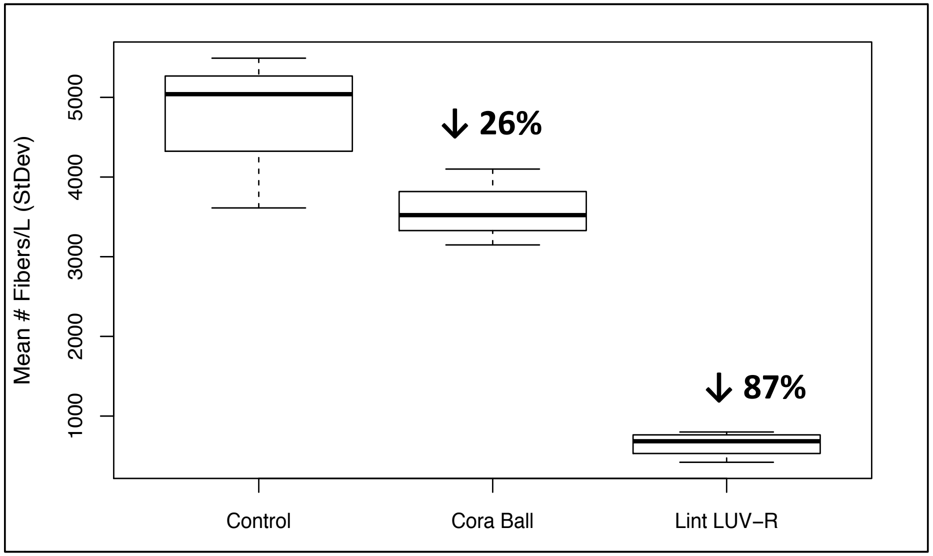


In the meantime, we have enough science to begin to mitigate now and prevent future sources of plastic pollution.


Think
Globally
Act
Locally

Testing microfiber mitigation

2 strategies: **both reduce microfibers** in washing machine effluent



Cora ball

Lint LUV-R

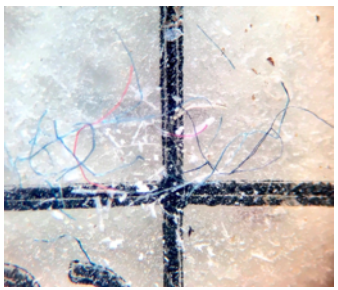
Photos: coraball.com / www.environmentalenhancements.com

Hayley McIlwraith

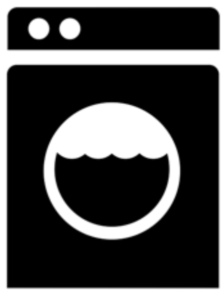
Jack Lin

McIlwraith, et al. *in review*

City of Toronto example



x



x

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90,700 to 138,000 microfibers per wash load

(our study)

219 wash loads per household per year

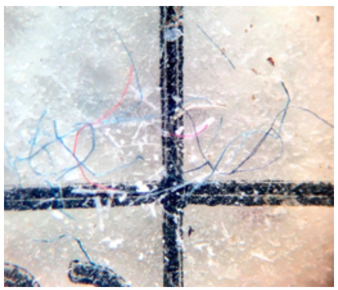
(NRC, 2011)

1,179,057 households

(Statistics Canada, 2017)

23 to 36 trillion microfibers emitted per year

City of Toronto example



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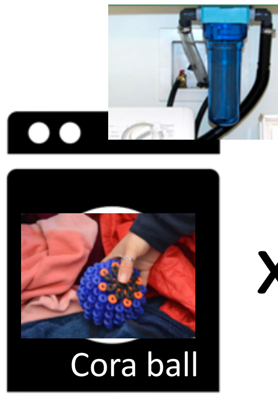
Lint LUV-R



