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ASSESSING MARINE LITTER ON MEDITERRANEAN BEACHES

Filling in the knowledge gaps via a participatory-science initiative



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1. INTRODUCTION

The Mediterranean Sea is one of the areas most affected by marine litter worldwide. Marine litter is found lying on the shores, as well as floating anywhere from the surface to the bottom of the sea. Even in pristine environments of the Mediterranean, such as coastal and marine protected areas, marine litter is building up threatening habitats and species. Impacts vary from entanglement and ingestion, to bio-accumulation and bio-magnification of toxics released from litter items, facilitation of introduction of invasive species, damages to benthic habitats, etc.

Effective and targeted measures to address the growing threat of marine litter in the Mediterranean are hampered by the lack of reliable, coherent and comparable data. This fact is highlighted by the 'In Depth Assessment of the EU Member States' Submissions for the Marine Strategy Framework Directive under articles 8, 9 and 10" (Palialexis et al., Joint Research Centre, 2014), that provides insights on the assessment of the environmental status of the Members States with regards to Descriptor 10 (Marine Litter). According to the aforementioned assessment, half of the Member States have limited, very limited or no data at all with regards to marine litter. Similar findings on the lack of marine litter data are reported in the UN Environment/MAP Quality Status Report (UN Environment/MAP, 2017).

Throughout the years Mediterranean NGOs have significantly contributed to providing data and information on the temporal and spatial distribution of marine litter found stranded on beaches, through dedicated monitoring surveys, adopt-a-beach schemes or beach clean-up campaigns. Furthermore, several Mediterranean countries within their monitoring programmes are considering community-based data collection initiatives as an essential tool to fill in the marine litter knowledge gaps. The involvement of NGOs in data collection is seen to be a cost-effective way to gather required evidence and detect the emerging issues supporting public authorities to improve efficiency with less administrative burden. The added value of participatory science across the European Union is clearly depicted also in the JRC publication on 'Citizen Engagement in Science and Policy-Making' (Figueiredo Nascimento et al., JRC 2016) and the European Commission White Paper on Citizens Science for Europe.

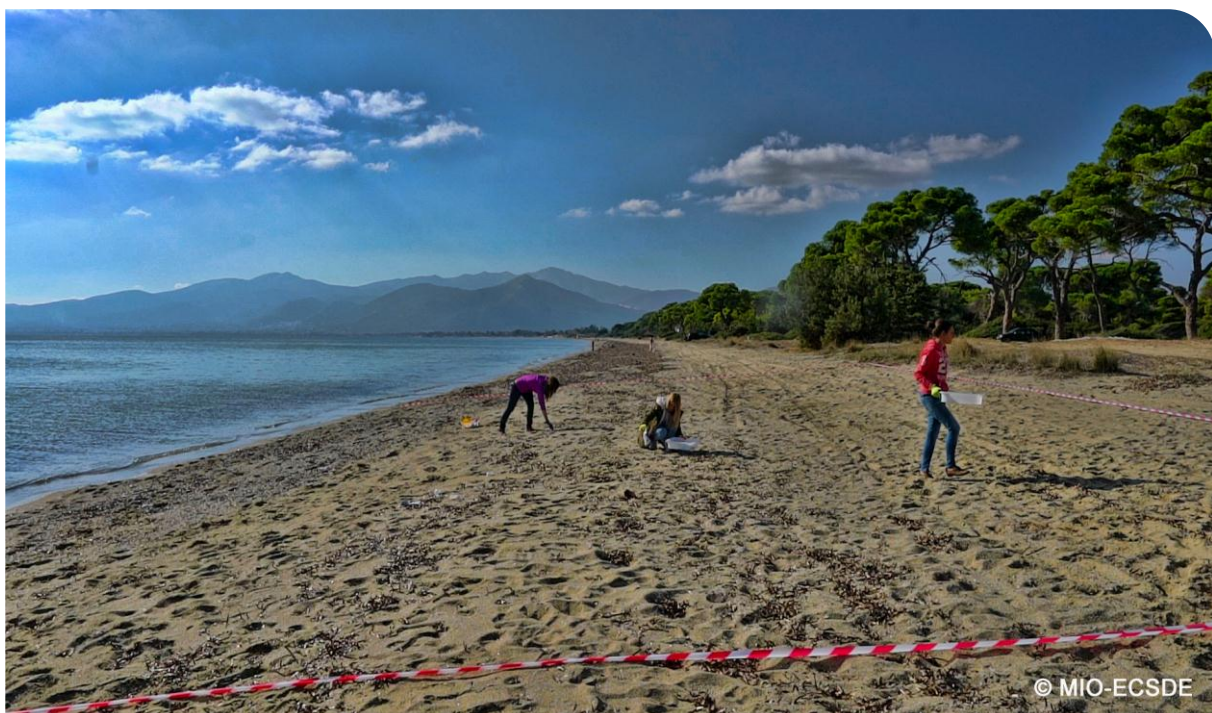


Figure 1-1. Beach litter survey performed by an environmental NGO.

Within this context, MIO-ECSDE set up and implemented a participatory-science campaign in order to fill in the knowledge gaps with regards to marine litter found on beaches and provide fit-for-purpose data for the effective management of marine litter in the Mediterranean. The campaign was carried out within the framework of the Annual Programme of MIO-ECSDE supported by the LIFE+ Operating Grant for NGOs.

Within this document marine litter is defined as any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment. Marine litter can be classified in size classes as follows: macro-litter referring to items above 25mm in the longest dimension; meso-litter from 5mm to 25 mm; and micro-litter from 1µm to 5mm. The main legislative frameworks related to marine litter monitoring in Mediterranean MPAs are the EU Marine Strategy Framework Directive (2008/56/EC, 2010/477/EC, 2017/848/EC) and the Barcelona Convention Ecosystem Approach (COP19 IMAP Decision IG.22/7) (see Box 1.1 and Box 1.2).



Box 2-1. 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 D10C1 - Primary: The composition, amount and spatial distribution of litter on the coastline, in the surface layer of the water column, and on the seabed, are at levels that do not cause harm to the coastal and marine environment.

- ✓ amount of litter washed ashore and/or deposited on coastlines, including analysis of its composition, spatial distribution and, where possible, source (10.1.1)
- ✓ 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)

Criteria D10C2 - Primary: The composition, amount and spatial distribution of micro-litter on the coastline, in the surface layer of the water column, and in seabed sediment, are at levels that do not cause harm to the coastal and marine environment.

- ✓ amount, distribution and, where possible, composition of microparticles (in particular microplastics) (10.1.3)

Criteria D10C3 - Secondary: The amount of litter and micro-litter ingested by marine animals is at a level that does not adversely affect the health of the species concerned.

- ✓ amount and composition of litter ingested by marine animals (10.2.1)

Criteria D10C4 - Secondary: The number of individuals of each species which are adversely affected due to litter, such as by entanglement, other types of injury or mortality, or health effects.

Box 2-1. The Marine Litter Operational Objectives and respective Indicators within the framework of the Barcelona Convention Ecosystem Approach and the Integrated Monitoring and Assessment Programme.

Marine Litter and the Barcelona Convention Ecosystem Approach

Ecological Objective 10 (EO10): Marine and coastal litter do not adversely affect the coastal and marine environment.

IMAP Common Indicator 22: Trends in the amount of litter washed ashore and/or deposited on coastlines (including analysis of its composition, spatial distribution and, where possible, source).

IMAP Common Indicator 23: Trends in the amount of litter in the water column including micro plastics and on the seafloor.

IMAP Candidate Indicator 24: Trends in the amount of litter ingested by or entangling marine organisms focusing on selected mammals, marine birds, and marine turtles.

3. THE BEACH LITTER SURVEYS METHODOLOGY

All beach litter surveys were performed in line with the guidelines described in the EU MSFD TG10 “Guidance on Monitoring of Marine Litter in European Seas” (Galgani et al., 2013).

The survey sites were selected taking into consideration the following criteria: they had a minimum length of 100 meters in order to allow a fixed 100-metre stretch to be surveyed; they were characterized by a low to moderate slope ($\sim 1.5\text{--}4.5^\circ$); they had clear access to the sea (not blocked by breakwaters or jetties); they were accessible to survey teams throughout the year. In each survey, the sampling unit used was a 100-metre stretch from the strandline to the back of the beach (Fig. 5.1). The back of the beach was identified using coastal features such as the presence of vegetation, dunes, cliff base, road, fence or other anthropogenic structures such as seawalls (either piled boulders or concrete structures). Two (2) sections of a 100-metre stretch on the same beach were monitored, separated at least by a distance of 50m. During the surveys, all macroscopic beach litter items larger than 2.5cm in the longest dimension were collected, counted and categorized in accordance with the ‘MSFD TG10 Master List of Categories of Litter Items’ (Annex I).

The macro-litter density was calculated as follows (Lippiatt et al., 2013): $CM = n / (w * l)$, where CM 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. The number of items per 100-metre stretch was also calculated. The beach cleanliness was assessed through the Clean Coast Index (CCI) (Alkalay et al., 2007): $CCI = CM * K$, where CM is the density of litter items per m^2 ; and K is a constant that equals to 20. According to the CCI scale: values from 0-2 indicate very clean beaches, 2–5 clean, 5–10 moderately clean, 10–20 dirty and > 20 extremely dirty.

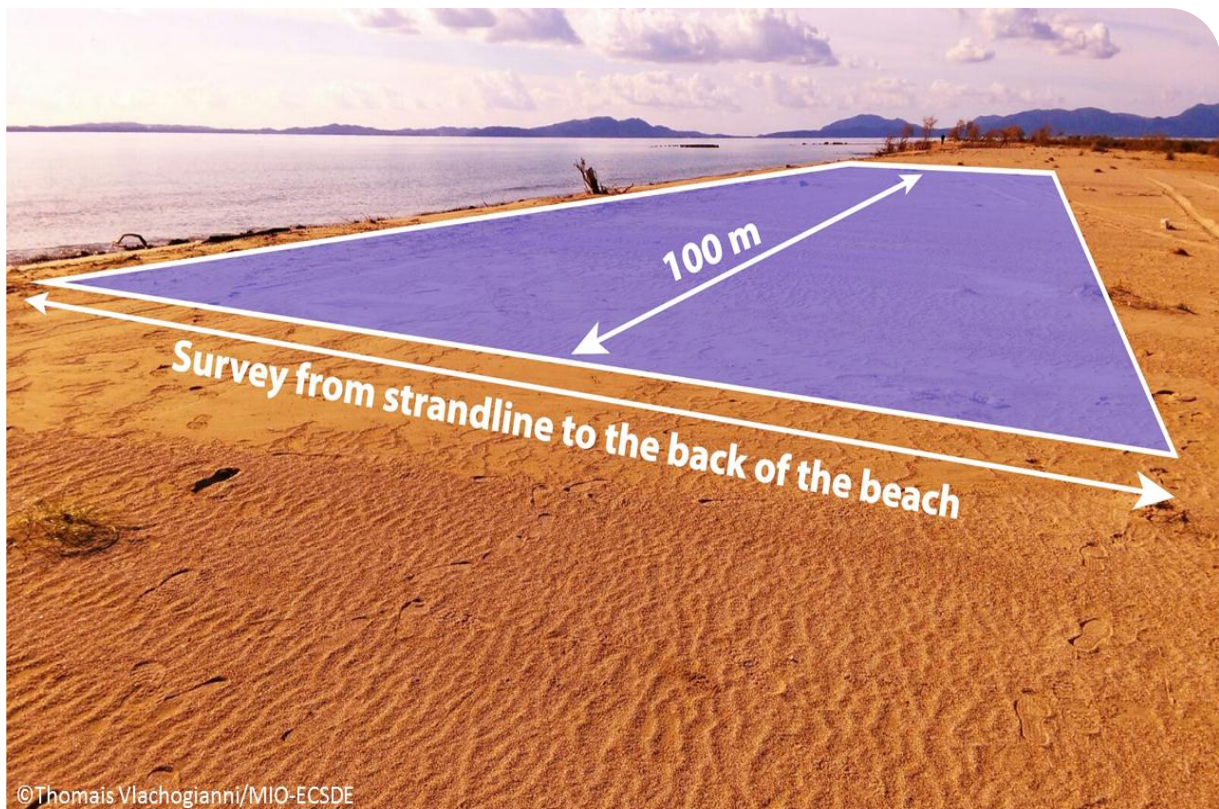


Figure 3-1. The sampling unit.

The attribution-by-litter type method was used to determine the sources of marine litter (Tudor and Williams, 2004). Within the present study, the assignment of specific sources to each litter item found was made in line with the approach described by Vlachogianni et al., 2018. The sources of marine litter were classified into eight major categories: (1) shoreline, including poor waste management practices, tourism and recreational activities; (2) fisheries and aquaculture; (3) shipping; (4) fly-tipping; (5) sanitary and sewage-related; (6) medical related; (7) agriculture; (8) non-sourced.

4. THE STUDY AREAS

The beach litter surveys were carried out on beaches located in five Mediterranean countries, namely in Croatia, Cyprus, France, Greece and Italy. A total of 23 sites were surveyed and two sets of surveys were performed; from mid-September to mid-October 2018 (autumn surveys) and from mid-November to mid-December (winter surveys). A total of 62 beach transects were surveyed, which extended over a distance of 6,200m and covered an area of 113,780m² (Table 4-1). The NGOs involved in the surveys were AKTI PROJECT AND RESEARCH CENTRE (Cyprus), MAREVIVO (Italy), HELMEPA (Greece), MIO-ECSDE (Greece), SEAQUARIUM MARINE INSTITUTE (FRANCE), SUNCE (Croatia) and U MARINU (France).

Table 4—1. Surveyed sites per country and organizations involved in the surveys.

Country	Surveyed Site	Site Code	Surveyed Area (m ²)	Data Producer
Croatia	Zaglav - Island Vis	HR-ZAG	2000	SUNCE
	Punta - Omis	HR-PUN	8000	
	Neretva river delta	HR-NER	8000	
Cyprus	Pervola	CY-PER	2550	AKTI PROJECT AND RESEARCH CENTRE
	Lara	CY-LAR	6200	
	Faros	CY-FAR	7400	
France	Boucanet	FR-BOU	5984	SEAQUARIUM MARINE INSTITUTE
	Seaquarium	FR-SEA	12246	
	Espiguette	FR-ESP	16120	
	Mucchiatana	FR-MUC	1331	U MARINU
	Stella Mare	FR-STE	1252	
	Arinella	FR-ARI	1284	
Greece	Legrena - Saronikos Gulf	EL-LEG	2800	HELMEPA
	Psatha - Korinthian Gulf	EL-PSA	4000	
	Varnavas - Evoikos Gulf	EL-VAR	1600	
	Galazia Akti - Saronikos Gulf	EL-GAL	5600	MIO-ECSDE
	Lagonisi - Saronikos Gulf	EL-LAG	3600	
	Almyros (Agios Nikolaos) - Crete	EL-ALM	1600	
	Ammoudara (Malevizi)- Crete	EL-AMM	2000	
	Navarchou Nearchou - Crete	EL-NAV	1600	
Italy	Bovo Marina	IT-BOV	1030	MAREVIVO
	San Marco	IT-MAR	1950	
	Siculiana Marina	IT-SIC	2700	

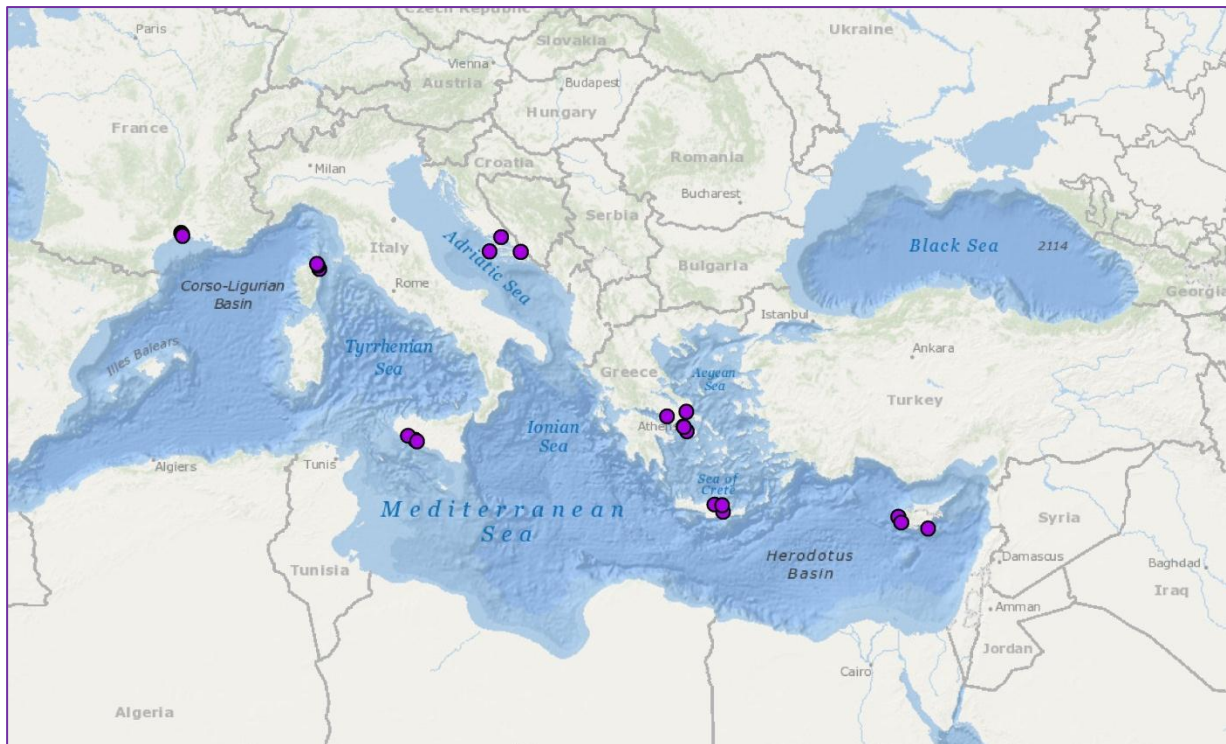


Figure 4-1. Map with the surveyed beaches.

