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Marine Litter Watch (MLW)
European Beach Litter Assessment
2013–2019

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Marine Litter Watch (MLW) European Beach Litter Assessment Report was developed and written by Prof. Dr. Ahmet Kıdeyş (METU, Turkey) and Mustafa Aydın (EEA). The EEA Project Manager for the report was Mustafa Aydın.

The report is based on the work of the European Topic Centre for Inland, Coastal and Marine waters (ETC/ICM) in relation to the EEA Marine Litter Watch (MLW) project, and the data collected and reported by MLW communities and individuals. We thank all the MLW communities and individuals who provided beach litter data and contributed to the initiative for more than six years.

We acknowledge the review done by Dr Angel Borja (AZTI, Spain), EEA support and guidance by Stéphane Isoard, and also Peter Christian Kjeld for compiling/sending the raw data.

Key messages

- Marine litter, plastics in particular, is accumulating in European beaches and posing negative environmental, social and economic effects.
- The European Environment Agency (EEA) developed the Marine Litter Watch (MLW) initiative to strengthen Europe's knowledge base on beach litter and thus provide support to European polices; mainly the Marine Strategy Framework Directive and the Single Use Plastics Directive.
- The data used for the assessment (2013–2019) presents a good coverage of European seas, river and lake beaches.
- MLW data reflects that sea-beach litter appeared to increase steadily over the years. However, this steady increase was mainly caused by the excessively high values from the Black Sea. When data from the Black Sea was excluded, litter pollution increased until 2017, with a steady decrease afterwards.
- Among the four EU regional seas, the Black Sea appeared to have the most littered beaches (652 items/100 m) and the Baltic Sea the least polluted (78 items/100 m).
- The share of plastics was relatively low for the Baltic Sea beaches (about 61 %) compared to other seas (80–88 %). Excluding 2014 data, the share of plastics in total litter abundances for all seas was decreasing gradually over time.
- The Top 10 litter items were dominated by cigarette butts and filters, pieces of plastics, cotton bud sticks and plastic drinking cups/lids.
- The only fisheries-related item in the Top 10 litter items list was the string and cords group, which constituted its highest share in the North-East Atlantic Ocean.
- With a share of 66.1 %, the Black Sea revealed the highest rate of SUP, followed by the Mediterranean Sea (40 %). With a share of 12 %, fishery-related litter was highest in the north-east Atlantic.
- The median values from lake and river beaches (35 and 67 items/100 m, respectively) were lower than that obtained from the sea beaches (379 items/100 m). Therefore, MLW data demonstrates that rivers serve as a pathway in particular for plastic litter transport from land to sea, making sea-beaches one of the sink areas for anthropogenic litter.
- Although there were no clear distinctions with regards to average values and SUP, MLW 'monitoring' data displayed more accurate results compared to clean-up data for survey lengths (there were less outliers for 100 m protocol survey length). Besides, monitoring events more strictly used the proposed protocol and full beach litter items list, in addition to supervised collection and data registry.

1 Introduction

1.1 Negative impacts of beach litter

Litter, in general, plastics, in particular, is piling up in all aquatic systems (Schwarz et al., 2019). The most visible environmental effect of beach litter is entanglement, which can cause fatal outcomes for marine species, compromising the ability to capture and ingest food, sense hunger, escape from predators, and reproduce, as well as decreasing body condition and impairing locomotion (GEF 2012). Macro litter items can also be mistaken for food and ingested by fish, mammals, birds or turtles, which may cause severe health effects (Kühn and van Franeker, 2020). Litter at the beaches degrades to microplastics in time with sunlight and other environmental factors and can be ingested by marine species. A comprehensive study revealed marine litter in 100 % of marine turtles, 59 % of whales, 36 % of seals and 40 % of seabird species examined (Kühn, et al., 2015). Following ingestion, microlitter is transferred through the food chain. Ingestion of litter may cause loss of biodiversity and a reduction in overall ecosystem functions (GEF 2012).

Beach and seafloor litter cause injuries; a study in Australia reflects that 21.6 % of beach users received injuries from beach litter at designated 'clean' beaches (using the clean coast index, Alkalay et al. 2007) – approximately 1.69 kg of litter per beach), illustrating that even 'clean' beaches pose a threat (Marnie et al., 2016). Beach litter can fracture into micro-pieces in the water where swimmers can accidentally ingest it. Accumulation of microlitter, particularly microplastics, in the human body may adversely affect health. The extent of such effects is still unknown, and a precautionary approach should be taken (EC, 2019a).

In addition to its environmental and health impacts, beach litter also has socio-economic costs, mostly affecting coastal communities (Beaumont et al. 2019). To improve the touristic charm, communities and businesses must clean up the beaches before the start of the summer season (EEA, 2016). The theoretically estimated cost of keeping all 34 million km of global coastlines clean is 69 billion USD per year (UNEP, 2017), and this figure will continue to increase if littering does not stop.

1.2 The European policy response to tackle with marine litter

The EU has introduced numerous environmental policies and strategies to tackle the plastics pollution and marine litter. The EU Green Deal, 7th Environmental Action plan and the Circular Economy Action Plan, which aims to "close the loop" and requires the change and integration of EU legislation through a material-efficient economy and its Plastics Strategy are the overarching EU policies to curb plastic pollution and marine litter.

The Marine Strategy Framework Directive (MSFD) (2008/56/EC) is the primary legislation that addresses marine litter. One of the descriptors of MSFD "good environmental status" in European seas is marine litter. The Directive requires the EU Member States to ensure that, by 2020, "properties and quantities of marine litter do not cause harm to the coastal and marine environment". Besides, the Single-Use Plastics Directive (SUPD) (2019/904/EC) introduces a set of ambitious measures such as a ban on selected single-use products made of plastic (including cutlery, plates, straws, cups), measures to reduce consumption of food containers and beverage cups made of plastic, and specific marking and labelling of certain products as well as measures to deal with waste fishing gear containing plastic (EC, 2019b).

EU legislation has been moving towards an integrated and holistic approach for the solution of the problem in the last decade: Waste Framework Directive (2008/98/EC), setting measurable targets for recycling, the Waste Package, which amended the Waste Framework Directive, the Packaging Waste Directive and the Landfill Directive in line with the Circular Economy and Plastic Strategy objectives; Plastic Carrier Bags Directive (2015/720/EU) aiming to minimise the negative environmental effects of plastic bags and their contribution to littering; the proposed Registration Evaluation Authorisation, the Restriction of Chemicals (REACH) Regulation (EC 1907/2006) bringing restrictions and bans for microplastics and the recently adopted waste collection measures within the Port Reception Facilities Directive (2019/883/EU) are good examples of the integration of EU policies to tackle with the plastic pollution and marine litter problem.

1.3 How does MLW work?

Information and data on marine litter is essential for tackling this important environmental problem. The European Environment Agency (EEA) developed the Marine Litter Watch (MLW) mobile app, and the MLW has been collecting beach litter data since 2013 with the participation of pan-European organisations and communities. Communities are organised volunteer groups of citizens, such as NGOs, civil society associations and other kinds of informal groups.

We work in close collaboration with more than 40 pan-European community members such as Arhus University, Black Sea NGO Network, Blue Flag Global, EMBLAS+, ECOEMBES, HELMEPA, Keep Sweden Tidy, Legambiente, Marine Conservation Society, Mare Nostrum, MARNOBA, MIO-ECSDE, Plastic Change, Portuguese Association of Marine Litter, Roskilde University Surfrider Foundation Europe and Swiss Litter. Besides the European wide NGO's, the MLW database includes voluntary data entries from the EU Member States. The up to date information on seven years of beach litter collection efforts with the MLW can be found at: http://www.eea.europa.eu/themes/coast_sea/marine-litterwatch.

Figure 1: The working structure of the EEA Marine Litter Watch

1.4 The purpose of the MLW European Beach Litter Assessment

MLW aims to strengthen Europe's knowledge base on marine litter and thus provide support to European policymaking. The MLW database, populated by clean-up and monitoring events (see Section 2.2), includes data from the beaches of four regional seas (the Baltic Sea, the Black Sea, the Mediterranean Sea and the North-East Atlantic Ocean) as well as from rivers and lakes. Monitoring activities are presumed to report better quality data, and we tested this hypothesis in this report.

We present an assessment of the data collected by the EEA MLW initiative activities, held on the beaches of Europe's regional seas, lakes and rivers between 2013–2019. We also evaluated the shares of single-use plastics (SUP), fishery-related items and the Top 10 litter items to reveal the composition of the beach litter and to define its possible sources. We performed analyses to answer the following questions:

a) Does MLW data provide indications on beach litter trends from the European seas?
b) Are there differences in the amount and composition of beach litter among the regional seas?
c) Are there differences in litter composition from lakes, rivers and sea beaches?
d) Does MLW 'monitoring' data give more reliable results than clean-up data?

2 Methodology

2.1 Geographical scope and the dataset

All up to date information on litter collection efforts within MLW can be found at: http://www.eea.europa.eu/themes/coast_sea/marine-litterwatch. The MLW includes data from beaches of four regional seas (the Baltic Sea, the Black Sea, the Mediterranean Sea and the North-East Atlantic Ocean) as well as from several rivers and lakes.

The EEA MLW database analysed in this report covers the period of the 12th March 2013 – 31st December 2019 and includes a total of 3 370 surveys. After excluding duplicates, offshore areas, ports/canals, non-European areas and non-aquatic areas (forest, land, town, etc.), the MLW database presented 1 894 070 litter items from 3 012 surveys belonging to lake, river and sea beaches (Figure 2, Table 1).