x

=

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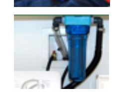
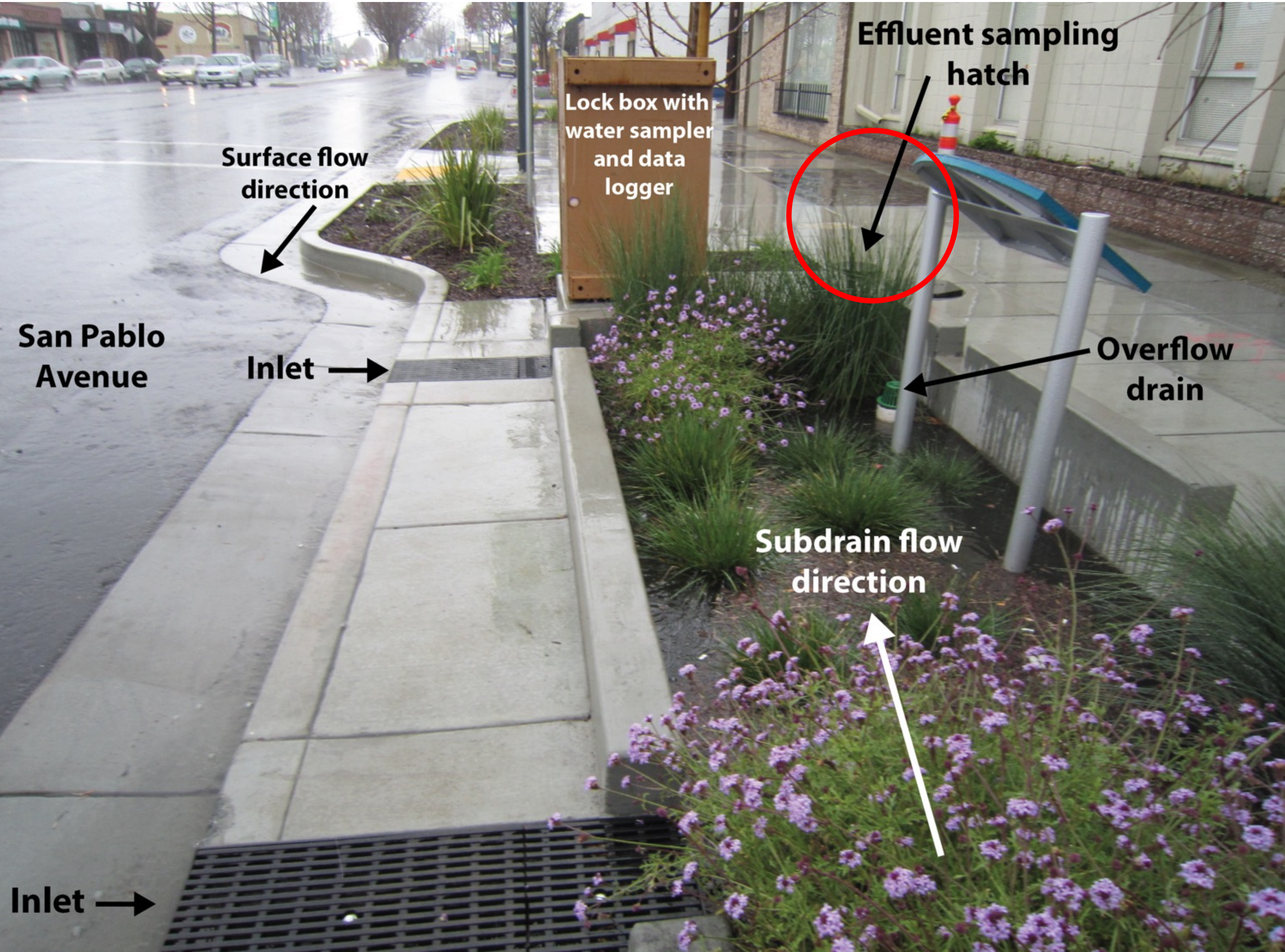
<u>23 to 36 trillion microfibers</u> emitted per year

