THE AGE OF PLASTIC SMOG

charting a future for our oceans and ourselves

by MARCUS ERIKSEN

THE DISTRIBUTION OF AN ESTIMATED 5.25 TRILLION PARTICLES OF PLASTIC MARINE POLLUTION IN THE WORLD'S OCEANS. GRAPHIC COURTESY: LAURENT LEBRETON.

A fellow of The Explorers Club since 2010, Marcus Eriksen is the research director of the 5 Gyres Institute, studying plastic marine pollution through transoceanic expeditions. He holds a Ph.D. in science education from University of Southern California.

Over the past half century we've witnessed the emergence of a host of global conservation threats, from the advent of single-use plastics to the planetwide distribution of persistent synthetic chemical pollutants. Sadly, the "wild places"–the frontiers we explored and celebrated in the last century–have become in our time "waste spaces." Nowhere is this more evident than in our oceans, where an abundance of particulate plastics threatens our shared planetary life-support system.

When we launched the 5 Gyres Institute in 2008, our goal was to answer the question, "How much plastic is out there?" Since then, our team of nine scientists has carried out 24 expeditions, including forays across each of the five subtropical gyres, voyages into the waters of the Mediterranean Sea, and a circumnavigation of Australia. Collectively, the data we have gathered have allowed us to estimate the volume of plastic pollution drifting in the oceans: It is a staggering 269,000 tons composed of more than 5.25 trillion particles of varying sizes. While such numbers may be startling, it is what they tell us about the ocean that is far more frightening than previously thought. For we have found that what once were described as "garbage patches" collectively form a "smog of microplastics" loaded with toxins, which pervades the entire marine ecosystem, in varied concentrations, from the Arctic to the Antarctic.

Imagine for a moment that you are standing on the seafloor looking up through the water column to the surface. From that vantage point, you would see five massive clouds of microplastic in the subtropical gyres, dark clouds of larger plastic pieces coming from the world's largest rivers and densely populated coastlines. The Bay of Bengal, Mediterranean Sea, and China Sea would have the darkest clouds on the planet. Having begun to unravel the complexity of plastic in the ocean, the question now is how to solve the problem it has created.

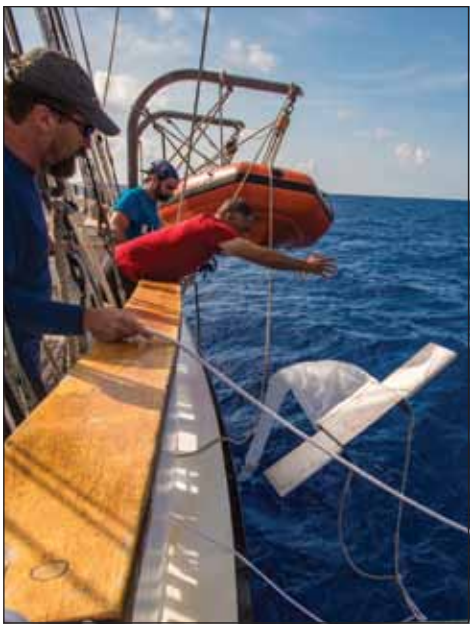
We first began to grasp the impact of plastic pollution on the oceans in 1972, when Edwin Carpenter, a Woods Hole oceanographer, published the first evidence of microplastic particles, which he found in his plankton tows in the waters between New York and Bermuda. Yet, the marine science community was slow to follow up on his observations, with only a few published papers following his: another in the North Atlantic in 1974, one on the South Atlantic in 1981, and another on the North Pacific in 1985. Otherwise, the scientific community was silent.

The first description of what came to be known as a "garbage patch" was penned by Captain Charles Moore, founder of Algalita Marine Research and Education, following his 1999 survey of the North Pacific Subtropical Gyre. Moore described a dense concentration of microplastics in the waters between Hawaii and San Francisco, giving American media outlets the impression that islands of plastic trash were drifting in the ocean. While the media spotlight proved to be a boon to ocean conservation, resulting in fame and funding for a few scientists, the misinformation that was conveyed became an Achilles heel for marine science that has endured until now.

Over the course of our expeditions, we have discovered that plastic in the ocean is rapidly pulverized into microplastics. Plastic is always moving, sometimes in violent motion. It becomes brittle under UV sunlight and it is constantly under attack from curious fish, seabirds, marine mammals, and reptiles. Plastics also attract colonies of microbes in the millions, and are ingested by zooplankton and other filter feeders, such as barnacles and jellyfish. Microplastics that are not ingested by marine life will likely be driven below the ocean surface, to be captured by deep ocean

currents for redistribution around the world. And, it seems, no place is spared.

