NO SUCH PLACE AS "AWAY"

Plastic Pollution in the Oceans, Why We Should Care, and What to Do About It

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Abstract: An enormous amount of plastic is in the oceans, only a tiny fraction of which is at the surface, and the problem of plastic pollution will grow exponentially absent rapid and significant action. Most of this pollution comes from uncollected and mismanaged plastic waste, particularly from developing economies in Asia. These plastics and the many chemicals they contain have impacts on human and marine health, human livelihoods, important economic sectors such as fishing and tourism, climate change, and the potential achievement of a number of Sustainable Development Goals. Cleaning up the pollution that exists to the extent feasible is important, but it is even more vital to drastically reduce the amount of plastic going into the oceans by improving waste collection and management, increasing reuse and recycling, and redesigning products and using alternative materials and business models. Many examples of governments, businesses, investors, NGOs, academics, and individuals taking action exist, but much more is urgently needed, including potentially a new international agreement to provide a harmonizing framework.

Stunning photographs and videos of trash floating on the surface of the oceans, such as in the highly-publicized "Great Pacific Garbage Patch," have raised global awareness of the marine plastic debris problem. These images, while powerful, do not convey the extent of the problem.

HOW BIG IS THE PROBLEM?

Between 5 and 14 million metric tons of plastic trash flow into the oceans from land every year.[1] That is enough coffee cups, cake forks, contact lenses, foam food containers, beverage bottles, bags, and other plastic waste to cover every inch of coastline from the Arctic to Antarctica – *every year*.[2] It is the same as dumping one garbage truck load of plastic into the ocean *every minute*.[3] The tens or hundreds of thousands of metric tons of plastic waste floating in the highly-publicized "Great Pacific Garbage Patch" and the four other ocean gyres in the South Pacific, North and South Atlantic, and Indian Ocean[4] contain just a tiny fraction of the plastics estimated to be in the oceans – many of which are microplastics below the ocean surface.[5] Indeed, some use terms such as "plastic soup" and "plastic smog" to describe the oceans' condition.[6]

Except for the 12% of plastic that has been incinerated – which usually uses fossil fuels and emits noxious gases – **every bit of plastic that has ever been made still exists.**[7] Plastic pollutes the entire water column, from the seafloor to the surface, and is in every ocean and sea, including remote areas far from human habitation.[8] It is even embedded in Arctic sea ice.

Where a particular piece of plastic ends up depends on its density, ocean movements, and the wind. Some of it washes onto beaches and shorelines, including wetlands and mangrove forests. Some of it floats, but not much (in relative terms). Plastic that is exposed to waves, sunlight, and oxygen, such as the plastic in the gyres, is constantly degrading; these microplastics and nanoplastics mix with sand or sediment and either drift in the water column or sink to the sea floor. (Even "biodegradable" plastics often do not biodegrade at all in the ocean, and if they do,

they break down into microplastics.) Plastic litter that sinks degrades slowly away from sun and air and so remains fairly intact deep in the ocean.[9] We do not, though, have precise data on where the plastic that goes into the oceans ends up. A lot of it is probably inside of animals[10] or on the seafloor.[11]

Unless rapid and significant action is taken, the amount of plastic in the oceans will increase exponentially. Population growth, rising plastics production, and economic development mean that plastic debris will keep growing. By 2025, only seven years from now, current trends suggest the oceans will contain about one ton of plastic for every three tons of fish, receiving about 17 million metric tons per year. By 2050, the ratio is projected to be one to one -- the oceans will contain as much plastic as fish.[17] Some say there will be more plastic than fish.[18]

WHAT IS PLASTIC?

The word "plastic" is a generic term that refers to many different combinations and sizes of materials. Plastics, also called polymers, are usually made of petroleum, natural gas, or coal, or by the conversion of certain elements (such as carbon, hydrogen, and chlorine).[19] Plastics contain a variety of chemical additives that allow them to have a range of attributes, forms, and functions. Beyond the obvious bottles, bags, and cups, plastics also include elastomers, coatings, and sealants, as well as polyester, acrylic, nylon, and other clothing fibers. Plastic also is not just the larger pieces that we can see. For instance, microbeads in body care and household products, such as toothpaste and paint, are plastics.

WHY SO MUCH PLASTIC WASTE?

Mass production of plastic began in the 1950s, with over 8 billion metric tons produced since then. The growth of plastics production in the past 60+ years has substantially outpaced most other manufactured materials. About half has been made since just 2004 -- society manufactures 20 times more plastic than we did 50 years ago. Around 5 or 6 billion tons has been thrown "away" – ending up in landfills or polluting the environment, including the oceans.[20]

A key problem with plastic is the mismatch between the lifespan of the material and the

WHICH PLASTICS CONTRIBUTE MOST TO THE PROBLEM?

