

D3.4.4

Seasonal concentration and characterization of marine litter in selected beaches of 8 Mediterranean islands

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Part B: GENERAL INTRODUCTION

I. The marine litter

Despite international, national and local regulations (e.g. ANZECC, 1996a; GESAMP, 2001; Kiessling, 2003), the level of manufactured litter lost or deliberately discarded into the world's seas and oceans is substantial and represents a growing threat to marine environments, industries and economy (e.g. ANZECC, 1996a, b; Barnes, 2002; Kiessling, 2003). Marine litter is now present in every ocean (Cheshire et al., 2009) and is defined as *“any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment. Marine litter consists of items that have been made or used by people and deliberately discarded into the sea or rivers or on beaches; brought indirectly to the sea with rivers, sewage, storm water or winds; accidentally lost, including material lost at sea in bad weather (fishing gear, cargo); or deliberately left by people on beaches and shores.”* (UNEP, 2005).

The problem of marine litter was recognized by the U.N General Assembly (UNGA), which in its Resolution A/60/L.22 (Nov. 2005) calls for national, regional and global actions to address the problem of marine litter. This resolution notes the lack of information and data on marine debris, encourages States to develop partnerships with industry and civil society, urges States to integrate the issue of marine debris within national strategies dealing with waste management; encourages the development of appropriate economic incentives to address this issue, and encourages states to cooperate regionally and sub-regionally to develop and implement joint prevention and recovery programs for marine debris. Only few regions and countries have taken some steps to address the marine litter issue but despite these efforts there are indications that the marine litter problem keeps growing.

Marine litter is found and accumulates in shorelines, sea floor and water column of all the oceans of the world, from densely populated regions to remote places far away from any obvious sources (e.g. Haynes, 1997; Convey et al., 2002). It has been estimated that 80% of marine litter is from land-based sources and the remaining 20% is from ocean based sources. There are four major groups of marine litter sources: tourism related litter at coast, sewage-related debris, fishing related debris and waste from ships and boats (Allsopp et al., 2006). To these may be added poor or inadequate waste management (Sheavly, 2005), items disposed illegally, improper disposal of pharmaceutical and medical products and products generated by agricultural activities (Vlachogianni et al., 2017). Marine litter causes a wide spectrum of environmental, economic, safety, health and cultural impacts. The very slow rate of degradation of most marine litter items, mainly plastics, together with the continuously growing quantity of the litter and debris disposed, is leading to a gradual, but dramatic increase in the quantities of marine litter in our oceans and world shores.

Current assessments indicates that much of the litter in the Mediterranean Sea is composed of packaging waste; a high amount (40% of the total number of items) arises from cigarette butts, while plastic account for about 80% of the overall quantity of floating litter. Under mechanical, photo (oxidative) and/or biological actions, those plastic items can be degraded into micro-plastics (Thompson et al., 2004; Browne et al., 2007; Cooper and Corcoran 2010; Andrady, 2011). The term micro-plastics refers to particles from < 5 mm (Arthur et al., 2009) down to few micrometers (Norén, 2007; Thompson et al., 2004; Browne et al., 2010 and 2011; Frias et al., 2010), although there are no

general consensus about a specific size nomenclature. Another source for those micro-plastics consists of manufactured raw plastic material, such as virgin plastic pellets, scrubbers, and microbeads (from personal care products such as exfoliants in face scrubs or toothpaste) (Browne et al., 2007; Arthur et al., 2009) that enter the ocean via runoff from land (Andrady, 2011).

Impacts of micro-plastics on wildlife are not well understood at this time. However, a number of organisms, both vertebrates and invertebrates have been found to ingest micro-plastics. These examples represent numerous organisms with differing feeding mechanisms, including detritivores, deposit feeders, and filter feeders. Examples include scleractinian corals (Hall et al., 2015), mussels (*Mytilus edulis*; Browne et al., 2007), fish (Carpenter et al., 1972), as well as lugworms, amphipods, and barnacles (Thompson et al., 2004). Scientists are also concerned that organisms ingesting plastic debris may be exposed to contaminants sorbed to the plastic (Teuten et al., 2007). Plastic debris provides a sink and a source for chemical contaminants. Additives used in the manufacturing of plastics can leach from the plastics into the marine environment (Andrady, 2011). On the other hand, hydrophobic contaminants present in the water may sorb to the plastic particles (Carpenter et al., 1972; Teuten et al. 2007, Andrady, 2011). Thus, micro-plastics may provide a mechanism to transport concentrated contaminants to organisms (Browne et al., 2007).

II. The Mediterranean Sea

The Mediterranean Sea is particularly vulnerable to this environmental threat. This semi-enclosed sea, only connected to the Atlantic Ocean by the Gibraltar Strait, is characterized by an anti-estuarine circulation (Pinardi and Masetti, 2000): the Atlantic waters enter at the surface while the Mediterranean waters exit at depth through the Gibraltar Strait. This very particular circulation makes the Mediterranean Sea a concentrating basin for marine litter at such point that models simulations (Lebreton et al., 2011; Maximenko et al., 2012) and in-situ observations (Cózar et al., 2015) have shown that the accumulation of marine litter in the basin is comparable to those observed in the five subtropical gyres, the most famous being the great garbage patch in the subtropical gyre of the North Pacific.

On the other hand, the Mediterranean Sea is one of the world's busiest shipping routes (UNEP/MAP, 2009) and receives waters from densely populated river catchment (e.g., Nile, Ebro, Rhones and Po): about 10% of the global coastal population lives on the Mediterranean coasts (CIESIN, Oct. 2012). It represents a population of nearly 150 million (UNEP/MAP, 2012) to who should be added 100 million of tourists visiting the coasts every year (UNEP/MAP/MED POL, 2005). The Mediterranean basin is by far the largest global tourism destination, attracting almost a third of the world's international tourists (UNEP/MAP, 2012). Coastal tourism is then fundamental for the economy of many Mediterranean countries and islands. However it represents a tremendous environmental pressure including contribution to the marine litter and plastic discharge (UNEP/MAP, 2012). These observations all taken together have shown that there is an urgent need to develop a new model for a more responsible and sustainable tourism in the Mediterranean Sea (Sabban, 2013).

III. Main objectives of the BLUEISLANDS project

One of the aims of the BLUEISLANDS project is to properly identify, address and mitigate the seasonal variation of waste generated on Mediterranean islands as an effect of tourism by assessing, amongst other, the seasonal dynamics of marine litter, with a special attention paid to both the micro- (<5mm)

and macroplastics (>5mm, including mesoplastics: 0.5cm – 2.5cm), in highly touristic coastal areas (i.e. beaches). The aim is to propose strategies to reduce the amount of litter related to touristic and recreational activities on beaches and to reduce its negative effects on the coastal environment. A total of 8 islands from the Mediterranean Sea (Mallorca, Sicily, Rab (Croatia), Malta, Crete, Mykonos, Rhodes and Cyprus) are involved. For each of these islands, 3 specific beaches have been periodically monitored to assess the seasonal variation of litter as an effect of tourism.

IV. Sampling strategy and methodology

In order to assess the seasonal variation of marine litter as an effect of tourism on Mediterranean islands, 24 beaches (3 per island) have been monitored for marine litter during both the low and high seasons. An exhaustive guideline regarding the implementation of these surveys has been provided (see deliverable D3.1.2: *Handbook for common approaches and methodologies – Field sampling and study measuring micro- and macroplastics input in partners coastal regions*). Briefly, for each selected site, a fixed 100m portion of beach was defined. This portion has been periodically monitored for marine litter: once a month during the high touristic season (from May to September) and one time before (February – April) and after (October – November) the high season. During the monitoring, all the items with an anthropogenic origin were collected, counted and characterized. The time elapsed between the survey and the last cleaning activity performed on the beach was taken into account in order to evaluate the accumulation rate of the marine litter (see below).

1. Methodology

For each island, 3 different beaches were selected and monitored for marine litter. The 3 beaches were selected in order to include 1 impact sites where tourists represent most of the visitors to the beach and 2 control sites including a beach where locals represent most of the visitors and a remote/preserved beach where the frequentation of both tourists and locals is low.

a) Touristic beaches

The touristic beaches are characterized by a high volume of visitors, mainly tourists, especially during the high touristic season. In the area situated directly behind the beach high levels of infrastructure dedicated to tourism and recreational activities, such as hotels, restaurants, bars, souvenir shops, etc., are found.

b) Beaches mainly used by locals

As for the touristic beaches, the beaches mainly used by locals are characterized by high volume of visitors, mainly locals, especially during the high touristic season. However, in the area situated directly behind the beach low level of infrastructures dedicated to tourism and recreational activities, such as hotels, restaurants, bars, souvenir shops, etc., are found.

c) Remote beaches

The remote beaches are assumed to be the less impacted type of beach. They are characterized by low volume of visitors, even during the high touristic season. In the area situated directly behind the beach no infrastructure dedicated to tourism and recreational activities, such as hotels, restaurants, bars, souvenir shops, etc., are found.

2. Data compilation and data analysis

In order to fully understand the results presented hereafter, it is important to take into account the following points:

a) Distance correction and surface of the surveyed area

For each of the 24 selected beaches a fixed 100m portion of beach was defined. The coordinates of the starting point and the ending point of the portion were recorded and the distance between the two points was calculated with the following equation:

$$D = \cos^{-1}(\sin(\text{rad}(\text{Lat}_S)) \times \sin(\text{rad}(\text{Lat}_E)) + \cos(\text{rad}(\text{Lat}_S)) \times \cos(\text{rad}(\text{Lat}_E)) \times \cos(\text{rad}(\text{Long}_S - \text{Long}_E))) \times 6371 \times 1000 \quad \text{Eq. 1}$$

Where D is the calculated distance in m, Lat_S is the starting latitude (in decimal degree), Long_S the starting longitude (in decimal degree), Lat_E the ending latitude (in decimal degree) and Long_E the ending longitude (in decimal degree). The functions \cos^{-1} returns the arccosine of an angle, \cos returns the cosine of an angle, \sin returns the sine of an angle and rad converts degrees into radians. When D is not equal to 100m (most of the cases) the number of items collected on the portion were corrected for the distance in order to normalize all the data for all the beaches. The following equation was used to correct the data:

$$NI_{cor} = \frac{(NI_{col} \times 100)}{D} \quad \text{Eq. 2}$$

Where NI_{cor} is the number of items corrected for distance, NI_{col} the number of items collected on the fixed portion of beach and D the calculated distance from Eq. 1. Note that the number of items corrected for distance is only use to show the number of items per 100m of beach: it is not used for the calculation of the accumulation rates or the accumulation index (see below).

Finally, for each beach, the surface of the 100m fixed portion was estimated by using the “Polygon” tool from Google Earth®. For each beach, the considered surface was measured from the water line to the back of the beach, between the starting and the ending points of the portion.

b) Accumulation rates

The accumulation rates of the marine litter is used here to estimate the accumulation of marine litter or of a given item per unit of surface and per unit of time. In this report, the accumulation rate can be given in number of items/m²/day or in number of items/km²/day. It is calculated as follow:

$$AR = NI_{col} / S / T \quad \text{Eq. 3}$$

Where AR is the accumulation rate in number of items/m²/day, NI_{col} the number of items collected on the fixed portion of beach, S the surface of the fixed portion of beach in m² and T the time elapsed between the survey and the last cleaning activity in days. Note: the time elapsed since the last cleaning corresponds to the number of days elapsed since the last cleaning performed by the local authorities (or the previous survey when no cleaning activities were conducted by the locals authorities). By multiplying the results of Eq. 3 by 1 000 000 (one million) we obtain the accumulation rate in number of items/km²/day.

c) Composition of the marine litter and possible source.

The composition of the marine litter was identified following the MSFD TG10 “Master List of Categories of Litter Items (Masterlist)” which divides the marine litter into 8 material type: artificial polymer materials, rubber, cloth/textile, paper/cardboard, processed/worked wood, metal, glass/ceramics and unidentified and/or chemicals. Note that this masterlist provides the correspondence between the TSG_ML General-Code, the OSPAR-Code and the UNEP-Code for each item.

The possible source of each item was identified and divided into 8 categories (directly from Vlachogianni et al., 2017):

- 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.
- 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.

d) Clean-Coast Index and Accumulation Index

- The clean-coast index (CCI) is a tool developed by Alkalay et al. (2007) to evaluate the cleanliness of a beach. It is calculated as follow:

$$CCI = \left(NI_{col} / S \right) \times K \quad Eq. 4$$

Where CCI is the clean-coast index, NI_{col} the number items collected on the fixed portion of beach, S the surface of the fixed portion of beach in m^2 and K is a constant that equals to 20. The value and definition for each quality class of the CCI are given in Table B.III.2-1.

Table B.III.2-1: Clean-coast index (CCI), value and definition for each quality class (Alkalay et al., 2007).

Quality	CCI	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 accumulation index (AI) was developed for this study. This index takes into account the accumulation rates of the marine litter and can be calculated as follow:

$$AI = \log_{10}(AR \times 1000000) \quad Eq. 5$$

Where AI is the accumulation index and AR the accumulation rate (see Eq. 3) in number of items/ m^2 /day. The value and the accumulation rate equivalence for each quality class of the AI are given in Table B.III.2-2.

Table B.III.2-2: Accumulation Index (AI), value and equivalence for the accumulation rate.

Quality	Extremely low	Very low	Low	Moderate	High	Very high	Extremely high
AI	≤ 1	1-2	2-3	3-4	4-5	5-6	≥ 6
AR (items/ m^2 /day)	0.000001	0.00001	0.0001	0.001	0.01	0.1	1
AR (items/ km^2 /day)	1	10	100	1000	10000	100000	1000000

V. References

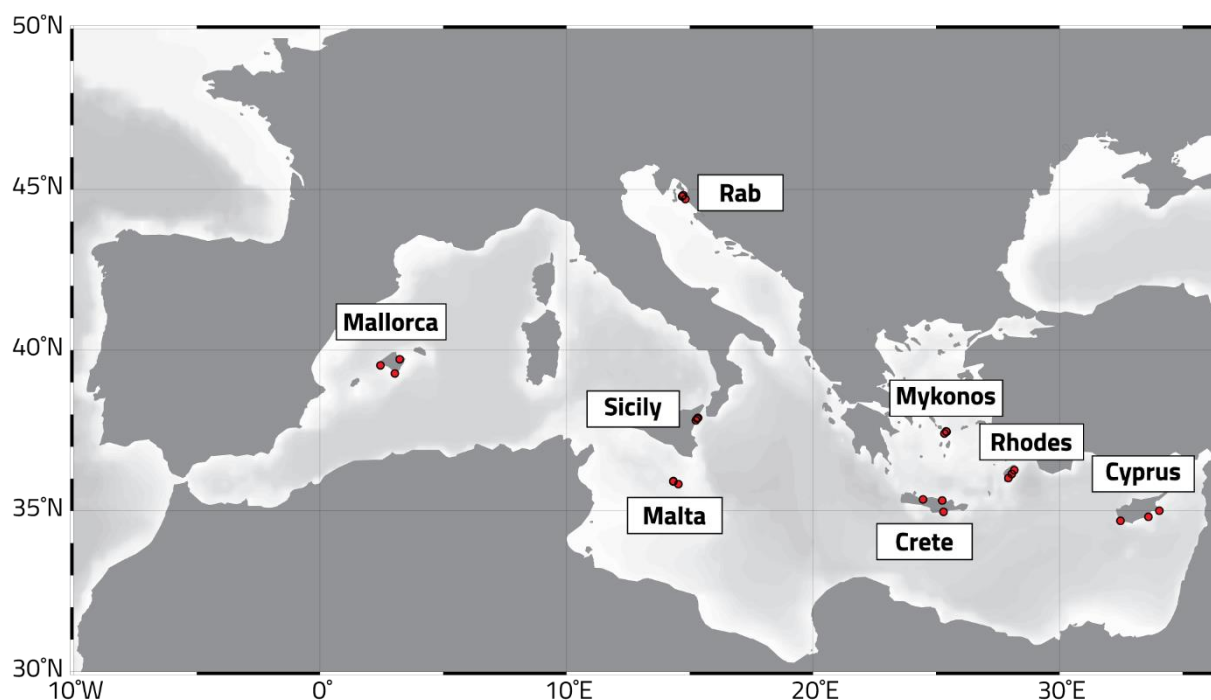
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Part C: GENERAL RESULTS AT THE MEDITERRANEAN SCALE

In this section, the results obtained from the 147 marine litter surveys performed on the 8 involved islands (Mallorca, Sicily, Rab, Malta, Crete, Mykonos, Rhodes and Cyprus, see Map 1) are summarized at the Mediterranean scale. The results will be presented by considering 1) the 8 islands, without considering the type of beach, 2) the 8 touristic beaches, 3) the 8 beaches mainly used by locals and 4) the 8 remote beaches.



Map 1: location map of the 8 islands involved in the monitoring of the marine litter. The selected sites are shown by red spots.

I. Results at the Mediterranean Scale

1. Seasonality of the marine litter

The 24 selected beaches were sampled for marine litter in February (5 surveys), March (12 surveys), April (4 surveys), May (18 surveys), June (21 surveys), July (21 surveys), August (21 surveys), September (21 surveys), October (3 surveys) and November (21 surveys) of 2017 (Fig. C.I-1a). A total of 172255 items (corrected for distance, see Part B.III.2.a) were collected on the same 100m portion of each beach during the 147 monitoring, representing an average of 1171.8 items (± 2908.3 items, $n=147$) per survey. The lowest average number of items was recorded in April (76.8 items, ± 55.5 items, $n=4$) while the highest number was recorded in November (2198.0 items, ± 5291.5 items, $n=21$) (Fig. C.I-1a). In general, the amount of marine litter continuously increased from February to November, with a slight decreases in April, August and October. No seasonal pattern was then visible (Fig. C.I-1a). When only the number of items collected is considered (Fig. C.I-1b), their average number per survey during the low season (October – April) was of 1390.8 (± 3743.5 items, $n=45$) and of 1075.2 (± 2467.9 items, $n=102$) during the high season (May – September). Then, the amount of marine litter collected per survey during the high season was on average 22.7% lower than during the low touristic season (Fig. C.I-1b). When the accumulation rates (see Part B.III.2.b) are considered, a clear seasonal pattern is observed despite a slight decrease in August (Fig. C.I-1c). The lowest value observed was of 0.00095 items/m²/day (± 0.0012 items/m²/day, $n=4$) in April and the highest was of 0.3236 items/m²/day

(± 0.5493 items/m²/day, n=21) in July (Fig. C.I-1c). The seasonal pattern of the marine litter seems to follow the average monthly number of tourists welcomed to the 8 selected islands (Fig. C.I-1c): higher accumulation rates are observed during the touristic season and lower accumulation rates are observed during the off season. During the low season, the average accumulation rate is of 0.1145 items/m²/day (± 0.2374 , n=45) and of 0.2486 items/m²/day (± 0.4199 , n=102) during the high season. These results show that, on average the accumulation rates of the marine litter are higher during the high season (+117.2%, Fig. C.I-1d) than during the low season.

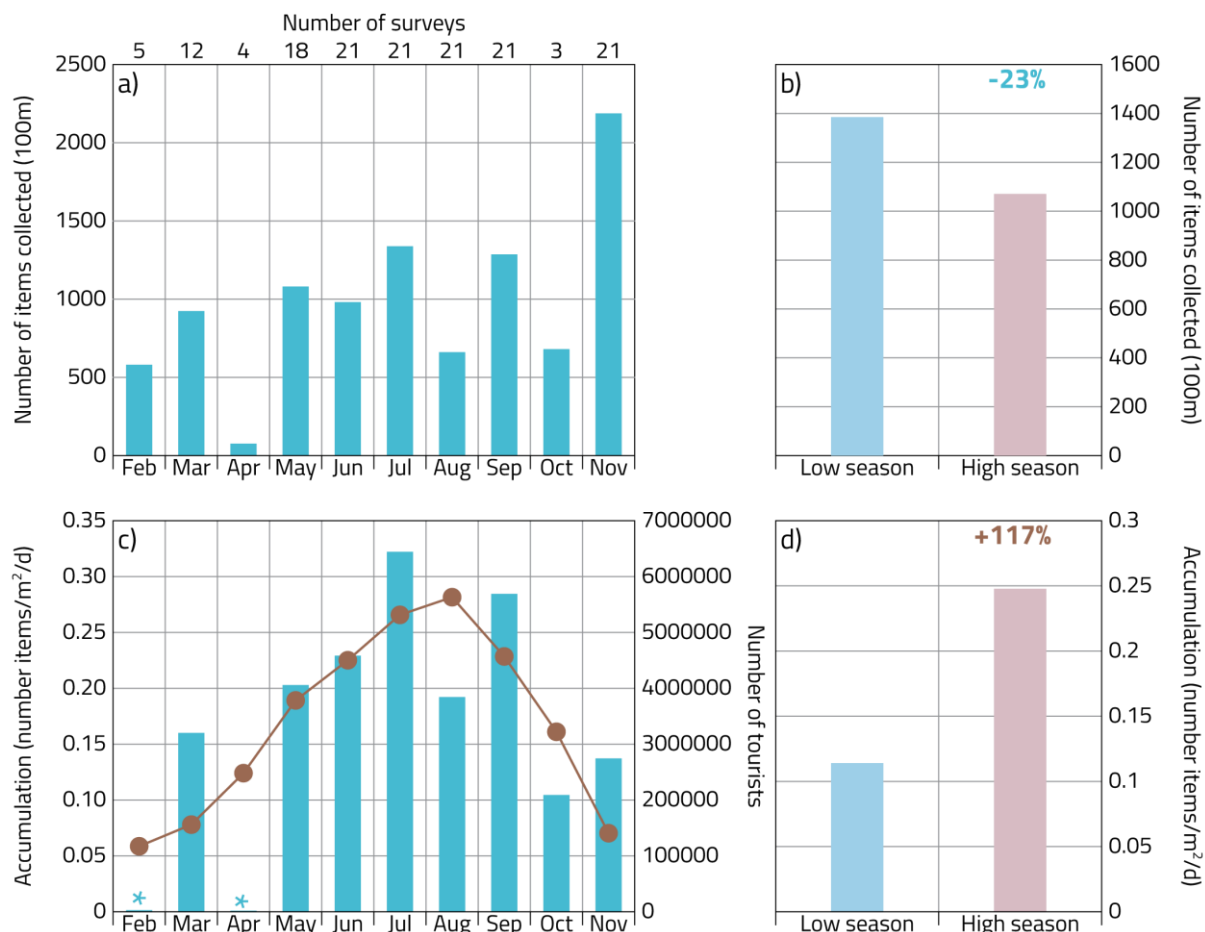


Figure C.I-1: average number and average accumulations rates of items collected for the 24 selected beaches. a) Average number of items collected each month on the fixed 100m portions of beach. The numbers at the top refer to the number of surveys performed each month; b) comparison of the average number of items collected per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (blue font) refers to the decrease with respect to the low season; c) average accumulation rates of the marine litter (left axis, blue bars, the blue asterisks (*) refer to values not visible at this scale) and the average monthly number of tourists¹ for the 8 islands (right axis, brown line and dots); and d) comparison of the average accumulation rates of marine litter per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season.

2. Composition of the marine litter

The marine litter collected on the 24 beaches was classified into 8 major categories of material type (see Part B.III.2.c). It is largely dominated by the artificial polymer materials (average=88.22% \pm 15.01; min=48.88% in October and max=97.76% in November), followed by the metal (average=4.10% \pm 6.55; min=0.58% in November and max=21.26% in October), the paper/cardboard (average=3.25% \pm 4.80;

¹ Data source: monthly average number of tourists welcomed to the 8 islands. See the *Part D Detailed results for each island*.

min=0.36% in November and max=16.24% in October), the glass/ceramics (average=1.46% \pm 1.59; min=0.00% in April and max=4.35% in March), the processed/worked wood (average=1.11% \pm 1.83; min=0.14% in November and max=6.17% in October), the unidentified and/or chemicals (average=0.85% \pm 1.12; min=0.00% in April and max=3.90% in October), the cloth/textile (average=0.56% \pm 0.33; min=0.11% in November and max=1.04% in February) and the rubber (average=0.45% \pm 0.23; min=0.20% in November and max=0.98% in February).

During the low season (Fig. C.I-2), the marine litter is largely dominated by the artificial polymer materials (84.37%), followed by the metal (5.61%), the paper/cardboard (4.25%), the glass/ceramics (1.69%), the processed/worked wood (1.58%), the unidentified and/or chemicals (1.24%), the cloth/textile (0.73%) and the rubber (0.53%).

During the high season (Fig. C.I-2), the marine litter is largely dominated by the artificial polymer materials (92.08%), followed by the metal (2.58%), the paper/cardboard (2.26%), the glass/ceramics (1.23%), the processed/worked wood (0.64%), the unidentified and/or chemicals (0.45%), the cloth/textile (0.40%) and the rubber (0.37%).

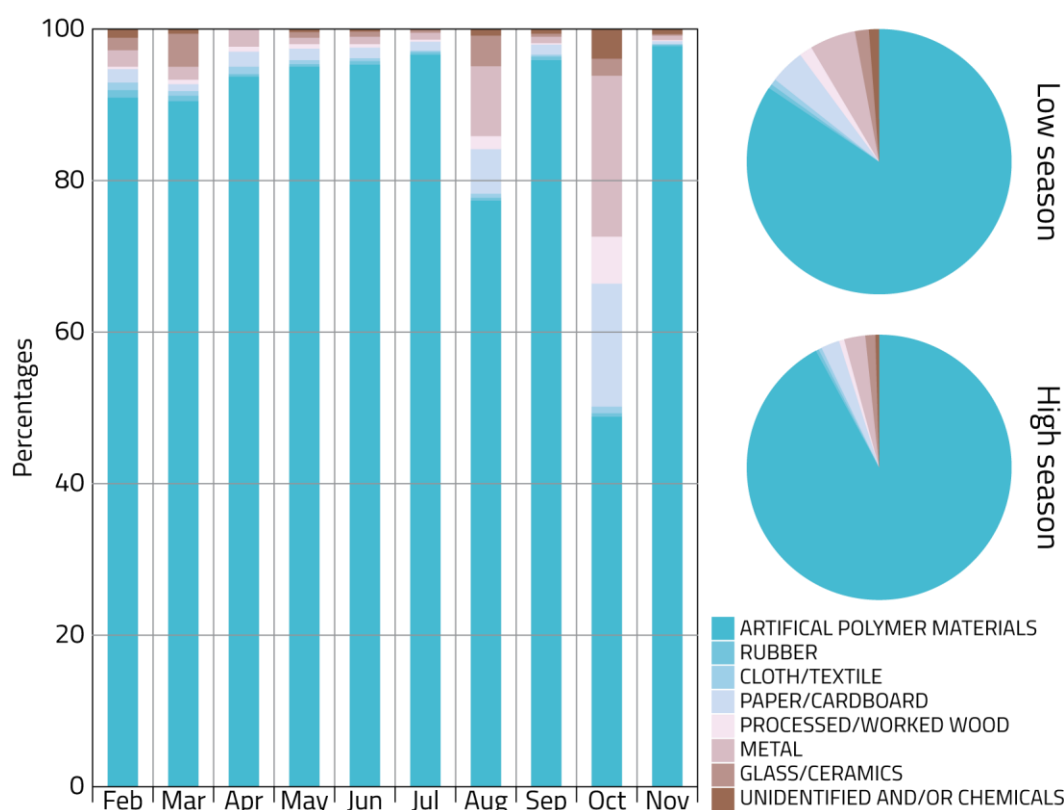


Figure C.I-2: average monthly composition of the marine litter collected on the 24 selected beaches. Left: histogram showing the monthly percentages of the 8 major categories of material type. Right: pie charts showing the average composition of the marine litter during the low (top) and high (bottom) seasons. The color scale (lower right) indicates the type of material.

3. The 10 items with the highest accumulation rates

In this section, we consider the items with the highest averaged accumulation rates, which are not necessarily the most abundant items collected during the marine litter monitoring performed on the 8 selected islands (Fig. C.I-3). These items account for 86.59% of the total marine litter items (149161) collected in 2017. They are dominated by the cigarette butts (0.0682 items/m²/day; 12.67% of the total marine litter items collected), followed by the mesoplastics (0.0441 items/m²/day; 34.64% of the total marine litter items collected), the microplastics (0.0206 items/m²/day; 11.10% of the total marine

litter items collected), the macroplastics (0.0170 items/m²/day; 8.37% of the total marine litter items collected), the pellets (0.0141 items/m²/day; 9.29% of the total marine litter items collected), the caps/lids (0.0084 items/m²/day; 3.60% of the total marine litter items collected), the cutlery/trays/straws (0.0056 items/m²/day; 1.65% of the total marine litter items collected), the crisp/sweet packets and lolly sticks (0.0048 items/m²/day; 1.47% of the total marine litter items collected), the strings and cords (diameter less than 1 cm) (0.0038 items/m²/day; 1.48% of the total marine litter items collected) and the other paper items (0.0033 items/m²/day; 0.69% of the total marine litter items collected).

In this top 10, the artificial polymer materials largely dominate as they are represented by 9 items, accounting for 84.27% of the total marine litter items collected.

In this top 10, 4 items (cigarette butts, caps/lids, cutlery/trays/straws and crisp/sweet packets and lolly sticks) accounting for 19.40% of the total marine litter items collected, can be attributed to the shoreline source, including poor waste management practices, tourism and recreational activities (see Part B.III.2.c). To this can possibly be added 3 items (mesoplastics, microplastics and other paper items) presenting a clear seasonal pattern (see Appendix, Fig. E.I-1) and accounting for additional 46.43% of the total marine litter items collected.

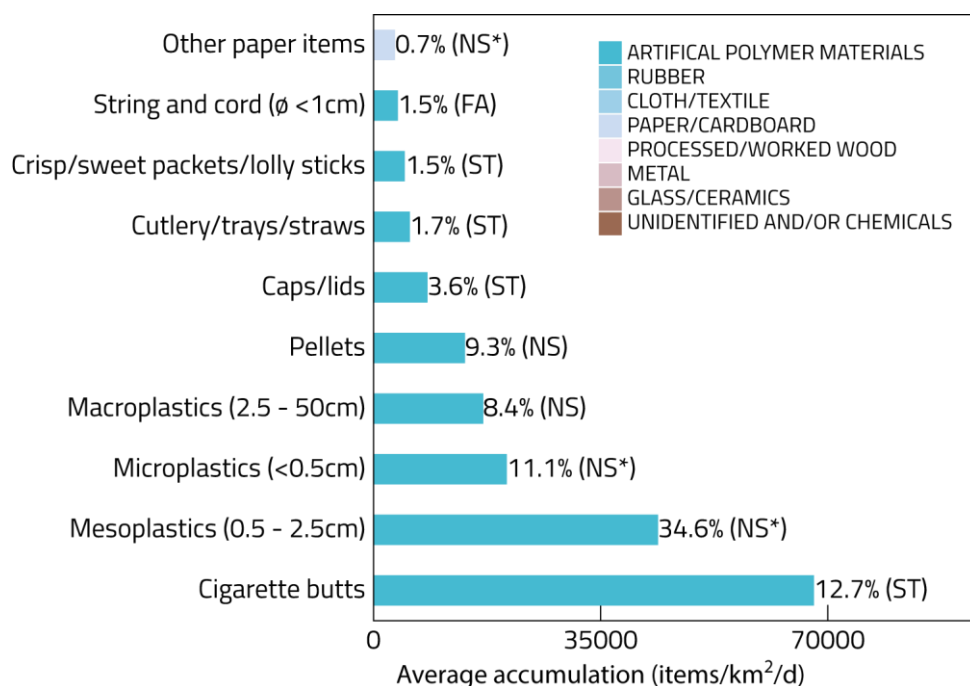


Figure C.I-3: list of the 10 items with the highest accumulation rates collected on the 24 selected beaches. The percentages next to each item refers to their relative abundance with respect to the total collected. The possible source of the items is given into parenthesis: ST=shoreline, including poor waste management, tourism and recreational activities; FA= fishing and aquaculture; and NS=non-sourced. The asterisk (*) associated to the non-sourced items (NS) shows that this specific item presents a clear seasonal increase. The color scale (upper right) indicates the type of material.

4. Clean-Coast Index and Accumulation Index

The clean-coast index (CCI) is a direct measurement of the cleanliness of a beach. Here is presented the average CCI for the 3 selected beaches of each island (Fig. C.I-4a). Thanks to the cleaning activities conducted by the local authorities, especially during the summer, the CCI is always lower during the high season (Fig. C.I-4a) with the exception of the islands of Rhodes and Cyprus. During the low season, all the islands taken together exhibit a CCI of 7.40 corresponding to beaches moderately clean. In details, during the low season, the beaches of Sicily (CCI=0.30), Mykonos (CCI=1.14) and Rhodes

(CCI=1.29) are very clean; the beaches of Cyprus (CCI=3.71) and Rab (CCI=4.20) are clean; the beaches of Malta (CCI=7.62) are moderately clean; the beaches of Crete (CCI=14.84) are dirty; and the beaches of Mallorca (CCI=23.84) are very dirty. During the high season, all the islands taken together exhibit a CCI of 5.96 corresponding to beaches moderately clean. In details, during the high season, the beaches of Sicily (CCI=0.26), Mykonos (CCI=0.91) and Rhodes (CCI=1.34) are very clean; the beaches of Rab (CCI=3.28) and Cyprus (CCI=4.08) are clean; the beaches of Malta (CCI=6.48) are moderately clean; and the beaches of Crete (CCI=10.89) and Mallorca (CCI=19.35) are dirty.

On the other hand, the accumulation index (AI) which takes into account the cleaning activities conducted by the local authorities on the beaches show that the accumulation of marine litter is always higher during the high season (Fig. C.I-4b) with the exception of Rab. During the low season, all the islands taken together show an AI of 3.65 corresponding to moderate accumulation of marine litter. In details the beaches of Sicily (AI=2.38) and Rhodes (AI=2.55) present low accumulation of marine litter; the beaches of Mykonos (AI=3.07), Crete (AI=3.37) and Cyprus (AI=3.72) present moderate accumulation of marine litter; the beaches of Mallorca (AI=4.09) and Rab (AI=4.80) exhibit high accumulation of marine litter; and the beaches of Malta (AI=5.80) show very high accumulation of marine litter. During the high season, all the islands taken together show an AI of 4.35 corresponding to high accumulation of marine litter. In details the beaches of Rhodes (AI=3.20), Sicily (AI=3.52), Rab (AI=3.63) and Crete (AI=3.88) present moderate accumulation of marine litter; the beaches of Mykonos (AI=4.03) and Cyprus (AI=4.69) show high accumulation of marine litter; and the beaches of Mallorca (AI=5.54) and Malta (AI=5.87) have very high accumulation of marine litter.

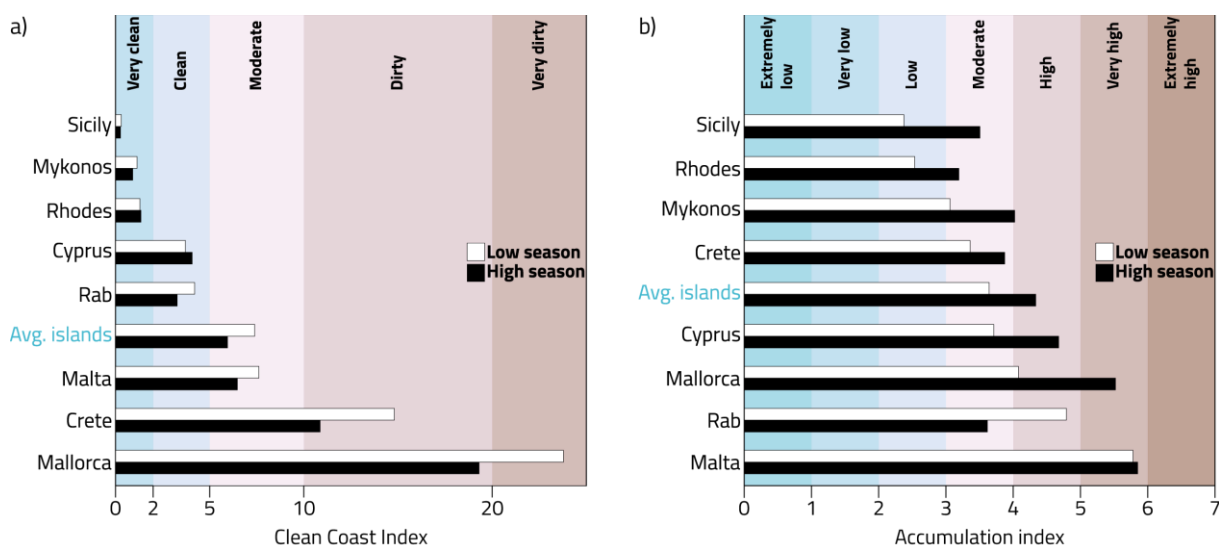


Figure C.I-4: average clean-coast index and accumulation index for each island. a) The average clean-coast index was calculated from the 3 selected beaches of each island for the low season (white bars) and the high season (black bars). The color scale (background) provides the quality of cleanliness. b) The average accumulation index was calculated from the 3 selected beaches of each island for the low season (white bars) and the high season (black bars). The color scale (background) provides the degree of accumulation.

5. Summary

The 147 marine litter surveys conducted on the 8 islands in 2017 have revealed that:

- If only the number of items collected is considered (corrected for distance, see Part B.III.2.a), no clear seasonal variability is observed. On average, the beaches are more affected by the marine litter during the low season (62586 items collected; average: 1390.8 items/survey

± 3743.5 items per survey, $n=45$) than during the high season (109669 items collected; average: 1075.2 items/survey ± 2467.9 items per survey, $n=102$), suggesting a decrease of 23% of the marine litter found during the high season in comparison to the low season.

