

A close-up photograph of a child's hand holding a pile of colorful plastic debris (microplastics) on a sandy beach. The child is wearing a white dress and a yellow top. The background is a vast expanse of sand.

# Microplastics in the Great Lakes

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Research Coordinator, Research Associate

Illinois-Indiana Sea Grant  
Purdue University

# Reflection....

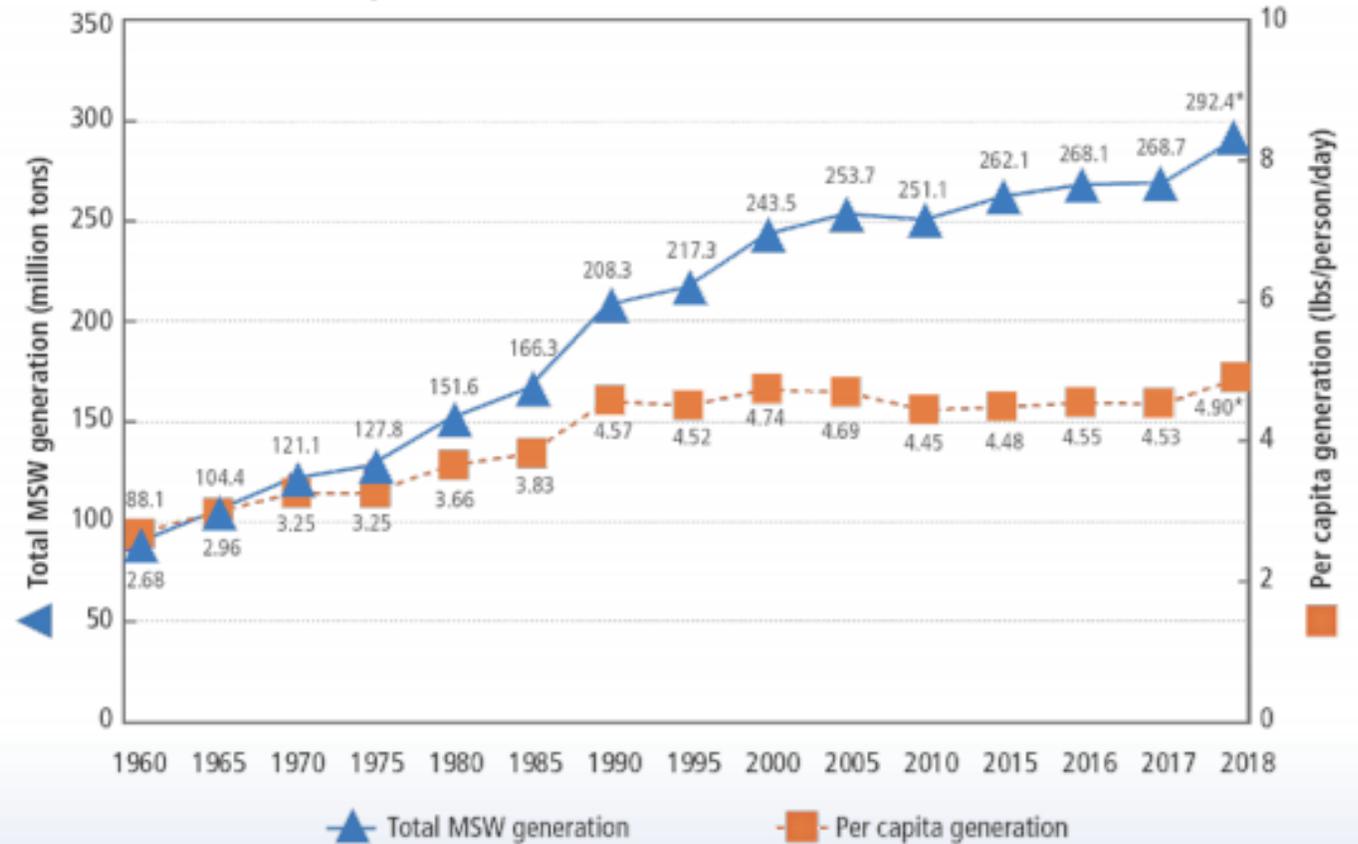
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1. What is the most common thing in your trash at home?
2. Do you separate your recyclables?
3. How much trash (in pounds) do you think you generate every day?
  - A gallon of milk = 8.6 lbs



We generated 4.9 lbs of municipal solid waste (MSW) per person per day in 2018, for a total of 292.4 million tons!

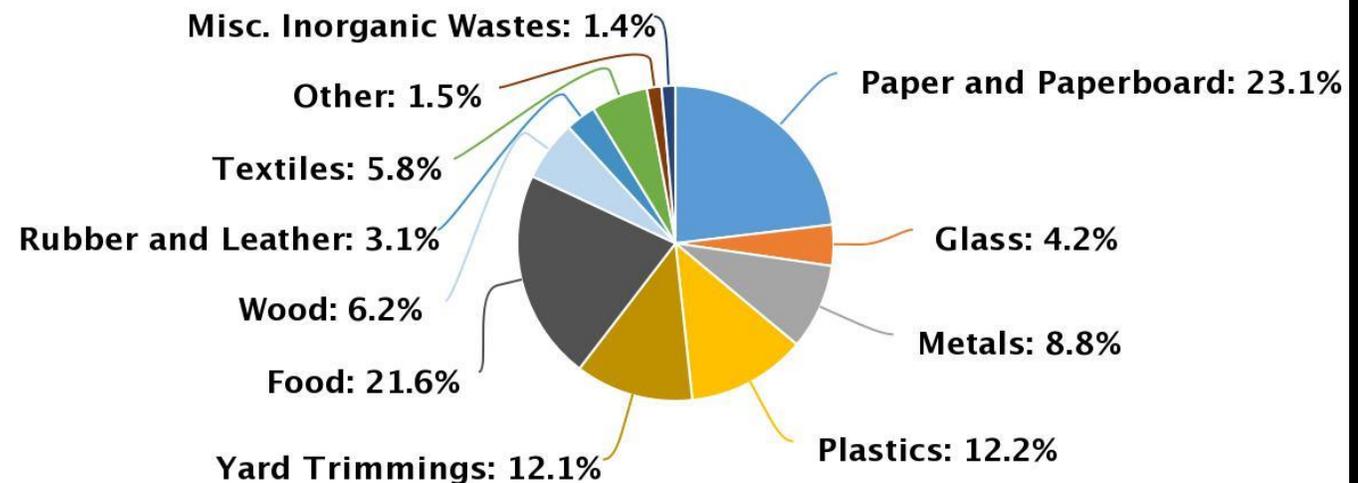
Figure 1. MSW Generation Rates, 1960 to 2018\*



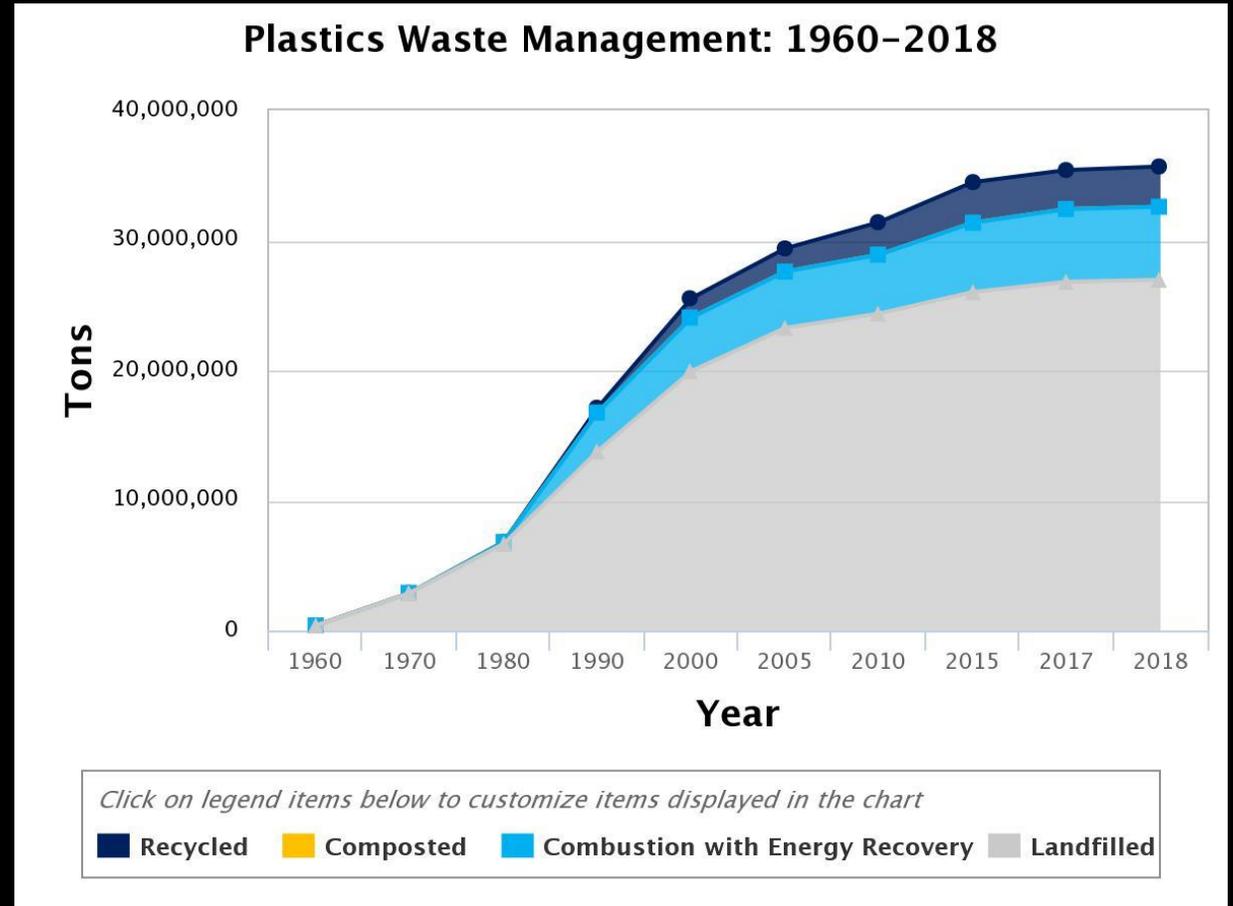
12.2% of this was plastic. That equates to *35.7 million tons*.

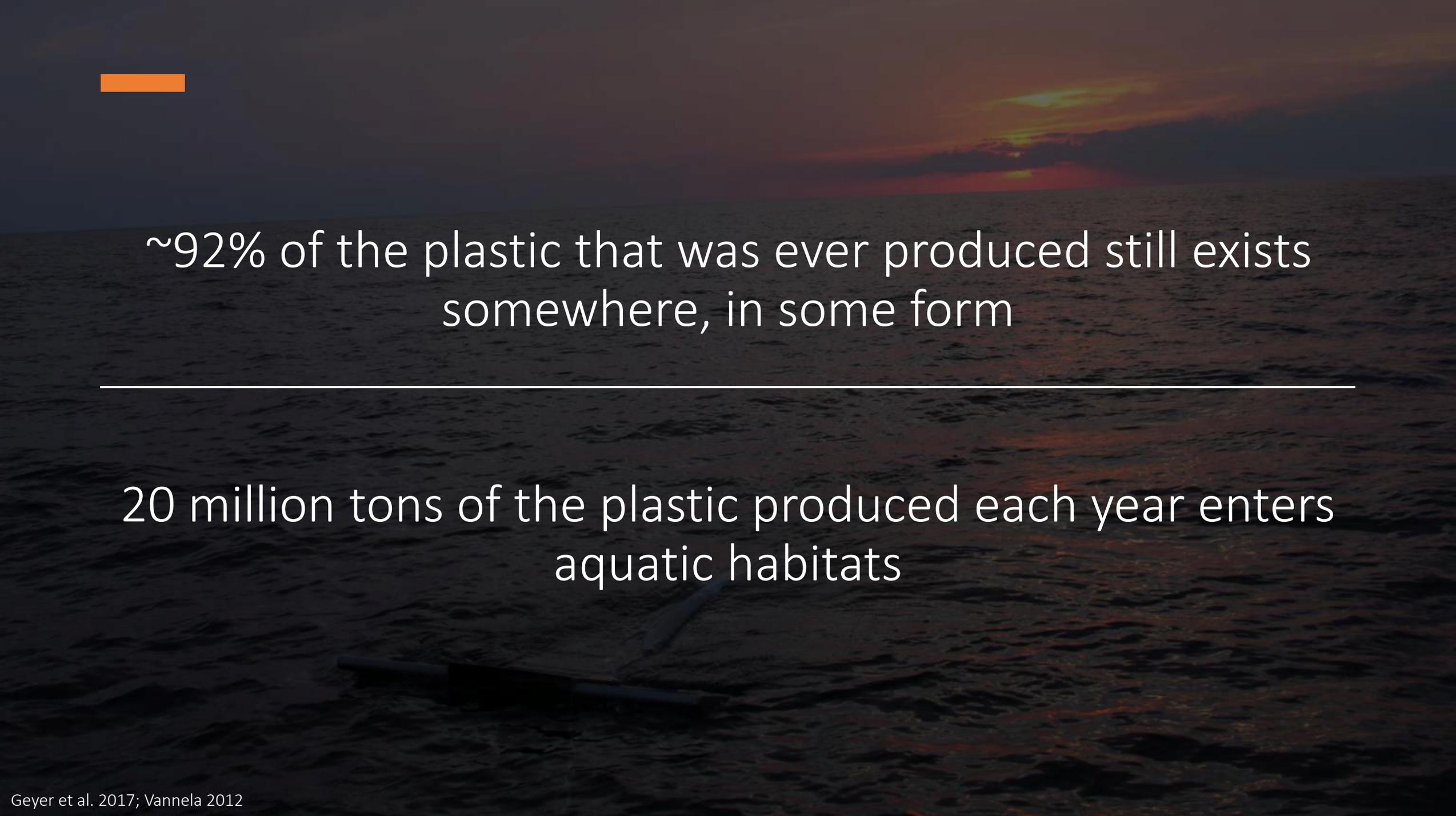
## Total MSW Generated by Material, 2018

292.4 million tons



This plastic may be landfilled, recycled, or used in “waste-to-energy”.





