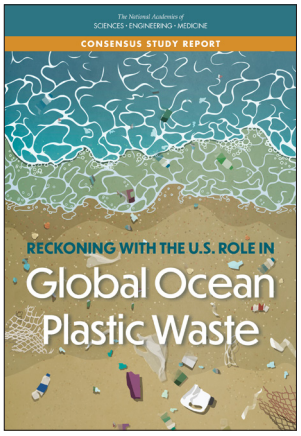
Consensus Study Report

DECEMBER 2021

HIGHLIGHTS

Reckoning with the U.S. Role in Global Ocean Plastic Waste



Researchers have found plastic waste in almost every marine habitat, from the ocean surface to deep sea sediments to the ocean's vast mid-water region, as well as the Great Lakes. An estimated 8 million metric tons (MMT) of plastic waste enters the world's ocean each year—the equivalent of dumping a garbage truck of plastic waste into the ocean every minute.

If current practices continue, the amount of plastic waste discharged into the ocean could reach up to 53 MMT per year by 2030, roughly half of the total weight of fish caught from the ocean annually. Society is grappling with the massive scale of the challenge of plastic waste with responses ranging from beach cleanups and local bans to extended producer responsibility schemes, circular economy commitments, country-level plans and commitments, and a call for a global treaty.

The U.S. Congress, in the bipartisan Save Our Seas 2.0 Act passed in December 2020, called for this report synthesizing scientific knowledge about the U.S. role in global ocean plastic waste. The report assesses the U.S. contribution to plastic production and waste generation, the mechanisms that move plastics from land into aquatic environments, and the distribution and fate of plastic waste entering the ocean. It recommends a national strategy for reducing the U.S. contribution to global ocean plastic waste, lays out a vision for a national marine debris tracking and monitoring system, and identifies priority knowledge gaps that are used in the national strategy along with the tracking and monitoring system.

U.S. PLASTIC PRODUCTION AND GLOBAL TRADE

Over a 50-year period, global plastic production dramatically increased, from 20 MMT in 1966 to 381 MMT in 2015. More than 99% of the plastic resin produced globally is made from fossil-based petrochemical feedstocks (e.g. crude oil, natural gas liquids). The majority of plastics are hydrocarbon plastics with a strong carbon-carbon bond, making them resistant to biodegradation.

The U.S. contribution to global ocean plastic waste begins with the plastics produced and used in this country or exported to other nations, as well as imported plastics. Data for plastic resin production is not available for the United States alone. However, North American production of plastic resin in 2019 represented almost 20% of total global production (70 MMT of the total 368 MMT). Trends in both U.S. plastic exports and imports have been increasing over the last three decades.

U.S. PLASTIC WASTE GENERATION

Plastic waste generation has been increasing in the United States since 1960, with the fastest increase seen from 1980 to 2000 (Figure 1). In 2016, the United States was the top generator of plastic waste, with an estimated 42 MMT. The majority of U.S. municipal solid waste ends up in landfills (Figure 2 on next page). While recycling and combustion expanded as plastic

waste management techniques in the 1980s and 1990s, the amount handled by these methods remained small relative to the large increase in plastic waste.

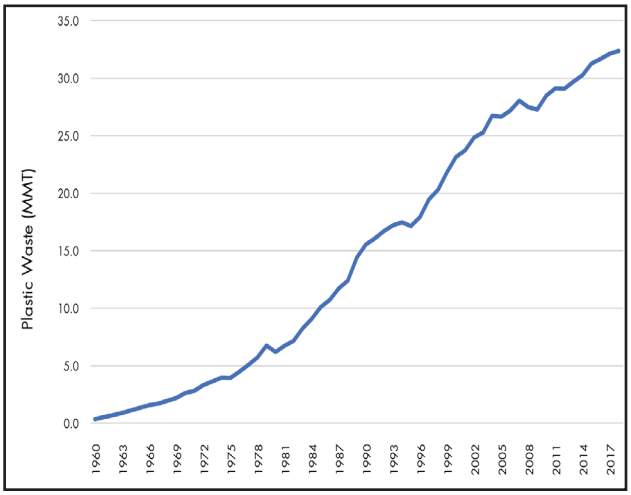


Figure 1 U.S. annual plastic solid waste generation from 1960 – 2018 in million metric tons. (Source: U.S. EPA (2020a))

