Microplastics in the Aquatic Environment: Locations and Consequences

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February 15, 2019, Washington, DC

Microplastic pollution is an emerging issue of global concern

U.S.News CIVIC

'Microplastics' in Dolphins, Seals Heighten Environmental Concerns

Feb. 4, 2019

BY ROBERT PREIDT, *HealthDay Reporter*

MONDAY, Feb. 4, 2019 (HealthDay News) -- In a microcosm of the planet's ocean woes, British researchers report that 50 dolphins, seals and whales examined after washing up on that country's shores all had pieces of discarded plastic trapped in their digestive tracts.

More than 80 percent of the tiny pieces were synthetic fibers from items such as discarded clothes, fishing nets and toothbrushes, according to researchers from the University of Exeter and Plymouth Marine Laboratory. Called microplastics, they are less than 0.2 inches in size.

(HEALTHDAY)

CNN Health + International Edition +

Microbead ban signed by President Obama

By Jareen Imam, CNN
Updated 1746 GMT (0146 HKT) December 31, 2015

Source: CNN

Is your toothpaste polluting the waterways? 01:14

EU proposes ban on 90% of microplastic pollutants

European Chemicals Agency draft law aims to cut 400,000 tonnes of plastic pollution

▲ A marine biologist holds up a sample of seawater containing microplastics. Photograph: Eric Gaillard/Reuters

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Press release

World leading microbeads ban comes into force

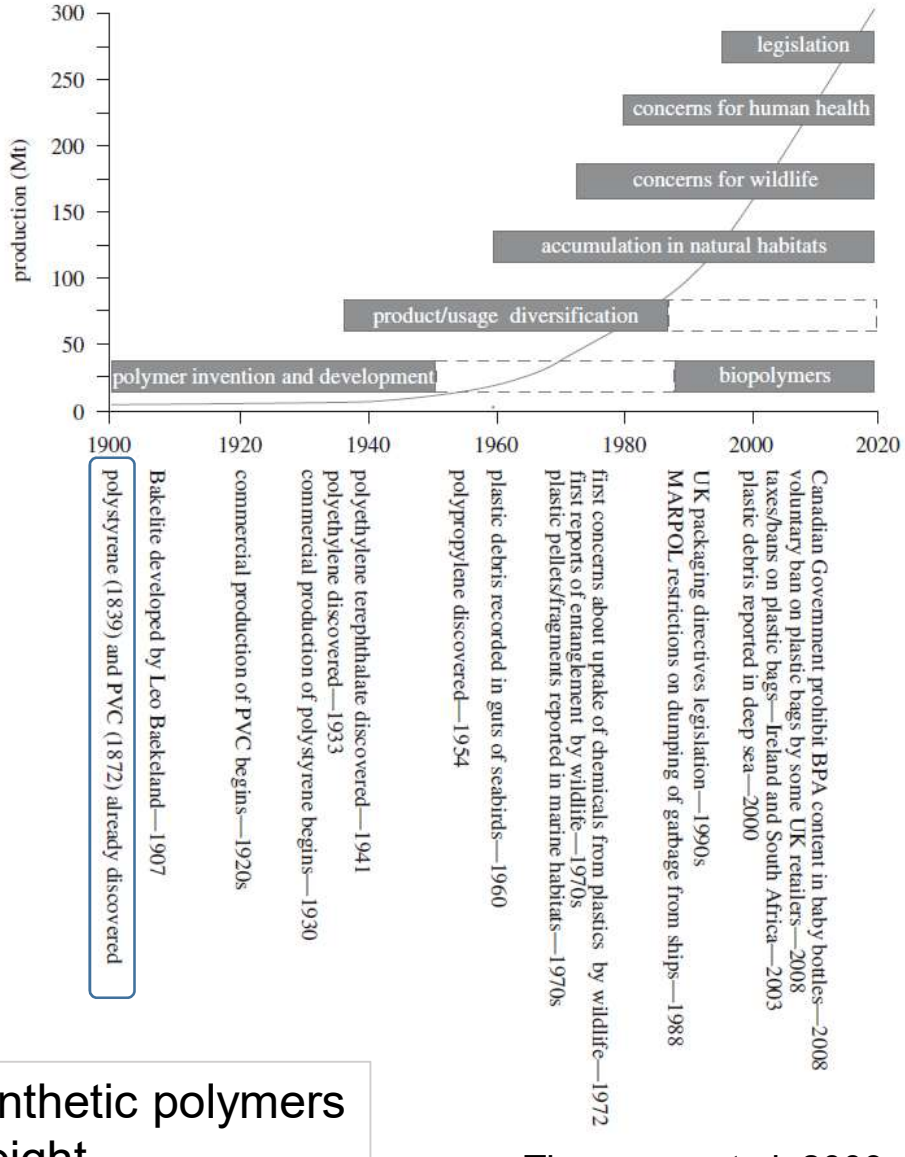
Ban on the sale of products containing microbeads comes into effect.

Published 19 June 2018
From: Department for Environment, Food & Rural Affairs and The Rt Hon Michael Gove MP

We are now in the “plastic age”

