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A review of the application of satellite mapping techniques for marine plastic litter monitoring

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Abstract

Plastic pollution is one of the largest anthropogenic threats to the marine environment of this century, with plastics representing over 80% of human-made debris present in the oceans[1]. Approximately 12 million tonnes of plastic waste enter our oceans annually, posing a significant threat to marine ecosystems[2]. Although plastics enter the marine environment through riverine and coastal sources or direct disposal, it is widely acknowledged that rivers play a crucial role in the transportation of ocean plastic pollution; acting as the arteries that carry waste from land to ocean. The transportation of plastic in rivers is influenced by wind, rain, and extreme meteorological events, which are particularly adept at hastening the transfer of terrestrial plastic related debris from land to sea. The global contamination of plastic pollution poses an issue for policymakers as it is not constrained by national boundaries, instead it is transported by water and air currents where it congregates at river mouths and coastal cities.

At an international scale, motivation for addressing the issue of plastic pollution is mounting and there are a plethora of agreements relating to maritime sources of plastic waste. However, at present, there is no overarching legally binding agreement addressing the land-based sources of marine litter, particularly with measurable reduction targets to limit future plastic emissions. One limitation on the implementation of such a policy is the absence of a global standardized methodology to ensure national compliance with, and monitor the

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[1] Carney Almroth, B. and Eggert, H., 2019. Marine plastic pollution: sources, impacts, and policy issues. *Review of environmental economics and policy*, *13*(2), pp.317-326.
European Parliament. 2019. Available from http:// www.europarl.europa.eu/news/en/press-room/ 20190321IPR32111/parliament-seals-ban-on-throwaway-plastics-by-2021 (Accessed 7th December 2021)

[2] https://www.ciel.org/wp-content/uploads/2020/06/Convention-on-Plastic-Pollution-June-2020-Single-Pages.pdf)
UNEP, Marine Litter: A Global Challenge

effectiveness, of proposed regulations, as well as supplying critical information regarding the status of marine litter to support the creation of new strategies.

At local and national scales, the ability to prevent and mitigate plastic pollution varies by nation and region and is heavily dependent on resource availability for waste and behaviour change management. However, over the last 5-10 years, there has been much development and mobilisation by both for-profit and non-governmental organizations (NGOs) who have focused on the clean-up of plastic waste. These work in a range of geographical regions and are focused on the collection, removal, and management of marine and riverine litter; however, they ultimately require knowledge about locally specific dense clusters to target operations and maximize their yields.

To date few studies have focused on a consistent monitoring service for identifying locally specific dense clusters of plastic waste, which could enable these organisations to streamline their cleaning efforts towards the areas with the greatest marine litter densities, collect substantial volumes of marine litter whilst reducing running costs, improve efficiency, and encourage positive behaviour change. A robust monitoring system, which is globally applicable, would therefore assist plastic policy at a regional, national, and international level, accelerating the pace and scale of the response to plastic emissions.

Over the last year, CGG Satellite Mapping, supported by the European Space Agency's Space Solutions and in collaboration with Mott Macdonald and Brunel University London, conducted a 12-month feasibility study to identify and monitor floating macro to mega marine litter in fluvial and coastal environments using Earth Observation (EO) data. Sustained observation via remote sensing offers distinct advantages for determining the marine plastic debris mass balance due to its extensive area coverage and frequent observation. The ability to detect large aggregations of floating plastics via EO data will support a better understanding of the sources, pathways, and trends of litter in the marine environment, before it becomes entangled, ingested, fragmented, or degraded. The study focused on identifying "hotspot" locations of large aggregations of floating marine litter, monitoring the source location and frequency of accumulations, and analysing the size and spatio-temporal distribution of the material. The parameters provide input into local drift models to improve knowledge of the spatio-temporal distribution of floating debris.

The study evaluated the extent to which current and planned remote sensing technology matches the spatial, spectral, and temporal scales required for marine plastic debris

observations in river and estuary environments. Three case study locations in Europe, SE Asia and the Caribbean were examined using a range of EO data and processing techniques. The expectation for marine litter (density, location, composition) in each of these settings is different and therefore the resolution, monitoring frequency, spectral range, and platform for data acquisition needs to be specifically targeted for each setting. The suitability of freely available, open-access EO data over each site was assessed, as well as high resolution commercial data as and when required to alleviate problems associated with cloud cover and weather conditions. In addition, in-situ ground truth (e.g. samples or photographs) was also used when available to validate the EO data, with the support of local NGO's and waste management organisations. The study also analysed environmental data, such as precipitation and wind information, to support the understanding of the movement of marine litter within these environments and transboundary migration of plastics.

With close engagement from a broad group of end users, CGG plan to develop a marine litter monitoring system to improve knowledge of the location and quantity of floating marine plastic debris within river and estuary environments globally. The service will inform governments, NGOs and policy developers, support local waste management programs and collection campaigns, increase awareness of plastic discharge and provide feedback on the long-term effects of environmental waste management initiatives in river and estuary environments. By identifying the presence of marine litters, its geographical origin, and modelling its future behaviour, the satellite-derived system has the potential to complement policy efforts to combat marine plastic pollution. It is hoped the system will assist in monitoring the specific, measurable, and time-bound targets set by the international community to reduce plastic emissions into the marine environment as the use of satellite data is universal and would ensure no country is immune from compliance; providing a transboundary solution to a global problem.