- If the accumulation rate of the marine litter is considered, a seasonal variation is observed. On average, the accumulation rate is higher during the high season (average: 0.2486 items/m²/day ± 0.4199 items/m²/day, $n=102$) than during the low season (0.1145 items/m²/day ± 0.2374 items/m²/day, $n=45$), suggesting an increase of 117% of the accumulation the marine litter during the high season in comparison to the low season.
- The items collected are mainly composed of artificial polymer materials: they represent 88.22% of the total marine litter items collected.
- The 4 items (cigarette butts, caps/lids, cutlery/trays/straws and crisp/sweet packets and lolly sticks), most likely related to tourism and recreational activities, are representing 19.4% of the total marine litter items collected. To this, can possibly be added 3 items (mesoplastics, microplastics and other paper items), accounting for additional 46.4% as they presented a recognizable seasonal variation.
- The cleanliness of the beaches is considered as moderately clean during both the low and high seasons (CCI of 7.40 and 5.96)
- Finally the accumulation index of the beaches is considered as moderate during the low season (AI=3.65) and high during the high season (AI=4.35).

II. Results for the touristic beaches

1. Seasonality of the marine litter

The 8 touristic beaches selected were sampled for marine litter in February (2 surveys), March (4 surveys), April (1 survey), May (6 surveys), June (7 surveys), July (7 surveys), August (7 surveys), September (7 surveys), October (1 survey) and November (7 surveys) of 2017 (Fig. C.II-1a). A total of 44096 items (corrected for distance, see Part B.III.2.a) were collected on the same 100m portion of each beach during the 49 monitoring, representing an average of 899.9 items (± 858.8 items, $n=49$) per survey. The lowest average number of items was recorded in April (114.7 items, $n=1$) while the highest number was recorded in October (1241.4 items, $n=1$) (Fig. C.II-1a). In general, the amount of marine litter continuously increased from February to November, with a slight decreases in April, June, July and September. No seasonal pattern was then visible (Fig. C.II-1a). When only the number of items collected is considered (Fig. C.II-1b), their average number per survey during the low season (October – April) was of 964.9 (± 871.3 items, $n=15$) and of 871.3 (± 861.6 items, $n=34$) during the high season (May – September). Then, the amount of marine litter collected per survey during the high season was on average 9.7% lower than during the low touristic season (Fig. C.II-1b). When the accumulation rates (see Part B.III.2.b) are considered, a clear seasonal pattern is observed despite a slight decrease in August (Fig. C.II-1c). The lowest value observed was of 0.0025 items/m²/day ($n=1$) in April and the highest was of 0.4621 items/m²/day (± 0.6623 items/m²/day, $n=7$) in July (Fig. C.II-1c). The seasonal pattern of the marine litter seems to follow the average monthly number of tourists welcomed to the 8 selected islands (Fig. C.II-1c): higher accumulation rates are observed during the touristic season and lower accumulation rates are observed during the off season. During the low season, the average accumulation rate is of 0.1350 items/m²/day (± 0.2601 , $n=15$) and of 0.3538 items/m²/day (± 0.4752 ,

n=34) during the high season. These results show that, on average the accumulation rates of the marine litter are higher during the high season (+162.1%, Fig. C.II-1d) than during the low season.

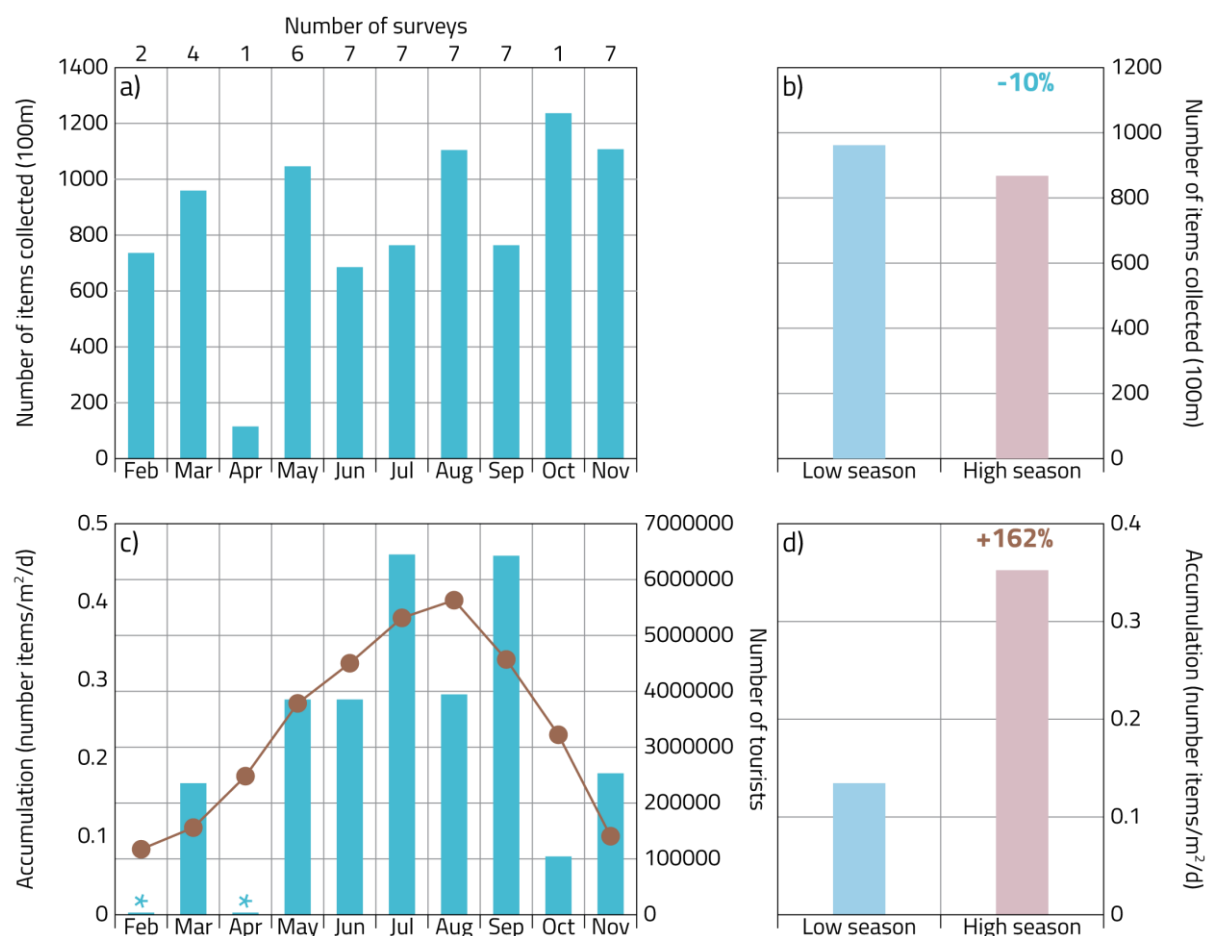


Figure C.II-1: average number and average accumulations rates of items collected for the 8 touristic beaches. a) Average number of items collected each month on the fixed 100m portions of beach. The numbers at the top refer to the number of surveys performed each month; b) comparison of the average number of items collected per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (blue font) refers to the decrease with respect to the low season; c) average accumulation rates of the marine litter (left axis, blue bars, the blue asterisks (*) refer to values not visible at this scale) and the average monthly number of tourists² for the 8 islands (right axis, brown line and dots); and d) comparison of the average accumulation rates of marine litter per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season.

2. Composition of the marine litter

The marine litter collected on the 8 touristic beaches was classified into 8 major categories of material type (see Part B.III.2.c). It is largely dominated by the artificial polymer materials (average=83.82% \pm 15.55; min=44.91% in October and max=94.88% in November), followed by the metal (average=4.96% \pm 6.66; min=1.25% in March and max=21.41% in October), the paper/cardboard (average=4.76% \pm 4.40; min=1.55% in November and max=16.17% in October), the glass/ceramics (average=2.45% \pm 3.04; min=0.00% in April and max=8.93% in March), the processed/worked wood (average=1.30% \pm 1.93; min=0.26% in February and max=6.59% in October), the unidentified and/or chemicals (average=1.25% \pm 1.86; min=0.00% in March and max=6.44% in October), the cloth/textile (average=0.97% \pm 0.67; min=0.31% in July and max=2.63% in April) and the rubber (average=0.49% \pm 0.31; min=0.00% in April and max=0.95% in March).

² Data source: monthly average number of tourists welcomed to the 8 islands. See the *Part D Detailed results for each island*.

During the low season (Fig. C.II-2), the marine litter is largely dominated by the artificial polymer materials (78.44%), followed by the metal (6.50%), the paper/cardboard (5.64%), the glass/ceramics (3.73%), the unidentified and/or chemicals (2.23%), the processed/worked wood (1.89%), the cloth/textile (0.94%) and the rubber (0.64%).

During the high season (Fig. C.II-2), the marine litter is largely dominated by the artificial polymer materials (86.99%), followed by paper/cardboard (4.48%), the metal (3.84%), the glass/ceramics (1.93%), the processed/worked wood (0.91%), the unidentified and/or chemicals (0.71%), the cloth/textile (0.65%) and the rubber (0.47%).

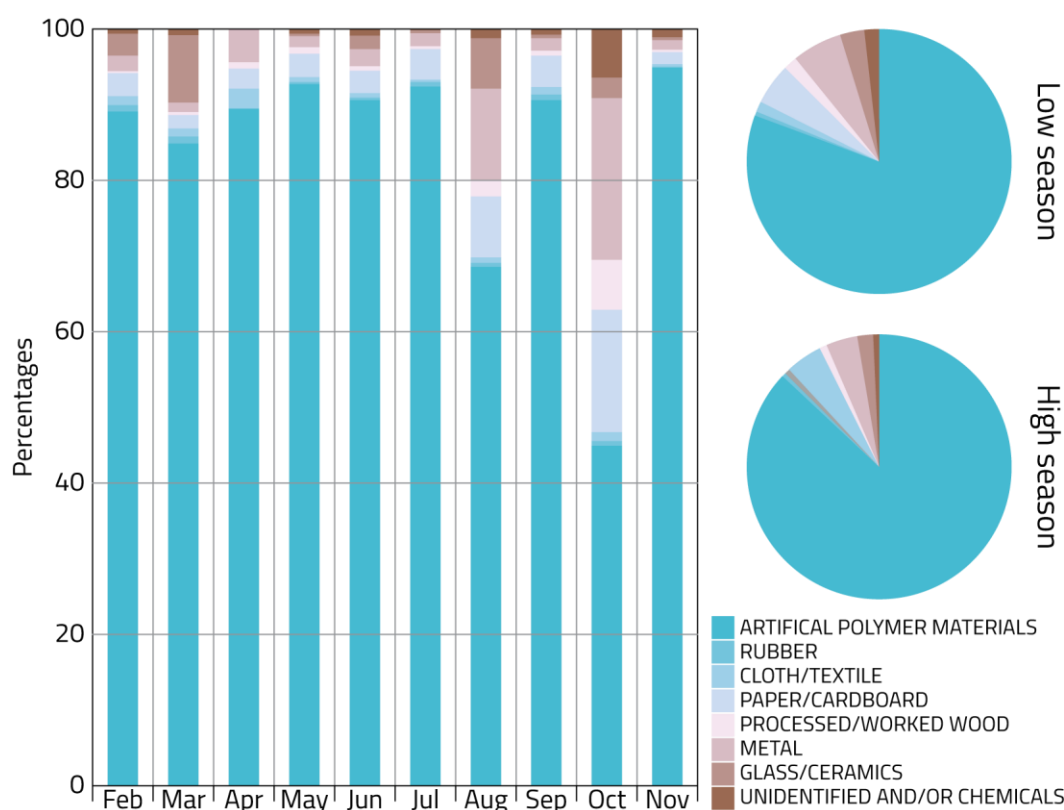


Figure C.II-2: average monthly composition of the marine litter collected on the 8 touristic beaches. Left: histogram showing the monthly percentages of the 8 major categories of material type. Right: pie charts showing the average composition of the marine litter during the low (top) and high (bottom) seasons. The color scale (lower right) indicates the type of material.

3. The 10 items with the highest accumulation rates

In this section, we consider the items with the highest averaged accumulation rates, which are not necessarily the most abundant items collected during the marine litter monitoring performed on the 8 touristic beaches (Fig. C.II-3). These items account for 76.67% of the total marine litter items (33808) collected in 2017. They are dominated by the cigarette butts (0.1309 items/m²/day; 32.35% of the total marine litter items collected), followed by the mesoplastics (0.0462 items/m²/day; 14.09% of the total marine litter items collected), the pellets (0.0254 items/m²/day; 6.74% of the total marine litter items collected), the microplastics (0.0234 items/m²/day; 5.13% of the total marine litter items collected), the macroplastics (0.0181 items/m²/day; 5.11% of the total marine litter items collected), the other paper items (0.0084 items/m²/day; 1.88% of the total marine litter items collected), the cutlery/trays/straws (0.0081 items/m²/day; 3.35% of the total marine litter items collected), the crisp/sweet packets and lolly sticks (0.0060 items/m²/day; 2.90% of the total marine litter items collected), the caps/lids (0.0060 items/m²/day; 3.60% of the total marine litter items collected) and

the strings and cords (diameter less than 1 cm) (0.0029 items/m²/day; 1.76% of the total marine litter items collected).

In this top 10, the artificial polymer materials largely dominate as they are represented by 9 items, accounting for 74.79% of the total marine litter items collected.

In this top 10, 4 items (cigarette butts, cutlery/trays/straws, crisp/sweet packets and lolly sticks and caps/lids) accounting for 41.95% of the total marine litter items collected, can be attributed to the shoreline source, including poor waste management practices, tourism and recreational activities (see Part B.III.2.c). To this, can possibly be added 3 items (microplastics, macroplastics and other paper items) presenting a clear seasonal pattern (see Appendix, Fig. E.I-2) and accounting for additional 12.12% of the total marine litter items collected.

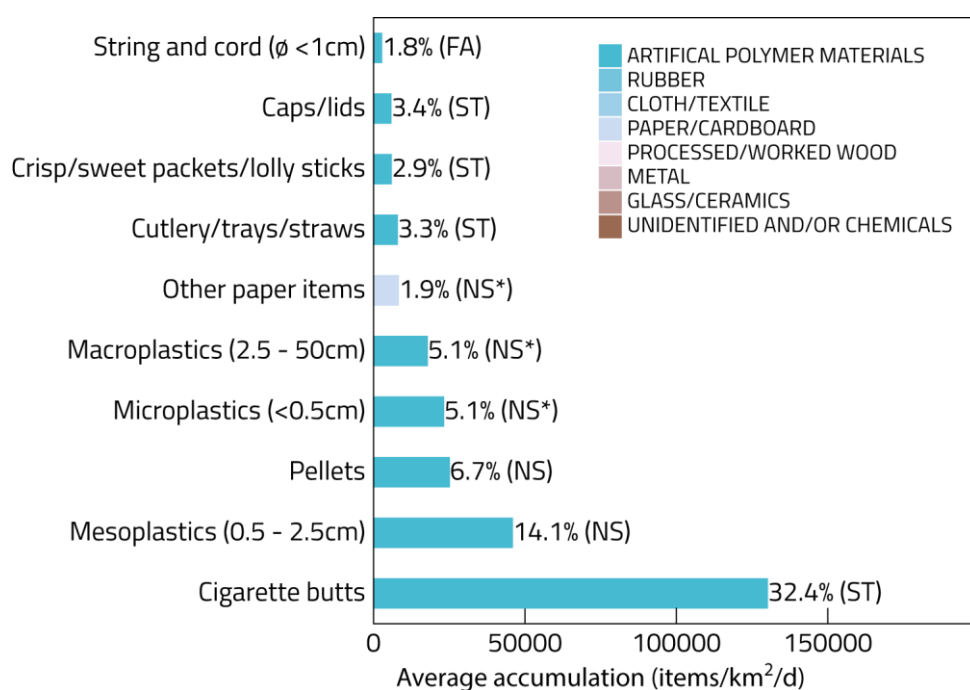


Figure C.II-3: list of the 10 items with the highest accumulation rates collected on the 8 touristic beaches. The percentages next to each item refers to their relative abundance with respect to the total collected. The possible source of the items is given into parenthesis: ST=shoreline, including poor waste management, tourism and recreational activities; FA= fishing and aquaculture; and NS=non-sourced. The asterisk (*) associated to the non-sourced items (NS) shows that this specific item presents a clear seasonal increase. The color scale (upper right) indicates the type of material.

4. Clean-Coast Index and Accumulation Index

The clean-coast index (CCI) is a direct measurement of the cleanliness of a beach. Here is presented the average CCI for the touristic beaches of each island (Fig. C.II-4a). Thanks to the cleaning activities conducted by the local authorities, especially during the summer, the CCI is always lower during the high season (Fig. C.II-4a) with the exception of the island of Rab. During the low season, all the touristic beaches taken together exhibit a CCI of 7.18 corresponding to beaches moderately clean. In details, during the low season, the beaches of Sicily (CCI=0.39), Mykonos (CCI=1.81) and Rhodes (CCI=1.96) are very clean; the beach of Rab (CCI=2.98) is clean; the beaches of Malta (CCI=7.26) and Cyprus (CCI=7.76) are moderately clean; and the beaches of Crete (CCI=15.08) and Mallorca (CCI=18.08) are dirty. During the high season, all the touristic beaches taken together exhibit a CCI of 6.43 corresponding to beaches moderately clean. In details, during the high season, the beaches of Sicily (CCI=0.16), Mykonos (CCI=1.37) and Rhodes (CCI=1.72) are very clean; the beaches of Malta (CCI=4.13) and Rab (CCI=4.67)

are clean; the beach of Cyprus (CCI=7.51) is moderately clean; and the beaches of Crete (CCI=13.29) and Mallorca (CCI=17.49) are dirty.

On the other hand, the accumulation index (AI) which takes into account the cleaning activities conducted by the local authorities on the beaches show that the accumulation of marine litter is always higher during the high season (Fig. C.II-4b) with the exception of Rab. During the low season, all the touristic beaches taken together show an AI of 4.15 corresponding to high accumulation of marine litter. In details the beach of Rhodes (AI=2.85) presents low accumulation of marine litter; the beaches of Sicily (AI=3.10) and Mykonos (AI=3.48) present moderate accumulation of marine litter; the beaches of Mallorca (AI=4.27), Cyprus (AI=4.43), Crete (AI=4.72) and Rab (AI=4.87) show high accumulation of marine litter; and the beach of Malta (AI=5.84) exhibits very high accumulation of marine litter. During the high season, all the touristic beaches taken together show an AI of 4.87 corresponding to high accumulation of marine litter. In details the beaches of Rhodes (AI=3.46) and Rab (AI=3.69) show moderate accumulation of marine litter; the beaches of Sicily (AI=4.12) and Mykonos (AI=4.37) present high accumulation of marine litter; the beaches of Crete (AI=5.12), Cyprus (AI=5.48) and Malta (AI=5.91) exhibit very high accumulation of marine litter; and the beach of Mallorca (AI=6.08) shows extremely high accumulation of marine litter.

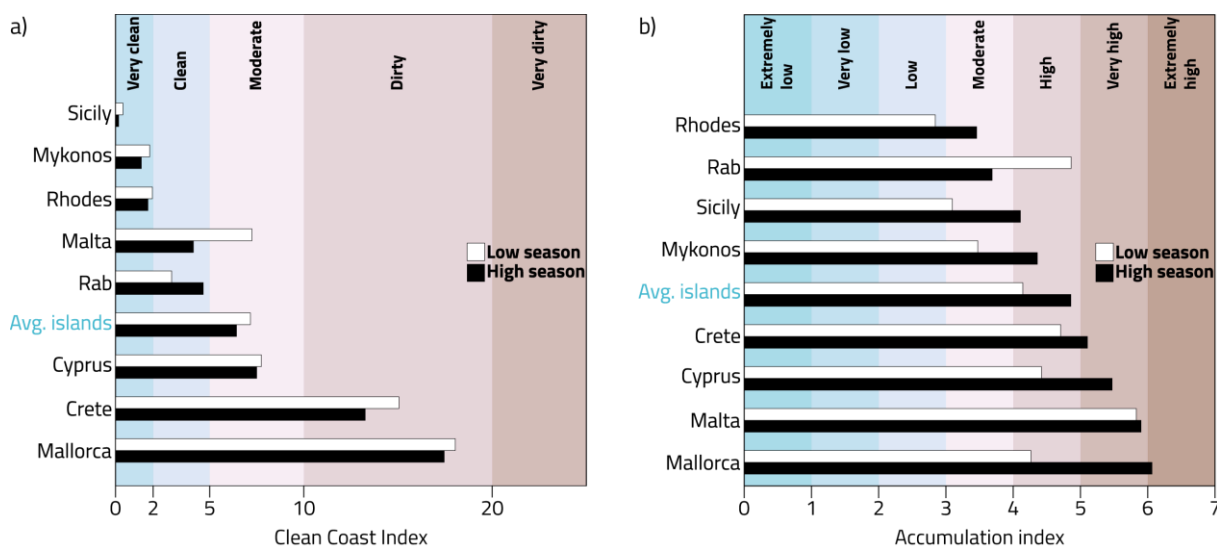


Figure C.II-4: clean-coast index and accumulation index for the touristic beach of each island. a) The clean-coast index is displayed for the low season (white bars) and the high season (black bars). The color scale (background) provides the quality of cleanliness. b) The accumulation index is displayed for the low season (white bars) and the high season (black bars). The color scale (background) provides the degree of accumulation.

5. Summary

The 49 marine litter surveys conducted on the 8 touristic beaches in 2017 have revealed that:

- If only the number of items collected is considered (corrected for distance, see Part B.III.2.a), no clear seasonal variability is observed. On average, the beaches are more affected by the marine litter during the low season (14473 items collected; average: 964.9 items/survey ± 878.8 items per survey, n=15) than during the high season (29623 items collected; average: 871.3 items/survey ± 861.6 items per survey, n=34), suggesting a decrease of 10% of the marine litter found during the high season in comparison to the low season.
- If the accumulation rate of the marine litter is considered, a seasonal variation is observed. On average, the accumulation rate is higher during the high season (average: 0.3538

items/m²/day ± 0.4752 items/m²/day, n=34) than during the low season (0.1350 items/m²/day ± 0.2601 items/m²/day, n=14), suggesting an increase of 162% of the accumulation of marine litter during the high season in comparison to the low season.

- The items collected are mainly composed of artificial polymer materials: they represent 83.82% of the total marine litter items collected.
- The 4 items (cigarette butts, cutlery/trays/straws, crisp/sweet packets and lolly sticks and caps/lids), most likely related to tourism and recreational activities, are representing 42.0% of the total marine litter items collected. To this, can possibly be added 3 items (microplastics, macroplastics and other paper items), accounting for additional 12.1% as they presented a recognizable seasonal variation.
- The cleanliness of the beaches is considered as moderately clean during both the low and high seasons (CCI of 7.18 and 4.15).
- Finally the accumulation index of the touristic beaches is considered as high during both the low and high seasons (AI of 4.15 and 4.87).

III. Results for the beaches mainly used by locals

1. Seasonality of the marine litter

The 8 beaches mainly used by locals were sampled for marine litter in February (2 surveys), March (4 surveys), April (1 survey), May (6 surveys), June (7 surveys), July (7 surveys), August (7 surveys), September (7 surveys), October (1 survey) and November (7 surveys) of 2017 (Fig. C.III-1a). A total of 105703 items (corrected for distance, see Part B.III.2.a) were collected on the same 100m portion of each beach during the 49 monitoring, representing an average of 2157.2 items (± 4680.2 items, n=49) per survey. The lowest average number of items was recorded in October (68.7 items, n=1) while the highest number was recorded in November (4255.1 items, ± 8776.0 items, n=7) (Fig. C.III-1a). In general, the amount of marine litter continuously increased from February to November, with a marked decreases in April, August and October. No seasonal pattern was then visible (Fig. C.III-1a). When only the number of items collected is considered (Fig. C.III-1b), their average number per survey during the low season (October – April) was of 2499.4 (± 6127.7 items, n=15) and of 2006.2 (± 3981.8 items, n=34) during the high season (May – September). Then, the amount of marine litter collected per survey during the high season was on average 19.7% lower than during the low touristic season (Fig. C.III-1b). When the accumulation rates (see Part B.III.2.b) are considered, a clear seasonal pattern is observed despite a slight decrease in August (Fig. C.III-1c). The lowest value observed was of 0.0008 items/m²/day (± 0.0006 items/m²/day, n=2) in February and the highest was of 0.3019 items/m²/day (± 0.5130 items/m²/day, n=7) in July (Fig. C.III-1c). The seasonal pattern of the marine litter seems to follow the average monthly number of tourists welcomed to the 8 selected islands (Fig. C.III-1c): higher accumulation rates are observed during the touristic season and lower accumulation rates are observed during the off season. During the low season, the average accumulation rate is of 0.0884 items/m²/day (± 0.1896 , n=15) and of 0.2078 items/m²/day (± 0.3422 , n=34) during the high season. These results show that, on average the accumulation rates of the marine litter are higher during the high season (+135.1%, Fig. C.III-1d) than during the low season.

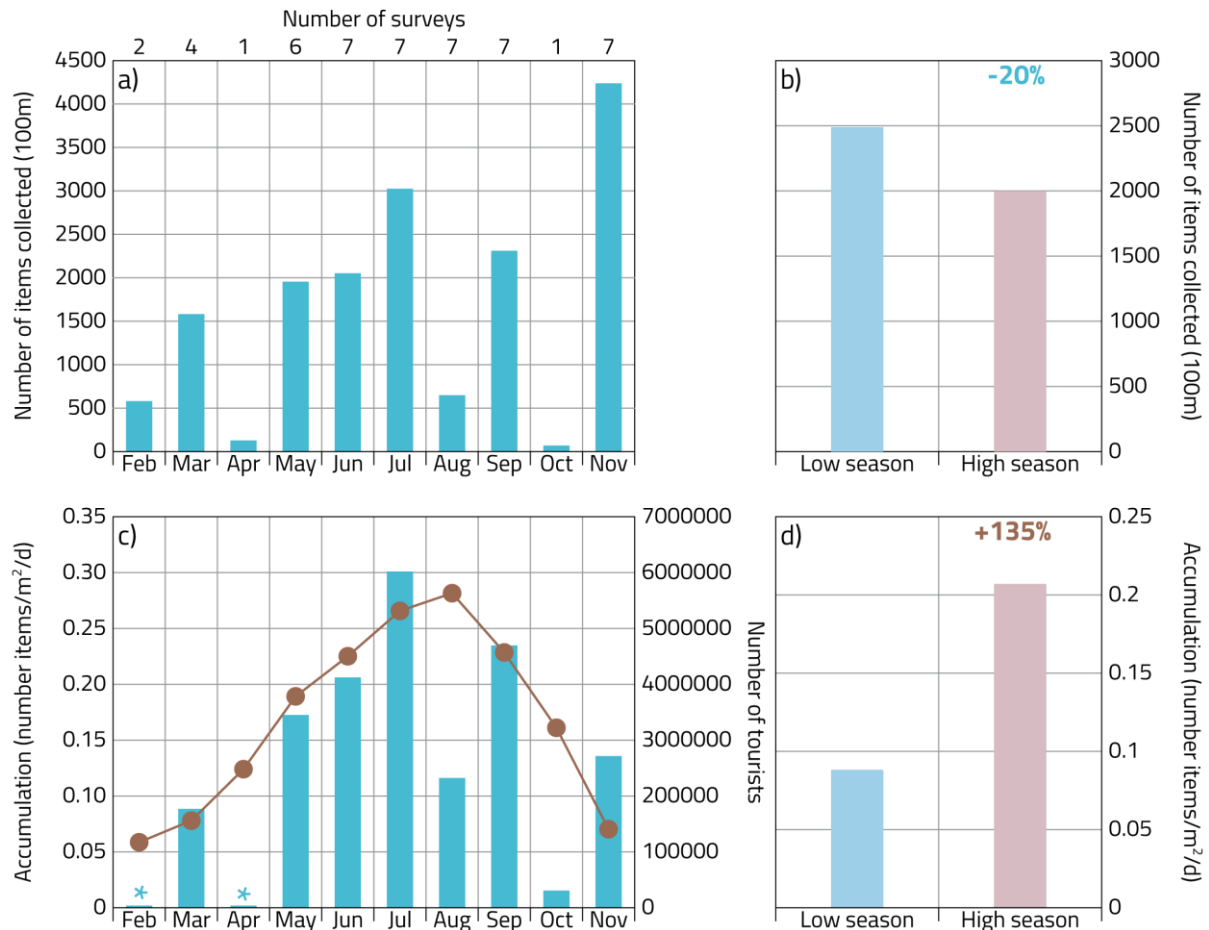


Figure C.III-1: total number and averaged accumulations rates of items collected for the 8 beaches mainly used by locals. a) Average number of items collected each month on the fixed 100m portions of beach. The numbers at the top refer to the number of surveys performed each month; b) comparison of the average number of items collected per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (blue font) refers to the decrease with respect to the low season; c) average accumulation rates of the marine litter (left axis, blue bars, the blue asterisks (*) refers to values not visible at this scale) and the average monthly number of tourists³ for the 8 islands (right axis, brown line and dots); and d) comparison of the average accumulation rates of marine litter per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season.

2. Composition of the marine litter

The marine litter collected on the 8 beaches mainly used by locals was classified into 8 major categories of material type (see Part B.III.2.c). It is largely dominated by the artificial polymer materials (average=94.35% \pm 7.67; min=73.33% in October and max=98.81% in November), followed by the metal (average=2.55% \pm 4.90; min=0.38% in November and max=16.30% in October), the paper/cardboard (average=1.39% \pm 2.01; min=0.08% in November and max=6.67% in October), the glass/ceramics (average=0.49% \pm 0.64; min=0.00% in April and max=2.22% in October), the processed/worked wood (average=0.45% \pm 0.54; min=0.00% in April and max=1.48% in October), the rubber (average=0.36% \pm 0.26; min=0.00% in October and max=0.80% in February), the cloth/textile (average=0.24% \pm 0.24; min=0.00% in October and max=0.73% in February) and the unidentified and/or chemicals (average=0.18% \pm 0.14; min=0.00% in October and max=0.44% in March).

During the low season (Fig. C.III-2), the marine litter is largely dominated by the artificial polymer materials (91.03%), followed by the metal (4.90%), the paper/cardboard (1.80%), the glass/ceramics

³ Data source: monthly average number of tourists welcomed to the 8 islands. See the *Part D Detailed results for each island*.

(0.81%), the processed/worked wood (0.63%), the rubber (0.33%), the cloth/textile (0.30%) and the unidentified and/or chemicals (0.19%).

During the high season (Fig. C.III-2), the marine litter is largely dominated by the artificial polymer materials (96.52%), followed by the metal (1.03%), the paper/cardboard (1.01%), the processed/worked wood (0.39%), the glass/ceramics (0.32%), the rubber (0.29%), the cloth/textile (0.23%) and the unidentified and/or chemicals (0.20%).

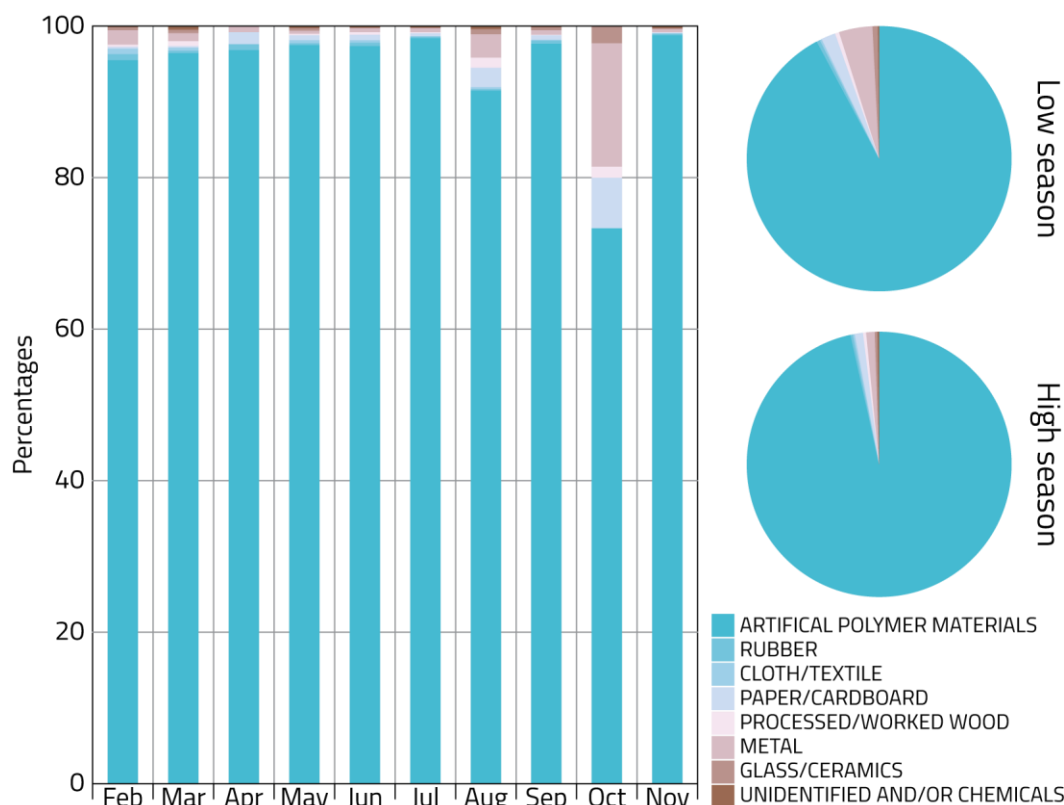


Figure C.III-2: average monthly composition of the marine litter collected on the 8 beaches mainly used by locals. Left: histogram showing the monthly percentages of the 8 major categories of material type. Right: pie charts showing the average composition of the marine litter during the low (top) and high (bottom) seasons. The color scale (lower right) indicates the type of material.

3. The 10 items with the highest accumulation rates

In this section, we consider the items with the highest averaged accumulation rates, which are not necessarily the most abundant items collected during the marine litter monitoring performed on the 8 beaches mainly used by locals (Fig. C.III-3). These items account for 91.66% of the total marine litter items (96885) collected in 2017. They are dominated by the mesoplastics (0.0643 items/m²/day; 44.38% of the total marine litter items collected), followed by cigarette butts (0.0300 items/m²/day; 5.46% of the total marine litter items collected), the microplastics (0.0233 items/m²/day; 14.07% of the total marine litter items collected), the pellets (0.0164 items/m²/day; 10.47% of the total marine litter items collected), the macroplastics (0.0139 items/m²/day; 8.36% of the total marine litter items collected), the caps/lids (0.0070 items/m²/day; 3.38% of the total marine litter items collected), the cutlery/trays/straws (0.0030 items/m²/day; 1.05% of the total marine litter items collected), the crisp/sweet packets and lolly sticks (0.0027 items/m²/day; 0.80% of the total marine litter items collected), the cotton bud sticks (0.0022 items/m²/day; 2.37% of the total marine litter items collected) and the strings and cords (diameter less than 1 cm) (0.0020 items/m²/day; 1.31% of the total marine litter items collected).

In this top 10, all the items are made of artificial polymer materials accounting then for 91.66% of the total marine litter items collected.

In this top 10, 4 items (cigarette butts, caps/lids, cutlery/trays/straws and crisp/sweet packets and lolly sticks) accounting for 10.70% of the total marine litter items collected, can be attributed to the shoreline source, including poor waste management practices, tourism and recreational activities (see Part B.III.2.c). To this, can possibly be added 2 items (mesoplastics and microplastics) presenting a clear seasonal pattern (see Appendix, Fig. E.I-3) and accounting for additional 58.44% of the total marine litter items collected.

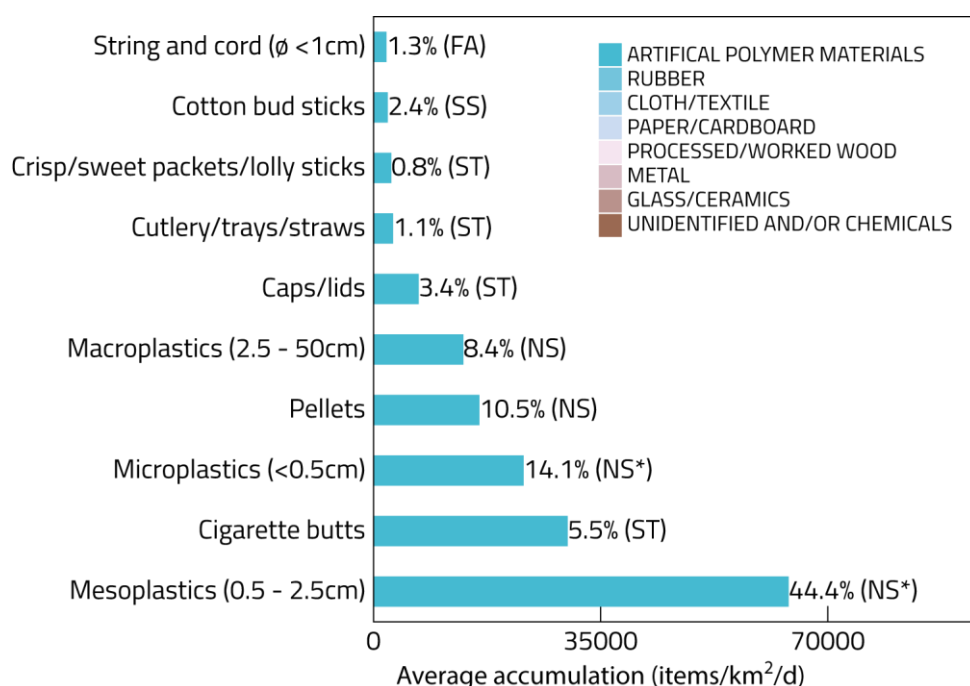


Figure C.III-3: list of the 10 items with the highest accumulation rates collected on the 8 beaches mainly used by locals. The percentages next to each item refers to their relative abundance with respect to the total collected. The possible source of the items is given into parenthesis: ST=shoreline, including poor waste management, tourism and recreational activities; FA=fishing and aquaculture; SS= sanitary and sewage related litter; and NS=non-sourced. The asterisk (*) associated to the non-sourced items (NS) shows that this specific item presents a clear seasonal increase. The color scale (upper right) indicates the type of material.

