Impacts of Plastic Pollution on Our Oceans

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Figure 1: Photo by Cambria Bartlett. July 2017.

This research paper explores the many environmental threats of the useful material we call plastic. You will learn the importance of our oceans and how plastic affects the marine ecosystems. I will tell you how plastic gets into our oceans. I will explain how plastic is affecting us and marine animals. Then, I will tell you about some of the solutions that are out there in the world.

Plastic has changed our lives. Take a minute and think about plastic… It is great! You probably got out of your warm, fuzzy polyester (aka *plastic*) blankets this morning. Then, pulled on a polyester (aka *plastic*) t-shirt, walked into the kitchen and poured cereal out of a *plastic* bag into a *plastic* bowl, opened the *plastic* refrigerator door, pulled out the *plastic* milk jug, poured the

milk into the bowl with your cereal and sat down for breakfast. The first ten minutes of your day are already full of large amounts of plastic.

We use a lot of plastic in our lives, and it is almost impossible not to use this important material. But, let's think about plastic again. This time we are not thinking about our everyday use of plastic, we are thinking about something that happens after that, after we used the plastic, after we threw it 'away', after it has made its way into the environment. We are going to think about the animals that accidentally eat the plastic, the animals that get entangled by plastic, the animals whose homes are a plastic soup, the animals who are dying from the plastic that fills our lives. What if plastic is not the best thing to use? What are we going to do about the plastic that is harming our planet?

Before I get into the problems with plastic pollution, I am going to tell you a little bit about the importance of our oceans. To understand why plastic in the oceans should worry you, you need to first understand how the health of our oceans directly affects you.

Figure 2: "Earth." *NASA*. www.nasa.gov. Accessed 15 Oct. 2017.

You and I live on a little blue dot. A beautiful blue planet that we call home. It is colorful because it is covered in water. 71% of the surface of our planet is covered in water.[1] This water is vital to our survival. Let's start with the gift of breathing. To stay alive, humans need oxygen. You need it every minute of every day. What is making that important oxygen? Trees? Plants? Land botanicals (plants) only produce 28% of the oxygen we breathe. We can thank the ocean for almost all of the rest. 70% of the oxygen we breathe comes from the ocean!![2] Breathe in… Now breathe out…In, out. In, out. Every time you

[1]Perlman, Howard. "How Much Water Is There on, in, and above the Earth?" *How Much Water Is There on Earth, from the USGS Water Science School*, water.usgs.gov/edu/earthhowmuch.html. Accessed 14 Oct. 2017.

[2] Society, National Geographic. "Save the Plankton, Breathe Freely." *National Geographic Society*, 7 Aug. 2015, www.nationalgeographic.org/activity/save-the-plankton-breathe-freely/.

breathe you are connected to the ocean. Isn't that amazing?! Just by breathing you are connected to the ocean no matter where you live on Earth!

I could spend this entire research paper on the importance of the ocean and how we are directly connected to it, but that is not what this paper is about. It is about plastic pollution, so let's begin.

HOW IT ALL BEGAN

I want you to come away from reading this paper with the fullest explanation of plastic pollution that I can give you. I don't want to skip over anything important, so I am going to start at the very beginning of the story, in a time before plastics were found in the ocean, a time before plastics were even invented.

Figure 3: "Ivory Billiard Balls, C.1880." *Albany Institute*, www.albanyinstitute.org/details/items/hyatt-billiard-balls.html. Accessed 25 Jan. 2018.

In the 1800s, there was a growing popularity of the game pool. As the game grew in popularity, so did the market for ivory to make billiard balls. The problem was that there was a growing number of pool players and a declining number of elephants to supply the increasing need for ivory to make the billiard balls. Seeing the problem, a New York billiards company offered $10,000 to the person who could invent a sturdy material that could be used for billiard balls as an alternative for ivory. In 1863, John Westley Hyatt saw the offer and got to work. Hyatt succeeded in his goal and made a material to replace ivory. He called his material "Celluloid".[3] Though he did end up making the material, it seems that he never received

[3] The Editors of Encyclopædia Britannica. "John Wesley Hyatt." *Encyclopædia Britannica*, Encyclopædia Britannica, Inc., 30 Sept. 2013, www.britannica.com/biography/John-Wesley-Hyatt.

the reward. Celluloid was the first plastic though it was not *fully* synthetic. The first *fully* synthetic plastic was invented by Leo Baekeland in 1907, years later. Baekeland's plastic was called Bakelite.[4]

That's right, plastic was originally invented to solve an environmental issue: saving elephants. At the time they had no idea that it was about to become a very popular material, used all over the world, and that plastic would become another serious environmental problem. Isn't it ironic that a material meant to save elephants has ended up harming the ocean?!

Plastic seemed to be a genius invention until we began to find our beloved plastic in our oceans and environment. Our plastic was not biodegrading[5] like other materials such as paper, wood and food waste. Plastic was different. There is some debate as to how long plastic stays plastic. Plastic is *not* a natural material. It is synthetically produced. Some people say plastic lasts forever and others say it lasts for hundreds to thousands of years, but it is hard to know because hundreds of years have not passed since plastic was invented. We don't know if plastic will break down into the Earth or just stay plastic until…well who knows when. Even though it is unknown how long plastic stays in the environment, whether it will be several hundred years or forever, it is still too long. We do know it is long enough to be harming our world.

