

What works to reduce marine plastic pollution? What we know and what we need to do

"[Ocean plastic] isn't a problem where we don't know what the solution is. We know how to pick up garbage. Anyone can do it. We know how to dispose of it. We know how to recycle."

--- *Ted Siegler, DSM Environmental Services, on building the institutions and systems needed to deal with plastic before it reaches the ocean*

Editor's note: Marine plastic has a profound impact on marine ecosystems – entangling and killing wildlife, spreading disease and non-native species, and even impairing the oceans' creation of oxygen. Managing marine ecosystems will need to include managing the marine plastic problem. Last month the Skimmer reported on the impacts of marine plastic on the Blue Economy, including on tourism, fishing, and ecosystem services. This month, in the second half of our plastics coverage, we examine which policies to reduce marine plastic seem to work best.

There is an abundance of information out there on how to reduce one's personal plastic consumption, with the ultimate goal of reducing the amount of plastic that is polluting marine (and terrestrial) ecosystems. There are also numerous great reports (examples [here](#) and [here](#)) on government and industry interventions for reducing marine plastic pollution. But what do we know about the efficacy and level of impact of these activities? Are we lumping actions which are likely to have relatively little impact on the problem with actions that potentially have huge impacts? Of course, the ideal is to eliminate all plastic pollution – marine and terrestrial – but in this article, we attempt to:

1. Provide perspective (by way of lots of numbers) for what actions are most likely to make the biggest difference in marine plastic pollution
2. Provide information on what has been shown to work to reduce marine plastic pollution.

These proved to be quite difficult tasks due to how dispersed relevant information is and a dearth of research on the efficacy of marine plastic pollution reduction activities. What you read in this issue of Skimmer is a work in progress, and we welcome your feedback and additional input to improve it.

So how much plastic are we talking about?

- As we think about ways to reduce marine plastic pollution, it is critical to consider some key numbers to get a sense of scale of the problem and the efficacy of possible solutions.
- **~ 275 million metric tons:** This is our best estimate of the amount of plastic waste that was produced globally in 2010 (and currently our best estimate of the amount of plastic waste produced globally annually). Some perspective on this:
 - Plastic is used globally, but, typically, high-income and island nations generate the most plastic waste per capita. The US is the largest generator of plastic waste on a per capita basis, followed by the UK, Brazil, China, and Canada.
 - As of 2015, ~ 47% of plastic waste was packaging, which has an average useful life of 6 months or less. Textiles and consumer and institutional products are the next largest sectors of plastic waste, each with ~ 14% of the annual plastic waste in 2015.
 - As of 2015, ~ 55% of the global plastic waste produced annually is discarded, 25% incinerated, and 20% recycled.
- **~ 2-5% or 5-13 million metric tons:** This is our best estimate of the amount of that ~ 275 million metric tons of plastic waste that entered the ocean in 2010. Some perspective on this:
 - Marine plastic pollution comes from ***mismanaged*** plastic waste (i.e., littered or inadequately disposed). Littered waste is waste that is dumped in inappropriate and unauthorized locations, whereas inadequately disposed waste is waste that is in uncontained dumps or landfills where it can be transported to the oceans by rivers, wind, or tides.
 - The bulk of mismanaged plastic waste comes from East Asia and the Pacific. It is estimated that in 2010, China contributed 28% of global mismanaged plastic waste, Indonesia 10%, and Philippines and Vietnam 6% each, and Sri Lanka 5%. Despite their high per capita waste generation, high-income countries generally have very effective waste management systems (i.e., waste is discarded in secure landfills, incinerated, or recycled), and very little waste is inadequately managed.
 - In fact, based on estimates of mismanaged plastic waste, even if North America and Europe completely eliminated plastic waste, the global level of mismanaged plastic would decrease less than 5%. [It should be noted, however, that marine plastic pollution can be a very costly problem in areas, such as the United States and Europe, where relative marine plastic pollution levels are low. So even governments with effective waste management systems can have strong incentives to reduce their levels of plastic waste and mismanaged plastic.]
 - The United States is the only high-income country in the list of top 20 marine plastic polluters. Although its litter and leakage^[1] rates are low compared to some of the other countries on the list, it produces so much plastic waste that the small percentage of waste that is mismanaged and ends up in the oceans is notable.
 - One particularly interesting facet of the plastic waste problem is that high income countries with effective waste management systems (including Japan, the US, Canada, Australia, and a number of countries in the EU) are actually shipping some of their waste (nominally recyclable plastics) to middle and lower-income countries with poor waste management systems, increasing its potential to become marine plastic pollution. Until 2018, most of this waste was going to China, and it is estimated that between 2010 and 2016, roughly 10% (~7 million tons) of China's annual plastic waste was imported from other countries, much of it contaminated by non-recyclable material.
 - China restricted imports of plastic waste at the beginning of 2018, leading to a dramatic increase in the amount of plastic waste shipped to Southeast Asia, including Thailand, Malaysia, Vietnam, and Indonesia. This has led to an increase in illegal dumping and burning and other social and environmental hazards in these countries. In May 2019, recognition of these problems led 187 nations to agree to amend the Basel Convention to make the global trade in plastic waste more transparent and better regulated.

