海洋プラスチックの由来と影響
総合知で捉える地球規模の課題

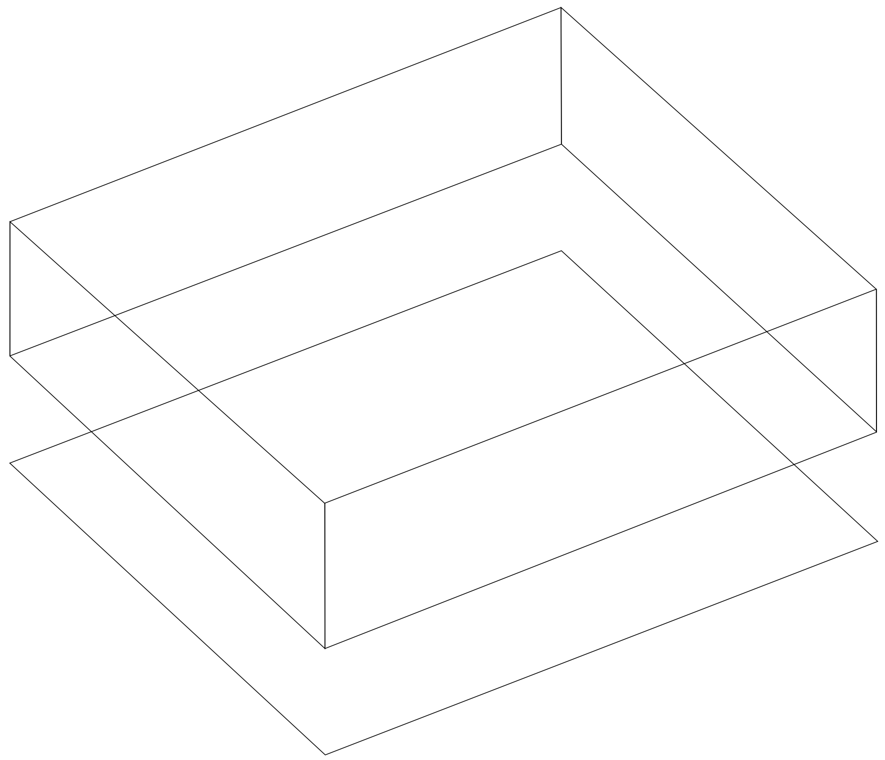
The Origins and Impacts of Ocean Plastic
- A Global Challenge Through Integrated Knowledge -

Large Print Guide

Large Print gives you the exhibition text and source information in bigger type. Carry it around the gallery, and return it here when you're done — anyone is welcome to use it.

This guide provides the exhibition's text in a larger font. It is designed for visitors with low vision or difficulty reading small print, but anyone is welcome to use it. It also includes source information for the references cited throughout the exhibition text. Superscript numbers in the text correspond to the source information at the end of each chapter.

In recent years, museums and galleries in Japan have been gradually introducing large print materials so that all visitors — regardless of age or ability — can enjoy exhibitions more comfortably. This guide is part of that effort. Please return it to its original place after use, so that other visitors may use it too.



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1 Introduction

Ocean plastic pollution arises within a vast continuum that stretches from our everyday lives to the sea, and ultimately to the entire globe. Along the way, plastic gradually breaks down into smaller fragments, becoming "microplastics" — particles 5 mm or less in diameter — that drift through the ocean and are taken up into ecosystems.

To help visitors trace this flow and understand what happens at each stage, this exhibition is structured around two elements.

The long banners suspended from the ceiling let you follow, as a single continuous narrative, where plastic originates, how it transforms along the way, and what effects it has on ecosystems.

The large stage-like platform on the floor uses actual specimens, washed-up debris, ocean observation data, and global-scale simulations to explain, from a scientific perspective, the reality of this problem and its impact on ecosystems — while also introducing the research efforts working to unravel it, the technologies being developed toward solutions, and international efforts to establish shared rules.

As you follow the flow of ocean plastic along the banners, take a closer look at the actual objects, data, photographs, and footage displayed on the stage at each stage of that journey. By moving back and forth between the overall flow and the exhibits at each stage, you can build a multifaceted understanding of the full picture of the ocean plastic problem.

2 What Is Plastic Made Of?

Plastic is a type of synthetic polymer material made from raw materials such as petroleum and natural gas. It is lightweight yet durable, resistant to rust, water, and chemicals, and can be molded into virtually any shape. These properties have made it indispensable across every aspect of daily life — from packaging materials and home appliances to automobile parts, clothing, electronic and information devices, and medical instruments. Over time, plastic has become a foundational material of modern society, supporting convenience and safety in food, healthcare, and logistics.

3 Plastic in Our Everyday Lives

Plastic plays a vital role in countless aspects of our daily lives. Food packaging keeps contents clean, inhibits oxidation, and extends shelf life, helping to reduce food waste. Its use in home appliances and automobiles makes products lighter, contributing to energy savings.

Mobile phones, too, have become compact and lightweight through the use of plastic in batteries and other components, making them an indispensable part of everyday life.

In medicine, plastic is essential for syringes, IV equipment, contact lenses, and prosthetic components — supporting infection prevention and safe medical care, and contributing to improved quality of life (QOL). It is a material that underpins both the convenience and safety of modern society.

When thinking about the plastic problem, we cannot overlook these benefits. The question is not simply "how do we eliminate plastic," but where and how we use it — and how we manage it responsibly.