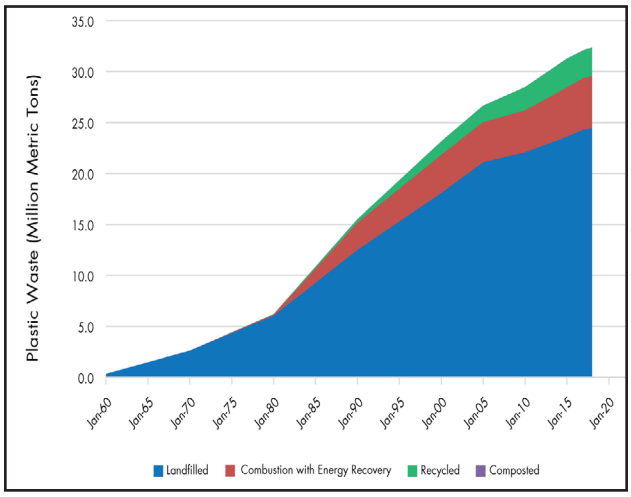


Figure 2 U.S. plastic waste management of municipal solid waste from 1960 – 2018 in million metric tons (MMT) per year. (Source: U.S. EPA (2020a))

U.S. Contribution to Plastic Waste Leakage

Plastic waste can leak into the environment from managed MSW as well as, litter, illegal dumping, permitted or unintentional discharges, and the mismanagement of exported plastic waste to other countries. A number of researchers have estimated the amounts of U.S. inputs to global ocean plastic waste, although a lack of data has hindered those efforts. Despite a well-developed formal solid waste management system, approximately 1 to 2 MMT of U.S. plastic solid waste was estimated to enter the environment at home and abroad (after export for recycling) in 2016 (Law et al. 2020). This would rank the United States in a range of the third to twelfth largest contributor of plastic waste into the coastal environment. Because many leakage estimates rely only on MSW data they are likely conservative

The U.S. municipal solid waste management system is fundamentally important for preventing leakage of plastic waste into the ocean—especially near waterways—but is historically decentralized. Waste management should be improved to ensure communities and regions are served equitably, efficiently, and economically. Although recycling will likely always be a component of the strategy to manage plastic waste, today's U.S. recycling processes and infrastructure are grossly insufficient to manage the diversity, complexity and quantity of plastic waste.

PHYSICAL TRANSPORT AND PATHWAYS TO THE OCEAN

The ocean is the Earth's ultimate sink, the downstream reservoir of all activities. Almost any plastic waste on land has the potential to eventually reach the ocean. Major paths of plastics to the ocean are summarized in Figure 3. These include urban, coastal, and inland stormwater; treated wastewater discharges; atmospheric deposition; direct deposits from boats and ships; beach and shoreline wastes; and transport from inland areas by rivers and streams.

Waterborne Pathways

The presumptive largest path of plastic mass from land to the ocean is from rivers and streams moving plastic wastes from inland and coastal areas to the sea. Rain and snowmelt flow over impervious surfaces such as paved streets and parking lots, carrying pollutants, including plastic waste, either into urban and stormwater systems that discharge to local areas, or directly into rivers, streams, lakes, and coastal waters. Urban and suburban sewer flows to wastewater treatment plants are a smaller contributor, carrying appreciable quantities of microplastics shed from clothing and other textiles, as well as from tire and roadwear particles.

Other Pathways for Plastic Waste: Wind and Direct Input

Another pathway of plastic waste to the ocean is through atmospheric deposition. Plastic waste, ranging from microplastics, bags and wrappers, and even larger items can be carried by winds to adjacent water bodies. Direct deposition of plastic materials into the ocean occurs through losses of fishing and aquaculture gear, recreational gear (e.g., during boating or scuba diving), overboard litter, unregulated direct discharge, and

cargo lost from ships and barges. Major storm events, such as hurricanes, floods or tsunamis, can deposit massive amounts of debris in a relatively short period.

