PLASTICS AND OCEAN HEALTH

Mark Hahn

(mhahn@whoi.edu)

Woods Hole Oceanographic Institution

John Stegeman

Kara Lavender Law

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WILL STAHL-TIMMINS

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*Author affiliations can be found in the back matter of this article

ABSTRACT

Background: Plastics have conveyed great benefits to humanity and made possible some of the most significant advances of modern civilization in fields as diverse as medicine, electronics, aerospace, construction, food packaging, and sports. It is now clear, however, that plastics are also responsible for significant harms to human health, the economy, and the earth's environment. These harms occur at every stage of the plastic life cycle, from extraction of the coal, oil, and gas that are its main feedstocks through to ultimate disposal into the environment. The extent of these harms not been systematically assessed, their magnitude not fully quantified, and their economic costs not comprehensively counted.

Annals of Global Health

ORIGINAL RESEARCH

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CORRESPONDING AUTHOR:
Philip J. Landrigan, MD, MSc
Global Observatory on Planetary Health, Boston College, Chestnut Hill, MA, US; Centre Scientifique de Monaco, Medical Biology Department, MC
landrigp@bc.edu

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plastic life cycle; human health; ocean health; microplastics; plastic additives; environmental health

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John Stegeman

Kara Lavender Law

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PLASTICS AND OCEAN HEALTH

- Distribution and fates of plastics in the ocean
- Plastics in marine biota and food webs
- Impacts of plastics in the ocean
- Knowledge gaps and Recommendations

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Plastics contaminate the marine environment globally

Plastics on the Sargasso Sea Surface

Abstract. *Plastic particles, in concentrations averaging 3500 pieces and 290 grams per square kilometer, are widespread in the western Sargasso Sea. Pieces are brittle, apparently due to the weathering of the plasticizers, and many are in a pellet shape about 0.25 to 0.5 centimeters in diameter. The particles are surfaces for the attachment of diatoms and hydroids. Increasing production of plastics, combined with present waste-disposal practices, will undoubtedly lead to increases in the concentration of these particles. Plastics could be a source of some of the polychlorinated biphenyls recently observed in oceanic organisms.*

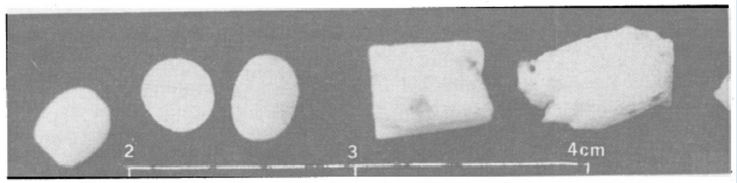

Fig. 1. Typical plastic particles from tow 2. White pellets are on the left.

EDWARD J. CARPENTER
K. L. SMITH, JR.
Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543

Polystyrene Spherules in Coastal Waters

Abstract. *Polystyrene spherules averaging 0.5 millimeter in diameter (range 0.1 to 2 millimeters) are abundant in the coastal waters of southern New England. Two types are present, a crystalline (clear) form and a white, opaque form with pigmentation resulting from a diene rubber. The spherules have bacteria on their surfaces and contain polychlorinated biphenyls, apparently absorbed from ambient seawater, in a concentration of 5 parts per million. White, opaque spherules are selectively consumed by 8 species of fish out of 14 species examined, and a chaetognath. Ingestion of the plastic may lead to intestinal blockage in smaller fish.*

EDWARD J. CARPENTER
SUSAN J. ANDERSON, GEORGE R. HARVEY
HELEN P. MIKLAS, BRADFORD B. PECK
Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543

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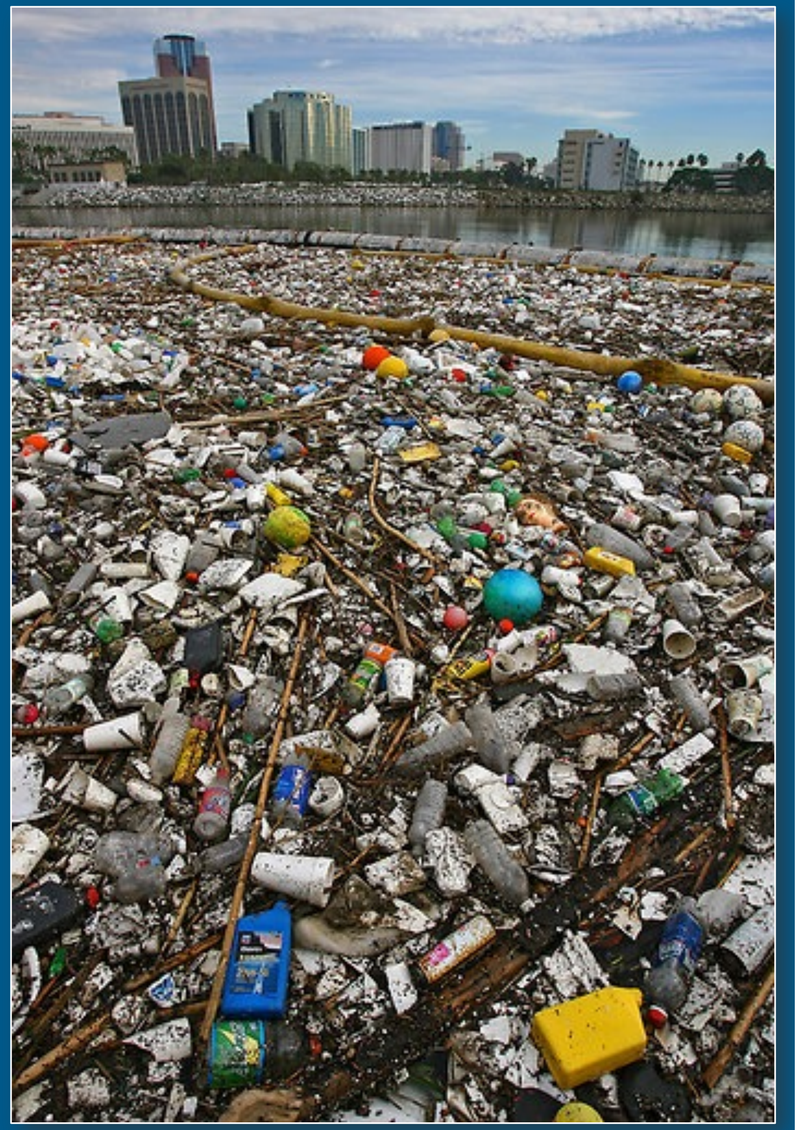

