

The ecological cost of convenience: Plastic pollution along the shore and in the foodwebs of Lake Ontario

Black River Watershed Conference June 4, 2019

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Acknowledgements

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SUNY Oswego: Dr. Richard Back, Dr. Casey Raymond

SUNY Fredonia: Dr. Sherri Mason

SUNY Plattsburgh: Dr. Danielle Garneau



Fish samples

United States Geological Survey

New York Department of Environmental Conservation

Salmon River Fish Hatchery

Ontario Ministry of Natural Resources and Forestry



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Scholarly and Creative Activities Grant

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Dean's Office: College of Liberal Arts and Sciences

Background

Shoreline
macroplastics



Microplastics
in prey (forage) fish

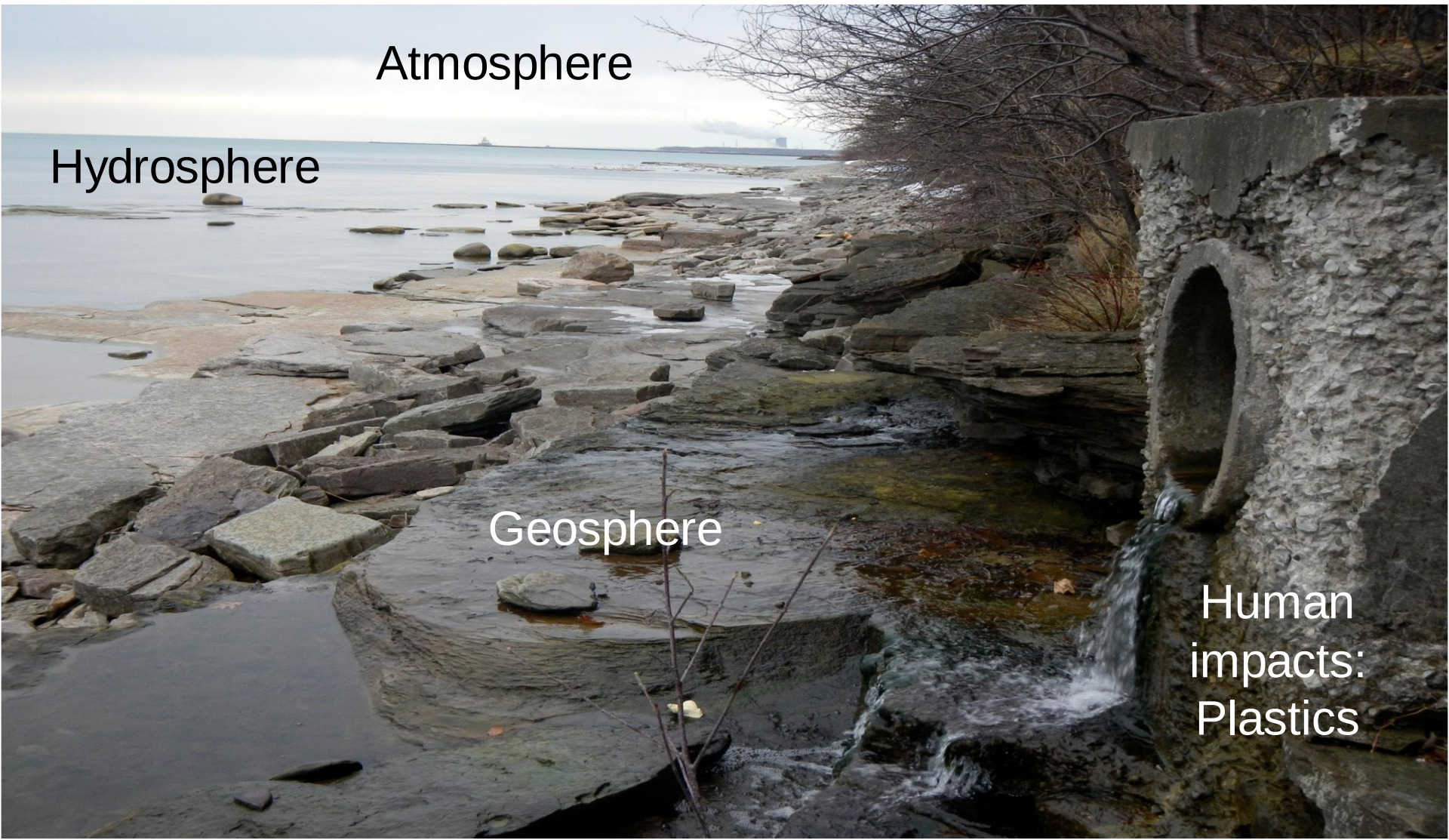


Microplastics
in salmon



“...The Round River, a river that flowed into itself, and thus sped around and around in a never-ending circuit.”

Aldo Leopold *The Round River*



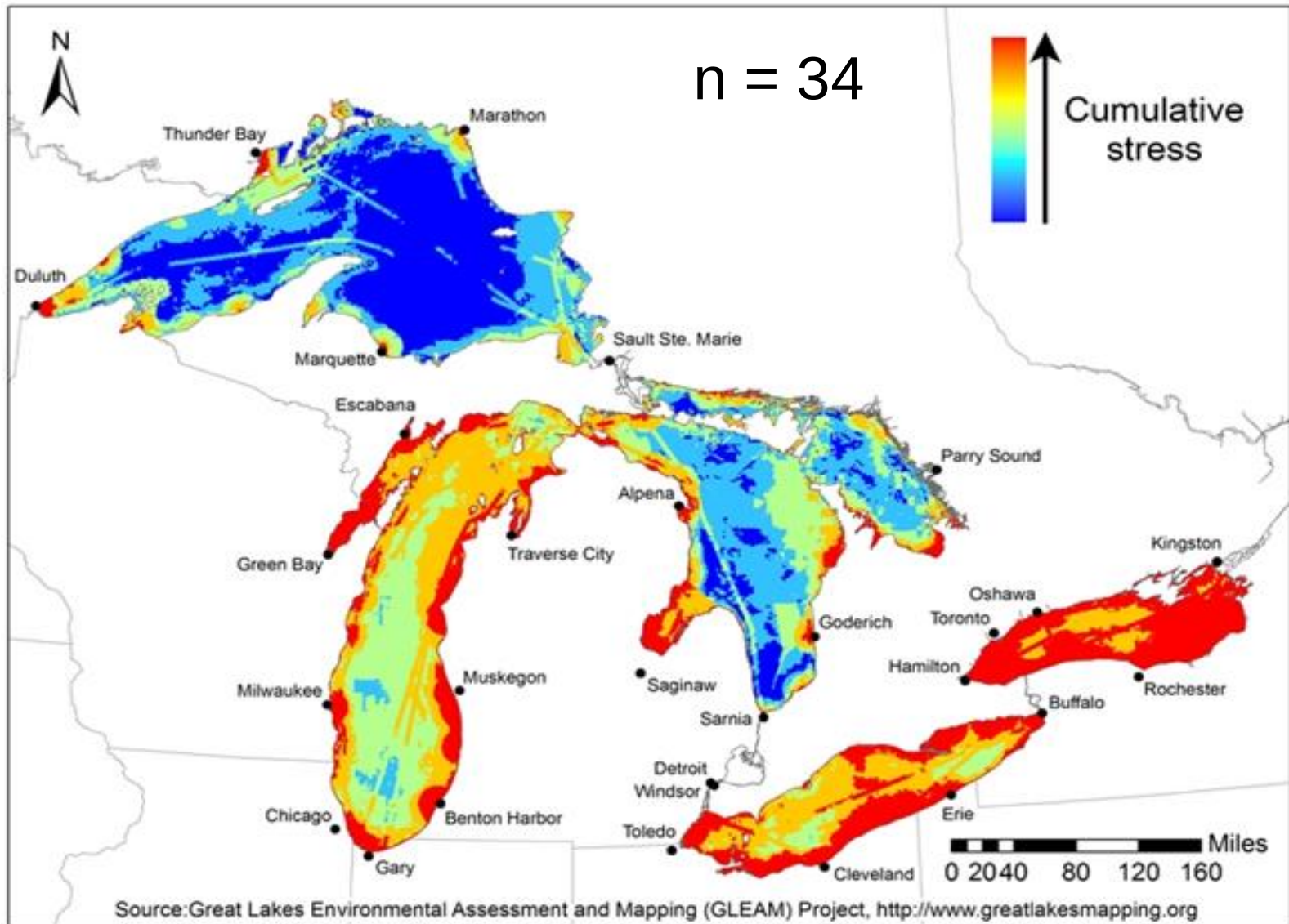
Atmosphere

Hydrosphere

Geosphere

Human
impacts:
Plastics

Great Lakes: Greatly stressed ecosystems



Plastic pollution in *The Round River*

Plastic communities have recurring “species”



Unmanipulated photo of Lake Ontario plastics and wrack

Estimate of global plastic production:1950-2017

8.3 billion metric tons

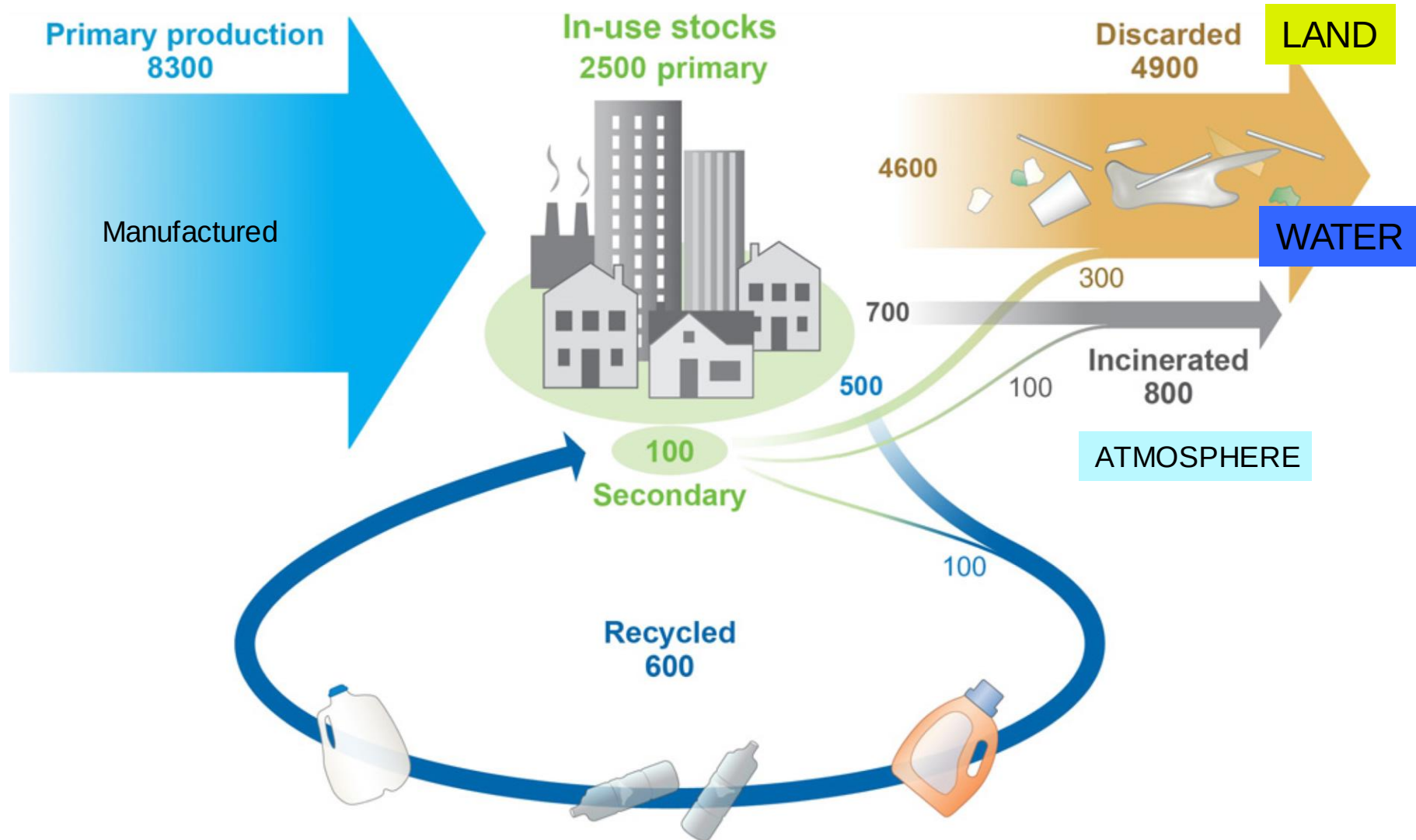


822,000x



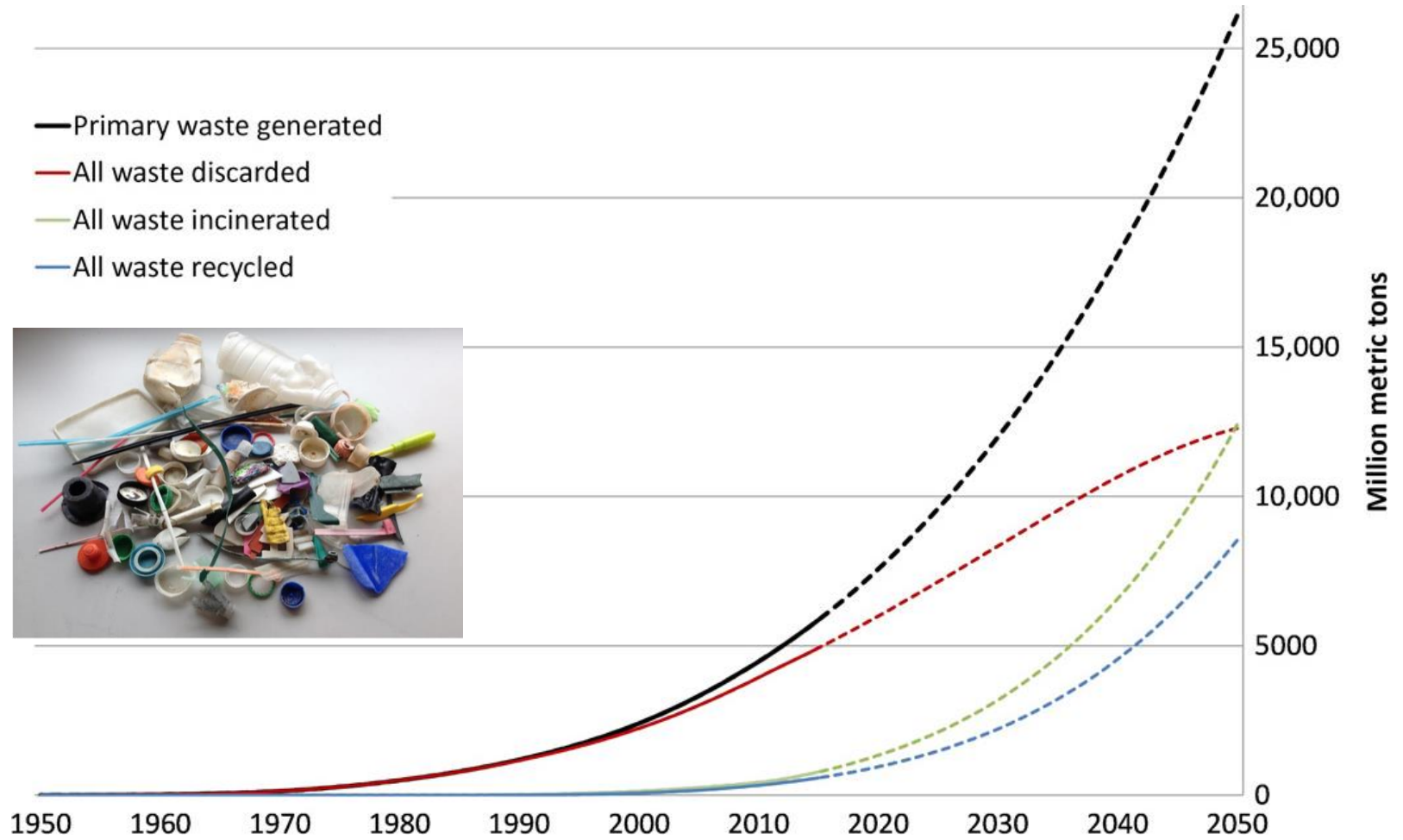
25,000x

1950-2015: Global plastic “cycle” (million metric tons)



Cumulative plastic waste generation and disposal (in million metric tons)