Food Packaging

Wrapping a bell pepper in plastic film extends its shelf life from 4 days to 20. For chicken, it goes from 7 days to 20.[1] Beyond improving hygiene and safety, plastic packaging plays an indispensable role in reducing food waste.

Everyday Essentials

In 2024, approximately 5.6 billion masks were produced and imported in Japan, 84% of which were for household use.[2] Even the masks woven into the fabric of our daily lives cannot be made without a petroleum-derived plastic fiber.

Infrastructure & Utilities

The 1995 Great Hanshin Earthquake

demonstrated the seismic resilience of polyethylene pipes, marking the beginning of their widespread adoption in water and gas pipelines. The 2011 Great East Japan Earthquake recorded a damage rate of nearly zero for these pipes as well,[3] further accelerating the shift toward resin-based piping materials.

Medical Supplies

As of the end of 2024, approximately 340,000 people in Japan are undergoing dialysis treatment.[4] The dialysis circuits essential to their care are all single-use petrochemical products.
It is also estimated that approximately 15 to 18 million people in Japan wear contact lenses — roughly one in every ten citizens. Contact lenses were originally made from glass, but the spread of acrylic resin lenses has driven a steady increase in the number of users.

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2) 一般社団法人 日本衛生材料工業連合会（2025）「マスクの生産・在庫数量 推移」 https://www.jhpia.or.jp/data/data7.html

3) 平成 25 年度管路の耐震化に関する検討会（2014）「管路の耐震化に関する検討報告書」 https://www.mlit.go.jp/common/830003341.pdf

4) 一般社団法人 日本透析医学会　統計調査委員会（2025）「わが国の慢性透析療法の現況」 https://docs.jsdt.or.jp/overview/

4 Where Does Waste Go?

Waste that is improperly managed or littered in urban and inland areas is carried by rain and wind into rivers, and eventually out to sea. At least 85% of marine debris is plastic,[5] with single-use products such as takeaway containers and food packaging among the most common items found.[6]
The amount flowing from land to sea exceeds 2 million tonnes per year[7] — the equivalent of dumping one truckload of plastic into the ocean every minute.[8] Without sufficient action, that figure could rise to approximately 29 million tonnes per year by 2040.[9]

Pathways and Classification of Marine Debris

- Scattered products from mismanagement: Products that end up in the environment unintentionally — blown away by wind during outdoor use, dropped without notice, or fragmented through deterioration over time.

- Scattered waste from collection points: Waste properly placed in designated collection areas that ends up outside the intended disposal route due to some external factor.
- Illegally dumped and littered waste: Waste intentionally discarded in streets, forests, or other areas without following proper disposal rules.
- Land-based debris: Waste scattered across land areas, excluding riverine debris.
- Riverine debris: Waste scattered along riverbanks and riverbeds, or debris flowing within rivers.

from Rivers into the Ocean

The total amount of plastic flowing from the world's rivers into the ocean is estimated at approximately 2 million tonnes per year,[10] with large rivers in Asia identified as the primary

source. The top 10 rivers alone account for roughly 90% of all river-based plastic input (though some estimates put 80% within 1,000 rivers)[11] — either way, the vast majority are concentrated in Asia.[12]

What Is Washing Up on Japan's Shores?

A survey on the composition of shoreline debris was conducted[13] at 80 sites across all prefectures with coastlines, following established research guidelines.[14] The results showed that most of the washed-up debris consisted of plastic waste — meaning that the marine litter problem is, in essence, a problem of plastic leaking into the ocean.

Production Doubled — Recycling Stuck at 9%

Global plastic production doubled from 230 million tonnes in 2000 to 460 million tonnes in 2019,[15] and if current trends continue, it is projected to triple again to 1.32 billion tonnes by 2060.[16] Single-use applications such as packaging and containers account for roughly two-thirds of all production and are discarded within a short period of time.[17] Of the 8.3 billion tonnes of plastic produced between 1950 and 2015, a cumulative 6.3 billion tonnes were discarded — and only around 9% of that was recycled.[18]

Flow of Waste Plastic in Japan (2024)

Compared to the original source, energy recovery has been combined with incineration, and recycling into petrochemical feedstocks has been grouped under the recycling category. Exports, which were included under recycling in the original source, are shown as a separate category. For reference: recycling into petrochemical feedstocks is also known as

chemical recycling; energy recovery as thermal recycling; and exports combined with other material recovery as material recycling.
*Some figures may not add up exactly due to rounding.

A Small Fraction, A Massive Problem

In Japan, the majority of discarded plastic is incinerated or reused through appropriate disposal channels. However, it is estimated that up to approximately 30,000 tonnes per year escapes proper management and leaks into the environment.[19]
This may seem like a small fraction of total plastic waste — but it is precisely this fraction that becomes the primary source of marine pollution. That is why the importance of reduction at the source, or reduce, cannot be overstated.

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9) Winnie W. Y. Lau et al. (2020). Evaluating scenarios toward zero plastic pollution. *Science,* 369(6510), 1455-1461. DOI:10.1126/science.aba9475

10) Lebreton, L., van der Zwet, J., Damsteeg, JW. et al. (2017). River plastic emissions to the world's oceans. *Nature Communications*, 8(15611). https://doi.org/10.1038/ncomms15611

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13) 日本エヌ・ユー・エス株式会社（2026）「令和７年度 海洋ごみの実態把握及び効率的な回収に関する総合検討業務 報告書」 https://www.env.go.jp/content/000318995.pdf

14) 環境省（2021）「海洋プラスチックごみに関する各種調査ガイドライン等」 https://www.env.go.jp/content/900527998.pdf

15) OECD. (2022). Global Plastics Outlook: Economic Drivers, Environmental Impacts and Policy Options. *OECD Publishing*, Paris. https://doi.org/10.1787/de747aef-en.