Rick Loomis/L.A. Times

Plastics contaminate the marine environment globally

Plastic Accumulation in the North Atlantic Subtropical Gyre

Kara Lavender Law,[1*] Skye Morét-Ferguson,[1,2] Nikolai A. Maximenko,[3] Giora Proskurowski,[1,2] Emily E. Peacock,[2] Jan Hafner,[3] Christopher M. Reddy[2]

Plastic marine pollution is a major environmental concern, yet a quantitative description of the scope of this problem in the open ocean is lackin
at the surface of the western North Atlantic Oce
than 60% of 6136 surface plankton net tows col
in size. The highest concentration of plastic deb
associated with the observed large-scale conver
dynamics. Despite a rapid increase in plastic pr
trend in plastic concentration was observed in t

Plastics are a major contaminant in the world's oceans. Their chemically engineered durability and slow rate of biodegradation (*1*) allow these synthetic polymers to withstand the ocean environment for years to

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microbial and colonizing species to potentially non-native waters (*6*, *7*), and concentration and transport of organic contaminants to marine organisms at multiple trophic levels (*8–10*). In the open ocean, the abundance, distribution, and temporal and spatial variability of plastic debris are poorly known, despite an increasing awareness of the problem. Although high concentrations of floating plastic debris have been found in the Pacific Ocean (*11–14*), only limited data exist to

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Research

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Received: 18 September 2014
Accepted: 18 November 2014

Subject category:
Earth science

The deep sea is a major sink for microplastic debris

Lucy C. Woodall[1], Anna Sanchez-Vidal[2], Miquel Canals[2], Gordon L. J. Paterson[1], Rachel Coppock[3], Victoria Sleight[3], Antonio Calafat[2], Alex D. Rogers[4],

nature COMMUNICATIONS

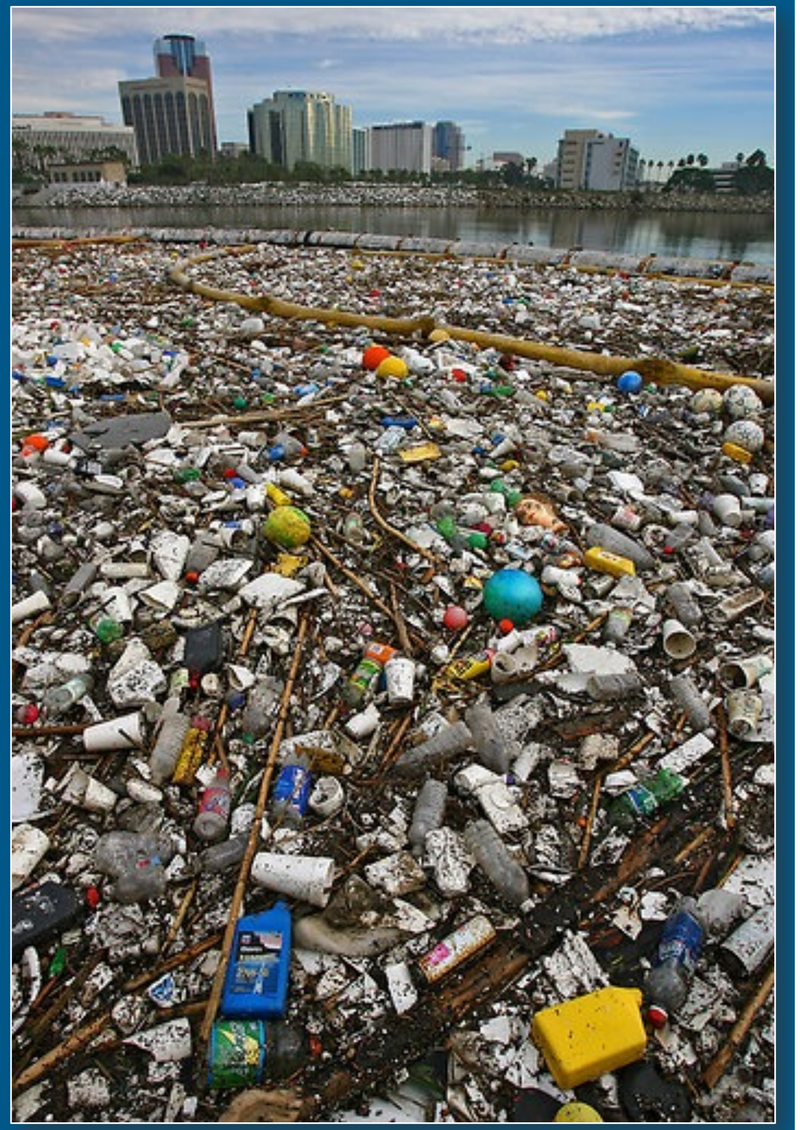
ARTICLE

DOI: 10.1038/s41467-018-03825-5 OPEN

Arctic sea ice is an important temporal sink and means of transport for microplastic

