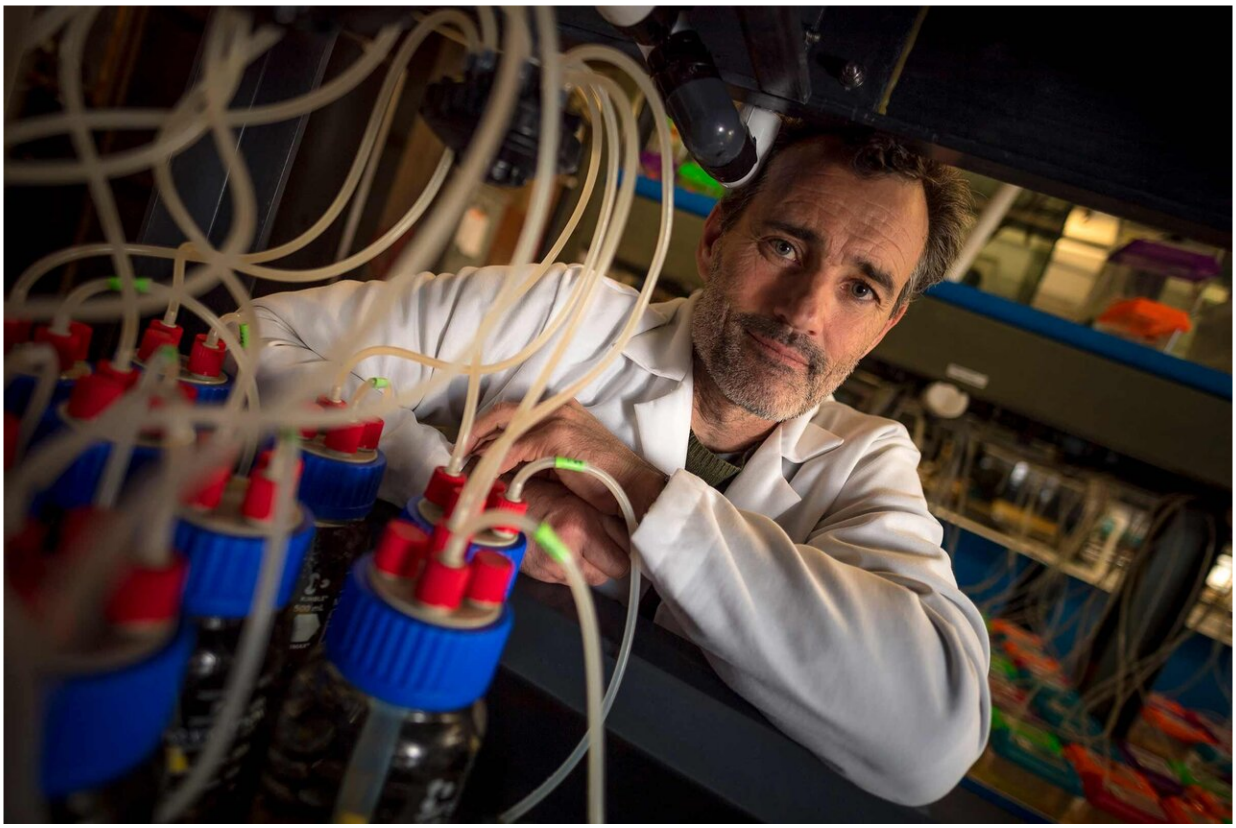
Microplastics: A macro problem

February 17 2020



Associate Researcher Dimitri Deheyn is studying how microfibers degrade in the environment, through experiments in the ocean and in the lab. Credit: Erik Jepsen/UC San Diego Publications

Flying somewhere over the planet, there's a plane equipped with research-grade, double-sided tape on the outside of its hull. Each time the pilot lands the plane, he removes the tape, seals it in a package, and replaces it with a new one before he takes off again. He then mails the package to Scripps Institution of Oceanography at UC San Diego, care of Dimitri Deheyn, Associate Researcher.

Looking at the tape under a microscope, Deheyn sees what he's looking for: microfibers, stuck to the adhesives.

Microfibers are a subset of microplastics, tiny pieces of petroleum-based materials that break down from larger plastic pieces or are manufactured at their microscopic sizes: less than 5 millimeters across. The strands of fiber—about five times thinner than a human hair—are used in textile manufacturing; they shed from our clothes during wear, during washing and drying, flowing into waterways and drifting into the air.