~92% of the plastic that was ever produced still exists  
somewhere, in some form

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20 million tons of the plastic produced each year enters  
aquatic habitats



Accumulation



Litter in aquatic environments has several fates



Ingestion



Breakdown & Decomposition

# Types of Microplastics

## 1° - Production pellets



www.frbiz.com



www.alibaba.com

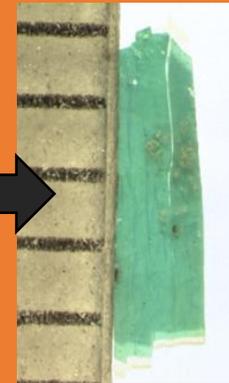
## 2° - Fragments, foam, film



archipelago.gr



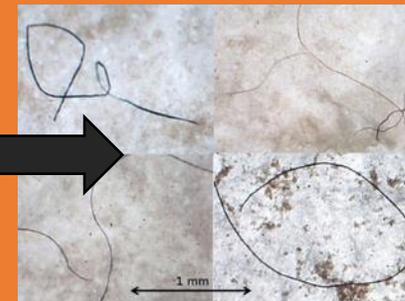
kasitIndustry.com



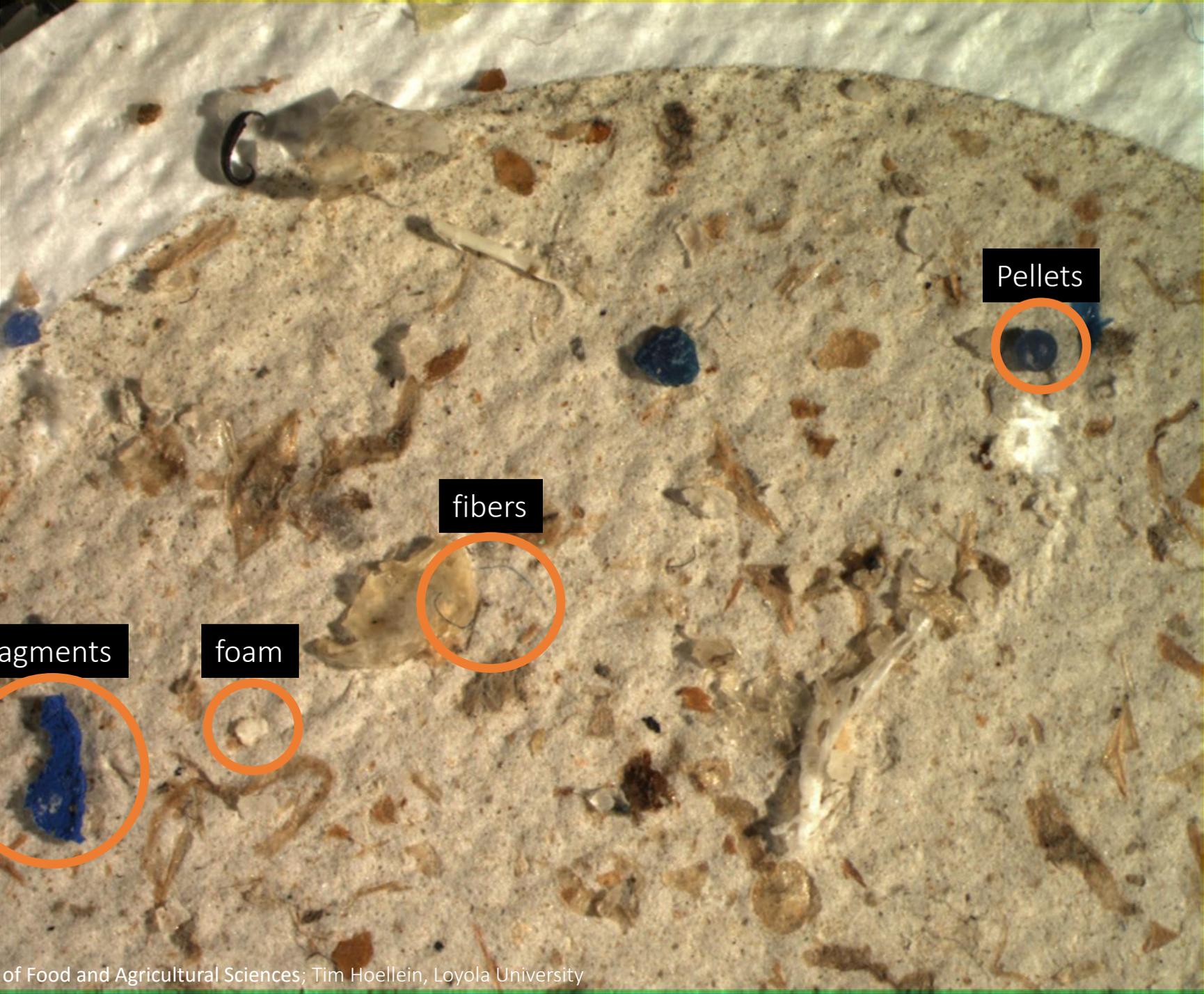
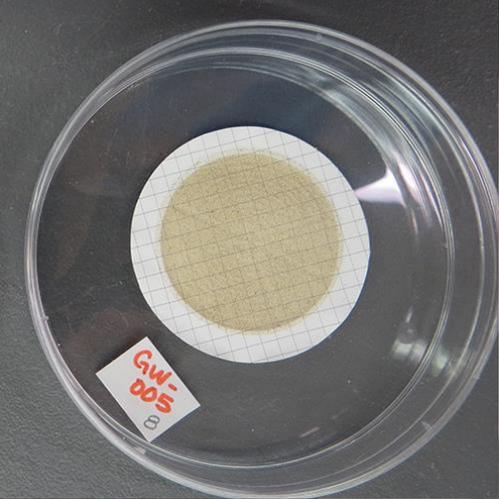
## 1° - Microbeads



## 2° - Synthetic fibers



<http://workjournal.archipelago.gr/tag/microplastics/>



fragments

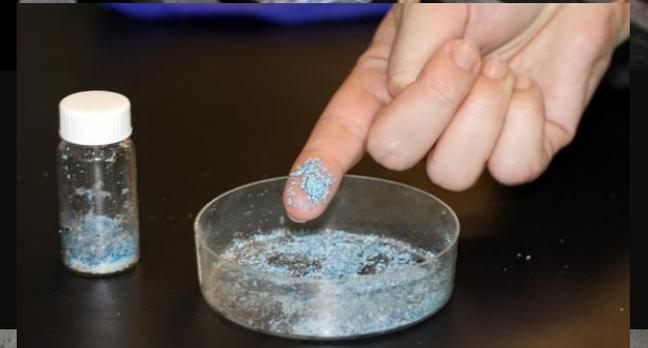
foam

fibers

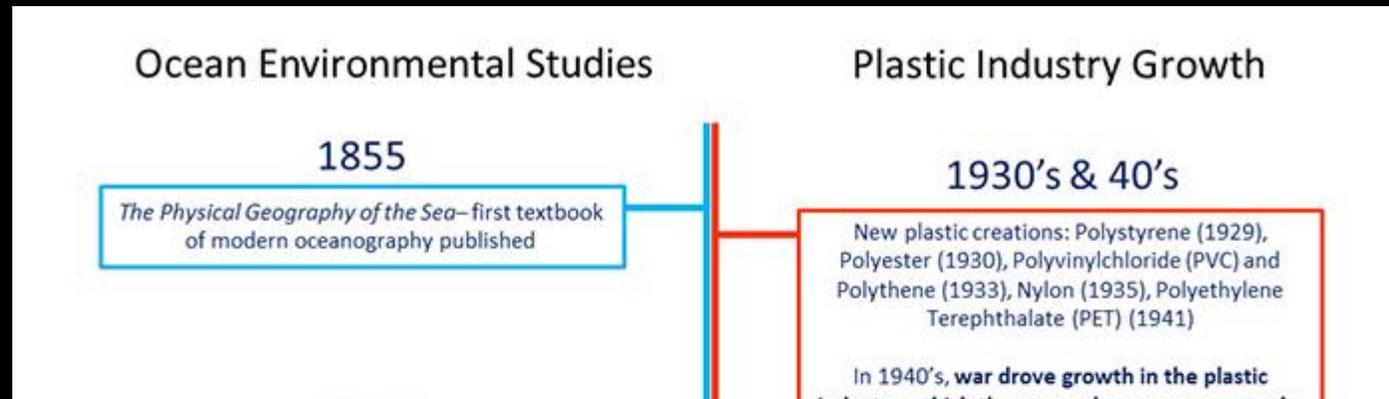
Pellets

# Microplastic Sources

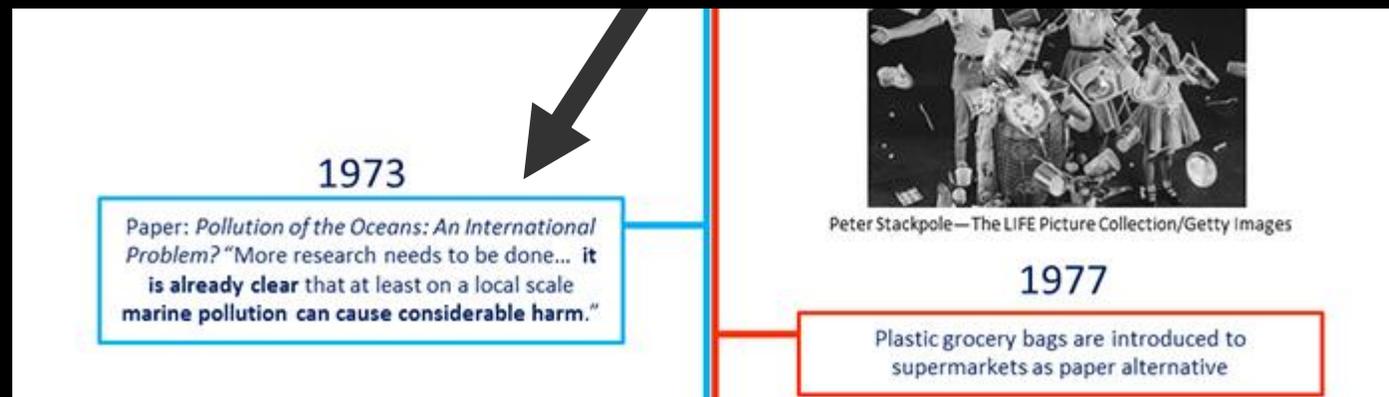
- Domestic wastewater
  - Fibers from clothing
  - Incomplete treatment removal
    - 75-99% removed
- Personal care products
- Terrestrial runoff and river movement to downstream ecosystems
- Breakdown from larger litter



# Microplastic is pervasive and persistent in marine ecosystems



1973: Marine pollution found to cause “considerable harm”



1982

Paper: *Oceanic Plastic Particle Pollution: Suspected Effect on Fat Deposition in Red Phalaropes* "A negative correlation between the amount of plastic and fat condition suggests a detrimental effect of a widespread oceanic pollutant on a marine bird."

