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MARINE LITTER ASSESSMENT

IN THE ADRIATIC & IONIAN SEAS

2017

THOMAIS VLACHOGIANNI • AIKATERINI ANASTASOPOULOU
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The project is co-funded by the European Union,
Instrument for the Pre-Accession Assistance

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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

Marine litter -any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment- is globally acknowledged as a major societal challenge of our times due to its significant environmental, economic, social, political and cultural implications.

Marine litter related information in the Adriatic and Ionian Seas and furthermore in the Mediterranean, remains limited, inconsistent and fragmented, although it is widely accepted that the Mediterranean is one of the most affected seas by marine litter, worldwide. Effective measures to tackle marine litter in the region are seriously hampered by the lack of reliable scientific data. Within this context the need for accurate, coherent and comparable scientific data on marine litter in the Adriatic and Ionian Seas is evident, in order to set priorities for action and address marine litter effectively, thus ensuring the sustainable management and use of the marine and coastal environment of the Adriatic-Ionian macroregion.

The IPA-Adriatic funded DeFishGear project undertook the challenge to address the need for accurate, coherent and comparable scientific data on marine litter in the Adriatic-Ionian macroregion. The DeFishGear project was a 3-year long project piloting coordinated and harmonized actions on the science-policy-society interface for litter-free Adriatic and Ionian Seas.

The DeFishGear marine litter assessment report presents the results of the one-year long marine litter surveys aiming to assess the amounts, sources and impacts of marine macro-litter in the Adriatic and Ionian Seas. This is the first effort to-date aiming to assess in a coordinated, consistent, comprehensive and harmonized way the amounts, composition and to the extent possible, the sources of marine litter in all marine matrices (beaches, sea surface, seafloor, biota) of seven countries sharing the Adriatic and Ionian Seas. This is, in fact, the first of its kind marine litter assessment - at European and European Regional Seas level - which is based on comparable field data obtained for all marine compartments within the same timeframe, through the application of harmonized monitoring protocols, developed within the framework of the project, thus providing also strategic input with regards to coordinating, harmonizing and even standardizing marine litter monitoring.

This assessment aims to be a direct and concrete contribution to the implementation of the main legislative marine litter related frameworks in the Adriatic-Ionian macroregion, the EU Marine Strategy Framework Directive (2008/56/EC), the UNEP/MAP Regional Plan for Marine Litter Management in the Mediterranean and the EU Strategy for the Adriatic and Ionian Region. Furthermore, it provides valuable information and strategic input to European and European Regional Seas efforts in achieving good environmental status with regards to marine litter.

This assessment is based on one-year long surveys carried out in all marine compartments in the seven countries of the Adriatic-Ionian macroregion, namely Albania, Bosnia and Herzegovina, Croatia, Italy, Greece, Montenegro and Slovenia. More specifically: (i) 180 beach transects were surveyed in 31 locations, covering 32,200 m^2 and extending over 18 km of coastline; (ii) 66 floating litter transects were

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conducted with small-scale vessels covering a distance of 415 km, while a total of 9,062 km were surveyed by observers on ferries; (iii) for the seafloor litter 11 locations were investigated with bottom trawl surveys and 121 hauls were performed, while 38 transects were performed in 10 locations with underwater visual surveys with scuba/snorkelling, thus covering a total area of 5.83 km^2 of seafloor; (iv) for litter in biota 81 hauls were conducted and 614 fish individuals were studied.

The main findings of this assessment can be summarized as follows:

Amounts of marine litter

The average beach litter density of 0.67 items/m^2 (average: 658 items/100m; range: 219-2914 items/100m) found within this study for the Adriatic and Ionian macroregion is considered to be relatively high and is comparable to the values reported by the very few other studies carried out in the region and to the values reported within the updated UNEP/MAP 'Marine Litter Assessment in the Mediterranean'(UNEP/MAP, 2015). Aggregated results on national level showing the abundance of beach litter reveal that the beaches most affected are those surveyed in Croatia (2.91 items/m^2); followed by beaches in Slovenia (0.50 items/m^2); Montenegro (0.37 items/m^2), Italy (0.28 items/m^2), Greece (0.24 items/m^2), Albania (0.22 items/m^2), and Bosnia and Herzegovina (0.17 items/m^2). When assessing the cleanliness of the surveyed beaches following the Clean Coast Index approach, 16% of the beaches were classified as 'Very dirty beach' and 'Dirty'; 32% were classified as 'Moderate';39% were classified as 'Clean'; while 13% were classified as 'Very Clean'. The highest average litter densities were recorded in Zaglav (Vis Island) in Croatia (10.6 ± 3.85 items/m^2), in Ipsos in Greece (0.91 items/m^2) and in Strunjan in Slovenia (0.83 ± 0.28 items/m^2), while the lowest average litter densities were found to be in Issos (0.08 items/m^2), Mega Ammos (0.08 ± 0.09 items/m^2), Chalikounas (0.09 items/m^2) and Kalamas (0.09 ± 0.05 items/m^2) all located in Greece.

The average density of floating macro-litter (items > 2.5 cm) in coastal Adriatic waters obtained by small-scale vessels was found to be 332 ± 749 items/km^2 while the average density of items (items > 20 cm) measured by observers on ferries in the Adriatic-Ionian waters was 4 ± 3 items/km^2. This considerable discrepancy between the two datasets is attributed to the inability of the observers on the ferries to discern small sized items. The highest average abundances were recorded in the coastal waters of Hvar Aquatorium (Croatian coast) (576 ± 650 items/km^2), in the Gulf of Venice (475 ± 1203 items/km^2) and in Cesenatico (324 ± 492 items/km^2). All these areas are directly affected by the major urban-touristic centres located in their vicinity and by pathways such as the Po River. The lowest abundance of floating macro-litter items was found in two enclosed areas that were surveyed (Kotor Gulf-Montenegro and Brac Channel-Croatia). They are isolated areas and were not expected to be affected by the major transportation mechanisms of sea-surface litter, in any case.

The average seafloor litter density found at regional level by bottom trawl surveys was 510 ± 517 items/km^2 (range: 79-1099 items/km^2) and 65 ± 322 kg/km^2 (range: 3-339 kg/km^2). In terms of the amount of litter per surface area (kg/km^2), the DeFishGear results are comparable to those reported by other studies in the Adriatic and Ionian Seas. When comparing the DeFishGear results with other seafloor litter densities reported worldwide, it is evident that the seafloor of the Adriatic and Ionian Seas is impacted by marine litter, with amounts of litter being 2-5 times higher than those reported for some other seas. These surveys showed that the most affected countries are Greece (847 items/km^2), Croatia (679 items/km^2) and Italy (400 items/km^2). The average seafloor litter density found at regional level by visual surveys with scuba/snorkelling was 2.78 ± 3.35 items/100 m^2. It is worth noting that the seafloor litter densities obtained within the DeFishGear project through visual surveys with scuba/snorkelling (27,800 items/km^2) are not comparable to the seafloor litter densities found in the bottom trawl surveys (510 items/km^2) but they are more similar to the beach densities found within this study.

A total of 11 fish species were examined for the presence of marine litter in their gut contents. Marine litter was found in the gut contents of three demersal fish species (*Citharus linguatula, Mullus barbatus,* and *Solea solea*), two mesopelagic species (*Pagellus erythrinus* and *Trachurus trachurus*) and two pelagic species (*Sardina pilchardus* and *Scomber japonicus*) from the Adriatic-Ionian macroregion. More specifically, marine litter was found in *P. erythrinus* and *S. pilchardus* in the N. Adriatic, in *M. barbatus, S. pilchardus, S. solea, T. trachurus* and *S. japonicus* in the S. Adriatic Sea and in *C. linguatula, M. barbatus* and *P. erythrinus* in the NE Ionian Sea, representing 2.6%, 25.9% and 2.7% of examined fish individuals for each area, respectively. The percentage of litter frequency of occurrence (%F) at the regional level was 2.61% for the N. Adriatic, 25.96% for the S. Adriatic and 3.05% for the NE Ionian Sea. The marine litter abundance (%N) of the two common fish species examined in all three areas (*M. barbatus, S. pilchardus*) was statistically higher in the S. Adriatic Sea relatively to the other areas. Ninety three percent (93.2%) of the ingested litter items were found in the guts of the fish caught in S. Adriatic, whereas the remaining 6.8% was observed in the guts of fish from the N. Adriatic and NE Ionian Sea. In the NE Ionian Sea, marine litter was found more frequently in demersal fish whereas in the Adriatic it was mainly detected in the guts of the pelagic fish species.

Composition of marine litter

When it comes to the material composition of litter found in all marine compartments of the Adriatic and Ionian seas, the majority of litter items were artificial polymer materials accounting for 91.1% of all beach litter; 91.4% of all floating litter; 89.4% of all seafloor litter (bottom trawl surveys); 36.4% of all seafloor litter (visual surveys with scuba/snorkelling); 98% of biota; clearly reflecting the global trend of plastics in marine litter composition. On an aggregated basis at regional level, the 'top 20 items' accounted for the vast majority of litter items found in the different marine compartments (beach, sea surface and seafloor). The most abundant items for beaches included: plastic pieces 2.5cm > < 50cm (19.89%), polystyrene pieces 2.5cm > <50cm (11.93%), cotton bud sticks (9.17%), plastic caps/lids from drinks (6.67%), cigarette butts and filters (6.60%), unidentified plastic caps/lids (2.47%), mussel and oyster nets (2.43%), plastic crisp packets/sweet wrappers (2.11%), etc. The most abundant floating litter items were: plastic bags (26.5%), plastic pieces (20.3%), plastic sheets (13.3%), polystyrene fish boxes (11.4%), plastic cover/

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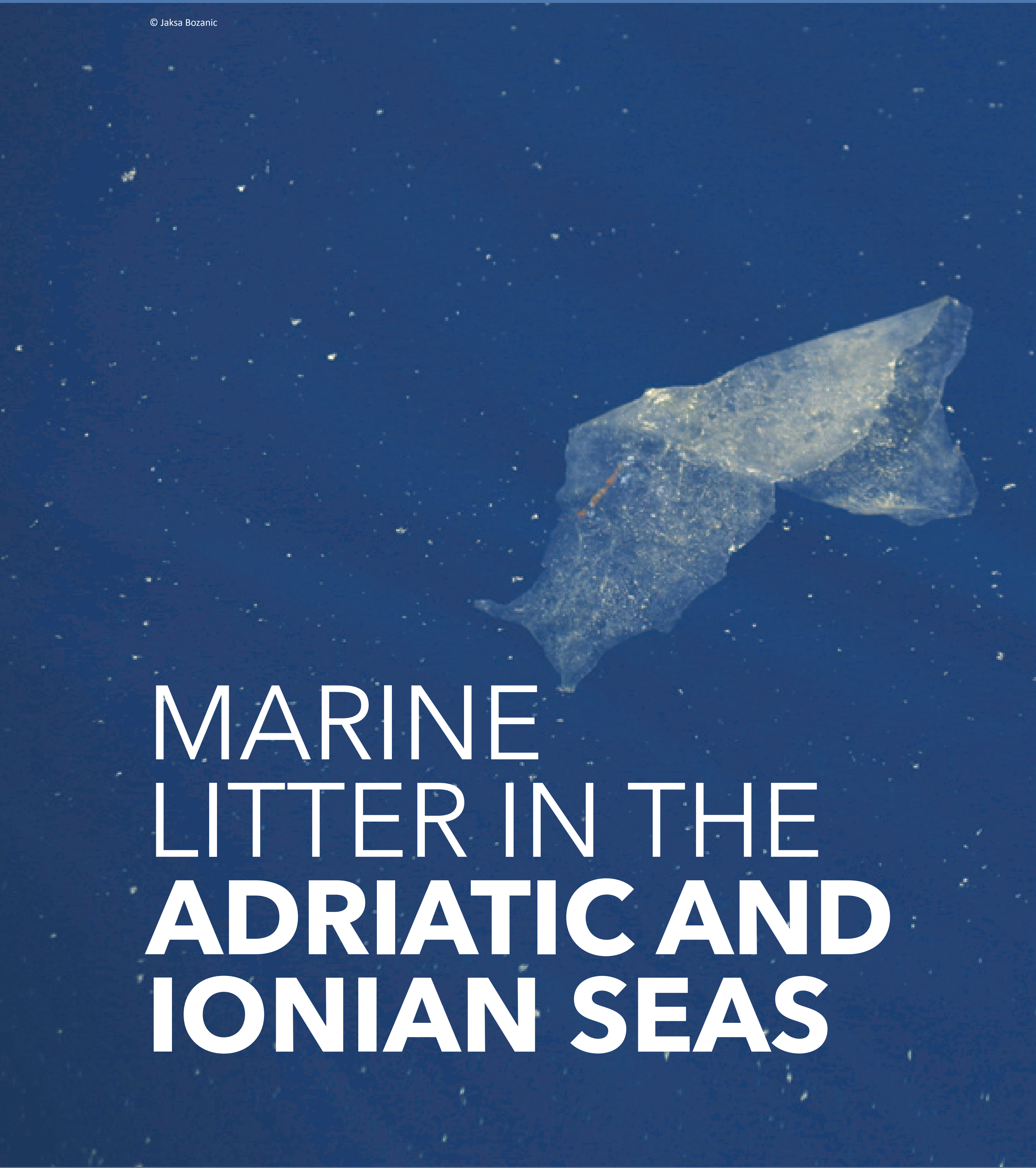
packaging (8.1%), other plastic items (6.0%), etc. Results obtained from the bottom trawl surveys showed that plastic sheets, plastic industrial packaging and plastic sheeting are the most abundant types of litter (27.8%), followed by bags and food containers including fast food containers, both accounting for about 11% of all items recorded. In the visual seafloor surveys with scuba/snorkelling the most common items found were glass bottles or pieces thereof (29.2%), followed by plastic bottles and metal cans (14.3% and 12.1% respectively). The data obtained highlighted the emerging issue of mussel nets ranking in the 7th position of the top 20 items found on beaches, while in Italy these items were the 3rd most abundant items recorded on the seafloor (8.4%).

When it comes to the biota, nine marine litter categories were found in the guts of the examined species in the Adriatic-Ionian macroregion. Among the nine litter categories, filaments < 5 mm accounted for the highest percentage, 79% of the total litter items found to be ingested in all species examined in the Adriatic-Ionian macroregion. The second more abundant litter item was the films < 5 mm with 6%, followed by sheets, industrial packaging and plastic sheeting with 5%. The average litter item per fish (taking into account individuals with litter in their guts) was found significantly higher in the S. Adriatic (average: 2.2 ± 0.22) in relation to other areas (in both the N. Adriatic and SE Ionian Sea, average: 1 ± 0). All marine litter items found in the guts of *C. linguatula* and *P. erythrinus* from the NE Ionian Sea were filaments < 5mm.

Sources of marine litter

The attribution of sources to the litter items collected was a rather challenging task given that on an aggregated basis at national and regional level a considerable amount of items could not be attributed to a source. The methodology followed provided a good basis for detecting the major sources. In particular, the contribution of the fisheries and aquaculture sector to the marine litter issue could be established with a very high level of confidence.

In the present study, litter from shoreline sources -including poor waste management practices, tourism and recreational activities- accounted for 33.4% of total litter items collected on beaches; for the sea surface they accounted for 38.5%; and for the seafloor for 36.6% (bottom trawl surveys), values which are much lower than the Mediterranean average of 52% (UNEP/MAP MEDPOL, 2011) and the global average of 68.2% (Ocean Conservancy, 2011). At a regional level, smoking related items accounted for 7.80% of all items collected, a value which is much lower than the 40% value indicated for the Mediterranean. When looking at the sea-based sources of litter (fisheries and aquaculture, shipping) these ranged from 1.54% to 14.84% between countries, with an average of 6.30% at regional level for beach litter. For floating litter fisheries and aquaculture related items accounted for 8.75% of total sampled litter. The contribution of fisheries and aquaculture related items to the total number of items collected by the seafloor trawl surveys and the seafloor visual surveys with scuba/snorkelling was at regional level 17% and 6%, respectively. This value is much higher than the 5% calculated for the Mediterranean (UNEP/MAP, 2015) and adds to the growing body of evidence that the fisheries and aquaculture industries are largely responsible for marine debris.



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MARINE LITTER IN THE **ADRIATIC AND IONIAN SEAS**

1


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1.1 INTRODUCTION

Marine litter -any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment- is globally acknowledged as a major societal challenge of our times due to its significant environmental, economic, social, political and cultural implications (Galgani et al., 2010, Sutherland et al., 2010). Marine litter negatively impacts coastal and marine ecosystems and the services they provide, ultimately affecting people's livelihoods and well-being (Oosterhuis et al., 2014; Gall and Thompson, 2015; Veiga et al., 2016).

Growing scientific literature (Galgani et al., 2011; Gall & Thompson, 2015) documents the threats that marine litter poses to wildlife and ecosystems, with impacts varying from entanglement and ingestion, to bio-accumulation and bio-magnification of toxics either released from plastic items (e.g. PBDEs, phthalates, Bisphenol A) or adsorbed and accumulated on plastic particles (e.g. POPs, PAHs) (Teuten et al., 2009; Oehlmann et al., 2009; Rochman et al., 2013 & 2014;); facilitation of introduction of invasive alien species (Aliani and Molcard, 2003; Barnes and Milner, 2005); damages to benthic habitats and communities (e.g. through abrasion of coral reefs from fishing gear, disruption of colonies, reduced oxygenation or 'smothering' of communities) (Gregory, 2009; Richards and Beger, 2011).

Marine litter related information in the Adriatic and Ionian Seas as well as in the Mediterranean, remains limited, inconsistent and fragmented, however it is widely accepted that the latter is one of the most affected seas by marine litter worldwide (Cozar et al., 2015; UNEP/MAP 2015). Effective measures to tackle marine litter in the region are seriously hampered by the lack of reliable scientific data. Within this context the need for accurate, coherent and comparable scientific data on marine litter in the Adriatic and Ionian Seas is evident in order to set priorities for action and address marine litter effectively, thus ensuring the sustainable management and use of the marine and coastal environment of the Adriatic-Ionian macroregion.

This document presents the results of the one-year long DeFishGear marine litter surveys aiming to assess the amounts, sources and impacts of marine macro-litter of the Adriatic and Ionian Seas. This is the first-ever effort to-date aiming to assess in a coordinated, consistent, comprehensive and harmonized way the amounts, composition and to the extent possible the sources of marine litter in all marine matrices (beaches, sea surface, seafloor, biota) of seven countries sharing the Adriatic and Ionian Seas. This is, in fact, the first-ever marine litter assessment based on comparable data obtained within the same timeframe for all marine compartments that has taken place in any of the European Regional Seas. Hence, it provides strategic input with regard to coordinating, harmonizing and even standardizing marine litter monitoring.

This assessment aims to be a direct and concrete contribution to the implementation of the main legislative marine litter related frameworks in the Adriatic-Ionian macroregion, the EU Marine Strategy Framework Directive (2008/56/EC) and the UNEP/MAP Regional Plan for Marine Litter Management in the Mediterranean (UNEP/MAP IG.21/9). Furthermore, it provides valuable insights to the EU Strategy for the Adriatic and Ionian Region aiming to address a number of pressing socio-economic and environmental challenges facing the region, among which marine litter.

1.2 THE DEFISHGEAR IN A NUTSHELL

The DeFishGear project was a 3-year long project piloting coordinated and harmonized actions on the science-policy-society interface for litter-free Adriatic and Ionian Seas (Tab. 1.1.). It was implemented within the framework of the IPA-Adriatic Cross-border Cooperation Programme, co-funded by the European Union (Fig. 1.1). The overarching aim of the project was to facilitate efforts for integrated planning to reduce the environmental impacts of litter-generating activities and ensure the sustainable management of the marine and coastal environment of the Adriatic and Ionian Seas. The DeFishGear project provides strategic input to European and European Regional Seas efforts in achieving good environmental status with regards to marine litter.

Figure 1.1. *Map of the eligible areas under the IPA-Adriatic Cross-border Cooperation Programme.*

The DeFishGear main lines of action included the following:

- carrying out a comprehensive assessment of the status (amounts, composition, impacts) of marine litter (macro-litter & micro-litter) in the Adriatic and Ionian Seas through harmonized and coordinated monitoring activities;
- development of recommendations and policy options based on sound scientific evidence and knowledge to meet regional and national objectives regarding marine litter (EU Marine Strategy Framework Directive, UNEP/MAP Regional Action Plan on Marine Litter Management in the Mediterranean and Ecosystem Approach, EU Strategy for the Adriatic and Ionian Region, etc.).
- establishment of a Regional Network of Experts on marine litter;
- development of capacities to monitor marine litter in a harmonized way through reinforced exchange of experiences, techniques and know-how;
- setting up schemes to collect and recycle derelict fishing gear; to carry out 'fishing for litter' activities in an environment-friendly way; to implement targeted recovery of ghost nets; to raise awareness of different target groups (fishermen, policy makers, educational community, etc.) on the impacts of marine litter and the types of action they should undertake to effectively address this issue.

Table 1.1. Key facts and figures for the DeFishGear project.

Title	Derelict Fishing Gear Management System in the Adriatic Region
Acronym	DeFishGear
Funding instrument	IPA-Adriatic Cross-border Cooperation Programme
Theme	Improving marine, coastal and delta rivers environment by joint management in the Adriatic area
Project duration	1 November 2013 – 30 September 2016 (35 months)
Project budget	5,254,186 €
Partnership	National Institute of Chemistry (Slovenia) - Lead Partner Italian National Institute for Environmental Protection and Research (Italy) Ca' Foscari University of Venice, Department of Philosophy and Cultural Heritage (Italy) Mediterranean Consortium (Italy) Regional Agency for Environmental Protection in the Emilia-Romagna region (Italy) Institute for Water of the Republic of Slovenia (Slovenia) University of Nova Gorica, the Laboratory for Environmental Research (Slovenia) Institute of Oceanography and Fisheries (Croatia) Hydro-Engineering Institute of the Faculty of Civil Engineering (Bosnia and Herzegovina) University of Montenegro, Institute of Marine Biology (Montenegro) Agricultural University of Tirana, Laboratory of Fisheries and Aquaculture (Albania) Regional Council of Lezha (Albania) Mediterranean Information Office for Environment, Culture and Sustainable Development (Greece) Hellenic Centre for Marine Research (Greece) Public Institution RERA SD for coordination and development of Split County (Croatia) Euro-Mediterranean Centre on Climate Change (Italy)
Website	www.defishgear.net

1.3 THE DEFISHGEAR MARINE LITTER MONITORING APPROACH

The DeFishGear project undertook the challenge to address the need for accurate, coherent and comparable scientific data on marine litter in the Adriatic-Ionian macroregion in November 2013. The starting point of the marine macro-litter monitoring and assessment related activities of the project was the elaboration of a review on available marine litter data and monitoring methods applied in the region (Vlachogianni and Kalampokis, 2014). This review enabled the establishment of a common understanding and holistic take with regards to the scientific/research advances on marine litter in the region and directly fed into the process of elaborating the monitoring strategy and selecting the methodologies to be applied within the scope of the project. The review document fed directly into the process of defining the key elements for the harmonized marine litter monitoring approach, whose main building blocks were the "Guidance Document on Monitoring of Marine Litter in European Seas" developed by the EU MSFD Technical Sub-Group on Marine Litter (MSFD TG10) (Galgani et al., 2013) and the UNEP/MAP MEDPOL draft Monitoring Guidance Document on Ecological Objective 10: Marine Litter (UNEP/MAP MEDPOL, 2014).

The monitoring methodologies considered to be applied within the DeFishGear pilot macro-litter surveys in all environmental compartments (beach, sea surface, seafloor, biota) are presented in Table 1.2. The key elements of the DeFishGear monitoring approach, including the methodologies to be applied, were elaborated by a group of more than thirty-five marine litter experts from all seven countries of the Adriatic and Ionian Seas, the European Commission, international organizations, including the Regional Sea Conventions (Barcelona Convention, OSPAR Convention), Non-Governmental Organizations and other stakeholders at a dedicated DeFishGear experts group meeting held in Athens, Greece in May 2014.

The working group, after thoroughly reviewing all the considered methodologies, decided that those related to ingestion (turtles) and entanglement (beached animals) are not mature enough and bear inherent difficulties in being carried out within the timeframe of the DeFishGear project. Therefore, they were not taken up.

Based on the discussions held at the aforementioned experts group meeting and taking into consideration the feedback received by the members of the MSFD TG10 at Riga (June 2014), the DeFishGear partners formulated the key elements and parameters of the DeFishGear marine litter monitoring approach (sampling/survey methodologies, site selection, sampling units, frequency and timing of the surveys, etc.). More specifically, the Mediterranean Information Office for Environment, Culture and Sustainable Development (leading the marine monitoring and assessment component of the project) in close collaboration with the involved DeFishGear partners, namely the Agricultural University of Tirana (Albania), the Hydro-Engineering Institute of the Faculty of Civil Engineering (Bosnia and Herzegovina), the Institute of Oceanography and Fisheries (Croatia); the Hellenic Centre for Marine Research (Greece), the Regional Agency for Environmental Protection in the Emilia-Romagna region (Italy), the Italian National Institute for Environmental Protection and Research (ISPRA), the Institute of Marine Biology (Montenegro) and the Institute for Water (Slovenia) prepared the:

- Monitoring methodology for beach litter;
- Monitoring methodology for floating litter;
- Monitoring methodology for seafloor litter (bottom trawl surveys);
- Monitoring methodology for seafloor litter (visual surveys with SCUBA/snorkelling);
- Monitoring methodology for macro-litter ingested by fishes.

In June 2014, some thirty DeFishGear partner representatives as well as invited technical experts gathered in Split (Croatia), in a workshop co-organized by MIO-ECSDE and IWRS, to exchange experiences and know-how with regards to the aforementioned marine litter monitoring methodologies. The participants also had the opportunity to gain hands-on experience on floating macro-litter monitoring at the sea surface, beach litter monitoring, pellets sampling for POPs analysis, on-site identification of synthetic materials with NIR spectroscopy, microplastics sampling, beach sediment sampling for micro-litter, microplastics sample preparation and separation. The workshop was a stepping stone towards harmonized marine litter monitoring in the Adriatic and Ionian Seas.

By November 2014 the DeFishGear project was ready to launch one-year-long coordinated marine litter monitoring surveys in the seven countries of the Adriatic and Ionian Seas, namely Albania, Bosnia and Herzegovina, Croatia, Greece, Italy, Montenegro, Slovenia (Table 1.3).

The DeFishGear project and its respective activities serve as a pilot, showcasing how marine litter coordinated monitoring programmes could be designed and implemented at EU and European Regional Seas level (Box 1.1 and 1.2).

Box. 1.1. *The Marine Litter Descriptor, criteria, and respective Indicators within the framework of the EU MSFD.*

Marine Litter within the EU MSFD

Properties and quantities of marine litter do not cause harm to the coastal and marine environment (Descriptor 10)

Criteria 10.1 Characteristics of litter in the marine and coastal environment

- *trends in the amount of litter washed ashore and/or deposited on coastlines, including analysis of its composition, spatial distribution and, where possible, source (10.1.1)*
- *trends in the amount of litter in the water column (including floating at the surface) and deposited on the seafloor, including analysis of its composition, spatial distribution and, where possible, source (10.1.2)*
- *trends in the amount, distribution and, where possible, composition of microparticles (in particular microplastics) (10.1.3)*

Criteria 10.2 Impacts of litter on marine life

- *trends in the amount and composition of litter ingested by marine animals (e.g. stomach analysis) (10.2.1)*

Table 1.2. Overview of considered monitoring methods to be applied within the DeFishGear macro-litter pilot surveys.

Environmental matrix	Method/ protocol	Level of maturity	Technical requirements	Expertise needed	Implemented
Beach	Visual identification and collection	HIGH	LOW	LOW/ MEDIUM	YES
Floating	Visual identification	HIGH	LOW	LOW/ MEDIUM	YES
Seafloor	Diving Collection and identification	MEDIUM	MEDIUM	MEDIUM	YES
Seafloor	Bottom-trawling collection and identification	MEDIUM/ HIGH	LOW/ MEDIUM	LOW/ MEDIUM	YES
Biota	Fish (ingestion) Visual identification under a stereoscope	LOW	MEDIUM/ HIGH	MEDIUM/ HIGH	YES
Biota	Turtles (ingestion)	MEDIUM/ LOW	LOW	MEDIUM	NO
Biota	Entanglement (Beached animals)	LOW	LOW	MEDIUM	NO

Table 1.3. Overview of surveyed marine compartments per country.

Country	Beach	Sea surface	Seafloor	Biota
Albania				
Bosnia and Herzegovina				
Croatia				
Greece				
Italy				
Montenegro				
Slovenia				

Box. 1.2. The Marine Litter Operational Objectives and respective Indicators within the framework of the Barcelona Convention Ecosystem Approach.

Marine Litter and the Barcelona Convention Ecosystem Approach

10.1. The impacts related to properties and quantities of marine litter in the marine and coastal environment are minimized.

- *Trends in the amount of litter washed ashore and/or deposited on coastlines, including analysis of its composition, spatial distribution and, where possible, source. (10.1.1)*
- *Trends in amounts of litter in the water column, including microplastics, and on the seafloor (10.1.2)*

10.2. Impacts of litter on marine life are controlled to the maximum extent practicable

- *Trends in the amount of litter ingested by or entangling marine organisms, especially mammals, marine birds and turtles (10.2.1)*


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1.4 THE DEFISHGEAR DATA QUALITY ASSURANCE APPROACH

Quality assurance of the data collected within the DeFishGear project has been of integral importance. The data produced by DefishGear were to provide the basis for decisions to be taken towards good environmental status of the Adriatic and Ionian Seas. Therefore, from the design phase of the DeFishGear activities quality control measures were identified and subsequently applied at all stages of the project research activities, during data collection, data recording and digitisation, and data checking.

Given that the quality of data is strongly reliant on the collection method applied, great effort was invested at the start of the project activities to develop comprehensive and standardised protocols for monitoring marine litter in the different marine compartments. Data recording forms were developed with clear instructions on how to record marine litter data. These forms also facilitated the documentation of how these data were collected (metadata). Following the UNEP (Cheshire et al., 2009) and MSFD TG10 (Galgani et al., 2013) guidelines for data quality assurance, high level training to the partners and the organizations involved in the monitoring activities was provided. A capacity building workshop was organized in June 2014 (see para 1.3) and the project partners had the opportunity to frequently meet, review each other's data and provide expert judgement regarding the validity of the measurements. The majority of the project partners are institutions and organizations with extensive experience that provide their technical expertise in the implementation of the MSFD monitoring programmes at national or regional level and the technical work carried out within the UNEP/MAP Regional Plan for Marine Litter Management in the Mediterranean. To ensure enhanced quality of data, measurements were made in replicates (two samplings per location), in a large number of locations, at a high frequency.

Regarding the data digitization and data collation, dedicated reporting spreadsheets were developed for each monitoring protocol applied. The spreadsheets were developed in consultation with all project partners and include detailed labelling of variables and entry names to avoid confusion, controlled vocabularies, code lists and choice lists to minimize manual data entry. Furthermore, a user manual was also elaborated. For the macro-litter pilot surveys the following reporting templates were developed:

- Beach Macro (coded BeMa)
- Biota Macro (coded BiMa)
- Sea surface Macro (coded SsMa)
- Seafloor Macro Scuba (coded SfMaSc)
- Seafloor Macro Trawl (coded SfMaTr)

The data collected were checked by the authors of the report and when necessary they were cleaned, verified, edited, cross-checked and validated. Apart from the automated checking measures embedded in the reporting templates, the authors double-checked the coding of measurements and out-of-range values; checked the data completeness and looked for any double entries of data; made the statistical analyses such as means, ranges, standard deviation, etc.; and peer reviewed the data.

When raw data were digitized, they were collated through an online GIS (Geographical Information System) database management system, a purpose-built database developed within the scope of the project and publicly accessible at http://defishgear.izvrs.si/defishgearpublic. The DeFishGear database uses the "ArcGIS Server" software for spatial manipulation and the "Nukleus GIS" software for viewing environmental information and it is hosted by the Institute of Water of Slovenia. The DeFishGear database uses data entry screens and input masks for data entry and is accompanied by a detailed user manual.

The DeFishGear data were presented, reviewed and discussed in a series of events attended by the UNEP/MAP Secretariat and the UNEP/MAP MEDPOL Focal Points; representatives of the European Commission and the competent authorities of the EU MSs in charge of the implementation of the EU MSFD; experts of the MSFD TG10; representatives of the European Environment Agency, etc. An indicative list of these events is presented in Box 1.3. In addition, almost all project partners have held bilateral meetings to discuss the DeFishGear data with their national UNEP/MAP MEDPOL and MSFD Focal Points. MIO-ECSDE held several meetings with the UNEP/MAP Secretariat to present the advances of the DeFishGear project and upon the Secretariat's request to provide data input to the updated UNEP/MAP Marine Litter Assessment Report in the Mediterranean (UNEP/MAP, 2015).

Box. 1.3. *The Regional Meeting entitled 'Joint commitment for a marine litter free Mediterranean Sea', jointly co-organized by UNEP/MAP and the IPA-Adriatic funded DeFishGear project (Tirana, 19-20 July 2016).*

- *The Regional Meeting entitled 'Joint commitment for a marine litter free Mediterranean Sea', jointly co-organized by UNEP/MAP and the IPA-Adriatic funded DeFishGear project (Tirana, 19-20 July 2016).*
- *The European Maritime Day workshop entitled 'Marine litter and derelict fishing gear: from observation to blue growth", organized by MIO-ECSDE (Turku, 18 May 2016).*
- *The Barcelona Convention COP19 side event entitled 'Tackling marine litter in the Mediterranean', organised by MIO-ECSDE jointly with UNEP/MAP (Athens, 9 February 2016).*
- *The DeFishGear Stakeholders Conference entitled 'Sub-regional cooperation on marine litter management in the Adriatic-Ionian Macro-Region' organized by RERA (Split, 25 March 2015).*

1.5 THE DEFISHGEAR STUDY AREA: THE ADRIATIC AND IONIAN SEAS

The Adriatic Sea is an elongated water body in the central Mediterranean Sea, stretching from NW to SW for some 800 km. It separates the Italian Peninsula from the Balkan Peninsula and extends from the Gulf of Venice to the Strait of Otranto, through which it connects to the Ionian Sea. The countries surrounding the Adriatic Sea are Italy, Slovenia, Croatia, Bosnia and Herzegovina, Montenegro, Albania. The north-western regions of Greece (Thesprotia regional unit and Corfu Island) are in the transition zone between the Adriatic and Ionian Seas. The Ionian Sea is bounded by southern Italy including Calabria, Sicily, and the Salento peninsula to the west, southern Albania to the north, and the west coast of Greece including seven major islands also known as 'the Heptanese'. The Adriatic-Ionian coastline, being long and complex, creates a high diversity of hydrodynamic and sedimentary environments. The Adriatic contains over 1300 islands, mostly located along its eastern, Dalmatian, coast. It is divided into three basins, the northern being the shallowest and the southern being the deepest. The seafloor deepens with regular and gentle gradients in the north and north-western side, thus forming an extending shallow shelf with some 35 m depth from the Gulf of Venice to the Ancona–Zadar transect. The middle Adriatic has an average depth of 140 m while two depressions are formed reaching a depth of approximately 250 m (Pomo Pits). The South Adriatic is characterised by the presence of the deep Jabuka Pit, a depression approximately 1200 m deep, which is restricted by the sill of the Otranto strait to the South. The Otranto Strait, an underwater ridge, is located at the border between the Adriatic and Ionian Seas. The prevailing currents flow counter clockwise (cyclonic) from the Strait of Otranto, along the eastern coast and back to the strait along the western (Italian) coast. A South-North current coming from the eastern Mediterranean flows along the eastern coast and upon reaching the Gulf of Venice is diverted southwards along the western coast until it outflows into the Ionian Sea (Artegiani et al., 1997).

Several rivers outflow into the Adriatic Sea. The most important ones in terms of water and sediment transport are situated in its north-western part (Po, Reno, Adige, Brenta, Tagliamento, Piave and Soča rivers). The contribution of rivers outflowing in the eastern Adriatic coasts is negligible (Rječina, Zrmanja, Krka, Cetina, Ombla, Dragonja, Mirna, Raša, Neretva and Buna/Bojana rivers). Several rivers outflow into the Ionian Sea as well. From the Italian side Sinni, Agri and Basento river; Butrinto River in Albania and several Greek rivers, such as Kalamas, Thyamis, Arachthos, Acheloos, Evinos, Pineios, Alfeios and Neda. The important discharges of nutrient-rich freshwater give rise to biological productivity in the north-western shallow part of the Adriatic Sea and a N-S trophic gradient is established (Giordani et al., 2002). Hence, the northern Adriatic is particularly rich in endemic fish fauna. Overall in the Adriatic Sea, there are at least 410 species and subspecies of fish, representing approximately 70% of Mediterranean taxa, with at least 7 species endemic to the Adriatic. The high biodiversity in the flora and fauna of the Adriatic basin has led to the establishment of some 18 marine protected areas and 10 Ramsar protected wetlands in the Adriatic countries.

The coastal population around the Adriatic basin is more than 3.5 million people; the largest cities are Bari, Venice, Trieste and Split. Fisheries and tourism are the two most important sources of income. In 2000 the total landings of fisheries for the whole basin reached 110,000 tons (Mannini et al., 2012). Its long history, reflected in numerous archaeological sites and medieval cities, make the Adriatic and Ionian Seas a popular touristic destination, with over 200 million overnight stays per year. Maritime transport for both commercial and tourism purposes is quite high given the large number of harbours and marinas situated around the Adriatic and Ionian coasts.

The increased concentration of population and the intensive economic activities, combined with the riverine inputs from large drainage basins (such as the Po), have led to a deterioration of the marine environment of the Adriatic Sea. Eutrophication problems have often been reported (Giani et al., 2012) due to wastewater discharges from the large cities or from agricultural land. In addition, oil spills pose another threat to the marine environment. Recently, marine pollution from solid waste has been identified as a major growing environmental problem for the Adriatic and Ionian Seas.

MARINE LITTER **ON BEACHES**

2

2.1 STUDY AREA

The pilot beach litter surveys were carried out on beaches located in all countries of the Adriatic-Ionian macroregion, namely Albania, Bosnia and Herzegovina, Croatia, Greece, Italy, Montenegro and Slovenia (Fig. 2.1 and 2.2). A total of 31 beaches (locations) (Tab. 2.1) were investigated, which varied in terms of: (i) distance from neighbouring town, harbour, river outflow, shipping lane, etc.; (ii) prevailing sea currents, prevailing winds, beach orientation, beach material type, slope, size, etc.; and (iii) usage, such as tourism and recreational activities, agriculture, industrial activities, etc.

From October 2014 to April 2016 some 180 beach transects were surveyed, covering ~ 33,200 m^2 and extending over 18 km of coastline.

Table 2.1. *Location of beaches surveyed in each country and surveying organization.*

COUNTRY	BEACH LOCATION	SURVEYING ORGANIZATION
ALBANIA	Plepa, Durres	Agricultural University of Tirana (AUT)
	Shengjin, Lezhe	
	Velipoje	
BOSNIA & HERZEGOVINA	Sunce, Neum	Hydro-Engineering Institute of the Faculty of Civil Engineering (HEIS)
	Zenit, Neum	
CROATIA	Zaglav, Vis	Institute for Oceanography and Fisheries (IOF) & NGO SUNCE
	Mljet	
	Neretva	
	Omiš	
GREECE	Valtos, Parga	Mediterranean Information Office for Environment, Culture and Sustainable Development (MIO-ECSDE)
	Arillas	
	Mega Ammos, Sivota	
	Drepano, Igoumenitsa	
	Kalamas	
	Sagiada	
	Acharavi, Corfu	Hellenic Centre for Marine Research (HCMR)
	Ipsos, Corfu	
	Issos, Corfu	
	Chalikounas, Corfu	
ITALY	Foce Bevano	Regional Agency for Environmental Protection in the Emilia-Romagna region (ARPA)
	Cesenatico	
	Rimini	
	Boccasette	Italian National Institute for Environmental Protection and Research (ISPRA)
	Rosolina	
	Torre Cerrano Nord	
	Torre Cerrano Sud	
MONTENEGRO	Kamenovo	Institute of Marine Biology (IMB)
	Igalo	
SLOVENIA	Bele skale	Institute for water of the Republic of Slovenia (IWRS)
	Piran-Fiesa	
	Strunjan	

Figure 2.1. Map of the 31 study sites located on the coastline of the Adriatic and Ionian Seas.

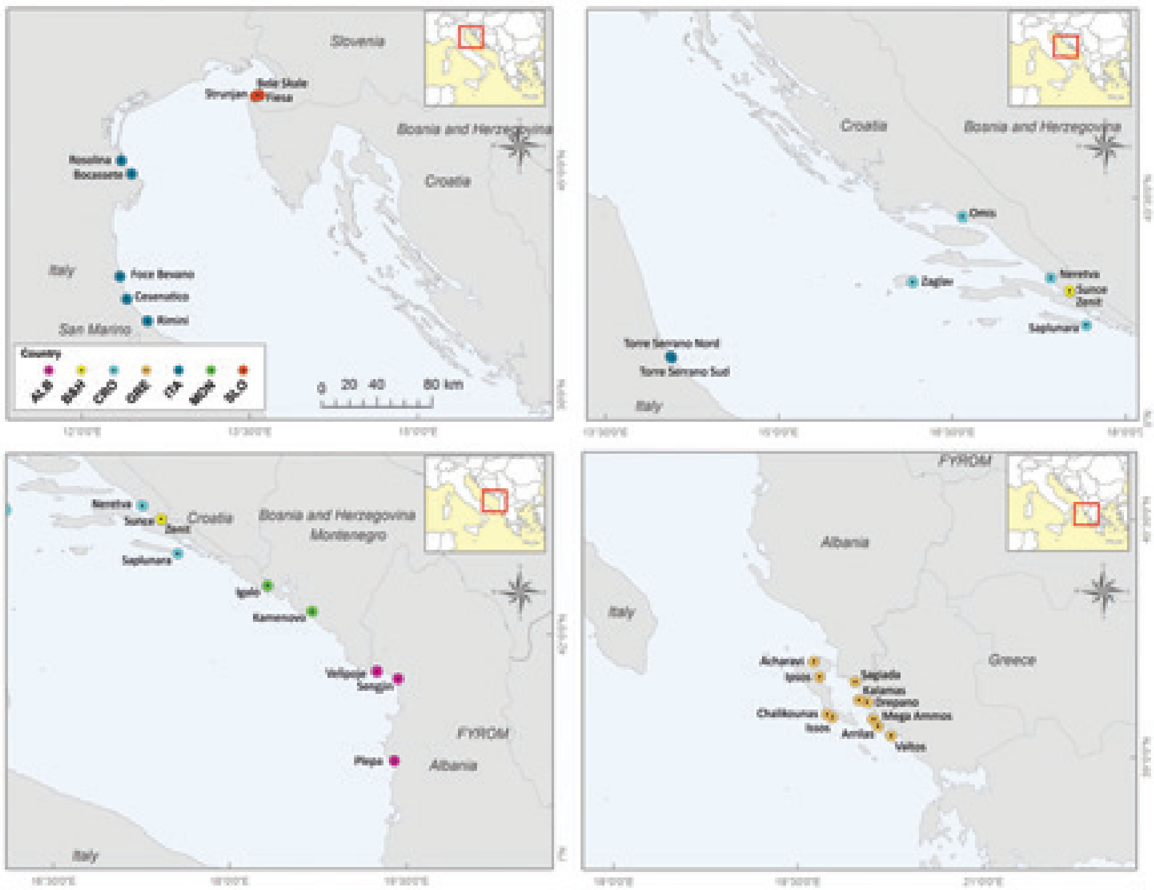

Figure 2.2. Magnified maps of the 31 study sites located on the coastline of the Adriatic and Ionian Seas.

2.2 SURVEY METHOD

All surveys performed followed the "Methodology for Monitoring Marine Litter on Beaches (Macro-Debris >2.5 cm)" that was developed within the framework of the DeFishGear project (IPA-Adriatic DeFishGear project, 2014a). The methodology was prepared based on the EU MSFD TG10 "Guidance on Monitoring of Marine Litter in European Seas" (Galgani et al., 2013), the OSPAR "Guideline for Monitoring Marine Litter on the Beaches in the OSPAR Maritime Area" (OSPAR, 2010) and the NOAA "Marine Debris Monitoring and Assessment: Recommendations for Monitoring Debris Trends in the Marine Environment (Lippiatt et al., 2013), taking into consideration the draft UNEP/MAP MEDPOL "Monitoring Guidance Document on Ecological Objective 10: Marine Litter (UNEP/MAP MEDPOL, 2014)".

The survey sites were selected randomly but taking into consideration certain criteria. The selected beaches were situated:

- in the vicinity of ports or harbours;
- in the vicinity of river mouths;
- in the vicinity of coastal urban areas;
- in the vicinity of tourism destinations;
- in relatively remote areas.

In addition, the selected beaches:

- had a minimum length of 100 m;
- were characterised by a low to moderate slope (~1.5-4.5 º);
- had clear access to the sea (not blocked by breakwaters or jetties);
- were accessible to survey teams throughout the year;
- were ideally not subject to cleaning activities.

Surveys were carried out at intervals of three months in autumn (mid-September-mid October), winter (mid-December-mid-January), spring (April), summer (mid-June-mid-July).

During the surveys, the abundance of macroscopic beach litter larger than 2.5 cm in the longest dimension was recorded, ensuring the inclusion of caps & lids and cigarette butts. In each survey a predefined sampling unit was used, corresponding to a fixed section of a beach covering the whole area from the strandline to the back of the beach. The sampling unit was a 100-metre stretch of beach along the strandline and covering a width of 10 m towards the back of the beach (Fig. 2.3). Two (2) sampling units (100 m * 10 m) were monitored on each beach, wherever possible, and were separated at least by a 50-metre stretch. The boundaries of each sampling unit were georeferenced using a GPS in order to ensure that the same sampling units were monitored for all repeat surveys. It should be noted that half-way through the beach pilot surveys it was decided to expand the sampling unit width all the way back to the end of the beach, fully in line with the MSFD TG10 guidelines. Therefore, both the initially defined sampling unit (100 m * 10 m) and the expanded sampling unit (100 m * (beach width (m))) were surveyed, wherever applicable.


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All litter items found in each sampling unit were classified by type according to the MSFD TG10 'Master List of Categories of Litter Items (Masterlist)', including 8 material types (artificial polymer material, rubber, cloth/textile, paper/cardboard, processed/worked wood, metal, glass/ceramics, unidentified and/or chemicals) and 159 types of litter items (Annex I). Each litter item was assigned to a standard general code, thus providing comparable results. During each survey, all items were removed, sorted, classified and counted. Large items that could not be removed were registered *in situ*, marked and photographed to avoid counting them again at the repeat surveys. To reduce bias of detectability, litter removal was carried out by the same trained surveyors, while data collection and classification of items were performed by the same operator. The total number of items in each sampling unit was registered and reported using the litter density of 'number of items per square metre (m^2)' and per 100-metre stretch of shoreline.

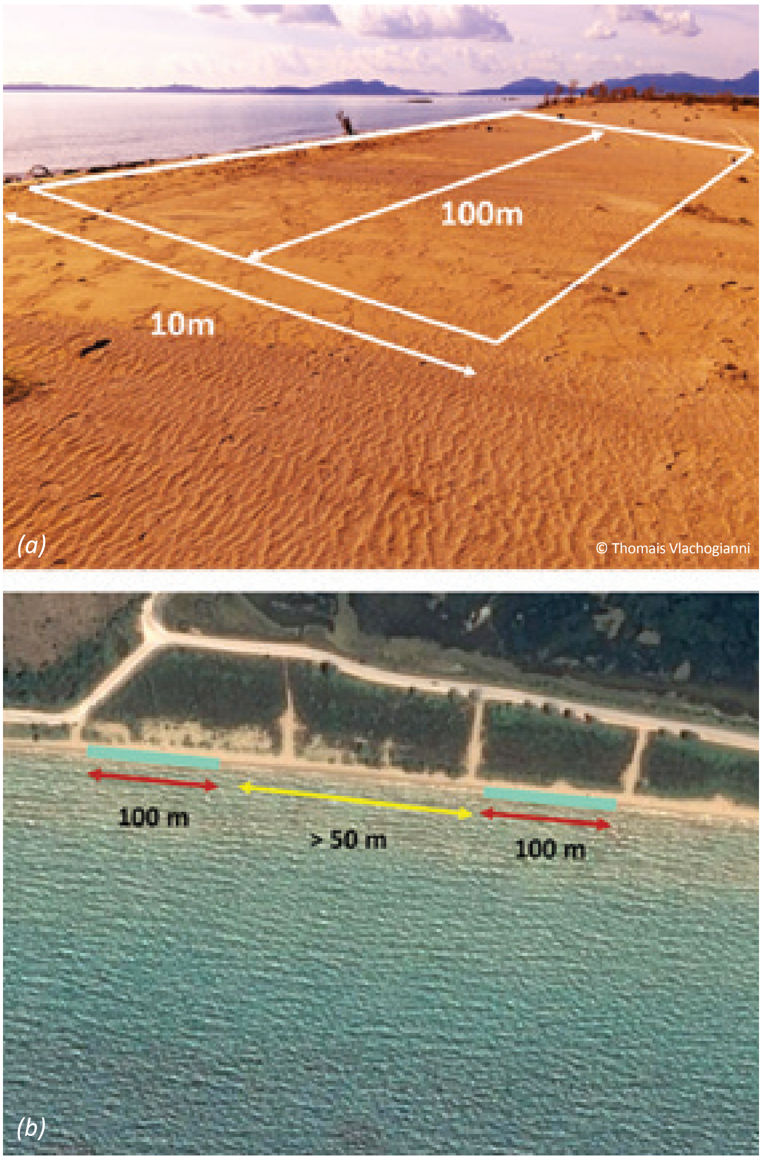

Figure 2.3. *(a) The sampling unit; (b) Two sampling units (replicates) separated at least by a 50-metre stretch.*

2.3 DATA COLLECTION AND DATA PROCESSING

All 180 transects datasets were collected by MIO-ECSDE from the nine project partners via the use of the 'Beach Litter Reporting Template' developed within the framework of the project in order also to facilitate the uploading of the datasets on the web GIS database developed within the scope of the project (http://defishgear.izvrs.si/defishgearpublic). All raw data were checked and cleaned from errors before analysis. Furthermore, they were standardized to 100-metre beach length by 10-metre width multiplying and/or dividing by a scaling factor to make the effective sampling unit 1000 m^2, whenever necessary. All data were processed and aggregated to mean values and total values per site and country, to mean and total values for the Adriatic and Ionian Seas.

The beaches surveyed, depending on their level of development and urbanization, were classified into four major categories: urban; semi-urban; semi-rural; remote/natural (Tab. 2.2). This classification was chosen after a literature review on existing beach classification approaches and the selected approach (Semeoshenkova et al., 2016) was somewhat refined and optimized by adding the last category for remote/natural beaches in order to describe all types of beaches investigated within the DeFishGear project. In addition, those beaches located by river outflows were flagged (^{R}: river outflow). The majority of surveyed sites were either semi-urban or semi-rural, while very few beaches could be characterised as urban or remote/natural (Tab. 2.4).

***Table 2.2.** Beach type classification modified from Semeoshenkova et al., 2016.*

	Environment	Accessibility	Habitation, accommodation	Services and facilities
Urban	Located in front of urban areas, with a wide range of well-established public services (banks, shopping areas, business districts, etc.)	Accessible by both public and private transport.	Large population and large-scale residential accommodation units and tourist accommodation.	Extensively developed range of services and facilities provided to beach users.
Semi-urban	Located in the surroundings of the main urban areas, adjacent or within a small coastal town with small scale community services.	Accessible by both public and private transport.	Small residential population and large number of users during the bathing season; different tourist accommodation (hotels, B&B, camping).	A full range of services and facilities provided to beach users.
Semi-rural	A semi-rural environment, located in the surroundings of a small town or village with the predominance of natural elements and absence of community services.	Usually is accessible by private transport or only by walking.	Presence of very small residential population, or its absence. Housing and tourist accommodation is limited, usually temporary or absent.	If there is a presence of tourist accommodation units, there might be a limited number of services and facilities.
Remote / natural	A remote and natural environment, located quite far from small towns or villages, the predominance of natural elements and absence of community services.	Accessible only via private transport or by walking.	Absence of residential population, housing or tourist accommodation.	Total absence of services and facilities.

Macro-debris density was calculated as follows (Lippiatt et al., 2013):

$C_M = n / (w \times l)$,

where, C_M is the density of litter items per m^2; n is the number of litter items recorded; w and l are the width and length of the sampling unit respectively.

Beach cleanliness was assessed through the Clean Coast Index (Alkalay et al., 2007):

Clean Coast Index (CCI) = (Total litter on sampling unit/total area of sampling unit) x K,

where CCI is the number of litter items per m^2; the total area of the sampling unit is generated by multiplying the sampling unit's length by the width; and K is a constant that equals to 20.

Table 2.3. *Clean Coast Index: value and definition for each quality class (Alkalay et al., 2007).*

Quality	Value	Definition
Very clean	0-2	No litter is seen
Clean	2-5	No litter is seen over a large area
Moderate	5-10	A few pieces of litter can be detected
Dirty	10-20	A lot of litter on shore
Very dirty	20+	Most of the beach is covered with litter

The sources of marine litter were classified into eight major categories as follows (see Paragraph 2.5):

i. Shoreline, including poor waste management practices, tourism and recreational activities;
ii. fisheries and aquaculture;
iii. shipping;
iv. fly-tipping;
v. sanitary and sewage related;
vi. medical related;
vii. agriculture;
viii. non-sourced.

2.4 ABUNDANCE AND COMPOSITION OF BEACH LITTER

In the 31-sites surveyed area a total of 70,581 marine litter items were recorded, removed and classified. Items varied widely in abundance and types. Some litter items types were widespread among sites, e.g. shopping bags (G3) or plastic drink bottles (G7), whereas many categories occurred with low frequency e.g. oyster trays (G46) or carpet & furnishing (G141).

The abundance of litter items at Zaglav, Vis (Croatia) was found to be extremely high in comparison to the abundance of litter items recorded in the rest of the sites, with the average number of items being 10.6 items/m^2 (1,055 items/100 m). The second highest abundance of litter items was recorded at Ipsos (Greece) with the average number of items being 0.91 items/m^2 (455 items/100 m), followed by Strunjan (Slovenia) with 0.83 items/m^2 (828 items/100 m), Foce Bevano (Italy) with 0.55 items/m^2 (549 items/100 m), Kamenovo (Montenegro) with 0.52 items/m^2 (524 items/100 m), Bele Skale (Slovenia) with 0.49 items/m^2 (490 items/100 m), Neretva (Croatia) with 0.48 items/m^2 (479 items/100 m), and Arrilas, Thesprotia (Greece) with 0.43 items/m^2 (426 items/100 m). The lowest abundances of litter items were found on the beaches of Issos, Mega Ammos, Chalikounas and Kalamas, all located in Greece, with average number of items for all surveys being: 0.08 items/m^2 (154 items/100m), 0.08 items/m^2 (84 items/100m), 0.09 items/m^2 (177 items/100m) and 0.09 items/m^2 (92.0 items/100m), respectively (Tab. 2.4, Fig. 2.4-2.6).

Table 2.4. The average density of litter items recorded in each of the 31 surveyed beaches assessed in average numbers of items per 100 m stretch and the average number of items per square meter (m2) ± standard deviation (S.D.). The superscript R (R) in the beach type column indicates that the beach is located in the vicinity of a river outflow.

Country code	Beach name	Beach type	Average number of items per 100 m stretch	Average number of items per m2 ± S.D.
ALB	Plepa, Durres	Urban	297 ± 275	0.30 ± 0.28
ALB	Shengjin, Lezhe	Semi-urban	156 ± 80	0.16 ± 0.08
ALB	Velipoje	Semi-urban^R	204 ± 64	0.20 ± 0.06
B & H	Sunce, Neum	Semi-urban	200	0.20
B & H	Zenit, Neum	Semi-urban	158 ± 33	0.16 ± 0.03
CRO	Zaglav, Vis	Semi-rural	10,554 ± 3845	10.6 ± 3.85
CRO	Saplunara, Mljet	Semi-rural	407 ± 469	0.41 ± 0.47
CRO	Neretva	Semi-rural^R	479 ± 435	0.48 ± 0.43
CRO	Omiš	Semi-urban^R	214.13	0.21 ± 0.29
GRE	Valtos, Parga	Semi-urban	110 ±68	0.11 ± 0.07
GRE	Arillas	Semi-rural	426 ± 393	0.42 ± 0.39
GRE	Mega Ammos	Semi-rural	84 ± 94	0.08 ± 0.09
GRE	Drepano, Igoumenitsa	Urban	276 ± 160	0.28 ± 0.16
GRE	Kalamas	Remote/natural^R	92 ± 47	0.09 ± 0.05
GRE	Sagiada	Remote/natural	166 ± 82	0.17 ±0.08
CRE	Acharavi	Semi-rural	244	0.14
GRE	Ipsos	Semi-rural	455	0.91
GRE	Issos	Remote/natural	155	0.08
GRE	Chalikounas	Remote/natural	177	0.09
ITA	Foce Bevano	Remote/natural^R	549 ± 361	0.55 ± 0.36
ITA	Cesenatico	Semi-urban	255 ± 170	0.26 ± 0.17
ITA	Rimini	Urban	106 ± 50	0.11 ± 0.05
ITA	Boccasette	Semi-rural^R	375 ± 261	0.38 ± 0.26
ITA	Rosolina	Semi-urban^R	276 ± 98	0.28 ± 0.10
ITA	Torre Cerrano Sud	Semi-urban	221 ± 149	0.22 ± 0.15
ITA	Torre Cerrano Nord	Semi-urban	285 ± 350	0.29 ± 0.35
MON	Kamenovo	Semi-urban	524 ± 327	0.52 ± 0.33
MON	Igalo	Urban	225 ± 148	0.23 ± 0.15
SLO	Bele skale	Semi-urban	490 ± 203	0.49 ± 0.20
SLO	Fiesa, Piran	Semi-urban	167 ± 44	0.17 ± 0.04
SLO	Strunjan	Semi-rural	828 ± 278	0.83 ± 0.28

The Clean Coast Index classified Zaglav (Croatia) as 'Very dirty beach' (CCI = 211). The beaches of Ipsos (Greece), Strunjan (Slovenia), Foce Bevano (Italy) and Kamenovo (Montenegro) were classified as 'Dirty' with CCI values 18.2, 16.6, 11.0 and 10.5 respectively. The remaining beaches ranked as 'Moderate' and 'Clean' as shown in table 2.5. Only four beaches ranked as very clean, all located in Greece. These were the beach of Issos (Corfu), the beach of Chalikounas (Corfu), the beach of Mega Ammos (Thesprotia) and the beach of Kalamas (Thesprotia), with CCI values 1.5, 1.7, 1.7 and 1.8 respectively. From the table below we can see that there is no straightforward correlation between the CCI and the beach type. The beach classified as very dirty was a semi-rural one, while the ones classified as dirt were semi-rural or semi-urban, with one being remote/natural but located close to a river outflow. Most beaches classified as moderate were semi-rural or semi-urban, while the cleanest ones where mainly remote/natural, with one however being semi-urban.

Figure 2.4. *Average marine litter densities found on the 31 survey sites (number of items per 100-metre stretch).*

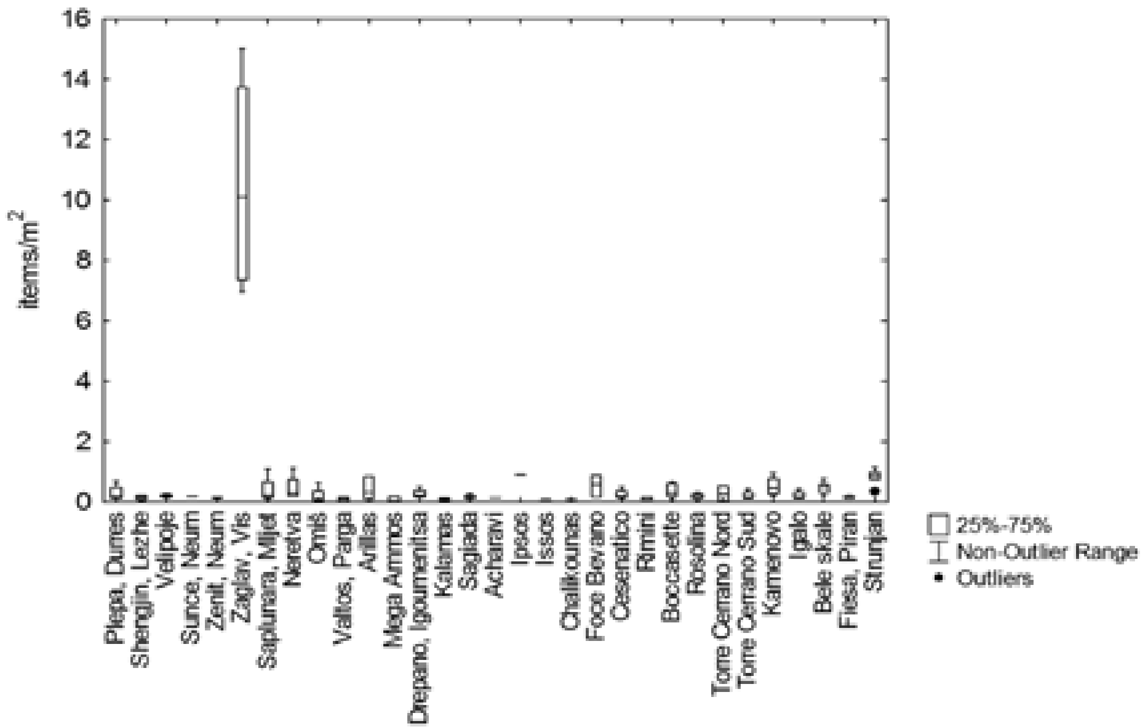

Figure 2.5. Beach litter densities. The boundaries of the boxes indicate the 25th and 75th percentiles, the whiskers above and below the boxes the 95th and 5th percentiles. Outliers are indicated by black dots. The horizontal line denotes the median value.