It is worth mentioning that litter data from rivers play an essential role in assessing the sources of beach litter. Therefore, this report also included data analyses from river and lake beaches (in total 1138 surveys). However, the primary analyses were focused on data obtained from the sea beaches (in total 1884 surveys).

Figure 2: EEA Marine Litter Watch data locations between 12th March 2013 – 31st December 2019 (locations from outside the European area are not shown)

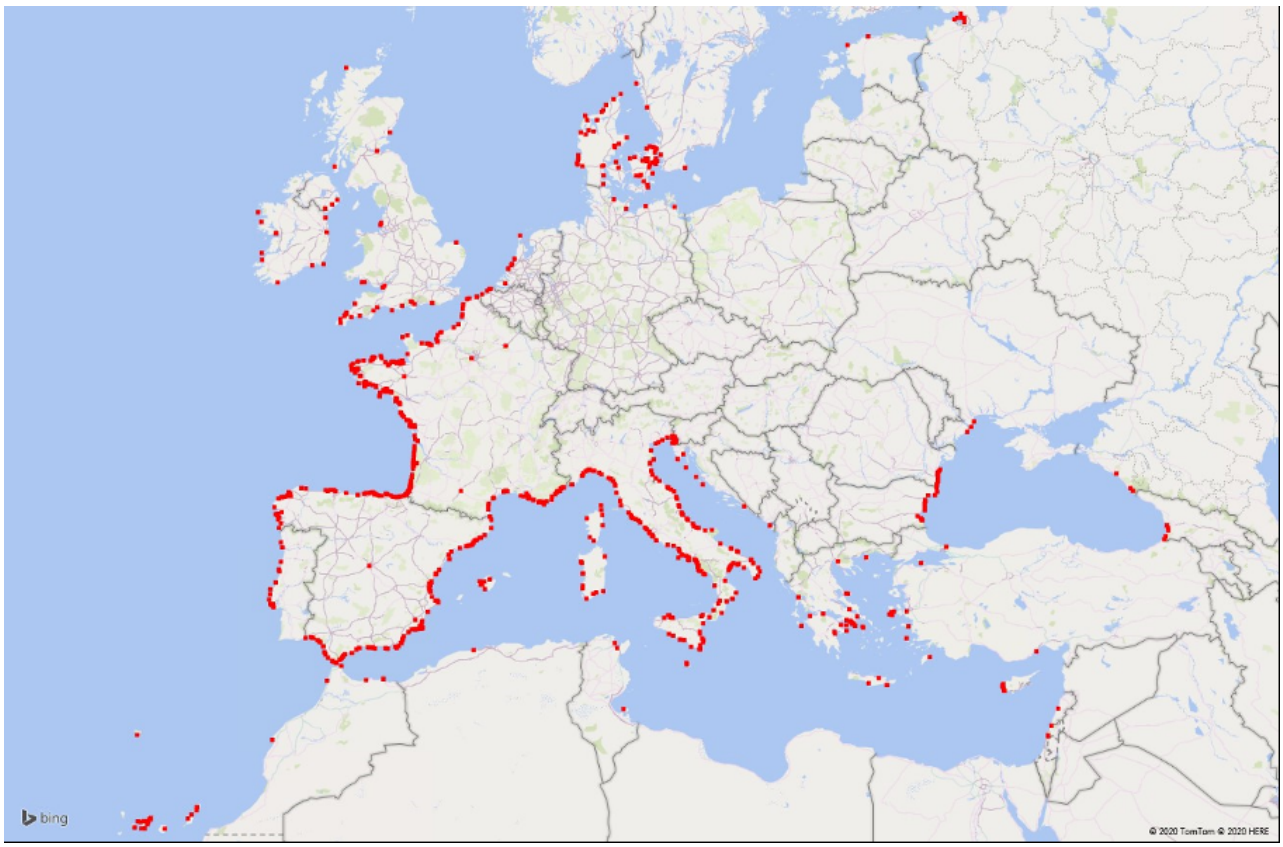


Table 1 Total surveys and total number of litter items reported in the EEA-Marine Litter Watch database between 12th March 2013 – 31st December 2019 (only European data from lake, river and sea beaches. Besides clean-up and monitoring, events that their type were not indicated were also included).

Sampling Area	Number of Surveys	Sum of Litter Items from All Beaches
European Lake-beaches	370	79 378
European River-beaches	758	193 747
European Sea-beaches	1 884	1 620 945
Total	**3 012**	**1 894 070**

In this report, analyses were performed on data from the sea beaches obtained either through clean-up or 'monitoring' events (in total 1 830 surveys, excluding events of which type not indicated). Monitoring activities are presumed to report better quality data and this hypothesis was also tested. The total number of monitoring surveys (640) was about half the number of clean-up surveys (1189 surveys; Table 2). Amongst the European regional seas, the highest numbers of clean-up and monitoring surveys were obtained from the Mediterranean which was followed by the north-east Atlantic communities whilst the lowest number of surveys pertained to the Baltic Sea (Table 2).

For the calculation of average values, when necessary, often median values (rather than means) were used for this report as suggested by Hanke et al (2019), to eliminate error caused by extreme values in the data set which are common with marine litter data.

Table 2 The number of surveys and litter items reported to the EEA-Marine Litter Watch for different types of events between 2013–2019 (only European data from sea beaches)

Database	Number of Surveys	Sum of Litter Items from All Beaches
Cleanup events	**1 189**	**1 026 503**
Baltic Sea	47	16 634
Black Sea	146	108 458
Mediterranean Sea	435	456 520
North-east Atlantic Ocean	561	444 891
'Monitoring' events	**640**	**496 048**
Baltic Sea	36	13 941
Black Sea	75	106 192
Mediterranean Sea	402	303 746
North-east Atlantic Ocean	127	72 169
Event type not indicated	**55**	**98 394**
Mediterranean Sea	**34**	**51 602**
North-east Atlantic Ocean	**21**	**46 792**
Total EU Sea-Beaches	**1 884**	**1 620 945**

2.2 Clean up vs 'Monitoring' events

There are two types of data collection events in the MLW: Clean-up (since 12th March 2013) and Monitoring (since 7th April 2014). While tables and figures in this report for all MLW data constitute the 2013–2019 time frame, monitoring data tables and figures constitute 2014–2019.

Except for some instances where countries provide their own official monitoring results to the MLW database, MLW monitoring data cannot otherwise be regarded as official monitoring data. Within the scope of the MLW initiative, the terms 'monitoring' event or survey are used to describe the data collected at preferably seasonal intervals from the same beach by the experienced MLW communities, fully using Methodology for Monitoring Marine Litter on Beaches (https://www.eea.europa.eu/themes/water/europes-seas-and-coasts/assessments/marine-litterwatch/get-started/how).

MLW monitoring methodology was first adopted by the DeFishGear Project (Vlachogianni et al. 2014) based on the "Guidance on Monitoring of Marine Litter in European Seas of the EU Marine Strategy Framework Directive – Technical Group on Marine Litter (MSFD-TGML, Galgani et al. 2013)", the "Guideline for Monitoring Marine Litter on the Beaches in the OSPAR Maritime Area (OSPAR, 2010)" 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 "UNEP/MAP MEDPOL Monitoring Guidance Document on Ecological Objective 10: Marine Litter". MLW monitoring events implement the "joint list" of EU MFSFD TGML (Galgani et al. 2013). On the other hand, clean-up surveys may not take MLW methodology fully into account and are typified by a relatively simple protocol and a reduction in the levels of standardisation required. Any individual or community might organise a clean-up at a beach and register the collected litter items using the MLW app.

Since 2016, MLW communities have been moving towards organising monitoring events, in order to provide more reliable information in support of relevant European policies.

3 Assessment

3.1 Does MLW data provide indications of trends of European beach litter?

MLW data reflects that sea-beach litter appeared to increase steadily over the years. However, when data from the Black Sea was excluded, litter pollution increased until 2017, with a steady decrease afterwards.

Excluding 2014 data, the share of plastics in total litter abundance demonstrated a gradual decrease.

3.1.1 Indications of trends for total abundance

A 6–7 year period of data collection may not be of adequate duration to infer trends in marine litter from beaches; however, evolutions in data were evaluated to realise annual changes. Annual median values per 100 m sea beach are shown in Figure 3 (for all seas combined) and Figure 3 (for each regional sea separately).

For the combined data, sea-beach litter is shown to increase steadily through the years with median values from 125 to 436 items per 100 m of beach (Figure 3). Spearman's rank correlation analysis showed that such an increase was statistically significant (Correlation coefficient 0.94, $P < 0.004$). When data were displayed separately for each regional sea (Figure 4), litter levels were generally observed to fluctuate through the years with no significant correlation ($P > 0.05$). The Black Sea, however, differed completely from the other seas as its litter content increased almost steadily over the years. Thus, high values from the Black Sea caused an overall increasing trend in beach litter on a European scale. When data from the Black Sea was excluded, litter pollution initially displayed an increase until 2017, after which a steady decrease was evident (Figure 5).