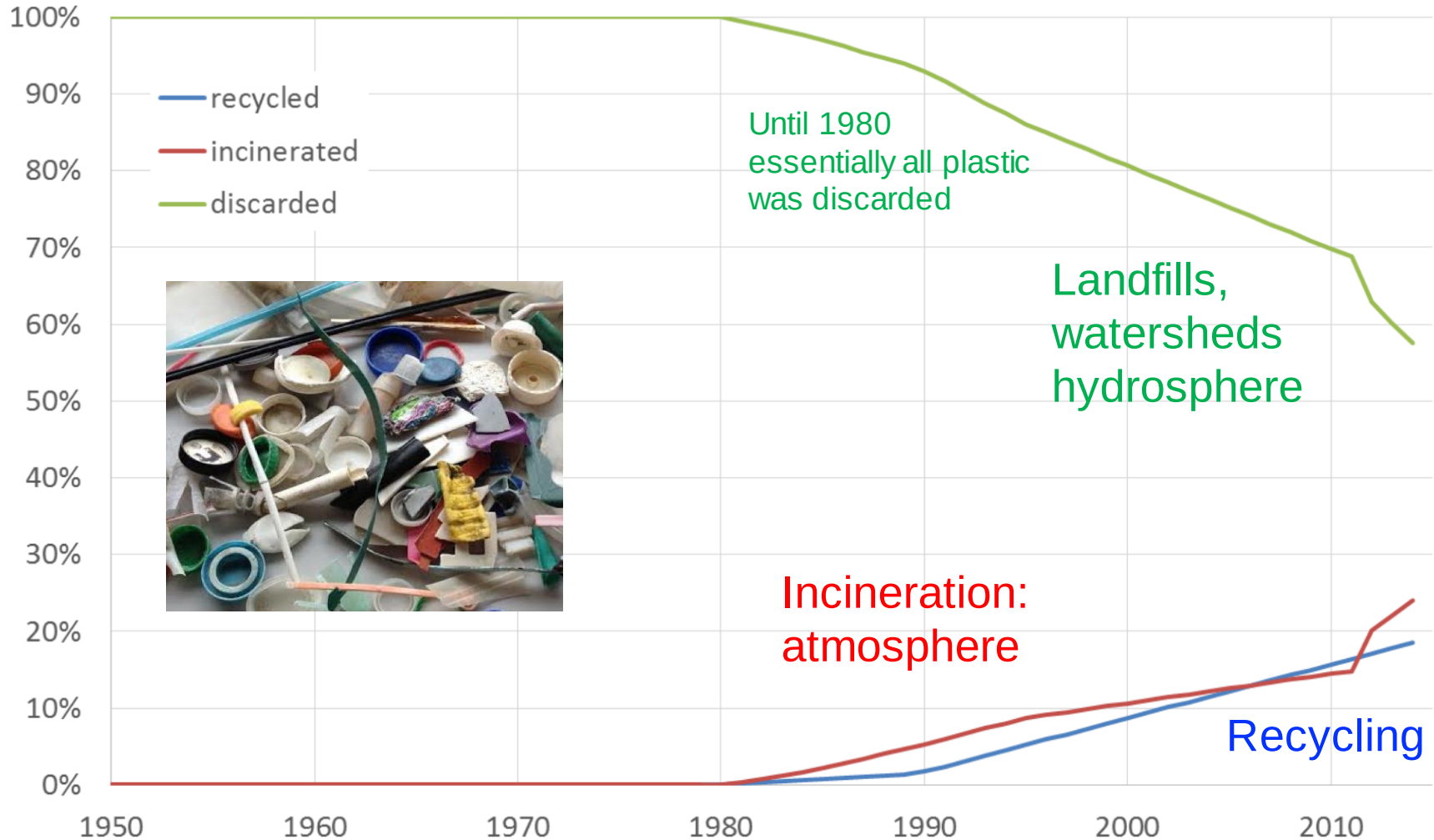
Plastic production is exploding: Where will it all go?



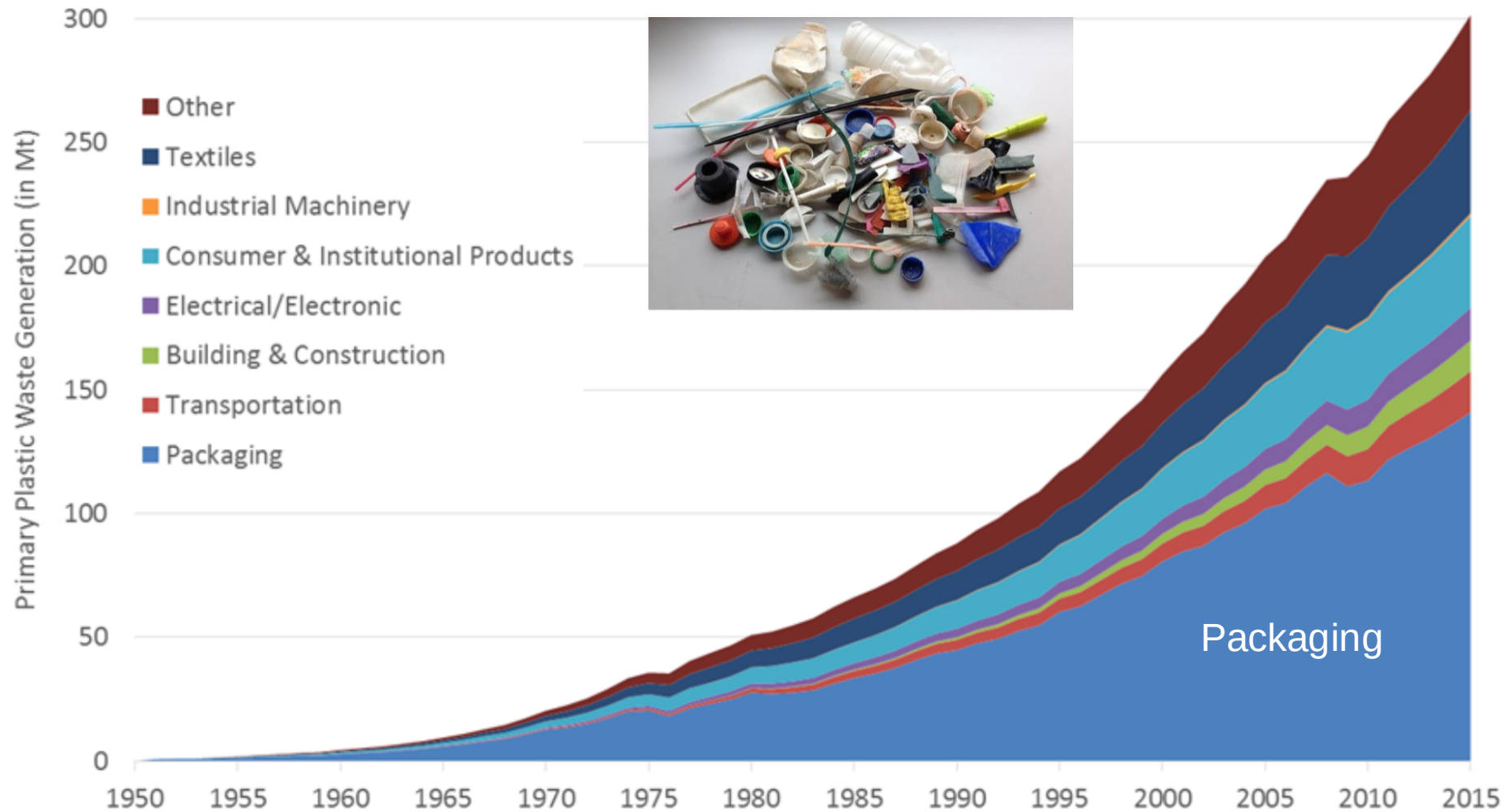
Geyer et al. 2017

ScienceAdvances

Fate of global plastics waste (est. million metric tons): 1950-2014



Global plastics waste (million metric tons): 1950-2015



Geyer et al. 2017

Environmental residence time: 450 yrs

**THE BEST STUFF
ON EARTH,
NOW IN A
PLASTIC BOTTLE**



Spring 2018

Health risks of plastics

- | | |
|---------------|--|
| #1 PET | Can leach antimony when exposed to high temperatures; likely carcinogen (AVOID) |
| #2 HDPE | Generally stable, has been linked to endocrine disruption |
| #3 PVC | Monomer is a known carcinogen; softeners (phthalates) are endocrine disruptors; carcinogens; when burned forms dioxins... extremely toxic carcinogen (AVOID) |
| #4 LDPE | Relatively stable with low toxicity; can leach endocrine disruptors |
| #5 PP | Relatively stable, health risks seem low |
| #6 PS | Styrene is a likely carcinogen, nervous system toxin (AVOID) |
| #7 and beyond | Contains BPA a serious endocrine disruptor (AVOID) |

OH THE PLACES SNAPPLE CAN GO NOW IN PLASTIC



Spring 2018

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**OH THE PLACES
SNAPPLE
CAN GO NOW
IN PLASTIC**

Why did Snapple switch to plastic bottles?

It's lighter, virtually unbreakable, and resealable, making it more convenient for our consumers to enjoy Snapple on the go – and easier for distributors and retailers to handle.

Spring 2018

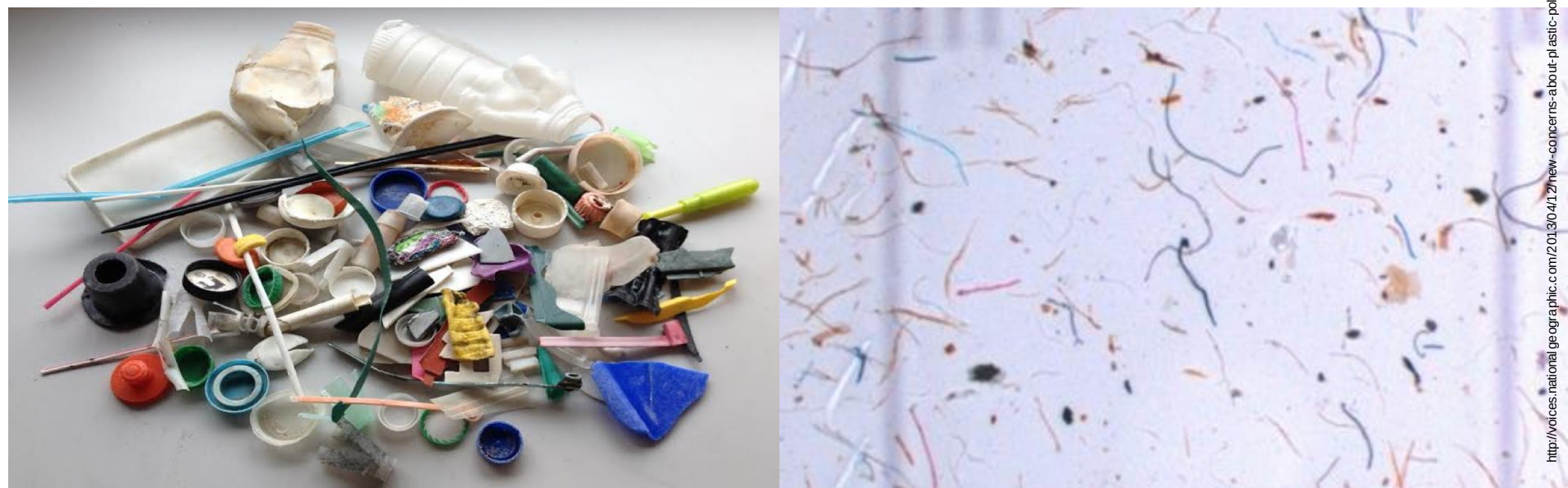


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The costs of convenience

- Xenobiotics with long term residency
- Physical (external and internal) stressors
- Release and binding of harmful chemicals
- Food web contamination
- Human health costs
- Decreased aesthetic value

Prata 2018, Smith et al. 2018, Koelmans 2015, Boerger et al. 2010



More plastic than fish in the sea by 2050, says Ellen MacArthur

One refuse truck's-worth of plastic is dumped into the sea every minute, and the situation is getting worse

Graeme Wearden

Tue 19 Jan 2016 09.23 EST



10,107 101



▲ Just 5% of waste plastic is effectively recycled, at plants like this one in Indonesia. Photograph: Hotli Simanjuntak/EPA

As a record-breaking sailor, Dame [Ellen MacArthur](#) has seen more of the world's oceans than almost anyone else. Now she is warning that there will be more waste plastic in the sea than fish by 2050, unless the industry cleans up its act.

According to [a new Ellen MacArthur Foundation report launched at the World Economic Forum on Tuesday](#), new plastics will consume 20% of all oil production within 35 years, up from an estimated 5% today.

Plastics production has increased twentyfold since 1964, reaching 311m tonnes in 2014, the report says. It is expected to double again in the next 20 years and

Sea salt around the world is contaminated by plastic, studies show

Exclusive: New studies find microplastics in salt from the US, Europe and China, adding to evidence that plastic pollution is pervasive in the environment

- **We are living on a plastic planet. What does that mean for our health?**

Jessica Glenza *in New York*

🐦 @JessicaGlenza

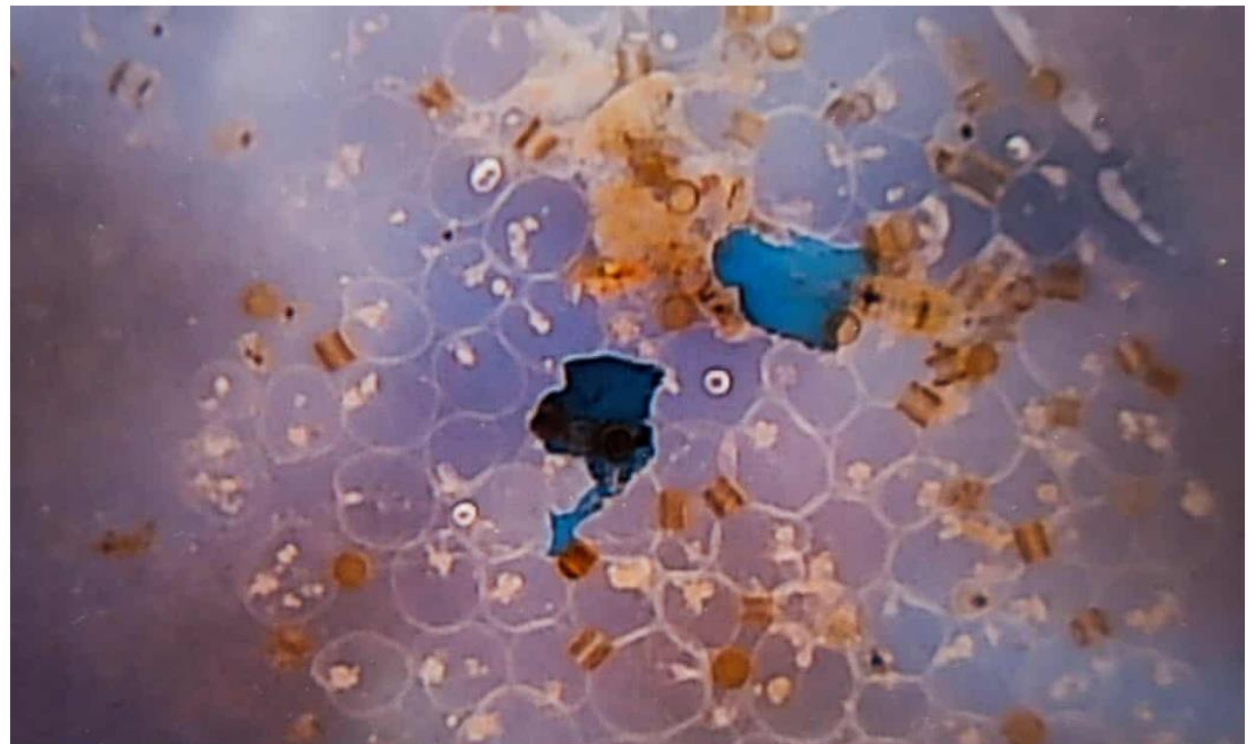
Fri 8 Sep 2017 11.33 EDT



19,088



997



▲ Two fragments of blue microplastic surrounded by diatom phytoplankton (seen under a microscope) after being collected from the sea in a fine mesh trawl net. Photograph: Alex Hofford/EPA

The Guardian

Sea salt around the world has been contaminated by plastic pollution, adding to experts' fears that microplastics are becoming ubiquitous in the environment

Plastic pollution discovered at deepest point of ocean

High levels of contamination in Mariana Trench show how pervasively planet has been contaminated

