COastal Management and MOnitoring Network

for tackling marine litter in Mediterranean sea

Activity 3.1.1

I- Literature review on litter sources and impact in the Mediterranean Sea environment

Document Information	
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This document (Deliverable 3.1.1 I) is focused on literature review on litter in the different Mediterranean Sea environments in order to define the baseline information of impact.

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1. Presence of marine litter in Mediterranean Sea

The presence, quantity and effects of litter in the marine environment are increasingly worrying, with increasing interest from governments, international and national organisations, private companies, environmental NGOs, the scientific community, media and the general public. The Mediterranean Sea, being a semi-enclosed basin, characterised by a low surface water exchange with the densely populated Atlantic Ocean and subject to high anthropogenic pressures, is particularly sensitive to accumulate high quantities of plastic waste as documented in numerous scientific studies in the literature. Within the COMMON project, a database has been created to collect all the published scientific studies on marine litter and its impacts in the Mediterranean Sea area in order to compare and assess the environmental status of the 5 project areas in the Mediterranean context.

Specifically, this document Deliverable 3.1.1 I is focused on literature review on macro and micro litter presence in the different Mediterranean Sea environments:

- Data on macro and microlitter in surface waters
- Data on macro and microlitter on beaches

For the bibliographic sources, search engines such as *Google* and *Google scholar* and databases such as *ISI Web of Knowledge* and *Scopus* were used. The search lasted until the end of September 2021 and considered the time interval 1980-2021. In total 117 documents published were insert into the dataset and, as can be seen from figure 1, since the 1980s, when their presence in the Mediterranean basin was first highlighted, the number of scientific studies published on these issues has increased steadily. In the last ten years, their number has almost doubled, confirming the seriousness of this problem and the need to identify strategies to mitigate this issue.

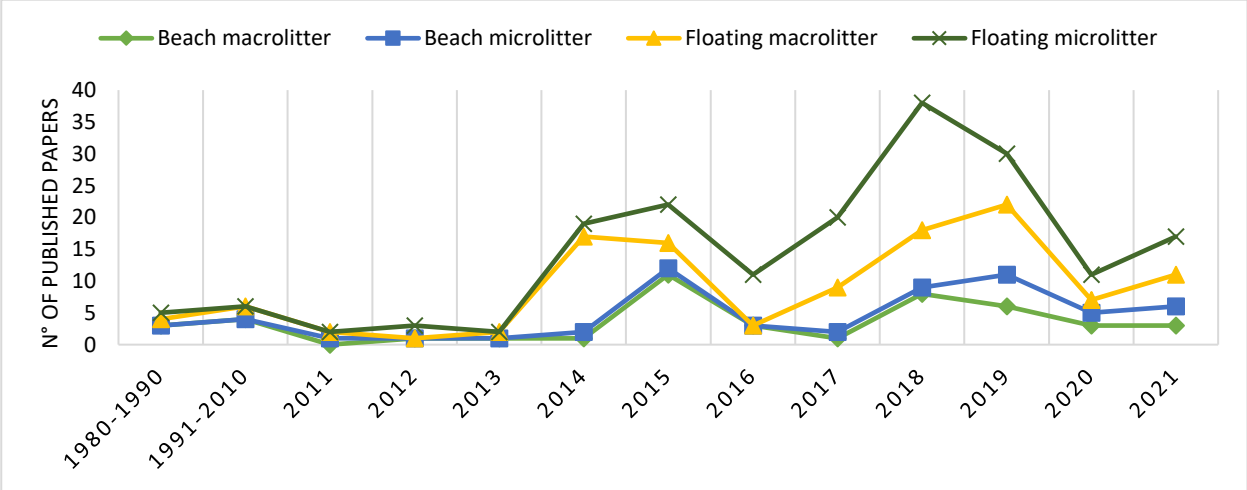

Fig. 1. Number of scientific articles published since the 1980s, concerning the presence of macro and microplastics in the different environmental compartments of the Mediterranean Sea.

Looking at the distribution of these studies in the different basins within the Mediterranean Sea, it is possible to observe that 40% of these studies were carried out in the western sector of the Mediterranean Sea. The Adriatic Sea is the second most studied basin with 21% of the publications, followed by the central and eastern sector both with a value of 16%. The relatively uniform distribution of studies throughout the Mediterranean Sea, underlines once again how the marine litter is a threat present throughout the basin.