5. RESULTS

5.1. Abundance of marine litter

On the 23 sites surveyed a total of 37,991 items were recorded, removed and classified. Items varied widely in abundance and types. The average litter density was calculated to be 714 items/100m ranging from 53 items/100m to 6,660 items/100m. As shown of Table 5-1, the highest litter density of 6,660 items/100m was recorded in Zaglav (Croatia), followed by a density of 986 items/100m recorded in Psatha (Greece). Relatively high litter densities were recorded also in San Marco (Italy) with 977 items/100m, Neretva river delta (Croatia) with 867 items/100m and Varnavas (Greece) with 840 items/100m. The lowest densities in terms of items found on 100-metre stretch of coastline were recorded in Lara (Cyprus) with 89 items/100m and Boucanet (France) with 53 items/100m.

The average litter density was calculated to be 0.61 items/m². The abundance of litter items expressed in items/m² was found to be the highest in Zaglav (Croatia) with a density of 6.66 items/m² (6,660/100m). The second highest abundance of litter items was recorded at Bovo Marina (Italy) with the average number of items being 1.40 items/m² (720 items/100m), followed by Varnavas (Greece) with 1.05 items/m² (840 items/100m) and San Marco (Italy) with 1.00 items/m² (977 items/100m). The lowest abundances of litter items were found on the beaches of Galazia Akti (Greece) with 0.08 items/m² (230 items/100m), Lara (Cyprus) with 0.06 items/m² (89 items/100m), Espiguette (France) with 0.05 items/m² (204 items/100m) and Boucanet (France) with 0.04 items/m² (53 items/100m) (Tab. 5-2).

The Clean Coast Index classified Zaglav (Croatia), Bovo Marina (Italy) and Varnavas (Greece) as ‘Very dirty’ beaches with CCI values 133.2, 28.0 and 21.0 respectively. The beach of San Marco (Italy) was classified as ‘Dirty’ with CCI value 20.0. The remaining beaches ranked as ‘Moderately clean’, ‘Clean’ and ‘Very clean’ as shown in Table 5.2. Only four beaches ranked as very clean; one located in Greece, one located in Cyprus and two located in France. These were the beach of Galazia Akti (Greece), Lara (Cyprus), Espiguette (France) and Boucanet (France), with CCI values 1.6, 1.1, 1.0 and 0.7 respectively.

As shown in Figure 5-1, almost one fifth (17%) of the surveyed beaches were characterized by very low litter densities and were classified as very clean, while 31% were classified as clean. 35 % of the beaches were moderately littered. Very high litter densities were found for 13% of the surveyed beaches and were classified as very dirty, while only one beach was classified as dirty.

Table 5—1. The average density of litter items recorded in the 23 surveyed beaches, assessed in number of items per 100-metre stretch.

Beach Code	Beach name	Average number of items per 100m stretch
HR-ZAG	Zaglav - Island Vis	6,660
EL-PSA	Psatha - Korinthian Gulf	989
IT-MAR	San Marco	977
HR-NER	Neretva river delta	867
EL-VAR	Varnavas - Evoikos Gulf	840
IT-BOV	Bovo Marina	720
FR-MUC	Mucchiatana	666
FR-ARI	Arinella	642
FR-STE	Stella Mare	626
EL-LAG	Lagonisi - Saronikos Gulf	539
HR-PUN	Punta - Omis	517
FR-SEA	Seaquarium	385
CY-FAR	Faros	293
EL-NAV	Navarchou Klearchou - Crete	267
EL-GAL	Galazia Akti - Saronikos Gulf	230
IT-SIC	Siculiana Marina	213
EL-LEG	Legrena - Saronikos Gulf	210
FR-ESP	Espiguette	204
EL-AMM	Ammoudaras - Crete	151
CY-PER	Pervola	149
EL-ALM	Almyros - Crete	108
CY-LAR	Lara	89
FR-BOU	Boucanet	53

Table 5—2. The average density of litter items recorded in the 23 surveyed beaches assessed in number of items per square metre.

Beach Code	Beach name	Average number of items per square metre (items/m ²)
HR-ZAG	Zaglav - Island Vis	6,66
IT-BOV	Bovo Marina	1,40
EL-VAR	Varnavas - Evoikos Gulf	1,05
IT-MAR	San Marco	1,00
EL-PSA	Psatha - Korinthian Gulf	0,49
HR-NER	Neretva river delta	0,43
FR-STE	Stella Mare	0,35
EL-CRE	Navarchou Klearchou - Crete	0,33
FR-MUC	Mucchiatana	0,33
EL-LAG	Lagonisi - Saronikos Gulf	0,30
HR-PUN	Punta - Omis	0,26
CY-PER	Pervola	0,23
CY-FAR	Faros	0,16
IT-SIC	Siculiana Marina	0,16
EL-CAN	Ammoudara - Crete	0,15
EL-LEG	Legrena - Saronikos Gulf	0,15
FR-ARI	Arinella	0,14
EL-ALM	Almyros - Crete	0,14
FR-SEA	Seaquarium	0,13
EL-GAL	Galazia Akti - Saronikos Gulf	0,08
CY-LAR	Lara	0,06
FR-ESP	Espiguette	0,05
FR-BOU	Boucanet	0,04

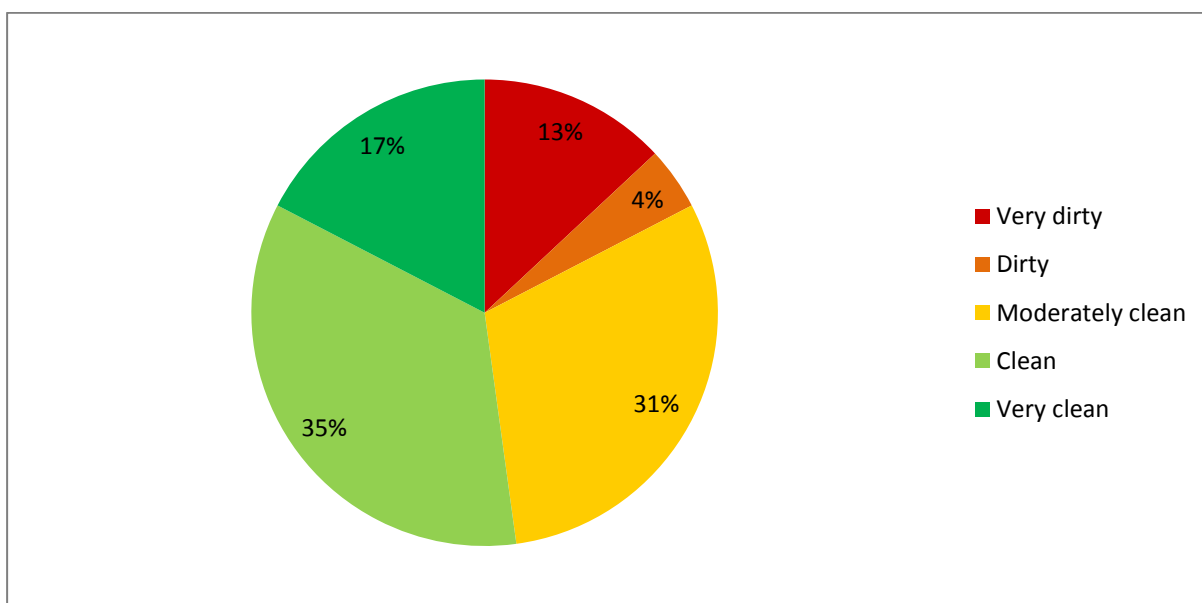


Figure 5-1. Distribution of the studied beaches based on cleanliness.

Table 5—3. Beach cleanliness classification of survey sites according to the Clean Coast Index.

Beach code	Beach name	Clean Coast Index (CCI)	Cleanliness
HR-ZAG	Zaglav - Island Vis	133,2	Very dirty
IT-BOV	Bovo Marina	28,0	Very dirty
EL-VAR	Varnavas - Evoikos Gulf	21,0	Very dirty
IT-MAR	San Marco	20,0	Dirty
EL-PSA	Psatha - Korinthian Gulf	9,9	Moderately clean
HR-NER	Neretva river delta	8,7	Moderately clean
FR-STE	Stella Mare	7,0	Moderately clean
EL-CRE	Navarchou Klearchou - Crete	6,7	Moderately clean
FR-MUC	Mucchiatana	6,7	Moderately clean
EL-LAG	Lagonisi - Saronikos Gulf	6,0	Moderately clean
HR-PUN	Punta - Omis	5,2	Moderately clean
CY-PER	Pervola	4,7	Clean
CY-FAR	Faros	3,2	Clean
IT-SIC	Siculiana Marina	3,1	Clean
EL-CAN	Ammoudara - Crete	3,0	Clean
EL-LEG	Legrena - Saronikos Gulf	3,0	Clean
FR-ARI	Arinella	2,8	Clean
EL-ALM	Almyros - Crete	2,7	Clean
FR-SEA	Seaquarium	2,5	Clean
EL-GAL	Galazia Akti - Saronikos Gulf	1,6	Very clean
CY-LAR	Lara	1,1	Very clean
FR-ESP	Espiguette	1,0	Very clean
FR-BOU	Boucanet	0,7	Very clean

5.2. Composition of marine litter

The marine litter items recorded were classified into 8 major groups of material types on aggregated basis (Fig. 5-2). The vast majority of litter items (90%) were made out of artificial polymer materials, a category of litter dominant on beaches all over the world. The second most abundant group of litter items found were glass/ceramics (3%). Items made of metal and paper accounted for 2% each, while rubber for 1%, processed wood for 1% and cloth/textile for 1%. Only 42 items were classified as unidentified items and/or chemicals.

It should be noted that the percentage of plastic items differed in each site; the lowest amounts of plastic items were found in Arinella (France) with plastics accounting for some 53% of all litter collected and Punta – Omis (Croatia) with plastics accounting for some 63%. The highest amount of plastic items was found in Zaglav (Croatia) with plastics accounting for some 98% of all litter collected.

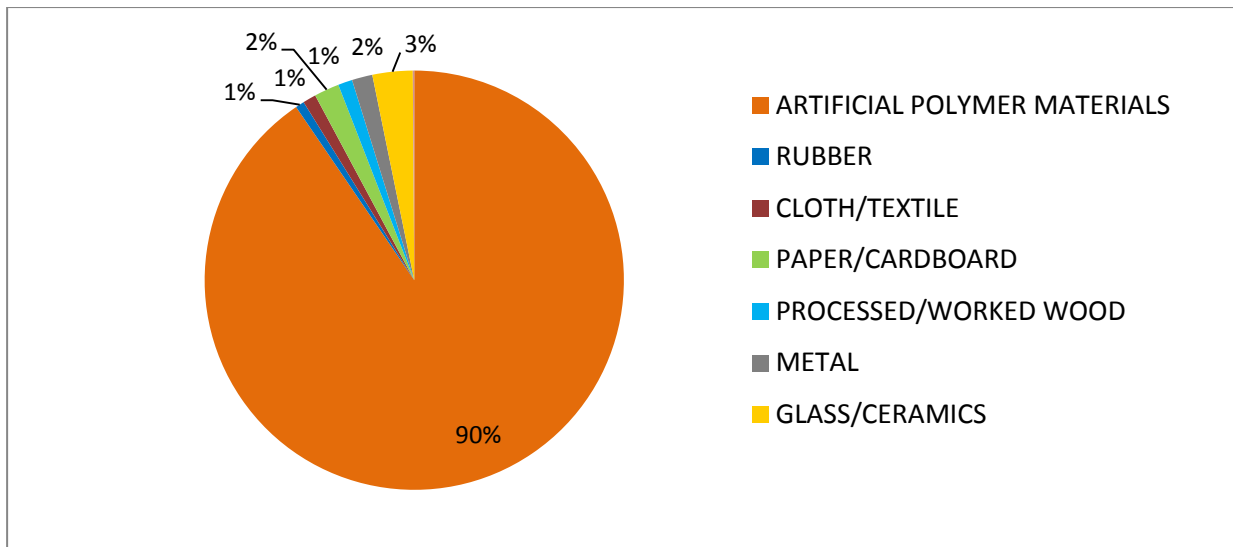


Figure 5-2. Aggregated results of the percentage (%) of total litter items per category type (artificial polymer material; rubber; cloth/textile; paper/cardboard; processed/worked wood; metal, glass/ceramics).

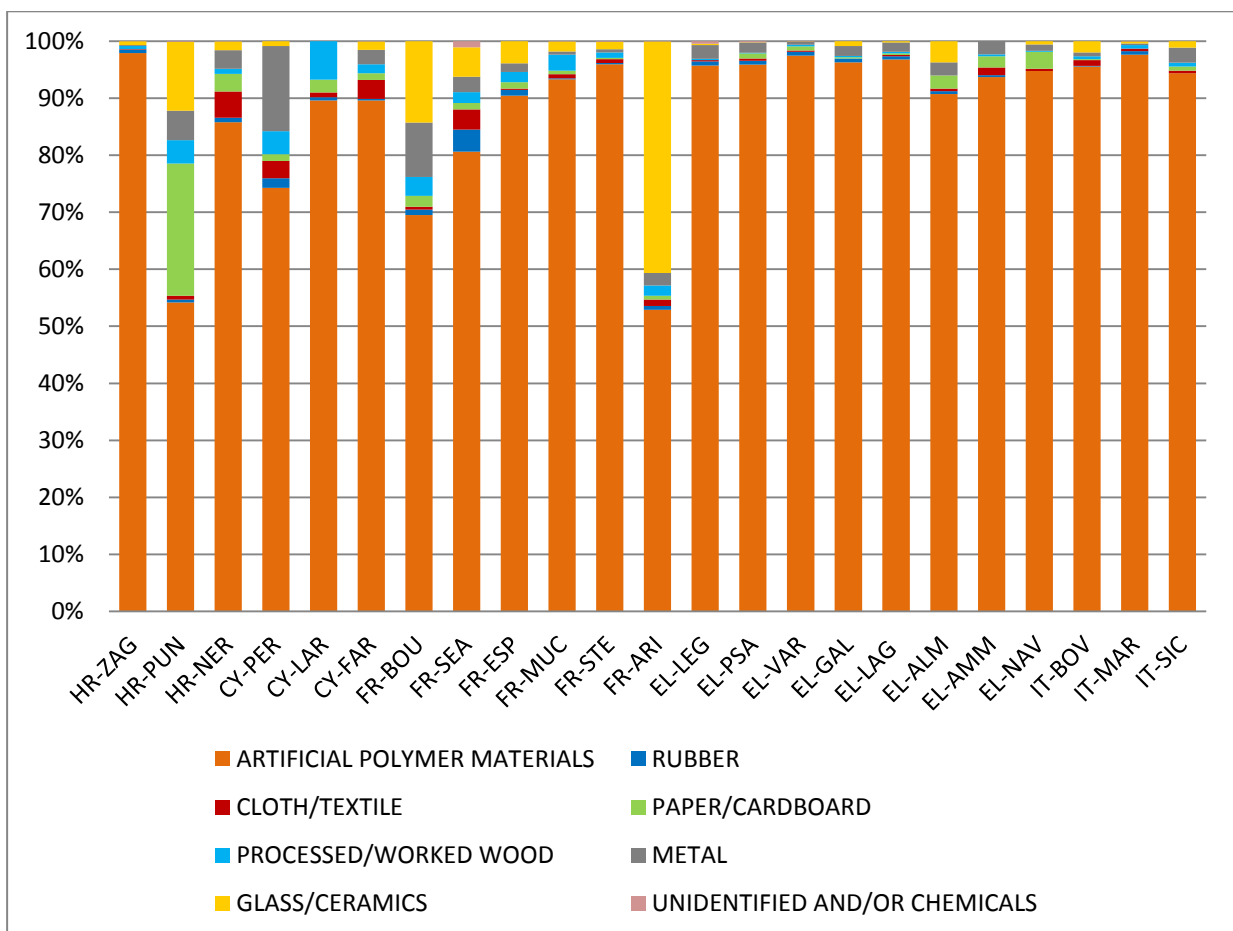


Figure 5-3. Percentage (%) of total litter items per category type (artificial polymer material; rubber; cloth/textile; paper/cardboard; processed/worked wood; metal, glass/ceramics) in the 23 surveyed beaches.