1979  
1982: Research first demonstrates detrimental effects of plastic to marine birds

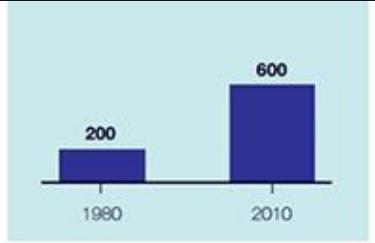
1987

The *Sixth International Ocean Disposal Symposium* publishes a comprehensive set of papers on the theme of sea disposal of plastics. Major inputs of ocean plastics are from land based sources in densely-populated and industrialized areas. Ocean plastic debris has negative biological effects: Marine life including seals, birds, and turtles are dying of entanglement with and ingestion of plastics.

1987: Major inputs to ocean debris found to be land-based

1993

Paper: *A Mechanism for the Accumulation of Floating Marine Debris North of Hawaii* studies drifts and currents of the Pacific Ocean, which explains the persistence of Garbage Patches.



1996

1999

Captain Charles Moore's first expedition to study plastic content of the Pacific Gyre. Finding published in 2001 paper: *A Comparison of Plastic and Plankton in the North Pacific Central Gyre*. The results? Plastic outweighs plankton 6 to 1.

1999: Research finds that plastic outweighs plankton 6 to 1.  
addressed globally due to potential human and environmental toxicity.



2007

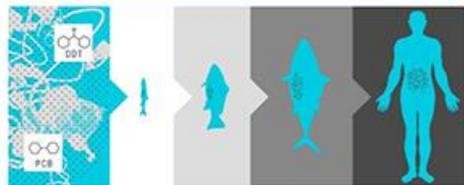
Paper: *Persistent organic pollutants carried by synthetic polymers in the ocean environment* confirms that plastic debris is a trap for POPs.

2009

Theme Issue in the *Philosophical Transactions Journal: Plastics, the Environment, and Human Health* addresses implications of human dependency on plastics, in particular the concerns for human health that arise from production, usage, and disposal of plastics.

2010

Paper: *Plastic Ingestion by Planktivorous Fishes in the North Pacific Central Gyre* is the first study to document fish from the gyre eating plastic. **35% of fish examined had ingested plastic.**



2013

Paper: *Ingested Plastic Transfers Hazardous Chemicals to Fish and Induces Hepatic Stress*. Microplastics naturally sorb chemical pollutants. **Fish eat these plastics and suffer liver toxicity**

2015

Paper: *Plastic Waste Inputs from Land into the Ocean* estimates 8 Million metric tons of plastic enter the ocean each year, **equivalent to dumping one garbage truck of plastic into the ocean every minute**

2016

United Nations Environmental Program Report estimates the total number of floating macro and microplastics in the open ocean to be **5.25 trillion pieces**

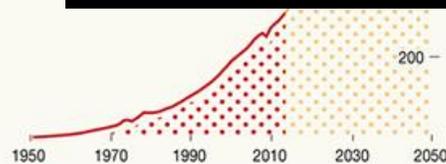
### Global plastic production...

Million tonnes, 2013



2010: Fish found to be eating plastic in N. Pacific Gyre

...and  
Million t

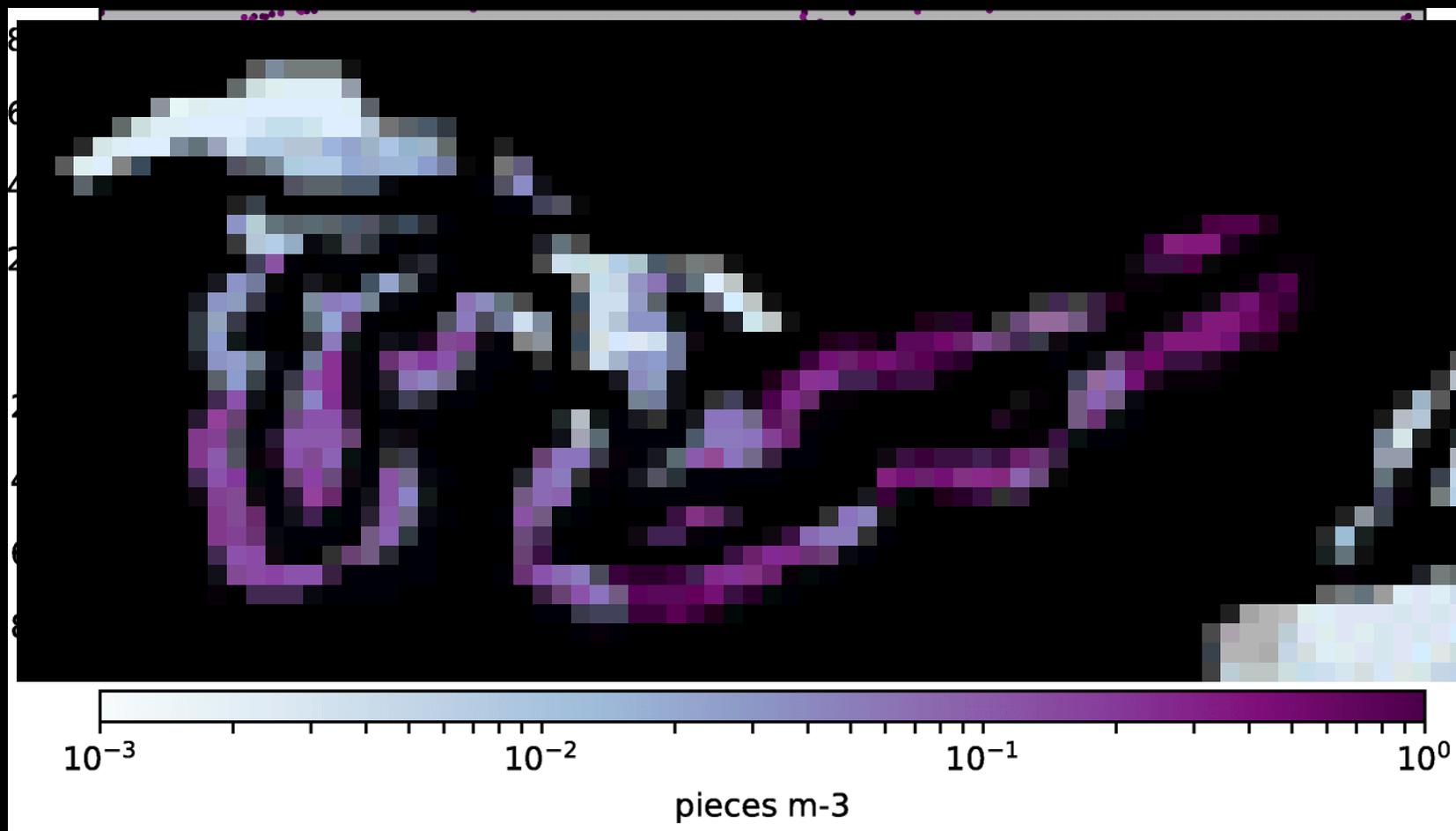


Source: Ryan, A Brief History of Marine Litter Research, in M. Bergmann, L. Gutow, M. Klages (Eds.), *Marine Anthropogenic Litter*, Berlin Springer, 2015; *Plastics Europe*

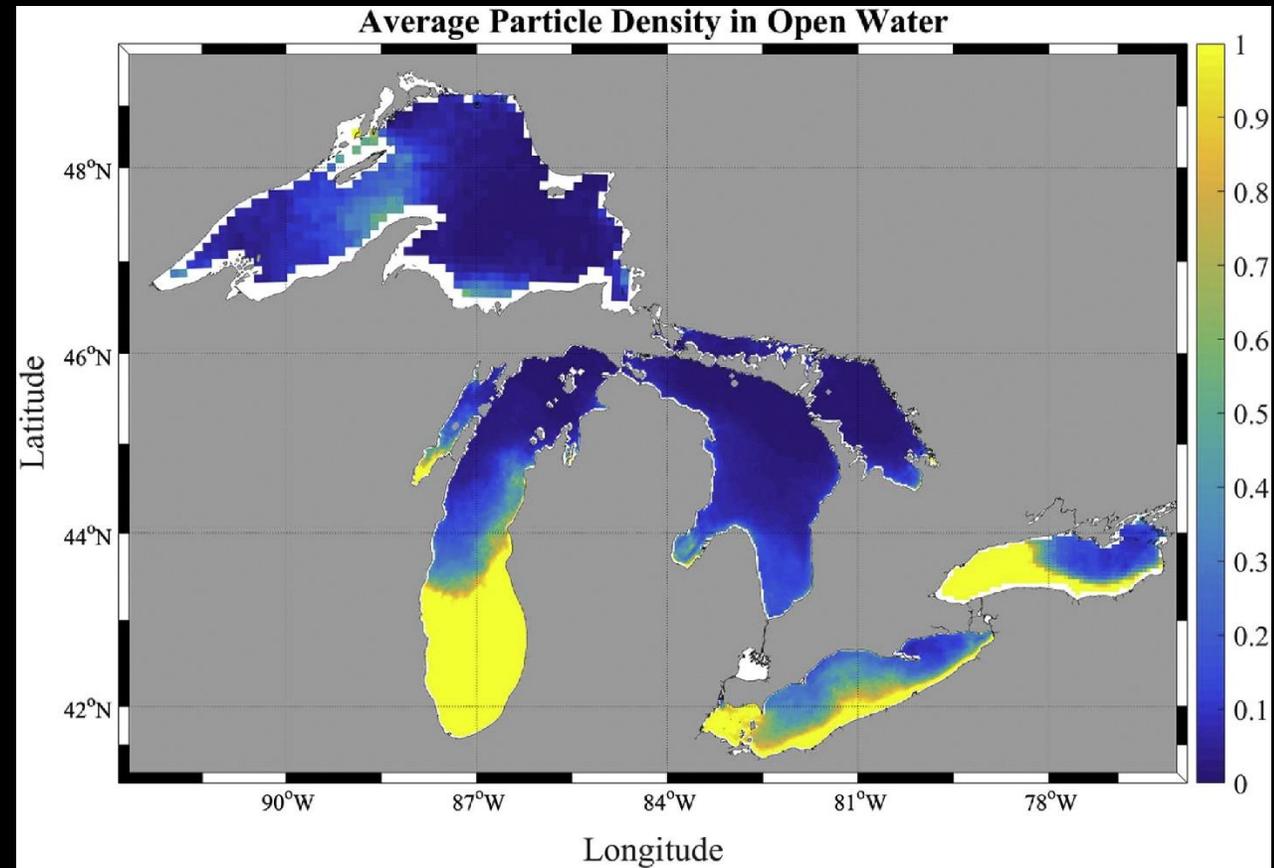
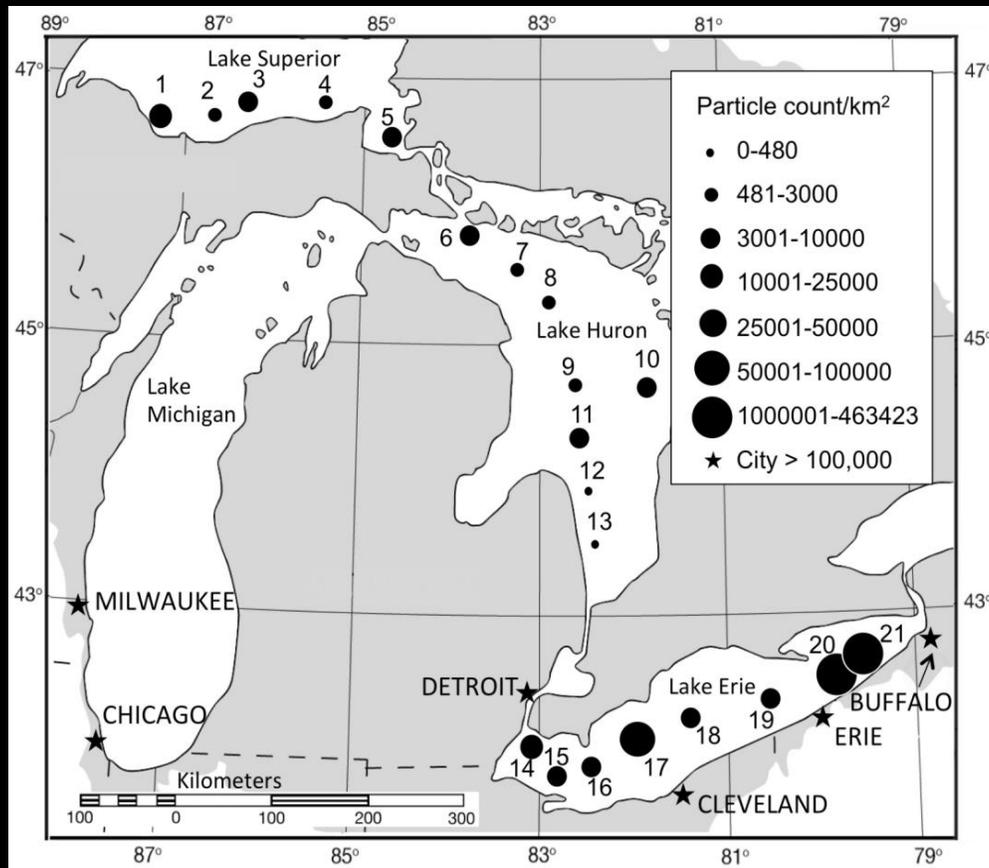
2016: U.N. estimates there to be 5.25 trillion pieces of oceanic macro and microplastics

