ECOS
SCIENCE FOR SUSTAINABILITY

www.ecosmagazine.com

Published: 1 September 2014

Where is the oceans' missing plastic?

Carlos Duarte

In a recent paper published in one of the world's most prestigious scientific journals, researchers admitted that the available data 'cannot account for the fate of 99 per cent of the plastic litter entering the open ocean'. What's happening to this plastic? And how can we reduce pollution in the world's oceans?

Credit: Joan Costa, CSIC

The journal *Proceedings of the National Academy of Sciences* (PNAS) recently published a scientific paper communicating research, led by Andrés Cozar from the University of Cádiz (Spain) and co-authored by me, which resulted from the Malaspina Circumnavigation Expedition that I lead. This paper provides a first estimate of the amount of plastic litter floating in the open ocean.

General circulation models predict that plastic particles should accumulate in the central areas of the oceans, known as the subtropical gyres. There are five of these gyres across the globe, but only the two in the northern hemisphere (North Pacific and the North Atlantic) had been sampled for plastic litter before.

We found plastic litter to be scattered all over the open ocean – 88 per cent of the samples collected contained plastic debris, including significant loads around Australia.

In particular, we surveyed all five gyres and confirmed in our paper that all of them accumulate similar concentrations of plastic litter, with the load being somewhat larger in the South Atlantic subtropical gyre.

The mass media have popularised the plastic accumulation in the North Pacific gyre as the 'great garbage patch' or the 'oceanic plastic island', but this is a gross overstatement. The subtropical gyres support plastic litter loads of about 200–600 grams per square kilometre – certainly nothing that could be thought of as an island, or even a dense patch.

Globally, this represents an estimated total load of 6–35 thousand tons of plastic debris across the entire open ocean.

This result was striking, as the expected load – based on the calculation that 0.1 per cent of the global production of plastic reaches the ocean, half of which is buoyant and two-thirds of which reaches the open ocean – was in the order of 1 million tons, or 100 times larger than the global load of plastic debris we found in the open ocean.

Credit: Joan Costa, CSIC

This may seem good news, but in fact it means that, if our calculations are correct, we cannot account for the fate of 99 per cent of the plastic litter entering the open ocean, a disturbing realisation.

This means that – contrary to the assumption that the floating plastic debris remains in the open ocean for decades – there must be mechanisms operating that efficiently remove this debris. Moreover, these mechanisms must operate at a rate comparable to that of the current input of plastic into the oceans, as available time-series data show no evidence that the plastic debris has increased over the past decade.

In our paper, we've discussed several possibilities as to what these removal mechanisms may be.

First, current estimates of how much plastic enter the ocean could be wrong, as campaigns to avoid plastic use, recycle plastic, and improved water treatment systems may have reduced this load. While these actions have certainly helped, they do not seem sufficient to curve the trajectory of plastic load into the ocean provided global plastic production has continued to grow exponentially.

Multiple loss mechanisms are possible:

1. Microbial activity may be more effective than previously thought in breaking down the plastic, and a search for microbes able to chew down plastic litter is on going across the world.
2. Plastic particles could simply fragment through the effect of solar radiation to result in plastic particles too small (< 0.2 mm) to be collected by the nets used to sample them, so that the missing particle could be present as nanoparticles.
3. Marine organisms grow on the plastic particles and, where these organisms may produce carbonate or silicate shells, ballast the particles so they would sink. However, these minerals dissolve below 2000 m depth in the ocean, so the particles would return to the surface.
4. Lastly, the particles may be ingested by marine organisms and enter the marine food web.

The latter is a plausible mechanism. Analysis of particle size distribution shows the abundance of particles increases as size decreases – according to the expectation from the fragmentation process – but only down to 4 mm in size. The abundance of particles is much less than expected in the range of 1–4 mm, where the losses seem to concentrate.

This suggests that the process responsible for the removal of the plastics must be size-dependent, selectively removing particles within the 1–4 mm range.

Credit: Joan Costa, CSIC

The five great subtropical oceanic gyres where the plastic accumulates are inhabited by mesopelagic fish, including lantern fish, light fish and dragon fish. Data from the Malaspina Expedition show these to be the most abundant fish in the planet, contributing 10 times more biomass than the rest of the world's marine fish combined.

Mesopelagic fishes inhabit precisely those areas where plastic accumulates, and feed on particles ranging from 1-4 mm – exactly the size range where the loss of particles has been detected.

Moreover, these fish migrate from 400–700 m depths, where they stay during the daytime, to the surface to feed at night. This is where they could encounter and ingest very small plastic particles before returning to the depths, as shown in some research papers documenting the presence of plastic particles in the 1–4 mm range in the fishes' guts. These fishes are, in turn, preyed upon by tuna, swordfish, squid and possibly some whales, opening up the possibility that the small plastic particles may be transferred up the food web of the open ocean.

These are all plausible explanations, and are all likely to be operating to various extents. Therefore they all need be addressed in order for us to answer the burning question 'where is the 99 per cent of the oceans' "hidden" plastic?'

Researchers from the Malaspina Expedition are busy trying to resolve this mystery and are sampling areas not yet surveyed, such as the Arctic and the Mediterranean. We will report on our findings soon.

Understanding where the plastic is, however, will do little to stop the multiple impacts that marine plastic pollution has on marine life. For example, the plastic waste entering the oceans is not easily degraded and is associated with organic pollutants that enter the food chain, causing major problems for all types of marine organisms, from copepods to whales.

The best solution would be, no doubt, cutting down the amount of plastic entering the ocean, which would require cutting down the consumption and production of plastic.

While plastic is indeed a convenient and inexpensive material, is our overconsumption of this material really necessary? Almost all products and produce in Australian supermarkets are packaged or wrapped in plastic. No wonder that each human being on the planet currently consumes an average 38 kg of plastic per year, a figure likely to be much higher in the case of Australian consumers.

Further, a recent scientific article published in the Philosophical Transactions of the Royal Society reports that some components used in plastics – such as BPA, TBBPA or PBDE, which disrupt the endocrine system – have been identified in humans. Experimental investigations in animals indicate a wide range of effects associated with exposure to these compounds, causing concern about the potential risks they might have for human health. Do we really want to wrap our food in materials that may be potentially toxic?

Clearly, the solution to plastic pollution relies on curbing our consumption of, and demand for, plastic, and de-plastifying our lives so that we come to rely less and less on this material. This would propel the industry to search for innovative alternative materials.

This would do far more for marine animals, not to mention human beings, than discovering where the 99 per cent missing plastic has gone, important as it is. So my message is that you, too, can be part of a global solution: take action to avoid an ocean of plastic and de-plastify your life.

Professor Carlos Duarte is Director of The University of Western Australia Oceans Institute and Research Professor with the Spanish National Research Council (CSIC). He has conducted research across Europe, South-East Asia, Cuba, México, USA, Australia, the Amazonia, the Arctic, the Southern Ocean, and the Atlantic, Indian and Pacific oceans, spanning most marine ecosystem types, from near-shore to the deep sea. Prof. Duarte has received many awards and honours for his work including from the United States and Spain. In 2011, he also received the Prix d'Excellence, the highest honour awarded by the International Council for the Exploration of the Seas (ICES). This article was co-authored with Guiomar Duarte-Agustí, Digital Marketing Consultant and was originally published inThe C The Conversation

From **ECOS** online http://www.ecosmagazine.com/?paper=EC14197