2. Presence and distribution of macrolitter and microliter on surface waters

The concentration of marine litter in the surface layers of the Mediterranean Sea is strongly influenced both by the various anthropogenic pressures and by the geomorphological and hydrodynamic factors that characterise this basin locally. The semi-enclosed nature with a low water exchange with other seas and oceans (Cózar et al., 2015; Danovaro et al., 2020) favours the temporary formation of convergence areas for litter (Fossi et al., 2017; Suaria et al., 2016) and it is estimated that 62 million macrolitter objects float on the sea surface of the entire basin (Compa et al., 2019; Suaria and Aliani, 2014). Differences in vessel types used, ranging from small or medium-sized boats (Di-Méglio and Campana, 2017; Fossi et al., 2014; Zeri et al., 2018;) to large vessels (Aliani et al., 2003; Campanale et al., 2018; Ryan, 2013), including ferries and cargo ships (Arcangeli et al., 2018), observation conditions (i.e., observation height and width), sea and wind conditions (Kukulka et al., 2012), survey methods used and technical equipment (e.g., Manta net, Neuston net, WP2) (Collignon et al., 2014; Compa et al., 2020; Fossi et al., 2017; Pedrotti et al., 2016) can also strongly influence marine debris monitoring and collection. Their presence was first highlighted in the 1980s by two studies conducted by Morris and McCoy in the central and eastern parts of the Mediterranean Sea, which found concentrations of 1,300 and 2,000 items per km^2, respectively (McCoy, 1988; Morris, 1980). Since that time, the attention of the scientific community to this issue has increased considerably, as shown by the approximately 80 scientific articles published in the literature to date (Tabs. 1 and 2).

Number of publications on the presence and distribution of microplastics and macro-litter floating on the surface divided by FAO Mediterranean Sea areas.

Concentrations of floating macrolitter are very variable in the different sub-regions considered according to the MSFD classification, and in all cases exceed the median threshold proposed by UNEP/MAP for 2020 (5 items/km^2) (Tab.1). The highest abundances were reported in the Adriatic Sea (avg. 212.4 ± 336.1 items/km^2), followed by the Ionian and CMS (avg. 118 ± 250.7 items/km^2) and the Aegean Levantine Sea (avg. 117.1 ± 162.6 items/km^2). The lowest concentrations were found in the western sector of this basin with an average of 29.7 ± 46.8 items/km^2.

Floating microliter and MPs particularly in the Mediterranean Sea sub-region (Tab. 2) showed an average concentration of 573,703 ± 1,331,658 items/km^2. As mentioned above, the highest average values were reported for the Aegean-Levantine basin (1,964,488 ± 3,224,132 items/km^2) and the Adriatic Sea (498,813 ± 456,768 items/km^2). These two sub-regions showed values exceeding the mean baseline of 340,000

items/km^2 proposed by UNEP/MAP in 2017. In contrast, the western sector (216,399 ± 284,360 items/km^2) and the Ionian and CMS (avg. 197,739 ± 204,808 items/km^2) showed mean concentrations below the proposed threshold. The heterogeneity of the data distribution reported in the Mediterranean Sea could be due to the variability of sea surface circulation patterns, as well as to the location of survey sites (i.e. coastal waters, open sea) and proximity to potential sources of marine debris (i.e. urban and tourist centres, shipping lanes, fishing areas) and transmission pathways (i.e. rivers, sewage treatment plants). In particular, in the Adriatic Sea, land-based sources have been considered as an important input of marine litter (UNEP/MAP, 2015; Vlachogianni et al., 2017, Zeri et al., 2018), with fisheries and aquaculture being important contributors. In addition, freshwater inputs, mainly from the Pò River, are assumed to contribute 46.3 litter items (>3.2 mm) per second to the Adriatic Sea, which has been extrapolated to 120 tonnes per year (Van der Wall et al., 2015). In the eastern part of the Mediterranean Sea, the Lagrangian circulation model worked by Mansui et al. (2015) shows how hydrological conditions make this area more prone to the accumulation of significant amounts of marine litter, as suggested by the high concentration of floating objects (max. 136,514 items/km^2) reported by Tata et al. (2020) and MPs (7,699,716 items/km^2) (Gündoğdu et al., 2018). The western and central sectors of the Mediterranean appear to be less affected by floating litter accumulation, except for the highest levels reported in the waters around the islands of Malta and Gozo (average 681 pieces/km^2) (Curmi and Axiak, 2021). These basins seem to be more affected by currents and hydrological features that promote particle circulation rather than accumulation (Mansui et al., 2015). Nevertheless, some coastal accumulation areas may occur along the Ligurian coast (Fossi et al., 2012, 2017; Panti et al., 2015), between Corsica and the Capraia Islands (Collignon et al., 2014; Fossi et al., 2017) and in the waters off the Balearic Islands (Compa et al., 2020; Ruiz-Orejón et al., 2018).

Tab. 1: Peer-reviewed papers published (update September 2021) on floating macrolitter abundance (items/km^2) in the Mediterranean Sea Sub Regions proposed by MSFD. UNEP/MAP threshold value for the Mediterranean Sea is reported in red.