It is hard to say which plastics contribute most to the ocean pollution problem.[12] By weight, abandoned and lost fishing nets and gear account for about 46% of ocean plastic debris in the Pacific gyre.[13]

However, a more useful measurement is by count, though where counts occur affects what is found. For instance, in terms of what washes up on beaches, the Ocean Conservancy reports that the top plastic items found during its annual international beach cleanups were cigarette butts, food wrappers, beverage bottles and caps, plastic bags, straws and stirrers, plastic take-away containers, lids, and foam take-away containers,[14] though different types of debris may accumulate on different types of shorelines. Few surveys have been done in the Southern Hemisphere oceans and outside of the subtropical gyres.[15]

Tiny microplastics and nanoplastics particles are even more pervasive in the oceans than visible pieces. In addition to larger pieces of plastic waste breaking down into microplastics in the oceans, as many as 100,000 plastic microbeads in some cosmetic cleansers can wash down the drain in a single shower, and about 1,600 plastic microfibers are released every time a synthetic garment is washed.[16]

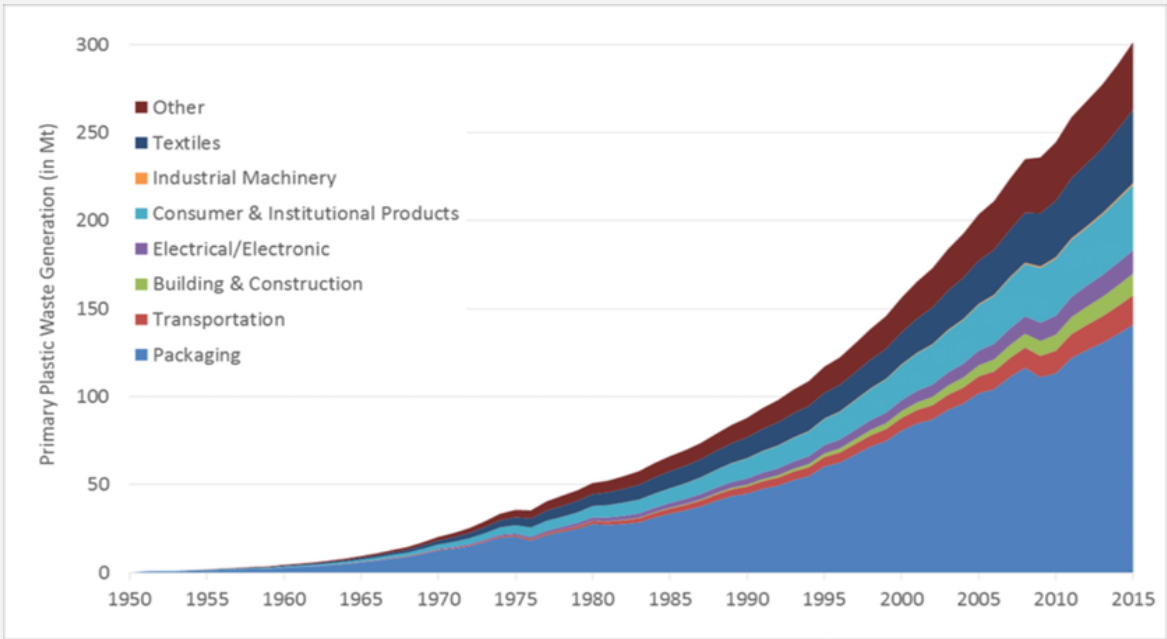
lifespan of most products made from it. The vast majority of the skyrocketing rise in plastic production is due to single-use packaging, which accounted for about 42% of non-fiber plastic production in 2015 and about 54% of the non-fiber plastic that was thrown out that year. The shift from reusable to single-use containers is responsible for the increase in the share of plastics in municipal solid waste (by mass) from less than 1% in 1960 to more than 10% by 2005 in middle- and high-income countries. Plastic packaging for food, beverage, and tobacco products, which is overwhelmingly used one time, constitutes over 60% of global beach litter.[21] An estimated 1 to 5 trillion plastic bags are consumed worldwide each year – or about 2 to 10 million bags per minute.[22] One million plastic bottles are bought worldwide every minute, and more than half a trillion will be sold each year by the end of the decade.[23] In the United States alone, 500 million plastic straws are discarded every day.[24]

Plastics have very poor recycling rates, and recycling only delays the time before plastic becomes permanent waste. Europe has the highest recycling rate of non-fiber plastic waste in the world at 26%-30% and the highest incineration rate (40%),[25] while China recycles about 25% and burns about 30% of its plastic waste.[26] Most of the rest of the world, including the United States, recycles about 9% (and the United States incinerates around 16%). Options in small island nations are often limited, with most trash, including plastic waste, either burned or ending up in the ocean. Options have narrowed in high-income countries recently as well; much of the material destined for recycling was exported to East Asia and the Pacific, especially China,[27] but China has now banned the import of most non-industrial plastic waste as part of its anti-pollution campaign. The United States and other waste exporters are scrambling to cope. Some recyclables are going to India and Southeast Asia – which have an increasing amount of plastic to deal with themselves and lack the infrastructure to do so – and some are piling up, going to landfills, or being burned.[28]

Products are rarely recyclable when they are made of more than one type of plastic, nor is recycling possible if certain additives are present or when material is soiled. Likewise, textiles that produce plastic fiber waste are almost never recycled, and the fibers that come off in the wash usually go directly into wastewater with no opportunity for capture or reclamation. Even when technically recyclable, a plastic product may not actually be recycled, due to lack of recycling facilities or confusion over what is recyclable. Many plastics also degrade each time they are processed, making them progressively less valuable, unlike metal or glass which can be perpetually recycled.[29] In addition, almost no plastic was recycled before the 1980s.