16) OECD. (2022). Global Plastics Outlook: Policy Scenarios to 2060. *OECD Publishing*, Paris. https://doi.org/10.1787/aa1edf33-en.

17) UNEP. (2018). Single-use plastics: A roadmap for sustainability. *United Nations Environment Programme*. https://wedocs.unep.org/handle/20.500.11822/25496

18) Roland Geyer et al. (2017). Production, use, and fate of all plastics ever made. *Science Advances*, 3(7). DOI:10.1126/sciadv.1700782

19) 環境省 海洋環境課 海洋プラスチック汚染対策室（2025）「令和６年度検討結果 日本の海洋プラスチックごみ流出量の推計」 https://www.env.go.jp/content/000320690.pdf

5 Not Thrown Away — Yet It Flows Out

Most people never think of themselves as someone who dumps waste into the ocean. Yet countless forms of plastic are entering the environment unnoticed every day — synthetic fibers shed from clothing during washing, particles worn off tires onto roads, rubber crumbs from artificial turf and shoe soles. These "unintentional" plastic emissions originate in cities and inland areas, carried by wind into rivers and eventually out to distant seas.

This is a structural problem: pollution accumulates continuously, with no one aware that they are the source. Without rethinking product design and material regulations, there is no way to address it at the root.

Paint Flakes Off, and Flows to Sea

Paint on building exteriors, bridges, road

markings, and ship hulls constantly weathers, abrades, and peels, releasing fine particles into the environment. In the EU, microplastics from paint are estimated at up to 860,000 tonnes per year, placing them alongside tire wear particles (up to 540,000 tonnes) as one of the largest sources.[20] Global estimates put the figure at approximately 1.86 million tonnes per year.[21] Ship hull paint is a particularly direct source — it peels off in direct contact with seawater during navigation, leaving virtually no distance between the point of release and the ocean.

Every Drive, Tires Wear Away

The synthetic rubber in tires is itself a petroleum-derived polymer, and tire wear particles are detected in marine environments as pollutants comparable to microplastics. These particles accumulate on road surfaces and wash into drains and rivers via rainwater, but they also become airborne again through

wind and passing traffic.[22][23]
Globally, annual tire wear particle emissions are estimated at approximately 0.81 kg per person when divided by the world's population.[24]
Studies have also shown that coarse particles (10 μm and above) in the air near high-traffic roads consist of approximately 90% traffic-related wear particles.[25]
Electric vehicles, often regarded as environmentally friendly, raise concerns of their own: the added weight from battery loading increases tire wear. In response, a range of measures are being developed, including tires engineered for greater wear resistance and motor control technologies that suppress sudden acceleration and hard braking — a multi-pronged approach to reducing wear particle emissions.

Every Wash Releases Invisible Fibers

Every time synthetic garments such as fleece

and acrylic knitwear are washed, enormous quantities of invisibly fine microfibers are shed. A single wash of 6 kg of acrylic fabric is estimated to release up to 728,000 fibers[26] — many of which pass through wastewater treatment facilities and reach aquatic environments, where they have been found accumulating on shorelines around the world.[27]
Research has also shown that using a dryer releases even more microfibers into the air than washing does,[28] meaning fibers are spreading into the environment through two distinct pathways: wastewater and the atmosphere.

Artificial Turf Rubber Chips Are Microplastics

Artificial turf fields, now common in sports facilities and parks, are filled with rubber chips made from recycled tires, used as cushioning material. Because these particles are 5mm or smaller, they are classified as microplastics

— and they escape the field through player movement and rainfall.[29]
What began as an environmentally conscious effort to repurpose waste tires has, ironically, created a new source of microplastic pollution. Efforts to shift toward biodegradable alternatives for artificial turf are underway, though the higher manufacturing cost of biodegradable materials remains a barrier to widespread adoption.

Is "Eco-Friendly" Always the Full Story?

Conventional petroleum-based plastics barely degrade in natural environments and persist for extended periods. Bioplastics have emerged as a response to this challenge — developed in a variety of forms, including biomass-derived materials sourced from plants, polymers produced by microorganisms, and biodegradable materials that break down

through microbial activity.
However, "biodegradable" primarily refers to decomposition in soil or composting environments, and many such materials show little to no degradation in seawater. "Plant-derived" and "returns to nature" are also not the same thing. These materials only deliver on their promise when matched with the right disposal conditions and processing infrastructure — and that understanding is what makes their potential achievable. Careful attention is also being given in development to ensuring that the byproducts of degradation do not prove toxic in the environment.