- And what exactly is all this plastic waste that ends up in the ocean?
 - We don't know exactly what the plastic in the ocean looks like (e.g., size, shape, what it used to be) because we haven't found most of it. [Seriously, read about the 'missing plastics' problem here.] Our best estimate, however, of where plastic is in the ocean is that roughly 0.5% is floating at the sea surface in the open ocean, 26.8% is in coastal ocean waters, 39% is in open ocean waters, and 33.7% is on coastlines and on the ocean floor.
- Our best estimates are that at least 80% of marine plastic pollution comes from land-based sources; ~ 10% is abandoned, lost, or discarded fishing gear; and the remainder comes from other fishing and shipping activities.
 - The items most commonly collected by global beach cleanups in 2018 (and therefore one of our best clues as to what a lot of the macroplastic (plastic pieces > 5 mm long) in the ocean actually is/was) are: 1) cigarette butts, 2) food wrappers, 3) plastic beverage bottles, 4) plastic bottle caps, 5) plastic grocery bags, 6) other plastic bags, 7) straws/stirrers, 8) plastic take out/away containers, 9) plastic lids, and 10) foam take out/away containers – all single-use plastic items.
 - And we estimate that ~ 1.5 million tons (give or take a million tons) of the plastic entering the ocean is primary microplastics^[2] (plastic pieces < 5 mm long). Microfibers from washing synthetic textiles and bits of synthetic rubber that wear off tires are the largest sources of primary microplastics entering the ocean.

Thanks for that, but that didn't really say anything about what is effective at reducing marine plastic pollution...

- Right. Broadly speaking there are four ways to reduce marine plastic pollution.
 1. We can reduce the amount of plastic produced (and consumed) with the expectation that if there is less plastic in circulation, less plastic would wind up in the ocean.^[3]
 2. We can increase the reuse and recycling of plastic with the expectation that this would lead to less plastic waste, therefore less plastic would wind up in the ocean. This idea is related to the first since increasing reuse/recycling of plastic could decrease demand for plastic products made from virgin materials. We made it its own thing though because this doesn't necessarily mean a decrease in plastic in circulation.
 3. We can reduce the mismanagement of plastic waste so that it doesn't end up in the ocean.
 4. We can remove plastic from the ocean (or at least from the coast).
- The figure below gives an idea of the range of actions that can be taken to reduce marine plastic pollution. Realistically, plastic is so ubiquitous in our lives that society needs to work on many – if not all – of these fronts (using locally appropriate approaches) to fully eliminate marine plastic pollution.

So, what seems most likely to have the biggest impact on marine plastic pollution?

