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WRITTEN TESTIMONY OF:

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BEFORE

THE U.S. SENATE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

Hearing: "Cleaning Up the Oceans: How to Reduce the Impact of Man-Made Trash on the Environment, Wildlife, and Human Health?"

September 26, 2018

Introduction

Good morning. Thank you Chairman Barrasso, Ranking Member Carper, and members of the Committee, for the invitation to testify at this important hearing on man-made debris in the marine environment. My name is Dr. Kara Lavender Law, and I am a Research Professor of Oceanography at Sea Education Association (SEA), a non-profit educational organization based in Woods Hole, MA. Since 1971, SEA has taken undergraduate students to sea on tall sailing ships to study the open ocean, first-hand, as navigators, sailors, shipmates and scientists. More than 8,000 SEA Semester students have contributed to our 30+-year data set on floating plastics in the ocean, assembled by towing plankton nets from our sailing research ships twice a day, every day, and hand-counting their contents. In 2016, for our work in, "fostering scientific discovery and stewardship of the world's oceans", the National Science Board awarded SEA its Public Service Award.

As an oceanographer trained in ocean physics, I knew little about marine debris before joining the faculty at SEA 15 years ago. More seasoned faculty quickly taught me that the "plastics project" was a popular independent research topic for our students who were concerned about ocean pollution, and also one of the most reliable because, unlike projects focused on particular marine organisms, one could guarantee that along certain cruise tracks small bits of plastic debris would be found floating at the sea surface. It wasn't until 2007 when I first heard the term "garbage patch", a term rife with misconceptions about immense floating islands of recognizable plastic trash. In fact, the most numerous type of plastic debris in the ocean, and what we typically collect in our plankton nets, are "microplastics", particles smaller than your pinky fingernail that are composed of a variety of synthetic polymers (Figure 1). These microplastics are not readily visible from the deck of a ship, let alone from an aircraft or satellite. At SEA, we recognized the need to shift the focus away from mythical floating islands of trash and towards a scientifically informed description of ocean plastics pollution. To this end, in 2010 we published an analysis of our unprecedented data set, which now consists of more than 10,000 measurements of the concentration of floating plastic particles in the Atlantic and Pacific Oceans. For the past 10 years, I have carried out scientific research on ocean plastics to better understand their sources, abundance, distribution and transformation in the marine environment, not only to advance scientific understanding, but also to inform solutions to this global problem.

It is important to remember than not all marine debris is plastic, and not all is found floating at the sea surface. Trash on beaches and shorelines is marine debris (Figure 2). Litter on the seabed is marine debris, whether close to land (Figure 3) or in deep and remote places (Figure 4). Debris can be tens of meters long, such as lost fishing nets (Figure 5) or derelict vessels, or it can be microscopic in size. Man-made debris is composed of paper, glass, aluminum or other metals, as well as plastics. Yet the debris of greatest concern and focus, both by scientists and citizens, is that made of plastics.

Plastics: Ubiquitous, long-lived and harmful to wildlife

We focus on plastics in the marine environment because of their ubiquity, and the risks they pose to wildlife and potentially human health. In a 2017 study[1] led by Roland Geyer of University of California, Santa Barbara, we estimated that since the start of mass production, 8.3 billion metric tons of plastics have been produced, more than most other man-made materials, with the exceptions of steel and cement. Further, we estimated that 90% of these plastics still exist on the planet, with only a small fraction of plastic waste having been incinerated, and the majority of waste either residing in landfills or in the environment. Plastics are designed for strength and durability and do not biodegrade; thus, once in the environment, plastics persist for years to decades or longer. Other man-made materials such as glass and metals are also persistent in the environment; however, unlike glass and metals, the light weight of plastics makes them easily transportable. As plastics are carried by wind or water in the environment, they are weakened by sunlight and fragment to smaller and smaller pieces. Their chemical composition changes as well, as additives leach out and contaminants already present in seawater transfer to plastics. Thus, as plastic debris moves around in the oceans, its size, shape, and chemical makeup change. As these debris characteristics evolve, so too do the potential impacts on wildlife that encounter these plastics.

