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Oceans of Plastic

By Amanda R. Martinez

Last summer, Dr. Marcus Eriksen and Joel Paschal were adrift on a makeshift raft in the middle of the Pacific Ocean. As seasoned sailors and ocean conservationists, their mission was simple if not brazenly quixotic – to build a boat out of plastic trash and salvaged ship parts and sail it from California to Hawaii to draw attention to the growing plague of plastics in the oceans.

In a mere two and a half months, the men fashioned 15,000 reclaimed plastic bottles into six, 30-foot-long pontoons, added a few sailboat masts, and attached an old fuselage from a Cessna 310 aircraft to serve as their cabin. Dispensing with any symbolism, they named the raft *JUNK* and with nothing but the currents and wind to propel them, set sail from Long Beach on June 1.

"We started sinking from day one," Eriksen says. Almost immediately, ocean waves unwound caps from about 1,000 plastic bottles, which promptly began filling with water. They solved their wayward cap problem with epoxy, but over the next three months, drifting at approximately 1.5 miles per hour across 2,600 miles of open ocean, the men endured an unrelenting barrage of fraying ropes and nets, cracking masts and loosening eyebolts. And those were just the maintenance problems. "We got hit with squalls daily," says Eriksen. "And we had to stay clear of the hurricanes. There were three hurricanes that passed within a few hundred miles of us."

A former Marine and Gulf War veteran, Eriksen is barely shaken in the face of harrowing adventure. If anything, he seems to thrive on it. What did surprise him, however, was an event that occurred about two-thirds of the way through the journey when he did what any man who'd been subsisting for weeks on peanut butter and canned beans in the middle of the ocean would do – he went fishing.

"I pulled out this little ten-inch-long rainbow runner," he recalls. "I actually filleted it, planning to eat it. The fillet's in the pan. I open its stomach and I couldn't believe it. I counted 17 fragments of plastic in its gut. This is a fish that you see in fish markets. You see them on menus in restaurants. And here was one that we harvested to eat directly from the sea. And now we're seeing that they're eating our trash."

SARAH KLAIN

Hermit crabs, spotted on beaches in the Cayman Islands, Costa Rica and Micronesia, have swapped their shells for PVC pipe, old film canisters and the caps from detergent bottles.

'GREAT PACIFIC GARBAGE PATCH'

It's been more than 10 years since Capt. Charles Moore discovered what has come to be known as the "Great Pacific Garbage Patch" on his way home to California from a yacht race in Hawaii. Moore took a detour, grazing the southern edge of the

North Pacific subtropical gyre, a unique ocean region that features a high pressure system of little to no wind hovering atop a convergence of ocean currents. The result is an eerily becalmed sea that sailors long ago dubbed "the doldrums" and have steadfastly avoided ever since.

Moore was stunned by what he saw – copious amounts of trash ranging from large recognizable items like plastic bags and detergent bottles down to tiny plastic fragments resembling confetti. Scientists have since learned that trash is accumulating in this remote region of the North Pacific by the ton and that 60 to 80 percent of that trash comes from land, swept into storm drains and out to sea or blown from beaches.

Upon his return, Moore founded the Algalita Marine Research Foundation to study the gyre. Over the last decade, Moore, along with Eriksen, who serves as the foundation's director of education, have made several research expeditions to the region. Eriksen doesn't mince words in relaying the results of their latest analyses. "The amount of trash on the ocean's surface has doubled," he says. "And that's just in 10 years."

MARKUS ERIKSEN

Eriksen discovered plastic fragments in the stomach of the 10-inch rainbow runner he caught at sea.

What we're learning now, however, is that this phenomenon of aggregating trash isn't isolated to the North Pacific – it's global. As reported by The Royal Society in its July 27 issue, "Plastics have been found on the seabed of all seas and oceans across the planet."

For some time, scientists have been speculating as to whether tons of trash are accumulating in the four other major oceanic gyres in the South Pacific, North and South Atlantic and Indian Ocean. Could the same combination of wind, waves and currents that trap trash in the North Pacific have created four other "great garbage patches?" A new map from a study published earlier this year in the Journal of Atmospheric and Oceanic Technology may help to relieve some of the guesswork.

"This is the first accurate map of surface circulation in the world. No one's ever done this before," says Dr. Peter Niiler of Scripps Institution of Oceanography, a world expert on ocean circulation and co-author of the study. Using data collected over the last 20 years from over 14,000 drifting buoys planted worldwide, Niiler and his co-authors have successfully displaced centuries of speculative ocean circulation based on cobbled-together regional buoy studies and anecdotal observations of ship drift.

