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Marine litter in the upper São Vicente submarine canyon (SW Portugal): Abundance, distribution, composition and fauna interactions

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ABSTRACT

Marine litter has become a worldwide environmental problem, tainting all ocean habitats. The abundance, distribution and composition of litter and its interactions with fauna were evaluated in the upper S. Vicente canyon using video images from 3 remote operated vehicle exploratory dives. Litter was present in all dives and the abundance was as high as 3.31 items 100 m^{-1}. Mean abundance of litter over rock bottom was higher than on soft substrate. Mean litter abundance was slightly higher than reported for other canyons on the Portuguese margin, but lower in comparison to more urbanized coastal areas of the world. Lost fishing gear was the prevalent type of litter, indicating that the majority of litter originates from maritime sources, mainly fishing activity. Physical contact with sessile fauna and entanglement of specimens were the major impacts of lost fishing gear. Based on the importance of this region for the local fishermen, litter abundance is expected to increase.

1. Introduction

Marine litter has become ubiquitous in all oceans. From the most remote and inaccessible regions of the planet (e.g. Ryan and Moloney, 1993; Benton, 1995; Convey et al., 2002; Bergmann and Klages, 2012) to more common recreational beaches (e.g. Moore et al., 2001; Nagelkerken et al., 2001; Oigman-Pszczol and Creed, 2007; Ariza et al., 2008; Corcoran et al., 2009) marine litter has been accounted in all types, shapes and sizes. Marine litter composition is highly variable, ranging from microscopic plastic particles and fibers (Thompson et al., 2004; Martins and Sobral, 2011; Frias et al., 2014) to more visible items such as boat wrecks (Galgani et al., 1996), oil drums (Watters et al., 2010; Ramirez-Llodra et al., 2011; Schlining et al., 2013) and even radioactive waste containers (Calmet, 1989; Thiel, 2003). Nevertheless plastic, mainly due to its everyday use and high durability, is typically the major constituent of litter found in the marine environment, even in the deep sea (Galgani et al., 1996, 2000; Ryan et al., 2009; Schlining et al., 2013).

Though strong currents and winds may transport litter, particularly the more buoyant, far away from its original source, marine litter will eventually sink to amass in the deep sea. Accumulation occurs in areas of complex geomorphology and where hydrodynamic conditions are more favorable, such is the case of submarine canyons (Galgani et al., 1995, 1996, 2000; Mordecai et al., 2011; Schlining et al., 2013; Pham et al., 2014a). Submarine canyons often act as natural traps, deposits and transport pathways of particles from the shelf to the abyssal plains (Granata et al., 1999; Oliveira et al., 2007; Turchetto et al., 2007) and this same role as been described for marine litter (Galgani et al., 1996; Ramirez-Llodra et al., 2011; Schlining et al., 2013). In the Iberian west coast several major submarine canyons cut across the continental margin: the Mugía, Arosa, Porto, Aveiro, Lisboa, Setúbal, and S. Vicente Canyons (Peliz and Fiúza, 1999). The submarine canyons located off the north-western section of the Portuguese coast have been the subject of research in past years, with research programmes and multidisciplinary projects: OMEX II (1997–2000), EUROSTRATAFORM (van Weering and Weaver, 2007), HERMES (Weaver and Gunn, 2009) and HERMIONE (Weaver et al., 2009) focusing on oceanography, geology and biology of these ecosystems. Under the scope of these later projects, abundance and distribution of marine litter was also studied by Mordecai et al. (2011). Information regarding the canyons located in the south and south-western portions of the Portuguese margin is more limited, and the few studies conducted in the area focus primarily on geology.

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Using underwater video records taken during exploratory surveys, the present study aims to quantify the abundance, distribution and composition of marine litter across the upper section of São Vicente canyon, and describe visible effects of marine litter on the surrounding fauna.

2. Material and methods

2.1. Study area

The study area is located in the southwest coast of Portugal, a mesotidal moderately exposed Atlantic coast (Monteiro et al., in press) with a narrow and steep continental shelf (Peliz and Fiúza, 1999; Relvas and Barton, 2002) and a gentle slope (Alves et al., 2003). The São Vicente submarine canyon, with its head scarp at 70 m below sea level, is one of the major geomorphological features incising this section of the continental shelf and slope (Terrinha et al., 2009). Located approximately 12 km offshore mainland Portugal (Fig. 1), the canyon is shaped as a wide, 120 km long corridor following a NE–SW orientation, aligned with the Odemira–Ávila fault, connecting the Alentejo margin to the Horseshoe Abyssal Plain (Alves et al., 2003; Terrinha et al., 2009).