More than 800 marine species have been affected by man-made debris[2] through interactions such as ingestion, entanglement (including ghost fishing), and displacement of species that drift with, or upon, floating debris. Further, plastic debris accounts for 92% of reported encounters with individual organisms[3]. Large whales have ingested items as large as flower pots and meters-long lengths of rope and plastic sheeting[4]; bottle caps and cigarette lighters have been found in the guts of dead albatross chicks[5]; and small microplastics particles contaminate a multitude of species, including fish and shellfish we consume as seafood[6]. Plastics ingestion has now been documented for more than 200 marine species, including all species of sea turtles, 59% of whale species, and 59% of seabird species[7,8]. Further, for particular populations, such as the northern fulmar seabird population in the North Sea, as many as 95% of individuals studied have ingested plastics[9]. The direct consequences to wildlife of ingesting relatively large plastic debris can include physical injury and gut obstruction, ultimately leading to death, whereas the

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[1] Geyer, R., J. R. Jambeck and K. L. Law, 2017. Production, use, and fate of all plastics ever made. *Sci. Adv.* 3, e1700782.

[2] *Marine Debris: Understanding, Preventing and Mitigating the Significant Adverse Impacts on Marine and Coastal Biodiversity.* Technical Series No. 83. Secretariat of the Convention on Biological Diversity, Montreal, 78 pp.

[3] Gall, S. C. and R. C. Thompson, 2015. The impact of debris on marine life. *Mar. Poll. Bull.* 92, 170-179.

[4] de Stephanis, R. *et al.*, 2013. As main meal for sperm whales: Plastics debris. *Mar. Poll. Bull.* 69, 206-214.

[5] http://www.chrisjordan.com

[6] Rochman, C. M. *et al.*, 2015. Anthropogenic debris in seafood: Plastic debris and fibers from textiles in fish and bivalves sold for human consumption. *Sci. Rep.* 5:14340.

[7] Kühn, S., E. L. Bravo Rebolledo and J. A. van Franeker, 2015. Deleterious effects of litter on marine life. In: *Marine Anthropogenic Litter*, Bergmann, M., L. Gutow and M. Klages, Eds. Springer: Heidelberg, Germany, 447 pp.

[8] Wilcox, C., E. van Sebille and B. D. Hardesty, 2015. Threat of plastic pollution to seabirds is global, pervasive, and increasing. *PNAS* 112, 11899-11904.

[9] van Franeker, J. A. *et al.*, 2011. Monitoring plastic ingestion by the northern fulmar *Fulmarus glacialis* in the North Sea. *Environ. Pollut.* 159, 2609-2615.

consequences of ingesting microplastics remain less well understood. An area of intense scientific inquiry asks whether or not chemicals associated with ingested microplastics transfer into animal tissue and cause physiological damage. Some laboratory studies have demonstrated that for particular animal-plastic-chemical combinations, physiological harm does occur[10,11], yet more work remains to determine whether or not these impacts are occurring in nature and, if so, at what scale.

Although recent scientific research has largely focused on impacts of microplastics ingestion, evidence clearly demonstrates impacts of debris on marine wildlife through entanglement and species transport. Entanglements, now reported for 344 marine species, most commonly involve components of derelict fishing gear, such as plastic rope and netting, as well as looped packing or strapping bands, which may cause severe injury and death[3,7]. In 29 years of surveying the critically endangered North Atlantic right whale, 83% of individuals showed evidence of entanglement[12]. The most recent demonstration of species transport on floating debris was the delivery of 289 living marine species from the coast of Japan across the Pacific Ocean to North America for six years following the 2011 Tohoku earthquake and tsunami[13]. Although we don't yet know whether these species will become established and threaten native species, the six-year duration of the invasion is unprecedented, and is likely due to the persistence of plastics in the ocean.

