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Baseline

Composition and abundance of benthic marine litter in a coastal area of the central Mediterranean Sea

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ABSTRACT

Abundance and qualitative composition of benthic marine litter were investigated in a coastal area of the central Mediterranean Sea. Almost 30 km of video footage, collected by a Remotely Operated Vehicle between 5 and 30 m depth, were analyzed. Litter density ranged from 0 to 0.64 items/m^2 with a mean of 0.11 (± 0.16) items/m^2. General wastes, made up almost entirely of plastic objects, were the dominant sources of debris representing 68% of the overall litter. The remaining 32% consisted of lost or abandoned fishing gears. Synthetic polymers, considering both fishing gears and general waste, represented 73% of total debris items. Our results are comparable with litter amounts reported in other Mediterranean sites at similar depths. Overall, the results are discussed in terms of monitoring strategy, to support the implementation of the Marine Strategy Framework Directive (2008/56/EC) for descriptor 10 and the Mediterranean UN Environment (UNEP/MAP) regional Plan on Marine Litter.

The pollution of the oceans by anthropogenic litter has been identified as one of the major environmental threats of the twenty-first century (UNEP, 2011). Every year, millions of tons of solid waste are discharged into the sea with harmful environmental implications such as the transport of persistent organic pollutants (POPs; Mathalon and Hill, 2014), the release of toxic compounds (Teuten et al., 2009), the assistance of species transportation (Gregory, 2009; Tutman et al., 2017), the entanglement and mortality of many marine species (Consoli et al., 2018), the alteration of benthic communities structure (Katsanevakis et al., 2007). Moreover, the marine litter has an important impact on the marine trophic web (Carbery et al., 2018; Nelms et al., 2018), being the litter ingestion by marine organisms one of the main threats to biodiversity (Fossi et al., 2018). In addition there are also socioeconomic impacts such as the impact of floating debris on navigation, the reduction of the recreational value of beaches, the loss of income for the tourism industry and damage to fishing gear (CIESM, 2014). The detrimental impact that debris has on marine environment encouraged the UNEP Global Initiative on Marine Litter initiative providing recommendations on the management of this problem and the coordination of regional activities addressing ML, including 12 Regional Seas programmes. At European level, ML represents one of the 11 Descriptors for the assessment of the Good Environmental Status (GES) of marine environment within the European Marine Strategy Framework Directive, MSFD (Directive, 2008; (EU-COM, 2010; Galgani et al., 2013).

The abundance and spatial distribution of marine debris is dependent upon several factors, including its origin/source (e.g., terrestrial and/or maritime), ocean currents, wind patterns and physiographic characteristics (Galgani et al., 2000). The Mediterranean Sea shows the greatest densities of marine litter due to the combination of heavily populated coastlines, coastal shipping traffic and negligible tidal flow (Barnes et al., 2009). Moreover, the Mediterranean Sea is a closed basin with limited water exchange with the Atlantic Ocean through the Strait of Gibraltar (Bergmann et al., 2015).

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The first data on Mediterranean benthic marine litter comes from trawls conducted by commercial and research vessels (Bingel et al., 1987; Cannizarro et al., 1995; Galgani et al., 1996; Stefatos et al., 1999; Galgani et al., 2000; Katsanevakis and Katsarou, 2004; Koutsodendris et al., 2008; Petovic and Markovic, 2013; Ramirez-Llodra et al., 2013; Sánchez et al., 2013; Ioakeimidis et al., 2014; Strafella et al., 2015; Pasquini et al., 2016) and more recently from Remotely Operated Vehicles (ROVs) (Bo et al., 2014; Fabri et al., 2014; Angiolillo et al., 2015; Melli et al., 2017; Consoli et al., 2018) mostly focused on deep rocky bottom. Specifically, in the Strait of Sicily no study on the seafloor marine debris in shallow coastal areas has been made so far. Then, the present research aims to quantify the amount of marine benthic litter on the shallow seafloors along the coasts of south-western Sicily by the use of a ROV. It also represents a pilot study for the monitoring of seafloor ML and its future trend in shallow coastal habitats of the Strait of Sicily, in order to provide data for achieve objectives of the Marine Strategy Framework Directive (2008/56/EC) at national level. In fact, it helps identifying the composition and sources of marine litter under the criteria 10DC1 (Litter stranded and at sea), and supporting the possible implementation of criteria 10DC4 for determining GES of Italian marine waters.

The data on ML occurring in the south-western coast of Sicily were collected during a research cruise carried out on-board the R/V Astrea of ISPRA, during June–July 2012. (See Fig. 1.)

The study area was mapped using a Kongsberg EM2040Multibeam (Kongsberg, Norway), then video sampling was performed along 27 transects carried out by a Remotely-Operated Vehicle (ROV "Pollux III" Global Electric Italiana) between 5 and 30 m depth.

The ROV was also equipped with a digital camera (Canon EOS 5D, 20 megapixel), a high definition video camera (Sony HDR-HC7), two strobes (Canon), and 3 jaw grabbers. The ROV also had a depth sensor, a compass, three parallel laser beams (providing a 10-cm scale for the measurements) and an underwater acoustic tracking position system (Tracklink 1500 MA, Link Quest Inc.) able to give geographic position of the ROV along the seabed. All navigation track data were post-processed and smoothed with a moving average filter. The ROV moved at approximately 1.5 m above the seabed and at a constant speed (approximately 0.5 knots). Along each transect, videos were constantly recorded to quantify the marine benthic litter, and high-resolution images were acquired to better identify the objects.