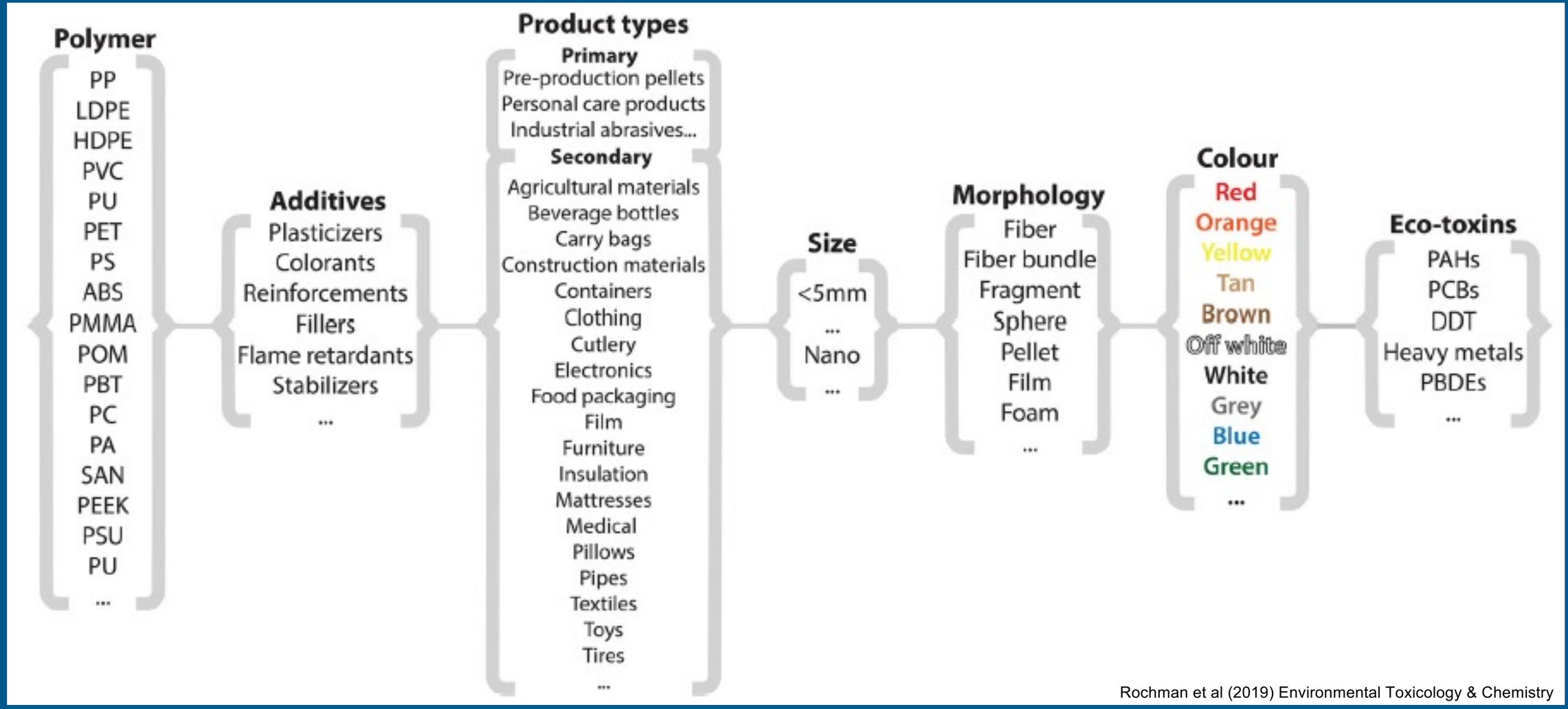
Ilka Peeken[1], Sebastian Primpke[1], Birte Beyer[1], Julia Gütermann[1], Christian Katlein[1], Thomas Krumpen[1], Melanie Bergmann[1], Laura Hehemann[1] & Gunnar Gerdts[1]

Microplastics (MP) are recognized as a growing environmental hazard and have been identified as far as the remote Polar Regions, with particularly high concentrations of microplastics in sea ice. Little is known regarding the horizontal variability of MP within sea ice and how the underlying water body affects MP composition during sea ice growth. Here we show that sea ice MP has no uniform polymer composition and that, depending on the growth region and drift paths of the sea ice, unique MP patterns can be observed in different sea ice horizons. Thus even in remote regions such as the Arctic Ocean, certain MP indicate the presence of localized sources. Increasing exploitation of Arctic resources will likely lead to a higher MP load in the Arctic sea ice and will enhance the release of MP in the areas of strong seasonal sea ice melt and the outflow gateways.



Rick Loomis/L.A. Times

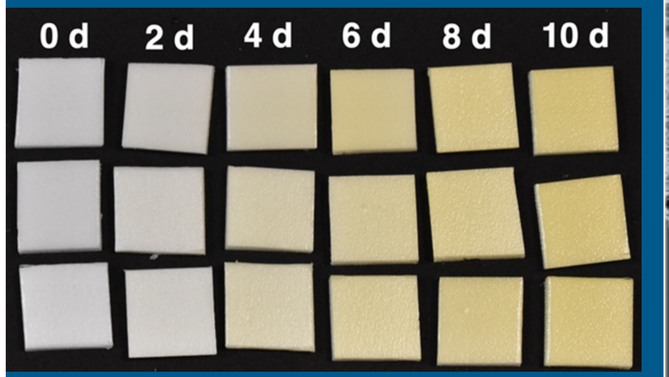
Plastics in the ocean are incredibly diverse and complex