PLAS  
PRODUCT  
  
RATIO OF PLAS  
TO FISH IN  
OC  
(BY WEI

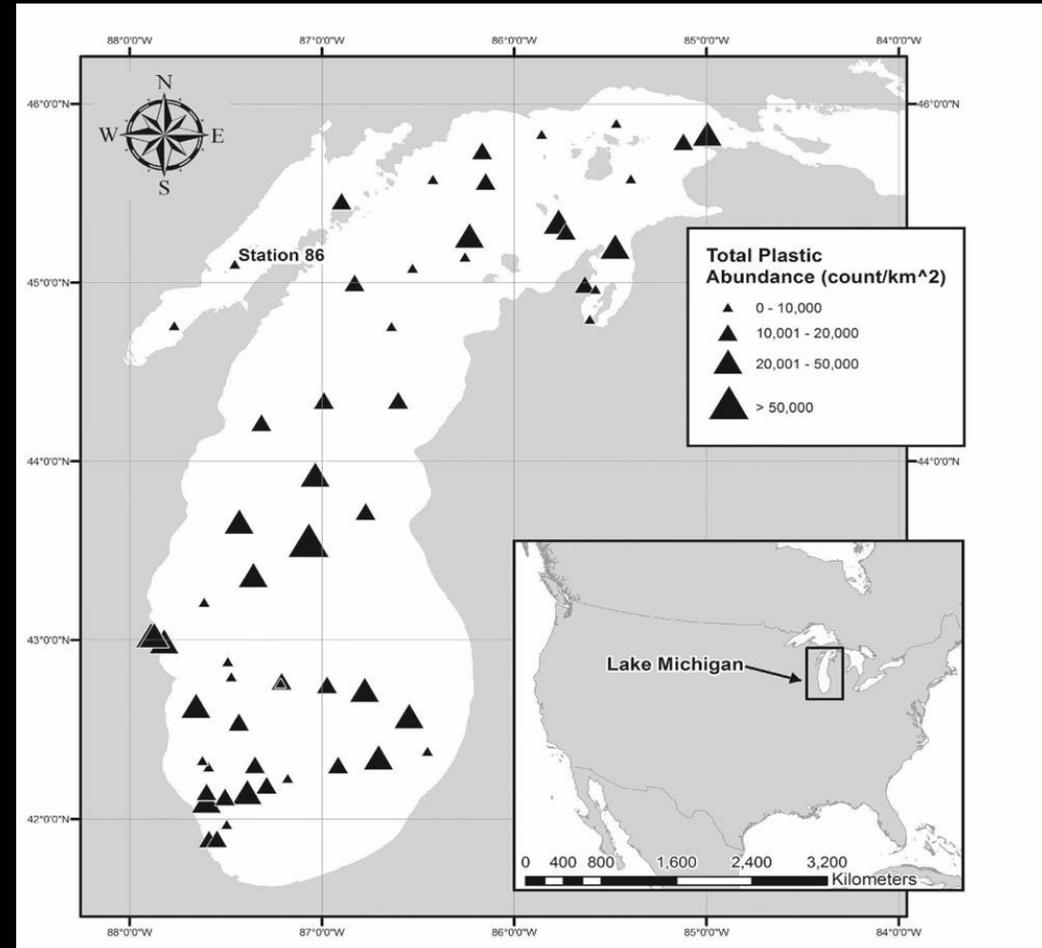
# Microplastic is pervasive and persistent in ecosystems *worldwide*



# Microplastic is present in Great Lakes waters



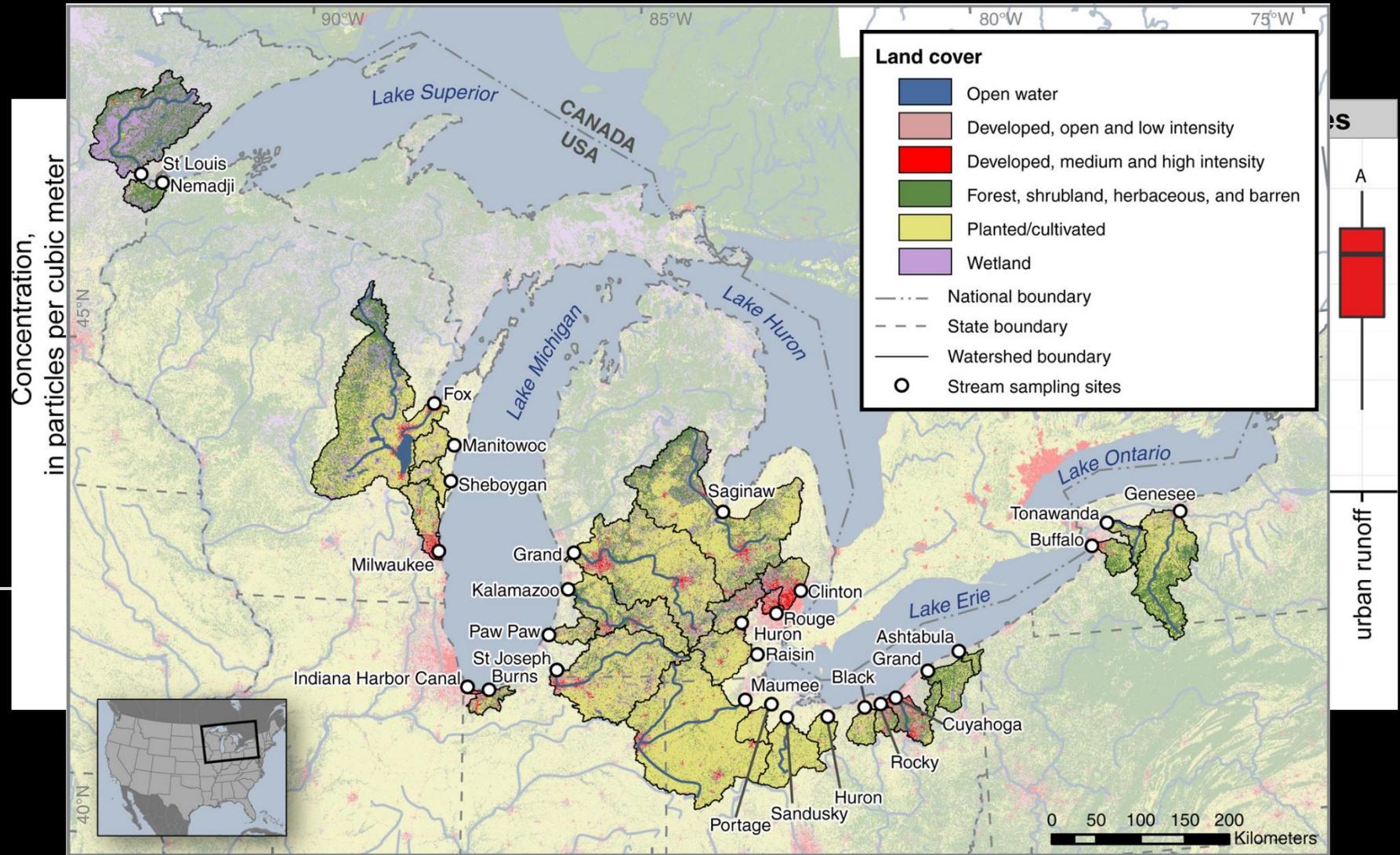
# 2013 Lake Michigan Survey



Microplastics are also in Great Lakes sediment.



And tributaries





WILL PARSON/CHESAPEAKE BAY PROGRAM

Microplastics collected from the Magothy River in Maryland.

# MICROPLASTICS ARE EVERYWHERE — BUT ARE THEY HARMFUL?

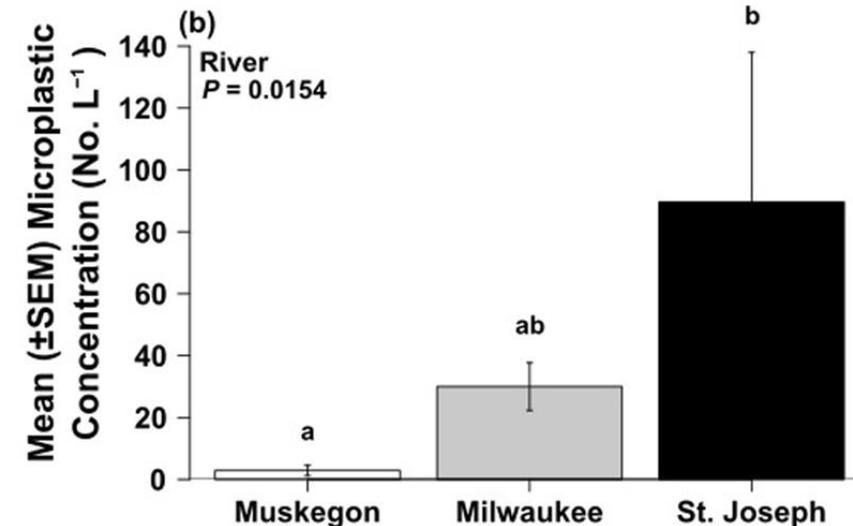
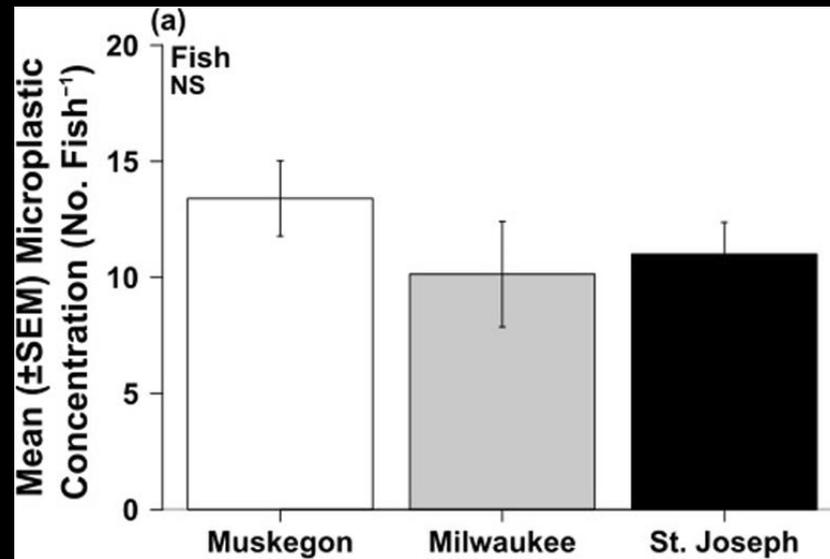
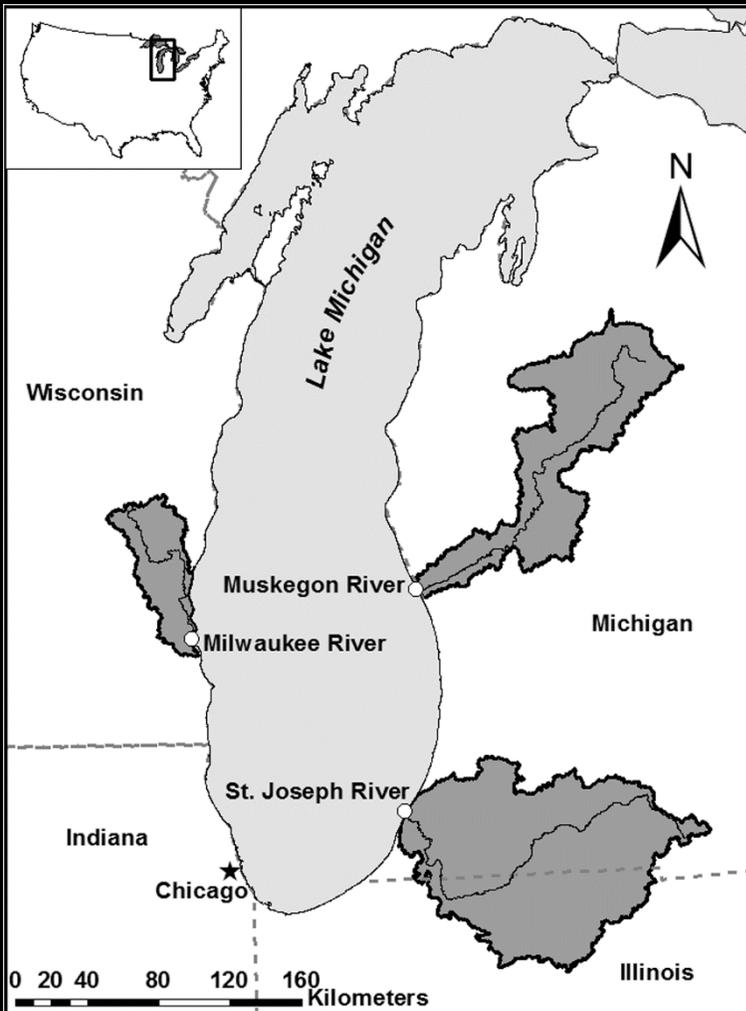
Scientists are rushing to study the tiny plastic specks that are in marine animals — and in us.