The amount of plastic waste is likely to grow. The world produces more than 300 million tons of plastic, half of which is designed for single use.[30] Following current trends, by 2050 we will be making more than three times as much plastic as we did in 2014,[31] and global peak waste is not anticipated until 2100.[32] Because most plastic is made from fossil fuel feedstocks, cheap fossil fuels are leading to massive investments in plastics infrastructure in the United States, Europe, Asia, and the Middle East. For example, Aramco in Saudi Arabia has partnered with large chemical companies such as Dow and Sabic to construct massive chemical and plastics manufacturing facilities.[33] Likewise, underutilized coal in China is leading to heavy investment in plastics infrastructure there, including carbon-intensive coal-to-olefins technology.[34] If all these facilities are built, we could face more, cheaper, "disposable" plastics for decades.[35]

Global primary plastics production (in million metric tons) by industrial use sector, 1950-2015



Source: Geyer, Jambeck, & Law, SCIENCE ADVANCES, fig. S1 (2017)

WHERE DOES PLASTIC WASTE COME FROM?

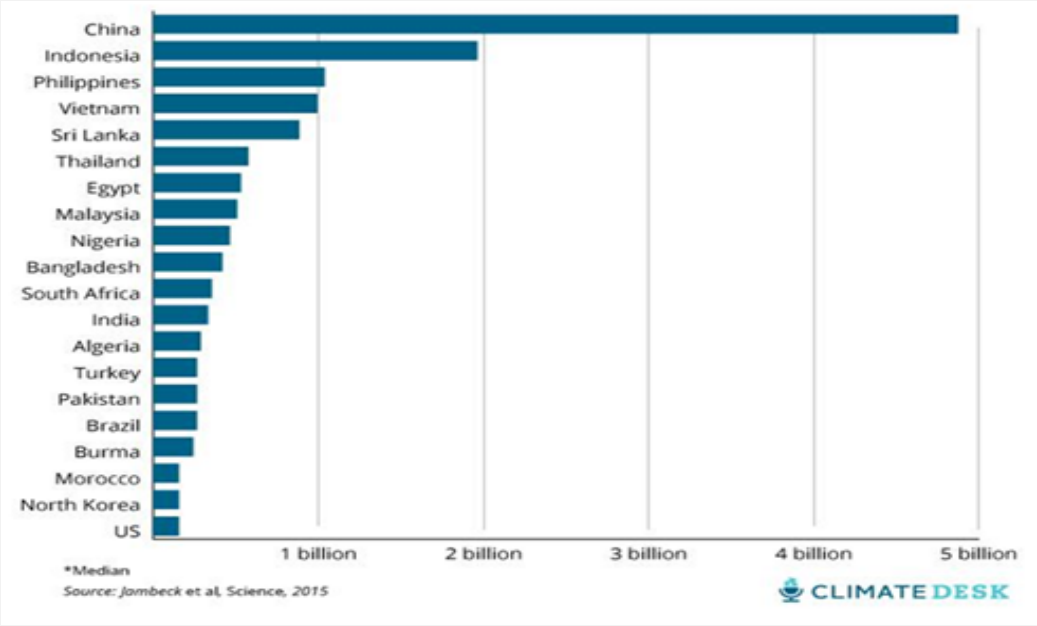
The vast majority of plastic trash in the oceans – upwards of 80% – comes from land-based sources.[36] Most of this comes from uncollected waste (e.g., littering, illegal dumping, stormwater discharges), while the remainder comes from gaps in the collection system (e.g., leakage during collection, transportation, and storage).[37] Plastic is blown, washed, or discharged into the oceans, often via drinking and wastewater systems and rivers. Some plastic in the oceans also comes from sea-based activities, including boats, losses from shipping containers, offshore operations, military operations, and the growing aquaculture industry.[38]

Scientists have researched how plastic enters the oceans, using country-level data to determine where the greatest sources are. They are quick to point out that the purpose of the rankings is not to blame any countries; rather their research reveals what the determining factors are that lead to the creation of marine debris, namely population density (especially close to coasts), miles of coastline, and the amount of mismanaged waste. The data can also help pinpoint the most strategic places to focus in pursuing short-term remedies.

About half the plastic waste from land originates in four countries: China, the Philippines, Indonesia, and Vietnam. (Vietnam is responsible for nearly as much plastic waste per person entering the ocean as China, but with a much smaller population, its overall contribution is smaller.) The other half comes largely from other developing economies in Asia, Africa, and Latin America that have growing populations and emerging middle classes that use ever more plastic. Of the top 20 plastic waste generators, 12 are in Asia and 5 in Africa. Waste management infrastructure has not kept pace with economic development, and many developing countries (e.g., in Latin America, the Caribbean, and Small Island Developing States) need