FROM LAND TO SEA

We know that plastics are in our oceans, but how do they get there? 80% of the ocean's plastic pollution comes from land-based sources.[6] When you throw "away" plastic, most people are probably not thinking: "Oh no, this plastic could be at the beginning of its journey to the ocean!" While you're not thinking about it, though, the plastic lives on. What happens after you've

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[4] The Editors of Encyclopædia Britannica. "Bakelite." *Encyclopædia Britannica*, Encyclopædia Britannica, Inc., 22 July 2009, www.britannica.com/science/Bakelite.

[5] Harris, William. "How Long Does It Take for Plastics to Biodegrade?" *HowStuffWorks Science*, HowStuffWorks, 15 Dec. 2010, science.howstuffworks.com/science-vs-myth/everyday-myths/how-long-does-it-take-for-plastics-to-biodegrade.htm.

[6] McKinsey Center for Business and Environment. "Stemming the Tide: Land-Based Strategies for a Plastic- Free Ocean." *Ocean Conservancy*, Apr. 2017, oceanconservancy.org/wp-content/uploads/2017/04/full-report-stemming-the.pdf. pg 7.

forgotten about that plastic cup, bottle, straw or bag? Sadly, too much of it ends up in the ocean. How does it get there?

Most of us are not throwing our plastic straight in the ocean. However, when the garbage truck comes and picks up our trash, it is brought to a landfill where piles of garbage are stacked in mountains. The wind blows some of it out of the landfill where the rain washes it downhill to a waterway such as a river or storm drain. Sooner or later that water flows into the ocean with its garbage stowaways. I talked to Dr. Chelsea Rochman, a plastic pollution scientist, and she told me: "We need to reduce land pollution because it can become marine debris. All waterways are like arteries of garbage flowing to our ocean."[7]

Figure 4: "Person Digging through Plastic Bottles." *The Economist*, 3 Aug. 2017, www.economist.com/news/china/21725815-how-new-rule-could-wallop-recycling-industry-china-tries-keep-foreign-rubbish-out.

Further, while the United States has great waste management systems, much of our plastic recycling is shipped to Asia to be sorted and recycled. The most valuable pieces are pulled out and the rest is typically left at waste collection spots.[8] Many are next to rivers. A lot of the plastic ends up in the rivers and is carried, you guessed it, to the ocean. This means the water bottle you faithfully recycled, and felt environmentally responsible recycling, may be floating in the ocean.

There is an even bigger issue at hand right now regarding recycling. China was taking approximately 1.42 million tons[9] of scrap plastic from the United States to recycle. In 2013,

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[7] Rochman, Chelsea, and Cambria Bartlett. "Interview with Dr. Chelsea Rochman - Marine Debris & Plastics." 24 July 2016.

[8] Winn, Patrick. "5 Countries Dump More Plastic into the Oceans than the Rest of the World Combined." *Public Radio International.* 13 Jan. 2016. www.pri.org/stories/2016-01-13/5-countries-dump-more-plastic-oceans-rest-world-combined.

[9] Bodamer, David. "China Notifies WTO of Intent to Ban 24 Types of Solid Waste Imports." *Waste360*, 19 July 2017, www.waste360.com/recycling/china-notifies-wto-intent-ban-24-types-solid-waste-imports.

China set up regulations to stop the import of dirty recyclables, but the regulations did not work as well as they had hoped. Now, China has filed with the World Trade Organization to ban "plastic waste from living sources" starting in January 2018. That's our plastic. Food containers, bottles, cups, etc., which will no longer be accepted. Without China buying a large portion of our recycling, it's garbage. That's right, at least part of what we are recycling is actually headed to a landfill.[10]

At this point, recycling is not very efficient or economical and it may not be the solution we've been told is helpful to our environment. Our waste management system allows our plastic to leak into the environment.

Am I saying that a piece of plastic that you use could end up in the ocean? I am afraid to say that yes, the oceans are full of *our* trash. Humanity's trash. We are all responsible for the plastic in the oceans. I will tell you later what you can do about it, but for now I am going to give you a deeper understanding of why plastics in the ocean is a problem.

A PLASTIC SOUP

Some people have the idea in their head that all the plastic in the oceans has collected into one place and become a big floating island of trash called the Great Pacific Garbage Patch. The truth is, there is such thing as the Great Pacific Garbage Patch. There is plastic, and lots of it, but it is not an island. In fact, the Great Pacific Garbage Patch is not solid at all. Rather it is more of a great, big, swirling soup of plastic. Plastic that is in the ocean collects in large circular-moving ocean currents called gyres.

There are five large subtropical gyres in the world located in the North Atlantic, South Atlantic, North Pacific, South Pacific and Indian Oceans.[11] Wind and the Earth's rotation causes circular-moving currents to be made. The circular-moving currents are the gyres. As the gyres move,

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[10] Profita, Cassandra, and Jes Burns. "Recycling Chaos In U.S. As China Bans 'Foreign Waste'." *NPR*, 9 Dec. 2017, www.npr.org/2017/12/09/568797388/recycling-chaos-in-u-s-as-china-bans-foreign-waste.