The top 20 items accounted for some 81.4% of all items recorded. Among the 159 litter categories, plastic pieces 2.5 cm > < 50 cm (G79) accounted for the highest percentage 26% (9,846 items) of the total litter items recorded in all surveys, followed by cigarette butts and filters (G27) with 12% (4,555 items). The third most abundant items were plastic caps/lids from drinks (G21) with 8.1% (3,086 items), followed by cotton bud sticks (G95) with 6.3% (2,373) and polystyrene pieces 2.5 cm > < 50cm (G82) with 5.8% (2,207). Straws and stirrers (G35), plastic pieces > 50 cm (G80), polystyrene pieces > 50 cm (G83), glass bottles (G200) and crisps packets/sweets wrappers (G30) were among the top 10 items found. The top 10 items for each beach are presented in Annex II. It should be noted that the high amount (354 items) of CDs and CD-cases (G84) was recorded only in one location, in San Marco (Italy).

Figure 5-4. Top 20 items found on the 23 surveyed beaches of Mediterranean coastal and marine, protected areas calculated on an aggregated basis of total litter counts in all beaches.

	Item code	Item name	Items count	%
1	G79	Plastic pieces 2.5 cm > < 50cm	9846	26
2	G27	Cigarette butts and filters	4555	12
3	G21	Plastic caps/lids from drinks	3086	8,1
4	G95	Cotton bud sticks	2373	6,3
5	G82	Polystyrene pieces 2.5 cm > < 50cm	2207	5,8
6	G35	Straws and stirrers	1128	3,0
7	G80	Plastic pieces > 50 cm	817	2,2
8	G83	Polystyrene pieces > 50 cm	755	2,0
9	G200	Bottles, including pieces	675	1,8
10	G30	Crisps packets/sweets wrappers	661	1,7
11	G124	Other plastic/polystyrene items (identifiable)	624	1,6
12	G22	Plastic caps/lids from chemicals, detergents (non-food)	595	1,6
13	G50	String and cord (diameter less than 1cm)	589	1,6
14	G24	Plastic rings from bottle caps/lids	554	1,5
15	G23	Plastic caps/lids unidentified	466	1,2
16	G33	Cups and cup lids	427	1,1
17	G3	Shopping bags, incl. pieces	410	1,1
18	G156	Paper fragments	378	1,0
19	G84	CD, CD-boxes	354	0,9
20	G31	Lolly sticks	341	0,9



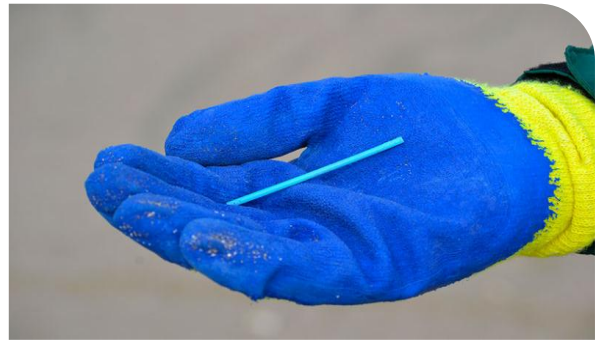
Plastic pieces 2.5 cm > < 50cm (G79)



Cigarette butts and filters (G27)



Plastic caps/lids from drinks (G21)



Cotton bud sticks (G95)



Straws and stirrers (G35)



Glass bottles (G200)



Crisps packets/sweets wrappers (G30)



String and cord (diameter less than 1cm) (G50)

Table 5—4. Indicative photos of some of the most frequently found items in the present study.

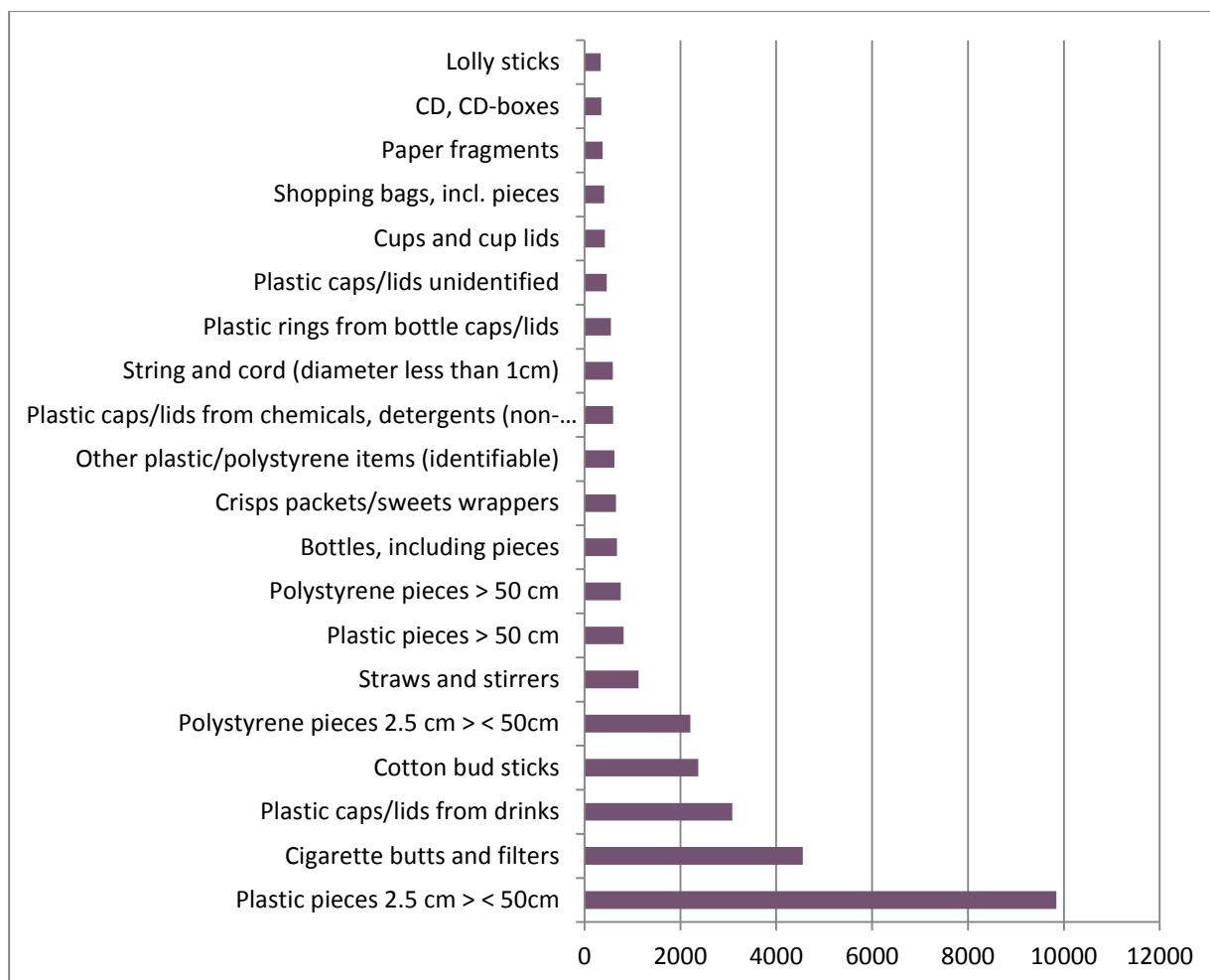


Figure 5-5. Top 20 items found on the 22 surveyed beaches of Mediterranean coastal and marine, protected areas calculated on an aggregated basis of total litter counts in all beaches.

When it comes to smoking activities as a source of marine litter items, on an aggregated basis 13% of the total litter items collected 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. 5-6). The highest percentage of smoking-related items was recorded in Faros (Cyprus), where they accounted for 51% of sampled items, followed by Punta - Omis (Croatia) with 41% and Seaquarium (France), Almyros (Greece) and Navarchou Klearchou (Greece) with 40% each. The lowest percentages of smoking-related items were observed for Bovo Marina (Italy) with 2%, San Marco (Italy) with 1% and Siculiana (Italy) with 1%. In Zaglav (Croatia) only 49 items were smoking related out of the 13,320 items recorded.

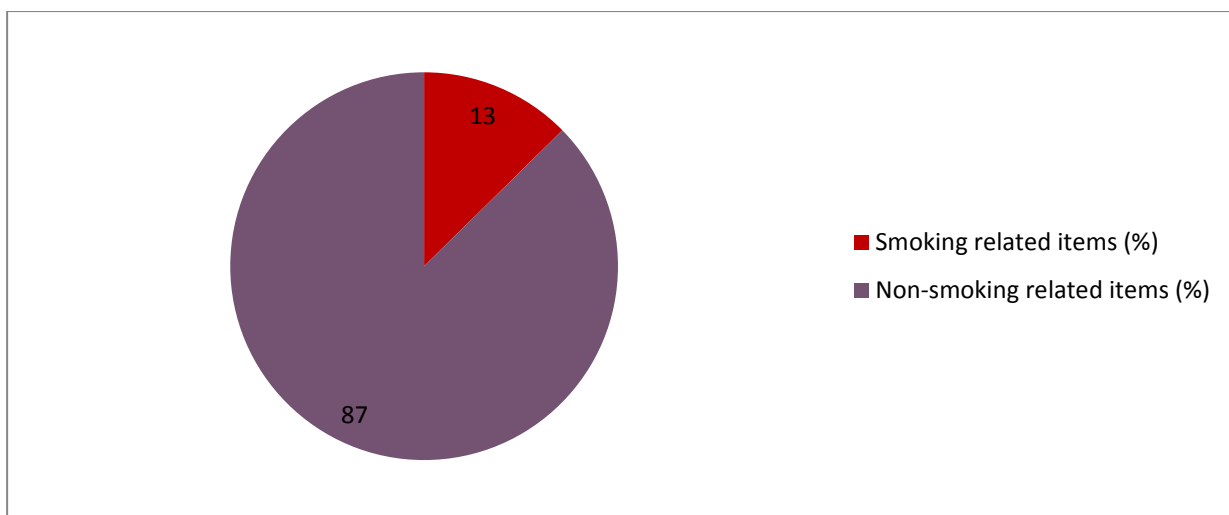


Figure 5-6. Abundance (%) of smoking related items on the basis of aggregated results.

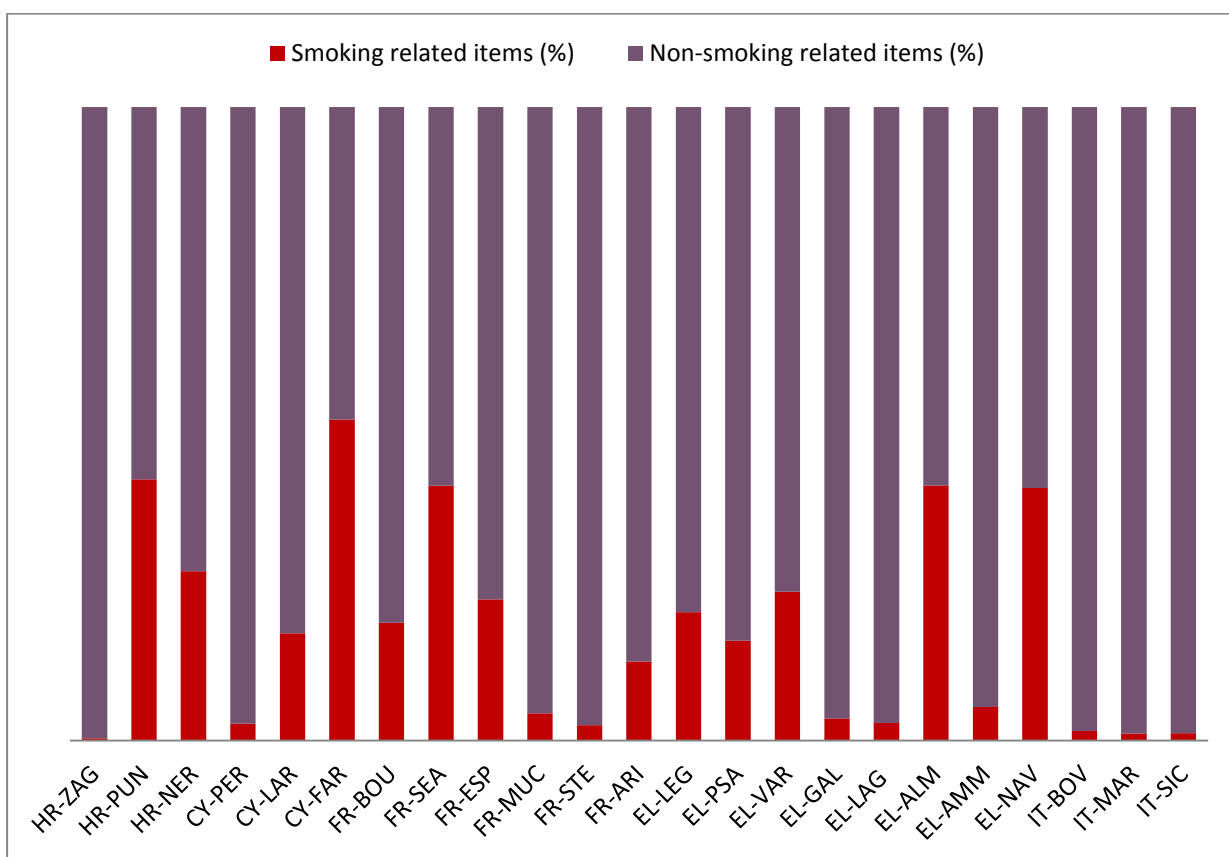


Figure 5-7. Abundance (%) of smoking related items in each of the surveyed beaches.

5.3. Sources of marine litter

Within the present study, the assignment of specific sources to each litter item found was made in line with the approach described by Vlachogianni et al., 2018. The sources of marine litter were classified into the following eight major categories.

- 1 - 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.
- 2 - 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.
- 3 - 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.
- 4 - 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.
- 5 - 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.
- 6 - 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.
- 7 - 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.
- 8 - 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.

Litter from shoreline sources, such as tourism and recreational activities and poor waste management practices, accounted for 38% of all litter collected; while the amount of litter from fisheries and aquaculture was at a level of 3% (Fig. 5-8). Sanitary and sewage related items accounted for 7%, while shipping, fly-tipping and medical related items accounted for 1% each. Almost half of the litter items collected could not be attributed to a source.

At individual beach level, the inputs of litter from the different sectors and their comparative importance varied substantially (Fig. 5-9). The highest marine litter inputs from shoreline sources, including tourism and recreational activities and poor waste management practices were recorded for Faros (Cyprus) with 74%, followed by Varnavas (Greece) with 68.5%. The highest marine litter

inputs from fisheries and aquaculture were recorded at Lagonisi (Greece) with 9.7%, Seaquarium (France) with 8.8%, Psatha (Greece) with 8.2% and Varnavas (Greece) with 8.1%. High levels of sanitary and sewage related waste was recorded at Stella Mare (France) with 15.7%, followed by Espiguette (France) with 13.4% and Mucchiatana (France) with 11%. Some 15.5% of litter items coming from fly-tipping were recorded in Arinella (France) followed by Boucanet (France) with some 54.3%. The highest percentage of shipping related items was found in Siculiana Marina (Italy) with 3.3% and Boucanet (France) with 2.9%.