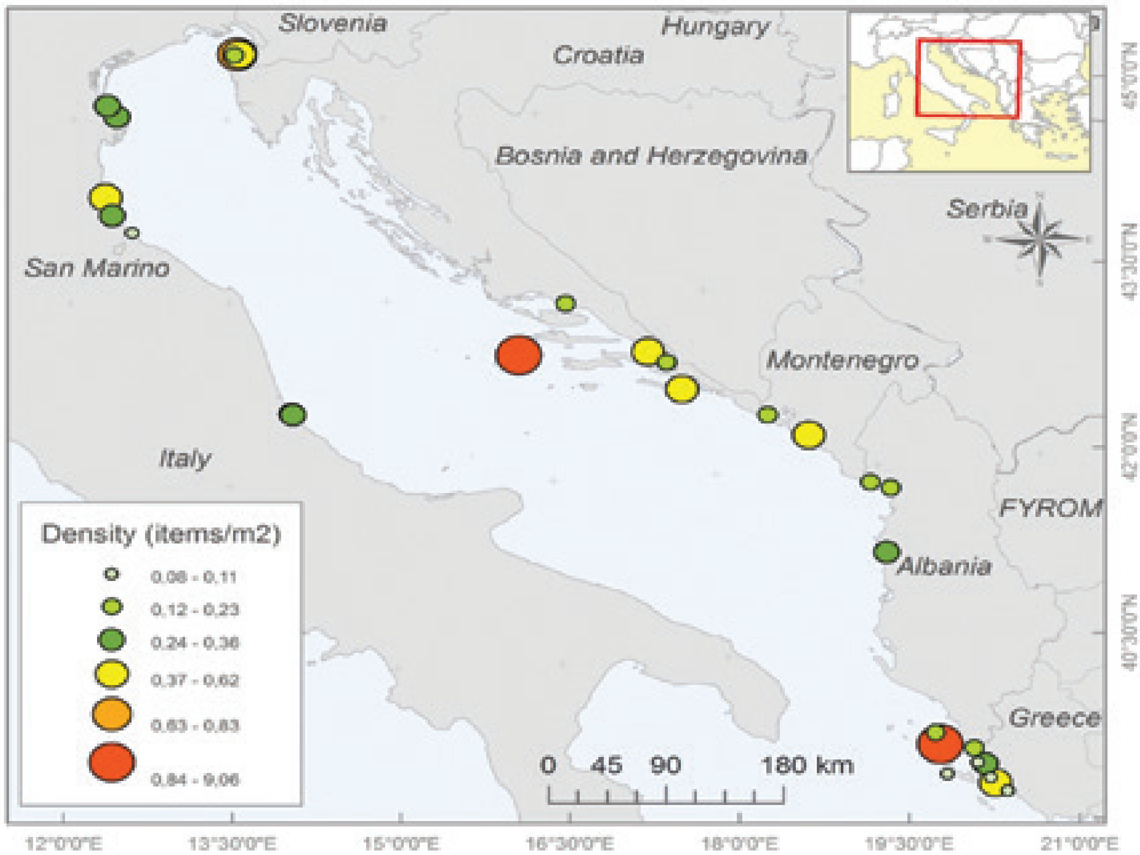

Figure 2.6. Spatial distribution of beach litter densities for the 180 beach transects surveyed.

Table 2.5. Beach cleanliness classification of survey sites according to the Clean Coast Index.

Country code	Beach name	CCI	Cleanliness	Beach type
CRO	Zaglav, Vis	211	Very dirty	Semi-rural
GRE	Ipsos	18.2	Dirty	Semi-rural
SLO	Strunjan	16.6	Dirty	Semi-rural
ITA	Foce Bevano	11.0	Dirty	Remote/natural[R]
MON	Kamenovo	10.5	Dirty	Semi-urban
SLO	Bele skale	9.8	Moderate	Semi-urban
CRO	Neretva	9.6	Moderate	Semi-rural[R]
GRE	Arillas	8.5	Moderate	Semi-rural
CRO	Saplunara, Mljet	8.1	Moderate	Semi-rural
ALB	Boccasette	7.5	Moderate	Semi-rural[R]
ITA	Plepa, Durres	5.9	Moderate	Urban
ITA	Torre Cerrano Nord	5.7	Moderate	Semi-urban
GRE	Drepano	5.5	Moderate	Urban
ITA	Rosolina	5.5	Moderate	Semi-urban[R]
ITA	Cesenatico	5.1	Moderate	Semi-urban
MON	Igalo	4.5	Clean	Urban
ITA	Torre Cerrano Sud	4.4	Clean	Semi-urban
CRO	Omiš	4.3	Clean	Semi-urban[R]
ALB	Velipoje	4.1	Clean	Semi-urban[R]
B & H	Sunce, Neum	4.0	Clean	Semi-urban
SLO	Fiesa, Piran	3.3	Clean	Semi-urban
GRE	Sagiada	3.3	Clean	Remote/natural
B & H	Zenit, Neum	3.2	Clean	Semi-urban
ALB	Shengjin, Lezhe	3.1	Clean	Semi-urban
GRE	Acharavi	2.9	Clean	Semi-rural
GRE	Valtos, Parga	2.2	Clean	Semi-urban
ITA	Rimini	2.1	Clean	Urban
GRE	Kalamas	1.8	Very clean	Remote/natural[R]
GRE	Chalikounas	1.7	Very Clean	Remote/natural
GRE	Mega Ammos	1.7	Very Clean	Semi-rural
GRE	Issos	1.5	Very Clean	Remote/natural

Aggregated results on national level (Fig. 2.7 and 2.8) show that the abundance of litter on average is higher for the surveyed beaches in Croatia with an average value of 2.91 items/m^2 (2914 items/100 m stretch), followed by beaches in Slovenia with 0.50 items/m^2 (494.9 items/100 m stretch) and beaches in Montenegro with 0.37 items/m^2 (374.2 items/100 m stretch). For the beaches in Italy, Greece and Albania the following averages were calculated: 0.28 items/m^2 (280 items/100 m stretch), 0.24 items/m^2 (201 items/100 m stretch) and 0.22 items/m^2 (219 items/100 m stretch) respectively. The lowest abundance of litter items on aggregated basis at national level was found on the beaches of Bosnia and Herzegovina, which are located in front of large scale hotels and are cleaned up on a regular basis, with average value 0.17 items/m^2 (168 items/100 m stretch).

It should be noted that the marine litter densities reported for the Italian beaches may have been underestimated given that the densities found have derived from item counts on the first 10 meters from the strandline and towards the back of the beach. Calculated densities seem to me much higher when considering the item counts from the strandline and all the way back to the end of the beach. In Greek beaches, similar calculations were made, however no significant differences were found.

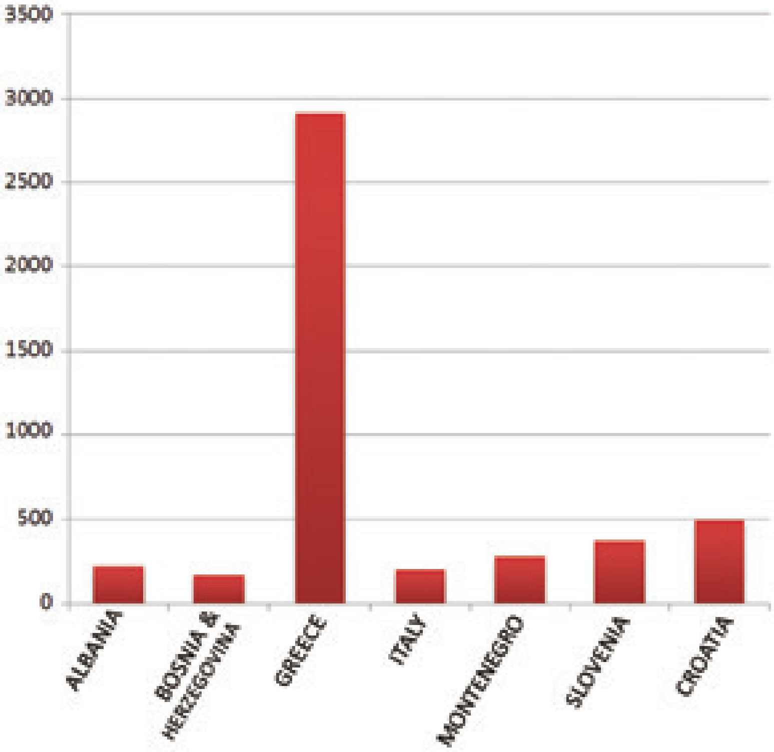

Figure 2.7. Aggregated results on national level showing the abundance of litter on average (number of items per 100-metre stretch)

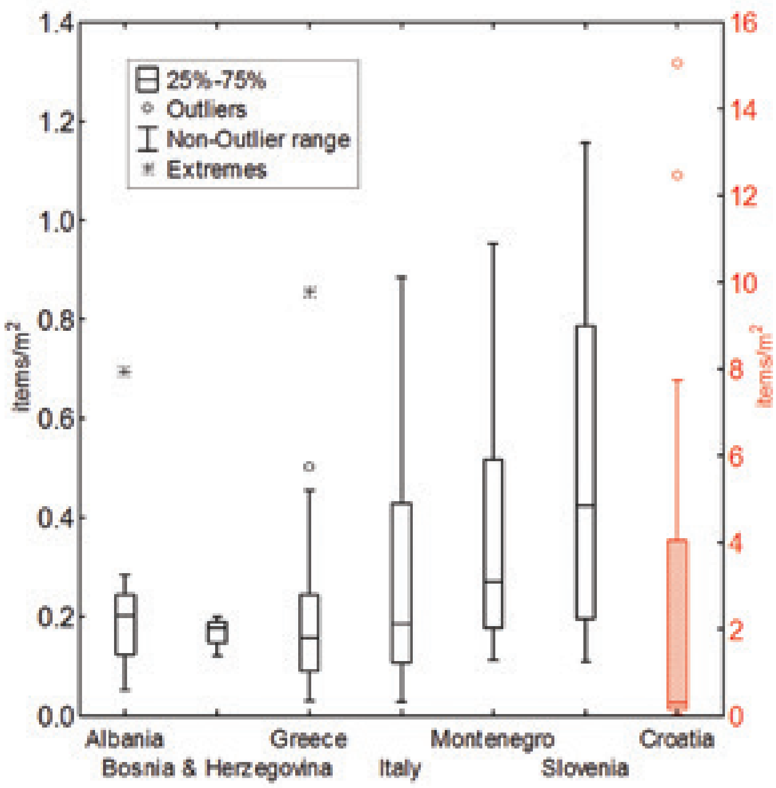

Figure 2.8. Beach litter densities on aggregated basis at national level (Croatia is on the secondary y-axis). The boundaries of the boxes indicate the 25th and 75th percentiles, the whiskers above and below the boxes the 95th and 5th percentiles. Outliers are indicated by black dots. The horizontal line denotes the median value.

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Marine litter items recorded were classified into 8 major groups of material types on aggregated basis at national level and regional (Adriatic-Ionian) level (Fig. 2.9). The majority of litter items were made out of artificial polymer materials, a category of litter dominant on beaches all over the world. In almost all countries of the Adriatic-Ionian region (with the exception of Albania) plastic items were in the range of 74-92% of total items recorded, while on an aggregated level of total counts of litter items in all surveyed beaches in the region the amount of plastics reached 91%. At regional level, the second most abundant group of litter items found were glass/ceramics (3.2%), followed by items made of metal (1.5%), paper (1.4%) and cloth/textile (1.1%). Rubber items represented 0.6% of the total 70,581 items recorded in the region and only some 0.1% were classified as unidentified items and/or chemicals.

Among the 159 litter categories, plastic pieces 2.5 cm > < 50 cm (G79) accounted for the highest percentage 19.89% (14,040 items) of the total 70,581 litter items recorded in all surveys, followed by polystyrene pieces 2.5 cm > < 50 cm (G82) with 11.93% (Tab. 2.6, Fig. 2.10). The third most abundant items were cotton bud sticks (G95) accounting for 9.17% of total items recorded, followed by plastic caps/ lids from drinks (G21) with 6.67% and cigarette butts and filters (G27) with 6.60%. Plastic caps/lids unidentified (G23), mussel & oyster nets (G45), crisp packets/sweet wrappers (G30), glass or ceramic fragments 2.5 cm (G208) and other identifiable plastic/polystyrene items (G124) were among the top 10 items found. At national level the top 20 items varied as shown in the following figures (Fig. 2.11-2.17)

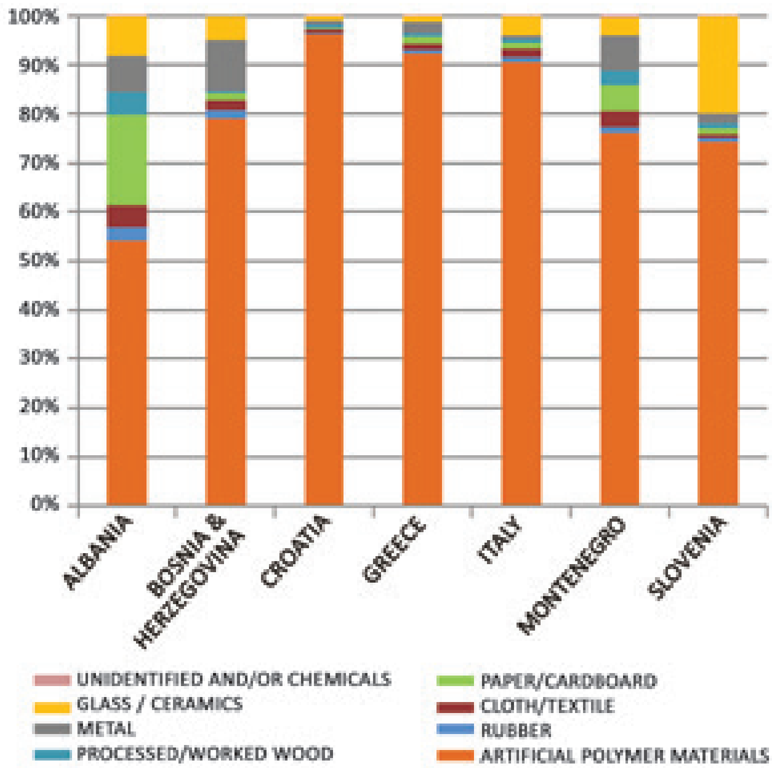

***Figure 2.9.** National aggregated results of the percentage (%) of total litter items per category type (artificial polymer material; rubber; cloth/textile; paper/cardboard; processed/worked wood; metal, glass/ ceramics; unidentified and/or chemicals.*

Table 2.6. Top 20 items found in the 31 surveyed beaches of the Adriatic and Ionian coastline, calculated on an aggregated basis of total litter counts in all beaches.

TOP 20	Code	Items name	Total counts	%
1	G79	Plastic pieces 2.5 cm > < 50 cm	14,040	19.89
2	G82	Polystyrene pieces 2.5 cm > < 50 cm	8,422	11.93
3	G95	Cotton bud sticks	6,475	9.17
4	G21	Plastic caps/lids from drinks	4,705	6.67
5	G27	Cigarette butts and filters	4,660	6.60
6	G23	Plastic caps/lids unidentified	1,743	2.47
7	G45	Mussel nets, Oyster nets	1,716	2.43
8	G30	Crisps packets/sweets wrappers	1,492	2.11
9	G208	Glass or ceramic fragments >2.5 cm	1,368	1.94
10	G124	Other plastic/polystyrene items (identifiable)	1,350	1.91
11	G67	Sheets, industrial packaging, plastic sheeting	1,336	1.89
12	G10	Food containers incl. fast food containers	1,332	1.89
13	G35	Straws and stirrers	1,273	1.80
14	G33	Cups and cup lids	1,161	1.65
15	G22	Plastic caps/lids from chemicals, detergents	1,058	1.50
16	G3	Shopping bags, incl. pieces	974	1.38
17	G7	Drink bottles <=0.5 l	872	1.24
18	G8	Drink bottles >0.5 l	794	1.13
19	G24	Plastic rings from bottle caps/lids	770	1.09
20	G50	String and cord (diameter less than 1 cm)	748	1.06

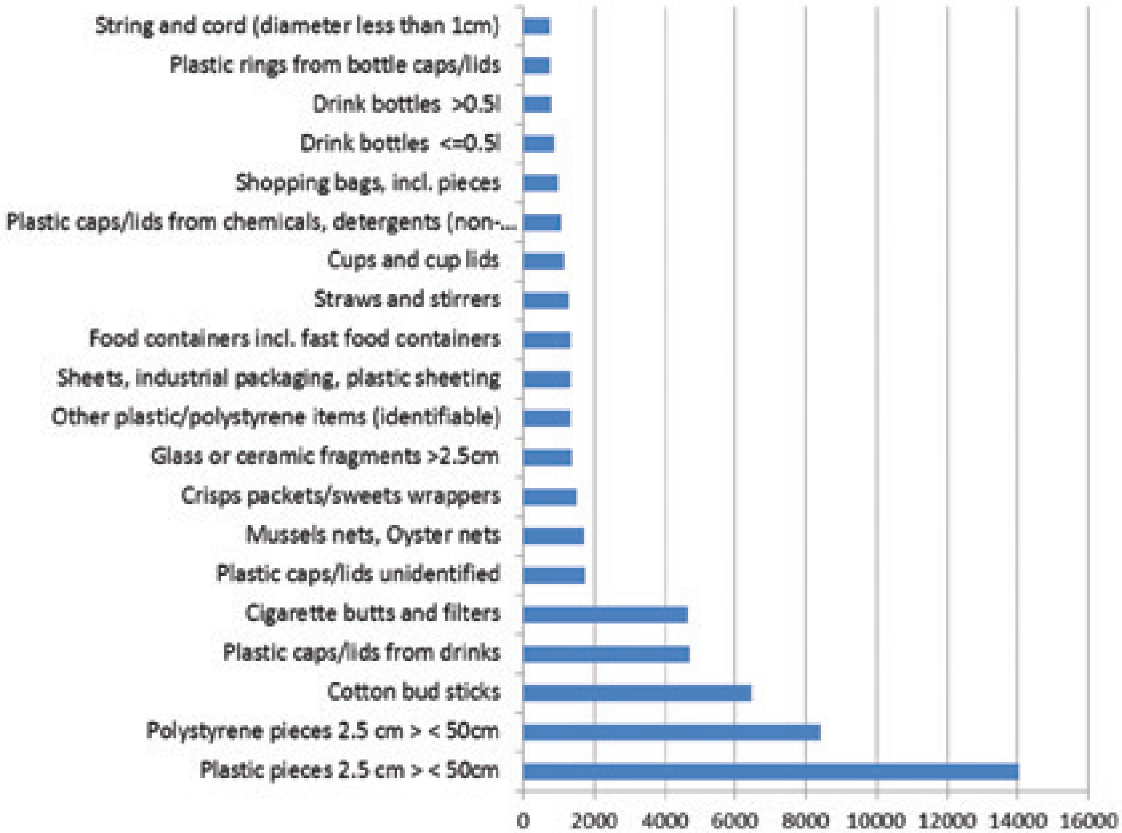

Figure 2.10. Top 20 items found in the 31 surveyed beaches of the Adriatic & Ionian coastline.

In the 3 beaches surveyed in Albania the top 20 litter categories accounted for 59.1% of the total 2,628 marine litter items recorded (Fig. 2.11). Among these categories, other bottles & containers/drums (G13) represented 6% of the total sampled litter, closely followed by cartons & tetra pack (others) (G151) which represented 5.7% of the total sampled litter. Cigarette packets (G152) and shopping bags (G3) accounted for 3.7% and 3.5% of total sampled litter respectively. Within the top 10 litter categories were beach use related cosmetic bottles and containers (G11) (3.2%); plastic caps/lids from drinks (G21) (3.1%); jars (G201) (3%); food containers (G10) (3%); drink bottles <= 0.5 l (G7) (2.7%).

In the 2 beaches surveyed in Bosnia and Herzegovina, the top 20 litter categories accounted for 91.3% of the total 673 litter items recorded (Fig. 2.12). The highest abundance was observed for cigarette butts & filters (G27) accounting for 35.5% of total items recorded. A rather high abundance was also observed for plastic caps/lids from drinks (G21) accounting for 17.2%. Within the top 10 litter categories were bottle caps, lids & pull tabs (G178) (9.2%); straws and stirrers (G35) (4%); plastic caps/lids unidentified (G23) (3%); lolly sticks (G31) (3%); bottles (G200) (2.5%); other glass items (210) (2.5%); plastic pieces 2.5 cm > < 50 cm (G79) (2.4%); shopping bags, incl. pieces (G3) (1.6%).

In Croatia 4 beaches were surveyed and some 46,618 litter items were recorded. The top 20 litter categories accounted for 85.3% of all litter items recorded and the highest abundance was observed for plastic pieces 2.5 cm > < 50 cm (G79) with 26.2%. Polystyrene pieces 2.5 cm > < 50 cm (G82) and cotton bud sticks (G95) represented 14.4% and 12.0% of the total sampled litter, respectively (Fig. 2.13). Within the top 10 litter categories were plastic caps/lids from drinks (G21) (8.4%); plastic caps/lids unidentified (G23) (3.2%); crisps packets/sweets wrappers (G30) (2%); straws & stirrers (G35) (1.9%); plastic caps/lids from chemicals, detergents (G22) (1.8%); cigarette butts & filters (G27) (1.8%); mussel & oyster nets (G45) (1.7%).

In the 10 beaches surveyed in Greece, the top 20 litter categories accounted for 80.4% of the total 5,027 litter items recorded (Fig. 2.14). The most abundant litter items were cigarette butts and filters (G27), plastic pieces 2.5 cm > < 50 cm (G79) and polystyrene pieces 2.5 cm > < 50 cm (G82) representing 13.1%, 10.8% and 10.5% of total sampled litter. The abundance of fish boxes - expanded polystyrene (G58) - was high accounting for 8.1% followed by plastic caps/lids from drinks (G58) (6.3%), straws and stirrers (G35) (4.5%), cups and cup lids (G7) (3.9%), other plastic/polystyrene items (identifiable) (G124) (3.6%) and crisps packets/sweets wrappers (G30) (2.6%).

In Italy, 7 beaches were investigated and some 7,280 litter items were recorded, out of which 81.9% consisted of the top 20 litter items categories (Fig. 2.15). The highest abundances were observed for sheets, industrial packaging, plastic sheeting (G67), plastic pieces 2.5 cm > < 50 cm (G79) and mussel & oyster nets (G45) accounting for 14.6%, 12.9% and 10.3% of all sampled litter items, respectively. It should be stressed that the litter items found on Italian beaches and classified under category type G45 were almost always mussel nets. The abundances for the following items making up the top 10 list included: cotton bud sticks (G95) (7.9%), polystyrene pieces 2.5 cm > < 50 cm (G82) (6.7%), food containers incl. fast food containers (G10) (4.8%), cigarette butts and filters (G27) (3.2%), construction material (G204) (2.7%), other plastic/ polystyrene items (identifiable) (G124) (2.1%), plastic caps/lids from drinks (G21) (2.1%).

In the 2 beaches surveyed in Montenegro a total of 2,994 litter items were sampled. The top 20 litter item categories accounted for 85.4% of the total recorded litter, with cigarette butts and filters (G27) being by far the most abundant litter item accounting for 40.8 of the sampled litter (Fig. 2.16). Crisps packets/sweets wrappers (G30) and other plastic/polystyrene items (identifiable) (G124) represented 7.7% and 5.5% of total items recorded. The remaining top 10 items included: shopping bags (G3) (3.4%), cups and cup lids (G33) (2.9%), plastic caps/lids from drinks (G21) (2.2%), drink bottles ≤ 0.5 l (G7) (2.1%), polystyrene pieces 2.5 cm > < 50 cm (G82) (2.1), drink bottles > 0.5 l (G8) (1.9%) and cans (beverage) (G175) (1.9%).

In the 3 beaches surveyed in Slovenia, the top 20 litter categories accounted for 88.1% of the total 5,362 litter items recorded (Fig. 2. 17). The highest abundance was observed for cigarette butts & filters (G27) and glass or ceramic fragments > 2.5 cm (G208) accounting for 27.6% and 18.2 of total items recorded. Polystyrene pieces 2.5 cm > < 50 cm (G82) and plastic pieces 2.5 cm > < 50 cm (G79) represented 11.7% and 5.8% of total items sampled, followed by cotton bud sticks (G95) (3.7%), shopping bags, incl. pieces (G3) (3.3%), food containers incl. fast food containers (G10), mussel & oyster nets (2.5%) (G45), tobacco pouches/plastic cigarette box packaging (G25) (1.8%) and string and cord (diameter < 1 cm) (G50)(1.5%).

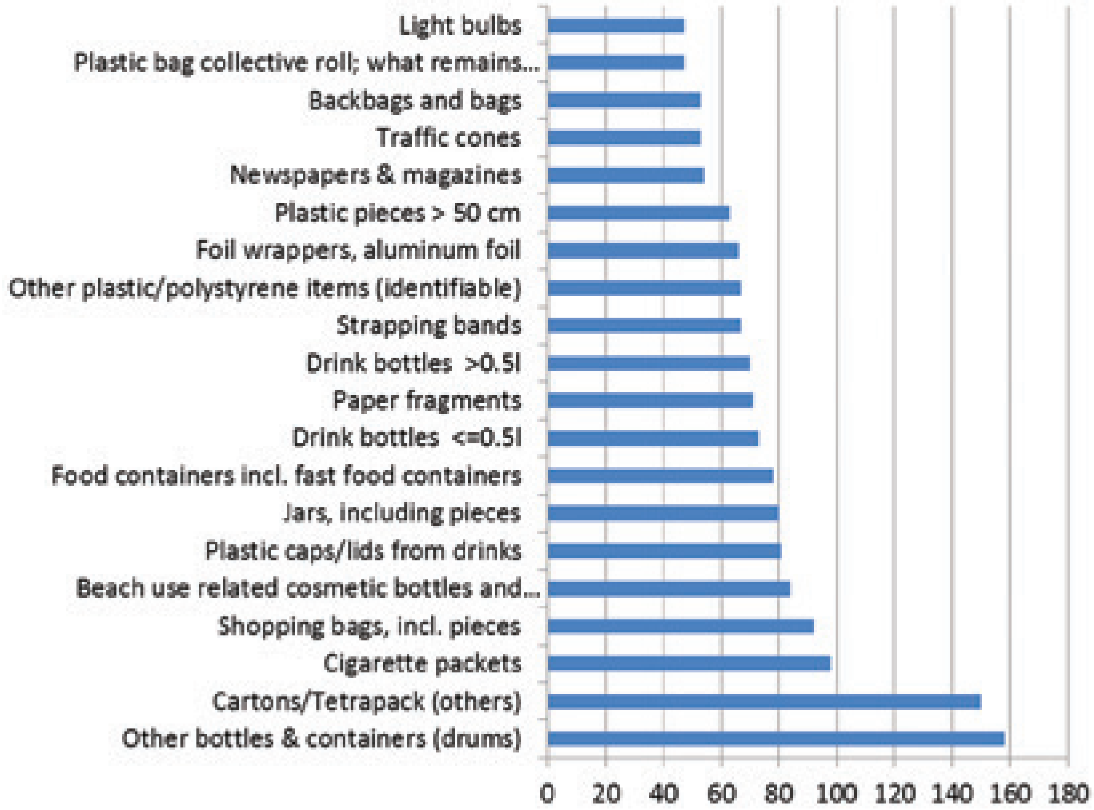

*Figure 2.11. Top 20 items found in **Albania**, on an aggregated basis of total litter counts in all surveyed beaches.*

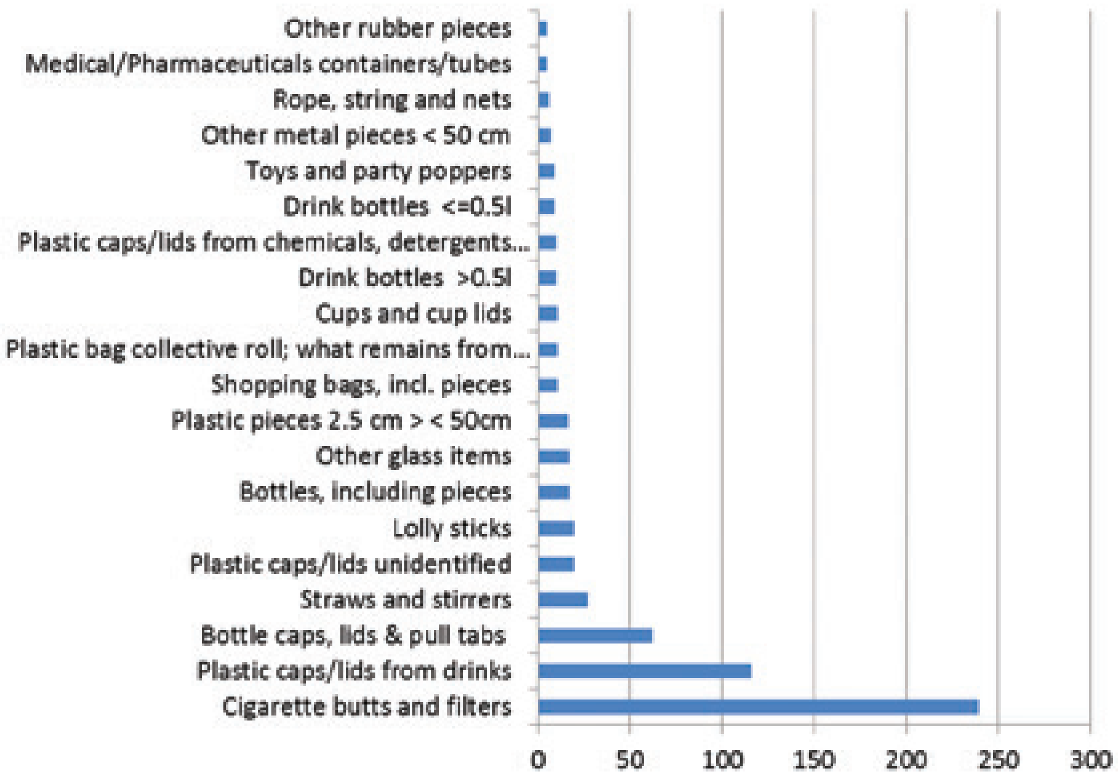

*Figure 2.12. Top 20 items found in **Bosnia and Herzegovina**, on an aggregated basis of total litter counts in all surveyed beaches.*

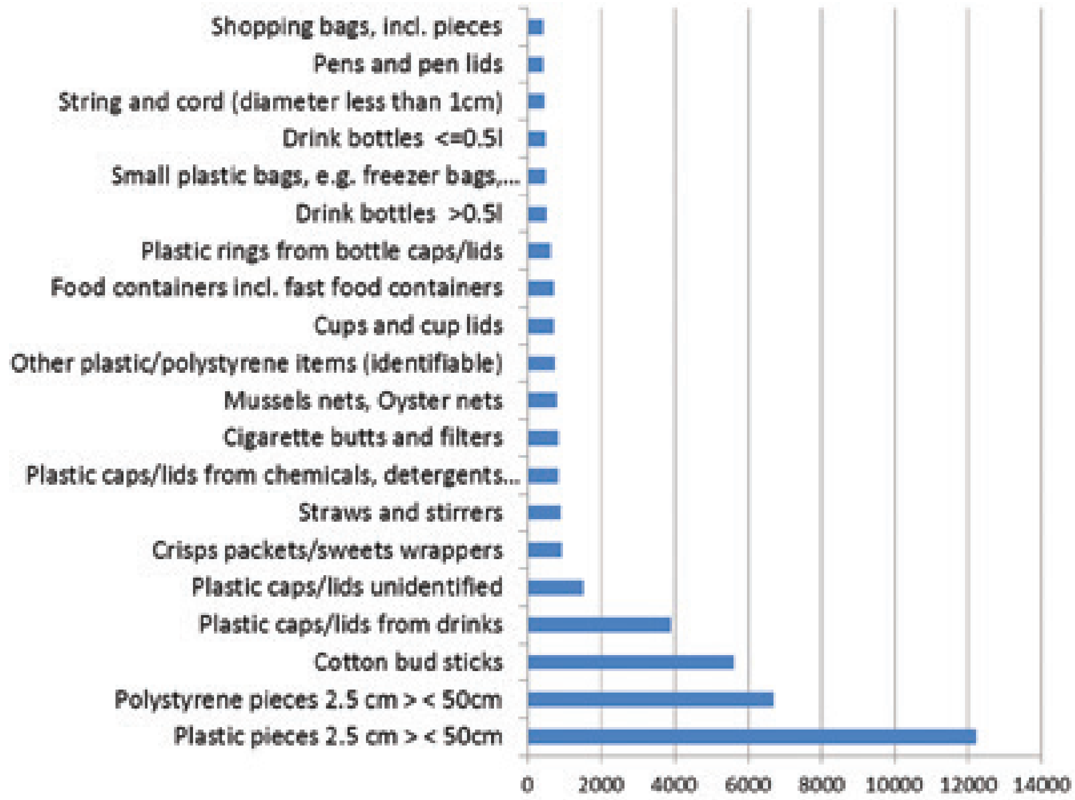

Figure 2.13. *Top 20 items found in **Croatia**, on an aggregated basis of total litter counts in all surveyed beaches.*

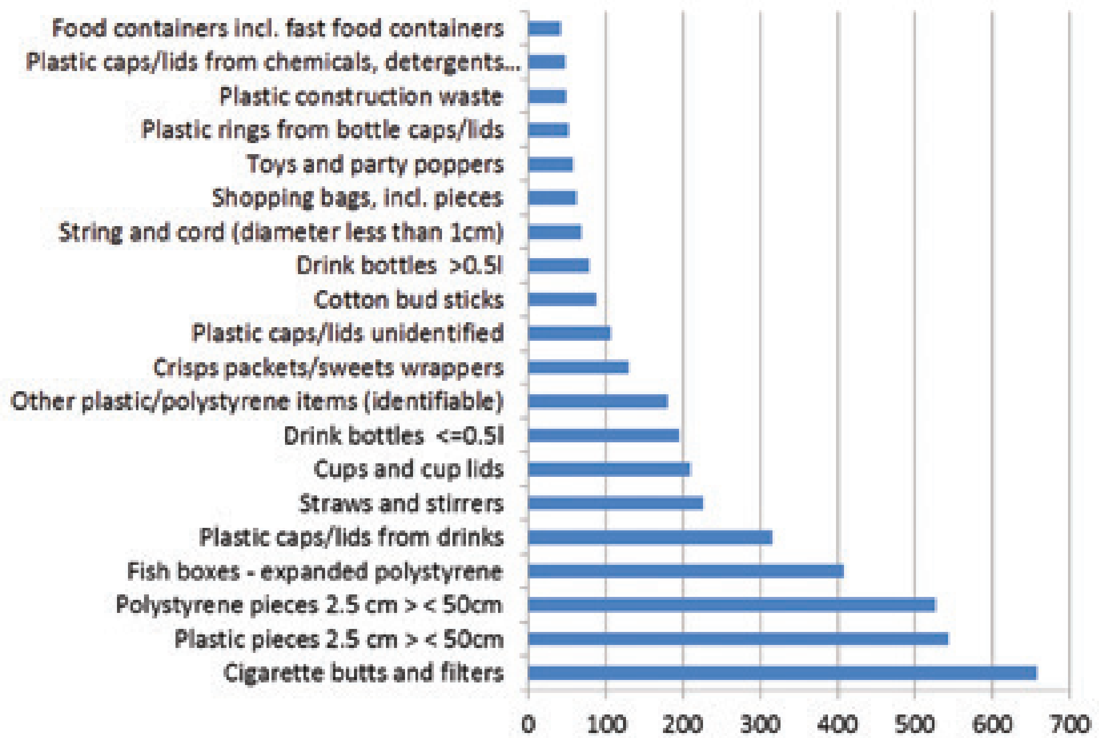

Figure 2.14. *Top 20 items found in **Greece**, on an aggregated basis of total litter counts in all surveyed beaches.*

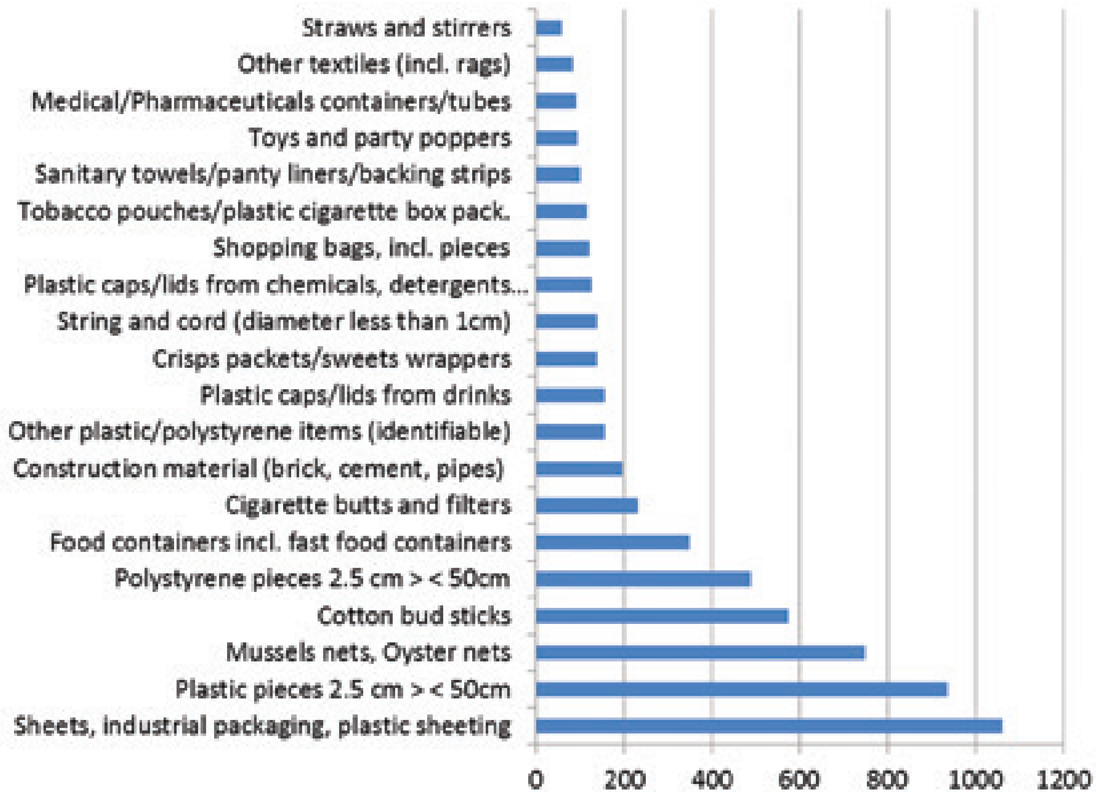

Figure 2.15. *Top 20 items found in* ***Italy****, on an aggregated basis of total litter counts in all surveyed beaches.*

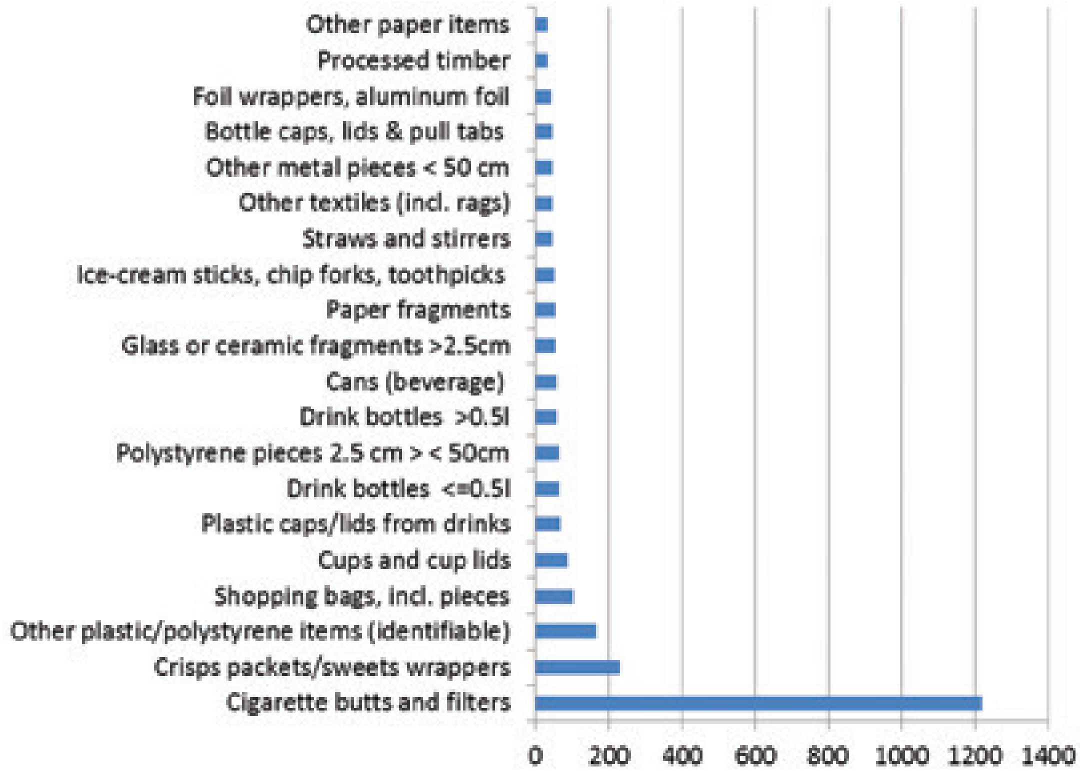

Figure 2.16. *Top 20 items found in* ***Montenegro****, on an aggregated basis of total litter counts in all surveyed beaches.*

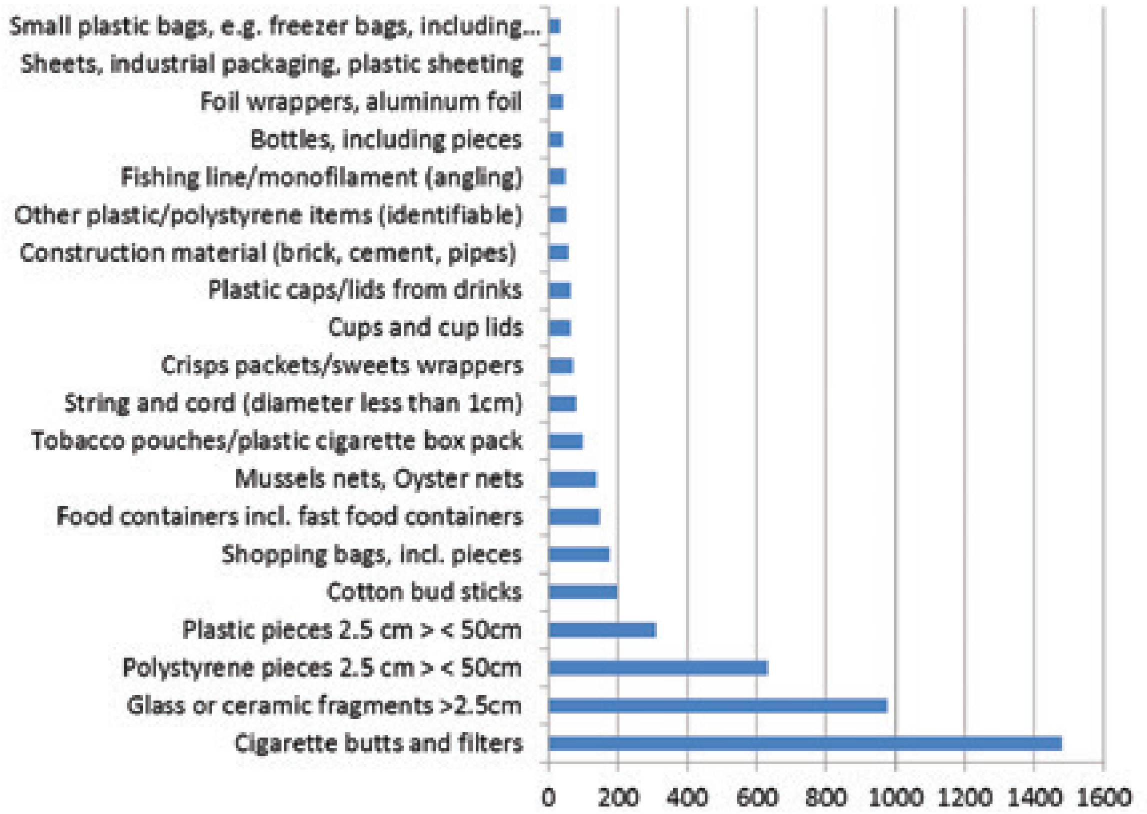

Figure 2.17. *Top 20 items found in* ***Slovenia****, on an aggregated basis of total litter counts in all surveyed beaches.*

2.5 SOURCES OF BEACH LITTER

Litter enters the coastal and marine environment from diverse diffuse and point sources, which can be both land- and sea-based. Detecting the source –the economic sector or human activity from which litter originates– is fundamental for identifying targeted measures to tackle marine litter and ensure good environmental status. Some easily identifiable marine litter items have a clear function and can be attributed, with a high level of confidence, to specific economic or consumer sectors (e.g. tourism, shipping, fishing, agriculture, etc.). Fishing nets or mussel nets are such an example and they can be attributed directly to the fisheries and aquaculture sector, respectively. However, the majority of litter items often cannot be directly connected to a particular source, way of release or pathway (Veiga et al., 2016).

A wide variety of methods have been used over the years to determine the sources of marine litter, ranging from simple counts of items to more complex statistical methods. Within this report, the sources of marine litter have been determined by the attribution of marine litter items to sources according to their category type. This approach is based on the assumption that certain litter items are typically or widely used by particular commercial or public sectors or are released into the environment via well-defined pathways (e.g. sewage outlets). It should be noted that the method of allocating an item to one specific source has limitations given that it is based on the assumption that all occurring items from a certain category originate from a particular source, thus dismissing potential contributions from other sources (Veiga et al., 2016). In addition, there might be regional differences in the source of a given item as for example in the case of cotton bud sticks where in the OSPAR region it is considered to originate from sewage outlets (flushed down the toilet by consumers), however for the Adriatic and Ionian region it is not clear whether this is the case. Furthermore, when it comes to regional differences, under a specific litter item category, litter items with totally different origin may be recorded. A representative example is that of injection gun containers (G17). In a study carried out in Germany and the North Sea, these have been attributed to shipping as the injection gun containers contained grease, however in the Adriatic and Ionian coastline these containers contained silicone and are used for construction purposes, thus not attributed to shipping.

Building upon the different existing marine litter sources classification lists (UNEP/MAP, 2011; MCS, 2013; Veiga et al., 2016) and taking into consideration the 'Masterlist' of litter item categories, the specificities of the Adriatic and Ionian region with regards to the sources of the different litter items, as well as the beach compartment where these litter items were found, the existing classification list for items and their respective sources was refined (Annex V). A summary of the different sources considered is presented below.

- **Shoreline, including poor waste management practices, tourism and recreational activities.** Litter items that are attributed to this source include those generated by land-based activities, such as tourism and recreation (beachgoers, sports and recreation businesses, beach bars, hotels, festivals, mismanaged waste at the beaches, etc.) as well as litter produced inland and carried by winds, storms and rivers as a result of poor waste management by municipalities. Indicative items are shopping bags, drink bottles, food containers, straws and stirrers, etc.
- **Fisheries and aquaculture**. Litter items that are attributed to this source include those items that are exclusively generated from commercial and recreational fishing and aquaculture farms. Indicative items are crab and lobster pots, octopus' pots, mussel nets and oyster nets, fishing nets, fish boxes, etc.
- **Shipping**. Litter items that are attributed to this source include those items that have been generated by any kind of vessel such as recreational boats, fishing boats, cruise ships, ferries, etc. Indicative items are engine oil bottles and containers, jerry cans, gloves (industrial/professional rubber gloves), oil drums, etc.
- **Fly-tipping**. Litter items that are attributed to this source include those items that have been disposed illegally. Indicative items are car parts, traffic cones, construction waste, appliances (refrigerators, washing machines, etc.), etc.
- **Sanitary and sewage related**. Litter items that are attributed to this source include sanitary, personal hygiene and care items that have been disposed improperly. These items may come from consumers who dispose them on the coast or flush them down the toilet, thus reaching the coastal and marine environment through the sewage outlets and systems. They may also come from mismanaged waste on the coast or at sea. Indicative items are cotton bud sticks, diapers and nappies, condoms (incl. packaging), tampons and tampon applicators, etc.

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- **Medical related.** Litter items that are attributed to this source include items that come from improper disposal of pharmaceutical and medical products, either by individuals or medical units and mismanaged hospital waste. Indicative items are syringes and needles, medical and pharmaceuticals containers, etc.
- **Agriculture**. Litter items that are attributed to this source are generated by agricultural activities. Indicative items are: fertilizer and animal feed bags, olive harvesting nets, greenhouse sheeting, flower pots from retailer plant nurseries, etc.
- **Non-sourced**. Classified within this category are all items that cannot be attributed to any of the aforementioned sources, either because they could have been generated by several sources, or they are too small or damaged/weathered to be identified. Indicative items are foam sponge, buckets, gloves, small plastic or polystyrene pieces, etc.

On an aggregated basis at regional level and following the aforementioned approach only 53.7% of the 70,581 litter items collected could be attributed to one of the following sources: shoreline, including poor waste management practices, tourism and recreational activities; fisheries and aquaculture; sanitary and sewage related; shipping; fly-tipping; medical related; agriculture. Of the total litter items collected, 33.4% originated from shoreline sources, including poor waste management practices, tourism and recreational activities (Fig. 2.18). Some 9.68% of litter items were sanitary and sewage related, while 5.25% was generated by fisheries and aquaculture. 1.23% of litter was attributed to fly-tipping, 1.06% to shipping, 1.01% to medical related activities and only 0.04% to agriculture. However, in relation to the latter, many items actually generated by the agriculture sector could only be recorded under other identifiable items and in other non-sourced litter item categories. Such items included olive harvesting nets, plastic sheets from greenhouses, plastic parts of grass cutters, plant pots from retail plant nurseries, etc.

On an aggregated basis at national level, the inputs of litter from the different sectors and their comparative importance were somewhat different.

In Albania out of the 2,628 items collected, 60.3% could be attributed to the main sources. 47.4% was attributed to shoreline sources, including poor waste management practices, tourism and recreational activities, while 4.72% of all litter items was attributed to shipping, which is reasonable since one of the sampling sites was located near the harbour of Durres. 3.01% of all items collected came from fisheries and aquaculture, 2.44% from fly-tipping, 0.76% were sanitary and sewage related; 0.88% from agriculture and 0.61% medical related.

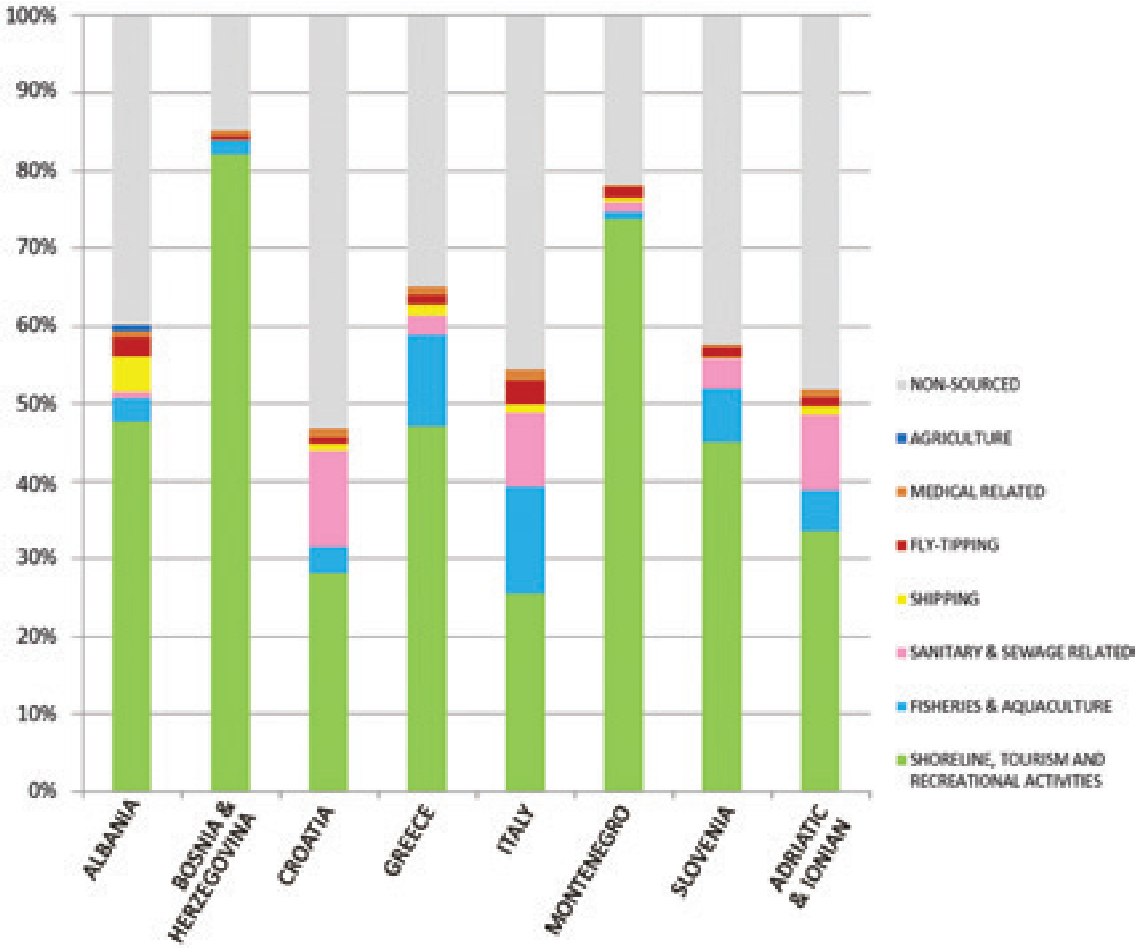


Figure 2.18. *Sources of marine litter on the basis of aggregated results at national level and at regional level.*

In Bosnia and Herzegovina, 85.1% of the total 673 litter items collected could be attributed to a source. The vast majority of items (82%) originated from shoreline sources, including poor waste management practices, tourism and recreational activities. Fisheries and aquaculture related items accounted for 1.93%, medical related items for 0.74%, fly-tipping related items for 0.45%.

In Croatia out of the 46,618 items sampled, less than half (46.8%) could be attributed to the main sources. Shoreline sources, including poor waste management practices, tourism and recreational activities were responsible for some 28% of all litter items sampled. Sanitary and sewage related items had a considerable input of 12.33% of total items, fisheries and aquaculture related ones accounted for 3.49% while 1.11% were medical related. Shipping accounted for 0.95% and 0.85% were from fly-tipping.

In Greece out of the 5,028 items collected and classified, 65% could be attributed to the main source categories. The majority of the sourced items originated from shoreline sources, including poor waste management practices, tourism and recreational activities (46.1%). Fisheries and aquaculture related items had a substantial contribution of 11.72% of all items collected. Sanitary and sewage related items accounted for 2.41%, shipping related for 1.53%, fly-tipping related items for 1.35% and medical related items for 0.90%.

In Italy, 54.48% of the 7,280 items collected could be attributed to the main sources. One-fourth (25.5%) of the sampled items were attributed to shoreline sources, including poor waste management practices, tourism and recreation activities. Fisheries and aquaculture related items had a substantial input of 13.73% of total items sampled, while sanitary and sewage related items accounted for 9.57%. Litter from fly-tipping accounted for 3.08%, medical related items for 1.39%, shipping for 1.11% and items from agriculture 0.07%.

In Montenegro, 78.16% of all 2,994 litter items sampled were attributed to mainly one of the litter sources.

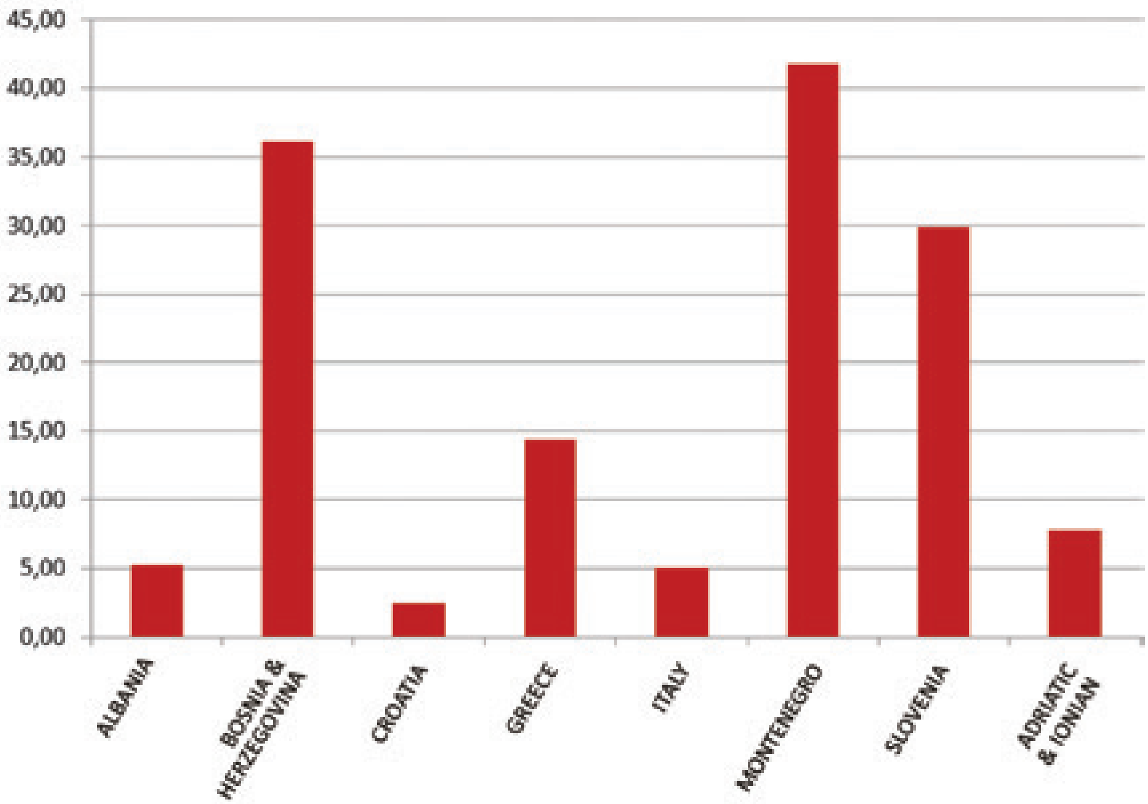


Figure 2.19. *Smoking related activities as sources of marine litter on the basis of aggregated results at national level and at regional level.*

The vast majority of items originated from shoreline sources, tourism and recreational activities (73.7%), while the contribution of the remaining sources was low. Fly-tipped items accounted for 1.24% of total items sampled, sanitary and sewage related items for 1.20%, fisheries and aquaculture related for 0.97%, shipping related for 0.57% and medical related items for 0.37%.

In Slovenia, some 57.58% of all 5,362 items sampled could be attributed to the various main sources, with the shoreline, tourism and recreational related items accounting for 45.1%. The contribution of fisheries and aquaculture related items were 6.80%, followed by sanitary and sewage related items with 3.90%, fly-tipping related items with 1.37%, medical related items with 0.27% and shipping related items 0.27%.

When it comes to smoking activities as a source, on an aggregated basis at regional level 7.80% of total litter items collected (70,581) fell under one of the following category types of litter: tobacco pouches / plastic cigarette box packaging (G25), cigarette lighters (G26), cigarette butts and filters (G27) and paper cigarette packets (G152) (Fig. 2.19). The highest percentage of smoking-related items was recorded in Montenegro, where they accounted for 41.75% of sampled items, followed by Bosnia and Herzegovina with 36.11% and Slovenia with 29.91%. In Greece, the contribution of smoking related items was 14.40%, in Albania 5.25% and in Italy 5.06%. The lowest contribution was observed for Croatia, where smoking related items accounted for 2.52% of total sampled items.

Interesting results are obtained when trying to assess the comparative importance of land-based *versus* sea-based sources in the Adriatic and Ionian Seas and the respective countries (Fig. 2.20). The contribution of the sea-based sources (fisheries and aquaculture, shipping), the land-based sources (shoreline, tourism and recreational activities, agriculture, medical related) and mixed sources (sanitary and sewage related, fly-tipping, non-sourced items) were calculated bearing in mind that (a) a considerable amount of litter items could not be attributed to a specific source (sea-based or land-based) category, with percentages of items from mixed sources ranging from 15.3% to 66.4%; (b) the items attributed to shoreline, tourism and recreational related sources may also originate from fisheries and aquaculture or shipping.