Stone age

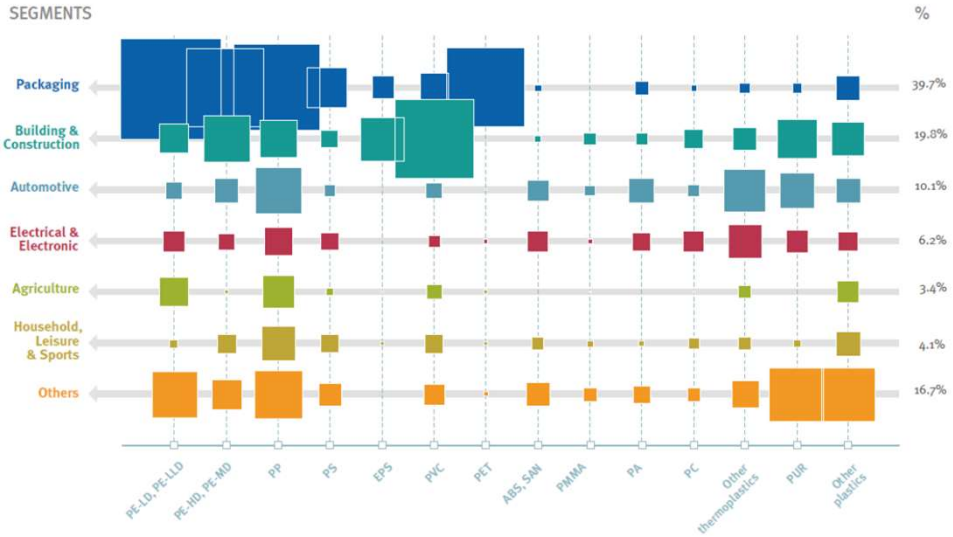
Plastic age



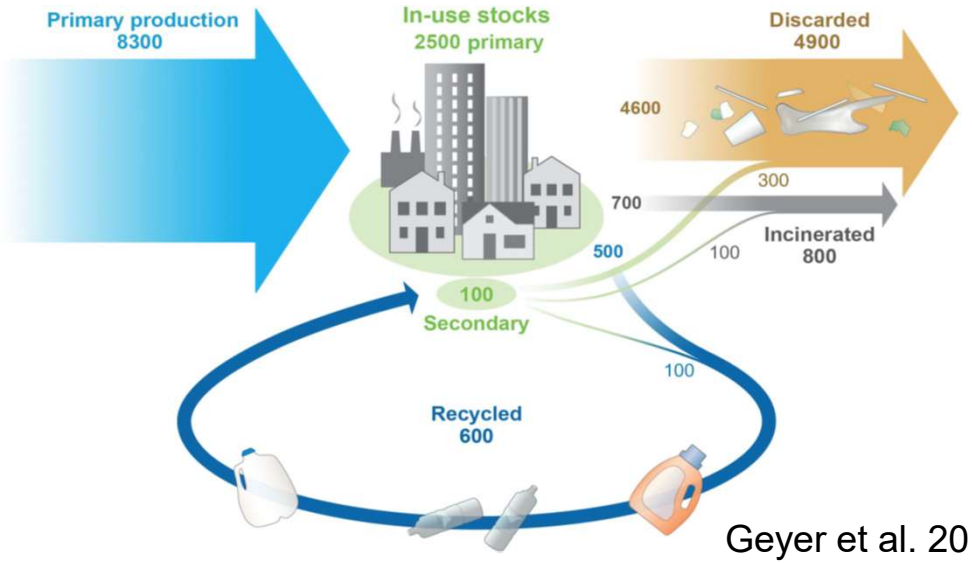
Thompson et al. 2009

Plastics are synthetic or semi-synthetic polymers of high molecular weight

Poor management leads to pollution issues

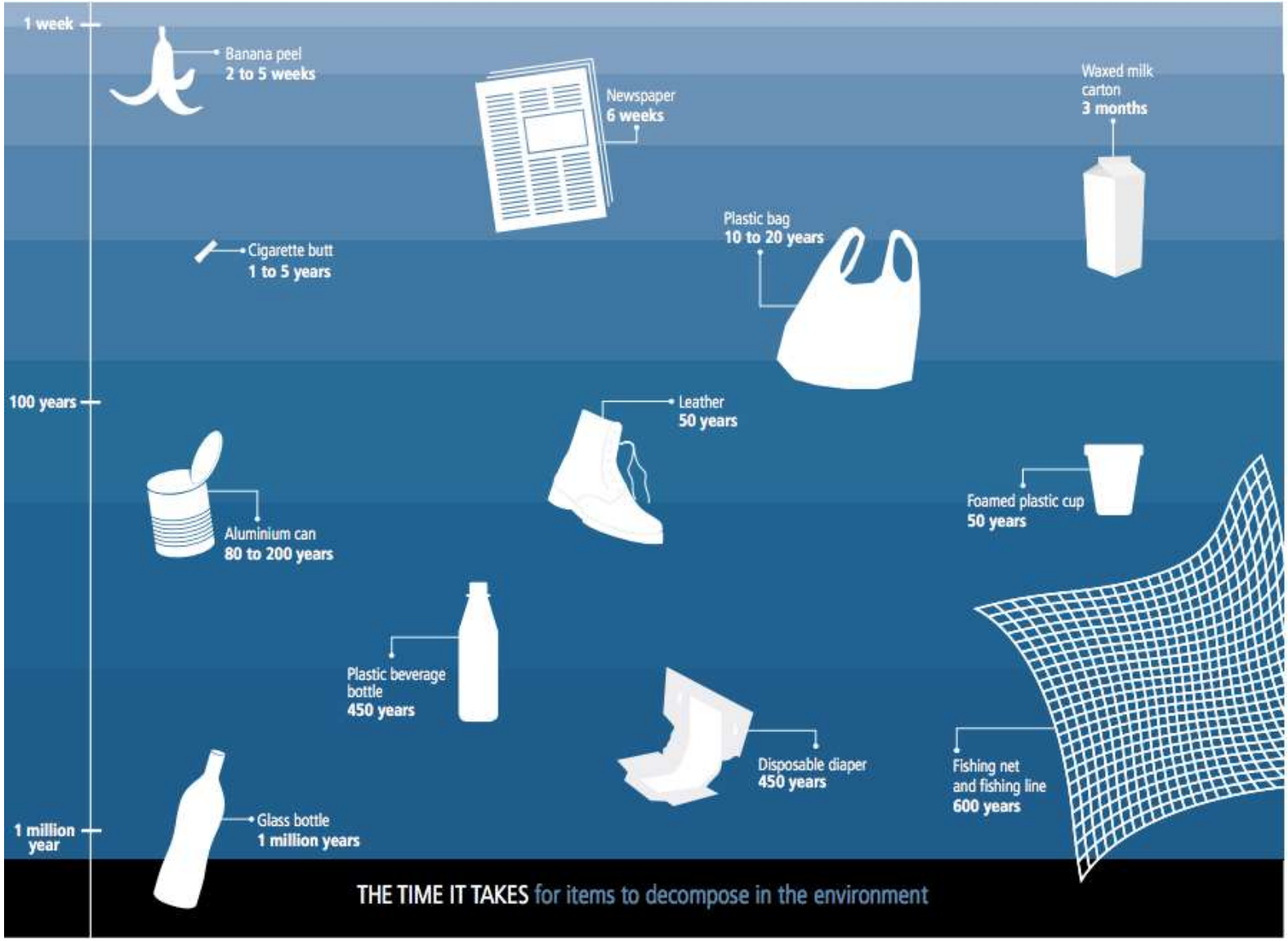


Source: PlasticsEurope



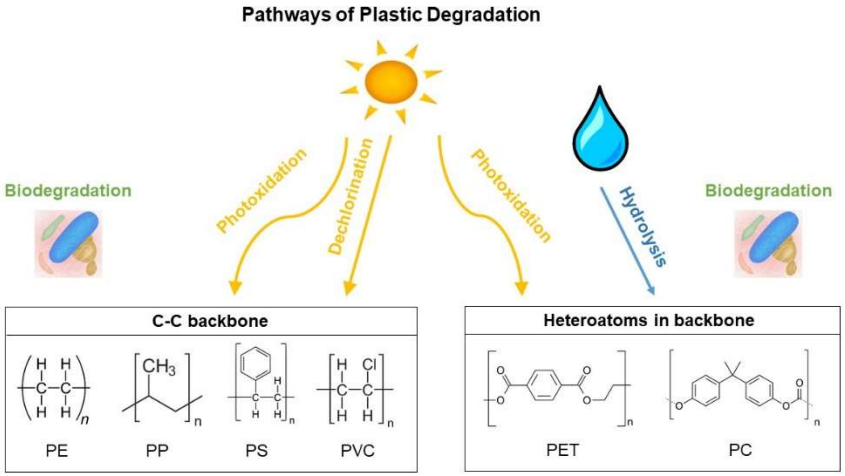
Geyer et al. 2017

Plastics are very persistent in the environment