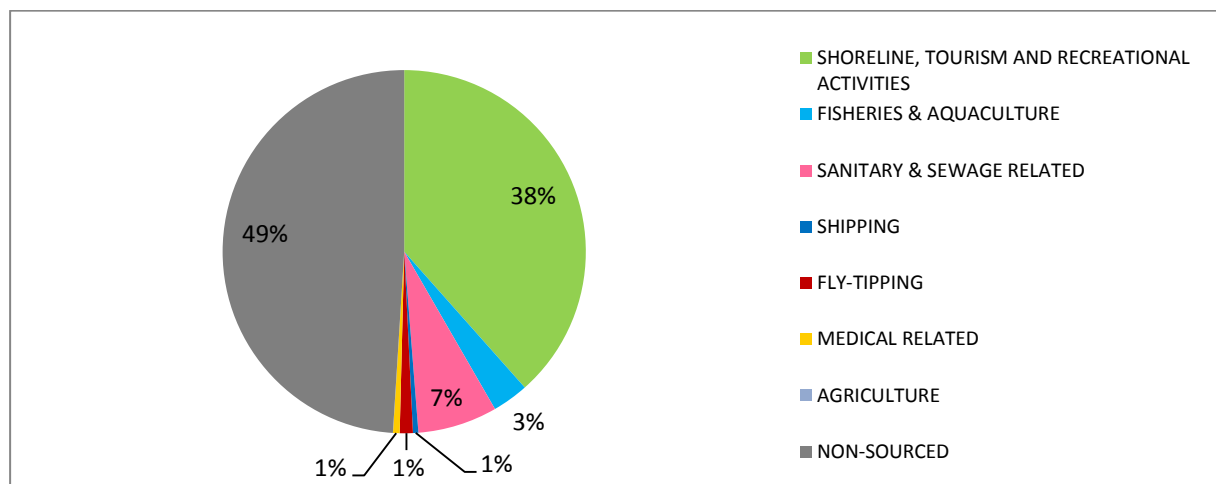


Figure 5-8. Sources of marine litter on the basis of aggregated results at national and regional level.

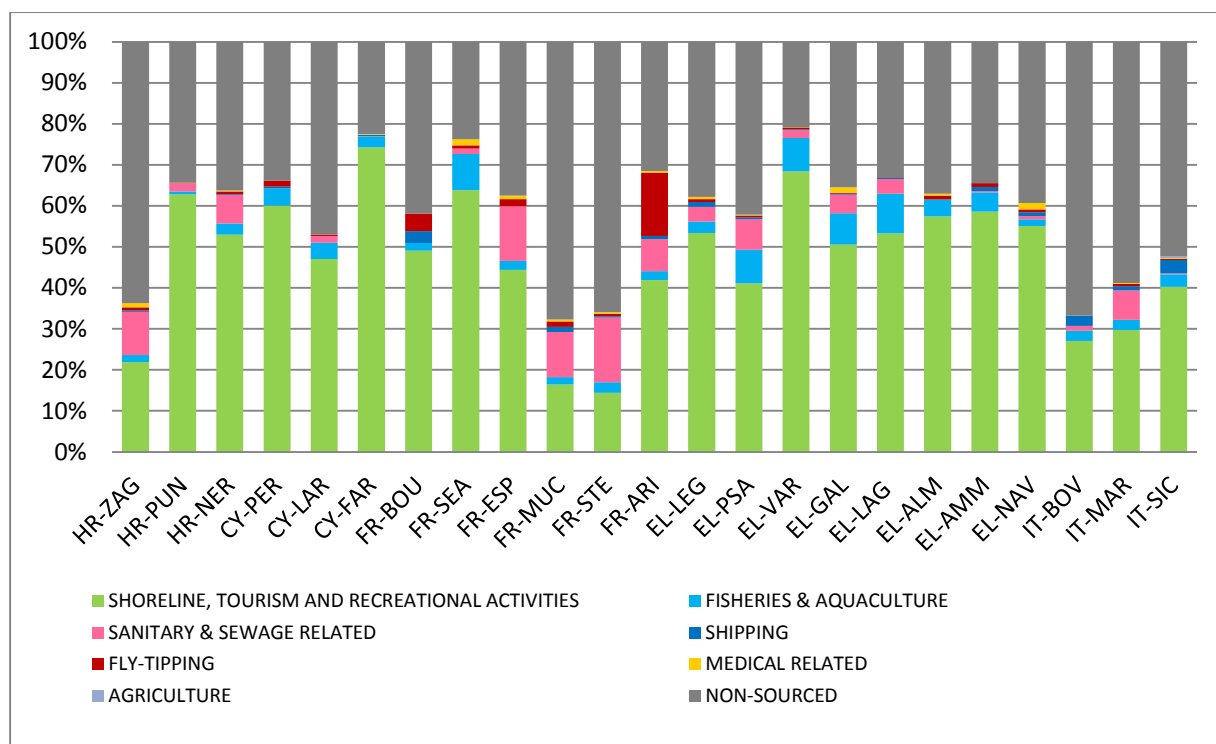


Figure 5-9. Sources of marine litter on the basis of aggregated results at national and regional level.

6. DISCUSSION & CONCLUDING REMARKS

The average litter densities reported within this study ranged from 0.04–6.66 items/m² and are similar and comparable to the values reported by other surveys carried out in the Mediterranean (Laglbauer et al., 2014; Giovacchini et al., 2018; Asensio-Montesinos et al., 2019). It needs to be noted that the discrepancy in reporting marine litter densities in terms of units makes the comparison of results difficult. Within the present study we opted to focus the discussion on marine litter densities expressed in items per m² for the following reason: the land-based sources of marine litter appear to be the dominant ones and thus the number of items/m² is probably the most appropriate unit to be used instead of the items/100-m stretch (Vlachogianni et al., 2018). The latter unit is more suitable when the sea-based sources of litter are the prevailing ones as it is associated with floating litter fluxes washed ashore.

Table 6—1. Summary of beach litter densities reported in recent scientific literature.

Study areas	Classification list	Litter densities	Reference
Slovenia	UNEP/IOC Litter classification list	0.81 - 3.45 items/m ²	Laglbauer et al., 2014
North-western Adriatic coast, Italy	UNEP/IOC Litter classification list	0.2 items/m ²	Munari et al., 2016
Israel	UNEP/IOC Litter classification list	0.05 – 0.2 items/m ²	Pasternak et al., 2017
Mediterranean coastline, Morocco	UNEP List	0.02 - 0.153 items/m ²	Maziane et al., 2018
Pelagos Sanctuary, Italy	OSPAR List	1.06 items/m ²	Giovacchini et al., 2018
Greece	MSFD TG10 Masterlist	0.08–0.91 items/m ²	Prevenios et al., 2017
Albania, Bosnia & Herzegovina, Croatia, Greece, Italy, Slovenia	MSFD TG10 Masterlist	0.08 - 11 items/m ²	Vlachogianni et al., 2018
Spain	MSFD TG10 Masterlist	0.005 - 0.373	Asensio-Montesinos et al., 2019
Coastline of Croatia, Cyprus, France, Greece, Italy	MSFD TG10 Masterlist	0.04–6.66 items/m ²	Present study

The extremely high density of 6.66 items/m² recorded in Zaglav (Croatian) is similar to the density reported for the same site by Vlachogianni et al., (2018) of 11 items/m² and it is to some extent in agreement with the fluxes of plastic debris onto the Adriatic and Ionian coastline, calculated by models related to the transport of floating debris in the Adriatic and Ionian Seas (Liubartseva et al., 2016).

The greater majority of litter items surveyed were made out of artificial/anthropogenic polymer materials with percentages ranging from 62% to 98% for the different countries, thus reflecting the global trend in plastics accounting for the majority of recorded items (Eriksen et al., 2013; UNEP/MAP, 2015; Arun Kumar et al., 2016; Asensio-Montesinos et al., 2019). Also the results of the present study, similarly to other 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; Prevenios et al., 2017).

Similar to other studies, the top 5 items recorded included plastic pieces 2.5 cm > < 50 cm (G79) accounting for 26% (9,846 items) of the total litter items recorded in all surveys, followed by cigarette butts and filters (G27) with 12% (4,555 items), plastic caps/lids from drinks (G21) with 8.1% (3,086 items), cotton bud sticks (G95) with 6.3% (2,373), polystyrene pieces 2.5 cm > < 50cm (G82) with 5.8% (2,207 items) and straws and stirrers (G35) with 3% (1,128 items). The large amount of smoking-related items and single-use items such as straws and stirrers are indicative of the typology of investigated beaches which primarily were tourism and recreation destinations.

Regarding the sources, the present study clearly illustrates that these depend on the specificities of the surveyed beaches and thus targeted and localized measures are needed to address marine litter effectively. Litter from shoreline sources, such as tourism and recreational activities and poor waste management practices accounted for 38% of all litter collected; a value which is similar to the values found in the other studies carried out in the Mediterranean coastline (Munari et al., 2016; Vlachogianni et al., 2018).

To-date and to our knowledge, the present study is one of the very few collective efforts of NGOs to assess in a comprehensive and harmonized way marine litter deposited on Mediterranean beaches. The present study provides fit-for-purpose data and baseline information on the amounts, composition and sources of marine litter in several Mediterranean beaches, as well as a useful tool for decision-makers to gear up their efforts in the combat against the marine litter threat and identify targeted measures to tackle this threat at its source. The results of the present study are a direct contribution to the EU Marine Strategy Framework Directive and the Plastics Strategy, as well as to the Regional Plan for Marine Litter Management in the Mediterranean, adopted by the Contracting Parties to the Barcelona Convention. Last but not least, the present study illustrates the essential role that NGOs can play in fit-for-purpose data generation initiatives as an essential tool to fill in the marine litter knowledge gaps.

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8. LIST OF ACRONYMS

Acronym	Definition
CCI	Clean Coast Index
D10	Descriptor 10 (Marine Litter)
DeFishGear	Derelict Fishing Gear Management System in the Adriatic Region
EC	European Commission
EcAp	Ecosystem Approach
EO	Ecological Objective
EU	European Union
GES	Good Environmental Status
IMAP	Integrated Monitoring and Assessment Programme
IOC	Intergovernmental Oceanographic Commission
IPA	Instrument for Pre-accession Assistance
MAP	Mediterranean Action Plan
MEDPOL	Mediterranean Pollution Monitoring Programme
MPAs	Marine Protected Areas
MSFD	Marine Strategy Framework Directive
MSFD TG10	MSFD Technical Sub-Group on Marine Litter
NGO	Non-Governmental Organisation
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
UNEP	United Nations Environment Programme

9. ANNEX I. MARINE LITTER ITEMS CLASSIFICATION LIST

Code	Items name
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
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
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	Mussels nets, Oyster nets
G46	Oyster trays (round from oyster cultures)
G47	Plastic sheeting from mussel culture (Tahitians)
G49	Rope (diameter more than 1cm)

G50	String and cord (diameter less than 1cm)
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 > < 50cm
G80	Plastic pieces > 50 cm
G82	Polystyrene pieces 2.5 cm > < 50cm
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)
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
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)
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
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
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
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 >2.5cm
G210	Other glass items
G211	Other medical items (swabs, bandaging, adhesive plaster, etc.)
G213	Paraffin/Wax

10. ANNEX II. TOP 10 ITEMS FOUND IN EACH SURVEYED BEACH

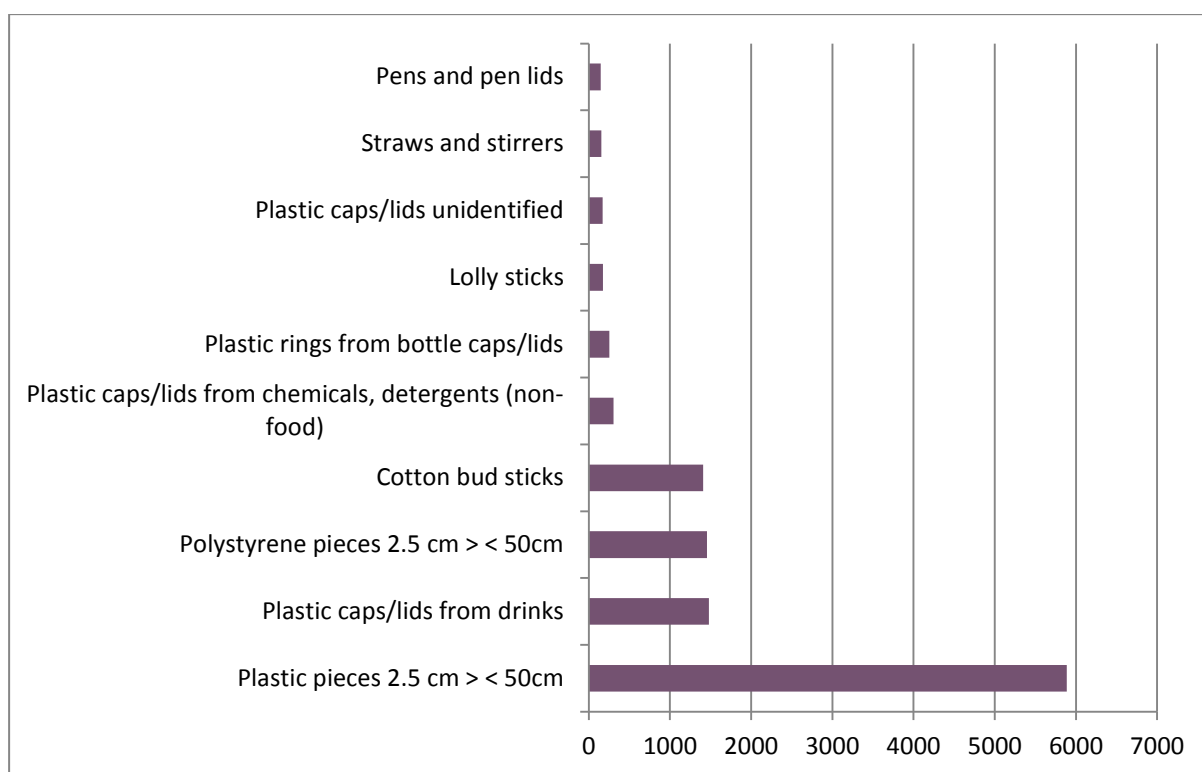


Figure 10-1. Top 10 items found at Zaglav - Island Vis (Croatia). Punta – Omis (Croatia).

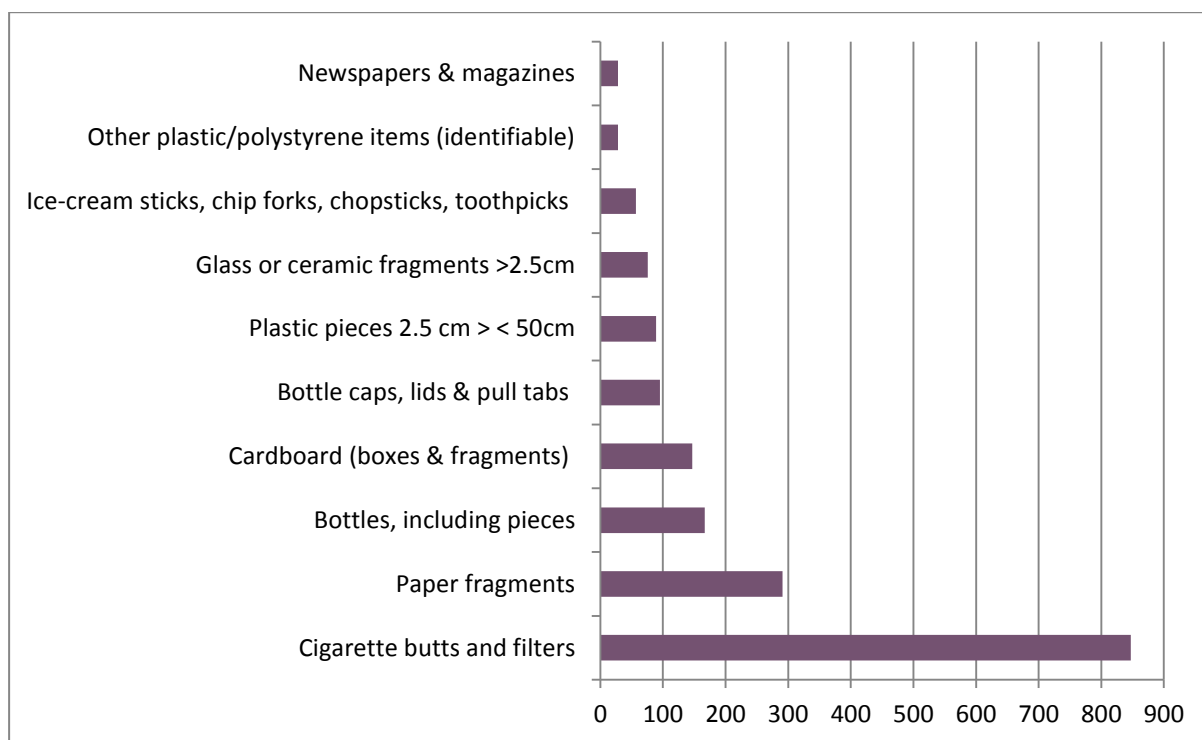


Figure 10-2. Top 10 items found at Punta – Omis (Croatia).