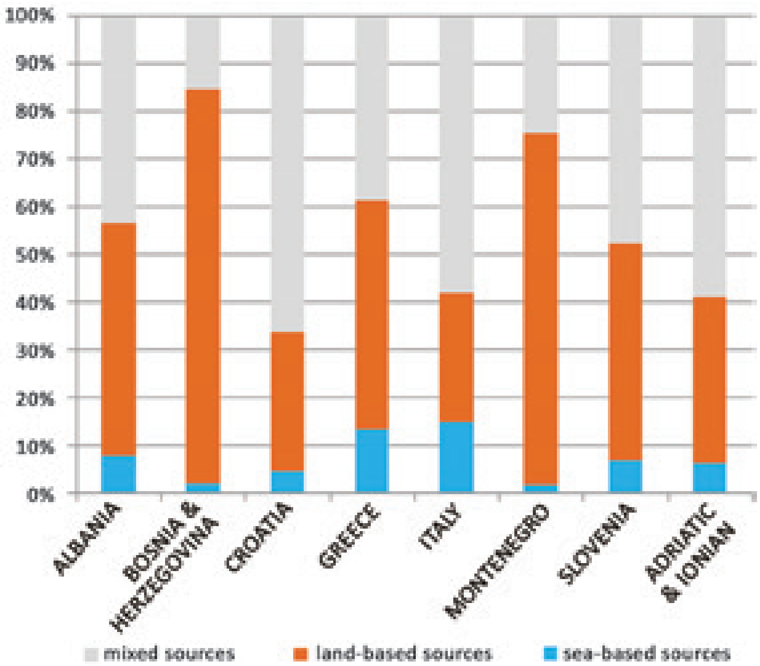


Figure 2.20. Assessing the comparative importance of sea-based versus land-based sources of litter within the sourced items fraction.

On an aggregated basis at regional level, the items coming from sea-based activities accounted for 6.3% *vs* 34.7% of items attributed to land-based sources. On an aggregated basis at national level the contribution of items from sea-based activities *vs* land-based activities were for: Albania 7.8% (sea-based sources) *vs* 48.9% (land-based sources), Bosnia and Herzegovina 1.9% *vs* 82.8%, Croatia 4.4% *vs* 29.2%, Greece 13.2% *vs* 48.0%, Italy 14.8% *vs* 27%, Montenegro 1.5% *vs* 74.1%, Slovenia 6.9% *vs* 34.7%.

These figures give an indication of the comparative importance of sea-based *versus* land-based sources and they highlight that the contribution from sea-based sources varies substantially from country to country and from site to site. These variations reflect mainly the variation of the fisheries and aquaculture related litter items found in the different countries.

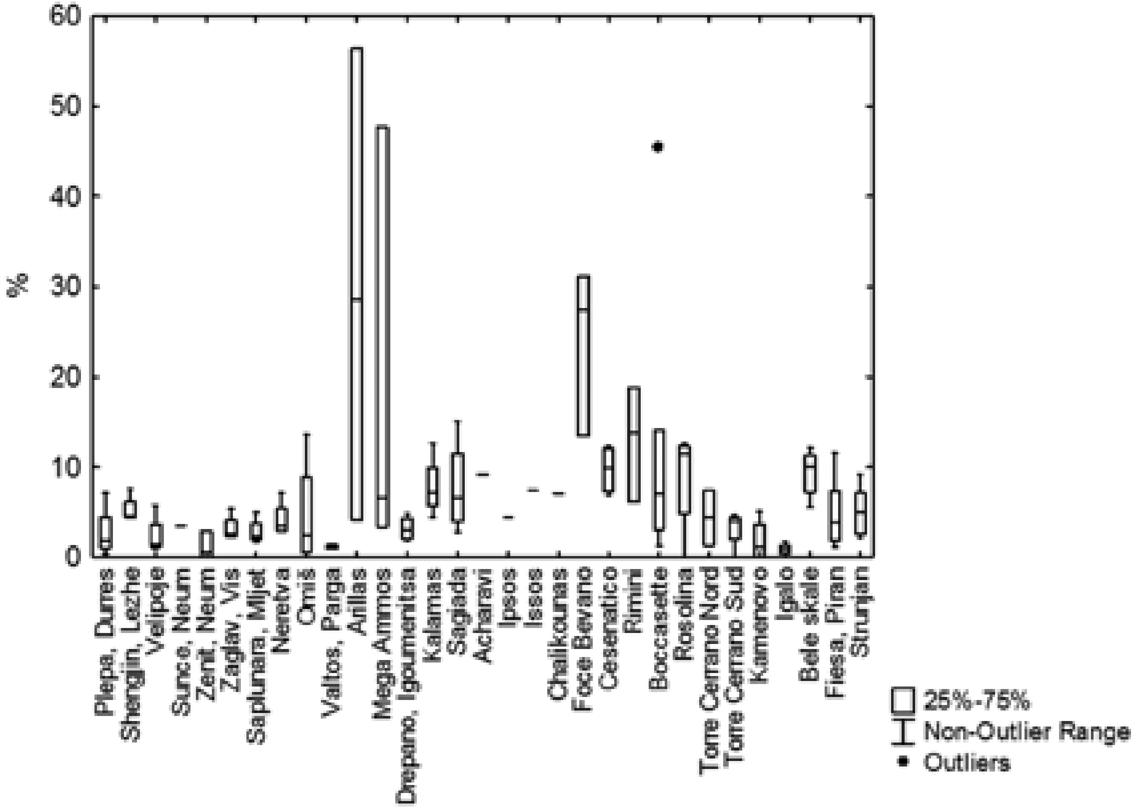
It should be stressed that despite the fact that it has been repeatedly quoted that 80% of marine litter in the Mediterranean and elsewhere originates from land-based sources and 20% from sea-based sources, caution should be exercised because these figures do not necessarily apply at national and sub-regional or even regional level while, in addition, there is a considerable amount of litter items classified in the mixed sources category that is very difficult to attribute to any specific source. Even when litter items are attributed to a specific source category it is not always possible to classify them in a sea-based or land-based source with a high level of confidence.

Given the special emphasis of the DeFishGear project on abandoned, lost and discarded fishing gear (ALDFG), the percentage (%) of marine litter inputs from the fisheries and aquaculture sector was calculated for each survey site (Tab. 2.7, Fig. 2.21 and 2.22). The lowest marine litter contributions from the fisheries and aquaculture sectors were found for Montenegrin beaches, Kamenovo (0.6%) and Igalo (0.9%). The highest

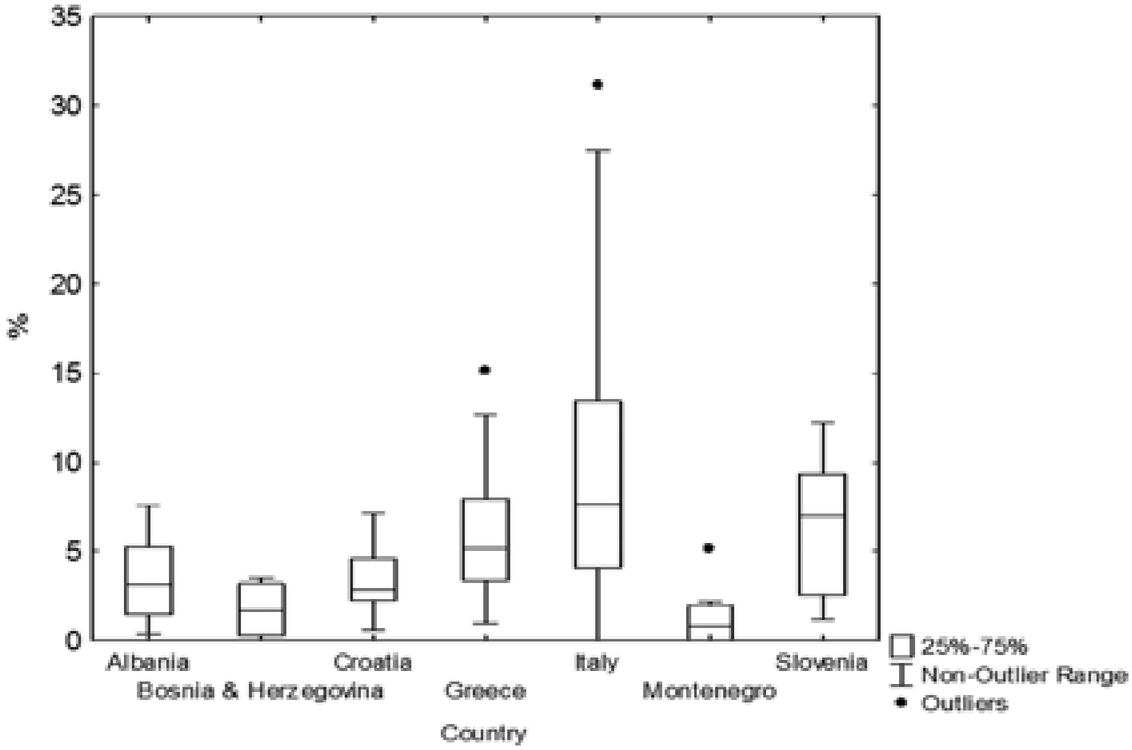
contributions were obtained for beaches in Greece and Italy (Fig. 2.21). Specifically, the following percentages were calculated: for Arillas (Greece) 24%, for Foce Bevano (Italy) 20.3%, for Boccasette (Italy) 31.3%, for Mega Ammos (Greece) 37.5%. These figures illustrate the need for localized measures to effectively address the issue of marine litter generated by the fisheries and aquaculture sectors. The main fisheries and aquaculture related items for Greece were polystyrene fish boxes and string and cord (among the top 20 items found), while for Italy the main items found were mussel nets and string and cord. Aggregated results at national level show that the fishing related items contribution is highest for Italy (13.7%), followed by Greece (11.7%) and Slovenia (6.3%).

Table 2.7. *Marine litter inputs of the fisheries and aquaculture sectors, expressed in percentage (%) of total litter items recorded at each survey site.*

Country code	Beach name	Beach type	Fisheries and aquaculture marine litter inputs (%)
ALB	Plepa, Durres	Urban	1.8
ALB	Shengjin, Lezhe	Semi-urban	4.8
ALB	Velipoje	Semi-urban[R]	2.3
B & H	Sunce, Neum	Semi-urban	1.2
B & H	Zenit, Neum	Semi-urban	1.0
CRO	Zaglav, Vis	Semi-rural	2.1
CRO	Saplunara, Mljet	Semi-rural	3.3
CRO	Neretva	Semi-rural[R]	3.7
CRO	Omiš	Semi-urban[R]	2.2
GRE	Valtos, Parga	Semi-urban	1.2
GRE	Arillas	Semi-rural	24.0
GRE	Mega Ammos	Semi-rural	37.5
GRE	Drepano, Igoumenitsa	Urban	3.0
GRE	Kalamas	Remote/natural[R]	7.1
GRE	Sagiada	Remote/natural	7.8
GRE	Acharavi	Semi-rural	9.2
GRE	Ipsos	Semi-rural	4.5
GRE	Issos	Remote/natural	7.4
GRE	Chalikounas	Remote/natural	7.1
ITA	Foce Bevano	Remote/natural[R]	20.3
ITA	Cesenatico	Semi-urban	9.4
ITA	Rimini	Urban	11.1
ITA	Boccasette	Semi-rural[R]	31.3
ITA	Rosolina	Semi-urban[R]	7.5
ITA	Torre Cerrano Nord	Semi-urban	7.0
ITA	Torre Cerrano Sud	Semi-urban	4.7
MON	Kamenovo	Semi-urban	1.0
MON	Igalo	Urban	0.6
SLO	Bele skale	Semi-urban	8.2
SLO	Fiesa, Piran	Semi-urban	5.9
SLO	Strunjan	Semi-rural	5.0



(a)



(b)

Figure 2.21. *Aggregated results of fishing related items (%) at location level (a) and at national level (b). The boundaries of the boxes indicate the 25th and 75th percentiles, the whiskers above and below the boxes the 95th and 5th percentiles. Outliers are indicated by black dots. The horizontal line denotes the median value.*

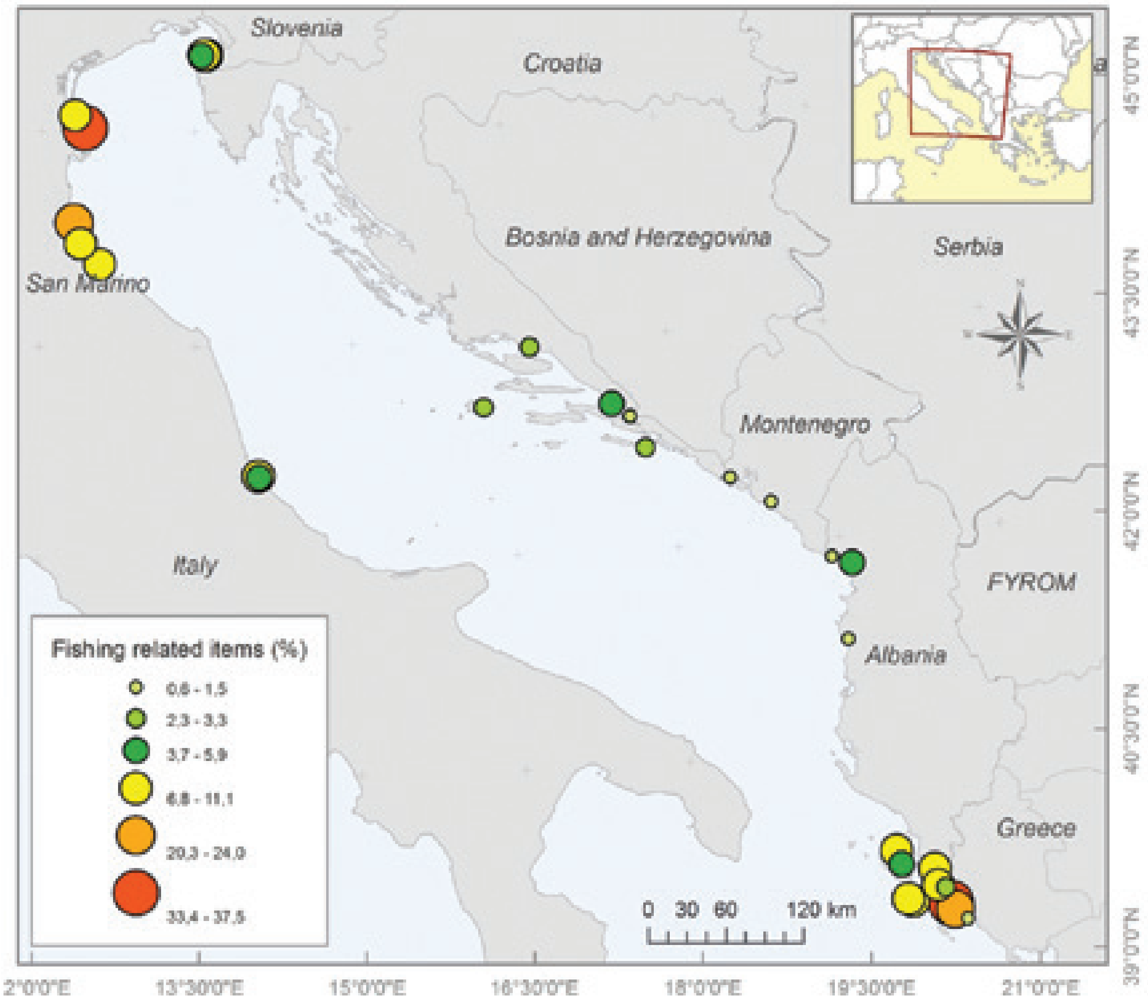


Figure 2.22. *Spatial distribution of the amount of fishing related items (%) for the 31 survey sites located on coasts of the Adriatic and Ionian Seas.*

As already stated, assessing the relative importance of the different sources of litter is difficult given that a considerable percentage of litter items cannot be attributed to any specific category of source. Nevertheless, the sources attribution method used within the DeFishGear project provides a good overall basis for detecting the major sources and feeding the information into the management process. In particular, the contribution of the fisheries and aquaculture sector to the marine litter problem was established with a very high level of confidence.

2.6 DISCUSSION

The DeFishGear beach litter surveys were the first effort to-date aiming to assess in a coordinated, consistent, comprehensive and harmonized way the amounts, composition and, to the extent possible, the sources of marine litter found on the coastline of seven countries sharing the Adriatic and Ionian Seas. Systematic efforts to collect data on beach litter along the coastline of the Adriatic and Ionian Seas have been very limited until now (Kordella et al., 2013; Laglbauer et al., 2014; Vlachogianni and Kalampokis, 2014; Munari et al., 2016). In most cases, data collected were reported as total quantity of marine litter collected, or amounts of litter collected by material type without any further classification of types of items, while the main survey methodology used has been the International Coastal Cleanup (ICC) related one, which has been designed to provide a "snapshot" assessment of the types and amounts of debris found during clean-up activities worldwide.

The results and findings of the very few beach litter research studies carried out along the coastline of the Adriatic and Ionian Seas are presented in Table 2.8. The average litter densities reported within this study for the countries of the Adriatic and Ionian macroregion ranged from 0.22-2.91 items/m^2 and are similar and comparable to the values reported by the very few surveys carried out in the region (Laglbauer et al., 2014; Munari et al., 2016). When comparing the litter abundances reported for this study expressed in items per 100 m (219-2,914 items/100 m) with the values presented within the updated 'Marine Litter Assessment in the Mediterranean' (UNEP/MAP, 2016), we see that they are in the same order of magnitude. Indicatively, the values reported within the assessment report for Spain are 11-2,263 items/100 m for 2013 and 27-1,955 items/100 m for 2014; for Turkey 0.085 to 5,058 items/m^2. It needs to be noted that the discrepancy in reporting marine litter densities in terms of units makes the comparison of results difficult. In Table 2.9 and Figure 2.23, the indicative beach litter densities reported worldwide the past decade or so are presented. The average litter densities reported for Bosnia and Herzegovina, Greece, Italy, Montenegro, and Slovenia are less than 0.5 items/m^2 and are similar to the densities reported for Australia, Brazil, Taiwan and Tasmania. The average litter density recorded in Croatian beaches was close to 3 items/m^2 and it is similar to the litter densities found in Japan and Jordan.

Table 2.8. *Summary of beach litter densities reported in the Adriatic and Ionian Seas.*

Study area	No of surveyed beaches	Averaged litter density (items/m^2)	Reference
Adriatic & Ionian Seas	31	0.67	present study
Albania	3	0.22	present study
Bosnia & Herzegovina	2	0.17	present study
Croatia	4	2.91	present study
Greece	10	0.24	present study
Italy	7	0.28	present study
Montenegro	2	0.37	present study
Slovenia	3	0.45	present study
Slovenia	6	1.51	Laglbauer et al., 2014
Italy	5	0.2	Munari et al., 2016

Table 2.9. *Indicative beach litter densities reported worldwide (Munari et al., 2016).*

Study area	No of surveyed beaches	Averaged litter density (items/m^2)	Reference
Australia	6	0.1	Cunningham & Wilson, 2003
Brazil	10	0.14	Oigman-Pszczol & Creed, 2007
Chile	43	1.8	Bravo et al., 2009
Japan	18	3.4	Kusui and Noda, 2003
Jordan	3	4	Abu-Hilal and Al-Najjar, 2004
Russia	8	0.2	Kusui and Noda, 2003
South Korea	6	1	Lee et al., 2013
Taiwan	6	0.15	Kuo and Huang, 2014
Tasmania	9	0.28	Slavin et al., 2012
Turkey	10	0.88	Topçu et al., 2013

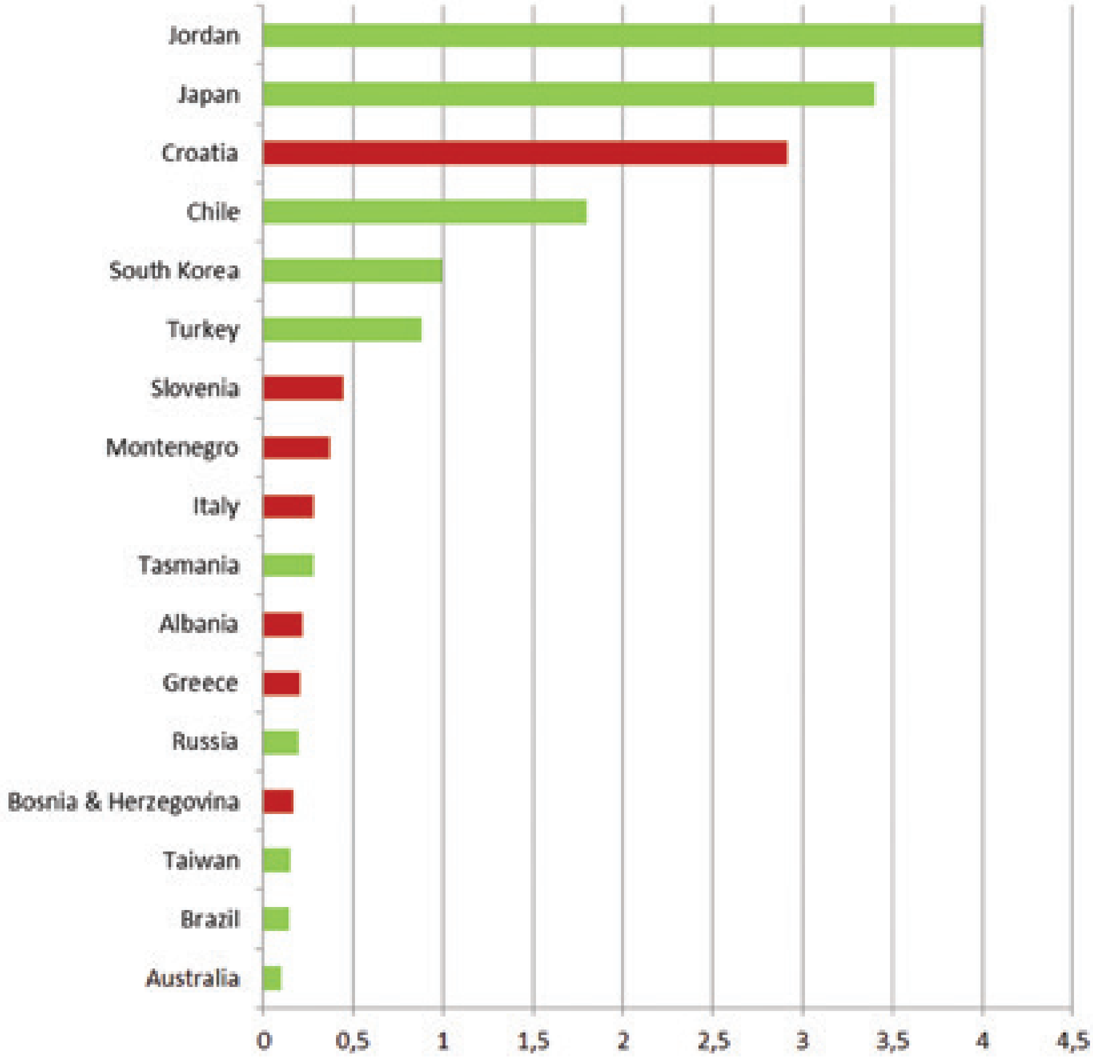


Figure 2.23. Comparison of average litter densities recorded by the DeFishGear beach surveys (in red) with those reported worldwide (in green).

The extremely higher densities of litter items recorded in Croatian beaches, in particular at the islands of Vis and Mljet with average densities 10.6 and 0.41 items/m^2 and maximum densities recorded 15.0 items/m^2 and 1.10 items/m^2 respectively, are to some extent in agreement with the plastic debris fluxes onto the Adriatic and Ionian coastline, as these were calculated within the framework of the DeFishGear regional approach to modelling the transport of floating debris in the Adriatic and Ionian Seas (Liubartseva et al., 2016). It should be noted though that a direct comparison is not possible given that the model calculates the plastic debris fluxes in mass of litter items washed ashore per day (kg/(km day), while the beach litter surveys recorded litter item counts per beach surface area. The modeling results for plastic debris fluxes onto the coastline calculated for 54 selected coastal segments over a 6-year interval show that the islands of Vis and Mljet are characterised by high plastic debris fluxes, 4kg/(km day) and 18.8 kg/(km day) respectively. In general, the modelling results revealed an asymmetry in plastic debris fluxes between the eastern and the western coastlines of the Adriatic and Ionian Seas, where the eastern part from Igoumenitsa to Marano lagoon tends to get less debris than the western part, from Marano lagoon to Crotone. However, there are some distinctive hotspots found in Po Delta, Venice, Chioggia and Reno Mouth, as well as in Vis and Mljet islands.

When it comes to material composition, the greater majority of litter items were made out of artificial polymer materials with percentages ranging from 54.3% to 96.1% for the different countries, while on aggregated level the percentage was 91.1, thus reflecting the global trend in plastics accounting for the majority of collected items (Derraik, 2002; Eriksen et al., 2013; Poeta et al., 2015; UNEP/MAP, 2016; Bouwman et al., 2016; Munari et al., 2016; Arun Kumar et al., 2016). Also the results of the present study, similarly to other recent studies illustrate that few litter items categories constitute the majority of the total amount of items collected (Munari et al., 2016; Bouwman et al., 2016; Williams et al, 2016). On an aggregated basis at regional level, the top 20 items accounted for 79.75% of total items collected, while at national level the top 20 accounted for 59.1% of total items collected in Albania, 91.3% in Bosnia and Herzegovina, 85.3% in Croatia, 80.4% in Greece, 81.9% in Italy, 85.4% in Montenegro, 88.1% in Slovenia.

On an aggregated basis at regional level, among the most common litter items found (top 20) are plastic pieces 2.5 cm > < 50 cm (G79) and plastic polystyrene pieces 2.5 cm > < 50 cm (G82) accounting for a total of 31.82% of the total 70,581 litter items collected. Unfortunately, it is difficult to attribute these litter item categories to a specific source, however when it comes to the latter category (G82) and taking into account the high percentages of fisheries and aquaculture related items found in certain countries (e.g. Italy, Greece), it can be assumed that these items are likely to be related to the aforementioned economic sectors, as mentioned in other studies on the region (Poeta et al., 2016). Among the top 3 items recorded are cotton bud sticks. It has been suggested by studies carried out in northern European countries (OSPAR, 2009; Veiga et al., 2016; Poeta et al., 2016) that these items are commonly discarded with domestic sewage and reach the coastal and marine environment due to the inefficiency of the sewage treatment plants. Given the differences with regards to the type of items discarded with domestic sewage in the Adriatic-Ionian macroregion, the DeFishGear beach surveyors made an attempt to track and verify the source of these items by asking local inhabitants living nearby the sampling sites. In the majority of the sites, the individuals interviewed claimed that the cotton bud sticks together with other sanitary and sewage related items are not disposed of with domestic sewage but with domestic waste. Therefore, the pathways through which these items reach the coastal and marine environment should be further researched, including rivers, or perhaps additional sources should be considered such as sewage or waste discharges from cruise ships. The latter need is underlined by the fact that cruising is one of the fastest growing sectors in the Adriatic-Ionian macroregion, while efficient monitoring with regards to the implementation of MARPOL and relevant EU directives is not consistently applied throughout the region (Caric and Mackelworth, 2014).

Of the top 20 items 18.95% were short-lived single-use plastic items such as plastic cups/lids from drinks (G21), crisp packets and sweet wrappers (G30), food wrappers and fast food containers (G10), straws and stirrers (G35), cups and cup lids (G33), shopping bags (G3), drink bottles (G7, G8) similar to the findings of other studies (OSPAR, 2009; Galgani et al., 2011; UNEP/MAP, 2015). This highlights the need to recognize the fact that marine litter is not merely a waste management issue but one of the underlying causes of waste accumulation on land and at sea is also the linear use of resources from production to a short-lived single-use stage to disposal (Veiga et al., 2016b).

The DeFishGear results bring to light an issue that had not been identified before in the region and that is the importance of the fisheries and aquaculture sector with regards to marine litter. On an aggregated basis at regional level, mussel nets ranked in the 7th position of the top 20 items found, while in Italy these items were the 3rd most abundant items recorded. Mussel nets, used for grafting and breeding, derive from intensive mussel farming along the Adriatic Italian coast, with 185 active mussel farm installations and an annual production of some 40,000 tons of mussel, accounting for 50% of the national shellfish production (Priori, 2001; Strafella et al., 2015; Pasquini et al., 2016). The present study's results regarding the contribution of the fisheries sector to beach litter are in agreement with the findings of the seafloor surveys presented in Chapter 4.

The attribution of sources to the litter items collected was a rather challenging task, given that on an aggregated basis at regional level, only some 53.7% of litter items could be attributed to a specific source. In addition, the deployed methodology for the attribution of sources has inherent limitations (UNEP/MAP MEDPOL, 2011; Veiga et al., 2016). In accordance with other studies in the Mediterranean and worldwide (UNEP/MAP, 2015; Laglbauer et al., 2014; Kumar et al., 2016) shoreline sources, including poor waste management practices, tourism and recreational activities contributed significantly to the amount of litter collected, however it should be kept in mind that shipping (including cruising) and/or fisheries and aquaculture cannot be excluded from being potential sources of some of the litter items attributed to shoreline sources, including poor waste management practices, tourism and recreational activities. The issue of poor and/or insufficient waste management practices in the Adriatic-Ionian macroregion and the Mediterranean has been highlighted by several reports and scientific papers (Scoullos, 2010; UNEP/MAP, 2016; Spiteri et al., 2016). The findings of the related DeFishGear survey on understanding the socio-economic implications of marine litter in the Adriatic-Ionian macroregion highlight the irresponsible behaviour of tourists and local residents together with coastal and maritime tourism related activities (e.g. touristic establishments on beaches, cruise ships, etc.) as the most important sources of marine litter, as these were perceived by interviewees from the tourism sector, from municipalities and NGOs (Vlachogianni et al., 2016). In the present study litter items from shoreline, tourism and recreational activities accounted for 33.4% of total litter items collected, a value which is similar to the values found in another study carried out in the Adriatic coastline (Munari et al., 2016), which is much lower than the Mediterranean average of 52% (UNEP/MAP MEDPOL, 2011) and the global average of 68.2% (Ocean Conservancy, 2011). On an aggregated basis at regional level, smoking related items accounted for 7.80% of all items collected, a value which is much lower than the 40% value indicated for the Mediterranean (UNEP/MAP MEDPOL; 2011) or the 25.5% indicated by another study in the Adriatic region (Munari et al., 2016). The highest percentages of smoking related items were recorded in Montenegro (41.75%), Bosnia and Herzegovina (36.11%) and Slovenia (29.91%), where the studied beaches were mainly tourist destinations or urbanized areas. When looking at the sea-based sources of litter (fisheries and aquaculture, shipping) these ranged from 1.54% to 14.84% among countries, with an average of 6.30% on an aggregated basis at regional level. If the

plastic polystyrene pieces 2.5 cm > < 50 cm (G82) were attributed to the fisheries and aquaculture sectors the average calculated value for the sea-based sources would be 18.23% (17.18% from the fisheries and aquaculture sector). This value is much higher than 5% calculated for the Mediterranean (UNEP/MAP, 2015) and similar to the value of 11-19.4% reported by another study (Munari et al., 2016). Furthermore, extremely high was the fraction of fisheries and aquaculture related items in certain survey sites in Greece and Italy: for Arillas (Greece) they accounted for 24% of total items collected, for Foce Bevano (Italy) 20.3%, for Boccasette (Italy) 33.4%, for Mega Ammos (Greece) 37.5%. The results add to the growing body of evidence that the fisheries and aquaculture industries are also responsible for marine debris (Unger and Harisson, 2016). These results, therefore, illustrate the need for strengthened implementation of MARPOL Annex V and for localized targeted measures, such as the establishment of derelict fishing gear management schemes to effectively address the issue of marine litter generated by the fisheries and aquaculture sectors. Furthermore, tailor made awareness raising campaigns targeted to these sectors are necessary.

The DeFishGear results, when compared to the findings of the UNEP/MAP marine litter assessment in the Mediterranean (UNEP/MAP, 2015), clearly illustrate that the litter inputs originating from sea-based sources have been underestimated in the Adriatic and Ionian Seas. The deployed monitoring approach and the use of the 'Masterlist' to track the sources of litter allowed for a more illustrative picture of the comparative importance of each source, crucial to support and guide the marine litter management measures. Litter items from fly-tipping accounted for 1.23% of all litter items recorded which is close to the 2% reported for the Mediterranean. Similarly, the medical related items were some 1%, whereas the same value was reported for the Mediterranean. The percentage of sanitary and sewage related waste was quite high reaching the value of 9.68%. This is considerably higher than the average reported for the Mediterranean, were sanitary and sewage related items and medical items were counted together. These items cannot be attributed to a specific source, given that some of these are likely to originate from tourism and recreational activities (land-based and sea-based) or mismanaged solid waste or insufficient/inefficient sewage treatment plants.

From a methodological point of view, the deployed harmonized monitoring approach reflected in the DeFishGear beach litter protocol and the use of the 'Master List of Categories of Litter Items' (Galgani et al., 2013) was an effective way to identify the main sources of marine litter in the Adriatic-Ionian macroregion. Unlike what it seems at first, the classification of litter items in 159 litter items category types is relatively fast and easy (Poeta et al., 2016) and once the main operator is trained and has practiced this task several times the margin of error in terms of classifying the litter items is considerably reduced (Laglbauer et al., 2014). It should be stressed that based on the DeFishGear and other regional litter 'monitoring' initiatives and associated experiences, the 'Masterlist' should be enriched, updated and refined in order to attribute more items to a certain source. Many items found in the DeFishGear surveys were either recorded under the category type 'other identifiable plastic/polystyrene pieces' (G124) or under other category types of litter such as 'sheets, industrial packaging, plastic sheeting' (G67), with most of these items originating

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from the agriculture sector such as olive harvesting nets, plastic sheets from greenhouses, plant pots from retail plant nurseries, etc.

In general, the deployed approach was straightforward and not demanding when it comes to resources (financial, human resources). Assuming that for each survey 4 operators are required and some 2-3 hours on average are needed for the collection, classification and recording of items, some 4-6 mandays per year are needed for monitoring one location. Therefore, countries should not be discouraged to design and implement beach litter monitoring programmes following the DeFishGear protocol. It is worthwhile mentioning that the DeFishGear beach litter surveys were the end result of 360-540 hours of fieldwork.

2.7 CONCLUSIONS

The present study provided the first assessment of marine litter pollution in 31 beaches located along the coastline of the Adriatic and Ionian Seas and it is the first coordinated, consistent and harmonized sub-basin-wide effort to monitor beach litter, thus providing strategic input for the Mediterranean region as a whole. The applied methodology that basically operationalized the marine litter related monitoring guidelines developed by the EU MSFD TG10, while taking into consideration the respective UNEP/MAP MEDPOL guidelines, provided valuable results with regards to the amounts, composition and sources of marine litter on the coastlines of the Adriatic and Ionian Seas. The use of the 159-category-types 'Masterlist' for recording litter items has proven instrumental in terms of detecting the sources of litter and has been rather easy to use. However, certain additions and refinements need to be made to the list in order to capture more effectively the litter inputs of certain sources that are relevant not only to the Adriatic and Ionian macroregion but to the whole Mediterranean.

The assessment of the cleanliness of the surveyed sites showed that half of the investigated beaches are rather clean, while the other half is characterised by a moderate quality. Few beaches were found to be dirty or very dirty and even fewer were found to be very clean.

The present study results suggest that a high proportion of litter is generated and deposited in situ by beach users or is released into the coastal environment due to insufficient waste facilities on the beaches and in general due to mismanaged waste along the coastal zone. Sea-based sources of litter, in particular the inputs from fisheries and aquaculture, were found to be significant and call for targeted management measures. The sources of certain ubiquitous items such as cotton bud sticks should be further investigated in order to facilitate the development of relevant measures. The fact that the largest proportion of the total amount of items collected is consistently made of a limited number of litter item categories (top 20) –may vary from country to country– supports the approach of prioritizing the implementation of tailor-made measures to tackle a set of priority litter items, thus attaining greater impact towards achieving good environmental status.

MARINE LITTER **ON THE SEA SURFACE**

3

3.1 METHODOLOGY AND STUDY AREA

The pilot floating litter surveys were carried out in both coastal and open waters of the Adriatic and the Ionian Seas following two different approaches regarding the vessels used. Small vessels were used for surveying coastal Adriatic waters by the following partners and contributing organizations: Institute of Marine Biology (Montenegro), Institute for Oceanography and Fisheries in collaboration with Sunce (Croatia), Institute for Water of the Republic of Slovenia (Slovenia), Italian National Institute for Environmental Protection and Research & Regional Agency for Environmental Protection in the Emilia-Romagna region (Italy). Adriatic and Ionian waters were surveyed using the ferries connecting Greece to Italy by 'Accademia del Leviatano' (Italy) in collaboration with the Mediterranean Information Office for Environment, Culture and Sustainable Development (Greece).

All surveys performed followed the "Methodology for Monitoring Marine Litter on the Sea Surface-Visual observation (> 2.5 cm)" that was developed within the framework of the DeFishGear project (IPA-Adriatic DeFishGear project, 2014b). The methodology on monitoring floating macro-litter through visual observation by a dedicated surveyor on a vessel was prepared based on the EU MSFD TG10 "Guidance on Monitoring of Marine Litter in European Seas"(Galgani et al., 2013) and the NOOA "Marine Debris Monitoring and Assessment: Recommendations for Monitoring Debris Trends in the Marine Environment"(Lippiat et al., 2013), taking into consideration the draft "UNEP/MAP MEDPOL Monitoring Guidance Document on Ecological Objective 10: Marine Litter (2014)".

In Table 3.1 detailed information is presented regarding the conditions and related parameters of the visual surveys made. Observations in coastal waters were conducted by five different small-sized vessels and included two enclosed embayments along the Dalmatian coast (Gulf of Kotor and Brac Channel), the coastal Croatian waters (Hvar Aquatorium), the Gulfs of Trieste and Venice at the northern part of the Adriatic Sea and Cesenatico waters along the northwestern Adriatic coast (South of the Po river delta and the Cesenatico river) (Fig. 3.1). In total, 66 transects were conducted, some of them were repeated 2 or 3 times on a seasonal basis (Oct.-Dec. 2014; Apr.-July 2015). A distance of 415 km was covered corresponding to 89h of observation (Fig. 3.2). Observations were conducted always from one side of the ship, without the use of binoculars.

For the Adriatic–Ionian waters, all observations were made by dedicated observers on ferries connecting Patras (Greece) to Ancona (Italy). The area surveyed included the Gulfs of Patras and Corfu in the Ionian Sea and open waters of the Adriatic Sea along the route from Corfu Island to Ancona port (Fig. 3.3). Since both coastal and open waters were surveyed we will refer to this data set as 'Adriatic-Ionian waters'. Vessel speed and observation height were about 10 times higher than those used for coastal waters resulting in a substantially wider observation width (up to 100 m), while a total of 9,062 km were surveyed (Tab. 3.1). All surveys were performed under low wind speed conditions (< 3 Beaufort).

Litter items were identified according to litter type and size. Six size classes were recorded (2.5-5 cm; 5-10 cm; 10-20 cm; 20-30 cm; 30-50 cm; > 50 cm) for coastal waters and three for open waters (20-30 cm; 30-50 cm; > 50 cm). The total surface of the surveyed area for coastal waters was estimated by multiplying the transect distance by the observation width. The litter density (items/km^2) was calculated by dividing the items count with the surveyed area surface. No specific methodology (Buckland et al., 1993) or correction factors (Ryan, 2013) regarding the effective strip width were applied. It was assumed that the detection efficiency for all items larger than 2.5 cm was highest at a distance of 8 m from the side of the boat. Observations from heights similar to the DeFishGear ones have been conducted also by Thiel et al. (2003) and Suaria et al. (2015) (1 m and 4 m respectively). These surveyors have conducted width measurements and have concluded that 10 m was their observation width.

For the Adriatic-Ionian waters, the distance of items observed was checked against a measuring stick (range finder) and items were recorded within a fixed strip according to three distance ranges (50 m, 75 m, 100 m). The strip was defined at the beginning of each survey depending on visibility conditions in order to ensure that the dedicated observer can detect with the naked eye all items larger than 20 cm. Given the observation height and the observation width, the small sized items (<20 cm) couldn't be distinguished and therefore during these surveys only larger (> 20 cm) floating litter was recorded (Arcangeli et al., 2015). For this reason, data between coastal and Adriatic-Ionian waters are not directly comparable and therefore are treated separately.

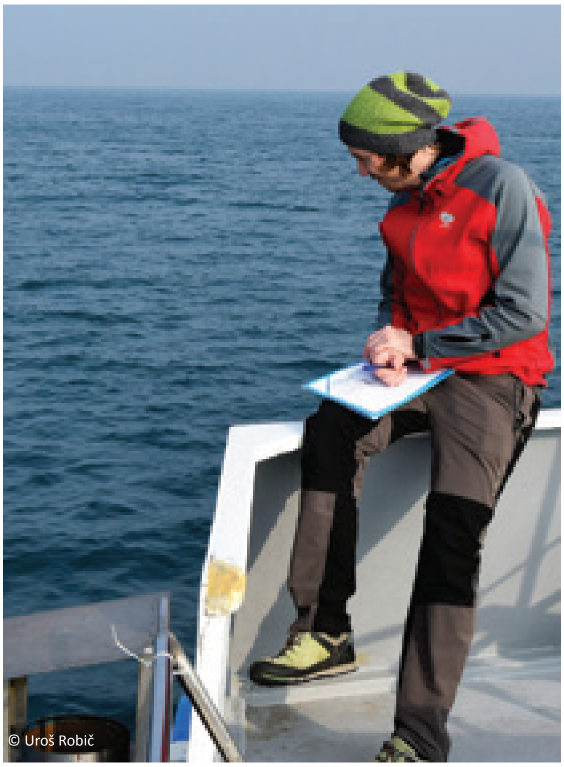


Figure 3.1. *Observational transects for floating litter in Adriatic coastal waters using small vessels.*

Table 3.1. *Conditions of observational surveys for floating macro-litter. (*For open waters a measuring stick (range finder) was used).*

Area	Vessel Speed (knots)	Obs. Height (m)	*Obs. Width (m)	Wind Speed (Beaufort)	No of transects (seasonal replicates)	Distance from coast (km)	Total distance covered (km)
Gulf of Kotor (Montenegro)	2	2.5	8	-	(1x3) + 1 = 4	~1-2	146
Brac Channel & Hvar Aquatorium (Croatia)	2.8±0.17	3	8	1.4±1.1	(10x2) = 20	~2-10	101
Gulf of Trieste (Slovenia)	2.9±0.44	2.5	8	2±1.4	(5x3) = 15	~4 -7	74
Gulf of Venice (Italy)	2.4±0.15	3.2	8	1±1.3	(8x2) + 5 = 21	~4-33	56
Cesenatico (Italy)	3	1	6	2±0.9	(3x2) = 6	~4-5	39
Total coastal waters					66		415
Adriatic Sea (Corfu port to Ancona port)	26.6±0.94	25	50 75 100	1.4±0.7	45	~ 100	5,089
Ionian Sea (Patras port to Corfu port)	26.0±1.90	25	50 75 100	1.5±0.6	46	~10 - 40	3,973
Total Adriatic-Ionian waters					91		9,062

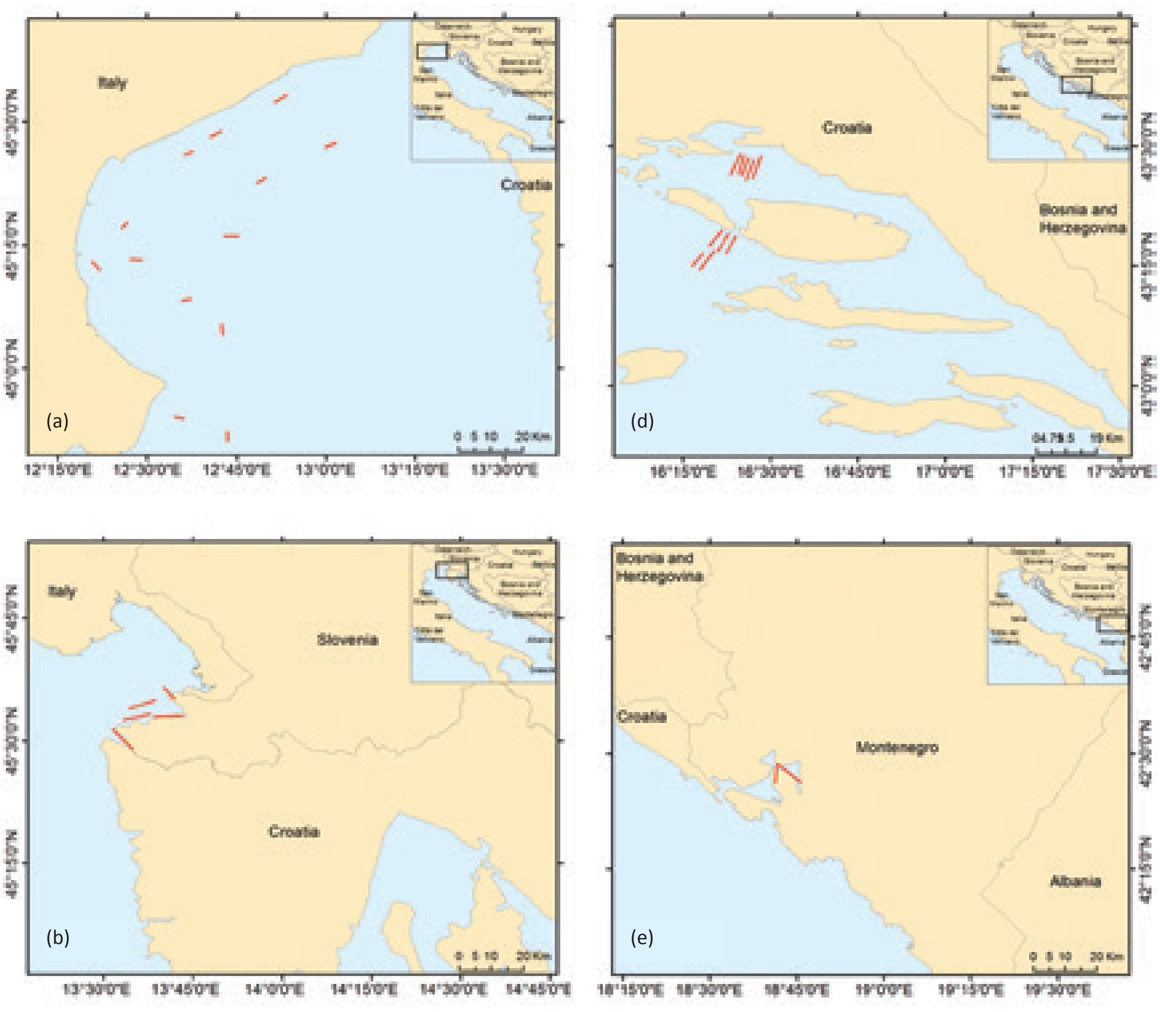
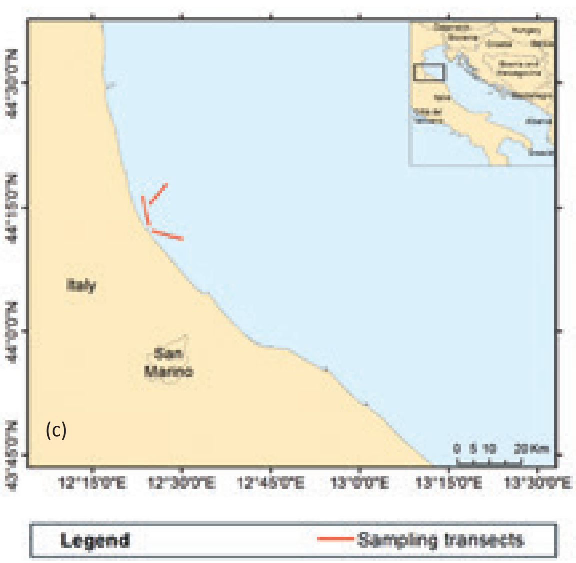



Figure 3.2. *The positions of the observational transects (in red) in coastal Adriatic waters: (a) Gulf of Venice; (b) Gulf of Trieste; (c) Cesenatico coastal area; (d) Brac Channel and Hvar Aquatorium; (e) Gulf of Kotor.*

Figure 3.3. *The survey line (in red) covered for floating litter observations in the Adriatic–Ionian waters using ferry boats.*

3.2 ABUNDANCE AND SIZE DISTRIBUTION OF FLOATING LITTER

In total 3,552 marine litter items were identified, out of which 720 were found floating in coastal waters and 2,832 in the Adriatic-Ionian waters. No litter items were recorded in 13 out of the 66 transects in coastal waters (20% of the transects were litter-free), while litter was always present during the ferry line transects.

Based on these results, the average density of floating macro-litter in coastal Adriatic waters was found 332 ± 749 items/km^2 and in the Adriatic-Ionian waters 4 ± 3 items/km^2. This considerable discrepancy (two orders of magnitude) between the two datasets is attributed to the different lower size limit that can be detected during the ferry line transects (only items bigger than 20 cm are detected) and possibly to the different waters investigated during the ferry line transects. The distribution of litter abundances in the various sub-areas surveyed is presented as a box plot diagram in Figure 3.4.

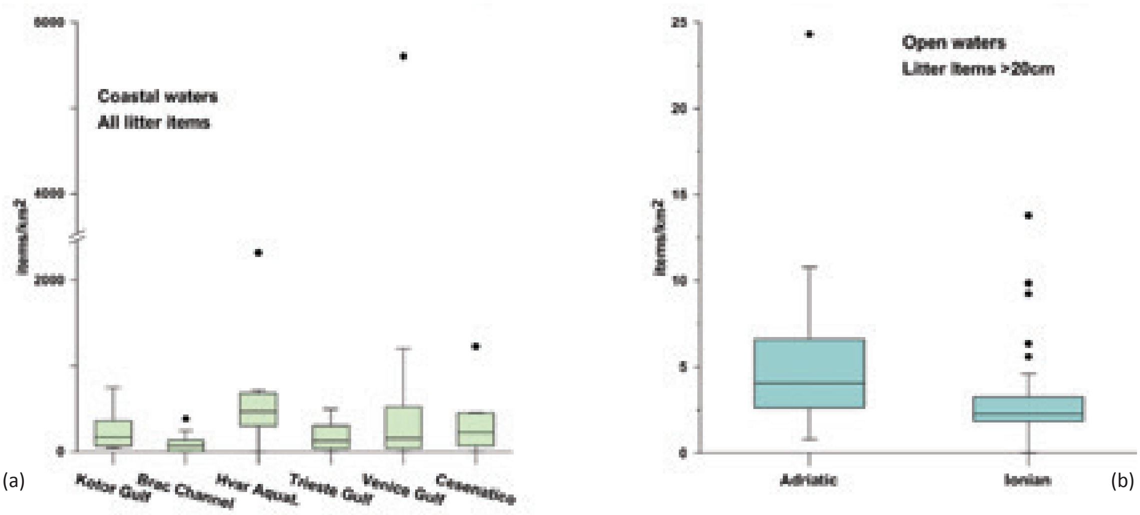


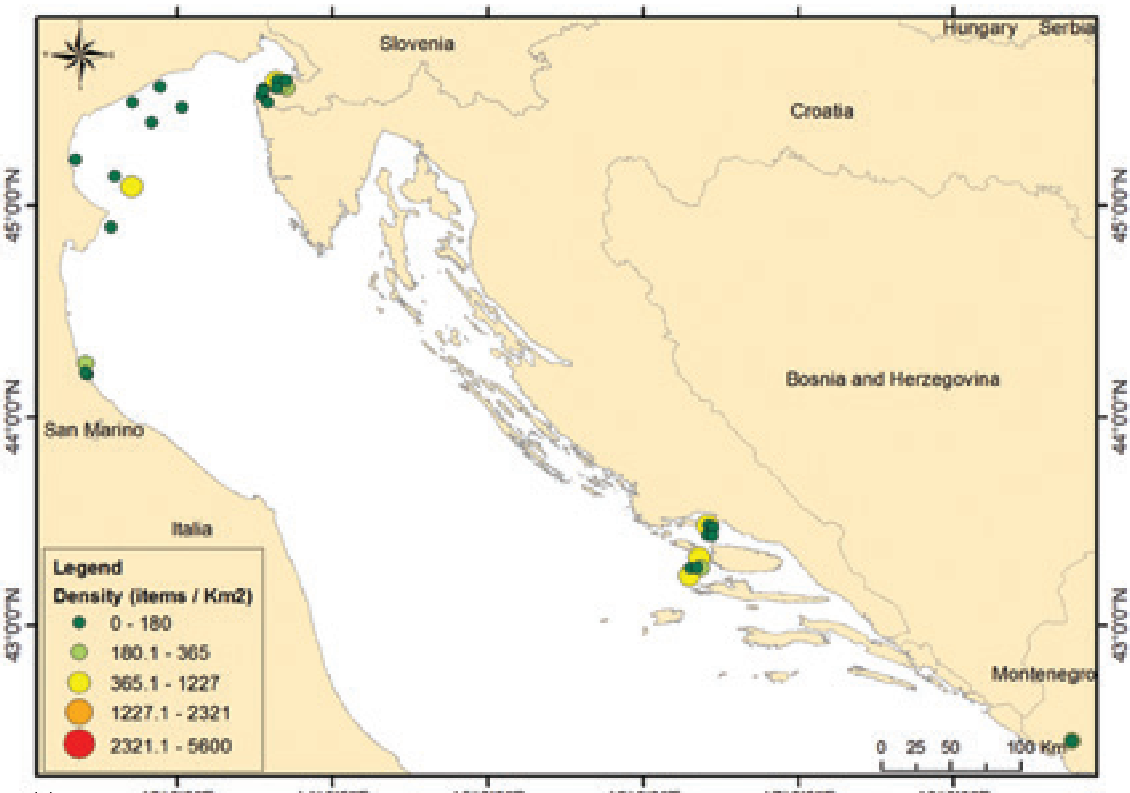
Figure 3.4. *The range of floating litter abundances measured in: (a) coastal Adriatic waters (n = 66) using small vessels; (b) Adriatic and Ionian waters (n = 91) using ferries. The boundaries of the boxes indicate the 25th and 75th percentiles, the whiskers above and below the boxes the 95th and 5th percentiles. Outliers are indicated by black dots. The horizontal line denotes the median value.*

3.2.1. Coastal waters

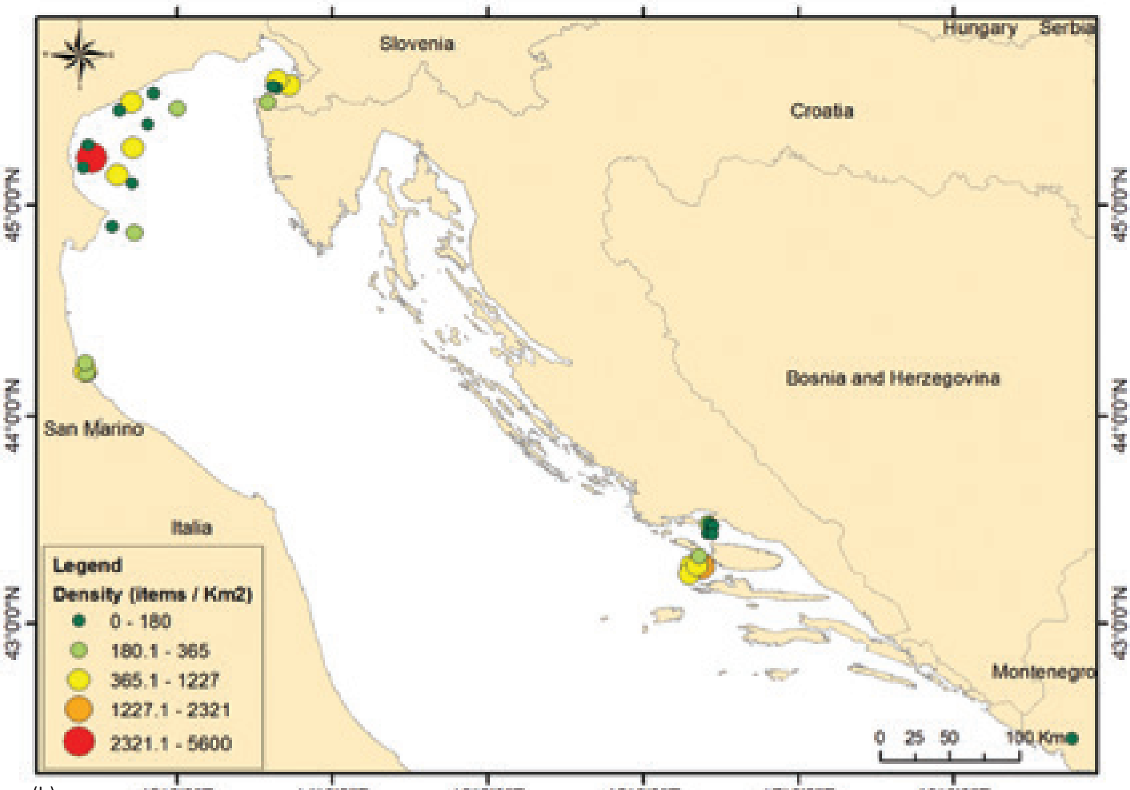
Floating litter densities were comparable among the various areas surveyed ($p = 0.074$) (Kruskal-Wallis significance test for $p < 0.05$) (Fig. 3.4(a)). The highest average abundances were recorded in the coastal waters of Hvar Aquatorium (Croatian coast) (576 ± 650 items/km^2; median 393 items/km^2), followed by the Gulf of Venice (475 ± 1203 items/km^2; median 154 items/km^2) and Cesenatico related area (324 ± 492 items/km^2; median 210 items/km^2).

The distribution of floating litter densities for the transects surveyed, in autumn 2014 and spring 2015, is depicted in Figure 3.5. Densities were highly variable in the small geographical scale of each area studied (CV% range: 65% - 225%); while differences between the two seasons were not found significant for all areas ($p > 0.05$) (Mann-Whitney test). More specifically, floating litter densities were elevated during spring at the Hvar Aquatorium, Gulf of Trieste, Gulf of Venice and Cesenatico and during autumn at the Gulf of Kotor and Brac Channel. These observations underline the complexity of factors controlling the distribution of litter in the marine environment and will be discussed in paragraph 3.3.

Figure 3.6(a) presents the percentage contribution of the 5 size classes in the various areas surveyed. For coastal waters, about 48% of surveyed litter items correspond to small-sized items ranging between 2.5 cm and 5 cm, with progressive diminishing contributions of items with larger sizes. This trend was followed in all areas with the exception of the Gulf of Kotor, where the size classes were more or less equally distributed. Items larger than 50 cm were identified only in coastal waters of Hvar Aquatorium; while in Cesenatico all size classes larger than 10 cm were absent. This fact could be related to the short distance (39 km) and sampling time (7h) at Cesenatico and therefore the low probability to encounter larger litter items.



(a)



(b)

Figure 3.5. *Spatial distribution of floating litter densities for the 66 transects conducted in coastal Adriatic waters: (a) in autumn 2014; and (b) in spring 2015.*

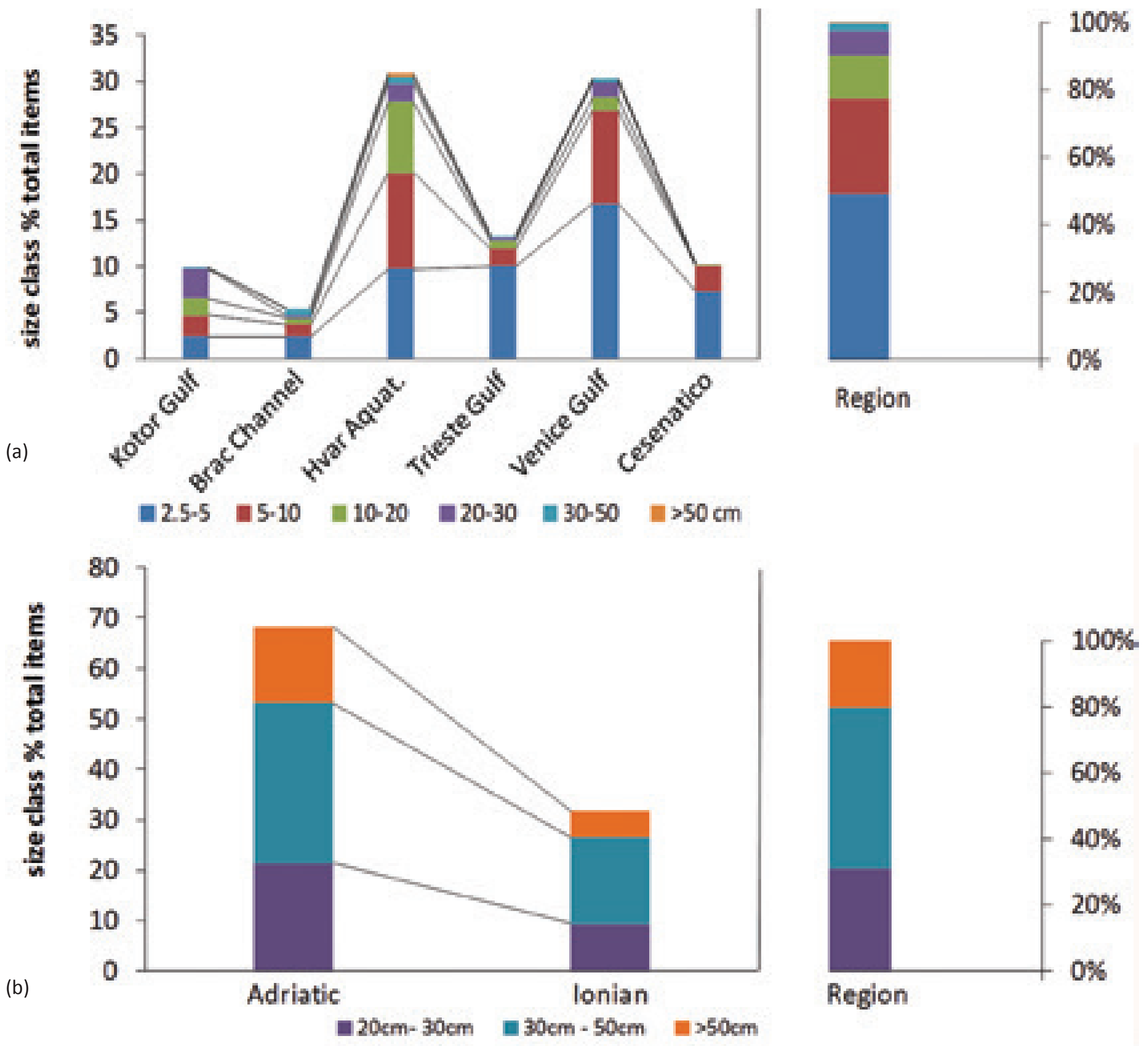


Figure 3.6. *Percentage contribution of the various size classes in floating litter (a) in coastal Adriatic waters; (b) in Adriatic-Ionian waters.*

3.2.2. Adriatic-Ionian waters

During the surveys carried out by observers on ferries (Fig. 3.4(b), litter abundances were found about two times higher in the Adriatic (5.03 ± 3.86 items/km^2) compared to the Ionian Sea (2.94 ± 2.54 items/km^2).