Mediterranean Sea sub-region	Sampling_area (MPAs)	Vessel speed (kt)	Observed width (m)	Density items/km^2	Min. detected size (cm)	References
Mediterranean Sea	-	-	-	**5**	-	**UNEP/MAP, 2020**
Western Mediterranean Sea	Catalan Sea	n.a.	10	19.7 ± 25.8	n.a.	Garcia-garin et al., 2020
Western Mediterranean Sea	Balearic basin	2	Nets mouth: 0.8×0.6 m.	116.6 ± 254.3 kg/km2	2.5	Compa et al., 2019
Western Mediterranean Sea	Ligurian Sea (Pelagos Sanctuary)	19-25	n.a.	1.8 ± 0.2	20	Arcangeli et al., 2018
Western Mediterranean Sea	Sardinian-Balearic basin	19-25	n.a.	2.5 ± 0.3	20	Arcangeli et al., 2018
Western Mediterranean Sea	Bonifacio Strait (Bouches de Bonifacio)	19-25	n.a.	2.4 ± 0.4	20	Arcangeli et al., 2018
Western Mediterranean Sea	Central Tyrrhenian Sea	19-25	n.a.	2.1 ± 0.4	20	Arcangeli et al., 2018
Western Mediterranean Sea	Sicilian-Sardinian Channel	19-25	n.a.	2.8 ± 0.5	20	Arcangeli et al., 2018
Western Mediterranean Sea	Balearic Sea, Bonifacio Strait and Tyrrhenian Sea	19–25	100	2.3 ± 0.4	20	Campana et al., 2018
Western Mediterranean Sea	Ligurian Sea (Pelagos Sanctuary)	6	n.a.	15 ± 23	1	Di-Méglio and Campana, 2017
Western Mediterranean Sea	Ligurian Sea (Pelagos Sanctuary)	n.a.	20	175.2	2.5	Fossi et al., 2017
Western Mediterranean Sea	Ligurian Sea (Pelagos Sanctuary)	3.2–11.5	50	15 –25 (range)	n.a.	Aliani et al., 2003
Western Mediterranean Sea	Ligurian Sea (Pelagos Sanctuary)	6	n.a.	1.5 - 3.0 (range)	n.a.	Aliani et al., 2003
Western Mediterranean Sea	Ligurian Sea (Pelagos Sanctuary)	10	30	24.9 ± 2.5	2	Suaria and Aliani, 2014
Western Mediterranean Sea	Corsica Channel (Pelagos Sanctuary)	10	n.a.	24.7	2	Suaria and Aliani, 2014
Western Mediterranean Sea	Strait of Sicily	10	n.a.	10.4	2	Suaria and Aliani, 2014
Western Mediterranean Sea	Central Tyrrhenian Sea	10	n.a.	4.9	2	Suaria and Aliani, 2014
Western Mediterranean Sea	South Tyrrhenian Sea	10	n.a.	24.1	2	Suaria and Aliani, 2014
Western Mediterranean Sea	Sea of Sardinia	10	n.a.	19.3	2	Suaria and Aliani, 2014
Western Mediterranean Sea	Balearic Sea	10	n.a.	30.7	2	Suaria and Aliani, 2014
Western Mediterranean Sea	Algerian Basin	10	n.a.	52.9	2	Suaria and Aliani, 2014

Western Mediterranean Sea	Sardinia Channel	10	n.a.	10.9	2	Suaria and Aliani, 2014
Western Mediterranean Sea	Corsica Channel (Pelagos Sanctuary)	7	10	165	2.5	Campanale et al., 2019
Western Mediterranean Sea	Sardinian Sea	7	10	47	2.5	Campanale et al., 2019
Western Mediterranean Sea	Central-southern Tyrrhenian Sea	7	10	16	2.5	Campanale et al., 2019
Western Mediterranean Sea	Strait of Messina	7	10	4.8	2.5	Campanale et al., 2019
Western Mediterranean Sea	n.a.	n.a.	n.a.	40.5	n.a.	Galgani et al., 2013
Western Mediterranean Sea	n.a.	n.a.	n.a.	3.1	n.a.	UNEP/MAP, 2015
Adriatic Sea	Croatia (Archipelago of Zadar)	2–3	7	175 ± 181	2.5	Palatinus et al., 2019
Adriatic Sea	Italy, Slovenia, Croatia, and Montenegro	2–3	10	260 ± 596	2.5–5	Zeri et al., 2018
Adriatic Sea	Italy, Slovenia, Croatia, and Montenegro	26	100	4 ± 3	20	Vlachogianni et al., 2017
Adriatic Sea	Italy, Slovenia, Croatia, and Montenegro	25	8	332 ± 749	2.5	Vlachogianni et al., 2017
Adriatic Sea	Slovenia	n.a.	n.a.	5.7	n.a.	UNEP/MAP, 2015
Adriatic Sea	Slovenia	n.a.	n.a.	2	n.a.	UNEP/MAP, 2015
Adriatic Sea	Central sector	10	n.a.	54.6	n.a.	Suaria and Aliani, 2014
Adriatic Sea	Southwestern sector	10	n.a.	52.1	n.a.	Suaria and Aliani, 2014
Adriatic Sea	Southeaster sector	10	n.a.	25.8	n.a.	Suaria and Aliani, 2014
Adriatic Sea	Central southern sector	19-25	n.a.	4.7 ± 0.5	20	Arcangeli et al., 2018
Adriatic Sea	Northern sector	7	10	414	2.5	Campanale et al., 2019
Adriatic Sea	Central sector	7	10	535	2.5	Campanale et al., 2019
Adriatic Sea	Southern sector	7	10	1,313	2.5	Campanale et al., 2019
Adriatic Sea	Central sector.	n.a.	31	31.5	2.5	Carlson et al., 2017
Adriatic Sea	Southern sector	n.a.	23.6	114.7	2.5	Carlson et al., 2017
Adriatic Sea	Northern central sector	n.a.	10	74.8	2.5	Carlson et al., 2017
Ionian and CMS	Ionian Sea	7	10	100	2.5	Campanale et al., 2019
Ionian and CMS	Ionian Sea	19-25	n.a.	1.9 ± 0.2	20	Arcangeli et al., 2018
Ionian and CMS	Strait of Otranto	10	n.a.	12.9	2	Suaria and Aliani, 2014
Ionian and CMS	North-western Ionian Sea	10	n.a.	21.6	2	Suaria and Aliani, 2014

