

FORECASTING AND MONITORING MARINE LITTER IN COASTAL REGIONS COMBINING NUMERICAL MODELLING AND CITIZEN SCIENCE

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INTRODUCTION

It is assumed that the main source of marine litter is terrestrial from rivers and waterways. Therefore, the dominant marine litter pathways from land sources to the ocean is via coastal regions. In coastal zones, debris can accumulate, return to the emerging beach, sink to the seafloor, or migrate to the open sea where it can converge in oceanic accumulation regions such as subtropical gyres. Near the shoreline, coastal transport processes are crucial in determining marine debris' residence times and accumulation zones. However, the transport mechanisms of floating marine debris in coastal zones remain poorly understood, primarily due to the complex geometry and influence of coastal processes which pose difficulties in incorporating them into Lagrangian numerical models at coastal scales. Moreover, coastal regions are highly susceptible to the impacts of the presence of marine litter affecting ecological resources, social activities and economic assets.

This work presents an integrated approach to marine litter pollution in coastal regions using developed coastal numerical models and scientific monitoring using a citizen science approach. The methodology is presented for the Barcelona coastline region.

MARINE LITTER IN THE BARCELONA COASTLINE

The presence of marine debris in the Barcelona coastline is a well-known problem that has been subject to widespread reporting in the mainstream media. The city of Barcelona is identified as a major source of plastic emissions in the area with some studies suggesting 1,787 tonnes emitted annually as a function of the population and approximations of total amounts entering the Mediterranean basin (Liubartseva et al., 2019). Recent findings show that plastic concentrations in the coastal waters around Barcelona are of a similar magnitude to those found in some subtropical oceanic gyres, with a constant exchange of debris between coastal and open waters and between beaches and coastal waters (De Haan et al., 2022). Moreover, it is a highly anthropized area where environmental groups have identified the inadequate sanitation system in some parts of the metropolitan area and high amounts of microplastics have been found ingested by various organisms of commercial importance in comparison to other less industrialized areas. Indeed, using citizen science approaches where samples were collected using paddle surf boards and manta trawls, a recent study by

De Haan et al. (2022) demonstrated high proportions of microplastics in nearshore waters around Barcelona with a degree of seasonal variability probably due to changes in hydrodynamic conditions. De Haan et al. (2022) also pointed towards the highly rugose Barcelona coastline with multiple breakwaters and semi enclosed beaches as possible traps for debris, where there may be a high fragmentation rate coupled with a prolonged accumulation of debris in coastal zones.

COASTAL PARTICLE DISPERSION MODEL

The developed numerical approach uses nested domains with resolution increasing as approaching the shoreline to resolve coastal processes but covering long distances travelled by persistent plastic particles at the same time (Figure 1).

Operational hydrodynamic eulerian simulations (waves and currents) are coupled to Oceanparcels software for Lagrangian tracking. Numerical modelling includes the influence of waves, currents and turbulent diffusion in the marine litter particles movement. The beaching process (particles returning to the shoreline) is also implemented as a function of the particle distance to the shoreline.

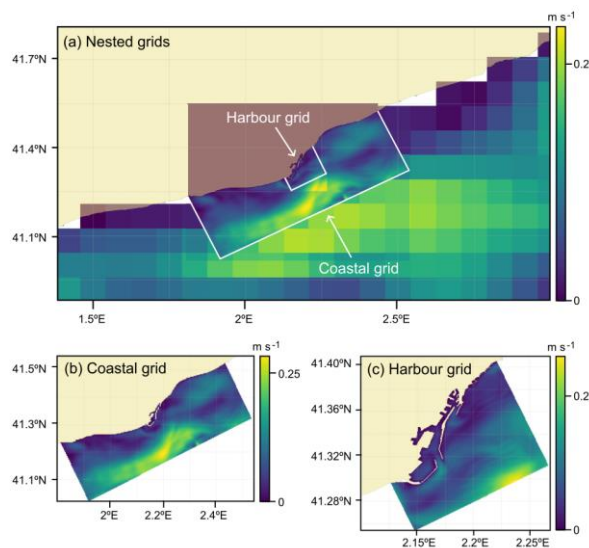


Figure 1 - Example of nested hydrodynamic grids displaying module intensity and current velocity (m s^{-1}) for 23 March 2017.