The distribution of the different size classes for the Adriatic-Ionian waters is presented in Figure 3.6(b). It appears that the general trend of a diminishing percentage contribution of items with increasing size class is not followed. The size class of 30 cm-50 cm holds the highest percentage 49% (32% for the Adriatic and 17% for the Ionian waters). This is quite unexpected, knowing the general fragmentation trend of marine litter and in particular of plastic in the marine environment (Cózar et al., 2015), as well as that most packaging material falls into the range of 20 cm – 30 cm rather than in size classes larger than 30 cm. We believe, that under the conditions of the surveys carried out by observers on ferries, items in the size class of 20-30 cm were underestimated, either because they were misconceived as larger, or they were not detected at all. In order to investigate the comparability of the two data sets, we calculated marine litter densities in coastal waters only for the larger size classes. For items larger than 20 cm the average density was found 72 ± 72 items/km^2 (median 50 items/km^2), and for items larger than 30 cm the average density was 91 ± 96 items/km^2 (median 47 items/km^2). Both numbers are still one order of magnitude higher than the ones derived from the ferry related surveys. Whether these differences are due solely to methodological inconsistencies and/or to oceanographic factors leading to the accumulation of litter along the Adriatic and Ionian coasts is discussed in paragraph 3.3.

3.3 COMPOSITION OF FLOATING LITTER

3.3.1. Coastal waters

The 720 items identified in coastal Adriatic waters were classified in 22 out of the 44 floating litter type categories as described in the MSFD TG10 guidance document (Galgani et al., 2013) and the DeFishGear protocol. Plastic items were dominant (91.4% of total items), followed by paper (7.5%) and wood items (2.1%). The most abundant categories were bags (G2) reaching 26.5% of total items, followed by plastic pieces (G79) 20.3%, sheets (G76) 13.3% and fish polystyrene boxes (G58) 11.4%. Other categories with significant contribution were: cover/packaging (G38) 8.1%, other plastic items (G124) 6.0%, other paper items (G158) 3.3 %, polystyrene pieces (G82) 3.9%, other wood items (G173) 2.1%, paper packaging (G149) 1.3% and bottles (G6) 1.3%. These 11 litter categories hold 97 % of all litter identified (Fig. 3.7(a)).

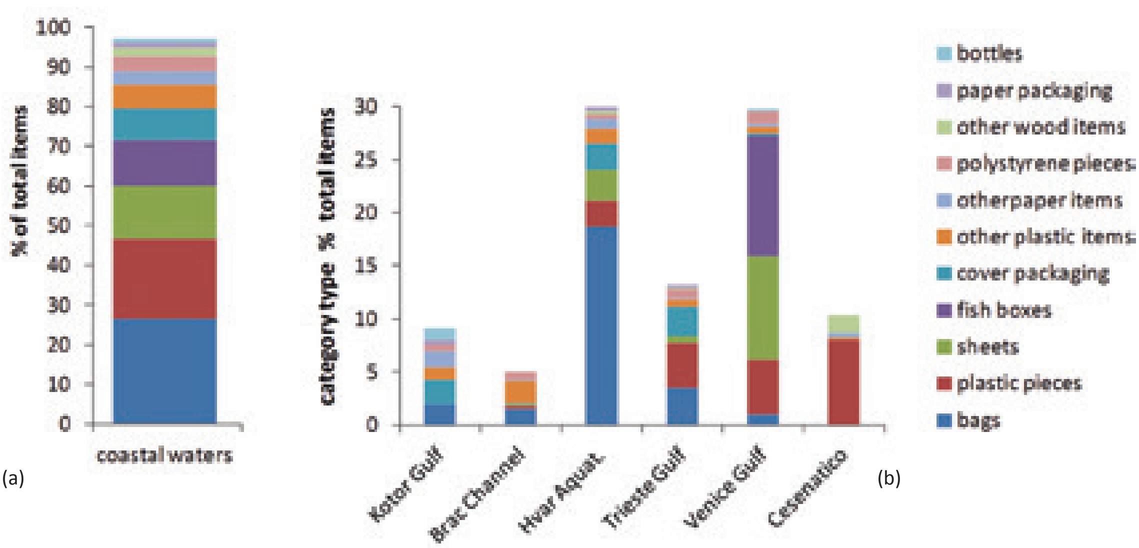
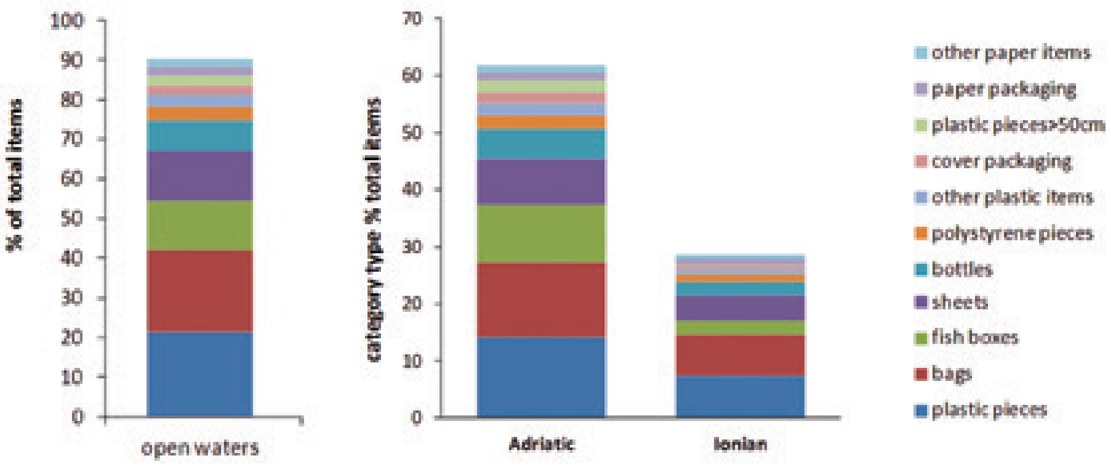


Figure 3.7. *Percentage contribution of the floating litter category types: (a) for all 66 transects in coastal waters; (b) for each sub-area separately.*

The percentage contribution of the top 11 items at the 6 surveyed areas in coastal Adriatic waters is presented in Figure 3.7(b). It becomes clear that the distribution of the various marine litter types was not homogenous among the surveyed areas. Polystyrene fish boxes were present only in the Gulf of Venice (11%), while the contribution of plastic bags (G2) was found elevated at the Hvar Aquatorium (18.6%). The intense fishing and aquaculture activities in the Gulf of Venice, relatively to the other surveyed areas, may explain the presence of polystyrene fish boxes there. At the same time polystyrene pieces (2.5 cm < < 50 cm) (G82) were found everywhere except Cesenatico, indicating the fast fragmentation and dispersal of this material. Traces of paper were present in all areas with the highest contribution in the Gulf of Kotor (G38 and G149 equal to 2.1%). Knowing that paper litter disintegrates quite fast in the marine environment, these results clearly show that all surveyed areas are in close vicinity to sources. Finally, bottles (G6), were found only in the Gulf of Kotor (1.1%) and the Gulf of Venice but with a much lower contribution (0.1%). Although plastic bottles are widely used in product packaging, especially for drinking water, their scarce presence in floating litter indicates that they are removed rapidly from surface waters, either to the shore and/or to the seafloor via stranding or sinking mechanisms. From the qualitative composition of the litter already described (Fig. 3.7(b)), it is understood that the increased abundances found in (i) Hvar Aquatorium are mostly attributed to the presence of bags (G2) (18.6%); (ii) the Gulf of Venice to polystyrene fish boxes (G58) (11.4%) and sheets (G67) (9.7%); and (iii) the Cesenatico waters to plastic pieces 2.5 cm < < 50 cm (G79) (8.1%). All other items contributed by less than 8% in all areas surveyed.

3.3.2. Adriatic-Ionian waters

In the Adriatic and Ionian Seas, the 2,832 items identified fall into 32 out of 44 marine litter categories used for floating litter. Similarly to coastal waters, the three most abundant litter categories were plastic (91.6%), paper (5.1%) and wood (1.4%). The 11 most abundant categories hold 90.4% of all items and include the same types of items as for coastal waters. The only exception is other wood items (G173), which are not included in the top 11 list of Adriatic-Ionian waters; instead larger plastic pieces (> 50 cm) (G80) appear. Plastic pieces (G79) corresponded to 21.5%, bags (G2) to 20.4%, polystyrene fish boxes (G58) and sheets (G76) to 12.5% each, and bottles (G6) to 7.7% of total items found. Other categories with significant contribution were: polystyrene pieces (G82) 3.6%, other plastic items (G124) 2.9%, cover/ packaging (G38) 2.5%, plastic pieces (> 50 cm) (G80) 2.4%, paper packaging (G149) 2.4% and other paper items (G158) 2.0% (Fig. 3.8(a)).



(a) (b)

Figure 3.8 Percentage contribution of the floating litter category types (a) for all 91 transects in Adriatic-Ionian waters; (b) for each sub-area separately.

If we consider the Adriatic and Ionian waters separately it appears that the 11 most abundant categories are homogenously distributed in the two seas, i.e. individual category proportions were about double in the Adriatic than in the Ionian Sea following the abundances pattern (Fig. 3.8(b)). Only polystyrene fish boxes (G58) have a substantially higher contribution (10%) in the Adriatic marine litter assortment than in the Ionian one (2.5%).

3.4 DISCUSSION

3.4.1. Methodological constraints – Comparability of macro-litter densities

The incompatibility between the two data sets (coastal *vs* Ionian-Adriatic waters) obtained during the DeFishGear surveys highlights the importance of common strategies regarding observations of floating marine litter and calculations of their densities. One important issue is that anthropogenic (marine) litter in contrast to natural litter (e.g. kelp) is present at the sea surface in a variety of sizes. While litter items in the micro-litter range (300 µm < <1 cm) are adequately sampled using surface towed nets, the visual observation methodology applied for recording litter items in the macro-litter size range (2.5 cm < < 50 cm) is dependent on many factors not always common among surveys. Two major constraints are: i) the accurate estimation of the observation width (or strip) and hence of litter densities, and ii) the loss of detection ability of the smaller sizes with increasing observation height and vessel speed.

In Table 3.2 information has been gathered regarding floating litter densities and observation conditions as reported in the literature. Most published works have been conducted with oceanographic vessels traveling with a speed of ~10 knots and from an observation height ranging from 4 m to 10 m. Equally variable was the observation width of each survey. In many studies, a range finder was used in order to classify observed items to specific distance ranges and then based on distance sampling probability analysis the effective strip width (ESW) was estimated. In this way, however, size classes are considered as unequally distributed within the ESW with the smaller sizes being detected closest to the ship. Some workers have further refined this approach by applying correction factors on the various litter sizes and then extrapolating their abundances on the total width of the ESW (Ryan, 2013; Goldstein et al., 2013).

The problem of detection of the small macro-litter sizes (2.5 cm to 5 cm) has been already acknowledged (Galgani et al., 2013; Ryan, 2013) and it is now advisable to report data on floating litter along with the minimum size detected. Until now, only some studies report the minimum size class detected and even fewer have recorded detailed size classes of the litter items observed (Morris, 1980; Ryan, 2013; Suaria and Aliani, 2014; Shiomoto and Kameda, 2015; Sa et al., 2016). The implementation of a common methodology including the use of a range finder, the statistical estimation of the ESW and application of correction factors, along with the definition of the minimum detection size will definitely improve the accuracy and comparability of reported marine litter densities. Nevertheless, the small size items (2.5-5 cm) will still be prone to underestimation when medium or large size vessels traveling with increased speed are used. This drawback is reflected in the percentage distribution of size classes reported in some of these studies for open waters (i.e. far from land sources) where the highest contribution corresponds to the 5-15 cm (or < 10 cm) size class rather than to the < 5 cm one (Tab. 3.2) (Ryan, 2013; Suaria and Aliani, 2014; Sa et al., 2016). It is expected that the ability to detect small-sized items (2.5-5 cm) will increase if small vessels with low velocities are used instead. This is the case of the DeFishGear coastal surveys during which the observation height was 1-3 m and the vessel speed was always kept between 2-3 knots. Under such conditions, it is assumed that the observation width is narrow (8-10 m) and also that each item size class is homogenously distributed within the 8-10 m strip (i.e. the observer can detect all items present within the strip) (Thiel et al., 2003; Suaria et al., 2015). Indeed, the percentage distribution of the size classes recorded in the present work for the surveyed areas affected mostly by the Adriatic open waters (Trieste Gulf, Venice Gulf, Cesenatico) follows an inverse linear relationship between item size *vs* percentage (%) contribution, with the smallest size class (2.5-5 cm) contribution reaching 49% of total items recorded (Fig. 3.7, Tab. 3.2). The detection of small macro-litter sizes is especially relevant for estimates of the total amount of plastics present in the marine environment, while for monitoring litter on the sea surface, data on larger size classes obtained from larger vessels, such 'ships of opportunity' (e.g. ferries) can be considered adequate.

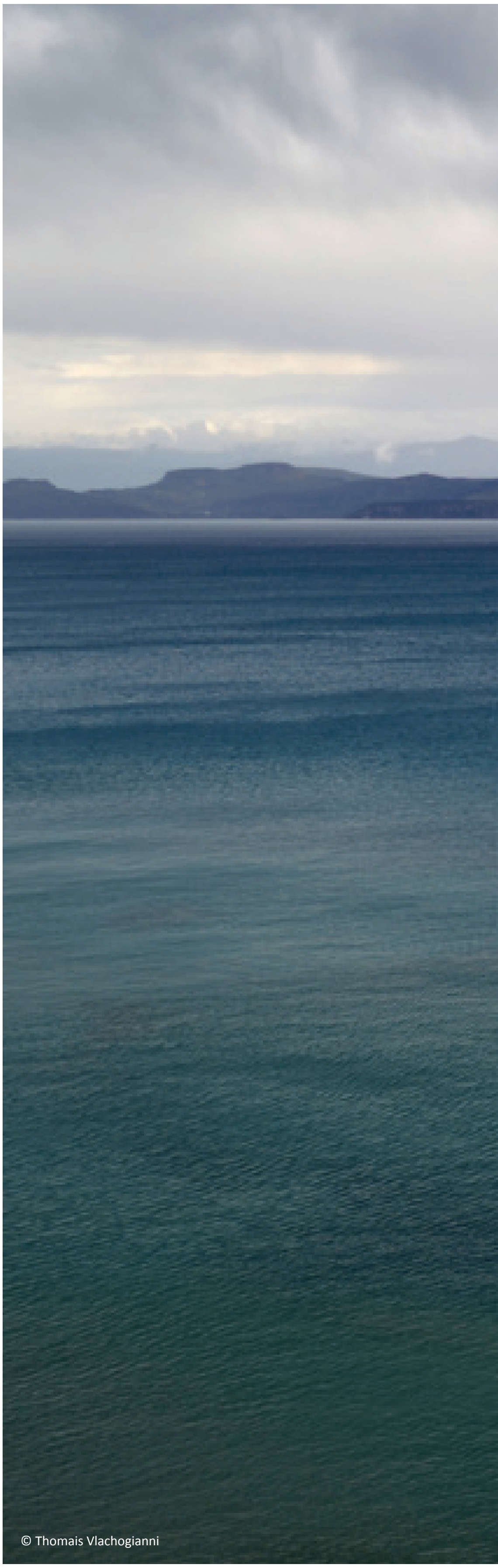
Given the aforementioned differences in the minimum litter size detected, the density data presented in Table 3.2 cannot be considered directly comparable. It is interesting to note, however, that for the Mediterranean Sea, the highest litter density of 2,000 items/km^2 was reported by Morris (1980). Although his observations were made from an elevation of 12 m this author clearly stated that observation conditions enabled him to detect small sized items > 1.5 cm. For the Adriatic Sea, the DeFishGear density data include items > 2.5 cm and were found one order of magnitude lower 332 ± 749 items/km^2 than those by Morris (1980), while in the work by Suaria and Aliani (2014) the lowest detectable size was ~ 10 cm and two orders of magnitude lower litter densities (55 ± 11 items/km^2) were reported. Finally, the DeFishGear density data obtained by observers on ferries for items > 20 cm are the lowest 4 ± 3 items/km^2. It is worth mentioning, that for coastal Adriatic waters, density calculations for larger size classes only, give numbers clearly comparable to those by Suaria and Aliani (2014) (for items > 20 cm: average density 72 ± 72 items/km^2; median 50 items/km^2; for items > 30 cm: average density 91 ± 96 items/km^2; median 47 items/km^2). The slightly elevated densities calculated from the DeFishGear surveys could be related to differences in the geographical coverage and sampling period (Suaria and Aliani (2014) have surveyed the Central and South Adriatic including coastal and open areas, whereas our transects were confined to coastal areas of the North Adriatic Sea).

3.4.2. Possible sources and distribution pattern of floating litter in the Adriatic and Ionian Seas

The most important factors affecting the distribution of litter in the marine environment are the vicinity of marine litter sources (i.e. urban and touristic centres, shipping lanes, fishing areas, aquaculture farms) and pathways (i.e. rivers, waste water management plants), with high uncertainties regarding their fluxes, as well as the prevailing specific oceanographic conditions.

For the Adriatic and Ionian Seas, the major litter sources include (i) shipping lanes and fishing activities, (ii) the populated urban and touristic centres of Venice, Bari, Trieste, Split, Ravenna, Patras, Corfu; while important pathways of litter from land to sea are the rivers flowing into the Adriatic and Ionian Seas (Po and Adige Rivers on the west coast, Buna/Bojana, Neretva and Kalamas Rivers on the east coast).

In order to get a rough idea of the contribution of the major litter sources in the assortment of floating litter in the Adriatic Sea, we attributed the litter category types found to general litter sources. We followed the approach proposed by the Marine Conservation Society (MCS, 2013) and refined herein (Chapter 2, Annex II). The 22 litter type categories found floating in the Adriatic Sea were grouped as follows: Categories G2, G38, G6, G149, G154, G175 under shoreline sources, including poor waste management, tourism and recreational activities; categories G18, G67, G79, G82, G124, G134, G145, G148, G158, G169, G173, G197 under mixed sources and categories G48, G51, G58, G142 under fishing related sources. No items could be directly linked to shipping activities other than fishing. The contribution of these three sources to floating litter is presented in Table 3.3. In addition, in Table 3.4 information on the dominant types of litter found (i.e. bags and sheets, plastic pieces) as well as on three types of litter indicative of recent littering (paper), public litter (bottles) and fishing activities (fish boxes) has been extracted (Fig. 3.9). From both tables, it is understood that fisheries hold a significant share only during spring 2015 (17%) attributed to the presence of fish boxes (15%) at the Gulf of Venice. The elevated abundances of styrofoam in Adriatic waters are in agreement with a previous study (Suaria and Aliani, 2014) covering several Mediterranean areas and point to fisheries as a local source of styrofoam litter. Inputs from the shoreline sources and mixed–unidentified sources were the dominant sources of floating litter. Plastic bags and sheets hold ~40% and plastic pieces hold ~ 30% of litter found floating in Adriatic coastal waters. The substantial presence of paper (12% in autumn and 2.5% in spring) shows recent littering activities. On the other hand, the paucity of bottles in floating litter can be related to the fast sinking of these items. This simple grouping of items reflects that the surface waters of the Adriatic Sea are affected by litter that come from items commonly used in our daily life and are not indicative of a specific economic sector and/or other anthropogenic activity. The sources and pathways of this kind of litter include all those aforementioned. Plastic pieces that can be produced either *in situ* (at sea) or transported via rivers and wastewater treatment plants from land hold about one third of floating litter. They are actually fragmented plastics and therefore can be considered 'old' – 'aged' litter which recirculates at the sea surface and probably is being exchanged between the shore and the sea several times.



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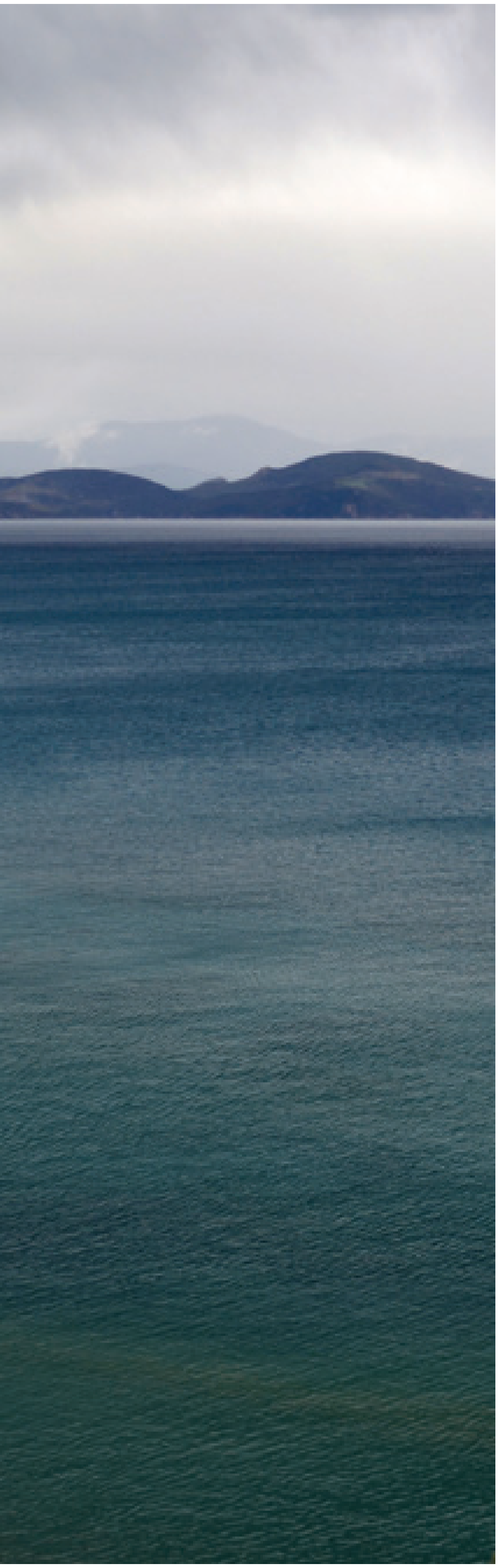


Within the framework of the DeFishGear project the spatio-temporal distribution and transport of plastic litter in the Adriatic Sea based on surface current and wind analysis was modeled (Liurbatseva et al., 2016). The model's simulations show that during all seasons litter accumulates along an elongated band starting from the northern Adriatic and following the west (Italian) coast, with some 'lenses' of increased litter scattered along the east (Dalmatian) coast, a picture closely reflecting the proximity and intensity of litter sources. Nevertheless, this distribution shows substantial seasonal variation driven by the seasonality in the meteo-oceanographic conditions. More specifically, maximum litter concentrations are confined in the Northern Adriatic (Venice and Trieste Gulfs) during spring, while during summer the gradient between the east and west coasts becomes even sharper. In autumn and winter, the band of elevated litter concentrations relaxes and expands in the middle and southern Adriatic resulting in concentration increases there, especially during autumn.

The limited number of areas surveyed within the framework of the DeFishGear project does not allow us to get a clear picture of the distribution gradients in floating litter. Only 4 surveyed areas are affected by the surface water circulation, namely Hvar Aquatorium, Gulf of Trieste, Gulf of Venice and Cesenatico. The two enclosed areas of the Gulf of Kotor and Brac Channel are isolated and litter items found there are not expected to be related to major transportation mechanisms. Litter concentrations were found comparable at the Gulf of Venice (475 ± 1203 items/km^2), the Gulf of Trieste (178 ± 177 items/km^2) and Cesenatico (324 ± 492 items/km^2); all areas directly affected by the major urban-touristic centres and pathways (Po River). In addition, comparable results (though somewhat higher on average) were found at Hvar Aquatorium (576 ± 650 items/km^2). This is probably related to local conditions of stagnant waters ('lenses') in the Split area which receives important litter fluxes on the east coast of the Adriatic (Liubartseva at al., 2016). Seasonal differences show that during autumn-winter months, the average litter concentrations in the above mentioned coastal areas diminish to more than half of the concentrations found during spring-summer. This is in general agreement with the expansion of the litter band towards the interior of the Adriatic basin described by Liubartseva et al. (2016). However, the increased variability in the DeFishGear data and the lack of statistical significance of the seasonal differences do not allow us to draw concrete conclusions.

Figure 3.9*. Plastic bags and pieces (left image); Styrofoam boxes, afloat on coastal Adriatic waters (right image).*

Table 3.2. Literature data on floating litter densities and observation conditions.

Area	Year	Vessel speed (Knots)	Obs. height (m)	Obs. width (m)	Distance travelled (km)	Total items (No)	Density items/km²	size classes	%	Source
SE Pacific coastal	2002	4-10	1	10			1 - 36			*Thiel et al., 2003*
NE Pacific	2009	-	10	600	4400	3868	0 - 15.202	2-10 cm 10-30 cm > 30 cm	81 14 5	*Goldstein et al., 2013*
Southern Chile (Fjords, gulfs)	2002-05	10	4	20	900	-	16.4 ± 14.4	-		*Hinojosa and Thiel, 2009*
Sea of Japan	2000	10	5	100	-	-	0.7 ± 0.76	> 5 cm		*Shiomoto & Kameda, 2015*
Bay of Bengal	2013	-	10-13	50	2161	537	8.7 ± 1.4	< 5 cm 5-15 cm 15-30 cm 30-60 cm > 60 cm	37 38 16 7 3	*Ryan, 2013*
Straits of Malacca					1113	17740	578 ± 219	< 5 cm 5-15 cm 15-30 cm 30-60 cm > 60 cm	25 52 18 5 1	*Ryan, 2013*
South Atlantic coastal open	2013	-	12-15 (6)	5	51 1911	84 197	67 2.9	> 5 cm	-	*Ryan, 2014*
Portuguese Atlantic waters	2011	4.9-10	6	300	1594	608	2.98	< 2.5 cm < 10 cm < 100 cm > 100 cm	15 34 46 5	*Sa et al., 2016*
North Sea	2006-08	5-12	11	50	504	816	0-300 (32.4)	-	-	*Thiel et al., 2011*
Black Sea	2014	7	4	10	186.62	55	30.9 ± 7.4	-	-	*Suaria et al., 2015*
Ligurian Sea	1996 2000	3.2-11.5 6	top deck top deck	50 50	175.9 252	281 74	14-25 1.5-3.0	- -	- -	*Aliani et al., 2003*
Mediterranean Sea	1979		12	10	-	-	2000	> 1.5 cm		*Morris, 1980*
Western Mediterranean Adriatic	2013	10	5	30	1538 277	1402 282	0-162 (24.9 ± 2.5) 55 ± 11	< 10 cm < 50 cm < 100 cm > 100 cm	35 53 10 25	*Suaria and Aliani, 2014*
Adriatic-Ionian waters	2014 -15	26	25	100	9062	2832	4 ± 3	20-30 cm 30-50 cm > 50 cm	31 49 20	*Present work*
Adriatic coastal waters	2014 -15	2 - 3	1 -3	8	415	720	332 ± 749	2.5-5 cm 5-10 cm 10-20 cm 20-30 cm 30-50 cm > 50 cm	49 29 13 7 2 0.4	*Present work*

Table 3.3. *The percentage contribution of litter sources to the floating litter assortment in Adriatic coastal waters during autumn 2014 (A) and spring 2015 (S).*

Sources	Kotor Gulf		Brac Channel		Hvar Aquatorium		Trieste Gulf		Venice Gulf		Cesenatico		Region	
%	A	S	A	S	A	S	A	S	A	S	A	S	A	S
Shoreline, tourism & recreational activities	9.4	4.6	4.0	1	13	25	8.9	5.6	4.5	0.2	0.0	0	**40**	**37**
Mixed Sources	11	1.2	6.4	2.9	14	6.2	13	4.1	8.9	19	5.4	14	**60**	**46**
Fisheries	0.0	0	0.0	0.2	0.0	0	0.5	0	0.0	16	0.0	0	**0.5**	**17**

Table 3.4. *The percentage contribution of major (bags and sheets; plastic pieces) and indicative (paper; bottles; fish boxes) litter types to the floating litter assortment in Adriatic coastal waters during autumn 2014 (A) and spring 2015 (S).*

Litter type	Kotor Gulf		Brac Channel		Hvar Aquatorium		Trieste Gulf		Venice Gulf		Cesenatico		Region	
%	A	S	A	S	A	S	A	S	A	S	A	S	A	S
bags+sheets	3.0	1.5	4.0	0.8	15	24	6.4	3.1	8.9	11			**37**	**41**
plastic pieces	4.5	0.6	4.5	2.5	4.0	4.6	12	3.5	2.5	6.9	0.5	11.2	**28**	**30**
paper	7.9	0.4		0.2	3.0	1.0	1.5			0.4		0.6	**12**	**2.5**
bottles	1.1	0.9							0.4				**1.5**	**0.9**
fish boxes										15			**0.0**	**15**

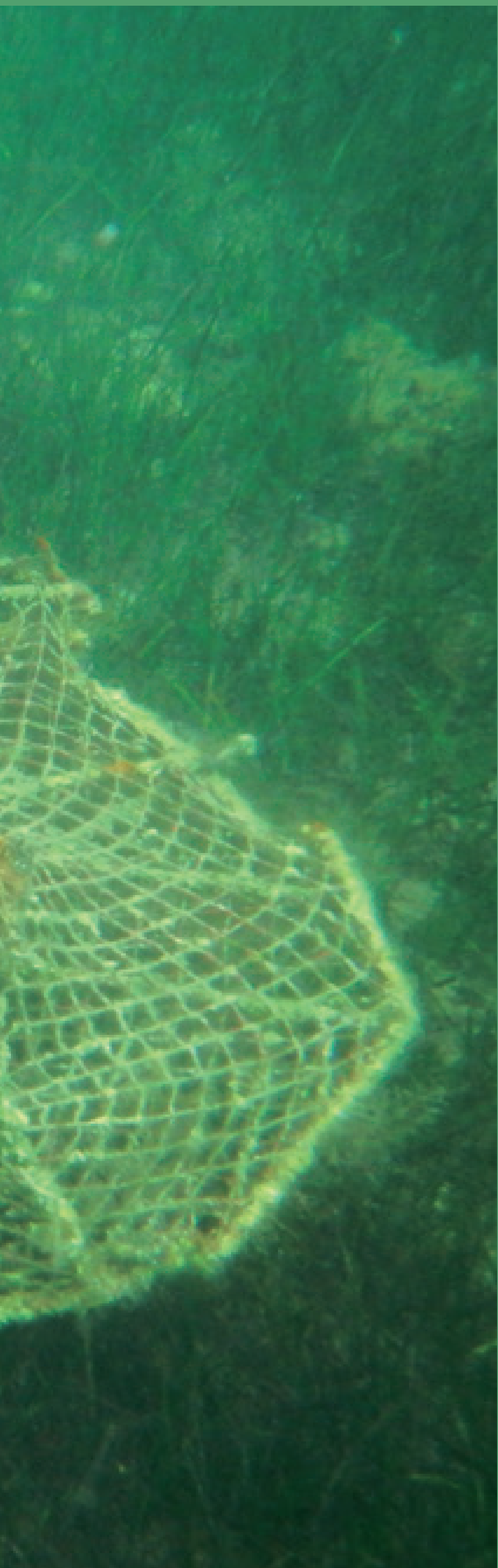
3.5 CONCLUSIONS

Monitoring surveys for floating litter are conducted in most cases from large oceanographic vessels in parallel to other research and/or monitoring activities, or from ferries during their standard routes. In this way, a lot of data can be produced in a cost-effective way. The need to report the minimum detection size and to apply correction factors to density calculations has been highlighted (Ryan, 2013) in order to produce comparable results. In the present work, we used small vessels and found abundances of floating litter one order of magnitude higher than those previously reported for the Adriatic Sea. The different observation conditions applied during the monitoring surveys of the DeFishGear project and in particular the low vessel speed and observation height proved to be critical in improving the observer's detection ability. The abundance of small size litter items (2.5 cm > < 5 cm) (~50% of all items detected) is significant and hence taking them into account in floating litter densities becomes important. This is especially relevant for estimates of the amount of total plastic present in the marine environment while for monitoring litter on the sea surface, data on larger size classes obtained from larger vessels can be considered adequate.

The composition and distribution of floating litter suggest that everyday public and touristic activities are mostly responsible for this kind of pollution in the Adriatic and Ionian waters. It appears that the region suffers from both recent (based on the presence of paper) and past (based on the presence of fragments) littering activities. Fisheries are the only specific economic sector that has an apparent share in floating litter. Of course, other economic sectors (e.g. shipping) may also pollute with waste and litter that cannot be attributed to a specific source and hence their share cannot be quantified.

Findings also indicate that efforts towards minimizing mismanaged waste on land should be reinforced. At the same time, raising awareness of the public and of all economic sectors related to marine litter sources in the Adriatic and Ionian Seas (tourism, shipping, fisheries) is highly recommended in order to prevent and reduce marine litter. Finally, targeted measures such as the banning of plastic bags or plastic bag levies and management of styrofoam fish boxes are expected to have a direct effect on minimizing floating litter in the Adriatic and Ionian Seas.

MARINE LITTER **ON THE SEAFLOOR**



4

4.1 STUDY AREA

The pilot seafloor litter surveys were carried out in almost all countries of the Adriatic-Ionian macroregion, namely Bosnia and Herzegovina, Croatia, Greece, Italy, Montenegro and Slovenia. In shallow waters (<20 m depth), underwater visual surveys with scuba diving/snorkelling were performed, while at depths higher than 20 m the bottom trawling method was applied. In particular, in Bosnia and Herzegovina only underwater visual surveys were done; in Croatia, Greece and Italy only trawl surveys, while in Slovenia and Montenegro both methods were applied.

Twenty-one locations (Tab. 4.1) were investigated differing in terms of: (i) vicinity to potential litter sources such as towns, harbours, rivers, shipping lanes, etc.; (ii) environmental features such as prevailing sea currents, prevailing winds, sediment type, depth, etc. Trawl surveys were performed in 11 locations (Fig. 4.1), while underwater visual surveys in 10 locations (Fig. 4.2).

Table 4.1. *Locations of seafloor litter surveyed in each country and surveying organization.*

COUNTRY	SURVEY LOCATION	SURVEYING ORGANIZATION	SURVEY TYPE
BOSNIA & HERZEGOVINA	Neum 1	Hydro-Engineering Institute of the Faculty of Civil Engineering (HEIS)	Underwater visual survey
	Neum 2		Underwater visual survey
CROATIA	Dubrovnik	Institute of Oceanography and Fisheries (IOF) & NGO Sunce	Trawl survey
	Hvar		Trawl survey
GREECE	Gulf of Corfu	Hellenic Centre for Marine Research (HCMR)	Trawl survey
	SW Corfu		Trawl survey
	N Corfu		Trawl survey
ITALY	Rimini offshore	Regional Agency for Environmental Protection in the Emilia-Romagna region (ARPAE)	Trawl survey
	Savio offshore		Trawl survey
	Western Gulf of Venice N	Italian National Institute for Environmental Protection and Research (ISPRA)	Trawl survey
	Western Gulf of Venice S		Trawl survey
MONTENEGRO	Sv Nedelja	Institute of marine biology (IBM)	Underwater visual survey
	Kostanjica		Underwater visual survey
	Strp		Underwater visual survey
	Montenegrin waters		Trawl survey
SLOVENIA	Slovenian waters	Institute for Water of the Republic of Slovenia (IWRS)	Trawl survey
	Debeli rtič		Underwater visual survey
	Dragonja		Underwater visual survey
	Koper		Underwater visual survey
	Portorož		Underwater visual survey
	Semedela		Underwater visual survey

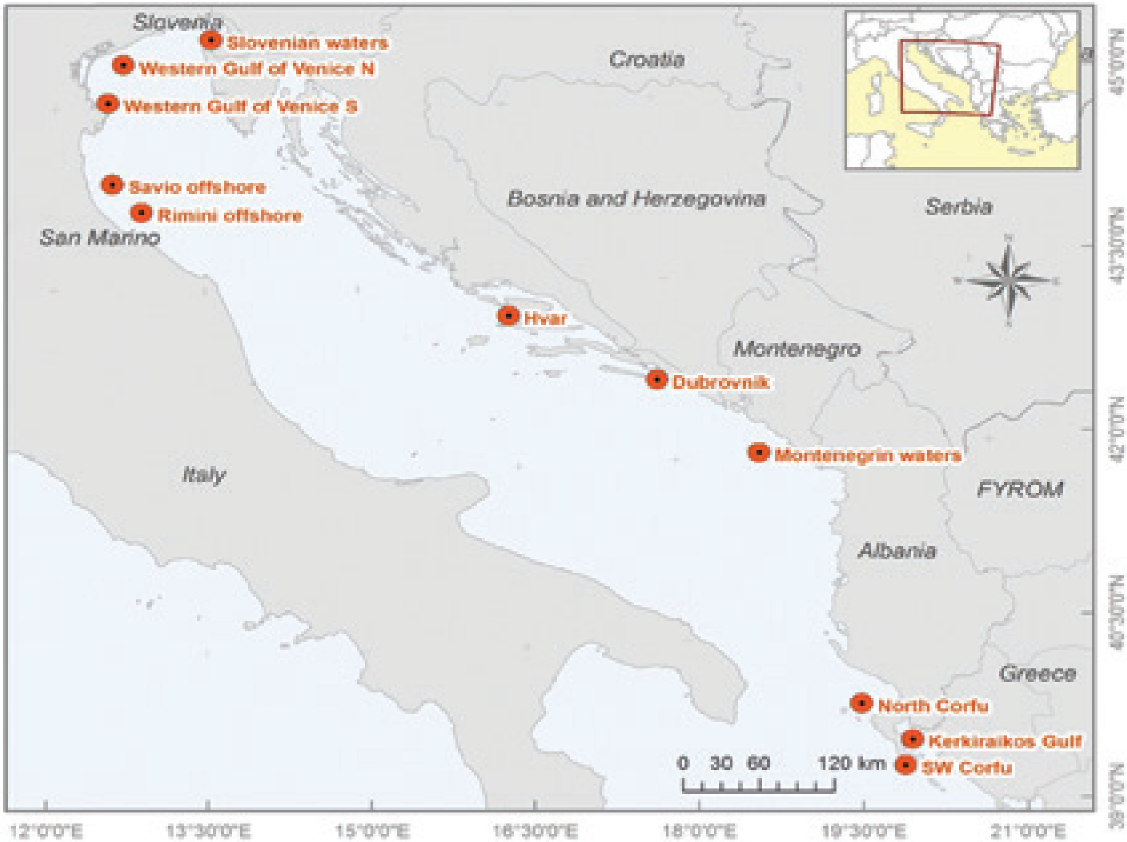


Figure 4.1. *Locations where trawl surveys were performed in the Adriatic and Ionian Seas.*

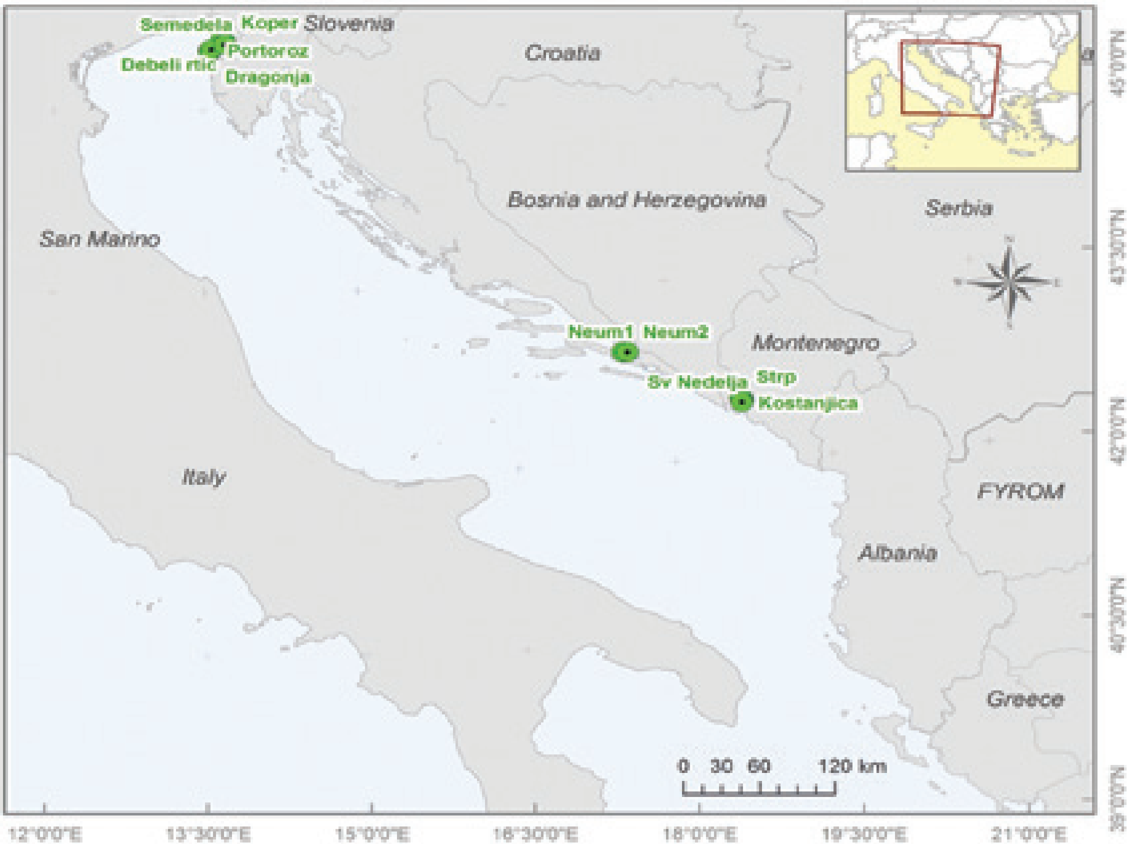


Figure 4.2. *Locations where the underwater visual surveys were performed in the Adriatic and Ionian Seas.*

4.2 SURVEY METHOD

Surveys were performed following the "Methodology for Monitoring Marine Litter on the Seafloor (continental shelf) – bottom trawl surveys" (IPA-Adriatic DeFishGear project, 2014c) and the "Methodology for Monitoring Marine Litter on the Seafloor (Shallow coastal waters 0 – 20 m) - Visual surveys with SCUBA/ snorkelling" (IPA-Adriatic DeFishGear project, 2014d) that were prepared within the framework of the DeFishGear project.

The methodologies were prepared based on the EU MSFD TG10 "Guidance on Monitoring of Marine Litter in European Seas" (Galgani et al., 2013), the NOOA "Marine Debris Monitoring and Assessment: Recommendations for Monitoring Debris Trends in the Marine Environment (Lippiatt et al., 2013) and the "International bottom trawl survey in the Mediterranean, Instructional Manual" (MEDITS Working Group, 2013), taking into consideration the draft UNEP/MAP MEDPOL "Monitoring Guidance Document on Ecological Objective 10: Marine Litter (UNEP/MAP MEDPOL, 2014)".

4.2.1. Bottom trawl surveys

Sites were selected to ensure that they:

- comprise areas with uniform substrate (ideally sand/silt bottom);
- consider areas that might accumulate litter;
- avoid areas of risk (presence of munitions), sensitive or protected areas;
- do not exert impacts on any endangered or protected species.

Moreover, sites were chosen following a two-fold approach: (i) selecting sites that meet certain criteria (e.g. are close to ports, river mouths, cities, etc.); (ii) choosing randomly from a large number of sites.

Vessels (e.g. type, length) and net (e.g. mesh size/type) characteristics were recorded for each survey. Haul details (e.g. latitude/longitude start/end, vessel speed, depth) and environmental parameters (e.g. wind speed, sea state) were recorded during surveys. For more details on the information collected during the surveys see the "Monitoring Marine Litter (Macro) on the Seafloor - Data Sheet" (ANNEX III).

Between October 2014 and August 2015, two surveys were performed at each location (Tab. 4.2, Fig. 4.3 and 4.4), with a total of 121 hauls covering a depth range from 10 to 281 m. Hauls were performed at a constant depth and were rectilinear. Hauls' mean length was 2,698 ± 687 m, hauls' mean duration was 34 ± 7 minutes and vessel mean speed was 2.6 ± 0.3 knots.

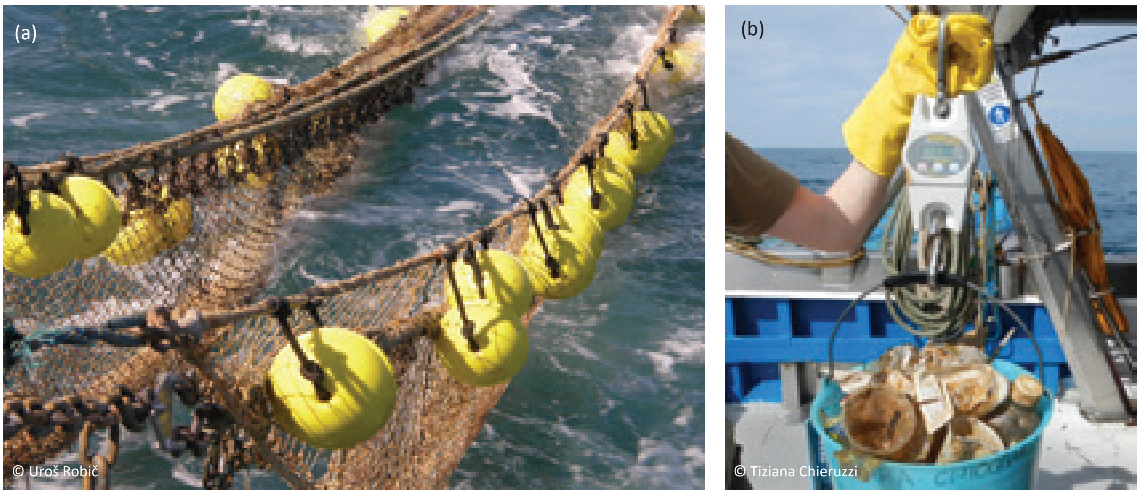


__Figure 4.3.__ (a) Otter-trawl net retrieved at the end of the haul; (b) Weighing of the plastic fraction of the litter collected).

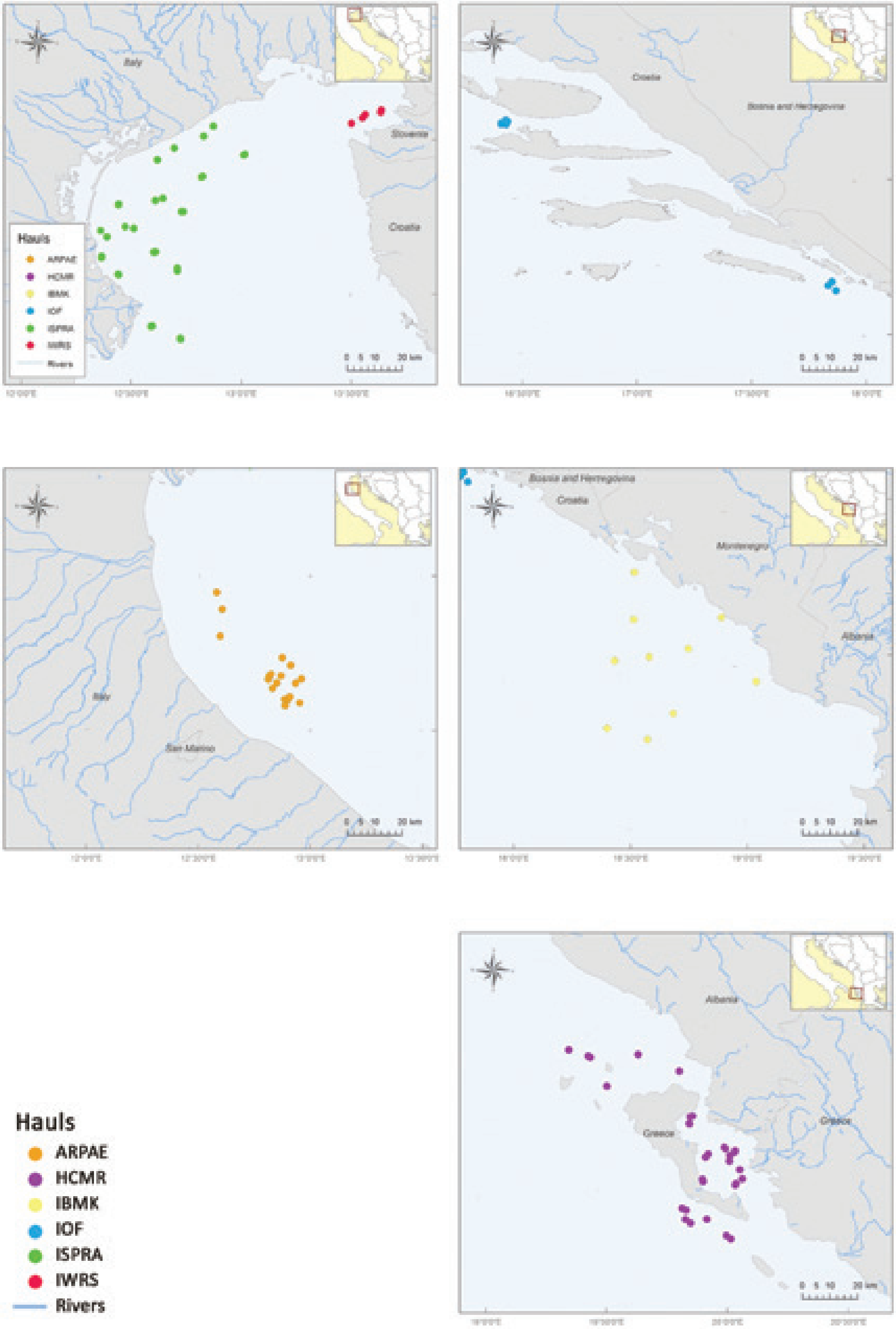


Figure 4.4. *Magnified maps of the locations for bottom trawl surveys showing a central point for every haul performed by ARPAE, HCMR, IOF, ISPRA, IWRS and IBM.*

Table 4.2. Location and key features of each survey.

Country	Location	Period	No of hauls	Min depth (m)	Max depth (m)	Mesh size (mm)	Cod type
Croatia	Dubrovnik	Spring 2015	3	101	200	24	Diamond
		Winter 2015	3	101	200		
	Hvar	Spring 2015	3	51	100		
		Winter 2015	3	51	100		
Greece	Gulf of Corfu	Autumn 2014	9	43	68	40	Diamond
		Spring 2015	9	47	69		
	N Corfu	Autumn 2014	4	71	267		
		Spring 2015	4	63	260		
	SW Corfu	Autumn 2014	4	84	281		
		Spring 2015	4	86	279		
Italy	Rimini offshore	Autumn 2014	9	20	50	40	Square
		Spring 2015	6	20	50		
	Savio offshore	Spring 2015	3	20	50		
	Western Gulf of Venice N	Autumn 2014	9	12	29		
		Spring 2015	9	15	27		
	Western Gulf of Venice S	Autumn 2014	7	10	31		
		Spring 2015	7	15	31		
Montenegro	Montenegrin waters	Summer 2014	20	20	200	10	Square
		Summer 2015	20	20	200		
Slovenia	Slovenian waters	Autumn 2014	2	20	25	20	Square
		Autumn 2015	3	20	25	40	

All items visible to the naked eye were collected from the haul and recorded on the data sheet developed in the framework of the DeFishGear project (ANNEX III). On the sheet, each type of item is given a unique identification number, according to 53 categories. Litter items were subdivided according to their material type (artificial polymer material, rubber, cloth/textile, paper/card-board, processed/worked wood, metal, glass/ceramics), and each material was weighed (Fig. 4.3(b)). Digital photos of litter items were taken when possible (Fig. 4.6).

Moreover, the following size range classes were reported for each recorded litter item:

A. < 5 cm * 5 cm = 25 cm^2

B. < 10 cm*10 cm = 100 cm^2

C. < 20 cm * 20 cm = 400 cm^2

D. < 50 cm * 50 cm = 2500 cm^2

E. < 100 cm * 100 cm = 10000 cm^2 = 1 m^2

F. > 100 cm * 100 cm = 10000 cm^2 = 1 m^2

Litter was expressed as counts of litter items per square kilometer (litter items/km^2). The estimation of litter items/km^2 required the estimation of the "swept area" (the trawl sweeps a path, the area of which is the length of the path times the width of the trawl). The latter is difficult to be monitored accurately during the haul because it requires the use of specialized equipment, like acoustic devices mounted on the trawl net. Such instruments were used only by HCMR during the DeFishGear samplings.

Thus, the swept area (a) was estimated following the method of Sparre and Venema (1998) (Fig. 4.5):

$$a = D * h * X \qquad \text{where } D = V * t$$

Where:
V *is the velocity of the trawl over the ground when trawling;*
h *is the length of the head-rope;*
D *is the cover of distance;*
t *is the time spent trawling;*
X *is that fraction of the head-rope length, which is equal to the width of the path swept by the trawl. The value of X varies from 0.4 to 0.66 for tropical waters and a value of X = 0.5 has been suggested as the best compromise value for the Mediterranean Sea (*Sparre and Venema, 1992*).*

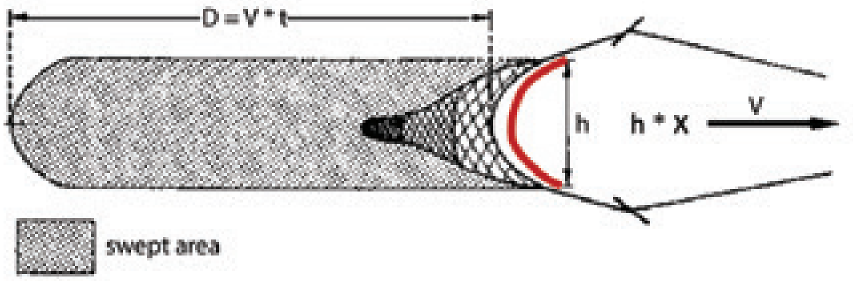


Figure 4.5. *Swept area (source: http://www.fao.org/docrep/w5449e/w5449e0f.htm).*

Figure 4.6. *Photos of seafloor litter items collected during the trawl surveys.*

4.2.2. Visual surveys with scuba/snorkelling

Sites were selected to ensure that they:

- consider areas that might accumulate litter;
- avoid areas of risk (presence of munitions and other hazardous waste), sensitive or protected areas;
- do not exert impacts on any endangered or protected species;
- avoid areas with strong currents or waves;
- avoid navigation routes of vessels that might put divers in danger.

Moreover, sites were chosen following a two-fold approach: (i) selecting sites that meet certain criteria (e.g. are close to ports, river mouths, cities, etc.); (ii) choosing randomly from a large number of sites.

One or two transects were surveyed for each location per season (Fig. 4.8, Tab. 4.3). The line transects were defined with a nylon line, marked every 5 meters with resistant paint, that was deployed using a diving reel while scuba diving. Distances were determined either by laying

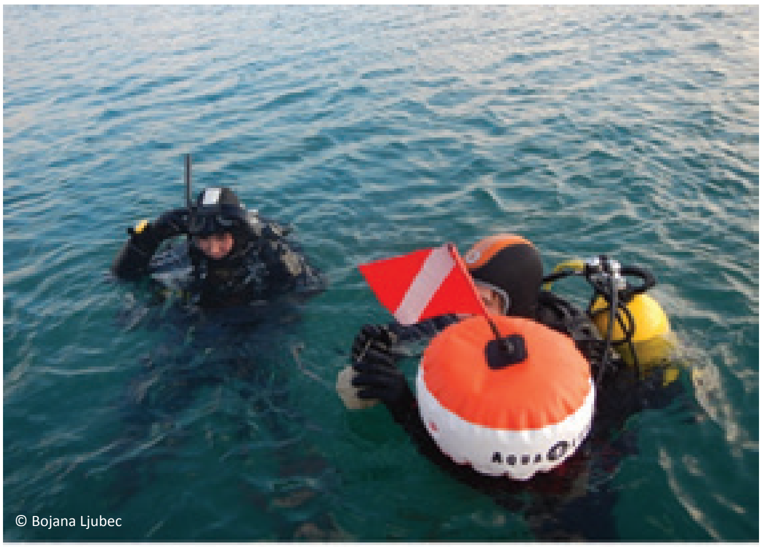


Figure 4.7. Underwater visual surveys with scuba diving/snorkelling.

out a 100-metre tape measure or alternatively by laying a 100-metre rope across the bottom. The start and end point of each transect were identified with marker buoys and recorded using a GPS.

Between October 2014 and December 2015, 2 to 4 surveys were performed in each location for a total of 38 transects, covering a depth range of 0-24 m (Tab. 4.3). The length of the line transects varied between 20 m to 200 m, and the width from 0.1 m to 8 m, depending on the depth, the depth gradient, the turbidity, the current, the habitat complexity and the litter density.

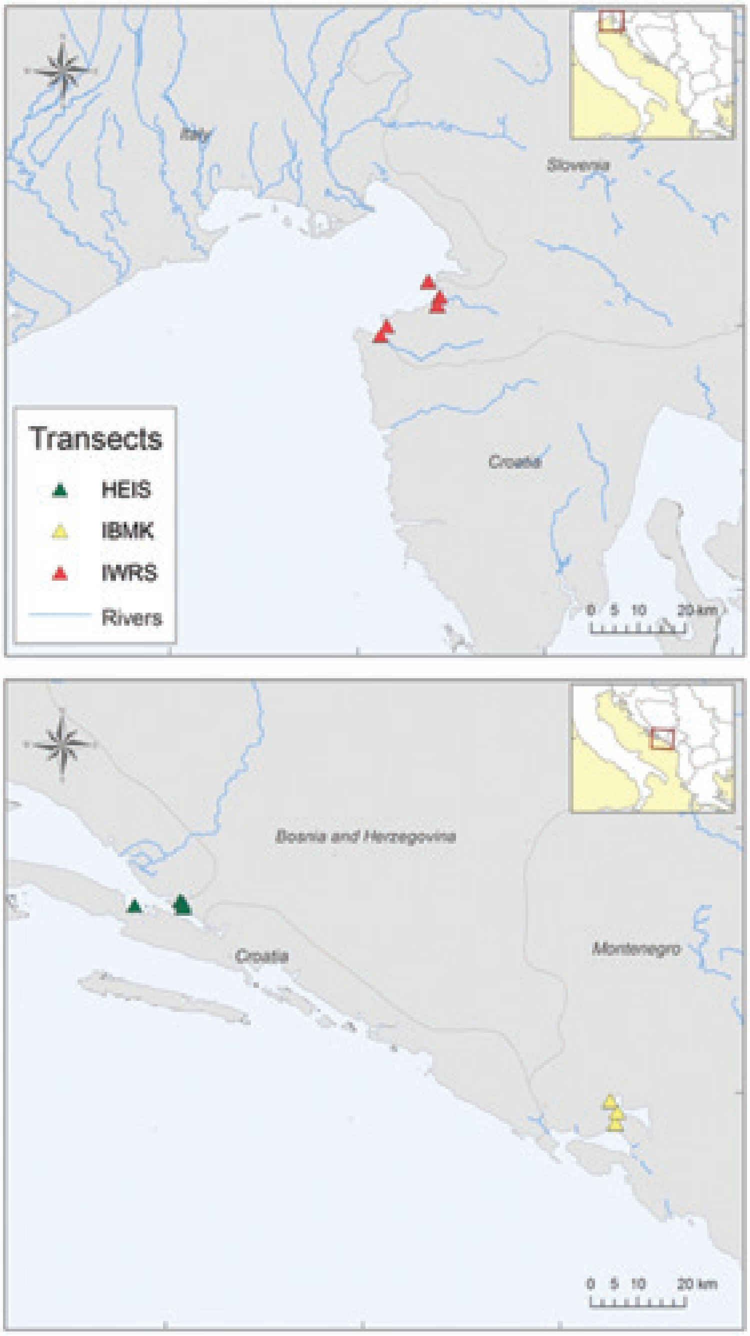


Figure 4.8. *Magnified maps for underwater visual surveys showing a central point for every transect. The visual surveys were performed by HEIS, IWRS and IBM.*

Figure 4.9. Photos of seafloor litter collected during the underwater visual surveys with scuba/snorkelling.

