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Spatial distribution of floating marine debris in offshore continental Portuguese waters

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ABSTRACT

This study presents data on abundance and density of macro-floating marine debris (FMD), including their composition, spatial distribution and potential sources off continental Portugal. FMD were assessed by shipboard visual surveys covering ±252,833 km^2 until the 220 nm limit. The FMD average density was 2.98 items/km^2 and abundance amounted to 752,740 items. Unidentified plastics constitute the major bulk of FMD (density = 0.46 items/km^2; abundance = 117,390 items), followed by styrofoam, derelict or lost materials from fisheries, paper/cardboard and wood material. The North sector of the area presents higher FMD diversity and abundances, probably as a result of the high number of navigation corridors and fisheries operating in that sector. Most FMD originate from local sources, namely discharges from vessels and derelict material from fisheries. Considering the identifiable items, cables and fishing lines were the only fishing related items among the top ten FMD items in Portuguese offshore waters.

1. Introduction

Pollution by marine litter is presently recognized as a worldwide problem and a major threat to marine ecosystems (Galgani et al., 2010; Cole et al., 2011; Hammer et al., 2012; Depledge et al., 2013; Pham et al., 2014). Some of the major impacts of marine debris on marine fauna are related to entanglement and ingestion, mostly due to several types of plastics (e.g. synthetic fiber ropes, plastic sheets and strapping tape) or discarded fishing gear (e.g. rope, nets, lines and trawls) particularly affecting seabirds (Votier et al., 2011), sea turtles (Casale et al., 2010; Vélez-Rubio et al., 2013) and marine mammals (Boren et al., 2006).

Entanglement consequences to marine animals range from restriction of movements to amputation and death (Marine Mammal Commission, 2001; Derraik, 2002; National Research Council, 2009). Ingestion of marine debris by marine animals (Ryan, 2008; Bond et al., 2013; Campani et al., 2013; Codina-García et al., 2013; Schuyler et al., 2014) can cause physical blockage in the digestive system and reduced absorption of nutrients (National Research Council, 2009), leading to starvation or digestive injuries and death (Derraik, 2002).

Plastics are predominant among marine litter worldwide (Derraik, 2002; UNEP, 2009; Depledge et al., 2013) being presently considered a serious hazard to the environment (GESAMP, 2010; Hammer et al., 2012). Most plastics degrade slowly into different sized objects ultimately becoming microplastics measuring <5 mm in diameter (Arthur et al., 2009), which represent a long-term threat to entire marine food webs (Andrady, 2011; Cole et al., 2011; Martins and Sobral, 2011; Fossi et al., 2012).

Marine debris can be found floating at the sea surface, in the water column, stranded on coastlines, and/or deposited on the seafloor (Barnes et al., 2009; Ryan et al., 2009; Goldstein et al., 2013; Galgani et al., 2015) including the Arctic (Bergmann and Klages, 2012; Bergmann et al., 2015) and surveying the different marine compartments requires different methodologies (Ryan et al., 2009; Galgani et al., 2013, 2015). Larger debris on beaches are surveyed by item counts along transects, floating debris are surveyed by ship-based observations of the sea surface, and sank/deposited debris on the seafloor are surveyed by bottom-trawls, ROV's and divers. Microplastic surveys require sampling the top of the intertidal and subtidal sediment using appropriate collection instruments, neuston net tows for the sea surface, and zooplankton net tows for sampling the water column (Galgani et al., 2013). Several techniques have been used to assess microplastics in sediments (see Van Cauwenberghe et al., 2015 for a review).

With respect to larger floating marine debris (FMD), representing a wide range of marine litter items floating on the oceans' surface, they