[11] Society, National Geographic. "Great Pacific Garbage Patch." *National Geographic Society*, 9 Oct. 2012, www.nationalgeographic.org/encyclopedia/great-pacific-garbage-patch/.

plastic gets swept into the currents. The plastic makes its way to the center of the gyre where it could remain for years. Garbage continues to accumulate in the center of the gyres. So, why is there not a garbage island? When plastic is in the ocean for a long time it breaks down from various stresses such as ultraviolet rays and currents. Plastic does not break back down into natural elements, instead it turns into smaller and smaller pieces of plastic. These pieces are called microplastics.[12] (I will explain more about microplastics later.)

Figure 5: "Illustration of 5 Gyres on Earth." *World Minded*, worldminded.com/the-5-gyres-institute/. Accessed 15 Oct. 2017.

We have created a plastic soup. Some of the plastic is floating on the top, some is hanging in the middle, some plastic is on the sea floor, and bigger pieces of plastic, including fishing gear, floats about with millions of tiny microplastics. If you went to a gyre you could not stand on the garbage, it is not like an island or a ship. Being in the gyre would be more like drowning in a soup of plastic.

PLASTICS HARM MARINE ANIMALS AND US

In the ocean, plastic is bad news for animals. They can get entangled in plastic or ingest plastic resulting in severe injuries or death. Why should you care about these marine animals? Personally, I think it is reason enough that they are living beings and they deserve not to suffer because of us. However there is another good reason you should care about them, animals also hold up the food chain and the food chain holds up our ecosystem, our world. The next

[12] Cho, Renee. "Our Oceans: A Plastic Soup." *State of the Planet*, 24 Feb. 2011, blogs.ei.columbia.edu/2011/01/26/our-oceans-a-plastic-soup/.

generation, including myself, *cannot* live without healthy ecosystems. We cannot live without healthy animals.

Our blue planet's marine animals (and land animals) are suffering and dying because their stomachs are being filled with *far* too much plastic. In 1960, less than 5% of seabirds had eaten plastic. Now *90%* of seabird species have plastic in their stomachs and, as if that number is not bad enough, it is only growing. Some scientists even predict that by 2050 nearly every species of seabird will have consumed plastic.[13] A bottle cap may appear to look like food to a bird, so the bird eats the plastic or feeds it to its young. The plastic can choke the birds. Plastic fills up birds' stomachs leaving no room for food with nutrients.

Midway Atoll is an island in the middle of the Pacific Ocean. There is *no* civilization on the island, yet it is heaped with *plastic* pieces that have washed up from the ocean. Plastic washes up on the shore of Midway Island every day. Not only are there hundreds of pieces of plastic on Midway Island, Midway is also home to the largest single colony of albatrosses in the world.

Figure 6: Jordan, Chris. "Dead Albatross with Plastic in Stomach Cavity." *Kickstarter - Midway Film Project,* www.kickstarter.com/projects/midwayfilm/join-the-midway-film-project. Accessed 15 Dec. 2017.

Plastics and albatrosses are not a good combination. The island is also covered in dead birds, birds with their stomachs filled with plastic. A parent albatross may fly more than 10,000 miles to deliver one meal to its chick.[14] Albatross eat mostly squid. They forage by resting on the ocean and dipping their heads down into the water. Unfortunately, they do not only come up with healthy nutrients, but also plastic that they have mistaken for food. Every time the albatross eats, it might come

[13] Parker, Laura. "Nearly Every Seabird on Earth Is Eating Plastic." *National Geographic*, National Geographic Society, 2 Sept. 2015, news.nationalgeographic.com/2015/09/15092-plastic-seabirds-albatross-australia/.

[14] Safina, Carl. "On the Wings of the Albatross." *National Geographic Magazine*, Dec. 2007, ngm.nationalgeographic.com/print/2007/12/albatross/safina-text.

up with plastic in its beak. Imagine, every time you eat, you swallow sharp pieces of plastic. Their food is swimming in a soup of harmful plastic. Time and time again, they will pull up plastic instead of the food they *need*. The mother or father albatross flies back to their young after days of looking for food and regurgitates plastic into the chick's mouth. That chick may starve because it has plastic in its stomach instead of food. Plastic that we used — bottle caps, cigarette lighters, combs, bags, toothbrushes, and much more — could be the cause of death for these beautiful birds. It is hard to even imagine. We use a bottle cap without even thinking twice, yet later that cap could rest in an albatross chick's stomach. This plastic is coming from us and it is not fair for the birds and the next generation.

Maybe you're not convinced this matters. Maybe you don't like birds and don't see how they could be important to our world. I do hope you care about birds, and realize that they matter not only in their own right but because they play an important role in our ecosystem. However, let me share another reason plastics in the ocean is a problem. A study by Dr. Rochman of University of Toronto found that one in four fish that are being sold for *our* consumption have microplastics in their stomachs.[15] This study was done on the coast of California and on the opposite side of the Pacific Ocean in Indonesia. Take a moment to think about that: Our man-made material is flowing into our oceans and is coming back to us on our dinner plates, globally. Dr. Rochman is continuing her studies to find out whether or not the plastic is leaching toxins into the meat of the fish, the part we eat.

Figure 7: "Fish with Plastic in Gut." *EcoWatch*, www.ecowatch.com/25-of-fish-sold-at-markets-contain-plastic-or-man-made-debris-1882105614.html. Accessed 15 Dec. 2017.

