The SSV *Corwith Cramer* with all its sails set.

OCEANS OF PLASTIC

Grad Student Scours the Sea for Plastic Debris

by Samantha Drake

Photograph by Roman Shor

Roman Shor, C'09, EAS'09, GEng'10, didn't expect to see piles of floating litter when he set off on the Plastics at SEA expedition, the first federally funded venture to study the accumulation of plastics in the North Atlantic Ocean. He already knew that the term commonly used to describe the debris—"garbage patch"—is a misnomer. The plastics he encountered on the voyage were, in fact, tiny: no bigger than a fingernail in most cases. But the garbage was definitely there—an incalculable number of miniscule bits of plastic that had amassed in a swirl of ocean currents near Bermuda.

Shor, a doctoral student in the Department of Earth and Environmental Sciences and a Penn mathematics and computer science alumnus, was one of 33 crew members who took part in a landmark study organized by the Sea Education Association (SEA). All hands served as both field scientists and crew aboard SEA's vessel, the SSV *Corwith Cramer*, which departed last summer from Bermuda on June 10 and returned on July 14. The volunteers were all veterans of previous SEA expeditions—recent college grads as well as mid-career professionals—selected from a pool of 100 applicants interested in plastic-pollution research.

Plastic—primarily polyethylene, polypropylene and polystyrene—accumulates in specific regions of the oceans carried by currents all over the world, according to SEA. The most notorious of these oceanic plastic debris concentrations is located in the eastern North Pacific Ocean and is dubbed the "Great Pacific Garbage Patch." Shor saw the Pacific patch in his sophomore year while on a 40-day SEA Semester. For Shor, an avid

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rower who grew up in Telluride, Colo., it was his first time sailing on the ocean, and the experience sparked his interest in oceanography.

"We know more about the surface of the moon than we do about the surface of the ocean," he says. "Even the most high-tech equipment we have doesn't show us what's really there. It's still a great unknown."

SEA has been studying the Pacific garbage patch and its lesser-known counterpart in the North Atlantic, southeast of Bermuda, since 1986. The debris patches

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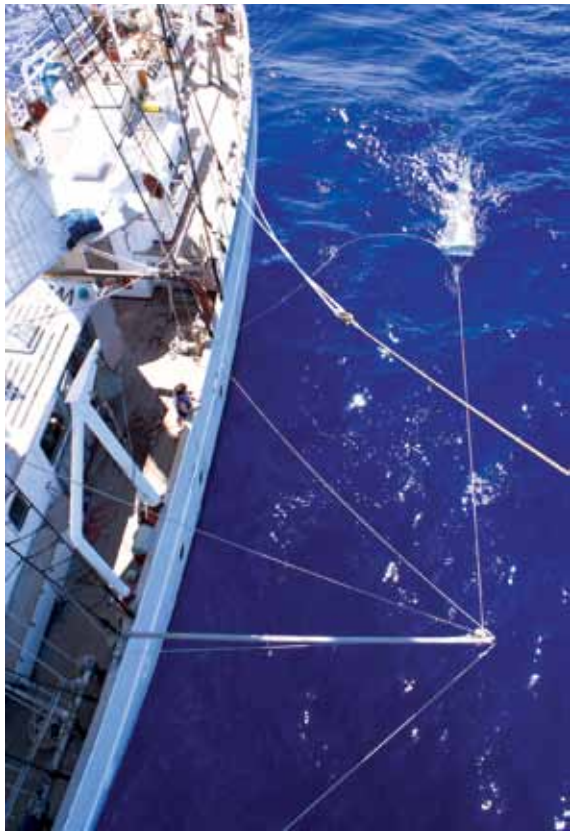
gathered up by the currents are more accurately described as regions, and they have yet to be reliably measured due to changing currents and ocean conditions.

Many questions remain about the presence of plastic in the ocean. Much of the plastic that finds its way there comes from litter and runoff. Shor says he was initially surprised by the small size of the plastic particles. "The interesting thing about plastic is it just gets smaller—it doesn't disappear," he explains. "That's the current theory, at least." Researchers say it's impossible to tell what each bit of plastic was or what it came from before the larger object broke down.