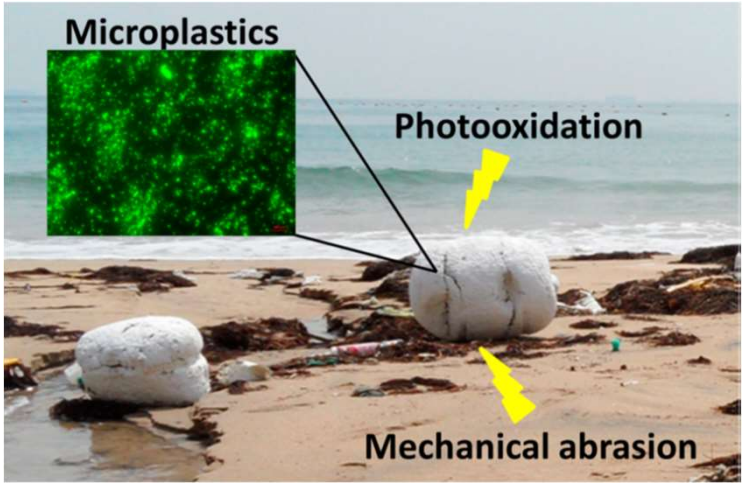


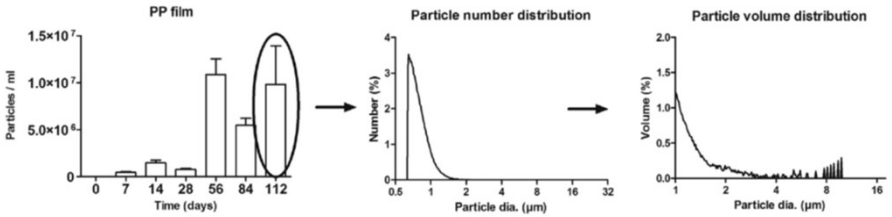
Source: DNV GL®

Plastics slowly decompose into small particles

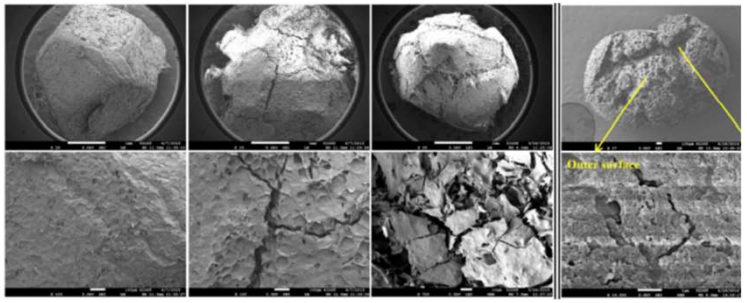


Gewert et al. 2015





Lambert and Wagner 2016

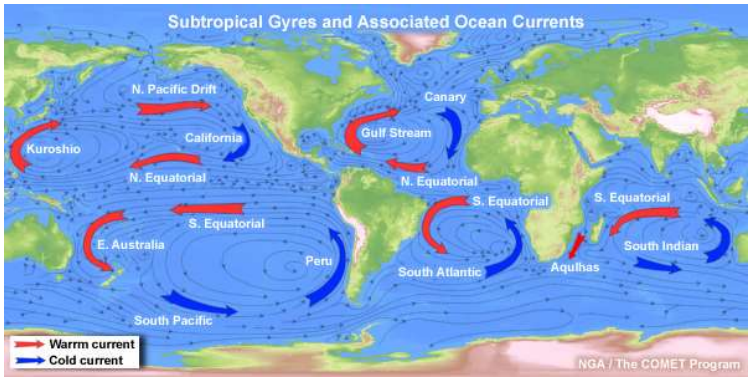


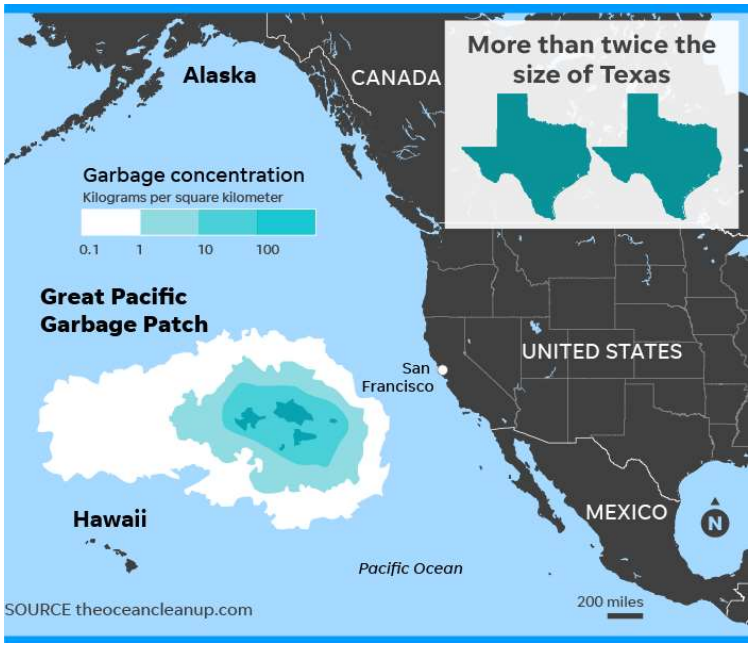
Song et al. 2017

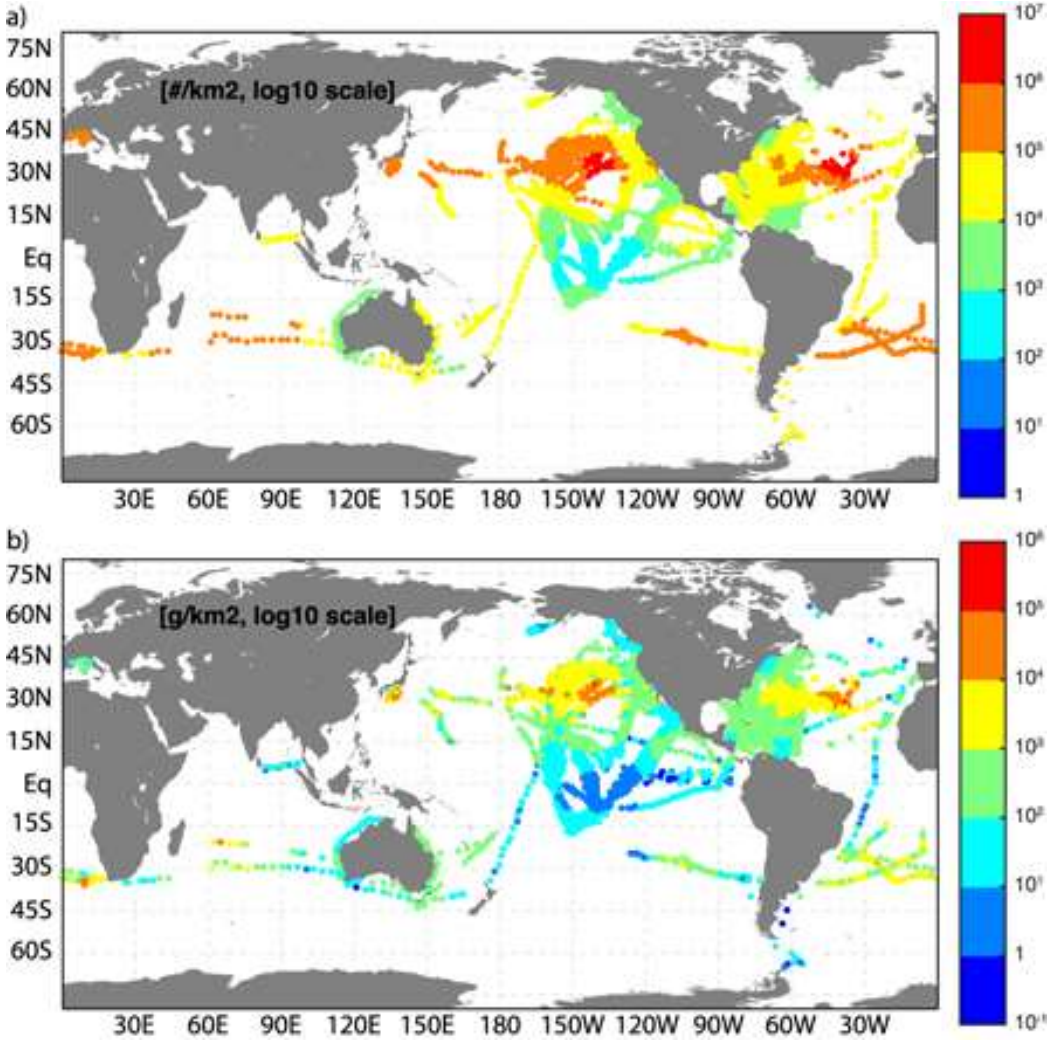
Microplastics: plastic particles <5 mm in size (Thompson et al., 2004)