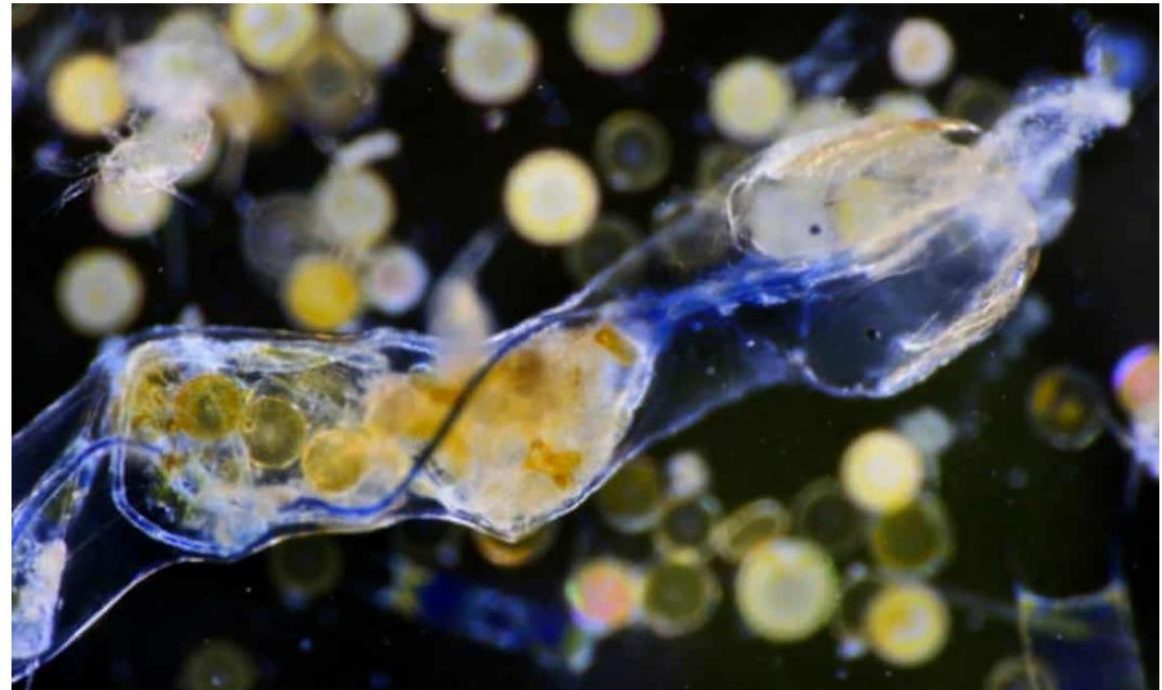
Damian Carrington
Environment editor

🐦 @dpcarrington

Thu 20 Dec 2018 10.01 EST



2,887

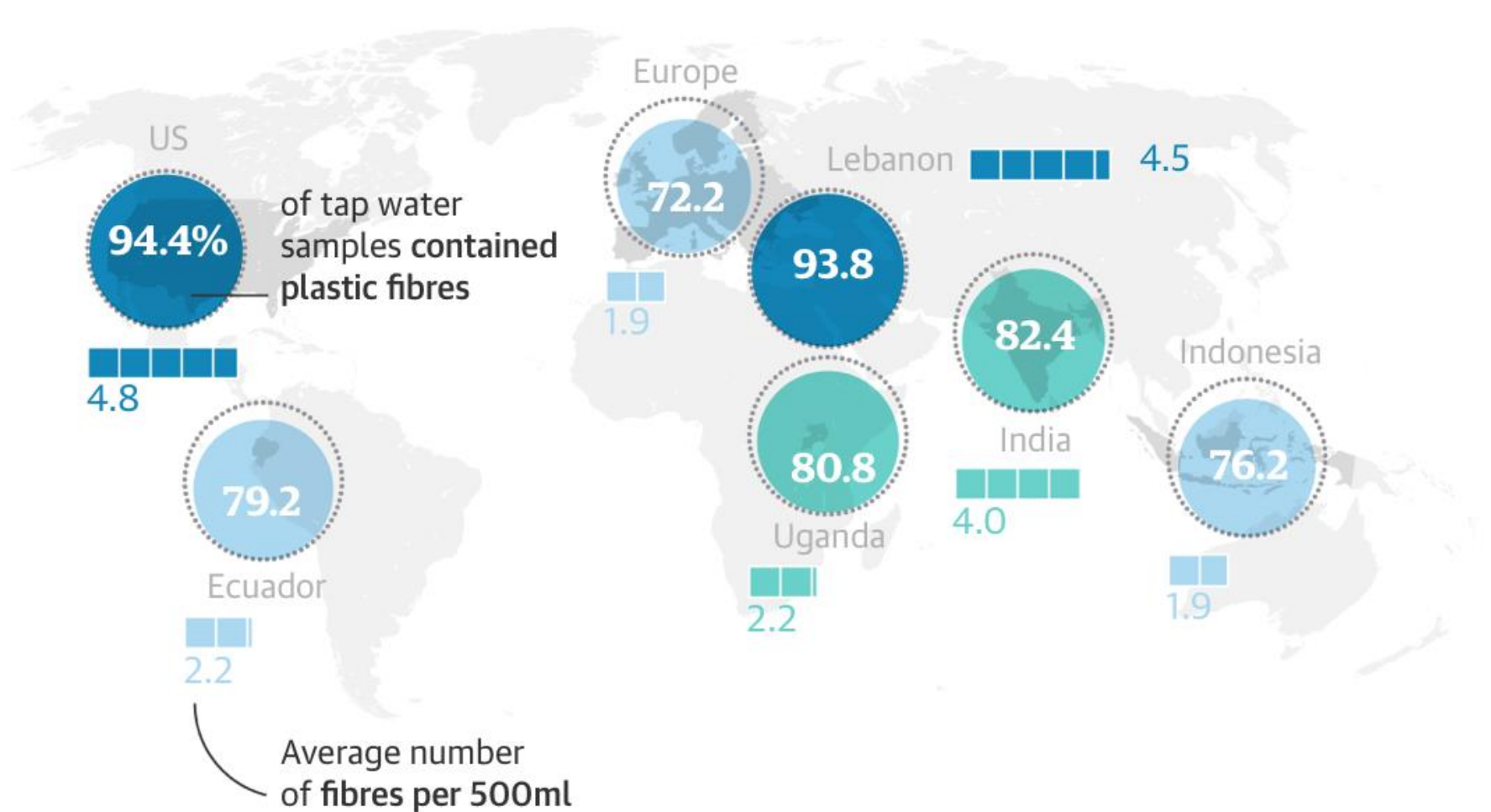


▲ This planktonic arrow worm, *Sagitta setosa*, has eaten a blue plastic fibre about 3mm long. Photograph: Dr Richard Kirby

The deepest point on Earth is heavily polluted with plastic, scientists have discovered, showing how pervasively the world has been contaminated.

The researchers plumbed the depths of the Mariana Trench in the western Pacific Ocean, near Challenger Deep, the lowest place on the face of the planet. They found the highest levels of microplastics yet found in the open ocean, compared with surveys from elsewhere in the Pacific, Atlantic and Arctic oceans.

Our water supplies are contaminated with plastic



Microplastics in our mussels: the sea is feeding human garbage back to us

A new report found the seafood contains an alarming amount of plastic - and in fact no sea creature is immune. It's as if the ocean is wreaking its revenge



Philip Hoare

🐦 @philipwhale

Fri 8 Jun 2018 12.28 EDT



🔗 13,944
💬 214



▲ Blue or common mussels on rocks in Cornwall. Photograph: Alamy Stock Photo

Shellfish are the natural filter systems of our seas, mechanisms of purity. So, to discover in a report released on World Oceans Day that mussels bought from UK supermarkets were infested with microplastic seems like a final irony in the terrible story of the plasticisation of the sea. According to the study by the University of Hull and Brunel University London, 70 particles of microplastic were found in every 100 grams of mussels.

Microplastics found in human stools for the first time

Study suggests the tiny particles may be widespread in the human food chain

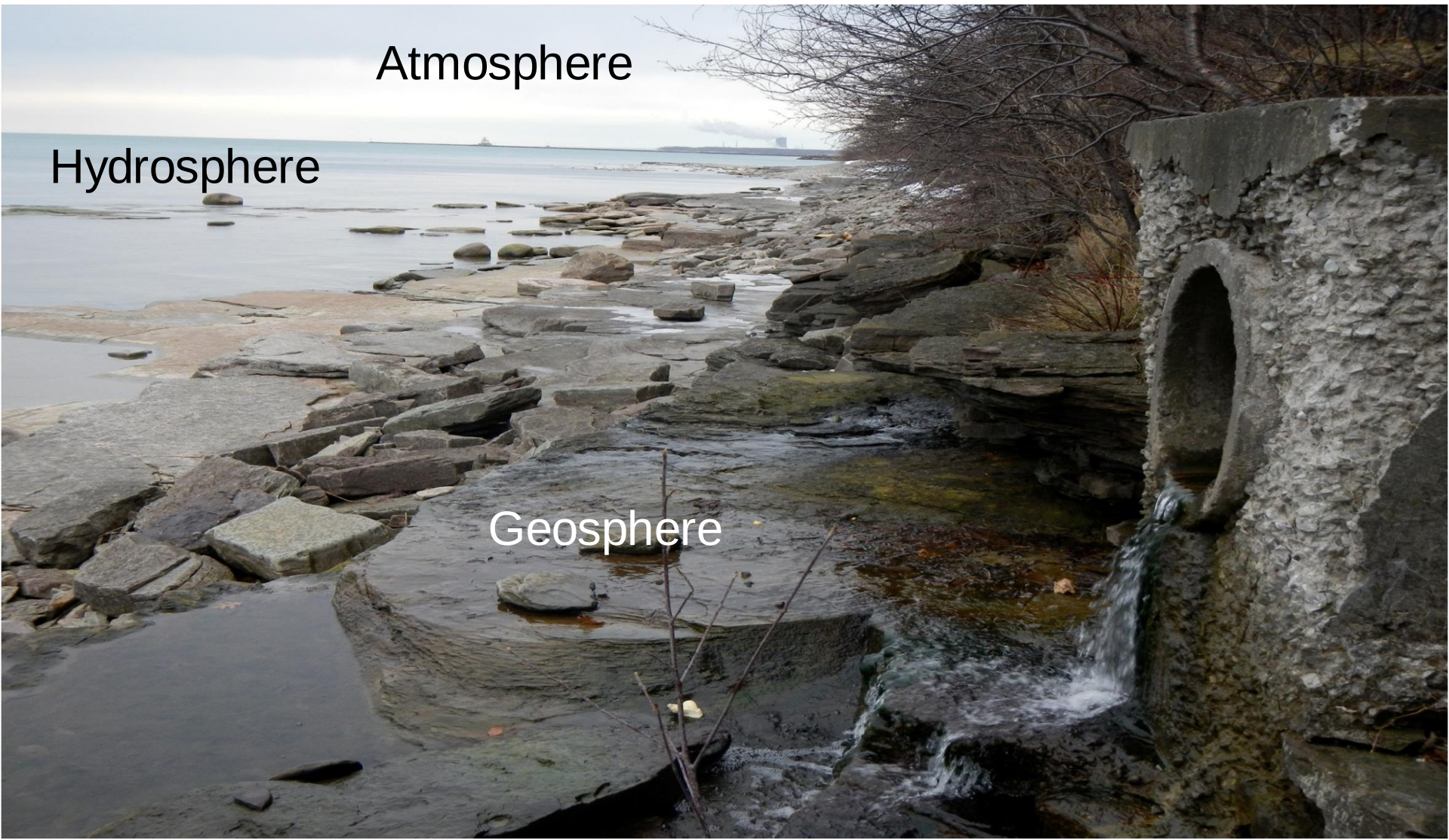
The Guardian

Combined Sewer Overflow:
Oswego River, Oswego, NY

Greasy film of sewage effluent
and stormwater runoff on its
way to Lake Ontario



Plastic pollution is everywhere and inescapable

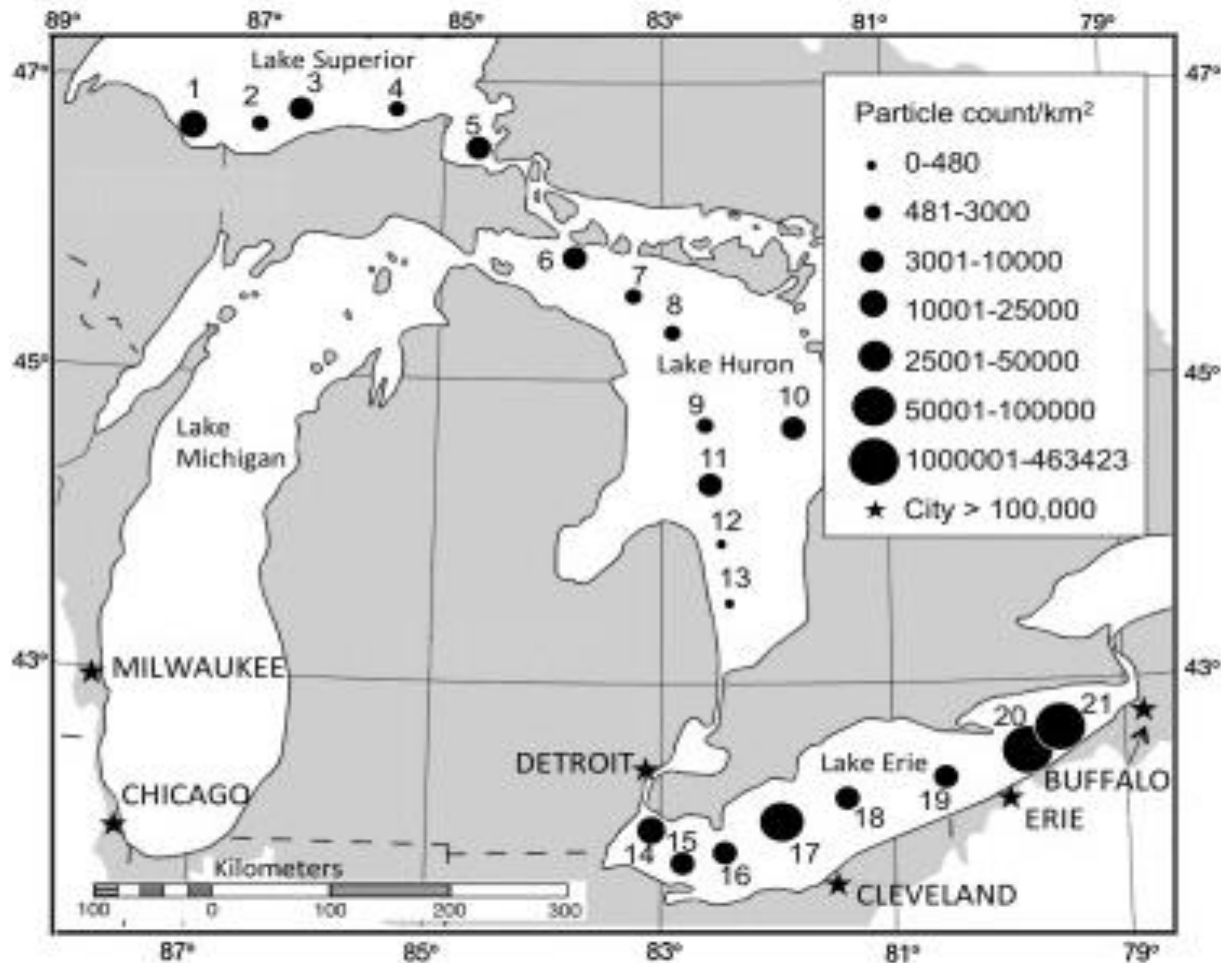


Atmosphere

Hydrosphere

Geosphere

80% of Great Lakes litter is plastic (Driedger et al. 2015)
>4 metric tons in Lake Erie (Hoffman and Hittinger 2017)



