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Composition, spatial distribution and sources of macro-marine litter on the Gulf of Alicante seafloor (Spanish Mediterranean)

Santiago García-Rivera[a,b,*], Jose Luis Sánchez Lizaso[a], Jose María Bellido Millán[b]

[a] Unidad de Biología Marina, Departamento de Ciencias del Mar y Biología Aplicada, Universidad de Alicante, PO Box 99, Edificio Ciencias V, Campus de San Vicente del Raspeig, E-03080 Alicante, Spain

[b] Instituto Español de Oceanografía, Centro Oceanográfico de Murcia (IEO), C/Varadero 1, Apdo. 22, San Pedro del Pinatar, 30740 Murcia, Spain

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ABSTRACT

The composition, spatial distribution and source of marine litter in the Spanish Southeast Mediterranean were assessed. The data proceed from a marine litter retention programme implemented by commercial trawlers and were analysed by GIS. By weight, 75.9% was plastic, metal and glass. Glass and plastics were mainly found close to the coast. A high concentration of metal was observed in some isolated zones of both open and coastal waters. Fishing activity was the source of 29.16% of the macro-marine litter, almost 68.1% of the plastics, and 25.1% of the metal. The source of the other 60.84% could not be directly identified, revealing the high degree of uncertainty regarding its specific origin. Indirectly however, a qualitative analysis of marine traffic shows that the likely sources were merchant ships mainly in open waters and recreational and fishing vessels in coastal waters.

1. Introduction

Marine litter is a consequence of human action and behaviour, whether deliberate or accidental. It is also the result of deficient waste management and a lack of public awareness of the potential consequences of inappropriate waste disposal (Andrady, 2011) (UNEP, 2009).

Marine litter is defined as any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment (Galgani et al., 2013). It includes any item made or used by people and deliberately discarded or unintentionally lost in the sea and along the coastline, or transported into the marine environment by rivers, drainage, sewage systems or winds. This definition does not include semi-solid remains of for example vegetable and mineral oils, and chemicals that often pollute sea and shores. The Technical Subgroup on Marine Litter under the Marine Strategy Framework Directive suggested a Master List of Categories to differentiate marine litter by size (macro, *meso* and micro) and by material (8 materials with 217 categories) (Galgani et al., 2013).

Around 6.4 million tonnes of litter ends up in the oceans each year, which is distributed among all the oceans in both densely populated and remote areas far from human contact (UNEP, 2009). The increase in marine litter is closely linked to the development of plastics worldwide (Bergmann et al., 2015). Since the 1950s, the total amount of plastic produced (and thus its waste) has increased continuously at about 4% per year, to an estimated 288 million tonnes in 2012 (Ramirez-Llodra et al., 2013; Bergmann et al., 2015). As a consequence, the abundance of plastics at sea has significantly increased over time (Thomson et al., 2004). In the meantime, a large amount of other marine litter categories has also proliferated, such as metal, glass, rubber, wood, paper, textile or fishing items (Serrano et al., 2012; Ramirez-Llodra et al., 2013; CIESM, 2014; Ioakeimidis et al., 2014; Neves et al., 2015a; Strafella et al., 2015). Marine litter is present on beaches, floating, on the seafloor, inside and on biota and as microlitter in the environment (Galgani et al., 2013). At sea, an estimation of the marine litter distribution shows 15% floating on the sea surface, another 15% remains in the water column and 70% lies on the sea floor (UNEP, 2005).

Marine litter is certainly a problem due to its causing detrimental effects on the environment, whether social, economic or ecological damage (Nash, 1992; Barnes, 2002; Katsanevakis et al., 2007; Baeta et al., 2009; Gregory, 2009; UNEP, 2009; Mouat et al., 2010; Andrady, 2011; Cole et al., 2011; Ramirez-Llodra et al., 2011; Serrano et al., 2012; Neves et al., 2015b).

The Mediterranean Sea is the most affected area in the world with the highest amounts of municipal solid waste generated annually per person (208–760 kg/year (Anon, 2014). Considering already existing data, this sea may be the most affected in Europe, with densities higher

* Corresponding author at: Unidad mixta de investigación, Instituto Español de Oceanografía, Universidad de Alicante, PO Box 99, Edificio Ciencias V, Campus de San Vicente del Raspeig, E-03080 Alicante, Spain.

E-mail addresses: sgarcia.rivera@ua.es (S. García-Rivera), jl.sanchez@ua.es (J.L.S. Lizaso), josem.bellido@mu.ieo.es (J.M.B. Millán).