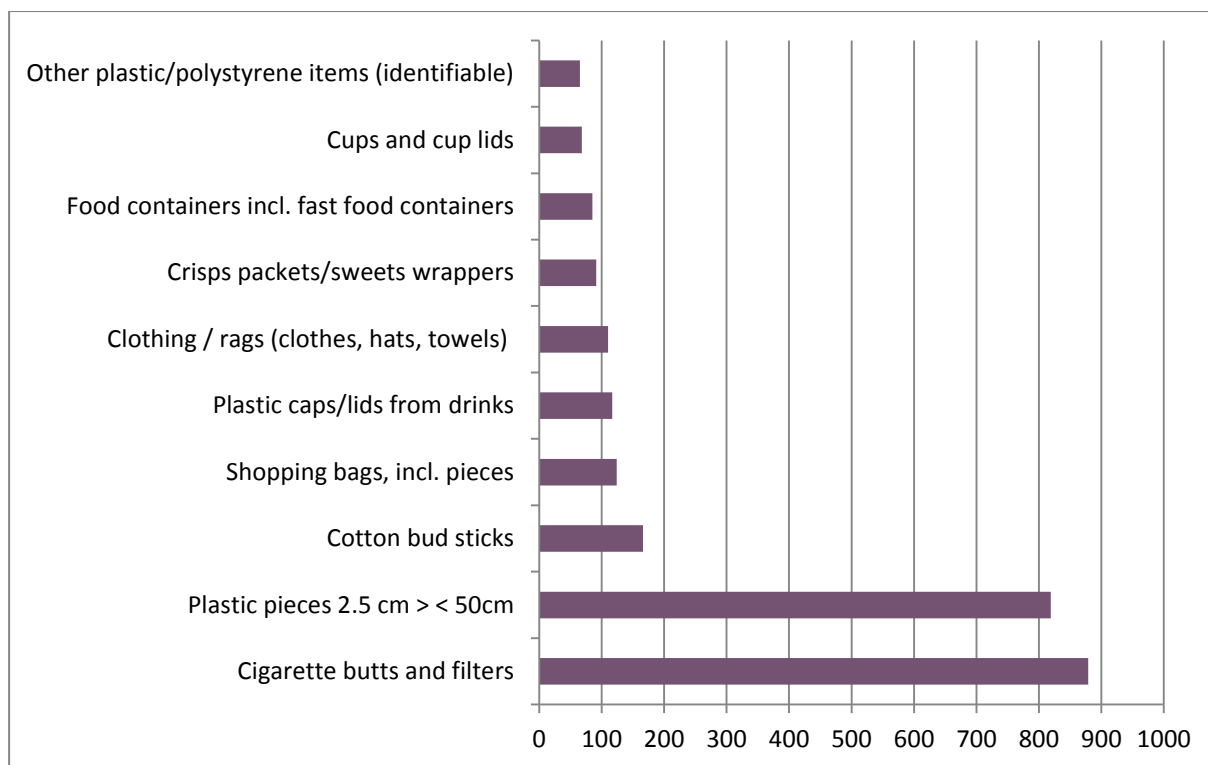


Figure 10-3. Top 10 items found at the Neretva river delta (Croatia).

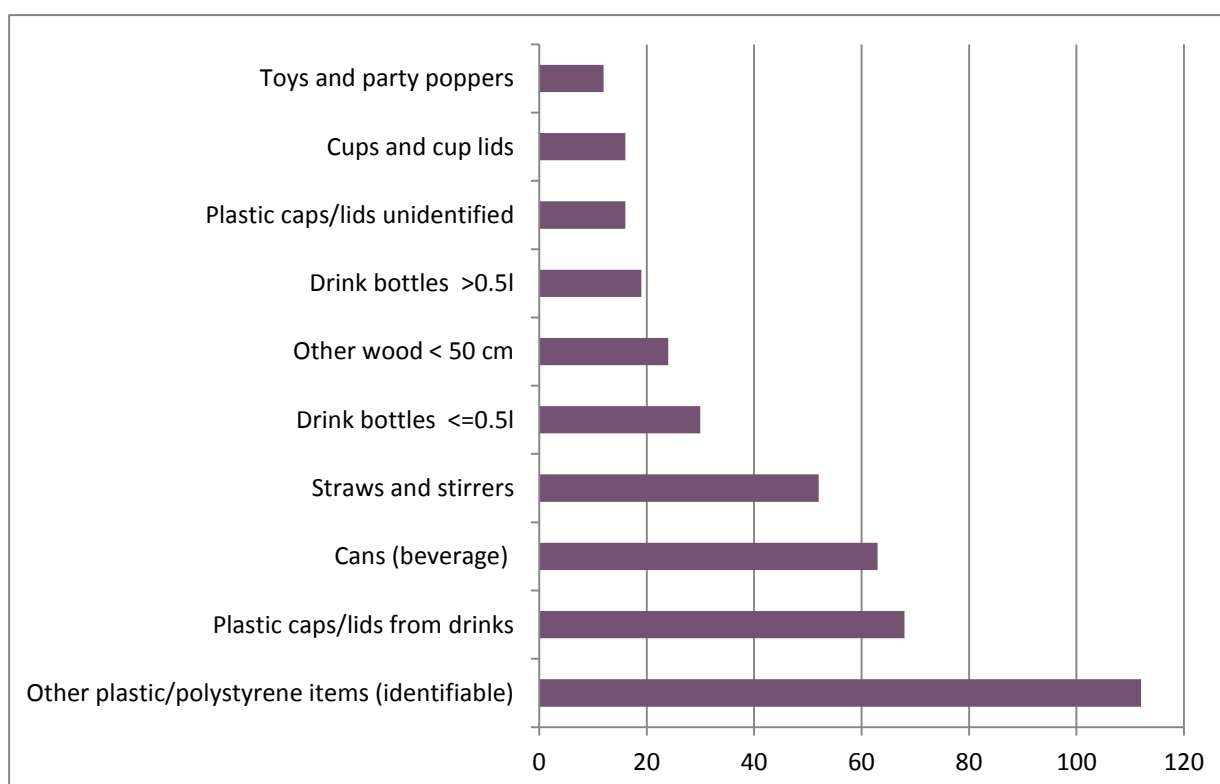


Figure 10-4. Top 10 items found at Pervola (Cyprus).

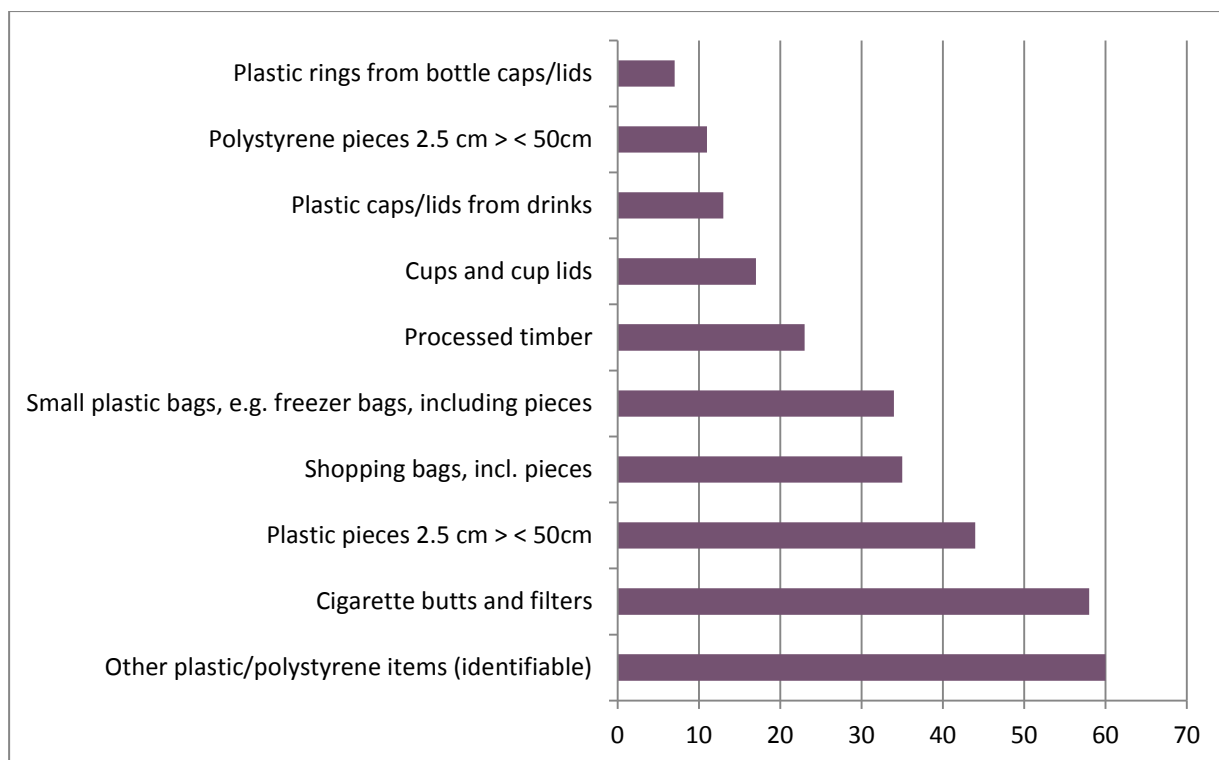


Figure 10-5. Top 10 items found at Lara (Cyprus).

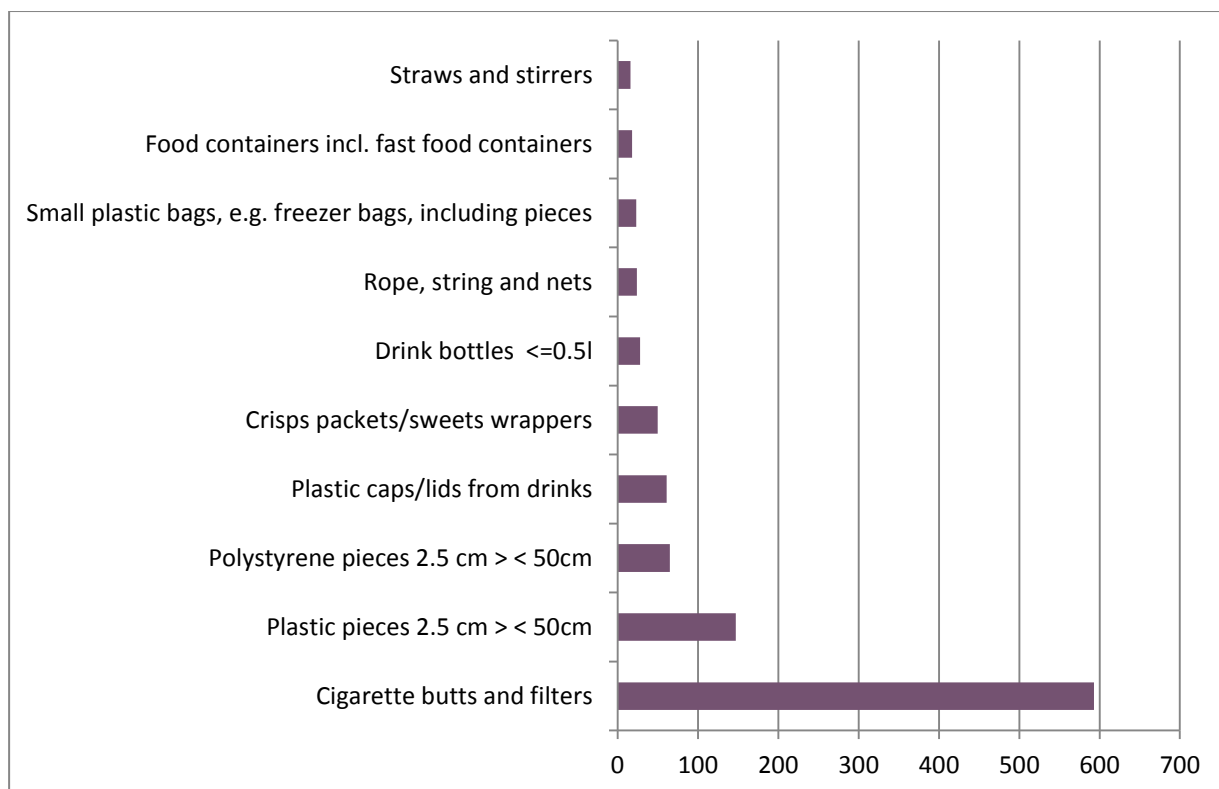


Figure 10-6. Top 10 items found at Faros (Cyprus).

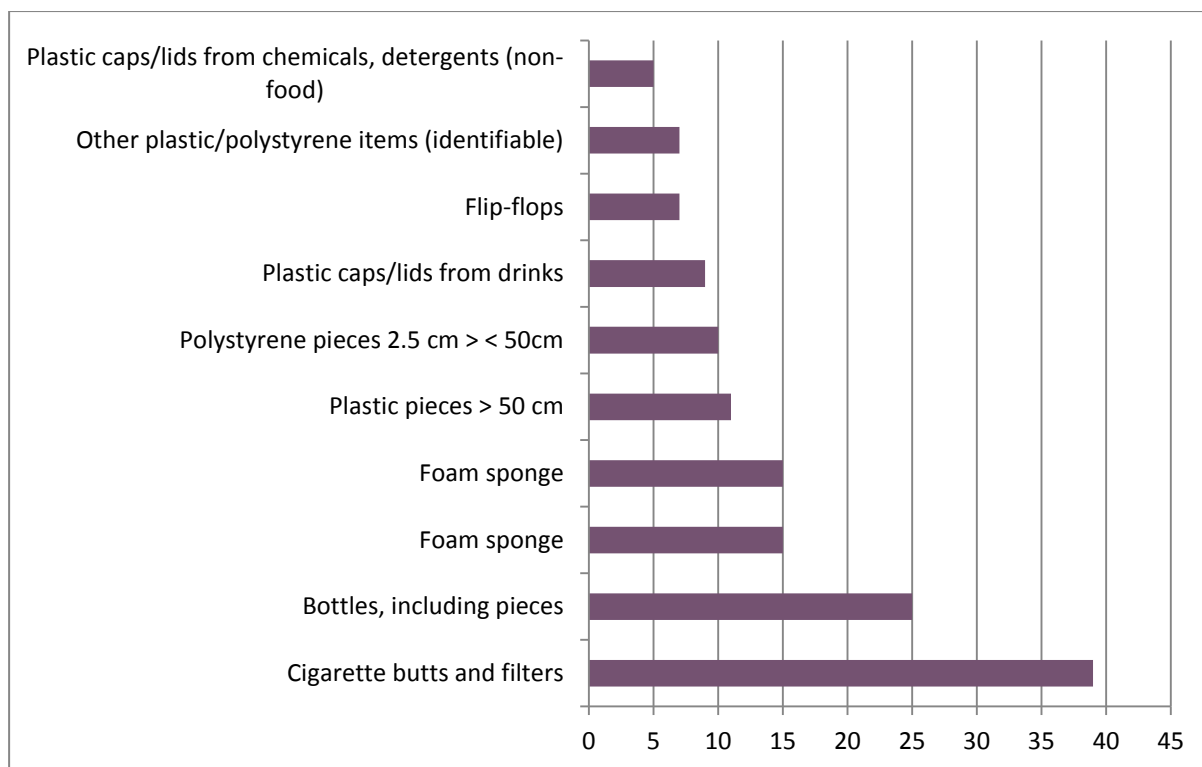


Figure 10-7. Top 10 items found at Boucanet (France).