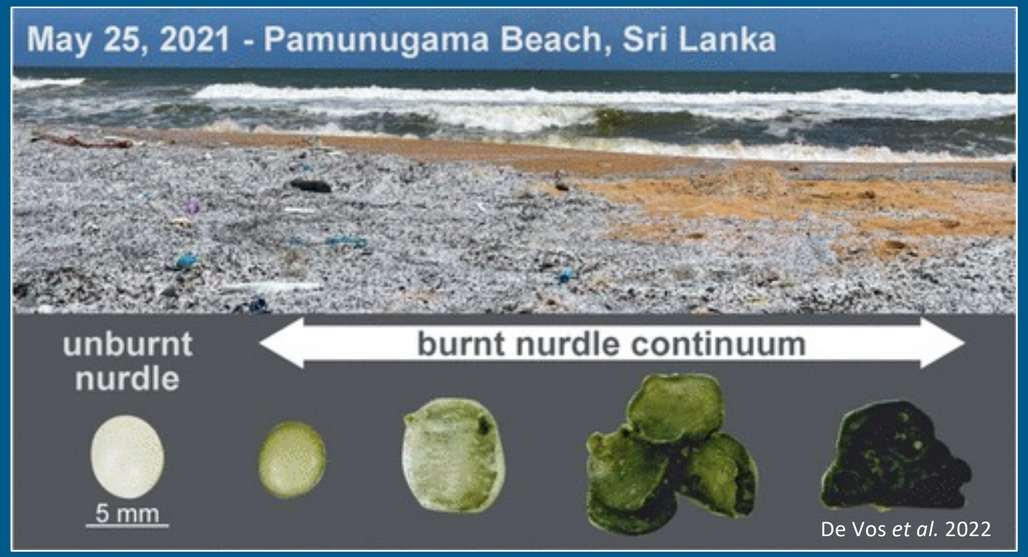
Rochman et al (2019) Environmental Toxicology & Chemistry

Plastics become even more complex in the marine environment

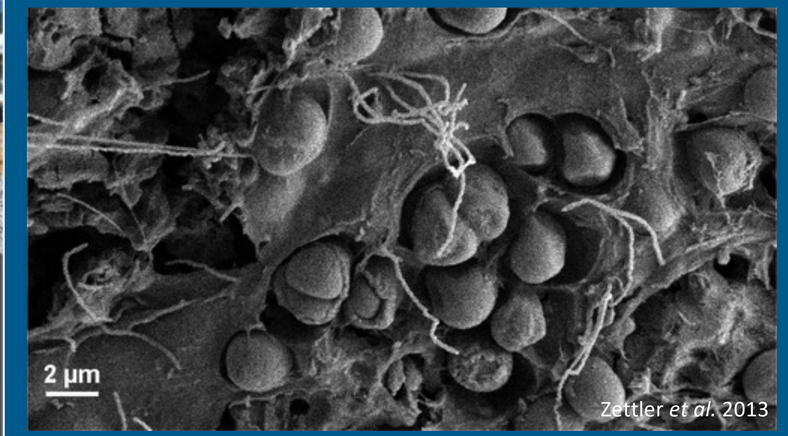
Plastics are transformed by chemical, physical, and biological processes in the marine environment.



Collin Ward (WHOI)



De Vos *et al.* 2022

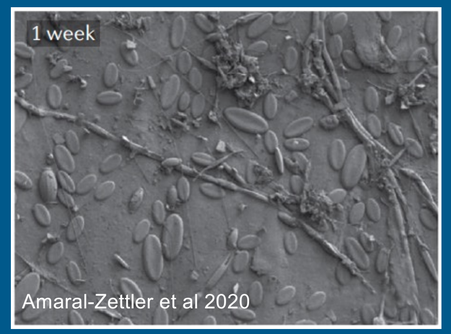


Zettler *et al.* 2013

These transformations do not lead to complete removal of plastics from the marine environment.

