Task Force on
Remote Sensing of Marine Litter and Debris

Second Workshop Report

07 - 08 March 2022

1 Introduction

Anthropogenic solid litter and debris is an environmental problem that poses socioeconomic and health risks to humankind. In particular, plastics make up to 80 % of the litter in the aquatic environment. It has been found in rivers flowing into coastal zones and accumulating on the surface and near surface of the water column in remote areas of the open ocean, including polar regions. Multiple studies have reported marine litter related injuries or deaths in the order of millions of seabirds as well as hundreds of thousands of marine biota a year resulting from ingestion or entanglements with derelict fishing gear and plastic litter (UNEP, 2016; Rochman et al., 2013). The annual price tag attached to plastic litter damage within the blue economic activities is over US$1.5 trillion (Forrest et al., 2019). Plastic litter in the marine environment has become of concern for human health, as related harmful contaminants continue being recovered and are identified in seafood (Thevenon et al., 2014; Vethaak and Leslie, 2016).

With plastic litter disposal and dumping expected to increase over the coming years and the long life of this material in the aquatic environments, urgent action is needed to better understand sources, pathways, geo-location and temporal distribution of plastic litter to inform effective mitigation strategies. Net trawl survey counts have been regressed against numerical models to infer the geo-spatial and temporal distributions of plastics, but these data are sparse and come with large uncertainties (van Sebille et al., 2015). Echoing the need for sustainable, innovative and complementary monitoring strategies, remote sensing is anticipated to improve the information gaps about plastic litter. Furthermore, international environmental agencies (e.g. United Nations Environment Programme, UNEP), space agencies (e.g. ESA and NASA), global leaders, stakeholders (e.g. World Bank) and scientists foresee the interdisciplinary prospects of remote sensing technologies in monitoring plastic litter (Maximenko et al., 2019; Garaba et al., 2018; Martínez-Vicente et al., 2019). ESA has dedicated resources towards remote sensing of marine litter with initial efforts having started in 2017 and further advanced research funded already underway since July 2020 (ESA, 2020). NASA has also dedicated resources to remote sensing of marine plastic litter activities started in 2021 (NASA, 2021).

In this context, the International Ocean-Colour Coordinating Group (IOCCG) Task Force on Remote Sensing of Marine Litter and Debris (RSMLD) has, as an overarching goal, **to coordinate the advancement of current and future remote sensing technologies and techniques that have potential to provide observations of plastic litter over all aquatic environments,** in the frame of a wider International Marine Debris Observation System (Maximenko et al., 2019). Considering all remote sensing technologies (with a special focus on radiometric approaches), the Task Force aims to promote a unified interdisciplinary international team of remote sensing experts with the goal to coordinate the development of traceable and transparent approaches for **detecting**, **identifying**, **quantifying** and **tracking requirements** of **aggregated plastic litter patches** (composed of all size classes). These requirements are supported by four interlinked core topics that are the foundation pillars of the Task Force; (i) technologies, (ii) algorithms and applications, (ii) datasets and (iv) interdisciplinary aspects. These core topics are essential for creating a **scientific roadmap for remote sensing of plastic litter in all aquatic environments**. Furthermore, the Task Force aims to produce living guidelines on best practices in remote sensing of plastics. It will also thrive to promote **F**indability, **A**ccessibility, **I**nteroperability, and **R**euse (**FAIR** policy) of relevant datasets as well as algorithms.

The Task Force includes 41 members already cooperating with the international community, including space agencies, research institutes, companies and foundations, and in international initiatives in the field of marine litter, e.g. with UNEP in the Sustainable Development Goals framework. The Task Force members are distributed over five continents, eighteen countries, with a gender distribution of 43% women and 57% men. The Task Force steering committee is composed by 4 Space Agency Chairs, 1 Scientific Chair, 4 Core Topic Coordinators, and 2 founding members.
For more details refer to the Task Force website[1].