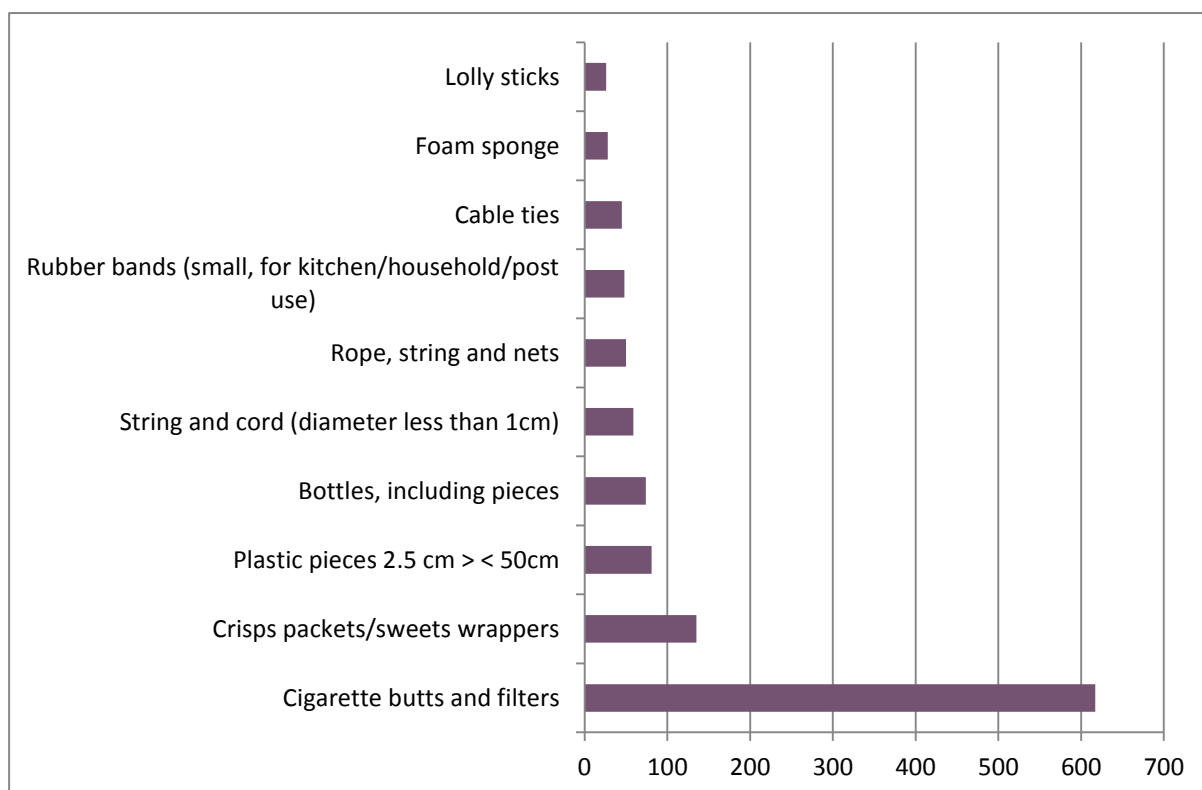


Figure 10-8. Top 10 items found at Seaquarium (France).

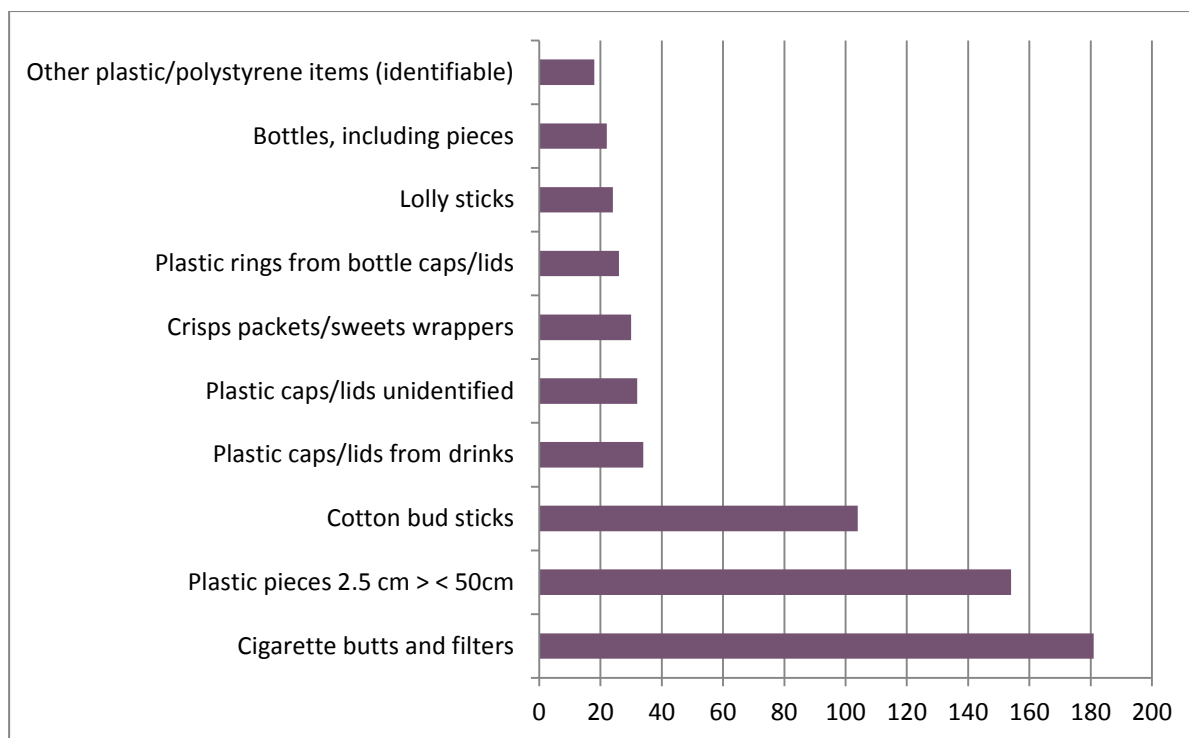


Figure 10-9. Top 10 items found at Espiguette (France).

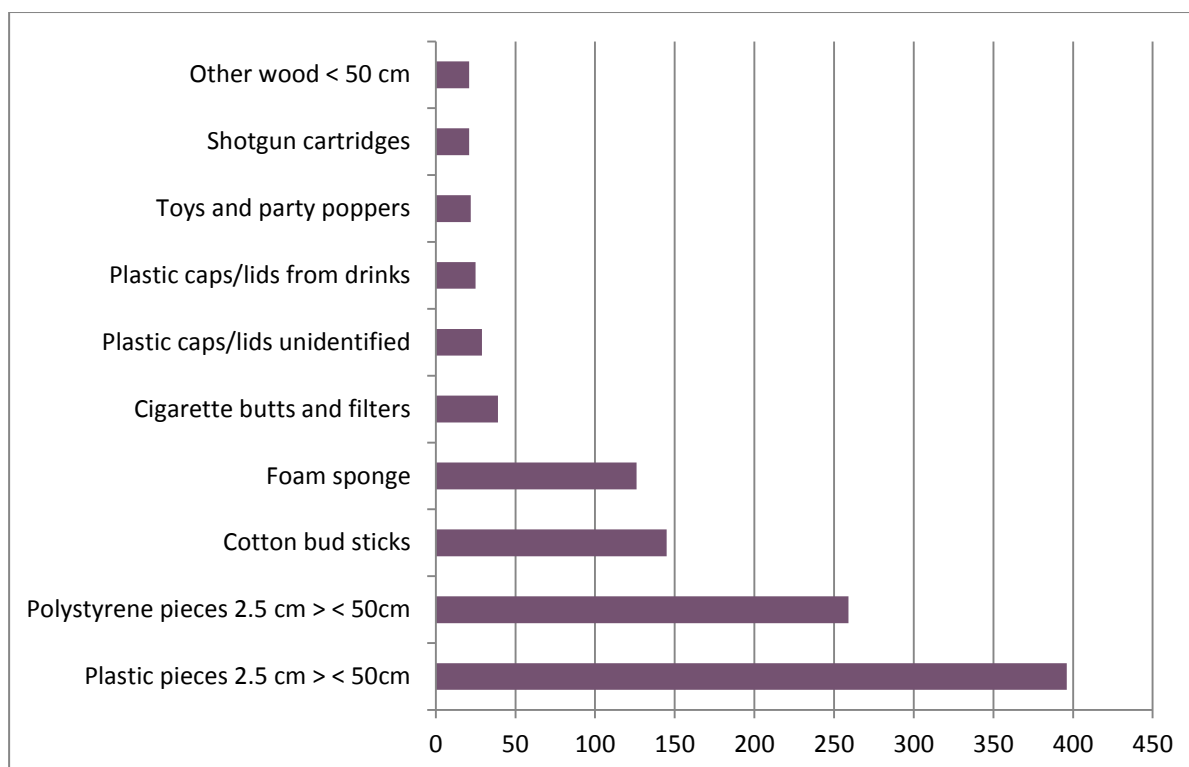


Figure 10-10. Top 10 items found at Mucchiatana (France).

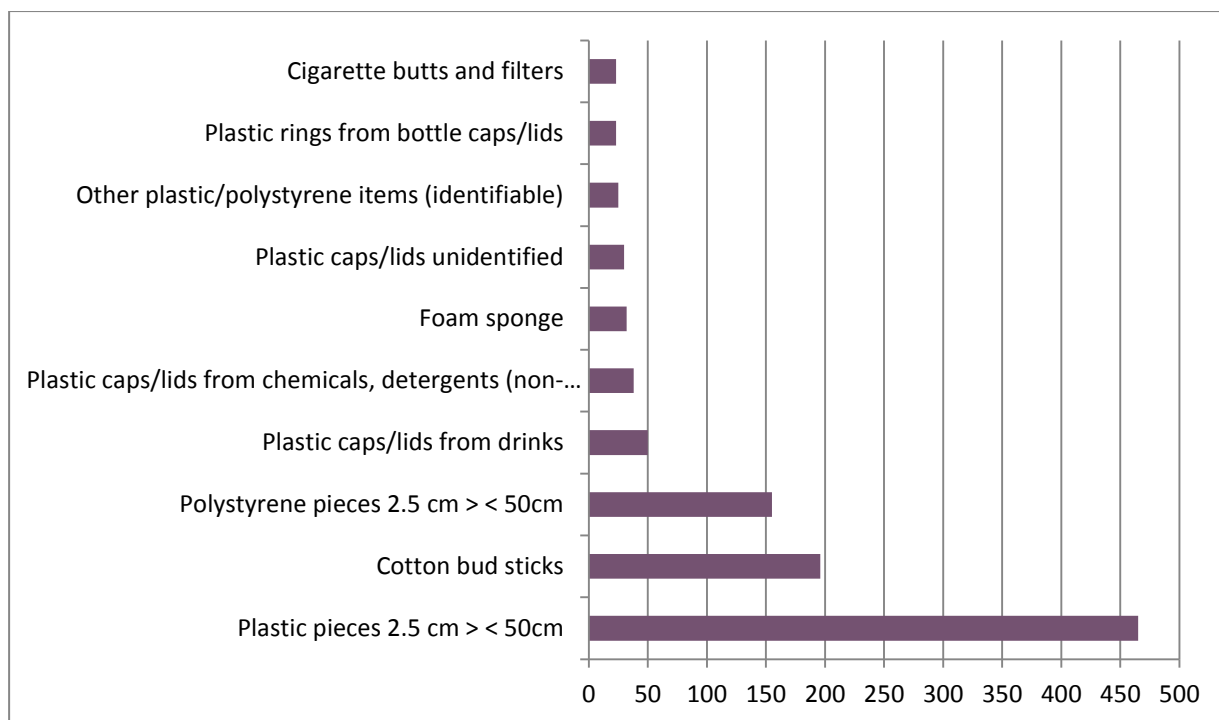


Figure 10-11. Top 10 items found at Stella Mare (France).

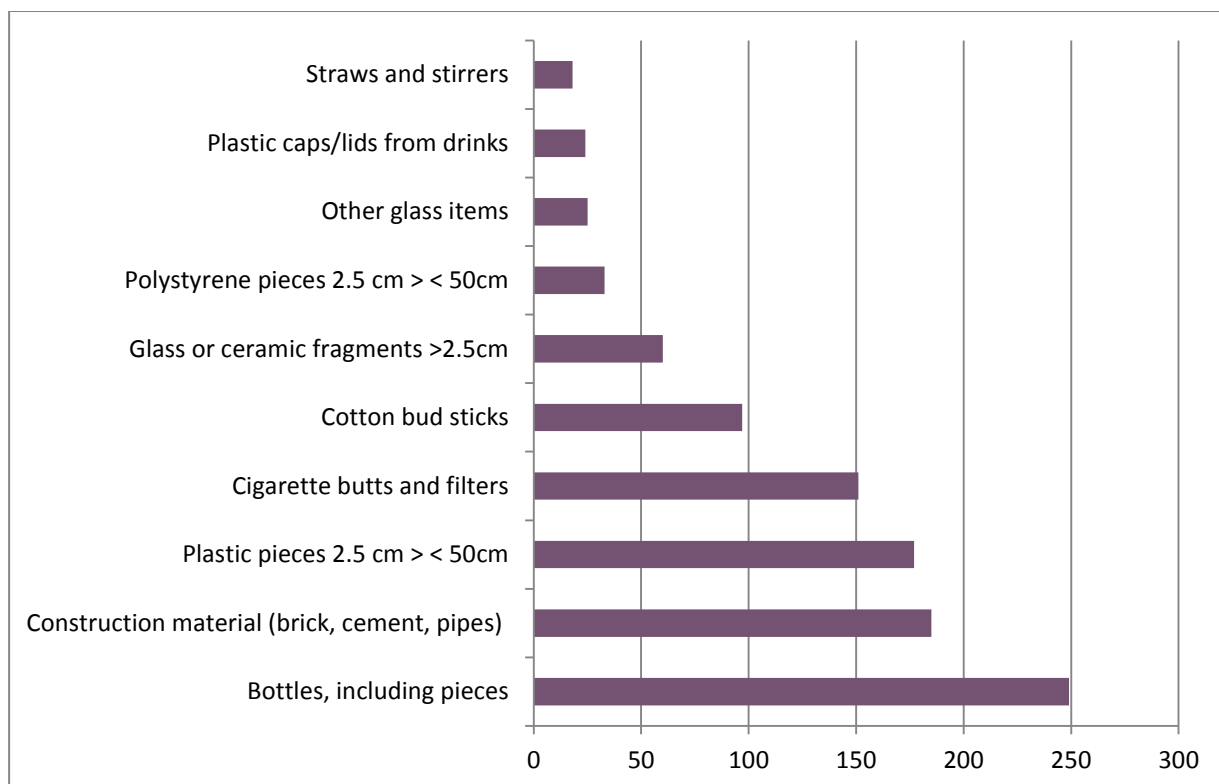


Figure 10-12. Top 10 items found at Arinella (France).