20) European Commission. (2023). *Impact assessment report: Combatting microplastic pollution in the European Union (Commission Staff Working Document SWD(2023)*. 332 final). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52023SC0332

21) Paruta, P., Pucino, M., Boucher, J. 2022. *Plastic Paints the Environment: A global assessment of paint's contribution to plastic leakage to Land Ocean & Waterways*. EA – Environmental Action. https://www.e-a.earth/wp-content/uploads/2023/07/plastic-paint-the-environment.pdf

22) Brahney, J., Mahowald, N., et al. (2021). Constraining the atmospheric limb of the plastic cycle. *Proceedings of the National Academy of Sciences (PNAS)*, 118(16), e2020719118. https://doi.org/10.1073/pnas.2020719118

23) Saladin, S., Boies, A. et al. (2024). Airborne Tire Wear Particles: A Critical Reanalysis of the Literature Reveals Emission Factors Lower than Expected. *Environmental Science & Technology Letters*, 11, 1296–1307. https://doi.org/10.1021/acs.estlett.4c00792

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27) Browne, M. A., Crump, P., Niven, S. J., Teuten, E., Tonkin, A., Galloway, T., & Thompson, R. (2011). Accumulation of microplastic on shorelines woldwide: sources and sinks. *Environmental science & technology*, 45(21), 9175-9179. https://pubs.acs.org/doi/10.1021/es201811s

28) Tao, D., Zhang, K., Xu, S., Lin, H., Liu, Y., Kang, J., ... & Leung, K. M. (2022). Microfibers released into the air from a household tumble dryer. *Environmental Science & Technology Letters*, 9(2), 120-126. https://doi.org/10.1021/acs.estlett.1c00911

29) Luo, Z., Zhou, X., Su, Y., Wang, H., Yu, R., Zhou, S., ... & Xing, B. (2021). Environmental occurrence, fate, impact, and potential solution of tire microplastics: Similarities and differences with tire wear particles. *Science of the Total Environment*, 795, 148902. https://doi.org/10.1016/j.scitotenv.2021.148902

6 How Big Plastic Becomes Small

Most microplastics originate from larger plastic products that physically and chemically fragment or degrade in natural environments. On shorelines, plastic is exposed to ultraviolet radiation from sunlight and breaks down through contact with oxygen and water, becoming increasingly brittle under the impact of waves.[30] In the ocean, however, algae and other organisms colonize the surface and suppress UV degradation — yet the plastic is thought to gradually break apart through friction with waves and sand.

Why Does Plastic Get Smaller Offshore?

A research team led by Professor Atsuhiko Isobe of Kyushu University collected microplastics drifting at sea and discovered that particle size decreases the further offshore the samples are taken. They also proposed that mesoplastics of a few centimeters or less have high buoyancy and drift near the surface, gradually carried shoreward by waves until they eventually wash up on beaches. Once stranded, these particles progressively degrade into microplastics of 5mm or smaller. In this way, the ocean has a mechanism for converting mesoplastics into microplastics. Once reduced to microplastic size, the particles have lower buoyancy and tend to drift slightly below the surface — less influenced by waves — and are steadily transported further offshore, eventually spreading across the open ocean.[31]

As It Gets Smaller, the Name Changes Too

Fragments that retain the original form of a product are called macroplastics. As fragmentation progresses and pieces reach a few centimeters or less, they become mesoplastics. Below 5mm, they are classified

as microplastics, and fragments smaller than one-thousandth of a millimeter (1 μ m) are known as nanoplastics.[32 33]

Shapes That Nature Never Makes

Microplastics are not only secondary microplastics — fragments formed when larger plastics break apart on shorelines and elsewhere — but also primary microplastics, which are manufactured at 5mm or smaller from the outset, such as microbeads used in exfoliating scrubs. These have been found in enclosed coastal waters in Japan,[34] though voluntary restrictions by cosmetics manufacturers since 2016 have contributed to a declining trend.[35] However, secondary microplastics remain by far the more prevalent type found in the ocean.[36]

30) Andrady, A. L. (2011). Microplastics in the marine environment. *Marine pollution bulletin*, 62(8), 1596-1605. https://doi.org/10.1016/j.marpolbul.2011.05.030

31) Isobe, A., Kubo, K., Tamura, Y., Kako, S., Nakashima, E., & Fujii, N. (2014). Selective transport of microplastics and mesoplastics by drifting in coastal waters. *Marine pollution bulletin*, 89(1-2), 324–330. https://doi.org/10.1016/j.marpolbul.2014.09.041

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7 Riding Ocean Currents Around the World

Microplastics that reach the ocean disperse on a global scale, carried by ocean currents and wind. Driven by the equatorial currents, the North Pacific gyre, and powerful coastal flows such as the Kuroshio and Oyashio, they can travel thousands of kilometers and drift on the ocean surface for years or even decades.[37 38] Marine scientists have been collecting seawater samples from locations around the world to measure the quantity and types of plastic they contain. By combining these observational data with simulations of ocean current movements, researchers have been able to visualize the global distribution of microplastics.

Japan's Waters: Uniquely Concentrated

In many areas surrounding Japan, microplastic concentrations reach over 100 particles per cubic meter of seawater. This appears to stem from two factors: Asia, including Japan, is a region where significant amounts of plastic waste escape into the environment, and much of what enters the ocean is carried toward Japanese waters by surrounding currents.

Scooped from the Sea, Counted One by One

Microplastics floating in the ocean are sampled primarily by skimming the surface with a net[39] — a method modeled on techniques used to collect zooplankton, using a specialized tool known as a neuston net.
To date, under the standardized sampling methodology used among researchers worldwide, trawling with this net can only capture particles floating within approximately 1 meter of the surface, and is further limited to microplastics of 0.3mm or larger — the minimum size that the mesh can retain.

Plastic Has Reached Even Antarctica

A research team led by Professor Isobe conducted a survey across 38 sites spanning from the Southern Ocean to Tokyo, and detected microplastics at every single location.[40] Even in the Southern Ocean — the place on Earth most removed from the rhythms of everyday human life — plastic is floating on the surface.