4. Clean-Coast Index and Accumulation Index

The clean-coast index (CCI) is a direct measurement of the cleanliness of a beach. Here is presented the average CCI for the beaches mainly used by locals of each island (Fig. C.III-4a). Compared to the touristic beaches, the results for the beaches mainly used by locals are more variable, this is probably due to less effort put by the local authorities to regularly clean these beaches: the CCI is higher during the low season for Mallorca, Crete, Malta and Mykonos, and lower for Rab, Cyprus, Rhodes and Sicily (Fig. C.III-4a). During the low season, all the beaches mainly used by locals taken together exhibit a CCI of 10.38 corresponding to dirty beaches. In details, during the low season, the beaches of Sicily (CCI=0.26), Rab (CCI=0.62), Mykonos (CCI=0.68), Cyprus (CCI=1.40) and Rhodes (CCI=1.58) are very clean; the beach of Malta (CCI=5.86) is moderately clean; and the beaches of Crete (CCI=29.40) and Mallorca (CCI=38.36) are very dirty. During the high season, all the beaches mainly used by locals taken together exhibit a CCI of 8.27 corresponding to beaches moderately clean. In details, during the high season, the beaches of Sicily (CCI=0.31), Mykonos (CCI=0.48), Rhodes (CCI=1.91), Cyprus (CCI=1.92)

and Rab (CCI=1.96) are very clean; the beach of Malta (CCI=3.19) is clean; the beach of Crete (CCI=19.32) is dirty; and the beach of Mallorca (CCI=35.59) is very dirty.

On the other hand, the accumulation index (AI) which takes into account the cleaning activities conducted by the local authorities on the beaches show that the accumulation of marine litter is always higher during the high season (Fig. C.III-4b) with the exception of Malta and Rab. During the low season, all the beaches mainly used by locals taken together show an AI of 3.67 corresponding to moderate accumulation of marine litter. In details the beaches of Sicily (AI=2.06) and Rhodes (2.75) show low accumulation of marine litter; the beaches of Mykonos (AI=3.05) and Cyprus (AI=3.42) present moderate accumulation of marine litter; the beaches of Rab (AI=4.19), Crete (AI=4.20) and Mallorca (AI=4.26) exhibit high accumulation of marine litter; and the beach of Malta (AI=5.68) shows very high accumulation of marine litter. During the high season, all the beaches mainly used by locals taken together show an AI of 4.60 corresponding to high accumulation of marine litter. In details the beaches of Rhodes (AI=3.44), Rab (AI=3.55) and Sicily (AI=3.64) show moderate accumulation of marine litter; the beaches of Mykonos (AI=4.23), Crete (AI=4.73) and Cyprus (AI=4.98) present high accumulation of marine litter; and the beaches of Malta (AI=5.62) and Mallorca (AI=5.95) exhibit very high accumulation of marine litter.

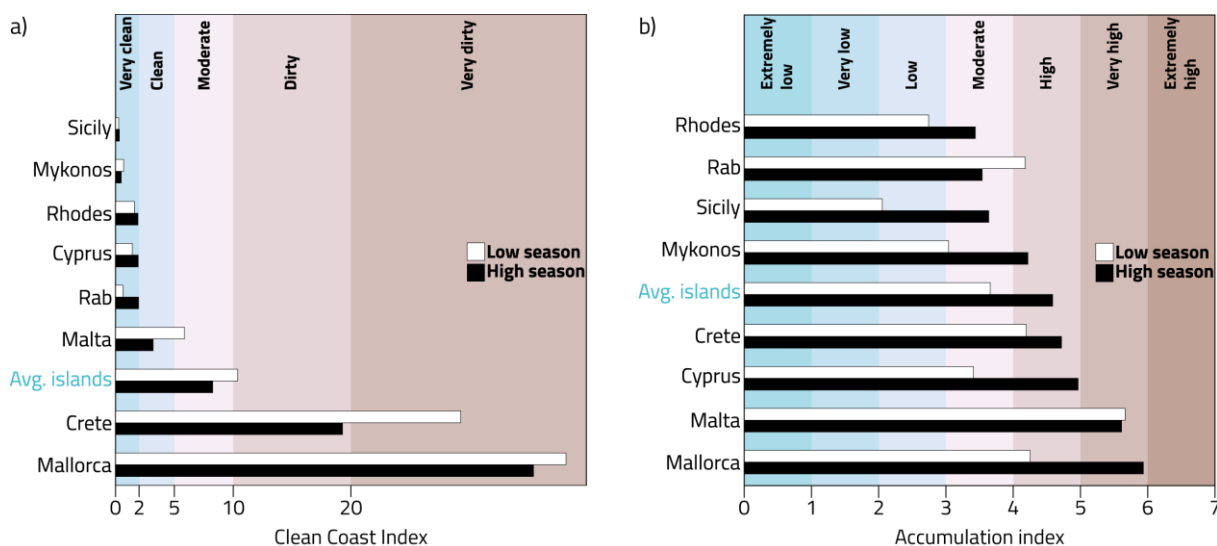


Figure C.III-4: clean-coast index and accumulation index for the beach mainly used by locals of each island. a) The clean-coast index is displayed for the low season (white bars) and the high season (black bars). The color scale (background) provides the quality of cleanliness. b) The accumulation index is displayed for the low season (white bars) and the high season (black bars). The color scale (background) provides the degree of accumulation.

5. Summary

The 49 marine litter surveys conducted on the 8 beaches mainly used by locals in 2017 have revealed that:

- If only the number of items collected is considered (corrected for distance, see Part B.III.2.a), no clear seasonal variability is observed. On average, the beaches are more affected by the marine litter during the low season (37491 items collected; average: 2499.4 items/survey ± 6127.7 items per survey, $n=15$) than during the high season (68212 items collected; average: 2006.2 items/survey ± 3981.8 items per survey, $n=34$), suggesting a decrease of 20% of the marine litter found during the high season in comparison to the low season.
- If the accumulation rate of the marine litter is considered, a seasonal variation is observed. On average, the accumulation rate is higher during the high season (average: 0.2078

items/m²/day ± 0.3422 items/m²/day, n=34) than during the low season (0.0884 items/m²/day ± 0.1896 items/m²/day, n=14), suggesting an increase of 135% of the accumulation of marine litter during the high season in comparison to the low season.

- The items collected are mainly composed of artificial polymer materials: they represent 94.35% of the total marine litter items collected.
- The 4 items (cigarette butts, caps/lids, cutlery/trays/straws and crisp/sweet packets and lolly sticks), most likely related to tourism and recreational activities, are representing 10.7% of the total marine litter items collected. To this, can possibly be added 2 items (mesoplastics and microplastics), accounting for additional 58.4% as they presented a recognizable seasonal variation.
- The cleanliness of the beaches is considered as dirty during the low season (CCI=10.38) and moderately clean during the high season (CCI=8.27).
- Finally the accumulation index of the remote beaches is considered as moderate during the low season (AI=3.67) and high during the high season (AI=4.60).

IV. Results for the remote beaches

1. Seasonality of the marine litter

The 8 remote beaches were sampled for marine litter in February (1 survey), March (4 surveys), April (2 surveys), May (6 surveys), June (7 surveys), July (7 surveys), August (7 surveys), September (7 surveys), October (1 survey) and November (7 surveys) of 2017 (Fig. C.IV-1a). A total of 22456 items (corrected for distance, see Part B.III.2.a) were collected on the same 100m portion of each beach during the 49 monitoring, representing an average of 458.3 items (± 1224.0 items, n=49) per survey. The lowest average number of items was recorded in April (32.1 items, ± 34.1 items, n=2) while the highest number was recorded in November (1226.6 items, ± 2820.4 items, n=7) (Fig. C.IV-1a). In general, the amount of marine litter remain quite low and stable from February to August before to sharply increase from September to November. No seasonal pattern was then visible (Fig. C.IV-1a). When only the number of items collected is considered (Fig. C.IV-1b), their average number per survey during the low season (October – April) was of 708.1 (± 1926.7 items, n=15) and of 348.1 (± 750.5 items, n=34) during the high season (May – September). Then, the amount of marine litter collected per survey during the high season was on average 50.8% lower than during the low touristic season (Fig. C.IV-1b). When the accumulation rates (see Part B.III.2.b) are considered, a seasonal pattern is observed although masked by the high accumulation rates recorded in March and October (Fig. C.IV-1c). The lowest value observed was of 0.0001 items/m²/day (± 0.0001 items/m²/day, n=2) in April and the highest was of 0.2254 items/m²/day (± 0.4500 items/m²/day, n=4) in March (Fig. C.IV-1c). The seasonal pattern of the marine litter seems to follow the average monthly number of tourists welcomed to the 8 selected islands (Fig. C.IV-1c), again if the high values recorded in March and October are not taken into account. During the low season, the average accumulation rate is of 0.1200 items/m²/day (± 0.2688 , n=15) and of 0.1844 items/m²/day (± 0.4235 , n=34) during the high season. These results show that, on average the accumulation rates of the marine litter are higher during the high season (+53.6%, Fig. C.IV-1d) than during the low season.

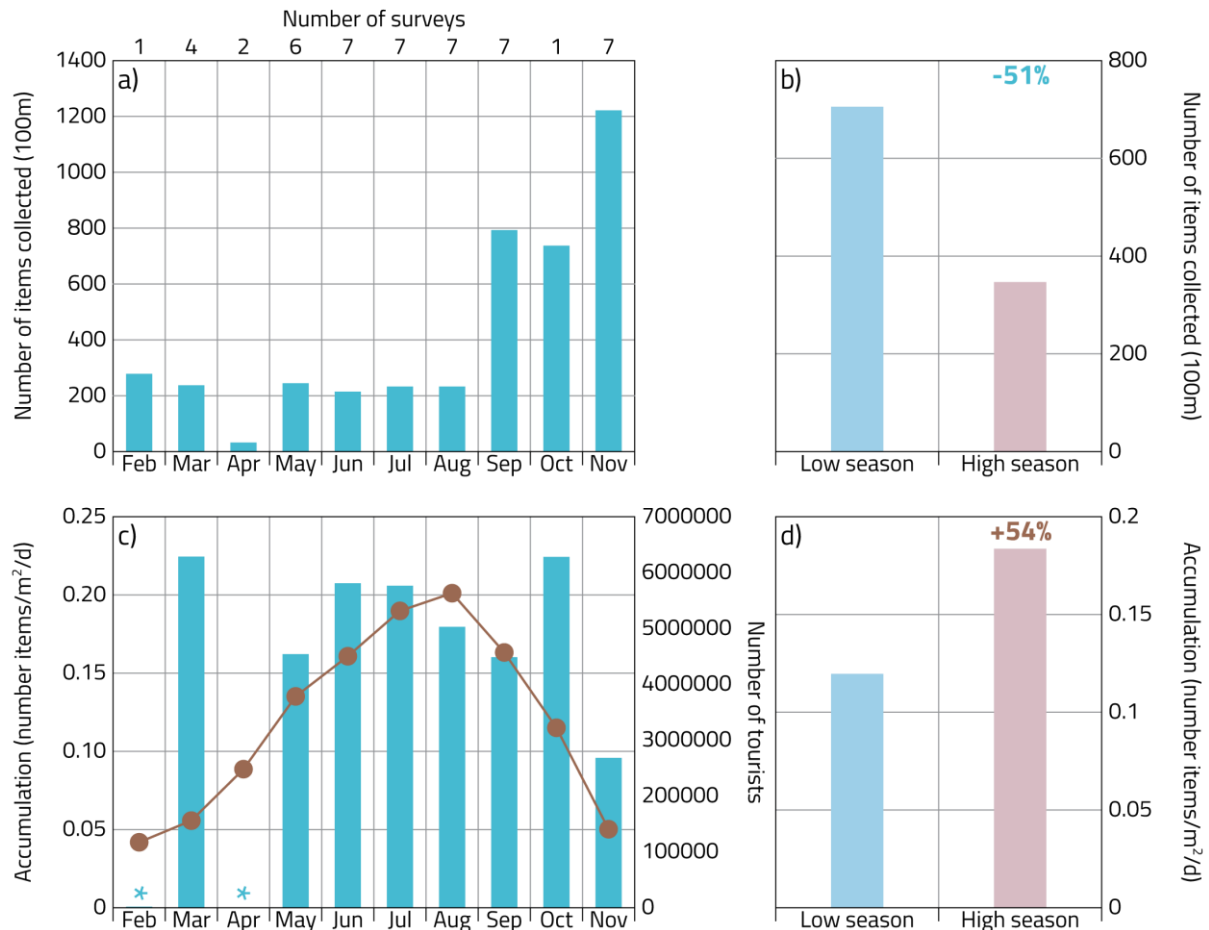


Figure C.IV-1: average number and average accumulations rates of items collected for the 8 remote beaches. a) Average number of items collected each month on the fixed 100m portions of beach. The numbers at the top refer to the number of surveys performed each month; b) comparison of the average number of items collected per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (blue font) refers to the decrease with respect to the low season; c) average accumulation rates of the marine litter (left axis, blue bars, the blue asterisks (*) refer to values not visible at this scale) and the average monthly number of tourists⁴ for the 8 islands (right axis, brown line and dots); and d) comparison of the average accumulation rates of marine litter per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season.

2. Composition of the marine litter

The marine litter collected on the 8 remote beaches was classified into 8 major categories of material type (see Part B.III.2.c). It is largely dominated by the artificial polymer materials (average=84.03% \pm 13.16; min=53.26% in October and max=96.73% in November), followed by the metal (average=5.66% \pm 6.69; min=0.58% in November and max=21.47% in October), the paper/cardboard (average=3.37% \pm 5.01; min=0.25% in February and max=17.26% in October), the glass/ceramics (average=2.56% \pm 3.69; min=0.00% in February and max=11.77% in March), the processed/worked wood (average=1.59% \pm 1.63; min=0.11% in November and max=5.89% in October), the unidentified and/or chemicals (average=1.31% \pm 2.44; min=0.00% in April and max=8.02% in February), the rubber (average=0.82% \pm 0.86; min=0.00% in April and max=2.37% in March) and the cloth/textile (average=0.66% \pm 0.56; min=0.00% in April and max=1.53% in February).

During the low season (Fig. C.IV-2), the marine litter is largely dominated by the artificial polymer materials (76.38%), followed by the metal (8.58%), the paper/cardboard (5.21%), the glass/ceramics

⁴ Data source: monthly average number of tourists welcomed to the 8 islands. See the Part D Detailed results for each island.

(3.39%), the unidentified and/or chemicals (2.57%), the processed/worked wood (1.98%), the rubber (1.26%) and the cloth/textile (0.63%).

During the high season (Fig. C.IV-2), the marine litter is largely dominated by the artificial polymer materials (87.94%), followed by the metal (4.13%), the glass/ceramics (2.41%), paper/cardboard (2.24%), the processed/worked wood (1.28%), the cloth/textile (0.82%), the rubber (0.62%) and the unidentified and/or chemicals (0.56%).

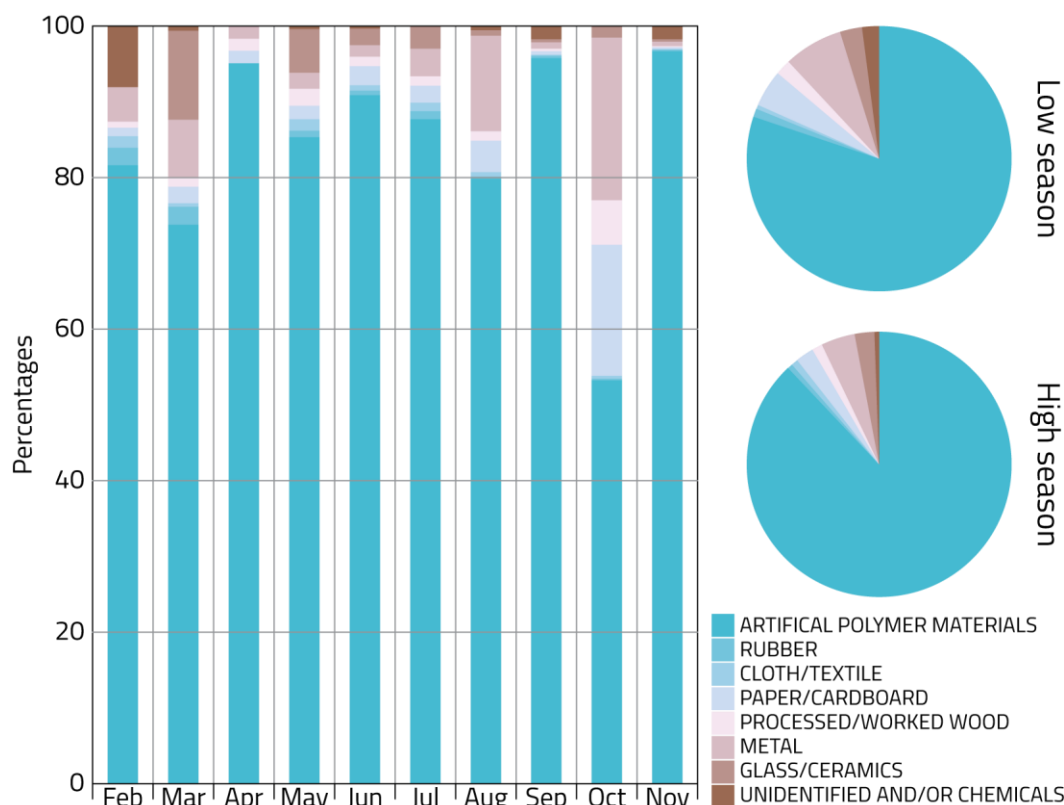


Figure C.IV-2: average monthly composition of the marine litter collected on the 8 remote beaches. Left: histogram showing the monthly percentages of the 8 major categories of material type. Right: pie charts showing the average composition of the marine litter during the low (top) and high (bottom) seasons. The color scale (lower right) indicates the type of material.

3. The 10 items with the highest accumulation rates

In this section, we consider the items with the highest averaged accumulation rates, which are not necessarily the most abundant items collected during the marine litter monitoring performed on the 8 remote beaches (Fig. C.IV-3). These items account for 73.37% of the total marine litter items (16252) collected in 2017. They are dominated by the cigarette butts (0.0437 items/m²/day; 7.98% of the total marine litter items collected), followed by the mesoplastics (0.0217 items/m²/day; 29.16% of the total marine litter items collected), the macroplastics (0.0190 items/m²/day; 14.79% of the total marine litter items collected), the microplastics (0.152 items/m²/day; 8.89% of the total marine litter items collected), the caps/lids (0.0121 items/m²/day; 5.14% of the total marine litter items collected), the strings and cords (diameter less than 1 cm) (0.0064 items/m²/day; 1.67% of the total marine litter items collected), the crisp/sweet packets and lolly sticks (0.0057 items/m²/day; 1.84% of the total marine litter items collected), the cutlery/trays/straws (0.0057 items/m²/day; 1.12% of the total marine litter items collected), the glass bottles (0.0051 items/m²/day; 0.87% of the total marine litter items collected) and the foam sponges (0.0039 items/m²/day; 0.91% of the total marine litter items collected).

In this top 10, the artificial polymer materials largely dominate as they are represented by 9 items, accounting for 71.50% of the total marine litter items collected.

In this top 10, 5 items (cigarette butts, caps/lids, cutlery/trays/straws, crisp/sweet packets and lolly sticks and glass bottles) accounting for 16.95% of the total marine litter items collected, can be attributed to the shoreline source, including poor waste management practices, tourism and recreational activities (see Part B.III.2.c). To this, can possibly be added 1 item (microplastics) presenting a clear seasonal pattern (see Appendix, Fig. E.I-4) and accounting for additional 8.89% of the total marine litter items collected.

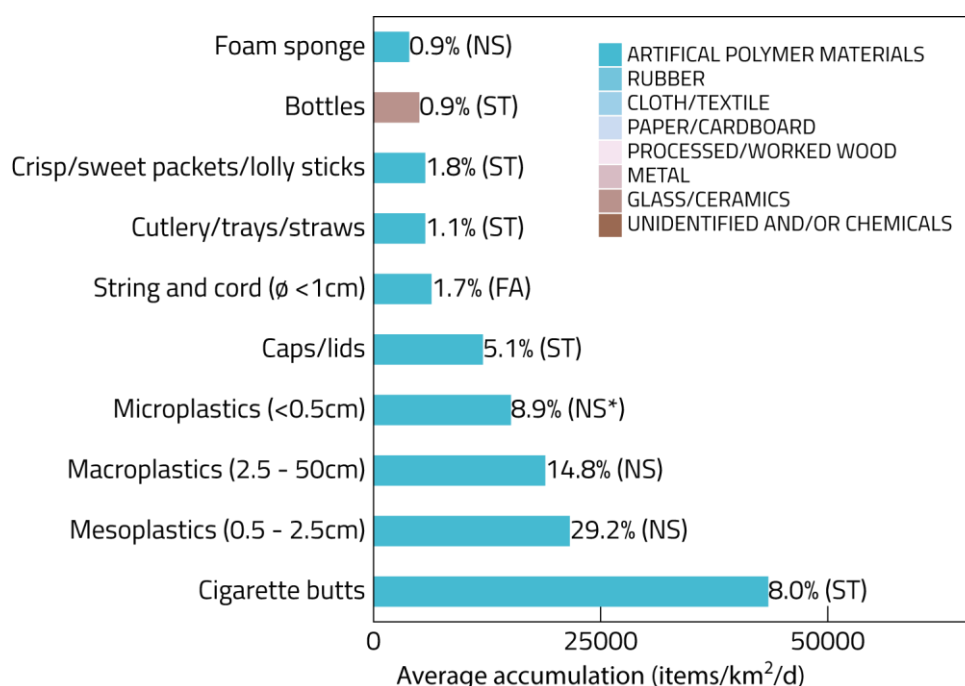


Figure C.IV-3: list of the 10 items with the highest accumulation rates collected on the 8 remote beaches. The percentages next to each item refers to their relative abundance with respect to the total collected. The possible source of the items is given into parenthesis: ST=shoreline, including poor waste management, tourism and recreational activities; FA= fishing and aquaculture; and NS=non-sourced. The asterisk (*) associated to the non-sourced items (NS) shows that this specific item presents a clear seasonal increase. The color scale (upper right) indicates the type of material.

4. Clean-Coast Index and Accumulation Index

The clean-coast index (CCI) is a direct measurement of the cleanliness of a beach. Here is presented the average CCI for the remote beaches of each island (Fig. C.IV-4a). As for the beaches mainly used by locals, the results for the remote beaches are more variable, this is probably due to less effort put by the local authorities to regularly clean these beaches: the CCI is higher during the low season for Mallorca, Rab and Mykonos, and lower for Malta, Cyprus, Rhodes, Sicily and Crete (Fig. C.IV-4a). During the low season, all the remote beaches taken together exhibit a CCI of 4.38 corresponding to clean beaches. In details, during the low season, the beaches of Crete (CCI=0.05), Sicily (CCI=0.26), Rhodes (CCI=0.33), Mykonos (CCI=0.92) and Cyprus (CCI=1.95) are very clean; the beaches of Rab (CCI=9.00) and Malta (CCI=9.76) are moderately clean; and the beach of Mallorca (CCI=15.07) is dirty. During the high season, all the remote beaches taken together exhibit a CCI of 3.17 corresponding to clean beaches. In details, during the high season, the beaches of Crete (CCI=0.05), Sicily (CCI=0.30), Rhodes (CCI=0.39) and Mykonos (CCI=0.88) are very clean; the beaches of Cyprus (CCI=2.80), Rab (CCI=3.20) and Mallorca (CCI=4.97) are moderately clean; and the beach of Malta (CCI=12.13) is dirty.

On the other hand, the accumulation index (AI) which takes into account the cleaning activities conducted by the local authorities on the beaches show that the accumulation of marine litter is always higher during the high season (Fig. C.IV-4b) with the exception of Rab. During the low season, all the remote beaches taken together show an AI of 3.13 corresponding to moderate accumulation of marine litter. In details the beaches of Crete (AI=1.18) and Sicily (AI=1.98) show very low accumulation of marine litter; the beaches of Rhodes (AI=2.04) and Mykonos (AI=2.68) present low accumulation of marine litter; the beaches of Cyprus (AI=3.31) and Mallorca (AI=3.73) exhibit moderate accumulation of marine litter; and the beaches of Rab (AI=5.35) and Malta (AI=5.87) show very high accumulation of marine litter. During the high season, all the remote beaches taken together show an AI of 3.58 corresponding to moderate accumulation of marine litter. In details the beach of Crete (AI=1.81) shows very low accumulation of marine litter; the beaches of Rhodes (AI=2.70) and Sicily (AI=2.79) present low accumulation of marine litter; the beaches of Mykonos (AI=3.51), Cyprus (AI=3.61) and Rab (AI=3.64) exhibit moderate accumulation of marine litter; the beach of Mallorca (AI=4.58) shows high accumulation of marine litter; and the beach of Malta (AI=6.06) exhibits extremely high accumulation of marine litter.

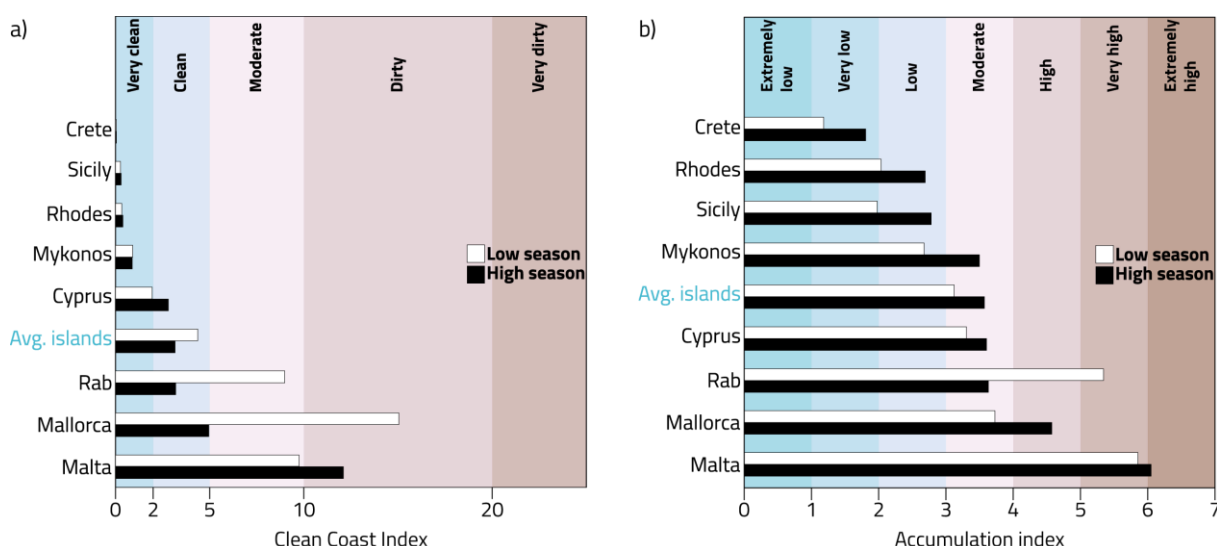


Figure C.IV-4: clean-coast index and accumulation index for the remote beach of each island. a) The clean-coast index is displayed for the low season (white bars) and the high season (black bars). The color scale (background) provides the quality of cleanliness. b) The accumulation index is displayed for the low season (white bars) and the high season (black bars). The color scale (background) provides the degree of accumulation.

5. Summary

The 49 marine litter surveys conducted on the 8 remote beaches in 2017 have revealed that:

- If only the number of items collected is considered (corrected for distance, see Part B.III.2.a), no clear seasonal variability is observed. On average, the beaches are more affected by the marine litter during the low season (10621 items collected; average: 708.1 items/survey ± 1926.7 items per survey, $n=15$) than during the high season (11835 items collected; average: 348.1 items/survey ± 750.5 items per survey, $n=34$), suggesting a decrease of 51% of the marine litter found during the high season in comparison to the low season.
- If the accumulation rate of the marine litter is considered, a seasonal variation is observed. On average, the accumulation rate is higher during the high season (average: 0.1844 items/m²/day ± 0.4235 items/m²/day, $n=34$) than during the low season (0.1200 items/m²/day).

± 0.2688 items/m²/day, n=14), suggesting an increase of 54% of the accumulation of marine litter during the high season in comparison to the low season.

- The items collected are mainly composed of artificial polymer materials: they represent 84.03% of the total marine litter items collected.
- The 5 items (cigarette butts, caps/lids, cutlery/trays/straws, crisp/sweet packets and lolly sticks and glass bottles), most likely related to tourism and recreational activities, are representing 17.0% of the total marine litter items collected. To this, can possibly be added 1 item (microplastics), accounting for additional 8.9% as they presented a recognizable seasonal variation.
- The cleanliness of the beaches is considered as clean during both the low and high seasons (CCI of 4.38 and 3.17).
- Finally the accumulation index of the remote beaches is considered as moderate during both the low and high seasons (AI of 3.13 and 3.58).

V. General conclusions

The 147 marine litter surveys conducted on 3 types of beach of 8 Mediterranean islands in 2017 have revealed that all the monitored beaches are affected by marine litter. In terms of number of items collected (corrected for distance), the beaches mainly used by locals are the most affected by marine litter (105703 items), followed by the touristic beaches (44096 items) and the remote beaches (22456). However, when the accumulation rates are considered, this is on the touristic beaches that more marine litter will accumulate (286822 items/km²/day), followed by the beaches mainly used by locals (171204 items/km²/day) and the remote beaches (164667 items/km²/day).

In order to estimate the seasonal variations of the marine litter, it is necessary to consider the accumulation rates rather than the number of items collected. Indeed, when only the number of items collected is considered, it is not possible to observe any seasonal variations. But when the accumulation rates are considered, the 3 types of beach present a clear seasonal pattern, although less marked for the remote beaches, following the seasonal variations of the number of tourists. This suggests a direct relation between the accumulation of marine litter on the selected beaches and the number of tourists.

For the 3 types of beaches the items made of artificial polymer materials largely dominate as they represent on average 88.22% of the total marine litter collected, followed by the metal (4.10%), the paper/cardboard (3.25%), the glass/ceramics (1.46%), the processed/worked wood (1.11%), the unidentified and/or chemicals (0.85%), the cloth/textile (0.56%) and the rubber (0.45%).

In the top 10 of the items with the highest accumulation rates 8 items are common to the 3 types of beach: the cigarette butts, the mesoplastics, the microplastics, the macroplastics, the caps/lids, the cutlery/trays/straws, the crisp/sweet packets and lolly sticks, and the string and cord (diameter less than 1 cm). Note that all these items are made of artificial polymer materials. They represent 75.0% of all the marine litter items collected. The items that should be prioritized for any action plan aiming to reduce the amount of marine litter generated on beaches as an effect of tourism should be: the cigarette butts (12.7% of the total marine litter items collected), the caps/lids (3.6%), the cutlery/trays/straws (1.5%) and the crisp/sweet packets/lolly sticks (1.5%) as all these items belong to

the “shoreline, including poor waste management, tourism and recreational activities” category. The small pieces of plastic (including the meso- and microplastics) should be considered too, although they belong to the non-sourced category, they present a clear seasonal variation and account for 45.7% of the total marine litter items collected.

The clean-coast index, which provides the state of cleanliness of a beach at the moment of the survey, only gives limited information about the marine litter. It is then recommended to use the accumulation index in order to take into account the accumulation rates of the marine litter.

Finally, the comparison of the normalized monthly number of tourists per island with the normalized monthly accumulation rates of marine litter (Fig. C.V-1) shows a clear relation between the number of tourists welcomed to each island and the accumulation rates of marine litter on the selected beaches. The correlation between these two parameters is the highest for the touristic beaches ($R^2=0.5954$) followed by the beaches mainly used by locals ($R^2=0.4951$) and the remote beaches ($R^2=0.3747$).

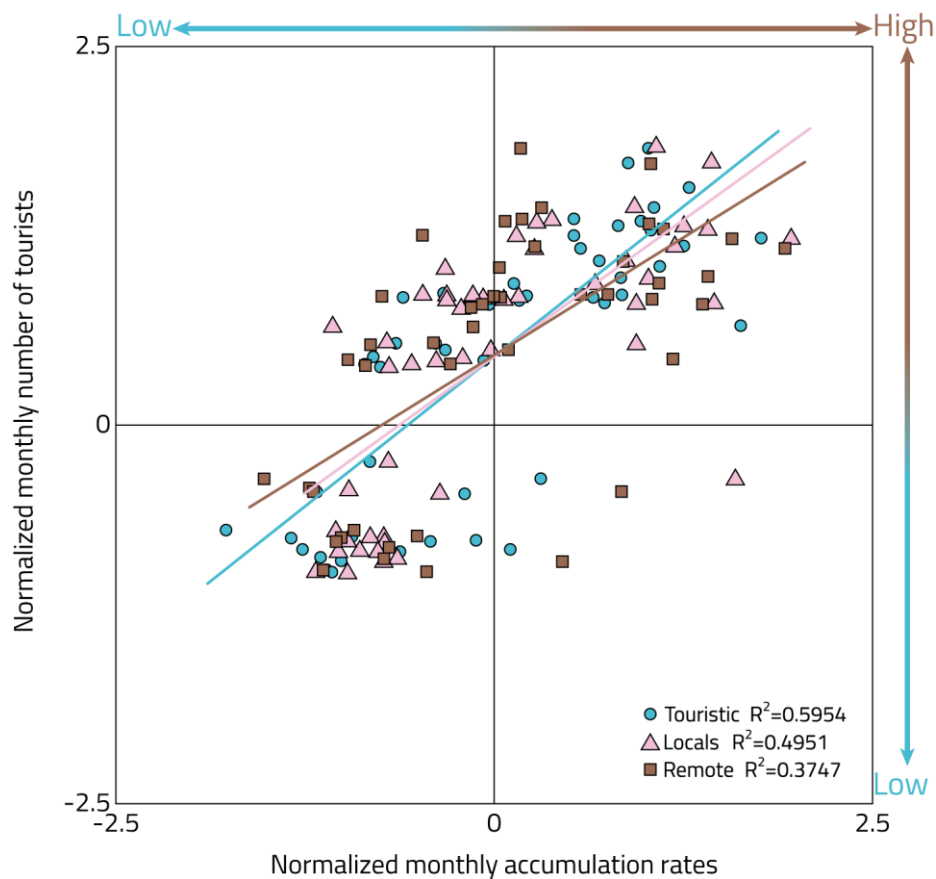


Figure C.V-1: comparison of the normalized monthly number of tourists (Y axis) with the normalized monthly accumulation rates (X axis) for the 24 selected beaches. The type of beach is provided by the symbols (circles= touristic beach, triangles=beaches mainly used by locals and squares=remote beaches). The 3 colored lines show the linear regressions.

Part D: DETAILED RESULTS FOR EACH SELECTED BEACH

I. Mallorca

1. Touristic beach: Torà

a) Characteristics of the beach

The touristic beach of Torà is an urban beach, located in the municipality of Paguera in the SW of Mallorca, facing the sea to the SW. It has a total length of $\pm 500\text{m}$, a width of $\pm 40\text{m}$ and is composed at 100% of sand with a smooth slope. The monitored fixed portion of the beach has a surface of 2149 m^2 . It has a pier situated on its west side. The beach is mainly used for recreational activities during the high season (tourists and locals) and the low season (locals). It is accessible by vehicles/boats and for pedestrians. The area situated directly behind the beach is an urban area with many services and facilities provided to the beach users. The coordinates of the fixed 100m portion selected for the monitoring are: 39.5348N, 2.5444E (starting point) and 39.5351N, 2.4555E (ending point) (Fig. D.I.1-1). Drink and food outlets are situated directly on the beach and the closest harbor is situated 4 km away to the SE. The beach is cleaned daily from May to October.



Figure D.I.1-1: location map showing the beach of Torà and the selected 100m portion of beach monitored (red area).

b) Seasonality of the marine litter

The touristic beach of Torà was sampled for marine litter in February, May, June, July, September and November of 2017. A total of 11122 items (corrected for distance, see Part B.III.2.a) were collected on the same 100m portion of beach during the 6 monitoring, representing an average of 1853.7 items (± 490.4 items, $n=6$) per survey. The lowest number of items was recorded in February (1195 items) while the highest number was recorded in November (2589 items) (Fig. D.I.1-2a). In general, the amount of marine litter continuously increased from February to November, with a slight decrease in June and no seasonal pattern was visible (Fig. D.I.1-2a). When only the number of items collected is considered (Fig. D.I.1-2b), their average number per survey during the low season (October – April) was of $1892.0 (\pm 985.7 \text{ items}, n=2)$ and of $1834.5 (\pm 274.5 \text{ items}, n=4)$ during the high season (May – September). Then, the amount of marine litter collected per survey during the high season was on average 3.0% lower than during the low touristic season (Fig. D.I.1-2b). When the accumulation rates (see Part B.III.2.b) are considered, a clear seasonal pattern is observed (Fig. D.I.1-2c). The lowest value

observed was of 0.0049 items/m²/day (4866 items/km²/day) in February and the highest was of 1.7961 items/m²/day (1796184 items/km²/day) in July (Fig. D.I.1-2c). The seasonal pattern of the marine litter seems to follow the monthly number of tourists welcomed on Mallorca (Fig. D.I.1-2c): higher accumulation rates are observed during the touristic season and lower accumulation rates are observed during the off season. During the low season, the average accumulation rate is of 0.0387 items/m²/day (± 0.032 , n=2) and of 1.2493 items/m²/day (± 0.677 , n=4) during the high season. These results show that, on average the accumulation rates of the marine litter are by far higher during the high season (+3126%, Fig. D.I.1-2d) than during the low season.