By XiaoZhi Lim

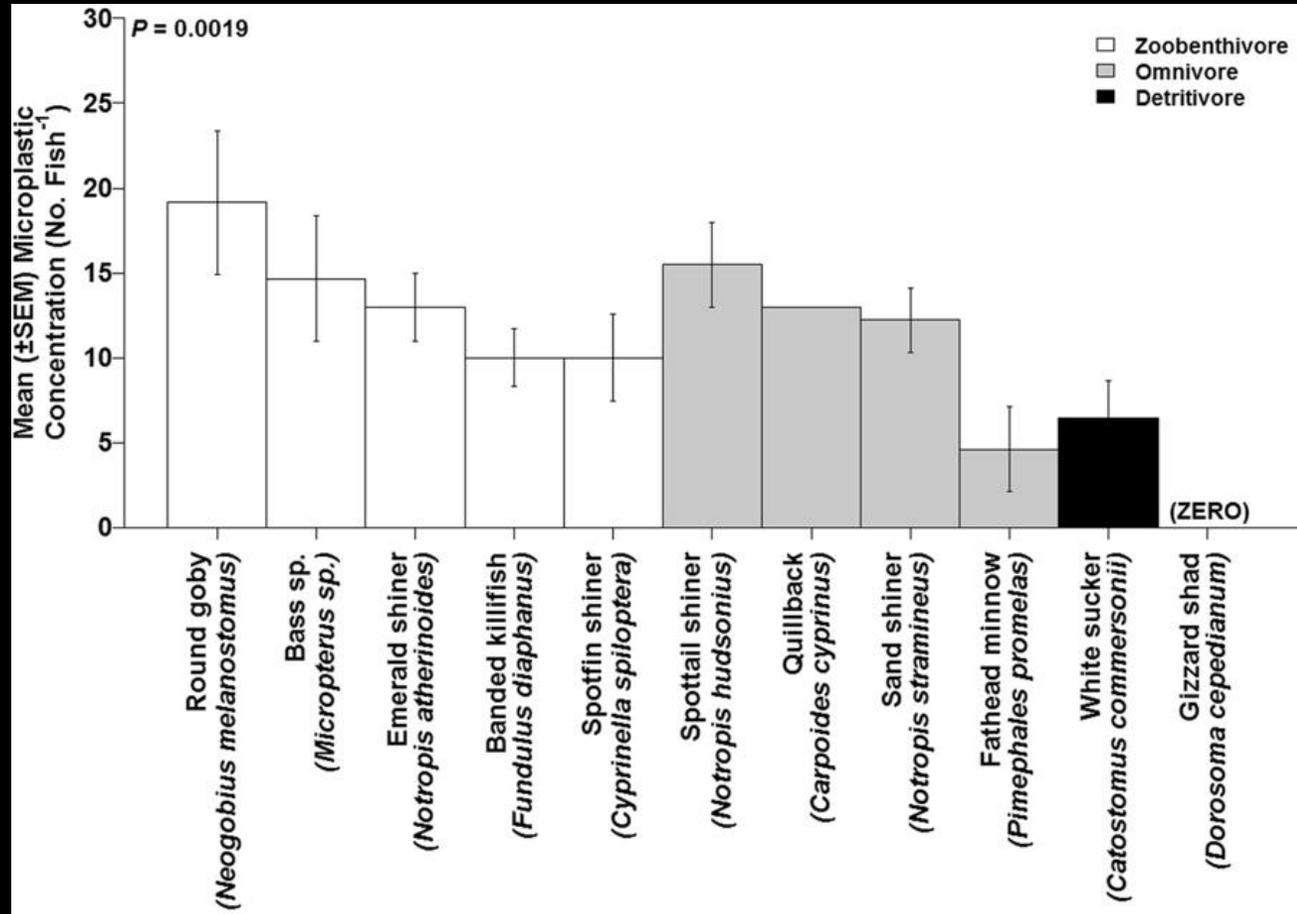
end,” says Tamara Galloway, an ecotoxicologist at the University of Exeter, UK. “I think it is fair to say the potential risk might be high,” says Li, choosing his words carefully.

Researchers have been worried about the potential harms of microplastics for almost 20 years — although most studies have focused on the risks to marine life. Richard Thompson, a marine ecologist at the University of Plymouth, UK, coined the term in 2004 to describe plastic particles smaller than 5 millimetres across, after his team found them on British beaches. Scientists have since seen microplastics everywhere they have looked: in deep oceans; in Arctic snow and Antarctic ice; in shellfish, table salt, drinking water and beer; and drifting in the air or falling with rain over mountains and cities. These tiny pieces could take decades or more to degrade fully. “It’s almost certain that there is a level of exposure in just about all species,” says Galloway.

# Lake Michigan Fishes



# Lake Michigan Fishes

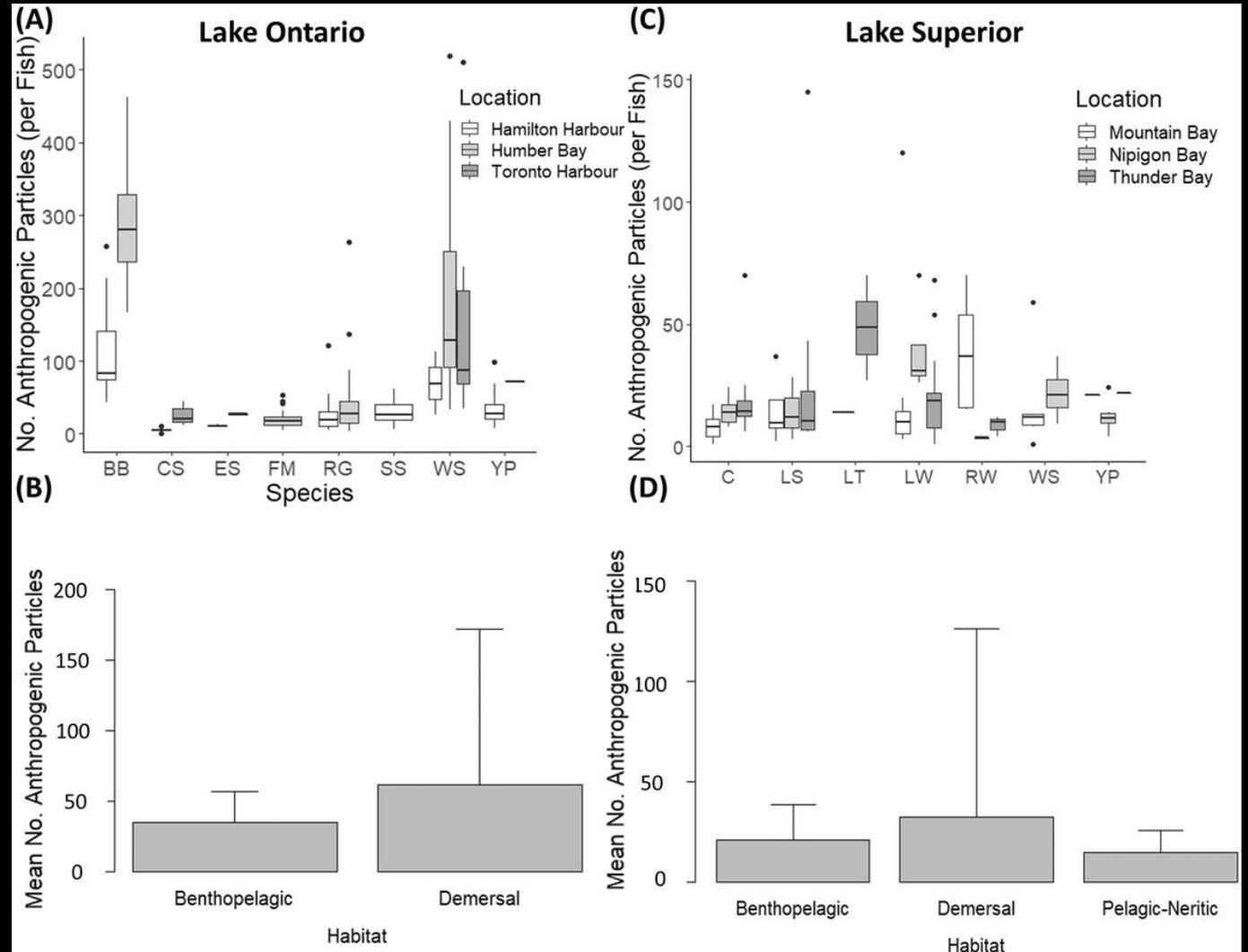


**LOYOLA**  
UNIVERSITY CHICAGO

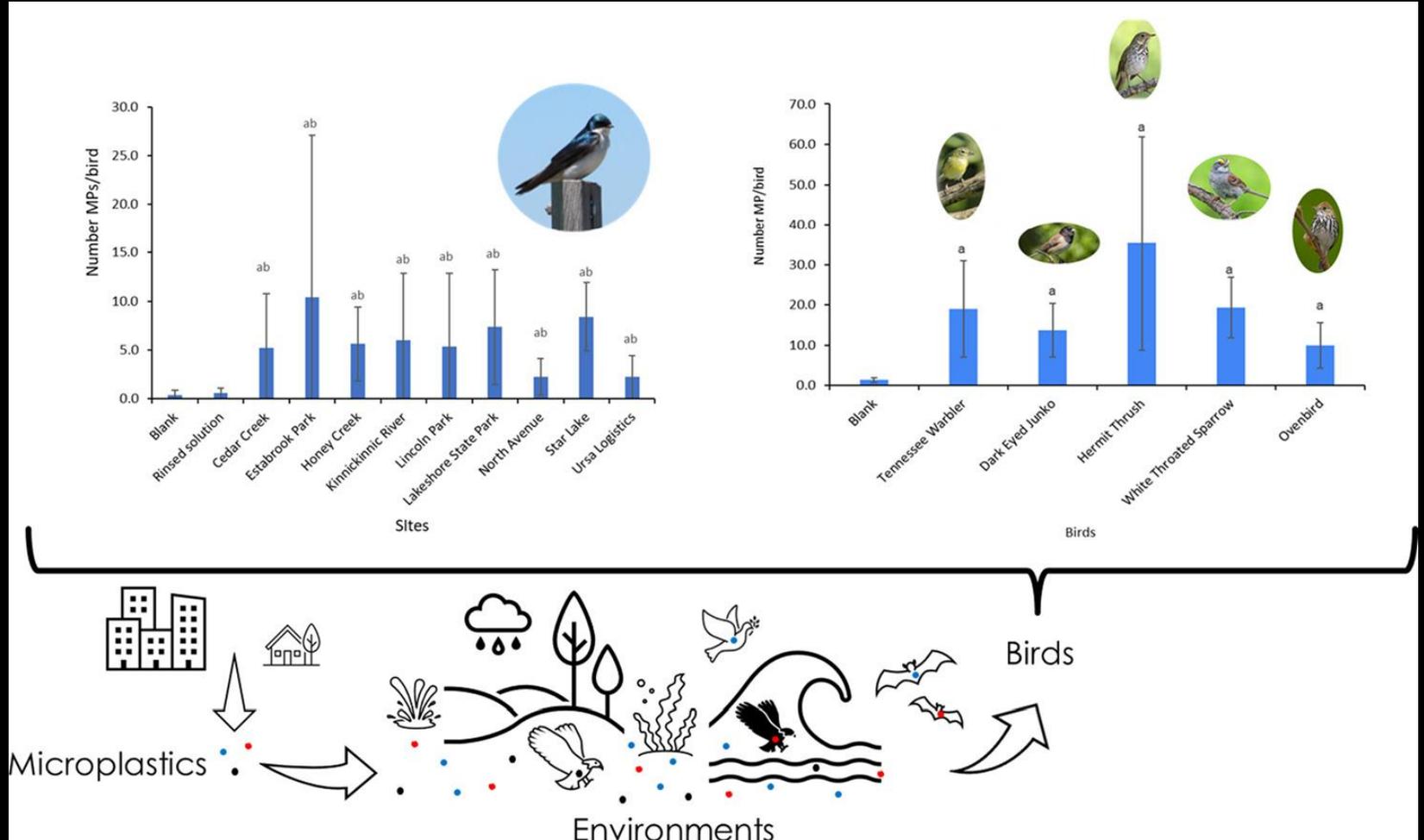
# Lakes Superior and Ontario Fishes

All fish sampled were contaminated with anthropogenic particles

Range: 2 – 915 particles/fish



# Great Lakes Migratory Birds



Ingestion is happening, but what is the risk to an organism's health?