Marine organisms interact with plastics in several ways

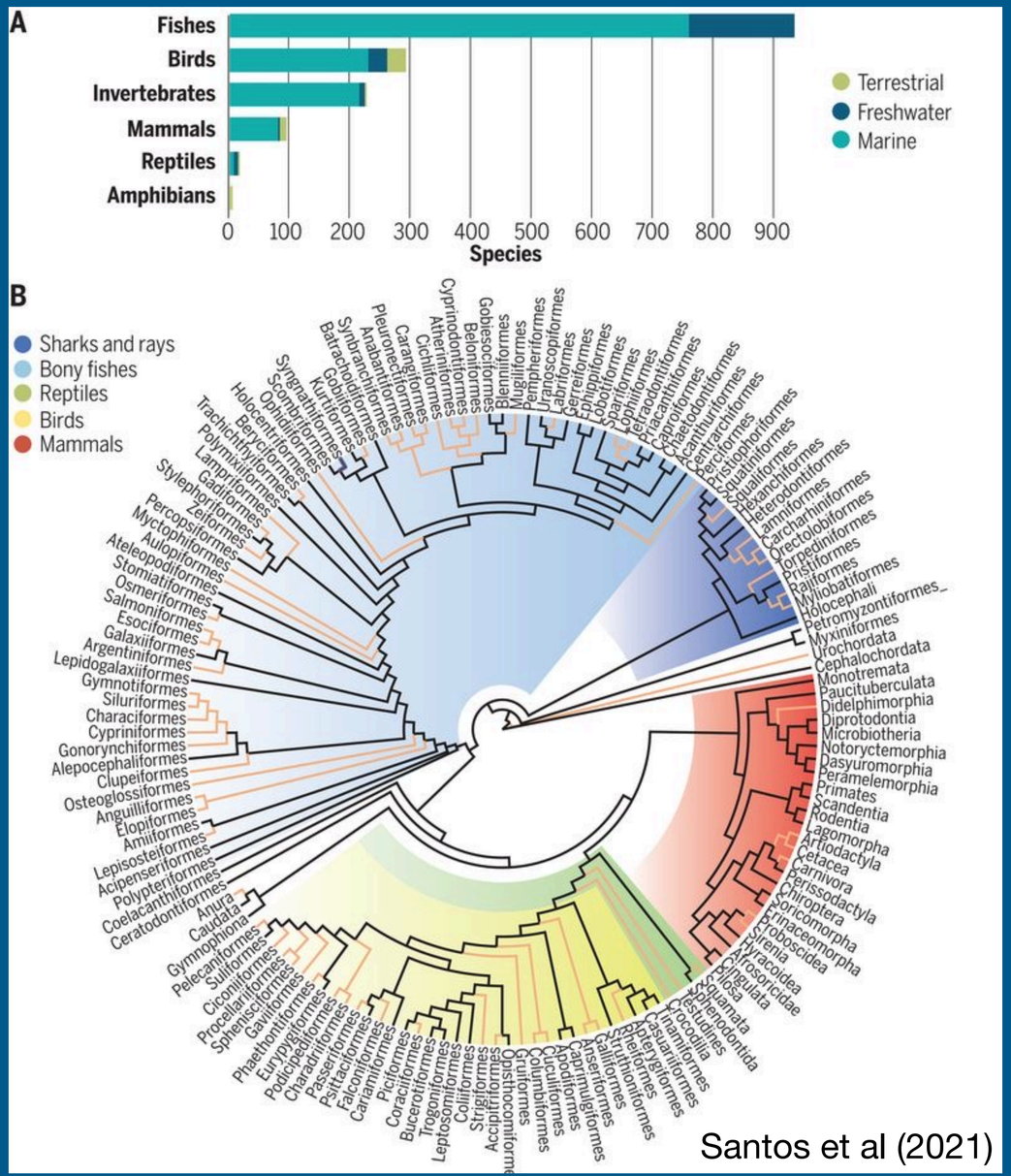
Colonization



Entanglement

Ingestion

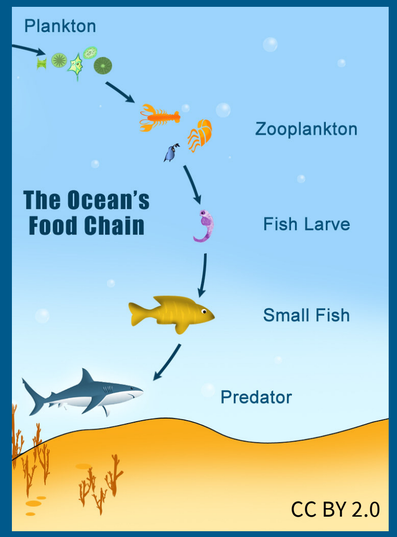
Plastic ingestion has been documented in over 1200 marine species, from a variety of taxa



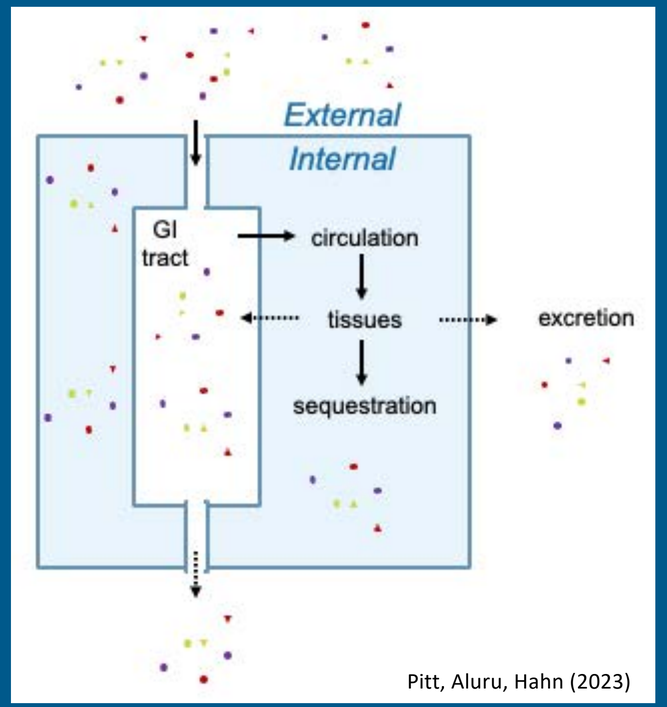
Santos et al (2021)

Behavior of microplastics in marine food webs

Trophic transfer

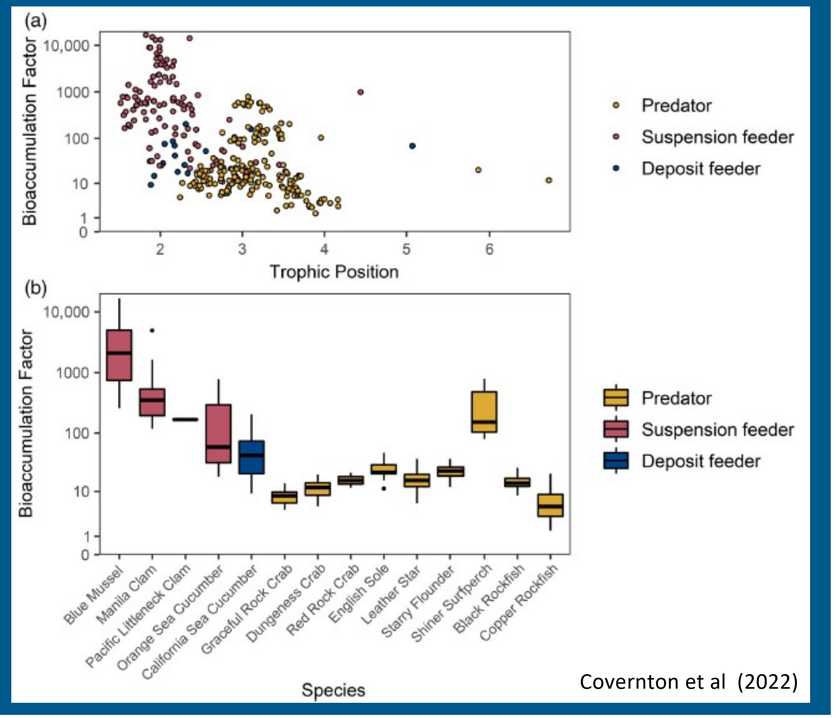


Bioaccumulation



Pitt, Aluru, Hahn (2023)

Biomagnification



Covernton et al (2022)

Nanoplastics??