Finally, the beach of Torà can be considered as dirty during both the low and high seasons, according to the Clean-Coast Index (see Part B.III.2.d) exhibiting values of respectively 18.1 and 17.5 (Fig. C.II-4a). The accumulation index shows that the accumulation of marine litter can be considered as high during the low season (AI=4.59) and extremely high during the high season (AI=6.10) (Fig. C.II-4b).

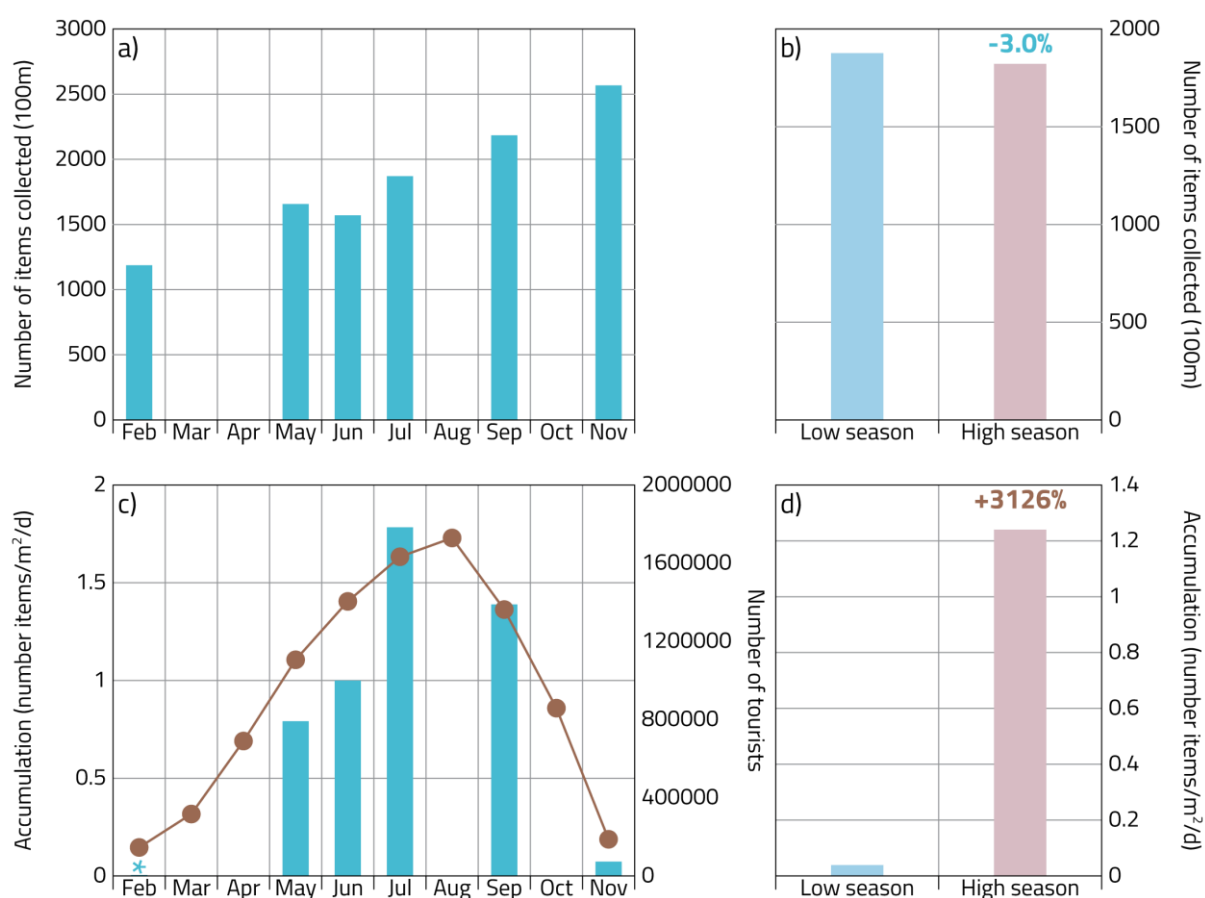


Figure D.I.1-2: total number and accumulations rates of items collected at the beach of Torà. a) number of items collected during each survey on the fixed 100m portion of beach; b) comparison of the average number of items collected per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (blue font) refers to the decrease with respect to the low season; c) accumulation rates of the marine litter (left axis, blue bars, the blue asterisk (*) refers to values not visible at this scale) and the monthly number of tourists⁵ in Mallorca (right axis, brown line and dots); and d) comparison of the accumulation rates of marine litter per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season.

c) Composition of the marine litter

The marine litter collected on the beach of Torà (Fig. D.I.1-3) was classified into 8 major categories of material type (see Part B.III.2.c). It is largely dominated by the artificial polymer materials

⁵ Data source: number of tourists welcomed on Mallorca in 2014, <https://ibestat.caib.es>

(average=88.86% \pm 2.54; min=85.71% in September and max=92.23% in July), followed by the paper/cardboard (average=5.10% \pm 1.74; min=2.83% in November and max=7.28% in September), the metal (average=1.95% \pm 0.51; min=1.35% in July and max=2.53% in Jun), the cloth/textile (average=1.37% \pm 0.70; min=0.62% in July and max=2.34% in May), the glass/ceramics (average=1.28% \pm 1.11; min=0.35% in May and max=2.92% in February), the rubber (average=0.57% \pm 0.46; min=0.10% in July and max=1.33% in September), the unidentified and/or chemicals (average=0.55% \pm 0.53; min=0.00% in July and max=1.47% in November), and the processed/worked wood (average=0.32% \pm 0.17; min=0.10% in July and max=0.49% in June).

During the low season (Fig. D.I.1-3), the marine litter is largely dominated by the artificial polymer materials (89.94%), followed by the paper/cardboard (3.20%), the metal (1.98%), the glass/ceramics (1.85%), the cloth/textile (1.12%), the unidentified and/or chemicals (1.10%), the rubber (0.42%) and the processed/worked wood (0.39%).

During the high season (Fig. D.I.1-3), the marine litter is largely dominated by the artificial polymer materials (88.32%), followed by paper/cardboard (6.05%), the metal (1.93%), the cloth/textile (1.50%), the glass/ceramics (0.99%), the rubber (0.64%), the processed/worked wood (0.28%) and the unidentified and/or chemicals (0.28%).

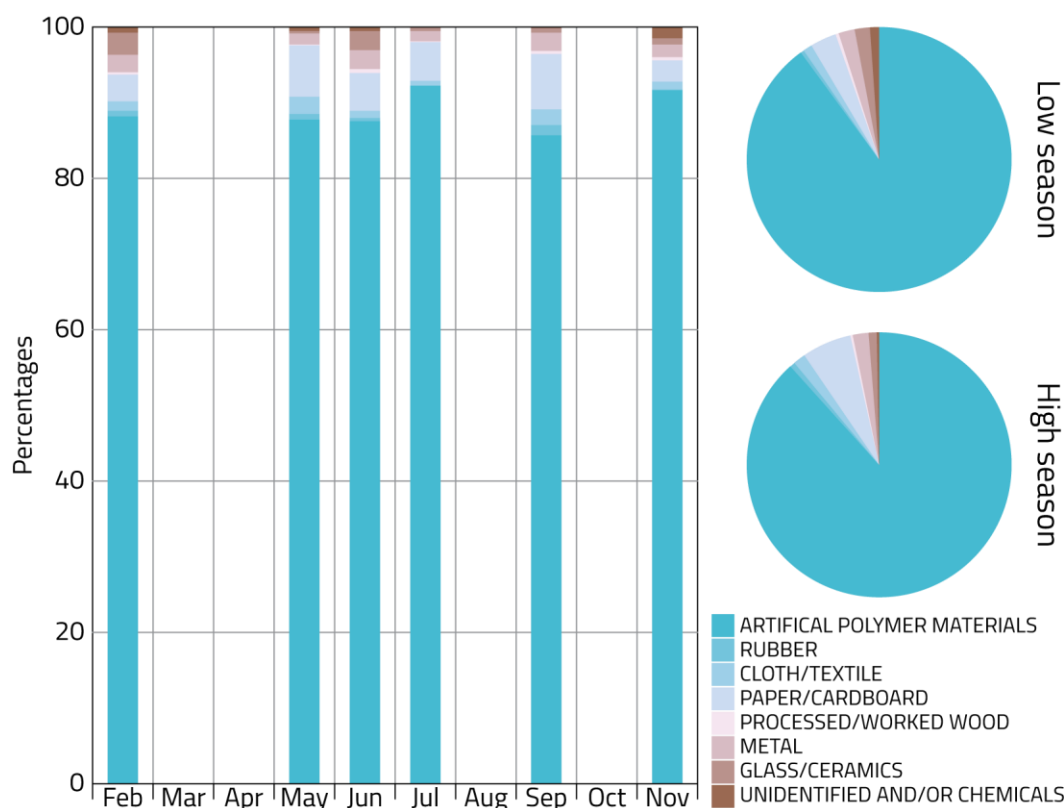


Figure D.I.1-3: composition of the marine litter collected at the beach of Torà. Left: histogram showing the monthly percentages of the 8 major categories of material type. Right: pie charts showing the average composition of the marine litter during the low (top) and high (bottom) seasons. The color scale (lower right) indicates the type of material.

d) The 10 items with the highest accumulation rates

In this section, we consider the items with the highest averaged accumulation rates, which are not necessarily the most abundant items collected during the marine litter monitoring performed on the beach of Torà (Fig. D.I.1.4). These items account for 90.78% of the total marine litter items (11122) collected in 2017. They are dominated by the cigarette butts (0.4293 items/m²/day; 46.53% of the

total marine litter items collected), followed by the mesoplastics (0.0979 items/m²/day; 14.09% of the total marine litter items collected), the macroplastics (0.0822 items/m²/day; 9.86% of the total marine litter items collected), the microplastics (0.0619 items/m²/day; 7.36% of the total marine litter items collected), the other paper items (0.0477 items/m²/day; 4.75% of the total marine litter items collected), the crisp/sweet packets and lolly sticks (0.0184 items/m²/day; 2.36% of the total marine litter items collected), the strings and cords (diameter less than 1 cm) (0.016 items/m²/day; 1.86% of the total marine litter items collected), the other plastic/polystyrene items (0.0144 items/m²/day; 1.61% of the total marine litter items collected), the other textiles (0.0112 items/m²/day; 1.25% of the total marine litter items collected) and the foil wrappers (0.0106 items/m²/day; 1.11% of the total marine litter items collected).

In this top 10, the artificial polymer materials largely dominate as they are represented by 7 items, accounting for 83.68% of the total marine litter items collected.

In this top 10, 3 items (cigarette butts, crisp/sweet packets and lolly sticks and foil wrappers) accounting for 50% of the total marine litter items collected, can be attributed to the shoreline source, including poor waste management practices, tourism and recreational activities (see Part B.III.2.c). To this, can possibly be added 2 items (mesoplastics and macroplastics) presenting a clear seasonal pattern (see Appendix, Fig. E.II-1) and accounting for additional 23.95% of the total marine litter items collected.

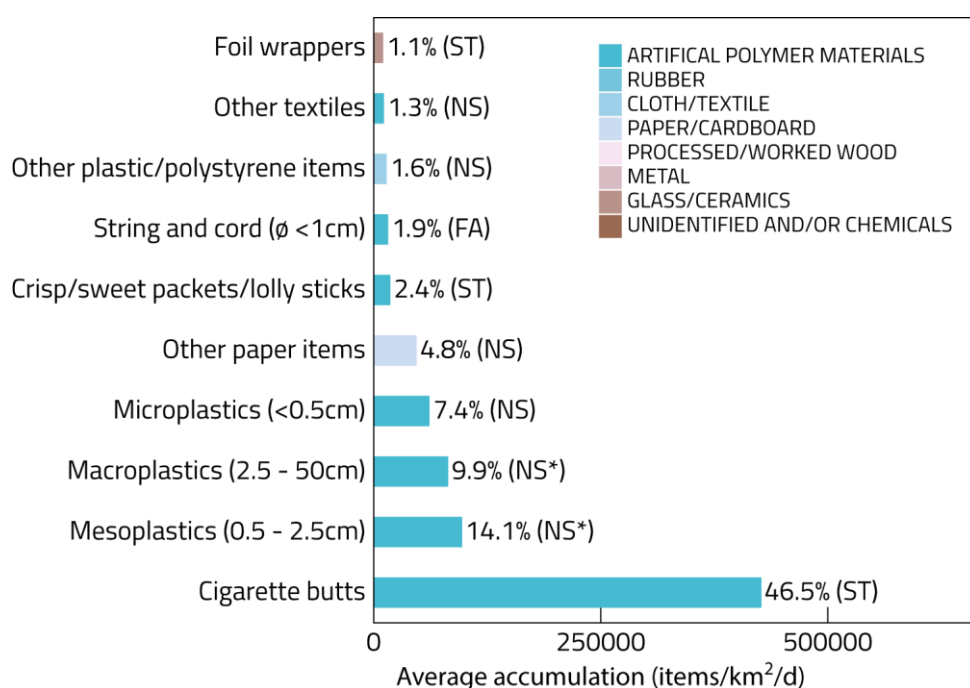


Figure D.I.1-4: list of the 10 items with the highest accumulation rates collected at the beach of Torá. The percentages next to each item refers to their relative abundance with respect to the total collected. The possible source of the items is given into parenthesis: ST=shoreline, including poor waste management, tourism and recreational activities; FA= fishing and aquaculture; and NS=non-sourced. The asterisk (*) associated to the non-sourced items (NS) shows that this specific item presents a clear seasonal increase. The color scale (upper right) indicates the type of material.

2. Beach mainly used by locals: Es Caragol

a) Characteristics of the beach

The beach of Es Caragol was selected as it is a popular beach mainly used by locals. It is a rural beach located in the municipality of Santanyi in the SE of Mallorca. The beach is facing the sea to the SW, has a total length of ±500m, a width of ±60m and is composed at 100% of sand with a smooth slope. The

monitored fixed portion of the beach has a surface of 6015 m². The beach is mainly used for recreational activities during both the high and low seasons by locals. It is only accessible by boats and for pedestrians. In the area situated directly behind the beach, no services and facilities provided to the beach users are found. The coordinates of the fixed 100m portion selected for the monitoring are: 39.2765N, 3.0439E (starting point) and 39.2773N, 3.0440E (ending point) (Fig. D.I.2-1). The closest harbor is situated 7.8 km away to the NW. The beach is cleaned 2 times a week from May to October.



Figure D.I.2-1: location map showing the beach of Es Caragol and the selected 100m portion of beach monitored (red area).

b) Seasonality of the marine litter

The beach of Es Caragol, mainly used by locals, was sampled for marine litter in February, May, June, July, September and November of 2017. A total of 71010 items (corrected for distance, see Part B.III.2.a) were collected on the same 100m portion of beach during the 6 monitoring, representing an average of 11834.9 items (± 8222.5 items, $n=6$) per survey. The lowest number of items was recorded in February (957 items) while the highest number was recorded in November (23908 items) (Fig. D.I.2-2a). In general, the amount of marine litter continuously increased from February to November, with a slight decrease in September. A seasonal pattern can be observed (Fig. D.I.2-2a), although minimized by the high amounts of marine litter collected in November. When only the number of items collected is considered (Fig. D.I.2-2b), their average number per survey during the low season (October – April) was of 12432.5 (± 16228.8 items, $n=2$) and of 11536.1 (± 4953.1 items, $n=4$) during the high season (May – September). Then, the amount of marine litter collected per survey during the high season was on average 7.2% lower than during the low touristic season (Fig. D.I.2-2b). When the accumulation rates (see Part B.III.2.b) are considered, a clear seasonal pattern is observed (Fig. D.I.2-2c). The lowest value observed was of 0.0013 items/m²/day (1251 items/km²/day) in February and the highest was of 1.3842 items/m²/day (1384206 items/km²/day) in July (Fig. D.I.2-2c). The seasonal pattern of the marine litter seems to follow the monthly number of tourists welcomed on Mallorca (Fig. D.I.2-2c): higher accumulation rates are observed during the touristic season and lower accumulation rates are observed during the off season. During the low season, the average accumulation rate is of 0.1323 items/m²/day (± 0.1177 , $n=2$) and of 0.9671 items/m²/day (± 0.566 , $n=4$) during the high season. These results show that, on average the accumulation rates of the marine litter are by far higher during the high season (+631%, Fig. D.I.2-2d) than during the low season.

Finally, the beach of Es Caragol can be considered as very dirty during both the low and high seasons, according to the Clean-Coast Index (see Part B.III.2.d) exhibiting values of respectively 38.4 and 35.6 (Fig. C.III-4a). The accumulation index shows that the accumulation of marine litter can be considered as very high during both the low season and high seasons (AI=5.12 and 5.99) (Fig. C.III-4b).

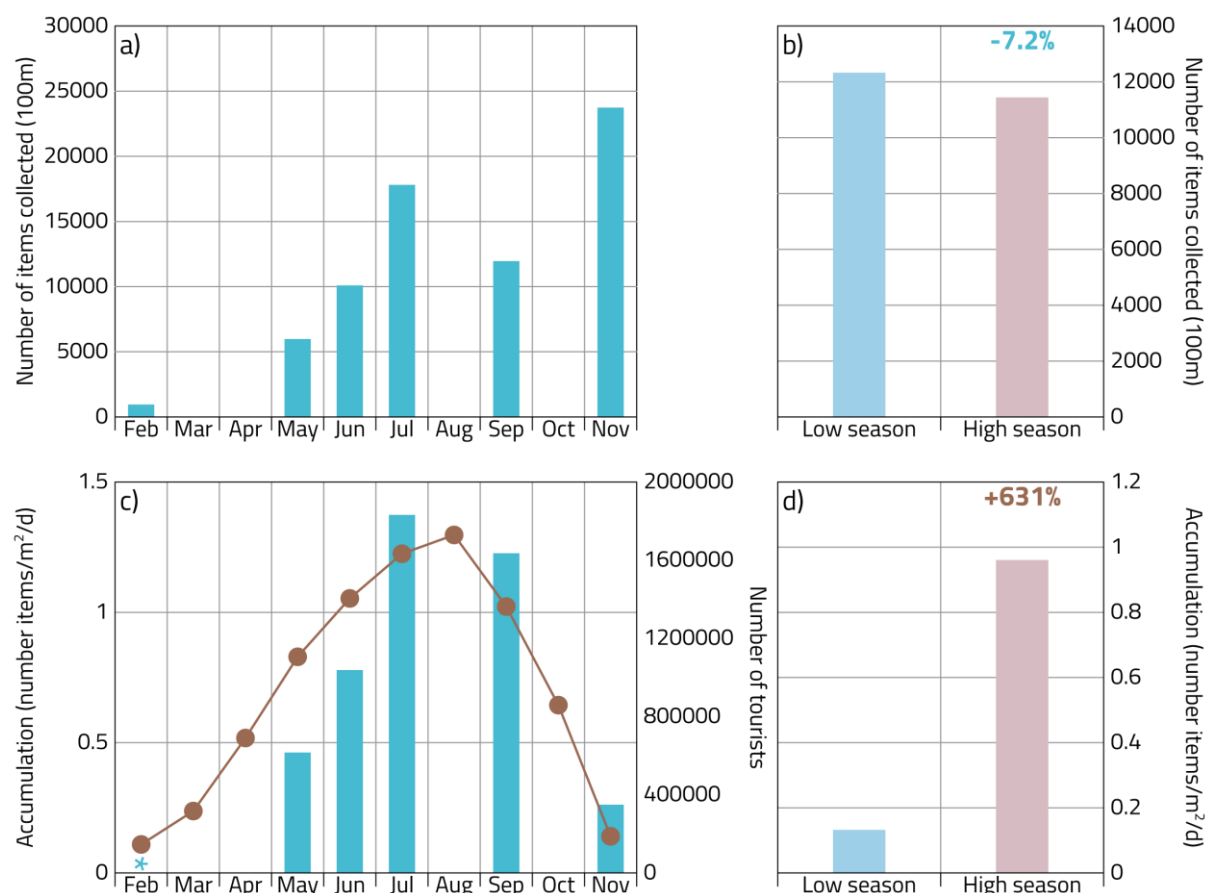


Figure D.I.2-2: total number and accumulations rates of items collected at the beach of Es Caragol. a) number of items collected during each survey on the fixed 100m portion of beach; b) comparison of the average number of items collected per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (blue font) refers to the decrease with respect to the low season; c) accumulation rates of the marine litter (left axis, blue bars, the blue asterisk (*) refers to values not visible at this scale) and the monthly number of tourists⁶ in Mallorca (right axis, brown line and dots); and d) comparison of the accumulation rates of marine litter per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season.

c) Composition of the marine litter

The marine litter collected on the beach of Es Caragol (Fig. D.I.2-3) was classified into 8 major categories of material type (see Part B.III.2.c). It is largely dominated by the artificial polymer materials (average=98.77% \pm 0.90; min=96.96% in February and max=99.33% in July), followed by the rubber (average=0.32% \pm 0.14; min=0.16% in May and max=0.45% in February), the metal (average=0.31% \pm 0.41; min=0.04% in May and max=1.13% in February), the cloth/textile (average=0.24% \pm 0.28; min=0.05% in November and max=0.79% in February), the paper/cardboard (average=0.11% \pm 0.08; min=0.02% in November and max=0.23% in February), the processed/worked wood (average=0.10% \pm 0.13; min=0.00% in July and max=0.21% in May), the unidentified and/or chemicals (average=0.09% \pm 0.09; min=0.00% in February and max=0.21% in May), and the glass/ceramics (average=0.07% \pm 0.07; min=0.00% in July and max=0.18% in September).

⁶ Data source: number of tourists welcomed on Mallorca in 2014, <https://ibestat.caib.es>

During the low season (Fig. D.I.2-3), the marine litter is largely dominated by the artificial polymer materials (98.05%), followed by the metal (0.68%), the cloth/textile (0.42%), the rubber (0.036%), the processed/worked wood (0.21%), the paper/cardboard (0.12%), the unidentified and/or chemicals (0.08%) and the glass/ceramics (0.08%).

During the high season (Fig. D.I.2-3), the marine litter is largely dominated by the artificial polymer materials (99.13%), followed by the rubber (0.30%), the cloth/textile (0.15%), the metal (0.13%), the paper/cardboard (0.10%), the unidentified and/or chemicals (0.09%), the glass/ceramics (0.06%) and the processed/worked wood (0.05%).

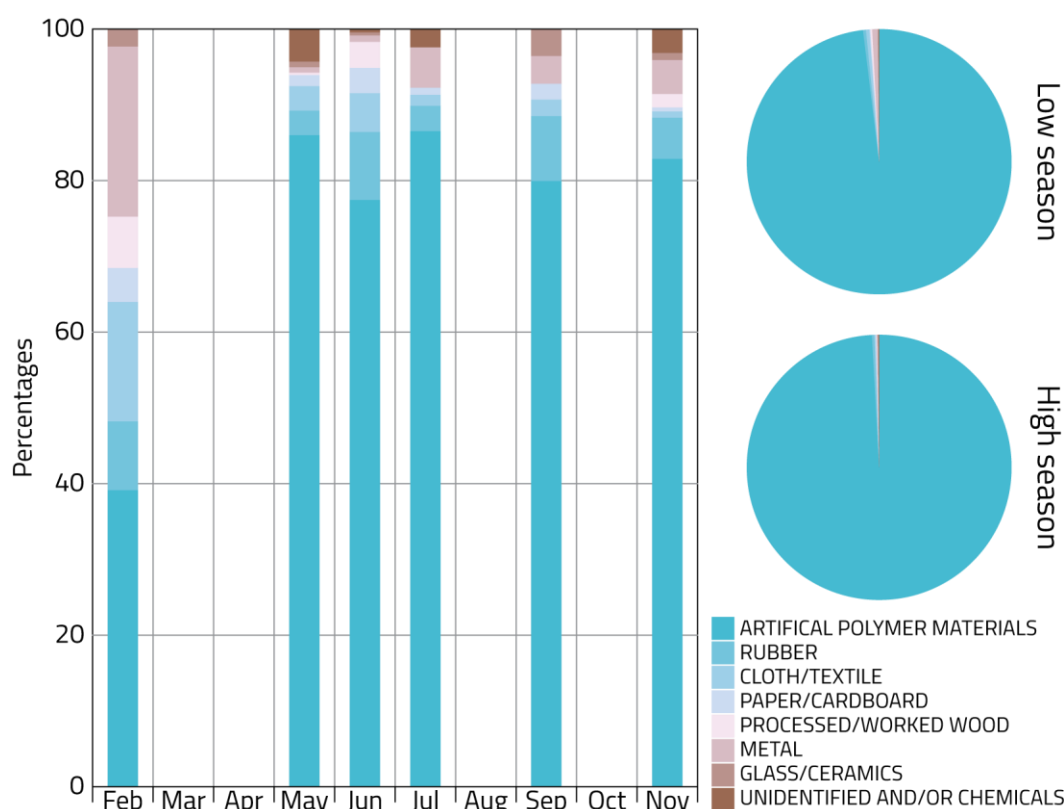


Figure D.I.2-3: composition of the marine litter collected at the beach of Es Caragol. Left: histogram showing the monthly percentages of the 8 major categories of material type. Right: pie charts showing the average composition of the marine litter during the low (top) and high (bottom) seasons. The color scale (lower right) indicates the type of material.

d) The 10 items with the highest accumulation rates

In this section, we consider the items with the highest averaged accumulation rates, which are not necessarily the most abundant items collected during the marine litter monitoring performed on the beach of Es Caragol (Fig. D.I.2-4). These items account for 97.2% of the total marine litter items (71010) collected in 2017. They are dominated by the mesoplastics (0.3522 items/m²/day; 51.72% of the total marine litter items collected), followed by the microplastics (0.1347 items/m²/day; 18.95% of the total marine litter items collected), the macroplastics (0.0646 items/m²/day; 9.02% of the total marine litter items collected), the pellets (0.0578 items/m²/day; 9.53% of the total marine litter items collected), the caps/lids (0.0176 items/m²/day; 2.24% of the total marine litter items collected), the cotton bud sticks (0.0144 items/m²/day; 2.02% of the total marine litter items collected), the strings and cords (diameter less than 1 cm) (0.0103 items/m²/day; 1.46% of the total marine litter items collected), the cigarette butts (0.0081 items/m²/day; 1.1% of the total marine litter items collected), the crisp/sweet packets and lolly sticks (0.005 items/m²/day; 0.7% of the total marine litter items collected) and the

ropes (diameter more than 1 cm) (0.0045 items/m²/day; 0.47% of the total marine litter items collected).

In this top 10, all the items are exclusively artificial polymer materials, accounting then for 97.20% of the total marine litter items collected.

In this top 10, 3 items (caps/lids, cigarette butts and crisp/sweet packets and lolly sticks) accounting for 4.04% of the total marine litter items collected, can be attributed to the shoreline source, including poor waste management practices, tourism and recreational activities (see Part B.III.2.c). To this can possibly be added 2 items (mesoplastics and macroplastics) presenting a clear seasonal pattern (see Appendix, Fig. E.II-2) and accounting for additional 60.74% of the total marine litter items collected.

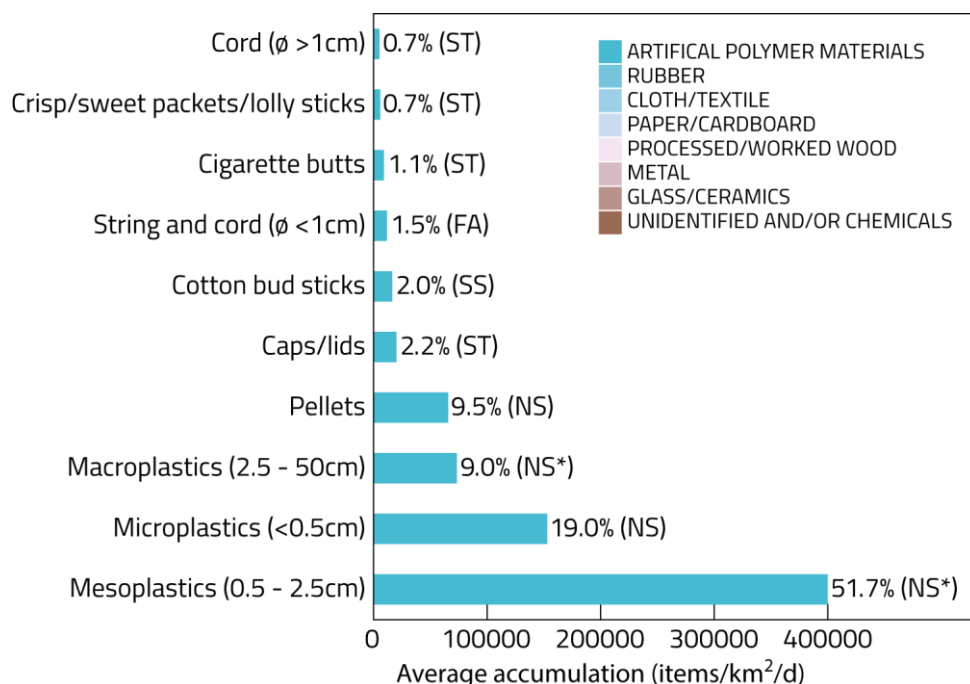


Figure D.I.2-4: list of the 10 items with the highest accumulation rates collected at the beach of Es Caragol. The percentages next to each item refers to their relative abundance with respect to the total collected. The possible source of the items is given into parenthesis: ST=shoreline, including poor waste management, tourism and recreational activities; FA= fishing and aquaculture; SS= sanitary and sewage related litter; and NS=non-sourced. The asterisk (*) associated to the non-sourced items (NS) shows that this specific item presents a clear seasonal increase. The color scale (upper right) indicates the type of material.

3. Remote beach: Sa Canova

a) Characteristics of the beach

The beach of Sa Canova is a natural beach, located in the municipality of Colòna de Sant Pere in the NE of Mallorca, facing the sea to the north. It has a total length of ±1500m, a width of ±40m and is composed at 100% of sand with a smooth slope. The monitored fixed portion of the beach has a surface of 4918 m². The beach is mainly used for recreational activities: swimming and sunbathing during the high season and walks during the low season. It is only accessible by boats and for pedestrians. In the area situated directly behind the beach, no services and facilities provided to the beach users are found. The coordinates of the fixed 100m portion selected for the monitoring are: 39.7294N, 3.2506E (starting point) and 39.7292N, 3.2516E (ending point) (Fig. D.I.3-1). The closest harbor is situated 16 km away to the NW. The beach is cleaned once every 2 weeks from May to October.



Figure D.I.3-1: location map showing the beach of Sa Canova and the selected 100m portion of beach monitored (red area).

b) Seasonality of the marine litter

The remote beach of Sa Canova was sampled for marine litter in February, May, June, July, September and November of 2017. A total of 13093 items (corrected for distance, see Part B.III.2.a) were collected on the same 100m portion of beach during the 6 monitoring, representing an average of 2182.1 items (± 3125.3 items, $n=6$) per survey. The lowest number of items was recorded in June (248 items) while the highest number was recorded in November (7613 items) (Fig. D.I.3-2a). The amount of marine litter was very low from February to July and suddenly increased in September and November (Fig. D.I.3-2a), probably due to bad weather affecting the area few days before the 2 last surveys. Then, no seasonal pattern is visible. When only the number of items collected is considered (Fig. D.I.3-2b), their average number per survey during the low season (October – April) was of 3945.8 (± 5185.7 items, $n=2$) and of 1300.3 (± 2050.6 items, $n=4$) during the high season (May – September). Then, the amount of marine litter collected per survey during the high season was on average 67.0% lower than during the low touristic season (Fig. D.I.3-2b). When the accumulation rates (see Part B.III.2.b) are considered, a seasonal pattern is somehow observed (Fig. D.I.3-2c), although minimized by the high values of September and November. The lowest value observed was of 0.0004 items/m²/day (444 items/km²/day) in February and the highest was of 0.1045 items/m²/day (104463 items/km²/day) in September (Fig. D.I.3-2c). The seeming seasonal pattern of the marine litter seems to follow the monthly number of tourists welcomed on Mallorca (Fig. D.I.3-2c): higher accumulation rates are observed during the touristic season and lower accumulation rates are observed during the off season, with the exception of November. During the low season, the average accumulation rate is of 0.0333 items/m²/day (± 0.0295 , $n=2$) and of 0.0544 items/m²/day (± 0.0423 , $n=4$) during the low season. These results show that, on average the accumulation rates of the marine litter are higher during the high season (+64%, Fig. D.I.3-2d) than during the low season.

Finally, the beach of Sa Canova can be considered as dirty during the low season and moderately clean during the high season according to the Clean-Coast Index (see Part B.III.2.d) exhibiting values of respectively 15.1 and 5.0 (Fig. C.IV-4a). The accumulation index shows that the accumulation of marine litter can be considered high during both the low and high seasons (AI=4.52 and 4.74) (Fig. C.IV-4b).

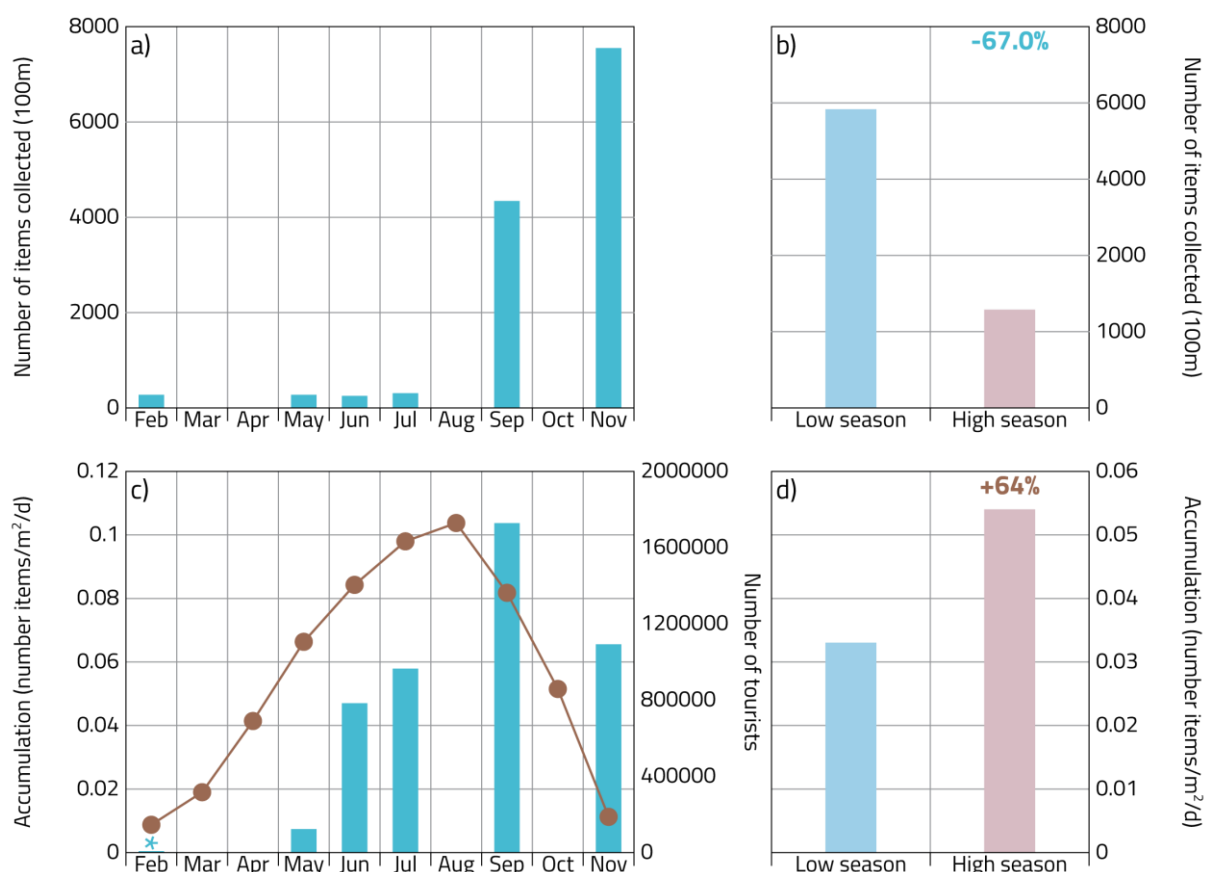


Figure D.I.3-2: total number and accumulations rates of items collected at the beach of Sa Canova. a) number of items collected during each survey on the fixed 100m portion of beach; b) comparison of the average number of items collected per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (blue font) refers to the decrease with respect to the low season; c) accumulation rates of the marine litter (left axis, blue bars, the blue asterisk (*) refers to values not visible at this scale) and the monthly number of tourists⁷ in Mallorca (right axis, brown line and dots); and d) comparison of the accumulation rates of marine litter per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season.

c) Composition of the marine litter

The marine litter collected on the beach of Sa Canova (Fig. D.I.3-3) was classified into 8 major categories of material type (see Part B.III.2.c). It is largely dominated by the artificial polymer materials (average=90.60% \pm 6.61; min=81.68% in February and max=97.79% in November), followed by the cloth/textile (average=2.27% \pm 2.58; min=0.07% in November and max=5.92% in July), the unidentified and/or chemicals (average=2.15% \pm 3.02; min=0.00% in June and max=8.02% in February), the metal (average=1.70% \pm 1.80; min=0.06% in November and max=4.58% in February), the rubber (average=1.53% \pm 1.14; min=0.15% in November and max=3.14% in July), the paper/cardboard (average=0.92% \pm 0.82; min=0.00% in November and max=2.15% in June), the processed/worked wood (average=0.54% \pm 0.76; min=0.00% in July and max=0.196% in May) and the glass/ceramics (average=0.30% \pm 0.56; min=0.00% in February and max=1.39% in July).