I don't think we need a report to prove that there are toxins in our fish. We know that plastics leach toxins[16] and we know that plastic is being ingested by the fish. So, I think we can assume there are toxins leaching into our dinners. There is not time to wait for it to be proven. We can't

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[15] Rochman, Chelsea M., et al. "Anthropogenic Debris in Seafood: Plastic Debris and Fibers from Textiles in Fish and Bivalves Sold for Human Consumption." *Nature News*, Nature Publishing Group, 24 Sept. 2015, www.nature.com/articles/srep14340.

[16] Hamilton, Jon. "Study: Most Plastics Leach Hormone-Like Chemicals." *NPR*, 2 Mar. 2011, www.npr.org/2011/03/02/134196209/study-most-plastics-leach-hormone-like-chemicals.

wait for the day when a report finally says, “Oh, by the way you should not have been eating fish for the past ten years,” because by then it is too late. You can’t un-eat that fish. There is not time for us to wait. We must stop the flow of plastics into our oceans.

Birds and fish are not the only animals that are affected by plastic. A plastic bag that has blown out of a landfill, can be easily mistaken as a jellyfish to a passing sea turtle. Plastics have been found in other animals too, like whales. These animals probably don’t have the knowledge to tell the difference between plastic and food because in the past that was not a skill that was needed. Plastic floating in our oceans is a new problem and animals have not evolved to face it. It is not their fault that there is plastic floating around in *their* home.

Figure 8: “Gull Entangled in Plastic 6-Pack Ring.” *Oceans Lending*, www.oceanslending.com/ediblesixpackrings/. Accessed 15 Dec. 2017.

Now, I have told you about birds, fish, turtles and whales. These animals are ingesting plastic, but there is another threat that these animals face: entanglement. Lost or abandoned fishing gear, six-pack rings, and other plastic can be the cause of death to marine life due to entanglement. In 2016, sixty-six whales were reported to be entangled off the coast of California alone! This number only includes whales that were seen *and* reported. This is the highest number of reported whale entanglements since the National Oceanic and Atmospheric Administration (NOAA) started keeping track of them in 1982.[17] Most of the whales are entangled by fishing gear. Not all of the fishing gear is in use when the whales get entangled, some of it is derelict fishing gear. Derelict fishing gear is any fishing nets, ropes, crab pots, and other fishing equipment that has been discarded into the ocean on purpose or accidentally lost or forgotten.[18] It is difficult for a whale to see a rope suspended in the water with a crab pot at

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[17] NOAA Fisheries, West Coast Region. “2016 West Coast Entanglement Summary.” *National Oceanic & Atmospheric Administration*, Mar. 2017, www.westcoast.fisheries.noaa.gov/publications/protected_species/marine_mammals/cetaceans/wcr_2016_whale_entanglements_3-26-17_final.pdf.

[18] NOAA Marine Debris Program. “2015 Report on the Impacts of “Ghost Fishing” via Derelict Fishing Gear.” *National Oceanic and Atmospheric Administration*, Mar. 2015, www.marinedebris.noaa.gov/sites/default/files/publications-files/Ghostfishing_DFG.pdf.

the bottom and a buoy at the top. Lines, ropes and nets are a trap to a passing whale and they often get entangled in the lines. With only flippers to help them, they are stuck. Being entangled can take away their ability to dive deep, swim fast, or move, making them unable to eat. Other marine mammals are also swimming into and entangling themselves in derelict fishing gear. When these animals are caught in derelict fishing gear it is called ghost fishing. The nets are still 'fishing' after they are abandoned. They are 'fishing' the important animals that live in our ocean. Further, most fishing gear is made of plastic, so derelict fishing gear will break down into microplastics in the ocean, even if it doesn't cause an entanglement.

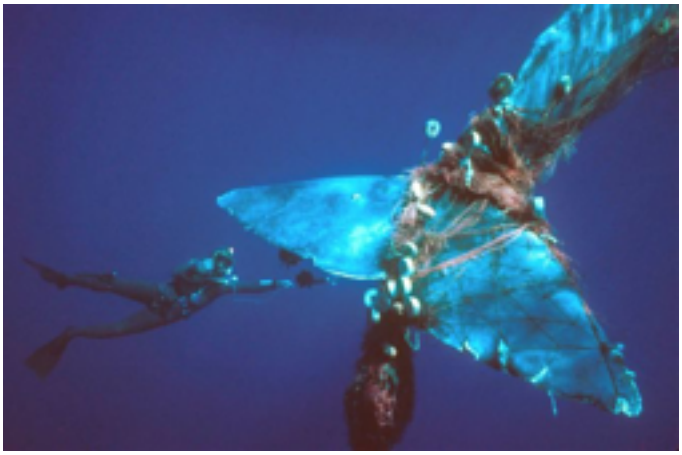

Figure 9: "Entangled Whale and Diver." *Ocean Alliance*, www.whale.org/save-a-whale-while-we-save-the-whales/. Accessed 15 Dec. 2017.

Several times I have written about plastics breaking down into microplastics. Now, I am going to tell you more about microplastics so you have a better understanding of what they are and why they are a problem.

MICROPLASTICS

The definition of a microplastic is a small piece of plastic, smaller than five millimeters in size. Five millimeters is approximately the size of a small grain of rice. There are five main types of microplastics: microbeads, nurdles, foam, microfibers, and secondary plastics. Some of these start as microplastics and some of them break down into microplastics over time.