Microplastics in seafood vs. other sources

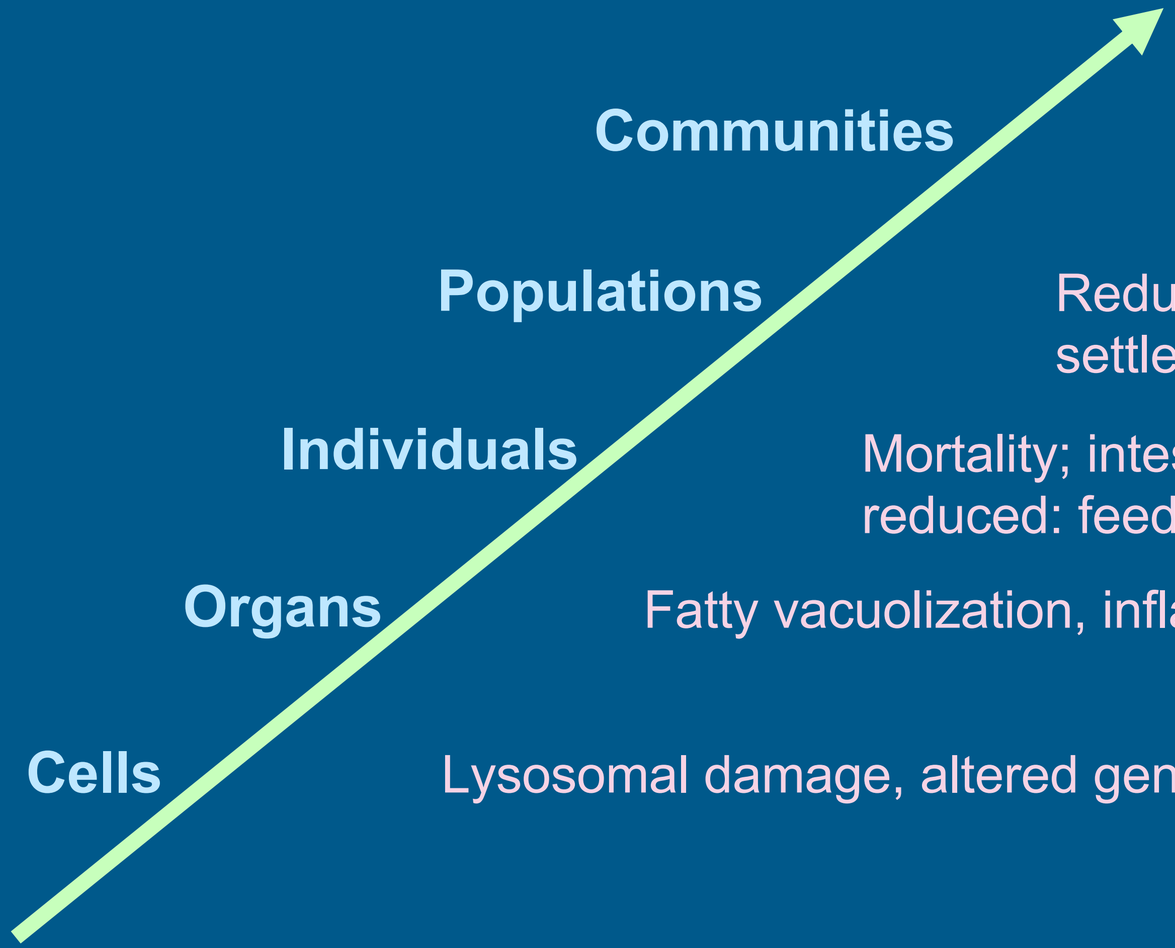
Microplastics consumption (annual particle intake per capita)

	Cox et al. 2019	Domenech & Marcos 2021	Zhang et al. 2020
Shellfish			0 – 13,000
Total seafood	17,448	22,000	
Fruits & vegetables		19 x 10^9	
Bottled water	15,156	2,610 – 3.96 x 10^{10}	
Tap water	3,358		0 – 4,700
Total water			0 – 2.8 x 10^{10}
Salt	86	261	0 – 73,000
Alcohol	294	26	
Honey	73		
Sugar	8,319		
Indoor air	46,501	2,160	1,900 – 100,000

Landrigan et al. 2023
Ann Global Health

Impacts of Plastics in the Ocean

Levels of Biological Organization



Ecosystems — Reduced primary productivity, altered carbon export, deoxygenation

Communities — Reduced species diversity

Populations — Reduced fecundity, hatching success, larval settlement

Individuals — Mortality; intestinal obstruction; coral bleaching; reduced: feeding behavior, growth, photosynthesis