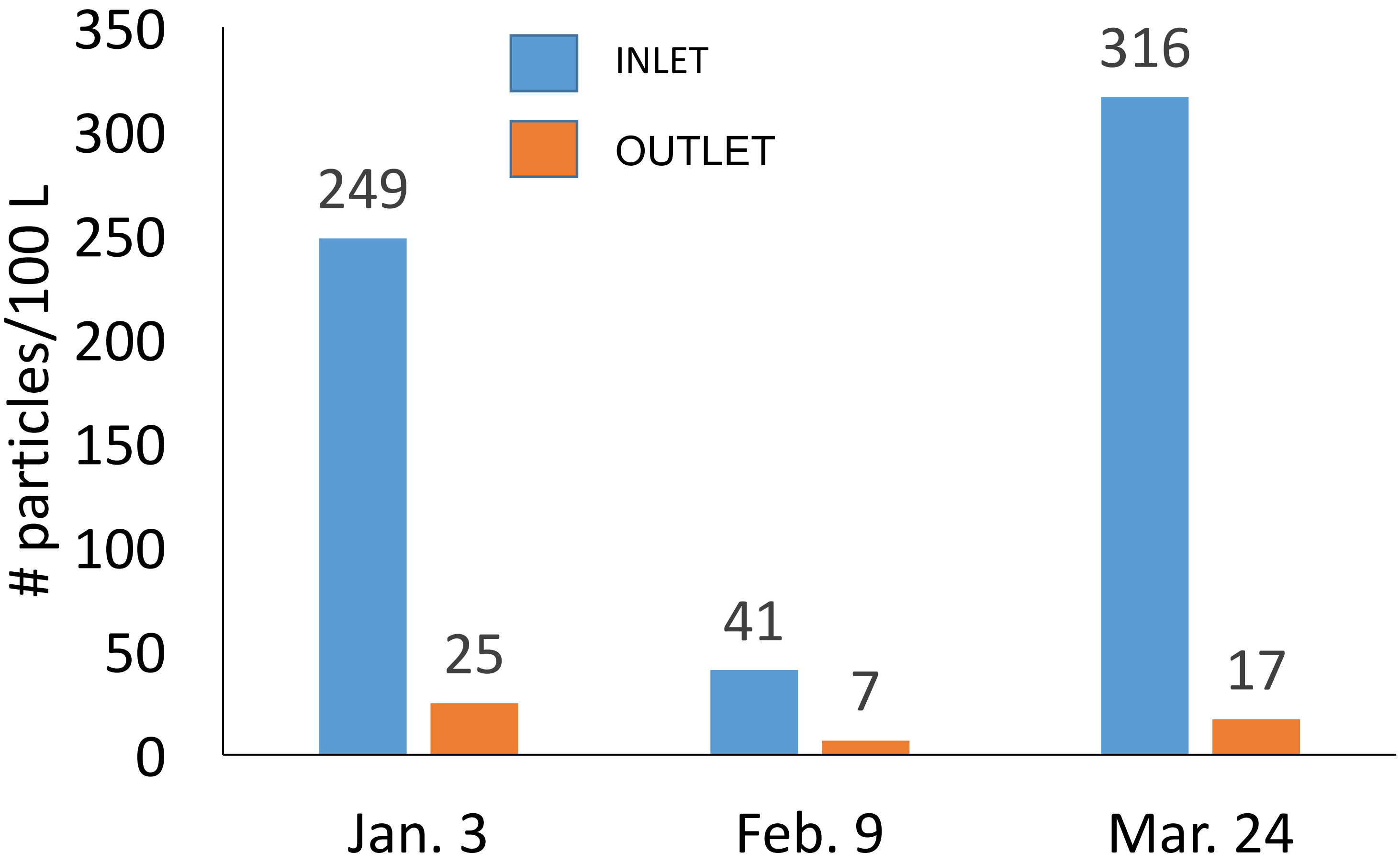
 **↓ 6 to 9 trillion microfibers**

 **↓ 20 to 31 trillion microfibers**


Effluent sampling hatch
Lock box with water sampler and data logger
Surface flow direction
San Pablo Avenue
Inlet
Overflow drain
Subdrain flow direction
Inlet

Treatment Efficiency

- Mean 92% reduction (n=3)



Environment and Climate Change Canada

Fisheries and Oceans Canada

Smith Fellows — David H. Smith Conservation Research Program — www.smithfellows.org

Ocean Conservancy

University of Toronto

NCEAS

Ontario Ministry of the Environment and Climate Change

NSERC CRSNG

Georgian Bay Forever — Protecting your water.

Thank you!

Rochman Lab postdocs, students and staff
Georgian Bay Forever
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ECCC: A DaSilva, L Jantunen, J. Parrott
SFEI & Moore Foundation
Miriam Diamond & Lab
Dave Sinton & Lab
Bob Andrews & Lab
HORIBA Scientific
Erik van Sebille, Kara Lavender Law, Jenna Jambeck, Roland Geyer
Susan Williams, Bodega Marine Lab
Teh Lab, UC Davis
Eunha Hoh, SDSU

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