Figure 3: Evolution in median beach litter numbers (per 100 m of beach) for all regional seas combined, between 2014–2019 (data only from monitoring)

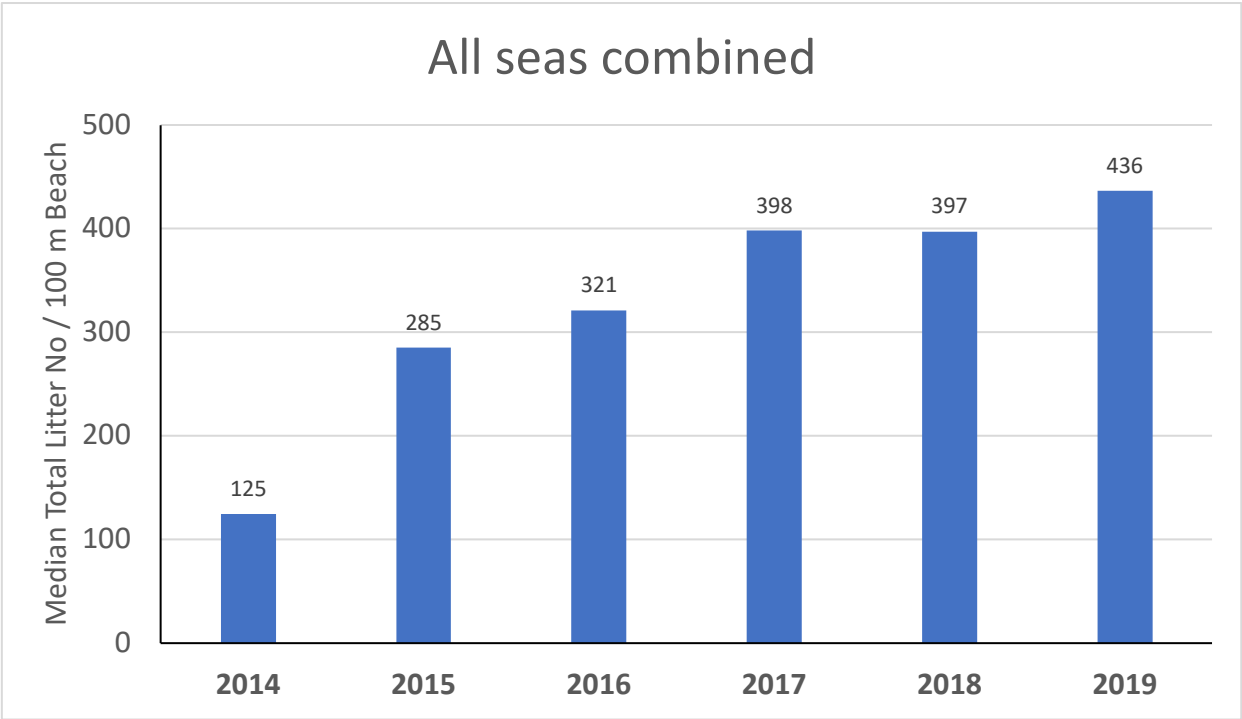
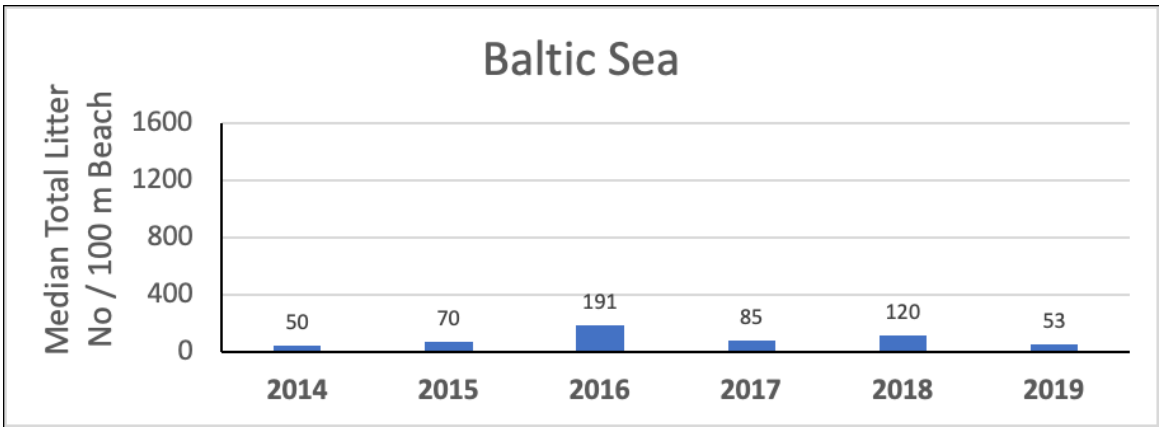
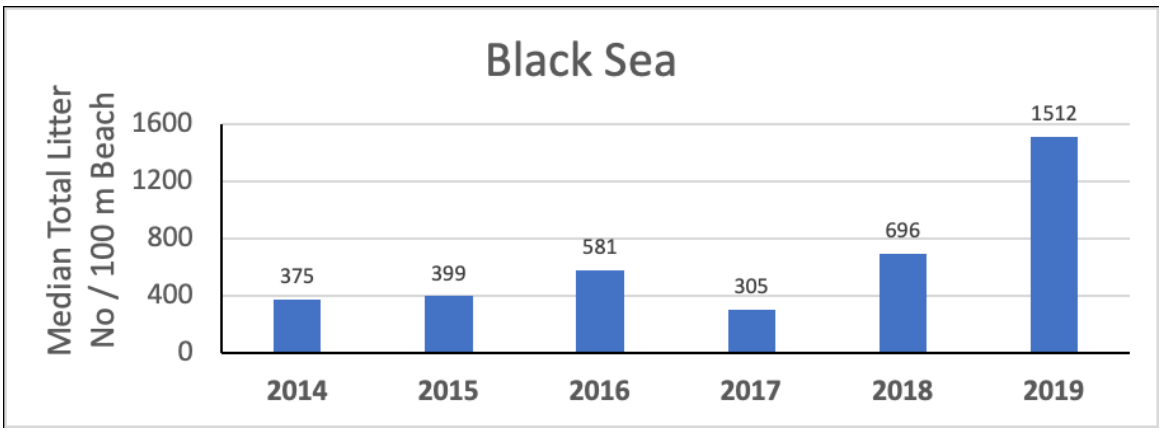
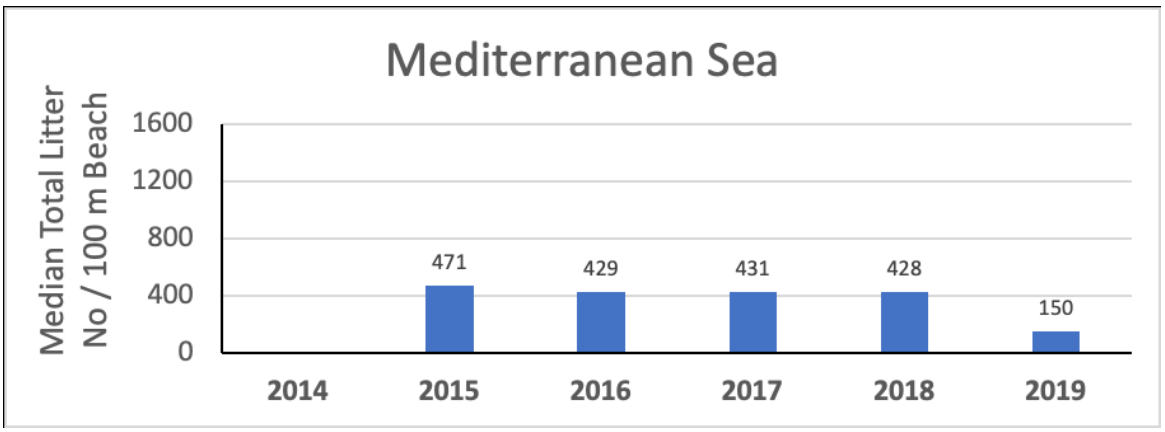


Figure 4: Evolution in median beach litter numbers (per 100 m of beach) for the four regional seas, between 2014–2019 (monitoring data only)







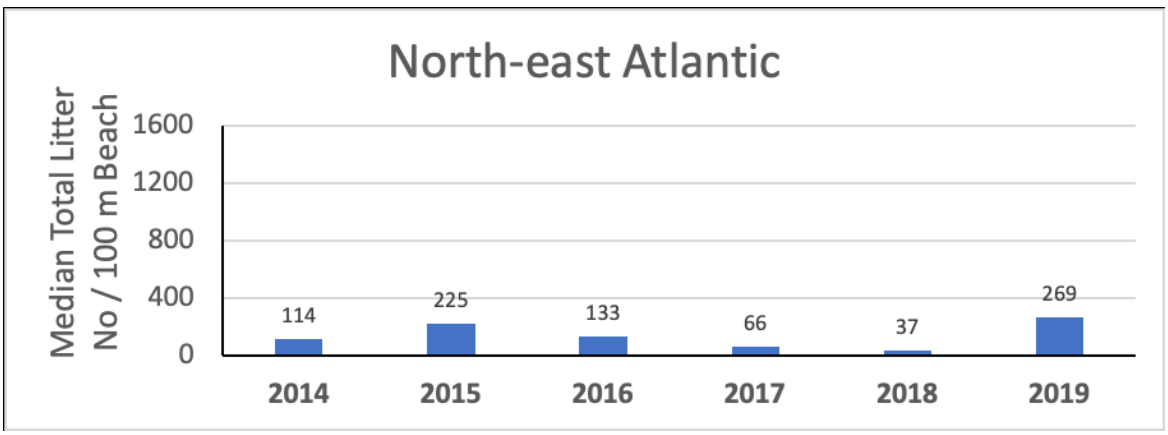
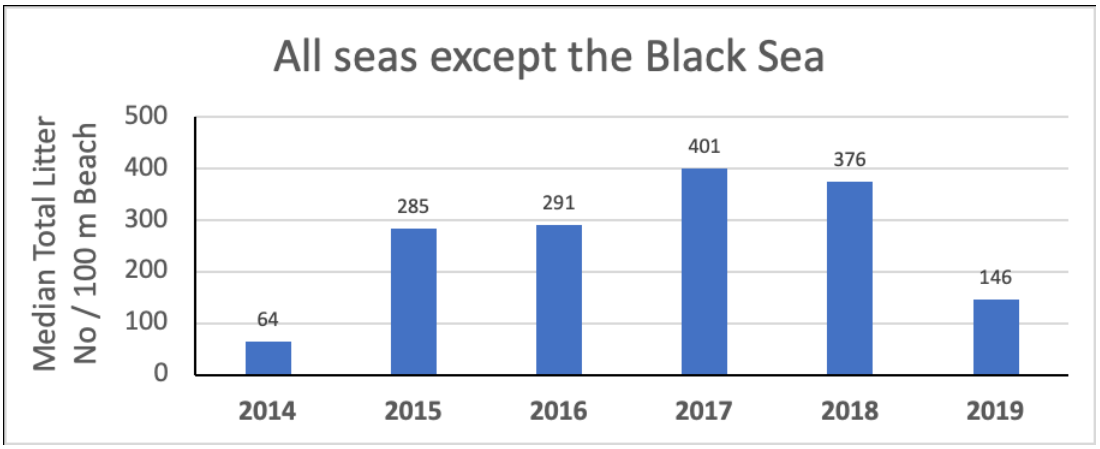