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# Ecological Impacts

- Ingestion
  - Filter feeders, zooplankton, fish
- Prey transfers to predator
- Decreased reproductive success, survival
- Selects for distinct microbial communities



Cole et al. 2013



M. Eriksen, 5 Gyres



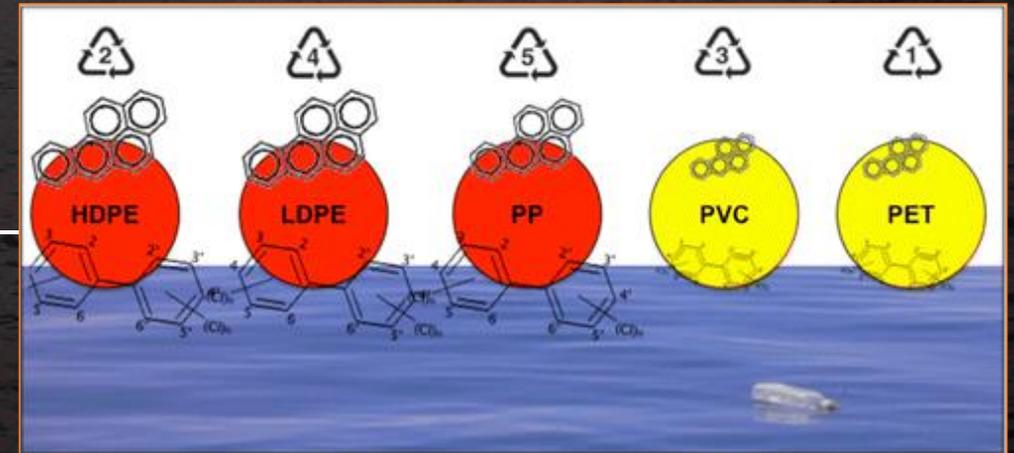
Zettler et al. 2013



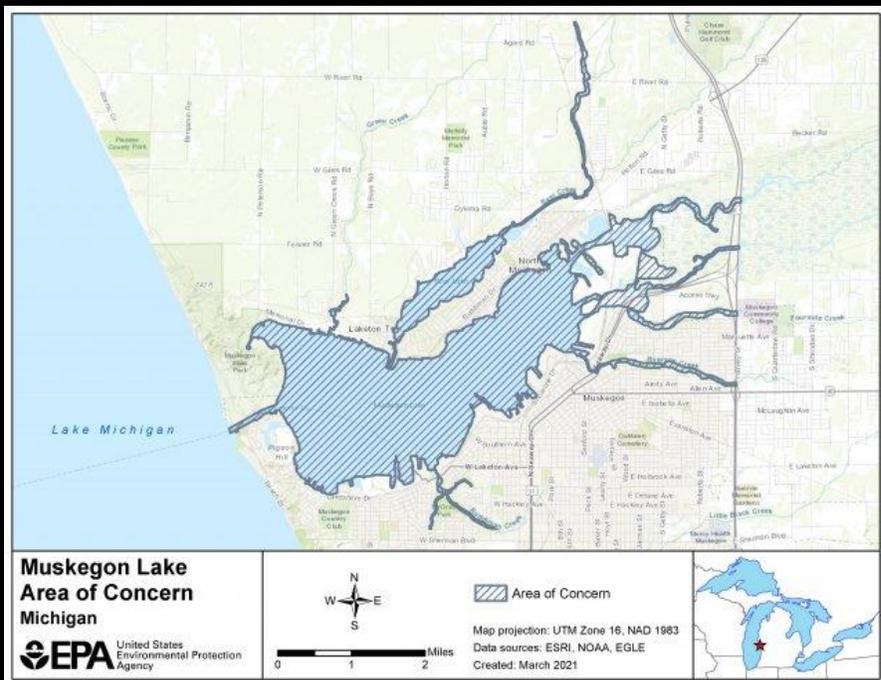
J. Schluep, Loyola Univ.

# Toxicological Impacts

- Leach chemicals
  - BPA: endocrine disruptor
- Adsorb chemicals
  - Hydrophobic surfaces easily adsorb persistent organic pollutants (POPs)
  - Research on marine plastic has demonstrated that the risk to marine animals *differs by plastic type*



# Microplastic Arrays in Muskegon



 GRAND VALLEY STATE UNIVERSITY

 ILLINOIS

Illinois Sustainable Technology Center

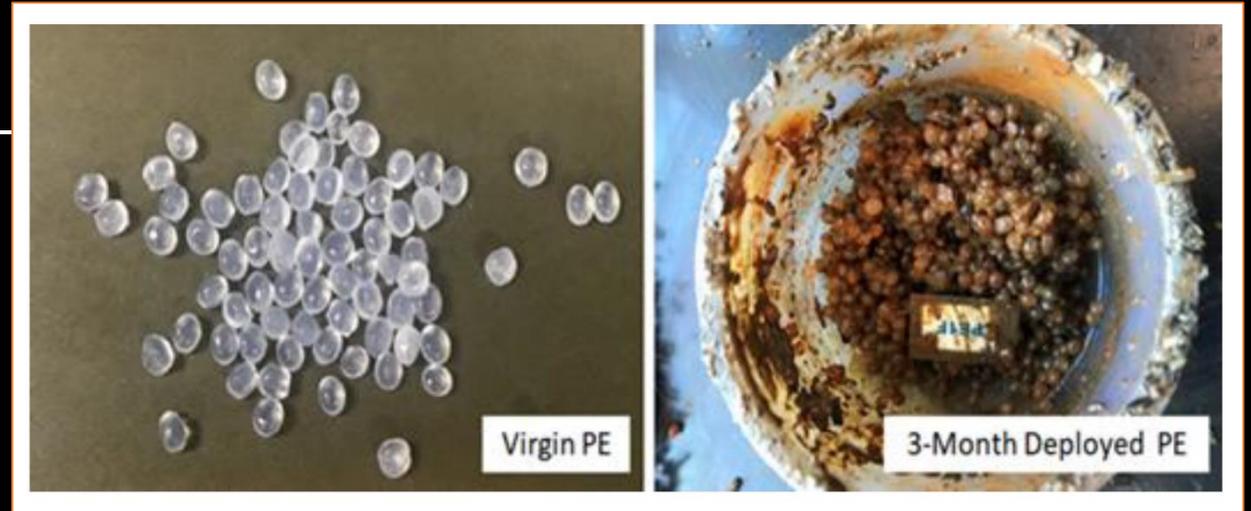
PRAIRIE RESEARCH INSTITUTE



Image credit: Tony Packer

# Microplastic Arrays in Muskegon: PFAS

*The adsorption of PFAS was much greater in the field-incubated plastic than what was observed in the laboratory with plastic and water alone.*





# Microplastics Arrays in Muskegon Others

Polyaromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), organochlorine pesticides (OCs), select metals, microbes

*Overall, our results indicate that persistent organic pollutants are capable of accumulating on MPs but the concentrations generally were low; feeding trials are needed to determine if these environmentally realistic concentrations of pollutants attached to microplastics result in impacts to aquatic biota.*

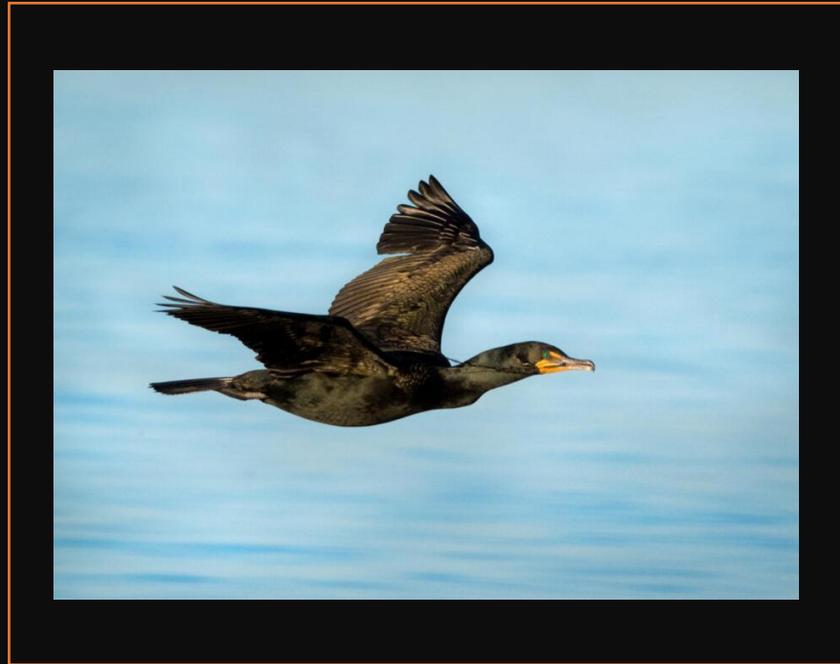
# Environmentally Relevant Concentrations



- Many lab studies use concentrations that are far higher than what is present in the environment
- Push for environmentally relevant concentrations\*

# Microplastics Summary

- Present in Great Lakes waters, sediments, and organisms
- Fibers and fragments abundant
- Some other contaminants can adsorb onto them
- Are they a problem?