- Of all the measures described to reduce marine plastic pollution, working with less developed and other nations with high leakage rates to improve their waste infrastructure is likely to be the most effective strategy for dramatically reducing marine plastic pollution in the near term. It could also significantly improve the quality of life for people in these countries. In low-income countries, over 90% of waste is disposed of in unregulated dumps or openly burned. In addition to leaking plastic waste into waterways and the ocean, unregulated dumps can be breeding grounds for pests, pollute water sources, emit toxic fumes, and spontaneously combust. Likewise, openly burning waste pollutes the surrounding air, soil, and water.
- It is estimated that 50-60% of total global plastic waste leakage occurs from just five countries: China, Indonesia, the Philippines, Thailand, and Vietnam and that three-quarters of the leakage from these countries comes from uncollected waste while the remainder comes from within the waste management system (e.g., improper dumping, dump sites near waterways, and dumps without proper controls).
- While formal recycling systems are rare in low-income countries, informal systems involving waste pickers – people who collect material and sell it to recyclers – are often extremely effective at extracting high-value plastics (e.g., polyethylene bottles). High-value plastics make up about 20% of waste streams, and in the Philippines for instance the extraction rate for polyethylene bottles is near 90%.
- The World Bank estimates that over 7 million people worldwide earn a living picking waste. Waste picking involves many hazards (e.g., exposure to toxins and medical waste, 'junk slides', fires, and wild animals scavenging), and waste pickers often come from vulnerable communities. Measures could provide incentives for collecting low-value plastic, as well as improve conditions to make the job safer, more efficient, and more profitable.
- More generalized aid to high leakage countries could include financial and technical investments for: 1) increasing waste collection rates, 2) eliminating illegal dumping, 3) developing sanitary waste sorting and treatment facilities, 4) closing or improving dump sites near waterways, and 4) developing modern, low emissions waste-to-energy conversion facilities^[4].
- These changes would not be cheap, however. The five focus countries now spend ~ US\$6 billion on waste management a year. The World Bank estimates that reaching a goal of 80% waste collection (including plastic waste) would require another \$5 billion a year.
- There is increasing recognition of the importance of addressing waste management in less developed countries – particularly in Asia – and groups such as the new investment firm Circulate Capital and the industry-led Alliance to End Plastic Waste are joining traditional development agencies in directing funding to this area. One plastics expert has also suggested that the funding needed to improve waste collection in developing nations could be collected with a small tax on the manufacture of plastic resin.
- Another interesting – and unfortunate in terms of marine plastic pollution – trend is that many countries that have poor waste management systems are also developing burgeoning "sachet economies". Selling products in small individually-packaged units – sachets – makes them affordable to lower-income consumers but uses more packaging (and ultimately costs more) than larger volumes of a product.
- And, finally, we would mention that investments in waste management can also lead to decreases in marine plastic pollution in countries with effective waste management systems. A study from Australia showed that local councils that invested at least 8% of their annual budgets in coastal waste management and programs to reduce illegal dumping, prevent litter, and promote recycling all had reduced marine pollution along their coastlines. In addition, there is evidence that providing waste disposal bins on

beaches can lead to [reduced beach litter](#).

What else should we be thinking about for reducing marine plastic pollution?

- Well, by its very nature, removing plastic from coastal and marine environments reduces marine plastic pollution. However, capture rates for in situ removal of marine plastic vary dramatically, and some methods may not use limited funds and labor particularly efficiently. In addition, some removal methods may have other impacts on marine ecosystems such as [bycatch of marine organisms](#).
- To give a sense of the efficiency of various methods of removing plastic from coastal and marine environments:
 - Litter catchment systems in harbors and rivers (e.g., [Mr. Trash Wheel](#) in Baltimore Harbor in the US, [Seabins](#), [WasteSharks](#), river booms, and trash skimmer boats) can be effective at removing debris at the surface of the water column in localized areas. Mr. Trash Wheel's record high collection rate is [19 tons of debris in a 24-hr period](#) after a significant rainfall. And according to the Ocean Conservancy, surface booms and trash traps are just about the [easiest marine plastic pollution intervention method to implement](#). They are "[uncontroversial to install and, provided human resources are made available to clean and maintain them, can function with little or no hindrance.](#)"
 - Large-scale beach cleanups, which are often based on volunteer labor, can also clean up tons of plastic in a matter of hours – [~30 tons in 3 hours in Indonesia](#) and [California](#) for example. With the help of [800,000 volunteers](#) globally, the annual International Coastal Cleanup has collected [over 8,000 tons of trash](#) in a day.
 - Fishing collectives are also starting to purposefully remove trash from the ocean. A group of 5,000 fishers in southern India has [removed over 70 tons of plastic](#) from the ocean. Similarly, the French government is [paying fishers to 'fish' for marine debris](#) with special nets for marine debris, and programs in [other locations such as Hawaii and the Republic of Korea](#) pay fishers specifically [to retrieve 'ghost nets'](#) and other discarded, lost, and abandoned fishing gear – sometimes with the recovered nets being [turned into carpeting and clothing or being combusted for energy](#).
 - And, of course, there is the much-talked about open-ocean [Ocean Cleanup project](#) which is working to put enormous booms in the ocean to collect plastics and other debris. The Ocean Cleanup has currently cleaned up about [2 tons of plastic](#) over a couple of months for [millions of dollars](#)... Read about some of the [problems with the Ocean Cleanup project here](#).