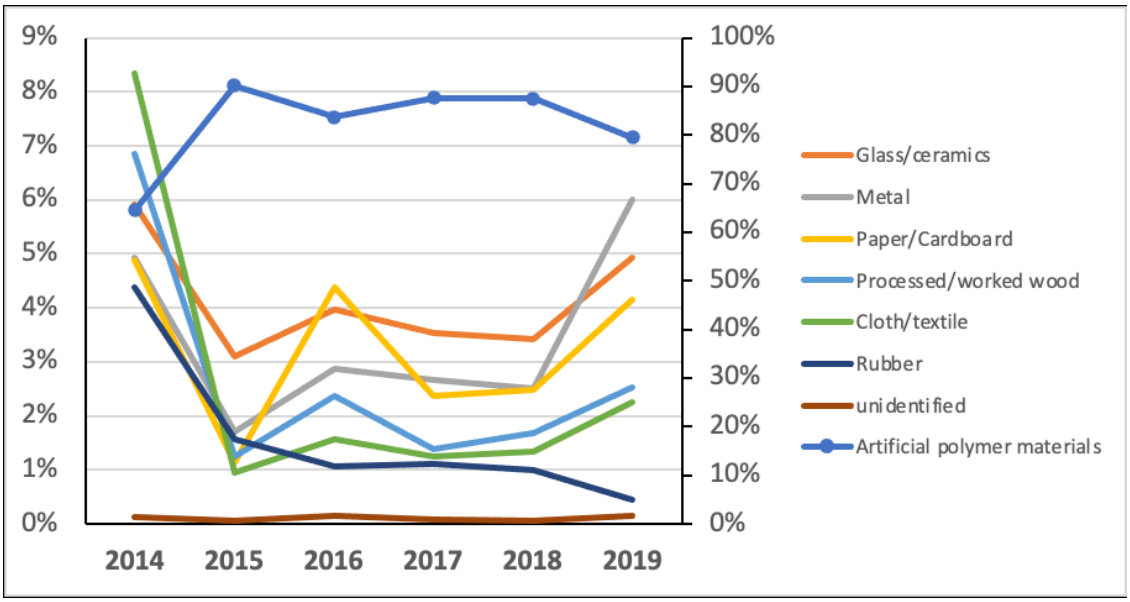
Figure 5: Evolution in median beach litter numbers, using European data for the three regional seas combined (Baltic, north-east Atlantic and the Mediterranean), between 2014–2019 (monitoring data only)



3.1.2 Indications of trends for litter categories

Annual data for MLW categories, for all EU sea beach data, are shown in **Figure 6**. Excluding 2014 data, the share of plastics in total litter abundance demonstrated a gradual decrease, whilst the majority of remaining categories increased through the years.

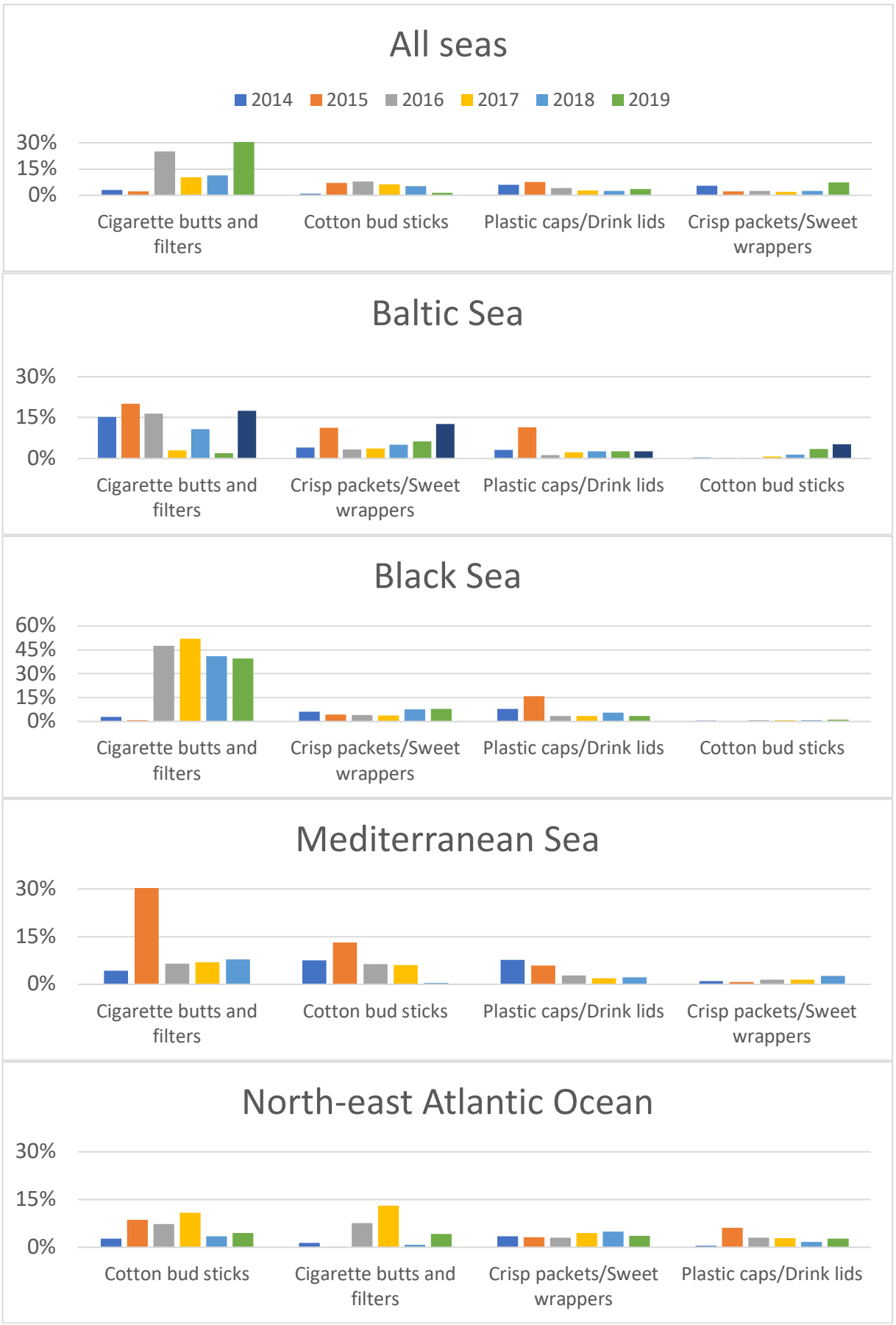
Figure 6: Percentage of different litter categories between 2014–2019 (EU sea-beach data, monitoring only, paraffin excluded; Y-axis on the right for the Artificial polymer materials/plastics only)



3.1.3 Indications of trends for Top 10 items

Annual evolution of specific items is shown in Figure 7 for the European sea beaches based on monitoring data, between 2014–2019. As seen in this figure, changes in percentages of these selected items were not uniform across the regional seas. When all regional seas were combined, after 2017, decreasing values in the share (as well as in absolute numbers) of cotton bud sticks were apparent.