Microbeads

Microbeads are small pieces of plastic found in some facial scrubs, body wash, make-up and toothpaste. Not only are you rubbing pieces of plastic all over your skin, but most microbeads are washed down the drain. They are too small to be filtered out by water treatment plants and they end up in the ocean. In December 2015, a bill was passed to ban microbeads in the United

States. The bill states that in July 2017 no more microbeads can be manufactured for products and by 2019 no more microbeads can be sold.[19] This is great news! It means that we will be getting plastics out of our products and drains!

Figure 10: "Toothpaste with Microbeads." *The Science Explorer*, thescienceexplorer.com/nature/throw-out-toothpaste-full-microbeads. Accessed 15 Dec. 2017.

Nurdles

The next microplastics are nurdles, which are preproduction pellets. They are the base material of most of the plastic that we use. When manufacturers are ready to make a product, the plastic pellets, or nurdles, are melted down, dyed, and then made into the plastic we use everyday. In 2012, shipping containers transporting 150 tons of nurdles were knocked off of a ship during a typhoon off the coast of Hong Kong.[20] The beaches of Hong Kong were covered in a white blanket of nurdles. Regardless of the money and time spent to clean the beaches, hundreds of millions of nurdles from the spill are still in our oceans, on our beaches, or in fish that we could consume.

Figure 11: "Handful of Nurdles." *Wikipedia*, en.wikipedia.org/wiki/Plastic_resin_pellet_pollution. Accessed 15 Dec. 2017.

Foam

The third type of microplastic is foam or polystyrene. Polystyrene is a type of plastic. If you add air to polystyrene then you get polystyrene foam, more commonly known as Styrofoam. Remember when you opened a box from the post office and it had huge chunks of Styrofoam in it? Then, you pulled out the Styrofoam packaging and it fell apart into tiny Styrofoam beads. Those Styrofoam beads, which are less than five millimeters in size, are microplastics. You can

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[19] 114th Congress (2015-2016). *H.R.1321 - Microbead-Free Waters Act of 2015*. U.S. Government Publishing Office, 28 Dec. 2015, www.congress.gov/bill/114th-congress/house-bill/1321/text.

[20] Gottlieb, Benjamin. "Hong Kong's Plastic Pellet Problem." *The Washington Post*, WP Company, 6 Aug. 2012, www.washingtonpost.com/blogs/blogpost/post/hong-kongs-plastic-pellet-problem/2012/08/06/6bbc018a-dfe3-11e1-a19c-fcfa365396c8_blog.html?utm_term=.abf3c8135e10.

imagine that if the Styrofoam breaks apart easily in your hand, then it will break apart very easily in the ocean.

Microfibers

Microfibers are small fibers that wash off of your clothing. You might have noticed that a lot of fabric is made out of polyester which is a type of plastic. Your fuzzy blankets and soft clothing are covered in tags labeled “polyester”. Whenever you wash your clothing and blankets, small polyester fibers, microfibers, wash off of the cloth. In the dryer, the microfibers are caught as lint and thrown in the trash, but in the washing machine the plastic fibers are flushed to a water treatment plant where the small microfibers slip through the filtration system and go into the ocean.[21] In Dr. Chelsea Rochman’s study, which I told you about earlier, of all the microplastics found in the fish in the Half Moon Bay, CA, study, 80% were microfibers.[22] We can already see that microfibers are heading into our food chain, even though they are microscopic.

Secondary Plastics

Secondary plastics are plastics that have broken down in the ocean. All the big pieces of plastic that are in the ocean will most likely become microplastics because they will keep breaking down until they are smaller than five millimeters. Like I mentioned earlier, derelict fishing gear is also a big contributor to secondary plastics in our oceans. When the pieces of plastic are that small, they can easily travel into the food chain.

Figure 12: 5Gyres. “Plastics on a Beach.” *Great Lakes Connection*, ijc.org/greatlakesconnection/en/2016/05/getting-ahead-curve-learning-manage-reduce-microplastics-great-lakes/. Accessed 15 Dec. 2017.

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[21] Boddy, Jessica. “Are We Eating Our Fleece Jackets? Microfibers Are Migrating Into Field And Food.” *NPR*, 6 Feb. 2017, www.npr.org/sections/thesalt/2017/02/06/511843443/are-we-eating-our-fleece-jackets-microfibers-are-migrating-into-field-and-food.

[22] Rochman, Chelsea M., et al. “Anthropogenic Debris in Seafood: Plastic Debris and Fibers from Textiles in Fish and Bivalves Sold for Human Consumption.” *Nature News*, Nature Publishing Group, 24 Sept. 2015, www.nature.com/articles/srep14340.

MICROPLASTICS ON OUR DINNER TABLE!

I hope this gives you a better understanding of what microplastics are and how they play such a large roll in ocean plastic pollution. Not only are microplastics making their way into the food chain in the ocean, they are also finding their way onto our plates through table salts[23], seafood, and even our drinking water![24] Can you believe that you might be sprinkling microplastics on your dinner plate tonight?!

During Dr. Rochman's research she also tested levels of plastics in shellfish and found it present in shellfish in California, right here in my back yard. While eating fish that have eaten plastic could be harmful due to toxins leaching into the edible parts, you are not always eating the actual plastic that is in stomach. However, if you eat seafood like sardines, mussels, and oysters, you are eating the entire fish including the stomach. If there is plastic in that stomach, then you are eating it too. Dr. Rochman found one in four oysters sold for human consumption in Half Moon Bay, California, had plastic in them. 100% of the plastic found in the oysters were microfibers.[25] To make matters worse, ocean microplastics attract chemicals and toxins from the surrounding water, making them more toxic to the animals that eat them.[26] Plastic pollution is really coming into our lives and our dinners. I don't think you want to have plastic on your dinner plate. I certainly don't!