But you mentioned that prevention is generally superior. Other than improving waste management, what works for preventing marine plastic pollution in the first place?

- Almost certainly, preventing most marine plastic pollution would be less expensive than removing the plastic from the ocean, particularly once it is in the open ocean or has degraded into smaller fragments. Moreover, cleanup of most plastic in the ocean is not even technologically or economically feasible with current methods because [more than 95% of marine plastic pollution is below the surface](#).
- Prevention efforts largely focus on packaging and other single-use items because they comprise a large percentage of plastic waste and are the most egregious example of the [mismatch between its time in use and how long it remains in the environment](#).
- In terms of prevention actions, we found two methods with demonstrated efficacy at reducing marine plastic pollution – the implementation of plastic bag bans and fees and deposit-return schemes. These are discussed in detail in the next two sections.

Let's talk plastic bag fees and bans – they work but one should proceed carefully

- Plastic bags are at the forefront of the world's efforts to reduce plastic usage. Consequently, the body of research on (1) the effectiveness of plastic bag fees/bans at reducing plastic usage and marine plastic pollution and (2) the environmental impacts of switching to other alternatives is much more developed for plastic bags than it is for other plastic products.
- To put it mildly, the world uses a lot of plastic bags – somewhere between [1 and 5 trillion a year](#). And a lot of them end up in the ocean. In 2012, [23% of drifting marine litter and 59% of the marine litter found on beaches in China](#) was plastic bags.
- Measures to reduce the number of plastic bags (and amount of plastic) that reach the ocean include:
 - Banning them
 - Charging a fee for using them (usually between [\\$0.05-\\$0.30 a bag](#)),
 - Taxing manufacturers for making them,
 - Otherwise restricting the manufacture, distribution, use, and trade of them (e.g., banning imports or exports of them), and/or
 - Regulating their disposal (in the form of collection and recycling, take back, and/or deposit-refund requirements or fines for improper disposal).

As of July 2018, [127 countries had taken at least one of these measures](#) at a national scale. And numerous cities and regions around the world have also [taken action on this front](#) even if their national government has not.

- Many of these measures work. You can find [reports of situations](#) where they don't, but in general, the weight of evidence indicates that [bans and fees work](#) in places where they are [well-implemented and enforced](#). And they work at both reducing plastic bag usage AND reducing the number of plastic bags that become marine litter. Plastic bag use went down by [80% in Australia](#) after its gradual ban went fully into effect. Annual plastic bag usage went from [328 to 21 bags per person in Ireland](#) after its tax went into place and [plastic bags went from 5% to < 0.2% of marine litter](#). Often the reduction in single use plastic bags provided by retailers is somewhat offset by the purchase of other plastic bags – [often thicker ones](#) – for household uses such as disposing of [pet waste or lining small waste bins](#). Even with these new purchases, however, the plastic waste bans generally result in a [net reduction in overall plastic use](#).
- Okay, you say, but what about all those articles about how other types of carrier bags are so much worse for the environment? The key to the ultimate environmental friendliness of plastic bag bans seems to lie in what other measures are taken alongside it and what other options are available for transporting items for which one might otherwise use a plastic bag. In many locations, fees and bans are also placed on [alternative single-use bags](#) (i.e., paper bags) encouraging consumers to provide their own reusable bags.
- Several studies ([here](#) and [here](#)) have analyzed a variety of environmental impacts such as greenhouse gas emissions, water use, eutrophication, and toxicity to people and marine life from a variety of types of plastic bags and non-plastic alternatives such as paper and cotton. They have found that most options need to be reused a number of times – [paper several times and cotton hundreds to thousands of times](#) – to make their environmental 'footprint' from the factors examined as low as that of the conventional lightweight plastic bag. These studies do not consider the full suite of environmental impacts of the various options, however. Some of these other impacts include [harm to marine and terrestrial ecosystems](#), the urban flooding caused by [plastic bags clogging sewer systems](#), and the problems that plastic bags create for [waste treatment and recycling facilities](#).