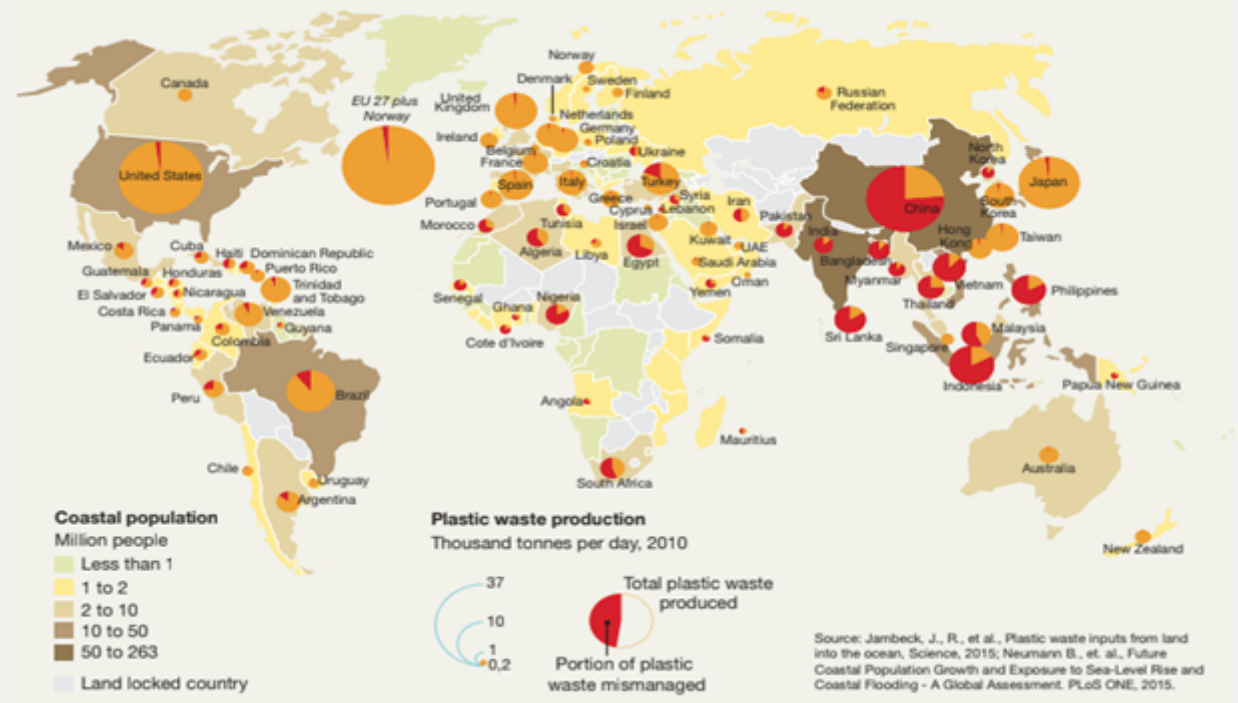
culturally and environmentally appropriate waste management systems[39] and, where necessary, drinking water systems to minimize the use of plastic bottles.

Plastics debris (in pounds) contributed to ocean, 2010



Source: McDonnell, CLIMATE DESK (2015)

Plastic waste produced and mismanaged, 2010



Source: Maphoto/Riccardo Pravettoni, GRID Arendal, MARINE LITTER VITAL GRAPHICS (2018)

The United States has the distinction of being the only high-income country in the top 20. Though litter and leakage rates in the United States are comparatively low, the volume of waste is so large that the small percentage of mismanaged waste that ends up in the oceans is significant.[40] Other high-income countries also contribute. For example, though Finland has a 100% waste collection rate, about 150,000 to 500,000 tons of plastic debris enter the oceans from the EU every year and end up in vulnerable marine areas such as the Mediterranean Sea and parts of the Arctic Ocean.[41]

WHY IS OCEAN PLASTIC BAD?

Plastic is an important material. Life-saving medical devices are crafted of it. Cars are lighter because of it, which saves fuel and reduces greenhouse gas emissions. Plastic provides time and money-saving conveniences. However, the very qualities that make plastic so useful and ubiquitous – its strength, light weight, low cost, durability, and resistance to degradation – are also what make it such a pernicious and persistent problem. Though plastic may seem cheap, it creates high, unaccounted-for costs to human and environmental health and exacts significant economic and social costs.[42] (Although the focus of this paper is marine plastic debris, plastic waste in soils, freshwater, and air is also extremely problematic in terms of impacts on human and environmental health.[43])

Human & Marine Health

Plastic is killing and harming marine animals and degrading ecosystems in a variety of ways. Algae and bacteria can stick to small and micro pieces of plastic, helping them sink into the water column or to the seafloor. Zooplankton and fish then eat these micro "plastic sandwiches," mistaking them for food.[44] The plastic ends up in the animals' systems – in flesh or fecal material – either to be eaten again by another organism and bio-accumulate up the food chain, or to sink into sediments with unknown impacts on deep-sea ecosystems. Consumption of cigarette butts (which are made of plastic fibers – cellulose acetate) by marine organisms can lead to death through choking or starvation, and they also contain toxins that can have harmful effects on aquatic organisms.[45] Sea birds and mammals also ingest larger plastic items, such as grocery bags that look like tasty jellyfish.[46] Corals appear to be ingesting plastic too.[47] Animals starve due to the lack of calories and intestinal blockages, and they suffocate from swallowing larger items such as balloons, bags, and sachets.