Is it true that plastic is in our drinking water? As scary as this is, *yes*. Researchers are finding that there are tiny, microscopic pieces of plastic in the water we drink every day. Though the studies aren't final, plastics were found in 94% of the drinking water tested in the USA.[27] I don't have any words that could explain what I think about plastic in my drinking water, my family's

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[23] Karami, Ali, et al. "The Presence of Microplastics in Commercial Salts from Different Countries." *Nature News*, Nature Publishing Group, 6 Apr. 2017, www.nature.com/articles/srep46173.

[24] Tyree, Chris, and Dan Morrison. "Invisibles, The Plastics Inside US." *Orb Media*, 2017, orbmedia.org/stories/Invisibles_plastics.

[25] Rochman, Chelsea M., et al. "Anthropogenic Debris in Seafood: Plastic Debris and Fibers from Textiles in Fish and Bivalves Sold for Human Consumption." *Nature News*, Nature Publishing Group, 24 Sept. 2015, www.nature.com/articles/srep14340.

[26] Chelsea M. Rochman, et al. "Long-Term Field Measurement of Sorption of Organic Contaminants to Five Types of Plastic Pellets: Implications for Plastic Marine Debris." *Environmental Science & Technology*. 2013, 1646-1654.

[27] Tyree, Chris, and Dan Morrison. "Invisibles, The Plastics Inside US." *Orb Media*, 2017, orbmedia.org/stories/Invisibles_plastics.

water, my friends' water. We all deserve to have access to clean water, so why are we not trying harder to make that need a reality?

Figure 13: "Filling Glass with Water." *Bonita Springs Utilities, Inc.*, www.bsu.us. Accessed 15 Dec. 2017.

When animals suffer from something like plastic pollution it disturbs the food chain and ecosystems. We need healthy ecosystems to survive, which means the plastic (*our* plastic) in the ocean and the environment is going to affect us. I have more bad news that is really important: toxins are leaching from plastic into the food we eat. Foods and beverages that we buy are packaged in plastic and that plastic can leach into what we eat and drink, especially what is acidic or hot. That is scary. We must make changes to our use of plastics.

Finally, I have finished telling you about the doom and gloom of plastic pollution. That does not mean I have finished, so don't put down this paper yet! I still need to tell you some really important things…

THERE ARE SOLUTIONS!

Let me start with this: It would take me a lifetime to tell you every solution to plastics in the ocean that are out there in the world right now, so I am going to tell you some of the areas I have taken action on in my life and some large solutions that have a greater reach. I don't want to tell you what to do, because I want you to figure that out for yourself. What are you going to do about plastic pollution that affects all of us, you and your children and children of the future? That question is for you to answer and you alone. I would, though, like to share some ideas. I am going to tell you what Heirs To Our Oceans and I are doing about plastic pollution, and maybe you will get inspired to take action!

A lot of people have asked me why don't we just go out into the ocean, pull out all the garbage and be done? It does not work that way. First, like I said earlier, all of the trash in the ocean is not piled up in one place for a convenient "one scoop, we're done" action. Second, it would be like trying to take water out of an ever-flowing waterfall. You are taking garbage out, but there is always garbage going in too. And third, where are you going to put that garbage? In a landfill where it might escape again?

There are some people that are trying to "clean the ocean" like Boyan Slat's Ocean Clean Up project. His project is quite successful, but even if he does succeed in cleaning up huge amounts of trash from the ocean more will continue to pour in. I think that pulling trash out of the ocean is part of the solution, I just don't think that it is *the* solution. Please don't take me wrong, I do think that cleanups are important and we should not leave them out of the solution, but we also can't be satisfied with *only* cleanup efforts. So, what is a bigger part of the solution? I agree with many people researching this issue that the best way to go about this, to achieve a long-term solution, is to stop plastic at the source. We go back up the streams and waterways, back into the trashcan, back into your hand. *Your* hand, *my* hand, our neighbor's hand. We are the source. When we use plastic, we start the plastic-pollution story.

Several years ago, before I began my research on plastic pollution, I thought I was eco-friendly. My family recycled and conserved water, but we also used plastic. I did not use plastic because I did not care if it got in the ocean, I used it because I was *oblivious*. I had *no idea* it had a chance of getting into the environment. It was only one plastic water bottle, what harm could it do? Now I know it is *not* just one water bottle. What about all the water bottles I had used that month, that year? What about the world's water bottles? But, I was not thinking about that then. Why should I? But, now you and I do know, so will we buy them again?

Sometimes we need to stop and think about the cumulative effect of everyone's plastic usage. I am not just talking about plastic water bottles, I am talking about plastic bags, utensils, cups, plates and straws. It does make a difference to reduce the amount of plastic used in our everyday lives. Especially single-use plastics. We use single-use plastics for only minutes and they stay in the environment for centuries. If you refuse a straw, people will notice you and you will be setting an example for others. You may end up inspiring them to reduce their plastic usage! Plastic has become such a big part of our lives and it is hard to completely cut out

plastic, but if we all make adjustments in our everyday life, we can lower the amount of plastic we use. This would lead to us having less impact on the oceans.