To date, widespread encounters of marine wildlife with plastic debris have been well documented, and scientific evidence clearly demonstrates harm from interactions with large debris. Laboratory studies have also provided evidence of harm from animal uptake of microplastics. However, because experiments are carefully controlled to test single outcomes, it is impossible to generalize results across species or debris types, or from the laboratory to populations in nature. Further research into the ecological impacts of contamination by microplastics is sorely needed.

Identifying the sources

The most effective way to reduce the impacts of plastic debris on wildlife and the marine environment is to prevent plastics from becoming ocean debris in the first place. This can only be accomplished by first understanding the origins of the debris, and the pathways by which it enters the ocean. Plastics can enter the environment at any point in their life cycle, starting from losses of industrial resin pellets (the material feedstock for plastic products), to accidental loss during product use, such as with fishing and aquaculture gear, to accidental or deliberate

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[10] Rochman, C. M. *et al.*, 2013. Ingested plastic transfers hazardous chemicals to fish and induces hepatic stress. *Sci. Rep.* 3, 3263.

[11] Oliveira, M. *et al.*, 2013. Single and combined effects of microplastics and pyrene on juvenils (0+ group) of the common goby *Pomatoschistus microps* (Teleostei, Gobiidae). *Ecol. Indic.* 34, 641-647.

[12] Knowlton, A. R. *et al.*, 2012. Monitoring North Atlantic right whale *Eubalaena glacialis* entanglement rates: a 30 yr retrospective. *Mar. Ecol. Prog. Ser.* 466, 293-302.

[13] Carlton, J. T. *et al.*, 2017. Tsunami-driven rafting: Transoceanic species dispersal and implications for marine biogeography. *Science* 357, 1402-1406.

discard of plastic waste into the environment. A 2015 study[14] led by Jenna Jambeck of University of Georgia estimated that between 5 and 13 million metric tons of plastic trash generated in coastal regions worldwide enters the ocean in a single year because the waste is not properly captured and contained. We estimated that nearly half of this mismanaged plastic waste originates from four countries in southeast Asia (China, Indonesia, Philippines and Vietnam), countries that have experienced rapid economic growth accompanied by an increase in the amount of plastic waste produced by large coastal populations. When waste generation rates outpace the capacity of existing waste management systems, uncaptured plastic waste can flow into the oceans from rivers and waterways, or wash out to sea during storms or with the tides.

The United States also has a large coastal population, and the amount of plastic waste generated per capita outranks that in each of the four southeast Asian countries. According to our analysis, the amount of plastic waste generated each day in the coastal United States is the highest of any country in the world. We are fortunate to also have a robust waste management system – garbage and recycling collection, material sorting, and treatment either in sanitary landfills or by incineration. However, because of the sheer amount of plastic waste we create, even the small amount that is accidentally lost, or intentionally littered, adds up to a large amount available to enter the ocean.

Not all plastic debris in the marine environment originates from improperly managed waste on land. Abandoned, lost or otherwise discarded fishing gear is also a very large source of plastic debris, although no estimate of the global input yet exists. Natural disasters, such as hurricanes, floods and tsunamis, can inject a tremendous amount of debris of all materials into the ocean in a single, short-term event. And microplastics from a variety of sources – including microbeads in cosmetics, dust from tire wear, fragments of agricultural films, and fibers from synthetic clothing – can enter the ocean by pathways such as runoff into waterways, and stormwater and wastewater outflows.

From sources to solutions

Ocean plastics pollution is a global problem that has grown in size and scale since the 1950s as an unintended consequence of rapidly increasing production and use of these innovative and, in many cases, indispensible materials. Plastics were never intended to contaminate our oceans, rivers, lakes and soils, posing risks to wildlife and potentially even human health. Yet we are faced with ever increasing applications and use of these materials, without a clear strategy for management at the end of their useful life. Preventing plastics from becoming marine debris requires a suite of actions from local to global scales, carried out by individual consumers as well as material and product manufacturers; by municipal, state and national governments as well as international bodies. These actions should always be appropriate to place – there is no silver bullet, or one-size-fits-all solution.