Microplastics can also originate from primary sources

Oceans are important sinks for microplastics

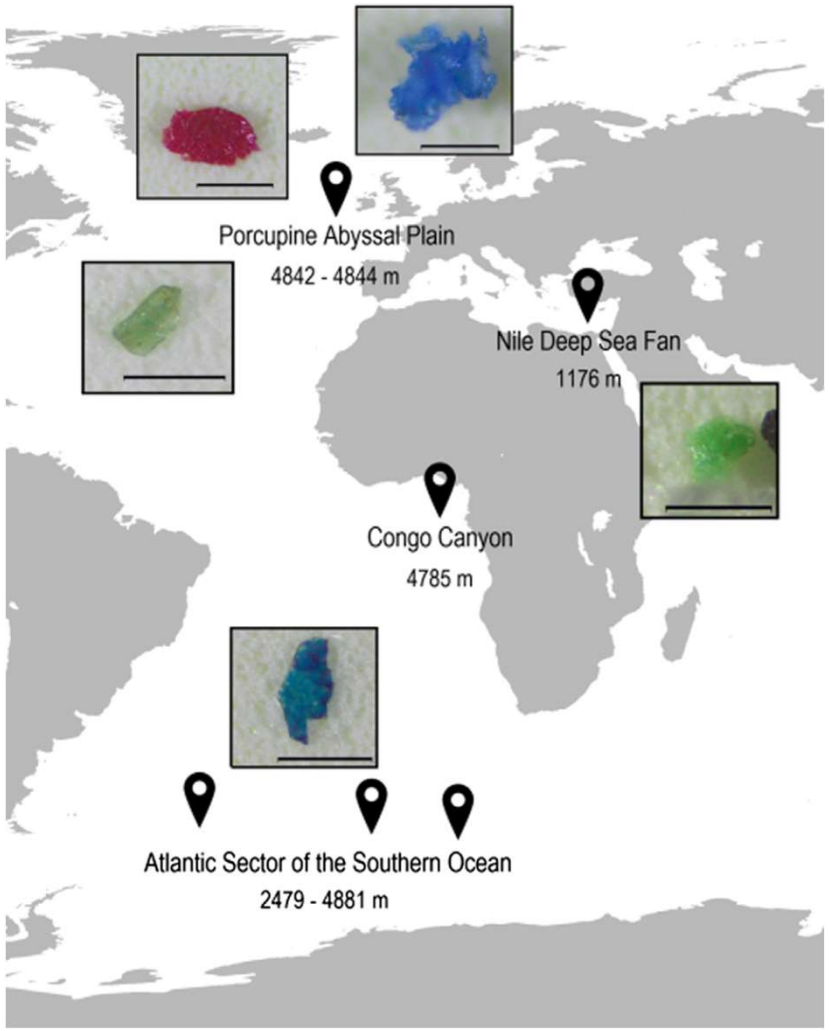




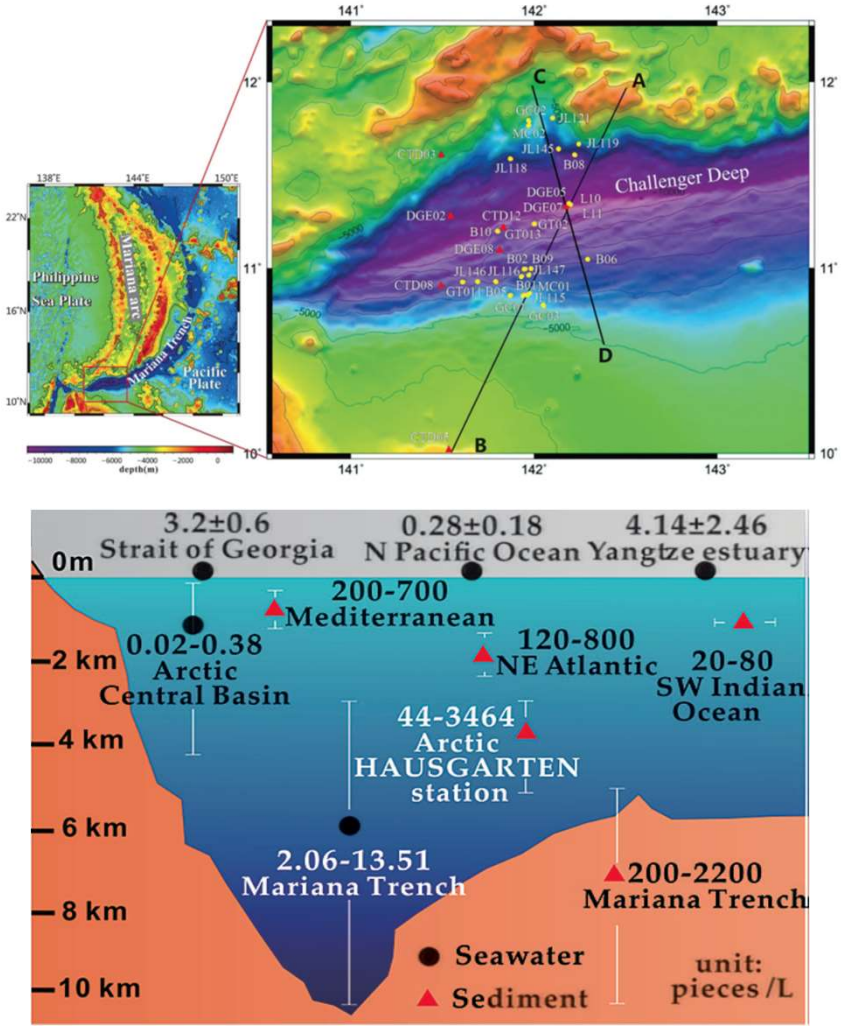


Sebille et al. 2015

The deep sea is a major sink for microplastics

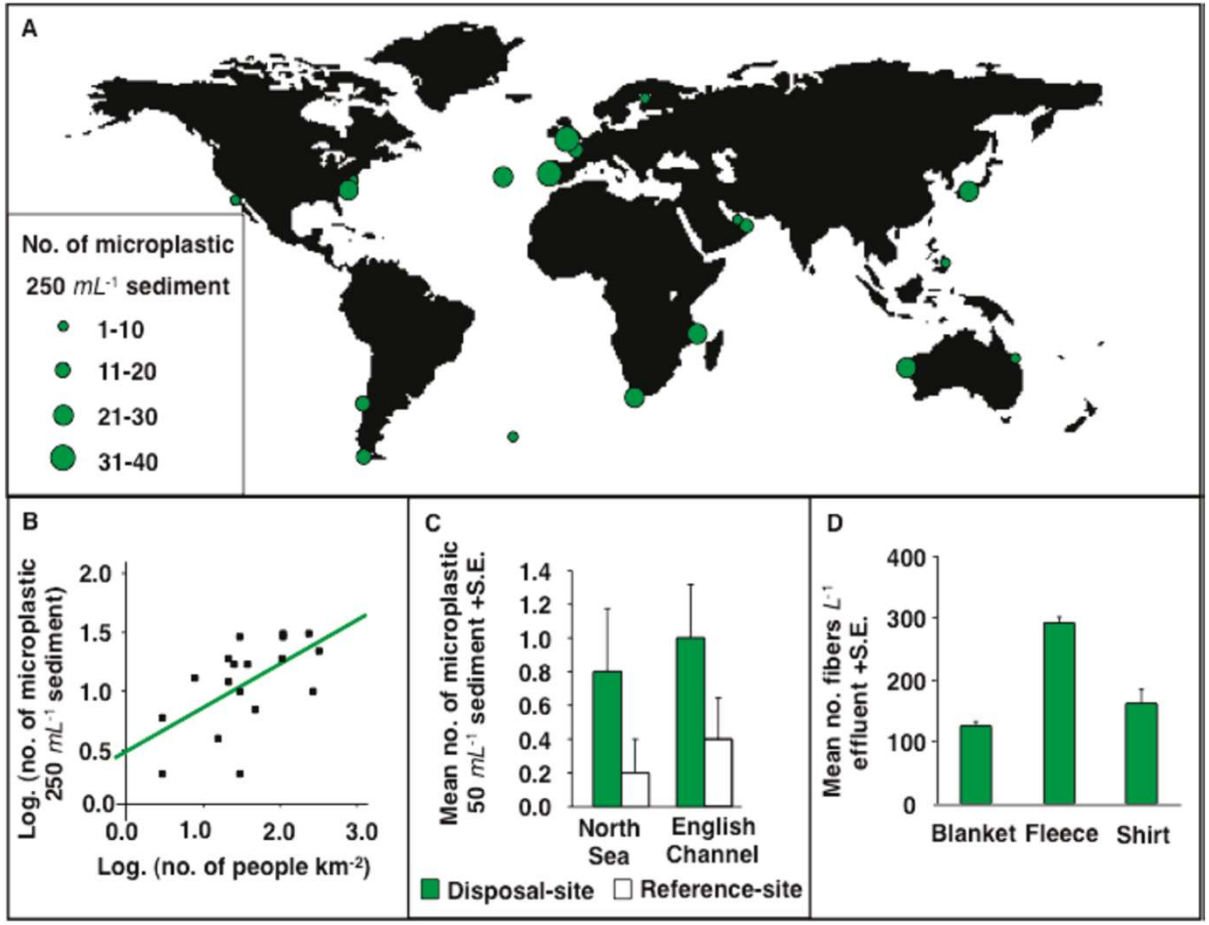


Cauwenberghe et al. 2013



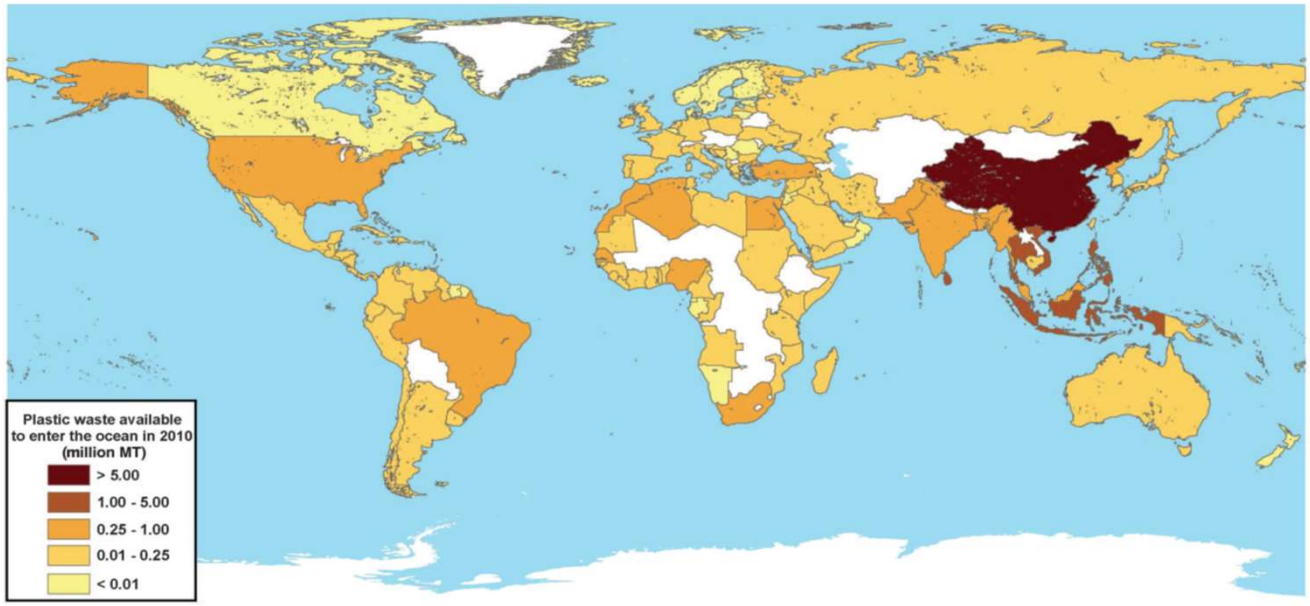
Peng et al. 2018

Coastal environments are vulnerable to microplastic pollution



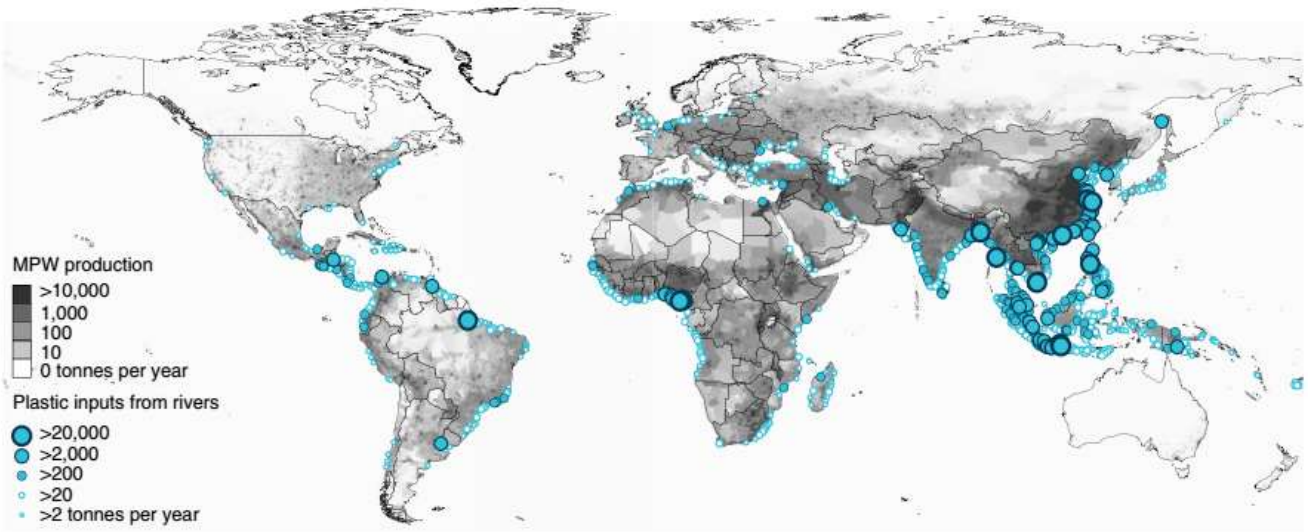
Browne et al. 2011

Land based sources are mainly responsible for ocean pollution



Jambeck et al. 2015

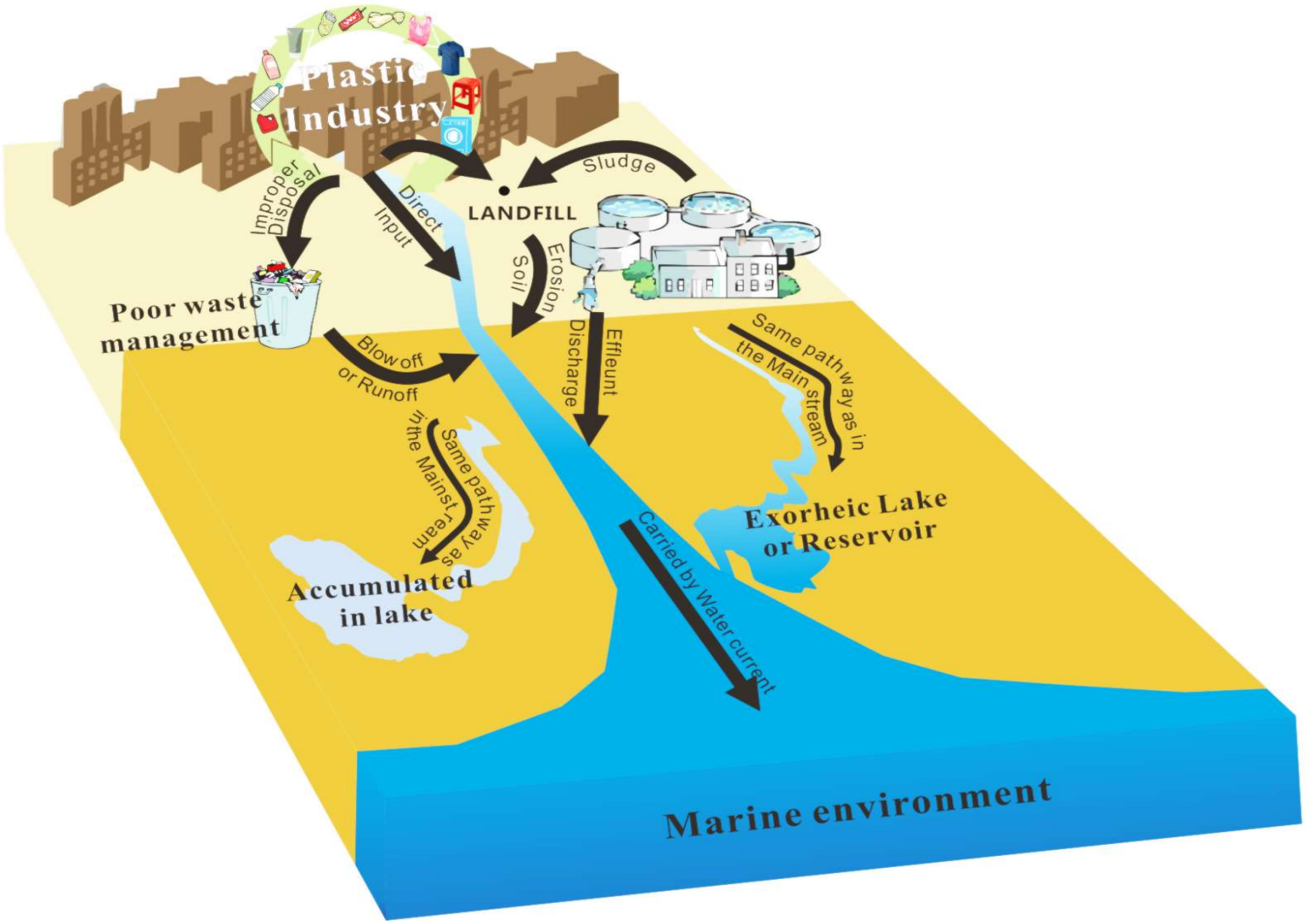
- In 2010, 4.80-12.70 Mt of plastic waste enter oceans from 192 costal countries



Lebreton et al. 2017

- 1.15-2.41 Mt of plastic debris are transported from rivers to oceans yearly

Inland waters are important sink of microplastics on continents



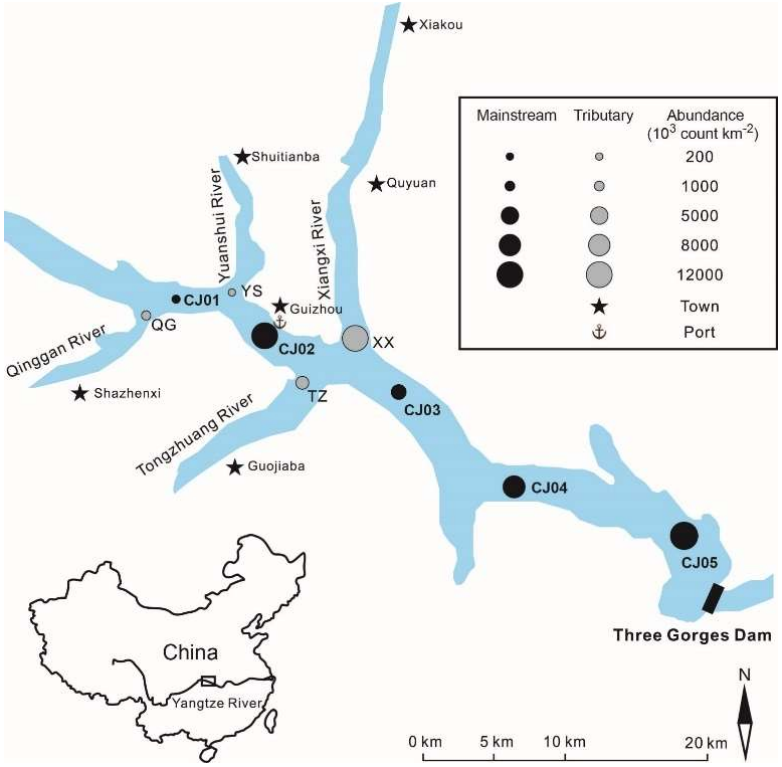
Zhang et al., 2018

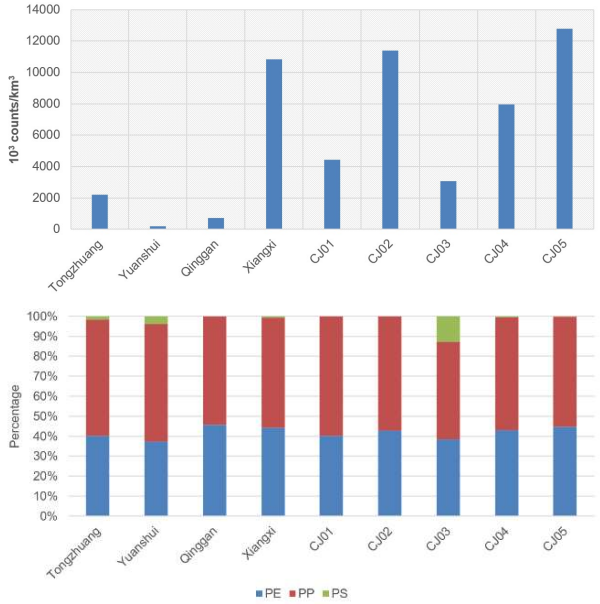
Rivers are more than carriers of microplastics

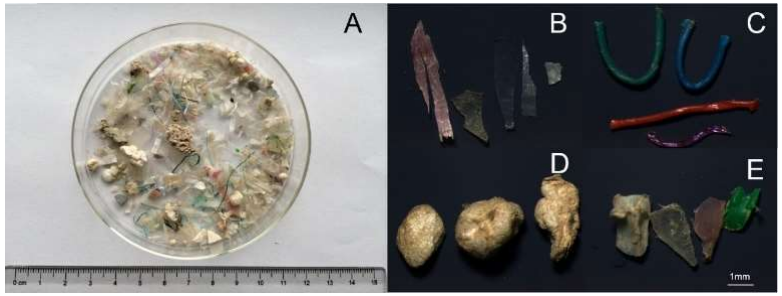
Water body type	Sample type	Sample location and description	Study findings (reported units)	Study findings (converted units)	Study
River	Water	Great Lakes tributaries (USA)	Particle abundance range: 0.05–32 m^{-3}	0.00005–0.032 particles L^{-1}	Baldwin et al. (2016)
River	Water	River Seine, urban area (Paris, France)	Average particle abundance 30 m^{-3} (plankton trawl) Average particle abundance 0.35 m^{-3} (manta trawl)	Average 0.03 particles L^{-1} Average 0.00035 particles L^{-1}	Dris et al. (2015a)