When the wind died and the ocean was calm during his expedition last summer, Shor could look down into the water and see a mass of speckles. Larger objects, such as plastic bottles, were relatively few; perhaps three or four bottles a day might be spotted. He and his shipmates sampled the ocean surface every few hours by towing nets through the water. They then sorted what was hauled aboard into biomass and plastic. Plastic particles were also found in the stomachs of fish that the crew cut open.

Members of the expedition divided their time between conducting science and contributing to the work of sailing the 135-foot long brigantine-rigged tall ship. The ship operated on the three-shift Swedish watch system, which allows the crew to operate a ship 24 hours a day. "It was all about teamwork," Shor notes. And adaptability. On a typical day, he might have been on watch from 11 p.m. to 3 a.m., off until noon, back on duty from 1p.m. to 7 p.m., then off again at 3 a.m. Alarm clocks weren't necessary, he says, because "somebody always made sure you were awake."



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A net is towed through the water to collect microscopic organisms and plastic marine debris.

"Being a scientist at 3 a.m. was interesting," he says, recalling hours of sorting and cataloging plastic particles in the early morning hours as the ship swayed. His favorite job was standing watch on the bow at night, with starlight above and a blue-green bioluminescent glow from marine life in the water below. Still, it was impossible to forget the ugly fact of plastic debris.

The Plastics at SEA crew spent 34 days conducting 128 net tows over 3,817 nautical miles. In all, they collected and counted 48,571 bits of plastic. "The numbers to me were just appalling," Shor says.

The amount of plastic finding its way into the oceans is declining, Shor observes, because industries are making an effort to reduce the amount of plastic they use and discard. But researchers have no idea how much plastic degrades in the ocean or how long

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it remains there. Most commonly used plastics never fully break down, according to SEA. Even worse, it's impractical, if not impossible, to clean up the vast quantity of tiny plastic fragments mingled with the ocean's waters. According to SEA's website (www.sea.edu), a typical net tow operation filters 120,000 gallons of water—and yields about a handful of plastic particles. In the process, the nets also catch loads of microscopic plankton and other organisms, meaning that large-scale attempts to filter out plastic particles could actually harm the ocean ecosystem.

According to Shor, the best way to deal with plastic in the ocean is to prevent it from getting there in the first place by protecting the watersheds surrounding rivers that flow into the ocean. Everyone should also make an effort to reduce the use of plastic, he says, and reuse or recycle what they do use. But he isn't one to get up on a soapbox. "I try to raise awareness by setting an example," he says. And that example includes experiences like his summer with SEA. "It was a way for me to give back because the Atlantic patch is not well known," Shor remarks. "It was also a good way to go sailing," he adds with a smile. ◆

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Plastic Pollution

A research vessel from the Sea Education Association (SEA) has sailed from the Woods Hole Oceanographic Institution in Massachusetts to the Caribbean every fall for more than 20 years. On each trip, students conduct net tows to study marine biodiversity and also hand pick, count and measure all the bits of floating plastic collected. The undertaking has given us a high-resolution image of the progression of plastic garbage in the oceans.

The data produced by 64,000 bits of plastic—most smaller than a half-inch across—from more than 6,000 net tows was analyzed in a recent study published in the journal *Science*. The paper showed that there has been no significant increase over the period, which is surprising since plastic production has increased three-fold over the last two decades. The data also showed that, following the publication of an EPA study of industrial plastic pellets in the oceans and subsequent industry actions, the number of pellets has decreased appreciably.

The predicted center of the plastic debris field, somewhere in a vortex of ocean currents in the Sargasso Sea, was not in the existing dataset, so SEA organized a research expedition last summer, which I was part of, to carry out net tows there. We never found the eastern edge of the debris field. In fact, the area of greatest density of plastic occurred on the eastern-most point of our cruise track and resulted in concentrations of well over 20 pounds of plastic per square kilometer of ocean, compared to the usual two to four pounds per square kilometer.

The only conclusion that can be reached without more study is that there is indeed a lot of plastic in the ocean, that it is not spread evenly, and most importantly, that it cannot be economically cleaned up. It has been shown that this problem can be solved at the source, so it is our responsibility to use less, recycle more and properly dispose of everything else.

—Roman Shor