Where Did All the Plastic Go?

There is a significant gap between the estimated volume of plastic flowing into rivers and the ocean and the amount actually detected floating on the surface[41] — a discrepancy that has sparked considerable debate among researchers. This unaccounted plastic is known as "missing plastics." Some has been found in seafloor sediments[42] and Arctic sea ice[43], but for now, these remain only fragmentary findings and working hypotheses. The microplastics that have broken down into ever-smaller pieces must exist somewhere on Earth — but locating and addressing them is far from straightforward.

37) Cózar, A., Echevarría, F., González-Gordillo, J. I., Irigoien, X., Úbeda, B., Hernández-León, S., ... & Duarte, C. M. (2014). Plastic debris in the open ocean. Proceedings of the National Academy of Sciences, 111(28), 10239-10244. https://doi.org/10.1073/pnas.1314705111

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8 Just How Different They Are

The word "microplastic" covers a remarkably diverse range of forms and textures. Some particles are long and fibrous, others are angular fragments, and still others are small rounded pellets — varying widely in size, color, and material composition.
Sorting plastic pieces from collected seawater samples and preparing them for analysis is an entirely manual process, demanding both meticulous attention and considerable patience.

Counting What the Eye Cannot See

No automated technology exists to extract plastic directly from raw seawater samples, so researchers use tweezers to isolate microplastics by hand. Particles too small to see with the naked eye are identified using magnifying lenses or analytical instruments

that determine material composition, and their sizes are then measured.
But if analytical methods differ between researchers and countries, the resulting data cannot be meaningfully compared. Assistant Professor Haruka Nakano of the Research Institute for Applied Mechanics at Kyushu University is working to develop affordable analytical methods accessible even in developing countries, and to establish their international standardization through ISO certification. Spreading a shared set of rules for "how to measure" is the foundation that connects science to policy.

Measuring Litter from Above

Professor Isobe's research team initially used a balloon-mounted digital camera to photograph coastlines from the air, surveying the area covered by washed-up debris. By simultaneously measuring the weight of debris per unit area at multiple on-site locations, they were able to estimate the total weight of debris along entire stretches of coastline simply by multiplying area by weight per unit.[44] Since then, the technology has advanced toward measurement using drones and deep learning.[45]

44) Nakashima, E., Isobe, A., Magome, S., Kako, S. I., & Deki, N. (2011). Using aerial photography and in situ measurements to estimate the quantity of macro-litter on beaches. *Marine pollution bulletin*, 62(4), 762-769. https://doi.org/10.1016/j.marpolbul.2011.01.006

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9 A Map of Plastic in the Ocean

Microplastics have been spreading through the world's oceans from the past into the present — and will continue to do so into the future. Understanding where they are, how much exists, and how their distribution shifts over time is essential for developing effective responses.

In research by Professor Isobe and colleagues,[46] observational data combined with a global ocean circulation model were used to run simulations reflecting plastic waste input since 1957, producing visualizations of microplastic distribution in 2016 and projections for 2066. In the waters of East Asia, including those surrounding Japan, concentrations are predicted to reach as high as 1 gram of microplastics per cubic meter at the ocean surface.

Simulation of the mass concentration

distribution of microplastics floating near the sea surface (floating mass per cubic meter of seawater)

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10 Plastic Inside Living Things

Microplastics have been detected inside a wide range of marine organisms, including seabirds, fish, shellfish, and crustaceans. Among seabirds, reports indicate that approximately 90% of individuals surveyed have ingested plastic, and by 2050, ingestion is predicted to be confirmed in 99% of species.[47] Multiple particles have also been found in the digestive tracts of fish[48] and inside shellfish[49] — and while the amount ingested varies by species and habitat, microplastics are thought to be taken in routinely through accidental ingestion or mistaken identification as food.[50] The physiological effects of this ingestion also remain an important area for future research.

What Parents Feed Their Chicks

At Midway Atoll in Hawaii, Laysan albatrosses have been observed mistaking plastic fragments for food at sea and feeding them to their chicks. In one survey, plastic was detected in the digestive tracts of 97.6% of 251 chicks examined.[51] This behavior is a striking example of how accidental ingestion is not merely an individual problem — it can affect reproductive success and the survival rate of the next generation.[52]

The Cost of Eating the Wrong Thing

Organisms that accidentally ingest plastic waste suffer a range of effects, including reduced appetite,[53] stunted growth,[54] and damage to the digestive tract.[55] Even when plastic itself carries no direct toxicity, consuming something with no nutritional value still expends energy and places a burden on the body. This burden is known as "particle toxicity," and the smaller the organism, the greater the impact.[56]

Large debris tends to be ingested only by

larger animals, which are fewer in number — but microplastics are small enough to be accidentally consumed by an enormous range of species, from whales[57] and mackerel[58] to zooplankton.[59]

Plastic Invades Coral — Inside and Out

Plastic debris settles directly on top of corals, seagrass, and other seafloor organisms — cutting off oxygen and causing suffocation, blocking light and preventing photosynthesis.[60] Beyond these physical effects, plastic also carries pathogenic bacteria that can raise the rate of coral disease by as much as 20-fold.[61] A joint research team from Kyushu University and Thailand was the first in the world to detect microplastic fragments within coral skeletons.[62] Once embedded in the skeleton, these microplastics persist long after the coral dies — with the potential to accumulate on geological timescales spanning thousands of years.