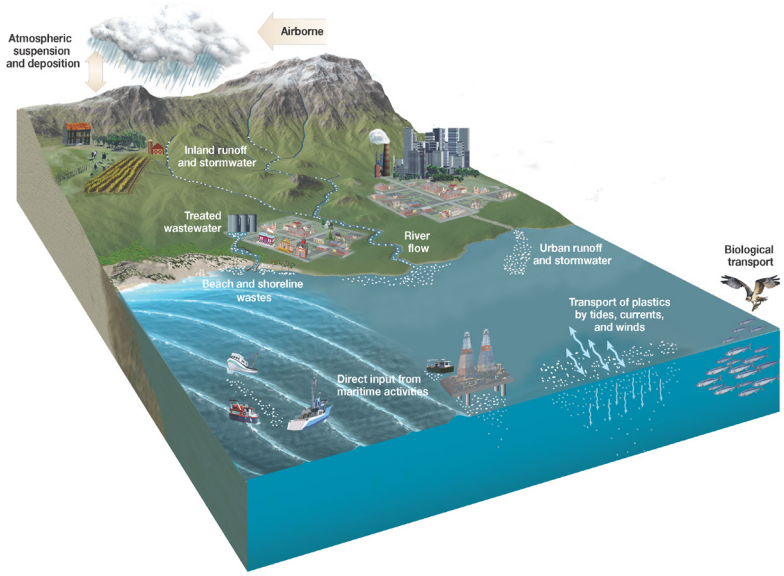


Figure 3 Major transport paths for plastics from land to the ocean.

DISTRIBUTION AND FATES OF PLASTIC WASTE IN THE OCEAN

The input of plastic waste in the ocean and Great Lakes is a reflection of both the amount and type of plastic waste and how it is transported from upstream locations. The distribution and fate of plastics once in the ocean is determined by ocean currents and surface winds, and the degradation of plastics in the ocean. Plastic waste is found on shorelines from ocean beaches, in estuaries, in the open ocean water column, on the seafloor, and in marine life.

Coastlines, including sandy beaches, rocky shorelines, estuarine and wetland environments, are littered by plastic waste that may be generated locally, carried from inland sources, or brought ashore by storms, tides, or other nearshore processes. In 2019, more than 32 million individual items were collected and categorized from more than 24,000 miles of beaches around the globe in the International Coastal Cleanup (Ocean Conservancy). The Top 10 list (highest number of items collected) has included some of the consumer products year after year, including cigarette filters, food wrappers, beverage bottles and cans, bags, bottle caps and straws.

Sampling of the ocean's surface has allowed scientists to assess the large-scale accumulation of floating debris across ocean basins, particularly in ocean gyres in both the northern and southern hemispheres (commonly referred to as "garbage patches"). Contrary to common misperceptions, floating plastic debris is not aggregated together in a single large mass but instead is dispersed across millions of square kilometers.

Impacts on and Distribution by Marine Life

Entanglement and ingestion of plastic waste represent two especially well-studied impacts on marine and freshwater life. One review, by Kuhn and van Franeker (2020), found documented cases of entanglement or ingestion by marine biota in 914 species based on 747 studies—701 species have documented ingestion and 354 species have been found entangled in plastic debris. Microplastics ingested by marine biota may move through the food web, ultimately to humans, but not much is known about the effects on the food web and humans specifically.

THE NEED FOR TRACKING AND MONITORING SYSTEMS

A national scale tracking and monitoring program (or system of systems) that spans the plastic life cycle from plastic production to leakage into the ocean is needed to inform U.S. strategies and policies on plastic source reduction. Tracking and monitoring systems currently in place focus on solid waste management inputs and plastic waste items detected in the environment and ocean.

The Marine Debris Monitoring and Assessment Project (MDMAP) is the flagship community science initiative of the NOAA Marine Debris Program (MDP) that engages partner organizations and volunteers to foster a national shoreline monitoring program. To date, MDMAP has completed 9055 surveys at 443 sites that span 21 U.S. states and territories and nine countries. The project has helped estimate marine debris abundance and temporal trends, but the lack of a comprehensive national baseline for debris densities along the coast hinders the ability to monitor change in general.