During the low season (Fig. D.I.3-3), the marine litter is largely dominated by the artificial polymer materials (89.73%), followed by the unidentified and/or chemicals (4.96%), the metal (2.32%), the rubber (1.22%), the cloth/textile (0.80%), the paper/cardboard (0.57%), the processed/worked wood (0.39%) and the glass/ceramics (0.01%).

⁷ Data source: number of tourists welcomed on Mallorca in 2014, <https://ibestat.caib.es>

During the high season (Fig. D.I.3-3), the marine litter is largely dominated by the artificial polymer materials (91.03%), followed by the cloth/textile (3.01%), the rubber (1.69%), the metal (1.38%), the paper/cardboard (1.09%), the unidentified and/or chemicals (0.74%), the processed/worked wood (0.61%) and the glass/ceramics (0.45%).

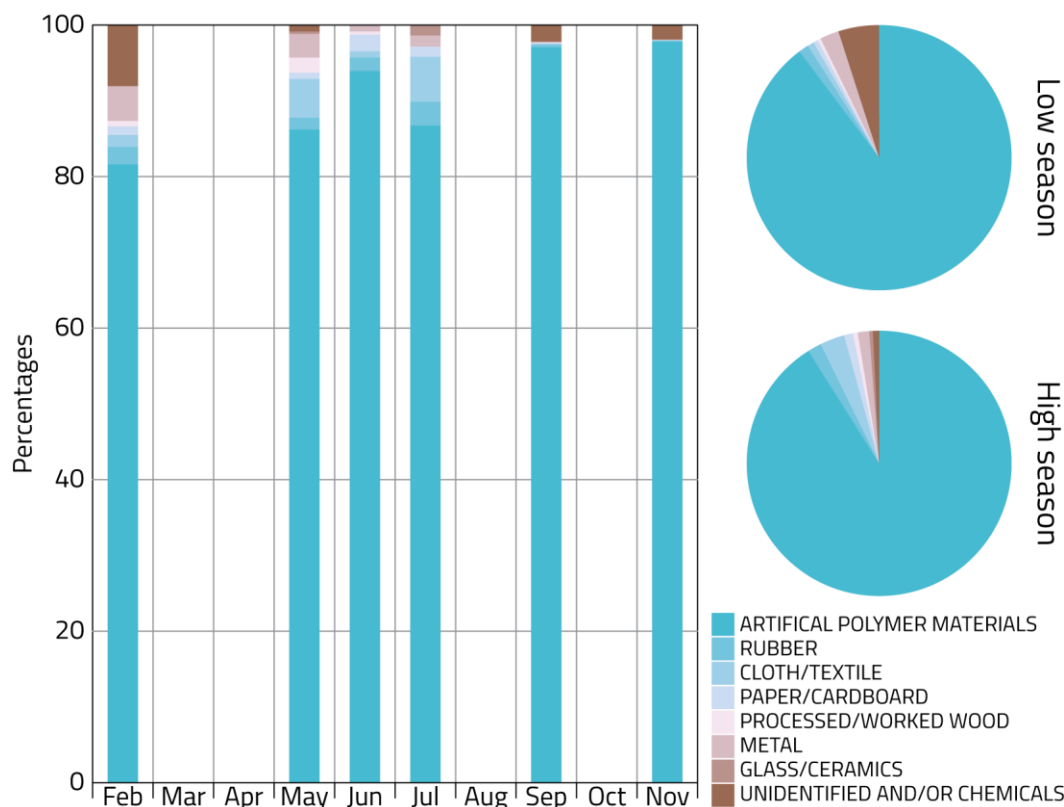


Figure D.I.3-3: composition of the marine litter collected at the beach of Sa Canova. Left: histogram showing the monthly percentages of the 8 major categories of material type. Right: pie charts showing the average composition of the marine litter during the low (top) and high (bottom) seasons. The color scale (lower right) indicates the type of material.

d) The 10 items with the highest accumulation rates

In this section, we consider the items with the highest averaged accumulation rates, which are not necessarily the most abundant items collected during the marine litter monitoring performed on the beach of Sa Canova (Fig. D.I.3-4). These items account for 92.74% of the total marine litter items (13093) collected in 2017. They are dominated by the mesoplastics (0.014 items/m²/day; 35.45% of the total marine litter items collected), followed by the macroplastics (0.0098 items/m²/day; 20.66% of the total marine litter items collected), the pellets (0.0048 items/m²/day; 14.62% of the total marine litter items collected), the microplastics (0.0027 items/m²/day; 9.49% of the total marine litter items collected), the caps/lids (0.0024 items/m²/day; 4.2% of the total marine litter items collected), the tangled nets/cords/ropes and strings (0.0023 items/m²/day; 0.72% of the total marine litter items collected), the cigarette butts (0.0019 items/m²/day; 1.4% of the total marine litter items collected), the cotton bud sticks (0.0019 items/m²/day; 4.35% of the total marine litter items collected), the strings and cords (diameter less than 1 cm) (0.001 items/m²/day; 1.18% of the total marine litter items collected) and the other plastic/polystyrene items (0.0009 items/m²/day; 0.67% of the total marine litter items collected).

In this top 10, all the items are exclusively artificial polymer materials, accounting then for 92.74% of the total marine litter items collected.

In this top 10, 2 items (caps/lids, cigarette butts) accounting for 5.6% of the total marine litter items collected, can be attributed to the shoreline source, including poor waste management practices, tourism and recreational activities (see Part B.III.2.c). To this, can possibly be added 1 item (other plastic/polystyrene items) presenting a clear seasonal pattern (see Appendix, Fig. E.II-3) and accounting for additional 0.67% of the total marine litter items collected.

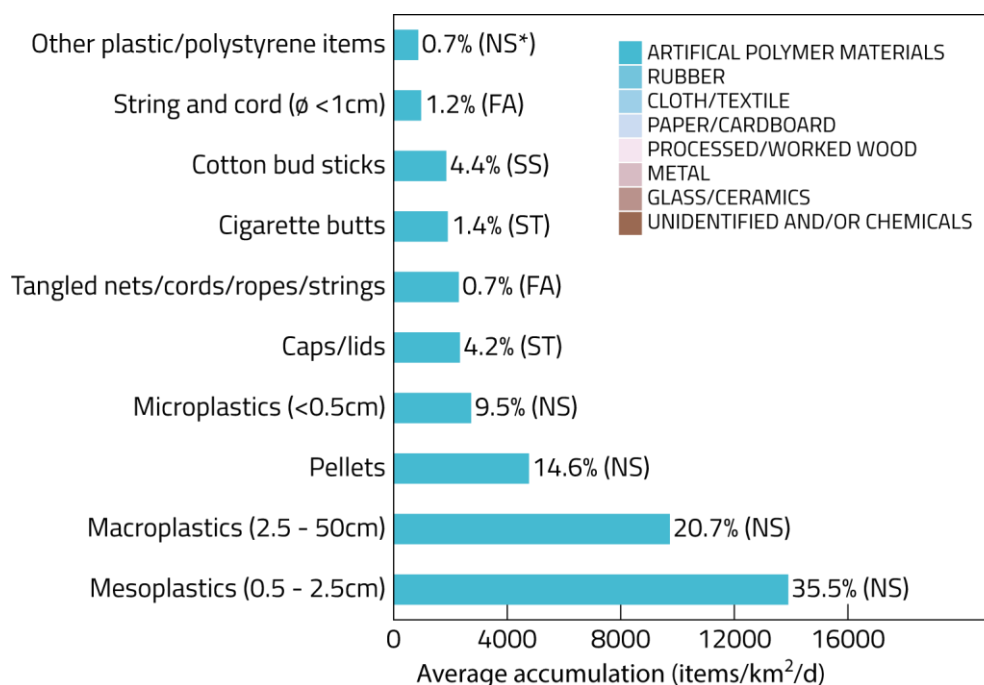


Figure D.I.3-4: list of the 10 items with the highest accumulation rates collected at the beach of Sa Canova. The percentages next to each item refers to their relative abundance with respect to the total collected. The possible source of the items is given into parenthesis: ST=shoreline, including poor waste management, tourism and recreational activities; FA= fishing and aquaculture; SS= sanitary and sewage related litter; and NS=non-sourced. The asterisk (*) associated to the non-sourced items (NS) shows that this specific item presents a clear seasonal increase. The color scale (upper right) indicates the type of material.

4. Summary

The 18 marine litter surveys conducted in Mallorca in 2017 have revealed that:

- If only the number of items collected is considered, the beach of Es Caragol mainly used by locals is the most affected by the marine litter (71010 items collected; average: 11834.9 items/survey; 12432.5 items/survey during the low season; 11536.1 items/survey during the high season), followed by the remote beach of Sa Canova (13093 items collected; average: 2182.1 items/survey; 3945.8 items/survey during the low season; 1300.3 items/survey during the high season) and the touristic beach of Torá (11122 items collected; average: 1853.7 items/survey; 1892.0 items/survey during the low season; 1834.5 items/survey during the high season). For the 3 beaches, no clear seasonal variability was observed from the number of items collected.
- If the accumulation rate of the marine litter is considered, the touristic beach of Torá is the most affected by marine litter accumulation (average: 0.8458 items/m²/day; 0.0387 items/m²/day during the low season; 1.2493 items/m²/day during the high season), followed by the beach of Es Caragol, mainly used by locals (average: 0.6889 items/m²/day; 0.1323 items/m²/day during the low season; 0.9671 items/m²/day during the high season) and the remote beach of Sa Canova (average: 0.0474 items/m²/day; 0.0333 items/m²/day during the

low season; 0.0544 items/m²/day during the high season). The 3 beaches presented recognizable seasonal variations with a relative increase of the accumulation rates of 3126% (Torá), 631% (Es Caragol) and 64% (Sa Canova) during the high season with respect to the low season.

- The items collected are mainly composed of artificial polymer materials: they represent 88.86% (Torá), 98.77% (Es Caragol) and 90.60% (Sa Canova) of the total marine litter items collected.
- On the touristic beach of Torá, 3 items (cigarette butts, crisp/sweet packets and lolly sticks and foil wrappers), most likely related to tourism and recreational activities, are representing 50.00% of the total marine litter items collected. To this, can possibly be added 2 items (mesoplastics and macroplastics), accounting for additional 23.95% as they presented a recognizable seasonal variation.
- On the beach of Es Caragol, mainly used by locals, 3 items (caps/lids, cigarette butts and crisp/sweet packets and lolly sticks), most likely related to tourism and recreational activities, are representing 4.04% of the total marine litter items collected. To this, can possibly be added 2 items (mesoplastics and macroplastics), accounting for additional 60.74% as they presented a recognizable seasonal variation.
- On the remote beach of Sa Canova, 2 items (caps/lids and cigarette butts), most likely related to tourism and recreational activities, are representing 5.6% of the total marine litter items collected. To this, can possibly be added 1 item (other plastic/polystyrene items), accounting for additional 0.67% as they presented a recognizable seasonal variation.
- The cleanliness of the beaches is considered as dirty/dirty for the low/high season in Torá (Clean-Coast Index of 18.1/17.5), very dirty/very dirty for the low/high season in Es caragol (CCI of 38.4/35.6) and dirty/moderate for the low/high season in Sa Cavova (CCI of 15.1/5.0).
- Finally the accumulation index of the beaches is considered as high/extremely high for the low/high season in Torá (Accumulation Index of 4.59/6.10), very high/very high for the low/high season in Es Caragol (AI of 5.12/5.99) and high/high for the low/high season in Sa Canova (AI of 4.52/4.74).

II. Sicily

1. Touristic beach: Giardini Naxos

a) Characteristics of the beach

The touristic beach of Giardini Naxos is an urban beach, located in the municipality of Giardini Naxos in the eastern side of Sicily, facing the sea to the NE. It has a total length of 528m, a width ranging from 40m to 100m and is composed at 95% of sand and 5% of pebbles with a very smooth slope. The monitored fixed portion of the beach has a surface of 6507 m². It has a pier situated on its SE side. The beach is mainly used for recreational activities during the high season (swimming, sunbathing, fishing and sailing) and the low season (fishing). It is accessible by vehicles/boats and for pedestrians. The area situated directly behind the beach is an urban area with many services and facilities provided to the beach users. The coordinates of the fixed 100m portion selected for the monitoring are: 37.8261N, 15.2700E (starting point) and 37.8254N, 15.2704E (ending point) (Fig. D.II.1-1). Drink and food outlets are situated directly on the beach and the closest harbor is situated 0.1km away to the SE. The beach is cleaned weekly from August to September.



Figure D.II.1-1: location map showing the beach of Giardini Naxos and the selected 100m portion of beach monitored (red area).

b) Seasonality of the marine litter

The touristic beach of Giardini Naxos was sampled for marine litter in March, June, July, August, September and November of 2017. A total of 453 items (corrected for distance, see Part B.III.2.a) were collected on the same 100m portion of beach during the 6 monitoring, representing an average of 75.6 items (± 69.6 items, $n=6$) per survey. The lowest number of items was recorded in June (18 items) while the highest number was recorded in March (209 items) (Fig. D.II.1-2a). In general, the amount of marine litter continuously decreased from March to November, with a sharp decrease in June. No seasonal pattern was visible (Fig. D.II.1-2a). When only the number of items collected is considered (Fig. D.II.1-2b), their average number per survey during the low season (October – April) was of 115.8 (± 131.8 items, $n=2$) and of 55.5 (± 25.6 items, $n=4$) during the high season (May – September). Then, the amount of marine litter collected per survey during the high season was on average 52.1% lower than during the low touristic season (Fig. D.II.1-2b). When the accumulation rates (see Part B.III.2.b) are considered, a clear seasonal pattern is observed (Fig. D.II.1-2c). The lowest value observed was of 0.0002 items/m²/day (213 items/km²/day) in March and the highest was of 0.0178 items/m²/day (17829 items/km²/day) in August (Fig. D.II.1-2c). The seasonal pattern of the marine litter seems to follow the monthly number of tourists welcomed on Sicily (Fig. D.II.1-2c): higher accumulation rates are observed during the touristic season and lower accumulation rates are observed during the off season. During the low season, the average accumulation rate is of 0.0039 items/m²/day (± 0.0033 , $n=2$) and of 0.0143 items/m²/day (± 0.0081 , $n=4$) during the high season. These results show that, on average the accumulation rates of the marine litter are higher during the high season (+271%, Fig. D.II.1-2d) than during the low season.

Finally, the beach of Giardini Naxos can be considered as very clean during both the low and high seasons, according to the Clean-Coast Index (see Part B.III.2.d) exhibiting values of respectively 0.4 and 0.2 (Fig. C.II-4a). The accumulation index shows that the accumulation of marine litter can be considered as moderate for the low season (AI=3.59) and high during the high season (AI=4.16) (Fig. C.II-4b).

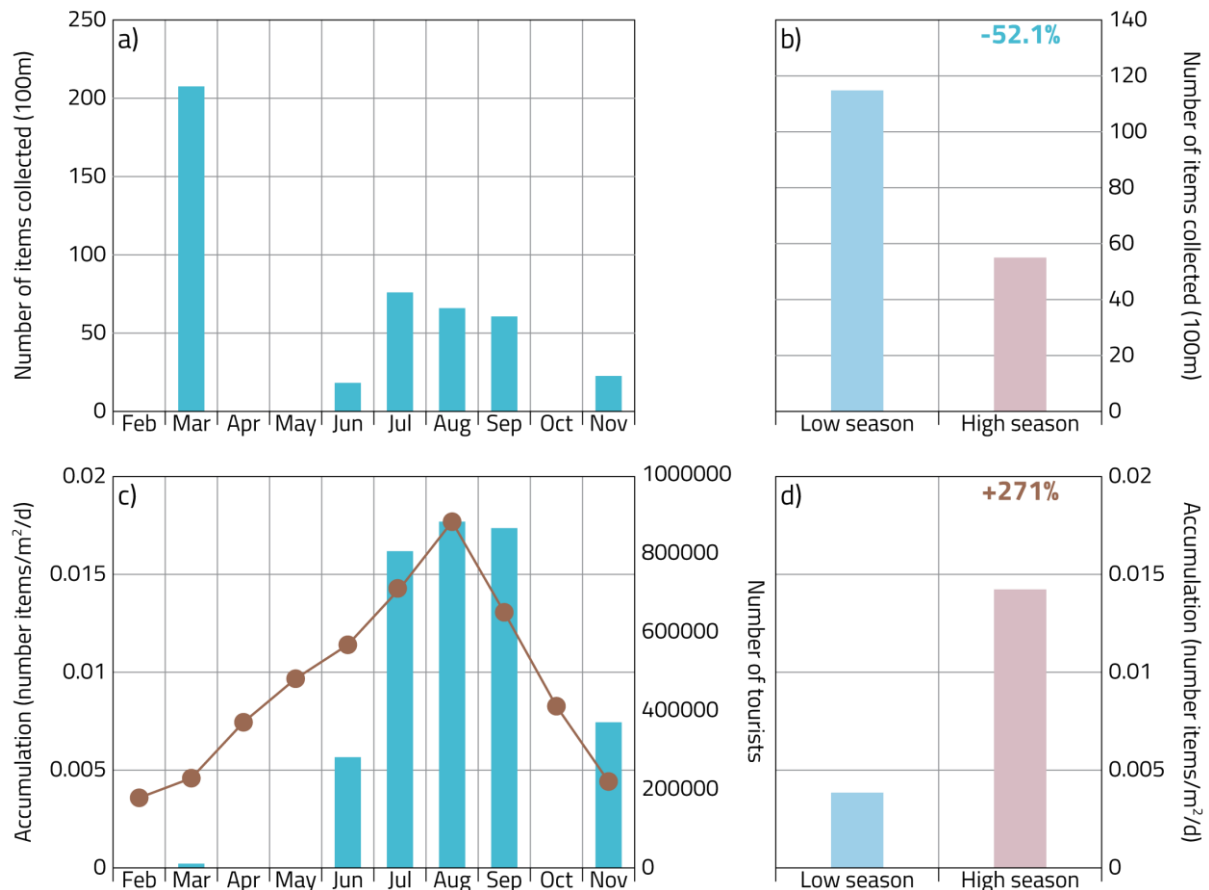


Figure D.II.1-2: total number and accumulations rates of items collected at the beach of Giardini Naxos. a) number of items collected during each survey on the fixed 100m portion of beach; b) comparison of the average number of items collected per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (blue font) refers to the decrease with respect to the low season; c) accumulation rates of the marine litter (left axis, blue bars) and the monthly number of tourists⁸ in Sicily (right axis, brown line and dots); and d) comparison of the accumulation rates of marine litter per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season.

c) Composition of the marine litter

The marine litter collected on the beach of Giardini Naxos (Fig. D.II.1-3) was classified into 8 major categories of material type (see Part B.III.2.c). It is largely dominated by the artificial polymer materials (average=84.89% \pm 3.64; min=78.26% in November and max=88.89% in September), followed by the paper/cardboard (average=6.60% \pm 4.60; min=1.30% in July and max=13.04% in November), the rubber (average=3.73% \pm 3.92; min=0.00% in August and max=8.70% in November), the metal (average=3.24% \pm 1.79; min=0.00% in November and max=4.84% in August), the glass/ceramics (average=0.83% \pm 2.03; min=0.00% in November and max=4.97% in March), the processed/worked wood (average=0.36% \pm 0.65; min=0.00% in November and max=1.61% in August) and the cloth/textile (average=0.36% \pm 0.64; min=0.00% in November and max=1.59% in September). No unidentified and/or chemicals were collected.

During the low season (Fig. D.II.1-3), the marine litter is largely dominated by the artificial polymer materials (81.12%), followed by the paper/cardboard (9.56%), the rubber (4.90%), the glass/ceramics (2.49%), the metal (1.38%), the cloth/textile (0.28%) and the processed/worked wood (0.28%).

⁸ Data source: data extrapolated for 2015, from the monthly distribution of overnight stays in travel accommodation in the Italian region of Sicily and the annual number of tourists welcomed on Sicily, <https://www.istat.it/>

During the high season (Fig. D.II.1-3), the marine litter is largely dominated by the artificial polymer materials (86.78%), followed by the paper/cardboard (5.12%), the metal (4.17%), the rubber (3.14%), the processed/worked wood (0.40%) and the cloth/textile (0.40%).

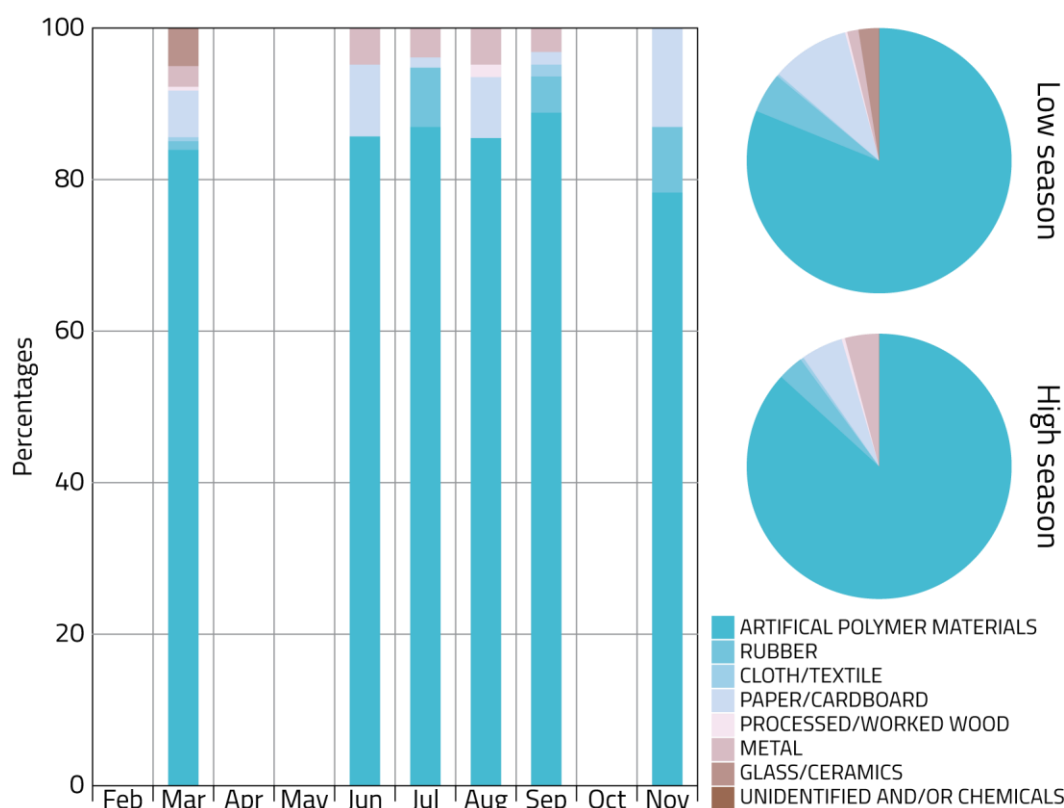


Figure D.II.1-3: composition of the marine litter collected at the beach of Giardini Naxos. Left: histogram showing the monthly percentages of the 8 major categories of material type. Right: pie charts showing the average composition of the marine litter during the low (top) and high (bottom) seasons. The color scale (lower right) indicates the type of material.

d) The 10 items with the highest accumulation rates

In this section, we consider the items with the highest averaged accumulation rates, which are not necessarily the most abundant items collected during the marine litter monitoring performed on the beach of Giardini Naxos (Fig. D.II.1-4). These items account for 78.65% of the total marine litter items (453) collected in 2017. They are dominated by the cigarette butts (0.0044 items/m²/day; 23.42% of the total marine litter items collected), followed by the macroplastics (0.0013 items/m²/day; 18.1% of the total marine litter items collected), the mesoplastics (0.0011 items/m²/day; 18.78% of the total marine litter items collected), the other paper items (0.0005 items/m²/day; 3.96% of the total marine litter items collected), the balloons, including plastic valves, ribbons (0.0004 items/m²/day; 2.42% of the total marine litter items collected), the strings and cords (diameter less than 1 cm) (0.0004 items/m²/day; 1.94% of the total marine litter items collected), the other plastic/polystyrene items (0.0004 items/m²/day; 5.6% of the total marine litter items collected), the crisp/sweet packets and lolly sticks (0.0002 items/m²/day; 1.41% of the total marine litter items collected), the food containers (e.g. fast food containers) (0.0002 items/m²/day; 1.63% of the total marine litter items collected) and the other sanitary items (0.0002 items/m²/day; 1.39% of the total marine litter items collected). In this top 10, the artificial polymer materials largely dominate as they are represented by 8 items, accounting for 72.27% of the total marine litter items collected.

In this top 10, 4 items (cigarette butts, balloons, crisp/sweet packets and lolly sticks and food containers) accounting for 28.88% of the total marine litter items collected, can be attributed to the shoreline source, including poor waste management practices, tourism and recreational activities (see Part B.III.2.c). To this, can possibly be added 1 item (other plastic/polystyrene items) presenting a clear seasonal pattern (see Appendix, Fig. E.III-1) and accounting for additional 5.6% of the total marine litter items collected.

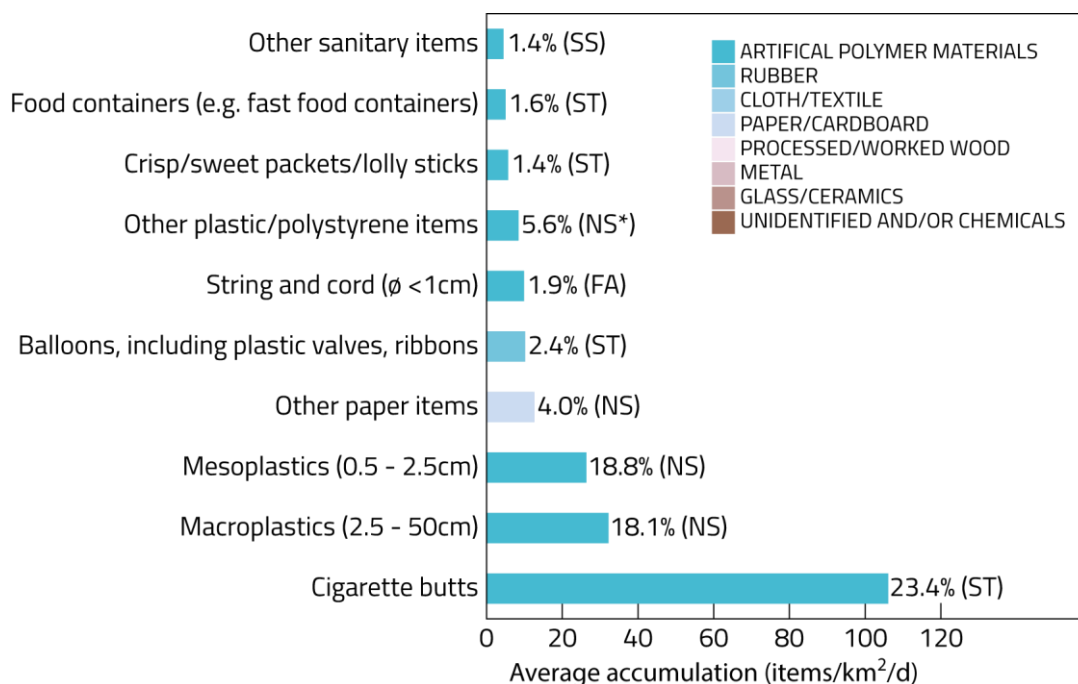


Figure D.II.1-4: list of the 10 items with the highest accumulation rates collected at the beach of Giardini Naxos. The percentages next to each item refers to their relative abundance with respect to the total collected. The possible source of the items is given into parenthesis: ST=shoreline, including poor waste management, tourism and recreational activities; FA=fishing and aquaculture; SS=sanitary and sewage related litter; and NS=non-sourced. The asterisk (*) associated to the non-sourced items (NS) shows that this specific item presents a clear seasonal increase. The color scale (upper right) indicates the type of material.

2. Beach mainly used by locals: Letojani

a) Characteristics of the beach

The beach of Letojani was selected as it is a popular beach mainly used by locals. It is a semi-urban beach, located in the municipality of Letojani in the eastern side of Sicily, facing the sea to the SE. It has a total length of 2193m, a width ranging from 25 to 65m and is composed at 90% of pebbles and 10% of sand with a slope of 10%. The monitored fixed portion of the beach has a surface of 3680 m². The beach is mainly used for recreational activities during the high season (swimming, sunbathing, fishing and local people) and the low season (fishing). It is accessible by vehicles/boats and for pedestrians. In the area situated directly behind the beach, very limited services and facilities provided to the beach users are found. The coordinates of the fixed 100m portion selected for the monitoring are: 37.8851N, 15.3136E (starting point) and 37.8844N, 15.3130E (ending point) (Fig. D.II.2-1). Drink and food outlets are situated directly on the beach and the closest harbor is situated 7.7 km away to the SW. The beach is cleaned twice a week from July to September.



Figure D.II.2-1: location map showing the beach of Letojani and the selected 100m portion of beach monitored (red area).

b) Seasonality of the marine litter

The beach of Letojani, mainly used by locals, was sampled for marine litter in March, June, July, August, September and November of 2017. A total of 328 items (corrected for distance, see Part B.III.2.a) were collected on the same 100m portion of beach during the 6 monitoring, representing an average of 54.7 items (± 36.8 items, $n=6$) per survey. The lowest number of items was recorded in September (19 items) while the highest number was recorded in June (117 items) (Fig. D.II.2-2a). A seasonal pattern seems to be visible (Fig. D.II.2-2a), although sharp decreases of the amount of marine litter are observed in July and September. When only the number of items collected is considered (Fig. D.II.2-2b), their average number per survey during the low season (October – April) was of 48.2 (± 22.5 items, $n=2$) and of 57.9 (± 45.2 items, $n=4$) during the high season (May – September). Then, the amount of marine litter collected per survey during the high season was on average 20.1% higher than during the low touristic season (Fig. D.II.2-2b). When the accumulation rates (see Part B.III.2.b) are considered, a clear seasonal pattern is observed (Fig. D.II.2-2c), centered on the months of July, August and September. The lowest value observed was of 0.0001 items/m²/day (102 items/km²/day) in March and the highest was of 0.0186 items/m²/day (18647 items/km²/day) in August (Fig. D.II.2-2c). The seasonal pattern of the marine litter seems to follow the monthly number of tourists welcomed on Sicily (Fig. D.II.2-2c): higher accumulation rates are observed during the touristic season and lower accumulation rates are observed during the off season. During the low season, the average accumulation rate is of 0.0001 items/m²/day (± 0.0001 , $n=2$) and of 0.0095 items/m²/day (± 0.0083 , $n=4$) during the high season. These results show that, on average the accumulation rates of the marine litter are by far higher during the high season (+8157%, Fig. D.II.2-2d) than during the low season.

Finally, the beach of Letojani can be considered as very clean during both the low and high seasons, according to the Clean-Coast Index (see Part B.III.2.d) exhibiting values of respectively 0.3 and 0.3 (Fig. C.III-4a). The accumulation index shows that the accumulation of marine litter can be considered low during the low season (AI=2.06) and moderate during the high season (AI=3.98) (Fig. C.III-4b).

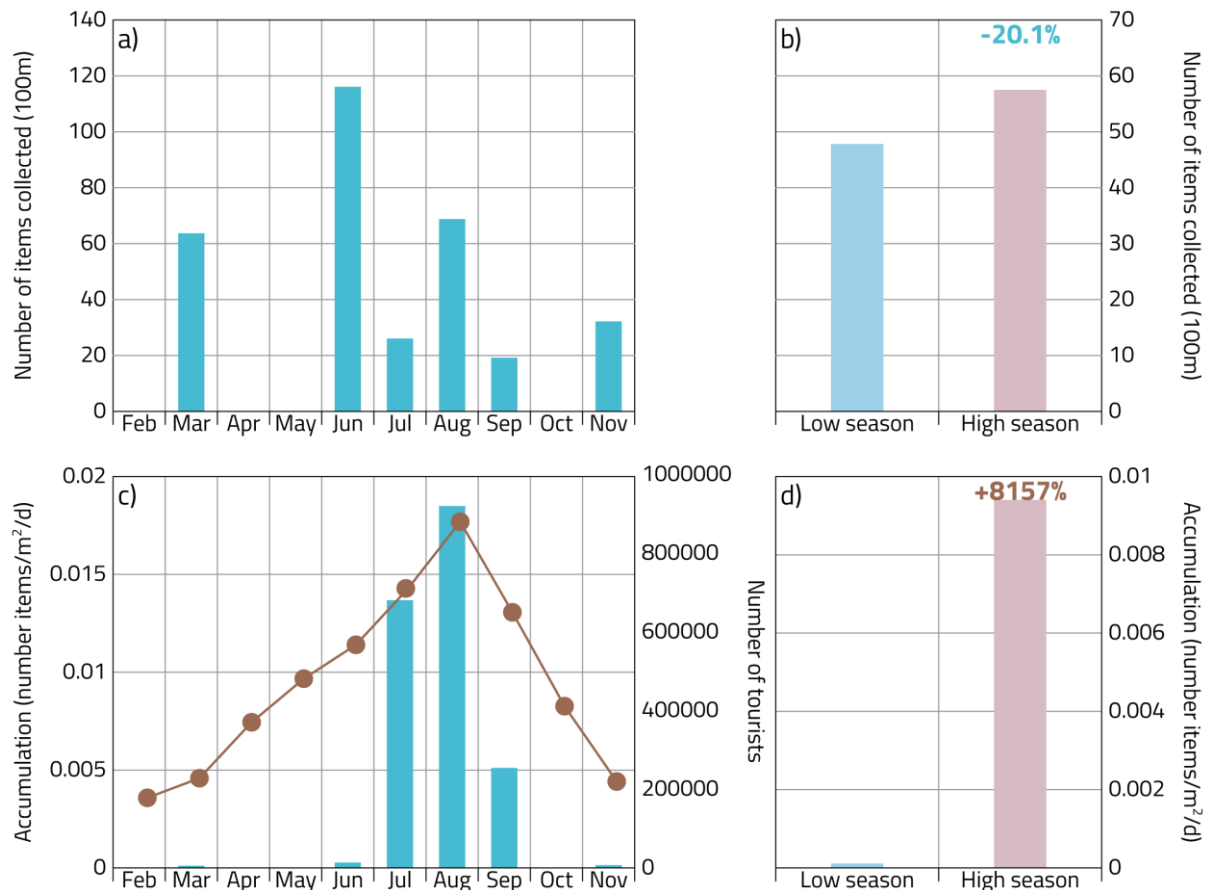


Figure D.II.2-2: total number and accumulations rates of items collected at the beach of Letojani. a) number of items collected during each survey on the fixed 100m portion of beach; b) comparison of the average number of items collected per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (blue font) refers to the decrease with respect to the low season; c) accumulation rates of the marine litter (left axis, blue bars) and the monthly number of tourists⁹ in Sicily (right axis, brown line and dots); and d) comparison of the accumulation rates of marine litter per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season.

c) Composition of the marine litter

The marine litter collected on the beach of Letojani (Fig. D.II.2-3) was classified into 8 major categories of material type (see Part B.III.2.c). It is dominated by the artificial polymer materials (average=45.74% \pm 22.06; min=26.92% in July and max=80.60% in August), followed by the metal (average=39.12% \pm 19.1; min=14.93% in August and max=65.38% in July), the paper/cardboard (average=6.26% \pm 5.70; min=0.00% in August and max=16.67% in June), the glass/ceramics (average=5.94% \pm 7.78; min=0.00% in September and max=16.13% in March), the processed/worked wood (average=1.35% \pm 1.63; min=0.00% in September and max=3.51% in June), the unidentified and/or chemicals (average=1.15% \pm 2.12; min=0.00% in November and max=5.26% in September), the rubber (average=0.29% \pm 0.72; min=0.00% in November and max=1.75% in June) and the cloth/textile (average=0.15% \pm 0.36; min=0.00% in November and max=0.88% in June).

During the low season (Fig. D.II.2-3), the marine litter is dominated by the metal (50.00%), followed by the artificial polymer materials (27.77%), the glass/ceramics (15.88%), the paper/cardboard (3.98%), the processed/worked wood (1.56%) and the unidentified and/or chemicals (0.81%).

⁹ Data source: data extrapolated for 2015, from the monthly distribution of overnight stays in travel accommodation in the Italian region of Sicily and the annual number of tourists welcomed on Sicily, <https://www.istat.it/>

During the high season (Fig. D.II.2-3), the marine litter is dominated by the artificial polymer materials (54.73%), followed by the metal (33.67%), the paper/cardboard (7.41%), the unidentified and/or chemicals (1.32%), the processed/worked wood (1.25%), the glass/ceramics (0.97%), the rubber (0.44%) and the cloth/textile (0.22%).