1.1 Objectives of the 2nd Workshop of the Task Force

The main objectives of the workshop were:

- To present the progress done by the Task Force to members and external attendees and introduce the Task Force to external attendees;
- To hold an open discussion with Task Force members and external attendees in view to advance in the preparation of the Task Force outcomes covering the four Core Topics: Technologies, Algorithms and Applications, Datasets and Interdisciplinary Aspects.

Differently from the 1st workshop, these two online working sessions gave the opportunity to non-members to register and to follow the discussion and contribute by leaving comments and suggestions on online sheets[2]:

[1] https://ioccg.org/group/marine-litter-debris/
[2] https://padlet.com/IOCCG_TaskForce_RSMLD/uv21lootwyliz8dg (Day1) and https://padlet.com/IOCCG_TaskForce_RSMLD/o4mk6mlemz1l8zkd (Day 2)

2 Presentations and Discussions

The workshop was structured around the presentations of the progresses done in the four Core Topics (CT) of the Task Force, namely:

- Technologies (Coordinator: Victor Martinez-Vicente, PML)
- Algorithms and Applications (Coordinator Manuel Arias, ICM-CSIC)
- Datasets (Coordinator: Shungu Garaba, University of Oldenburg)
- Interdisciplinary Aspects (Coordinator: Lauren Biermann, PML and Madeline Cowell, Ball Aerospace)

The descriptions of the Core Topics are reported in details in the Task Force Terms of Reference[3]. A synthesis of the updates and topics presented at the workshop for each Core Topic is reported in the following. An Agenda of the workshop is reported in Annex 1.

2.1 Core Topic 1 – Technologies

The aim of the CT1 (Technologies) is to review the current status of technologies, platforms and experimental and modelling tools with the aim to identify gaps and opportunities to produce a roadmap for the development of marine plastic debris observation from space. During last year the group has been focusing on the production of a peer reviewed paper on the status of research (I.e. maturity) and potential of different combinations of techniques (passive and active) and platforms to detect marine plastic debris in two scenarios: accumulations on frontal areas and on the shoreline. Leadership of the paper is now with Michelle Gierach (JPL, NASA). During 2021 the group has met monthly with full attendance on most meetings. It is expected a submission of this manuscript before summer 2022. During the workshop a summary of the status of the review for the different technologies was presented to the wider group, and links were proposed with other international groups.

2.2 Core Topic 2 – Algorithms and Applications

The aim of the CT2 (Algorithms and Applications) is to (i) identify the best retrieval and state-of-the-art strategies for each of the available acquisition technologies, attending to their nature, spatial/temporal resolutions and platforms; (ii) target algorithm development and action for critical aspects requiring novel approaches/solutions; (iii) Identify ancillary proxy datasets/variables that might be required for the various retrieval methods (e.g. related to current atmospheric correction techniques); (iv) define validation procedures and standards in order to obtain comparable metrics and performances from the various algorithms and methods; and (v) consolidate representative “use cases” for assessment of the algorithms and support to the design of simulators/modelling exercises.

During the past year the CT2 members collected and reviewed a compilation of 136 publications performing a critical analysis of the algorithms used and how they were applied in terms of scenarios. Publications were analyzed and sorted in different ways, e.g. sub-divided by used platforms (I.e. satellites, airplanes, drones, mast-based instruments on ground), signal acquired (from visible to microwaves), applications (e.g. river monitoring, beach mapping, floating debris

[3] https://zenodo.org/record/4446238

detection, large marine debris patches), and algorithms used. Successful or promising examples of research works were highlighted during the workshop presentation. The main findings and conclusions of the analysis were reported. Current research focus is on macroplastic and/or accumulations of marine debris, while little evidence has been reported on capabilities to detect microplastic from any of the assessed platforms. The used algorithms are, not surprisingly, strongly dependent on the spatial resolution offered by the combination of the sensors and platforms used. Satellite approaches are bound to have significant uncertainties due to lack of dedicated bands, relatively low SNR associated to the low resolution versus the scales of marine litter and debris, and water absorption in key bands for plastic detection.
An introductory presentation on marine debris detection using passive optical remote sensing was provided by Chuanmin Hu (USF, USA).