The following size range classes were reported for each recorded litter item:

A. < 5 cm * 5 cm = 25 cm^2
B. < 10 cm * 10 cm = 100 cm^2
C. < 20 cm * 20 cm = 400 cm^2
D. < 50 cm * 50 cm = 2500 cm^2
E. < 100 cm * 100 cm = 10000 cm^2 = 1 m^2
F. > 100 cm * 100 cm = 10000 cm^2 = 1 m^2

Lighter litter items were collected whenever possible, brought ashore and recorded on the data sheet developed in the framework of the DeFishGear project (Annex IV). Conversely, larger items were just marked. When conducting underwater visual surveys with snorkelling, digital photos were taken for all items with an underwater camera and they were then recorded on the aforementioned monitoring sheet once identified. On the recording sheet, each type of item is given a unique identification number, according to 53 categories.

The unit in which litter was recorded was the number of items and it was expressed as counts of litter items per 100 square meters (litter items/100 m^2). The survey area was defined by the transect width and length.

__Table 4.3.__ Location and key features of each survey.

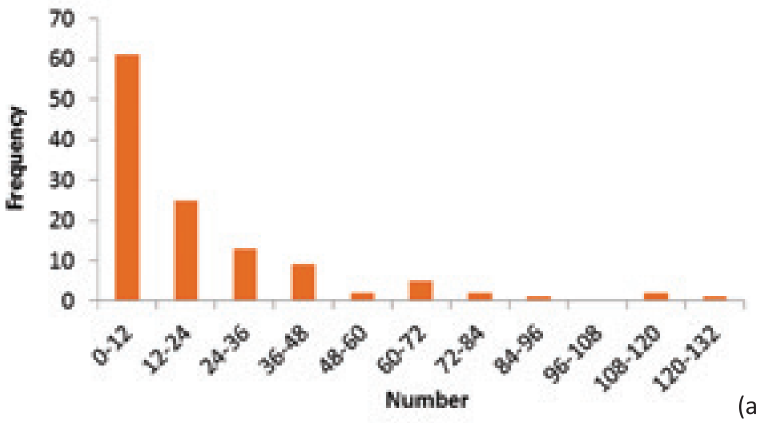
Country	Location	Period	No of transects	Depth (m)
Bosnia & Herzegovina	Neum 1	Winter 2014	1	
		Summer 2015	1	
		Winter 2015	1	15
	Neum 2	Winter 2014	1	
		Summer 2015	1	
		Winter 2015	1	10
Montenegro	Kostanjica	Autumn 2014	1	15
		Spring 2015	1	15
		Summer 2015	1	21
		Winter 2015	1	15
	Strp	Autumn 2014	1	13
		Spring 2015	1	13
		Summer 2015	1	24
		Winter 2015	1	13
	Sv Nedelja	Autumn 2014	1	9
		Spring 2015	1	9
		Summer 2015	1	22
		Winter 2015	1	9
Slovenia	Debeli rtič	Winter 2014	1	
		Summer 2015	2	17
		Winter 2015	1	17
	Dragonja	Winter 2014	1	14
		Summer 2015	2	10-15
		Winter 2015	1	14
	Koper	Winter 2014	1	10
		Summer 2015	2	10
		Winter 2015	1	10
	Portorož	Winter 2014	1	11
		Summer 2015	2	10-15
		Winter 2015	1	
	Semedela	Winter 2014	1	5
		Summer 2015	2	3
		Winter 2015	1	3

4.3 ABUNDANCE AND COMPOSITION

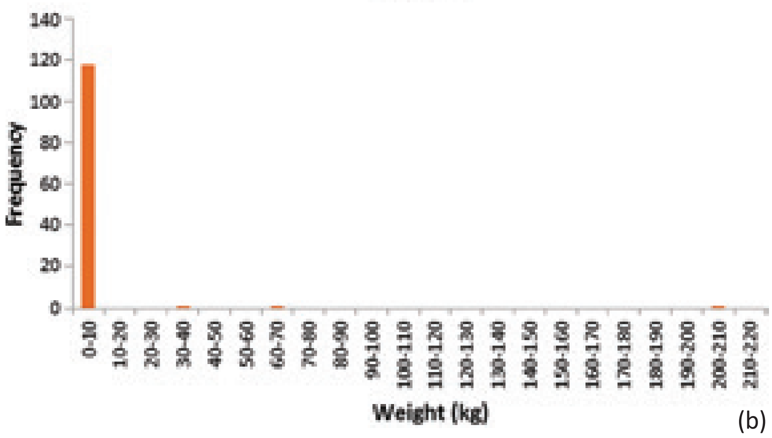
4.3.1. Bottom trawl surveys

Within the 121 transects (hauls) performed in the Adriatic and Ionian Seas (Fig. 4.2), 2,658 items in total were found in the trawl nets and classified. Litter was present in all hauls in a range from 1 to 123 items, giving a mean of 22 ± 24 items per haul (the geometric mean being 13). Some 82% of these hauls contained less than 36 items (Fig. 4.10(b)). The weight of all marine litter caught was 372.35 kg, ranging from 0.026 to 207.45 kg with a mean of 3.59 ± 19.81 kg per haul (0.52 geometric mean), but the distribution of weight per haul was strongly asymmetric: the 97.5% of the hauls (118 hauls) collected less than 10 kg of litter (Fig. 4.10(b)).

The debris densities calculated by haul ranged from 10.1 to 2,145 items/km^2, the latter being located in the Gulf of Corfu (Greece), and from 0.45 to 3,391 kg/km^2, the latter recorded in the Gulf of Venice, Italy (Fig. 4.11 and 4.12). For the 11 locations the highest density of litter items was found in the North Corfu area (Greece) (average density 1,099 ± 589 items/km^2) followed by the South area of the Western Gulf of Venice (1,023 ± 616 items/km^2) (Tab. 4.4, Fig. 4.11). On aggregated basis at regional level, the overall mean density of marine litter was 510 ± 517 items/km^2. The overall average litter density in weight per haul was 65 ± 322 kg/km^2. The highest quantity of litter in terms of weight was found in the South area of the Gulf of Venice (average density 339 ± 910 kg/km^2).



(a)



(b)

Figure 4.10. Frequency distribution (ten classes of frequency) of the number (a) and weight (b) of litter items found in the 121 hauls performed.

Table 4.4. Mean densities per location (S.D.: standard deviation).

Country	Location	Mean density (items/km²)	S.D.	Mean density (kg/km²)	S.D.
CROATIA	Dubrovnik	798	497	19	12
	Hvar	559	202	33	16
GREECE	Gulf of Corfu	948	478	43	64
	North Corfu	1,099	589	25	21
	SW Corfu	368	211	33	55
ITALY	Rimini offshore	127	9	15	20
	Savio offshore	79	13	3	2
	Western Gulf of Venice S	1,023	616	339	910
	Western Gulf of Venice N	212	99	11	17
MONTENEGRO	Montenegrin waters	200	242	53	138
SLOVENIA	Slovenian waters	110	110	8	9

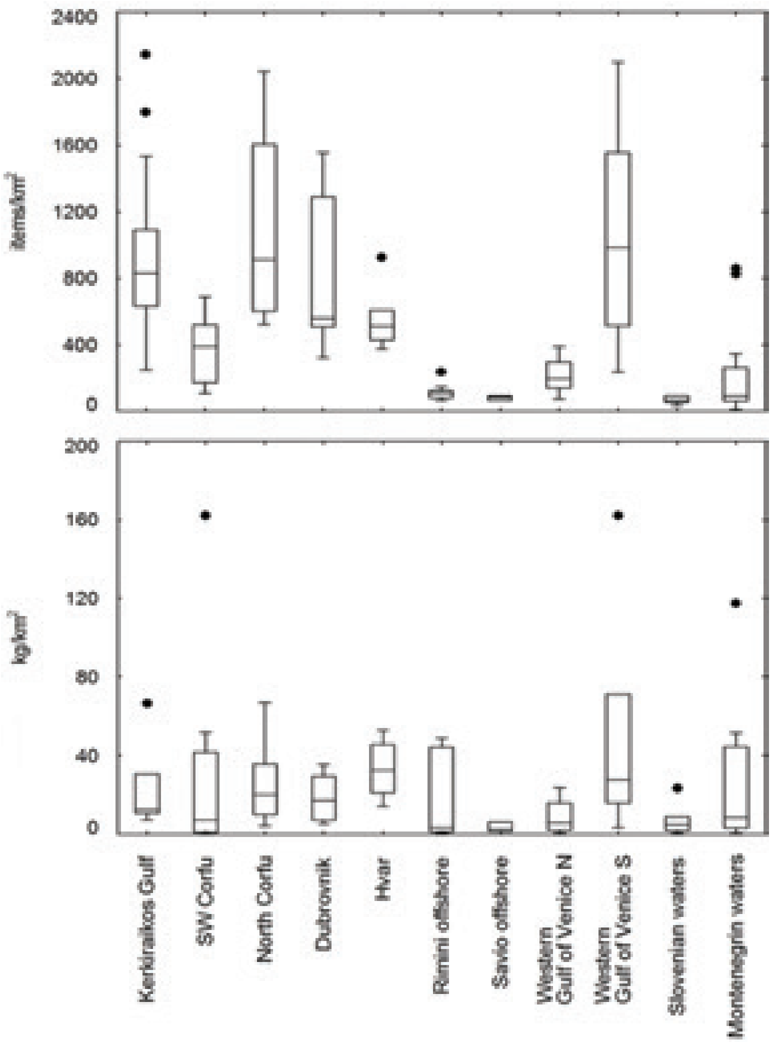


Figure 4.11. Seafloor litter densities by number (left) and weight (right) in different locations. The boxes indicate the 25th and 75th percentiles, the whiskers above and below the boxes the non-outlier range. Outliers are indicated by black dots. The median is marked by the horizontal line. An extreme value recorded in the Western Gulf of Venice S (3391.36 kg/km²) was excluded from the graph.

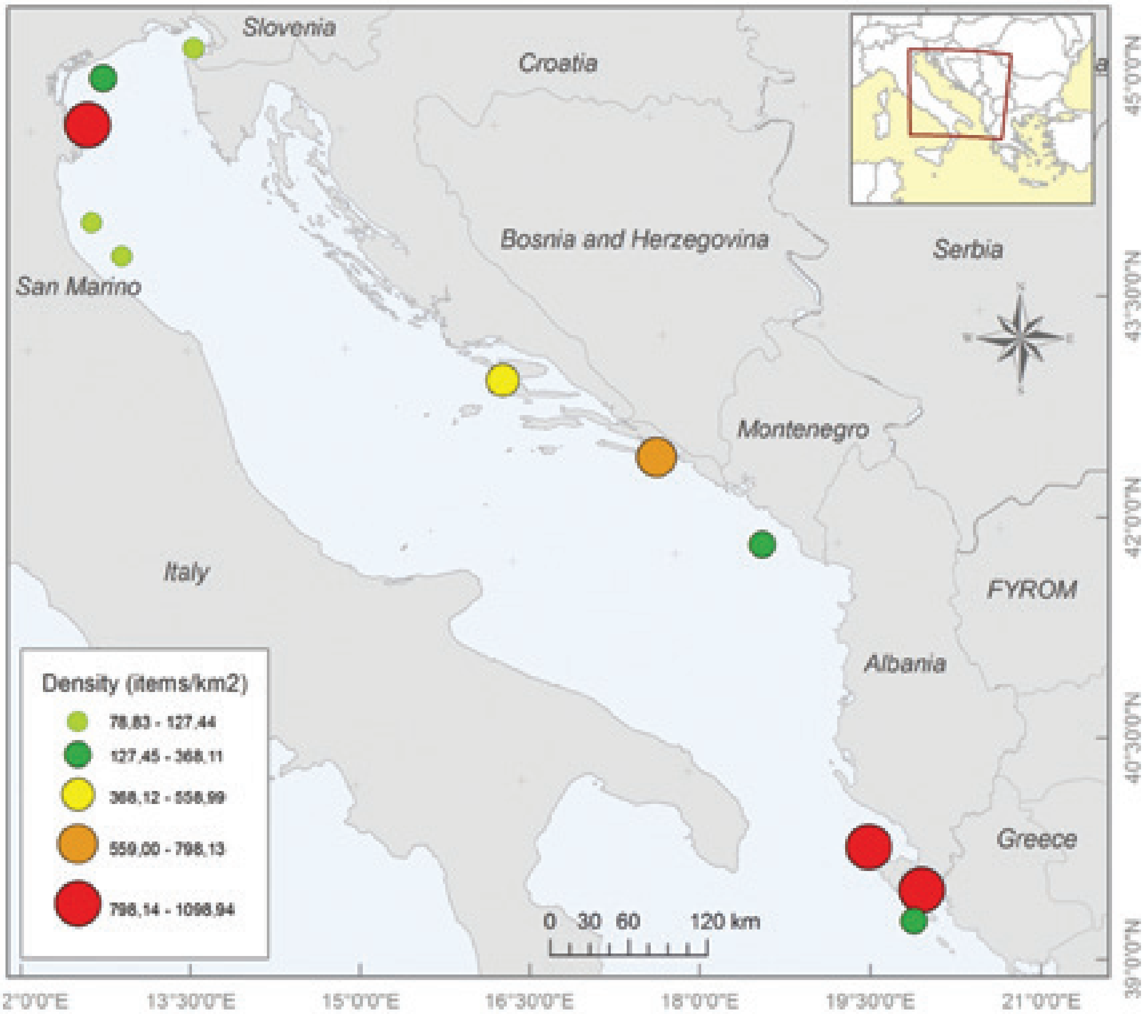


Figure 4.12. *Spatial distribution of seafloor litter densities by number in the Adriatic and Ionian Seas.*

The spatial distribution of seafloor litter densities by number of items found in the different locations within the Adriatic and Ionian shallow waters are shown in Figure 4.12. Aggregated results on national level in terms of items/km^2 revealed that the seafloor in Greece and Croatia (Tab. 4.5, Fig. 4.13) is most affected by the presence of marine litter items with average litter densities 847 ± 527 items/km^2 and 679 ± 383 items/km^2, respectively. In terms of weight of items per square kilometre, the highest litter density was found in Italy with 104 ± 492 kg/km^2. The lowest densities both in terms of number of items and of weight (110 ± 110 items/km^2 and 6 ± 10 kg/km^2) were recorded in Slovenia.

Table 4.5. *Mean item densities per country (S.D.: standard deviation).*

Country	items/km^2	S.D.	kg/km^2	S.D.
CROATIA	679	383	26	16
GREECE	847	527	36	54
ITALY	406	509	104	492
MONTENEGRO	200	242	53	138
SLOVENIA	110	110	6	10

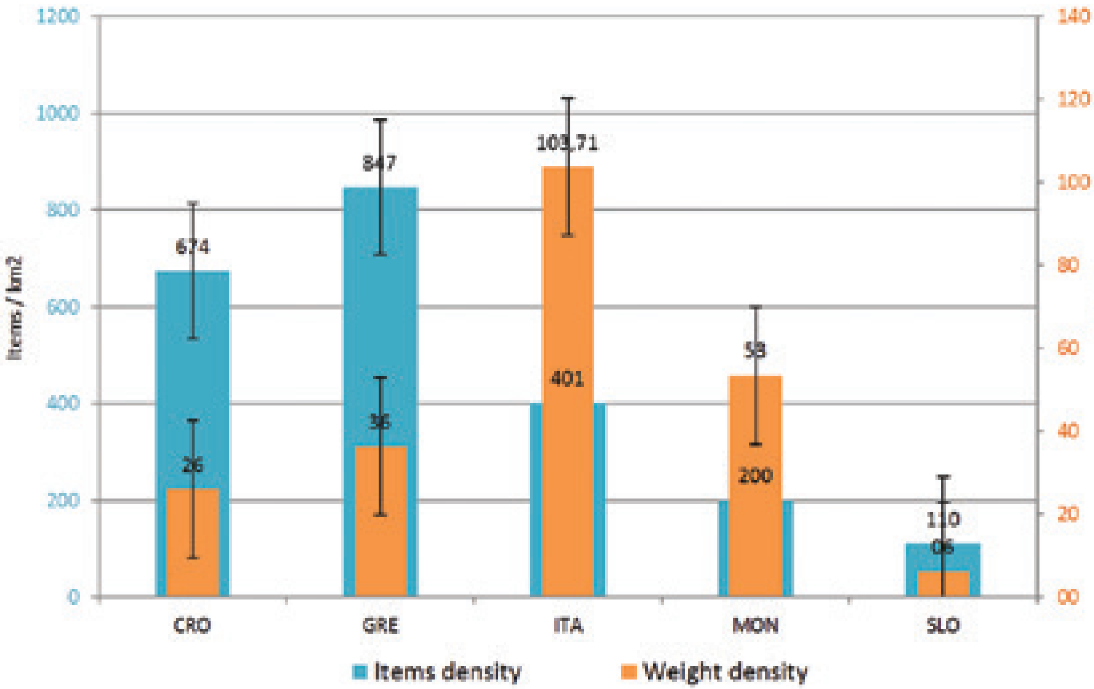


__Figure 4.13.__ Litter density in number of items and weight per country (CRO: Croatia; GRE: Greece; ITA: Italy; MON: Montenegro SLO: Slovenia).

When considering the number of items found, artificial polymer materials were the dominant category in all countries (78.6%-91.4%), followed by cloth/textile (3.2%-7.1%). On a regional (Adriatic-Ionian) level plastic items represented 89.4% of all items collected (Tab. 4.6, Fig. 4.14).

__Table 4.6.__ Aggregated results on the composition (%) of litter found on the seafloor, at national and regional level.

	CROATIA	GREECE	ITALY	MONTENEGRO	SLOVENIA	REGION
ART. POLYM. MATERIALS	86.4	91.4	89.0	86.0	78.6	86.3
CLOTH/TEXTILE	5.4	3.2	3.5	2.1	7.1	4.3
GLASS/CERAMICS	0.7	1.4	0.6	1.3	0.0	0.8
METAL	2.7	3.0	3.0	6.4	14.3	5.9
PAPER/CARDBOARD	0.0	0.6	0.9	0.4	0.0	0.4
PROCESSED/WORKED WOOD	0.0	0.2	0.5	0.0	0.0	0.1
RUBBER	4.8	0.3	2.5	3.8	0.0	2.3

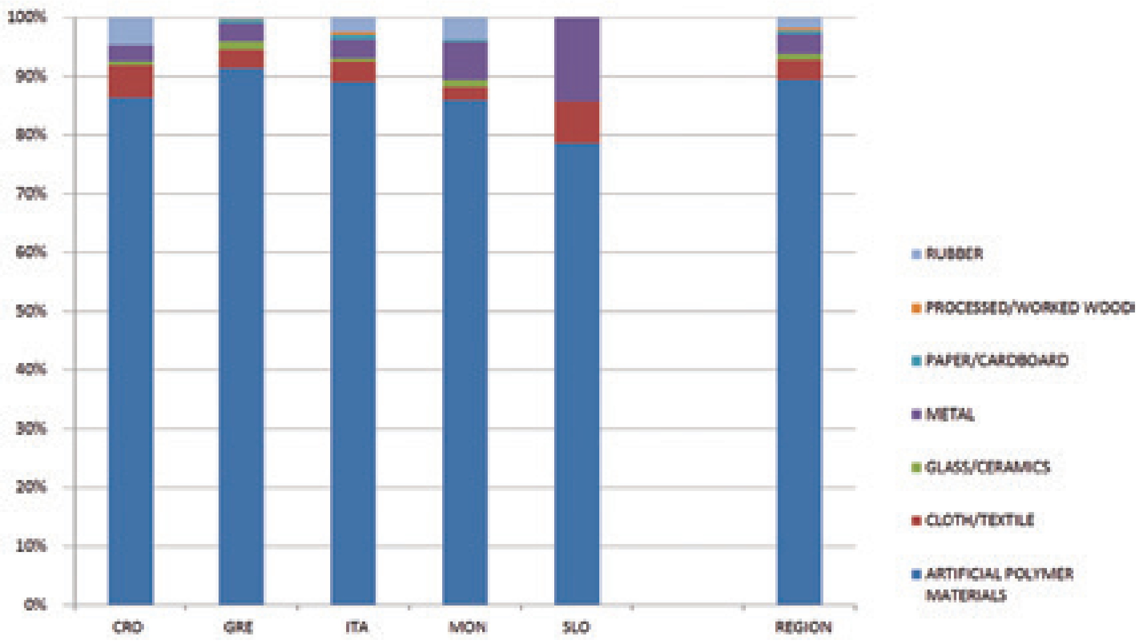


Figure 4.14. Aggregated results at national and regional level of litter composition in terms of % of number of items (CRO: Croatia; GRE: Greece; ITA: Italy; MON: Montenegro; SLO: Slovenia).

Almost all litter categories (51 out of 53, see Annex III) were found during the bottom trawl surveys. Aggregated results at regional level show that the 20 most abundant categories accounted for the great majority of litter found (93.9%). Sheets, industrial packaging, plastic sheeting (G67) were the most abundant types of litter (27.8%), followed by bags (G2) and food containers incl. fast food containers (G10), both accounting for about 11% of all items recorded. It is noteworthy that the number of items in the first category (G67) is more than double the number of the second (G2) and third (G10) categories. The data obtained confirm the emerging issue of mussel nets (G45) for the Adriatic Sea, accounting for 8.4% of the total sampled litter.

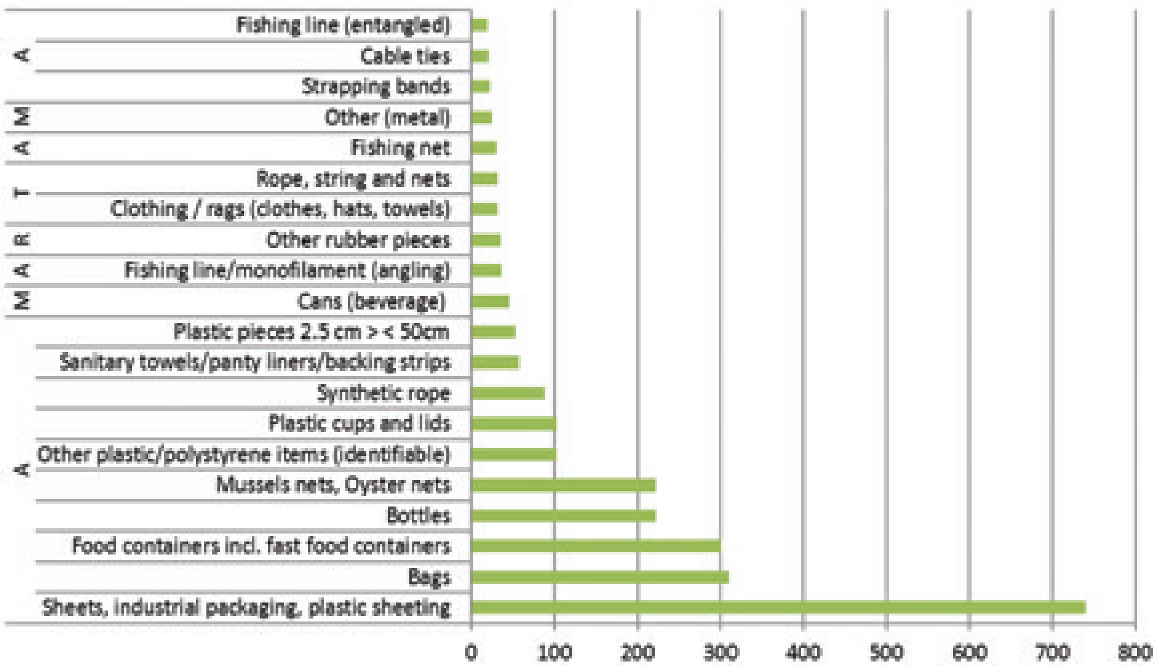


Figure 4.15. Top 20 items found in the seafloor of the Adriatic-Ionian Seas (as number of items).

Table 4.7. Top 20 items found in the seafloor of the Adriatic-Ionian Seas (as number of items). A = artificial polymer materials; G = glass/ceramics; M = metal; P = paper/cardboard; R = rubber; T = cloth/textile; W = processed/worked wood.

Code	Material	Item name	Total counts	%
G67	A	Sheets, industrial packaging, plastic sheeting	740	27.8
G2	A	Bags	311	11.7
G10	A	Food containers incl. fast food containers	301	11.3
G6	G	Bottles	222	8.4
G45	A	Mussel nets, Oyster nets	222	8.4
G124	A	Other plastic/polystyrene items (identifiable)	102	3.8
G20	A	Plastic cups and lids	102	3.8
G48	A	Synthetic rope	89	3.3
G96	A	Sanitary towels/panty liners/backing strips	58	2.2
G79	A	Plastic pieces 2.5 cm > < 50 cm	53	2.0
G175	M	Cans (beverage)	46	1.7
G59	A	Fishing line/monofilament (angling)	36	1.4
G134	R	Other rubber pieces	35	1.3
G137	T	Clothing/rags (clothes, hats, towels)	31	1.2
G142	A	Rope, string and nets	31	1.2
G51	A	Fishing net	30	1.1
G197	M	Other (metal)	24	0.9
G66	A	Strapping bands	22	0.8
G93	A	Cable ties	21	0.8
G55	A	Fishing line (entangled)	19	0.7

On an aggregated basis at national level, the top 20 items varied as shown in the following figures (Fig. 4.16-4.20).

In Croatia (Fig. 4.16), the top 20 litter item categories found on the seafloor accounted for 97.9% of the 147 items recorded. Plastic bags (G2) were the most commonly found items; consisting some 40% of all the sampled items, followed by food containers (G10) (12.2%) and other plastic/polystyrene items (identifiable) (G24) (6.8%). Only 3 mussel nets (G45) were sampled.

In Greece (Fig. 4.17), the top 20 litter item categories found on the seafloor accounted for almost the totality (97.7%) of the 1,032 items recorded. The highest abundance was observed for sheets, industrial packaging and plastic sheeting (G67), representing the 43.4% of all collected items. The second and third most abundant items were plastic cups and lids (G20) (9.3%) and bags (G2 (7.8%).

Also in Italy (Fig. 4.18), the top 20 litter item categories accounted for almost the totality (94.9%) of the 1,216 items recorded. Unlike Croatia and Greece, in Italy there wasn't a single dominating litter item category. The highest abundance was observed for sheets, industrial packaging and plastic sheeting (G67), closely followed by food containers (G10) and mussel nets (G45), representing 23.36%, 19.00% and 16.86% of all litter found, respectively.

During the surveys in Montenegro (Fig. 4.19) 235 items were collected. Some 31% of them were composed of plastic bottles (G6), while the other two predominant categories were bags (G2) (26.4%) and food containers incl. fast food containers (G10) (15.7%). The top 20 categories accounted for the 98.3% of all sampled items.

In Slovenia (Fig. 4.20), small quantities of litter were found. A total of 28 items was collected and these were classified into 11 litter item categories. Bags (G2), food containers incl. fast food containers (G10) and other plastic/polystyrene items (identifiable) (G24) represented the main three litter item categories with percentages of 25.00%, 21.43%, and 14.29%, respectively.

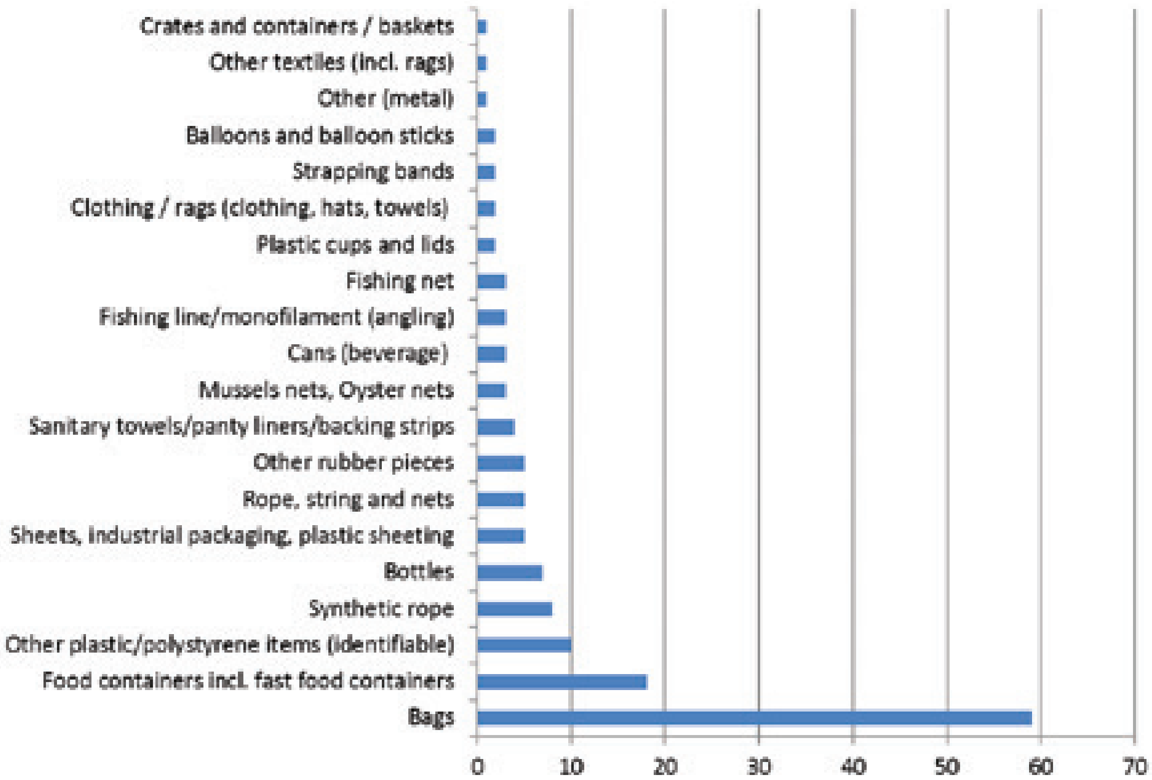


Figure 4.16. *Top 20 seafloor litter items found in **Croatia** (number of items).*

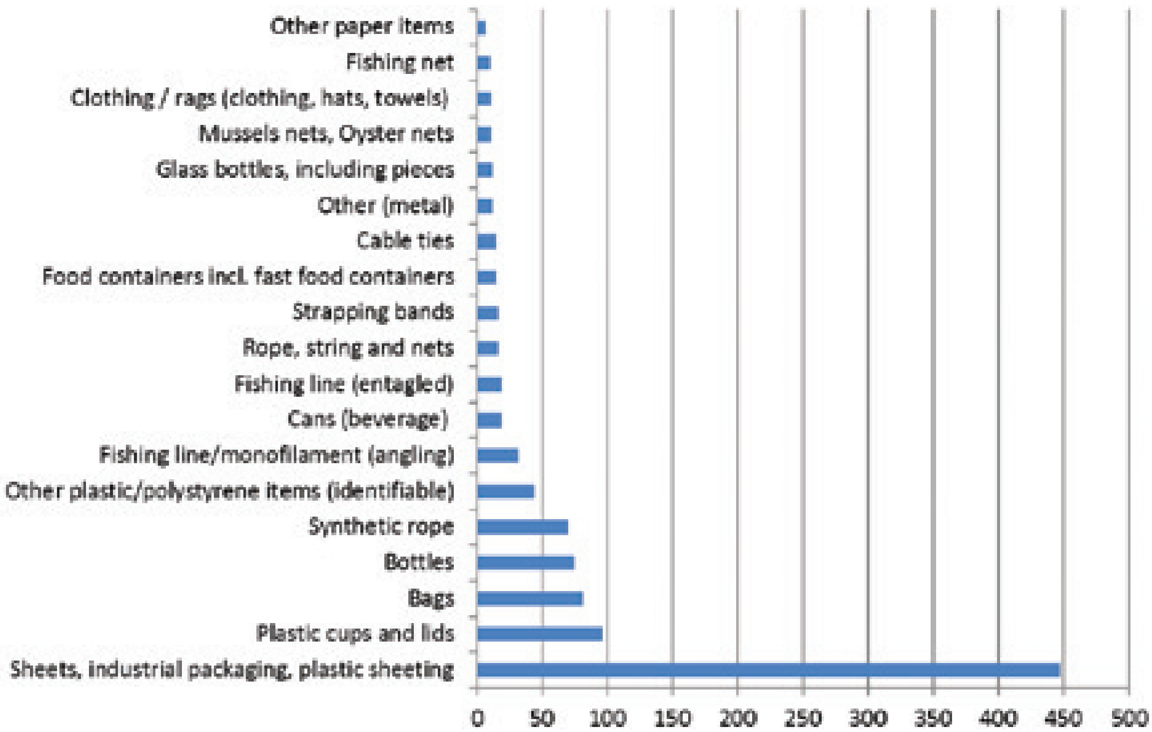


Figure 4.17. *Top 20 seafloor litter items found in **Greece** (number of items).*

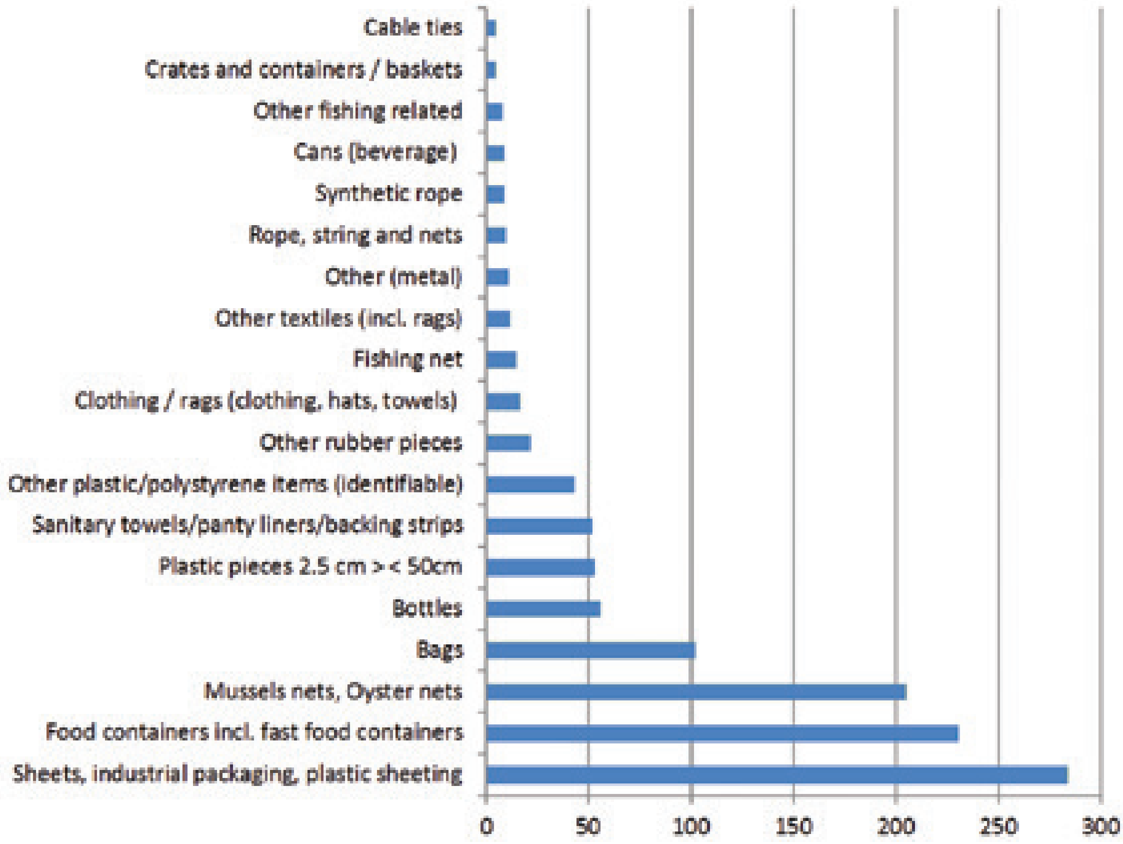


Figure 4.18. *Top 20 seafloor litter items found in **Italy** (number of items).*

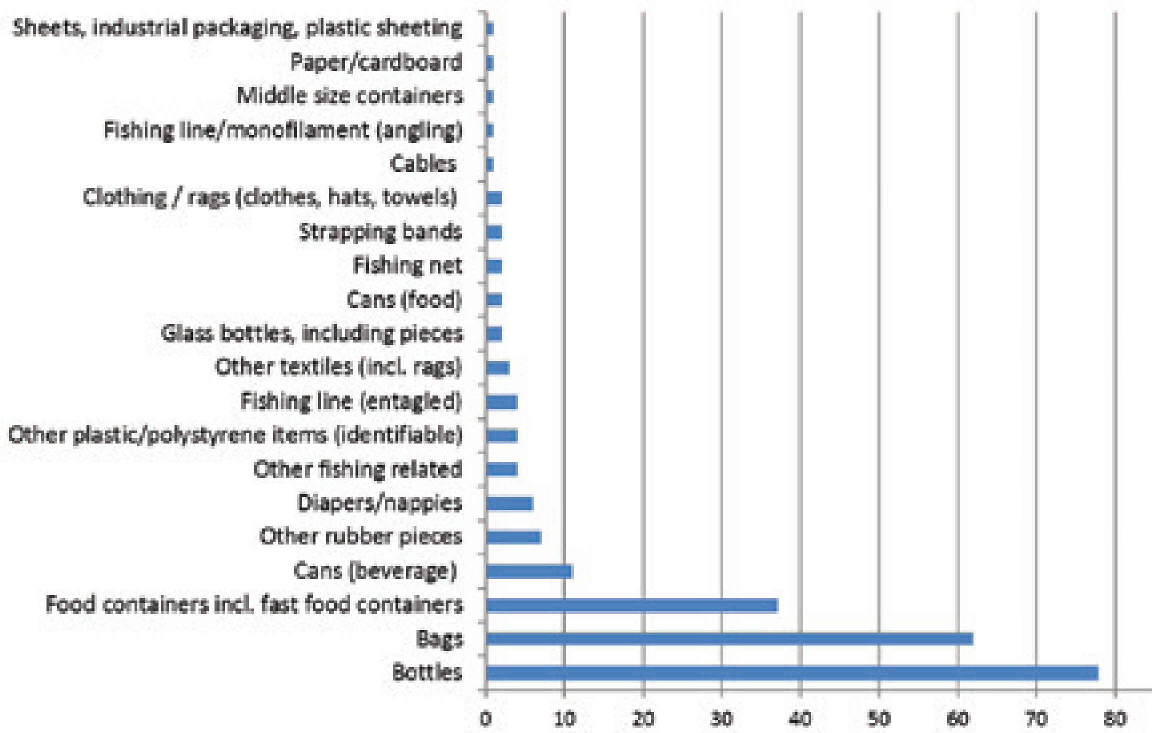


Figure 4.19. *Top 20 seafloor litter items found in **Montenegro** (number of items).*

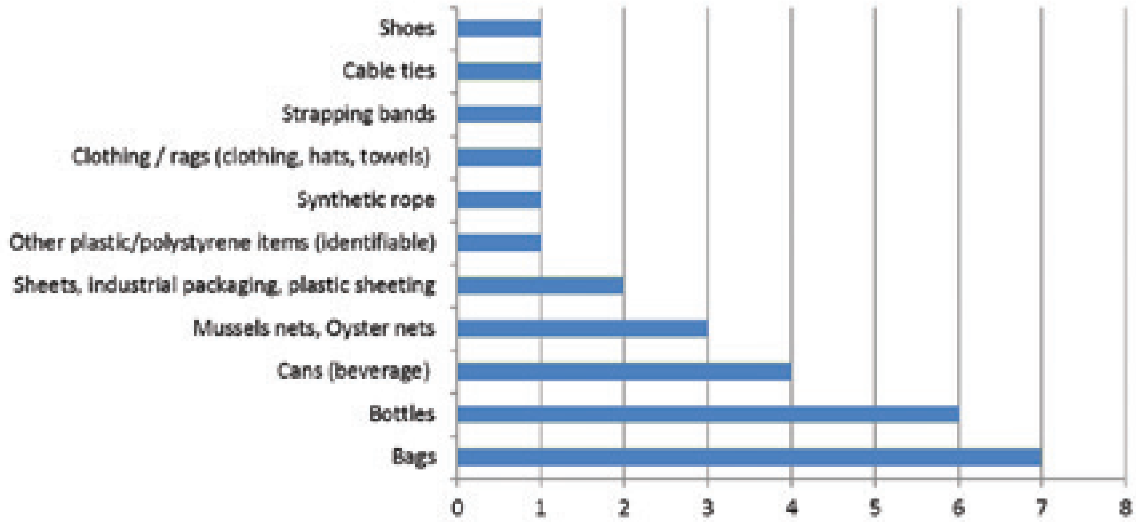


Figure 4.20. Top 11 seafloor litter items found in Slovenia (as number of items).

When looking at the dimensions and size classes of the litter items found on the seafloor at regional level (excluding Montenegro where the items were not measured), the most common size classes were 25-100 cm^2 and 100-400 cm^2 (27.7% of the total items were classified into those two categories), followed by 400-2,500 cm^2 (20.2%) and < 25 cm^2 (19.7%). The classes with biggest objects, within the size classes of 2,500-10,000 cm^2 and > 10,000 cm^2, represented a very small amount of the total recorded items (3.5% and 1.2% respectively).

Size classes' distribution varies among countries as shown in Figure 4.21, where the proportion of the size classes in every country is reported. Aggregated results at regional level show that the most common size class is the 25-100 cm^2, with average frequency value being 33%. All size classes were found in Italy and Greece, where also the largest items were found. Conversely, in Croatia and Slovenia, a predominance of small and medium sized litter was observed.

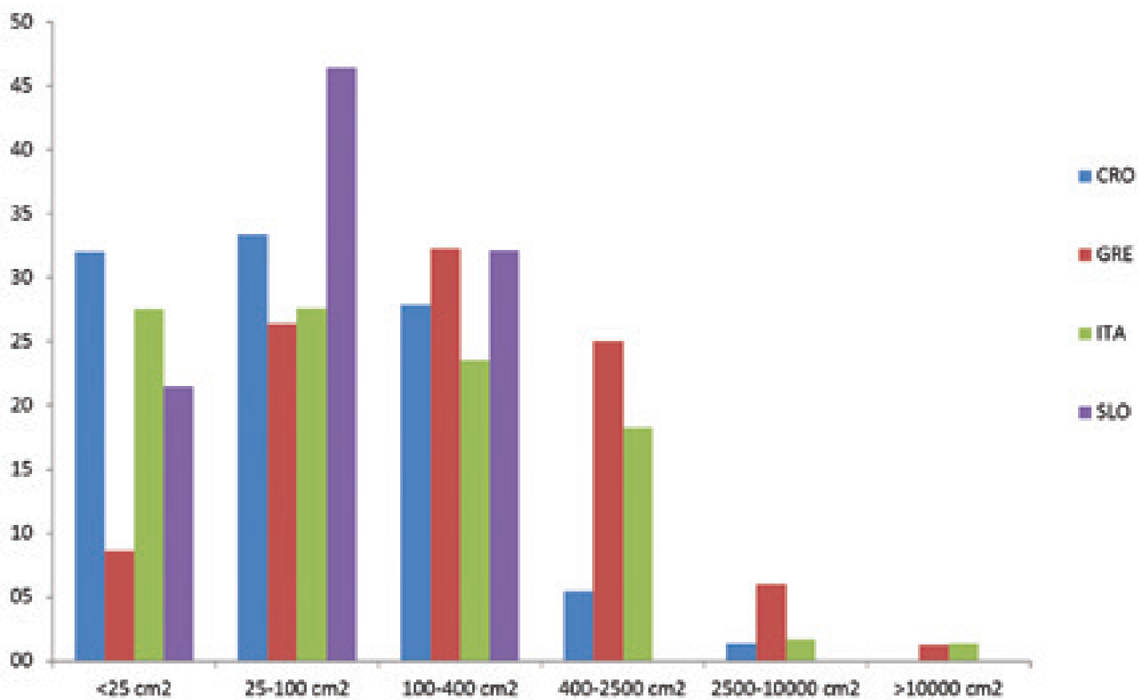


Figure 4.21. The frequency of the size classes of the seafloor litter items in every country (% per country).

4.3.2. Visual survey with scuba/snorkelling

A total of 489 items were collected and recorded during the 38 visual transects conducted with scuba/snorkelling: 294 items were recorded in surveys in Bosnia and Herzegovina, 163 in Montenegro and 32 in Slovenia, with an average number of litter items per transect 14 ± 21 items (range: 0-93). No litter was found in 10 transects (Fig. 4.22), and some 45% of the transects contained a low number of objects (between 1 and 9).

The overall mean density in terms of number of items per transect (Tab. 4.8, Fig. 4.9) was 2.78 ± 3.35 items/100 m², ranging from 0.06 ± 0.07 items/100 m² at Dragonja (Slovenia) to 7.25 ± 4.57 items/100 m² at Neum1 (Bosnia and Herzegovina).

Litter density distributions by number in the different locations in the Adriatic and Ionian shallow sub-littoral waters are shown in Figure 4.24, while aggregated results at national level are reported in Table 4.9.

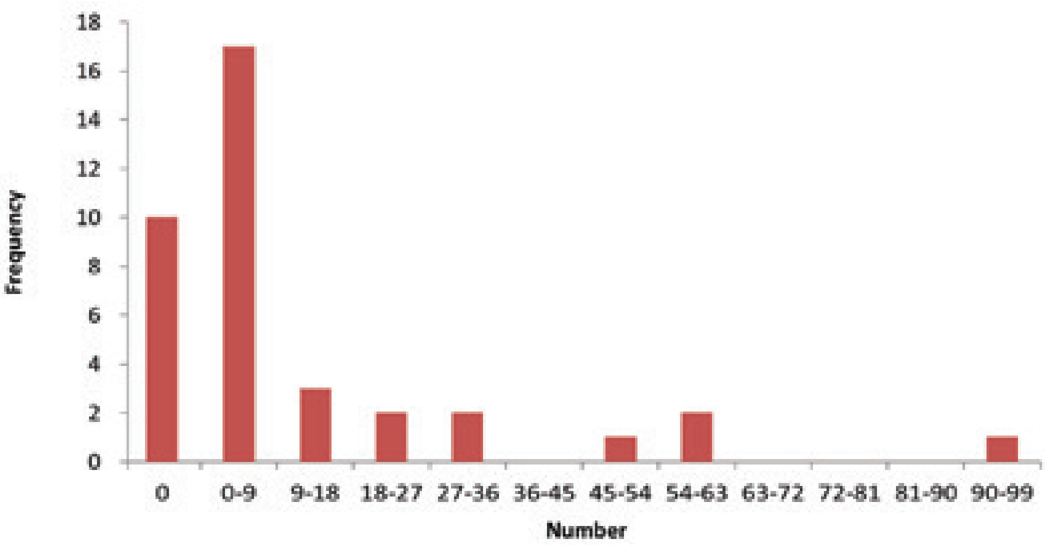


Figure 4.22. *Frequency distribution (ten classes of frequency) of the number of seafloor litter items found in the 38 transects performed.*

Table 4.8. *Mean densities per location (S.D.: standard deviation).*

Country	Location	Average density (items/100 m²)	S.D.
Bosnia & Herzegovina	Neum1	7.25	4.57
	Neum2	5.00	2.83
Montenegro	Kostanjica	4.56	2.13
	Strp	3.16	0.51
	Sv Nedelja	6.13	3.09
Slovenia	Debeli rtič	0.41	0.73
	Dragonja	0.06	0.07
	Koper	2.50	5.00
	Portorož	0.28	0.26
	Semedela	0.16	0.21

Table 4.9. *Mean seafloor litter item densities per country (S.D.: standard deviation).*

Country	items/100 m²	S.D.
Bosnia & Herzegovina	6.13	3.62
Montenegro	4.61	2.35
Slovenia	0.68	2.22

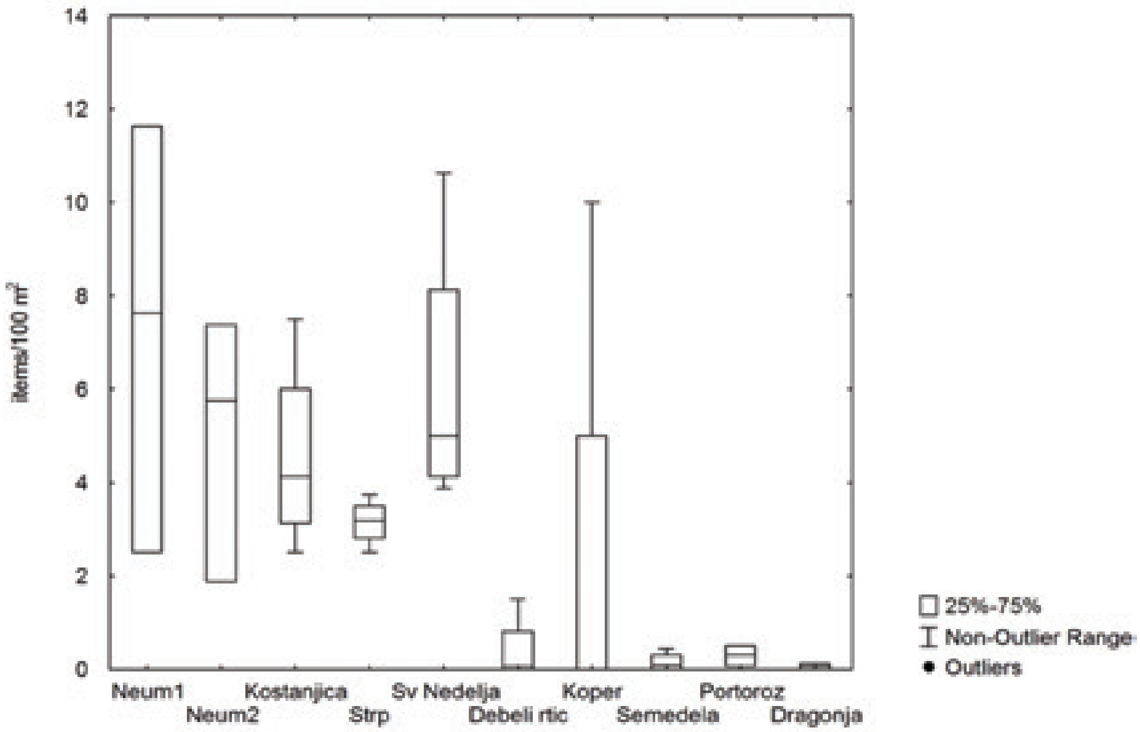


Figure 4.23. *Seafloor litter densities (items/100 m²) in different locations. The boxes indicate the 25th and 75th percentiles, the whiskers above and below the boxes the non-outlier range. Outliers are indicated by black dots (not present in the graph). The median is marked by the horizontal line.*

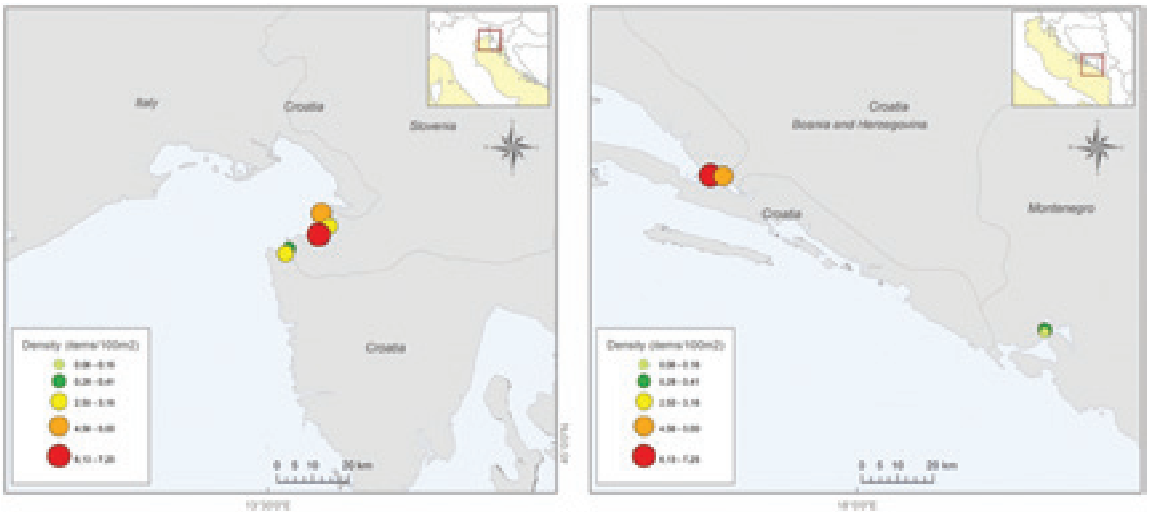


Figure 4.24*. Seafloor litter densities by number in different locations.*

When considering the number of items, the mean composition for the three countries showed that marine litter found on the sub-littoral seafloor through visual census was mainly composed of plastic items (36.4%), followed by glass/ceramics items (27.3%) and metal (24.8%) (Tab. 4.10, Fig. 4.25).

***Table 4.10**. The composition of litter found on the seafloor by visual surveys aggregated at the national level. Average value for the three countries is also reported (region) (%) (B&H: Bosnia and Herzegovina; MON: Montenegro; SLO: Slovenia; ALL: average value).*

	B&H	MON	SLO	ALL
ARTIFICIAL POLYMER MATERIALS	26.9	35.6	46.9	36.4
CLOTH/TEXTILE	0.3	7.4	0.0	2.6
GLASS/CERAMICS	40.1	32.5	9.4	27.3
METAL	25.5	20.9	28.1	24.8
PAPER/CARDBOARD	0.0	2.5	9.4	3.9
PROCESSED/WORKED WOOD	1.0	0.0	0.0	0.3
RUBBER	6.1	1.2	6.3	4.5

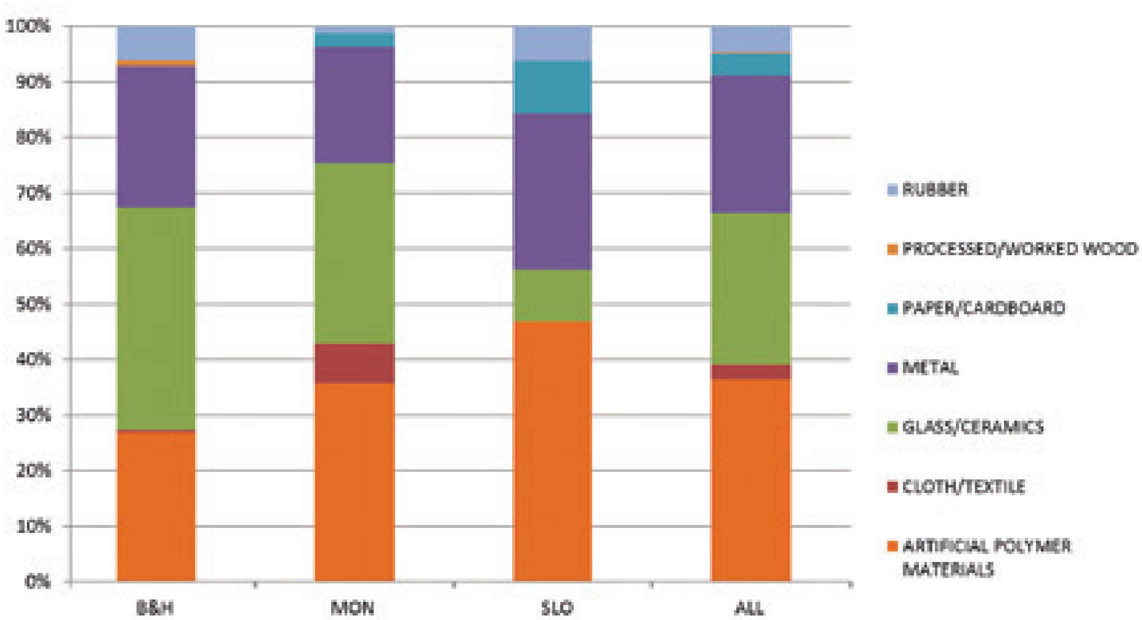
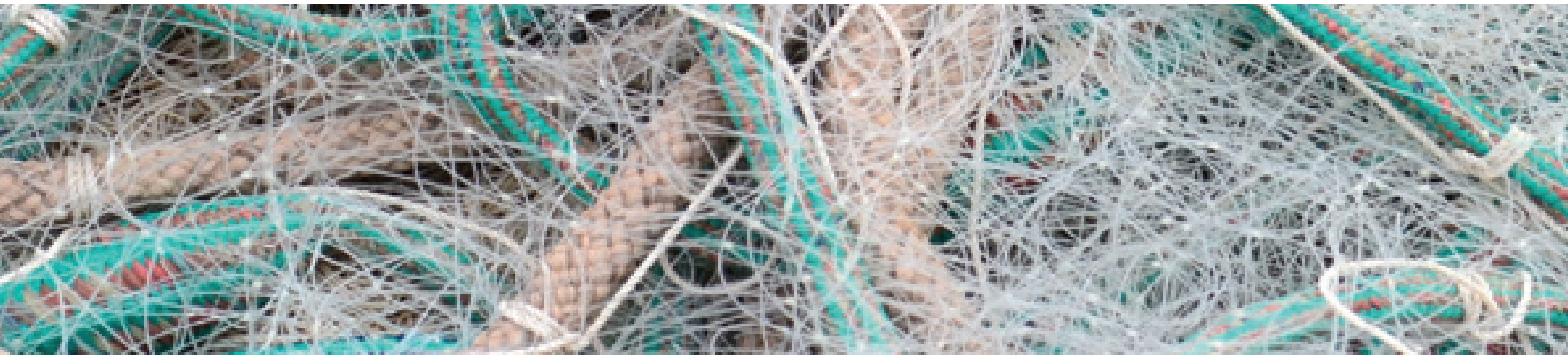


***Figure 4.25.** Seafloor litter composition in terms of number of items found in each country and as average value (B&H: Bosnia and Herzegovina; MON: Montenegro; SLO: Slovenia; ALL: average value).*



Forty (40) out of fifty three (53) litter item categories (see Annex IV) were found during the surveys from all countries. The top 20 litter categories accounted for 92.6% of all recorded items, and the most common items found were glass bottles, including pieces (29.2%), followed by plastic bottles and metal cans (14.3% and 12.1% respectively) (Tab. 4.11, Fig. 4.26). It is interesting to note that the top three items were all related to beverage packaging, while the top four were related to food and beverage.

Table 4.11. *Top 20 seafloor litter items found in the Adriatic-Ionian Seas (number of items). A = artificial polymer materials; G = glass/ceramics; M = metal; P = paper/cardboard; R = rubber; T = cloth/textile; W = processed/worked wood.*

Code	Material	Item name	Total counts	%
G200	G	Bottles, including pieces	143	29.2
G6	A	Bottles	70	14.3
G175	M	Cans (beverage)	59	12.1
G10	A	Food containers incl. fast food containers	19	3.9
G193	M	Car parts/batteries	19	3.9
G208	G	Glass or ceramic fragments >2.5 cm	18	3.7
G124	A	Other plastic/polystyrene items (identifiable)	17	3.5
G176	M	Cans (food)	15	3.1
G197	M	Other (metal)	12	2.5
G210	G	Other glass items	11	2.2
G134	R	Other rubber pieces	11	2.2
G18	A	Crates and containers/baskets	10	2.0
G128	R	Tyres and belts	10	2.0
G51	A	Fishing net	7	1.4
G137	T	Clothing/rags (clothes, hats, towels)	7	1.4
G2	A	Bags	5	1.0
g20	A	Plastic cups and lids	5	1.0
G67	A	Sheets, industrial packaging, plastic sheeting	5	1.0
g180	M	Appliances (refrigerators, washers, etc.)	5	1.0
G158	P	Other paper items	5	1.0

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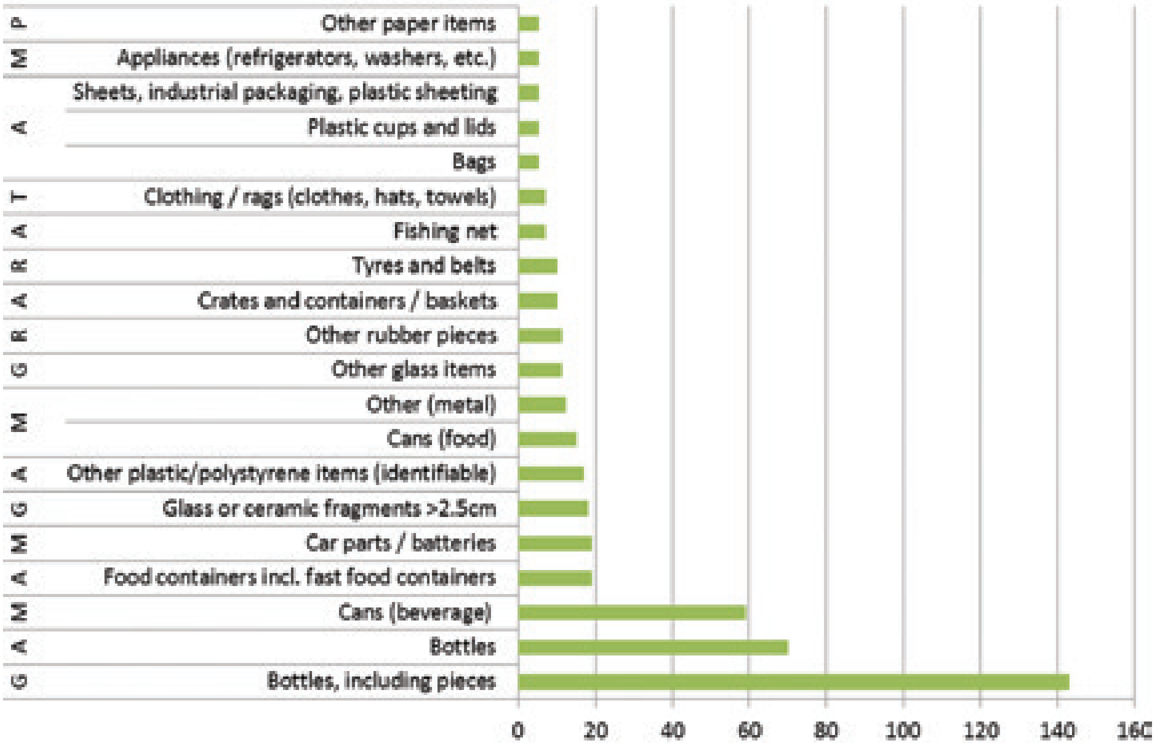

Figure 4.26. Top 20 seafloor litter items found in the Adriatic-Ionian Seas through visual census (number of items) (A = artificial polymer materials; G = glass/ceramics; M = metal; P = paper/cardboard; R = rubber; T = cloth/textile; W = processed/worked wood).