Ionian and CMS	Sicilian Sea	10	n.a.	6.3	n.a.	Suaria and Aliani, 2014
Ionian and CMS	n.a.	n.a.	n.a.	2.1	n.a.	UNEP/MAP, 2015
Ionian and CMS	Malta and Gozo mpa	n.a.	6	681 ± 1,004	2.5	Curmi and Axiak, 2021
Ionian and CMS	Malta and Gozo mpa	n.a.	6	933 ± 1,594	2.5	Curmi and Axiak, 2021
Ionian and CMS	Malta and Gozo mpa	n.a.	6	1,272 ± 4,403	2.5	Curmi and Axiak, 2021
Ionian and CMS	Malta and Gozo mpa	n.a.	6	2,392 ± 7,477	2.5	Curmi and Axiak, 2021
Aegean-Levantine Sea	Algeria	n.a.	n.a.	136,514 max items	2.5	Tata et al., 2020
Aegean-Levantine Sea	n.a.	n.a.	50	232 ± 325	2.5 - 50	Constantino et al., 2019
Aegean-Levantine Sea	n.a.	n.a.	n.a.	2.1	n.a.	UNEP, 2011
Black Sea	n.a.	n.a.	50	41.5 ± 30.1	2.5	Berov and Klayn, 2021
Mediterranean Sea	n.a.	n.a.	10	19.7 ± 25.8	1.5	Morris, 1980

Tab. 2: Peer-reviewed papers published (update September 2021) on floating microlitter abundance (items/km^2 and corresponding value expressed as items/m^3 "in parentheses") in the Mediterranean Sea Sub Regions proposed by MSFD. UNEP/MAP mean baseline value for the Mediterranean Sea is reported in red.

Mediterranean Sea sub-region	Sampling area (MPAs)	Sampling nets	Net mesh (µm)	Abundance items/km^2 (items/m^3)	References
Mediterranean Sea	-	-	-	340.000	UNEP/MAP, 2017
Western Mediterranean Sea	Ligurian Sea (Pelagos Sanctuary)	Manta trawl	300	59,388 ± 107,913	Tesán Onrubia et al., 2021
Western Mediterranean Sea	Balearic sea, Mallorca	Manta trawl	335	858,029 ± 4,082,964	Compa et al., 2020
Western Mediterranean Sea	Ligurian Sea	Manta trawl	330	255,865 ± 841,221	Caldwell et al., 2020
Western Mediterranean Sea	Balearic sea, (Menorca channel)	Manta trawl	333	224,294	Ruiz-Orejón et al., 2019
Western Mediterranean Sea	Ligurian Sea	Manta trawl	330	28,376 ± 28,917	Caldwell et al., 2019
Western Mediterranean Sea	Alboran and Catalan-Balearic Sea	Manta trawl	330	108,000 ± 90,000	de Haan et al., 2019
Western Mediterranean Sea	Gulf of Lion	Manta trawl	780	112,000	Schmidt et al., 2018
Western Mediterranean Sea	Balearic sea	Manta trawl	333	900,324 ± 1,171,738 (3.28 ± 4.05)	Ruiz-Orejón et al., 2018
Western Mediterranean Sea	Ligurian Sea	High-speed manta trawl	330	82,000 ± 79,000	Fossi et al., 2017
Western Mediterranean Sea	Ligurian Sea	Neuston net	200	125,930 ± 132,485	Pedrotti et al., 2016