# 2018 Meta-analysis

Science of the Total Environment 631–632 (2018) 550–559



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Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: [www.elsevier.com/locate/scitotenv](http://www.elsevier.com/locate/scitotenv)



Review

A meta-analysis of the effects of exposure to microplastics on fish and aquatic invertebrates

Carolyn J. Foley <sup>a,b,\*</sup>, Zachary S. Feiner <sup>a</sup>, Timothy D. Malinich <sup>a</sup>, Tomas O. Höök <sup>a,b</sup>

<sup>a</sup> Purdue University, Department of Forestry and Natural Resources, 195 Marsteller St., West Lafayette, Indiana 47907, USA

<sup>b</sup> Illinois-Indiana Sea Grant College Program, 195 Marsteller St., West Lafayette, Indiana 47907, USA



**PURDUE**  
UNIVERSITY

**Sea Grant**  
ILLINOIS-INDIANA

# IISG Meta-Analysis

- 43 published studies
- Question?? For aquatic organisms, what is the impact of exposure to microplastics on:
  - Consumption (feeding)
  - Growth
  - Reproduction
  - Survival

# IISG Meta-Analysis

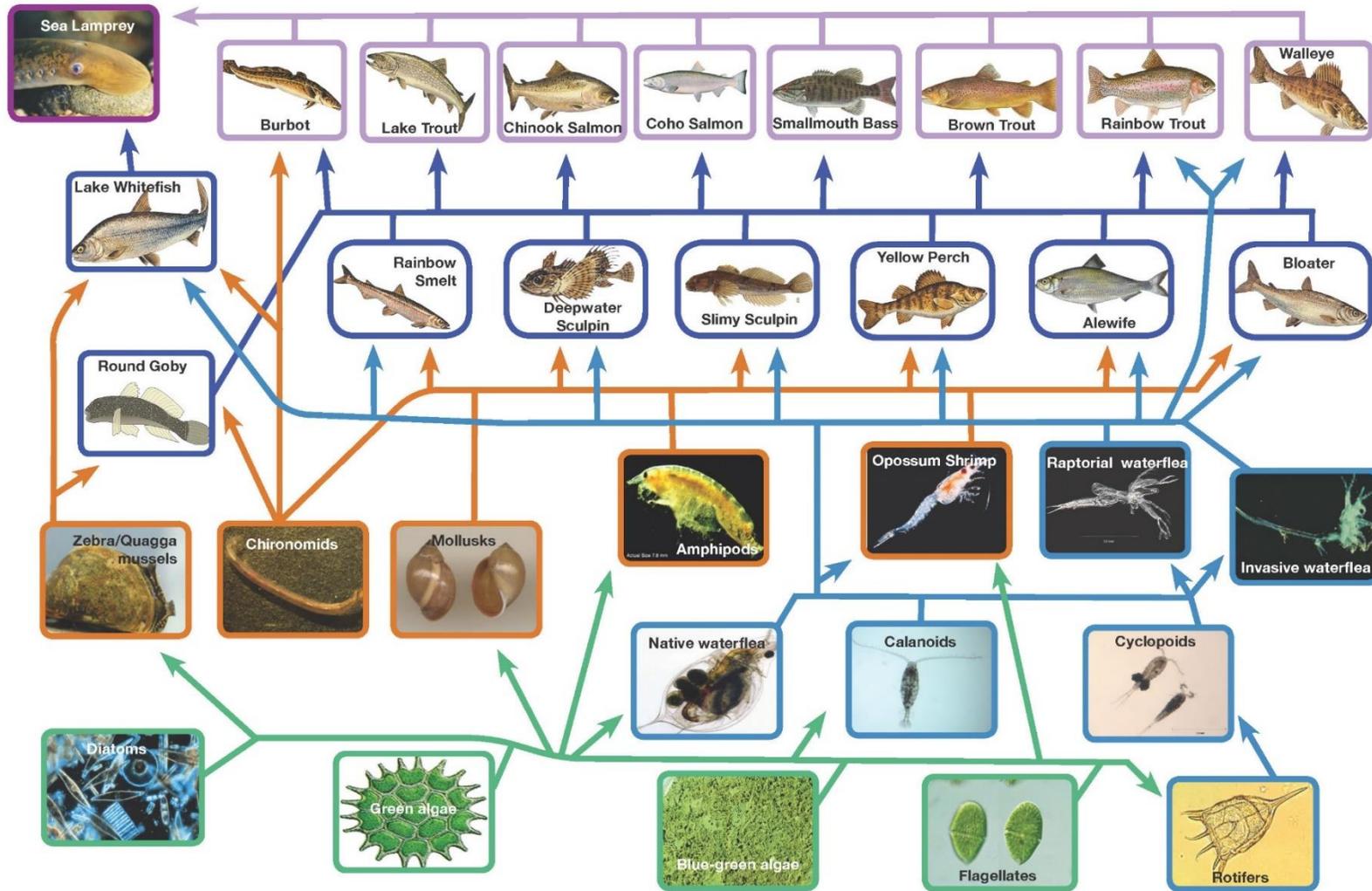
Determined that effect varied with taxonomic group

	Consumption	Growth	Reproduction	Survival
Zooplankton		*	*	*
Echinodermata			+	
Molluscs	+	+		
Macroinvertebrates		+		
Larval & Juvenile Fish	*			+
Adult Fish				

\* = significant negative effects  
+ = possible negative effects



# Lake Michigan Food Web



Put

- Low
- Over

Foodweb based on "Impact of exotic invertebrate invaders on food web structure and function in the Great Lakes: A network analysis approach" by Mason, Krause, and Ulanowicz, 2002 - Modifications for Lake Michigan, 2009.

NOAA, Great Lakes Environmental Research Laboratory, 4840 S. State Road, Ann Arbor, MI 734-741-2235 - www.glerl.noaa.gov



# What Are Some Other Stressors Acting on Great Lakes Organisms?

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- Aquatic invasions
- Habitat loss
- Changing climate
- Other pollutants
- Now add in little plastic particles filling your guts



# Ecological Effects of Microplastics: Impacts to humans?

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- Microplastics have been found in:
  - Sea, lake, rock, and well salt; chicken gizzards; honey; beer; tea bags; drinking water (bottled and tap); seafood & shellfish
- Humans consume up to 52,000 microplastic particles/year
- Inhalation adds 69,000 particles/year
- Consuming only bottled water adds an additional 90,000 particles/year (only 4,000 for tap)
- Polypropylene bottles release up to 16,200,000/liter



# Ecological Effects of Microplastics: Impacts to humans?

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- No published study has yet directly examined the effects of micro- and nanoplastic on people.
- Microplastics have been found in:
  - All regions of human lungs
    - Polypropylene and polyethylene fibers were most abundant
    - Inhalation is an important route of exposure
  - Human bloodstream
    - Only 22 people
    - Demonstrated that plastic nanoparticles are “bioavailable for uptake into the human bloodstream”
- Larger microplastics likely to have effects due to chemical toxicity – addition of hazardous chemicals like plasticizers, pigments, and stabilizers.



# What Can We Do?

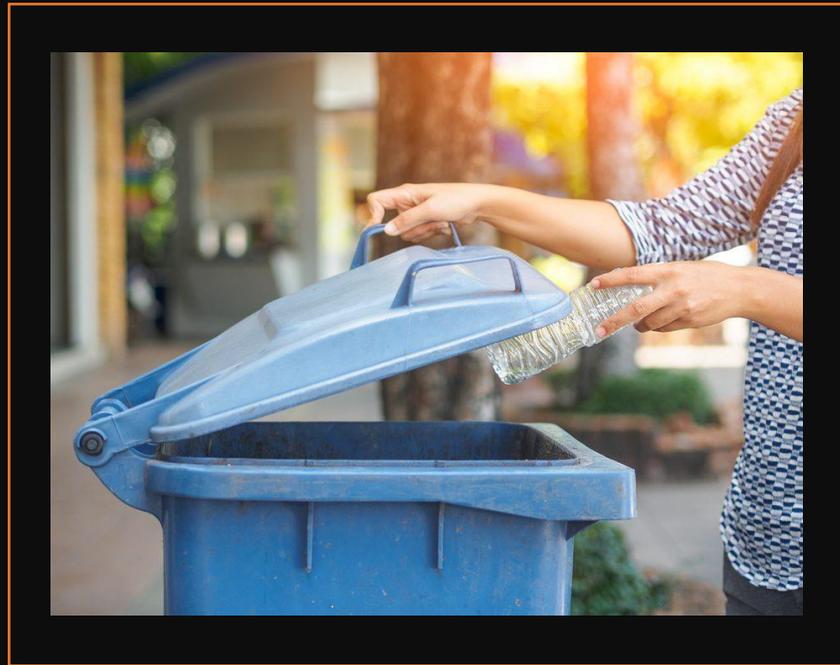
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- Reduce – reliance on plastic, amount of plastic entering environment
- Reuse – when possible limit single-use plastics, change behaviors
- Recycle – third for a reason

Won't be easy

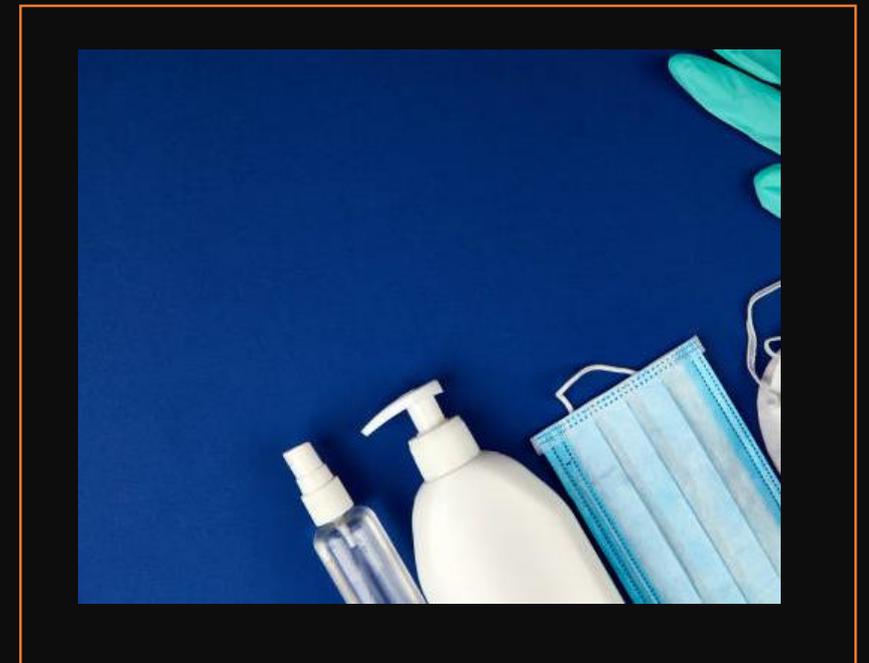
# Plastic Solutions: Consumer-driven or corporate responsibility?

- Big emphasis on ‘personal responsibility’
- Many argue that corporations bear the lion’s share of the blame for the plastic problem.
- Research has found that only 20 firms produce over half of the world’s plastic waste, led by Exxon-Mobil
- Based on global beach cleanup data, Coca-Cola is the #1 Global Top Polluter



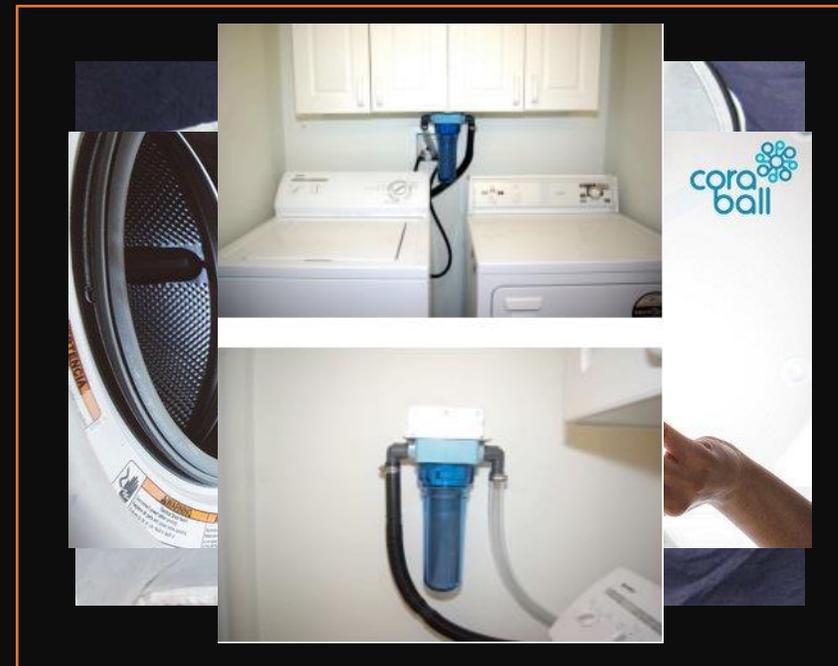
# Plastic Solutions: Challenges

- Equity
- Accessibility
- Benefits of plastic use (food, clean water)
- Pressing issues e.g., COVID
  - Recent research found PPE to be a new emerging source of plastic pollution in the Great Lakes region
  - Disposable gloves > face masks > wipes
  - Highest densities in grocery store parking lots



# Engineering Solutions At Home

- Fiber-catching products for laundry prevents release into wastewater (no endorsements!)
  - Guppyfriend
  - Cora Ball
  - Lint LUV-R
- McIlwraith et al. 2019 found Lint LUV-R (87%) and Cora Ball (26%) to significantly reduce microfibers in washing machine effluent



# Engineering Solutions in the Field

- Robots, vessels
  - FRED Robot (San Diego)
  - Mr. Trash Wheel (Baltimore)
- Seabin
- LittaTrap
- PixieDrone
- BeBot
- Gutter Bin



# Equity, Accessibility

## Legislative Solutions

- Straw Bans
  - MN
- Plastic Bag Bans
  - Chicago bag tax (2017), Evanston ban (2015)
  - IN, MI, MN, WI have a ban on bans
- Single-use plastic bans
  - NY (Styrofoam; statewide)
  - MN, PA (Styrofoam, straws, single use, etc.; local)





# Other Ideas?

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Please share in the chat

## Microbead-Free Waters Act of 2015

- Prohibits the manufacturing, packaging, and distribution of rinse-off cosmetics containing plastic microbeads
- Many manufacturers were voluntarily pulling microbeads from their products



