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Campaign on Remote Sensing of Plastic Marine Litter

FRONTAL: Satellite FRONTs for detection of Anthropogenic plastic Litter

FRONTAL Executive Summary Report

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Acronyms

EO	Earth observation
GSD	Ground Sample Distance
MSI	Multi Spectral Instrument
OLCI	Ocean and Land Colour Instrument
S-2	Sentinel-2
S-3	Sentine-3
SoW	Statement of Work
SST	Sea Surface Temperature

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1 Executive summary

In the ocean, transport and mixing processes tend to disperse matter in suspension over wide spatial (~100 km) and long temporal (~month) scales. Fronts appear at the boundary between water masses with different properties and are caused by diverse oceanic features and processes, including bottom topography. Frontal structures include tidal mixing fronts, shelf-break fronts, upwelling fronts, estuarine fronts, plume fronts, fronts generated by convergence or divergence of water masses, and frontal eddies (Acha et al. 2015; Largier 1993). The ability of convergent surface currents at fronts to accumulate material is well studied in the literature, especially in the context of different suspended particles such as phytoplankton (Mahadevan 2016) and oil from spills (Peacock and Haller 2013). The growth and convergence of plankton at and along fronts can also impact fisheries productivity (Woodson and Litvin 2015). At the smaller scales (<10 km and ~1 day, i.e. submesoscale), vertical motion of the water make filamentous structures appear on the surface. Model predictions of the accumulation of floating matter on submesoscale fronts (Taylor 2018), have been verified using in situ evidence (D'Asaro et al. 2018).

Following the precursor project OPTIMAL (2017-2019), frontal structures were identified by the community as a priority area to target detection efforts from satellite remote sensing (Martinez-Vicente et al. 2019). Also from OPTIMAL, the detection of accumulations of floating marine debris using satellite remote sensing was proven as a concept (Biermann et al. 2020). The **first aim of FRONTAL was to extend the validation** of the direct radiometric detection of floating marine plastic debris on fronts. Due to the impact of the COVID-19 pandemic, much of the validation work had to rely on datasets from the literature and from collocated very high resolution imagery, with limited success.

The **second aim was to support the refinement of observation requirements for marine litter over fronts, in terms of spatial scales of observations of the fronts**. This was approached by producing front maps from satellites with different ground sampling distance (GSD). Using stablished algorithms (Miller 2009) fronts were produced for SST imagery (GSD ~ 1Km) and optical imagery (from S3-OLCI with GSD~300m and from S2-MSI with GSD~60m). Using more experimental techniques, front detection was attempted for altimeter data. A satellite derived front dataset has been created for 2018 for the region of West of the China Sea and the coast of Vietnam, around the city of Da Nang.

The **third aim was to establish connection between pathways of plastics and accumulation on fronts**. Modelled data have been computed at two scales for 2018: one large scale at GSD~1/12° and another at local scale around Da Nang at GSD down to 100 m.

The **final aim of this project was to construct a prototype of risk of accumulation of floating marine plastic**, using all the information above. The prototype of a workflow to compute the risk of accumulation of marine debris is the first step to provide quantitative information of changes in the location of floating plastics hot spots. These in turn will inform monitoring agencies and policy makers about the hot-spot persistence and where to focus monitoring efforts. We propose that this prototype is applicable at different scales and geographic locations.

A roadmap, with recommendations for ESA in this area, is proposed, adding the wider landscape of a rapidly evolving research field in the last two years to the lessons learnt from FRONTAL.