

Reading the Message in the Bottles

Margherita Pryor

People have been sending messages in bottles for thousands of years, often for amusement or curiosity, sometimes in desperation, more recently for science. They've also been keeping account of the journeys those messages took—where they came from, where they were found, how long they had been traveling. Today researchers are using data from bottles—and flotsam such as sneakers, rubber ducks, and plastic pellets—to learn more about ocean currents. Already, new information about marine pathways has been applied in situations such as the crash in 2009 of an Air France flight from Brazil to Paris. Investigators were able to project where debris from the airplane, including the plane's flight recorder, would be likely to drift and settle. But it turns out that tracking trash for currents also tells us something about the trash itself, especially the expanses of materials that collect across the globe in five huge gyres popularly known as “garbage patches.” (See sidebar to right)

These areas made the popular news in the early 1990s when contents of cargo containers lost in heavy seas starting washing ashore in the Northwest U.S. Scientists seized on the incidents as opportunities to follow currents in real time and in the process located clusters of partly decomposed plastic, ghost nets from fishing operations and other flotsam and debris. Yet despite their notoriety, we still know little about the patches, including their actual size, where and how they move, and the size and types of materials found in them.

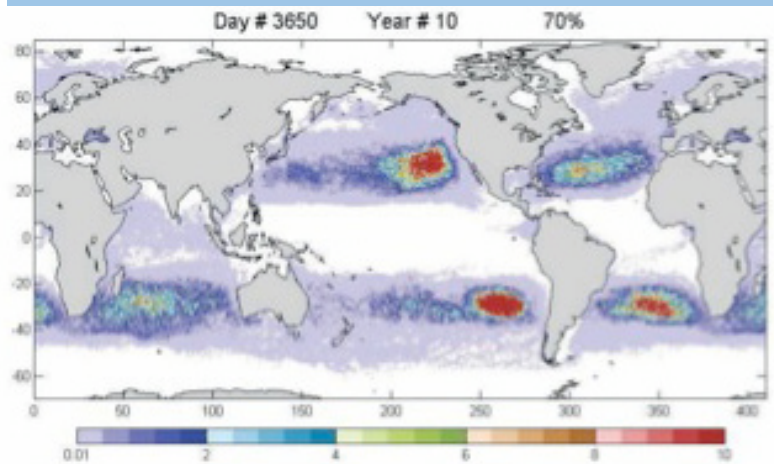
The National Oceanic and Atmospheric Administration (NOAA) has reported on the lack of accurate estimates because of biased and/or limited sampling and the fact that many oceanographic features do not have distinct boundaries or a permanent extent. Sightings of large concentrations of debris, especially of large debris items, are not very common. (See sidebar on page 2). Moreover, despite the catchy title of garbage patch, it is a mistake to envision these areas as mats of materials riding the surface of the waves. Rather, most of the observed debris consists of microplastic—pellets or tiny pieces of plastic, often less than 5 mm in size (about a fifth of an inch). Not only is this difficult to see with satellites or even with the naked eye, much of it may be suspended and hidden just below the surface of the water. Under these conditions, calculations of the extent of the patches have varied widely, ranging from twice the size of Texas to as large as the continental United States. But no one disputes the pervasive occurrence of debris in the ocean and the dominance of plastics.

Plastics that remain in the marine environment are a serious concern for many reasons. In the first place, the most commonly found plastic materials do not degrade; they simply break into smaller and smaller pieces—a factor that explains the frustration of trying to collect trash even on land, much less in the ocean. The

endurance of these materials means that they accumulate algae and microscopic biota on their surfaces, which in turn bioaccumulate chemicals in the water. Persistent organic pollutants such as PCBs (polychlorinated biphenyls) accumulate in plastic debris perhaps as much as 100,000 to 1,000,000 times the levels found in seawater; plastic oceanic fragments have also tested positive for DDT, PAHs, and aliphatic hydrocarbons. Many of these pollutants, such as PCBs and DDTs, are known endocrine disruptors and developmental toxicants. The effects of these chemicals on marine life have not been quantified. But we do know that environmental impacts are wide ranging and can include direct harm through ingestion or entanglement. Seabirds, sea turtles, fish, and marine mammals, for example, can mistake marine debris for food; a study of 38 green turtles found that 61 percent had ingested some form of marine debris including plastic bags, cloth,

Did You Know?

