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Plastic: The Subtle Mass Murderer

To an alien traveler, Earth would appear to be a blue marble, with 71% of its surface covered by a vast ocean (“Ocean”). However, even this staggering statistic does not fully capture how important the ocean is to planet Earth. The ocean is the lifeblood—the heartbeat—of our planet. It plays a central role in the health of the global ecosystem, providing a habitat for phytoplankton and other marine flora which produce over two-thirds of the oxygen in our atmosphere (Hall). The ocean’s high specific heat capacity and massive convection currents moderate global climate, enabling the spread of complex life like plants and animals throughout the world. Moreover, the ocean is the largest carbon reservoir on the planet, holding over 50 times more carbon than the atmosphere and reducing the impact of climate change (“Why... Oceans Important?”). On a human level, the ocean is also highly significant as the main artery of global trade and tourism, and as a source of dietary protein, salt, and pharmaceuticals. The food we eat, the air we breathe, the water we drink—all rely on the sea. It is evident that without a healthy ocean ecosystem, public health, the world economy, and finally all complex life on Earth would perish. Yet driven by greed and negligence, human activity continues to pollute and even sterilize this keystone of all ecosystems.

This human damage to the ocean takes a plethora of different forms. Increased emission of carbon dioxide from power plants, vehicles, and factories leads to the accumulation of carbonate ions and ocean acidification. This acidification induces the degradation of coral reef habitats and negatively impacts phytoplankton, zooplankton, and crustaceans among others, directly damaging various commercial fisheries and indirectly harming the rest (“Campaign”).

Runoff of nitrogenous fertilizers leads to eutrophication, and ultimately to the creation of algal blooms. By blocking light and consuming oxygen when they decompose, these masses of algae kill off local flora and fauna and leave dead zones in their wake (“General... Eutrophication”). Oil spills from grounded supertankers and offshore rigs have similar effects. The film of crude they leave over the ocean’s surface blocks gas exchange between the atmosphere and water, leading to a lack of oxygen in the water and the subsequent die-off of many marine animals. In turn, this has an impact on important fisheries such as those along the Gulf of Mexico, which form the foundation of local economies. While all of these factors have many deleterious effects on the health of the ocean ecosystem, none truly has the devastatingly global effect of plastic pollution. Coming in a variety of forms, plastic pollution is both chemically harmful and physically dangerous to a large spectrum of marine organisms.

Plastics, composed primarily of organic polymers, are among the most widely manufactured and used materials of modern times. Malleable, pliant, and waterproof, plastics are often molded into desired shapes, such as fibers and plates, and are used in products around the world. The earliest plastics, derived from rubber, were used from the 1600s BC by Mesoamerican tribes to create balls and elastic bands for sporting events (Andrady & Neal). In the subsequent centuries, various biological polymers, such as shellac and horn, were used for their plastic properties. But it was only in the late 1800s that wholly synthetic plastics were first produced. Parkesine, an ivory substitute, was first synthesized in 1862, while the related celluloid was isolated in 1870. The subsequent years saw the development of a wide range of plastics, from Bakelite to polyvinyl chloride. However, plastics did not truly see action until the Second World War, when their properties proved useful in producing parachutes, aircraft parts,

and paint (“History of Plastics”). As the production miracle of the war years transformed into a modern consumer economy in the 1950s, plastics came to be a staple of modern life. During this era, plastics began to be used in the fabrication of many items, from automobiles to home appliances, for their low cost and versatility.

Over time, technological improvements have led plastics to become less expensive and more ubiquitous. Today, global plastic consumption totals over 300 million tons per year and is rising at about 4% per year (“Plastics..Guide”). Unfortunately, much of it comes in disposable form, as shopping bags, water bottles, and utensils. In developed countries, these disposable plastics are either recycled, incinerated, or deposited in landfills; only a relatively minor proportion reaches the ocean through storm drains. However, most of the growth in plastic consumption is taking place in developing countries, like China, India, and Brazil, with underdeveloped sanitation systems. In general, plastic waste in these countries are thrown onto streets and dumped into rivers, and then carried by rain into the ocean. In this fashion, 10-20 million tons of plastic (“Global Plastic...Lags”), amounting to around 80% of total ocean waste (“Marine Debris”), are carried into the sea each year. As emerging economies continue to grow, this figure is set to rise dramatically in the years to come.

Public discourse concerning this epidemic usually centers around macroplastics, relatively large pieces of debris that are over 5 mm in size (Fendall & Sewell). Macroplastic pollution presents critical, well-publicized issues for marine life. Over 600 species (Joyce), including half of all marine mammals and one-fifth of marine birds, are afflicted by entanglement or ingestion (Thompson). These conditions compromise the ability to capture and digest food and to escape from predators. This plastic debris causes the death of over one million

seabirds and more than 100,000 marine mammals and sea turtles each year (Staff, Live Science), leading to far-reaching repercussions throughout the ocean food web. Moreover, commercial fish and shellfish commonly become bycatch in discarded fishing nets, unnecessarily damaging fish stocks and leading to secular decline in fishery productivity. In addition, shipping is also impacted by marine debris. Macroplastics entangle propellers and clog cooling water intake valves, requiring expensive and time-consuming repairs that smaller fishermen can simply not afford (“Marine Debris Impacts”).

In addition to the devastating effects they have on fisheries and the ocean ecosystem, macroplastics also tarnish the long-held symbol of oceanic beauty. Massive and slow-moving gyres cause floating plastics to accrue in specific regions of the ocean, leading over time to the creation of virtual islands of waste such as the Great Pacific garbage patch. Found in the North Pacific, this relatively stationary area is twice the size of Texas and is formed from waste material originating from Japan to California (Facts ... On Marine Pollution). Closer to shore, accumulations of garbage like this damage the tourist industry, spoiling beaches and repelling tourists who bring thousands of dollars to see them. This is particularly important because tourists contribute not only to national economies, but to foreign exchange reserves as well; thus, a reduction in tourist revenue could cripple international trade in general. But although isles of garbage and animals stuck in nets make for poignant imagery and media attention, the floating plastic debris that causes them is just a minuscule portion of the tens of millions of tons of plastic waste that enters the ocean every year.