Western Mediterranean Sea	Gulf of Lion, Balearic Islands, Sardinia and Corsica	Manta trawl	330	129,682	Faure et al., 2015
Western Mediterranean Sea	Ligurian Sea	WP2	200	115,000	Collignon et al., 2014
Western Mediterranean Sea	Gulf of Lion, Ligurian Sea and Tyrrhenian Sea	Manta trawl	333	116,000	Collignon et al., 2012
Western Mediterranean Sea	Tuscany Coast	Manta trawl	330	69,161 ± 83,244 (0.26 ± 0.33)	Baini et al., 2018
Western Mediterranean Sea	Balearic island and Tyrrhenian Sea	Manta trawl	333	101,408 ± 148,114	Ruiz-Orejón et al., 2016
Western Mediterranean Sea	Cabrera national park	Manta trawl	330	n.a. (3.52 ± 8.81)	Fagiano et al., 2022
Western Mediterranean Sea	Algerian coast	n.a.	n.a.	n.a. (0.86 ± 0.35)	Setiti et al., 2021
Western Mediterranean Sea	Bay of Marseille (Calanque National Park)	Manta trawl	150	n.a. (0.05)	Schmidt et al., 2021
Western Mediterranean Sea	Gulf of Lion	WP2 plankton net	200	n.a. (0.23 ± 0.20)	Lefebvre et al., 2019
Western Mediterranean Sea		Neuston net	200	n.a. (1.00 ± 1.84)	Suaria et al., 2016
Western Mediterranean Sea	Ligurian sea and Asinara National Park	WP2	200	n.a. (0.31 ± 1.17)	Fossi et al., 2016
Western Mediterranean Sea	Ligurian sea and Asinara National Park	WP2	200	n.a. (0.17 ± 0.32)	Panti et al., 2015
Western Mediterranean Sea	Sardinian Sea	Manta trawl	500	n.a. (0.15 ± 0.11)	de Lucia et al., 2014
Western Mediterranean Sea	Ligurian Sea and Sardinian Sea	WP2	200	n.a. (0.62 ± 2.00)	Fossi et al., 2012
Western Mediterranean Sea	Têt river	Manta trawl	333	n.a. (0.18)	Constant et al., 2018
Western Mediterranean Sea	Rhône river	Manta trawl	333	n.a. (0.19)	Constant et al., 2018
Western Mediterranean Sea	Tyrrhenian Sea, Eolie islands	Manta trawl and WP2	333	n.a. (0.27 ± 0.08)	de Lucia et al., 2018
Western Mediterranean Sea	Ischia, Regno di Nettuno MPA	Manta trawl and WP2	333	n.a. (0.49 ± 0.14)	de Lucia et al., 2018
Western Mediterranean Sea	Ventotene MPA	Manta trawl and WP2	333	n.a. (0.20 ± 0.09)	de Lucia et al., 2018
Western Mediterranean Sea	Tyrrhenian Sea	Manta trawl and WP2	333	n.a. (0.23 ± 0.06)	de Lucia et al., 2018
Western Mediterranean Sea	Asinara National Park	Manta trawl and WP2	333	n.a. (0.12 ± 0.04)	de Lucia et al., 2018
Western Mediterranean Sea	Tyrrhenian Sea	Manta trawl and WP2	333	n.a. (0.57 ± 0.16)	de Lucia et al., 2018
Ionian and CMS	Tunisian waters	Manta trawl	200	63,739	Zayen et al., 2020
Ionian and CMS	Italian and Greek waters	n.a.	n.a.	1,300	Morris, 1980

Ionian and CMS	Otranto Strait, North Ionian waters, and Kerkyraikos Gulf	Manta trawl	200	410,000	Digka et al., 2018
Ionian and CMS	n.a.	Manta trawl	333	181,918 ± 242,799	Ruiz-Orejón et al., 2016
Aegean-Levantine Sea	Iskenderun Bay	Manta trawl	333	1,067,120	Gündoğdu et al., 2017
Aegean-Levantine Sea	Iskenderun Bay and Mersin Bay	Manta trawl	333	539,189	Gündoğdu et al., 2018
Aegean-Levantine Sea	Iskenderun Bay and Mersin Bay	Manta trawl	333	7,699,716	Gündoğdu et al., 2018
Aegean-Levantine Sea	Turkish waters	Manta trawl	330	140,418 ± 120,671	Güven et al., 2017
Aegean-Levantine Sea	Iskenderun Bay and Mersin Bay	Manta trawl	333	376,000 (2.73)	Gündoğdu and Çevik, 2017
Aegean-Levantine Sea	n.a.	Manta trawl	333	n.a. (7.68 ± 2.38)	van der Hal et al., 2017
Aegean-Levantine Sea	Lebanese waters	Manta trawl	52	n.a. (4.3)	Kazour et al., 2019
Aegean-Levantine Sea	Turkish waters	Manta trawl	333	n.a. (0.7)	Güven et al. 2017
Aegean-Levantine Sea	Iskenderun Bay	Manta trawl	333	n.a. (7.26)	Gündoğdu 2017
Adriatic Sea	Northern sector	Manta trawl	330	1,200,861 ± 2,683,014	Vianello et al., 2018
Adriatic Sea	Northern sector	Neuston net	300	472,000 ± 201,000	Gajšt et al., 2016
Adriatic Sea	n.a.	Manta trawl	308	228,046 ± 30,060	UNEP/MAP, 2015
Adriatic Sea	n.a.	Manta trawl	308	287,924 ± 52,979.5	UNEP/MAP, 2015
Adriatic Sea	n.a.	n.a.	n.a.	63,175	UNEP/MAP, 2015
Adriatic Sea	Archipelago of Zadar	n.a.	308	127,135 ± 294,847 (0.9 ± 1.9)	Palatinus et al., 2019
Adriatic Sea	Northern central sector	Manta trawl	330	315,009 ± 568,578	Zeri et al., 2018
Adriatic Sea	Northern sector	n.a.	308	259,310 ±57,096	Viršek et al., 2017
Adriatic Sea	Northern sector	Manta trawl	308	1,304,811 ± 609,426	Viršek et al., 2017
Adriatic Sea	Northern sector	Manta trawl	333	178,676 ± 292,753	Ruiz-Orejón et al., 2016
Adriatic Sea	Central sector	Manta trawl	300	n.a. (0.8)	Capriotti et al., 2021
Adriatic Sea	Southern sector, Tremiti islands	Manta trawl and WP2	333	n.a. (0.16 ± 0.04)	de Lucia et al., 2018
Adriatic Sea	Northern sector, Po' river	Manta trawl and WP2	333	n.a. (0.64 ± 0.23)	de Lucia et al., 2018