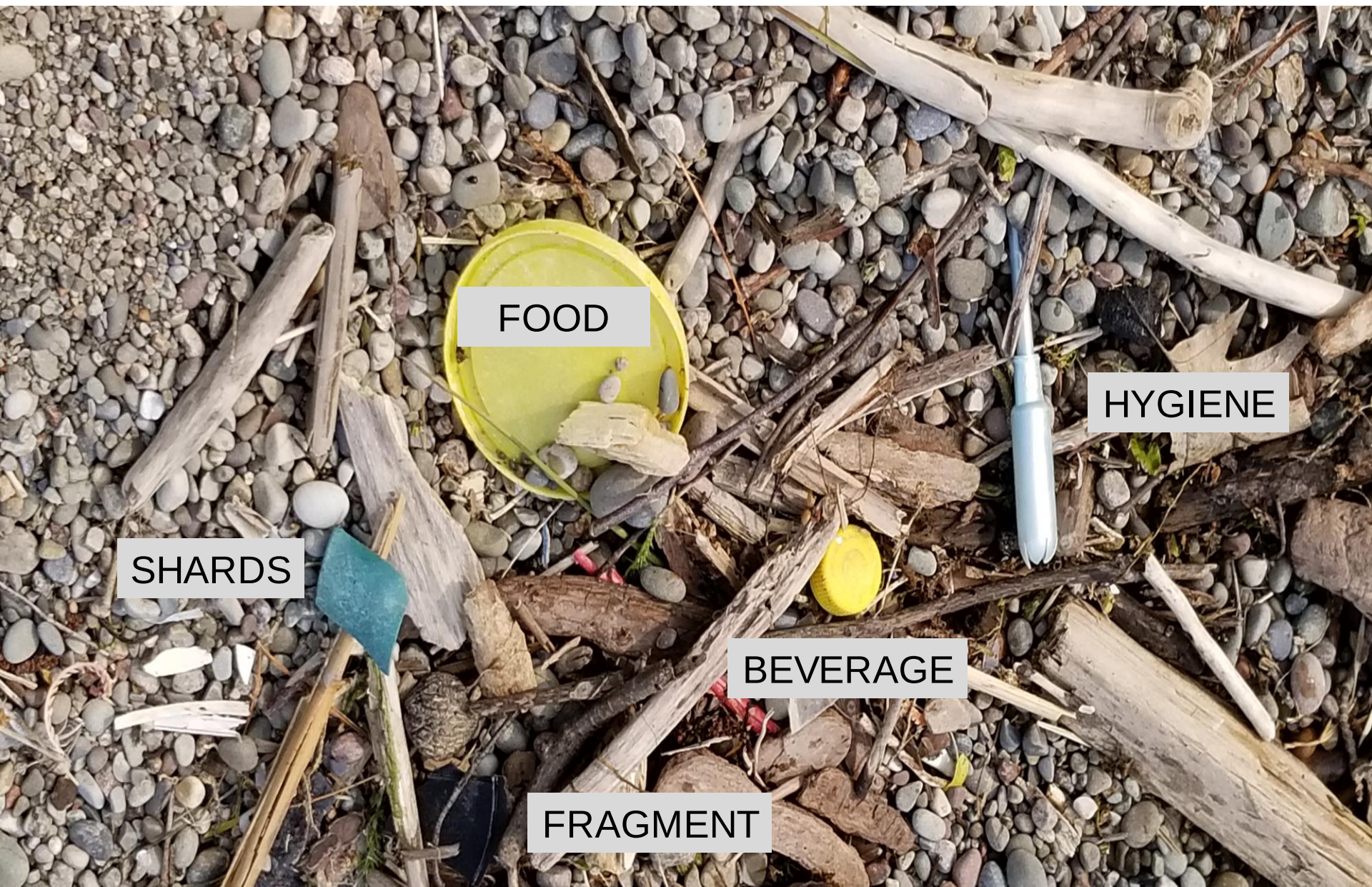
Estimate:

10,000 metric
tons of plastics
enter the
Great Lakes
annually

Hoffman and Hittinger 2017

[illegible]

Lake Ontario: Plastic “communities” in shoreline wrack



Community ecology of plastic:

Standardized sampling of surface and subsurface macroplastics



Randomized plot location
Timed sampling of 10 m² plots

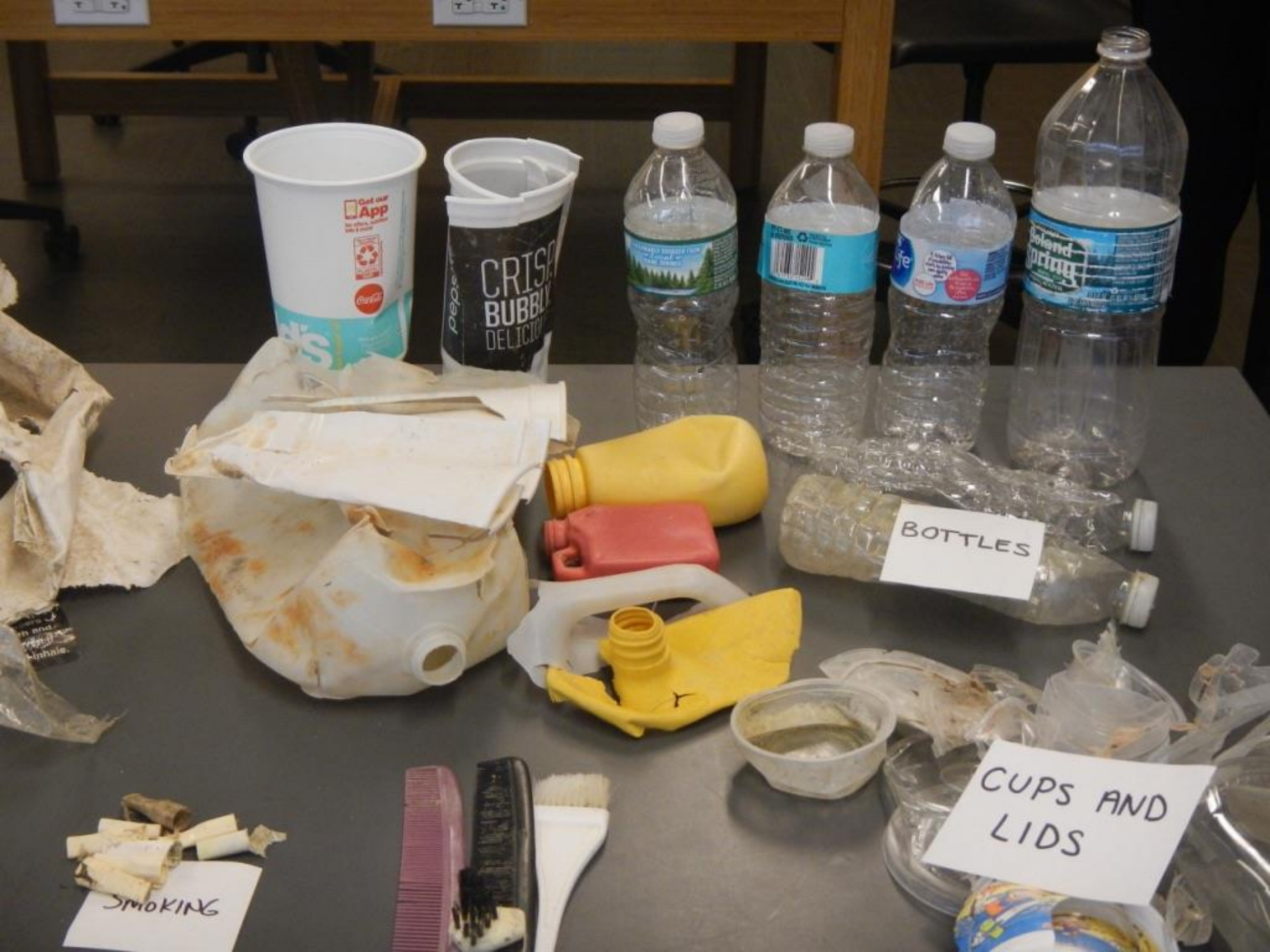


STRAWS

FRAGMENTS

BOTTLE
CAPS

142 W. Bridge St.
Oswego, NY 13126
(315) 342-4912



BOTTLES

CUPS AND
LIDS

SMOKING

BAG
WRAPERS
FILMS

BOTT

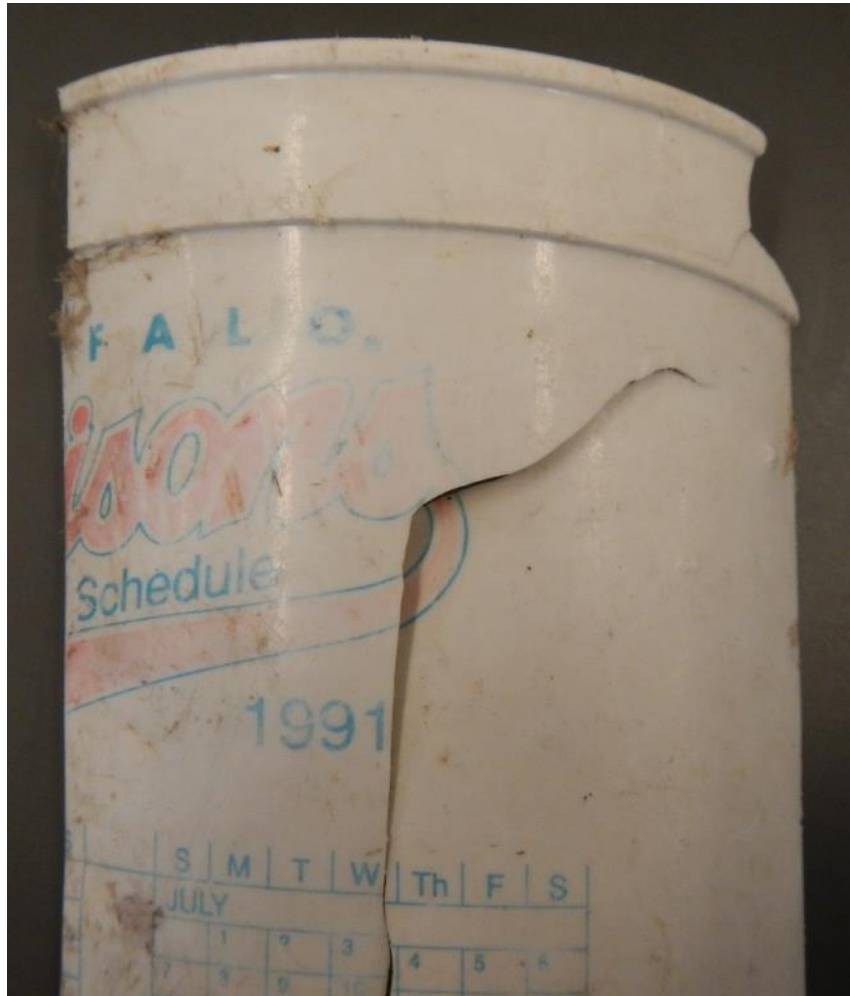
SMOKING

BEAUTY

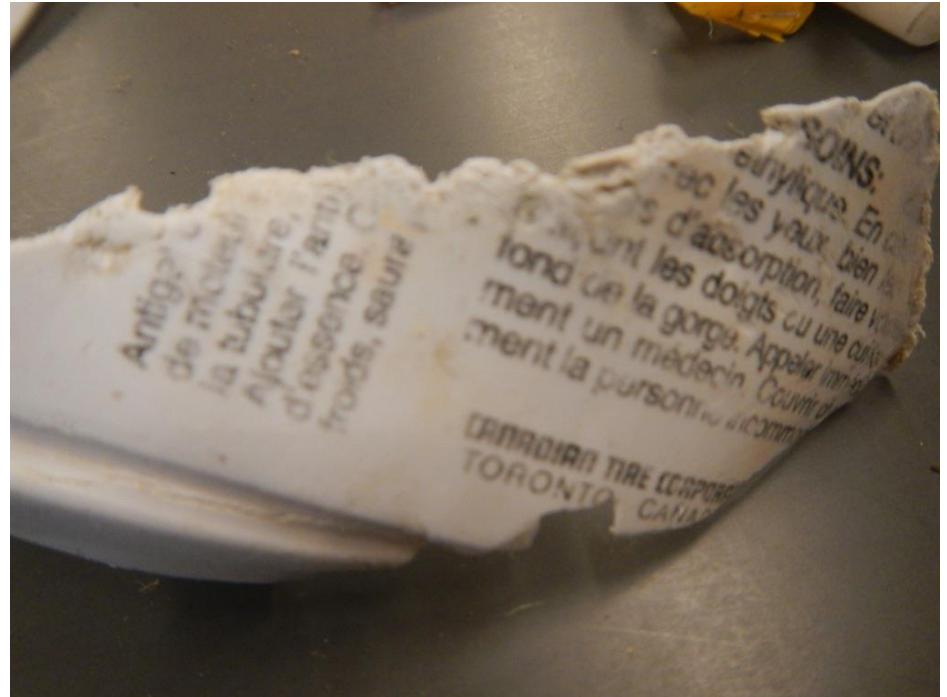
REPLACEMENT
WOOD, 1/2" DIA.
2" LONG
1-5000

MISC
FRAGMENTS

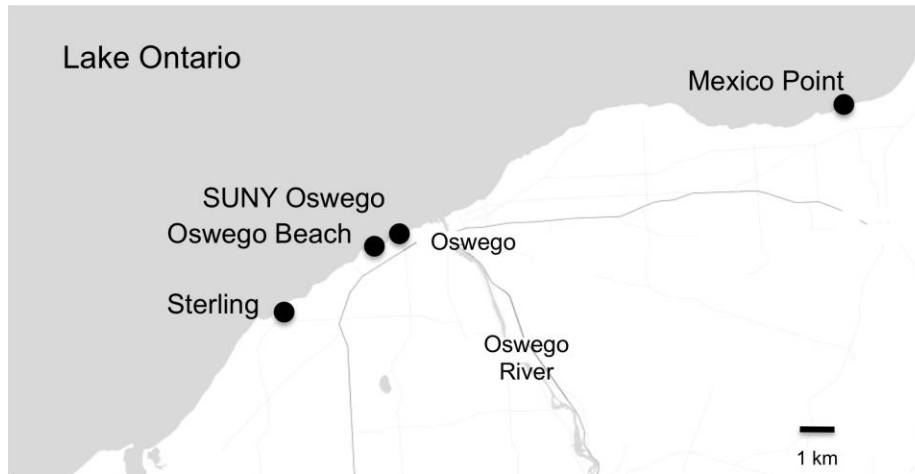
Time capsule?



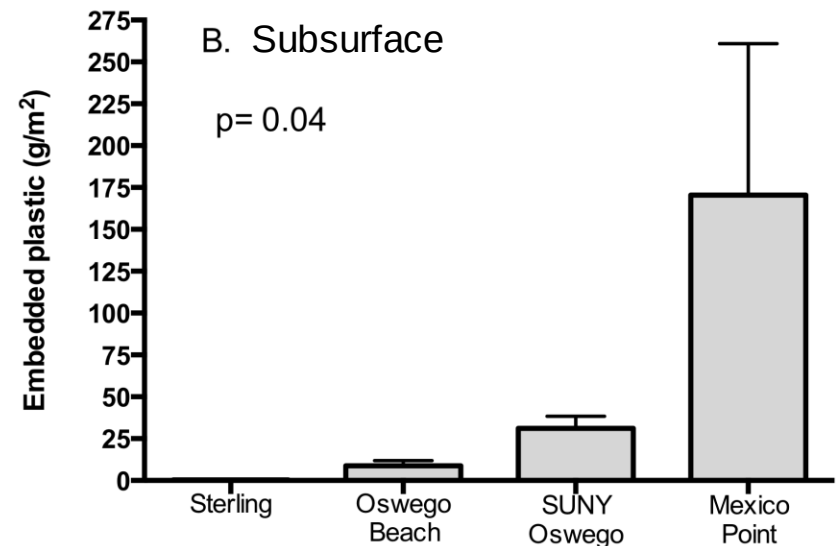
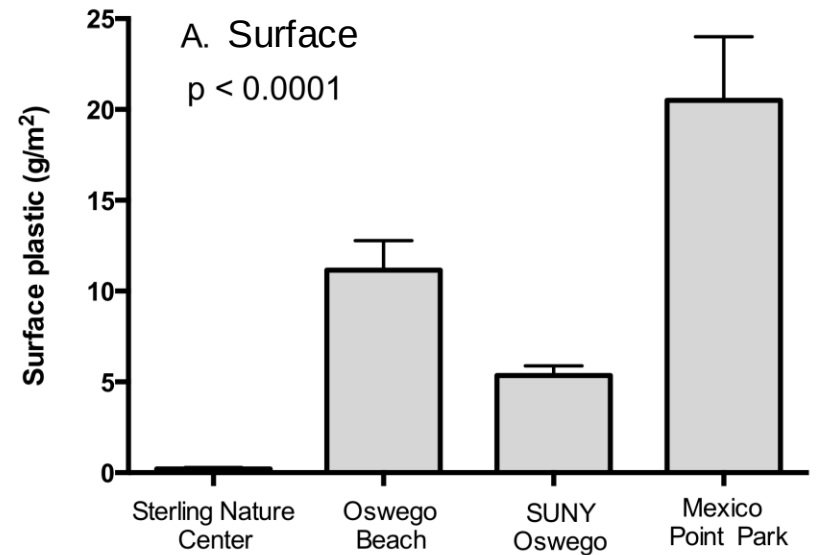
International Trash