Aggregated results at national level on the top 20 litter items found are shown in the following figures (Fig. 4.27–4.29).

In Bosnia and Herzegovina (Fig. 4.27), the most common material found was glass/ceramic (40.1%). The top 20 litter items accounted for 98% of the total items observed. Glass bottles represented 35.4% of the total items recorded, while plastic bottles were also very abundant (15.3% of the items), followed by metal beverage cans (13.6%).

In Montenegro (Fig. 4.28), the most abundant materials were artificial polymer materials (35.6%) and glass/ceramics (32.5%). The 20 most common items accounted for 92.6% of the total 163 observed. The highest abundance was recorder for glass bottles and plastic bottles accounting for 22.7% and the 12.9% of all surveyed items, respectively.

In Slovenia (Fig. 4.28), 32 items were recorded and were classified into 13 litter item categories. Despite the fact that the most abundant material was plastic (35.6% of the total items), metal cans were the most common item (25% of the items) recorded, followed by food containers and plastic bottles (15.6% and 12.5%).

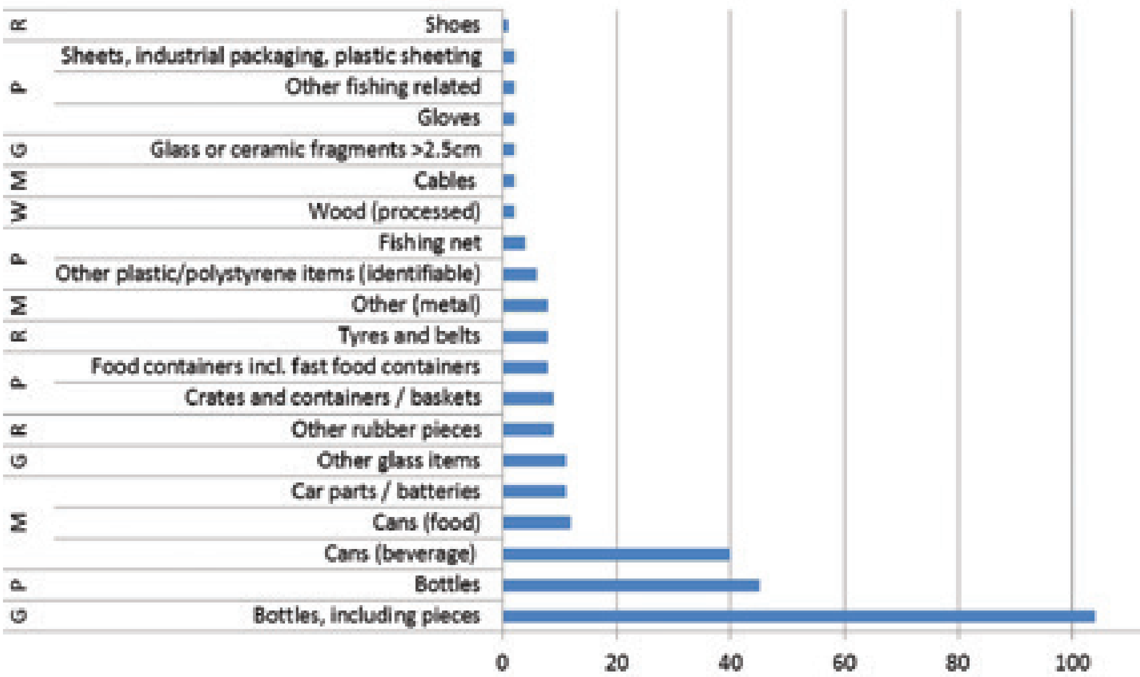

*Figure 4.27. Top 20 seafloor litter items found in **Bosnia and Herzegovina**, on an aggregated basis at national level (number of items). A = artificial polymer materials; G = glass/ceramics; M = metal; P = paper/ cardboard; R = rubber; T = cloth/textile; W = processed/worked wood.*

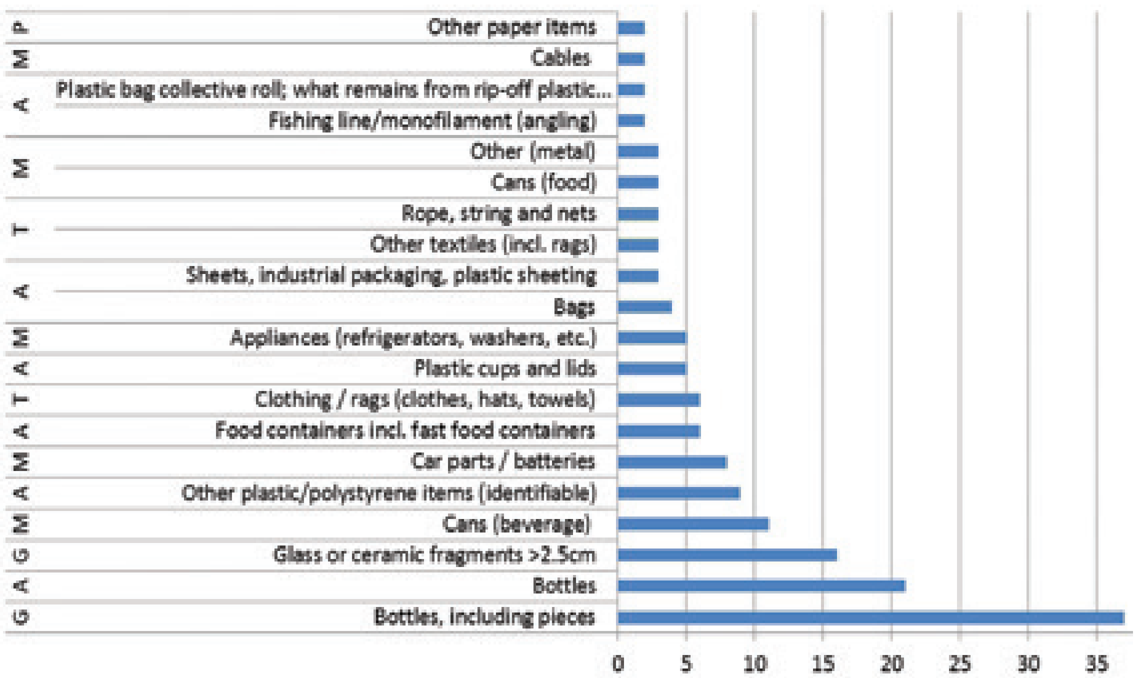

*Figure 4.28. Top 20 seafloor litter items found in **Montenegro**, on an aggregated basis on an aggregated basis at national level (number of items). (A=artificial polymer materials; G = glass/ceramics; M = metal; P = paper/cardboard; R = rubber; T = cloth/textile; W = processed/worked wood).*

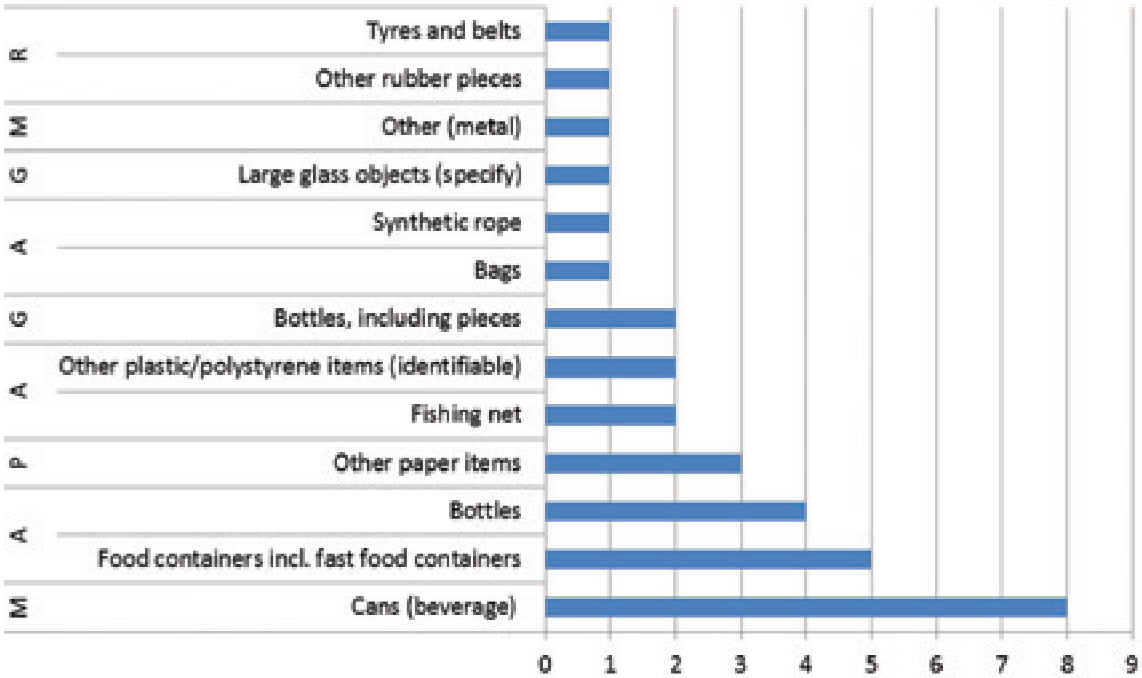

*Figure 4.29. Top 20 seafloor litter items found in **Slovenia**, on an aggregated basis on an aggregated basis at national level (number of items). (A = artificial polymer materials; G = glass/ceramics; M = metal; P = paper/cardboard; R = rubber; T = cloth/textile; W = processed/worked wood).*

The size classes' distribution in every country is reported in Figure 4.30. The most common size class was 25-100 cm^2, with average frequency being 48%.

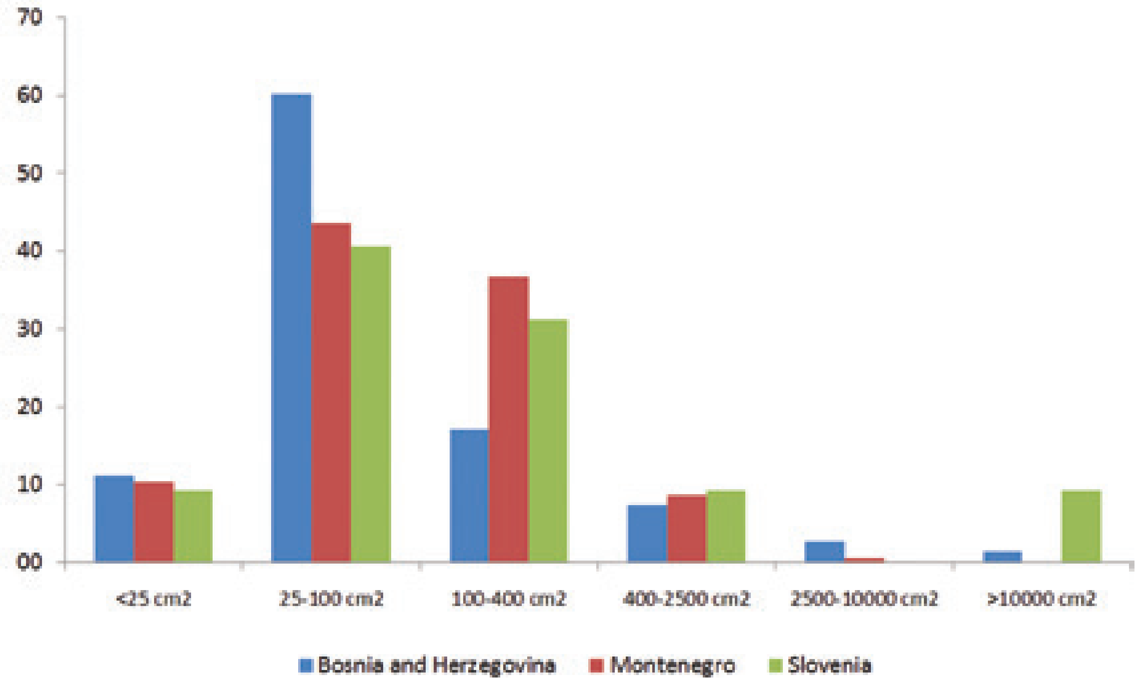

Figure 4.30. The frequency of the size classes of the seafloor litter items in the three countries (% per country).

4.4 SOURCES

4.4.1. Bottom trawl surveys

Taking into consideration the fact that heavy items like glass or metal objects sink rapidly, a slightly modified approach than the one described in paragraph 2.5 was adopted for detecting the sources of litter items found on the seafloor (see Annex V). Heavy items, such as tyres and belts (G128), glass bottles (G200), cans (beverage) (G175), cans (food) (G176), were assigned to shipping related sources instead of shoreline sources –including poor waste management practices, tourism and recreational activities– because when found on the continental shelf they are more likely to have come from sea-based sources rather than land-based ones. Paper/cardboard items and cigarette butts have a short lifetime in the water and it is unlikely to sink far away from their sources, thus they were attributed to shipping related sources. A complete classification list for items and their respective sources is available in Annex V.

Among the 2,658 litter items collected by all countries, 988 were classified as non-sourced, while the remaining 1,670 were attributed to one of the following sources: shoreline, tourism and recreational activities; fisheries & aquaculture; sanitary & sewage related; shipping; fly-tipping. Aggregated results at regional level (Tab. 4.12) show that 36.6% of the total litter items collected come from shoreline sources, including poor waste management practices, tourism and recreational activities. Some 17% of the litter items found on the seafloor were fisheries and aquaculture related, while the items coming from shipping accounted for 6.5% of the total items sampled. The remaining 2.6% was attributed to sanitary and sewage sources. Very few objects (3%) coming from fly-tipping were found.

Relative densities of the items depending on their source are shown in Figure 4.31 at location level and in Table 4.12 at national level.

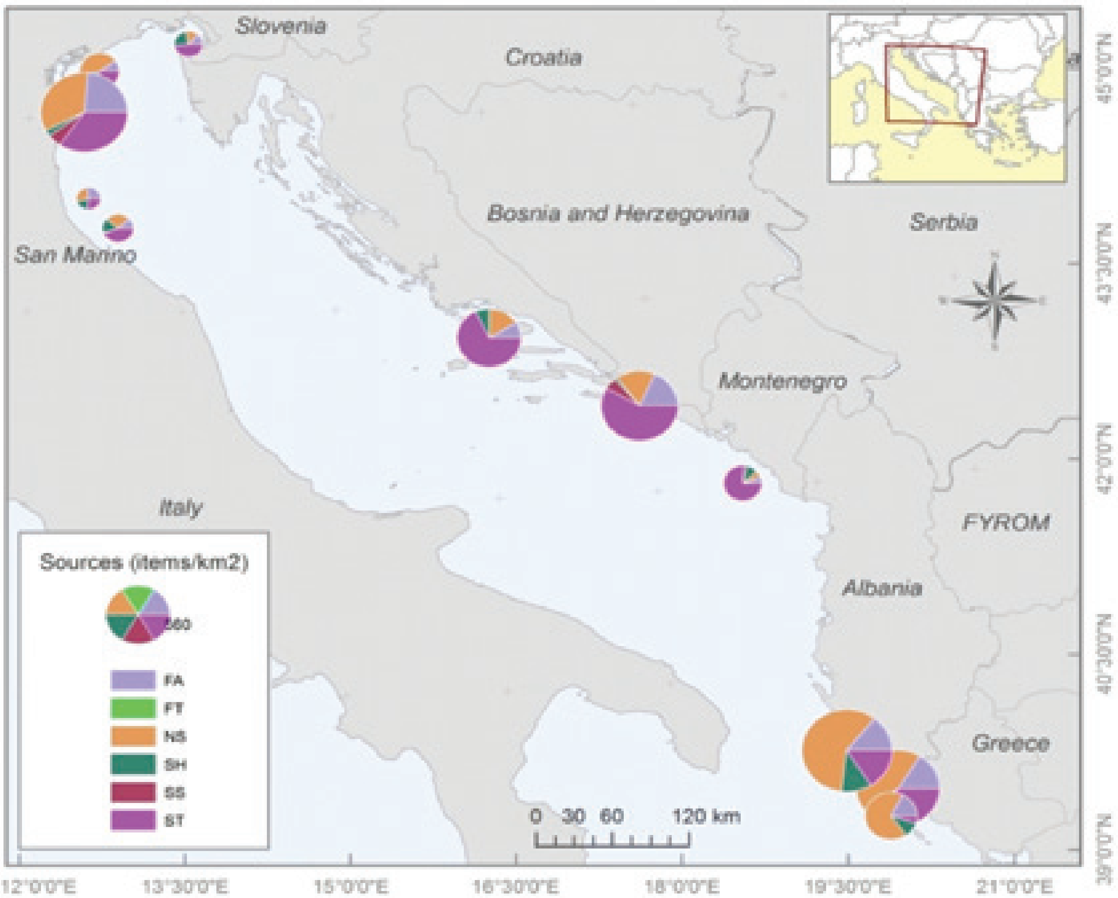

Figure 4.31. *Relative densities of litter items depending on their source (items/km^2), shown at location level. FA: fisheries & aquaculture; FT: fly-tipping; NS: non-sourced; SH: shipping; SS: sanitary & sewage related; ST: shoreline, including poor waste management practices, tourism and recreational activities.*

In Croatia, non-sourced items accounted for 16.3% of the total litter; a great fraction of the total litter came from shoreline, tourism & recreational activities (61.9%), while fisheries and aquaculture related items represented 15% of the total items recorded.

The highest percentage of non-sourced objects (50.1%) was found in Greece, explained by the huge number of sheets, industrial packaging and plastic sheeting found in the nets. Shoreline, including poor waste management practices, tourism and recreational activities were an important source of litter (27%), followed by fisheries and aquaculture (15.7%). Items coming from shipping accounted for 6.7% of the total items recorded.

In Italy, some 65% of the items could be attributed to a specific source. Similarly to the other countries, shoreline, including poor waste management practices, tourism and recreational activities were mainly responsible for marine litter on the seafloor (33.8%). An interesting result is that fisheries and aquaculture related items hold in Italy the highest percentage (20.7%) when compared with the results from the other countries, and it must be stressed that the vast majority of the fisheries and aquaculture related items were mussel nets (205 out of 252). Sanitary and sewage related items accounted for 4.5%, the highest value recorded among the DeFishGear project countries, most probably due to the vicinity of the Po river.

In the area surveyed in Montenegro, an impressive 76.2% of the items found were related to shoreline, including poor waste management practices, tourism and recreational activities. The country holds the highest percentage of items from this category when compared to the other project countries. Shipping items represented some 8.9% of the total litter collected. Only 7.2% of the items collected in Montenegro could not be attributed to a specific source and were classified as non-sourced.

Very few items were classified as non-sourced in Slovenia (14.3%) and shoreline, including poor waste management practices, tourism and recreational activities were also in this country the largest source of litter. An interesting result is that shipping related items accounted for 21% of the total items collected, the highest percentage recorded among countries, even if the number of items was very small (6 items out of 28).

Table 4.12. *Sources of litter found on the seafloor aggregated at national and regional level (% of items). In bold the source that contributed the most to the total litter items found in a given country; comparing the composition of the four countries, the country that showed the higher fraction of a given source is underlined (CRO: Croatia; GRE: Greece; ITA: Italy; MON: Montenegro; SLO: Slovenia).*

	CRO	GRE	ITA	MON	SLO	REGION
Fisheries & aquaculture	15.0	15.7	20.7	5.1	14.3	17.0
Fly-tipping	0.0	0.2	0.1	0.0	0.0	0.1
Shipping	3.4	6.7	5.8	8.9	21.4	6.5
Sanitary & sewage related	3.4	0.3	4.5	2.6	0.0	2.6
Shoreline, tourism & recreational activities	61.9	27.0	33.8	76.2	50.0	36.6
Non-sourced	16.3	50.1	35.0	7.2	14.3	37.2

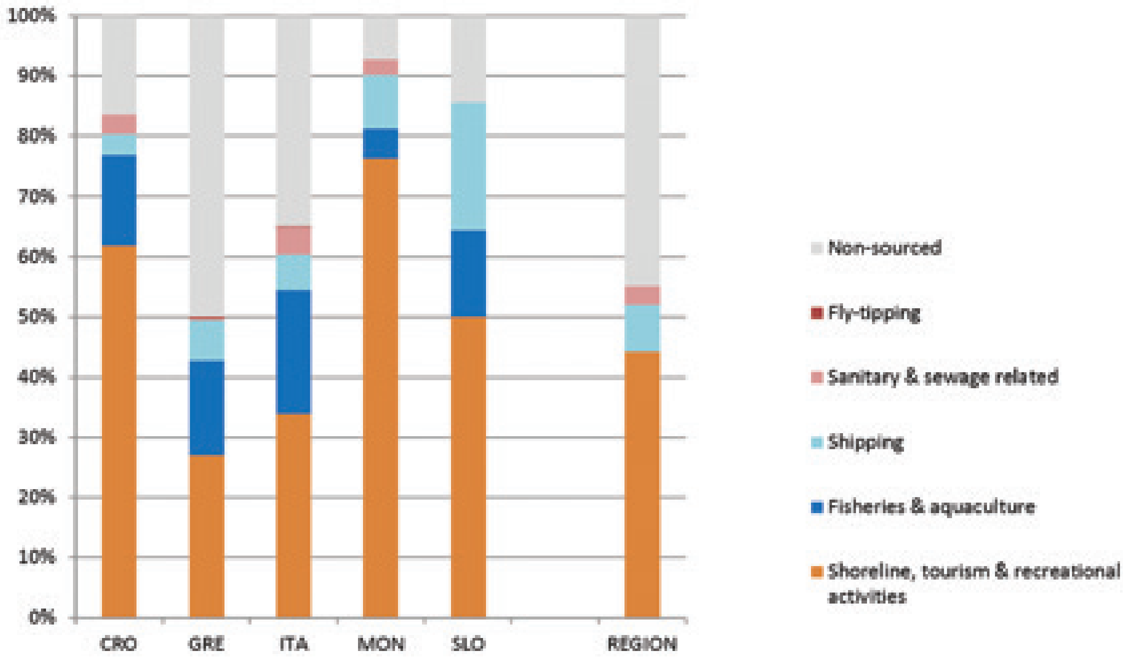

Figure 4.32. *Sources of marine litter found on the seafloor on the basis of aggregated results at national level and at regional level (CRO: Croatia; GRE: Greece; ITA: Italy; MON: Montenegro; SLO: Slovenia).*

For a better comprehension of the sources of the seafloor litter, we computed the relative importance of sea-based *versus* land-based sources (Fig. 4.33). The non-sourced items and the sanitary and sewage related were considered coming from mixed sources, since in this marine compartment (seafloor) they are likely to originate either from activities at land, including sewage outlets, or from cruise ships. Moreover, we considered fly-tipping as a sea-based source given that the litter items within this category are heavy and there is a very low probability that they come from inland. Thus, we compared the non-sourced items and the sanitary and sewage related items (mixed sources) with the litter items from shoreline, tourism and recreational activities (land-based sources) and the items coming from fisheries and aquaculture, shipping and fly-tipping (sea-based sources).

At a regional level, the average fraction of land-based sources accounted for 49.8% of the total litter items collected (Fig. 4.33); the sea-based sources represented the 23.5% of total items, while the remaining 26.7% was attributed to the mixed sources category. The contribution of these categories per country is also shown in Figure 4.33. Greece, Italy, and Slovenia showed similar contributions from sea- and land-based sources to the total litter items collected, while Croatia and Montenegro seemed to have a very low fraction of sea-based related items (18% and 14% respectively) compared to the land-based fraction.

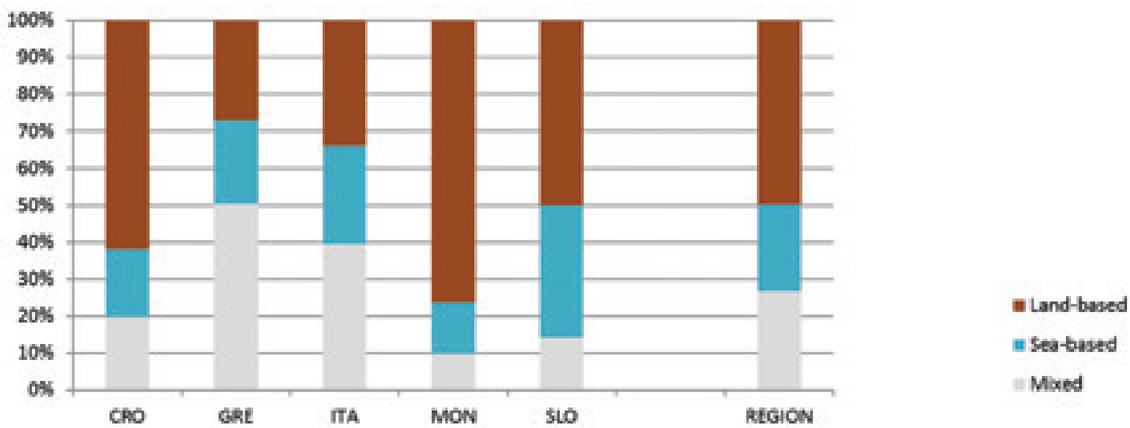

Figure 4.33. *Aggregated results at a national and regional level for the contribution land-, sea-based and mixed sources related items found on the seafloor (%). (CRO: Croatia; GRE: Greece; ITA: Italy; MON: Montenegro; SLO: Slovenia).*

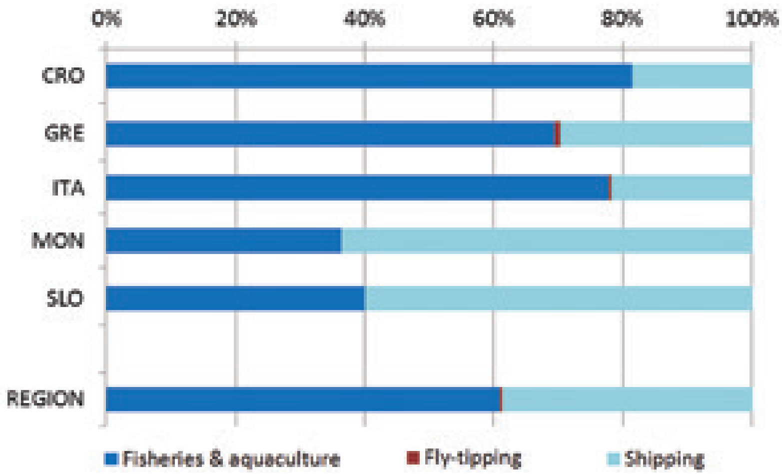

Figure 4.33. Aggregated results at a national and regional level for the contribution land-, sea-based and mixed sources related items found on the seafloor (%). (CRO: Croatia; GRE: Greece; ITA: Italy; MON: Montenegro; SLO: Slovenia).

The analysis of the sea-based fraction of litter items provides interesting differences among countries that should be highlighted (Fig. 4.34). Slovenia and Montenegro showed an opposite composition (shipping *vs* fisheries and aquaculture) of the sea-sourced items compared with the results from other countries and at regional scale, with the shipping fraction being higher than the fisheries and aquaculture related one. On an aggregated basis at regional level, 61% of the sea-based related items come from fisheries and aquaculture, and 39% comes from shipping, while the fly-tipping items were found in a very small number (3 items).

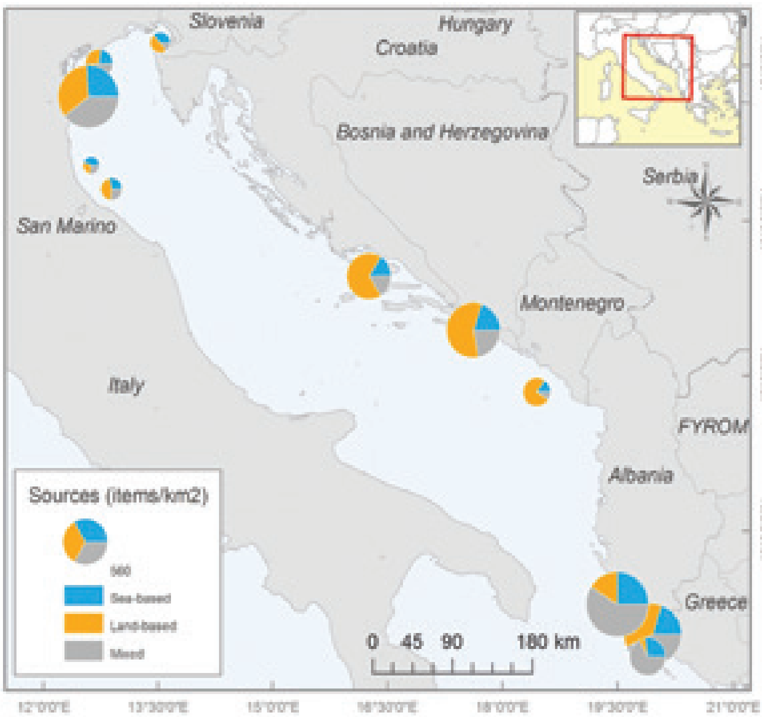

Figure 4.35. Relative densities of the sea-based vs land-based items found on the seafloor (items/km^2), showed by locations.

On the Adriatic seafloor, similar to the beach litter related findings, mussel nets are very abundant, accounting for some 8.35% of the total items found on the seafloor in all countries with a density of 49 items/km² (Fig. 4.36). When analyzing the sources of marine litter it must be taken into account that a large part of the fisheries and aquaculture related items is mussel nets (38.24% of all items collected) calling for tailor-made targeted measures. In Italy, an extraordinarily high density of mussel nets was recorded corresponding to a density of 73 items/km² (from aggregated data at national level). In Greece and Croatia, high densities of synthetic rope were recorded reaching the amount of 56 items/km² and 38 items/km², respectively. In Greece also a relatively high density of fishing line/monofilament was found (26 items/km²), while in Croatia rope, string and nets were rather abundant (23 items/km²).

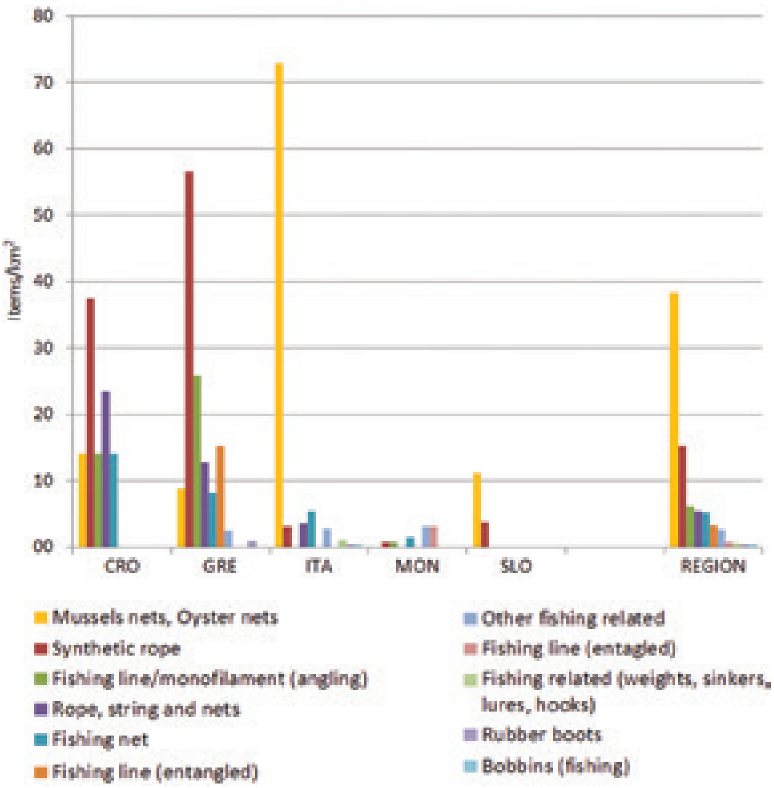

Figure 4.36. *Aggregated results at national and regional level for densities of the items categories that come from fisheries and aquaculture related sources (CRO: Croatia; GRE: Greece; ITA: Italy; MON: Montenegro; SLO: Slovenia).*

4.4.2. Visual seafloor surveys with scuba/snorkelling

In the analysis of the sources of the items found during visual surveys with scuba/snorkelling some modifications were made to the seafloor litter sources classification approach described in paragraph 4.4.1. Due to the close proximity of the seafloor transects to the shoreline, it was decided to assign some of the items to the shoreline, tourism and recreational activities related source (similarly to the beach litter sources classification approach), since items like cigarette butts, tyres, shoes or paper fragments are more likely coming from the

coast. As a result, only two items of the 'Masterlist' used for these surveys were assigned to the shipping source (pallets and drums, see Annex V).

From the 489 litter items collected, 117 were classified as non-sourced (24%), while the remaining items were attributed to one of the following sources: shoreline, including poor waste management practices, tourism and recreational activities; fisheries and aquaculture; sanitary and sewage related; fly-tipping. When considering the mean values for the three countries (Tab. 4.13), 64.3% of the items come from shoreline, tourism and recreational activities, while a very small fraction comes from the other three sources categories.

The results obtained from the seafloor transects carried out in Bosnia and Herzegovina (Tab. 4.13, Fig. 4.37) show that the highest amount of items comes from shoreline, including poor waste management practices, tourism and recreational activities (72.1%). Conversely, in Montenegro a high fraction of items – in comparison with the other countries – comes from fly-tipping (8%) due to the presence of car parts, batteries and appliances such as refrigerators, washers, etc. In the seafloor visual surveys, only a few fisheries and aquaculture-related items were found with Slovenia showing the highest number of items (9.4%) pertaining to this category, when compared to the other countries. However, it must be taken into account that in Slovenia only 32 items were recorded and therefore caution is needed when interpreting this result.

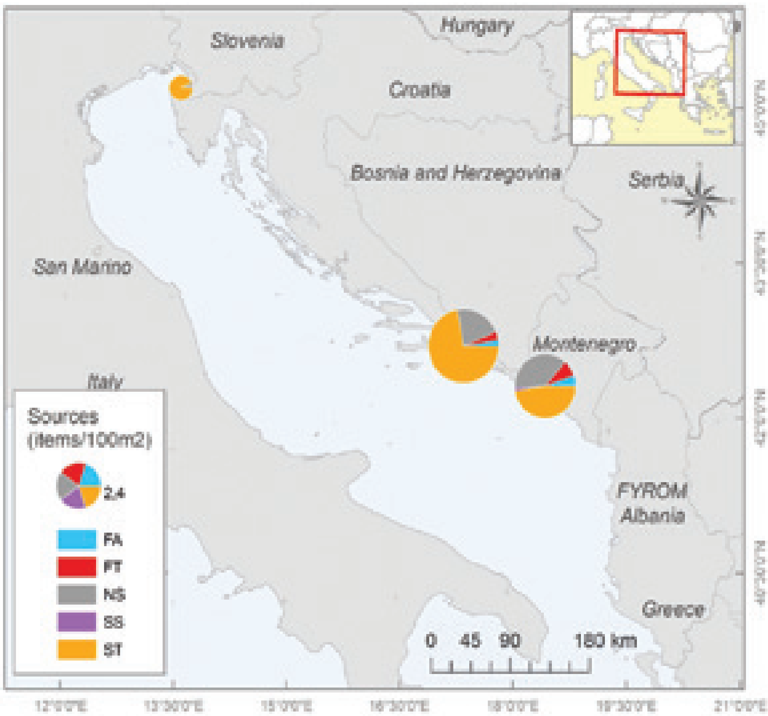

Figure 4.37. *Aggregated results at national level with the densities of the seafloor litter items according to their source (items/100 m²). (FA: fisheries & aquaculture; FT: fly-tipping; NS: non-sourced; SS: sanitary & sewage related; ST: shoreline, tourism and recreational activities).*

Table 4.13. Sources of litter found on the seafloor by visual census on the basis of aggregated at national level and at regional level (% of number of items). In bold the source that contributed the most to the total litter found in a given country; comparing the composition of the four countries, the country that showed the higher fraction of a given source is underlined.

	B&H	MONTENEGRO	SLOVENIA	ALL
Fisheries & aquaculture	2.7	4.9	9.4	5.7
Fly-tipping	3.7	8.0	0.0	3.9
Sanitary & sewage related	0.0	1.2	0.0	0.4
Shoreline, tourism & recreational activities	**72.1**	**58.3**	**62.5**	64.3
Non-sourced	21.4	27.6	28.1	25.7

In all surveyed countries, the vast majority of items recorded during the visual seafloor surveys are coming from land-based sources ranging from 58% to 72% of the total number of items recorded. In Montenegro, the sea-based sources related items showed the highest density with 0.6 items/100 m^2 (Fig. 4.38).

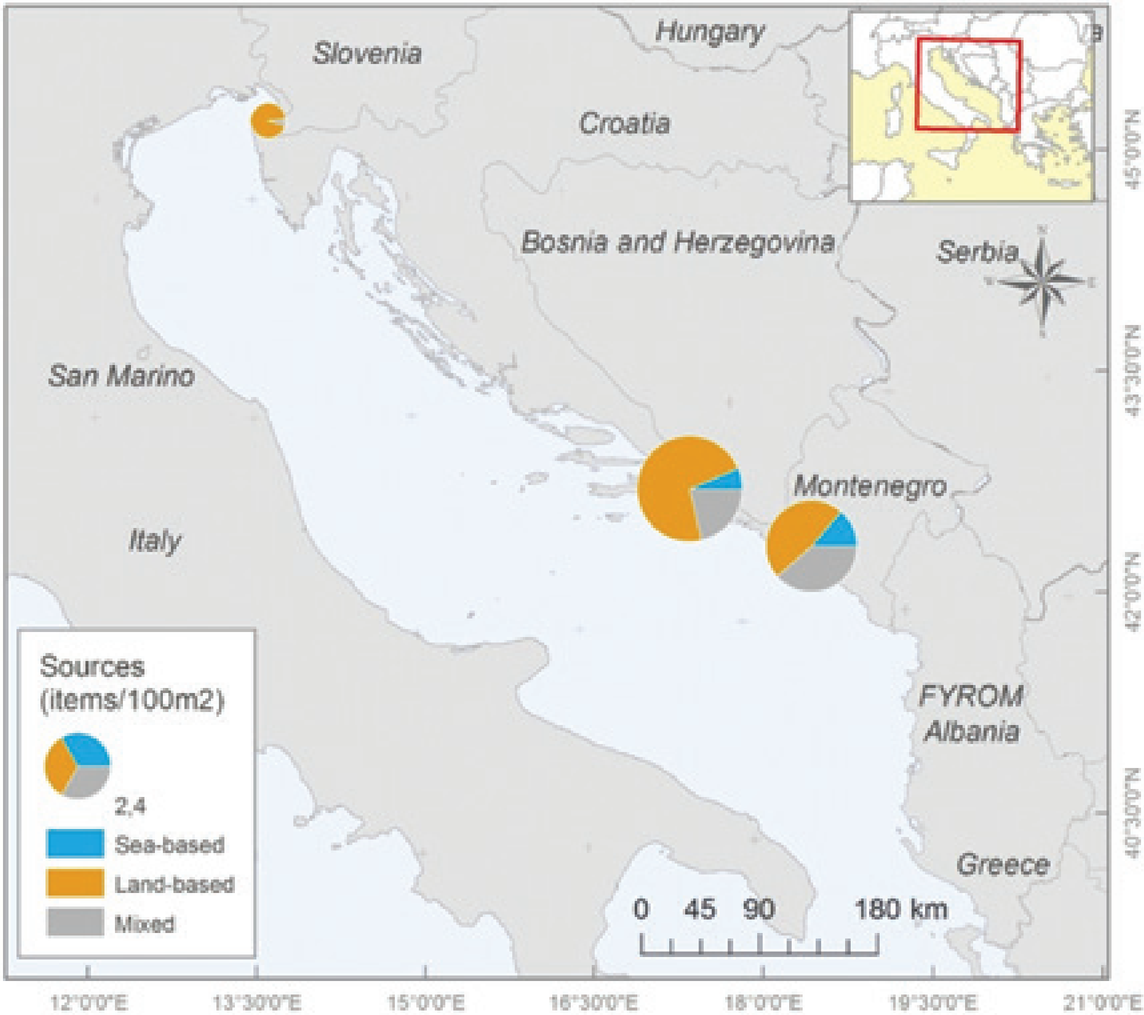

Figure 4.38. Relative densities of the sea-based vs land-based items (items/100 m^2), showed by country.

4.5 DISCUSSION

The methodologies commonly used in litter investigation on the seafloor are visual surveys with scuba diving/snorkelling for the shallow sub-littoral seafloor and bottom trawling for the continental shelf and slope up to 300m with fishing or research vessels (Spengler and Costa, 2008). The experts of the MSFD TG10 (Galgani et al., 2011) emphasized that surveys with bottom trawls provide the most suitable method to estimate the amount of litter along the continental shelves of European Regional Seas. Indeed, trawling (otter or beam trawl) is an efficient method for large-scale evaluation and monitoring of the seafloor litter that can efficiently be based on on-going monitoring schemes already implemented at European level. Existing fisheries stock assessment programmes are such an example and cover most European Regional Seas.

However, the use of trawls over complex rocky habitats is not appropriate, while visual surveys offer an excellent opportunity to investigate the abundance of litter items on rocky bottoms (Pham et al., 2013). In addition, they allow the determination of the exact locations of the items, whereas in trawl surveys the catch (including the debris) is integrated over the length of the tow (Watters et al., 2010). Furthermore, imaging is a non-intrusive method because it does not remove benthic organisms or damage the environment, making it a useful technique in protected areas (Melli et al., 2016). Visual investigations may be carried out by divers in shallow waters (Katsanevakis and Katsarou, 2004), through submersibles (Donohue et al., 2001) and remotely operated vehicles (ROVs) (Angiolillo et al., 2015; Melli et al., 2016). The most common approach to evaluate seafloor litter distribution in shallow waters (0–25 m) is to conduct underwater visual surveys with scuba diving/snorkelling (Katsanevakis and Katsarou 2004).

One of the key objectives of the DeFishGear project was the definition of a joint monitoring and assessment approach for marine litter and the enhancement of all project partners' capacities to monitor marine litter in a harmonized way. Seafloor monitoring with bottom trawls was conducted by different partners following the same protocol developed in the framework of the project. However, a complete harmonization among and between the surveying teams could not be achieved given that partners employed different vessels (both fishing and research vessels) equipped with different gear (Tab. 4.2), thus leading to differentiated handling operations and characteristics (such as type of mesh, mesh size of cod end, etc.) during the surveys. Therefore, some caution may be needed when comparing results across countries and surveying teams.

4.5.1. Bottom trawl surveys

In the Adriatic and Ionian Seas, there are ongoing trawl survey programs, such as the MEDITS trawl survey or the SOLEMON trawl survey (implemented in Northern and Central Adriatic), which collect seafloor litter data. However, these programmes collect litter data either on a voluntary basis (MEDITS trawl survey) or do not cover the whole Adriatic-Ionian macroregion (SOLEMON trawl survey) (Strafella et al., 2015; Pasquini et al., 2016). In order to enhance monitoring of marine litter on the seafloor and facilitate the implementation process of the EU MSFD and the UNEP/MAP Regional Plan on Marine Litter Management with regards to setting baselines towards achieving GES, it is highly recommended to make mandatory for ongoing trawl survey programs the collection of seafloor litter data.

Thanks to the DeFishGear project, it was possible to collect seafloor litter data in a harmonized and comprehensive way in pilot areas throughout the Adriatic and Ionian Seas, the first such effort to-date in the region providing valuable information for the aforementioned legislative frameworks. Albania was the only country for which seafloor litter data were not obtained through the DeFishGear project, however such data are being collected in the framework of the MEDITS trawl-survey. Within the framework of the DeFishGear project 121 hauls were performed in the region and none of them was completely litter-free. In total, 2,658 marine litter items were collected and removed from the sea, weighing 372.35 kg.

The average seafloor litter density at regional level was 510 ± 517 items/km^2 (range: 79-1,099 items/km^2) and 65 ± 322 kg/km^2 (range: 3-339 kg/km^2). In terms of the amount of litter per surface area (kg/km^2), the DeFishGear results are comparable to those reported by other studies in the Adriatic and Ionian Seas

(Tab. 4.14). Indicatively, some of the mean seafloor litter densities reported in the past few years for the Adriatic and Ionian Seas are: 85 ± 26 kg/km² (Strafella et al., 2015) and 82 ± 34 kg/km² (Pasquini et al., 2016) for the northern and central Adriatic Sea; 6.7 to 47.4 kg/km² for the eastern Ionian Sea (Koutsodendris et al., 2008). In terms of number of litter items per surface area (items/km²), the DeFishGear results are also comparable to those reported by other studies in the Adriatic and Ionian Seas. The mean seafloor litter densities reported in the past few years are: 913 ± 80 items/km² for the northern and central Adriatic Sea; 378 ± 251 items/km² for the Adriatic Sea (Galgani et al., 2000); 165 items/km² for the eastern Ionian Sea (Koutsodendris et al., 2008).

When comparing the DeFishGear results with other seafloor litter densities reported worldwide, it is evident that the seafloor of the Adriatic and Ionian Seas is impacted by marine litter, with amounts of litter being 2-5 times higher than those reported for some other seas (Tab. 4.14). These rather high seafloor litter densities could be explained by the combination of high anthropogenic pressures (e.g. densely populated coastline, intensive shipping, massive tourism, fishing and aquaculture) and special environmental features of the Adriatic and Ionian Seas, since the basin is a semi-closed one with a limited water exchange, negligible tidal flow and massive river flow inputs (Pasquini et al., 2016).

Seafloor litter showed an uneven distribution throughout the Adriatic and Ionian macroregion, with great differences in average litter densities among the surveyed areas, with values ranging from 79 to 1,099 items/km² (Tab. 4.4). Also at local level (within areas) marine litter resulted to be unevenly distributed, with only a few hauls with extremely high quantities of marine litter, while 97.5% of the hauls collected less than 10 kg of litter, and 82% contained less than 36 items. The highest density of litter items (1,099 ± 589 items/km²) was found in the North Corfu area (Greece), followed closely by the South area of the Gulf of Venice (1,023 ± 616 items/km²) and the Gulf of Corfu (948 ± 478 items/km²). Similar values were found in the Saronikos Gulf in Greece (1,211 ± 594 items/km²) (Ioakeimidis et al., 2014) and in the NW Mediterranean (1,935 ± 633 items/km²) in the vicinity of metropolitan areas (Galgani et al., 1995). The highest quantity of litter in terms of weight was found in the south part of the Gulf of Venice (Italy) (339 ± 910 kg/km²). Overall, according to the DeFishGear results the seafloor of the surveyed areas in Greece, Croatia and Italy were found to be the most polluted ones in terms of litter items. When it comes to mass of litter the seafloor of Italy (NW Adriatic Sea) seems to be the most impacted (104 ± 492 kg/km²). On the other hand in Slovenia, the seafloor was found to be the least polluted (110 ± 110 items/km²; 6 ± 10 kg/km²).

Plastic was the dominant material found on the seafloor of the areas investigated, ranging between and among countries from 78.6% to 91.4% in terms of number of items (89.4%, average value at regional level). This result is not surprising, considering the great amounts of plastic that are discharged annually in the Adriatic-Ionian basin. It is estimated that the total annual input of plastic in the Adriatic and Ionian Sea was 10,000–250,000 tons in 2010 (Jambeck et al., 2015). Nowadays, plastic debris in the oceans and seas is ubiquitous and

the same applies for the Adriatic-Ionian region. When comparing the amount of plastics (% of total litter items) found on the seafloor of the Adriatic and Ionian Seas with the amount of plastics recorded on the seafloor of other Mediterranean areas there are no major differences, however the related values observed in the Pacific Ocean and in the Baltic Sea are much lower with 23% and 36%, respectively (Tab. 4.14).

Table 4.14. *Densities and proportion of plastic in seafloor litter in worldwide seas collected from bottom trawl surveys. (N: Northern; C: Central; S: Southern; W: Western; E: Eastern).*

Sea	Litter density	Plastic %	References
Adriatic & Ionian	510 items/km^2 | 65 kg/km^2	89.4	Present study
N & C Adriatic	913 items/km^2 | 82 kg/km^2	80; 62	Pasquini et al., 2016
N & C Adriatic	85 kg/km^2	34	Strafella et al., 2015
Adriatic	378 items/km^2	70	Galgani et al., 2000
E Ionian	165 items/km^2	56	Koutsodendris et al., 2008
E Med & Black Sea	24-1,211 items/km^2	45-95	Ioakeimidis et al., 2014
Baltic	126 items/km^2	36	Galgani et al., 2000
W Pacific	185 items/km^2	54	Kuriyama et al., 2003
E Pacific	30 items/km^2	23	Keller et al., 2010
Atlantic/Portugal	179 ± 64 items/km^2	75	Neves et al., 2015
SE North Sea	10.6 ± 9.7 kg/km^2	-	Schultz et al., 2015

Almost all the seafloor litter categories included in the 'Masterlist' were found during the trawl surveys in the Adriatic and Ionian Seas, indicating a great diversification of litter items and possibly of sources. At a regional scale, the 20 most abundant categories accounted for the great majority of the litter found (93.9%). Sheets, industrial packaging, plastic sheeting were largely the most abundant type of litter (27.8%), followed by plastic bags and food containers, both accounting for about 11% of all the items recorded.

The DeFishGear data highlight the emerging issue of mussel nets for the Adriatic Sea, particularly in the northern Adriatic (Italy and Slovenia). Previous studies have also detected the high presence of mussel nets in the northern and central Adriatic Sea (Strafella et al., 2015; Pasquini et al., 2016), even in protected areas (Melli et al., 2016), suggesting the mismanagement of the waste produced by mussel farms in the area. Indeed, Melli et al. (2016) observed that, although full-size mussel nets might be lost accidentally during storms, net fragments are likely cut and lost/abandoned at sea during the collection and preparation of the product. Thus, correct handling and management of mussel nets should be practiced to reduce further inputs into the marine and coastal environment.

Some differences were observed among countries with regards to the most common litter items found on the seafloor. In Croatia and Greece, plastic sheets were by far the most common items found. In Italy, also, plastic sheets were among the most common items, however plastic food containers and mussel nets also ranked high. In Montenegro and Slovenia, plastic bottles were the most common litter items found, followed by plastic bags.

At a regional level, small- (i.e. 25-100 cm^2) and medium-sized (i.e. 100-400 cm^2) items were the most common ones, while large-sized items (i.e. 2,500-10,000 cm^2) represented only a very small portion of the litter collected. All size classes were found in Italy and Greece, while in Croatia and Slovenia a predominance of small- and medium-sized items was observed.

Sources of marine litter found on the seafloor are many and vary and the actual quantities involved remain largely unknown. Reliable quantitative comparisons between the input loads, their sources, their origin and users are not possible at present and this represents a significant knowledge gap (UNEP, 2016). Land-based inputs may enter the marine environment directly from shorelines or via pathways such as rivers and wastewater outlets. Inputs at sea may be from standard operations, accidental losses or deliberate discarding. Inadequate solid waste management at all stages is considered to result in substantial releases of litter to the oceans and seas. Losses from commercial shipping correlate with busy shipping routes (Pasquini et al., 2016). Locally, aquaculture structures (mainly mussel farms in the Adriatic-Ionian region) can produce significant quantities of plastic debris if affected by extreme weather conditions (e.g. storms) or if they mismanage their gear (Melli et al., 2016; Pasquini et al., 2016).

Litter that reaches the seafloor may already have been transported over considerable distances, sinking when weighed down by entanglement or fouling. The result is the accumulation of litter on specific seafloor locations depending not only on local sources but also oceanographic conditions, which lead to high spatial variability of seafloor litter abundance and consequently to further difficulty in attributing one specific source (Ramirez-Llodra et al., 2013; Pham et al., 2013). For instance, many types of plastic are denser than seawater so they will sink only once any initial buoyancy is removed, due to water filling and/or due to the settlement of living organisms on them.

Conversely, heavy items - like glass or metal objects - sink rapidly once released in the marine environment, making the attribution of a specific source easier. For this reason, the sources identification of the seafloor litter recorded was made using the classification approach adopted within this report for the beach litter data (see paragraph 2.5) with slight modifications. For example, heavy items found on the seafloor were assigned to the shipping source instead of shoreline, tourism and recreational activities. The same source was also attributed to paper/cardboard items and cigarette butts, since they have a short life in water and tend to sink close to where they were generated.

At regional level, for more than one-third (37%) of the litter items found on the seafloor, it was not possible to identify a specific source. Indeed, most litter items often cannot be connected to a specific source, way of release or pathway. Some items can have a number of potential sources and pathways of entry as well as geographic origins. Moreover, the source and way of release of marine litter are almost impossible to be defined in the case of fragments or pieces (Veiga et al., 2016).

In Croatia, Montenegro and Slovenia the seafloor litter was mainly associated with shoreline, including poor waste management, tourism and recreational activities, while in Greece the majority of litter items were non-sourced, being mainly plastic sheet pieces. However, also in Greece a high percentage (27%) of litter items was attributed to shoreline, including poor waste management, tourism and recreational activities. In Italy, approximately one-third was non-sourced and one-third was associated with shoreline, including poor waste management, tourism and recreational activities. Half of the hauls were conducted close to the coast (within ~ 4 nautical miles), that is highly populated and where a thriving tourism industry exists, thus this result was somehow expected. It is worth noting that Italy ranked highest in the region in terms of fisheries and aquaculture related items, with mussel nets representing almost the totality of the items from this specific source. Italy ranked highest also when it comes to sanitary and sewage related items, probably due to the presence of the Po river (the largest river in the region).

When considering the large groups of sources (land-based *vs* sea-based) at a regional level some 50% of the seafloor litter collected was attributed to land-based sources. Conversely, sea-based sources represented some 23.5% of total items, while the remaining 26.7% of items could not be attributed to a specific source. It is widely recognized that most marine litter comes from land-based sources (UNEP, 2005), and the Adriatic-Ionian region does not represent an exception, when it comes to the seafloor litter. In particular, land-based sources were largely predominant in Croatia (62%) and Montenegro (76%), where sea-based related items showed low percentages (18% and 14%, respectively). Conversely, Italy and Greece were characterised by high values for litter items that could not be attributed to a specific source (40% and 50%, respectively).

4.5.2. Visual surveys with scuba/snorkelling

No litter was found in 10 out of 38 transects and some 45% of the transects contained a low number of litter items (between 1 and 9). The average seafloor litter density from aggregated results at regional level was 2.78 ± 3.35 items/100 m^2. Slovenia was the country were the lowest seafloor litter densities were found (ranging between 0.06 ± 0.07 items/100 m^2 at Dragonja, and 2 ± 5 items/100 m^2 close to the city of Koper). Conversely, Bosnia and Herzegovina was the country with the highest density of litter items found on the seafloor (up to 7.25 ± 4.57 items/m^2).

It is worth noting that the seafloor litter densities obtained within the DeFishGear project through visual surveys with scuba/snorkelling (27,800 items/km^2) are not comparable to the seafloor litter densities found in the bottom trawl surveys (510 items/km^2). Similar discrepancies between surveys applying different seafloor litter monitoring methods are evident in results reported for the Mediterranean (UNEP/MAP, 2015) and worldwide (Donohue et al., 2001; Abu-Hilal and Al-Najjar, 2009) and can be attributed to different methodology applied per se or to the different sea compartment investigated during the different transects and their vicinity to the sources.

The densities obtained in the framework of the DeFishGear project via visual surveys with scuba/snorkelling are comparable to densities found in similar surveys performed in other areas worldwide (e.g. Gray's Reef National Marine Sanctuary, USA; Eastern Mediterranean Sea, Greece) (Bauer et al., 2008; Katsanevakis & Katsarou, 2004). In certain areas (e.g. the Gulf of Aqaba, the Red Sea) the reported seafloor litter densities are much higher (280 items/100 m^2) than the ones recorded within the present study and in some other areas (e.g. the N. Hawaiian Island and the Lisianski Island) they are much lower ($0.4*10^{-3} – 6.2*10^{-3}$ items/100 m^2) (Donohue et al., 2001; Abu-Hilal and Al-Najjar, 2009) (Tab. 4.15).

Table 4.15. *Seafloor litter densities (items/100 m²) from visual surveys with scuba/snorkelling in various parts of the world.*

Area	Depth (m)	items/100 m²	Plastic (%)	Source
Adriatic Sea	3-24	2.78 ± 3.35	36	*Present study*
Gulf of Aqaba, Red Sea	0-10	280	42	*Abu-Hilal and Al-Najjar, 2009*
N. Hawaiian Island, Lisianski Island	10	$0.4*10^{-3} – 6.2*10^{-3}$	-	*Donohue et al., 2001*
Gray's Reef National Marine Sanctuary, USA	16-20	0.52 ± 0.11	-	*Bauer et al., 2008*
Eastern Mediterranean Sea, Greece	0-25	1.5	55.47	*Katsanevakis and Katsarou, 2004*

Aggregated results at regional level show that plastic represented the most common material found on the seafloor (36%), even if glass and ceramics (27%) and metal (25%) were also common. Similar results are also found in other areas worldwide (Tab. 4.15) It is worth noting that the percentage of plastic found in coastal shallow waters is remarkably lower than the one found during bottom trawl surveys (89.4%). Similar results have been obtained through other seafloor bottom trawl or visual surveys. (Tab. 4.14 and 4.15). In the visual seafloor litter surveys the amount of plastics may have been underestimated due to the problematic recognition and identification of small items and/or items buried in the seafloor (e.g. sheets, caps and lids, bags, fragments), but it could also be due to the absence of typical sources of plastic in the vicinity of the few locations surveyed (river, big cities, sewer drains, cruises lines) or the fact that plastic items such as plastic bottles do not travel long distances, sink down to the seafloor due to water filling and therefore end up accumulating close to the coast. Differences were observed with regards to the most abundant litter items material among and between countries. In Bosnia and Herzegovina, the most common material was glass and ceramics (40%). Glass and ceramics were also abundant in Montenegro (32%).

Almost all litter categories were found, even if the top 20 litter categories (93%) accounted for almost the totality of items found. At regional level, the most common items found were glass bottles (including pieces), followed by plastic bottles and metal cans, which are all related to beverage packaging. Glass bottles were the most common litter items in all countries. These items have been characterised as "public litter" i.e. items dropped or left by the public on the coast or inland and carried by winds and rivers (Veiga et al., 2016). Glass bottles do not travel long distances and sink down to the seafloor due to water filling and therefore end up accumulating close to the coast.

Similarly to the seafloor litter bottom trawl surveys, the small- and medium-sized items were the most common ones recorded during the visual surveys with scuba/snorkelling.

Aggregated results at regional level show that only a small fraction of litter items (26%) observed in shallow waters during the visual surveys could not be attributed to a specific source. The large majority of items (64%) were attributed to shoreline, tourism and recreational activities, followed by fisheries & aquaculture (6%), sanitary & sewage related (4%) and fly-tipping (0.4%). Shoreline, tourism and recreational activities were the main sources of marine litter in shallow waters (9-24 m) for all countries, with values ranging from 72% in Bosnia and Herzegovina to 58% in Montenegro. This result was expected due to the high vicinity of sampling sites to the coast, and considering that surveys were performed in locations close to highly urbanized areas (e.g. the Bay of Kotor, Montenegro) and important tourism destinations (e.g. Neum, Bosnia and Herzegovina; Koper, Slovenia).

Interestingly, in the Bay of Kotor (Montenegro), the second most important source of litter was fly-tipping; litter found included car parts, batteries and appliances like refrigerators, washers, etc. Also in Bosnia and Herzegovina, the second most important source was fly-tipping too, while in Slovenian waters no items that originate from

this source were found. It is an evident fact that much waste is not introduced to proper management schemes and ends up in the marine and coastal environment due to illegal dumping activities, which should be prevented.