Adriatic Sea	Northern sector, Po' river	Manta trawl	300	n.a. (1 – 84 range)	Atwood et al., 2019
Black Sea	Marmara Sea	n.a.	333	12,626,775	Tuncer et al., 2018
Black Sea	South-western sector	Manta trawl	300	46,200	Berov and Klayn, 2020
Black Sea	Southern sector	Manta trawl	300	656,000	Oztekin and Bat, 2017
Black Sea	Marmara Sea	Manta trawl	333	n.a. (12.6)	Tuncer et al., 2018
Black Sea	Romanian waters	Neuston net	200	n.a. (7)	Pojar et al., 2021
Black Sea	n.a.	Neuston net	200	n.a. (11,000)	Aytan et al., 2016
Black Sea	North-western sector	Neuston net	200	n.a. (9)	Pojar and Stock 2019
Black Sea	Southern sector	Neuston net	300	n.a. (2.67 ± 2.33)	Oztekin and Bat, 2017
Mediterranean Sea	n.a.	Neuston net	200	243,853	Cózar et al., 2015

3. Presence and distribution of macrolitter and microliter on beaches

Beaches can be defined as a highly dynamic ecosystem in which the presence and distribution of debris are influenced by several factors. The geological setting, the complex hydrodynamics regulated by currents, wave action and tidal excursions that characterize the intertidal zone, and atmospheric events such as rain and wind can combine to promote the presence and distribution of litter (GESAMP, 2019). In this complex scenario, anthropogenic influences (e.g., tourism and recreational activities) and missed or improper recycling and storage processes of waste materials can strongly influence the accumulation of waste. The presence of macro waste, with particular attention to macro and microplastics, has been extensively studied on the beaches of different Mediterranean countries (Tabs. 3 and 4). Due to the different protocols (e.g., OSPAR, MSFD TG 10, EA /NALG 2000, UNEP list, SEACleaner protocol, ICC and UNEP/IOC), frequency and timing, sampling unit monitored (e.g., 50-m transect, 100-m transect, no fixed transect), heterogeneity of the target sampled (macro objects or microscopic particles), and different units of measure used to report results (items/m, items/m^2, items/m^3 and items/kg dry sediment), it is not always possible to adequately compare available data. For this reason, the MSFD Technical Group on Marine Litter (MSFD TG ML) has produced the Joint List (JL), which allows a comparable monitoring of marine litter in the European regional seas and the different marine compartments. It was based on the "Master List" published in 2013 by MSFD TG ML (Galgani et al., 2013) and combines litter types from different monitoring lists (OSPAR, ICES, UNEP, etc.) to provide an updated, refined and fine-tuned list of litter occurring in the coastal and marine environment. Based on a hierarchical system with different levels of detail in the characterization of the

collected objects, starting with the classes of materials they are composed of, the JL aims to facilitate the harmonized collection of litter items and to allow the linking of marine litter monitoring data with the potential sources of pollution to better define the mitigation and prevention actions to be taken (Fleet et al., 2021). Considering the abundance of macrolitter on beaches, the MSFD TG ML has set a threshold of 20 litter/100 m of coastline (Van Loon et al., 2020). Few studies report litter concentrations as suggested by the MSFD, and in every case, these levels exceed the threshold (Fortibuoni et al., 2021; Gjyli et al., 2020; Maziane et al., 2018; Nachite et al., 2019; Vlachogianni et al., 2020). Vlachogianni et al. (2020), who evaluated macrolitter densities on beaches in different sectors of the Mediterranean Sea, reported a mean concentration of 714 items/100m (0.61 items/m^2), with sites in the Adriatic, Ionian and Central Mediterranean Sectors identified as the most polluted. The highest concentrations were also identified in the Aegean and Levantine basins and on the Turkish coast (Gündogdu and Çevik 2019, Gündogdu et al., 2019). This area, already identified as particularly prone to the accumulation of scattered floating marine debris, also appears to be characterized by high flows of stranded objects (Mansui et al., 2015) and MPs, as confirmed by Lots et al. (2017). The presence and distribution of MPs on the beaches of the Mediterranean Sea are highly variable (Tab. 4), with some local pollution hotspots on the coasts of Slovenia (Adriatic Sea) (UNEP/MAP, 2015), the island of Malta (Ionian and CMS) (Turner and Holmes, 2011), Algeria (Western Mediterranean) (Tata et al., 2020), the Tyrrhenian Sea (Cesarini et al., 2021), Turkey and Israel (Aegean Sea) (Lots et al., 2017).