Plastic as a Carrier of Toxins

Because plastic is derived from petroleum, it readily adsorbs persistent organic pollutants (POPs) — compounds with chemical properties similar to oil. Prominent examples include polychlorinated biphenyls (PCBs), once widely used in lubricants and electrical insulation, and dichlorodiphenyldichloroethylene (DDE), a derivative of the pesticide DDT. These pollutants, dispersed at low concentrations throughout the ocean, can accumulate on plastic surfaces — and if marine organisms ingest that plastic, the pollutants may transfer into their bodies.[63] There is concern that this process, repeated through the food chain, could lead to bioaccumulation.[64] Research into the health risks of microplastics to humans is ongoing; while a causal relationship has not yet been established,[65] an increasing number of studies report suspected effects on the reproductive, digestive, and respiratory systems.[66]

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11 Inside Our Bodies Too?

What effects do microplastics have on human health? No clear answers have yet been found, but recent years have seen a growing number of reports detecting microplastics in human lungs,[67] blood,[68] brain tissue,[69] placentas,[70] and breast milk.[71] There are also indications that they may accumulate and concentrate within the body over time.

A longitudinal study has further found that individuals in whom microplastics were detected within arterial plaques — the buildup that forms inside blood vessels — had a higher risk of stroke and heart attack compared to those with no such detection.[72] It should be noted, however, that these particles may in some cases originate from wear particles of materials used in medical circuits such as hemodialysis or cardiopulmonary bypass equipment, and that no causal relationship has been established.

From Sea to Sky, and Back Down as Rain

Microplastics thrown into the atmosphere by sea spray and wind[73] may return to the surface as rain or snow. Through this process of "atmospheric transport," contamination is spreading even to mountain ranges and forests far removed from human activity.[74] This airborne dispersal pathway is attracting growing attention as a newly recognized route of pollution.

Microplastics Found at the Summit of Mt. Fuji

Airborne microplastics have been discovered at locations including the summit of Mt. Fuji,[75] detected in samples of cloud water collected in the atmosphere. There are indications that these particles may function as condensation nuclei for ice crystals and water droplets within clouds, potentially altering rainfall distribution and contributing to climate change.

Is Indoor Air More Polluted Than Outside?

Indoor microplastic accumulation has been found to exceed that outdoors,[76] and the amount inhaled inside the home is estimated to be greater than what is breathed in outside.[77] Carpets, synthetic fiber furniture, and clothing are considered the primary sources.

In Your Teacup?

Steeping a plastic tea bag in boiling water has been reported to release billions of microplastic and nanoplastic particles into the brew.[78] However, the measurement methods used in such studies remain a subject of debate among researchers, and the figures should be interpreted with caution.[79 80]

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12 Plastic That Disrupts the Web of Life

Floating Far: Plastic as a Raft for Life

Marine organisms such as mollusks, barnacles, and algae can attach themselves to plastic debris drifting through the ocean. The phenomenon of these organisms traveling long distances is known as "rafting."[81]
Research has confirmed large numbers of attached organisms on plastic fragments and floating debris collected in the open ocean, with some cases reported where species appear to have traveled far beyond their normal habitats.[82] This kind of dispersal carries risks of ecological disruption and the establishment of invasive species in new environments.[83]

The Net That Never Stops Fishing

"Ghost fishing" refers to the phenomenon in which fishing gear[84] — primarily made of nylon or polyester, such as nets and fishing lines — lost or discarded at sea continues to drift slowly through the ocean over many years, endlessly entangling and killing marine creatures.

Because plastic resists natural decomposition and retains its durability, fish, sea turtles, dolphins, seals, and seabirds[85] are among those affected.

When a captured animal dies and decomposes, its scent attracts new creatures, which are then ensnared in turn[86] — a repeating chain known as the "ghost fishing cycle."[87]

However, because marine animals entangled in nets that have sunk to the seafloor are rarely seen by human eyes, fully grasping the true scale of ghost fishing remains extremely difficult.

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13 Collection Technology and Citizen Power

Stop It Before It Reaches the Sea

Collect the waste in rivers before it ever reaches the ocean. Kawasemi,[88] developed by the NPO Clean Ocean Ensemble, is a simple collection device requiring no electricity or power — inspired by the net techniques of local fishermen. It can be installed simply by stretching floats and a net across the width of a river, making it low-cost and easy to adopt, with the goal of spreading its use across Japan. Compared to collection at sea, it offers greater efficiency, and the concept of "stopping waste at the river" is drawing attention as a new approach that intervenes at the root of the problem.

Your Snapshot Becomes Scientific Data

Pirika,[89] a smartphone app launched in 2012, is a social platform where users post photos of litter they have picked up and share their activities with people around the world. It is used in more than 132 countries, with a cumulative number of litter-picking reports reaching hundreds of millions. Research has also been published combining photo submissions from the app with AI image analysis to visualize the type, quantity, and location of litter in urban environments on a map.[90 91]

Data captured and posted by individual citizens on their smartphones is becoming a research foundation that could contribute to solving ocean pollution. Pirika stands as a compelling example of that potential.

