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Baseline

Protected areas in the Atlantic facing the hazards of micro-plastic pollution: First diagnosis of three islands in the Canary Current

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ABSTRACT

Coastal zones and the biosphere as a whole show signs of cumulative degradation due to the use and disposal of plastics. To better understand the manifestation of plastic pollution in the Atlantic Ocean, we partnered with local communities to determine the concentrations of micro-plastics in 125 beaches on three islands in the Canary Current: Lanzarote, La Graciosa, and Fuerteventura. We found that, in spite of being located in highly-protected natural areas, all beaches in our study area are exceedingly vulnerable to micro-plastic pollution, with pollution levels reaching concentrations greater than 100 g of plastic in 1 l of sediment. This paper contributes to ongoing efforts to develop solutions to plastic pollution by addressing the questions: (i) Where does this pollution come from?; (ii) How much plastic pollution is in the world's oceans and coastal zones?; (iii) What are the consequences for the biosphere?; and (iv) What are possible solutions?

Coastal zones are the most productive regions in the world, both biologically and economically, but they are also highly vulnerable, and the most densely-populated by our societies. Following the MARPOL Convention, signed in 1973, many national and transnational efforts have sought to better understand and regulate marine pollution. These efforts have led to tangible outcomes in the forms of improvements in environmental culture and national and international agreements, including: the MARPOL Protocol from 1978; the most recent communication from the European Commission to the Council and the European Parliament; the European Economic and Social Committee's work with the Committee of Regional Cooperation on marine pollution after 2007; and the United States' public law 109-449-dec. 22, 2006 "to help identify, determine sources of, assess, reduce, and prevent marine debris and its adverse impacts on the marine environment and navigation safety." These legislative efforts reflect societal awareness of open-ocean and coastal pollution. However, despite growing awareness of the mounting plastic pollution problem, plastics continue to be produced, consumed, and discarded at an increasing rate. This is problematic for the biosphere for a number of reasons. For example, wildlife can be physically harmed by plastics, which in turn negatively impacts biodiversity (Rochman et al., 2013). Another concern is that plastics can absorb and transport chemical pollutants, or can be toxic in and of themselves. Because of this, they serve as a proxy for chemical pollution, which has demonstrably crossed the boundary within which humanity can operate safely (Rockström et al., 2009). Transgressing a planetary boundary means we have entered into a time of high uncertainty, where abrupt global environmental change can no longer be unexpected (Rockström et al., 2009). With plastic pollution piling up, it seems that we are quickly approaching the planetary limit for plastics, if it has not already been surpassed.

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Concerted efforts to change the current inertias of plastic consumption, recycling, and pollution must continue. Such efforts must also include productive collaborations with concerned communities to answer four key questions:

(i) Where does this pollution come from?
(ii) How much plastic pollution is in the world's oceans and coastal zones?
(iii) What are the consequences for the biosphere?
(iv) What are possible solutions to the problem of plastic pollution in marine environments?

Our work in the Canary Islands addresses these questions by creating dialogue between local stakeholders and the scientific community, and by focusing on a specific component of the problem: micro-plastics. We chose micro-plastic pollution because it is a wide-spread problem and because the local populations and administrations working with us are struggling to confront it. The first step of this collaborative project was to determine the extent of micro-plastic pollution in the study area, in order to evaluate the magnitude of the problem, identify the most vulnerable sites, and establish baseline data for future actions.

Our study area included three of the Canary Islands in the Canary Current, located off the northwestern coast of Africa in the Atlantic Ocean. The studied islands were: Lanzarote, La Graciosa, and Fuerteventura, which share the same volcanic shelf (Fig. 1). They belong to the same national and regional governments, but have distinct local administrations. This area contains many well-preserved and protected natural areas, including: national parks, natural parks, marine protected areas, and Natura-2000 areas. It also contains two distinct UNESCO Biosphere Reserves.

The islands are relatively rural. In 2012, Lanzarote and La Graciosa had a combined population of 138,364 residents and Fuerteventura had 103,423 residents. However, they experience a tremendous influx of tourists every year: in 2012, Lanzarote and La Graciosa had 839,290 visitors and Fuerteventura had 296,907 (National Statistics Institute, *www.ine.es*).