I am going to list the top five single-use plastics I think are most important to cut out of our lives as a first step to reducing the downhill flow of plastic into our oceans.

Figure 14: Photo by Cambria Bartlett. May 2017.

1. Single-use plastic bottles. Humans buy one million plastic bottles a minute around the globe.[28] This is not sustainable. What's more crazy is that the recommended eight glasses of water per day in the United States costs about $0.49 per year; that same amount of bottled water is about $1,400 per year![29] This is one of the easiest things to start with to make change — use your own reusable water bottle!

2. Single-use plastic bags. This includes grocery bags, plastic produce bags, to-go bags, Ziplock sandwich bags, etc. There are plenty of reusable bags out there for all of these purposes! World-wide, we use one trillion plastic bags each year.[30] Yikes! It does not have to stay that way!

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[28] Nace, Trevor. "We're Now At A Million Plastic Bottles Per Minute - 91% Of Which Are Not Recycled." *Forbes*, Forbes Magazine, 28 July 2017, www.forbes.com/sites/trevornace/2017/07/26/million-plastic-bottles-minute-91-not-recycled/#52a987f3292c.

[29] "Bottled Water Facts." *Ban the Bottle*, 2007, www.banthebottle.net/bottled-water-facts/.

[30] Anderson, Marcia. "Confronting Plastic Pollution One Bag at a Time." *EPA*, Environmental Protection Agency, 1 Nov. 2016, blog.epa.gov/blog/tag/plastic-bags/.

3. Single-use plastic straws. 500 million straws are used in the United States every day![31] These straws are used once and then thrown away. This is not necessary! Just say “no straw please”! Or, if you are one of those people who just like drinking with a straw, get yourself a reusable metal, glass or bamboo straw.

4. Single-use plastic utensils. We use 40 billion plastic utensils every year, globally.[32] These utensils are not necessary either! I carry reusable utensils wherever I go, so I never need to use plastic utensils.

5. Single-use plastic to-go containers and cups. Bring your own reusable mug into the coffee shop, or sit down and enjoy your coffee in a provided mug. You can also take your own to-go containers when you eat out for your left-overs. Talk to a restaurant or shop owner who uses Styrofoam to-go containers and cups and ask them to change to a reusable or paper alternative. Give business to those restaurants and shops that are using biodegradable, paper products.

If you start reducing the amount of plastic that you use, you will be helping the environment and you won’t have toxic chemicals leaching into your body, it’s a win-win! You might have noticed that my top five plastics were all single-use plastics. Remember, you are only using that piece of plastic once, then throwing it away. Think about that. Do you really *need* that plastic straw that you are going to be using for five minutes then throwing away where it will last for a hundred years or more or possibly forever? I don’t think so. These single-use "conveniences" are a habit that can be changed. Carrying a reusable kit with you is not a hard lifestyle change. The oceans and future generations will thank you!

Another interesting area of solutions is related to microfibers. After talking to Dr. Rochman, I became very interested in microfibers and started researching what solutions were being considered. So, what can we do about microfibers? There are different ways you can deal with the problem of microfibers in the clothing you already own. Filters can be added to washing machines to catch clothing fibers before going into the waste stream. These filters are similar to

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[31] Bailey, Kate. “FAQs and Links | Milo's Be Straw Free Campaign.” *Eco-Cycle*, 2017, www.ecocycle.org/bestrawfree/faqs.

[32] Trent, Nancy. “Ending Take Out Waste.” *Whole Foods Magazine*, 14 June 2016, wholefoodsmagazine.com/blog/ending-take-out-waste/.

the filters on dryers that collect lint and can be cleaned after each wash. We, as consumers and as voters, can demand washing machine manufacturers to have microfiber filters on their products. This may be one of the best economic solutions for microfibers now, but since we do not have legislation that requires washing machine manufacturers to put filters on their products, it is possible to put a filter on your existing washing machine. In the mean time, Alexander Nolte and Oliver Spies invented a bag to wash your synthetic clothing in, so that the microfibers will be caught.[33] We can buy and use these bags now as responsible consumers. Though filters are a good solution, the plastic is still being produced and used for clothing, then brought to a landfill where it could still make its way to the ocean.

Figure 15: “Guppy Friend.” *The Guardian*, www.theguardian.com/sustainable-business/2017/feb/12/seafood-microfiber-pollution-patagonia-guppy-friend. Accessed 15 Dec. 2017.

The best solution: plastic-free clothing. This is the long-term solution I believe we need to work toward. Cloth is being made that completely avoids plastic. Fabrics are being made from flax and hemp and can be put in the compost when you are done with the clothes![34] There are also options with mushroom "leather" and other exciting materials that can move us toward sustainable clothing. As we move forward, I believe that biodegradable fabric is the best long-term solution to plastic microfibers.

Cleanups are another part of the solution. Doing a cleanup does not mean you need to rent a boat and go pull garbage out of the ocean. You can do a cleanup anywhere! If you see litter outside, it has a high chance of getting into the ocean sooner or later. Why not just pick it up? You don’t need to go to the beach or even a waterway, you can just walk outside your house.

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[33] O'Connor, Mary Catherine. “Microfibers Are Polluting Our Food Chain. This Laundry Bag Can Stop That.” *The Guardian*, Guardian News and Media, 12 Feb. 2017, www.theguardian.com/sustainable-business/2017/feb/12/seafood-microfiber-pollution-patagonia-guppy-friend.