2.2.1 A Simulator for Remote Sensing of Marine Litter and Debris (Noelia A. Zorrilla, Argans Ltd.)

The presentation introduced a breadboard for end-to-end (E2E) Marine Litter Optical Performance Simulations (ML-OPSI), designed in the frame of the ESA Discovery Campaign. ML-OPSI supports Earth observation scientists with the design of computational experiments for operations research. Thus, it allows EO scientists to create a model of the acquisition of an optical and IR signal by a remote sensor and use it to run simulations to characterize that signal under varying environmental conditions, such as sea state, etc., to assess the optimal characteristics required for a sensor designed with the aim to detect aggregates of marine litter. The ML-OPSI breadboard will estimate marine litter signal at Top-Of-Atmosphere (TOA) or at Bottom-Of-Atmosphere (BOA), representing the various case studies by the community (e.g., windrows, frontal areas, river mouths, sub-tropical gyres), coming from synthetic data or from real observations. It is a modular, pluggable and extensible framework, promoting re-use and being adapted for different missions, sensors and scenarios. ML-OPSI breadboard is based on a component-based architecture and is fundamentally built over several modules, both of the Simulator and of the Model, that take care of various aspects of the E2E simulation. The Simulator (OPSI) modules are responsible for the execution of the Model over varying initial conditions, these comprise the orchestrator, that controls the running of the processes, along with configuration management and the proposed GUI model-builder front end. A Domain, in this instance Marine Litter (ML) detection, can be represented by one or more EO Models, that are made up of one or more EO Components. Through a process of functional decomposition these top-level generic components have been refined to specify lower level modules, that are themselves components that can be modularized and the definition of inputs, outputs, parameters and interfaces of these components can be performed. The top level identified modules are scenario/model builder (OPSI), performance assessment module (OPSI), scene generation module, atmospheric propagation module, instrument detection module and retrieval module. A standalone demonstrator, which was built as a rapid prototype implementing three of the modules, was presented. This demonstrator is considered as a proof of concept of ML-OPSI. However, in view of making ML-OPSI a modular and pluggable framework, it is necessary to initiate a discussion within the community to have a common development considering its deployment, interface standards, models or types of available data to advance in that direction. In conclusion, the breadboard has been established and now needs the other blocks, which agencies should consider funding in view to advance with the development.

2.3 Core Topic 3 – Datasets

Summary: Datasets are the key end-product of the various remote sensing technologies that are gathering significant information relevant to the monitoring of plastic waste in the natural environment. These datasets are then ingested into classic to sophisticated algorithms to generate essential plastic descriptor variables that meet the interdisciplinary stakeholder needs to detect, identify, quantify and track plastic waste.