We are now finding microplastics in ice cores, on remote shores, and on the ocean floor. After three weeks of sailing north along the Greenland coast to Iceland, where we battled a few frigid storms, we were able to transect the subpolar gyre and found microplastics in nearly all of our samples. Though diminishing in concentration toward the Arctic Circle, we were expecting, hoping to find nothing. It was abundantly clear that where there's seawater, there's plastic.



DEPLOYING THE MANTA TRAWL WITH A .33MM NET FROM THE SCHOONER *MYSTIC*. PHOTOGRAPH BY SERGIO IZQUIERDO.

Since we began our expeditions, participating scientists have contributed to a number of important journals. Chelsea Rochman, an ecotoxicolgist from U.C. Davis who joined our 2010 and 2011 expeditions across the South Atlantic–which covered some 3,700 nautical miles from Rio de Janeiro to Cape Town–found that, like a sponge, plastic absorbs persistent organic pollutants, like PCBs and other industrial chemicals, DDT and other pesticides, flame retardants, PAHs from the incomplete burning of fossil fuels, and even oil drops from leaky cars. Subsequent work in the lab revealed pollutants from ingested plastics are desorbed into fish tissues and organs. Naturally, the more flame retardants (PBDEs) that are found on plastic, the greater the concentration found in fish. In February 2013, Rochman and a long list of coauthors published a comment in the journal *Nature*, arguing that due to the sorption of high concentrations of pollutants and desorption into wildlife, plastic in the ocean must be classified as a hazardous substance.

We have also found that among the debris, marine life is adapting. Miriam Goldstein, a marine biologists from Scripps Institute, found a hundredfold increase in the population size of the only oceanic insect, *Halobates*, largely due to floating trash creating increased real estate for egg laying. Plastic also increases the available substrate for sessile organisms, like barnacles and corals.

More recently, on December 10, 2014, my coauthors–Laurent C. M. Lebreton, Henry S. Carson, Martin Thiel, Charles J. Moore, Jose C. Borerro, François Galgani, Peter G. Ryan, Julia Reisser–and I had our article, "Plastic Pollution in the World's Oceans: More than 5 Trillion Plastic Pieces Weighing over 250,000 Tons Afloat at Sea," published in the peer-reviewed online journal *Plos One*. On the same day I also attended a conference in Washington, D.C., which brought together representatives from the EPA, UNEP, UNDP, and NOAA, to discuss their respective marine debris policies. Although we now know enough about the nature of plastics in the world's oceans to act, it was clear that policy makers and regulatory bodies are lagging far behind. The gap between the frontier of this fast-moving science and the policies that follow was all too evident. When I ask the entire panel, "The scientific community agrees microplastics at sea are hazardous waste. Do you agree, and if not, why not?" Only two respond, and both stated that not enough is known.

We do know that efforts to recover the smog of microplastics from the ocean are as nonsensical as putting vacuum cleaners on top of skyscrapers to clean up air pollution—an idea that was actually proposed in the 1970s. The ocean will disperse and sink what is out there now, after it cycles through entire marine ecosystems. Because plastics shred so quickly, absorb toxins, and distribute globally, the need is urgent for us to get our act together on land. All solutions must begin with better-designed products, packaging, and systems of waste recovery.

Herein lie the challenges. Who will pay for this shift, industry or government? The battle lines have been drawn between industry on one side and environmentalists and municipal waste managers on the other.

Industry tends to promote better recycling, beach cleanups, and energy recovery with incinerators—deflecting these costs to taxpayers—rather than ceasing production of environmentally destructive products in the first place. The other side promotes better municipal waste sorting and composting, and producer responsibility for the redesign or phase out of the most common and costly waste products.

The problem is that millions of poorly designed products are slipping past current waste management systems. A design overhaul for thousands of products is essential. We must embark on an "age of restoration," committing ourselves to building a future in which ecosystem services trump all other interests. If we can bring ourselves to do so, we just might ensure the health of our planet into the future.

BEACHCOMBING

PLASTICS ORIGINATING FROM INDONESIA LITTER THE WINDWARD SIDE OF CHRISTMAS ISLAND IN THE INDIAN OCEAN. MORE THAN 60 PERCENT OF THE AUSTRALIAN TERRITORY, WHICH HAS LARGE AREAS OF PRIMARY MONSOONAL FOREST, HAS BEEN DECLARED A NATIONAL PARK. PHOTOGRAPH BY MARCUS ERIKSEN.