[14] Jambeck, J. *et al.*, 2015. Plastic waste inputs from land into the ocean. *Science* 347, 768-771.

Contain the waste
The most pressing short-term need to prevent marine debris is to ensure that no waste is left uncontained in the natural environment, whether terrestrial, freshwater or marine. This requires global investment in waste management systems, especially where no formal waste management currently exists. In the 2015 Jambeck study, we estimated that if plastic waste generation were capped and total waste management achieved in the top ten emitting countries by 2025, then the annual input into the oceans would be reduced by 77%.

Even in countries like the United States, where we have established collection and processing of waste, we must ensure that trash cans are lidded and emptied before they overflow, and that the stray candy wrapper is caught before it blows away in the wind. We must invest in infrastructure that streamlines collection and processing of recyclable materials. The design of waste management systems anywhere in the world must be tailored for the needs of a particular community, understanding how, where and what kind of waste is generated, as well as existing social and cultural practices, to ensure community buy-in and long-term success in managing waste.

Clean up uncontained waste
Cleaning up litter on land, especially in rivers and on coastlines, will continue to be an important strategy to prevent waste from entering the ocean. Seemingly simple interventions can be extremely effective, such as Baltimore's Mr. Trash Wheel, a solar- and hydro-powered river trash collection device with a personality, which has prevented 1.7 million pounds of debris from flowing into the Chesapeake Bay. Cleanups are also effective ways to engage and educate citizens as volunteers, as demonstrated by the nearly 250 million pounds of trash collected by nearly 13 million volunteers around the world since 1985 in Ocean Conservancy's International Coastal Cleanup.

Cleaning up debris in the sea itself is more challenging and resource intensive, but can be effective when targeting large items in nearshore areas, or collecting floating trash before it can move offshore and break apart into millions of microplastics. Fishing for Litter programs engage those in the fishing industry to remove litter from the sea in the course of normal fishing activity, at the same time raising awareness of the importance of keeping trash and derelict fishing gear out of the ocean in the first place. Project AWARE's Dive Against Debris program engages scuba diving enthusiasts to participate in underwater debris cleanups to not only report and remove trash on the seafloor, but also to serve as citizen scientists, collecting data on types and amounts of debris in order to inform prevention efforts.

Sustainable solutions
Improved waste collection and cleanup of uncaptured waste are imperative in the short term, but long-term, sustainable solutions to ocean plastics pollution must address the increasing amounts of plastics in use by employing a variety of strategies to: eliminate unnecessary waste; increase demand for recovery and recycling; and identify suitable alternatives where possible. In some instances, where plastics are unnecessary for function (or are known to be particularly harmful), a mandated ban may be appropriate. The Microbead-Free Waters Act passed by the

U.S. Congress in 2015, banning plastic microbeads in rinse-off cosmetics, is an example of this type of action. In other cases, a reduction in use can be incentivized by government policies (municipal, state, or national), such as mandated fees for single-use retail bags. A complimentary positive incentive to reduce single-use bags is provided by individual businesses that give a discount to customers who bring their own bags. Municipalities and institutions can promote waste reduction not only by offering separate recycling and food waste collection, but also by making improvements to infrastructure, such as installing water bottle refill stations to facilitate use of reusable, rather than single-serve, water bottles, thereby reducing plastic waste. Finally, campaigns by individuals or organizations can influence changes in behavior that will reduce waste. For example, the plastic drinking straw movement has recently grown from a simple “Skip the Straw” pledge to refuse an unneeded drinking straw, to an all-out social media blitz promoted by conservation organizations and celebrities alike, driving strong responses from major consumer goods companies down to stand-alone restaurants and individuals. As consumers, we all make innumerable decisions every day about products that we buy, use and throw away. Although we bear ultimate responsibility for our own decisions, good choices can be made easier by employing a variety of strategies to encourage waste reduction.