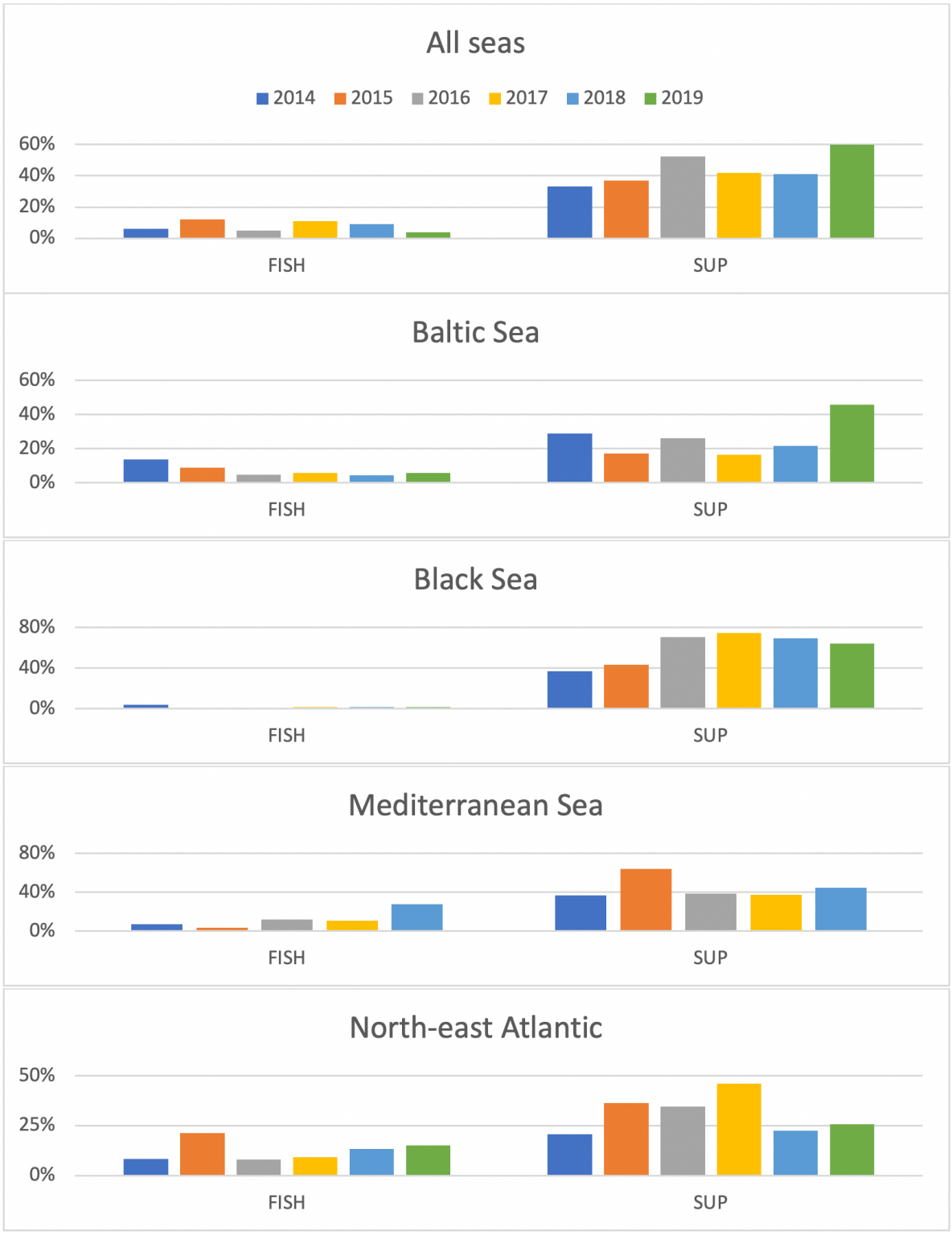
Figure 7: Annual evolution in some of the Top Ten Items of litter collected from EU sea beaches between 2014–2019 (monitoring data only, paraffin excluded)



3.1.4 *Indications of trends for total SUP and total fisheries related items*

No clear patterns in the inter-annual distribution of SUP and fishing-related items were detected for all European seas. However, fishing-related items reflected a decrease in the Baltic Sea since 2014. In contrast, fishing-related items were increased in the North-East Atlantic Ocean and the Mediterranean Sea since 2015. A slight decrease in abundance of SUP was observed in the Black Sea since 2017 (Figure 8).

Figure 8: Annual evolution in the percentage of Single-Use Plastics (SUP) and fishing-related items collected from European sea beaches, between 2014–2019



3.2 Are there differences in abundance and composition of beach litter among the regional seas?

Among the four EU regional seas, the Black Sea appeared to have the most littered beaches (652 items/100 m) and the Baltic Sea the least polluted (78 items/100 m).

The share of plastics was relatively low for Baltic Sea beaches (about 61 %) compared to other seas (80–88 %).

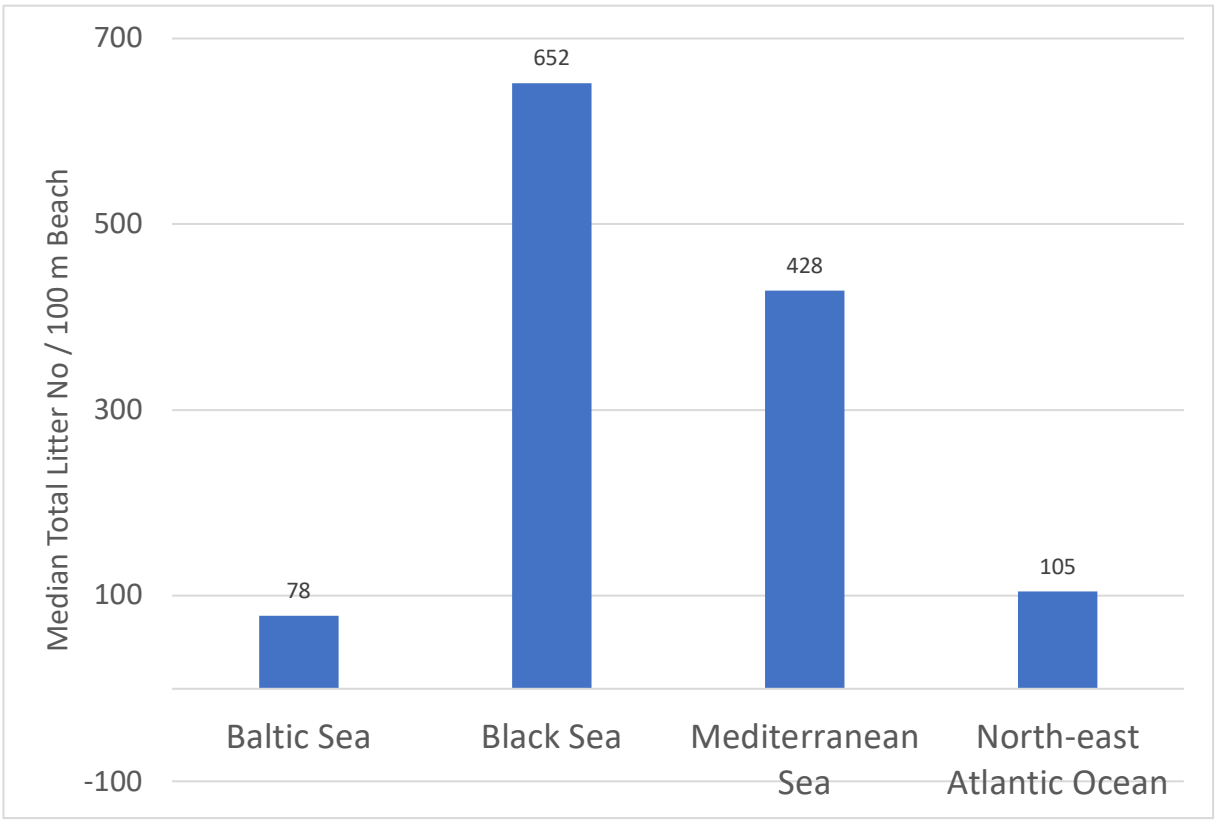
The Black Sea revealed the highest rate of SUP (66.1 %), followed by the Mediterranean Sea (40 %). Fishery-related litter was highest in the north-east Atlantic.

3.2.1 Regional differences for total abundance

Among the four EU seas, Mediterranean beaches displayed the highest number of monitoring surveys (402), followed by the north-east Atlantic (136 surveys), Black Sea (75 surveys) and the Baltic Sea (36 surveys).

The Black Sea beaches appeared as the most littered (with a median value of 652 litter items per 100 m) and the Baltic Sea the least polluted (with a median value of 78 litter items per 100 m) (Figure 9). Hanke et al. (2019) also found the Baltic Sea having a minimum median total of abundance values. However, the medians from the North-east Atlantic and the Mediterranean Sea surpassed the Black Sea for the 2015–2016 period. Comparison of median values with some other data which use mean values as the average proves difficult. The overall mean value found for the southern Black Sea was reported as 275 litter items/100 m for 2009 (Topçu et al. 2013). However, a much higher average value of 3 798 litter items/100 m was found for 2016/2017 from the same region (Aytan et al. 2020) which is higher than our average value of 1 416 litter items/100 m for the 2014–2019 period covering the entire Black Sea.

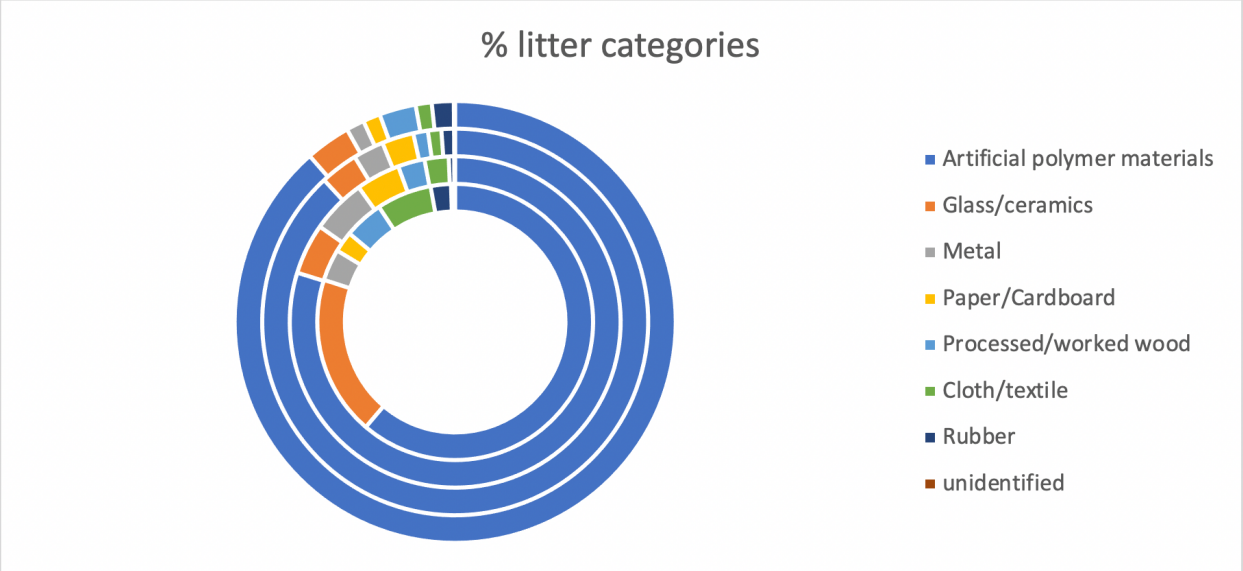
Figure 9: Comparison of litter numbers for beaches of different EU regional seas between 2014 –2019 (only European monitoring data from sea beaches)



3.2.2 *Regional differences for litter categories*

Extremely high values of paraffin data were collected by Aarhus University, especially in 2016, and hence paraffin was excluded from comparisons of litter composition for regional seas. Even after this exclusion, the percentage share of plastics was relatively low for Baltic Sea beaches (about 61 %) compared to other seas (79–88 %) (Figure 10).