Updates

The datasets team is composed of experts with backgrounds ranging from academia to industry. Highlights of the team member research was provided to motivate the attendees to further investigate related datasets and establish potential collaborations based on open-science. Tomas Acuna (University of Chile) has been working on the use of machine learning to classify and quantify beached plastics using very high geo-spatial resolution imagery. The research integrated the use of hyperspectral technologies to generate high quality spectral reflectance measurements from the ultraviolet to longwave infrared spectrum. Andy Hueni (University of Zurich) established a database for spectral measurements (Specchio). Field observations have utilized hyperspectral tools to produce open-access imaging and spectroradiometric datasets of floating plastics. These datasets have been shown to be useful in algorithm development and simulations to better understand the spectral characteristics of floating plastics in the environment. La Daana Kanhai (The University of the West Indies) has been combining field and laboratory work to understand the dynamics of plastics to support awareness of the problem through teaching and outreach campaigns. A comprehensive study from the group highlights the status of marine debris litter and plastics pollution from 1980 to 2020 in the Caribbean Large Marine Ecosystem. Konstantinos Topouzelis (University of the Aegean) has been leading the deployment of artificial targets of litter for sea-truthing of satellite imagery. The efforts combine gathering of drone imagery in the visible to near infrared spectrum and to develop algorithms for the detection of marine litter on satellite imagery. Extensive research has also been conducted by the team to train future scientist whilst also collecting large datasets of drone imagery around Greece. The imagery has been essential in the development of detection and identification maps of plastics supported by machine learning tools. Chris Ruf (University of Michigan) has been investigating if the anomalies in CYGNSS observations were correlated to surfactant indicators of ocean microplastics. The team also developed a CYGNSS based algorithm that generates daily maps of microplastic estimates. The datasets team aims to conduct monthly meetings that involve discussions on the living document/report, recommendation for a dataset roadmap and presentations about ongoing research on RSMLD. Datasets in open-access continue being compiled on the Task Force website and team members have also included datasets covering the ultraviolet to longwave infrared spectrum.

Recommendations and outlook

- The team proposed the need to initiate round-robin discussions amongst the stakeholders to identify the needs so as to better guide the technologies to generate the essential datasets that would be required to develop algorithms.

- The need for open-access datasets dedicated to RSMLD was emphasized and sufficient metadata in online repositories e.g. EcoSIS, Ocean Scan, Pangaea, SeaBASS.
- The living report is expected to be a guideline or roadmap related to the methodologies for collecting high quality essential plastic related data from the current and emerging suite of remote sensing technologies.

2.3.1 **Ocean Scan Database** (Laia Romero, isardSAT/Lobelia Earth)

This presentation introduced Ocean Scan, the first inclusive global labelled database to integrate in situ observations of marine plastic and litter with remote sensing (in particular satellite) data. Data are presented on a global interactive map, where users can access information about marine litter in situ observations and associated Earth Observation products. A web portal and a mobile application provide user-friendly access to the platform for data upload, consultation and download. Ocean Scan is designed to maximize interoperability and scalability and to ensure a consistent data format and schema to fit the requirements of remote sensing technologies. It will be free of charge and open to everybody, upon user registration (registration is already possible at the website[4]). By ensuring data provenance and different levels of privacy for uploaded observations, Ocean Scan will provide a unified reference point for marine plastic and litter observations to support and promote international collaboration and research. It is currently in a testing phase with a group of international volunteers and it is expected to go online in June 2022.

2.4 Core Topic 4 – Interdisciplinary Aspects

The goal of the Core Topic 4 time was to outline the first draft of the year's roadmap with objectives and measures of success. The CT4 topic will create a centralized repository for information in the field of remote sensing of plastics in or on the water. This centralized repository will create a space for anyone to visit, find information, make connections and feel at "home". The roadmap to achieve this goal is broken down into 3 areas:

1. Living document on sensors, algorithms and contributions from the growing community
2. Plastics remote sensing as a "new" interdisciplinary science
3. Create a space for others to learn how to engage

Focus area one: Create a centralized space for information on all thing's sensors, algorithms and plastics. The mission is to capture and publish the range of sensors and approaches for plastic detection and monitoring. The measures of success will include acknowledgements or mentions made in scientific papers, press, and reports. As well as performing analytics on the living lists to measure representation from communities and disciplines. Once the living documents have a landing page then website traffic and clicks can be used to ensure the information is visible and useful.

Focus area two: Grow remote sensing of marine litter and debris (RSMLD) interdisciplinary science. The mission is to continue connecting with scientists from a range of backgrounds who are now also researching plastics. The core topic will continue working conferences, working groups, and training opportunities. The measure of success will be measured in the number of

[4] https://www.oceanscan.org/

abstract submissions, collaborations across backgrounds, and publications with global sets of co-authors.