The study area supports a fragile eco-systemic equilibrium, which includes the following flora and fauna: over 40 species of endemic plants; more than 350 species of terrestrial invertebrates, 15 of which are endemic and exclusive to the study area; numerous marine birds and raptors, four species of which are in danger of extinction; one species of terrestrial mammal, *Crocidura canariensis*; 304 species of macroalgae and one phanerogam in the marine environment, the greatest example of biodiversity in the Canary Islands; 20 threatened marine invertebrates, classified through a combination designations from the ICONA and Catalog of Threatened Species of the Canary Islands (2001); four species of marine reptiles threatened by extinction: *Caretta caretta, Eretmochelys imbricate, Chelonia mydas,* and *Dermochelys coriacea;* and nine species of marine mammals, five species of which are in danger of extinction.

Unfortunately, the extensive protections for this area are not sufficient to prevent plastic pollution from threatening the ecology of its coasts and its larger ecosystem. The plastic pollution we found here largely originates inland, from sources ranging from local urban areas to urban areas in other countries, where it is typically transported to the ocean by water runoff and wind. In addition to land-based pollution, plastics also reach the ocean through sea-based industrial activity and unregulated or illegal trash dumping from shipping activity (Whiting, 1998; Lewis et al., 2003; Edyvane et al., 2004; Ng and Obbard, 2006). The Canary Current brings this pollution from the open Atlantic Ocean to the Canary Islands and deposits it on their shores.

This article presents the first published research results from a longitudinal project that began at the end of 2008, and will continue to 2020. The project focuses on Atlantic coastal zones, beginning with the Canary Islands, and its main goal is to develop common solutions to the ecological issues threatening these areas while working collaboratively with coastal communities and keeping their values at the core of the project. The problem of plastic pollution in this region was identified as the team's research priority for three reasons: (1) it reflects the extreme fragility of planetary equilibrium; (2) it represents the evident risks threatening preservation and development in the area; and (3) of identified critical concerns, the issue of plastics drew the most support from stakeholders and citizens associated with the project. Within the larger issue of plastic pollution, the initial research of this project focused on determining the extent of micro-plastic pollution in the area. Both macro- and micro-plastics are the main visible pollutants in the study area.

For this study, we define micro-plastic as a piece of plastic with at least two of its three dimensions less than 5 mm. Such criteria are applied in order to quantify the plastic that cannot be cleaned

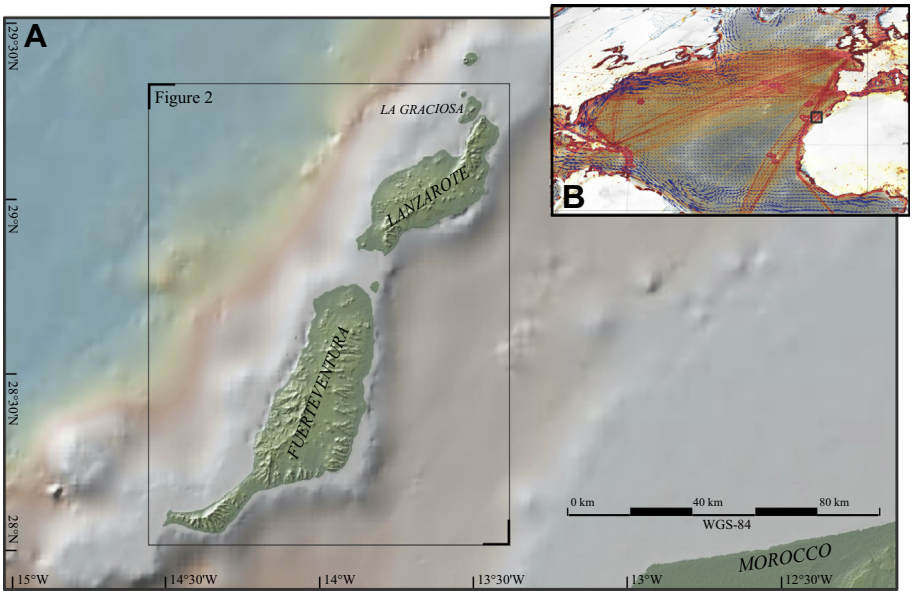

Fig. 1. (A) The three islands in study area, from North to South: La Graciosa, Lanzarote and Fuerteventura, in frame and (B) we observe the oceanographic conditions and the Atlantic regional context of anthropogenic impact (Halpern et al., 2008; GPWv3, 2011).