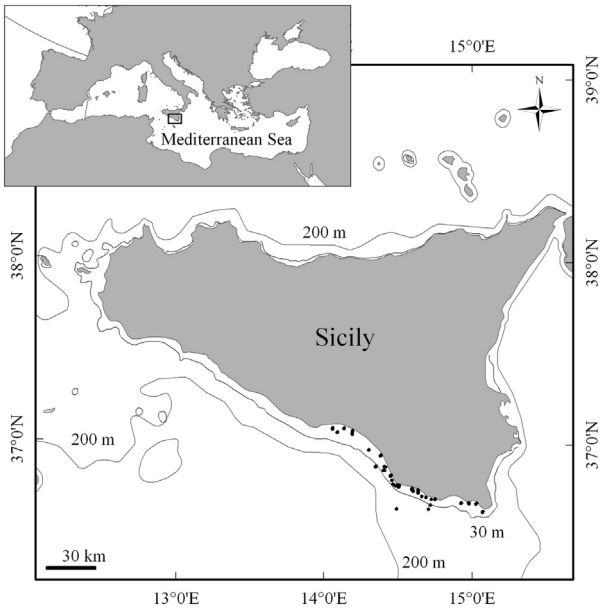

Fig. 1. The study area located in the south-western coast of Sicily. Black points indicate transects mean coordinates performed by ROV.

The investigated area is characterized by mobile bottoms with sporadic rocky outcrops and scattered *Posidonia oceanica* meadows. The whole coastal area is characterized by sandy beaches, very crowded during the summer season, and by thousands of closely packed plastic greenhouses which extend up to the beach.

Each dive was considered as a single continuous transect and all marine debris, defined as all man-made objects, were identified through video recording inspection.

According to Melli et al. (2017) and Consoli et al. (2018), the litter was separated into two main categories according to its source: 'General waste' (Plastic objects, Metal, Rubber, Glass/ceramic, processed Wood, Paper, Textile, other) and 'Fishing gear'. (Fishing lines, Rope, Set net, Trawl net, Trap, Wire, other).

Debris was counted once when it was first observed. Its size, in terms of seabed coverage, was visually estimated as 'Class 1' ($< 1\ m^2$), 'Class 2' (1–10 m^2), 'Class 3' ($> 10\ m^2$). For each debris position and along transects, depth was recorded and the nature of substrate (rocky or soft) was visually estimated; moreover, habitat complexity was described on the basis of three complexity degrees (low, medium and high) according to Consoli et al. (2017) as follows:

- low complexity: soft sediment with/out current ripples, rubbles, gravel; flat hard substrata; low profile;
- medium complexity: soft substrata with scattered boulders and/or pebbles and rocky outcrops; hard substrata with algae and *Posidonia* meadows, benthic invertebrates, pebbles, gravel; medium profile, height < 100 cm
- high complexity: soft substrata with close boulders and/or rocky outcrops; bedrock with walls, ridges, cavities, caves; steeply sloping; high profile, height > 100 cm.

Moreover, the degree of epibiosis (higher or lower than 50% of the debris surface) were also recorded. According to Melli et al., 2017, and Consoli et al. (2018) litter-fauna interactions were classified as 'No effect' (none interaction), 'Entanglement/Coverage' (when organisms were covered or entangled by marine litter but they did not show any visible damage) and 'Physical damage'(when the tissues of the organisms were injured or colonies were broken).

The presence of debris was evaluated in terms of density (debris items/100 m^2). The explored area was calculated by multiplying the transect length by a width of 2 m (the visual field of the ROV when moving at a distance of 1.5 m from the bottom). All debris items within the 2 m transect width, were then quantified. Transect length was calculated using ROV tracks by a geographic information system software (ESRI ArcMAP 10.1). Additionally, using GIS software, it was possible to georeference each occurrence of litter across the sea floor.

The transects total length was 29.8 km whereas single lengths ranged from 270 to 1680 m. Results on transect lengths, litter item and abundance are reported in Table 1.

A total of 56 litter items were observed in the video records from the twenty-seven dives performed on a total area of 59,616 m^2. Density of marine litter ranged from 0 items 100 m^{-2} to 0.64 items 100 m^{-2} with an average (± standard deviation) density of 0.11 (± 0.16) items 100 m^{-2}.

General wastes were the dominant sources of debris contributing 67.86% to the overall litter density. Ropes, disposable crockeries (plastic plates and cups) and pieces of papers accounted for 50% of the total litter density (Table 2). Lower percentages were recorded for plastic objects such as sheets (8.9%) and irrigation pipes (5.4%), most likely coming from the numerous coastal greenhouses.

Regarding litter size in terms of seabed coverage, the most common (92.86%) dimensional class was Class 1 ($< 1\ m^2$).

During the survey interactions between litter and fauna have never been observed. The epibiontic colonization of the debris was very low: only 14.29% of the items presented high fouling levels, with epibionts covering > 50% of their surface. Common organisms colonizing debris