River	Water	Various rivers (Switzerland)	Average particle abundance 7 m^{-3}	Average particles 0.007 L^{-1}	Faure et al. (2015)
River	Water	River Danube (Austria)	Average particle abundance 316.8 m^{-3}	Average 0.32 particles L^{-1}	Lechner et al. (2014)
River	Water	River Rhine (various) sampling depth 18 cm	Average particle abundance 892,777 km^{-2}	Average particles 0.005 L^{-1}	Mani et al. (2015)
River	Water	Nine different rivers, Chicago area (USA)	Average particle abundance 2.4 m^{-3}, upstream sewage treatment works (STW) Average particle abundance 5.7 m^{-3}, downstream STW	Average particles 0.002 L^{-1} Average particles 0.006 L^{-1}	McCormick et al. (2014)
River	Water	Rivers: Papatsco Corsica Rhode Magothy Sampling depth 15 cm	Average particle abundance 155,374 km^{-2} 40,852 km^{-2} 67,469 km^{-2} 112,590 km^{-2}	Average particles 0.001 L^{-1} 0.00027 L^{-1} 0.00045 L^{-1} 0.00075 L^{-1}	Yonkos et al. (2014)
River	Shore sediment	Rivers Rhine and Main (Germany)	Particle abundance range: 228–3763 kg^{-1}	–	Klein et al. (2015)
River	Benthic sediment	Lake Ontario tributaries (Canada)	Average particle abundance 610 kg^{-1}	–	Ballent et al. (2016)
River	Benthic sediment	St Lawrence river sediments, sampling depth 10–15 cm (Canada)	Average particle abundance 13,759 m^{-2}	Average approx. 70.6–105.8 particles kg^{-1} (depending on depth sampled)	Castañeda et al. (2014)
River	Benthic sediment	River Thames Basin (UK), sampling depth approx. 10 cm	Average particle abundance range: 185 kg^{-1} to 660 kg^{-1} depending on site	–	Horton et al. (2016)
River	Benthic sediment	Beijiang River (China)	Particle abundance range: 178–554 particles kg^{-1}	–	Wang et al. (2016)