There are many more types of impacts as well. For example, plastic debris such as lost or abandoned fishing nets, lines, and traps strangle or entangle many marine animals ("ghost fishing") and ocean-going birds; they can damage coral reefs too.[48] A high intake of microplastics also has adverse effects on fecundity, including in oysters and other organisms that play crucial roles in ecosystems.[49] In addition, because plastic absorbs and retains more heat than sand, microplastics and microbeads appear to be affecting sex determination of sea turtles, which nest in sand and for whom sand temperature determines sex.[50]

Plastic is now in many types of sea birds, mammals, invertebrates, and sea turtles, and in more than 25% of fish sampled from seafood markets around the world.[51] Plastics and the chemicals they contain are ending up in the species that humans eat. With the majority of small fish being ground up and used for animal feed, even people who do not eat seafood but do eat chicken,

pork, or other animals are eating ocean plastic.[52] Plastic has also been detected in salt, sugar, and beer.[53] Plastic pollution is not just a water quality problem; it is also a food safety problem.

In addition, plastics contain a smorgasbord of chemicals to imbue them with desired qualities, including flame retardants, softeners, hardeners, and stabilizers.[54] Scientists are only starting to comprehend the implications of these chemicals in the oceans and on land, as many are toxins, carcinogens, endocrine disruptors, or otherwise unhealthy to people, animals, and ecosystems. Some of the chemical compounds, such as persistent organic pollutants (POPs), bio-accumulate as they move up the food chain, meaning that their concentrations are the highest by the time top predators and people eat them. Humans are also exposed to these chemicals by eating or drinking out of plastic containers, and new research points to the strong possibility that humans are breathing in microplastic particles laden with chemicals as well.[55]

Though the biological effects of most plastic ingredients are unknown, some are confirmed hormones that affect human systems. The American Academy of Pediatrics issued a policy statement in July 2018 recommending limiting exposure to chemicals for infants and children, including bisphenols and phthalates (e.g., BPA) that are used to make plastics (e.g., to harden or soften them).[56] Human ingestion of these chemicals may be among the reasons that children are entering puberty earlier than they did twenty years ago.[57] Studies have also shown that these endocrine-disrupting chemicals are leading to significantly decreased sperm counts and testosterone levels in men around the world.[58]

Adding to the list of concerns, pathogenic microbes can accumulate on floating plastic, which can cause gastroenteritis, septicemia, and other diseases. With plastic waste reaching all corners of the globe, foreign organisms travel with them, which can spread disease.[59]

Efforts to keep plastic out of the oceans can have impacts as well. For example, disposing of plastic by burning it in open-air pits releases harmful gases.[60] Even more technologically advanced thermal treatments such as incineration, waste-to-energy, and pyrolysis create toxic pollution and may contribute to climate change. Where plastic is buried in landfills, toxic leachate can seep into groundwater and then to lakes, rivers, and oceans.

Economic & Social Costs

The costs to human and marine life and are not included in the price of plastic. Neither are the measurable costs that marine plastic pollution imposes on the fishing, shipping, and tourism industries and on coastal communities and the people who live there. The United Nations Environment Programme estimates that the total economic damage to the world's marine ecosystems from plastics is well over $15.5 billion every year, including losses to fisheries and tourism and the costs of beach cleaning.[61] The Asia-Pacific Economic Cooperation (APEC) countries estimate that the cost of ocean plastic pollution to their tourism, fishing, and shipping industries is $1.3 billion in that region alone.[62] The cost of litter to EU fisheries was estimated at about 1% of total revenues from catches by the EU fleet,[63] and Europe spends about $732 million dollars (€630 million) per year cleaning plastic waste from its coasts and beaches.[64] As the unrestrained disposal of plastic grows, so, too, will both the expense in dealing with it and the impact on human lives and livelihoods, such as when people endure floods caused by drains clogged with plastic or have to walk or paddle through plastic to earn their living.

Climate Change

Plastic production and waste incineration are also contributors to climate change, globally adding about 400 million tons of CO_2 per year (as of 2012). If the production and use of plastics continues on a business-as-usual trajectory, then by 2050, the global plastics sector will account for about 15% of the global annual carbon budget (based on remaining below a 2°C temperature rise above pre-industrial levels).[65] In addition, new research shows that the most common plastic present in litter – polyethylene, which is used to make bags and bottles – also emits methane, one of the most potent greenhouse gases, as it breaks down in sunlight.[66] Furthermore, since the vast majority of plastics are made from virgin fossil feedstocks, greenhouse gas emissions from fossil fuel production (e.g., methane leakage) are also part of plastics' carbon footprint.

Though plastics undeniably provide certain resource efficiencies, it is clearly important to factor in the climate-changing impacts of plastic production, use, and disposal, especially given the deep reductions needed in greenhouse gas emissions, the existing impacts of climate change, and the warnings, such as the recent one in the Proceedings of the (U.S.) National Academy of Sciences, that unless we change course quickly with regard to human-induced warming, we risk a "domino effect" of self-reinforcing feedback loops that would lead the Earth to become a "hothouse" with high sea levels and "conditions that would be inhospitable to current human societies and to many other contemporary species."[67]

WHAT CAN BE DONE ABOUT IT?

There are two key categories of solutions to the marine plastic pollution problem. First, we should clean up what we can. Second, and more important, we need to drastically reduce the amount of plastic going into the oceans. Trying to clean up the mess is useless if we do not "turn off the tap."