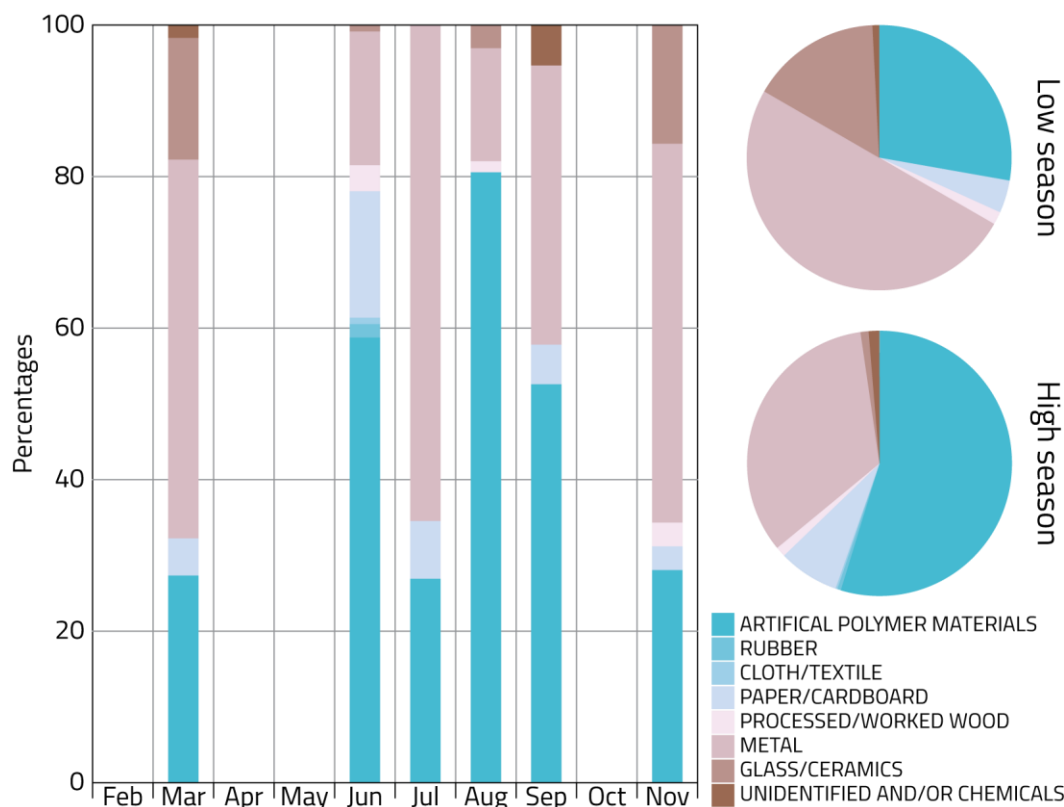


Figure D.II.2-3: composition of the marine litter collected at the beach of Letojani. Left: histogram showing the monthly percentages of the 8 major categories of material type. Right: pie charts showing the average composition of the marine litter during the low (top) and high (bottom) seasons. The color scale (lower right) indicates the type of material.

d) The 10 items with the highest accumulation rates

In this section, we consider the items with the highest averaged accumulation rates, which are not necessarily the most abundant items collected during the marine litter monitoring performed on the beach of Letojani (Fig. D.II.2-4). These items account for 61.83% of the total marine litter items (328) collected in 2017. They are dominated by the industrial scrap (0.0017 items/m²/day; 17.43% of the total marine litter items collected), followed by the cigarette butts (0.0014 items/m²/day; 14.77% of the total marine litter items collected), the mesoplastics (0.0005 items/m²/day; 4.05% of the total marine litter items collected), the drink bottles, containers and drums (0.0003 items/m²/day; 2.49% of the total marine litter items collected), the caps/lids (0.0003 items/m²/day; 1.88% of the total marine litter items collected), the macroplastics (0.0002 items/m²/day; 6.58% of the total marine litter items collected), the wire, wire mesh and barbed wire (0.0002 items/m²/day; 4.37% of the total marine litter items collected), the plastic/polystyrene pieces >50cm (0.0002 items/m²/day; 1.23% of the total marine litter items collected), the other metal pieces <50cm (0.0002 items/m²/day; 6.87% of the total marine litter items collected) and the bottles (0.0001 items/m²/day; 2.17% of the total marine litter items collected).

In this top 10, the artificial polymer materials and the metal are represented respectively by 6 and 3 items, accounting for 30.99% and 28.67% of the total marine litter items collected.

In this top 10, 4 items (cigarette butts, drink bottles, caps/lids and glass bottles) accounting for 21.31% of the total marine litter items collected, can be attributed to the shoreline source, including poor waste management practices, tourism and recreational activities (see Part B.III.2.c). To this, can possibly be added 4 items (mesoplastics, macroplastics, plastic/polystyrene pieces >50cm and other metal pieces <50cm) presenting a clear seasonal pattern (see Appendix, Fig. E.III-2) and accounting for additional 18.73% of the total marine litter items collected.

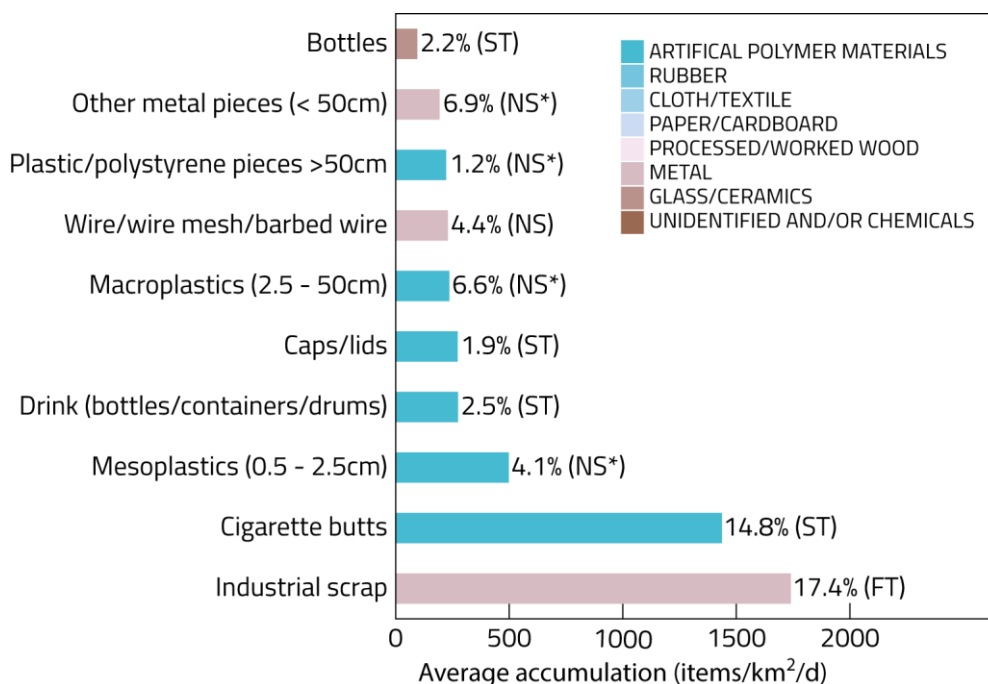


Figure D.II.2-4: list of the 10 items with the highest accumulation rates collected at the beach of Letojani. The percentages next to each item refers to their relative abundance with respect to the total collected. The possible source of the items is given into parenthesis: ST=shoreline, including poor waste management, tourism and recreational activities; FT=flying-tipping; and NS=non-sourced. The asterisk (*) associated to the non-sourced items (NS) shows that this specific item presents a clear seasonal increase. The color scale (upper right) indicates the type of material.

3. Remote beach: Fondaco Parrino

a) Characteristics of the beach

The beach of Fondaco Parrino is a semi-rural beach, located in the municipality of Letojani in the eastern side of Sicily, facing the sea to the SE. It has a total length of 612m, a width ranging from 12m to 47m and is composed at 90% of pebbles and 10% of sand with a slope of 5%. The monitored fixed portion of the beach has a surface of 2301 m². The beach is mainly used for recreational activities during the high season (local people, swimming and sunbathing). It is only accessible for pedestrians. In the area situated directly behind the beach, no services and facilities provided to the beach users are found. The coordinates of the fixed 100m portion selected for the monitoring are: 37.9068N, 15.3373E (starting point) and 37.9071N, 15.3377E (ending point) (Fig. D.II.3-1). Drink and food outlets are situated directly on the beach and the closest harbor is situated 19 km away to the SW. The beach is cleaned only once in August by local private owners.



Figure D.II.3-1: location map showing the beach of Fondaco Parrino and the selected 100m portion of beach monitored (red area).

b) Seasonality of the marine litter

The remote beach of Fondaco Parrino was sampled for marine litter in March, June, July, August, September and November of 2017. A total of 225 items (corrected for distance, see Part B.III.2.a) were collected on the same 100m portion of beach during the 6 monitoring, representing an average of 37.6 items (± 27.7 items, $n=6$) per survey. The lowest number of items was recorded in September (19 items) while the highest number was recorded in June (117 items) (Fig. D.II.3-2a). In general, the amount of marine litter collected are higher during the first half of the year and lower during the second half. Then no seasonal pattern is visible (Fig. D.II.3-2a). When only the number of items collected is considered (Fig. D.II.3-2b), their average number per survey during the low season (October – April) was of 35.5 (± 23.6 items, $n=2$) and of 38.6 (± 33.0 items, $n=4$) during the high season (May – September). Then, the amount of marine litter collected per survey during the high season was on average 8.7% higher than during the low touristic season (Fig. D.II.3-2b). When the accumulation rates (see Part B.III.2.b) are considered, a clear seasonal pattern is observed (Fig. D.II.3-2c). The lowest value observed was of 0.0001 items/m²/day (89 items/km²/day) in November and the highest was of 0.0008 items/m²/day (838 items/km²/day) in August (Fig. D.II.3-2c). The seasonal pattern of the marine litter seems to follow the monthly number of tourists welcomed on Sicily (Fig. D.II.3-2c): higher accumulation rates are observed during the touristic season and lower accumulation rates are observed during the off season. During the low season, the average accumulation rate is of 0.0001 items/m²/day (± 0.0001 , $n=2$) and of 0.0007 items/m²/day (± 0.0004 , $n=4$) during the high season. These results show that, on average the accumulation rates of the marine litter are by far higher during the high season (+581%, Fig. D.II.3-2d) than during the low season.

Finally, the beach of Fondaco Parrino can be considered as very clean during both the low and high seasons, according to the Clean-Coast Index (see Part B.III.2.d) exhibiting values of respectively 0.3 and 0.3 (Fig. C.IV-4a). The accumulation index shows that the accumulation of marine litter can be considered as very low during the low season (AI=1.98) and low during the high season (AI=2.81) (Fig. C.IV-4b).

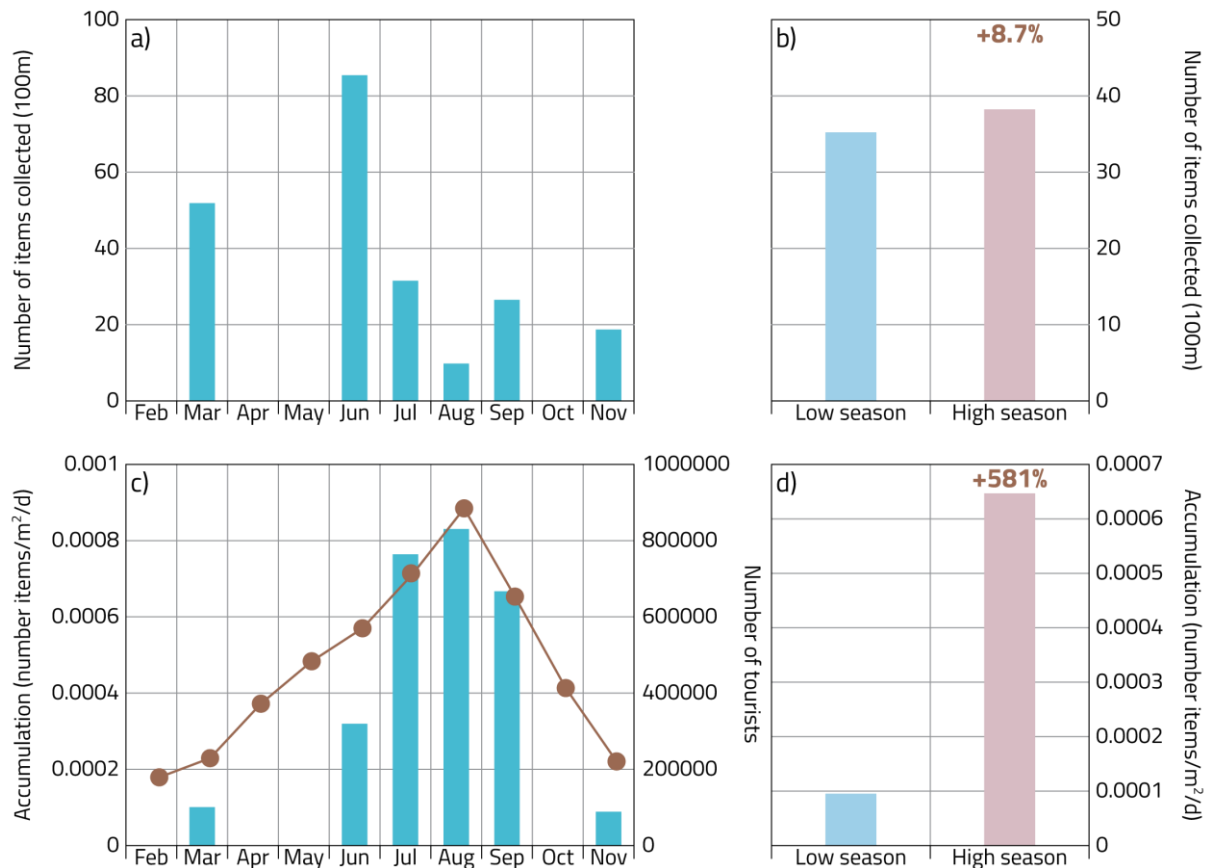


Figure D.II.3-2: total number and accumulations rates of items collected at the beach of Fondaco Parrino. a) number of items collected during each survey on the fixed 100m portion of beach; b) comparison of the average number of items collected per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season; c) accumulation rates of the marine litter (left axis, blue bars) and the monthly number of tourists¹⁰ in Sicily (right axis, brown line and dots); and d) comparison of the accumulation rates of marine litter per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season.

c) Composition of the marine litter

The marine litter collected on the beach of Fondaco Parrino (Fig. D.II.3-3) was classified into 8 major categories of material type (see Part B.III.2.c). It is dominated by the artificial polymer materials (average=60.96% \pm 19.88; min=25.00% in March and max=81.43% in June), followed by the metal (average=26.35% \pm 15.78; min=5.71% in June and max=54.17% in March), the paper/cardboard (average=3.76% \pm 5.90; min=0.00% in November and max=12.86% in June), the cloth/textile (average=2.94% \pm 7.20; min=0.00% in September and max=17.65% in November), the glass/ceramics (average=2.78% \pm 6.80; min=0.00% in November and max=16.67% in March), the rubber (average=2.55% \pm 4.51; min=0.00% in November and max=11.11% in August) and the processed/worked wood (average=0.67% \pm 1.63; min=0.00% in November and max=4.00% in March). No unidentified and/or chemicals were collected.

During the low season (Fig. D.II.3-3), the marine litter is dominated by the metal (41.79%), followed by the artificial polymer materials (38.97%), the cloth/textile (8.82%), the glass/ceramics (8.33%) and the rubber (2.08%).

¹⁰ Data source: data extrapolated for 2015, from the monthly distribution of overnight stays in travel accommodation in the Italian region of Sicily and the annual number of tourists welcomed on Sicily, <https://www.istat.it/>

During the high season (Fig. D.II.3-3), the marine litter is dominated by the artificial polymer materials (71.96%), followed by the metal (18.63%), the paper/cardboard (5.63%), the rubber (2.78%) and the processed/worked wood (1.00%).

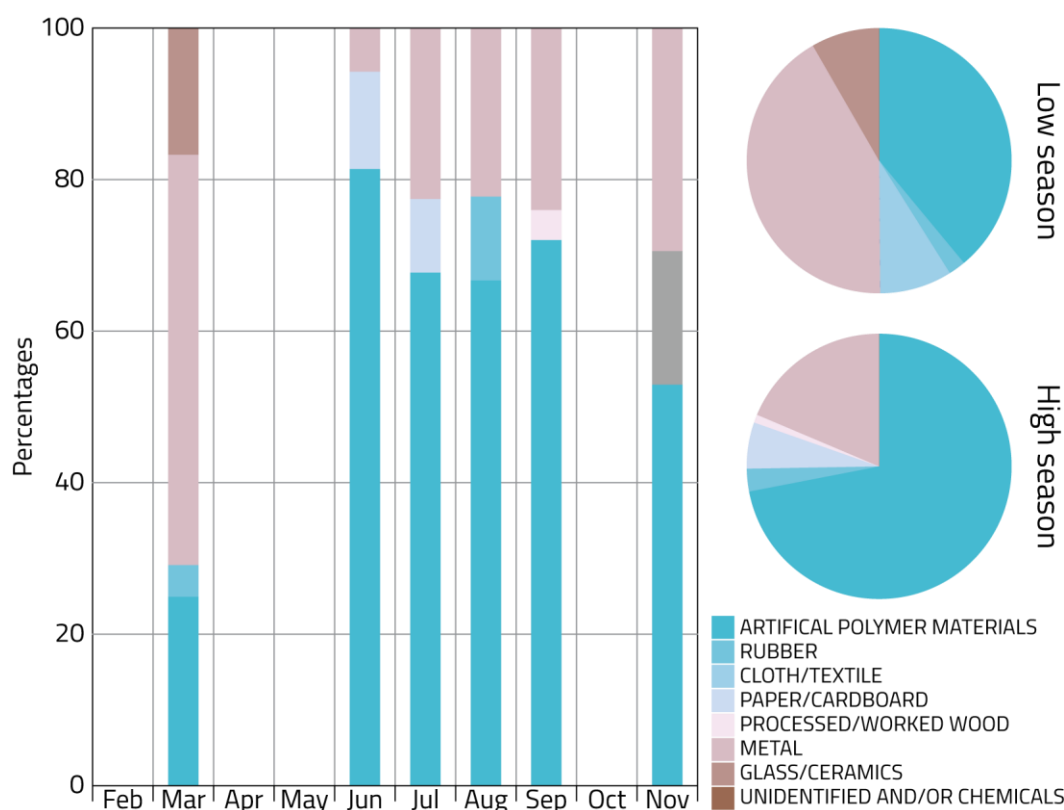


Figure D.II.3-3: composition of the marine litter collected at the beach of Fondaco Parrino. Left: histogram showing the monthly percentages of the 8 major categories of material type. Right: pie charts showing the average composition of the marine litter during the low (top) and high (bottom) seasons. The color scale (lower right) indicates the type of material.

d) The 10 items with the highest accumulation rates

In this section, we consider the items with the highest averaged accumulation rates, which are not necessarily the most abundant items collected during the marine litter monitoring performed on the beach of Fondaco Parrino (Fig. D.II.3-4). These items account for 60.23% of the total marine litter items (225) collected in 2017. They are dominated by the cigarette butts (0.00006 items/m²/day; 27.24% of the total marine litter items collected), followed by the drink bottles, containers and drums (0.00004 items/m²/day; 4.27% of the total marine litter items collected), the macroplastics (0.00004 items/m²/day; 4.84% of the total marine litter items collected), the food containers (e.g. fast food containers) (0.00003 items/m²/day; 2.34% of the total marine litter items collected), the industrial scrap (0.00003 items/m²/day; 1.87% of the total marine litter items collected), the other metal pieces <50cm (0.00003 items/m²/day; 13.02% of the total marine litter items collected), the bottle caps (0.00003 items/m²/day; 1.96% of the total marine litter items collected), the fish boxes (0.00002 items/m²/day; 1.45% of the total marine litter items collected), the mesoplastics (0.00002 items/m²/day; 2.27% of the total marine litter items collected) and the crisp/sweet packets and lolly sticks (0.00002 items/m²/day; 0.97% of the total marine litter items collected).

In this top 10, the artificial polymer materials and the metal are represented respectively by 7 and 3 items, accounting for 43.38% and 16.85% of the total marine litter items collected.

In this top 10, 5 items (cigarette butts, drink bottles, food containers, bottle caps and crisp/sweet packets and lolly sticks) accounting for 36.78% of the total marine litter items collected, can be attributed to the shoreline source, including poor waste management practices, tourism and recreational activities (see Part B.III.2.c). To this, can possibly be added 2 items (macroplastics and mesoplastics) presenting a clear seasonal pattern (see Appendix, Fig. E.III-3) and accounting for additional 7.11% of the total marine litter items collected.

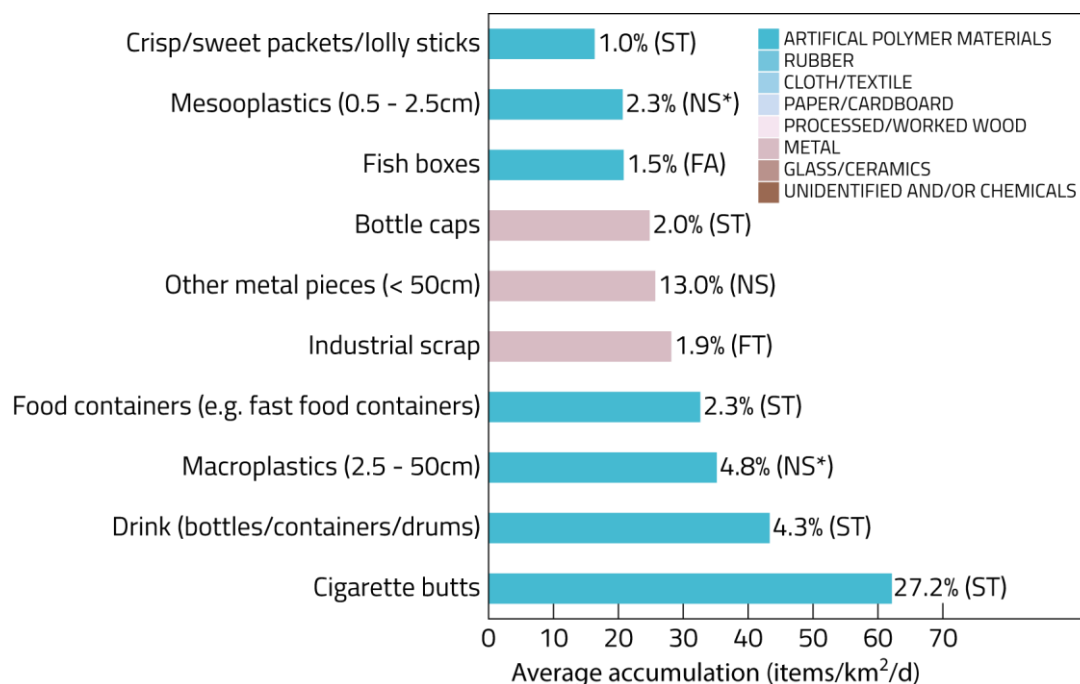


Figure D.II.3-4: list of the 10 items with the highest accumulation rates collected at the beach of Fondaco Parrino. The percentages next to each item refers to their relative abundance with respect to the total collected. The possible source of the items is given into parenthesis: ST=shoreline, including poor waste management, tourism and recreational activities; FA=fishing and aquaculture; FT=flying-tipping; and NS=non-sourced. The asterisk (*) associated to the non-sourced items (NS) shows that this specific item presents a clear seasonal increase. The color scale (upper right) indicates the type of material.

4. Summary

The 18 marine litter surveys conducted in Sicily in 2017 have revealed that:

- if only the number of items collected is considered, the touristic beach of Giardini Naxos is the most affected by the marine litter (453 items collected; average: 75.6 items/survey; 115.8 items/survey during the low season; 55.5 items/survey during the high season), followed by the beach of Letojani, mainly used by locals (328 items collected; average: 54.7 items/survey; 48.2 items/survey during the low season; 57.9 items/survey during the high season) and the remote beach of Fondaco Parrino (225 items collected; average: 37.6 items/survey; 35.5 items/survey during the low season; 38.6 items/survey during the high season). For the 3 beaches, no seasonal variability was observed from the number of items collected.
- If the accumulation rate of the marine litter is considered, the touristic beach of Giardini Naxos is the most affected by marine litter accumulation (average: 0.0108 items/m²/day; 0.0039 items/m²/day during the low season; 0.0143 items/m²/day during the high season), followed by the beach of Letojani, mainly used by locals (average: 0.0064 items/m²/day; 0.0001 items/m²/day during the low season; 0.0095 items/m²/day during the high season) and the remote beach of Fondaco Parrino (average: 0.0005 items/m²/day; 0.0001 items/m²/day during

the low season; 0.0007 items/m²/day during the high season). The 3 beaches presented recognizable seasonal variations with a relative increase of the accumulation rates of 271% (Giardini Naxos), 8157% (Letojani) and 581% (Fondaco Parrino) during the high season with respect to the low season.

- The items collected are mainly composed of artificial polymer materials: they represent 84.89% (Giardini Naxos), 45.74% (Letojani) and 60.96% (Fondaco Parrino) of the total marine litter items collected.
- On the touristic beach of Giardini Naxos, 4 items (cigarette butts, balloons, crisp/sweet packets and lolly sticks and food containers), most likely related to tourism and recreational activities, are representing 28.88% of the total marine litter items collected. To this, can possibly be added 1 item (other plastic/polystyrene items), accounting for additional 5.6% as they presented a recognizable seasonal variation.
- On the beach of Letojani, mainly used by locals, 4 items (cigarette butts, drink bottles, caps/lids and glass bottles), most likely related to tourism and recreational activities, are representing 21.31% of the total marine litter items collected. To this, can possibly be added 4 items (mesoplastics, macroplastics, plastic/polystyrene pieces >50cm and other metal pieces <50cm), accounting for additional 18.73% as they presented a recognizable seasonal variation.
- On the remote beach of Fondaco Parrino, 5 items (cigarette butts, drink bottles, food containers, bottle caps and crisp/sweet packets and lolly sticks), most likely related to tourism and recreational activities, are representing 36.78% of the total marine litter items collected. To this, can possibly be added 2 items (macroplastics and mesoplastics), accounting for additional 7.11% as they presented a recognizable seasonal variation.
- The cleanliness of the beaches is considered as very clean/very clean for the low/high season in Giardini Naxos (Clean-Coast Index of 0.4/0.2), very clean/very clean for the low/high season in Letojani (CCI of 0.3/0.3) and very clean/very clean for the low/high season in Fondaco Parrino (CCI of 0.3/0.3).
- Finally the accumulation index of the beaches is considered as moderate/high for the low/high season in Giardini Naxos (Accumulation Index of 3.59/4.16), low/moderate for the low/high season in Letojani (AI of 2.06/3.98) and very low/low for the low/high season in Fondaco Parrino (AI of 1.98/2.81).

III. Rab

1. Touristic beach: Rajska

a) Characteristics of the beach

The touristic beach of Rajska is a semi-urban beach, located in the municipality of Lopar in the north eastern side of Rab, facing the sea to the SE. It has a total length of $\pm 1000\text{m}$, a width of $\pm 45\text{m}$ and is composed at 100% of sand with a very smooth slope of 1%. The monitored fixed portion of the beach has a surface of 4476 m^2 . The beach is mainly used for recreational activities during the high season (swimming, sunbathing and diving). It is accessible by vehicles and for pedestrians. The area situated directly behind the beach is a semi-urban area with few services and facilities provided to the beach users. The coordinates of the fixed 100m portion selected for the monitoring are: 44.8240N, 14.7472E (starting point) and 44.8241N, 14.7465E (ending point) (Fig. D.III.1-1). Drink and food outlets are situated directly on the beach and the closest harbor is situated 129km away to the north. The beach is cleaned twice a day from May to October and when necessary during the low season.



Figure D.III.1-1: location map showing the beach of Rajska and the selected 100m portion of beach monitored (red area).

b) Seasonality of the marine litter

The touristic beach of Rajska was sampled for marine litter in May, August and October of 2017. A total of 5123 items (corrected for distance, see Part B.III.2.a) were collected on the same 100m portion of beach during the 3 monitoring, representing an average of 1707.8 items (± 1797.5 items, $n=3$) per survey. The lowest number of items was recorded in May (190 items) while the highest number was recorded in August (3693 items) (Fig. D.III.1-2a). A seeming seasonal pattern is observed (Fig. D.III.1-2a), although only 3 surveys were conducted. When only the number of items collected is considered (Fig. D.III.1-2b), their average number per survey during the low season (October – April) was of 1241.4 ($n=1$) and of 1941.0 (± 2477.0 items, $n=2$) during the high season (May – September). Then, the amount of marine litter collected per survey during the high season was on average 56.4% higher than during the low touristic season (Fig. D.III.1-2b). When the accumulation rates (see Part B.III.2.b) are considered, again a seasonal pattern seems to be observed (Fig. D.III.1-2c). The lowest value observed was of 0.0001 items/ m^2 /day (110 items/ km^2 /day) in May and the highest was of 0.2220 items/ m^2 /day (221962 items/ km^2 /day) in August (Fig. D.III.1-2c). The seasonal pattern of the marine litter seems to follow the monthly number of tourists welcomed on Rab (Fig. D.III.1-2c): higher accumulation rates are observed during the touristic season and lower accumulation rates are observed during the off season, although these results should be cautiously considered due to the low number of surveys. During the low season, the average accumulation rate is of 0.0746 items/ m^2 /day ($n=1$) and of 0.1110 items/ m^2 /day (± 0.0993 , $n=2$) during the high season. These results show that, on average the accumulation rates of the marine litter are higher during the high season (+49%, Fig. D.III.1-2) than during the low season.

Finally, the beach of Rajska can be considered as clean during both the low and high seasons, according to the Clean-Coast Index (see Part B.III.2.d) exhibiting values of respectively 3.0 and 4.7 (Fig. C.II-4a). The accumulation index shows that the accumulation of marine litter can be considered as high during the low season ($AI=4.87$) and very high during the high season ($AI=5.05$) (Fig. C.II-4b).

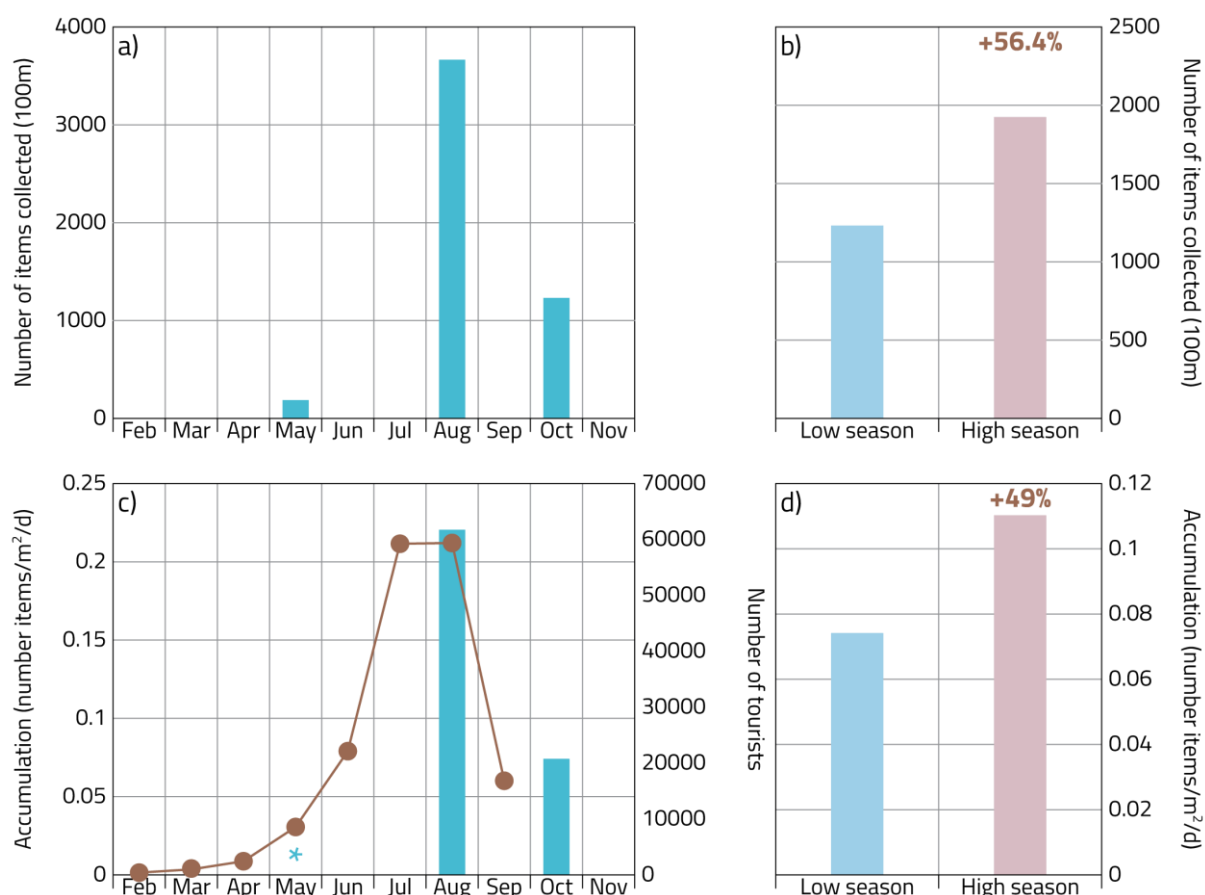


Figure D.III.1-2: total number and accumulations rates of items collected at the beach of Rajska. a) number of items collected during each survey on the fixed 100m portion of beach; b) comparison of the average number of items collected per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season; c) accumulation rates of the marine litter (left axis, blue bars, the blue asterisk (*) refers to values not visible at this scale) and the monthly number of tourists¹¹ in Rab (right axis, brown line and dots); and d) comparison of the accumulation rates of marine litter per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season.

c) Composition of the marine litter

The marine litter collected on the beach of Rajska (Fig. D.III.1-3) was classified into 8 major categories of material type (see Part B.III.2.c). It is dominated by the artificial polymer materials (average=61.83% \pm 23.17; min=44.91% in October and max=88.24% in May), followed by the metal (average=15.79% \pm 12.05; min=1.96% in May and max=24.01% in August), the paper/cardboard (average=10.00% \pm 8.74; min=0.00% in May and max=16.17% in October), the processed/worked wood (average=6.28% \pm 2.71; min=3.42% in August and max=8.82% in May), the unidentified and/or chemicals (average=2.75% \pm 3.32; min=0.00% in May and max=6.44% in October), the glass/ceramics (average=1.67% \pm 1.46; min=0.00% in May and max=2.69% in October), the cloth/textile (average=0.87% \pm 0.76; min=0.00% in May and max=1.41% in August) and the rubber (average=0.81% \pm 0.19; min=0.00% in October and max=0.98% in May).

During the low season (Fig. D.III.1-3), the marine litter is dominated by the artificial polymer materials (44.91%), followed by the metal (21.41%), the paper/cardboard (16.17%), the processed/worked wood (6.59%), the unidentified and/or chemicals (6.44%), the glass/ceramics (2.69%), the cloth/textile (1.20%) and the rubber (0.60%).

¹¹ Data source: monthly number of tourists welcomed on Rab in 2016. From the Rab Tourist Community.

During the high season (Fig. D.III.1-3), the marine litter is dominated by the artificial polymer materials (70.29%), followed by the metal (12.98%), the paper/cardboard (6.92%), the processed/worked wood (6.12%), the glass/ceramics (1.16%), the rubber (0.92%), the unidentified and/or chemicals (0.91%) and the cloth/textile (0.70%).

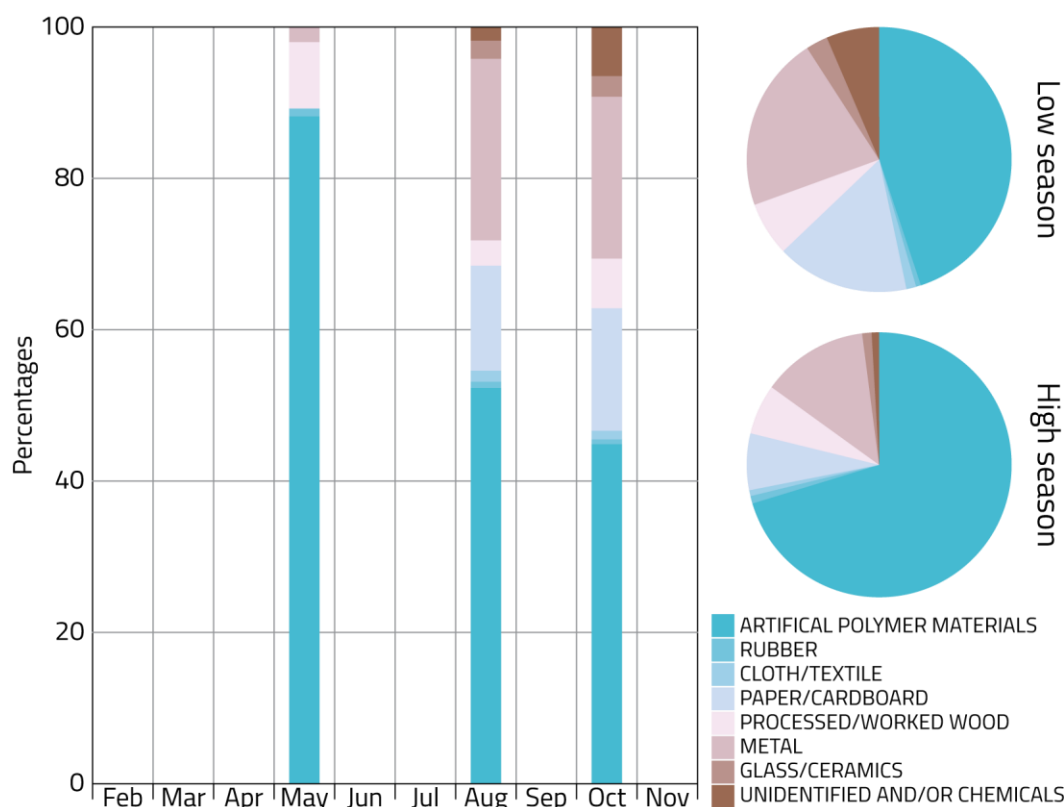


Figure D.III.1-3: composition of the marine litter collected at the beach of Rajska. Left: histogram showing the monthly percentages of the 8 major categories of material type. Right: pie charts showing the average composition of the marine litter during the low (top) and high (bottom) seasons. The color scale (lower right) indicates the type of material.

d) The 10 items with the highest accumulation rates

In this section, we consider the items with the highest averaged accumulation rates, which are not necessarily the most abundant items collected during the marine litter monitoring performed on the beach of Rajska (Fig. D.III.1-4). These items account for 56.37% of the total marine litter items (5123) collected in 2017. They are dominated by the bottle caps (0.0111 items/m²/day; 10.85% of the total marine litter items collected), followed by the cigarette butts (0.0089 items/m²/day; 9.07% of the total marine litter items collected), the drink cans (0.0068 items/m²/day; 6.6% of the total marine litter items collected), the cotton bud sticks (0.0063 items/m²/day; 6.2% of the total marine litter items collected), the caps/lids (0.0055 items/m²/day; 6.09% of the total marine litter items collected), the crisp/sweet packets and lolly sticks (0.0042 items/m²/day; 4.35% of the total marine litter items collected), the bags (0.0038 items/m²/day; 3.74% of the total marine litter items collected), the ice lolly sticks/chip forks (0.0035 items/m²/day; 3.74% of the total marine litter items collected), the food cans (0.003 items/m²/day; 2.9% of the total marine litter items collected) and the cigarette packets (0.0029 items/m²/day; 2.83% of the total marine litter items collected).