Deheyn is working with Robert DeLaurentis (aka Zen Pilot) on a study that analyzes the global distribution and concentration of microfibers. He says that the best science sometimes involves the most simple technology: in this case, double-sided tape. For every part of his 30-leg flight from the North Pole to the South Pole, DeLaurentis will have a sample for Deheyn.

"It might not give us absolute numbers, but at least it will give us a good hint on the types of particles found in the atmosphere," said Deheyn. "And it will be the first time samples like this have been gathered around the globe."

These samples will add to Deheyn's current research, which has uncovered microfibers in the Arctic, in the Amazon, in the most remote and deepest parts of the sea. Pretty much everywhere he has sampled or has received samples from.

"After finding microfibers in water samples from all over the world, it was clear that one main route of contamination had to be through the atmosphere," said Deheyn. "But as a marine biologist accustomed to collecting samples underwater, I clearly had no idea how to take air samples at high altitudes around the globe."

A microfiber sample retrieved from the Scripps pier, where these materials are being tested for degradation. Credit: Erik Jepsen/UC San Diego Publications

The end of a war, the start of an era

Recent Scripps Ph.D. graduate Jenni Brandon pulls out a seabed core sample in the Scripps Geological Collections. It was taken from offshore Southern California in the Santa Barbara Basin. Its contents represent a slice of geologic history, sediments that go back 200 years.

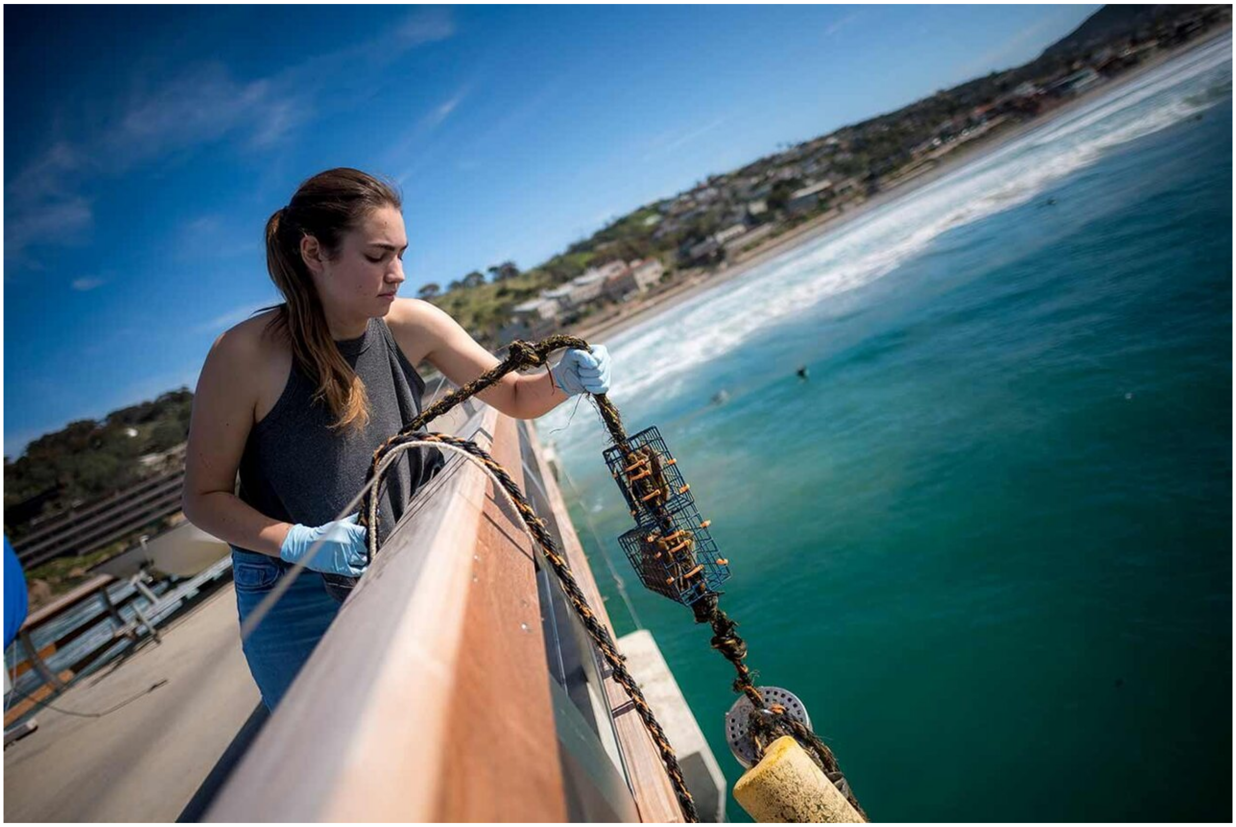
Brandon used this and other cores in a recent study in which she found that the amount of plastics accumulating in the environment has exploded since the end of World War II. The sharp exponential increase matches a rise in the rate of plastic production worldwide and a surge in California's coastal population during the same time period. The research team noted that since the 1940s the amount of microscopic plastics has doubled about every 15 years.