Only a few fisheries and aquaculture-related items were found, with Slovenia showing the highest percentage (9%), followed by Montenegro (5%) and Bosnia and Herzegovina (3%). It is worth noting that results obtained from the bottom trawl surveys show higher amounts of fisheries and aquaculture related items. Concluding, also in shallow waters land-based sources were predominant in all countries (58-72%).

4.6 CONCLUSIONS

Within the present study great effort has been invested by the project partners from almost all countries of the Adriatic-Ionian macroregion (except Albania) to assess in a comprehensive and harmonized way the amounts of litter on the seafloor of the Adriatic and Ionian Seas. Some 120 transects were performed through beam trawl vessels, while 38 transects were carried out by divers in shallow waters near the coastline, thus covering a total area of 5.83 km^2.

Bottom trawl surveys confirmed the general trend recorded in other seafloor litter studies, with plastic representing the great majority of the items found; the massive presence of packaging-derived fragments and single-use items is not only related to poor waste management practices and schemes, but also to the exponential use of plastic materials in our lives, emphasizing the urgency for a drastic behavioural change. Mussel nets emerged as a local/national problem - in Italy and Slovenia - affecting the marine environment and posing a severe threat to the economy of the local fishery communities mainly due to loss of catches and increased time for cleaning their gear. A simple and yet effective management scheme for this aquaculture waste needs to be urgently defined and implemented in order to address this issue.

Visual surveys with scuba/snorkelling provide valuable information -that could not be captured by the trawl surveys- related to glass, metals and fly-tipping objects making up a consistent part of marine litter; moreover, these surveys reveal that illegal dumping is a frequent practice with negative impacts to the marine environment due to chemical substances and contaminants that these items contain.

Bottom trawl surveys and visual surveys with scuba/snorkelling are complementary approaches to monitor marine litter. Bottom trawl surveys provide an excellent tool in investigating large seafloor areas with a relatively low time and cost /efficiency rate, while visual surveys with scuba/snorkelling make it possible to collect data in small marine areas with high ecological value such as protected areas or shallow waters, where trawling activities are not permitted, nor feasible. The differences in the results obtained within this study by both monitoring approaches highlight the need for implementing them in order to ensure an enhanced and more complete comprehension of the marine litter issue and an early detection of potential problems in areas of high ecological value.

MARINE LITTER **IN BIOTA**

5

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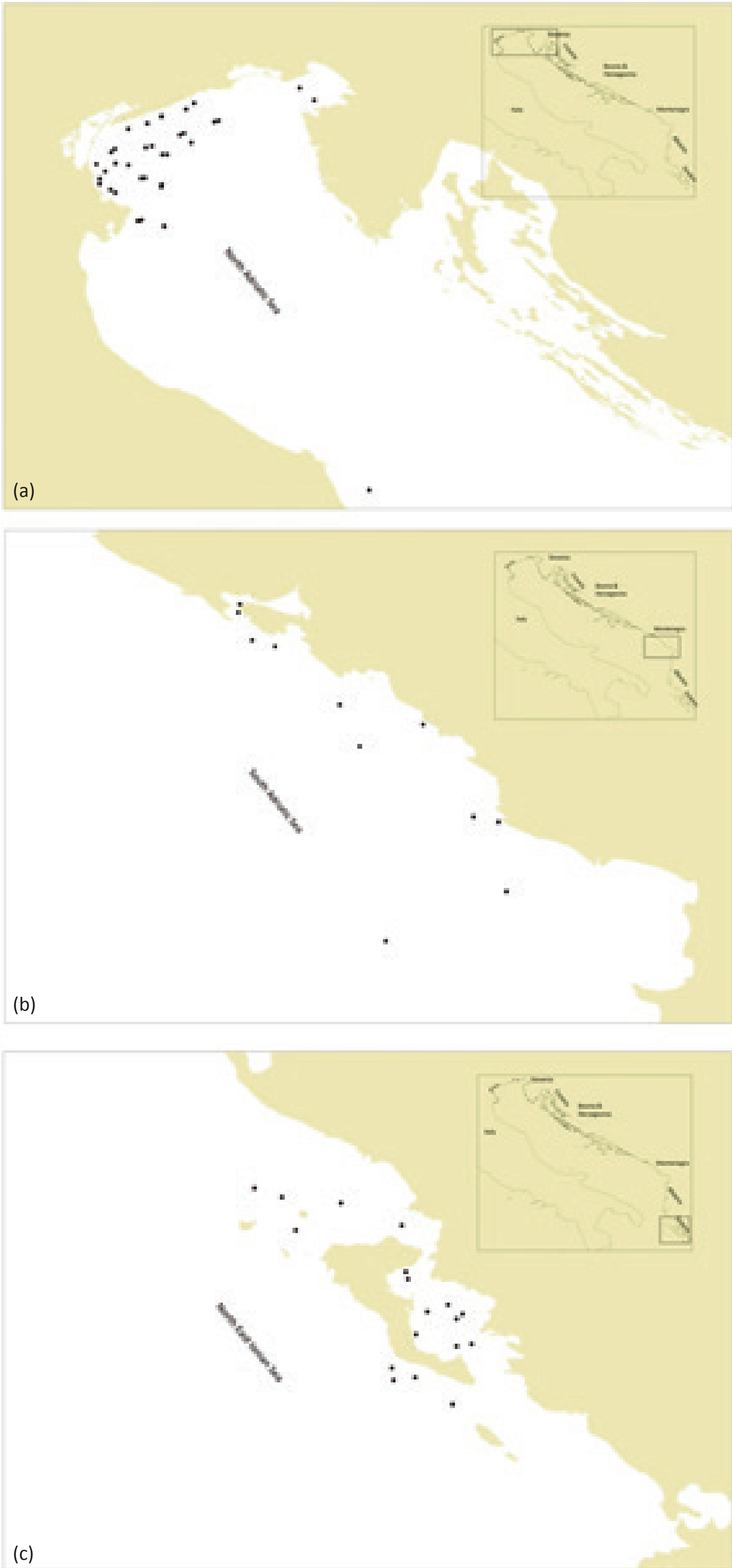


Figure 5.1. *Maps showing the position of bottom trawl hauls (the starting point) performed in the Adriatic-Ionian macroregion: (a) Gulf of Venice - N. Adriatic (ISPRA); (b) South Adriatic (IBM); and (c) NE Ionian Sea (HCMR).*

5.1 METHODOLOGY

The study of ingested macro-litter (>5 mm) by marine biota was one of the pilot activities of the DeFishGear project. Three countries (3 partners) participated in this activity: the Italian National Institute for Environmental Protection and Research (ISPRA) from Italy, the Institute of Marine Biology (IBM) from Montenegro, the Hellenic Centre for Marine Research (HCMR) from Greece. Fish were collected for gastrointestinal content analysis from surveys carried out mainly in the Gulf of Venice- North Adriatic Sea by ISPRA, in the South Adriatic Sea by IBM and in the northeastern Ionian Sea around Corfu Island by HCMR (Fig. 5.1). In total, 81 hauls were conducted; some of them were repeated on a seasonal basis (autumn 2014, spring-summer 2015). Most samples were collected from experimental bottom trawl surveys of 30-min duration under low vessel speed (< 4 knots) covering a depth range between 10 to 281 m depending on the area. IBM also used samples coming from purse seine vessels, pelagic trawls, and commercial bottom trawls. For each haul, the fishing location, date, and depth were recorded and the samples were frozen immediately after capture.

Within the framework of the DeFishGear project, a protocol for macro-litter ingested by fish was prepared and adopted by all partners (Anastasopoulou and Mytilineou, 2015). In each country laboratory, samples were analysed according to the adopted protocol. For each specimen, the main biological parameters (e.g. length, weight, sex, maturity stage) were recorded. Then, fish were dissected and stomachs and intestines were removed and placed in sealed bags and frozen again or stomach and intestine contents were quickly removed and transferred to plastic vials until the next processing steps. Stomach and intestine contents (gut contents) were weighed (Fig. 5.2). The gut content was subsequently examined under a binocular stereomicroscope. Marine litter items were measured, weighed and classified by type according to the 'Master List of Categories of Litter Items' (Galgani et al., 2013). Within the present study, all litter items visible under a stereoscope were included, i.e. items > 1 mm.

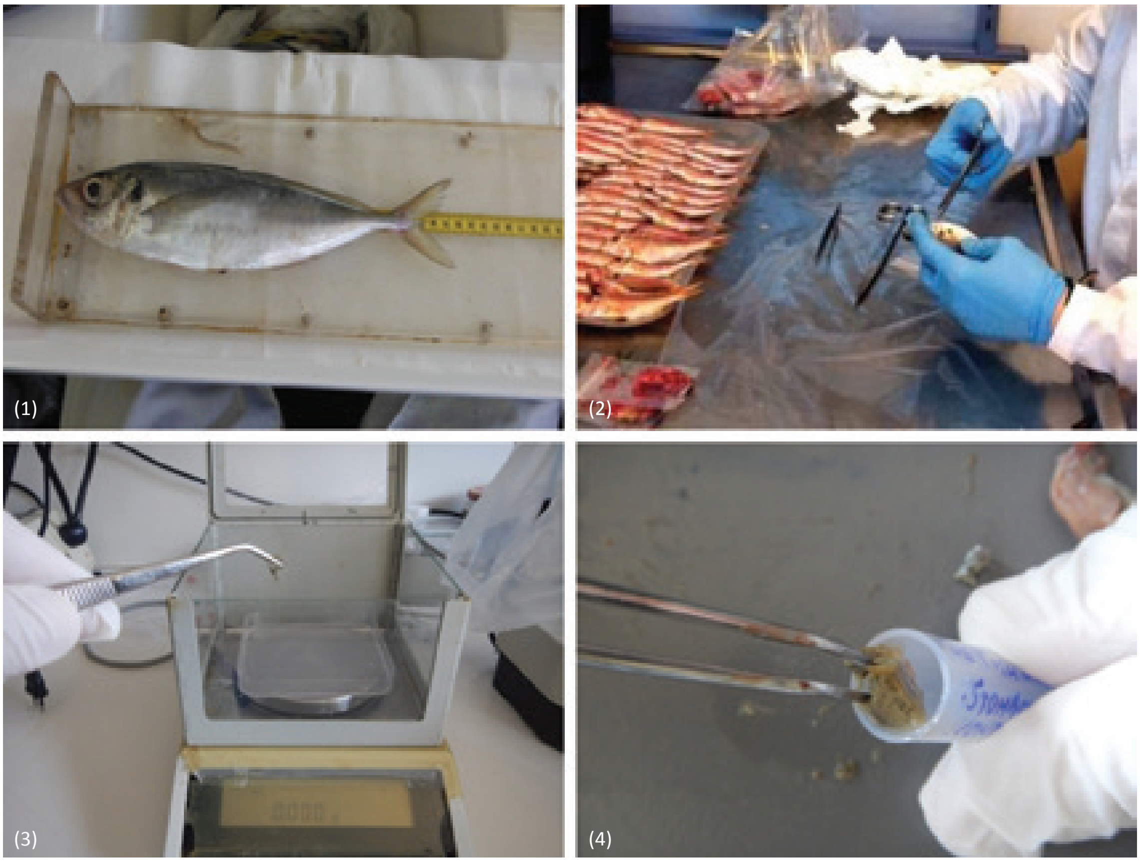


Figure 5.2. *Processing of fish samples for the gastrointestinal (gut) content analyses: (1) Fish length measurement; (2) dissection; (3) weighing of gut content; (4) storing of gut content in plastic vial.*

During sample processing in the laboratories, some precautionary measures were applied to minimize the risk of airborne contamination by plastic threads. Equipment and workbench were carefully cleaned, air conditioning was turned off and gloves and lab coats were used. HCMR used a plastic cover isolating the stereomicroscopic area (Torre et al., 2016) (Fig. 5.3). A similar cover was used by IBM. ISPRA used a clean petri-dish near the working area as a blank sample in order to exclude from the gut analysis the fibres that came from air contamination (Davison and Ash, 2011). However, in order to minimize the risk of air contamination, most of the filaments recorded in the ISPRA lab were excluded from the analysis, even if some clean lab procedures were adopted.

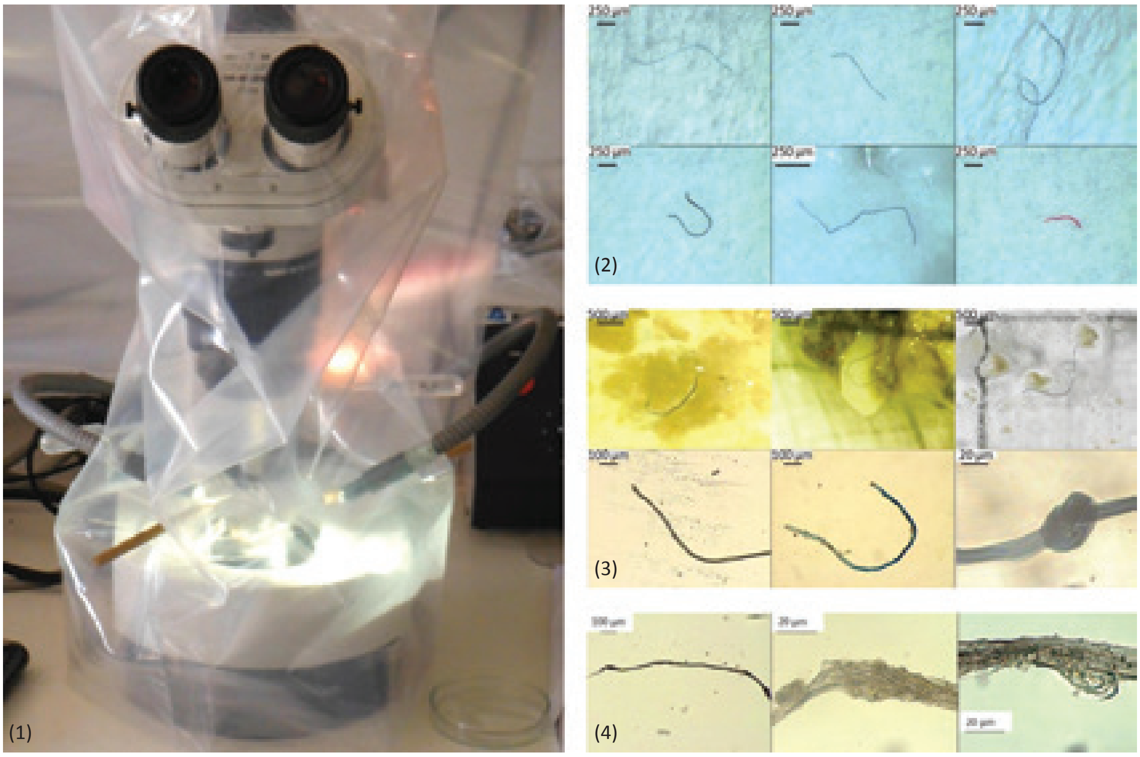


Figure 5.3. *(1) Microscope cover for airborne contamination; (2) airborne microfibers in blank-control petri dishes; (3) airborne microfibers in gut contents; (4) true marine anthropogenic microfibers.*

According to the DeFishGear protocol for biota, 8 fish species were selected belonging to demersal, mesopelagic and pelagic categories based on their behaviour. However, since it was difficult to obtain the same fish species in all areas or because the number of specimens caught was very small, some additional species belonging to the aforementioned three categories were also studied. The species studied by each partner are listed in Table 5.1. Based on fish behavior, the species *Mullus barbatus, Mullus surmuletus, Citharus linguatula, Solea solea, Chelinonichthys lucerna* were considered demersal; the species *Pagellus erythrinus, Trachurus trachurus, Trachurus mediterraneus and Trachurus picturatus* mesopelagic and *Sardina pilchardus, Scomber japonicus* were considered as pelagic.

The contribution of fish species with ingested marine litter was examined in relation to the total number of the fish examined by species and area.

Three indices were used in this study as follows:

- The percentage frequency of occurrence (%F) = the ratio of the number of guts containing a given litter item to the total number of non-empty guts examined (x 100).
- The percentage numerical abundance (%N) = the ratio of the number of litter items of a given litter category in all non-empty guts to the total number of litter items of all categories in all guts (x 100).
- The percentage weight (%W) = the ratio of the weight of litter items of a given litter category in all non-empty guts to the total weight of litter items of all categories in all guts (x 100).

For assessing if any significant differences exist regarding fish litter ingestion among the three areas studied, a Kruskal- Wallis test was performed on Log+1 transformed data on litter abundance found in the guts of the two common fish species examined in all three areas (*M. barbatus, S. pilchardus*) using the area as factor.

The average number of marine litter items found per gut was also examined. Average values higher than 1 indicate that more than one litter item was ingested by fish.

The weighting of ingested marine litter particles was difficult, especially for the filaments because they are very light. For this reason, ISPRA did not provide any weight measurements. However, in order to have a general idea of the weight of ingested marine (%W) occupied in the guts, a theoretical value of 0.001 g was added for those litter items for which no value was available.

5.2 RESULTS

In total, 614 fish individuals were studied (Tab. 5.1). Some 155 in the northern Adriatic Sea, 235 in the south Adriatic Sea and 224 in the northeastern Ionian Sea. Only some 5% of them had empty guts: 2 individuals in the North Adriatic, 27 individuals in the northeastern Ionian and none in the South Adriatic Sea.

Table 5.1. *Fish samples analysed for ingested litter in North Adriatic, South Adriatic, and the northeastern Ionian Sea. Min, Max and mean Total length (mm) is also shown. S.D.: standard deviation.*

Location	Species	No of individuals (n)	Total Length (TL, mm)			Total weight (TW, g)		
			Min	Max	Mean (S.D.)	Min	Max	Mean (S.D.)
North Adriatic Sea	*Mullus barbatus*	48	12.9	23.4	16.64 (1.76)	25.00	180.00	62.85 (25.0)
	Mullus surmuletus	8	16.9	21.5	19.75 (1.59)	73.00	171.00	116.5 (31.5)
	Pagellus erythrinus	30	7.8	21.7	17.36 (3.29)	17.00	148.00	86.63 (39.4)
	Sardina pilchardus	33	13	18	14.84 (1.05)	15.00	42.00	24.87 (5.49)
	Solea solea	36	21.4	35.4	26.30 (3.41)	105.00	502.00	187.5 (92.2)
Total North Adriatic		155						
South Adriatic Sea	*Mullus barbatus*	50	12.3	18.1	14.60 (1.31)	19.25	60.01	31.49 (9.51)
	Sardina pilchardus	48	12.2	13.5	12.88 (0.41)	10.22	16.06	13.18 (1.27)
	Scomber japonicus	37	26.6	30.4	28.33 (0.88)	26.60	30.40	28.33 (0.88)
	Solea solea	50	18.9	30	24.73 (2.26)	58.43	237.87	119.2 (39.0)
	Trachurus trachurus	50	15.1	21.3	18.03 (1.38)	24.00	79.47	46.22 (11.6)
Total South Adriatic		235						
Northeast Ionian Sea	*Chelidonichthys lucerna*	1	24	24		124.60	124.60	124.6 (0)
	Citharus linguatula	52	4.6	18	12.96 (2.98)	0.46	48.56	18.43 (11.1)
	Mullus barbatus	50	9.1	21.7	14.13 (2.77)	8.24	123.14	37.03 (24.6)
	Pagellus erythrinus	50	6.8	20.7	14.06 (3.91)	5.47	127.64	43.95 (28.5)
	Sardina pilchardus	58	8	13.4	10.29 (1.13)	2.95	14.89	7.814 (2.72)
	Solea solea	2	25	33.6	29.3 (6.08)	125.19	333.60	229.3 (147.)
	Trachurus mediterraneus	2	14.7	16.5	15.6 (1.27)	28.57	39.85	34.21 (7.97)
	Trachurus picturatus	9	24	38	29.06 (4.60)	105.71	439.77	204.8 (113.)
Total Northeast Ionian Sea		224						

Analysis of the gastrointestinal tracts (guts) of examined fish revealed that marine litter was present in the guts of 4, 61, and 6 individuals in the North Adriatic, South Adriatic, and the northeastern Ionian Sea, respectively; they represented 2.6%, 25.9% and 2.7%, of examined fish individuals for each area. Litter was found in two species (*P. erythrinus* and *S. pilchardus*) in the North Adriatic, in five species (*M. barbatus, S. pilchardus, S. solea, T. trachurus* and *S. japonicus*) in the South Adriatic Sea and in three species (*C. linguatula, M. barbatus* and *P. erythrinus*) in the northeastern Ionian Sea. In the South Adriatic, all species examined had ingested litter in their guts and especially for the pelagic species *S. pilchardus, S. japonicus,* and *T. trachurus* litter occurrence was quite high (50%, 43% and 24 % respectively).

The percentage of litter frequency of occurrence (%F) (i.e. the % ratio of the number of guts found with litter to the total number on non-empty guts) at the regional level was 2.61% for the North Adriatic, 25.96% for the South Adriatic and 3.05% for the northeastern Ionian Sea. More specifically, %F ranged between 3 and 9% in the North Adriatic, with *S. pilchardus* showing the highest value, between 4 and 50% in the South Adriatic Sea, with *S. pilchardus* showing the highest value, and in the northeastern Ionian Sea between 2 and 8%, with *M. barbatus* showing the highest value (Fig. 5.4).

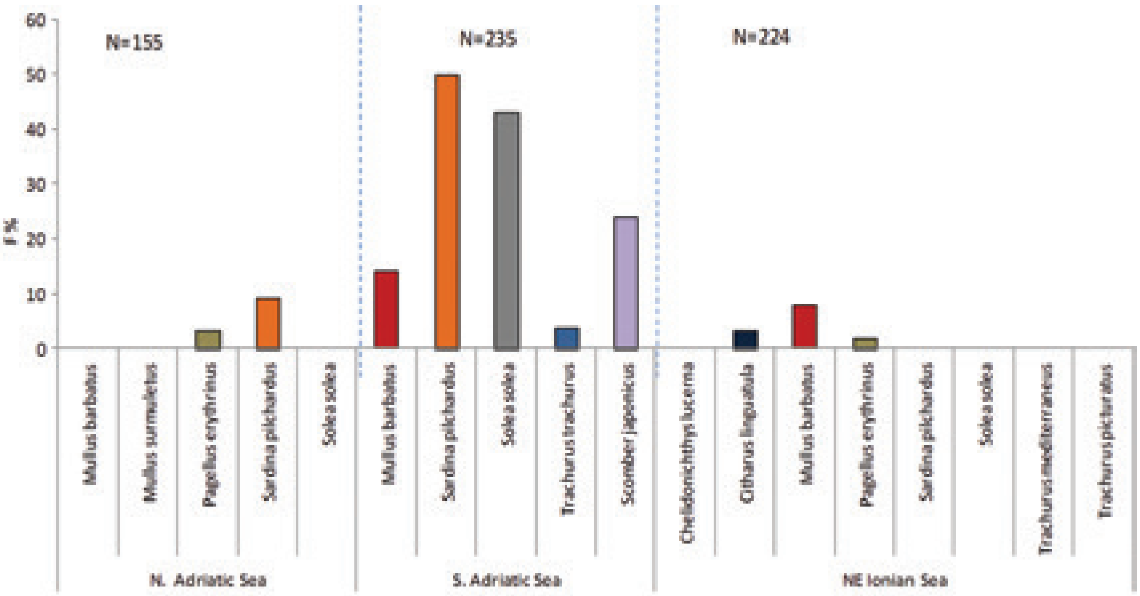
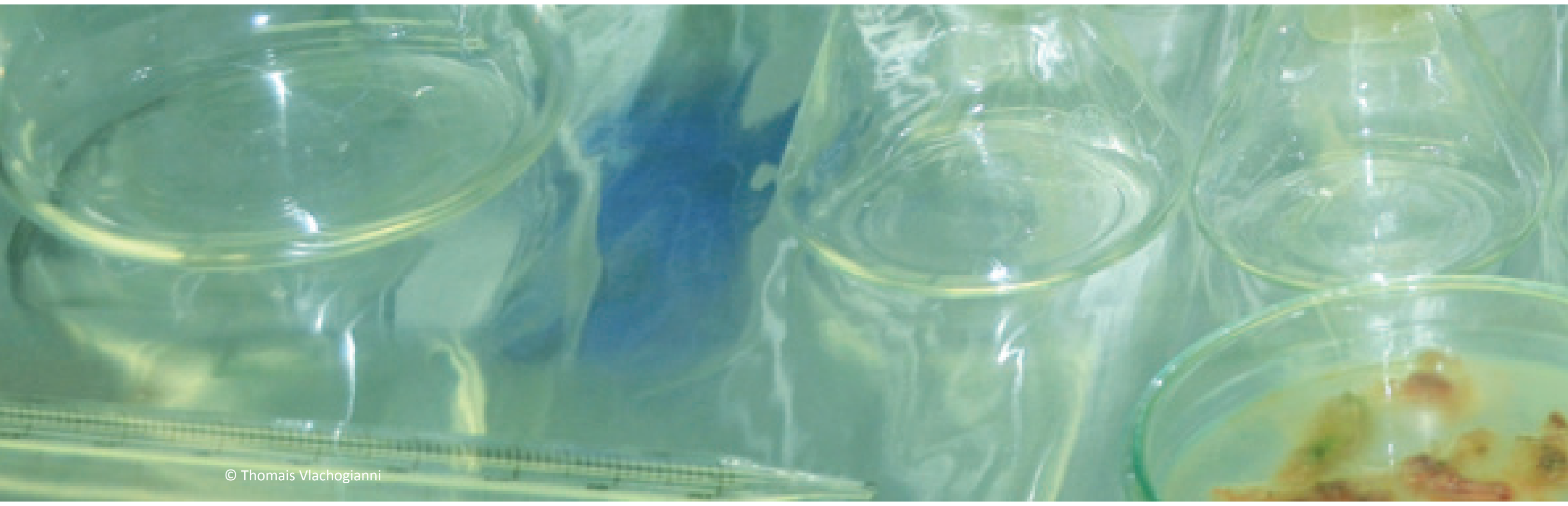


Figure 5.4. *Percentage frequency of occurrence (%F) of fish found with ingested litter by species studied in each area separately.*



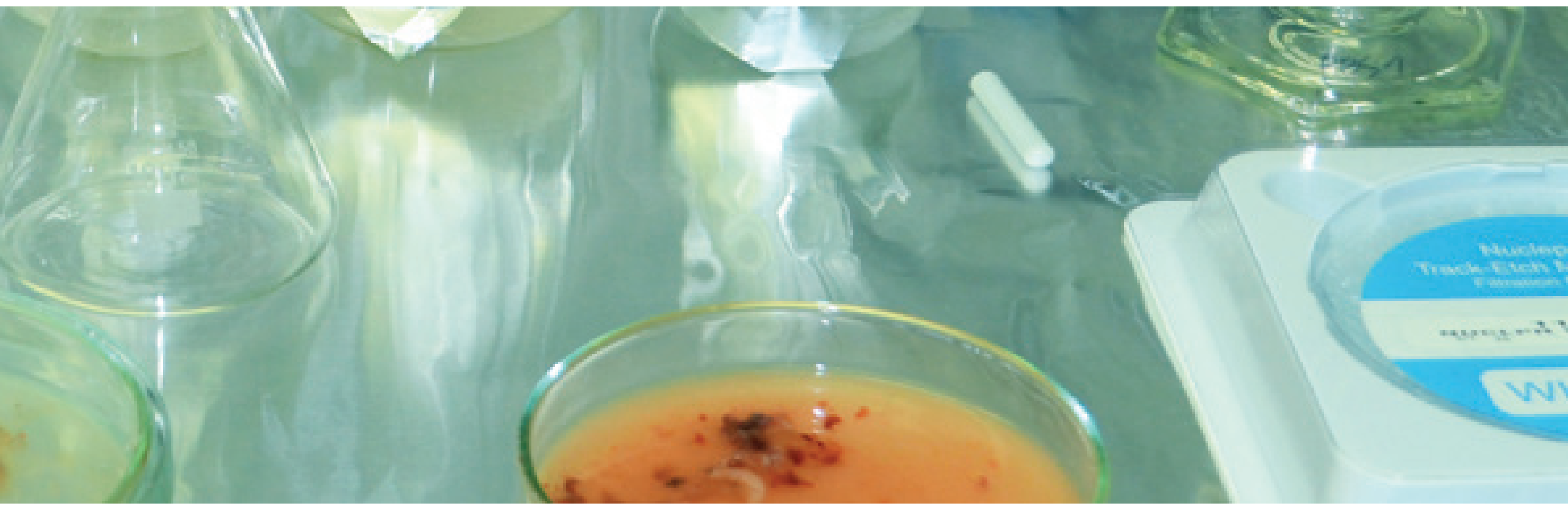
In total, 147 litter items were identified among all fish specimens examined (Tab. 5.2). 93.2% of the ingested litter items were found in the guts of the fish caught in the South Adriatic, whereas the remaining 6.8% was observed in the guts of fish from the North Adriatic and the northeastern Ionian Sea.

Table 5.2. *Number of marine litter (ML) particles found in the guts of the examined fish by species and area. The average number of ML (± S.D.) per gut examined is also included.*

N. Adriatic Sea	*Citharus linguatula*	*Mullus barbatus*	*Pagellus erythrinus*	*Sardina pilchardus*	*Scomber japonicus*	*Solea solea*	*Trachurus trachurus*
No of guts		48	30	33		36	
No of guts with ML			1	3			
No of ML in all guts			1	3			
ML item range			1	1			
Average ML/gut* (± S.D.)			0.03 (0.18)	0.09 (0.29)			
Average ML/gut** (± S.D.)			1	1			
S. Adriatic Sea	*Citharus linguatula*	*Mullus barbatus*	*Pagellus erythrinus*	*Sardina pilchardus*	*Scomber japonicus*	*Solea solea*	*Trachurus trachurus*
No of guts		50		48	37	50	50
No of guts with ML		7		24	16	2	12
No of ML in all guts		9		54	46	2	26
ML item range		1-2		1-5	1-7	1	1-9
Average ML/gut* (± S.D.)		0.18 (0.48)		1.12 (1.52)	1.24 (1.94)	0.04 (0.19)	0.52 (1.41)
Average ML/gut** (± S.D.)		1.2 (0.4)		2.2 (1.4)	2.8 (2.0)	1	2.1 (2.2)
NE Ionian Sea	*Citharus linguatula*	*Mullus barbatus*	*Pagellus erythrinus*	*Sardina pilchardus*	*Scomber japonicus*	*Solea solea*	*Trachurus trachurus*
No of guts	52	50	50	58		2	
No of guts with ML	1	4	1				
No of ML in all guts	1	4	1				
ML item range	1	1	1				
Average ML/gut* (± S.D.)	0.01 (0.13)	0.08 (0.27)	0.02 (0.14)				
Average ML/gut ** (± S.D.)	1	1	1				

* taking into account all the examined specimens

** taking into account only specimens with litter in their guts



The highest numeric abundance (%N) of ingested marine litter was found for *S. pilchardus* in both the N. Adriatic (75%) and S. Adriatic (39%) Seas and in *M. barbatus* (67%) in the northeastern Ionian Sea (Fig. 5.5).

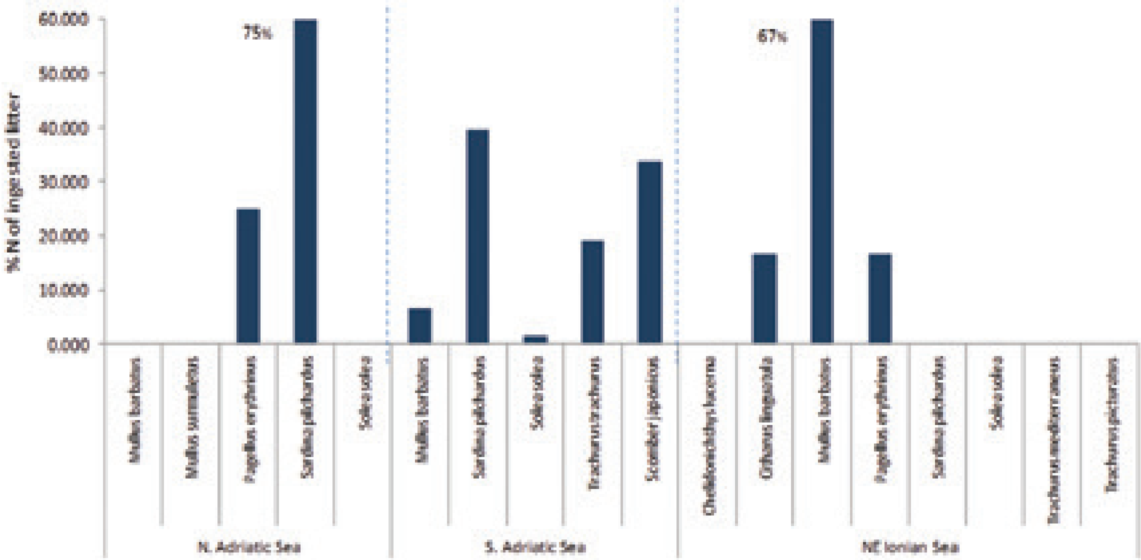


Figure 5.5. Numeric abundance (%N) of ingested marine litter by species in each area studied.

In addition, the Kruskal-Wallis test showed that the marine litter abundance (%N) in the guts of *M. barbatus* and *S. pilchardus* was statistically higher in the South Adriatic ($p < 0.05$) relatively to the other areas. Overall, among species with ingested litter, pelagic species were found to have ingested the highest number (70%) of the total litter found in the guts (Fig. 5.6).

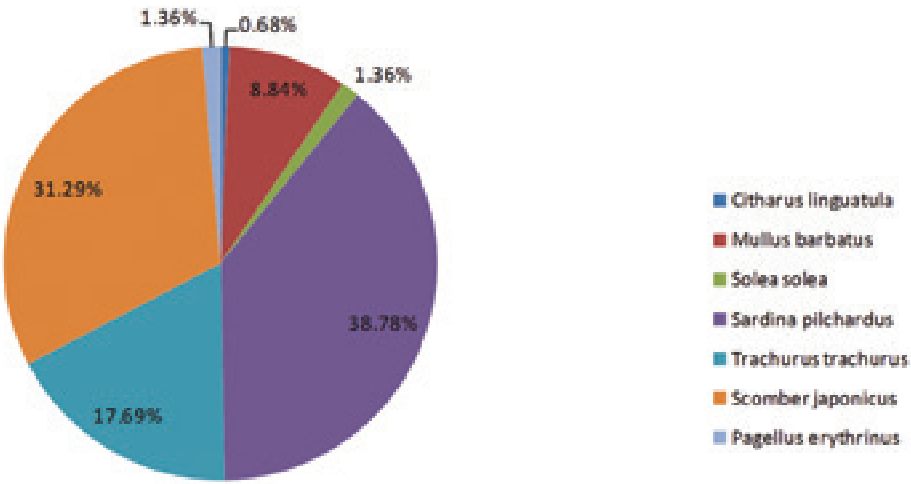


Figure 5.6. Abundance (%N) of ingested marine litter per species in the whole Adriatic-Ionian macroregion.

The average number of litter items per gut studied is presented in Table 5.2. Only 1 litter item per fish (taking into account specimens with litter in their guts) was found for the North Adriatic and the northeastern Ionian Sea. For the South Adriatic Sea, though, this ratio ranged from 1 to 9 (average: 2.2 ± 0.22), with the highest value observed for *T. trachurus*. This difference was statistically significant (Kruskal-Wallis test, t-statistic: 8.491, $p < 0.05$) among the areas. Comparing the average litter items per fish behavior there was not any significant difference (Kruskal-Wallis test, t-statistic: 11.98, $p = 0.06$) even though pelagic species were found to consume more litter items per fish. The nine marine litter categories found in the guts of the examined species according to MSFD TG10 'Master List of Categories of Litter Items' (Galgani et al., 2013) are presented in Table 5.3. Some litter items found in the guts of the examined fish species are shown in the photographs of Figure 5.7.

Table 5.3. Litter categories found in the guts of the species examined in the Adriatic-Ionian macroregion

Code	Item name
G67	sheets, industrial packaging, plastic sheeting
G113	filaments < 5 mm
G114	films < 5 mm
G116	granules < 5 mm
G117	styrofoam < 5mm
G119	sheet like user plastic > 1 mm
G121	foamed user plastic > 1 mm
G122	plastic fragments > 1 mm
G212	coal

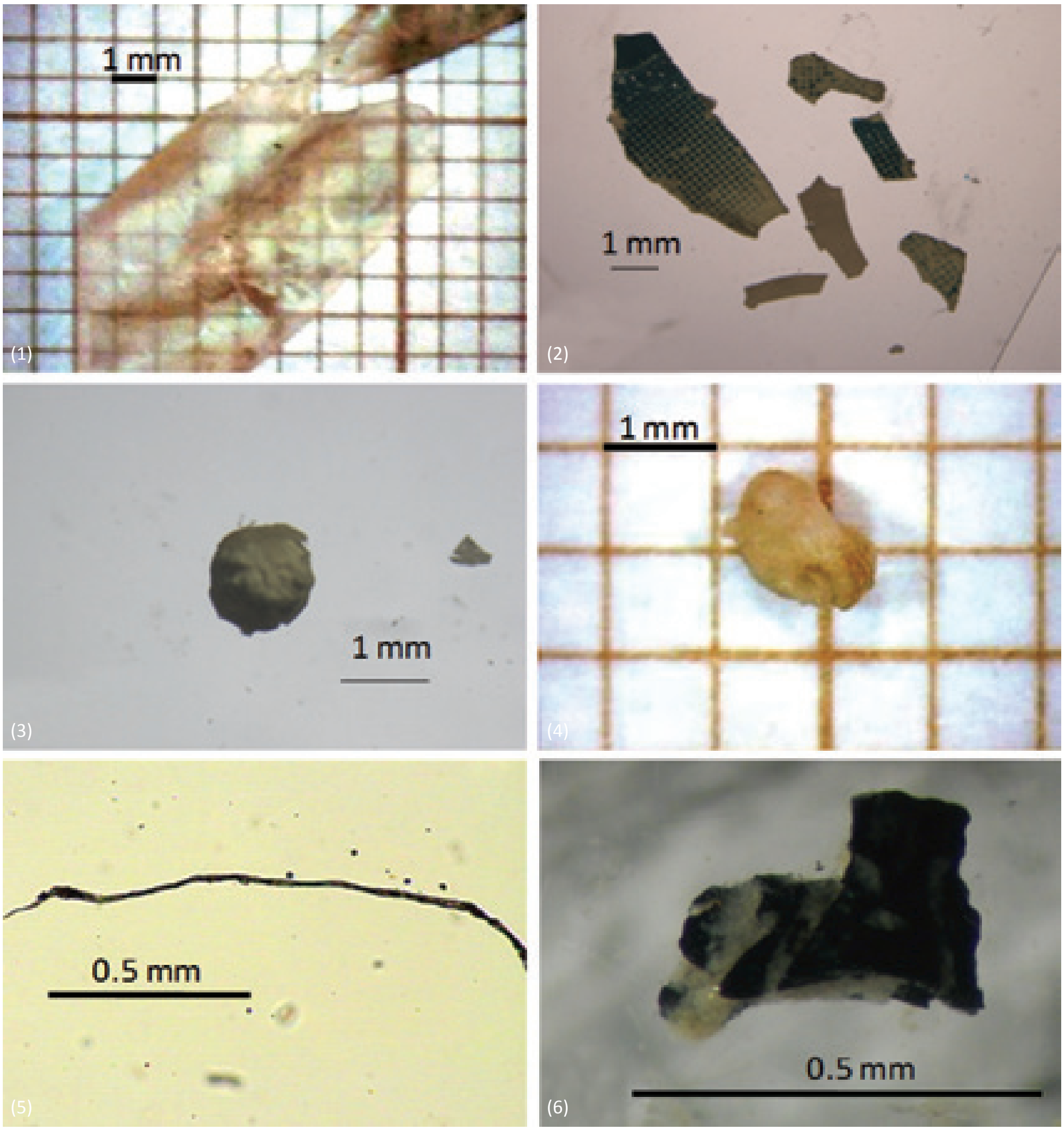


Figure 5.7. Litter items found in the fish guts examined. (1) a piece of plastic sheet in S. pilchardus and (2) in S. japonicus; (3) pieces of granule in M. barbatus; (4) piece of polystyrene in S. pilchardus; (5) violet fibre in M. barbatus; and (6) piece of coal in M. barbatus.

Figure 5.8 represents the contribution of each litter category by species in each area separately. Plastics were dominant in the guts of *P. erythrinus* and *S. pilchardus* caught in the north Adriatic Sea. Filaments were found in the guts of all species with ingested litter in the S. Adriatic Sea. All marine litter items found in the guts of *C. linguatula* and *P. erythrinus* from the NE Ionian Sea were filaments < 5 mm.

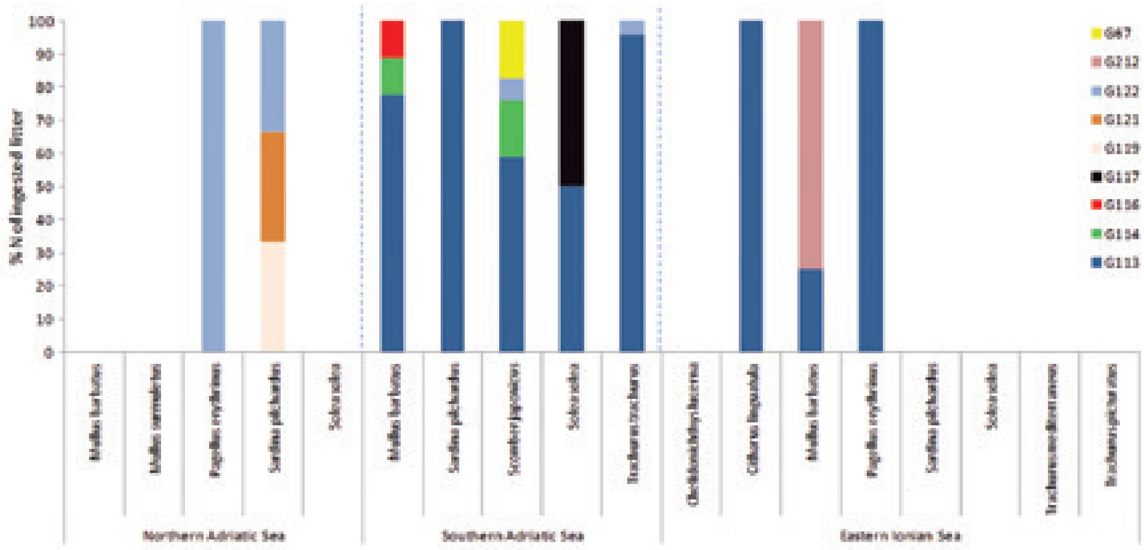


Figure 5.8. *Percentage contribution (%N) of the ingested litter categories by species and area.*

For the whole Adriatic-Ionian macroregion the total numeric percentage (%N) of the ingested marine litter per category is given in Figure 5.9.

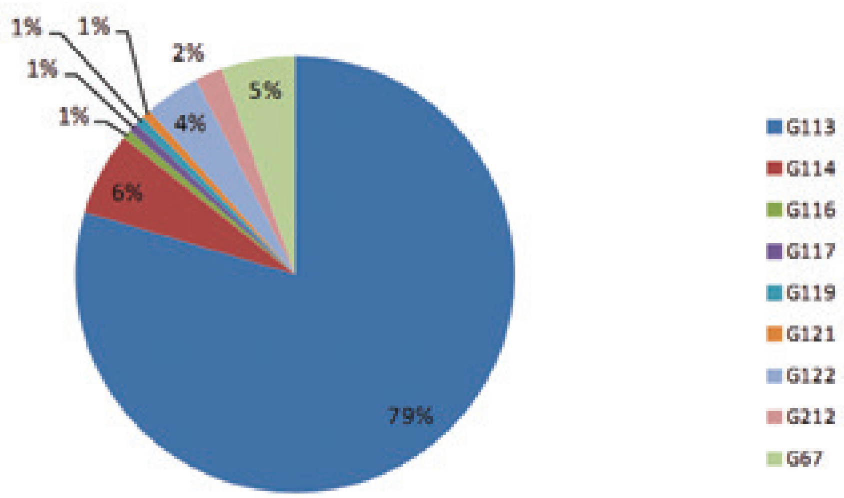


Figure 5.9. *Percentage contribution (%N) of marine litter categories found in the guts of the examined fish in the Adriatic-Ionian Sea (as number of items). (Items: G67 = Sheets, industrial packaging, plastic sheeting; G113 = filaments < 5 mm; G114 = Films < 5 mm; G116 = Granules < 5 mm; G117 = Styrofoam < 5 mm; G119 = sheet like user plastic > 1 mm; G121 = foamed user plastic > 1 mm; G122 = plastic fragments > 1 mm and G212 = coal).*

The percentage weight of the ingested (%W) marine litter was lower than 0.01% for all examined species in both the northeast Ionian and North Adriatic Sea, whereas in the S. Adriatic the weight percentage was found to be 2%, 1.7%, 0.8% and 0.3% for *S. pilchardus, T. trachurus, S. japonicus* and *M. barbatus* respectively. Fish species caught in the S. Adriatic presented the highest and heaviest proportion of marine litter in their guts.

5.3 DISCUSSION

The DeFishGear project offered the opportunity to produce data on litter ingestion by various fish species caught in the Adriatic and Ionian Seas for the first time. According to the results, the contribution of marine litter in the guts of all examined fish per area, as well as the frequency of marine litter occurrence in the non-empty guts, was very low for the North Adriatic and the Northeastern Ionian (< 3% in occurrence). However, this was not the case for the South Adriatic Sea, where %F was found 26%. These results are similar with those reported worldwide (Anastasopoulou et al., 2013; Fokaema et al., 2013; Brate et al., 2016; Romeo et al., 2016). Findings from the South Adriatic Sea are more consistent with the values reported for planktivorous species in the North Pacific Central Gyre (Boeger et al., 2010; Lusher et al., 2015) and seem to be associated with the high ingestion of microfibers. Table 5.4 shows the literature data on ingested marine litter worldwide.

Concerning the fish behaviour (demersal, mesopelagic and pelagic) of the fish species, there was a difference between the Adriatic and the northeastern Ionian Sea. In the northeastern Ionian Sea, marine litter was found more frequently in the demersal fish *M. barbatus* (in 4 of the 50 specimens, 8%) whereas in the Adriatic it was mainly detected in the guts of the pelagic fish species. More specifically, in the N. Adriatic litter was found more frequently in the pelagic species *S. pilchardus* (in 3 of 33 specimens, 9%) and in the S. Adriatic in the pelagic species *S. pilchardus* (in 24 of 48 specimens, 50%) and *S. japonicus* (in 16 of 37 specimens, 43%). Similarly, these species presented the highest abundance of ingested litter in each area.

The average number of litter per gut, taking into account only the guts with litter, was 1.0 for the northeastern Ionian and North Adriatic and is in accordance with that of 1.56 reported by Bellas et al. (2016) for demersal species in the Atlantic and Mediterranean coasts (Tab. 5.4). The average number of litter per gut found in the South Adriatic (2.2) was close to the reported (1.9) by Lusher et al. (2013) in demersal and pelagic fish from the English Channel and to 2.10 reported by Boerger et al. (2010) for planktivorous fish in the N. Pacific Central Gyre. As in previous studies (Lusher et al., 2013; Neves et al., 2015), we found no significant differences in the average number of litter per gut between demersal, mesopelagic and pelagic species, even though pelagic feeders were found to consume more litter items/fish. The detection of more than one particle in a single individual mainly for pelagic species may indicate that this group is more sensitive to litter ingestion because of their filter-feeding behaviour associated with their feeding habitat where floating or neutrally buoyant plastic particles may be available for ingestion. This was also the case for pelagic and demersal fish from the North and Baltic Sea (Rummel et al., 2016).

In the present study, the categories of ingested litter were mainly artificial polymer materials (e.g. filaments, films, granules, sheets, plastic sheeting, plastic fragments) and coal; most of them usually associated with plastics according to the 'Masterlist'. Plastics were the predominant ingested category as has been well documented for several organisms (Boeger et al., 2010; Anastasopoulou et al., 2013; Campani et al., 2013; Bond et al., 2014). Plastics have been found in the marine environment worldwide; they easily disperse and fragment into smaller pieces, which increase the potential for ingestion by the organisms (Boeger et al., 2010). In agreement with other studies, the predominant type of ingested litter was filaments. Filament presence has been reported worldwide because they can be derived from degradation and fragmentation of larger items or as a direct consequence of industrial activities or consumption habits (Bellas et al., 2016). Moreover, filaments can derive from natural materials (e.g. cotton fibres) or artificial material (e.g. aluminium foil). For this reason, it is of crucial importance to take all the precautionary measures to reduce the risk of any kind of contamination.

Concerning the sampling areas included in this work, they were very diverse, with different environmental characteristics and human impacts. For the North Adriatic and the northeastern Ionian Sea, the ingested litter was in relatively low abundance. The highest litter ingestion frequency, abundance, number of ingested litter per fish, was observed in the South Adriatic. The reasons for this are not so clear because litter ingestion depends on a range of factors and these may vary among different animal groups. Moreover, litter ingestion can occur as a result of secondary ingestion, which happens when animals feed on prey, which have already ingested litter. Uptake of plastic by filter-feeding fish has been reported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for herring (*Clupea harengus*) and horse mackerel (*T. trachurus*) from the North Sea and English Channel (Foekema et al., 2013; Lusher et al., 2013). An increase in the abundance of marine litter in the environment will affect its bioavailability and consequently increases the chance an organism will ingest it. According to Eriksson and Burton (2003), the density of plastics in the marine environment can influence the rate of plastic ingestion by fish whereas Ryan et al. (2009) stated that the amount of affected fish may change over time since plastic in the marine environment underlies a large spatial and temporal heterogeneity.

5.4 CONCLUSIONS

This study documented the presence of marine litter in gut contents of three demersal fish species (*C. linguatula, M. barbatus* and *S. solea*), two mesopelagic (*P. erythrinus, T. trachurus*) and two pelagic (*S. pilchardus* and *S. japonicus*) from the Adriatic and Ionian Seas. Although in the present work, no significant difference in ingested marine litter was found between different species, we suggest the monitoring of marine litter in a higher number of fish species of different behavior. Marine litter was found in 2.6%, 25.9%, and 2.7% of the examined fish individuals in the North Adriatic, South Adriatic and the northeastern Ionian Sea, respectively. These results indicate that fish in the South Adriatic ingest marine litter more than in other areas.

The predominant type of ingested litter was filaments; for this reason, it is of crucial importance that background contamination is eliminated, as it results in bias and wrong conclusions. The widespread and increasing cases of occurrence and ingestion of marine litter indicates that future research across a wider range of species and habitats should be considered in order to fully establish its potential effects in the marine environment (Azzolin et al., 2016). This study is in line with the EU MSFD TG10 "Guidance on Monitoring of Marine Litter in European Seas" (Galgani et al., 2013) and respective task for the identification of appropriate species for indicator 10.2.1 (trends in the amount and composition of litter ingested by marine animals) in order to develop tools for investigating trends in ingested litter in all the MSFD marine regions.

The potential accumulation of marine litter and especially of microplastics within the marine organisms or the bioaccumulation and biomagnification of toxic compounds either released from plastic items or adsorbed and accumulated on plastic particles released from microplastics, could pose risks to human health (Avio et al., 2016; Wesch et al., 2016). However, the potential human health risks from these toxic compounds that could potentially be transferred to higher-trophic-level organisms through the food chain is a relatively new area of research and there is currently a large degree of uncertainty surrounding this issue. Further research is required to improve our knowledge combined with monitoring of ingested litter to detect potential spatial and temporal changes and fully understand the ecosystem-level impacts in order to undertake the necessary management measures.

Table 5.4. Literature data on ingested marine litter. Individuals with marine litter are the proportion of individuals that were found to have ingested marine litter, calculated as the number of fish containing marine litter divided by the number of fish examined and including those with empty guts. Marine litter frequency of occurrence (%F) is the ratio of the number of guts containing a given litter item to the total number of non-empty guts examined (x 100), Average number of litter items (± S.D.) is presented in relation to all examined fishes and fishes with ingested marine litter (ML) were applicable.

Area	Species	Ind. with ML (%)	ML freq of occurrence (%F)	Average ML (items/all fish)	Average ML (items/fish with ingested ML	Source
Around the Balearic Islands	Boops boops	57.80%	42-80%		3.75 (± 0.25)	Nadal et al., 2016
English Channel	mesopelagic fish	11%		<0.13	1.20 (± 0.54)	Lusher et al. 2016
English Channel	demersal & pelagic fish	37%		0.37	1.90 (± 0.10)	Lusher et al. 2013
North Pacific Central Gyre	planktivorous fish	35%		2.1 (± 5.78)		Boerger et al., 2010
Off the Portuguese coast	commercial fish	19.8 %		0.27 ± 0.63	1.40 (± 0.66)	Neves et al., 2015
Central North Pacific	pelagic fish	19%			2.8 (± 2.2)	Choy and Drazen, 2013
Central Mediterranean Sea	large pelagic fish	18.2 %		0.2	1.32	Romeo et al. 2015
Spanish Atlantic & Mediterranean coasts	demersal fish	17.5%			1.56 (± 0.5)	Bellas et al., 2016
North Pacific Subtropical Gyre	demersal & pelagic fish	9.20%		0.11 (± 0.35)	1.15 (± 0.4)	Davison & Asch, 2011
The North Sea and Baltic Sea	demersal & pelagic fish	5.50%		0.03 (± 0.18): demersal; 0.19 (± 0.61): pelagic	1: demersal; 1.8: pelagic	Rummel et al. 2016
Off Norwegian Coast	Atlantic cod	3%	4.50%	0.05	1.80	Bråte et al., 2016
Central Mediterranean Sea	Myctophidae	2.7 %	0.3-6.8	0.027	1	Romeo et al., 2016
North Sea	demersal & pelagic fish	2.60%				Foekema et al., 2013
Eastern Mediterranean	deep water fish	1.90%		0.025	1.3 (±0.2)	Anastasopoulou et al.,2013
Southeast Australian waters	marine, freshwater fish & cephalopods	0.3 %		0.006	2	Cannon et al., 2016
North Adriatic Sea	Demersal, mesopelagic & pelagic fish	2.58 %	2.61	0.025 (±0.15)	1	Present study
South Adriatic Sea	Demersal, mesopelagic & pelagic fish	26%	26%	0.582 (±1.32)	2.2 (±1.7)	Present study
NE Ionian Sea	Demersal, mesopelagic & pelagic fish	2.70%	3.05%	0.027 (±0.16)	1	Present study

CONCLUSIONS AND RECOMMENDATIONS

6

CONCLUSIONS AND RECOMMENDATIONS

This DeFishGear marine litter assessment in the Adriatic and Ionian Seas is the first of its kind marine litter assessment - at European and European Regional Seas level - which is based on comparable field data obtained for all marine compartments (beaches, sea surface, seafloor, biota), during the same timeframe, through the application of harmonized monitoring protocols developed within the framework of the project. Not only do the DeFishGear pilot monitoring activities provide a clear picture of the amounts, composition and sources of marine litter in the Adriatic-Ionian macroregion - shared by seven EU and non-EU countries –namely Albania, Bosnia and Herzegovina, Croatia, Italy, Greece, Montenegro and Slovenia –but they also provide strategic input with regards to coordinating, harmonizing and even standardizing marine litter monitoring methodologies at regional (Adriatic-Ionian), European and European Regional Seas level.

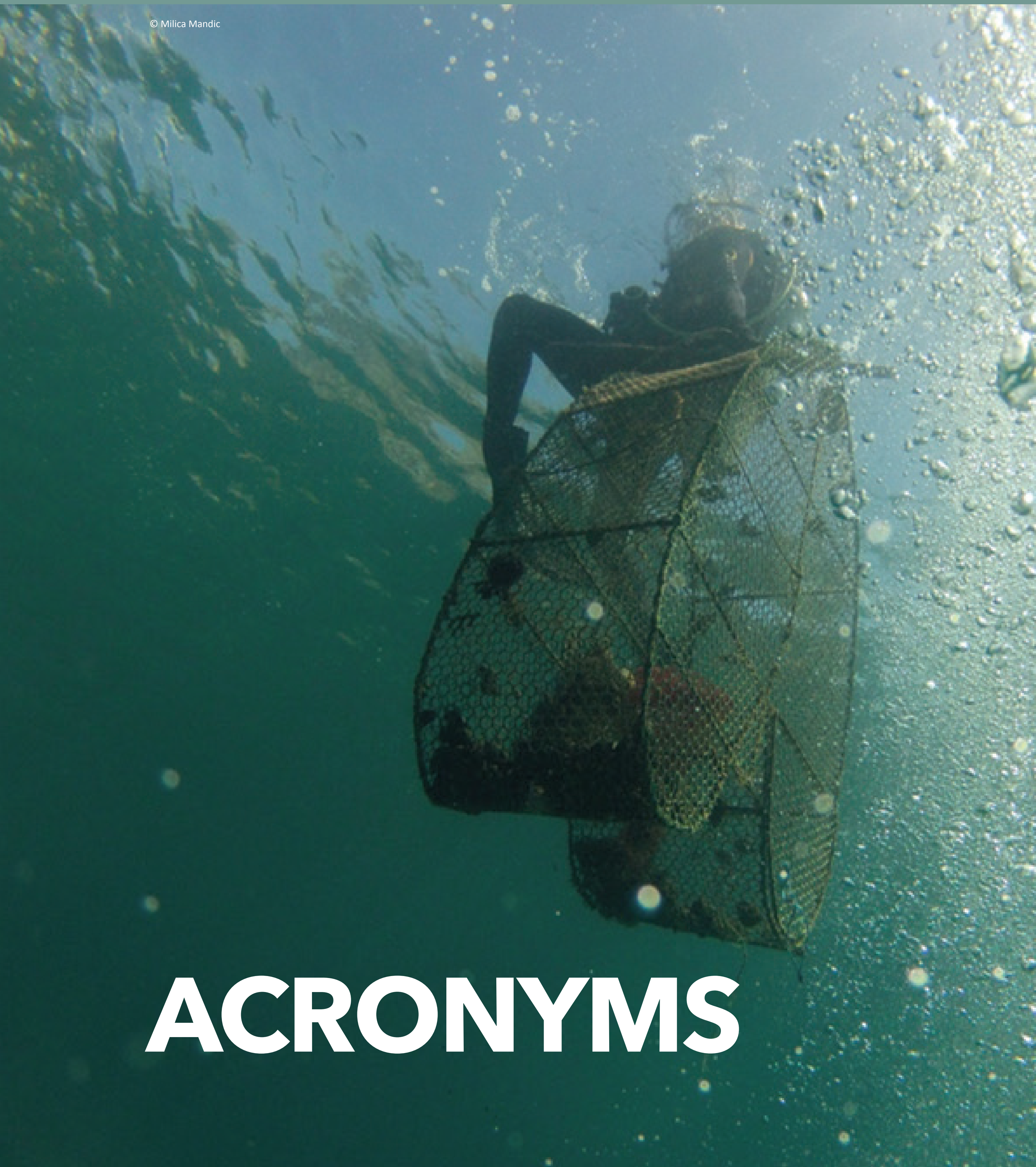
Policy recommendations

- The DeFishGear results on the amounts of litter found for the Adriatic-Ionian macroregion provide sufficient evidence to support immediate actions towards implementing the relevant legislative frameworks in the region: the EU Marine Strategy Framework Directive and the related Directives (such as the Waste Framework Directive, the Packaging and Packaging Waste Directive, the Landfill Directive, the Port Reception Facilities Directive, etc.); the Barcelona Convention Regional Plan for Marine Litter in the Mediterranean; the Convention for the Prevention of Pollution from Ships.
- Shoreline, tourism and recreational activities contributed significantly (~33.4-38.5% in the different marine compartments) to the amount of litter found in the Adriatic and Ionian Seas. However, it should be kept in mind that some of the litter items attributed to shoreline, tourism and recreational activities include commonly used items (e.g. drink bottles) that could be coming from other sources too. Furthermore, the contribution of items without an obvious source (mixed sources), which include to a large extent commonly used items, is of equal significance (~35-45%). These findings highlight the need for improving the poor and/or insufficient waste management practices in the Adriatic-Ionian macroregion - on shore and on board - and raising the awareness of tourists, local residents and other coastal and marine users (e.g. owners of touristic establishments on beaches, cruise ships staff, etc.) towards a behavioural change when it comes to marine litter.
- The DeFishGear results clearly illustrate that the litter inputs originating from sea-based sources may contribute up to 23.5% of total litter found depending on the marine compartment studied. This finding coupled with the fact that cruising is one of the fastest growing sectors in the Adriatic-Ionian macroregion, calls for the full implementation (including monitoring of its implementation) of the Convention for the prevention of pollution from ships (MARPOL-ANNEX V) and the implementation of the related EU Directive on port reception facilities for ship-generated waste and cargo residues.
- The substantial amount of fisheries and aquaculture related items found on beaches (~6%), the sea surface (~9%) and the seafloor (~17%) illustrate the urgent need for targeted measures to the respective sectors. The differences in fisheries and aquaculture related items at local and national level (e.g. for Greece the most abundant related items were polystyrene fish boxes, while in Italy, in addition, there were also mussel nets) call for localized and/or country-specific measures to tackle these items. Key measures to be applied include the establishment of derelict fishing gear management schemes (from collection to final treatment), their targeted removal from ALDFG hotspots in environmentally friendly ways and the implementation of tailor-made awareness raising campaigns targeted to these sectors (i.e. Fishing for Litter campaigns).
- A key fact that emerged from the DeFishGear results is that the largest proportion (~90-95%) of the total amount of items sampled in the Adriatic and Ionian coasts and seas is consistently made of a limited number of litter item categories (top 20), which may be similar or may vary from country to country. This finding supports the approach of prioritizing the implementation of tailor-made measures to specifically tackle these priority litter items (e.g. polystyrene pieces, plastic bags, mussel nets, etc.), thus achieving greater impact towards achieving good environmental status with regards to marine litter.
- A large fraction of the top 20 items found in the Adriatic and Ionian Seas were short-lived single-use plastic items such as plastic cups/lids from drinks, crisp packets and sweet wrappers, food wrappers and fast food containers, straws and stirrers, cups and cup lids, shopping bags, drink bottles, etc. This highlights the need to recognize the fact that marine litter is not merely a waste management issue. One of the root causes of waste accumulation on land and at sea is the linear use of resources from their production, to a short-lived, single use, to final disposal. Therefore, management measures

should focus on the one hand on awareness raising of consumers and citizens and on the other on fully implementing circular economy schemes (e.g. promoting eco-design) and/or policies that will drastically reduce the use of such items (e.g. banning or putting a levy on single use plastic bags).