Focus area three: Provide ‘user-friendly’ evidence to (and engaging with) external communities and other disciplines. The mission will make data and findings accessible in a read-to-use format preferred by non-expert and general downstream users and stakeholders. Measure of success will be the identification of the intended audience, a common landing page (something like Moodle), and data-driven related to traffic to links or clicks.

Actions from the meeting include continued development of the core topic roadmap after feedback received from the workshop. The core topic team will not develop in isolation and will solicit feedback once the roadmap with missions, visions, and measures of success are finalized.

2.5 Early Career Invited Talks

The workshop had a section dedicated to early career scientists to showcase ongoing and published research related to remote sensing of marine litter and debris.

2.5.1 Marida: A Sentinel-2 dataset for marine debris detection (Katerina Kikaki[5], National Technical University of Athens, Greece)

Summary: MARIDA is the first open-access dataset that discriminates floating marine debris from other floating materials (*Sargassum* macroalgae, natural organic material, ships), sea features (foam, wakes waves), dissimilar water types (clear, turbid, shallow), clouds and cloud shadows on multispectral satellite data. MARIDA aims to enable the research community to explore the spectral patterns of all annotated features. The second aspect is to facilitate the efforts on marine debris detection solutions development based on artificial intelligence. For this reason, MARIDA provides machine learning baselines for weakly-supervised semantic segmentation tasks. MARIDA is designed to be beneficial for several remote sensing and machine learning tasks which are described in detail in Kikaki et al. (2022). The dataset can be downloaded from the Zenodo repository[6]. The quick start guide with code for all machine learning benchmarks are on GitHub[7]. The detailed statistical analysis of MARIDA and the interactive online material is also published online[8].

Selected publications:

Kikaki, A., Karantzalos, K., Power, C. A., & Raitsos, D. E. (2020). Remotely sensing the source and transport of marine plastic debris in Bay Islands of Honduras (Caribbean Sea). *Remote Sensing*, *12*(11), 1727, https://doi.org/10.3390/rs12111727.

Kikaki, K., Kakogeorgiou, I., Mikeli, P., Raitsos, D. E., & Karantzalos, K. (2022). MARIDA: A benchmark for Marine Debris detection from Sentinel-2 remote sensing data. *PloS ONE*, *17*(1), e0262247, https://doi.org/10.1371/journal.pone.0262247.

[5] akikakh@central.ntua.gr
[6] https://zenodo.org/record/5151941#.YiyjkXozZD8
[7] https://github.com/marine-debris/marine-debris.github.io
[8] https://marine-debris.github.io/

2.5.2 Tackling the plastic debris challenge at its source – Linking EO data with multi-source in-situ data for modelling debris pathways from source to sink (Anna Brand[9], Remote Sensing Solutions, Germany)

Summary: The goal of our project is to develop a monitoring prototype that combines various technologies such as remote sensing, near-range sensing (fixed cameras and drones), deep learning, hydrodynamic modeling, in-situ sampling and lab analytics. As rivers are a major source of marine plastic it is crucial to monitor areas closer to plastic marine litter sources such as rivers and estuarine systems. This has the potential to increase our understanding of the transportation dynamics and improve mitigation strategies. Upscaling in situ litter point data with earth observation (EO) and hydrodynamic models is our central concept. Sentinel-2 and -3, together with data from similar satellite missions, are used to monitor discharging rivers and their estuaries based on river plume detection inferred from suspended particulate matter maps. Multi-type in situ data was collected at various points along the pollution pathway. Imagery taken from installed cameras on bridges or other infrastructure is analyzed using Deep Learning approaches to detect floating plastic in rivers. This will provide improved inputs to transport models. Water samples from estuaries and coastal areas using manta trawls are used to quantify plastic litter abundances. High-resolution monitoring via automated analysis of drone imagery along the shoreline was established for accumulation analyses as well as collecting beach samples through field surveys. Integration of in situ data, multi-scale EO and hydrodynamic modelling serves as the development basis for a monitoring system of plastic debris in aquatic ecosystems, allowing an end-to-end depiction of real-world debris transport pathways for the first time. Such source-to-sink monitoring systems can be used to identify environmental, economic, human health and safety-related impacts of plastic litter and would support targeted efforts of both off- and onshore-based clean-up and mitigation projects by focusing on smaller areas with higher plastic abundances.