"Plastic production is being almost perfectly copied in our sedimentary record. Our love of plastic is actually being left behind in our fossil record," said Brandon.

The rise of plastics beginning in 1945—as the world recovered from war—could serve as a proxy for a time period within the Anthropocene that scientists have labeled "the Great Acceleration." Scientists define the Anthropocene as the current geological age, during which human activity has been the dominant influence on the planet.

Prior to the "Great Acceleration," scientists had estimated that between 4.8 and 12.7 million metric tons of plastic waste enter the ocean every year. Because the amount of plastic waste tends to track with population, Brandon and coauthors anticipate that nearshore areas could bear a disproportionate brunt of that infusion of plastic as coastal population growth continues to accelerate.

Brandon's study is the first of its kind in that it examined accumulation of plastic over time in a location that afforded researchers the opportunity to resolve the trend in fine detail, and is among several that illustrate how pervasive plastic pollution is in the global oceans.



Undergraduate student Holly Nelson – who assists in Dimitri's research – retrieves the canisters that house the microfiber samples off of the Scripps pier. Credit: University of California - San Diego

Getting the numbers right

Pinpointing the start of our plastic assault on the environment wasn't the only eye opener for Brandon. In a separate study, Brandon found that jelly-like, filter-feeding marine invertebrates called salps are ingesting mini-microplastics; these pieces of ultra-tiny pieces of pollution had previously flown under scientists' radar.

While it's no surprise these organisms are eating plastic, Brandon was surprised by the sheer volume of microplastics that were previously missed: about a million times more than previously thought.

Analyzing seawater samples, Bandon found some of the tiniest countable microplastics in surface seawater at much higher concentrations than previously measured. Her method unveiled that the traditional way of counting marine microplastics was likely missing the smallest particles.

On average, Brandon estimates the ocean is contaminated by 8.3 million pieces of mini-microplastics per cubic meter of water. Previous studies measuring larger pieces of plastic found only 10 pieces per cubic meter.

Brandon teamed up with co-author Linsey Sala, collections manager of the Scripps Pelagic Invertebrate Collection, one of the world's preeminent collections of marine zooplankton that dates back to 1903. Brandon dissected salps collected over multiple years of sea-going expeditions and long-term monitoring networks across the North Pacific.

Of the 100 salps Brandon surveyed from water samples collected in 2009, 2013, 2014, 2015 and 2017, 100 percent had mini-microplastics in their guts. The results shocked Brandon.

"I definitely thought some of them would be clean because they have a relatively quick gut clearance time," Brandon said, noting that the time it takes a salp to consume and defecate food is between two to seven hours. As filter feeders, salps are almost always eating.

Sarah-Jeanne Royer holds pieces of plastic that have accumulated on Kamilo Beach in Hawaii. Credit: University of California - San Diego

Plastics in the stomachs of salps could travel up the food chain to creatures that feed upon them, including sea turtles and commercially caught rockfish and king crab. Eventually, these mini-microplastics could be making their way into humans.

"No one eats salps, but it's not far away on the food chain from the things you do eat," Brandon said.

The BEST path forward

Tethered by rope and submerged underwater off the Scripps pier, plastic samples are slowly degrading. The two experiments are owned by different labs but are part of efforts to understand the same process: how plastics degrade.

On one side of the pier, Deheyn and postdoctoral researcher Sarah-Jeanne Royer are monitoring petroleum-based and cellulose (wood fiber) microfibers.