- Reading all of these studies leads to two take-away messages: 1) bag users should reuse whatever kind of bag they get as much as possible, even as a waste bin liner after its useful carrying life is over, and 2) all conventional plastic alternatives – including paper and 'bio-based plastics' – come with their own distinct suites of environmental impacts, which may or may not be more attractive to consumers and governments than those of conventional plastics.^[5]
- In addition, while not as popular as plastic bag bans, 27 countries have banned the use or production of a variety of plastic products (including plates, cups, straws, and packaging) at a national level. Polystyrene (often used in the form of expanded polystyrene foam – referred to as Styrofoam in North America) – is often the explicit target of these bans. We didn't find any studies evaluating the effectiveness of these bans on reducing marine plastic pollution, but one could reasonably assume that they would have a similar effect on marine plastic pollution as plastic bag bans and that alternative items – e.g., paper straws – will come with their own suite of environmental impacts.
- Finally, one unfortunate trend for reducing marine plastic pollution in the US is that a number of US states have passed "bans of bans" to prevent municipalities from implementing local bans of disposable plastics. In these states, creating incentives to eliminate disposable plastics might be possible, although incentives are generally less effective than bans and fees at reducing plastic usage.

Deposit-refund programs also work – often really well.

- Deposit-refund programs (also known as container deposit legislation - CDL) also work. In deposit-refund programs, a small fee is added to the purchase price of something (most frequently beverage bottles) when it is purchased, and that deposit is returned to a consumer [or collector] when the container is returned. In general, the higher the deposit, the higher the return rate.
- Over 40 countries worldwide have some form of these CDL programs for plastic bottles. They are very effective at recovering materials^[6] – Norway's deposit-return program for plastic bottles captures 97% of the country's bottles for recycling – and new research shows that they can reduce coastal and marine plastic pollution. A comparison of litter in US and Australian states with and without CDL found 40% fewer containers in beach litter in states with CDL than states without CDL. This effect was even greater in poorer areas where mismanaged waste is a bigger problem.
- Unfortunately, deposit-refund programs are often opposed by industry, and the bottling industry, including Coca-Cola, is working to resist a national container deposit program in Australia.

Fixing one of the fundamental mismatches of marine plastic pollution with Extended Producer Responsibility

In last month's issue of The Skimmer, we described two fundamental mismatches that are at the heart of marine plastic pollution:

1. That we are using an incredibly durable material for a lot of very short-term uses
2. That the price of making and using things made out of plastic does not reflect the full cost of disposing of that plastic.

One of the most important mechanisms to address this second mismatch is Extended Producer Responsibility (EPR). EPR makes plastic producers or the businesses that sell the plastics responsible (financially and/or logistically) for products after consumers are done with them. This shifts the cost of managing post-use plastics from local governments to industry and business, in line with the 'polluter pays' principle, and it encourages the development of products that are more easily reusable and/or recyclable. Sixty-three (63) countries have some form of extended producer responsibility for single-use plastics, including deposit-refund programs (described above), product takebacks, and recycling targets.

In an interview with World Finance magazine in July 2018, Judith Schäli, a researcher at the World Trade Institute, gave this perspective about the importance of targeting measures to reduce marine plastic pollution at industry and businesses:

"Corporations that are involved in the market of plastic products, especially consumer products, play an important role in the shaping of our production and consumption patterns. They influence consumer behavior [through] commercials and subliminal advertisement in packaging. By their material choices and product designs, they determine the durability of their products, as well as their recyclability, biodegradability, ecotoxicity and susceptibility to end up in the environment. They further influence consumers' product choices by providing or withholding information about the materials they use, including the additives with potentially toxic or otherwise hazardous effects.

In order to reduce their impact, companies should be aware of, and take responsibility for, the whole life cycle of their products, including disposal... They can redefine their business models and overcome the phenomenon of planned and perceived obsolescence, which pushes consumers to constantly renew their belongings by artificially limiting the service life of the products or suggesting that they are outdated."

Finally, why reducing plastic consumption is an upstream swim.