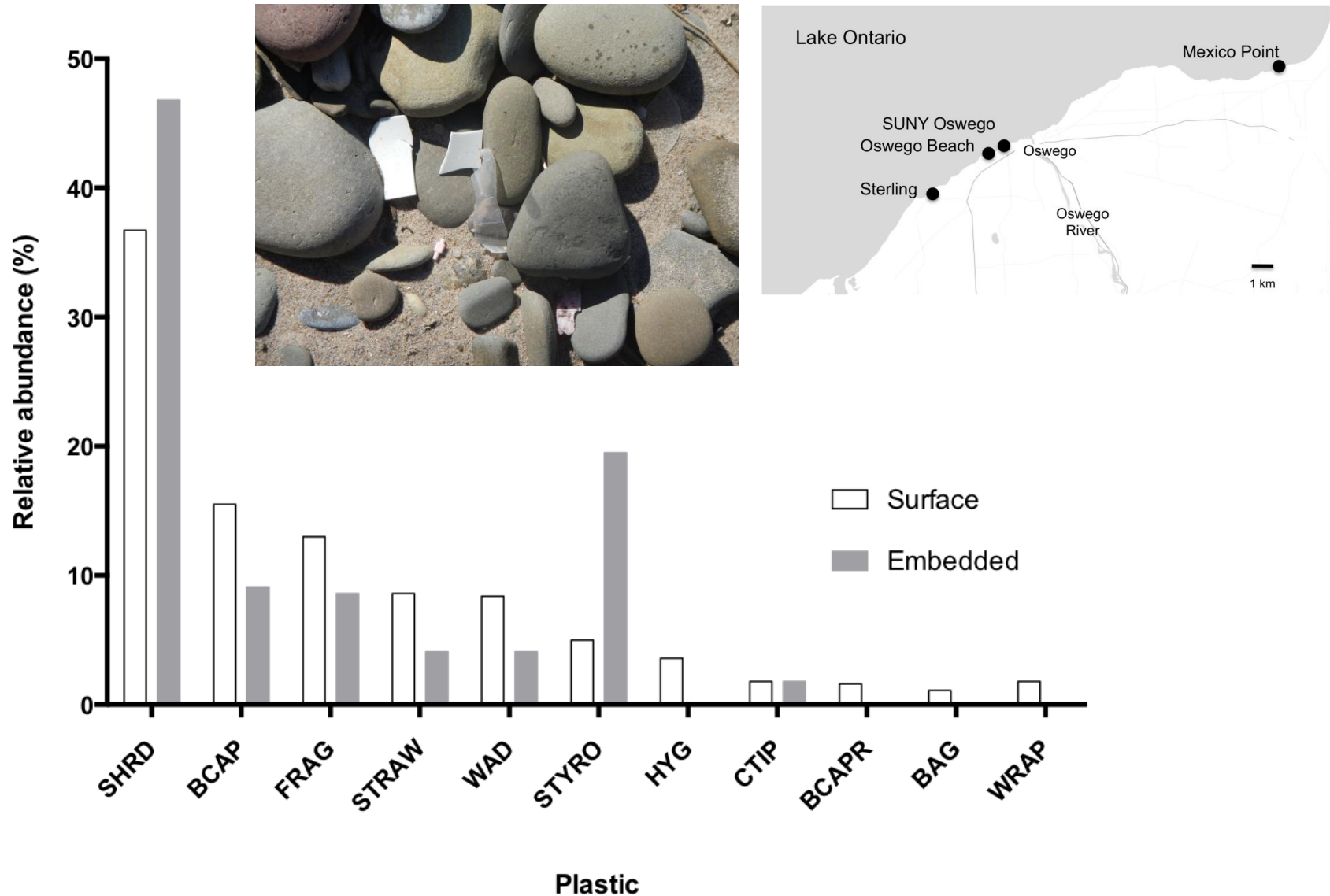
Shoreline characteristics influence plastic accumulation



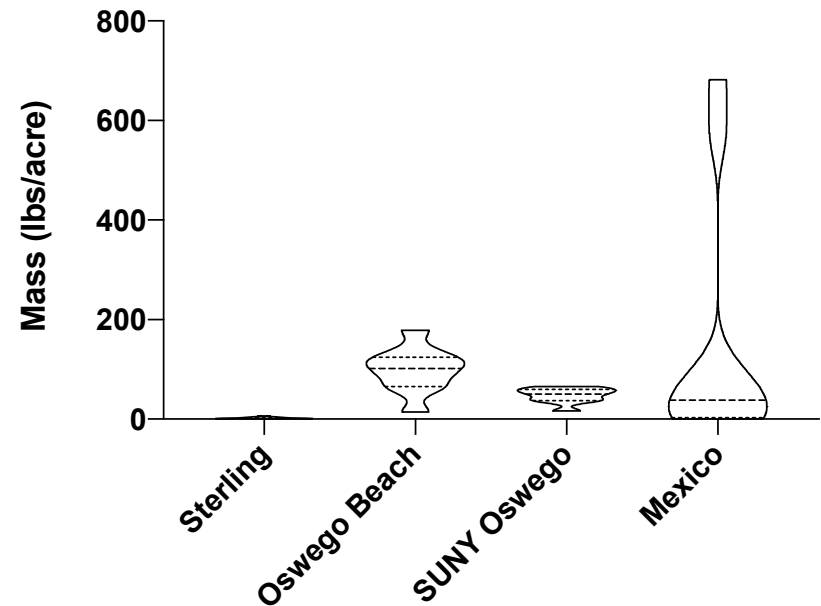
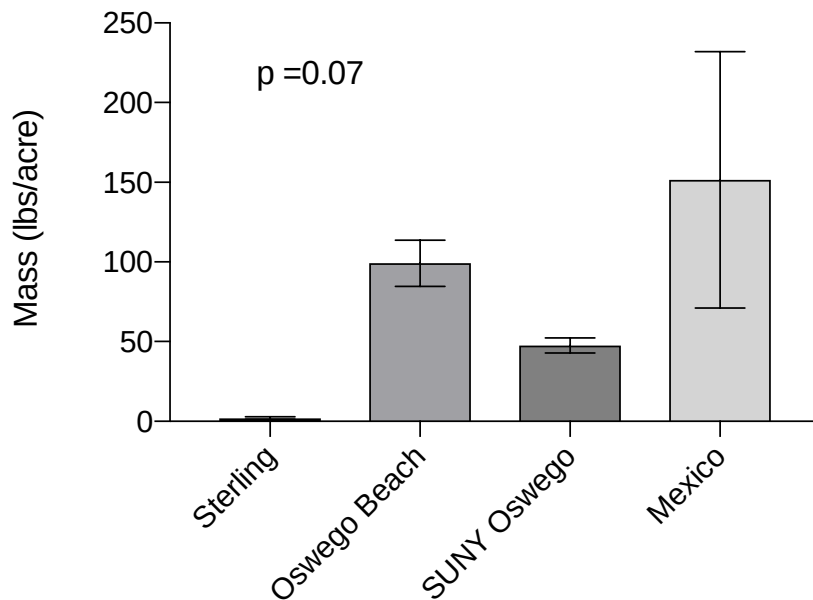
Plastics are entering soil communities as well



Dominated by shards, fragments, single use



Extrapolated mass of shoreline litter from Oswego, NY vicinity

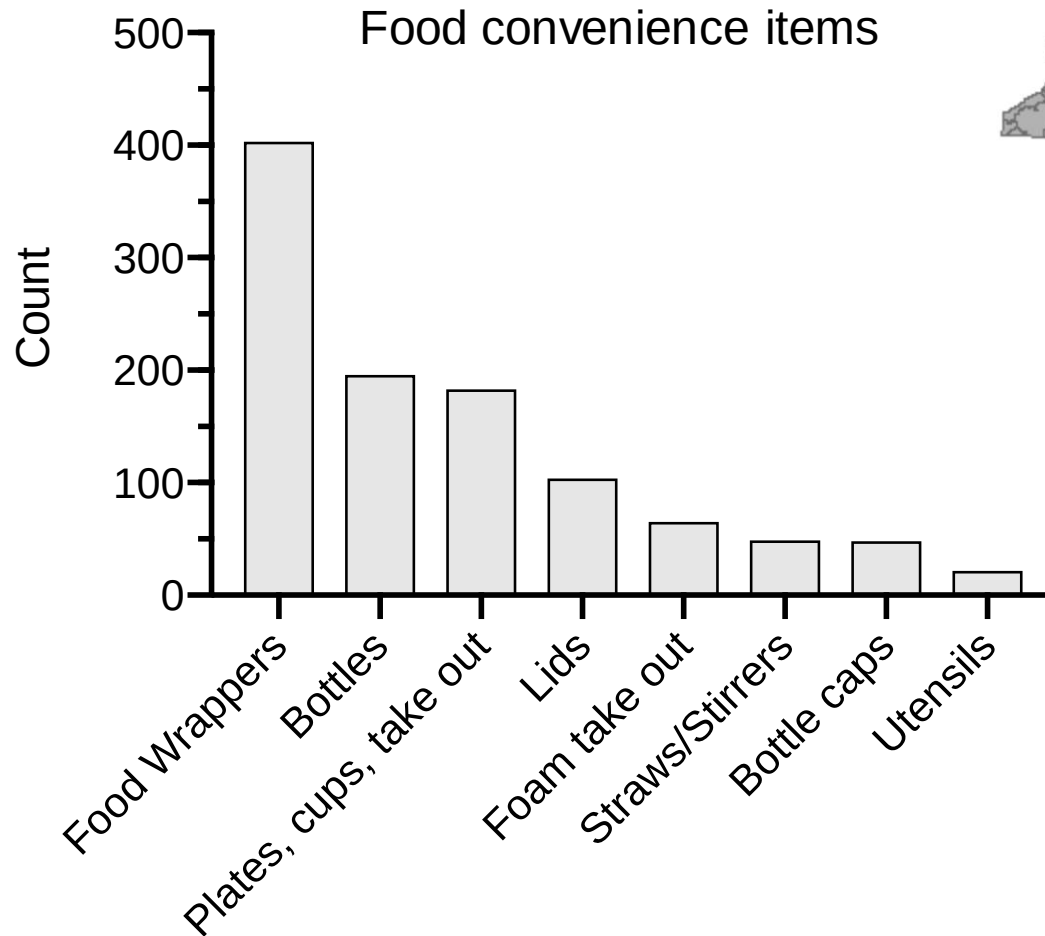


Estimate: 2-152 pounds of plastic per shoreline acre

Lake Ontario Bound: Black River shoreline plastics (2018)

Black River Trash Bash: Tug Hill Commission

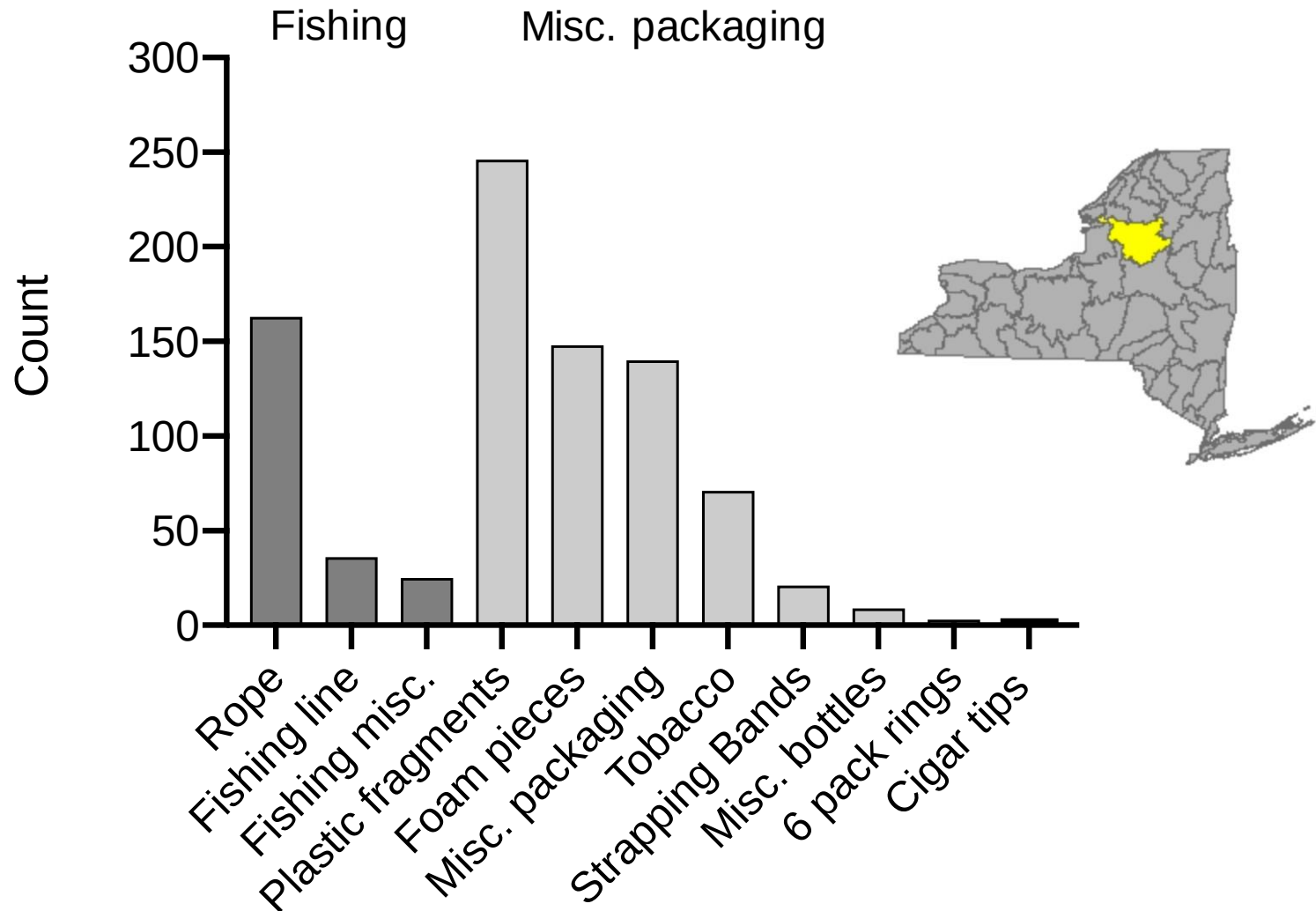
Data courtesy of Jennifer Harvill



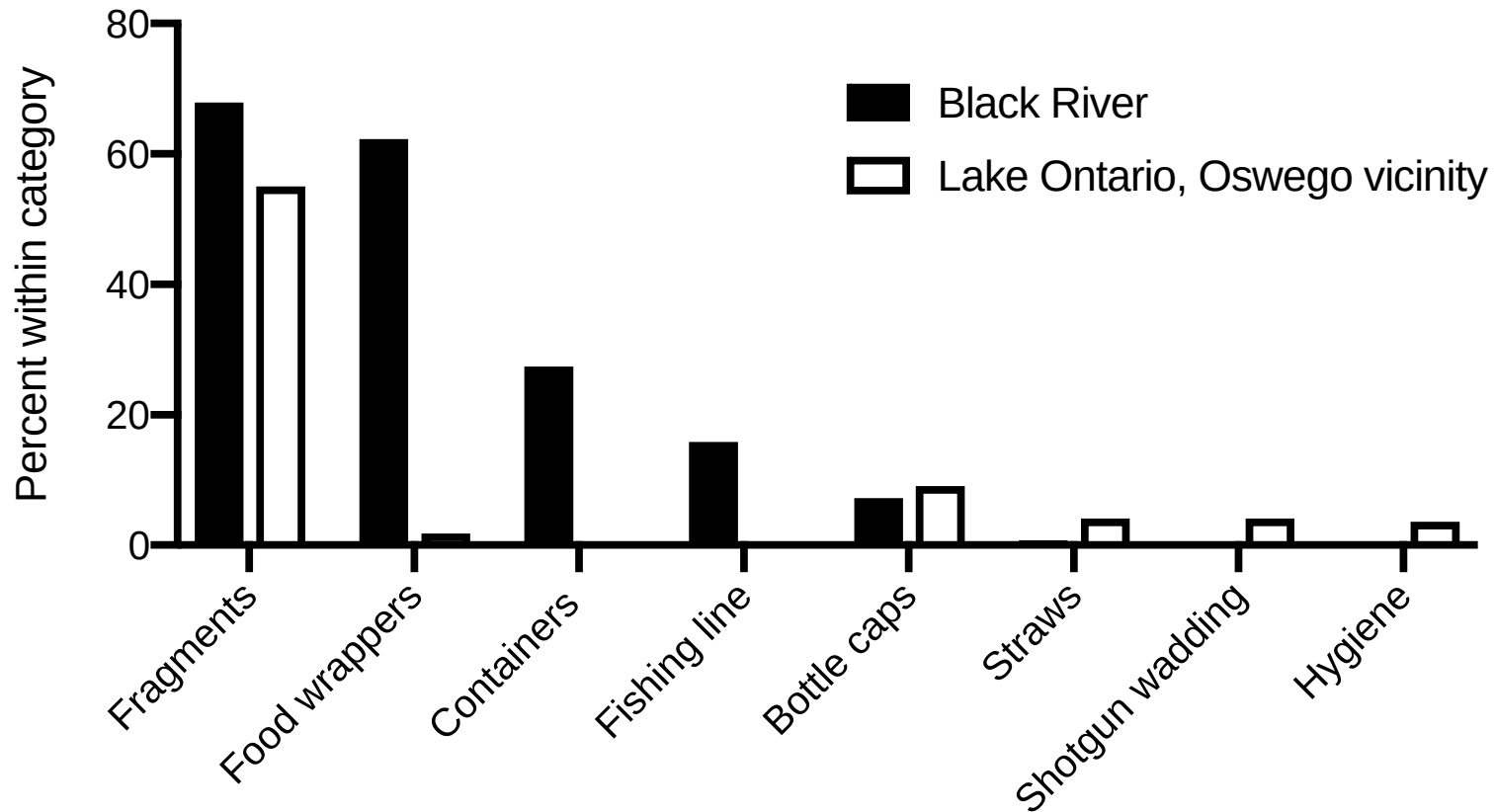
Lake Ontario Bound: Black River shoreline plastics (2018)