The vast majority of plastic debris in the ocean is microplastic—particles that are less than 5 mm in size (Fendall & Sewell), and generally smaller than the width of a human hair.

Many microplastic particles originate as macroplastics that are broken down through photolysis by ultraviolet radiation, or mechanical forces from waves or algal growth. An additional percentage of microplastics arise from plastic pellets used as raw material in manufacturing processes. If managed negligently during loading or transportation, these pellets may be blown away by wind currents and fall into the sea. In addition, plastics from cosmetics, wrappers and detergents also represent a sizeable component of this microplastic pollution, frequently reaching the sea by sewage water and rivers (“Plastic Garbage... Particles”). While microplastics are minute in size, their effect on the environment is colossal.

The biggest problem with microplastics is that they are difficult to contain once introduced into the marine environment, because their small size allows them to spread rapidly. Over time, they are colonized by microorganisms, causing them to sink and become embedded in the seabed and shoreline. There, the microplastics obstruct the flow of oxygen through the sediment, resulting in the deaths of the flora and fauna that reside there. In addition, filter-feeders like lugworms and mussels frequently consume these harmful particles, causing circulatory blockages. Moreover, pellets are often mistaken to be fish eggs to predators such as seabirds, turtles and carnivorous fishes. Once consumed, these particles lead to physical blockage of the digestive system and eventual death by starvation (Welden 39). As a case in point, 92.5% of Northern Fulmars contain microplastics in their stomachs (Avery-Gomme). Clearly, microplastics have a broad and devastating effect on a wide array of marine organisms.

However, the detrimental effects of these pollutants are not restricted to marine flora and fauna, but reach humans as well. The high surface-area to volume ratio of microplastics allows them to absorb carcinogenic aromatic compounds such as polychlorinated biphenyls (PCBs) and

the pesticide DDT, as well as neurotoxic substances like mercury (“About Microplastics”). Moreover, their photolysis by ultraviolet light releases bisphenol A (BPA), which has been linked to heart disease, hormonal imbalance in men, and impaired immune response (“Association...Disease”). As these toxic substances concentrate, they magnify as they travel up the food chain, damaging the global ocean ecosystem and major fisheries. Ultimately, microplastic consumption at the bottom of the ocean’s trophic web leads to decimation of fish stocks and bioaccumulation of toxins in humans, leaving malnutrition and disease in its wake.

Plastic pollution has already caused great harm to the oceans and to human society, and with the tremendous growth in plastic production and use, the costs of plastic debris in the ocean will continue to spiral upward. No silver-bullet technological solution currently exists—simply trawling the oceans would not collect the 99.9% of plastic waste that is microplastic—and given the current pace of plastic devastation, we cannot rely on one to be developed in time to save the ocean ecosystem and the fisheries they support from complete collapse. Regulation of plastic pollution would be of little use, because the countries in which most plastic pollution occurs lack the well-developed refuse collection systems needed to stop waste from flowing into the oceans. Another often-suggested measure for pollution and global warming problems in general—reduction in population growth in emerging countries—will not help either in this case, because it is the increased adoption of a modern, consumerist lifestyle in these countries that is leading to a rise in plastic pollution, not the raw growth in population. Yet, despite these growing concerns, there are still ways to command power of our ocean’s future.

The growing epidemic of plastic is one we have control over. People are usually lead to believe that their actions and voices don’t have a significant impact on the world around them.

However, only when we put the blame on ourselves for the heaps of plastic overflowing and polluting the ocean can we truly make a change. Our support and our voice are as valuable as our actions. We must hold cities responsible and require plastic to be recycled. We must change our grocery bags from plastic to paper and continuously reuse them. We must pick up our own trash and clean our local beaches. We must also support major environmental programs that aim to work with organizations such as the United Nations Environment Programme (UNEP) to establish international guidelines for curbing plastic litter. We must create online, global campaigns that reveal the large-scale devastation plastic pollution causes in order to raise awareness and pressure individuals and governments alike to take action and have an impact. We must take the initiative and hold community-wide movements to educate people about this plastic pandemic. We must do all this and more if we wish for our ocean's health. One small action can yield a domino effect that impacts nations across the globe. It only takes one person to make a difference and that person could be you.

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On June 11th 2014, I had just finished a grueling sophomore year — one that taxed my mind as well as my body. I was in desperate need of a long and relaxing break. My parents, understanding my predicament, suggested the scenic route and decided to take me to the island paradise of Bali. I had just arrived at one of its beaches and the first thing that caught my attention was not its breathtaking waterfront, but rather garbage littered in the sand. It ruined my experience and I came home disheartened. I decided to look up this pollution conundrum and discovered a wide assortment of issues that marine debris caused. As I viewed what seemed like an endless number of articles, I learned that marine litter was widespread and the majority was plastic. I happened to stumble upon Fromthebowseat while scrolling through pages of news that few seemed to care about. I saw the contest and the theme it presented and decided that as soon as my Junior year came to a close, I would research the plethora of detrimental effects plastic pollution caused. Along with two of my friends, I researched numerous scientific and government publications and discovered that plastic pollution might be the most significant complication that humans have caused. Hopefully, my analytical research paper can portray some of the many problems that plastic pollution presents and the pervasive societal impact that will be needed to prevent the desecration of the global marine ecosystem.