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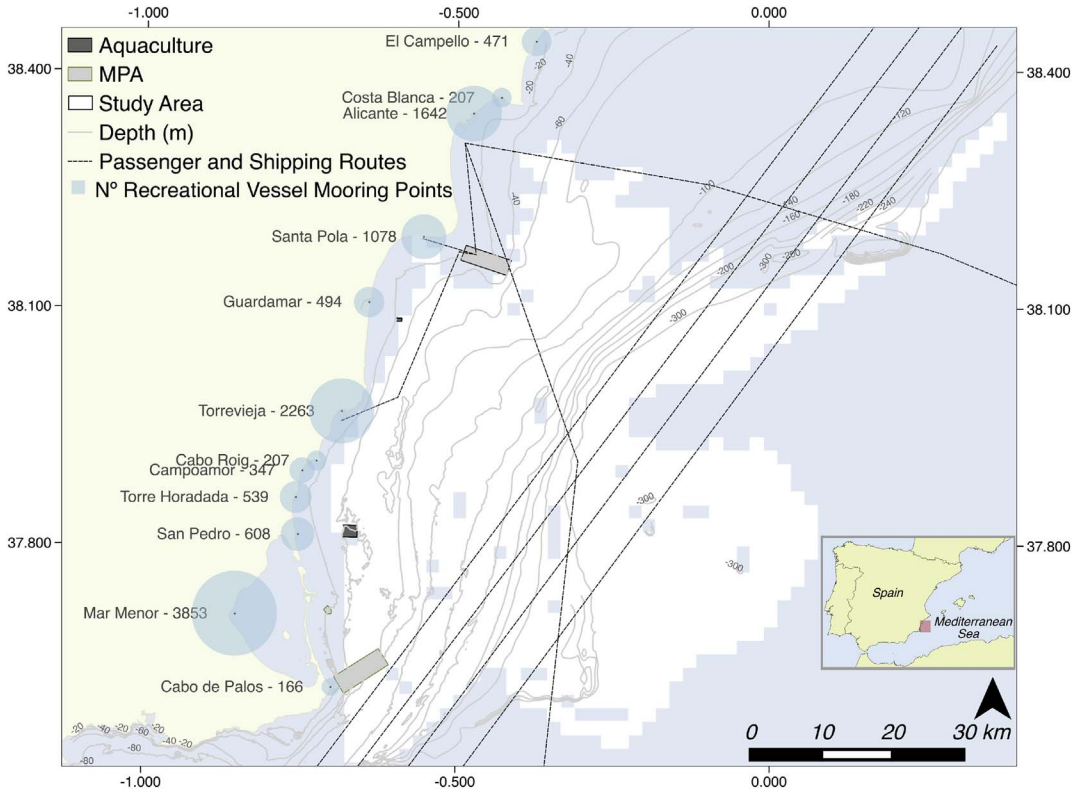

Fig. 1. Location of the study area and its activities. The number next to city/area and blue circles show the number of recreational vessels mooring points. MPA is Marine Protected Area. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

than 100,000 items/km^2 on the seafloor close to metropolitan areas (Galgani et al., 2013). It also has the fourth highest concentration of floating marine litter in the world with 22,000 t, representing 9% of the total (Eriksen et al., 2014; Suaria et al., 2016). The quantity of marine litter shows spatial variability across the Mediterranean Sea (Galgani et al., 2013), but on the seafloor in some areas it is equal to or greater than the biomass of megafauna (Ramirez-Llodra et al., 2013).

Two main categories of litter sources can be distinguished: land-based and ocean-based. Land-based sources include urban areas, industry, tourism, harbours, unprotected landfills, sewage outflows and accidental losses carried to the sea by local winds, rivers and runoffs. Ocean-based sources comprise shipping, ferries, fishing vessels, recreational boats and offshore installations, including aquaculture farms (Galgani et al., 2013; CIESM, 2014; Strafella et al., 2015; Pasquini et al., 2016; Melli et al., 2017).

On examining every item of marine litter individually, some can be attributed to sources such as fishing activities, sewage, tourism (Galgani et al., 2011) or shipping (Ramirez-Llodra et al., 2013), with a high level of confidence. These findings provide valuable information to set up marine litter reduction measures (Galgani et al., 2011). However, total identification of sources is generally very difficult, since some items may have several possible sources (Strafella et al., 2015; Pasquini et al., 2016; Melli et al., 2017).

The wide distribution, impact and persistence of marine litter are of particular concern regarding human and environmental health (Engler, 2012). Consequently, in recent years marine litter is now subject to increased interest from both researchers and policy makers, due to the need to reduce it significantly (Mouat et al., 2010). In fact, it is specifically addressed by EU legislation in the Marine Strategy Framework Directive (MSFD 2008/56/EC). Identifying the sources of marine litter is the first step in establishing measures to reduce marine litter, in order to prioritise the effort and focus on the most important culprits.

Through the MSFD, the European Commission lays down the framework for Member States (MS) to reach a Good Environmental Status (GES) for EU marine waters by 2020, setting 11 descriptors (Directive 2008/56/EC). Among them, descriptor number 10 focusses on litter, defining the GES when *properties and quantities of marine litter do not cause harm to the coastal and marine environment* (Directive 2008/56/EC).

According to the Commission Decision 2010/477/EU, descriptor 10 has indicators pertaining to the *Characteristics of litter in the marine and coastal environment (10.1)* and *Impacts of litter on marine life (10.2)*. The former includes *the trends in the amounts of litter […] deposited on the* seafloor, *with analysis of its composition, spatial distribution and, where possible, source* (10.1.2).

In 2012, Spain developed a Marine Strategy for its territory, establishing five marine areas. One of them is the Levantine-Balearic area in the Western Mediterranean Sea, comprising the Mediterranean waters between Gata Cape the French border and the Balearic Islands. The Marine Strategy report for this area shows marine litter reference levels based on the 2006, 2007 and 2010 data. However, it also shows information gaps and research was and is still required regarding the composition, distribution and possible sources of litter (Serrano et al., 2012).

The main objective of this work is therefore to determine the composition, spatial distribution and when possible source, of macrolitter deposited on or over the continental shelf. To achieve this goal, a litter retention programme was established with the cooperation of two trawling fleets, according to the protocols issued by the European Commission in the Guidance on Monitoring of Marine Litter in European Seas (Galgani et al., 2013). The information provided by this study will aid in improving marine governance, awareness and ecosystem health.