Black River Trash Bash: Tug Hill Commission

Data courtesy of Jennifer Harvill



Each watershed has its own plastic signature



Summary: Shoreline plastics

- Single use food packaging dominant
- Shards and fragments abundant on surface and sediments
- Influenced by shoreline and watershed characteristics



Lake Ontario: Microplastics

Prey (forage) fish

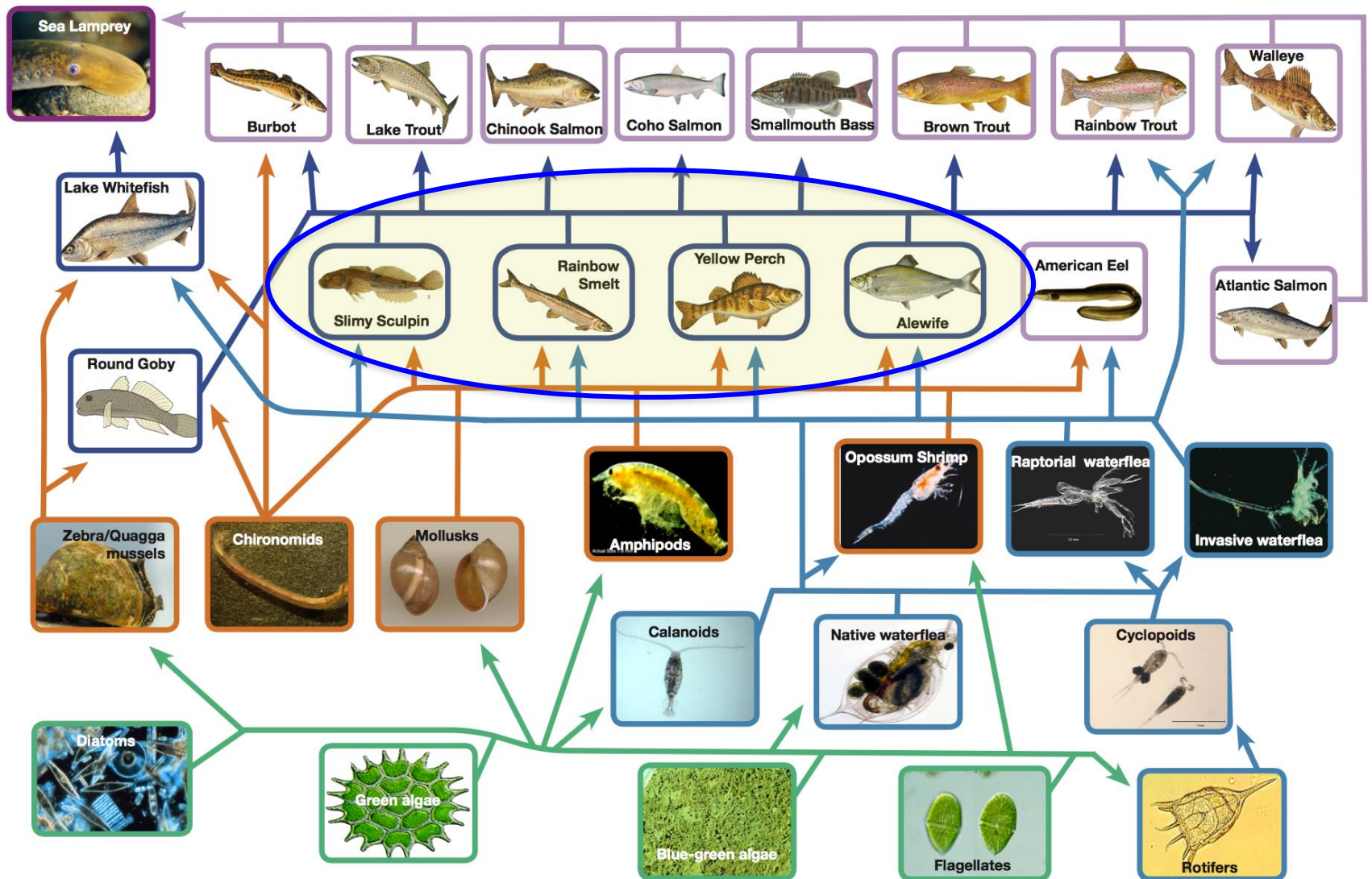


Methods: Microplastic recovery



- Dissolution in KOH and 30% H₂O₂
- Vacuum filtration
- Timed, **standardized** plastic counts under dissecting microscopes
- Plastic counts **calibrated** with controls

Lake Ontario Trophic Web: Prey fish



Species and habitats

Pelagic (open water)



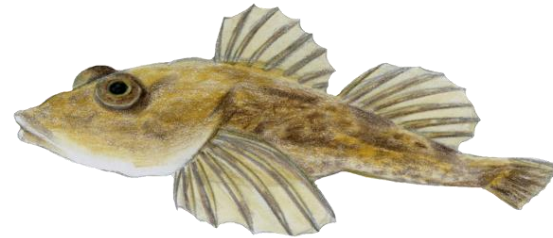
Alewife (n=145)

n = 330 fish

Benthic (near sediment surface)



Round goby (n=153)

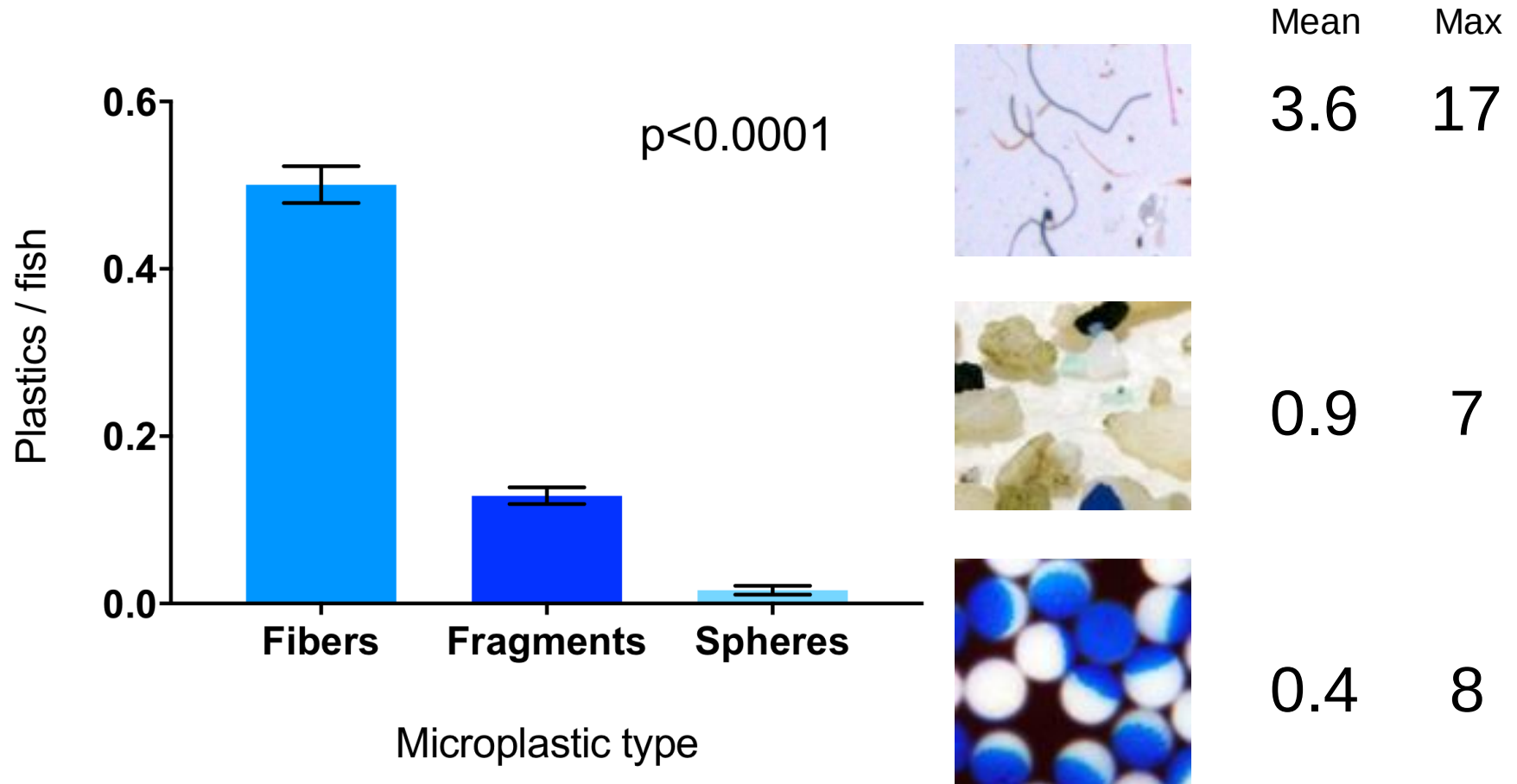


Deepwater sculpin (n=14)

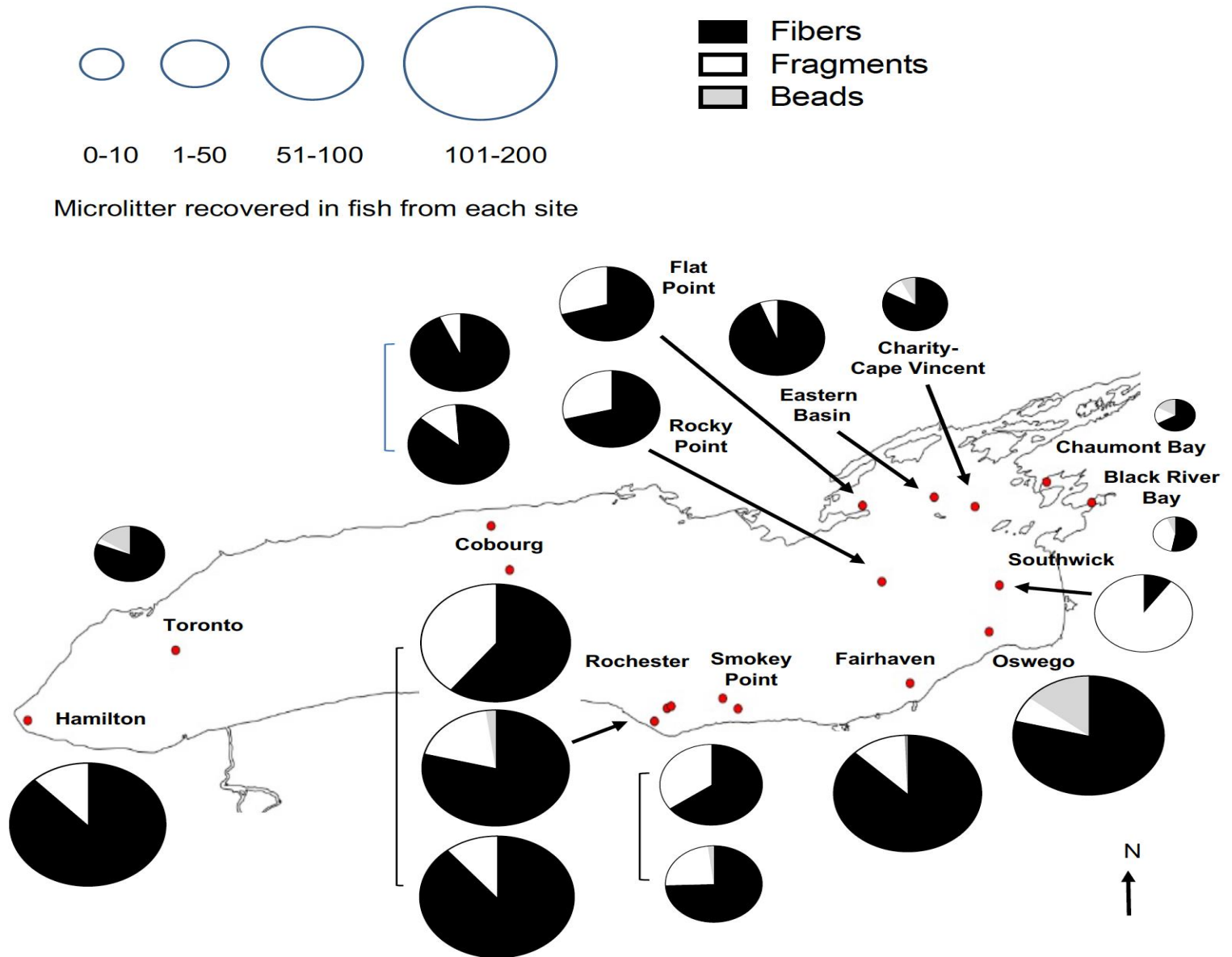


Slimy sculpin (n=18)

Basin wide: 5x more fibers than fragments



Lake Ontario microplastics (n=18 sites)