Tab. 3: Peer-reviewed papers published (update September 2021) on beach macrolitter abundance (items/100m, items/m^2 or specified) in the Mediterranean Sea Sub Regions proposed by MSFD. EU MSFD TG 10 and UNEP/MAP 2020 threshold values for the Mediterranean beaches are reported in red.

Mediterranean Sea sub-region	Sampling area (MPAs)	Beach litter Protocol	N°. Items	Density	Reference
Mediterranean Sea	-	-	-	20 items/100m 59 items/100m	Van Loon et al., 2020 UNEP/MAP, 2020
Western Mediterranean Sea	Spain	EA/NALG (2000)	10,101	0.12 items/m^2	Asensio-Montesinos et al., 2019a
Western Mediterranean Sea	Morocco	UNEP/MAP (2016) and EU MSFD TG10	n.a.	0.054 ± 0.036 items/m^2 (390.8 ± 255.3 items/100m)	Nachite et al., 2019
Western Mediterranean Sea	Tyrrhenian Sea (Torre Flavia Wetland)	n.a.	276	n.a.	Battisti et al., 2019
Western Mediterranean Sea	Ligurian Sea (Pelagos Sanctuary)	SEACleaner Protocol:	34,027	1.06 items/m^2	Giovacchini et al., 2018
Western Mediterranean Sea	Ligurian Sea (Pelagos Sanctuary)	OSPAR	500	0.72 ± 0.43 items/m^2 (plastic objects)	Merlino et al., 2020
Western Mediterranean Sea	Morocco	UNEP/MAP 2016	8,021	494 items/100m	Maziane et al., 2018
Western Mediterranean Sea	Tyrrhenian Sea (Torre Flavia Wetland)	n.a.	6,700	n.a.	Battisti et al., 2016
Western Mediterranean Sea	Sardinean Sea (Pelagos Sanctuary)	EU MSFD TG10	39,972	n.a.	Camedda et al., 2021

Western Mediterranean Sea	Spain	n.a.	n.a.	11-2,263 items/100m (range)	UNEP/MAP 2015
Western Mediterranean Sea	Spain	n.a.	n.a.	11-2,137 items/100m (range)	UNEP/MAP 2015
Western Mediterranean Sea	Spain	n.a.	n.a.	2,245 items/m^2	UNEP/MAP 2015
Western Mediterranean Sea	Tyrrhenian Sea	n.a.	n.a.	n.a.	Poeta et al., 2014
Western Mediterranean Sea	France	n.a.	n.a.	2,920 items/m^2	Klosterman et al., 2012
Western Mediterranean Sea	Balearic Islands	n.a.	11,321	36 items/m	Martinez et al., 2007
Western Mediterranean Sea	Spain	n.a.	n.a.	n.a.	Shiber 1987
Western Mediterranean Sea	Spain	n.a.	n.a.	n.a.	Shiber 1982
Ionian and CMS	Corfù	EU MSFD TG10	41,617	0.08 - 0.91 items/m^2 (range)	Prevenios et al., 2018
Ionian and CMS	Greece	n.a.	n.a.	0.715 items/m^2	UNEP/MAP 2015
Ionian and CMS	Greece	n.a.	n.a.	10 – 1218 items/m^2 (range)	UNEP/MAP 2015
Ionian and CMS	Greece	n.a.	110,423	n.a.	Kordella et al., 2013
Aegean-Levantine Sea	Turkey	n.a.	n.a.	19.5 ± 1.2 items/m^2	Gundogu et al., 2019
Aegean-Levantine Sea	Turkey	n.a.	1424	12.2 ± 3.5 items/m^2	Gündogdu and Çevik 2019
Aegean-Levantine Sea	Israel	ICC and UNEP/IOC	69,122	0.12 items/m^2	Pasternak et al., 2018
Aegean-Levantine Sea	Israel	EU MSFD TG10	n.a.	5.1 items/m^2	Portman et al., 2017
Aegean-Levantine Sea	Turkey	EU MSFD TG10	n.a.	0.92 ± 0.36 items/m^2	Aydın et al., 2016
Aegean-Levantine Sea	Greece, Lesvos Island	n.a.	810	n.a.	Katsanevakis et al., 2015
Aegean-Levantine Sea	Turkey	n.a.	n.a.	21,915 kg	Özdilek et al., 2006
Aegean-Levantine Sea	Israel	n.a.	17,355	n.a.	Golik 1992
Aegean-Levantine Sea	Lebanon	n.a.	n.a.	n.a.	Shiber 1979
Adriatic Sea	Southern sector (Torre Guaceto)	EU MSFD TG10	47	0.47 items/m^2	Rizzo et al., 2021
Adriatic Sea	Albania	EU MSFD TG10	n.a.	0.14 items/m^2 (333 items/100m)	Gjyli et al., 2020
Adriatic Sea	Slovenia	n.a.	231	7.2 ± 1.9 - 10.9 ± 6.0 items/kg (range)	Korez et al., 2019
Adriatic Sea	Central sector	OSPAR	2,040	n.a.	de Francesco et al., 2018