Perhaps with an ultimate long-term goal of zero waste, steps should be taken to bring value to products and materials at the end of their useful life. This will ultimately increase demand for reuse, recovery and recycling over disposal. Manufacturers engaged in product stewardship agree to share responsibility for their end-of-life product, such as through take-back and recycling programs, for example. A successful example of cross-brand product recovery and recycling is demonstrated in communities with container deposit schemes for beverage containers including plastic bottles, glass bottles and aluminum cans. Because of the uniformity in materials used across brands, and efficient recovery incentivized by the deposit, recycling of these materials is more cost effective and the waste material more valuable. With attention at the product design stage to ensure material value at the end of life, market incentives can reduce the number of one-way trips most items eventually take to the landfill or incinerator, or the environment.

Finally, continued scientific research to inform evidence-based decision-making is essential to addressing the problem of ocean plastics pollution, so that limited resources can be efficiently and effectively deployed to the greatest benefit. This does not mean that we must wait for all scientific questions to be definitively answered before taking action. Rather, prevention efforts will be most successful when research is first undertaken to understand the local sources and driving factors behind them. For example, Virginia Coastal Zone Management Program and Clean Virginia Waterways used data to identify balloon litter as items of concern, with nearly 9,000 balloons collected on Virginia beaches during 9 years of International Coastal Cleanups[15]. In response, they conducted public surveying and interviews to understand the who, where, when and why behind mass balloon releases in Virginia and, with this knowledge, designed a

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[15] Witmer, V., K. Register and L. McKay, 2017. *Balloon Release Research in Virginia and Reducing Balloon Debris through Community-Based Social Marketing.* Virginia Coastal Zone Management Program (Virginia Department of Environmental Quality), 117 pp.

community-based social marketing campaign to discourage balloon releases and provide context-specific alternatives, a more targeted and informed strategy than a simple information-sharing education campaign alone.

Concluding remarks

In summary, to reduce the impact of man-made trash on the oceans, wildlife and human health, **it is imperative that we prevent debris, especially that made of plastics, from entering the ocean**. There is an immediate and critical need to assist countries that have inadequate waste management systems, and there is much more we need to do in our own communities as well.

No matter where in the world we choose to work, a **necessary first step is to clearly identify and measure the local sources of ocean debris**, including item types and locations, as well as the pathways the debris follows from the source to the sea. **Second, we must determine the drivers behind each source**, which could be a lack of infrastructure, a consequence of product design or use, or factors influencing human behavior. With this information in hand, we can best focus our time, attention and resources to **design appropriate interventions that will reduce input from the source**. Interventions may be relatively simple and inexpensive, such as installing and servicing lidded trash cans. Interventions may be engineered, such as debris traps in waterways or storm drains. Interventions may involve technological design innovations to ensure effective recovery and recyclability, and they may aim to influence human behavior away from a "disposable" mentality to reduce unnecessary usage and waste. Interventions may be legislated to mandate or incentivize actions by plastics producers, product manufacturers and consumers that will ultimately reduce the input of plastics to the ocean. Finally, we must continue to increase waste literacy and raise public awareness of this problem in order to drive action by consumers, producers, and governments alike, to both reduce unnecessary consumption and revolutionize our management of waste.

Ocean plastics pollution is an environmental problem that is global in scope, in impact, and in responsibility. We all have a stake in a clean and healthy ocean. Whether in towns, cities or states in the United States, or through international partnerships, we must work together towards short-term and long-term solutions as citizens, scientists, businesses, governments and people. Thank you for the opportunity to testify. I look forward to the day when our oceans are clean because of the work we have accomplished together.