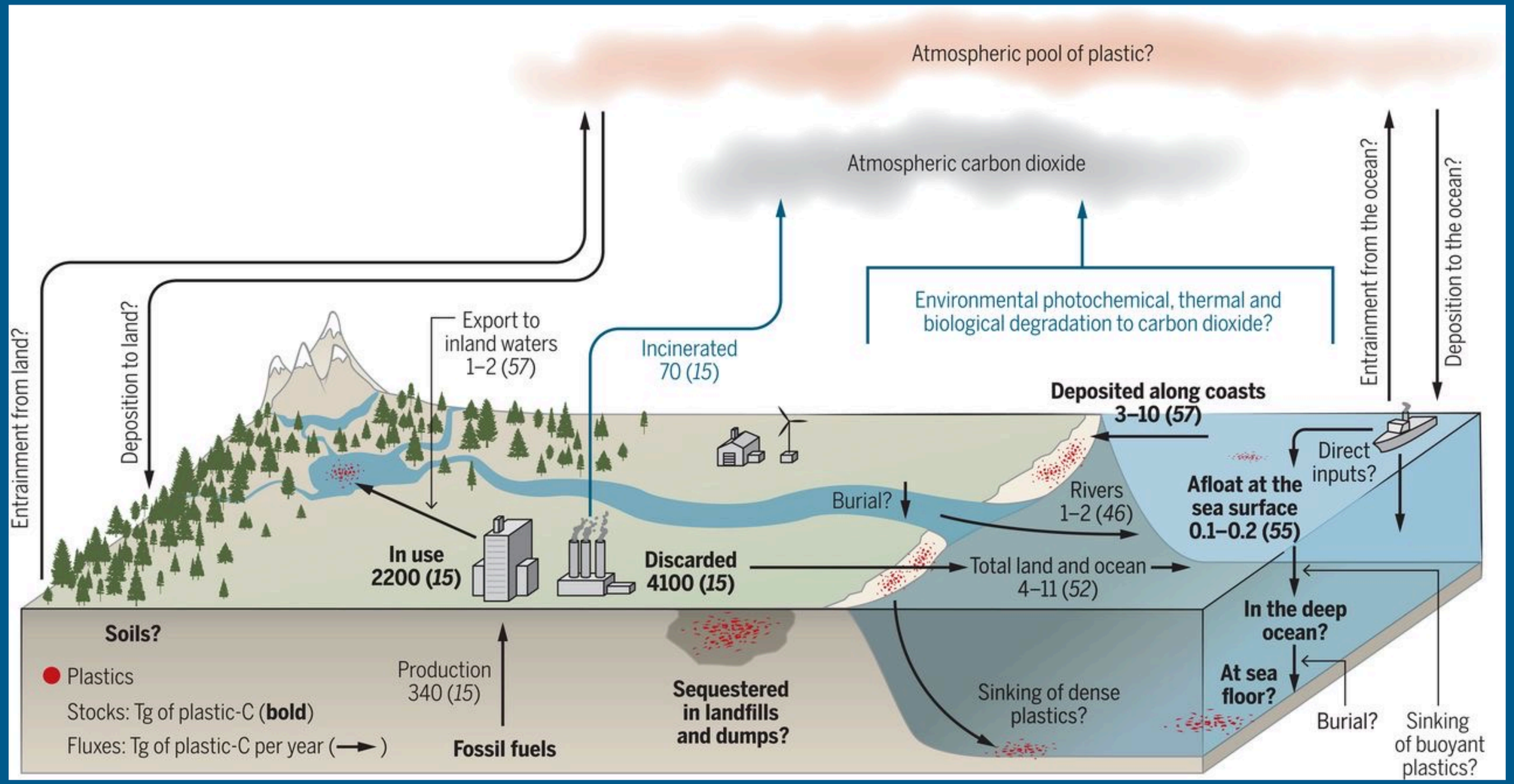
Organs — Fatty vacuolization, inflammation, fibrosis, altered microbiome

Cells — Lysosomal damage, altered gene expression

Molecules — ROS generation, oxidative stress, lipid peroxidation, reduced enzyme activity

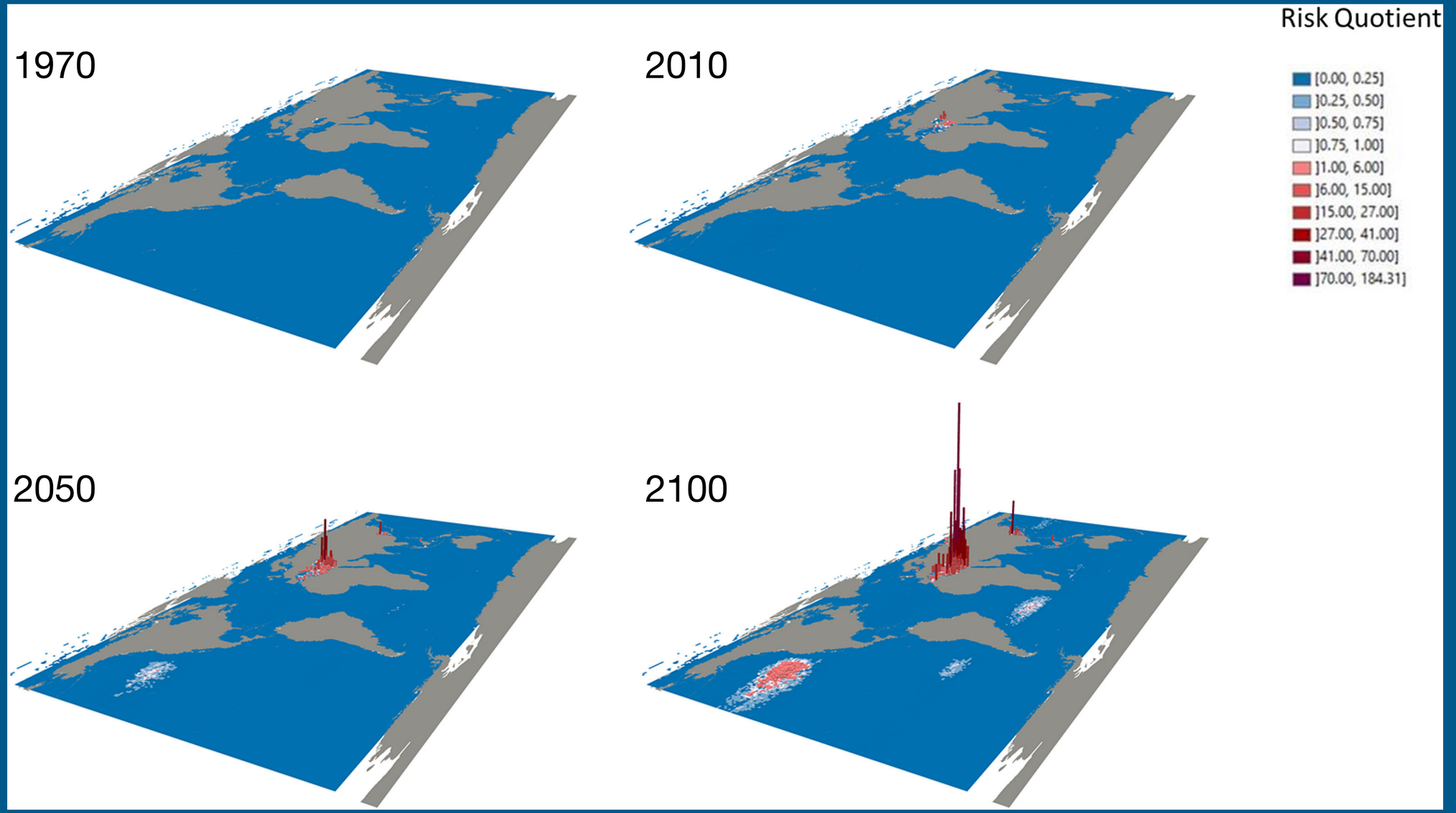
Data reviewed in Bucci et al 2020; Landrigan et al 2023