2.5.3 Detecting Floating Marine Debris from Small Satellite Imagery with Deep Learning (Lillianne Thomas[10], Development Seed, NASA IMPACT, USA)

Summary: Floating marine debris is a global pollution problem which threatens marine and human life and leads to the loss of biodiversity. Large swaths of marine debris are also navigational hazards to vessels. Artificial intelligence, specifically deep learning, can be used to detect floating marine debris in satellite imagery. This project presents an application of a deep learning model designed for object detection in the TensorFlow framework for observing marine debris floating on the surface of the ocean. The model was trained on a custom-labeled dataset that consisted of 1844 polygons containing marine debris as observed in PlanetScope visible imagery which has a spatial resolution of approximately 3 meters and a daily revisit rate. An overall precision score of 0.78 and recall score of 0.70 were obtained on the test dataset. In this

[9] brand@remote-sensing-solutions.com
[10] lilly@developmentseed.org

project, we highlight the strong potential of using commercial small satellite imagery for detecting marine debris pollution and strengthening current and future efforts to clean the oceans. Dataset is published on Radiant Earth's MLHub[11] and Github repository[12].

2.5.4 Monitoring Marine Plastic Pollution Using Radar: From Source to Sea (Morgan Simpson[13], University of Stirling, UK)

Summary: The potential and capabilities of radar remote sensing in the monitoring of marine plastic pollution is investigated to improve understanding of plastic waste and its dispersal through the environment. This research explores radars effectiveness in monitoring plastic from source to sea using remotely sensed satellite and ground-radar data. The studies show (i) The feasibility of detecting large accumulations of plastic near dams, using ESA Sentinel-1 data. This finding the use of single VV polarisation inadequate for the task, with PolSAR data being needed. (ii) Preliminary results from an experiment in the Deltares wave tank. This used C-band and X-band ground-radar data to monitor statistical differences in radar backscattering between experiment cases (plastics in waves) and reference cases (waves with no plastic), with multiple concentrations, plastic items and wave conditions being tested. Preliminary results also show that at the investigated wave heights, X-band frequency has better performance overall at larger and smaller concentrations of plastic when compared with C-band. (iii) The potential of identifying plastic pollution in the open ocean, specifically the Atlantic, Indian and Pacific Ocean Gyres, through the identification of surfactants / biofilms associated with microbes colonising the plastisphere. Future work comprises of understanding the concentrations of surfactants / biofilms that can be produced from the plastisphere.

3 Expected Outcomes

For each of the Task Force Core Topics a set of outcomes is planned. These outcomes include documents (e.g. literature analysis, roadmaps, guidelines, standards), living bibliography sites (e.g. refer to the Task Force Bibliography webpage), libraries of open-access datasets, dedicated workshops. Some of the documents are planned to be published already by the end of this year. Tools to involve more actively the emerging community on Remote Sensing of Marine Litter and Debris are also under evaluation for implementation.

4 Workshop Attendance

The workshop was attended by a total of 101 participants, including Task Force members and guests, from 18 countries.

[11] https://mlhub.earth/data/nasa_marine_debris
[12] https://github.com/NASA-IMPACT/marine_debris_ML
[13] m.d.simpson@stir.ac.uk

5 Acknowledgments

The IOCCG Task Force would like to thank all the speakers and contributing members and participants.
Many thanks to the AIR Centre[14] for supporting with the videoconference operations and registration process.