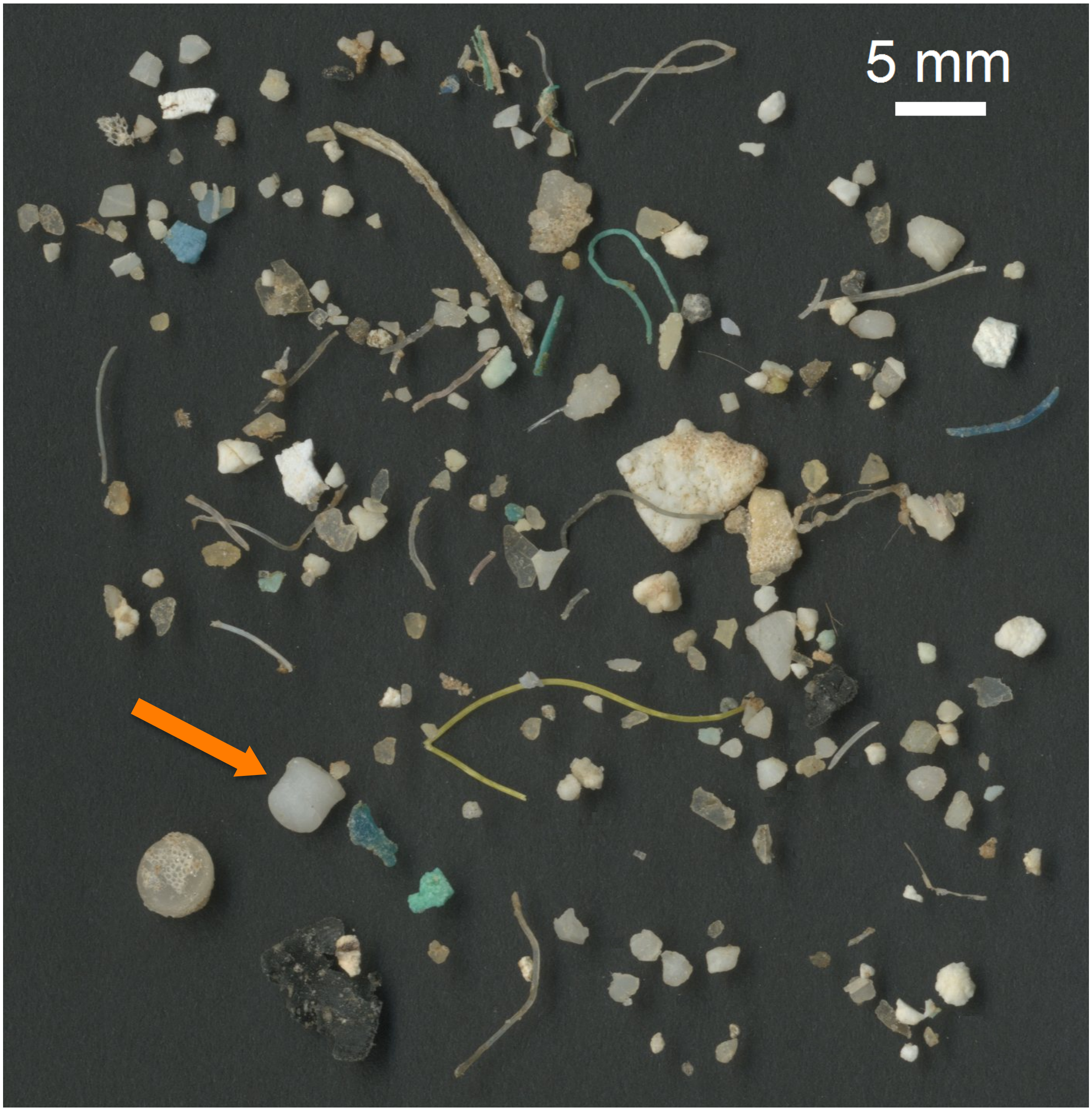

Figure 1: Microplastics collected from surface seawater in the North Pacific Ocean by towing a plankton net. Microplastics are typically defined as particles smaller than 5 mm in size, and are composed of a variety of plastics. Microplastics may be manufactured at this size, such as the industrial resin pellet indicated by the orange arrow, but most are generated when larger plastic items break apart upon exposure to sunlight.
Photo credit: Jessica Donohue/Sea Education Association.