In this top 10, the artificial polymer materials and the metal are represented respectively by 4 and 3 items, accounting for 25.72% and 20.35% of the total marine litter items collected.

In this top 10, 9 items (bottle caps, cigarette butts, drink cans, caps/lids, crisp/sweet packets and lolly sticks, bags, ice lolly sticks/chip forks, food cans and cigarette packets) accounting for 50.17% of the total marine litter items collected, can be attributed to the shoreline source, including poor waste management practices, tourism and recreational activities (see Part B.III.2.c).

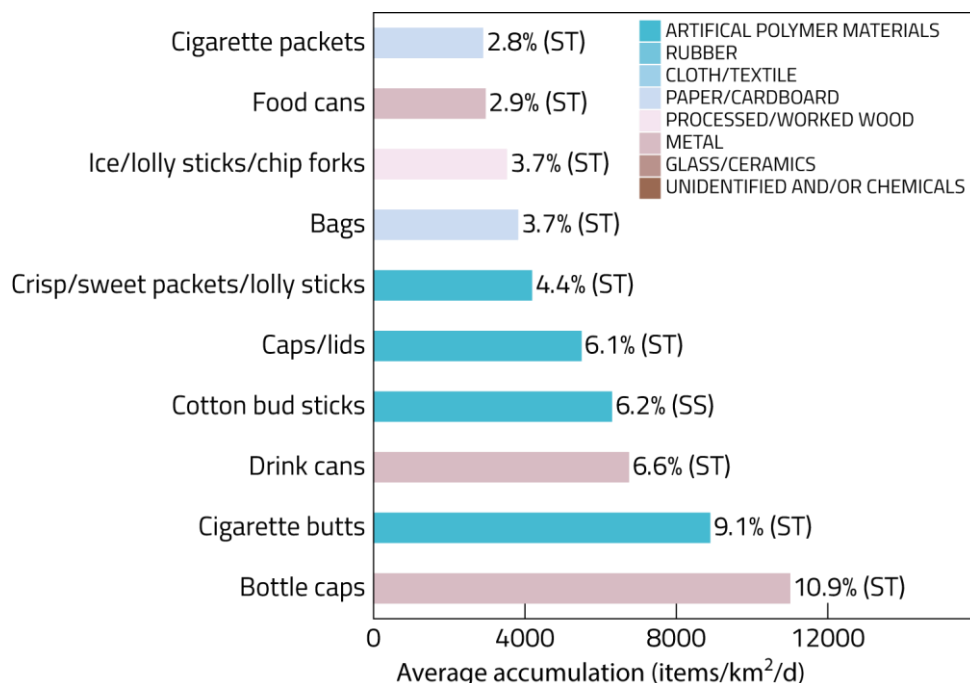


Figure D.III.1-4: list of the 10 items with the highest accumulation rates collected at the beach of Rajska. The percentages next to each item refers to their relative abundance with respect to the total collected. The possible source of the items is given into parenthesis: ST=shoreline, including poor waste management, tourism and recreational activities. The color scale (upper right) indicates the type of material.

2. Beach mainly used by locals: Kampor

a) Characteristics of the beach

The beach of Kampor was selected as it is a popular beach mainly used by locals. It is a semi-rural beach, located in the municipality of Kampor in the north western side of Rab, facing the sea to the NW. It has a total length of $\pm 500\text{m}$, a width ranging from 25m to 50m and is composed at 100% of sand with a smooth slope of 5%. The monitored fixed portion of the beach has a surface of 4389 m^2 . The beach is mainly used for recreational activities during the high season (swimming and sunbathing). It is accessible by vehicles and for pedestrians. In the area situated directly behind the beach, very limited services and facilities provided to the beach users are found. The coordinates of the fixed 100m portion selected for the monitoring are: 44.7854N, 14.7051E (starting point) and 44.7851N, 14.7075E (ending point) (Fig. D.III.2-1). Drink and food outlets are situated directly on the beach and the closest harbor is situated 120 km away to the north. The beach is cleaned once a day from May to September.



Figure D.III.2-1: location map showing the beach of Kampor and the selected 100m portion of beach monitored (red area).

b) Seasonality of the marine litter

The beach of Kampor, mainly used by locals, was sampled for marine litter in May, August and October of 2017. A total of 507 items (corrected for distance, see Part B.III.2.a) were collected on the same portion of 100m of beach during the 3 monitoring, representing an average of 168.8 items (± 159.5 items, $n=3$) per survey. The lowest number of items was recorded in October (69 items) while the highest number was recorded in August (353 items) (Fig. D.III.2-2a). A seeming seasonal pattern is observed (Fig. D.III.2-2a), although only 3 surveys were conducted. When only the number of items collected is considered (Fig. D.III.2-2b), their average number per survey during the low season (October – April) was of 69 ($n=1$) and of 218.9 (± 189.3 items, $n=2$) during the high season (May – September). Then, the amount of marine litter collected per survey during the high season was on average 218.5% higher than during the low touristic season (Fig. D.III.2-2b). When the accumulation rates (see Part B.III.2.b) are considered, again a seasonal pattern seems to be observed (Fig. D.III.2-2c). The lowest value observed was of 0.0002 items/m²/day (157 items/km²/day) in May and the highest was of 0.0789 items/m²/day (78947 items/km²/day) in August (Fig. D.III.2-2c). The seasonal pattern of the marine litter seems to follow the monthly number of tourists welcomed on Rab (Fig. D.III.2-2c): higher accumulation rates are observed during the touristic season and lower accumulation rates are observed during the off season, although these results should be cautiously considered due to the low number of surveys. During the low season, the average accumulation rate is of 0.0154 items/m²/day ($n=1$) and of 0.0396 items/m²/day (± 0.0353 , $n=2$) during the high season. These results show that, on average the accumulation rates of the marine litter are higher during the high season (+157%, Fig. D.III.2-2d) than during the low season.

Finally, the beach of Kampor can be considered as very clean during the low season and clean during the high seasons, according to the Clean-Coast Index (see Part B.III.2.d) exhibiting values of respectively 0.6 and 2.0 (Fig. C.III-4a). The accumulation index shows that the accumulation of marine litter can be considered as high during both the low and high seasons (AI=4.19 and 4.60) (Fig. C.III-4b).

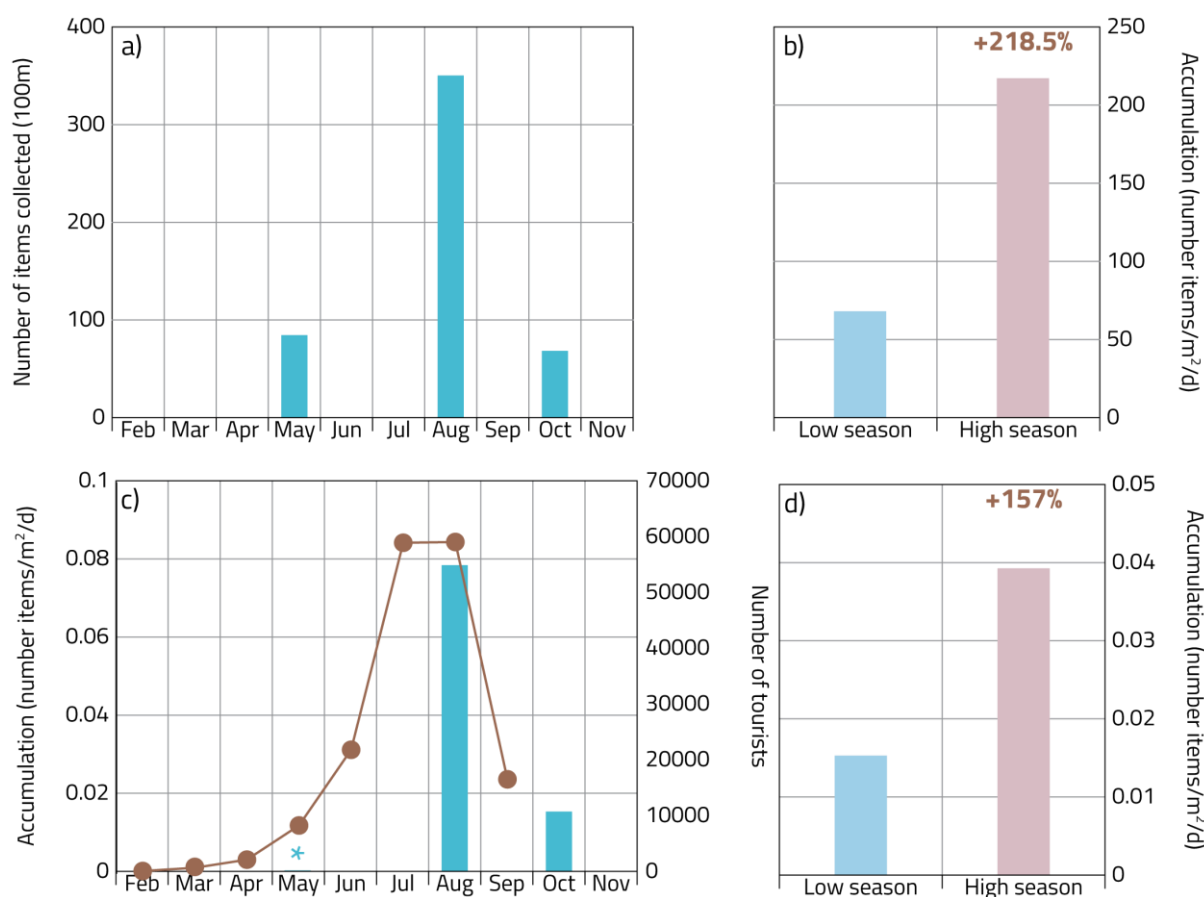


Figure D.III.2-2: total number and accumulations rates of items collected at the beach of Kampor. a) number of items collected during each survey on the fixed 100m portion of beach; b) comparison of the average number of items collected per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season; c) accumulation rates of the marine litter (left axis, blue bars, the blue asterisk (*) refers to values not visible at this scale) and the monthly number of tourists¹² in Rab (right axis, brown line and dots); and d) comparison of the accumulation rates of marine litter per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season.

c) Composition of the marine litter

The marine litter collected on the beach of Kampor (Fig. D.III.2-3) was classified into 8 major categories of material type (see Part B.III.2.c). It is dominated by the artificial polymer materials (average=73.58% \pm 16.12; min=57.58% in August and max=89.82% in May), followed by the metal (average=12.73% \pm 5.34; min=6.59% in May and max=16.30% in October), the paper/cardboard (average=7.29% \pm 6.42; min=1.20% in May and max=14.00% in August), the processed/worked wood (average=4.56% \pm 4.57; min=1.48% in October and max=9.81% in August), the glass/ceramics (average=1.13% \pm 1.11; min=0.00% in May and max=2.22% in October), the unidentified and/or chemicals (average=0.63% \pm 1.08; min=0.00% in October and max=1.88% in August), the rubber (average=0.05% \pm 0.08; min=0.00% in October and max=0.14% in August) and the cloth/textile (average=0.05% \pm 0.08; min=0.00% in October and max=0.14% in August).

During the low season (Fig. D.III.2-3), the marine litter is dominated by the artificial polymer materials (73.33%), followed by the metal (16.30%), the paper/cardboard (6.67%), the glass/ceramics (2.22%) and the processed/worked wood (1.48%).

During the high season (Fig. D.III.2-3), the marine litter is dominated by the artificial polymer materials (73.70%), followed by the metal (10.94%), the paper/cardboard (7.60%), the processed/worked wood

¹² Data source: monthly number of tourists welcomed on Rab in 2016. From the Rab Tourist Community.

(6.10%), the unidentified and/or chemicals (0.94%), the glass/ceramics (0.58%), the rubber (0.07%) and the cloth/textile (0.07%).

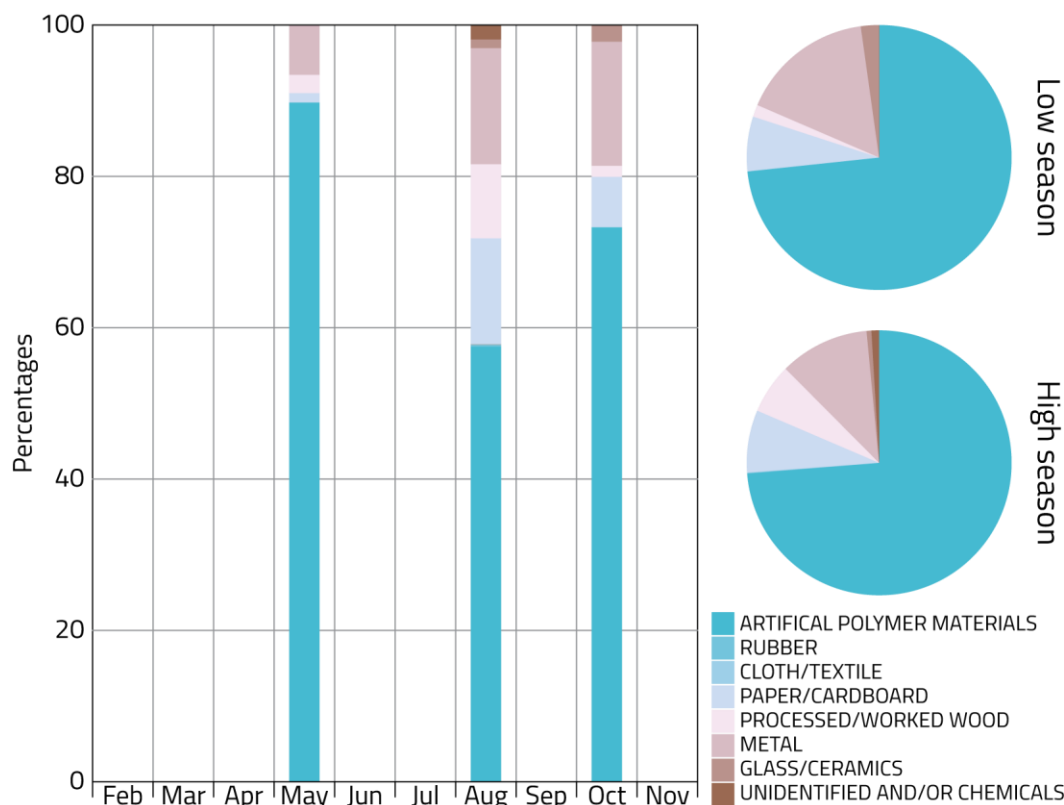


Figure D.III.2-3: composition of the marine litter collected at the beach of Kampor. Left: histogram showing the monthly percentages of the 8 major categories of material type. Right: pie charts showing the average composition of the marine litter during the low (top) and high (bottom) seasons. The color scale (lower right) indicates the type of material.

d) The 10 items with the highest accumulation rates

In this section, we consider the items with the highest averaged accumulation rates, which are not necessarily the most abundant items collected during the marine litter monitoring performed on the beach of Kampor (Fig. D.III.2-4). These items account for 61.01% of the total marine litter items (507) collected in 2017. They are dominated by the cigarette butts (0.0041 items/m²/day; 13.77% of the total marine litter items collected), followed by the ice lolly sticks/chip forks (0.0026 items/m²/day; 6.93% of the total marine litter items collected), the bottle caps (0.0025 items/m²/day; 7.64% of the total marine litter items collected), the cigarette packets (0.0019 items/m²/day; 5.13% of the total marine litter items collected), the small plastic bags, e.g., freezer bags (0.0019 items/m²/day; 5.13% of the total marine litter items collected), the drink cans (0.0015 items/m²/day; 4.02% of the total marine litter items collected), the crisp/sweet packets and lolly sticks (0.0014 items/m²/day; 4.12% of the total marine litter items collected), the caps/lids (0.0014 items/m²/day; 6.03% of the total marine litter items collected), the bags (e.g. shopping) (0.0012 items/m²/day; 3.42% of the total marine litter items collected) and the mesoplastics (0.0012 items/m²/day; 4.82% of the total marine litter items collected). In this top 10, the artificial polymer materials and the metal are represented respectively by 6 and 2 items, accounting for 37.29% and 11.66% of the total marine litter items collected.

In this top 10, 9 items (cigarette butts, ice lolly sticks/chip forks, bottle caps, cigarette packets, small plastic bags, e.g., freezer bags, drink cans, crisp/sweet packets and lolly sticks, caps/lids and bags) accounting for 56.19% of the total marine litter items collected, can be attributed to the shoreline

source, including poor waste management practices, tourism and recreational activities (see Part B.III.2.c). To this, can possibly be added 1 item (mesoplastics) presenting a clear seasonal pattern (see Appendix, Fig. E.IV-2) and accounting for additional 4.82% of the total marine litter items collected.

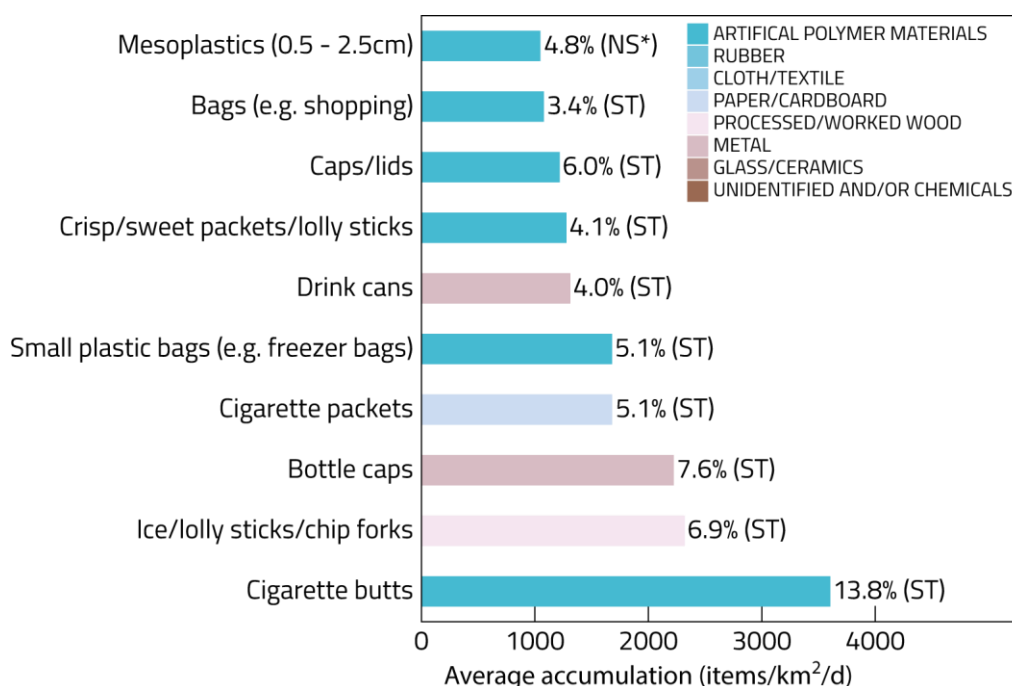


Figure D.III.2-4: list of the 10 items with the highest accumulation rates collected at the beach of Kampor. The percentages next to each item refers to their relative abundance with respect to the total collected. The possible source of the items is given into parenthesis: ST=shoreline, including poor waste management, tourism and recreational activities and NS=non-sourced. The asterisk (*) associated to the non-sourced items (NS) shows that this specific item presents a clear seasonal increase. The color scale (upper right) indicates the type of material.

3. Remote beach: Pudarica

a) Characteristics of the beach

The remote beach of Pudarica is a rural beach, located in the municipality of Barbat na Rabu in the south western side of Rab, facing the sea to the SW. It has a total length of $\pm 150\text{m}$, a width of $\pm 10\text{m}$ and is composed at 90% of sand and 10% of rocks with a very smooth slope of 1%. The monitored fixed portion of the beach has a surface of 1055 m^2 . The beach is mainly used for recreational activities during the high season (swimming, sunbathing, fishing and diving) and the low season (fishing). It is only accessible for pedestrians. The area situated directly behind the beach is a rural area with very limited services and facilities provided to the beach users (only 1 beach club). The coordinates of the fixed 100m portion selected for the monitoring are: 44.7076N, 14.8318E (starting point) and 44.7074N, 14.8311E (ending point) (Fig. D.III.3-1). The closest harbor is situated 116km away to the north. The beach is cleaned once a day from May to October.



Figure D.III.3-1: location map showing the beach of Pudarica and the selected 100m portion of beach monitored (red area).

b) Seasonality of the marine litter

The remote beach of Pudarica was sampled for marine litter in May, August and October of 2017. A total of 1266 items (corrected for distance, see Part B.III.2.a) were collected on the same 100m portion of beach during the 3 monitoring, representing an average of 422.0 items (± 346.3 items, $n=3$) per survey. The lowest number of items was recorded in May (53 items) while the highest number was recorded in October (740 items) (Fig. D.III.3-2a). In general the amount of marine litter seems to continuously increase from May to October. Then no seasonal pattern is observed (Fig. D.III.3-2a). When only the number of items collected is considered (Fig. D.III.3-2b), their average number per survey during the low season (October – April) was of 740 ($n=1$) and of 263.2 (± 297.3 items, $n=2$) during the high season (May – September). Then, the amount of marine litter collected per survey during the high season was on average 64.4% lower than during the low touristic season (Fig. D.III.3-2b). When the accumulation rates (see Part B.III.2.b) are considered (Fig. D.III.3-2c), the lowest value observed was of 0.0001 items/m²/day (133 items/km²/day) in May and the highest was of 0.2251 items/m²/day (225118 items/km²/day) in October (Fig. D.III.3-2c). Due to the high accumulation rate of November and the fact that only 3 surveys were conducted, it is difficult to state on a seasonality of the marine litter. During the low season, the average accumulation rate is of 0.2251 items/m²/day ($n=1$) and of 0.0721 items/m²/day (± 0.0644 , $n=2$) during the high season. These results show that, on average the accumulation rates of the marine litter are lower during the high season (-68%, Fig. D.III.3-2d) than during the low season.

Finally, the beach of Pudarica can be considered as moderately clean during the low season and clean during the high seasons, according to the Clean-Coast Index (see Part B.III.2.d) exhibiting values of respectively 9.0 and 3.2 (Fig. C.IV-4a). The accumulation index shows that the accumulation of marine litter can be considered as very high during the low season (AI=5.35) and high during the high season (AI=4.86) (Fig. C.IV-4b).

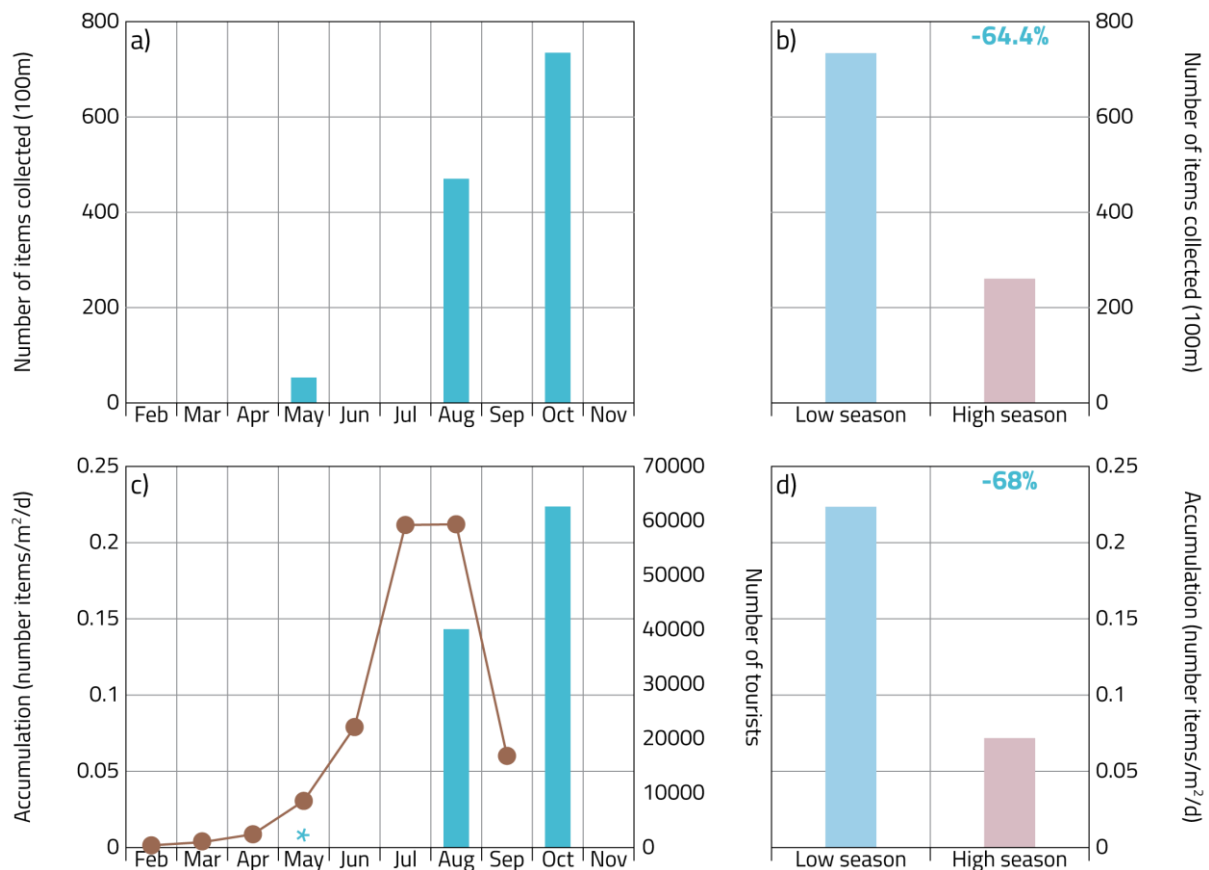


Figure D.III.3-2: Total number and accumulations rates of items collected at the beach of Pudarica. a) number of items collected during each survey on the fixed 100m portion of beach; b) comparison of the average number of items collected per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (blue font) refers to the decrease with respect to the low season; c) accumulation rates of the marine litter (left axis, blue bars, the blue asterisk (*) refers to values not visible at this scale) and the monthly number of tourists¹³ in Rab (right axis, brown line and dots); and d) comparison of the accumulation rates of marine litter per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (blue font) refers to the decrease with respect to the low season.

c) Composition of the marine litter

The marine litter collected on the beach of Pudarica (Fig. D.III.3-3) was classified into 8 major categories of material type (see Part B.III.2.c). It is dominated by the artificial polymer materials (average=64.70% \pm 23.00; min=49.67% in August and max=91.18% in May), followed by the metal (average=19.43% \pm 15.57; min=2.94% in May and max=33.88% in August), the paper/cardboard (average=9.04% \pm 8.66; min=0.00% in May and max=17.26% in October), the processed/worked wood (average=4.80% \pm 1.88; min=2.63% in August and max=5.89% in October), the glass/ceramics (average=0.93% \pm 0.81; min=0.00% in May and max=1.47% in August), the unidentified and/or chemicals (average=0.55% \pm 0.95; min=0.00% in October and max=1.64% in August), the cloth/textile (average=0.47% \pm 0.50; min=0.00% in May and max=0.99% in August) and the rubber (average=0.07% \pm 0.12; min=0.00% in August and max=0.21% in October).

During the low season (Fig. D.III.3-3), the marine litter is dominated by the artificial polymer materials (53.26%), followed by the metal (21.47%), the paper/cardboard (17.26%), the processed/worked wood (5.89%), the glass/ceramics (1.47%), the cloth/textile (0.42%) and the rubber (0.21%).

During the high season (Fig. D.III.3-3), the marine litter is dominated by the artificial polymer materials (70.42%), followed by the metal (18.41%), the paper/cardboard (4.93%), the processed/worked wood

¹³ Data source: monthly number of tourists welcomed on Rab in 2016. From the Rab Tourist Community.

(4.26%), the unidentified and/or chemicals (0.82%), the glass/ceramics (0.66%) and the cloth/textile (0.49%).

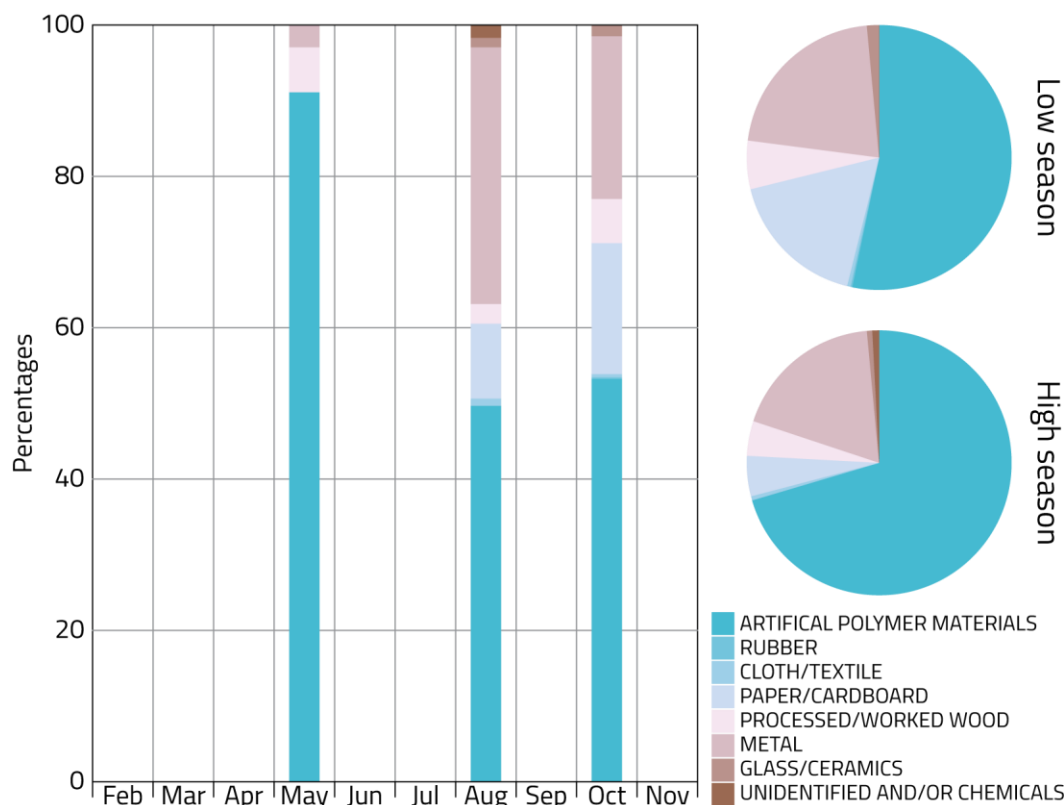


Figure D.III.3-3: composition of the marine litter collected at the beach of Pudarica. Left: histogram showing the monthly percentages of the 8 major categories of material type. Right: pie charts showing the average composition of the marine litter during the low (top) and high (bottom) seasons. The color scale (lower right) indicates the type of material.

d) The 10 items with the highest accumulation rates

In this section, we consider the items with the highest averaged accumulation rates, which are not necessarily the most abundant items collected during the marine litter monitoring performed on the beach of Pudarica (Fig. D.III.3-4). These items account for 73.43% of the total marine litter items (1266) collected in 2017. They are dominated by the cigarette butts (0.0231 items/m²/day; 18.7% of the total marine litter items collected), followed by the bottle caps (0.0212 items/m²/day; 16.61% of the total marine litter items collected), the drink cans (0.0104 items/m²/day; 8.12% of the total marine litter items collected), the cigarette packets (0.0084 items/m²/day; 6.52% of the total marine litter items collected), the caps/lids (0.0077 items/m²/day; 6.77% of the total marine litter items collected), the ice lolly sticks/chip forks (0.0057 items/m²/day; 4.55% of the total marine litter items collected), the crisp/sweet packets and lolly sticks (0.0052 items/m²/day; 4.18% of the total marine litter items collected), the mesoplastics (0.0035 items/m²/day; 3.08% of the total marine litter items collected), the cups (0.0032 items/m²/day; 2.46% of the total marine litter items collected) and the cartons e.g., tetrapack (0.0032 items/m²/day; 2.46% of the total marine litter items collected).

In this top 10, the artificial polymer materials and the metal are represented respectively by 5 and 2 items, accounting for 35.18% and 24.72% of the total marine litter items collected.

In this top 10, 9 items (cigarette butts, bottle caps, drink cans, cigarette packets, caps/lids, ice lolly sticks/chip forks, crisp/sweet packets and lolly sticks, cups and cartons e.g. tetrapack) accounting for

70.37% of the total marine litter items collected, can be attributed to the shoreline source, including poor waste management practices, tourism and recreational activities (see Part B.III.2.c).

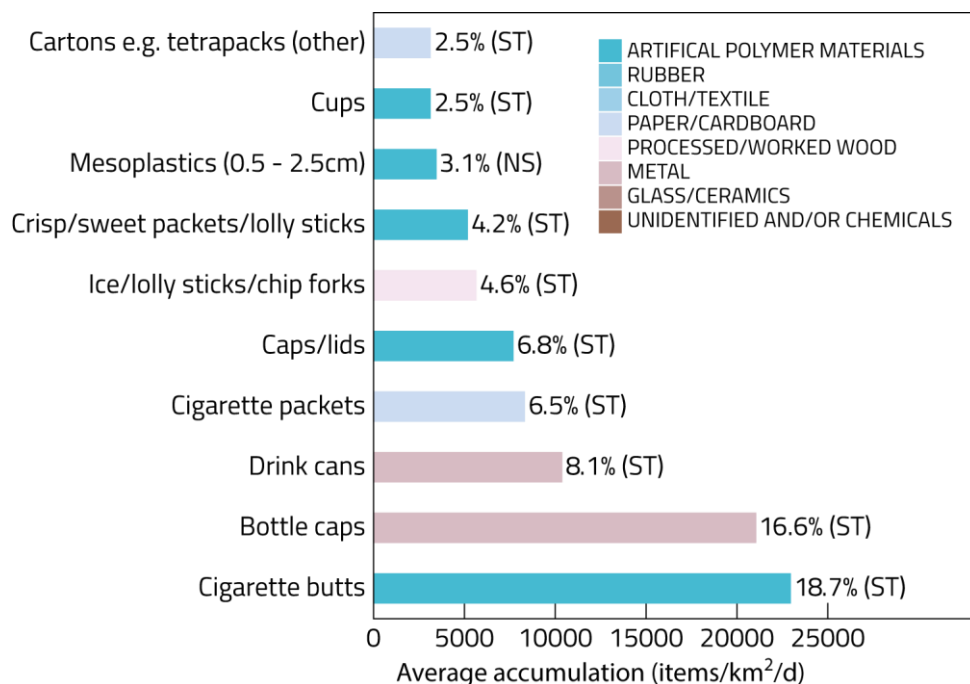


Figure D.III.3-4: list of the 10 items with the highest accumulation rates collected at the beach of Pudarica. The percentages next to each item refers to their relative abundance with respect to the total collected. The possible source of the items is given into parenthesis: ST=shoreline, including poor waste management, tourism and recreational activities. The color scale (upper right) indicates the type of material.

4. Summary

The 9 marine litter surveys conducted in Rab in 2017 have revealed that:

- If only the number of items collected is considered, the touristic beach of Rajska is the most affected by the marine litter (5123 items collected; average: 1707.8 items/survey; 1241.4 items/survey during the low season; 1941.0 items/survey during the high season), followed by the remote beach of Pudarica (1266 items collected; average: 422.0 items/survey; 739.7 items/survey during the low season; 263.2 items/survey during the high season) and the beach of Kampor, mainly used by locals (507 items collected; average: 168.8 items/survey; 68.7 items/survey during the low season; 218.9 items/survey during the high season). For the 3 beaches, no seasonal variability was observed from the number of items collected.
- If the accumulation rate of the marine litter is considered, the remote beach of Pudarica is the most affected by marine litter accumulation (average: 0.1231 items/m²/day; 0.2251 items/m²/day during the low season; 0.0721 items/m²/day during the high season), followed by the touristic beach of Rajska (average: 0.0989 items/m²/day; 0.0746 items/m²/day during the low season; 0.1110 items/m²/day during the high season) and the beach of Kampor, mainly used by locals (average: 0.0315 items/m²/day; 0.0154 items/m²/day during the low season; 0.0396 items/m²/day during the high season). The 3 beaches presented recognizable seasonal variations with a relative increase of the accumulation rates of 49% (Rajska) and 157% (Kampor), and a relative decrease of 68% (Pudarica) during the high season with respect to the low season.