Horton et al. 2017

Reservoirs are hot spots for the accumulation of microplastics







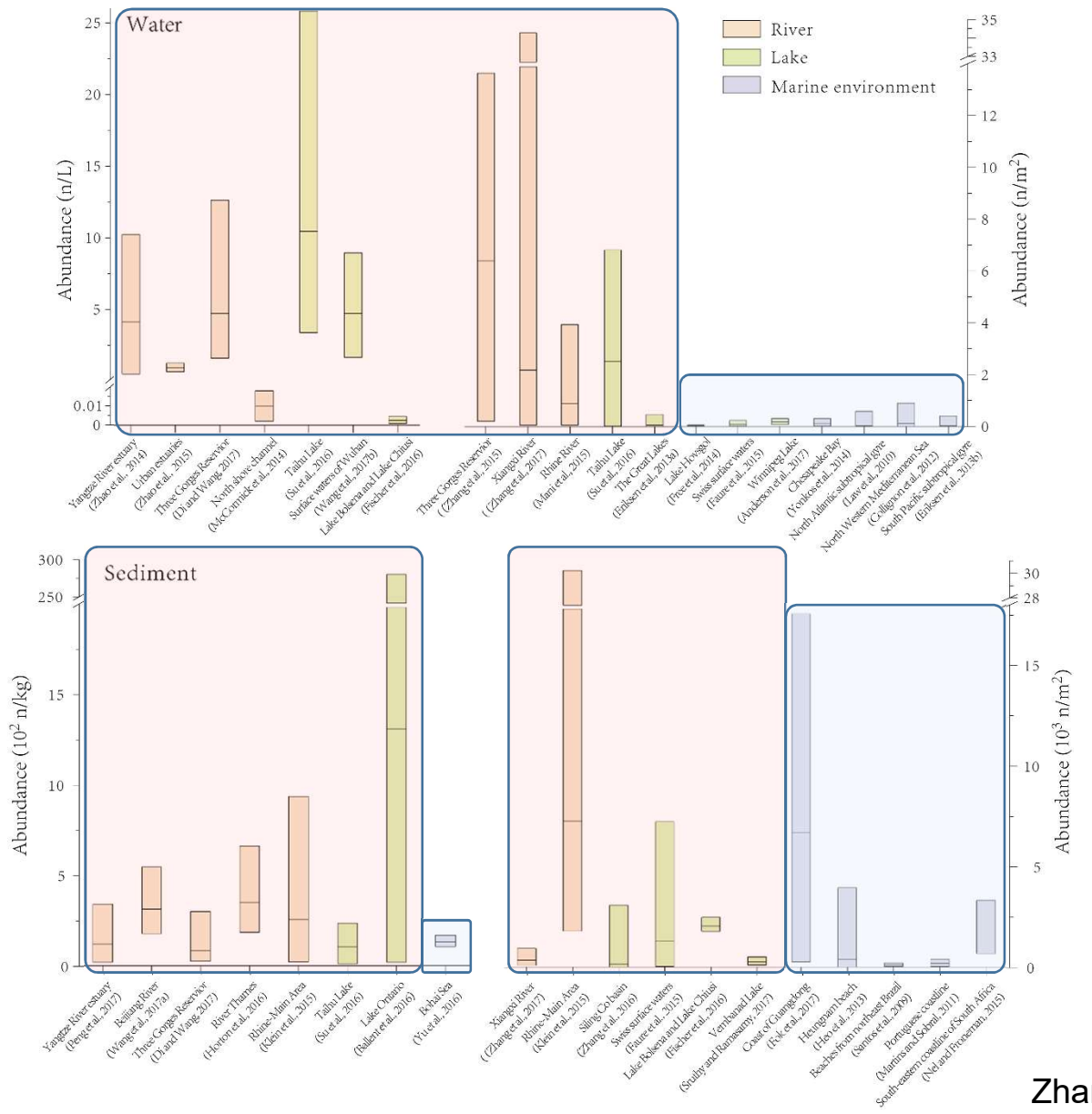
Zhang et al., 2015

Lakes receive microplastic pollution from the drainage basin

Water body type	Sample type	Sample location and description	Study findings (reported units)	Study findings (converted units)	Study
Lake	Water	Great Lakes (USA) 16 cm sampling depth	Average particle concentration 43,000 km^{-2}	Average 0.00027 particles L^{-1}	Eriksen et al. (2013)
Lake	Water	Lake Hovsgol (Mongolia), sampling depth 16 cm	Average particle concentration 20,264 km^{-2}	Average 0.00012 particles L^{-1}	Free et al. (2014)
Lake	Benthic sediment	Lake Ontario (Canada) sampling depth 8 cm	26 particles in 42.2 g (station 403) 9 particles in 103.2 g (station 208)	616.1 particles kg^{-1} (station 403) 87 particles kg^{-1} (station 208)	Corcoran et al. (2015)
Lake	Shore sediment	Lake Garda (Italy), sampling depth 5 cm	Average particle abundance 1108 and 108 m^{-2} (north and south shores respectively)	Average 17 particles kg^{-1} (north) 1.7 particles kg^{-1} (south)	Imhof et al. (2013)
Lake	Shore sediment	Lake Garda (Italy), sampling depth 5 cm	Average particle abundance 75 m^{-2}	Average 1.2 particles kg^{-1}	Imhof et al. (2016)
Lake	Shore sediment	Various lakes (Switzerland), sampling depth 5 cm	Average particle abundance 1300 m^{-2}	Average 20 particles kg^{-1}	Faure et al. (2015)
Lake	Water and shore sediment	Lake Chiusi and Lake Bolsena (Italy)	Average particle abundance 234 kg^{-1}, 3.02 m^{-3} surface water (Chiusi) Average particle abundance 112 kg^{-1}, 2.51 m^{-3} surface water (Bolsena)	Average 0.03 particles L^{-1} surface water (Chiusi) Average 0.025 particles L^{-1} surface water (Bolsena)	Fischer et al. (2016)
Lake	Water and benthic sediment	Taihu Lake (China)	Particle abundance range: 3.4–25.8 L^{-1} surface water 11–234.6 kg^{-1} benthic sediment	–	Su et al. (2016)

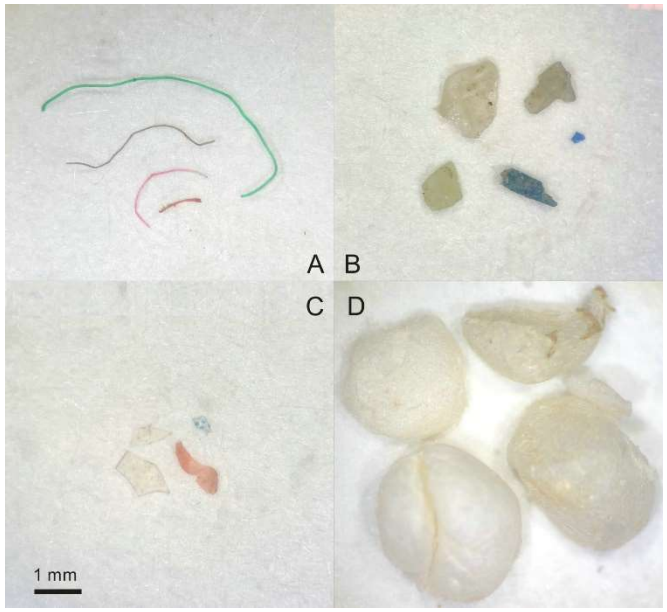
Horton et al. 2017

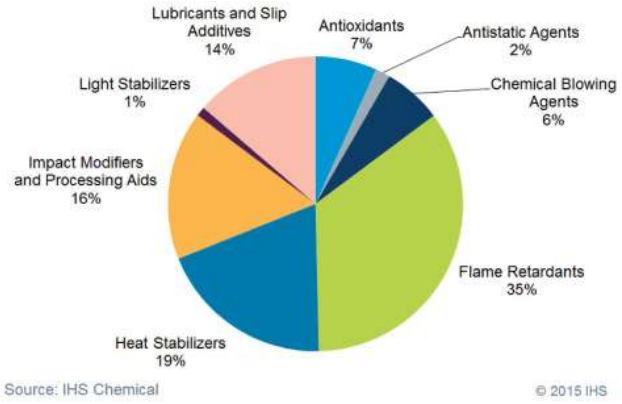
Microplastic pollution in inland waters can be more serious

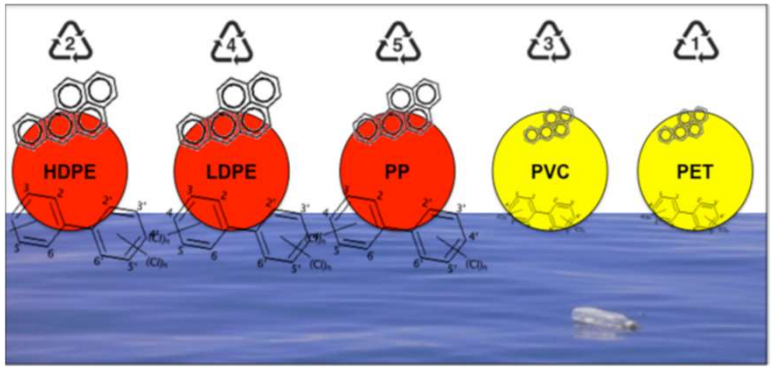


Zhang et al., 2018

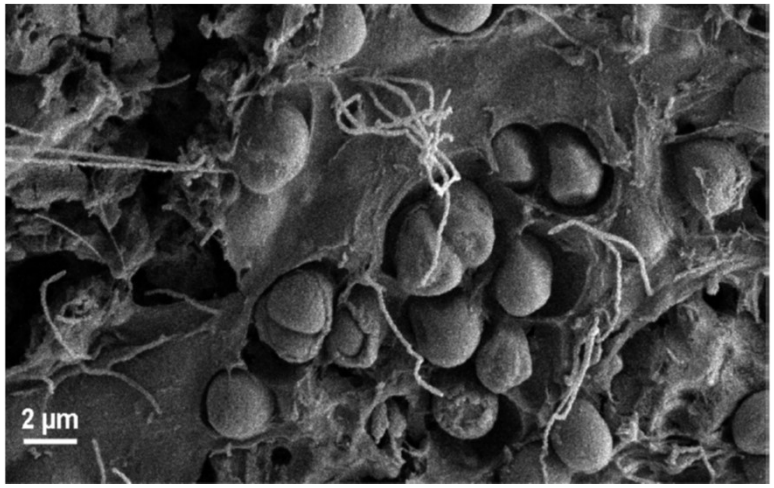
Characteristics of microplastics in the aquatic environment