2.1.1. Oceanography

The ocean circulation patterns in the region are complex and seasonal. Relvas et al. (2007) gives a detailed description of the different mechanisms and interactions affecting the local oceanography. In brief: during the winter season, starting in September–October, dominant winds are mainly westerly and southerly. Slope circulation is typically dominated by a poleward current (transporting warm and saline water), until the spring transition in April–May, when the northerly winds prevail. This current does not influence the shelf except during particular events.

According to Relvas and Barton (2002), coastal circulation depends on wind stress and the pressure gradient along the shore, and their relationship determines the direction and strength of the circulation. Wind-induced upwelling conditions in late spring are observed episodically when favorable winds occur (Peliz and Fiúza, 1999; Relvas et al., 2007).

2.1.2. Sources of land based litter – urban centers and rivers

Most of the land section of the southwest Portuguese coast was designated Protected Landscape in 1988, and in 1995, a Natural Park was created (Parque Natural do Sudoeste Alentejano e Costa Vicentina), including a 2 km wide marine strip along its entire length (Castro and Cruz, 2009). Relatively far from major urban centers and with a small resident population concentrated in small towns and villages, low anthropogenic impacts are expected in the area, with minor levels of sewage and agricultural run-off being the major sources of land based pollution in the adjacent coastal waters. The São Vicente submarine canyon is not fed by any major river course and along the coastline the fresh water inputs are limited to small rivers and streams.

2.1.3. Sources of marine based litter – fishing and other maritime activities

Off the southwest coast of Portugal there are important fishing grounds for local artisanal and industrial fleets operating different metiers targeting several species: surface and deep water longlines, purse-seine, gill nets, trammel nets, pots and traps, finfish and crustacean bottom trawls (Erzini et al., 1996; Gonçalves and Erzini, 1998; Galhardo et al., 2006; Campos et al., 2007; Coelho and Erzini, 2008).

This area is also part of important maritime corridors linking the Mediterranean and North Africa to Northern Europe. Since 2008, a Vessel Traffic Service (VTS) system has been monitoring the maritime traffic to 50 miles offshore mainland Portugal with an average of 800 vessels being tracked daily (MAMAOT, 2012). Taking as a reference the year 2010, the VTS system registered 11.3 thousand merchant ships crossing the Portuguese waters (MAMAOT, 2012).

2.2. Survey

The analysis of litter abundance and composition in the upper São Vicente submarine canyon was based on three exploratory remote operated vehicle (ROV) dives performed in June 2011 by the NGO *Oceana* (Fig. 1). The ROV platform, a *Saab Seaeye Falcon DR* rated 1000 m, was equipped with two forward facing color

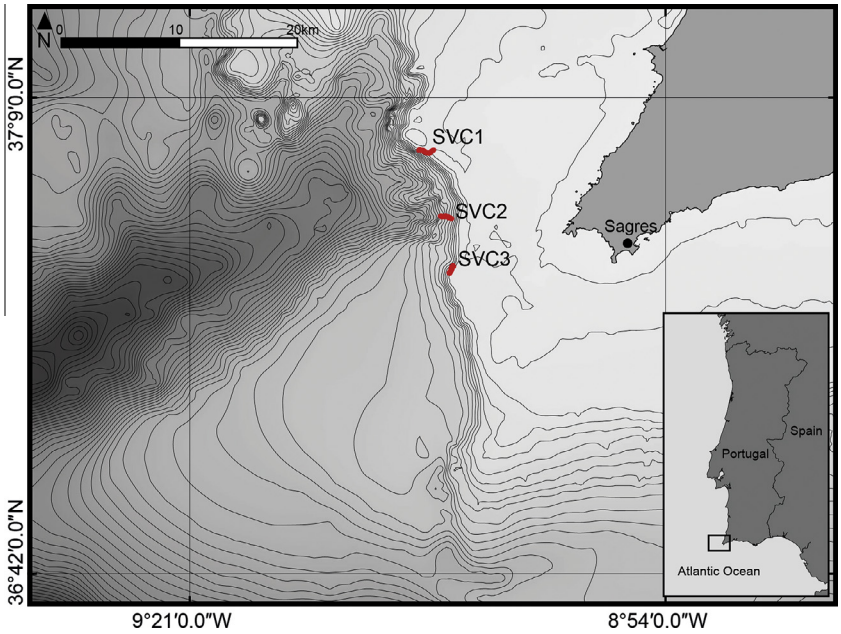

Fig. 1. Location of the dive transects in S. Vicente canyon (SW coast of Portugal). Red lines correspond to the track of each dive performed during the survey. Isobaths represent 50 m depth intervals. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

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