Marine Pollution Bulletin 135 (2018) 845–851

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Note

Dumping to the abyss: single-use marine litter invading bathyal plains of the Sardinian margin (Tyrrhenian Sea)

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ARTICLE INFO

Keywords:
Marine litter
Single use plastic
Sardinia
Trawl surveys
Deep Sea impact

ABSTRACT

This study reports data on benthic litter abundance, composition and distribution obtained during deep-sea trawl surveys conducted along the Sardinian continental margin down to the bathyal plain, at depths comprised from 740 to 1740 m. None of the investigated sites was litter free. Density ranged from a minimum of 4 to a maximum of > 1300 litter items per km^2, with a mean value of 258 ± 59 items. Plastic accounted for 56% of the total collected items, followed by glass (24%), metal (10%). Most items, irrespectively of the category, were single-use items. Fish abundance in all of the investigated catches was significantly higher than the number of litter items, the weight of which was similar to the reared fish biomass. Our results confirm that anthropogenic waste has reached the deep Mediterranean Sea, and that the most recent EU legislation banning single-use plastic tools represents a timely and necessary measure.

The accumulation of man-made marine litter is a global threat that has gained recently a considerable attention by policymakers, who set new conservation targets and promoted changes to old legislations (Woodall et al., 2015). There is an increasing evidence that no ocean is immune from this threat, from tropical to polar regions (Cózar et al., 2017; Galgani et al., 2000, 2013b; Levin and Le Bris, 2015; Pham et al., 2014). In this context, research over decades has focused on investigating the distribution of marine litter, with particular attention on plastic items which, globally, account up to 60–80% of marine litter. This is the ultimate result of 'throwaway' lifestyles, which have been blamed for being responsible of the estimated 4.8–12.7 million metric tons of plastic waste entering our oceans every year (Jambeck et al., 2015).

Evidence is accumulating about the global dimension of marine litter, which is documented in all oceans worldwide. For instance, the presence of plastic (spanning from macro-litter to micro-plastics) has been recently reported in the coastal Antarctica (Munari et al., 2017), Arctic (Peeken et al., 2018), as well as in the deepest portions of the world oceans (Woodall et al., 2014), including the Mariana Trench (ca. 11 km depth) in western Pacific Ocean (Chiba et al., 2018). Moreover, an increasing number of studies is documenting previously unthought patterns of dispersion and transfer of plastic items along the trophic web, involving a variety of organisms ranging from zooplankton to big predators (Bernardini et al., 2018; Carbery et al., 2018; Cole et al., 2013; Macali et al., 2018).

The Mediterranean is among the worlds' seas exhibiting the largest accumulation of marine litter (Eriksen et al., 2014; Pham et al., 2014; Ramirez-Llodra et al., 2011), with > 60 million macro items currently floating on its surface (Suaria and Aliani, 2014). Nevertheless, what remains still largely unknown is the fraction of marine litter that, as it sinks to the seafloor, escapes ours sight. Indeed, studies carried out so far have investigated benthic litter abundance, composition and distribution mostly on continental shelves and slope, whereas data from deeper habitats such as adjacent bathyal plains (Bergmann and Klages, 2012; Galgani et al., 1996, 2000; Pham et al., 2014; Ramirez-Llodra et al., 2013) are far less abundant, mostly due to the difficulties and associated costs of deep-sea sampling (Barnes et al., 2009).

The distribution, abundance and composition of benthic litter in the Mediterranean Sea has a patchy documentation, often obtained with different sampling techniques which, in principle, would not allow a proper comparison among different areas. Different methodologies

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https://doi.org/10.1016/j.marpolbul.2018.08.007
Received 17 June 2018; Received in revised form 27 July 2018; Accepted 1 August 2018

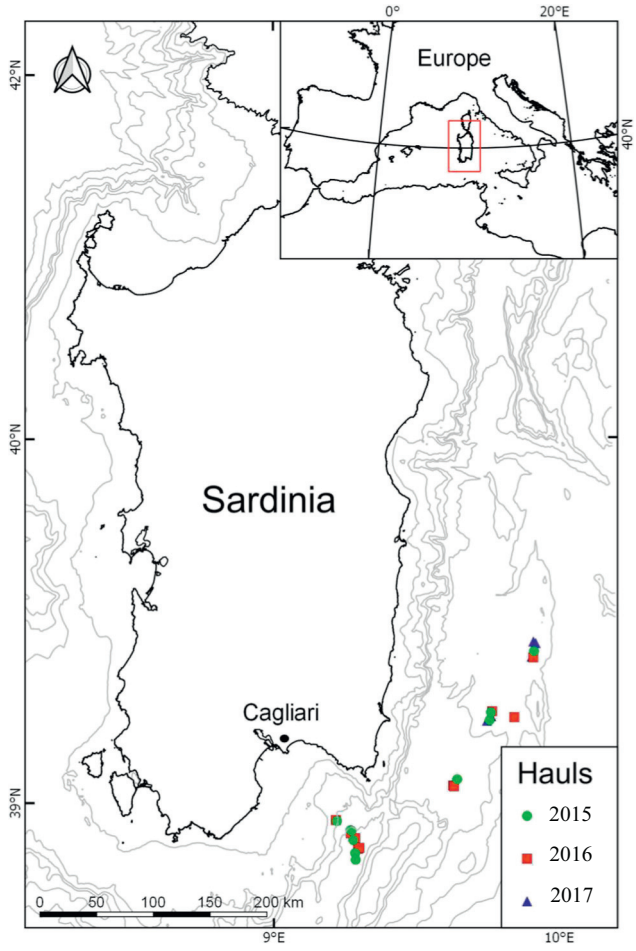

Fig. 1. Location of the study area and hauls carried out in 2015, 2016 and 2017.