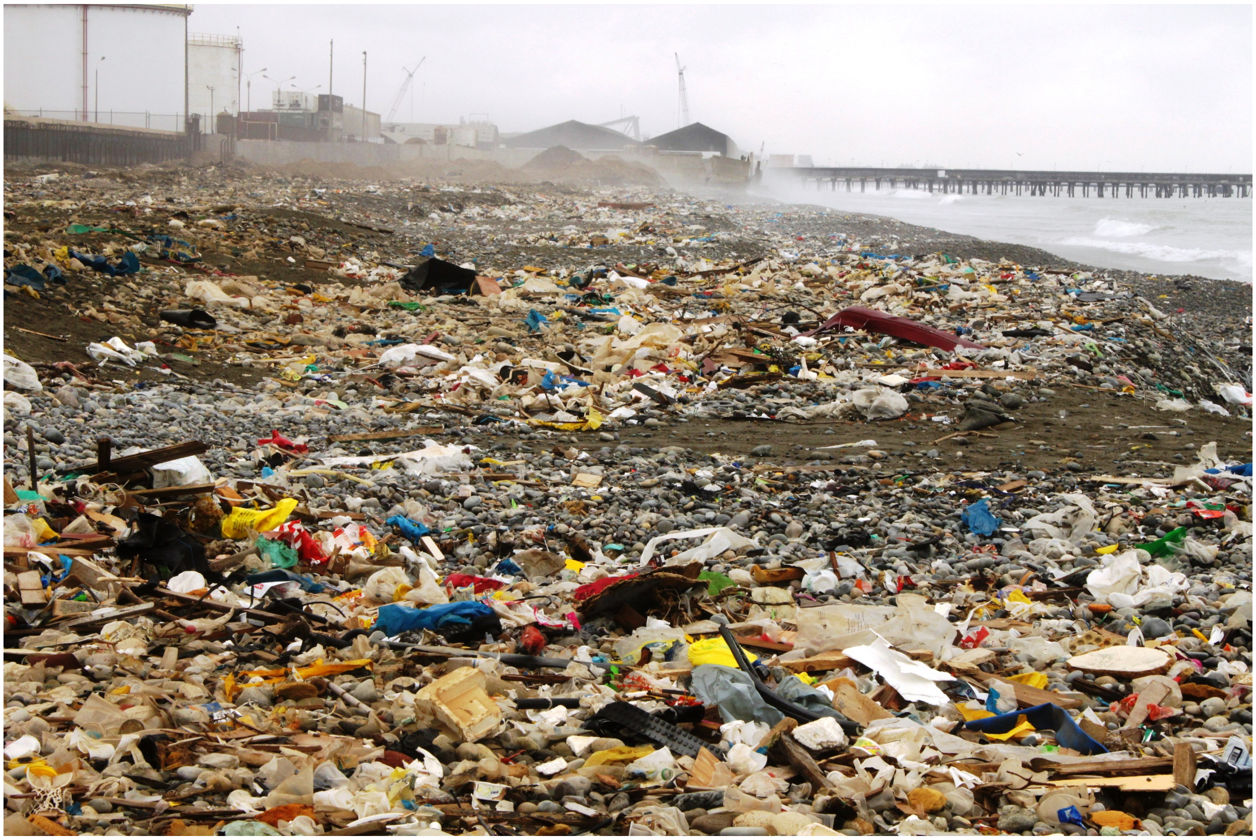

Figure 2: Litter piled high and wide on Marquez Beach, Peru.
Photo credit: Nicholas Mallos/Ocean Conservancy

Figure 3: Beverage cans, bottles, food wrappers and other trash in a composite of underwater photos of the seafloor in the harbor in Newport, RI.
Photo credit: Rachael Miller/Rozalia Project

Figure 4: Plastic bag at a depth of 2500 m (8202 ft) at HAUSGARTEN, the deepsea observatory of the Alfred Wegener Institute in Fram Strait in the Arctic.
Photo credit: Melanie Bergmann/OFOS, Alfred Wegener Institute

Figure 5: A NOAA diver removes derelict fishing gear from a reef habitat at Midway Atoll.
Photo credit: NOAA Marine Debris Program