The map depicts the world with continents grayed out. The oceans, awash in color, are covered in a swarm of wavy, black lines that represent currents. The colors range from a deep red at the equator, indicating high current velocities, to yellow as you move out from the equator and currents slow, to greens and blues, marking slower currents still. And finally, where we know each oceanic gyre to be, is a white spot designating minimal to no current velocity. Large swaths of the current lines come together and then stop.

If we use the North Pacific as a reference point, sure enough, where Algalita's researchers have found high concentrations of trash in the eastern and western areas of the ocean, there are two white spots. Moreover, if we move directly east into the region of the North Atlantic known as the Sargasso Sea, we hit another large white spot. Here, according to researchers at the Sea Education Association and the Woods Hole Oceanographic Institution, another area dense in plastics exists. The researchers are currently preparing to publish a study that will unveil what co-author Dr. Chris Reddy calls "an incredibly thorough,

scientifically robust data set" that examines 60,000 pieces of plastic collected from the region over 22 years.

"Now I'm going to tell you where the totally new thing is," Niiler says. "Go directly to the South Pacific." Here the map shows another white spot just off the coast of Chile and a bit south and east of Easter Island. But this one is different. It bears the most dramatic sweep of current lines across nearly the entire ocean basin (roughly 6,000 kilometers by Niiler's estimation), all of which feed that single area. If there's one area of the ocean with the potential to host the largest garbage patch, this is it.

PROJECT KAISEI

Ocean conservationists in particular are calling for an end to the era of disposable plastics.

"No one has ever gone there, except our buoys," says Niiler. "Over 100 buoys have ended up in that white spot and never returned. They just die there because they get covered up with crustacean and they get heavy and sink to the bottom. That is the world's most stable convergent place relative to where our buoys go and no one's ever been there."

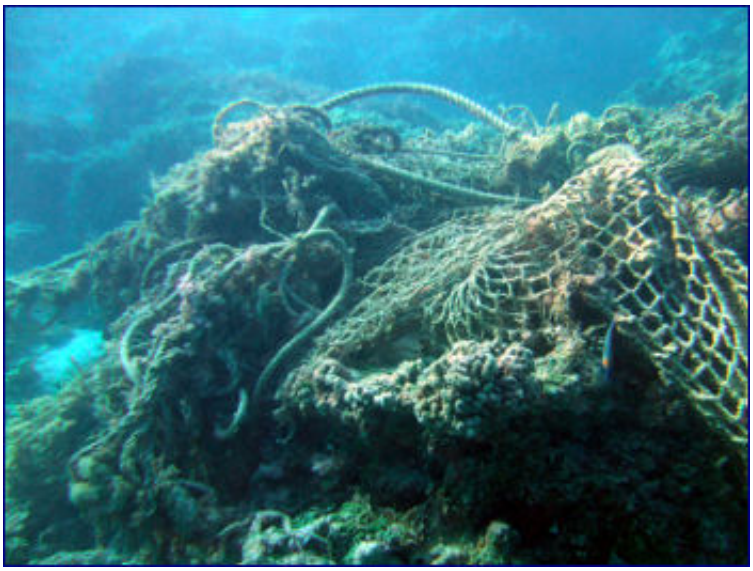
As we await hard data from what could be the world's largest garbage patch, it's crucial to note that it's not just the sheer quantity of debris littering our oceans that is most daunting. Rather, it's that quantity combined with the fact that an estimated 90 percent of it is plastic.

'WE MAY BE NEXT'

Unlike the flotsam of yore – mostly glass, wood and paper – plastic doesn't biodegrade. It persists. Reports from marine researchers stationed around the world confirm that the presence of plastic debris in marine and coastal habitats has now escalated to such an extent that it has actually begun to integrate into the natural environment. From the Caribbean to the Gulf of Aqaba south of Israel come stories of fish seeking refuge in plastic liter bottles and tires instead of coral reefs. Mangrove seedlings grow straight up through plastic bags lying on remote beaches in the Mergui Archipelago of Myanmar. Fur seal scat on Australia's Macquarie Island routinely comes in blue, green, yellow and white due to its high polymer content. There's even a beach on the southeastern coast of Hawaii that is said to have plastic sand because you have to dig about a foot down through plastic debris to hit traditional shore.

The same characteristics that made plastic such a boon to the manufacturing industry – it's water resistance, light weight and durability – are making it the home-design resource of choice for some marine animals. In Northwest Denmark, a type of gull called the kittiwake builds its nests using plastic string and rubber bands, and hermit crabs, spotted on beaches in the Cayman Islands, Costa Rica and Micronesia, have swapped their shells for PVC pipe, old film canisters and the caps from detergent bottles.