basically target different habitats (e.g., soft or rocky incoherent bottoms), similarly to fishermen using different gear to target species according to their characteristics (Moriarty et al., 2016). The most recurrent technique is based on surveys carried out as 'side' parts of other studies focused, for example, on fish stocks (e.g., trawl surveys; Alvito et al., 2018; Pasquini et al., 2016; Strafella et al., 2015) or benthic biodiversity (ROV surveys) (Angiolillo et al., 2015; Cau et al., 2017a; Consoli et al., 2018; Melli et al., 2016).

Marine litter has been recognized a major issue in European Seas since the entering into force of the Marine Strategy Framework Directive (MSFD; 2008/56/EC), within which marine litter quantification is the 10th of the 11 descriptors proposed for evaluating the environmental status of European seas (Galgani et al., 2013a). More recently, the EU, through the recent proposal for an "European Strategy for Plastics in a Circular Economy" (EUR-Lex-52018DC0028), is taking a leading role in the global plastic economy dynamic, with engaged countries cooperating in order to halt the flow of plastics into the oceans and taking remedial actions against plastics waste already accumulated.

Estimates of baseline abundance and composition of litter are vital in order to implement litter reduction policies and adequate monitoring schemes. In this perspective, to provide further evidence of marine litter accumulation in the deep Mediterranean Sea, we analyzed the abundance and composition of benthic marine litter on soft bottoms along the Sardinian continental margin at depths comprised from 740 to 1740 m (Fig. 1; Table 1), for three consecutive years (September 2015, 2016 and 2017).

During the three years of the study, a total of 25 trawl hauls (of which 10 in 2015, 10 in 2016 and 5 in 2017) were carried out using a trawl net used for commercial purpose (mesh size 40 mm) on board of a 35 m-length fishery vessel. All investigated sites are located from 38 to 56 km from the nearest coastline (Fig. 1). Since surveys conducted in the different years were not consistently replicated in the same sites, we did not include temporal variations among sampling years in the analysis and considered all of the hauls as replicates for spatial and bathymetric variations only.

The swept surface (in km^2) of each haul was calculated multiplying

Table 1
Geographical coordinates (decimal), swept surface (km^2) and benthic litter density (n. items per km^{-2}) for the investigated hauls.

Haul ID	Year	Depth (m)	Haul duration (hour:minute)	Latitude (North)	Longitude (East)	Swept area (km^2)	Litter density (n. items km^{-2})
1PSP15	2015	1029	01:58	38.906667	9.450556	0.1763	410.08
2PSP15	2015	991	02:38	38.904722	9.455833	0.2216	423.34
3PSP15	2015	795	01:33	38.940000	9.388611	0.1555	28.46
4PSP15	2015	1090	02:26	38.871389	9.463333	0.2130	279.4
5PSP15	2015	1194	02:12	38.825278	9.471667	0.1415	226.02
6PSP15	2015	1168	02:07	38.801389	9.473611	0.1543	5.45
7PSP15	2015	1419	02:18	39.085556	9.941389	0.1323	204.48
8PSP15	2015	1559	01:48	39.295833	10.093333	0.1028	661.8
9PSP15	2015	1697	01:43	39.540000	10.302778	0.1116	632.71
10PSP15	2015	1513	02:57	39.323889	10.100278	0.1726	161.46
1PSP16	2016	1028	02:45	38.895556	9.452222	0.1832	1305.91
2PSP16	2016	767	01:18	38.943056	9.384167	0.1044	133.67
3PSP16	2016	1089	02:44	38.878333	9.472222	0.2170	3.92
4PSP16	2016	1196	01:52	38.840278	9.485000	0.1619	223.47
5PSP16	2016	1190	01:52	38.843333	9.490833	0.1190	544.62
6PSP16	2016	1417	01:57	39.063333	9.922500	0.1473	105.73
7PSP16	2016	1418	02:24	39.060833	9.926389	0.1661	138.14
8PSP16	2016	1575	01:43	39.305000	10.207500	0.1146	121.07
9PSP16	2016	1702	02:23	39.518056	10.298889	0.1607	179.27
10PSP16	2016	1523	02:11	39.327222	10.105278	0.1701	19.28
1PSP17	2017	1711	02:40	39.520556	10.291667	0.1822	35.62
2PSP17	2017	1699	03:07	39.574444	10.300556	0.1870	8.68
3PSP17	2017	1516	02:25	39.309444	10.100833	0.1715	119.51
4PSP17	2017	1700	02:14	39.568889	10.310833	0.1467	447.87
5PSP17	2017	1484	02:09	39.293333	10.081111	0.1329	43.17