At the heart of the necessary measures is the need for a shift in mindset – one that recognizes that there is **no such place as "away"** that plastic waste (or other pollution) goes to.[68] Instead of the current "use and toss" model common in all aspects of our economy (not just plastics), we need to shift to a circular economy model that envisions a system that is restorative and regenerative by design, considers all materials as valuable and recoverable, reduces demands on finite raw materials, and minimizes waste and other negative externalities.[69]

Addressing the causes of ocean plastic pollution will improve the quality of life for millions of people around the world and will facilitate progress on the 2030 Agenda and the Sustainable Development Goals,[70] as well as other sustainability and development objectives set by countries and non-state actors around the world.

Cleanup

Understanding that the plastic floating on the surface of the oceans and washing up on shorelines is only a small fraction of the pollution present in the oceans, we still need to remove the plastic already in the oceans to the extent we can and reuse, recycle, or dispose of that material in the most environmentally-responsible ways possible.

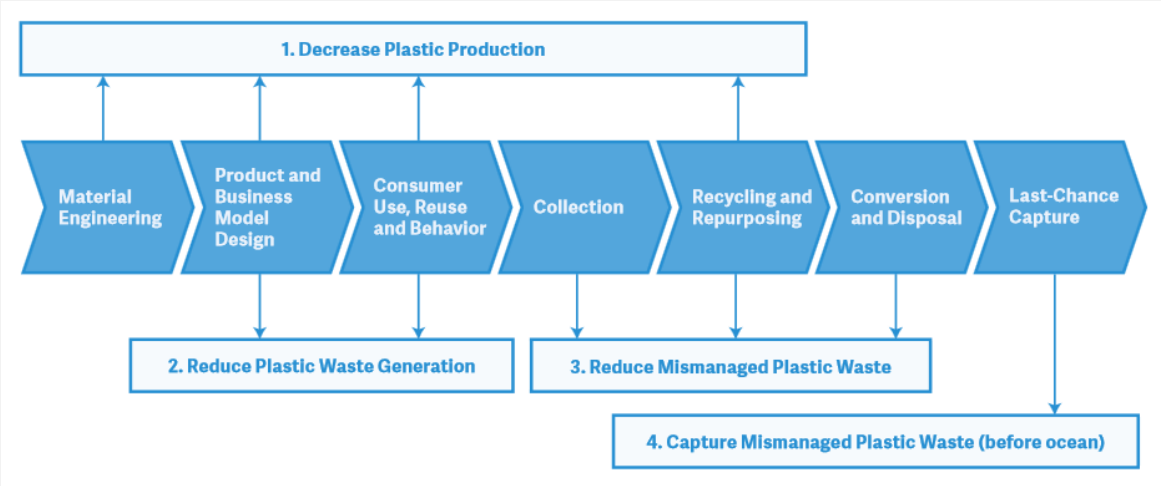
A host of civil society, government, business, and volunteer efforts and partnerships exist to try to "clean up" the oceans, with a focus on beaches, shorelines, and the plastic floating in the five gyres. One is the Ocean Conservancy's Trash Free Seas program, through which nearly 12 million volunteers from 153 countries have collected nearly 100,000 metric tons (220 million pounds) of plastic during the past 30 annual International Coastal Cleanup days.[71] Another initiative is 4Ocean, which provides an alternative income for fisher-people to collect ocean plastic, with the funds coming from selling bracelets made of re-used plastic to ocean advocates online.[72] (In contrast, fishermen in Ghana report that their nets bring in 70% rubbish – mostly plastic – and 30% fish, but they toss the garbage back into the sea; they do not even have bags to collect the wet, heavy trash, much less a place to bring it to or a way to make money from their trash collection.[73]) The ambitious and somewhat controversial Ocean Cleanup, which launched in September 2018, uses a floating system to capture plastic, in hopes of removing 50% of the plastic in the Pacific gyre within five years.[74]

No effort or combination of them, however, will be able to remove all the plastic pollution in the oceans. Even with a robust global effort, it is impossible to rid the oceans of floating and sunken microplastics without removing the similar size plankton that form the base of the food web. Furthermore, the cost-effectiveness and technical feasibility of large-scale removal of plastics from the ocean floor is questionable given that the average depth of the ocean is 14,000 feet. Prevention, therefore, is truly the top priority, and that starts primarily on land.[75]

Reducing the Flows of Plastic Pollution

Preventing plastic waste from entering the oceans requires three core strategies: (1) improving waste collection and management to keep plastic waste from finding its way to the oceans or elsewhere in the environment; (2) increasing reuse and recycling, as well as markets for repurposed and recycled material; and (3) redesigning products and using alternative materials and business models to reduce the amount of plastic used and the amount of plastic waste generated. It requires efforts throughout the value chain, as shown below.