This perverse melding of the natural and manmade, however, quickly devolves to tragedy when faced with just how much marine life is maimed or killed by this debris via entanglement, smothering and ingestion each year. Researchers and fishermen continue to relay gruesome stories of flippers severed and beaks tethered shut by discarded monofilament fishing line; sea lions strangled by net-improvised nooses; sea turtles disgorging the plastic bags they mistook for a jellyfish snack; and the countless seabird carcasses that litter beaches, sporting bellies full of the colorful plastic pieces that so closely resembled the birds' daily prey. But if these images don't profoundly unsettle you, perhaps the reigning hypothesis will, which is: on the list of casualties, we may be next.



NOAA

By far the biggest threat to the reefs and marine life are derelict fishing nets; they're also the most difficult to remove.

Last September, more than 40 marine biologists, toxicologists and other scientists gathered at the University of Washington in Tacoma for the first international conference on microplastics. Toss a large chunk of plastic into the ocean and while it'll never biodegrade, it will, through constant exposure to sunlight and roiling waves, break down into pieces small enough to be mistaken for microscopic plankton. Other sources of microplastics include industrial abrasives used to blast grime off of ship hulls and the micro-exfoliating beads we use to slough off skin in the shower. These microplastic particles have the unique ability to adsorb large amounts of persistent organic pollutants (POPs), meaning the pollutants cling to the plastic surface like iron filings to a magnet. They've been shown to concentrate POPs up to one million times the rate at which they float freely within the ocean.

CHEMICAL THREAT

Since 2005, Dr. Hideshige Takada, a toxicologist at the University of Tokyo, has been collecting microplastic pellets from beaches around the world. Not only do these pellets readily adsorb POPs like DDT and PCBs, Takada has found that the POP concentrations in these pellets mirror the POP concentration in the water itself.

Using pellet data collected from beaches in 16 countries, Takada has created a map of those coasts that have the highest concentrations of PCBs. San Francisco and Boston top the list, which makes sense given that the majority of PCB production occurred in the U.S. before it was banned in 1979. The EPA has since labeled the chemical a probable human carcinogen.

"We found very good correlation between concentrations of PCBs in pellets and those in mussels," says Takada. "So a high concentration of PCBs would be expected in the fish in those waters." That may take the appeal out of fresh, local seafood from the San Francisco Bay or Boston Harbor.

Scientists are just beginning to explore the effects these POP-laden microplastics have on marine life. Last year, researchers at the University of Plymouth proved that microplastics don't necessarily stay in the digestive system. They fed microplastics to blue mussels, an ubiquitous marine filter feeder and menu staple of seafood restaurants. The particles escaped the gut to the mussels' circulatory system where they remained for nearly seven weeks.

Meanwhile, Takada was busy feeding PCB-spiked pellets to a group of seabirds called streaked shearwaters. After seven days, the pellet-eaters had a significantly higher concentration of PCBs in their fat tissue than the non-pellet-eaters whose only source of PCBs came from their natural diet of fish.

Still to be answered are the questions of whether these POP-laden microplastics can accumulate up the food chain, and if so, what are the health implications for both marine life and humans?

There's also the issue of Takada's newest research. He's trying to find out whether chemical plasticizers, which are added to plastics during production, will leach out of microplastics when they're consumed by marine life and humans. These additives, like polybrominated diphenyl ethers (PBDEs), bisphenol A (BPA) and phthalates are responsible for plastics' remarkable versatility. PBDEs, however, are a known neurotoxin, while BPA and phthalates

are endocrine disruptors. They've affected reproduction in every animal group tested, caused birth defects and sabotaged development, often at exposure levels commonly present in the environment.

"We understand that plastics contain contaminants," says Takada. "Our concern is whether these contaminants can be transferred to aquatic organisms and humans. Now we are trying to answer that question."

NOAA

NOAA divers rely on free-diving, sans scuba gear, to remove debris so as to maintain maximum mobility and avoid becoming entangled themselves.

COMBATTING THE PROBLEM

No one is contesting the benefits plastics have afforded society. But the fact that the most substantial use of the material today is for disposable items has ocean conservationists in particular calling for an end to the era of disposable plastics. In the 1950s, when mass production of plastic began, annual output was 0.5 million tons. In 2008, it topped 260 million tons and by 2010, that number is expected to rise above 300 million tons. That will make the quantity of plastic generated over the last ten years roughly equal to that generated within the entire 20th century.

So the question remains: where are the solutions to remediate the trash that already exists and how do we prevent the onslaught of future debris?

Some demand action from industry. But with more than one-third of its production devoted to disposable plastics, the multi-billion dollar plastics industry remains comfortable with its efforts to promote recycling and reform litterbugs. In 2007, the U.S. recycled just 6.8 percent of the plastic it generated. In June, Society of the Plastics Industry Inc. announced its plans to launch a four-year, $10-million social media campaign to revitalize and strengthen the image of plastics in the eyes of the millennial generation.