Monitoring and assessment recommendations

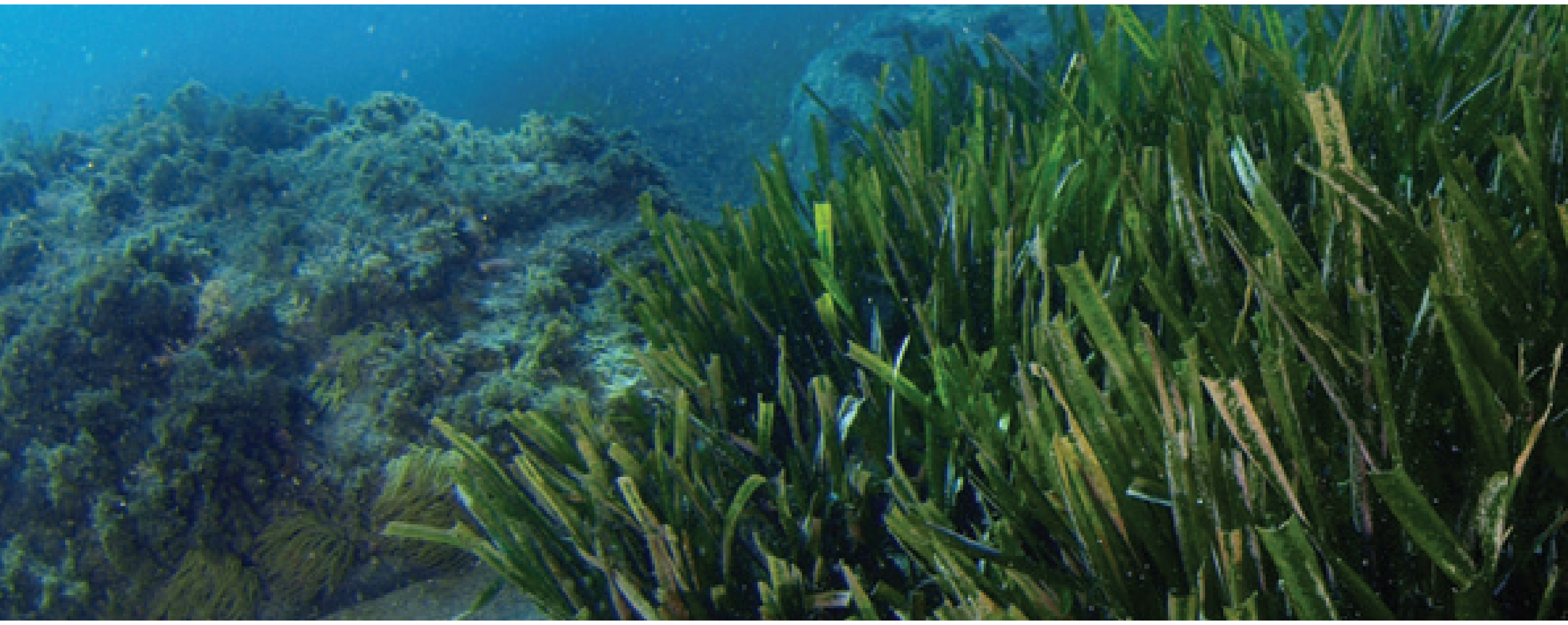
- The use of the 'Master List of Categories of Litter Items' developed by the EU MSFD TG10 for recording litter items has proven instrumental in terms of detecting the sources of litter and has been rather easy to use. Therefore it is highly recommended to adopt it in the design of marine litter monitoring programmes. However, certain additions of litter category types and further refinements need to be made to the list in order to capture more effectively the litter inputs of certain sources that are relevant to the Adriatic and Ionian macroregion and the Mediterranean.
- The application of the DeFishGear beach litter monitoring protocol was not demanding when it comes to resources (financial, human resources). Assuming that for each transect surveillance four operators are required and some 2-3 hours on average are needed for the collection, classification and recording of items, some 4-6 man-days per year are needed for monitoring one location. Therefore, countries should not be discouraged to design and implement beach litter monitoring programmes following the DeFishGear protocol.
- The DeFishGear results show that for monitoring the abundance of litter floating on the sea surface it is of utmost importance to report the minimum detection size and to apply correction factors to density calculations. By utilizing fast travelling large ships, the small-sized macro-litter (2.5 cm – 5 cm) is not accurately detected and these data should be used with caution in studies aiming to assess the amount of litter present in the marine environment. Nevertheless, for monitoring the trends of floating litter and the effectiveness of mitigation measures, data obtained from large oceanographic vessels or 'ships of opportunity' can be considered adequate.
- When monitoring seafloor litter both in continental shelves (bottom trawl surveys) and shallow waters (visual surveys with scuba/snorkelling), every effort must be made to increase the number and stratification of the transects (distance from the coastline, proximity to potential sources, depth, exposure to main currents, etc.) to provide a comprehensive picture of the distribution and composition of litter items.
- Due to the crucial role of the swept area for the litter density estimation in bottom trawl surveys, it is strongly recommended to use acoustic devices mounted on the trawl net for the exact calculation of the mouth opening.
- In order to enhance monitoring of marine litter on the seafloor litter and facilitate the implementation process of the EU MSFD and the UNEP/MAP Regional Plan on Marine Litter Management with regards to setting baselines towards achieving GES, it is highly recommended to make the collection of seafloor litter data mandatory for ongoing trawl survey programs (e.g. MEDITS).
- Detecting the source - the economic sector or human activity from which litter originates - is fundamental for identifying targeted measures to tackle marine litter and ensure good environmental status. It should be stressed that assessing the relative importance of the different sources of litter is difficult given that a considerable percentage of litter items cannot be attributed to any specific category of source. In addition, the attribution of sources has inherent limitations, among which the national and/or regional specificities of litter items and the marine compartment specificities that call for the enhancement of the methodology of attributing sources to specific litter items which should be coupled with the application of additional sources identification approaches (e.g. allocation of likelihoods). Furthermore, the assessment of the comparative importance of sea-based *vs* land-based sources of marine litter needs to be improved. Nevertheless, the sources attribution method used within the DeFishGear project provides a good overall basis for detecting the major sources and feed into the management process. In particular, the contribution of the fisheries and aquaculture sector to the marine litter issue was established with a very high level of confidence.
- In order to obtain a better understanding of the marine litter sources, it is of crucial importance to setup long-term marine litter monitoring programs that will ensure the detection of marine litter seasonal variations and respective trends.
- In order to enhance the understanding of marine litter impacts, it is recommended to monitor marine litter in biota in spatial and temporal scales.



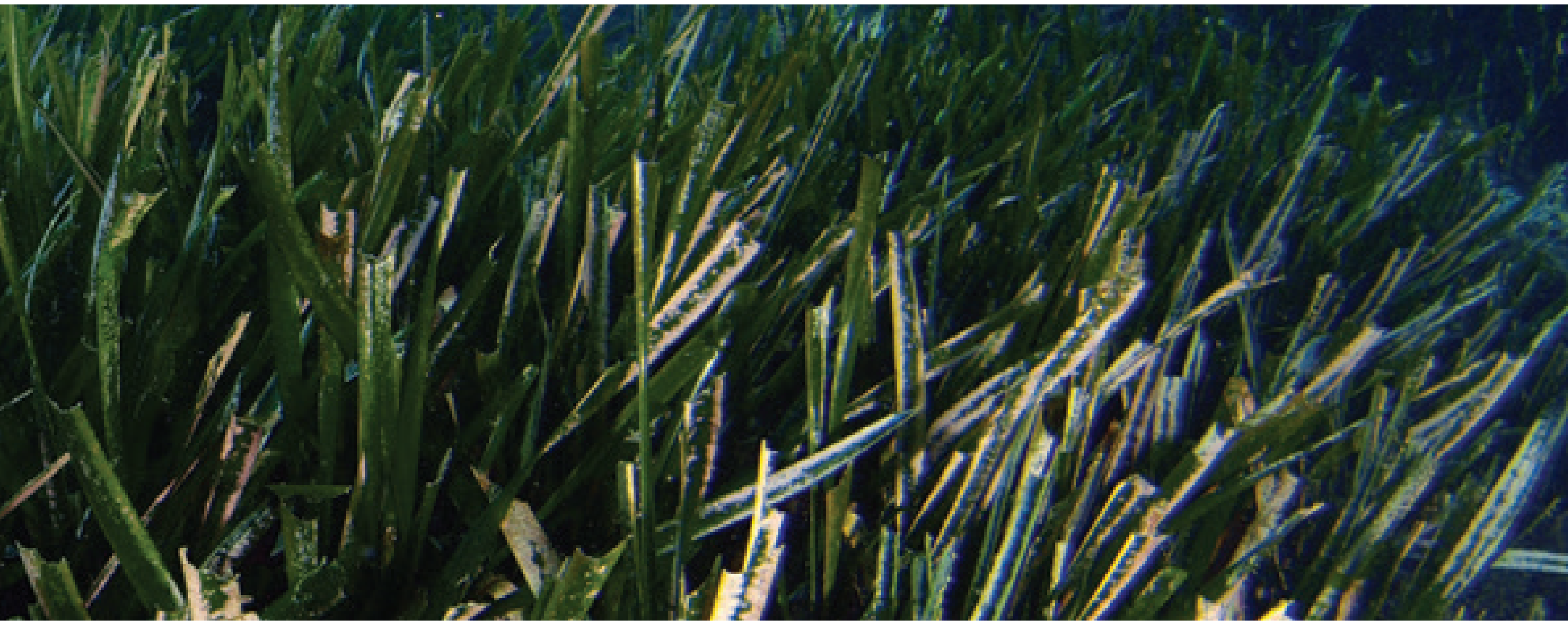
ACRONYMS

7

ALDFG	Abandoned, lost, discarded fishing gear
ARPAE	Regional Agency for Environmental Protection in the Emilia-Romagna region
AUT	Agricultural University of Tirana
CV	Co-efficient of Variation
DeFishGear	Derelict Fishing Gear Management System in the Adriatic Region
DFG	Discarded fishing gear
EC	European Commission
EcAp	Ecosystem Approach
ESW	Effective Strip Width
EU	European Union
FFL	Fishing for Litter
GES	Good Environmental Status
HCMR	Hellenic Centre for Marine Research
HEIS	Hydro-Engineering Institute of the Faculty of Civil Engineering
IBM	Institute of Marine Biology
ICC	International Coastal Cleanup
IOF	Institute of Oceanography and Fisheries



IPA	Instrument for Pre-accession Assistance
ISPRA	Italian National Institute for Environmental Protection and Research
IWRS	Institute for Water of the Republic of Slovenia
MAP	Mediterranean Action Plan
MARPOL	International Convention for the Prevention of Pollution from Ships
MEDPOL	Mediterranean Pollution Monitoring Programme
MIO-ECSDE	Mediterranean Information Office for Environment, Culture and Sustainable Development
MSFD	Marine Strategy Framework Directive
MSFD TG10	MSFD Technical Sub-Group on Marine Litter
NGO	Non-Governmental Organisation
NOOA	Marine Debris Monitoring and Assessment
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
POPs	Persistent organic pollutants
ROVs	Remotely operated vehicles
S.D.	Standard Deviation
UNEP	United Nations Environment Programme
WWTP's	Waste Water Treatment Plants



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ANNEXES

9

ANNEX I

Monitoring Marine Litter on Beaches Survey Sheet (100 m)

Name and area of beach: ....

Beach ID: ....

Country: ....

Name of surveyor 1: ....

e-mail address: ....

Name of surveyor 2: ....

e-mail address: ....

Total number of surveyors: ....

Date of survey: ..../............/............ (d/m/y)

Start time of the survey: ....

End time of the survey: ....

Additional Information

When was the beach last cleaned: ..../............/............ (d/m/y)

Did you divert from the predetermined 100 meters: ☐ No ☐ Yes, please specify..

....

Did any of the following weather conditions affect the data of the survey? If so, please tick appropriate box:

☐ Wind ☐ Rain ☐ Snow ☐ Ice ☐ Fog

☐ Sand storm ☐ Exceptionally high tide

Did you find stranded or dead animals: ☐ Yes ☐ No If so, how many:

Please describe the animal, or note the species name if known: ....

☐ Alive ☐ Dead

Sex of animal (if known): ....

Age of animal (if known): ....

Is the animal entangled in litter: ☐ Yes ☐ No

If so, please describe nature of the entanglement and type of litter: ....

....

Were there any circumstances that influenced the survey? (For example tracks on the beach (cleaning or other), recent replenishment/nourishment of the beach or other, difficulties in identifying items due to the presence of large amounts of wood washed ashore, etc.).

Please specify:...

....

.

Were there any events that led to unusual types and/or amounts of litter on the beach? (For example beach party or other)

Please specify:...

....

ARTIFICIAL POLYMER MATERIALS			
Code	Items name	Item counts	Total
G1	4/6-pack yokes, six-pack rings		
G3	Shopping bags, incl. pieces		
G4	Small plastic bags, e.g. freezer bags, including pieces		
G5	Plastic bag collective roll; what remains from rip-off plastic bags		
G7	Drink bottles <=0.5l		
G8	Drink bottles >0.5l		
G9	Cleaner/cleanser bottles & containers		
G10	Food containers incl. fast food containers		
G11	Beach use related cosmetic bottles and containers, e.g. Sunblocks		
G12	Other cosmetics bottles & containers		
G13	Other bottles & containers (drums)		
G14	Engine oil bottles & containers <50 cm		
G15	Engine oil bottles & containers > 50 cm		
G16	Jerry cans (square plastic containers with handle)		
G17	Injection gun containers		
G18	Crates and containers / baskets		
G19	Car parts		
G21	Plastic caps/lids from drinks		
G22	Plastic caps/lids from chemicals, detergents (non-food)		
G23	Plastic caps/lids unidentified		
G24	Plastic rings from bottle caps/lids		
G25	Tobacco pouches / plastic cigarette box packaging		
G26	Cigarette lighters		
G27	Cigarette butts and filters		
G28	Pens and pen lids		
G29	Combs/hair brushes/sunglasses		
G30	Crisps packets/sweets wrappers		
G31	Lolly sticks		
G32	Toys and party poppers		
G33	Cups and cup lids		
G34	Cutlery and trays		
G35	Straws and stirrers		
G36	Fertilizer/animal feed bags		
G37	Mesh vegetable bags		
G40	Gloves (washing up)		
G41	Gloves (industrial/professional rubber gloves)		
G42	Crab/lobster pots and tops		
G43	Tags (fishing and industry)		
G44	Octopus pots		
G45	Mussel nets, Oyster nets		
G46	Oyster trays (round from oyster cultures)		
G47	Plastic sheeting from mussel culture (Tahitians)		

G49	Rope (diameter more than 1 cm)		
G50	String and cord (diameter less than 1 cm)		
G53	Nets and pieces of net < 50 cm		
G54	Nets and pieces of net > 50 cm		
G56	Tangled nets/cord		
G57	Fish boxes – plastic		
G58	Fish boxes - expanded polystyrene		
G59	Fishing line/monofilament (angling)		
G60	Light sticks (tubes with fluid) incl. packaging		
G62	Floats for fishing nets		
G63	Buoys		
G64	Fenders		
G65	Buckets		
G66	Strapping bands		
G67	Sheets, industrial packaging, plastic sheeting		
G68	Fiberglass/fragments		
G69	Hard hats/Helmets		
G70	Shotgun cartridges		
G71	Shoes/sandals		
G72	Traffic cones		
G73	Foam sponge		
G79	Plastic pieces 2.5 cm > < 50 cm		
G80	Plastic pieces > 50 cm		
G82	Polystyrene pieces 2.5 cm > < 50 cm		
G83	Polystyrene pieces > 50 cm		
G84	CD, CD-boxes		
G85	Salt packaging		
G86	Fin trees (from fins for scuba diving)		
G87	Masking tape		
G88	Telephone (incl. parts)		
G89	Plastic construction waste		
G90	Plastic flower pots		
G91	Biomass holder from sewage treatment plants		
G92	Bait containers/packaging		
G93	Cable ties		
G95	Cotton bud sticks		
G96	Sanitary towels/panty liners/backing strips		
G97	Toilet fresheners		
G98	Diapers/nappies		
G99	Syringes/needles		
G100	Medical/Pharmaceuticals containers/tubes		
G101	Dog faeces bags		
G102	Flip-flops		
G124	Other plastic/polystyrene items (identifiable)		
		Total weight (kg)	

RUBBER			
Code	**Items name**	**Item counts**	**Total**
G125	Balloons and balloon sticks		
G126	Balls		
G127	Rubber boots		
G128	Tyres and belts		
G129	Inner-tubes and rubber sheets		
G130	Wheels		
G131	Rubber bands (small, for kitchen/household/post use)		
G132	Bobbins (fishing)		
G133	Condoms (incl. packaging)		
G134	Other rubber pieces		
		Total weight (kg)	

CLOTH/TEXTILE			
Code	**Items name**	**Item counts**	**Total**
G137	Clothing / rags (clothes, hats, towels)		
G138	Shoes and sandals (e.g. leather, cloth)		
G139	Backpacks & bags		
G140	Sacking (hessian)		
G141	Carpet & furnishing		
G142	Rope, string and nets		
G143	Sails, canvas		
G144	Tampons and tampon applicators		
G145	Other textiles (incl. rags)		
		Total weight (kg)	

PAPER/CARDBOARD			
Code	**Items name**	**Item counts**	**Total**
G147	Paper bags		
G148	Cardboard (boxes & fragments)		
G150	Cartons/Tetrapack Milk		
G151	Cartons/Tetrapack (others)		
G152	Cigarette packets		
G153	Cups, food trays, food wrappers, drink containers		
G154	Newspapers & magazines		
G155	Tubes for fireworks		
G156	Paper fragments		
G158	Other paper items		
		Total weight (kg)	

PROCESSED/WORKED WOOD			
Code	**Items name**	**Item counts**	**Total**
G159	Corks		
G160	Pallets		
G161	Processed timber		
G162	Crates		
G163	Crab/lobster pots		
G164	Fish boxes		
G165	Ice-cream sticks, chip forks, chopsticks, toothpicks		
G166	Paint brushes		
G167	Matches & fireworks		
G171	Other wood < 50 cm		
G172	Other wood > 50 cm		
		Total weight (kg)	

METAL			
Code	**Items name**	**Item counts**	**Total**
G174	Aerosol/Spray cans		
G175	Cans (beverage)		
G176	Cans (food)		
G177	Foil wrappers, aluminium foil		
G178	Bottle caps, lids & pull tabs		
G179	Disposable BBQs		
G180	Appliances (refrigerators, washers, etc.)		
G181	Tableware (plates, cups & cutlery)		
G182	Fishing related (weights, sinkers, lures, hooks)		
G184	Lobster/crab pots		
G186	Industrial scrap		
G187	Drums, e.g. oil		
G188	Other cans (< 4 L)		
G189	Gas bottles, drums & buckets (> 4 L)		
G190	Paint tins		
G191	Wire, wire mesh, barbed wire		
G193	Car parts / batteries		
G194	Cables		
G195	Household Batteries		
G198	Other metal pieces < 50 cm		
G199	Other metal pieces > 50 cm		
		Total weight (kg)	

GLASS/CERAMICS			
Code	**Items name**	**Item counts**	**Total**
G200	Bottles, including pieces		
G201	Jars, including pieces		
G202	Light bulbs		
G203	Tableware (plates & cups)		
G204	Construction material (brick, cement, pipes)		
G205	Fluorescent light tubes		
G206	Glass buoys		
G207	Octopus pots		
G208	Glass or ceramic fragments > 2.5 cm		
G210	Other glass items		
		Total weight (kg)	

UNIDENTIFIED AND/OR CHEMICALS			
Code	**Items name**	**Item counts**	**Total**
G211	Other medical items (swabs, bandaging, adhesive plaster, etc.)		
G213	Paraffin/Wax		
		Total weight (kg)	

ANNEX II

Monitoring Marine Litter (Macro) on the Water Surface
Data Sheet

Location name	
Location ID	
Country	
Surveyor Name	
e-mail address	
Date of survey	

VESSEL CHARACTERISTICS			
Vessel name			*Name of the vessel*
Type of vessel			*Type e.g. research, fishing, hired, regular ferry etc.*
Vessel length and weight			Length of the vessel (metres) Gross weight of the vessel (tonnes)

VISUAL SURVEY TRANSECT DETAILS			
Latitude/longitude start			*Recorded as nnn.nnnnn degrees at the start of the sample unit*
Latitude/longitude end			*Recorded as nnn.nnnnn degrees at the end of the sample unit*
Coordinates system			*Datum and coordinate system employed*
Vessel speed			*Average ship speed in knots*
Observation height			*Observation elevation above the sea*
Distance covered			*Total distance covered by the transect (m)*
Time start/end			*Time over which the survey took place*
Surface covered			Area covered by the vessel (km^2)

ENVIRONMENTAL PARAMETERS - OBSERVATION DETAILS			
Wind speed			*Recorded in (Beaufort)*
Wind direction	☐N ☐E ☐S ☐W		*Tick more than one boxes e.g. for SE wind*
Sea surface salinity			*Expressed in $^0/_{00}$ when reporting*
Viewing quality			*Good/Moderate/Poor ; in the latter two case state cause (e.g. fog)*
Sea state			*Expressed in accordance with the Douglas Sea Scale (0-9)*

SITE CHARACTERISTICS		
Nearest river name		*Name of nearest river*
Nearest river distance		*Distance to the nearest natural input (river or stream) (kilometres)*
Nearest river position	☐N ☐E ☐S ☐W	*Position of river mouth in relation to survey area*
Nearest major fishery		*Name of the nearest major fishery (named by type)*
Nearest major fishery distance		*Distance to the nearest major fishery (kilometres)*
Nearest major fishery position	☐N ☐E ☐S ☐W	*Position of the nearest major fishery in relation to survey area*
Nearest town		*Name of nearest town*
Nearest town distance		*Distance to the nearest town (kilometres)*
Nearest town position	☐N ☐E ☐S ☐W	*Position of the nearest town in relation to survey area*
Population size of this town		*No of inhabitants*
Additional features of the town	☐ Residential ☐ Tourist ☐ Residential & tourist ☐ Winter ☐ Spring ☐ Summer ☐ Autumn	*Indicate the main characteristic of the town, residential or touristic town; in case of the later indicate the high season peak*
Name of the nearest beach		*Name of the nearest beach*
Distance to nearest beach		*Distance to the closest coastline (kilometres)*
Position of the nearest coast	☐N ☐E ☐S ☐W	*Position of the closest coastline in relation to survey area*
Nearest shipping lane distance		*Distance to the nearest shipping lane (kilometres)*
Estimated traffic density		*Recorded in number of ships/year*
Vessel type		*Indicate the type of vessels that mainly use it e.g. merchant ships, etc.*
Position of the shipping lane	☐N ☐E ☐S ☐W	*Position of shipping lane in relation to survey area*
Name of the nearest harbour		*Name of nearest harbour*
Distance to nearest harbour		*Distance to the closest harbour (kilometres)*
Harbour position	☐N ☐E ☐S ☐W	*Position of the nearest harbour in relation to survey area*
Type of harbour		*Based on the types of vessels visiting the harbour*
Size of harbour		*Record the number of ships that reach the harbour per year*
Nearest discharge of waste water distance		*Distance to the closest waste water discharge point(kilometres)*
Position of nearest discharge point	☐N ☐E ☐S ☐W	*Position of nearest discharge points in relation to survey area*
Type of waste water discharge	☐Industrial ☐Municipal ☐Other	*Indicate type of waste water discharged*

TYPE OF MATERIAL	ARTIFICIAL POLYMER MATERIALS	G2	Bags									
		G6	Bottles									
		G10	Food containers inc. fast food containers									
		G18	Crates and containers / baskets									
		G20	Plastic cups and lids									
		G27	Cigarette butts and filters									
		G39	Gloves									
		G45	Mussel nets / Oyester nets									
		G48	Synthetic rope									
		G51	Fishing net									
		G55	Fishing line (entagled)									
		G59	Fishing line / monofilament (angling)									
		G61	Other fishing related									
		G66	Strapping bands									
		G67	Sheets, indus. packaging, plastic sheeting									
		G93	Cable ties									
		G95	Cotton bud sticks									
		G96	Sanitary towels/panty liners/backing strips									
		G98	Diapers/nappies									
		G99	Syringes/needles									
		G124	Other plastic/polystyrene items (identifiable)									
	RUBBER	G125	Balloons and balloon sticks									
		G127	Rubber boots									
		G128	Tyres and belts									
		G132	Bobbins (fishing)									
		G133	Condoms (inc.pacjaging)									
		G134	Other rubber pieces									
	CLOTH/ TEXTILE	G136	Shoes									
		G137	Clothing/rags (clothing, hats, towels)									
		G141	Carpet & Furnishing									
		G142	Rope, string and nets									
		G145	Others textiles (inc.rags)									
	PAPER/ CARD-BOARD	G146	Paper/cardboard									
		G148	Cardboard (boxes & fragments)									
		G158	Other paper items									
	PROCESSED/ WORKED WOOD	G160	Pallets									
		G170	Wood (processed)									
		G173	Other (specify)									
	METAL	G175	Cans (beverage)									
		G176	Cans (food)									
		G180	Appliances (refrigerators, washers, etc.)									
		G182	Fishing related (weights, hooks, sinkers, lures									
		G185	Middle size containers									
		G187	Drums, e.g. oil									
		G193	Car parts / batteries									
		G194	Cables									
		G196	Large metallic objects									
		G197	Other (metal)									
	GLASS/ CERAMICS	G200	Bottles (incl. pieces)									
		G201	Jars (incl. pieces)									
		G208	Glass or ceramic fragments (> 2.5 cm)									
		G209	Large glass objects (specify)									
		G210	Other glass items									
SIZE		CLASSES	G. < 5cm*5cm = 25cm² H. < 10cm*10cm = 100cm² I. < 20cm*20cm = 400cm² J. < 50cm*50cm = 2500cm² K. < 100cm-100cm = 10000cm² = 1m² L. > 100cm-100cm = 10000cm² = 1m²									

HAUL RESULTS		
Total weight of litter in the haul		*Record litter weight in Kg*
Total weight of artificial polymer materials		*Record litter weight in Kg*
Total No of items of artificial polymer materials		*Record number of items*
Total weight of rubber		*Record litter weight in Kg*
Total No of items of rubber		*Record number of items*
Total weight of cloth/textile		*Record litter weight in Kg*
Total No of items of cloth/textile		*Record number of items*
Total weight of paper/cardboard		*Record litter weight in Kg*
Total No of items of paper/cardboard		*Record number of items*
Total weight of processed/worked wood		*Record litter weight in Kg*
Total No of items of processed/worked wood		*Record number of items*
Total weight of metal		*Record litter weight in Kg*
Total No of items of metal		*Record number of items*
Total weight of glass/ceramics		*Record litter weight in Kg*
Total No of items of glass/ceramics		*Record number of items*

ANNEX III

Monitoring Marine Litter (Macro) on the Seafloor
Data Sheet

Location name	
Location ID	
Country	
Surveyor Name	
e-mail address	
Date of survey	

VESSEL CHARACTERISTICS			
Vessel name			*Name of the vessel*
Type of vessel			*Type e.g. research, fishing, hired, regular ferry etc.*
Vessel length and weight			*Length of the vessel (metres)* *Gross weight of the vessel (tonnes)*
Vessel engine power			*Vessel engine power (kilowatt)*

HAUL DETAILS			
Latitude/longitude start			*Recorded as nnn.nnnnn degrees at the start of the sample unit*
Latitude/longitude end			*Recorded as nnn.nnnnn degrees at the end of the sample unit*
Coordinates system			*Datum and coordinate system employed*
Vessel speed			*Average ship speed in knots*
Start time/end time			*Time over which the survey (haul) took place*
Mouth horizontal/ vertical opening			*Record the trawl mouth horizontal and vertical opening (mm)*
Haul position/depth			*Record the average haul position*
Cod end mesh size			*Record mesh size (mm)*
Cod end type			*Type of cod end e.g. diamond mesh, square mesh*
Head rope length			*Record the length of the head rope (m)*

ENVIRONMENTAL PARAMETERS - OBSERVATION DETAILS		
Wind speed		*Recorded in (Beaufort)*
Wind	☐N ☐E ☐S ☐W	*Tick more than one boxes e.g. for SE wind*
Sea state		*Expressed in accordance with the Douglas Sea Scale (0-9)*
NOTES		

SITE CHARACTERISTICS			
Nearest river name			*Name of nearest river*
Nearest river distance			*Distance to the nearest natural input (river or stream) (kilometres)*
Nearest river position	☐N ☐E ☐S ☐W		*Position of river mouth in relation to survey area*
Nearest major fishery			*Name of the nearest major fishery (named by type)*
Nearest major fishery distance			*Distance to the nearest major fishery (kilometres)*
Nearest major fishery position	☐N ☐E ☐S ☐W		*Position of the nearest major fishery in relation to survey area*
Nearest town			*Name of nearest town*
Nearest town distance			*Distance to the nearest town (kilometres)*
Nearest town position	☐N ☐E ☐S ☐W		*Position of the nearest town in relation to survey area*
Population size of this town			*No of inhabitants*
Additional features of the town	☐ Residential ☐ Tourist ☐ Residential & tourist	☐ Winter ☐ Spring ☐ Summer ☐ Autumn	*Indicate the main characteristic of the town, residential or touristic town; in case of the later indicate the high season peak*
Name of the nearest beach			*Name of the nearest beach*
Distance to nearest beach			*Distance to the closest coastline (kilometres)*
Position of the nearest coast	☐N ☐E ☐S ☐W		*Position of the closest coastline in relation to survey area*
Nearest shipping lane distance			*Distance to the nearest shipping lane (kilometres)*
Estimated traffic density			*Recorded in number of ships/year*
Vessel type			*Indicate the type of vessels that mainly use it e.g. merchant ships, etc.*
Position of the shipping lane	☐N ☐E ☐S ☐W		*Position of shipping lane in relation to survey area*
Name of the nearest harbour			*Name of nearest harbour*
Distance to nearest harbour			*Distance to the closest harbour (kilometres)*
Harbour position	☐N ☐E ☐S ☐W		*Position of the nearest harbour in relation to survey area*
Type of harbour			*Based on the types of vessels visiting the harbour*
Size of harbour			*Record the number of ships that reach the harbour per year*
Nearest discharge of waste water distance			
Position of nearest discharge point	☐N ☐E ☐S ☐W		*Position of nearest discharge points in relation to survey area*

TYPE OF MATERIAL	ARTIFICIAL POLYMER MATERIALS	G2	Bags									
		G6	Bottles									
		G10	Food containers inc. fast food containers									
		G18	Crates and containers / baskets									
		G20	Plastic cups and lids									
		G27	Cigarette butts and filters									
		G39	Gloves									
		G45	Mussel nets / Oyester nets									
		G48	Synthetic rope									
		G51	Fishing net									
		G55	Fishing line (entagled)									
		G59	Fishing line / monofilament (angling)									
		G61	Other fishing related									
		G66	Strapping bands									
		G67	Sheets, indus. packaging, plastic sheeting									
		G93	Cable ties									
		G95	Cotton bud sticks									
		G96	Sanitary towels/panty liners/backing strips									
		G98	Diapers/nappies									
		G99	Syringes/needles									
		G124	Other plastic/polystyrene items (identifiable)									
	RUBBER	G125	Balloons and balloon sticks									
		G127	Rubber boots									
		G128	Tyres and belts									
		G132	Bobbins (fishing)									
		G133	Condoms (inc.pacjaging)									
		G134	Other rubber pieces									
	CLOTH/ TEXTILE	G136	Shoes									
		G137	Clothing/rags (clothing, hats, towels)									
		G141	Carpet & Furnishing									
		G142	Rope, string and nets									
		G145	Others textiles (inc.rags)									
	PAPER/ CARD-BOARD	G146	Paper/cardboard									
		G148	Cardboard (boxes & fragments)									
		G158	Other paper items									
	PROCESSED/ WORKED WOOD	G160	Pallets									
		G170	Wood (processed)									
		G173	Other (specify)									
	METAL	G175	Cans (beverage)									
		G176	Cans (food)									
		G180	Appliances (refrigerators, washers, etc.)									
		G182	Fishing related (weights, hooks, sinkers, lures									
		G185	Middle size containers									
		G187	Drums, e.g. oil									
		G193	Car parts / batteries									
		G194	Cables									
		G196	Large metallic objects									
		G197	Other (metal)									
	GLASS/ CERAMICS	G200	Bottles (incl. pieces)									
		G201	Jars (incl. pieces)									
		G208	Glass or ceramic fragments (> 2.5 cm)									
		G209	Large glass objects (specify)									
		G210	Other glass items									
SIZE		CLASSES	G. < 5cm*5cm = 25cm^2 H. < 10cm*10cm = 100cm^2 I. < 20cm*20cm = 400cm^2 J. < 50cm*50cm = 2500cm^2 K. < 100cm-100cm = 10000cm^2 = 1m^2 L. > 100cm-100cm = 10000cm^2 = 1m^2									

HAUL RESULTS		
Total weight of litter in the haul		*Record litter weight in Kg*
Total weight of artificial polymer materials		*Record litter weight in Kg*
Total No of items of artificial polymer materials		*Record number of items*
Total weight of rubber		*Record litter weight in Kg*
Total No of items of rubber		*Record number of items*
Total weight of cloth/textile		*Record litter weight in Kg*
Total No of items of cloth/textile		*Record number of items*
Total weight of paper/cardboard		*Record litter weight in Kg*
Total No of items of paper/cardboard		*Record number of items*
Total weight of processed/worked wood		*Record litter weight in Kg*
Total No of items of processed/worked wood		*Record number of items*
Total weight of metal		*Record litter weight in Kg*
Total No of items of metal		*Record number of items*
Total weight of glass/ceramics		*Record litter weight in Kg*
Total No of items of glass/ceramics		*Record number of items*

ANNEX IV

Monitoring Marine Litter (Macro) on the Seafloor - visual survey

Data Sheet

Location name	
Location ID	
Country	
Surveyor Name	
e-mail address	
Date of survey	

SITE DETAILS			
Latitude/longitude start 100 m			*Recorded as nnn.nnnnn degrees at the start of the sample unit*
Latitude/longitude end 100 m			*Recorded as nnn.nnnnn degrees at the end of the sample unit*
Latitude/longitude start 8 m			*Recorded as nnn.nnnnn degrees at the end of the sample unit*
Latitude/longitude end 8 m			*Recorded as nnn.nnnnn degrees at the end of the sample unit*
Depth			*Record depth in m*
Coordinates system			*Datum and coordinate system employed*
Start time/end time			*Time over which the survey took place*

ENVIRONMENTAL PARAMETERS - OBSERVATION DETAILS		
Wind speed		*Recorded in (Beaufort)*
Wind	☐N ☐E ☐S ☐W	*Tick more than one boxes e.g. for SE wind*
Sea state		*Expressed in accordance with the Douglas Sea Scale (0-9)*

NOTES

SITE CHARACTERISTICS		
Nearest river name		*Name of nearest river*
Nearest river distance		*Distance to the nearest natural input (river or stream) (kilometres)*
Nearest river position	☐N ☐E ☐S ☐W	*Position of river mouth in relation to survey area*
Nearest major fishery		*Name of the nearest major fishery (named by type)*
Nearest major fishery distance		*Distance to the nearest major fishery (kilometres)*
Nearest major fishery position	☐N ☐E ☐S ☐W	*Position of the nearest major fishery in relation to survey area*
Nearest town		*Name of nearest town*
Nearest town distance		*Distance to the nearest town (kilometres)*
Nearest town position	☐N ☐E ☐S ☐W	*Position of the nearest town in relation to survey area*
Population size of this town		*No of inhabitants*
Additional features of the town	☐ Residential ☐ Tourist ☐ Residential & tourist | ☐ Winter ☐ Spring ☐ Summer ☐ Autumn	*Indicate the main characteristic of the town, residential or touristic town; in case of the later indicate the high season peak*
Name of the nearest beach		*Name of the nearest beach*
Distance to nearest beach		*Distance to the closest coastline (kilometres)*
Position of the nearest coast	☐N ☐E ☐S ☐W	*Position of the closest coastline in relation to survey area*
Nearest shipping lane distance		*Distance to the nearest shipping lane (kilometres)*
Estimated traffic density		*Recorded in number of ships/year*
Vessel type		*Indicate the type of vessels that mainly use it e.g. merchant ships, etc.*
Position of the shipping lane	☐N ☐E ☐S ☐W	*Position of shipping lane in relation to survey area*
Name of the nearest harbour		*Name of nearest harbour*
Harbour position	☐N ☐E ☐S ☐W	*Position of the nearest harbour in relation to survey area*
Type of harbour		*Based on the types of vessels visiting the harbour*
Size of harbour		*Record the number of ships that reach the harbour per year*
Nearest discharge of waste water distance		
Position of nearest discharge point	☐N ☐E ☐S ☐W	*Position of nearest discharge points in relation to survey area*
NOTES		

TYPE OF MATERIAL	ARTIFICIAL POLYMER MATERIALS	G2	Bags									
		G6	Bottles									
		G10	Food containers inc. fast food containers									
		G18	Crates and containers / baskets									
		G20	Plastic cups and lids									
		G27	Cigarette butts and filters									
		G39	Gloves									
		G45	Mussel nets / Oyester nets									
		G48	Synthetic rope									
		G51	Fishing net									
		G55	Fishing line (entagled)									
		G59	Fishing line / monofilament (angling)									
		G61	Other fishing related									
		G66	Strapping bands									
		G67	Sheets, indus. packaging, plastic sheeting									
		G93	Cable ties									
		G95	Cotton bud sticks									
		G96	Sanitary towels/panty liners/backing strips									
		G98	Diapers/nappies									
		G99	Syringes/needles									
		G124	Other plastic/polystyrene items (identifiable)									
	RUBBER	G125	Balloons and balloon sticks									
		G127	Rubber boots									
		G128	Tyres and belts									
		G132	Bobbins (fishing)									
		G133	Condoms (inc.pacjaging)									
		G134	Other rubber pieces									
	CLOTH/ TEXTILE	G136	Shoes									
		G137	Clothing/rags (clothing, hats, towels)									
		G141	Carpet & Furnishing									
		G142	Rope, string and nets									
		G145	Others textiles (inc.rags)									
	PAPER/ CARD-BOARD	G146	Paper/cardboard									
		G148	Cardboard (boxes & fragments)									
		G158	Other paper items									
	PROCESSED/ WORKED WOOD	G160	Pallets									
		G170	Wood (processed)									
		G173	Other (specify)									
	METAL	G175	Cans (beverage)									
		G176	Cans (food)									
		G180	Appliances (refrigerators, washers, etc.)									
		G182	Fishing related (weights, hooks, sinkers, lures									
		G185	Middle size containers									
		G187	Drums, e.g. oil									
		G193	Car parts / batteries									
		G194	Cables									
		G196	Large metallic objects									
		G197	Other (metal)									
	GLASS/ CERAMICS	G200	Bottles (incl. pieces)									
		G201	Jars (incl. pieces)									
		G208	Glass or ceramic fragments (> 2.5 cm)									
		G209	Large glass objects (specify)									
		G210	Other glass items									
SIZE		CLASSES	G. < 5cm*5cm = 25cm^2 H. < 10cm*10cm = 100cm^2 I. < 20cm*20cm = 400cm^2 J. < 50cm*50cm = 2500cm^2 K. < 100cm-100cm = 10000cm^2 = 1m^2 L. > 100cm-100cm = 10000cm^2 = 1m^2									

RESULTS		
Total weight of litter collected		*Record litter weight in Kg*
Total weight of artificial polymer materials		*Record litter weight in Kg*
Total No of items of artificial polymer materials		*Record number of items*
Total weight of rubber		*Record litter weight in Kg*
Total No of items of rubber		*Record number of items*
Total weight of cloth/textile		*Record litter weight in Kg*
Total No of items of cloth/textile		*Record number of items*
Total weight of paper/cardboard		*Record litter weight in Kg*
Total No of items of paper/cardboard		*Record number of items*
Total weight of processed/worked wood		*Record litter weight in Kg*
Total No of items of processed/worked wood		*Record number of items*
Total weight of metal		*Record litter weight in Kg*
Total No of items of metal		*Record number of items*
Total weight of glass/ceramics		*Record litter weight in Kg*
Total No of items of glass/ceramics		*Record number of items*

ANNEX V

Table 9.1. *'Masterlist' of litter item categories and attribution of sources for litter surveyed in the different marine compartments (beach, sea-surface, seafloor-continental selves, seafloor-swallow waters). The sources include: shoreline, including poor waste management, tourism and recreational activities (ST); fishing & aquaculture (FA); sanitary & sewage related litter (SS); fly-tipping (FT); shipping (SH); medical related (ME); agriculture (AG); non-sourced (NS).*

Material type	Code	Items name	Sources attribution			
			Beach	Sea surface	Seafloor trawl	Seafloor SCUBA
ARTIFICIAL POLYMER MATERIALS	G1	4/6-pack yokes, six-pack rings	ST			
ARTIFICIAL POLYMER MATERIALS	G2	Bags		ST	ST	ST
ARTIFICIAL POLYMER MATERIALS	G3	Shopping bags, incl. pieces	ST			
ARTIFICIAL POLYMER MATERIALS	G4	Small plastic bags, e.g. freezer bags, including pieces	ST			
ARTIFICIAL POLYMER MATERIALS	G5	Plastic bag collective roll; what remains from rip-off plastic bags	NS			
ARTIFICIAL POLYMER MATERIALS	G6	Bottles		ST	ST	ST
ARTIFICIAL POLYMER MATERIALS	G7	Drink bottles <=0.5 l	ST			
ARTIFICIAL POLYMER MATERIALS	G8	Drink bottles >0.5 l	ST			
ARTIFICIAL POLYMER MATERIALS	G9	Cleaner/cleanser bottles & containers	SH			
ARTIFICIAL POLYMER MATERIALS	G10	Food containers incl. fast food containers	ST		ST	ST
ARTIFICIAL POLYMER MATERIALS	G11	Beach use related cosmetic bottles and containers	ST			
ARTIFICIAL POLYMER MATERIALS	G12	Other cosmetics bottles & containers	ST			
ARTIFICIAL POLYMER MATERIALS	G13	Other bottles & containers (drums)	NS			
ARTIFICIAL POLYMER MATERIALS	G14	Engine oil bottles & containers < 50 cm	SH			
ARTIFICIAL POLYMER MATERIALS	G15	Engine oil bottles & containers > 50 cm	SH			
ARTIFICIAL POLYMER MATERIALS	G16	Jerry cans (square plastic containers with handle)	SH			
ARTIFICIAL POLYMER MATERIALS	G17	Injection gun containers	FT			
ARTIFICIAL POLYMER MATERIALS	G18	Crates and containers / baskets	NS	NS	NS	NS
ARTIFICIAL POLYMER MATERIALS	G19	Car parts	FT			
ARTIFICIAL POLYMER MATERIALS	G20	Plastic cups and lids			ST	ST
ARTIFICIAL POLYMER MATERIALS	G21	Plastic caps/lids from drinks	ST			
ARTIFICIAL POLYMER MATERIALS	G22	Plastic caps/lids from chemicals, detergents (non-food)	NS			
ARTIFICIAL POLYMER MATERIALS	G23	Plastic caps/lids unidentified	NS			
ARTIFICIAL POLYMER MATERIALS	G24	Plastic rings from bottle caps/lids	NS			

ARTIFICIAL POLYMER MATERIALS	G25	Tobacco pouches/plastic cigarette box packaging	ST			
ARTIFICIAL POLYMER MATERIALS	G26	Cigarette lighters	ST			
ARTIFICIAL POLYMER MATERIALS	G27	Cigarette butts and filters	ST		SH	ST
ARTIFICIAL POLYMER MATERIALS	G28	Pens and pen lids	ST			
ARTIFICIAL POLYMER MATERIALS	G29	Combs/hair brushes/sunglasses	ST			
ARTIFICIAL POLYMER MATERIALS	G30	Crisps packets/sweets wrappers	ST			
ARTIFICIAL POLYMER MATERIALS	G31	Lolly sticks	ST			
ARTIFICIAL POLYMER MATERIALS	G32	Toys and party poppers	ST			
ARTIFICIAL POLYMER MATERIALS	G33	Cups and cup lids	ST			
ARTIFICIAL POLYMER MATERIALS	G34	Cutlery and trays	ST			
ARTIFICIAL POLYMER MATERIALS	G35	Straws and stirrers	ST			
ARTIFICIAL POLYMER MATERIALS	G36	Fertilizer/animal feed bags	A			
ARTIFICIAL POLYMER MATERIALS	G37	Mesh vegetable bags	NS			
ARTIFICIAL POLYMER MATERIALS	G38	Cover/packaging		ST		
ARTIFICIAL POLYMER MATERIALS	G39	Gloves			SH	NS
ARTIFICIAL POLYMER MATERIALS	G40	Gloves (washing up)	NS			
ARTIFICIAL POLYMER MATERIALS	G41	Gloves (industrial/professional rubber gloves)	SH			
ARTIFICIAL POLYMER MATERIALS	G42	Crab/lobster pots and tops	FA			
ARTIFICIAL POLYMER MATERIALS	G43	Tags (fishing and industry)	FA			
ARTIFICIAL POLYMER MATERIALS	G44	Octopus pots	FA			
ARTIFICIAL POLYMER MATERIALS	G45	Mussel nets, Oyster nets	FA		FA	FA
ARTIFICIAL POLYMER MATERIALS	G46	Oyster trays (round from oyster cultures)	FA			
ARTIFICIAL POLYMER MATERIALS	G47	Plastic sheeting from mussel culture (Tahitians)	FA			
ARTIFICIAL POLYMER MATERIALS	G48	Synthetic rope		FA	FA	FA
ARTIFICIAL POLYMER MATERIALS	G49	Rope (diameter more than 1 cm)	FA			
ARTIFICIAL POLYMER MATERIALS	G50	String and cord (diameter less than 1 cm)	FA			
ARTIFICIAL POLYMER MATERIALS	G51	Fishing net		FA	FA	FA
ARTIFICIAL POLYMER MATERIALS	G53	Nets and pieces of net < 50 cm	FA			
ARTIFICIAL POLYMER MATERIALS	G54	Nets and pieces of net > 50 cm	FA			
ARTIFICIAL POLYMER MATERIALS	G55	Fishing line (entangled)			FA	FA

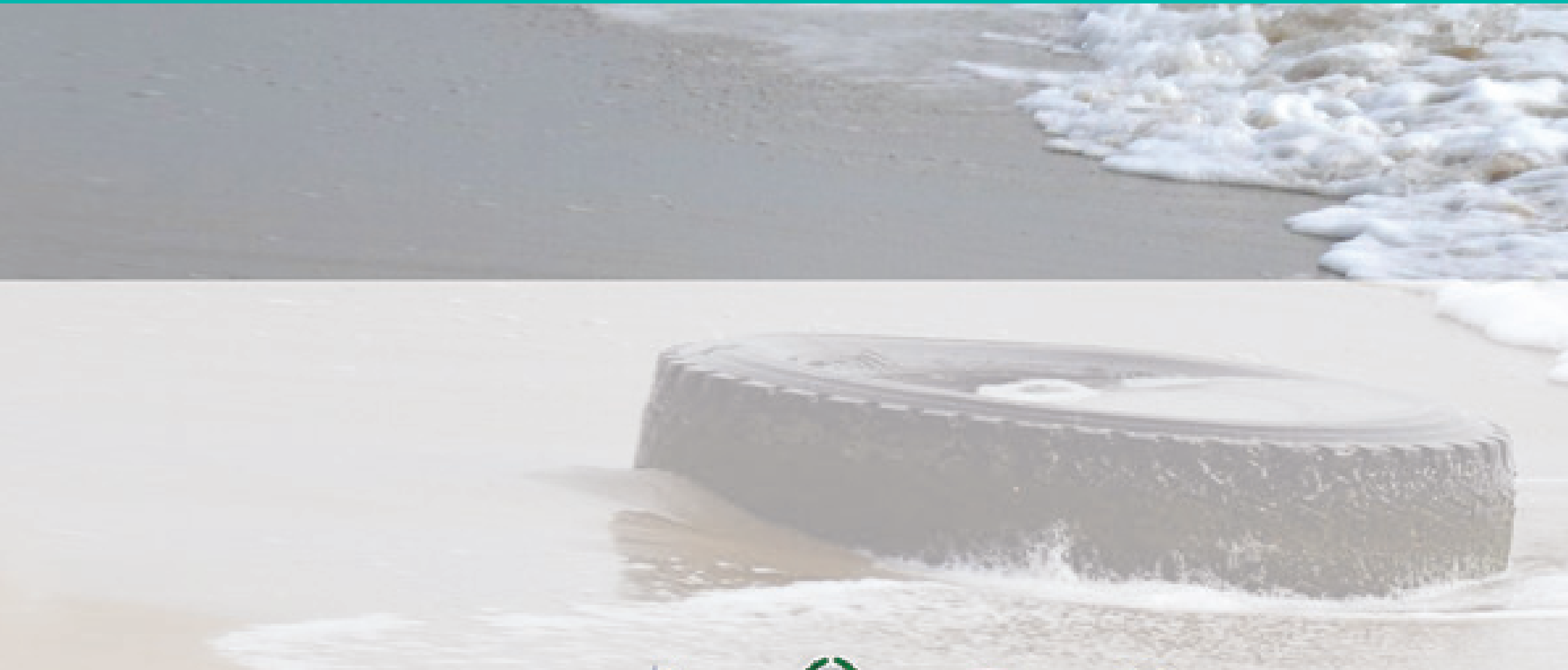
ARTIFICIAL POLYMER MATERIALS	G56	Tangled nets/cord	FA			
ARTIFICIAL POLYMER MATERIALS	G57	Fish boxes - plastic	FA			
ARTIFICIAL POLYMER MATERIALS	G58	Fish boxes - expanded polystyrene	FA	FA		
ARTIFICIAL POLYMER MATERIALS	G59	Fishing line/monofilament (angling)	FA		FA	FA
ARTIFICIAL POLYMER MATERIALS	G60	Light sticks (tubes with fluid) incl. packaging	FA			
ARTIFICIAL POLYMER MATERIALS	G61	Other fishing related			FA	FA
ARTIFICIAL POLYMER MATERIALS	G62	Floats for fishing nets	FA			
ARTIFICIAL POLYMER MATERIALS	G63	Buoys	FA			
ARTIFICIAL POLYMER MATERIALS	G64	Fenders	FA			
ARTIFICIAL POLYMER MATERIALS	G65	Buckets	NS			
ARTIFICIAL POLYMER MATERIALS	G66	Strapping bands	NS		NS	NS
ARTIFICIAL POLYMER MATERIALS	G67	Sheets, industrial packaging, plastic sheeting	NS	NS	NS	NS
ARTIFICIAL POLYMER MATERIALS	G68	Fiberglass/fragments	NS			
ARTIFICIAL POLYMER MATERIALS	G69	Hard hats/Helmets	SH			
ARTIFICIAL POLYMER MATERIALS	G70	Shotgun cartridges	ST			
ARTIFICIAL POLYMER MATERIALS	G71	Shoes/sandals	ST			
ARTIFICIAL POLYMER MATERIALS	G72	Traffic cones	FT			
ARTIFICIAL POLYMER MATERIALS	G73	Foam sponge	NS			
ARTIFICIAL POLYMER MATERIALS	G74	Foam packaging/insulation/polyurethane				
ARTIFICIAL POLYMER MATERIALS	G79	Plastic pieces 2.5 cm > < 50 cm	NS	NS	NS	NS
ARTIFICIAL POLYMER MATERIALS	G80	Plastic pieces > 50 cm	NS			
ARTIFICIAL POLYMER MATERIALS	G82	Polystyrene pieces 2.5 cm > < 50 cm	NS	NS		
ARTIFICIAL POLYMER MATERIALS	G83	Polystyrene pieces > 50 cm	NS			
ARTIFICIAL POLYMER MATERIALS	G84	CD, CD-boxes	NS			
ARTIFICIAL POLYMER MATERIALS	G85	Salt packaging	NS			
ARTIFICIAL POLYMER MATERIALS	G86	Fin trees (from fins for scuba diving)	ST			
ARTIFICIAL POLYMER MATERIALS	G87	Masking tape	NS			
ARTIFICIAL POLYMER MATERIALS	G88	Telephone (incl. parts)	NS			
ARTIFICIAL POLYMER MATERIALS	G89	Plastic construction waste	FT			
ARTIFICIAL POLYMER MATERIALS	G90	Plastic flower pots	NS			

ARTIFICIAL POLYMER MATERIALS	G91	Biomass holder from sewage treatment plants	SS			
ARTIFICIAL POLYMER MATERIALS	G92	Bait containers/packaging	FA			
ARTIFICIAL POLYMER MATERIALS	G93	Cable ties	NS		SH	NS
ARTIFICIAL POLYMER MATERIALS	G94	Table cloth				
ARTIFICIAL POLYMER MATERIALS	G95	Cotton bud sticks	SS		SS	SS
ARTIFICIAL POLYMER MATERIALS	G96	Sanitary towels/panty liners/backing strips	SS		SS	SS
ARTIFICIAL POLYMER MATERIALS	G97	Toilet fresheners	SS			
ARTIFICIAL POLYMER MATERIALS	G98	Diapers/nappies	SS		SS	SS
ARTIFICIAL POLYMER MATERIALS	G99	Syringes/needles	ME		ME	ME
ARTIFICIAL POLYMER MATERIALS	G100	Medical/Pharmaceuticals containers/tubes	ME			
ARTIFICIAL POLYMER MATERIALS	G101	Dog faeces bags	ST			
ARTIFICIAL POLYMER MATERIALS	G102	Flip-flops	ST			
ARTIFICIAL POLYMER MATERIALS	G123	Polyurethane granules <5mm				
ARTIFICIAL POLYMER MATERIALS	G124	Other plastic/polystyrene items (identifiable)	NS	NS	NS	NS
RUBBER	G125	Balloons and balloon sticks	ST		ST	ST
RUBBER	G126	Balls	ST			
RUBBER	G127	Rubber boots	FA		FA	FA
RUBBER	G128	Tyres and belts	NS		SH	NS
RUBBER	G129	Inner-tubes and rubber sheets	NS			
RUBBER	G130	Wheels	FT			
RUBBER	G131	Rubber bands (small, for kitchen/household/ post use)	NS			
RUBBER	G132	Bobbins (fishing)	FA		FA	FA
RUBBER	G133	Condoms (incl. packaging)	SS		SS	SS
RUBBER	G134	Other rubber pieces	NS	NS	NS	NS
CLOTH/TEXTILE	G136	Shoes			SH	ST
CLOTH/TEXTILE	G137	Clothing / rags (clothes, hats, towels)	ST		ST	ST
CLOTH/TEXTILE	G138	Shoes and sandals (e.g. leather, cloth)	ST			
CLOTH/TEXTILE	G139	Backpacks & bags	ST			
CLOTH/TEXTILE	G140	Sacking (hessian)	NS			
CLOTH/TEXTILE	G141	Carpet & furnishing	FT		FT	FT
CLOTH/TEXTILE	G142	Rope, string and nets	FA	FA	FA	FA
CLOTH/TEXTILE	G143	Sails, canvas	SH			

CLOTH/TEXTILE	G144	Tampons and tampon applicators	SS			
CLOTH/TEXTILE	G145	Other textiles (incl. rags)	NS	NS	NS	NS
PAPER/CARDBOARD	G146	Paper/cardboard			SH	NS
PAPER/CARDBOARD	G147	Paper bags	ST			
PAPER/CARDBOARD	G148	Cardboard (boxes & fragments)	NS	NS	SH	NS
PAPER/CARDBOARD	G149	Paper packaging		ST		
PAPER/CARDBOARD	G150	Cartons/Tetrapack Milk	ST			
PAPER/CARDBOARD	G151	Cartons/Tetrapack (others)	NS			
PAPER/CARDBOARD	G152	Cigarette packets	ST			
PAPER/CARDBOARD	G153	Cups, food trays, food wrappers, drink containers	ST			
PAPER/CARDBOARD	G154	Newspapers & magazines	ST	ST		
PAPER/CARDBOARD	G155	Tubes for fireworks	ST			
PAPER/CARDBOARD	G156	Paper fragments	NS			
PAPER/CARDBOARD	G158	Other paper items	NS	NS	SH	NS
PROCESSED/WORKED WOOD	G159	Corks	ST			
PROCESSED/WORKED WOOD	G160	Pallets	SH		SH	SH
PROCESSED/WORKED WOOD	G161	Processed timber	NS			
PROCESSED/WORKED WOOD	G162	Crates	SH			
PROCESSED/WORKED WOOD	G163	Crab/lobster pots	FA			
PROCESSED/WORKED WOOD	G164	Fish boxes	FA			
PROCESSED/WORKED WOOD	G165	Ice-cream sticks, chip forks, chopsticks, toothpicks	ST			
PROCESSED/WORKED WOOD	G166	Paint brushes	NS			
PROCESSED/WORKED WOOD	G167	Matches & fireworks	ST			
PROCESSED/WORKED WOOD	G168	Wood boards				
PROCESSED/WORKED WOOD	G169	Beams/dunnage		NS		
PROCESSED/WORKED WOOD	G170	Wood processed			NS	NS
PROCESSED/WORKED WOOD	G171	Other wood < 50 cm	NS			
PROCESSED/WORKED WOOD	G172	Other wood > 50 cm	NS			
PROCESSED/WORKED WOOD	G173	Other (specify)		NS	NS	NS
METAL	G174	Aerosol/Spray cans	SH			
METAL	G175	Cans (beverage)	ST	ST	SH	ST
METAL	G176	Cans (food)	ST		SH	ST

METAL	G177	Foil wrappers, aluminium foil	ST			
METAL	G178	Bottle caps, lids & pull tabs	ST			
METAL	G179	Disposable BBQs	ST			
METAL	G180	Appliances (refrigerators, washers, etc.)	FT		FT	FT
METAL	G181	Tableware (plates, cups & cutlery)	ST			
METAL	G182	Fishing related (weights, sinkers, lures, hooks)	FA		FA	FA
METAL	G184	Lobster/crab pots	FA			
METAL	G185	Middle size containers			SH	NS
METAL	G186	Industrial scrap	FT			
METAL	G187	Drums, e.g. oil	SH		SH	SH
METAL	G188	Other cans (< 4 L)	NS			
METAL	G189	Gas bottles, drums & buckets (> 4 l)	NS			
METAL	G190	Paint tins	FT			
METAL	G191	Wire, wire mesh, barbed wire	NS			
METAL	G192	Barrels				
METAL	G193	Car parts / batteries	FT		FT	FT
METAL	G194	Cables	NS		SH	NS
METAL	G195	Household Batteries	ST			
METAL	G196	Large metallic objects			SH	NS
METAL	G197	Other (metal)		NS	SH	NS
METAL	G198	Other metal pieces < 50 cm	NS			
METAL	G199	Other metal pieces > 50 cm	NS			
GLASS/CERAMICS	G200	Bottles, including pieces	ST		SH	ST
GLASS/CERAMICS	G201	Jars, including pieces	ST		SH	ST
GLASS/CERAMICS	G202	Light bulbs	SH			
GLASS/CERAMICS	G203	Tableware (plates & cups)	ST			
GLASS/CERAMICS	G204	Construction material (brick, cement, pipes)	FT			
GLASS/CERAMICS	G205	Fluorescent light tubes	SH			
GLASS/CERAMICS	G206	Glass buoys	FA			
GLASS/CERAMICS	G207	Octopus pots	FA			
GLASS/CERAMICS	G208	Glass or ceramic fragments >2.5 cm	NS		SH	NS
GLASS/CERAMICS	G209	Large glass objects (specify)			SH	NS
GLASS/CERAMICS	G210	Other glass items	NS		SH	NS
UNIDENTIFIED AND/ OR CHEMICALS	G211	Other medical items (swabs, bandaging, adhesive plaster, etc.)	ME			
UNIDENTIFIED AND/ OR CHEMICALS	G213	Paraffin/Wax	SH			

The DeFishGear partners involved in the Marine Litter Assessment in the Adriatic and Ionian Seas:



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Adriatic and Ionian Coast and Sea

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