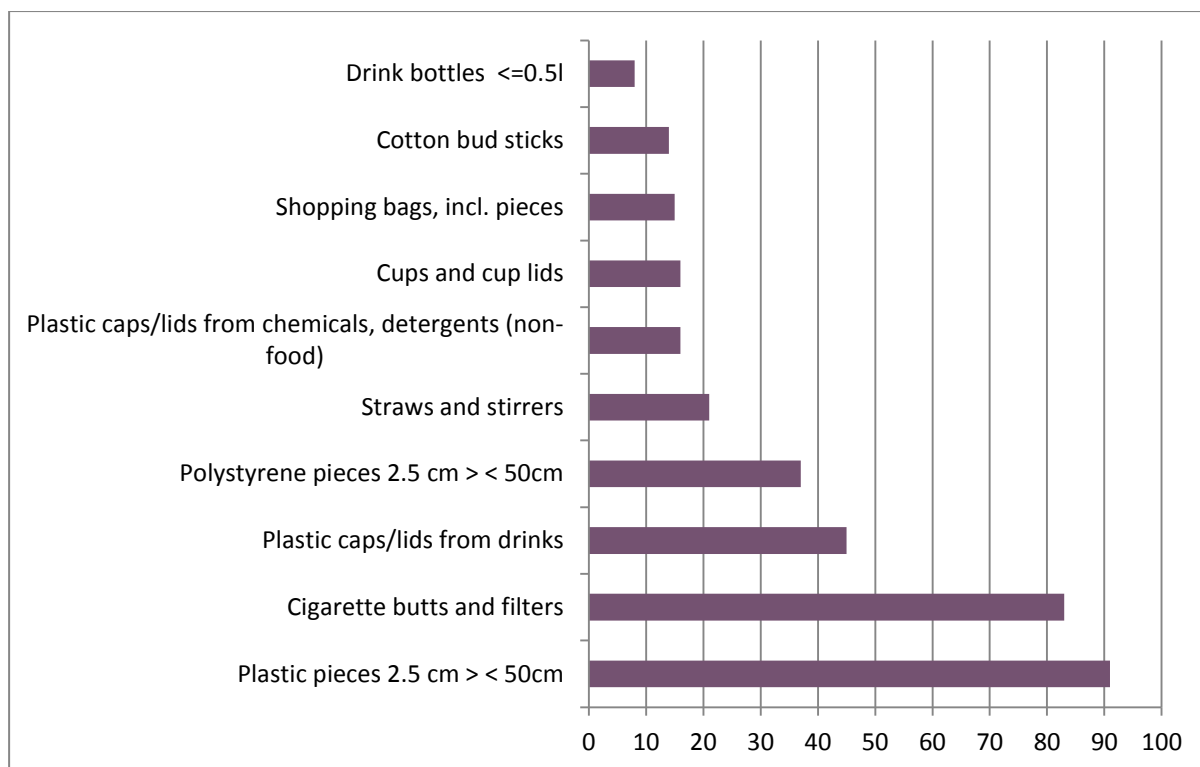


Figure 10-13. Top 10 items found at Legrena - Saronikos Gulf (Greece).

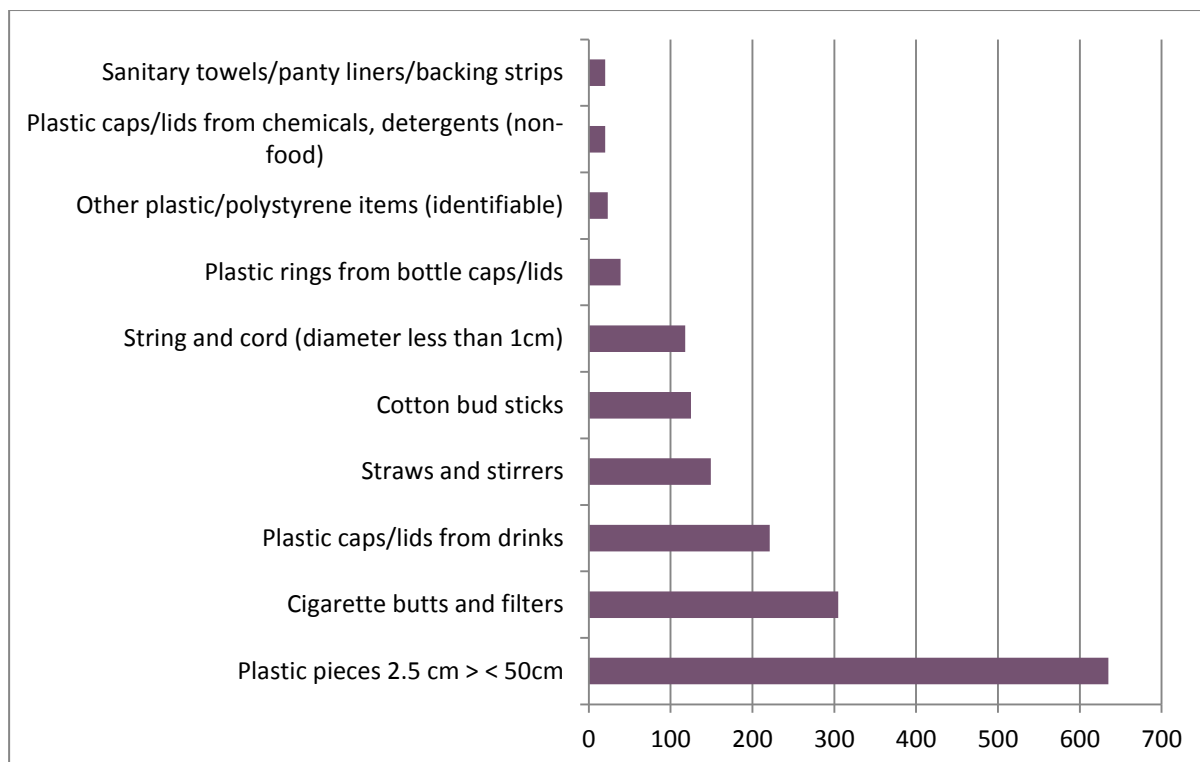


Figure 10-14. Top 10 items found at Psatha - Corinthian Gulf (Greece).

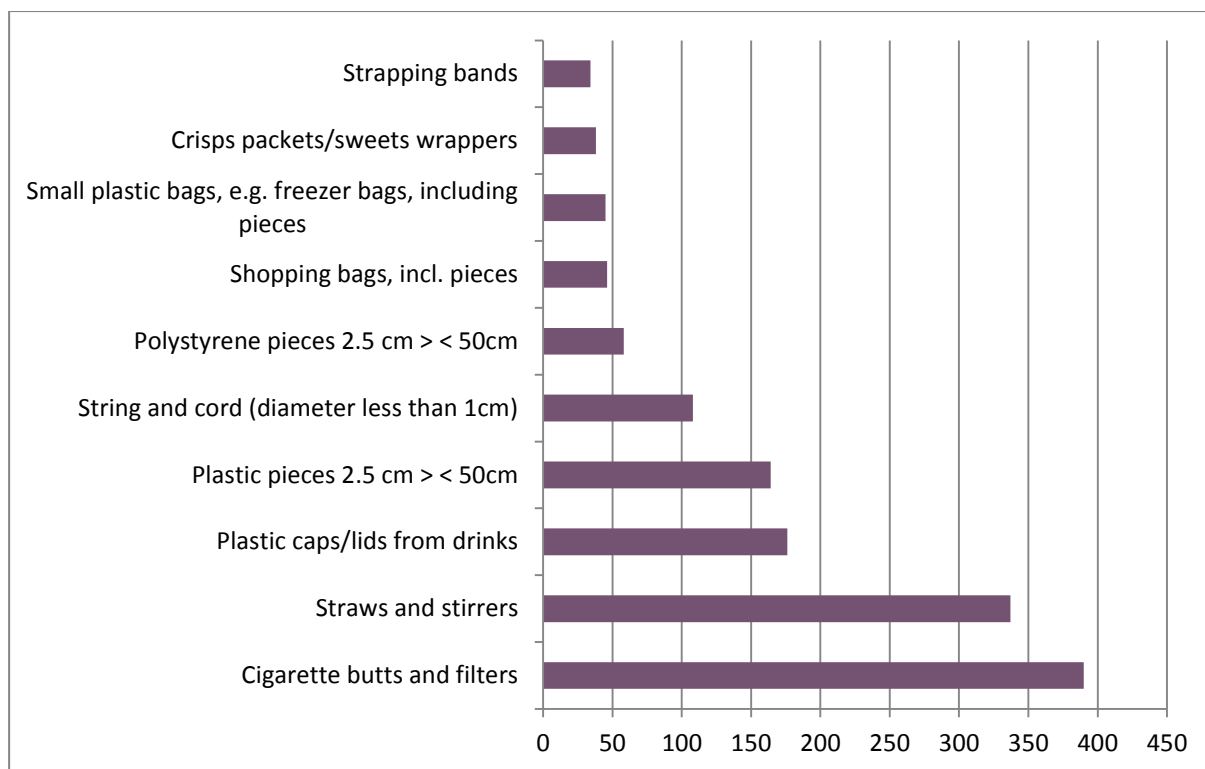


Figure 10-15. Top 10 items found at Varnavas - Evoikos Gulf (Greece).

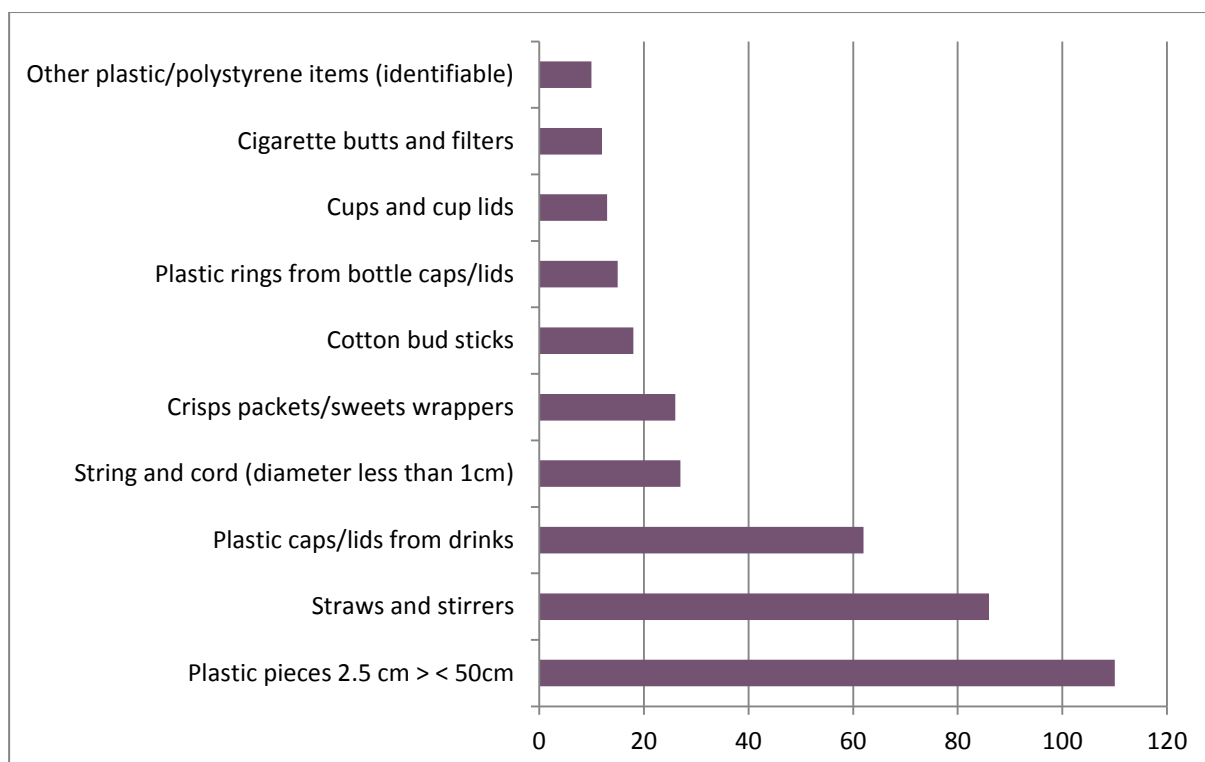


Figure 10-16. Top 10 items found at Galazia Akti - Saronikos Gulf (Greece).

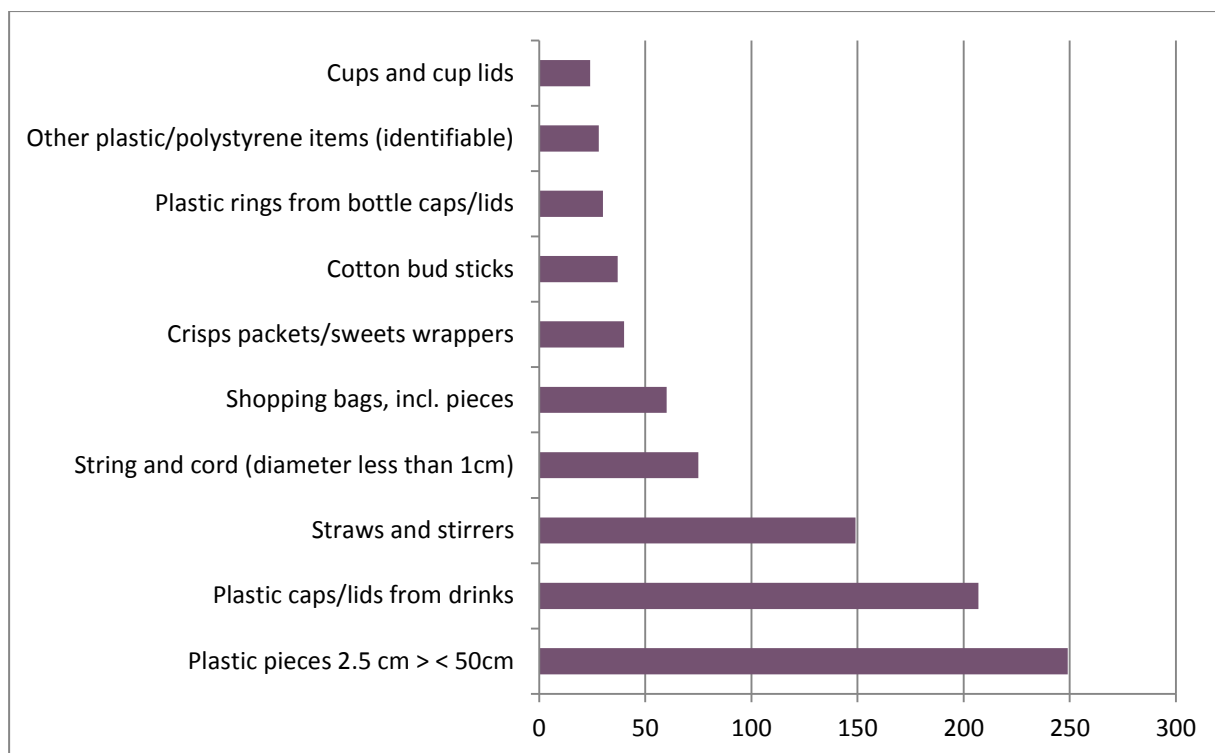


Figure 10-17. Top 10 items found at Lagonisi - Saronikos Gulf (Greece).

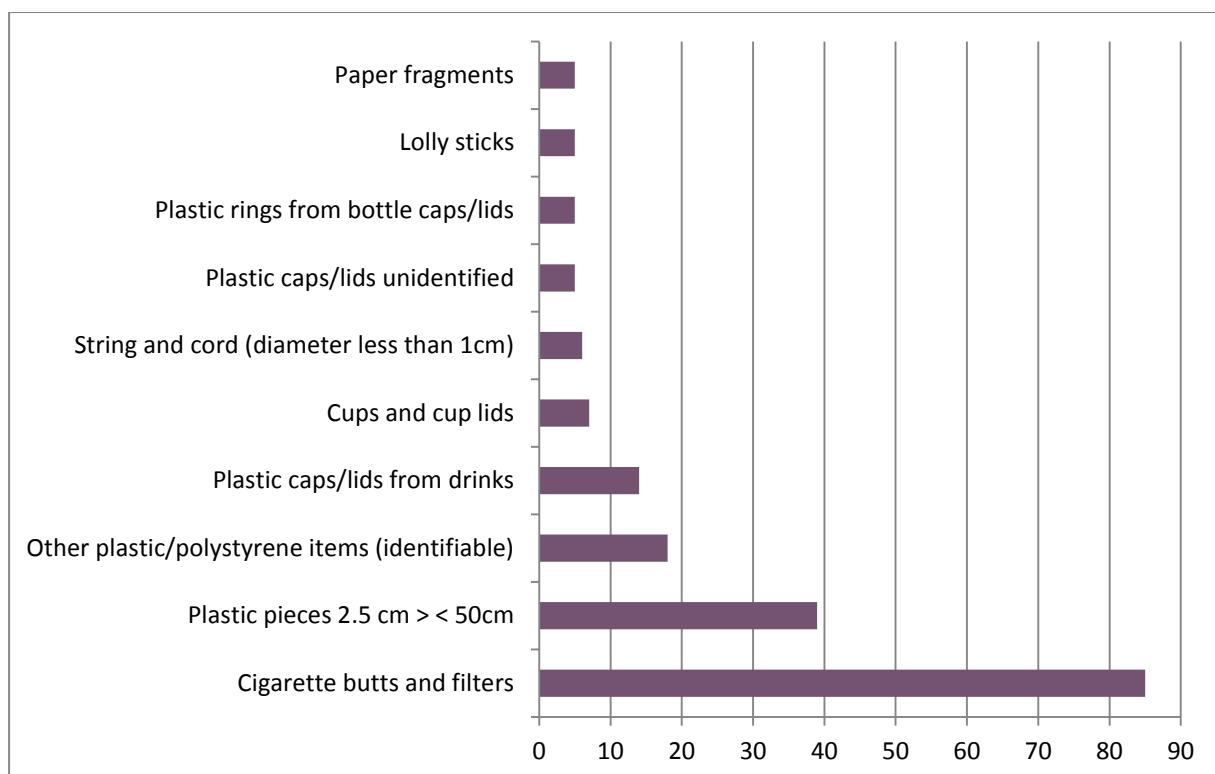


Figure 10-18. Top 10 items found at Almyros - Crete (Greece).

