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Modelling global distribution, risk and mitigation strategies of floating plastic pollution

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Microplastic debris floating at the ocean surface can harm marine life. Understanding the severity of this harm requires knowledge of plastic abundance and distributions. Dozens of expeditions measuring microplastics have been carried out since the 1970s, but they have primarily focused on the North Pacific and North Atlantic accumulation zones, with much sparser coverage elsewhere.

Here, we use the largest dataset of microplastic measurements assembled to date to assess the confidence we can have in global estimates of microplastic abundance and mass. We use a rigorous statistical framework to standardise a global dataset of plastic marine debris measured using surface-trawling plankton nets and couple this with three different ocean circulation models to spatially interpolate the observations. Our estimates show that the accumulated number of microplastic particles in 2014 ranges from 15 to 51 trillion particles, weighing between 93 and 236 thousand metric tons. A large fraction of the uncertainty in these estimates comes from sparse sampling in coastal and Southern Hemisphere regions.

We then use this global distribution of small floating plastic debris to map out where in the ocean the risk to marine life (in particular seabirds and plankton growth) is greatest, using a quantitative risk framework. We show that the largest risk occurs not necessarily in regions of high plastic concentration, but rather in regions of extensive foraging with medium-high plastic concentrations such as coastal upwelling regions and the Southern Ocean.

Finally, we use the estimates of distribution to investigate where in the ocean plastic can most optimally be removed, assuming hypothetical clean-up booms following the ideas from The Ocean Cleanup project. We show that mitigation of the plastic problem can most aptly be done near coastlines, particularly in Asia, rather than in the centres of the gyres.

Based on these results, we propose more focus on the coastal zones when considering future efforts in sampling, risk management and mitigation.