Coastal lagrangian drifters have been deployed around Barcelona coastline measuring transport processes with high temporal resolution to measure the drifter motion at relevant coastal scales. Drifters' measurements have been used to obtain a better understanding of the transport processes around Barcelona coastline and to validate the numerical approach.

MARINE LITTER SAMPLING AND ANALYSIS

Scientific sampling (including micro, meso and macro litter) covers the beach emerged area, the coastal water regions, the two main Barcelona river mouths (Besòs and Llobregat) and water discharge points. Coastal waters are sampled with trawling nets carried by SUP boards and kayaks using a citizen science approach. River mouths and sewer overflows are sampled using trawls net at fixed points at the discharge points. Finally, the emerged beach region is also sampled using volunteers for macro and specific sampling for micro plastics. With this approach the coastal region around Barcelona is monitored including the potential marine litter inputs.

OVERVIEW OF RESULTS

More than 90,000 plastics have been counted, precisely characterized, and classified using a novel processing methodology that incorporates a trained machine learning classification algorithm. Preliminary findings show clear temporal trends and hotspots of floating plastic concentrations in coastal areas.

Numerical simulations have been performed using visual observations of floating marine litter from the two major rivers and marine litter concentration from sampling as inputs. Numerical simulations suggest low marine litter export towards the open ocean and a large proportion of particles returning to the shoreline. Coastal drifters' measurements also suggest a high tendency or drifters to return to the shoreline during dominant wave and current conditions at the Barcelona coastline.

An example of particle accumulation from marine litter coming from river mouths in different regions of the Barcelona coastline is shown in Figure 2. Nested simulations show a relevant influence of coastline configuration on the marine litter accumulation (i.e. Barcelona harbor).

Statistical analysis suggests that wave energy and coastline orientation with respect to the wave direction are the main variables controlling particles beaching apart from the distance to the source.

The combined monitoring and modeling approach presented here provides a practical tool to monitor, predict and map potential hotspots, concentrations and fluctuations of floating plastic debris in coastal areas.

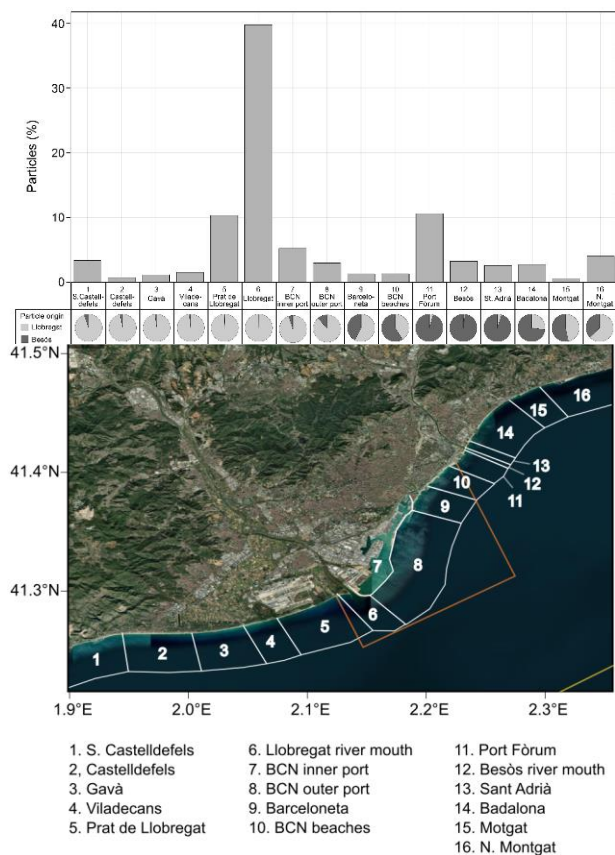


Figure 2 - Simulated particles returning to the beach (in % of the total particles released from Besòs and Llobregat rivers) (top panel) and coastal zones classification (bottom panel).

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