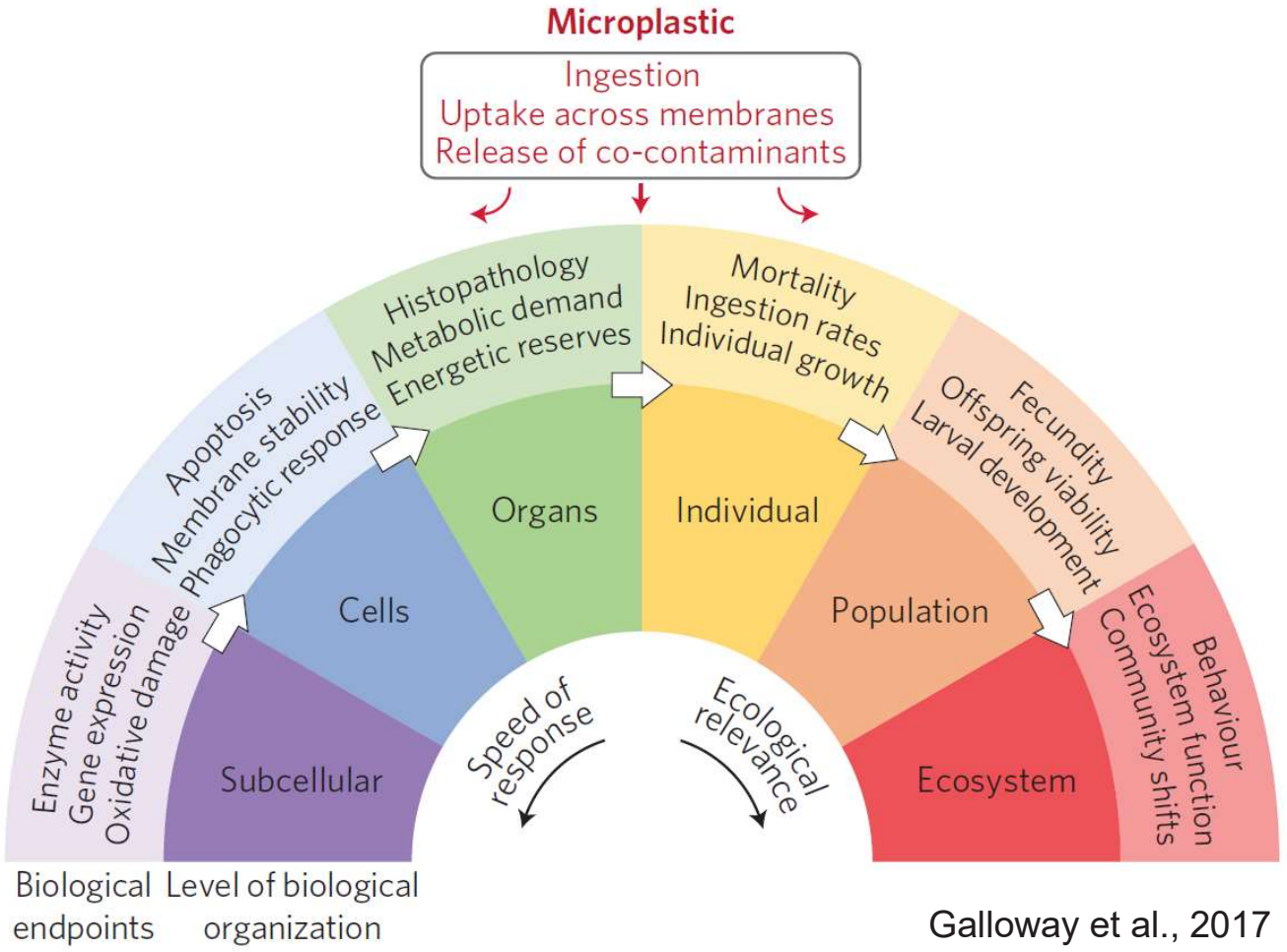
Rochman et al. 2012



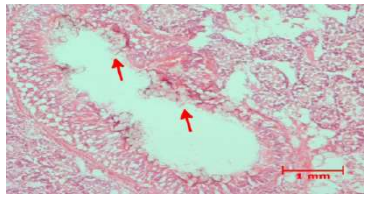
Zettler et al. 2013

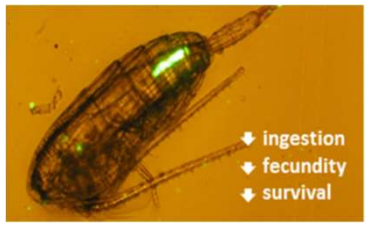
Microplastics are cocktails of pollutants

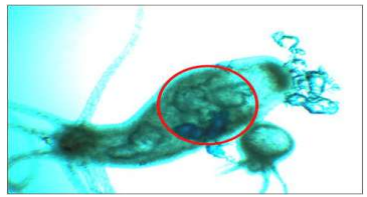
Potential effects of microplastics

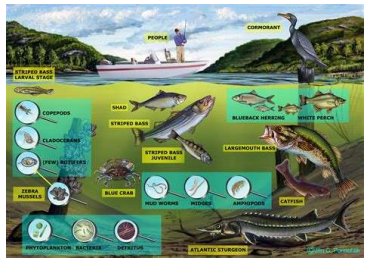


Galloway et al., 2017



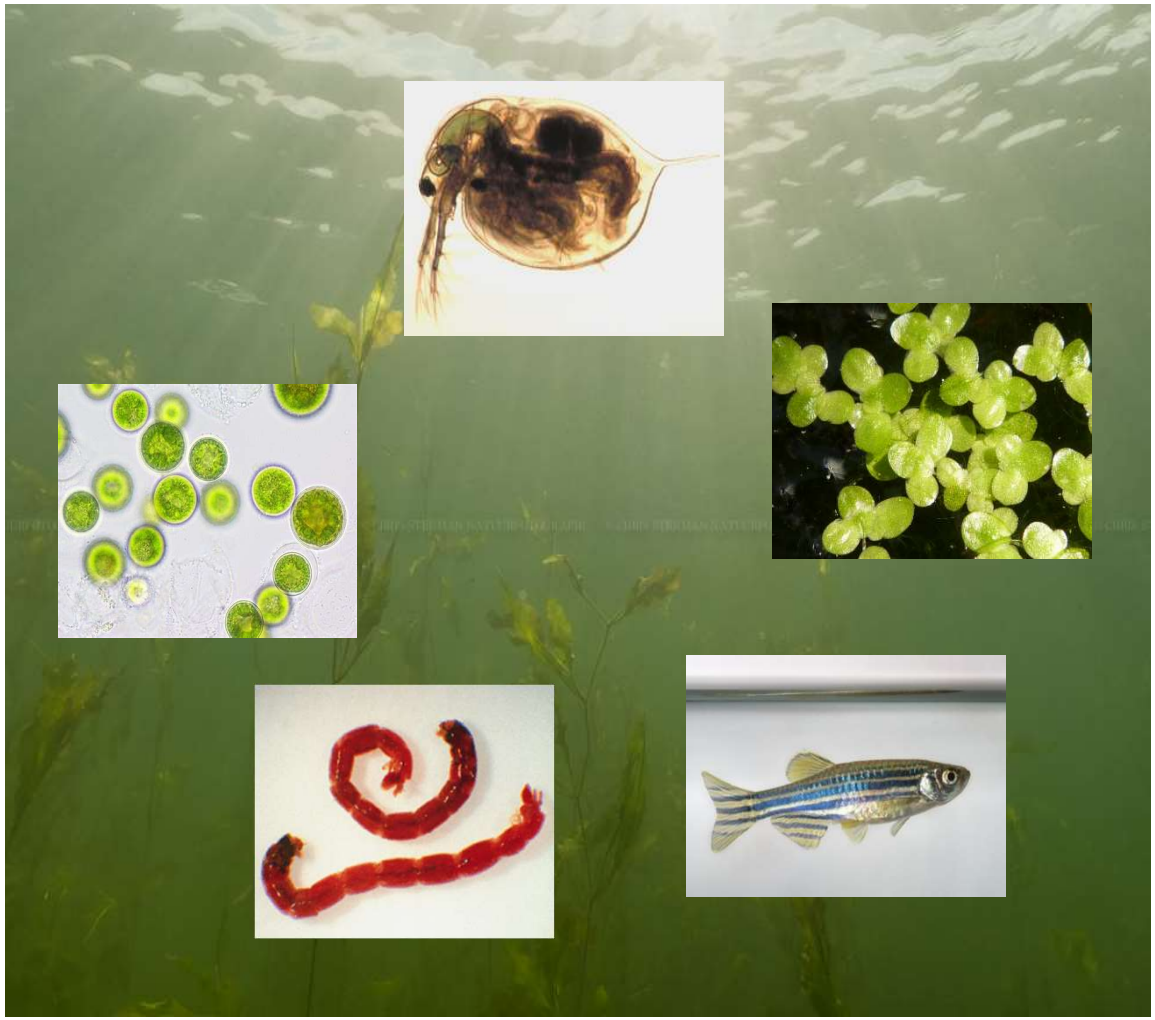






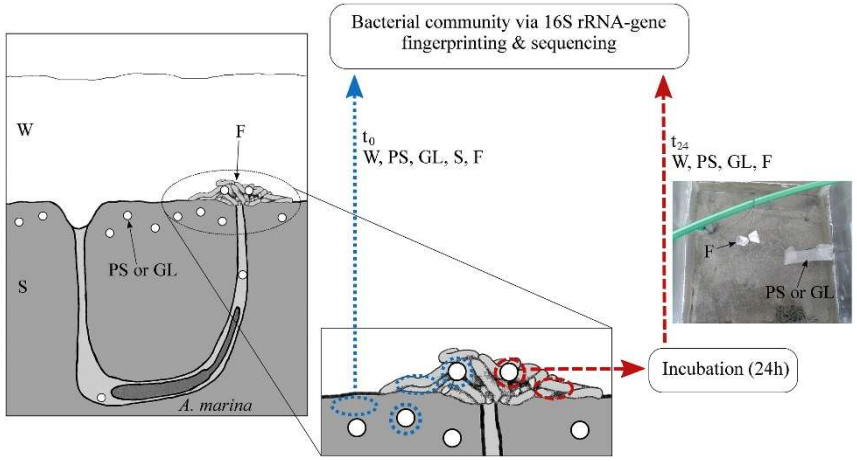
Microplastics are expected to adversely affect organisms from subcellular to ecosystem levels