97% of all individuals ingested microplastics



Alewife 98%



Round goby 97%

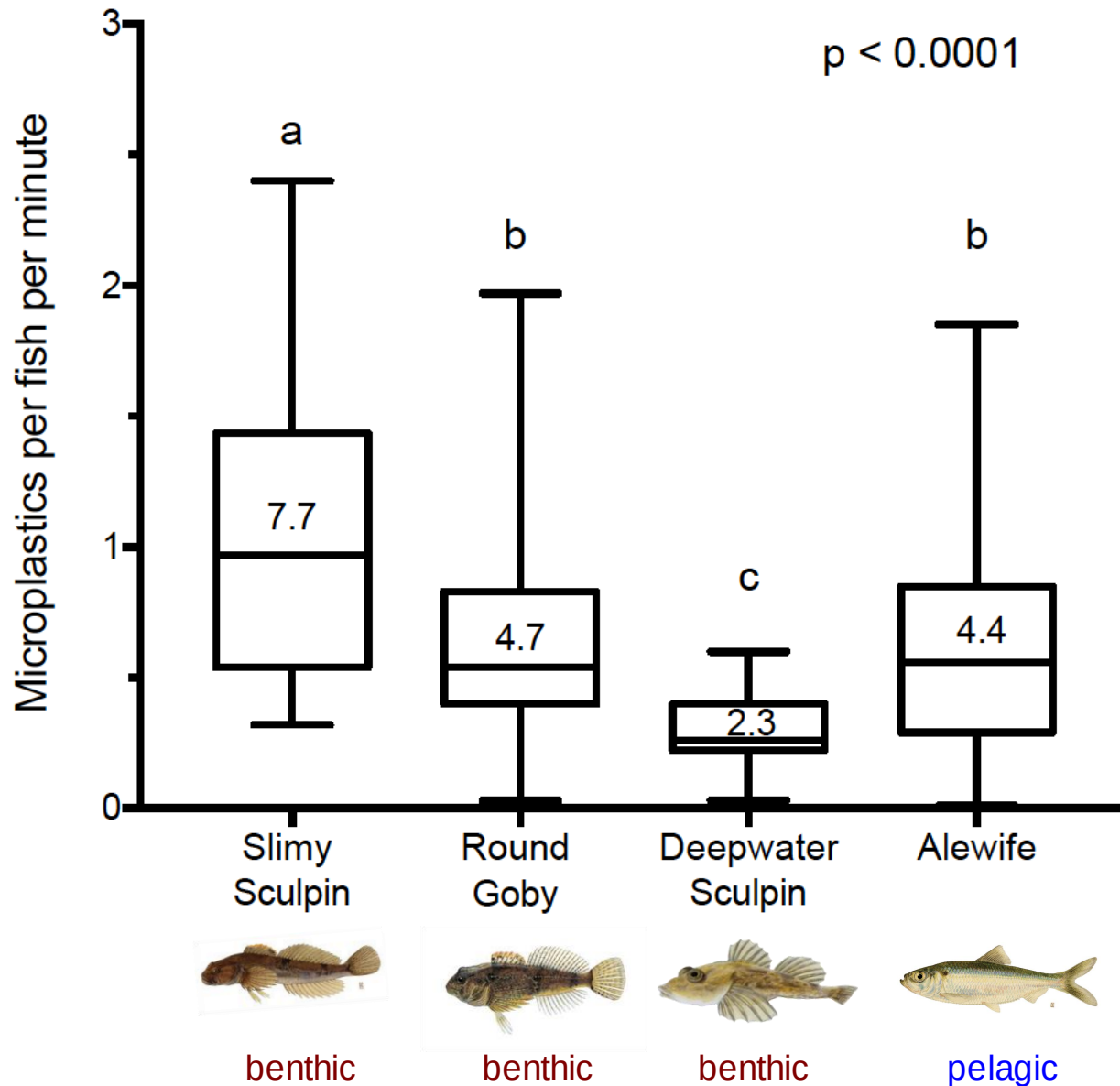


Deepwater sculpin 93%

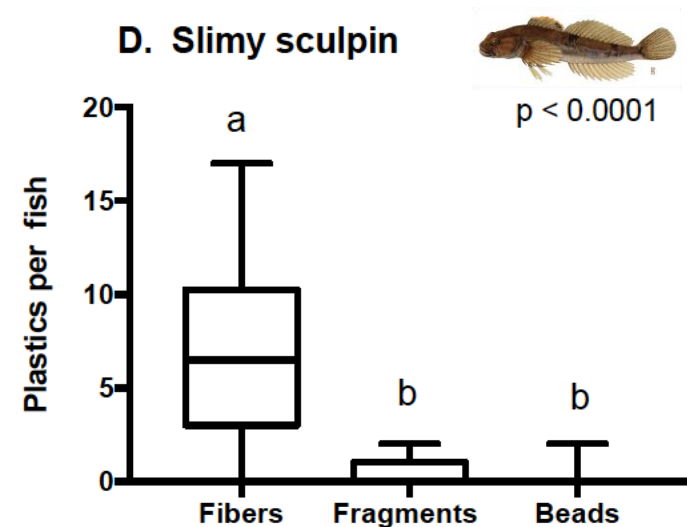
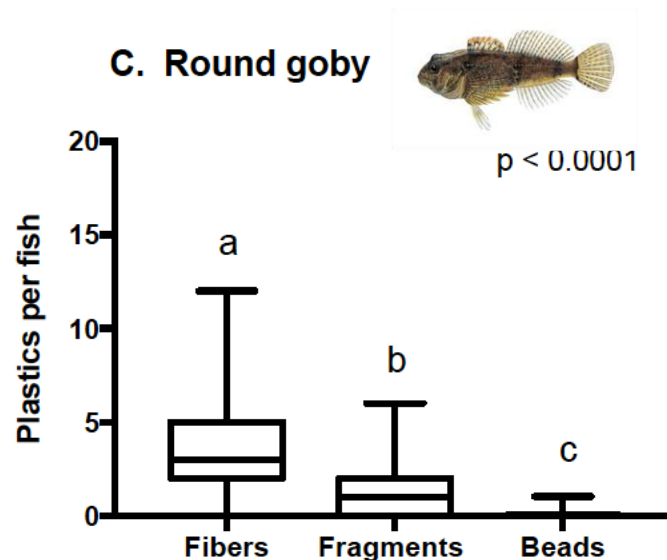
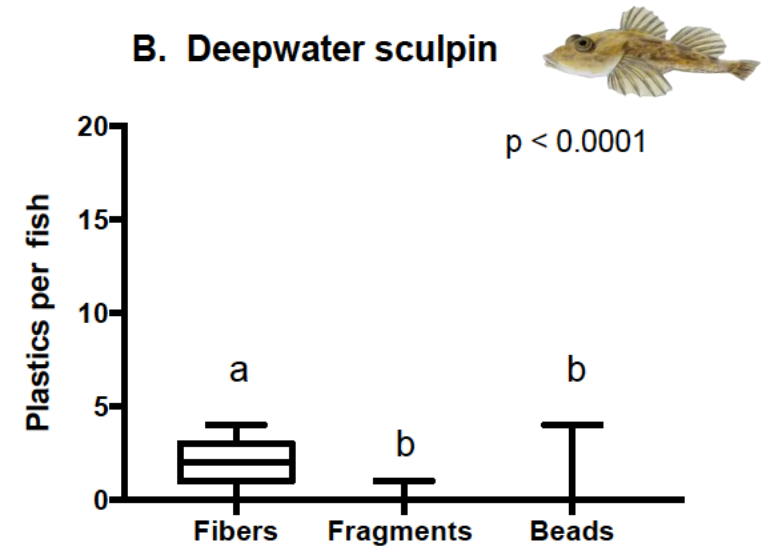
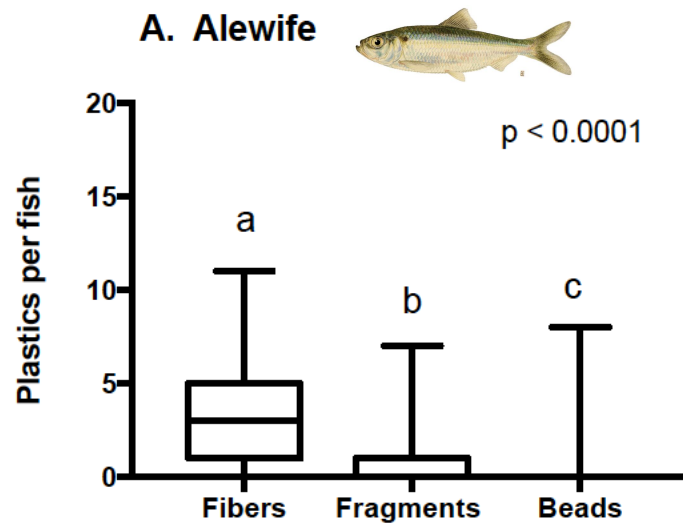


Slimy sculpin 100%

Total plastic consumption by fish species



Ingestion of microplastics by type across species

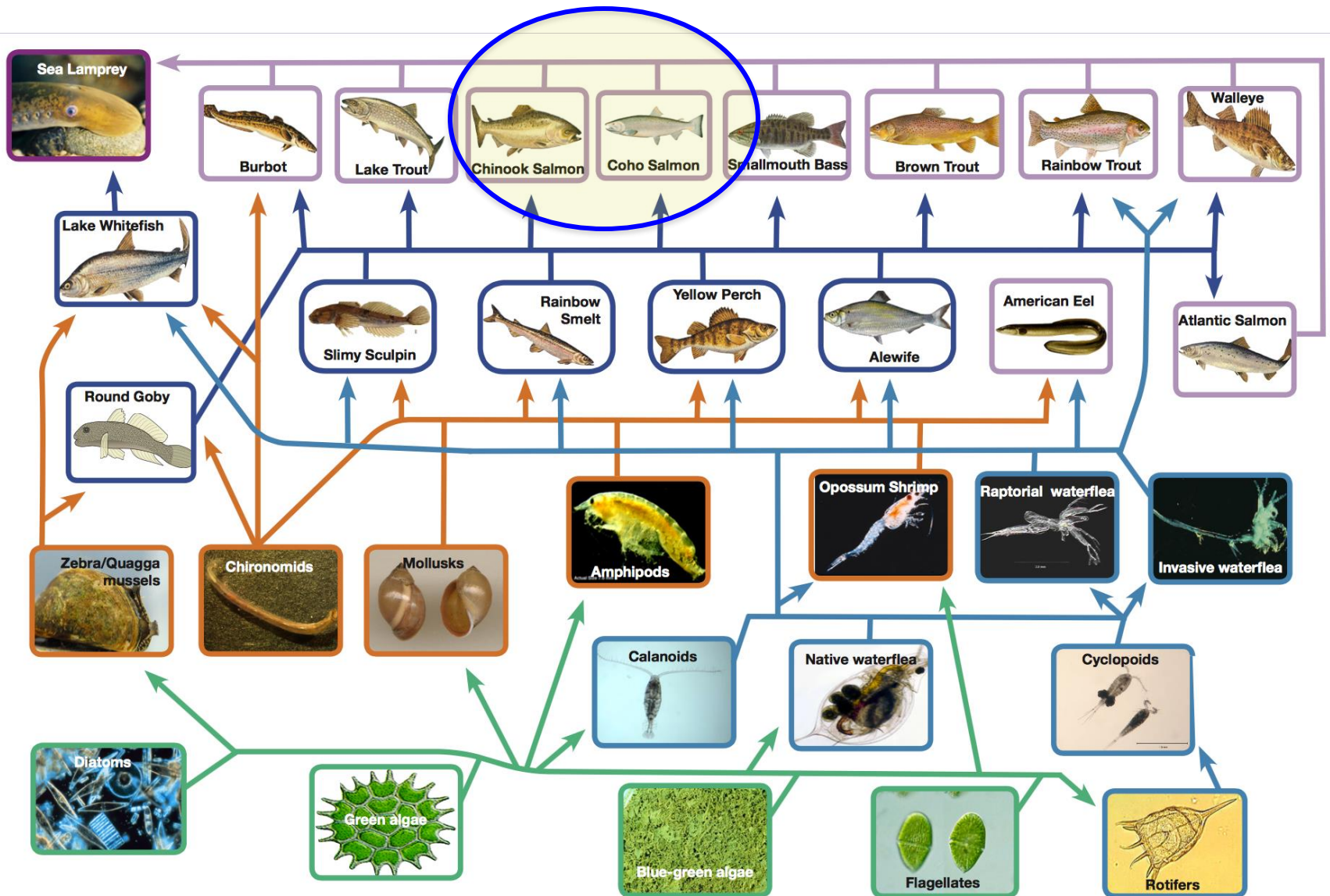


Summary: Prey fish plastic ingestion

- Comprehensive lake wide study
- Plastics are ubiquitous
- Incorporated into food webs
- Fibers are a major contaminant
- Microplastics are being ingested regardless of:
 - Species identity
 - Feeding strategy
 - Location within the basin



Lake Ontario Trophic Web: Top predators



Lake Ontario: Microplastics

Top predators (salmon)



Salmon River Fish Hatchery: Altmar, NY

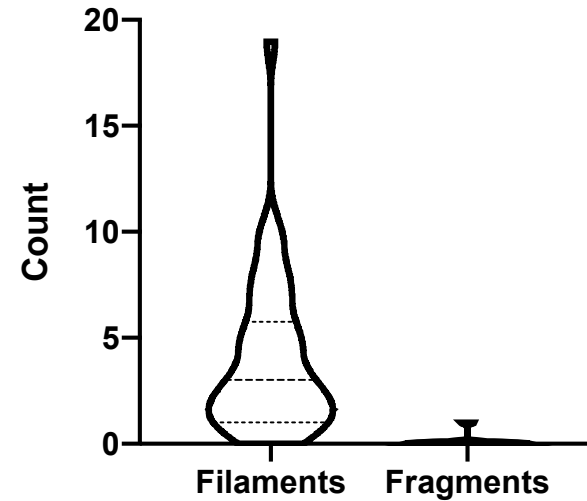
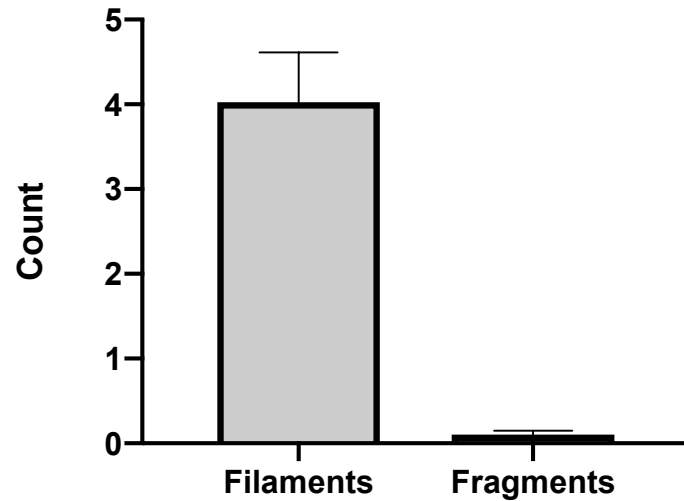


Dumpster diving for data



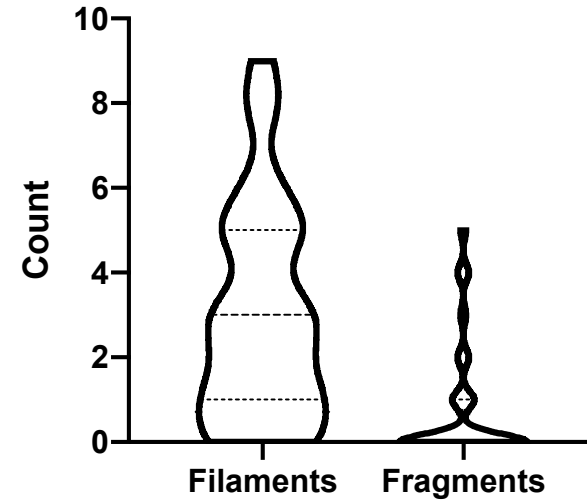
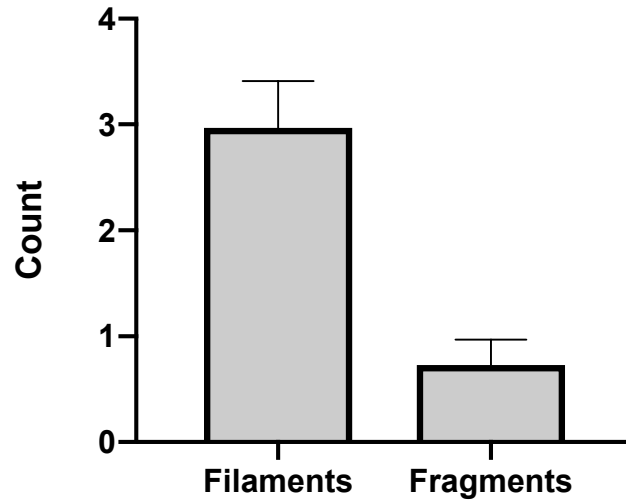
Chinook (n=40)

92% contained plastics



Coho (n=33)

82% contained plastics



Summary: Lake Ontario Salmon plastic ingestion

- Plastics are abundant but less so than expected
- Fibers are the dominant contaminant
- Incorporated into upper food web interactions in both species



Commerce will adapt to consumer pressure

Indiana-made Aardvark paper straws see ‘unprecedented growth’ as restaurants ditch plastic

Sarah Bowman, Indianapolis Star

Published 6:00 a.m. ET June 24, 2018 | Updated 10:44 a.m. ET June 25, 2018

Paper straw factory to open in Britain as restaurants ditch plastic

Production line in Ebbw Vale, Wales, to make straws for McDonald’s and others

The Guardian June 17, 2018

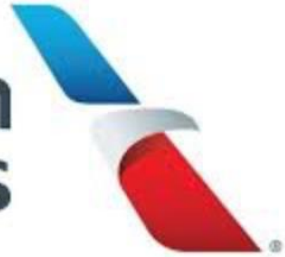
2018: Momentum grows to eliminate plastic straws

97,194 views | Apr 25, 2018, 11:36am

UK To Ban All Plastic Straws, Cotton Swabs, And Single-Use Plastics



American
Airlines



Alaska
AIRLINES®



Disney



As of July 18, 2018

“A conservationist is one who is humbly aware that with each stroke [of the axe] he is writing his signature on the face of the land.”