## Microbead-Free Waters Act of 2015

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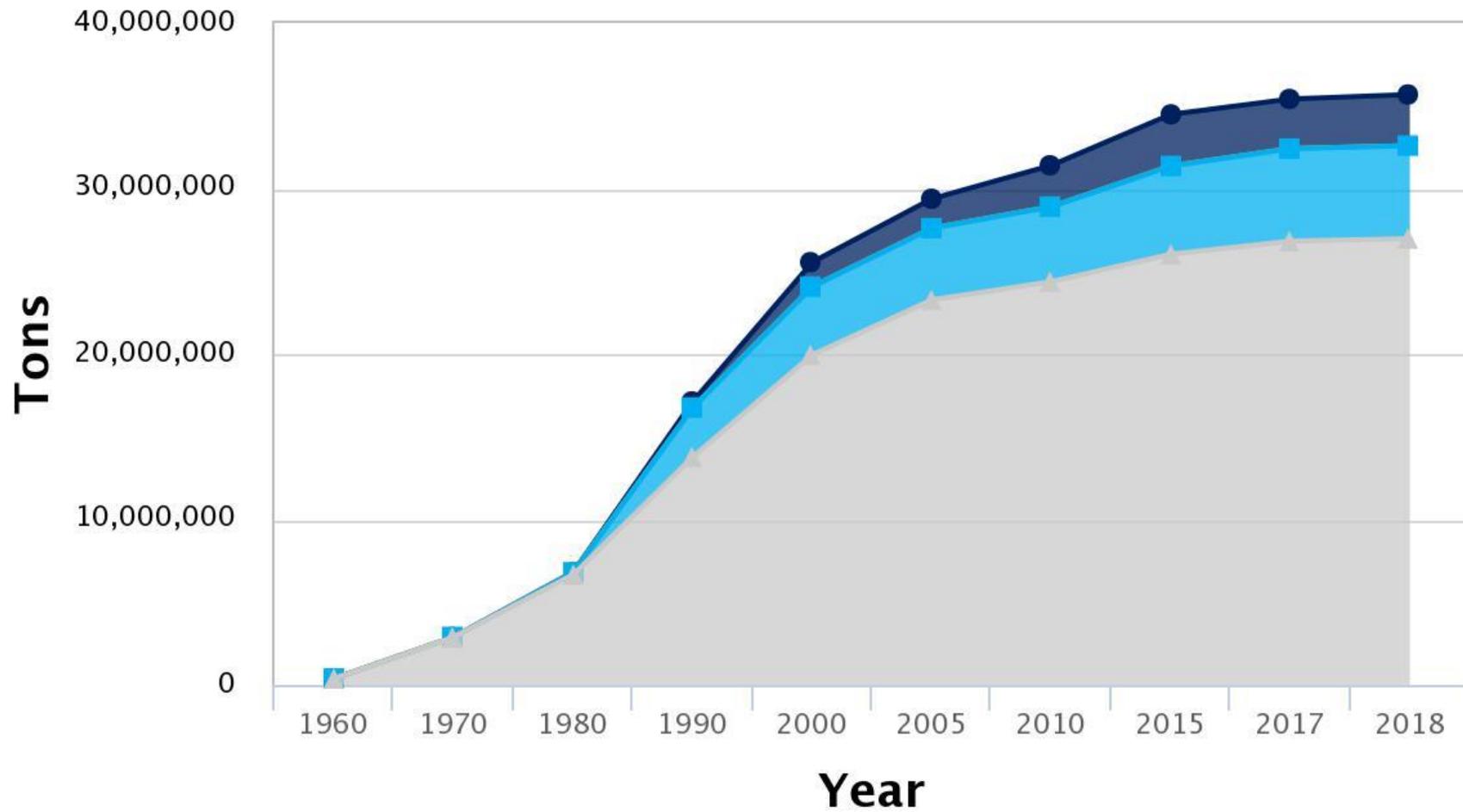




# Plastic

- Strong ch potential
- Gleick an water
- Energy re much or transport

## Plastics Waste Management: 1960-2018



*Click on legend items below to customize items displayed in the chart*

**Recycled** **Composted** **Combustion with Energy Recovery** **Landfilled**



The energy value of landfilled plastic waste in 2019 was enough to supply 5% of power for transportation sector, 5.5% for industrial.

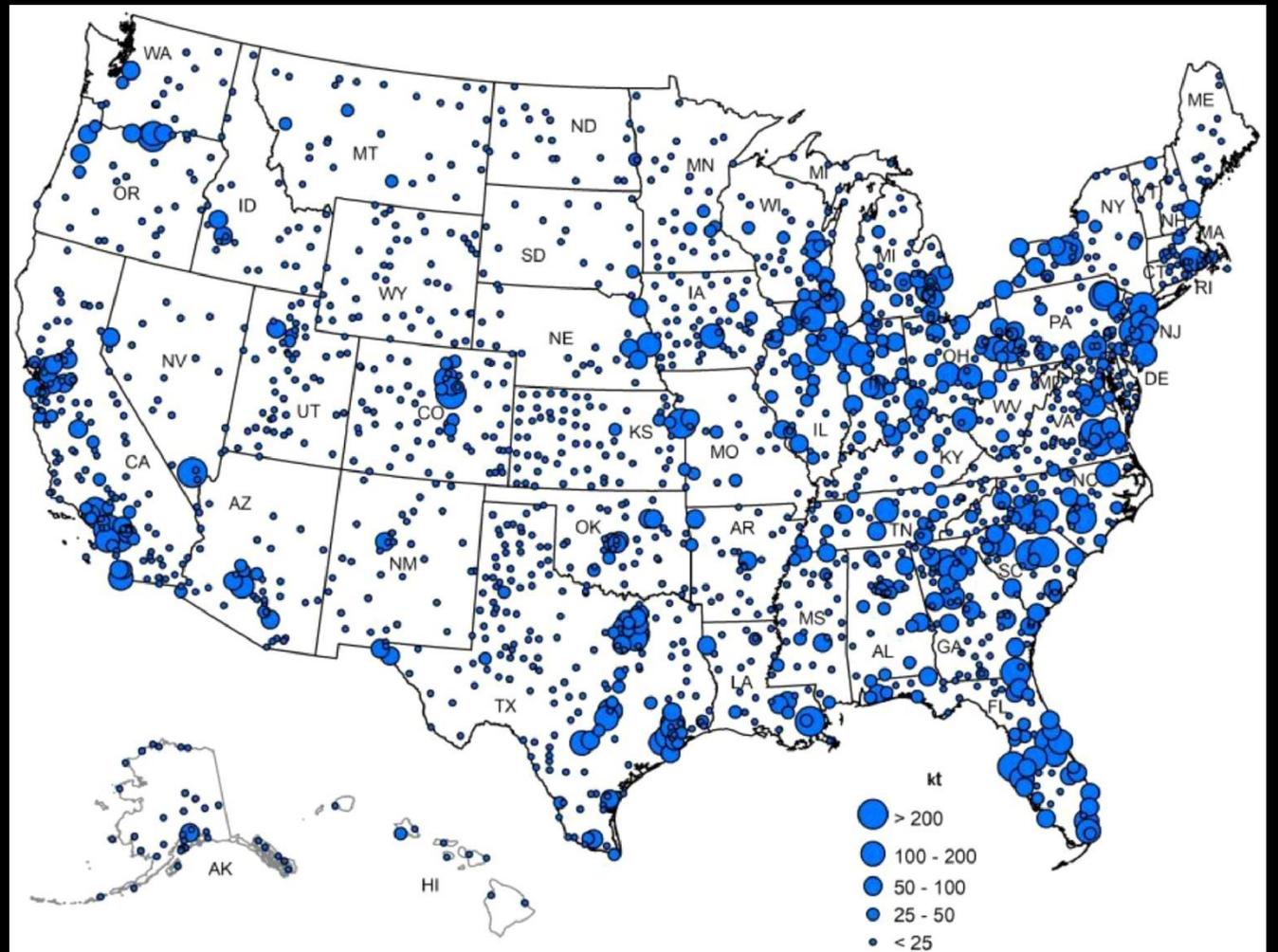
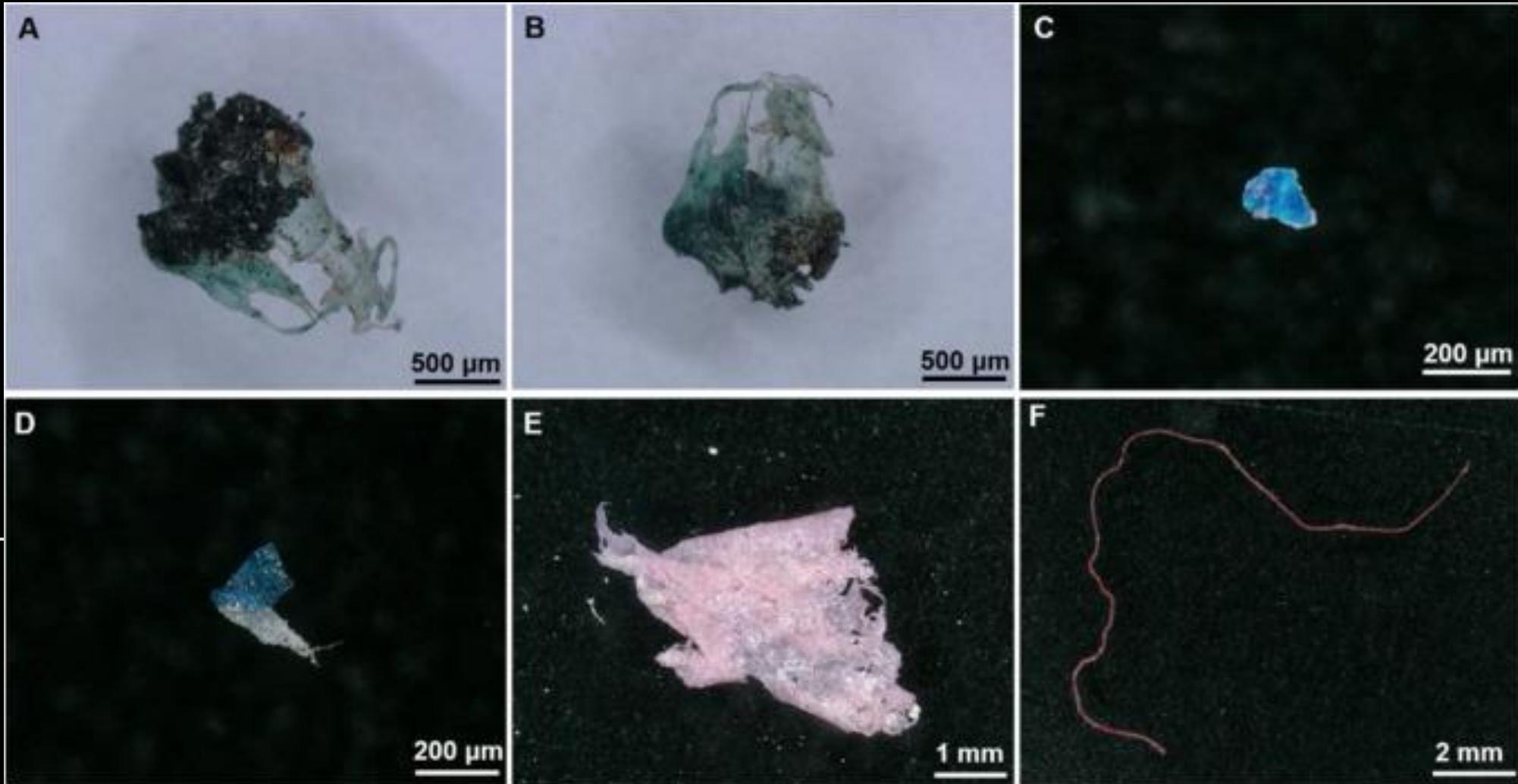


Fig. 3. Total plastic waste landfilled on site in 2019. The circles on the map depict landfill locations in the United States and the size of the circles corresponds to the amount of plastic waste disposed at the landfills (kt).





# Key Links

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- <https://www.greatlakesplasticcleanup.org/cleanup-technology>
- <https://greatlakes.org/2022/06/5-ways-plastic-pollution-is-different-in-the-great-lakes/>
- <https://marinedebris.noaa.gov/great-lakes>
- <https://www.michiganseagrant.org/topics/coastal-hazards-and-safety/marine-debris-and-plastic-pollution/>
- <https://iiseagrant.org/education/pollution-prevention-explorer/>



Thank you!

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