Mechanisms across the plastics value chain for reducing plastic waste entering the ocean



Source: Moss, Eidson, & Jambeck, *Sea of Opportunity* (2017)

Adequate plastic waste collection, management, and recycling systems are needed in many parts of the world, especially in developing countries and emerging economies in Asia, to reduce and stop unmanaged or mismanaged disposal.[76] Such systems must include both industrial and small-scale systems, be appropriate to local cultural norms and socio-economic conditions, and account for the informal economy, such as the large numbers of informal waste pickers that gather and sort recyclables in both rich and poor countries. Even the World Plastics Council, a global plastics industry group, supports the need for improved waste management, with a focus on emerging economies with large populations near rivers and coastlines.[77] Until the relevant countries have the appropriate facilities, we need to avoid exporting plastics to countries that do not have the capacity and facilities to contend with them.

Efforts to expand and improve plastics recycling and to increase the recycled content of products are also needed to prevent (or at least delay) plastics from becoming true waste. A focus on increased recycling should not overlook reuse and repurposing of materials, however. For example, the Circular Ocean is a three-year project to work with Arctic communities to make income-producing products from discarded fishing nets and ropes, thereby creating a market for those repurposed plastics.[78]

Many products, however, are "designed for the dump" and are neither reusable nor recyclable. Product redesign and alternative materials are needed so that products use less plastic and so the plastic that is used is recycled more easily. More robust extended producer responsibility through internalization of end-of-life collection and treatment costs would incentivize better design of products and packaging.[79] With regard to alternative materials, most current "biodegradable" or "compostable" plastics (which are only a very small fraction of the market) are usually not recyclable and only biodegrade under specific conditions, which are not necessarily present where the material ends up. Only PHA polymers, which are made from bacteria, are somewhat marine degradable; they degrade by 30% in about six months, but only in warm tropical waters.[80] Fortunately, new materials are being developed from natural sources – including algae, mushrooms, sorghum flour, and milk protein – that may be truly biodegradable.[81] Experiments are also taking place with new polymers that self-destruct.[82] Hopefully, carbon-removing materials – those made from waste carbon dioxide and methane – will be successful as well.[83]

Role of Governments, Businesses, & Investors

Focused advancement of these core prevention strategies, particularly in the countries that are the greatest sources of marine plastic pollution, could lead to significant reductions in waste flows into the oceans within a couple of decades, but it will require strong public-private partnerships, enabling policies and investments, and effective enforcement.

Governments can take a leadership role in reducing plastic waste. For instance, many cities and more than 60 countries – including Kenya, India, Costa Rica, and Vanuatu – have introduced policies to ban or reduce use of plastic bags and other single-use plastic materials.[84] Governments can also advance recycling. For example, some of the most developed cities in China are piloting innovative waste sorting programs that provide residents with rewards for properly sorting recyclables, hazardous wastes, and other trash.[85] The European Commission, through its Ecodesign Directive, has developed criteria to improve the recyclability of plastics, including marking plastic parts to facilitate sorting and designing packaging for recyclability.[86]

In addition, governments and companies can create bigger markets for recycled plastics by increasing minimum recycled content requirements in procurement policies. Governments can also adopt policies to foster development of benign materials.

Furthermore, numerous sub-regional, regional, and international agreements and policy frameworks exist that contend with different aspects of the issues related to plastics and their chemical additives at different points in the global value chain. The UN Convention on the Law of the Sea, for instance, aims to protect the marine environment and to prevent, reduce, and control pollution from all sources. Other pertinent agreements include the 2017 G-20 Action Plan on Marine Litter,[87] the 2018 G-7 voluntary Plastics Charter (minus the United States and Japan),[88] and the UN Environment Assembly's 2017 "Resolution on Marine Litter and Microplastics."[89] These agreements and frameworks, however, tend to lack binding commitments, timelines, and metrics – which need to be added as they are elaborated. Likewise, voluntary partnerships, such as the UN Environment Programme's Global Partnership on Marine Litter and its Global Program of Action for the Protection of the Marine Environment from Land-based Activities,[90] aim to reduce and manage marine litter and to enhance international cooperation and coordination.[91]

Ultimately, the plastic pollution challenge likely needs to be addressed by a **comprehensive global strategy** that knits these fragmented agreements together and fills in the gaps. Such a strategy would cover plastics and microplastics from land and marine sources and their chemical additives, harmonize standards and strategies, address trade and aid issues, and be adaptable to emerging scientific evidence and industry innovations. Negotiating such an agreement will likely take a long time, and it is unclear whether countries have the political will to adopt and implement one.

In the meantime, businesses do not need to – and should not – wait for governments or the global community to act. Urgent voluntary industry action is needed in the short term. An important step is for companies to start measuring, verifying, and reporting on their plastic use, including through tools such as the Plastic Scan and the Plastic Disclosure Project.[92] Encouragingly, many industries in the plastics value chain are already engaged in aspects of problem-solving. For example, the Global Plastics Outreach Alliance – formed by the U.S. Association of Plastic Recyclers, Plastics Recyclers Europe, and the European PET Bottle Platform – aims to reconcile product design and testing guidelines to facilitate recycling across borders by creating a global plastics recycling industry standard for certain resins.[93] Some major brands and plastics manufacturers have also recently announced the creation of new supply chains from plastic waste, including American Express, which will make credit cards from ocean plastic, and Adidas and Stella McCartney, which will make athletic shoes and garments from recycled nylon and polyester (though these will still shed plastic microfibers into water systems when washed).[94] Going even further, TerraCycle's Loop is a new partnership of major brands that aims to help eliminate the idea of disposability by bringing back the model of delivering products and then picking up or having customers return the empty packages, which will require new reusable packaging designs.[95]