Adriatic Sea	Southern sector, Montenegro	EU MSFD TG10	585	n.a.	Šilc et al., 2018
Adriatic Sea	Northern sector, Po' river	UNEP/IOC	2,502	0.2 items/m^2 282– 1,143 items/100m (range)	Munari et al., 2016
Adriatic Sea	Northern sector, Slovenia	n.a.	n.a.	(3.95 items/m)	UNEP/MAP 2015
Adriatic Sea	Northern sector, Slovenia	n.a.	n.a.	3-80 items/100g	Bajt et al., 2015
Adriatic Sea	Northern sector, Slovenia	n.a.	n.a.	1.9 items/m^2	UNEP/MAP 2015
Adriatic Sea	Northern sector	n.a.	n.a.	1.13 items/m^2	UNEP/MAP 2015
Adriatic Sea	Northern sector, Slovenia	n.a.	n.a.	12,158 items/km	UNEP/MAP 2015
Adriatic, Ionian and CMS	Albania, Bosnia and Herzegovina, Croatia, Greece, Italy, Montenegro, and Slovenia	EU MSFD TG10	70,581	0.67 items/m^2	Vlachogianni et al., 2018
Mediterranean Sea	Italy peninsula	EU MSFD TG10	317,745	477 items/100m	Fortibuoni et al., 2021
Mediterranean Sea	Croatia, Cyprus, France, Greece and Italy	EU MSFD TG10	37,991	0.61 items/m^2 (714 items/100m)	Vlachogianni et al., 2020
Mediterranean Sea	Mallorca, Sicily, Rab, Malta, Crete, Rhodes and Mikonos and Cyprus	EU MSFD TG10	162,320	526.9 ± 794.2 items/100m	Grelaud and Zivieri, 2020
Mediterranean Sea	Spain, Italy (Sicily), Turkey, Cyprus and Israel	n.a.	n.a.	32.4 items/m	Gabrielides et al., 1991

Tab. 4: Peer-reviewed papers published (update September 2021) on beach microlitter abundance (items/m^2, items/kg or specified) in the Mediterranean Sea Sub Regions proposed by MSFD.

Mediterranean Sea sub-region	Sampling area (MPAs)	Beach litter Protocol	N°. Items	Density	Reference
Western Mediterranean Sea	Ligurian Sea (Pelagos Sanctuary)	DeFishGear Protocols	n.a.	207 ± 30 items/kg dry sediment	Scopetani et al., 2021
Western Mediterranean Sea	Sardinean Sea (Pelagos Sanctuary)	EU MSFD TG10	72,922	n.a.	Camedda et al., 2021
Western Mediterranean Sea	Tyrrhenian Sea (Torre Flavia Wetland)	EU MSFD TG10	n.a.	140 items/m^2	Cesarini et al., 2021
Western Mediterranean Sea	Algeria	EU MSFD TG10 and OSPAR	1619	182.66 ± 27.32 - 649, 33 ± 184,02 items/kg dry sediment (range)	Tata et al., 2020
Western Mediterranean Sea	Ligurian Sea (Pelagos Sanctuary)	EU MSFD TG10	26,486	535.13 ± 389 items/m^2	Merlino et al., 2020
Western Mediterranean Sea	France, Tet River	n.a.	7,049	166 ± 205 - 58 ± 53 items/kg dry sediment (range)	Constant et al., 2019
Western Mediterranean Sea	Spain, Murcia (Mar Menor Lagoon)	n.a.	742	105.4 ± 9.2 items/kg dry sediment	Bayo et al., 2019
Ionian and CMS	(Malta MPA)	n.a.	10,975	n.a.	Gauci et al., 2019
Ionian and CMS	(Malta MPA)	n.a.	n.a.	14.2 items/m^2	Turner and Holmes. 2011
Ionian and CMS	Greece, Salamina island	n.a.	98	n.a.	Tziourrou et al., 2019
Aegean-Levantine Sea	Cyprus	n.a.	n.a.	45,497 ± 11,456 items/m^3	Duncan et al., 2018
Adriatic Sea	Northern sector	n.a.	3395	2.92 ± 4.86 items/kg dry sediment	Piehl et al., 2019
Adriatic Sea	Northern sector, Slovenia	n.a.	n.a.	MPs large: 516 ± 224 items/kg dry sediment MPs small: 616 ± 325 items/kg dry sediment	UNEP/MAP 2015
Adriatic Sea	Northern sector, Slovenia	Cheshire et al. (2009).	5870	1.25 items/m^2 (MPs: 1.51 items/m^2)	Laglbauer et al., 2014
Mediterranean Sea	Western and eastern sectors	www.lucmicroplastic.wordpress.com	n.a.	291 ± 62 items/kg dry sediment	Lots et al.,2017

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