88) https://cleanoceanensemble.com/columns/column4/

89) https://corp.pirika.org/sns-pirika/

90) Kako, S. I., Muroya, R., Matsuoka, D., & Isobe, A. (2024). Quantification of litter in cities using a smartphone application and citizen science in conjunction with deep learning-based image processing. *Waste Management*, 186, 271-279. https://doi.org/10.1016/j.wasman.2024.06.026

91) https://pmd.oce.kagoshima-u.ac.jp/research/

14 New Chemistry That Turns Waste into Resources

Turning Waste into Something More Valuable

The technology of chemically breaking down plastics and converting them into fuel or raw materials for chemical products is known as "chemical recycling." In recent years, research has advanced a step further into "chemical upcycling" — transforming waste plastics into substances of higher added value than the original materials — with studies progressing around the world.

At Kyushu University, research is underway to convert polypropylene into hydrogen-rich gas through microwave-assisted catalytic pyrolysis, as well as to recover value from POM (polyoxymethylene) — a material long considered difficult to recycle — using solid acid catalysts combined with microwave heating.[92] Associate Professor Andrew Chapman and colleagues are exploring pathways to put waste plastics to practical use within real social systems, by coupling these technological developments with life cycle assessment (LCA) to evaluate their environmental impact.[93]

Associate Professor Edalati Kaveh and his colleagues, also at Kyushu University, became the first in the world to successfully develop a photocatalyst capable of simultaneously converting two waste streams[94] — waste PET and CO_2 — into useful chemical products using only sunlight. This approach, in which two waste materials become each other's reaction partners, offers a new perspective that reframes waste as a "feedstock."

92) Chapman, A., Tsubaki, S., Honda, R., Maamoun, I., & Fujii, S. (2026). Plastic-to-Hydrogen Conversion in Island Contexts: A Socio-Technical Assessment of Microwave Pyrolysis in Okinawa. *Environmental Challenges*, 101544. https://doi.org/10.1016/j.envc.2026.101544

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15 Toward Materials That Return to Nature

Born from Wood, Gone in the Sea

The tiny plastic particles used as scrubbing agents in cosmetics and as industrial additives do not break down once they enter the ocean, making them a source of microplastic pollution. Agricultural materials such as coated seeds, controlled-release fertilizers, and plastic mulch films are also contributing factors in the accumulation of microplastics in soils and waterways.

Professor Takuya Kitaoka of Kyushu University's Faculty of Agriculture and his colleagues are developing marine-degradable perfectly spherical microparticles and biodegradable agricultural materials using cellulose nanofibers derived from the cell walls of trees[95] — a promising alternative to conventional plastics. Plants have long been broken down by marine microorganisms, and by harnessing this property, these materials can maintain their functional performance while significantly reducing environmental impact. Furthermore, the carbon contained in these materials is sequestered in the deep ocean after use, contributing to climate change mitigation. Grounded in natural polysaccharide nanomaterials, these technologies represent a practice of "ecosystems materialogy" — the design of materials that harmonize with nature's material cycles — and are opening a new path toward a society no longer dependent on petroleum-derived plastics.

Toward Plastic That Disappears in the Ocean

"Biodegradable plastics," while they may break down in soil, decompose barely at all in seawater. To address this fundamental challenge, Japan launched a full-scale industryacademia collaborative project centered on NEDO (New Energy and Industrial Technology Development Organization) from the 2020s onward.

Multiple new materials are under research and development ― including PHBH[96], a microorganism-derived polymer; LAHB[97], which combines polylactic acid with biodegradable materials; Nylon 4[98]; nylon-based copolymers[99]; and biodegradable elastomers[100] ― with decomposition confirmed both in marine field tests and in deep-sea floor verification experiments. In addition, a supramolecular plastic[101] that completely breaks down to its raw components in saltwater has been announced, reflecting the wide variety of approaches advancing in parallel.

Furthermore, in 2025, an international standard (ISO) for evaluating marine biodegradability under real-world environmental conditions was established and published under Japanese leadership.[102] The effort to spread common rules for "how to measure and how to verify" to the rest of the world ― not just material development itself ― underpins the scientific foundation of this field.

95) 九州大学 大学院農学研究院 環境農学部門 サスティナブル資源科学講座 生物資源科学分野、研究内容、ナノ機能材料　https://bm.wood.agr.kyushu-u.ac.jp/research/research02-2/

96) 福田竜司（2020 年）「微生物産生によるカネカ生分解性ポリマー PHBHTM の開発：バイオマス由来で海洋生分解性を有する生分解性ポリマー」化学と工業 , 73,(11), 849-851　https://students.csj.jp/wp-content/uploads/2021/05/ko73-849-tokushu.pdf

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101) 理化学研究所（2025 年）「堅牢なのに塩水中で分解するプラスチック－安価な木材成分から製造できる次世代高分子材料－」 https://www.riken.jp/press/2025/20251203_2/index.html

102) 産業技術総合研究所（2025 年）「実際の海・湖で海洋生分解性プラスチックは「分解」にどれだけ時間がかかるのか？」 https://www.aist.go.jp/aist_j/press_release/pr2025/pr20250512/pr20250512.html

16 How Is the World Responding?

INC-5.4 (Intergovernmental Negotiating Committee on Plastic Pollution)

The Intergovernmental Negotiating Committee (INC) of the United Nations Environment Programme (UNEP), tasked with developing a global treaty to end plastic pollution, launched negotiations in 2022 with the participation of more than 160 countries. Parties are now working toward reaching agreement at INC-5.4, scheduled for March 2027. However, negotiations have been fraught with difficulty: two consecutive sessions ― held in Busan, Republic of Korea, in late 2024, and in Geneva in August 2025 ― ended without agreement. While the European Union and small island developing states in the Pacific and Caribbean are calling for caps on plastic production and the international phase-out of single-use products, oil-producing countries in the

Middle East and industry stakeholders have strongly opposed production restrictions. Disagreements also persist over the framework for financial support and the modalities of decision-making, leaving no clear prospect for agreement at the level of treaty text.[103 104]

“The plastics problem cannot be solved unless rules cover everything from production to disposal in one comprehensive framework. A treaty that targets only part of the life cycle is meaningless.”
“Plastics play a major role in society. We should start with what can realistically be addressed, such as waste management, and set targets that take each nation's economic circumstances into account.”