A 2008 report by the International Pacific Research Center at the University of Hawaii reviewed decades of results from tracking ocean drifters, passive buoys deployed since 1982 to transmit data as they float with ocean currents. Not surprisingly, models by the IRPC based on these data showed that the regions where most drifters collect or converge are also the sites of the garbage patches.



Simulation of evolution of drifter density (or marine debris) after 10 years of advection by currents, as determined from real drifter movements. Units represent relative change in drifter concentration (Source, IRPC Climate, vol.8, no.2, 2008)

and rope or string. At other times, animals accidentally eat the marine debris while feeding on natural food. Ingestion can lead to starvation or malnutrition when the marine debris collects in the animal's stomach causing the animal to feel full. Starvation also occurs when ingested marine debris in the animal's system prevents vital nutrients from being absorbed. Internal injuries and infections may also result from ingestion. Some marine debris, especially some plastics, contains toxic substances that can cause death or reproductive failure in fish, shellfish, or any marine life.

Other direct harm from typical plastic debris includes entanglement that leads to suffocation, starvation, drowning, increased vulnerability to predators, or other injury. Marine debris can constrict an entangled animal's movement which results in exhaustion or development of an infection from deep wounds caused by tightening material. For example, volunteers participating in the 2008 International Coastal Cleanup event discovered 443 animals and birds entangled or trapped by marine debris. Finally, floating marine debris can serve as a vector for invasive species, moving them from one location to another. A study performed by the British Antarctic Survey in 2002 estimated that man-made debris found in the oceans has approximately doubled the number of different species found in the subtropics.

Determining where these materials come from is also difficult. One report estimates that about 300 million tons of plastic is produced globally each year. Numbers vary, but less than 10 percent of that is recycled, and of the plastic that is simply discarded, perhaps seven million tons ends up in the sea annually. Some no doubt is trapped in the gyre systems; some eventually exits the gyre and returns to litter beaches and shorelines. Separating out the sources of plastic material that ends up in the patches may not be possible as yet. But between 2001 and 2006, EPA provided support to the Ocean Conservancy to standardize marine debris data collection and assess marine debris sources and trends in the U.S. Their 2007 report indicates that approximately 18 percent of the marine debris items collected nationally during the study originated from ocean-based sources such as vessel discharges, mismanagement of ship wastes and equipment, or accidental loss of gear overboard, with plastic straws, plastic bottles, plastic bags, metal beverage cans and balloons being the most abundant items.

What can we do about this phenomenon? As with most environmental problems, prevention is the best cure. Source reduction, both from land-based and ocean-based sources, is the key.

~Margherita Pryor is the NBEP coordinator for U.S. EPA Region I.

Did You Know?

The earthquake and tsunami that struck Japan back in March of 2011 may have generated as much as 20 million tons of debris. Large items such as refrigerators, cars, even fishing boats, have been carried in a raft of debris estimated to spread across an area 2,000 miles long and 1,000 miles wide between Japan and the Midway Atoll. Independent models run by NOAA and University of Hawaii researchers suggest that some debris could pass near or wash ashore in the Northwestern Hawaiian Islands as early as this (2011/2012) winter, approach the West Coast of the United States in 2013, and circle back to Hawaii (the main Hawaiian Islands) from 2014 to 2016. The research center has asked boaters traveling in the area of the debris raft to send details such as GPS data, time, weather and descriptions of items found.



Image of the Pacific Ocean Garbage Patch from MarineInsight.com.



The mass of debris stretches for miles off the Honshu Coast. Photo: US Navy.