Vision for a U.S. Marine Debris Tracking and Monitoring

Multiple tracking and monitoring systems, which are complementary and synergistic, would contribute to: (1) understanding the scale of the plastic waste problem; and (2) the identification of priorities and progress for source reduction, management, and cleanup. Characteristics of a tracking and monitoring system that would be most effective in ultimately reducing plastic waste in aquatic systems include:

- A study design that is scientifically robust, hypothesis-driven, and conceptualized a priori to answer critical knowledge gaps, rather than approaches applied post-hoc to plastic waste tracking and monitoring questions.
- Technologically adaptive to incorporate and utilize current and emerging technologies such as remote sensing crowdsourcing apps, and biochemical

markers and tracers

- Applied with sufficient spatial and temporal resolution to capture meaningful data concerning knowledge and policy needs.
- Collects data that are comparable, and, when scientifically robust, compatible with prior efforts, for example, using standardized measurement units or experimental design.
- Leverages, rather than separates, the U.S. federal investment in the reduction of mismanaged plastic waste and creates synergies in the federal response to such waste.
- Encompasses the full life cycle of plastics, thereby achieving an understanding of the "upstream" plastic waste compartments and associated leakages.

As part of this vision, MDMAP should conduct a scientifically-designed national marine debris shoreline survey every 5 years using standardized protocols. In addition, federal agencies with mandates over coastal and inland waters should establish new or enhance existing plastic pollution monitoring programs for environments within their programs and coordinate across agencies, using standard protocols.

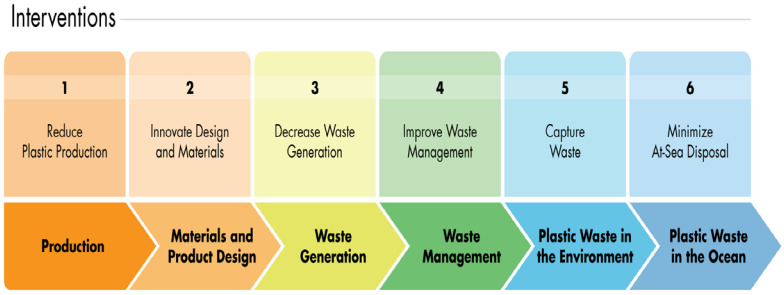


Figure 4 Flow diagram of potential plastic waste interventions from plastic production to direct input into the ocean to include in a U.S. strategy.

U.S. STRATEGY OF INTERVENTIONS TO REDUCE GLOBAL OCEAN PLASTIC WASTE

The United States should substantially reduce solid waste generation (absolute and per person) to reduce plastic in the environment and the environmental, economic, aesthetic, and health costs of managing waste and litter. There is no single solution to reduce the flow of plastic waste to the ocean. However, a suite of actions (or "interventions") taken across all stages of the path from source to ocean could reduce ocean plastic waste and achieve parallel environmental and social benefits (Figure 4).

Many other countries (and some states) have been taking steps to address the plastic waste problem. As of 2018, 127 out of 192 countries regulate plastic bags restricting free retail distribution and 63 countries mandate extended producer responsibility (EPR) for single-use plastics, including deposit-refunds, product take-back, and recycling targets. In addition, the European Union, Canada, and China, among others, have established national goals and strategies designed around interventions.

The United States should create a coherent, comprehensive, and crosscutting federal research and policy strategy that focuses on identifying, implementing, and assessing equitable and effective interventions across the entire plastic life cycle to reduce the US contribution of plastic waste to the environment, including the ocean. This systemic strategy should be developed at a high level with a group of experts (or external advisory body) by December 31, 2022 and its implementation assessed by December 31, 2025. Such a strategy would enhance United States' leadership in creating solutions to global plastic pollution and shaping modern industrial plastic policy.

COMMITTEE ON THE UNITED STATES CONTRIBUTIONS TO GLOBAL OCEAN PLASTIC WASTE

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For More Information . . . This Consensus Study Report Highlights was prepared by the National Academies of Sciences, Engineering, and Medicine based on the Consensus Study Report RECKONING WITH THE U.S. ROLE IN GLOBAL OCEAN PLASTIC WASTE (2021). The study was sponsored by the National Oceanic and Atmospheric Administration. Any opinions, findings, conclusions, or recommendations expressed in this publication do not necessarily reflect the views of any organization or agency that provided support for the project. Copies of the Consensus Study Report are available from the National Academies Press, (800) 624-6242; http://www.nap.edu or via the Ocean Studies Board web page at http://www.nationalacademies.org/oceanstudiesboard/osb.

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