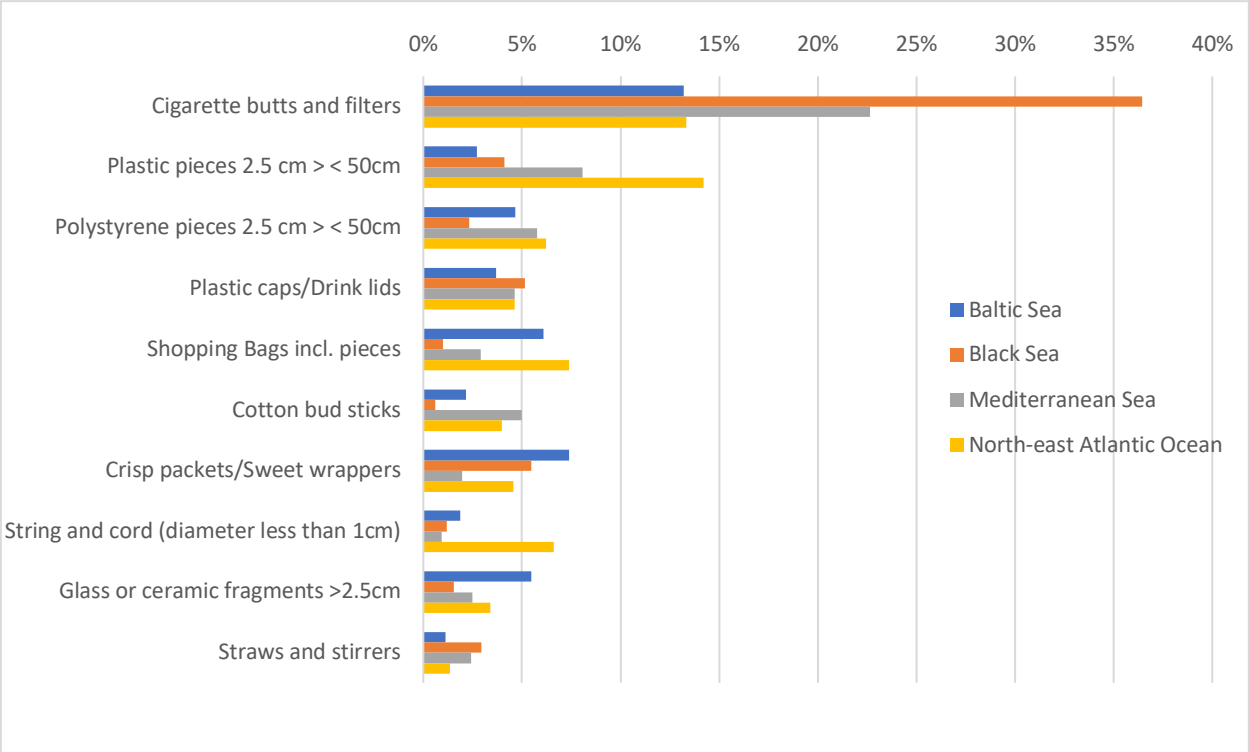
Figure 10: Percentage comparison of different litter categories (based on total litter items per beach values) among European regional seas between 2014–2019. (monitoring only, paraffin excluded) (inner to outer circles: Baltic Sea, Black Sea, Mediterranean and north-east Atlantic)



3.2.3 *Regional differences for the Top 10 Items*

Striking differences were apparent in relative shares of different litter items among the regional seas for the period 2014–2019 (Figure 11) obtained from monitoring events. The rations of cigarette butt and filters were much higher for the Black Sea (36.4 %) and the Mediterranean Sea (22.6 %), compared to those for the north-east Atlantic and the Baltic Sea (both 13.2 %). Araujo and Costa (2019) reported that the percentage share of cigarette butts/filters could be as high as 58 % from beaches globally. The pieces of plastics or polystyrene group together were the second most abundant category for all seas except in the north-east Atlantic where they were dominated. With a range of 3.7–5.1 %, the share of plastic drinking cups/lids was notable for all the regional seas. The only fisheries related item in the top ten items list was the string and cords group which constituted the highest share in the north-Atlantic. This could be due to intensive fishing operations there compared to other regional seas.

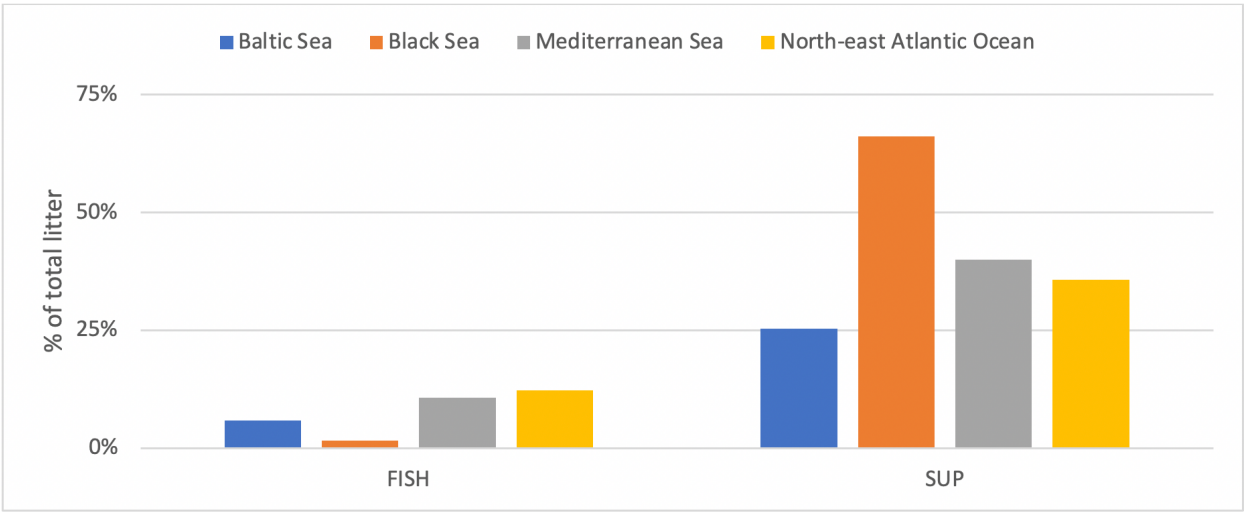
Figure 11: Comparison of the top ten items of litter collected by the regional sea beaches between 2014–2019 (monitoring data only, paraffin excluded)



3.2.4 Regional differences for total SUP and total fisheries related items

With a share of 66.1 %, the Black Sea presented the highest value for SUP among the regional seas followed by the Mediterranean Sea (40 %) (Figure 12). Similar to top ten litter items results, with a share of 12.2 %, fishing-related litter was highest in the north-east Atlantic but lowest in the Black Sea (1.6 %), among the regional seas. Despite being among the major fishing areas of Europe, the fishing-related litter also demonstrated a very low share (0.5 %) in 2009 from the southern Black Sea (Topçu et al. 2013).

Figure 12: Comparison of regional seas for SUP and fishing-related items collected from European sea beaches between 2014–2019 (European monitoring data only)



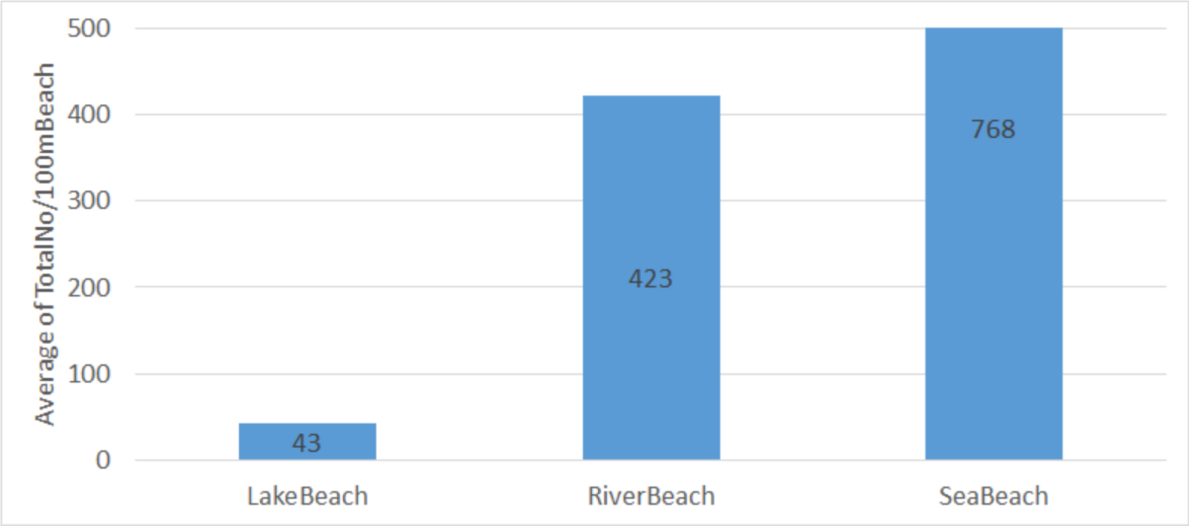
3.3 Are there differences in abundance and composition of beach litter from lakes, rivers and seas?