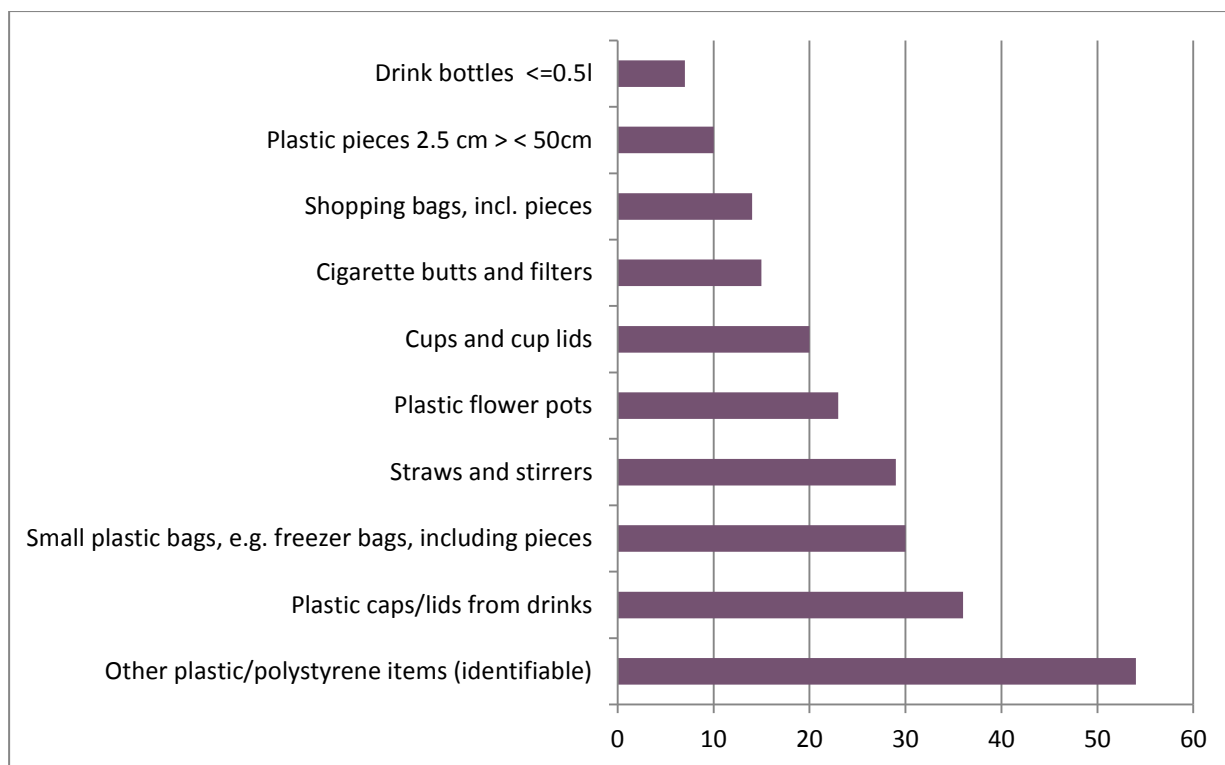


Figure 10-19. Top 10 items found at Ammoudara – Crete (Greece).

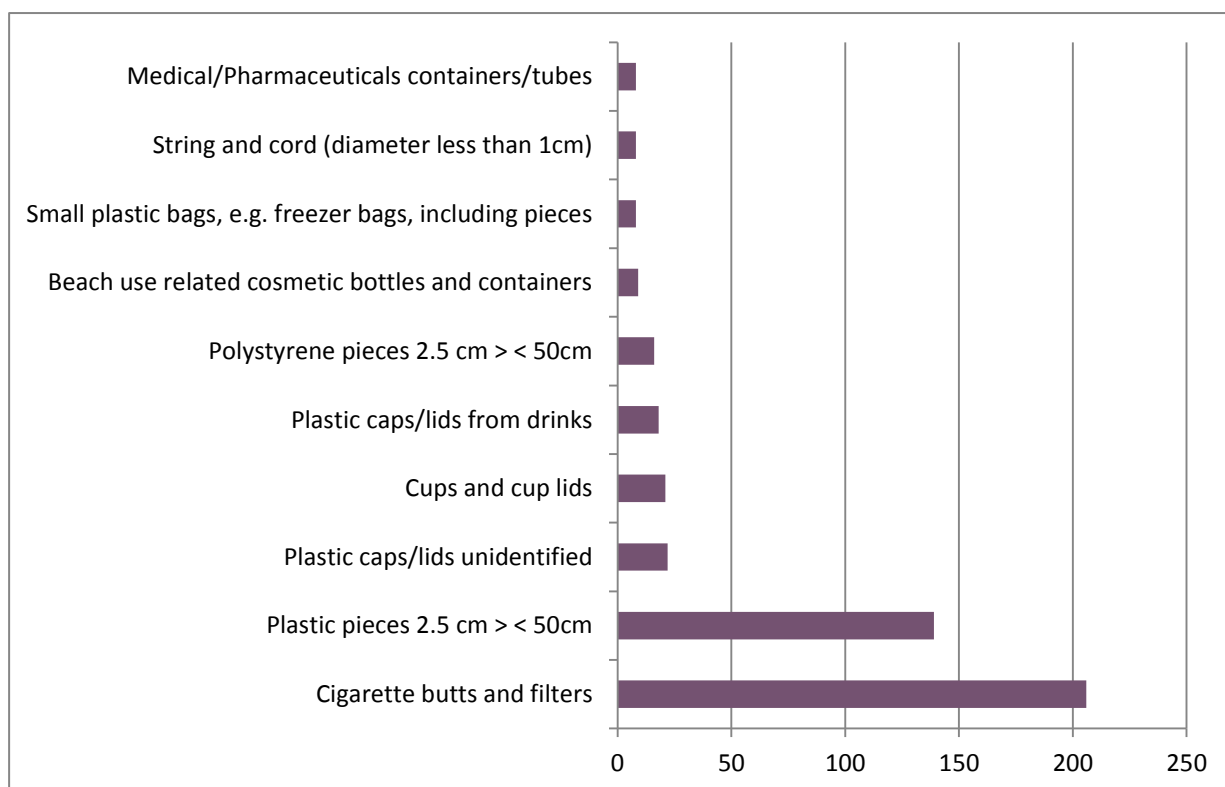


Figure 10-20. Top 10 items found at Navarchou Klearchou – Crete (Greece).

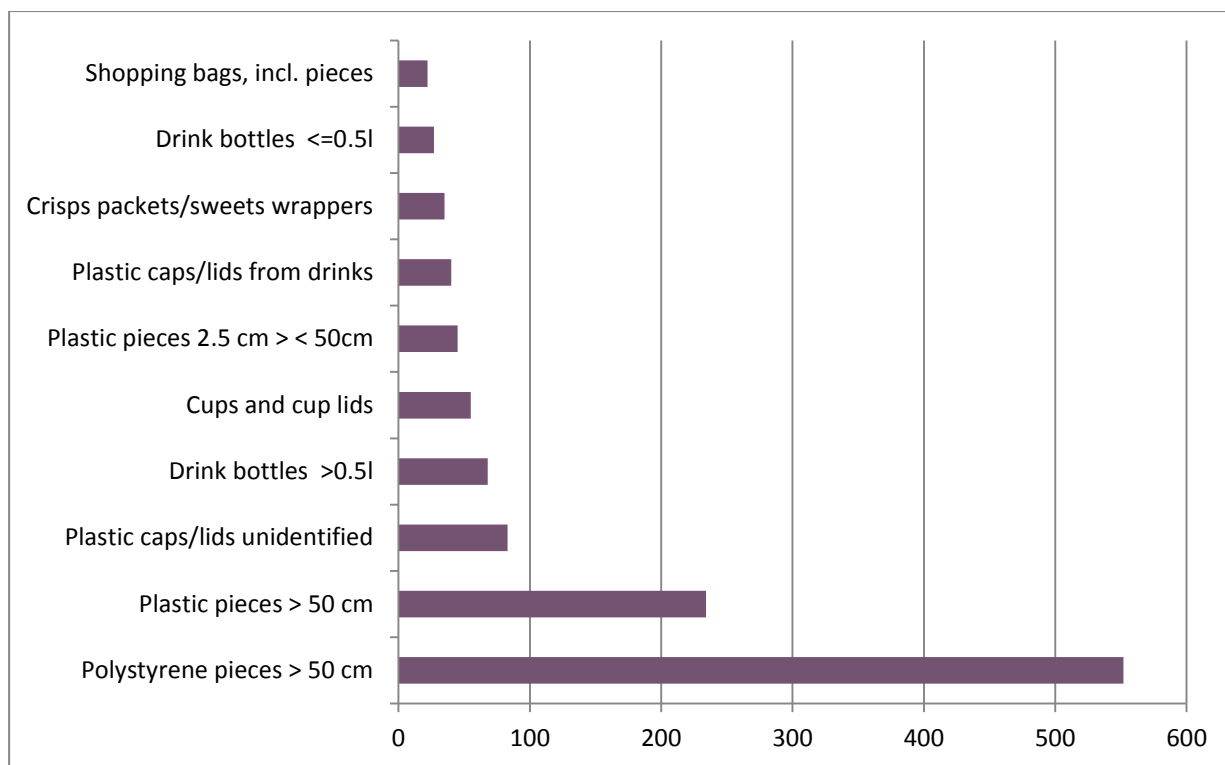


Figure 10-21. Top 10 items found at Bovo Marina (Italy).

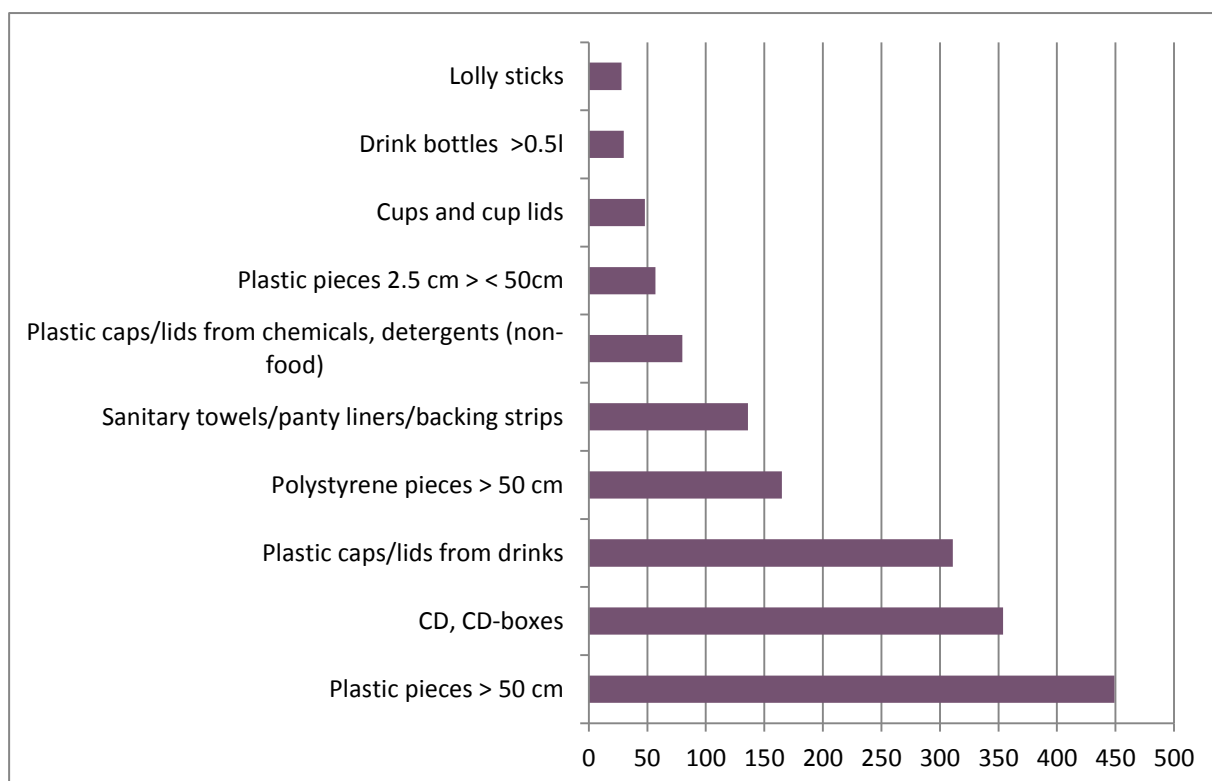


Figure 10-22. Top 10 items found at San Marco (Italy).

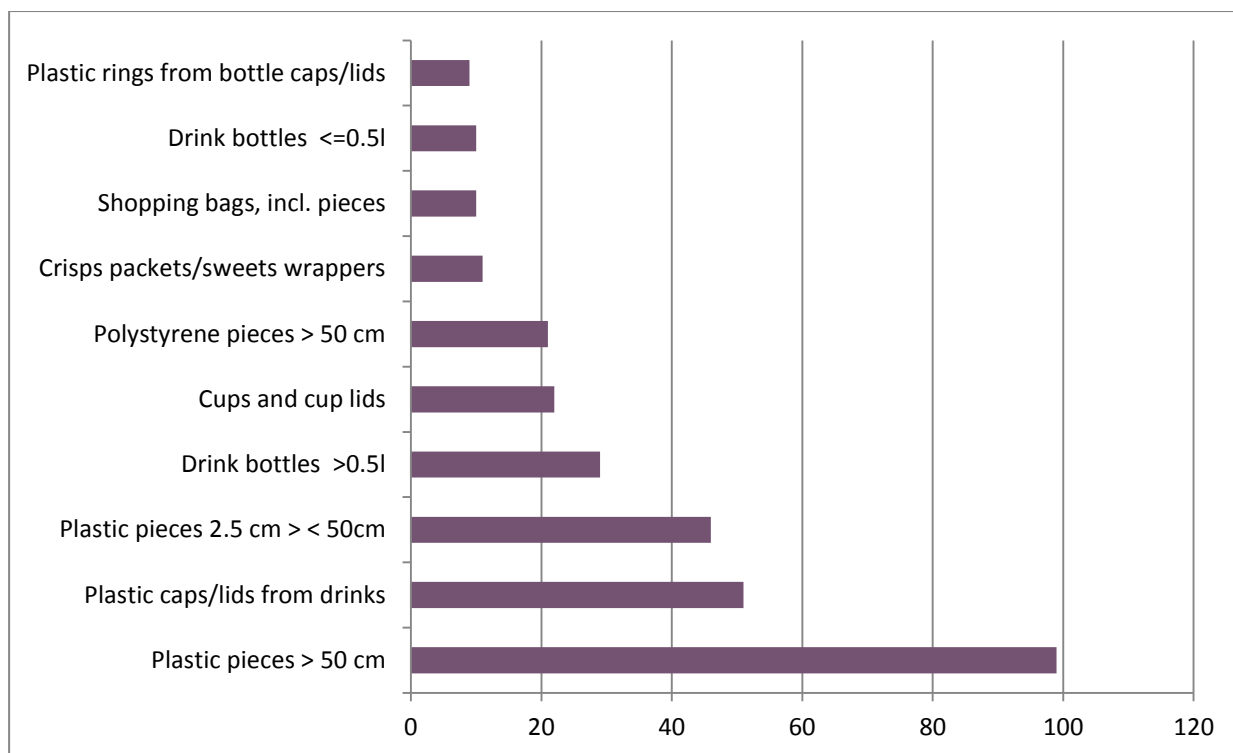


Figure 10-23. Top 10 items found at Siculiana Marina (Italy).