“Problematic single-use plastics should be listed in an international treaty and phased out worldwide under a common deadline. Leaving it

to nations will only create loopholes.”
“What's problematic differs by country. Regulated items and timing should be decided by each nation based on its own capacity and economic impact, not a uniform international list.”

“Cleaning up waste alone will not stop the pollution. We must turn off the tap — meaning production itself must be reduced worldwide under numerical targets. Without that, this treaty is meaningless.”
“Restricting production would cause immeasurable damage to the economy. Improvements in recycling and waste management are enough to address the problem. We oppose including any provision on production cuts in this treaty in the first place.”

“New obligations require new funding. Existing funds, where developed nations hold the

decision-making power, are unfair. We should establish a dedicated, independent fund for this treaty, where developing countries can decide on its use on an equal footing.”
“Creating a new fund from scratch takes time and costs money. It is more realistic and efficient to make use of proven existing mechanisms such as the GEF (Global Environment Facility), while also combining them with private finance.”

“Decisions should not be made while even a single nation strongly objects. All substantive decisions must be made by unanimous consensus.”
“If unanimity is required, a single country's veto can prevent anything from being decided. Unless there is a rule allowing decisions by a three-quarters majority vote when consensus cannot be reached, the treaty will not function.”

“Environmental regulations must not be used as a pretext for trade restrictions against specific countries. In addition, a ‘Just Transition’ — including employment and livelihood guarantees for vulnerable communities, such as waste pickers who lose their jobs due to regulation — should be made a core pillar of the treaty.”
“Unilateral trade measures taken by developed nations at their own discretion, in the name of environmental protection, hinder the economic independence of developing countries. We must first assess the negative impacts that such regulations would have on domestic industries and society, and establish mechanisms for financial support and technology transfer to offset them before proceeding.”

32% Less by 2035: The Target for Our Oceans

At the Osaka G20 Summit held in June 2019, the

"Osaka Blue Ocean Vision" was proposed — a commitment to reduce additional ocean plastic pollution to zero by 2050. To achieve this, a research team led by Professor Isobe of Kyushu University has estimated that a 32% reduction from 2019's annual outflow levels must be achieved on a global average by 2035.[105]

Seeking Zero Risk Can Create New Risks

The "precautionary principle"[106] refers to the idea that precautions and regulations should be considered in light of the potential magnitude of harm, even before science has sufficiently established proof of risk to the environment or human health. However, taken too far, the precautionary principle can itself give rise to situations where safe water, food, and sanitary medical care become inaccessible. In pursuing zero risk, there is a possibility of inviting a different kind of risk altogether. That is precisely why it is important for society as a whole to continually ask — while steadily accumulating scientific knowledge — what to prioritize and what to accept.

PET Bottled Water

- 2.1 billion people worldwide lack access to safely managed drinking water.[107]
- Of these, 106 million people drink untreated surface water directly from rivers and lakes.[108]
- In some regions, PET bottled water is the only low-cost means available for storage, transport, and distribution of water.
- The Great East Japan Earthquake left 2.57 million households without water; while 57% was restored within a week, full restoration took up to about 7 months in some areas.[109]

Food Packaging

- Approximately 14% of the world's food is lost between harvest and retail, mainly due to a lack of refrigeration and transport infrastructure.[110]

- Plastic packaging is a safe and low-cost means of food preservation in regions where refrigerated storage and transport infrastructure are not well developed.
- While the price of biomass plastics has been falling compared to petroleum-based plastics, it remains 3 to 6 times higher.[111]

Straws

- For people with dysphagia, ALS (amyotrophic lateral sclerosis), or cerebral palsy, bendable, soft, heat-resistant plastic straws are a means of drinking safely.[112]
- To prevent aspiration, users must drink while keeping their chin tucked without changing posture; the universal design of bendable straws helps with this, and also makes it easier to drink while lying in bed.
- When users cannot control their mouth movements and bite down on the straw, paper straws become useless, and metal or glass straws cannot be considered safe.[113]

Syringes

- Unsafe syringe use caused approximately 500,000 deaths globally in 2000,[114] driven by supply shortages, cost issues, and a lack of proper collection infrastructure.[115]
- The widespread adoption of disposable syringes led to a dramatic decline in healthcare-associated infections between 2000 and 2010. During this decade, medical injection-related transmissions of Hepatitis C virus (HCV) dropped by 83%, HIV by 87%, and Hepatitis B virus (HBV) by 91%. Concurrently, the syringe reuse rate itself fell sharply from 39.8% to 5.5% during the same period.[116]
- In Japan, disposable syringes from medical institutions are classified as Specially Controlled Industrial Waste (infectious

waste) and are legally required to be rendered harmless through methods such as incineration.117

- Globally, the technology and infrastructure to recycle such materials while ensuring safety against infection risks have not yet been established.

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