3.3.1 Sea, lake and river beach litter differences for total abundance

The median averages from lake and river beaches (35 and 67 items/100 m, respectively) were lower than that obtained from the sea (379 items/100 m). Therefore, MLW data demonstrates that rivers serve as a pathway in particular for plastic litter transport from land to sea, making sea-beaches one of the sink areas for anthropogenic litter.

Only the monitoring data was used for investigating spatial differences in total amounts of litter from the European lake, river and sea beaches. The number of surveys from monitoring activities were conducted mainly for sea beaches (643 surveys) compared to the low number of surveys from rivers (6) or lakes (only 3). The use of median values for smaller samples (as low as 3) would be biased. Therefore, arithmetic averages rather than median averages were used for the intercomparison of beaches lakes, rivers and seas (Figure 13). Average total litter number per 100 m of beach from lakes (43 items) and rivers (423 items) were much lower than those obtained from the sea beaches (768 items). The t-test statistical analysis with unequal variances showed that values from the river and sea beaches differed significantly ($P < 0.001$).

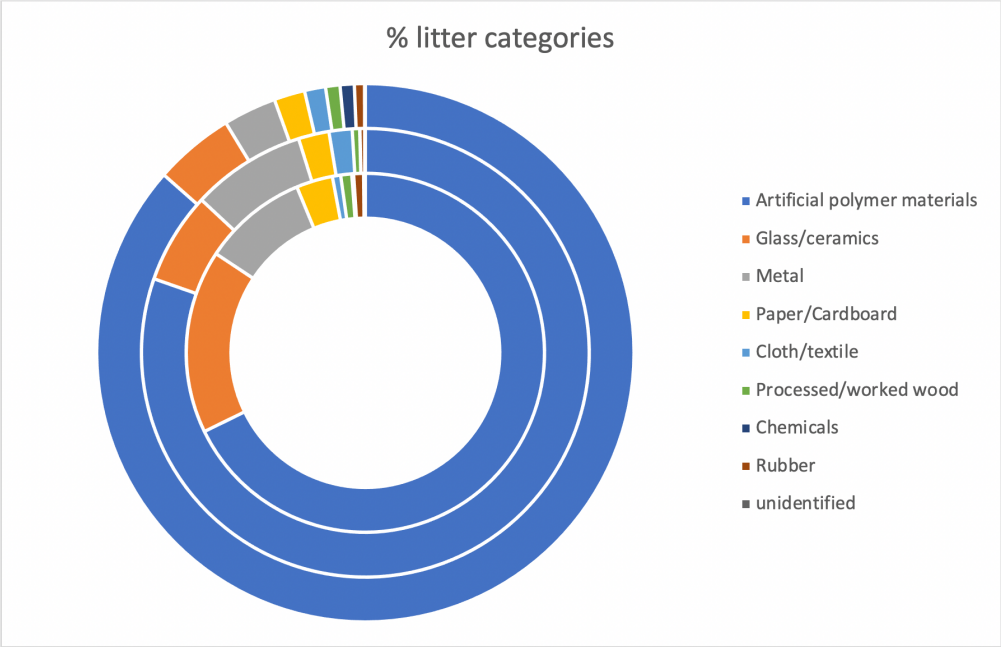
Figure 13: Comparison of average values for litter numbers per 100 m of beach among beaches of different water systems (i.e. river, lake and sea) between 2014–2019 (only European monitoring data)



3.3.2 Sea, lake and river beach litter differences for relative shares of litter categories

Among litter types, plastics were the dominant category in all water systems, with the highest percentage occurring at sea beaches (86.8 %), based on combined data from clean-up and monitoring (Figure 14). Compared to seashores, river and lake beaches displayed lower shares of plastics (79.7 % and 67.9 % of total debris, respectively) but revealed higher levels of glass/ceramics and metal litter. This indicates that these latter categories due to relatively heavier weights, may tend to remain/sink within freshwater systems, being the original source of deposition, contrary to drifting to the sea.

Figure 14: Percentage comparisons of different litter categories (based on total litter numbers per beach values) among European beaches of lakes (the inner circle), rivers (middle circle) and sea (outer circle) between 2013–2019 (blank, clean-up and monitoring data combined)



3.4 Does MLW monitoring data give more reliable results compared to clean-up data?

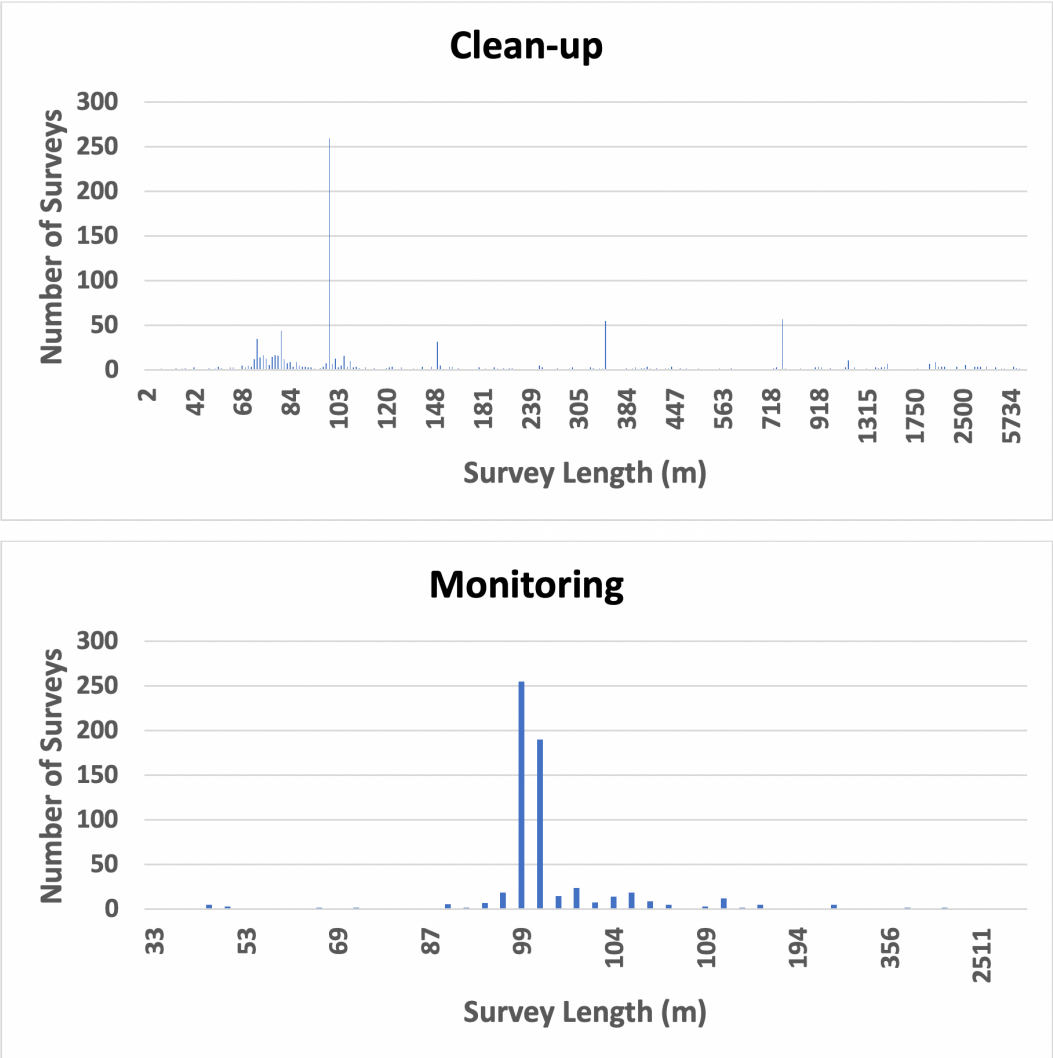
Although there were no clear distinctions with regards to average values and SUP, MLW 'monitoring' data displayed more accurate results compared to clean-up data for survey lengths (there were less outliers for 100 m protocol survey length). Besides, monitoring events used the proposed protocol and full beach litter items list more strictly, in addition to supervised collection and data registry.

3.4.1 Comparison of monitoring and clean-up results for survey lengths

Although the preferred sampling length for each survey is given as 100 m in the *MLW – Methodology for Monitoring Marine Litter on Beaches*, survey lengths in the MLW database exhibited a wide range. Survey lengths for the monitoring events displayed a more comprehensive range (33–3 443 m) compared to those for clean-up events (1–33 932 m). From Figure 15 it is clear that the four clean-up event surveys with lengths of less than 10 m and two of the longest surveys (10 000 and 33 392 m) are clear errors in clean-up events. Hanke et al (2019) found that the type composition and abundances of marine litter from survey lengths of 90 to 850 m are reasonably comparable. In the MLW database, whilst only 28 surveys exceeded this range for monitoring data, a total of 468 surveys were classified as outliers for the clean-up data.