Royer routinely checks the status of these fibers. A postdoctoral researcher in Deheyn's lab, she is working with industry to find new sustainable options for fibers. This research is established through the BEST Initiative, a platform founded by Deheyn that facilitates the interaction between industry and academia to provide a space for collaboration.

The key to this study was to acquire raw material fibers created from popular chemical processing methods that could ultimately affect fiber biodegradability, which has been successfully implemented with fiber producers such as the Austria-based Lenzing Group. The researchers hope to address two fundamental questions: which virgin materials degrade in the marine environment, and which process in the supply chain alters the degradation of textiles.

Deheyn didn't initially plan to study microplastics; he actually specializes in biofluorescence. But he noticed strange materials glowing in his samples. At first, he thought they were just scratches on the lens, but he came to find that they were actually microfibers.

Microfiber samples in various stages of degradation. Credit: Erik Jepsen/UC San Diego Publications

Deheyn's observation of fluorescent pollutants led to new opportunities. He and researchers at the UC San Diego Jacobs School of Engineering have been using fluorescence to develop new technology to detect microplastics filtered from water samples.

The technique, developed by engineering graduate student Jessica Sandoval, is called the Automated Microplastics Identifier (AMI). The protocol aims to replace manual counting by eye with automation processes that identify the fibers. Researchers first image the filters under UV illumination, so that the plastic fluoresces. Sandoval developed software to quantify the amount of plastic on each filter and to also generate information of features of the plastics using image recognition.

"It is an exciting first step, using automation technologies to assist with the monitoring of this prevalent marine pollutant," said Sandoval, who began developing this technology as an undergraduate student at UC San Diego. "With such technologies, we can more easily process samples from across the globe and generate a better understanding of microplastic distribution."

Deheyn is using this technology to analyze water samples that have been taken off the Scripps pier since the 1970s. These samples are analyzed for microfiber concentration in order to determine how quantities of this pollution have changed over time. This research will also show which types of fibers are the least biodegradable, and around what period in the past 50 years this particular plastic pollution became noticeable.

On the other side of the pier, post-consumer plastics such as water bottles and yogurt cups are amassing marine microbes. These organisms help break down plastics, and Scripps biological oceanographer Jeff Bowman is part of a group working to understand how, and which microbes are most important.

Bowman is working with San Diego-based National University on the CUREing Microbes on Ocean Plastics project, a program that uses Course-based Undergraduate Research Experiences (CUREs) to center student learning around real-world issues. Funded by the National Science Foundation, the program is focused on plastics, specifically simulating plastic debris in the ocean and studying the microbes that break them down. Students become part of the research team to help answer the questions around microbes and plastic degradation.

Every couple of months for the past year and a half, a new class from

National University has visited Scripps to check on the plastics off the pier. Using those samples, Bowman and other scientists teach them about marine microbiology and educate them on plastic pollution. The samples and data the students collect in these sessions are then incorporated into their coursework for the term.

Graduate students in the Bowman Lab later perform more detailed analyses of the samples in order to build a library of gene sequences of bacteria that build up on ocean plastics. They're hoping to learn more about the ability of the marine microbial community to degrade plastics, and how this understanding could then be applied to degrade plastics on an industrial scale.

"Ocean plastics are a huge environmental challenge, but also present a unique educational opportunity," said Bowman. "Undergraduate students hear about ocean plastics in the news and can see the problem when they visit local beaches. We're able to leverage this to build an understanding of the role of microbes in the marine system, and how microbes can be part of the big environmental solutions of this century."

Despite the breadth of research on this topic, scientists stress that we still have much to learn about the effects of microplastics on the environment, and ultimately us. Given headlines claiming that there will soon be more plastic in the ocean than fish, it's research that the scientific community, and society at large, is eager to explore.

"This is just the beginning of our understanding about the 'biology of plastics.' They are everywhere, in the air we breathe, the water we drink, the food we eat," said Deheyn. "So, we need to learn how to live with them around us and inside us. However, while the fundamental scientific questions are being worked on, the key question as a society remains poorly addressed: why do we keep making materials that do not degrade and that keep accumulating in such excess that they choke our ecosystems?"

Provided by University of California - San Diego

Citation: Microplastics: A macro problem (2020, February 17) retrieved 1 February 2025 from https://phys.org/news/2020-02-microplastics-macro-problem.html