Plastics may impact ocean ecosystems and climate-related processes involving the transfer of carbon and energy.



Stubbins *et al.* 2021

Impacts of plastics in the ocean are projected to increase



Everaert et al (2020)

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What we know

- Plastics are complex, persistent contaminants of the ocean.
- There is widespread exposure of marine organisms to plastics and plastic-associated chemicals.
- Adverse effects have been documented in lab and field.
- Continued inputs of plastics to the ocean are predicted to lead to increased concentrations and impacts.

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What we need to know better (examples)

- The global distribution and mass balance of plastics in the ocean, including transport pathways, sinks, and degradation rates.
- The health impacts of diverse plastic particles at environmentally realistic concentrations.
- The role of plastics as vectors for chemicals and pathogens.
- Effects of plastics on global carbon cycles.
- The amounts, fate, and impacts of the smallest microplastics and nanoplastics (<10 µm).

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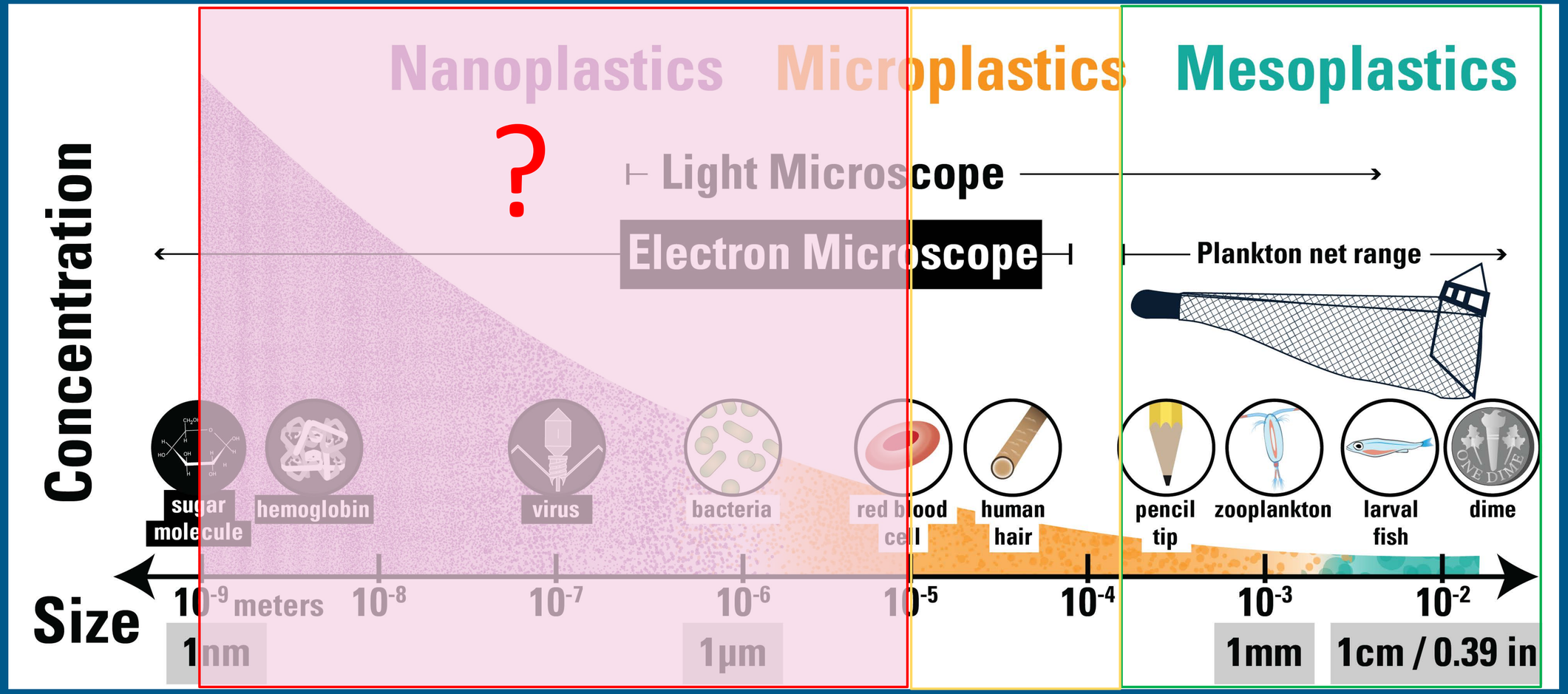
We know very little about the levels, fate, and impacts of the smallest microplastics and nanoplastics



Natalie Renier, WHOI

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Recommendations (MMC)

- The development of remote and *in situ* plastic sensing capabilities for global monitoring of plastics in the ocean.
- Investment in methods to detect the smallest particles in the environment and in tissues of organisms, including humans.
- Robust experiments to elucidate effects of diverse microplastics and nanoplastics at environmentally relevant doses.
- Despite incomplete understanding, action is needed to prevent further input of plastics to the marine environment.
- A strong and comprehensive Global Plastics Treaty and a Science Advisory Body to guide its implementation.

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