[14] https://www.aircentre.org/

References

ESA, 2020: A step forward in detecting plastic marine litter from space: https://www.esa.int/Enabling_Support/Preparing_for_the_Future/Discovery_and_Preparation/The_Discovery_Campaign_on_Remote_Sensing_of_Plastic_Marine_Litter

Forrest, A., Giacovazzi, L., Dunlop, S., Reisser, J., Tickler, D., Jamieson, A., and Meeuwig, J. J.: Eliminating plastic pollution: How a voluntary contribution from industry will drive the circular plastics economy, Front. Mar. Sci., 6, doi:10.3389/fmars.2019.00627, 2019.

Garaba, S. P., Aitken, J., Slat, B., Dierssen, H. M., Lebreton, L., Zielinski, O., and Reisser, J.: Sensing ocean plastics with an airborne hyperspectral shortwave infrared imager, Environ. Sci. Technol., 52, 11699-11707, doi:10.1021/acs.est.8b02855, 2018.

Martínez-Vicente, V., Clark, J. R., Corradi, P., Aliani, S., Arias, M., Bochow, M., Bonnery, G., Cole, M., Cózar, A., Donnelly, R., Echevarría, F., Galgani, F., Garaba, S. P., Goddijn-Murphy, L., Lebreton, L., Leslie, H. A., Lindeque, P. K., Maximenko, N., Martin-Lauzer, F.-R., Moller, D., Murphy, P., Palombi, L., Raimondi, V., Reisser, J., Romero, L., Simis, S. G. H., Sterckx, S., Thompson, R. C., Topouzelis, K. N., van Sebille, E., Veiga, J. M., and Vethaak, A. D.: Measuring marine plastic debris from space: Initial assessment of observation requirements, Remote Sens. (Basel), 11, 2443, doi:10.3390/rs11202443, 2019.

Maximenko, N., Corradi, P., Law, K. L., Van Sebille, E., Garaba, S. P., Lampitt, R. S., Galgani, F., Martinez-Vicente, V., Goddijn-Murphy, L., Veiga, J. M., Thompson, R. C., Maes, C., Moller, D., Löscher, C. R., Addamo, A. M., Lamson, M. R., Centurioni, L. R., Posth, N. R., Lumpkin, R., Vinci, M., Martins, A. M., Pieper, C. D., Isobe, A., Hanke, G., Edwards, M., Chubarenko, I. P., Rodriguez, E., Aliani, S., Arias, M., Asner, G. P., Brosich, A., Carlton, J. T., Chao, Y., Cook, A.-M., Cundy, A. B., Galloway, T. S., Giorgetti, A., Goni, G. J., Guichoux, Y., Haram, L. E., Hardesty, B. D., Holdsworth, N., Lebreton, L., Leslie, H. A., Macadam-Somer, I., Mace, T., Manuel, M., Marsh, R., Martinez, E., Mayor, D. J., Le Moigne, M., Molina Jack, M. E., Mowlem, M. C., Obbard, R. W., Pabortsava, K., Robberson, B., Rotaru, A.-E., Ruiz, G. M., Spedicato, M. T., Thiel, M., Turra, A., and Wilcox, C.: Toward the Integrated Marine Debris Observing System, Front. Mar. Sci., 6, doi:10.3389/fmars.2019.00447, 2019.
Rochman, C. M., Browne, M. A., Halpern, B. S., Hentschel, B. T., Hoh, E., Karapanagioti, H. K., Rios-Mendoza, L. M., Takada, H., Teh, S., and Thompson, R. C.: Classify plastic waste as hazardous, Nature, 494, 169-171, doi:10.1038/494169a, 2013.

NASA, 2021 projected selected from the ROSES project call on 2020 https://nspires.nasaprs.com/external/solicitations/summary!init.do?solId=%7BBCEE336B-D550-CCBA-1C8C-7A866DB06F45%7D&path=&redirectURL

Thevenon, F., Carroll, C., Sousa, J., and (editors): Plastic debris in the ocean: The characterization of marine plastics and their environmental impacts, situation analysis report, International Union for Conservation of Nature, Gland, Switzerland, 52 pp, 2014.