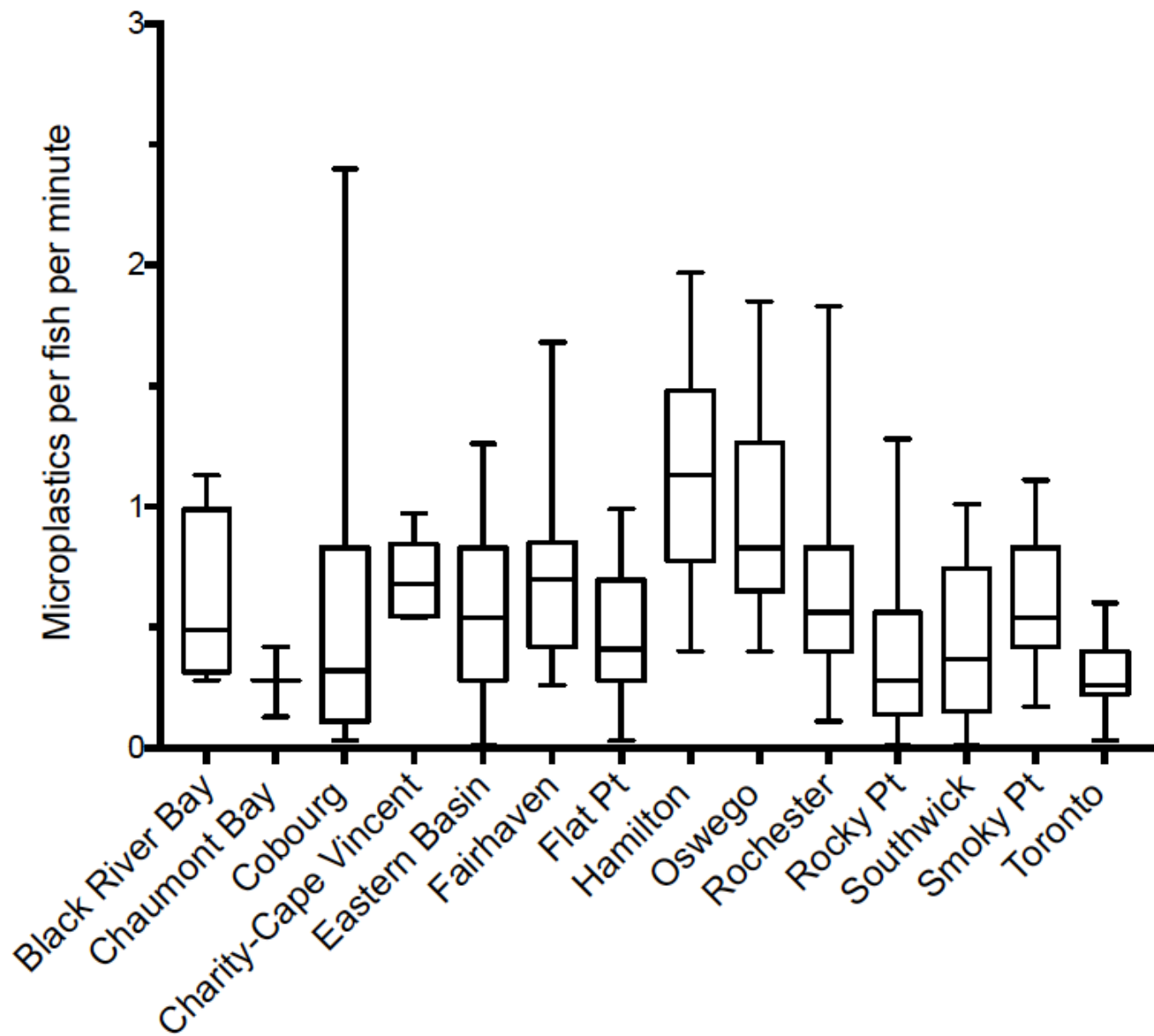
Aldo Leopold



“A conservationist is one who is humbly aware that by using each disposable, convenient plastic product they are writing their signature on the face of a watershed.”

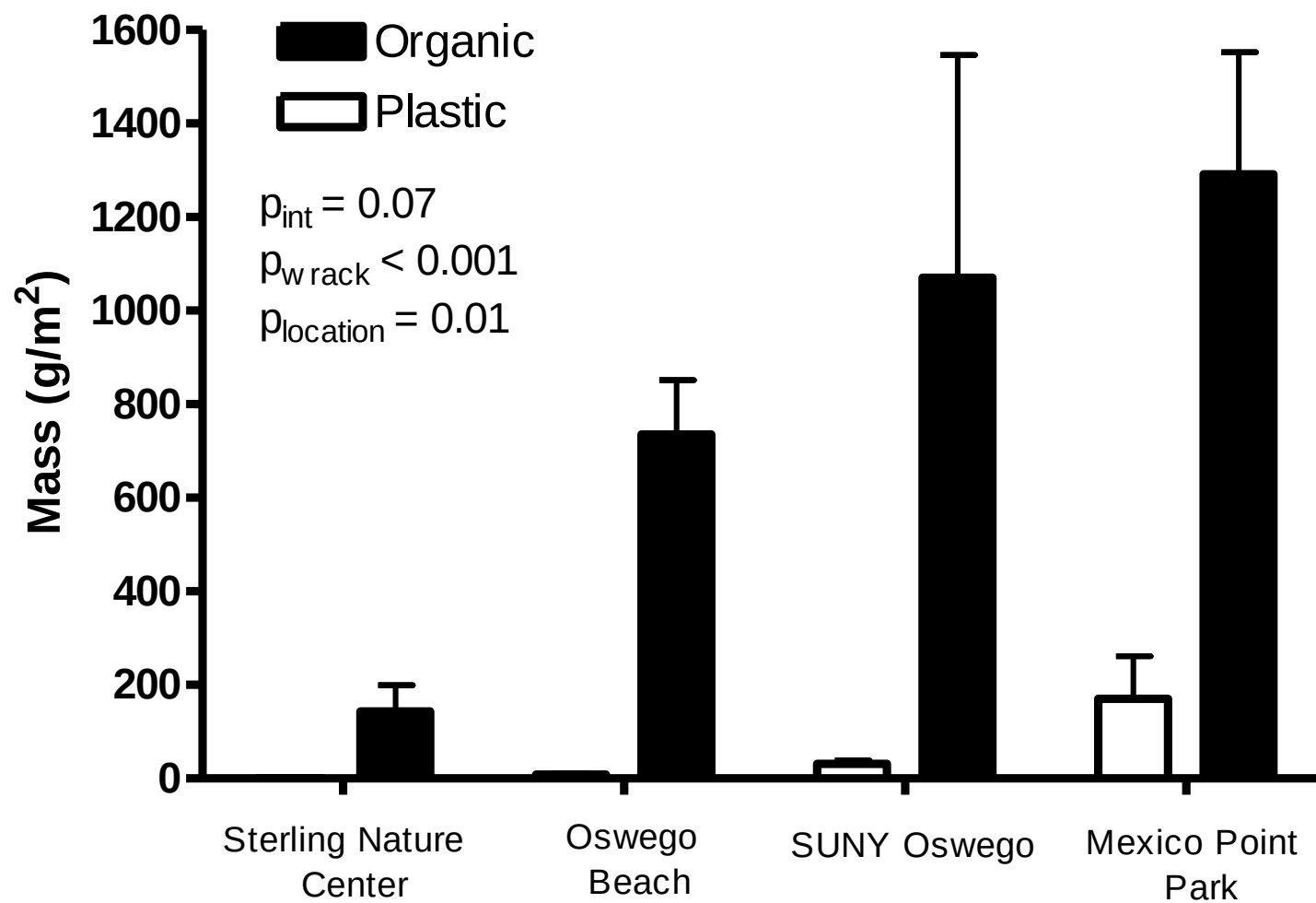


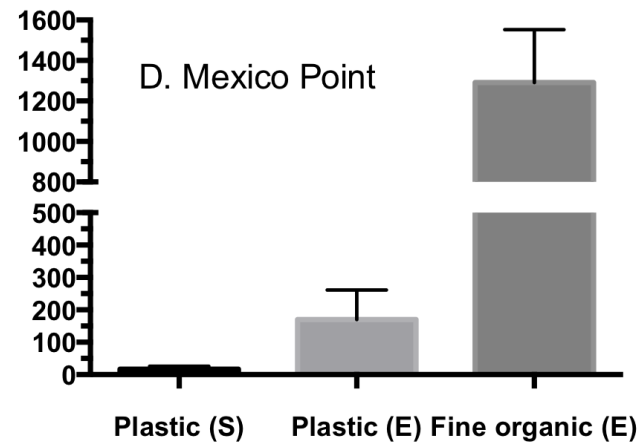
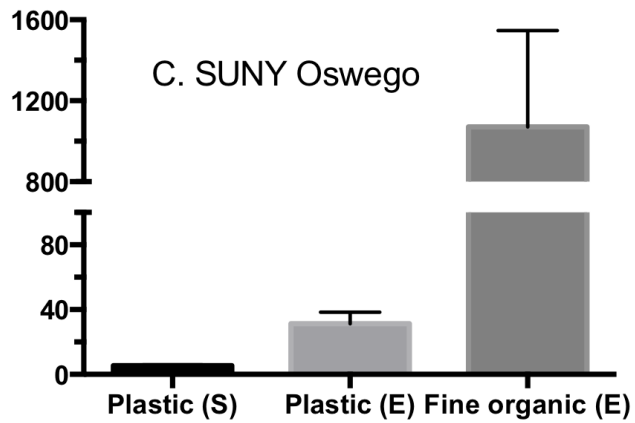
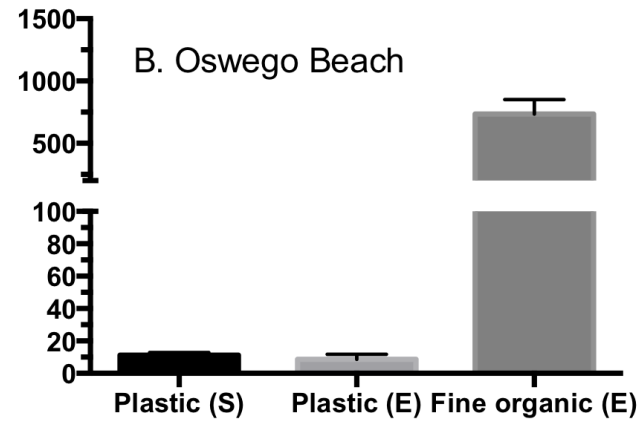
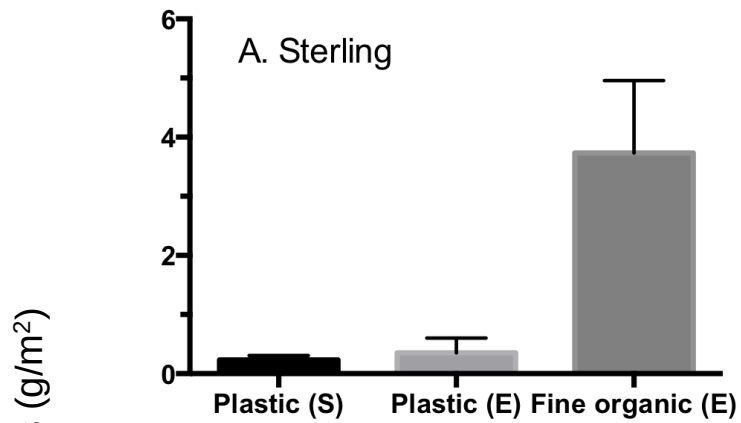
Plastic abundance is variable across Lake Ontario



Plastic abundance best explained by models using species, weight, and site patterns

Model	deltaAIC	df	weight	Residual Deviance
Spc+Wgt+Site	0.0	19	0.44	345.2
Wgt+Site	0.9	17	0.28	346.1
Spc+Dep+Wgt+Site	2.0	20	0.16	345.2
Dep+Wgt+Site	2.7	18	0.11	344
Spc+Dep+Site	71.5	19	<0.001	347.7
Dep+Site	74.9	17	<0.001	344
Spc+Site	76.0	18	<0.001	344.6
Site	86.8	16	<0.001	347.9
Wgt	122.0	3	<0.001	2499.9
Spc	178.1	5	<0.001	2740.7
Dep	204.4	3	<0.001	2286.5





Wrack composition

Estimated decomposition times

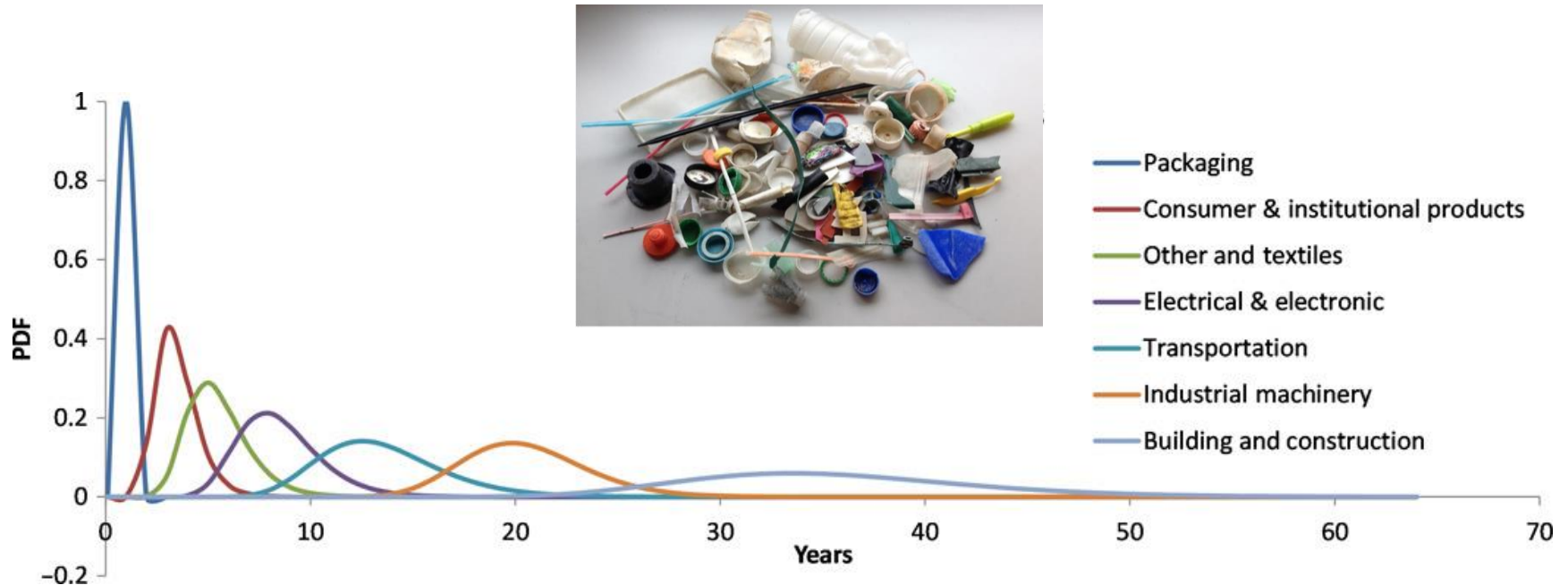


<http://news.nationalgeographic.com/2017/04/plastic-straws-ocean-trash-environment/#/02-straw-wars.jpg>

https://www.des.nh.gov/organization/divisions/water/wmb/coastal/trash/documents/marine_debris.pdf

Glass Bottle.....	1 million years
Monofilament Fishing Line...	600 years
Plastic Beverage Bottles.....	450 years
Disposable Diapers.....	450 years
Aluminum Can.....	80-200 years
Foamed Plastic Buoy.....	80 years
Foamed Plastic Cups.....	50 years
Rubber-Boot Sole.....	50-80 years
Tin Cans.....	50 years
Leather.....	50 years
Nylon Fabric.....	30-40 years
Plastic Film Container.....	20-30 years
Plastic Bag.....	10-20 years
Cigarette Butt.....	1-5 years
Wool Sock.....	1-5 years
Plywood.....	1-3 years
Waxed Milk Carton.....	3 months
Apple Core.....	2 months
Newspaper.....	6 weeks
Orange or Banana Peel.....	2-5 weeks
Paper Towel.....	2-4 weeks

Product lifetime (use) for industrial plastics



PDF: log-normal probability distribution functions

Geyer et al. 2017

ScienceAdvances

AAAS



"One of the penalties of an ecological education is that **one lives alone in a world of wounds**.

Much of the damage inflicted on land is quite invisible to laymen.

An ecologist must either harden his/her shell and make believe that the consequences of science are none of his/her business,

or

[s]he must be the doctor who [speaks to the] ... community that believes itself well and does not want to be told otherwise."

Aldo Leopold: *The Round River*