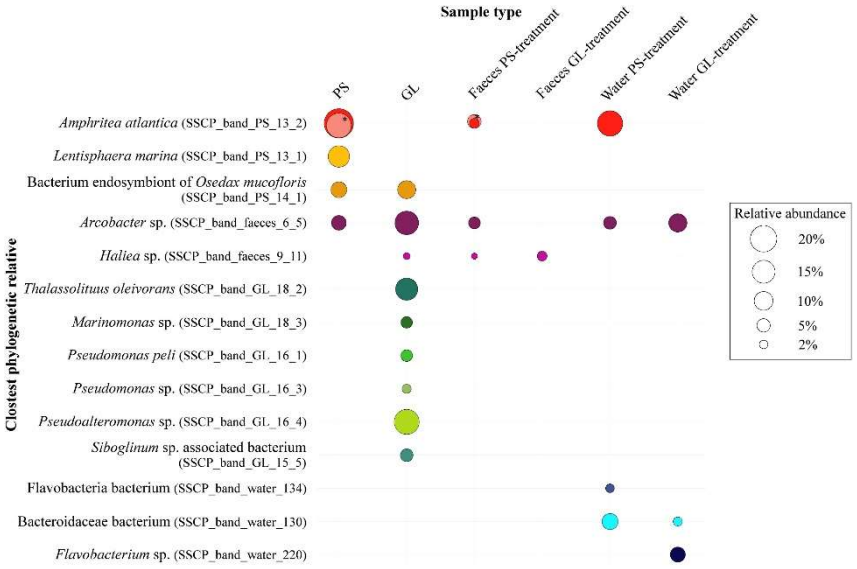
Observed effects of microplastics on aquatic organisms



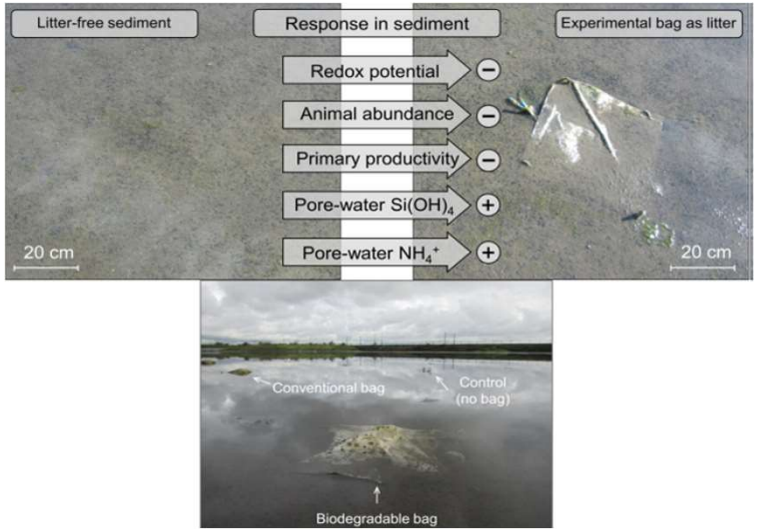
Behavioral effects	
Motion	Feeding
Reproductive effects	
Growth	Reproduction
Mortality	
Stress response	
Immune	Oxidative
inflammation	
Genetic effects	
Gene expression	
Combined effects	
Organic pollutants	Heavy metals
Pathogens	

Observed effects of microplastics on aquatic ecosystem

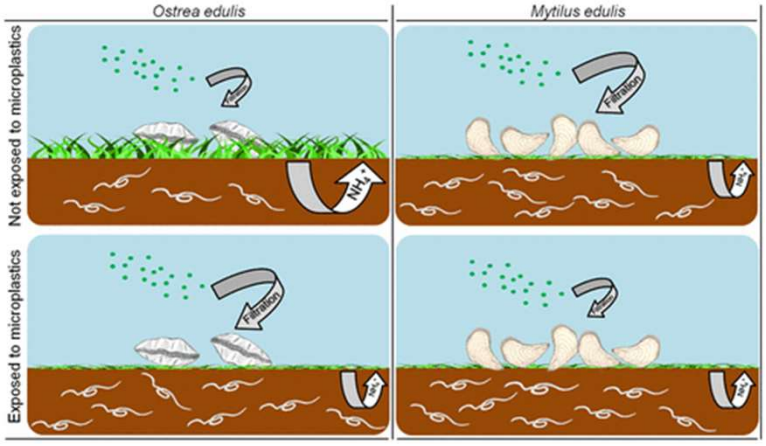




Kesy et al. (2016)



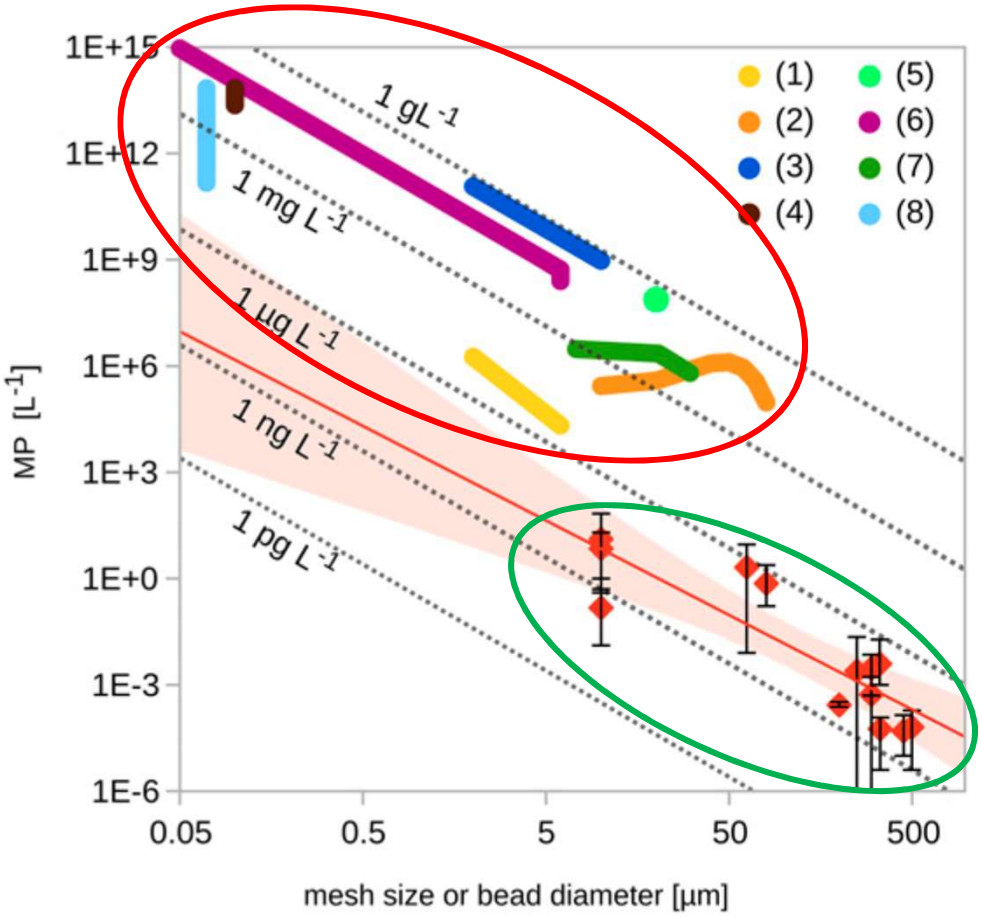
Green et al. (2015)



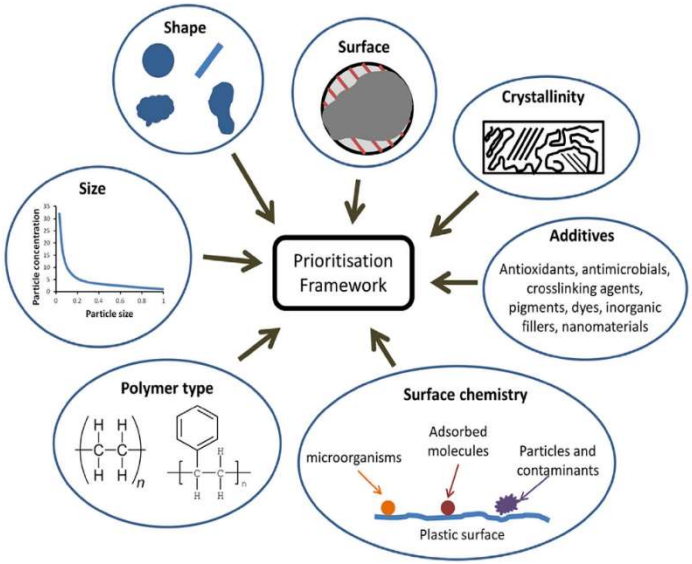
Green et al. (2017)

Microplastics affect the microbial community and ecosystem functions

Observed effects of microplastics on aquatic ecosystem



Lenz et al. 2016



Lambert et al. 2017

Big discrepancy exist between microplastics observed in the field and those used in the toxicity studies

Summary

- Extensive use of plastics have already caused serious global environmental issues
- Microplastics are ubiquitous in the aquatic environment
- Microplastics can be ingested by aquatic animals and cause potential adverse effects
- Environmental and ecological risks of microplastics are still unclear
- Additional works are required to elucidate the real risks of microplastics and to better support the government decision-making

Thank you!

Q & A

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