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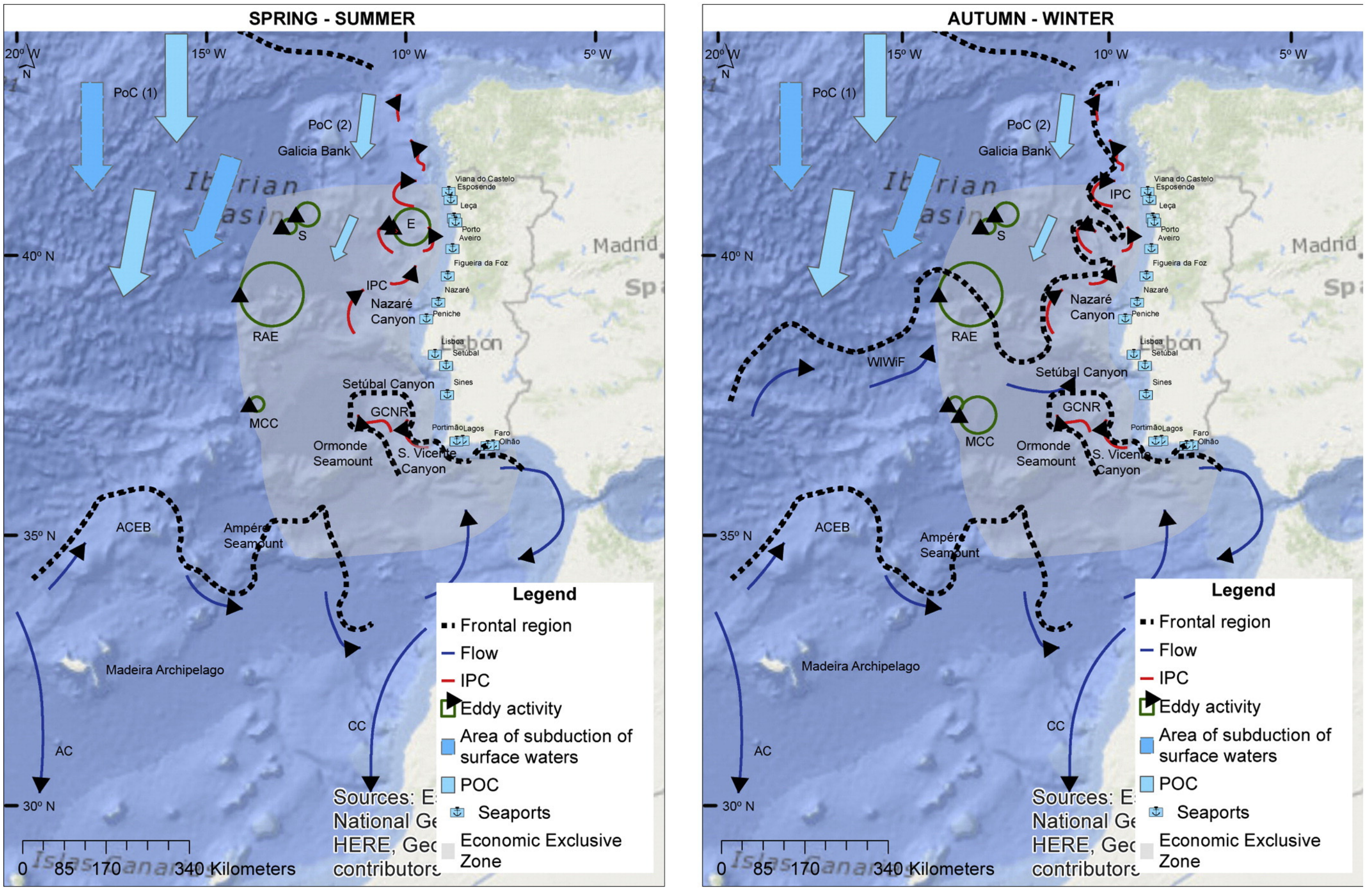

Fig. 1. Schemes of seasonal upper ocean circulation regimes in western Iberia and Gulf of Cadiz. PoC (1), Portugal Current; PoC (2), Portugal Current Eastern Branch; WIWiFs, Western Iberia Winter Fronts; IPC, Iberian Poleward Current; AC, Azores Current; GCNR, Gulf of Cadiz northern recirculation; ACEB, Azores Current Eastern Branch; RAE, Recurrent anticyclonic eddy; S, Swoddies; MCC, Meddies and companion cyclone; E, Eddy activity; CC, Canary current.
Adapted from Peliz et al. (2005) and Mason et al. (2005).

are present in all oceans and higher abundances are frequently found in the principal shipping routes and coastal waters adjacent to major urban regions (Thiel et al., 2003; Hinojosa and Thiel, 2009) and/or along the principal ocean current systems (Kubota, 1994; Shiomoto and Kameda, 2005).

The Portuguese continental waters comprise major shipping corridors connecting the Mediterranean, Northern Europe and the Western Atlantic. Also, fisheries represent a very significant part of the country's economy, with a fishing fleet with over 4800 vessels and more than 20,000 fishing licenses issued annually (INE, 2012). Therefore, ships potentially represent an important source of marine debris. However, no data on FMD abundance was ever recorded in order to evaluate the potential threats to the Portuguese continental marine ecosystems and their species. In fact, the only existing studies referring to marine litter in this region refer to benthic marine debris on the western Iberian continental margin (Mordecai et al., 2011; Neves, 2013), macrodebris and microplastics accumulated on beaches (Martins and Sobral, 2011; OSPAR, 2007; Frias et al., 2010; Antunes et al., 2013), and microplastics in the water column near the coastline (Frias et al., 2014).

According to the Marine Strategy Framework Directive (2008/56/EC), on the determination of Good Environmental Status, marine litter should not cause harm to the coastal and marine environment, and trends in the amount of litter in the water column (including floating at the surface) should be characterized (2010/477/EU). Therefore, the present study provides estimates of abundance and density of floating marine debris, as well as their spatial distribution along the Portuguese Continental offshore waters.

2. Methods

2.1. Study area

The Portuguese continental waters are confined between the 36.5°N and the 41.5°N. The country's EEZ comprises 327,667 km^2. The continental shelf (23,728 km^2) has a narrow profile apart from a region between the river Minho and the Nazaré Canyon. The offshore area is used by fisheries (mainly bottom or pelagic trawlers and long-liners) and hosts several well-defined navigation corridors connecting Europe, Africa and the American Continent.

The surveyed area is influenced by two major current systems: the Canary (CC) and Portugal (PoC) Currents that form the eastern limb of the North Atlantic Subtropical Gyre. Considering the circulation features described in the literature and those recurrently registered in hydrology observations and satellite data (see Mason et al., 2005; Peliz et al., 2005), the Iberian Basin is separated into two distinct areas. A northern area, where the large-scale current flow is predominantly southward due to the Portugal Current (PoC 1) (Fig. 1) and the poleward flow is confined to the vicinity of the slope. To the west, between the Galicia Bank and the coast, southward cold intrusions are recurrently observed (eastern branch of the Portugal Current, PoC 2). In this region there is a recurrent frontal system at about 39–40°N, designated as Western Iberia Winter Fronts (WIWiFs). They represent the transition to the southern area of the Iberian Atlantic Basin. In the southern area, the PoC is less influential and an eastward advection of relatively warm and salty waters becomes important as the main generating mechanism of the poleward flow. In the vicinity of the coast, this front is deflected northward