- As we noted above, plastic is part of just about every facet of modern life, and changing production and usage patterns is expensive and difficult. Making the price of plastic reflect its true costs to society, however, would change the cost-benefits calculations for using plastic in products, however, and would likely lead to decreases in its use.
- Unfortunately, there are currently very powerful forces working to counteract any decrease in the use of plastic. Petrochemical companies need to find uses for their products and are investing heavily in facilities that could increase plastic production by 40% in the next decade. Petrochemical companies and plastics manufacturers also invest heavily in lobbying against decreases in plastic use.
- What can you do as an individual other than reduce your personal plastic consumption? The InterAction Council provides a list of advocacy suggestions, including speaking out about increases in capacity/subsidies for plastic industry.

Want to discuss marine plastic pollution?

If you want to follow and discuss the latest on marine debris in real time online, join MarineDebris.info, the global online community for sharing knowledge on research, management, and prevention of ocean litter.

[1] Plastic waste leakage is the "amount of unmanaged plastic waste entering the ocean".

[2] 'Primary microplastics' are plastic pieces that enter the ocean in this size range, while 'secondary microplastic's are ones that form in the ocean as a result of the degradation of larger plastic pieces.

[3] Although this article would seem to vilify all plastic, that is not the case. Plastic is a rather amazing (and amazingly versatile) product. It can be manufactured in a mindboggling variety of ways to form everything from Saran wrap to Kevlar. It is lightweight, waterproof, stable over a fairly wide range of temperatures, and relatively easy and “inexpensive” to create (especially if you’re not responsible for cleanup…) It is used to do a lot of things we appreciate –reduce food waste, prevent the spread of diseases, insulate homes, help us transport things, etc. Very few groups are proposing that we get rid of all plastics. But we would like to keep them and related toxins out of our oceans, our groundwater, our air, our food, our bodies, etc.

[4] Waste-to-energy conversion (including incineration, gasification, and pyrolysis) is highly controversial in many locations because it produces toxic emissions (both gases and solids) and would likely compete with recycling processes. Modern incinerators are capable of meeting more stringent emissions standards than previous generations of incinerators, however, and there is likely a place for them among a portfolio of measures to reduce the negative effects of plastic pollution.

[5] Editor’s note: As an urban dweller who walks to the market and has experience with a wider variety of bags, my take from reading all of these reports is that using (and reusing) recycled PET or polyester bags and disposing of them properly at the end of their useful life is currently the most environmentally friendly option for grocery hauling.

[6] It is worth mentioning that the advent of reverse vending machines – currently found in grocery stores and other locations in Iceland, Norway, Australia, Canada, and some US states – is making deposit-refund programs even easier to implement.

Images:

1: Plastic waste produced and mismanaged. Maphoto/Riccardo Pravettoni for GRID Arendale, 2018. <http://www.grida.no/resources/6931>

2: A family who moved from the Guizho Province to the rich Yangtze River Coast in search of new opportunities, working in a landfill sifting for any valuable resellable items. Sheila, 2007. <https://www.flickr.com/photos/96434059@N00/408525044>

3: Reducing Plastic Pollution: Possible Actions. Allison Brown produced for OCTO and The Skimmer, 2019. <https://meam.openchannels.org/news/oc-overview/reducing-plastic-pollution-possible-actions>

4: Waste picker in General Santos, Philippines. Global Environment Facility, 2013. <https://www.flickr.com/photos/thegef/8652549158>

5: Mr Trash Wheel. Matthew Bellemare, 2016. [https://commons.wikimedia.org/wiki/File:Mr._Trash_Wheel_\(27582099121\).jpg](https://commons.wikimedia.org/wiki/File:Mr._Trash_Wheel_(27582099121).jpg)

6: Are most of the plastics produced still around? Maphoto/Riccardo Pravettoni for GRID Arendale, 2018. <http://www.grida.no/resources/6914>

7: Pollution on beach. Hhach. <https://pixabay.com/photos/garbage-environment-beach-pollution-2369821/>

8: Reverse vending machine for the NSW Container Deposit Scheme located in the Woolworths Wagga North (Gurwood St) car park. Bidgee, 2017. https://commons.wikimedia.org/wiki/File:Reverse_vending_machine_for_the_NSW_Container_Deposit_Scheme_located_in_the_Woolworths_Wagga_North_car_park_03.jpg

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