[34] Freitag, Markus, and Daniel Freitag. “From Fibers to F-ABRIC.” *FREITAG*, 8 Sept. 2017, www.freitag.ch/en/fabric.

You don’t have to spend your time driving to a cleanup and creating carbon emissions. Even better, don't do a cleanup alone! You could also invite your friends to join you!

Figure 16: Photo by Emily Bartlett. June 2017.

The Heirs To Our Oceans founding chapter and Pescadero Middle School chapter organize waterway cleanups every month, and we have fun! I have also actively cleaned up Tunitas Creek Beach, in Half Moon Bay, CA, for over a year. At California Coastal Cleanup Day on September 16, 2017, Heirs To Our Oceans, TLC Locals, and other volunteers collected over 1,480 pounds of trash! We picked up 1,480 pounds in two hours on one morning and this is only a small fraction of the trash we have picked up over the last year.

Every day, for fourteen days, my family and I filled a five-gallon bucket with trash we picked up from wherever we were that day. From Facebook, we are challenging others to fill one bucket with trash. It is the Heirs Trash Bucket Challenge! If you are interested in participating, get a bucket or a reusable bag and collect litter from wherever you are that day. Next, take a picture of you and your full, saving-the-oceans bucket, with the parking lot, stream, street, gutter, ocean, park, etc. in the background, then post it on Facebook. Tag us at #H2OOTrashBucketChallenge, so we can see your contribution to cleaner oceans.

Another important solution is legislation. Legislation can help reduce plastic. I would like to believe that if everyone was educated about plastic pollution they would change their lifestyle and stop using “convenience” plastic. Sadly, I know that it is not going happen with everyone. That is where legislation comes in to help everyone change. At this point, for us to reduce our plastic usage by how much is necessary, we *have to* put regulations in place. This is not to say you should stop whatever changes you are making in your household to reduce your plastic. However, regulations through legislation are a big part of the solution. There is some legislation in place reducing the amount of plastic used, but there is certainly not enough.

As an example of a law that is in place now, I will tell you about the California bag ban. In 2014, California was the first state to have legislation banning plastic bags.[35] This law has some exceptions. For instance, the law is only effective for certain large stores and does not include to-go bags at restaurants. The law also does not include plastic produce bags. Lastly, stores are allowed to *sell* “reusable" plastic bags, but they are only 10 cents and are they really going to be reused? This might not be a perfect law, but it is still a *huge* step! While California has taken steps forward, ten other states have been walking backwards. Arizona, Florida, Idaho, Indiana, Iowa, Michigan, Minnesota, Missouri, New York and Wisconsin have all banned banning single-use plastic bags.[36] That’s right, they have put in place a ban that bans bans! A ban against a ban is called a “preemption”. So, these ten states all have a preemption that says local governments cannot have any bans against single-use plastic bags. This is crazy, right?! We are in need of steps forward, not backward!

Another good example of legislation in action is in the Republic of Palau. Our chapter leader in Palau, Meil, helped draft a bill with Senate members to reduce the use of single-use plastic bags. This bill passed! See how much power kids have?!

I am a kid and I can’t vote, but that didn't stop me from going to Capitol Hill in Washington D.C.! In May 2017, seven Heirs and I went to Washington D.C. to participate in Blue Vision Summit.

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[35] National Conference of State Legislatures. “STATE PLASTIC AND PAPER BAG LEGISLATION.” *NCSL*, 5 July 2017, www.ncsl.org/research/environment-and-natural-resources/plastic-bag-legislation.aspx.

[36] Howe, Angela. “State Preemption: Taking Away ‘Home Rule’ on Plastic Pollution.” *Surfrider Foundation*, 9 June 2017, www.surfrider.org/coastal-blog/entry/state-preemption-taking-away-home-rule-on-plastic-pollution.

We were the first middle-school-aged kids ever to attend the Summit, and we marched up to Capitol Hill with all of the other adults. We talked to ten Congresspersons about bills to better improve the health of our planet and our future! As you can see, legislation can be part of the solution! Bills can be written! Laws can be passed!

Figure 17: Photo by Janet Clark. May 2017.

The last solution, where I am personally active, is education. Education is another big part of the solution. How are you supposed to do something about a problem you don't even knows exists? You can help the world by doing something as simple as telling your friends and family about what you have learned in this paper. If everyone knew that animals were dying and toxins were being leached into their bodies, maybe we would see more action. I have been doing presentations for Heirs To Our Oceans for a year and a half and whenever we present, we always educate our audience on at least one human impact on our oceans. I think that education is the first part of the solution. To understand what the solution is, you need to first fully understand the problem. That is why I wrote this paper, to help educate you and others about the problem of plastics in our oceans. And, please don't stop here! There are millions of articles about plastic pollution just waiting to be read! Educate yourself, then ask yourself: What am I going to do?

Figure 18: Photo by Emily Bartlett. October 2017.

We must make changes now. All of us must change habits of production and consumption now, as future generations of plants and animals, all over our blue planet need clean, healthy water. We can't sit around and wait, there is not time. The time is now. Not tomorrow. Not next week. Not next year. Now.

Here is the question I will leave you with:
What are you going to do to help save our little blue planet from plastic pollution?

Heirs To Our Oceans is creating the next generation of environmental leaders.

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