Investors, too, play a critical role. For example, the Circulate Capital investment fund will invest in opportunities to intercept ocean plastics at the source by collecting, sorting, processing, and recycling waste in South and Southeast Asia, working with municipalities, local entrepreneurs

and investors, and NGOs.[96] The Plastic Solutions Investor Alliance, an international coalition of investors, is working with publicly-traded consumer goods companies on the threats posed by plastic pollution.[97] Reports from the Ocean Conservancy, McKinsey, Vulcan/Encourage Capital, and others lay out numerous investment opportunities along the plastics value chain.[98]

Various new entrepreneurial incubators may also hold promise for some pioneering solutions, including the Ocean Solutions Accelerator, which provides early-stage companies from around the world with initial funding and opportunities to engage with mentors, partners, and investors who are transforming innovative ocean solutions into scalable businesses.[99]

Solving the ocean plastics and plastic hazards problems will require a holistic effort, with coordinated and collaborative global actions by all sectors of society – including individual citizens, civil society organizations, businesses, governments at all levels, philanthropists, and investors – across the plastics value chain, from product design to waste management. It will take decades, though, to achieve the massive cultural and economic shifts needed to forge a global economy that, like nature, produces no waste. Hopefully, the growing recognition of the connections between marine plastic pollution and human health, climate change, food security, clean drinking water, social justice, and many other issues will spur and accelerate the needed collaboration, innovations, policies, standards, and markets.

RECOMMENDATIONS FOR INTERACTION COUNCIL MEMBERS

Members of the InterAction Council can advance solutions through their own spheres of influence. Members can make positive change through the following measures:

- ***Notice, Model, & Educate*** – Members can increase their awareness of their own plastic use, seek to model behavior (e.g., bringing and using a metal bottle or ceramic mug at speaking engagements), and spread awareness to others. They can speak out about the issue, make the connections between plastic pollution, human health, climate change, and other issues, and use speaking engagements as opportunities to ask organizers whether they have zero-waste policies.
- ***Influence Organizations*** – Members can encourage companies and organizations they serve to advance zero-waste policies (including no-single-use-plastic procurement and extended producer responsibility policies), adopt measurement and reporting on plastic use and waste, collaborate with others in the supply chain to minimize plastic use and waste, and educate employees about plastic pollution.
- ***Call for Public & Private Infrastructure Investment*** – Members can call for public, private, and public-private investments in geographically and culturally appropriate infrastructure to reduce and stop unmanaged or mismanaged plastic waste disposal, including clean drinking water systems and public taps (to reduce use of plastic bottles) and solid waste collection and recycling facilities.
- ***Call for Analyses of Investments in New Plastics Production Facilities*** – Members can call for assessments of the human and environmental impacts of proposed investments in new plastics production and related chemicals facilities, which, if built, will lock in decades of additional disposable plastics production.

- ***Call on Industry to Increase Coordination Across the Plastics Value Chain*** – Members can call on industry representatives from companies and trade associations throughout the plastics value chain to develop harmonized design guidelines for the manufacture, recycling, and treatment of plastics to hasten the transition to a more circular economy.
- ***Call for Policies at All Levels of Government that Reduce Plastic Waste and Promote Development of Alternative Materials –*** Members can promote adoption of national and sub-national policies that ban or reduce single-use plastic materials, advance recycling, create bigger markets for recycled plastics, and spur development of benign materials.
- ***Call for an International Agreement on Plastics Pollution*** – Members can urge the G-7, G-20, ASEAN, and others to coordinate on their and others' ongoing work to develop, implement, and enforce multilateral agreements, in concert with other stakeholders, and to quickly build on the work of the UN Environment Assembly to develop a legally-binding international agreement to manage plastics throughout their lifecycle, reduce avoidable plastics, and prevent leakage of plastic waste and additives into the oceans.

About the Author

Holly Kaufman's expertise is in climate change, sustainable development, corporate responsibility and clean technology. She managed the climate change & national security portfolio at the US Department of Defense as a President Bill Clinton appointee, and was the liaison to the President's Council on Sustainable Development. She developed diplomatic strategy for the UN climate treaty negotiations as Special Advisor to the Assistant Secretary of State, receiving a Superior Team Honor Award. Ms. Kaufman also served at the White House Council on Environmental Quality, where she wrote President Clinton's report to Congress on environmental trends.

As founder of Environment & Enterprise Strategies, she provides strategic guidance to such organizations as the World Economic Forum, Hewlett Packard, Conoco, Proctor & Gamble, the Union of Concerned Scientists, and the California Wind Energy Association. She developed the outreach strategy for the Natural Resource Defense Council's coalition that led to the establishment of two California marine protected areas. Other positions include serving as Executive Director of an international ecological research network under the auspices of the US National Academy of Sciences, Acting Director of the Port of Oakland's environment department, head of environmental planning for the fourth largest waste management company in the U.S., and Deputy Director of a renewable energy NGO. She taught ecological agriculture at the University of California at Berkeley and the California Academy of Sciences. She has led community development or research projects in Asia, Africa, Latin America and the Caribbean.

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