UNEP: Marine plastic debris and microplastics – Global lessons and research to inspire action and guide policy change, United Nations Environment Programme, Nairobi, Kenya, 274 pp, 2016.

van Sebille, E., Wilcox, C., Lebreton, L., Maximenko, N., Hardesty, B. D., van Franeker, J. A., Eriksen, M., Siegel, D., Galgani, F., and Law, K. L.: A global inventory of small floating plastic debris, Environ. Res. Lett., 10, 124006, doi:10.1088/1748-9326/10/12/124006, 2015.

Vethaak, A. D., and Leslie, H. A.: Plastic Debris Is a Human Health Issue, Environ. Sci. Technol., 50, 6825-6826, doi:10.1021/acs.est.6b02569, 2016.

Annex 1: Agenda of the Workshop

07 March 2022, 14:00-17:00 CET

14:00 – 14:05 **Welcome to DAY 1** (Co-chairs: S. Garaba and M. Cowell)
Welcome Note (Raisha Lovindeer, IOCCG Scientific Officer)

14:05 – 14:15 **Introduction of Task Force** (Shungu Garaba, University of Oldenburg) **and Space Agency Initiatives** (Joel Scott, NASA, Carolina Sá, PT Space, Paolo Corradi, ESA)

14:15 – 15:15 **Core Topic 1** – Technologies.
- Status (V. Martinez-Vicente, PML, M. Gierarch, NASA).
- VHR imagery (Ellen Ramirez, NOAA)
- Hyperspectral and Polarimetry (Heidi Dierssen, UConn)
- Thermal (Lonneke Goddijn-Murphy, UHI)
- LIDAR (Valentina Raimondi CNR-IFAC)
- Microwaves (Paolo Corradi, ESA on behalf of Peter de Maagt, ESA)

5 minute break

15:20 – 15:50 **A Simulator for Remote Sensing of Marine Litter** (N.A. Zorrilla, Argans Ltd) **-** towards user requirements and interface standards

15:50 – 16:50 **Core Topic 2** – Algorithms and Applications.
- Status (Manuel Arias, ICM-CSIC)
- A few notes on marine debris detection using passive optical remote sensing (Chuanmin Hu, USF)
- Open discussion

16:50 – 17:00 **AOB and closure of day 1**

08 March 2022, 14:00-17:00 CET

14:00 – 14:05 **Welcome to DAY 2** (Co-chairs: Manuel Arias and Debashis Mitra)

14:05 – 14:30 **Core Topic 3** – Datasets. Status presentation and open discussion (Shungu Garaba, University of Oldenburg)

14:30 – 15:00 **Ocean Scan:** a database for remote sensing of marine litter and debris (Laia Romero, isardSAT/Lobelia Earth)

15:00 – 15:45	**Core Topic 4** – Interdisciplinary Aspects. Status presentation and open discussion (Madeline Cowell, Ball Aerospace and Lauren Biermann, PML)
	5 minute break
	Early Career Invited Talks
15:50 – 16:05	**Katerina Kikaki**, National Technical University of Athens, Greece **Title**: Marida: A Sentinel-2 dataset for marine debris detection
16:05 – 16:20	**Anna Brand**, Remote Sensing Solutions, Germany **Title**: Tackling the plastic debris challenge at its source – Linking EO data with multi-source in-situ data for modelling debris pathways from source to sink
16:20 – 16:35	**Lillianne (Lilly) Thomas,** Development Seed, USA **Title**: Detecting Floating Marine Debris from Small Satellite Imagery with Deep Learning
16:35 – 16:50	**Morgan Simpson,** University of Stirling, UK **Title**: Monitoring Marine Plastic Pollution Using Radar: From Source to Sea
16:50 – 17:00	**Closing Remarks** (M. Arias, ICM-CSIC)