Others swear by regulation. But so far a general lack of political will, encumbered by a powerful plastics lobby, has relegated these efforts to a sea snail's pace. And still others hang their faith on the lagging promise of biodegradable plastics. The potential is there, scientists insist, but they also admit a financially viable product that doesn't compete with global food production is still a long ways off.

And then there are those who are taking matters into their own hands.

THE NET THREAT

The National Oceanic and Atmospheric Administration (NOAA) has a passel of projects aimed at marine debris removal. One such project takes place on the Northwestern Hawaiian Islands, a slew of 10 remote islands and atolls that cover 140,000 square miles of ocean, boast vibrant coral reef ecosystems and serve as home to 7,000 species. They're also located smack in the middle of the North Pacific gyre, which means that more than 52 metric tons of debris pile up there each year.

By far the biggest threat to the reefs and marine life are derelict fishing nets; they're also the most difficult to remove. "There are some nets that we find and they're just tons. I mean they're huge," says NOAA diver Susie Holst. Notorious for drowning seals and sea turtles, these nets get tangled in the reefs. Driven by wind and currents, they rip the coral heads clean off. "It creates this path of destruction as it gets pulled across the reef," says Holst, "sort of like a tornado would."

PROJECT KAISEI

Doug Woodring is the founder of Project Kaisei, a motley yet consummate crew of scientists, inventors, environmentalists and plastic experts dedicated to ridding the ocean of its mounting trash.

The divers rely on free-diving, sans scuba gear, to remove debris so as to maintain maximum mobility and avoid becoming entangled themselves. They either cut the nets into smaller, more manageable pieces or tie lines to them, which they then use to haul the nets up to the surface. "it's quite easy to develop a breath-hold for over two minutes," Holst says.

To train for the program, NOAA divers face a terrifying challenge; they're blindfolded and entangled in a net, and they have to free themselves. But, says Holst, it's worth it. "Everyday you leave the environment better than you found it. How many jobs in your lifetime can you say that about?"

NO REMOVAL

Ask anyone who's been out to the North Pacific gyre if the trash can be removed and you'll most likely be met with an uncomfortable pause, followed by a hushed and solemn, "no." There's too much trash, they say. The pieces are too small and too widely dispersed. But what to most of us would be a call to disheartenment had the opposite effect on Doug Woodring.

Woodring is the founder of Project *Kaisei*, a motley yet consummate crew of scientists, inventors, environmentalists and plastic experts dedicated to ridding the ocean of its mounting trash. Hailed as a "Climate Hero" by the United Nations Environment Programme, the project will spend one month investigating the trash in the North Pacific gyre aboard two vessels.

The *New Horizon*, a research vessel loaded with grad students from the Scripps Institution of Oceanography, will explore the nature of the debris – what it's made of, how much there is and how it is affecting marine life. The *Kaisei*, a 151-foot brigantine, will test out novel capture methods to isolate the most cost-effective approach for removing plastic without sacrificing plankton and other surface sea life. Woodring, who is splitting his time between the two ships, hopes the synthesis of both ships' discoveries will equal at least the start of a remediation strategy.

"We're not saying that we're going to be the miracle project, but at least we're bringing hope," says Woodring, an environmental entrepreneur. "Even if we could get 10 percent of what's out there, does that mean it's good? I would argue yes."

Woodring has a point, but he also has a plan. If they can catch the plastic, he says, they can detoxify it and turn it into fuel. "And that fuel has a value," says Woodring. "So at the very worst, we could subsidize the cleanup by catching some of what is out there."

While its aims of purification may appear lofty at the outset, they're just a fraction of the impact Project *Kaisei* (Japanese for "ocean planet") hopes to have; the goals are to film a documentary about the expedition to spark education efforts and fuel a global microfinancing campaign that would finance future large-scale cleanup efforts.

"I see us as a portal for ocean solutions," says Woodring. "There are companies that are already changing their packaging because they want to be associated with us."

There is one other solution that doesn't get a lot of play in the press. It's not glamorous, technological or expensive, but scientists and advocates still hope it'll catch on for its simple elegance – that is for us to choose to use less disposable plastic.

This was the missive Dr. Marcus Eriksen repeated to anyone who would listen on a recent 2,000-mile bike ride from Canada to Mexico, during which he handed out jars of the North Pacific's plastic stew, lectured in classrooms and met with local politicians.

Recalling his epic drift on *JUNK*, Eriksen offers his motivation. "Even though, for five weeks during the middle of my trip I saw no human being, I saw no airplane, no contrails. I saw no ship go by, I saw no birds, very few fish – I could always see particles of plastic. This is not the legacy I want to leave behind for the next generation."

He's hoping we won't either.