Moreover, in comparison with clean-up events, the monitoring data points are more closely accumulated around the 100 m survey length (Figure 15) as requested by the MLW. Whilst the average mean value of survey lengths was 121 m (with a standard deviation of 213 m) for the monitoring data, the corresponding average length for the clean-up data measured was 502 m (with a standard deviation of 1 319 m). At least as far as survey length data, the more plausible range and closer values to the 100 m survey length as requested by the MLW for the monitoring event data present a good indication of its better quality data, standardisation and possibilities of comparison compared to figures obtained from the clean-up events. The outcome of maintaining required standardisation and accuracy of survey lengths is that litter data expressed per unit length (such as per 100 m) can be reliably used for comparative analyses between different regions or periods, monitoring data will thus display more accurate results compared to clean-up data.

Figure 15: Survey length-frequency distributions of clean-up and monitoring events from the MLW database between 2013–2019 (only European data from sea beaches, total 1 189 clean-up and 640 monitoring surveys)



3.4.2 Comparison of monitoring and clean-up results for average values of litter

The standard deviations of average values of litter from either clean-up or monitoring events, when expressed per beach or per 100 m of beach, are relatively high (**Table 3**). Although the average number of total litter items per beach for the clean-up surveys was higher than for monitoring (863 vs 775 items/beach, respectively), the reverse situation was the result when data were normalised per 100 m of beach: 547 items/100 m of beach for clean-up and 771 items/100 m of beach for the monitoring. When comparisons were made for the median values, as suggested by the TG-ML group recently (see Hanke et al. 2019), monitoring surveys presented higher results than that of clean-up, for both cases (per beach or 100 m length of beach comparisons (Table 3). By decreasing the weight of too low and high values in the samples, primarily caused by possible error as the reporting of incorrect survey lengths (more probable for the clean-up surveys), the use of median values produces more accurate results. Based on median values, monitoring data was found to yield 1.9 fold higher values than clean-up data. However, the t-test statistical analysis with unequal variances did not show any significant difference between clean-up and monitoring for the abundance values per 100 m of beach length (t-stat 1.3, P = 0.19). This indicates that for the total abundance per 100 m of beach length, values could be still combined. However, for most of the analyses below, only monitoring data is used in this report to decrease the level of uncertainty.

Table 3 Comparison of litter values for clean-up and monitoring events between 2013–2019

Values	Clean-up	Monitoring	Total
Count of Survey (No)	1 189	640	1 829
Sum of Total Litter Items from all beaches	1 026 503	496 048	1 522 551
Average of Total Litter Items/beach	863	775	832
StdDev of Total Litter Items/beach	1 676	1 183	1 522
MedianTotal Litter Number/Beach	353	393	365
Average of Total Litter Items/100 m beach	547	771	625
StdDev of Total Litter Items/100 m beach	1 051	1 203	1 111
MedianTotal Litter No/100 m Beach	197	379	248

3.4.3 Comparison of monitoring and clean-up results for different litter categories and Top 10 items

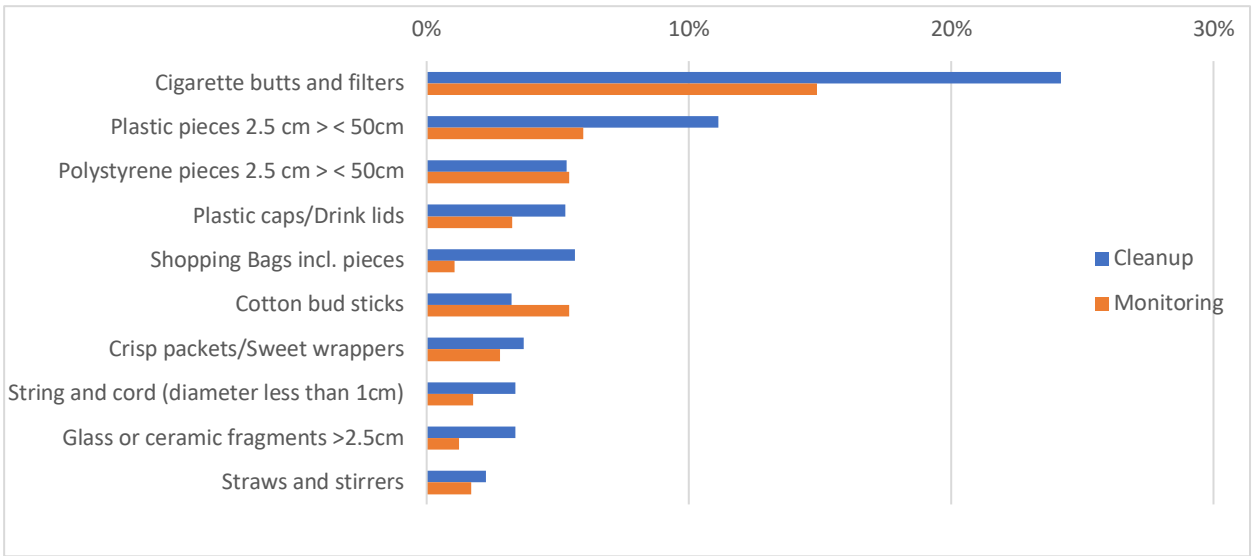
Compared to monitoring, clean-up events collected slightly higher percentages of plastics (87.1 % vs 83.7 %), glass/ceramics (5.7 % vs 3.6 %) and metal (3.4 % vs 2.9 %), respectively (**Table 4**).

Table 4 Percentage comparisons of different litter categories (based on total litter per beach values) FOR clean-up and monitoring events from European sea beaches between 2013–2019

Litter Category	Cleanup (%)	Monitoring (%)	Total (%)
Plastics	87.1	83.7	86.0
Glass/ceramics	5.7	3.6	5.0
Metal	3.4	2.9	3.2
Paper/Cardboard	1.6	2.8	2.0
Cloth/textile	1.2	1.4	1.3
Processed/worked wood	0.5	1.7	0.9
Chemicals	< 0.1	2.8	0.9
Rubber	0.5	1.0	0.6
Unidentified	< 0.1	0.1	< 0.1
Total	**100**	**100**	**100**

The Top Ten items list (Table 4) is overall rather similar to that reported for the European scale (Addamo et al. 2017). Although there was a general similarity in the Top Ten Item lists compiled for clean-up and monitoring events, they differed in terms of relative shares of certain litter items; for example, clean-up events collected more cigarette butts and filters, shopping bags or glass/ceramic pieces compared to monitoring (Figure 16).

Figure 16: Comparison of monitoring and clean-up data for the Top Ten Items of litter collected from European sea beaches between 2013 and 2019

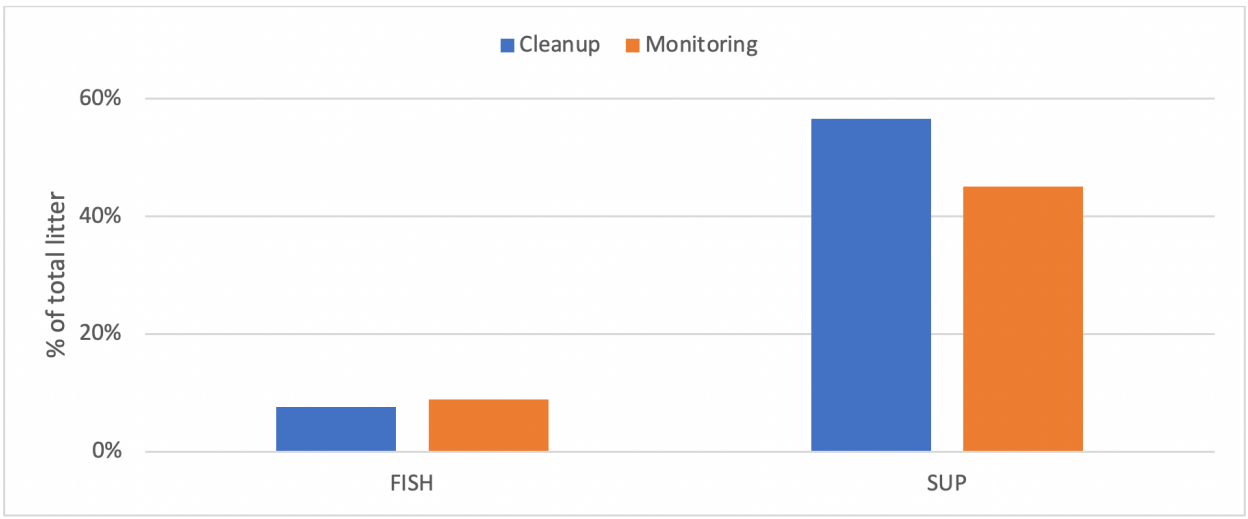


3.4.4 Comparison of monitoring and clean-up results for SUP and fishery-related items

Percentage shares of fishing-related items were relatively close to each other between clean-up and monitoring surveys (about 8 % vs 9 %, respectively). However, clean-up collected somewhat relatively higher amounts of SUP compared to monitoring (about 57 % vs 45 %, respectively, Figure 17).

Overall, few differences were identified between outcomes of clean-up and monitoring analyses apart from certain aspects whereby monitoring surveys appeared to collect more accurate data.

Figure 17: Comparison of monitoring and clean-up data for Single-Use Plastics (SUP) and fishing-related items collected from European sea beaches between 2013 and 2019



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