- The items collected are mainly composed of artificial polymer materials: they represent 61.83% (Rajska), 73.58% (Kampor) and 64.70% (Pudarica) of the total marine litter items collected.
- On the touristic beach of Rajska, 9 items (bottle caps, cigarette butts, drink cans, caps/lids, crisp/sweet packets and lolly sticks, bags, ice lolly sticks/chip forks, food cans and cigarette packets), most likely related to tourism and recreational activities, are representing 50.17% of the total marine litter items collected.
- On the beach of Kampor, mainly used by locals, 9 items (cigarette butts, ice lolly sticks/chip forks, bottle caps, cigarette packets, small plastic bags, drink cans, crisp/sweet packets and lolly sticks, caps/lids and bags), most likely related to tourism and recreational activities, are representing 56.19% of the total marine litter items collected. To this, can possibly be added 1 item (mesoplastics), accounting for additional 4.82% as they presented a recognizable seasonal variation.
- On the remote beach of Pudarica, 9 items (cigarette butts, bottle caps, drink cans, cigarette packets, caps/lids, ice lolly sticks/chip forks, crisp/sweet packets and lolly sticks, cups and cartons e.g. tetrapack), most likely related to tourism and recreational activities, are representing 70.37% of the total marine litter items collected.
- The cleanliness of the beaches is considered as clean/clean for the low/high season in Rajska (Clean-Coast Index of 2.98/4.7), very clean/clean for the low/high season in Kampor (CCI of 0.6/2.0) and moderate/clean for the low/high season in Pudarica (CCI of 9.0/3.2).
- Finally the accumulation index of the beaches is considered as high/very high for the low/high season in Rajska (Accumulation Index of 4.87/5.05), high/high for the low/high season in Kampor (AI of 4.19/4.60) and very high/high for the low/high season in Pudarica (AI of 5.35/4.86).

IV. Malta

1. Touristic beach: Golden Bay

a) Characteristics of the beach

The touristic beach of Golden Bay is a semi-urban beach, located in the municipality of Il-Mellieħa in the north western side of Malta, facing the sea to the SW. It has a total length of $\pm 230\text{m}$, a width of $\pm 44\text{m}$ and is composed at 90% of sand and 10% of pebbles with a slope of 26.8%. The monitored fixed portion of the beach has a surface of 3230 m^2 . The beach is mainly used for recreational activities during the high season (swimming, sunbathing and barbecues) and the low season (sunbathing). It is accessible by vehicles/boats and for pedestrians. The area situated directly behind the beach, has many services and facilities provided to the beach users. The coordinates of the fixed 100m portion selected for the monitoring are: 35.9334N, 14.3448E (starting point) and 35.9341N, 14.3444E (ending point) (Fig. D.IV.1-1). Drink and food outlets are situated directly on the beach and the closest harbor is situated 6 km away to the north. The beach is cleaned once a day all year long.



Figure D.IV.1-1: location map showing the beach of Golden Bay and the selected 100m portion of beach monitored (red area).

b) Seasonality of the marine litter

The touristic beach of Golden Bay was sampled for marine litter in March, May, June, July, August, September and November of 2017. A total of 6784 items (corrected for distance, see Part B.III.2.a) were collected on the same 100m portion of beach during the 7 monitoring, representing an average of 969.1 items (± 516.8 items, $n=7$) per survey. The lowest number of items was recorded in September (261 items) while the highest number was recorded in November (1797 items) (Fig. D.IV.1-2a). In general, the amount of marine litter is quite constant between March and July, then it falls in August and September before to sharply increase in November. No seasonal pattern was visible (Fig. D.IV.1-2a). When only the number of items collected is considered (Fig. D.IV.1-2b), their average number per survey during the low season (October – April) was of 1415.4 (± 540.3 items, $n=2$) and of 790.6 (± 433.9 items, $n=5$) during the high season (May – September). Then, the amount of marine litter collected per survey during the high season was on average 44.1% lower than during the low touristic season (Fig. D.IV.1-2b). When the accumulation rates (see Part B.III.2.b) are considered, a seasonal pattern can be observed (Fig. D.IV.1-2c). The lowest value observed was of 0.5300 items/m²/day (530031 items/km²/day) in March and the highest was of 1.3375 items/m²/day (1337461 items/km²/day) in September (Fig. D.IV.1-2c). The seasonal pattern of the marine litter seems to follow the monthly number of tourists welcomed on Malta (Fig. D.IV.1-2c): higher accumulation rates are observed during the touristic season and lower accumulation rates are observed during the off season, even if the peak of the number of tourists (August) does not coincide with the peak of marine litter (September). During the low season, the average accumulation rate is of 0.7260 items/m²/day (± 0.4211 , $n=2$) and of 0.8649 items/m²/day (± 0.3236 , $n=5$) during the high season. These results show that, on average the accumulation rates of the marine litter are slightly higher during the high season (+19%, Fig. D.IV.1-2d) than during the low season.

Finally, the beach of Golden Bay can be considered as moderately clean during the low season and clean during the high season, according to the Clean-Coast Index (see Part B.III.2.d) exhibiting values of respectively 7.3 and 4.1 (Fig. C.II-4a). The accumulation index shows that the accumulation of marine litter can be considered as very high during both the low and high seasons (AI=5.86 and 5.94) (Fig. C.II-4b).

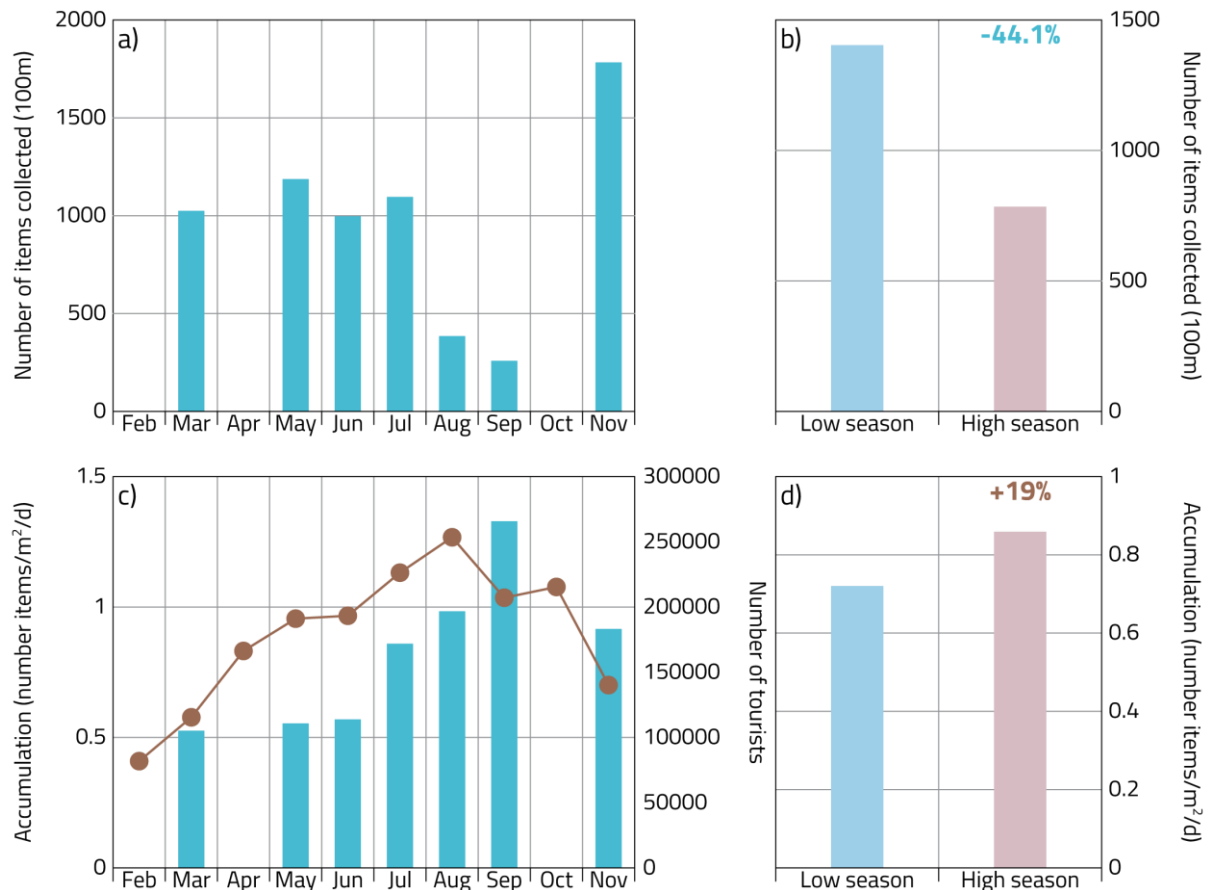


Figure D.IV.1-2: total number and accumulations rates of items collected at the beach of Golden Bay. a) number of items collected during each survey on the fixed 100m portion of beach; b) comparison of the average number of items collected per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (blue font) refers to the decrease with respect to the low season; c) accumulation rates of the marine litter (left axis, blue bars) and the monthly number of tourists¹⁴ in Malta (right axis, brown line and dots); and d) comparison of the accumulation rates of marine litter per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season.

c) Composition of the marine litter

The marine litter collected on the beach of Golden Bay (Fig. D.IV.1-3) was classified into 8 major categories of material type (see Part B.III.2.c). It is largely dominated by the artificial polymer materials (average=94.27% \pm 3.27; min=89.06% in August and max=99.40% in November), followed by the paper/cardboard (average=2.13% \pm 1.92; min=0.00% in September and max=5.63% in August), the metal (average=1.59% \pm 0.77; min=0.13% in November and max=2.40% in June), the processed/worked wood (average=0.99% \pm 0.84; min=0.13% in November and max=2.19% in August), the glass/ceramics (average=0.55% \pm 0.45; min=0.13% in November and max=1.39% in September), the cloth/textile (average=0.24% \pm 0.48; min=0.00% in November and max=1.29% in March), the unidentified and/or chemicals (average=0.13% \pm 0.22; min=0.00% in September and max=0.58% in March) and the rubber (average=0.10% \pm 0.18; min=0.00% in November and max=0.48% in June).

During the low season (Fig. D.IV.1-3), the marine litter is largely dominated by the artificial polymer materials (96.84%), followed by the paper/cardboard (0.85%), the metal (0.71%), the cloth/textile (0.64%), the processed/worked wood (0.36%), the unidentified and/or chemicals (0.36%) and the glass/ceramics (0.24%).

¹⁴ Data source: monthly number of tourists welcomed on Malta in 2016, Malta Tourism Authority: <http://www.mta.com.mt/>

During the high season (Fig. D.IV.1-3), the marine litter is largely dominated by the artificial polymer materials (93.25%), followed by the paper/cardboard (2.64%), the metal (1.95%), the processed/worked wood (1.24%), the glass/ceramics (0.68%), the rubber (0.14%), the cloth/textile (0.07%) and the unidentified and/or chemicals (0.04%).

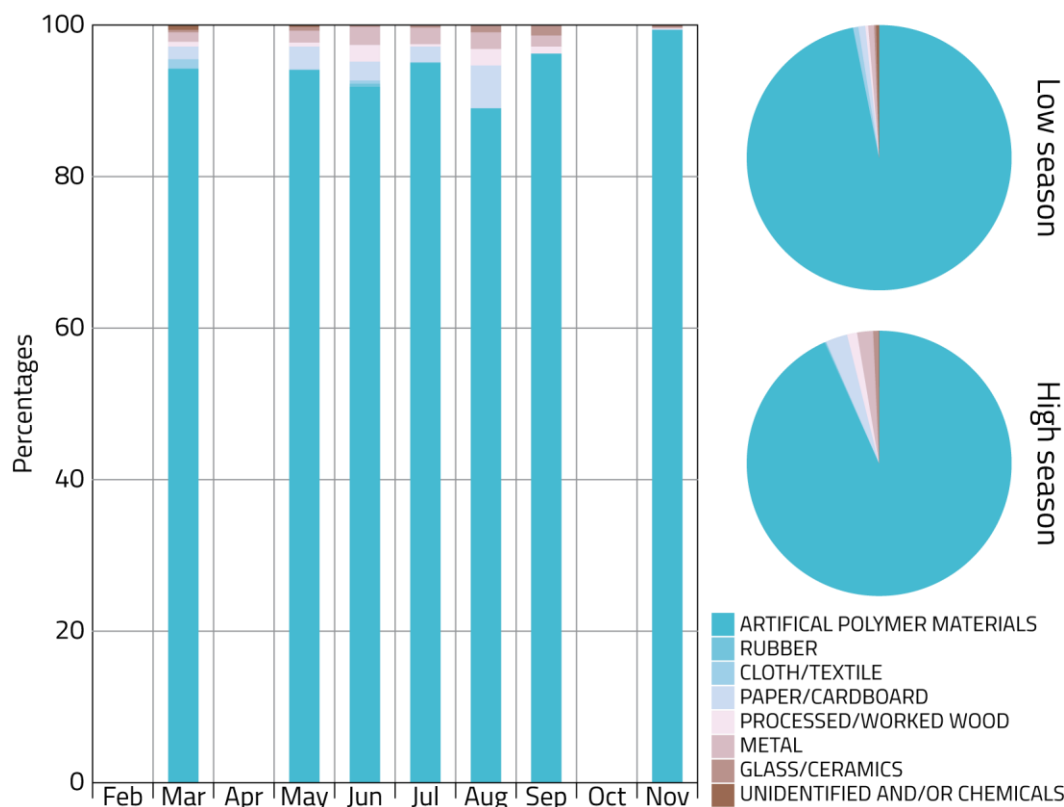


Figure D.IV.1-3: composition of the marine litter collected at the beach of Golden Bay. Left: histogram showing the monthly percentages of the 8 major categories of material type. Right: pie charts showing the average composition of the marine litter during the low (top) and high (bottom) seasons. The color scale (lower right) indicates the type of material.

d) The 10 items with the highest accumulation rates

In this section, we consider the items with the highest averaged accumulation rates, which are not necessarily the most abundant items collected during the marine litter monitoring performed on the beach of Golden Bay (Fig. D.IV.1-4). These items account for 94.75% of the total marine litter items (6784) collected in 2017. They are dominated by the cigarette butts (0.3682 items/m²/day; 40.4% of the total marine litter items collected), followed by the mesoplastics (0.1141 items/m²/day; 12.3% of the total marine litter items collected), the pellets (0.1046 items/m²/day; 21.05% of the total marine litter items collected), the microplastics (0.0723 items/m²/day; 9.73% of the total marine litter items collected), the macroplastics (0.0342 items/m²/day; 2.59% of the total marine litter items collected), the cutlery/trays/straws (0.0279 items/m²/day; 2.06% of the total marine litter items collected), the caps/lids (0.0188 items/m²/day; 1.91% of the total marine litter items collected), the crisp/sweet packets and lolly sticks (0.0115 items/m²/day; 1.59% of the total marine litter items collected), the other paper items (0.0108 items/m²/day; 1.31% of the total marine litter items collected) and the drink bottles, containers and drums (0.0105 items/m²/day; 1.8% of the total marine litter items collected).

In this top 10, the artificial polymer materials largely dominate as they are represented by 9 items, accounting for 93.44% of the total marine litter items collected.

In this top 10, 5 items (cigarette butts, cutlery/trays/straws, caps/lids, crisp/sweet packets and lolly sticks and drink bottles) accounting for 47.76% of the total marine litter items collected, can be attributed to the shoreline source, including poor waste management practices, tourism and recreational activities (see Part B.III.2.c). To this, can possibly be added 3 items (mesoplastics, microplastics and other paper items) presenting a clear seasonal pattern (see Appendix, Fig. E.V-1) and accounting for additional 23.34% of the total marine litter items collected.

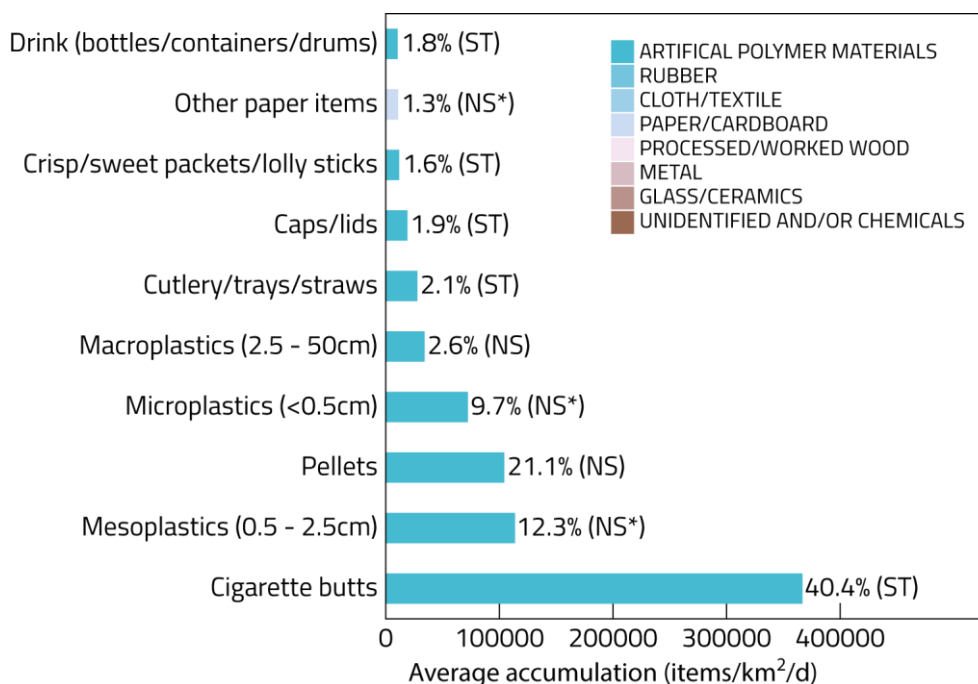


Figure D.IV.1-4: list of the 10 items with the highest accumulation rates collected at the beach of Golden Bay. The percentages next to each item refers to their relative abundance with respect to the total collected. The possible source of the items is given into parenthesis: ST=shoreline, including poor waste management, tourism and recreational activities; and NS=non-sourced. The asterisk (*) associated to the non-sourced items (NS) shows that this specific item presents a clear seasonal increase. The color scale (upper right) indicates the type of material.

2. Beach mainly used by locals: Gnejna Bay

a) Characteristics of the beach

The beach of Gnejna was selected as it is a popular beach mainly used by locals. It is a semi-rural beach, located in the municipality of L-Imġarr in the north western side of Malta, facing the sea to the NW. It has a total length of 204m, a width of 52m and is composed at 95% of sand and 5% of pebbles with a slope of 36.4%. The monitored fixed portion of the beach has a surface of 3187 m². The beach is mainly used for recreational activities during the high season (swimming, sunbathing and barbecues). It is accessible by vehicles/boats and for pedestrians. In the area situated directly behind the beach, very limited services and facilities provided to the beach users are found. The coordinates of the fixed 100m portion selected for the monitoring are: 35.9207N, 14.3439E (starting point) and 35.9204N, 14.3429E (ending point) (Fig. D.IV.2-1). Drink and food outlets are situated directly on the beach and the closest harbor is situated 8 km away to the north. The beach is cleaned once a day all year long.



Figure D.IV.2-1: location map showing the beach of Gnejna and the selected 100m portion of beach monitored (red area).

b) Seasonality of the marine litter

The beach of Gnejna, mainly used by locals, was sampled for marine litter in March, May, June, July, August, September and November of 2017. A total of 4552 items (corrected for distance, see Part B.III.2.a) were collected on the same 100m portion of beach during the 7 monitoring, representing an average of 650.3 items (± 314.6 items, $n=7$) per survey. The lowest number of items was recorded in September (153 items) while the highest number was recorded in November (1083 items) (Fig. D.IV.2-2a). In general, the amount of marine litter continuously decreases from March to September, with a slight increase in July and before the sharp increase of November. No seasonal pattern was visible (Fig. D.IV.2-2a). When only the number of items collected is considered (Fig. D.IV.2-2b), their average number per survey during the low season (October – April) was of 963.7 (± 169.4 items, $n=2$) and of 524.9 (± 269.3 items, $n=5$) during the high season (May – September). Then, the amount of marine litter collected per survey during the high season was on average 45.5% lower than during the low touristic season (Fig. D.IV.2-2b). When the accumulation rates (see Part B.III.2.b) are considered, a clear seasonal pattern is observed (Fig. D.IV.2-2c). The lowest value observed was of 0.3096 items/m²/day (309591 items/km²/day) in September and the highest was of 0.6583 items/m²/day (658299 items/km²/day) in November (Fig. D.IV.2-2c). The seasonal pattern of the marine litter seems to follow the monthly number of tourists welcomed on Malta (Fig. D.IV.2-2c): higher accumulation rates are observed during the touristic season and lower accumulation rates are observed during the off season, even if the highest accumulation rates are observed in November. During the low season, the average accumulation rate is of 0.5001 items/m²/day (± 0.2959 , $n=2$) and of 0.4291 items/m²/day (± 0.0915 , $n=5$) during the high season. These results show that, on average the accumulation rates of the marine litter are slightly lower during the high season (-14%, Fig. D.IV.2-2d) than during the low season.

Finally, the beach of Gnejna can be considered as moderately clean during the low season and clean during the high season, according to the Clean-Coast Index (see Part B.III.2.d) exhibiting values of respectively 5.9 and 3.2 (Fig. C.III-4a). The accumulation index shows that the accumulation of marine litter can be considered as very high during both the low and high seasons (AI=5.70 and 5.63) (Fig. C.III-4b).

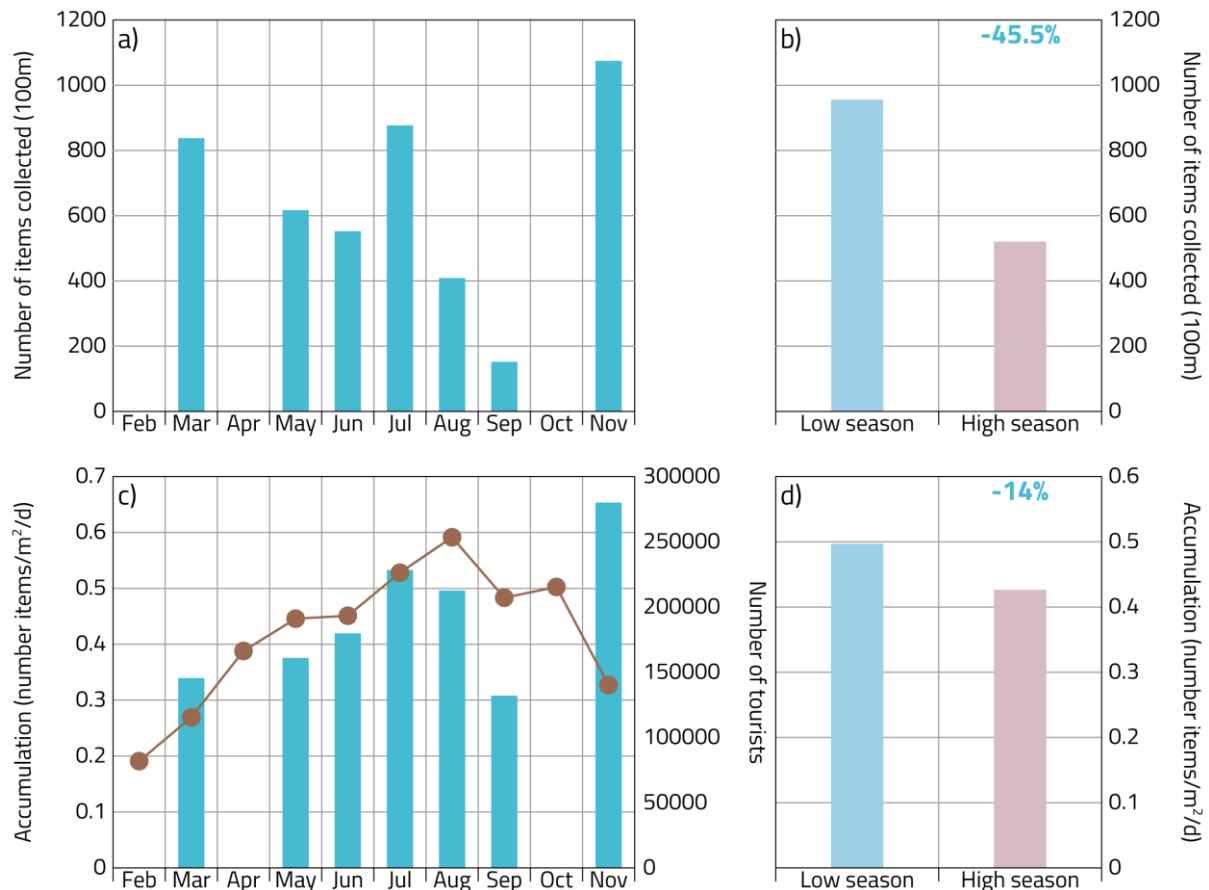


Figure D.IV.2-2: total number and accumulations rates of items collected at the beach of Gnejna. a) number of items collected during each survey on the fixed 100m portion of beach; b) comparison of the average number of items collected per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (blue font) refers to the decrease with respect to the low season; c) accumulation rates of the marine litter (left axis, blue bars) and the monthly number of tourists¹⁵ in Malta (right axis, brown line and dots); and d) comparison of the accumulation rates of marine litter per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (blue font) refers to the decrease with respect to the low season.

c) Composition of the marine litter

The marine litter collected on the beach of Gnejna (Fig. D.IV.2-3) was classified into 8 major categories of material type (see Part B.III.2.c). It is largely dominated by the artificial polymer materials (average=95.06% \pm 1.21; min=91.36% in May and max=98.86% in November), followed by the metal (average=1.73% \pm 1.21; min=0.37% in March and max=4.02% in August), the paper/cardboard (average=1.58% \pm 2.08; min=0.00% in November and max=5.03% in July), the processed/worked wood (average=0.88% \pm 0.53; min=0.00% in November and max=1.50% in May), the glass/ceramics (average=0.43% \pm 0.45; min=0.00% in September and max=1.16% in May), the rubber (average=0.19% \pm 0.33; min=0.00% in November and max=0.93% in June), the cloth/textile (average=0.09% \pm 0.19; min=0.00% in November and max=0.50% in May) and the unidentified and/or chemicals (average=0.04% \pm 0.08; min=0.00% in September and max=0.19% in November).

During the low season (Fig. D.IV.2-3), the marine litter is largely dominated by the artificial polymer materials (98.45%), followed by the glass/ceramics (0.54%), the metal (0.42%), the processed/worked wood (0.31%), the unidentified and/or chemicals (0.16%), the rubber (0.06%) and the paper/cardboard (0.06%).

¹⁵ Data source: monthly number of tourists welcomed on Malta in 2016, Malta Tourism Authority: <http://www.mta.com.mt/>

During the high season (Fig. D.IV.2-3), the marine litter is largely dominated by the artificial polymer materials (93.70%), followed by the metal (2.25%), the paper/cardboard (2.19%), the processed/worked wood (1.11%), the rubber (0.38%), the glass/ceramics (0.24%) and the cloth/textile (0.12%).

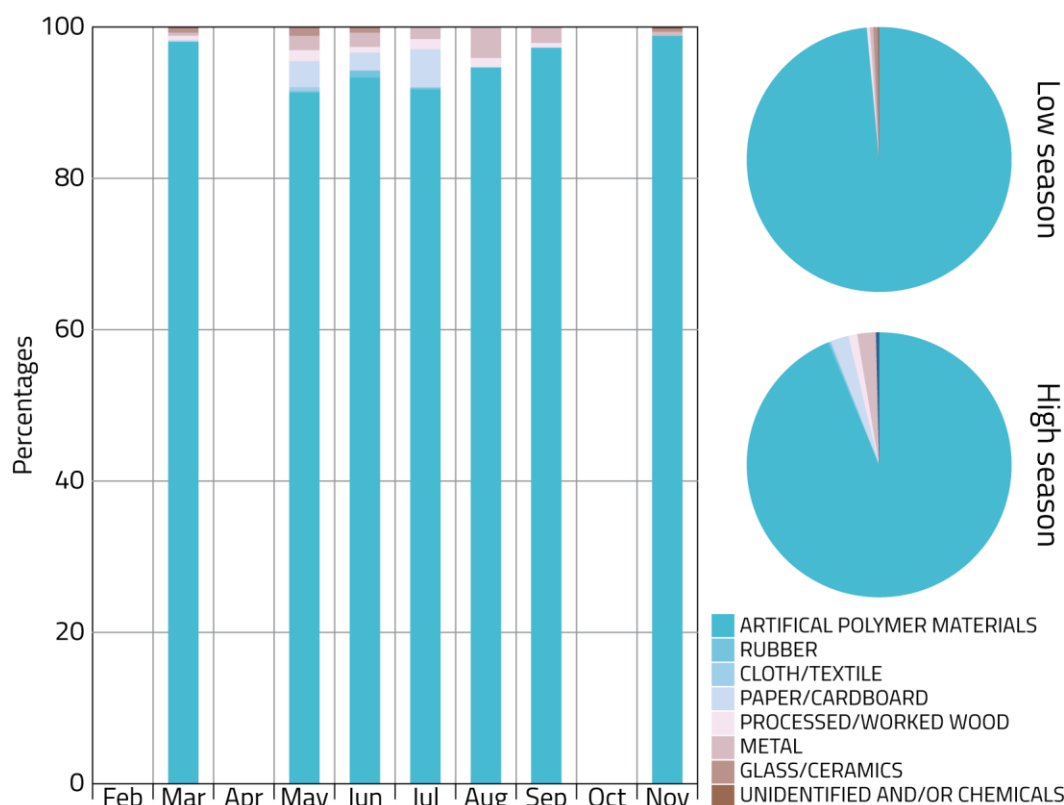


Figure D.IV.2-3: composition of the marine litter collected at the beach of Gnejna. Left: histogram showing the monthly percentages of the 8 major categories of material type. Right: pie charts showing the average composition of the marine litter during the low (top) and high (bottom) seasons. The color scale (lower right) indicates the type of material.

d) The 10 items with the highest accumulation rates

In this section, we consider the items with the highest averaged accumulation rates, which are not necessarily the most abundant items collected during the marine litter monitoring performed on the beach of Gnejna (Fig. D.IV.2-4). These items account for 91.17% of the total marine litter items (4552) collected in 2017. They are dominated by the cigarette butts (0.1735 items/m²/day; 35.01% of the total marine litter items collected), followed by the mesoplastics (0.0654 items/m²/day; 13.8% of the total marine litter items collected), the pellets (0.051 items/m²/day; 13.75% of the total marine litter items collected), the macroplastics (0.0305 items/m²/day; 7.76% of the total marine litter items collected), the microplastics (0.027 items/m²/day; 6.33% of the total marine litter items collected), the caps/lids (0.0259 items/m²/day; 6.31% of the total marine litter items collected), the cutlery/trays/straws (0.0147 items/m²/day; 2.9% of the total marine litter items collected), the crisp/sweet packets and lolly sticks (0.0127 items/m²/day; 3.22% of the total marine litter items collected), the other paper items (0.0061 items/m²/day; 1.5% of the total marine litter items collected) and the bottle caps (0.004 items/m²/day; 0.59% of the total marine litter items collected).

In this top 10, the artificial polymer materials largely dominate as they are represented by 8 items, accounting for 89.09% of the total marine litter items collected.

In this top 10, 5 items (cigarette butts, caps/lids, cutlery/trays/straws, crisp/sweet packets and lolly sticks and bottle caps) accounting for 48.03% of the total marine litter items collected, can be attributed to the shoreline source, including poor waste management practices, tourism and recreational activities (see Part B.III.2.c). To this, can possibly be added 1 item (other paper items) presenting a clear seasonal pattern (see Appendix, Fig. E.V-2) and accounting for additional 1.48% of the total marine litter items collected.

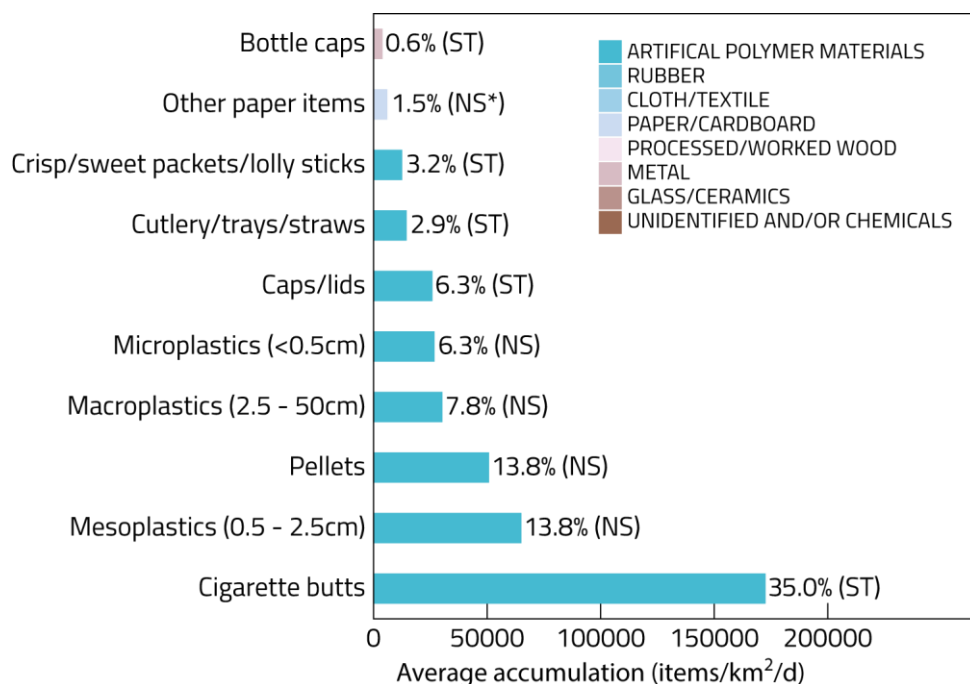


Figure D.IV.2-4: list of the 10 items with the highest accumulation rates collected at the beach of Gnejna. The percentages next to each item refers to their relative abundance with respect to the total collected. The possible source of the items is given into parenthesis: ST=shoreline, including poor waste management, tourism and recreational activities; and NS=non-sourced. The asterisk (*) associated to the non-sourced items (NS) shows that this specific item presents a clear seasonal increase. The color scale (upper right) indicates the type of material.

3. Remote beach: Marsaxlokk

a) Characteristics of the beach

The term “remote” to characterize the beach of Marsaxlokk is questionable as it is a semi-urban beach, located in the municipality of Marsaxlokk in the south eastern side of Malta, facing the sea to the south. It has a total length of 216m, a width ranging from 6 to 16m and is composed at 65% of sand and 35% of pebbles with a slope of 46.6%. The monitored fixed portion of the beach has a surface of 1061 m². The beach is mainly used for recreational activities during the high season (sunbathing, fishing and barbecues) and the low season (fishing). It is accessible by vehicles/boats and for pedestrians. The area situated directly behind the beach, has few services and facilities provided to the beach users. The coordinates of the fixed 100m portion selected for the monitoring are: 35.8387N, 14.5491E (starting point) and 35.8391N, 14.5482E (ending point) (Fig. D.IV.3-1). The closest harbor is situated 0.02 km away to the NW. The beach is cleaned once every 2 days all year long.



Figure D.IV.3-1: location map showing the beach of Marsaxlokk and the selected 100m portion of beach monitored (red area).

b) Seasonality of the marine litter

The beach of Marsaxlokk was sampled for marine litter in March, May, June, July, August, September and November of 2017. A total of 4591 items (corrected for distance, see Part B.III.2.a) were collected on the same 100m portion of beach during the 7 monitoring, representing an average of 655.8 items (± 164.7 items, $n=7$) per survey. The lowest number of items was recorded in November (342 items) while the highest number was recorded in May (824 items) (Fig. D.IV.3-2a). In general, the amount of marine litter continuously decreases from March to November, with a slight decrease in June. No seasonal pattern was visible (Fig. D.IV.3-2a). When only the number of items collected is considered (Fig. D.IV.3-2b), their average number per survey during the low season (October – April) was of 554.3 (± 300.9 items, $n=2$) and of 696.4 (± 104.0 items, $n=5$) during the high season (May – September). Then, the amount of marine litter collected per survey during the high season was on average 25.6% higher than during the low touristic season (Fig. D.IV.3-2b). When the accumulation rates (see Part B.III.2.b) are considered, a clear seasonal pattern is observed (Fig. D.IV.3-2c). The lowest value observed was of 0.6013 items/m²/day (601345 items/km²/day) in November and the highest was of 1.4028 items/m²/day (1402801 items/km²/day) in June (Fig. D.IV.3-2c). The seasonal pattern of the marine litter seems to follow the monthly number of tourists welcomed on Malta (Fig. D.IV.3-2c): higher accumulation rates are observed during the touristic season and lower accumulation rates are observed during the off season. During the low season, the average accumulation rate is of 0.7509 items/m²/day (± 0.4246 , $n=2$) and of 1.1721 items/m²/day (± 0.2039 , $n=5$) during the high season. These results show that, on average the accumulation rates of the marine litter are higher during the high season +56%, Fig. D.IV.3-2d) than during the low season.

Finally, the beach of Marsaxlokk can be considered as moderately clean during the low season and dirty during the high season, according to the Clean-Coast Index (see Part B.III.2.d) exhibiting values of respectively 9.8 and 12.1 (Fig. C.IV-4a). The accumulation index shows that the accumulation of marine litter can be considered as very high during the low season (AI=5.88) and extremely High during the high season (AI=6.07) (Fig. C.IV-4b).

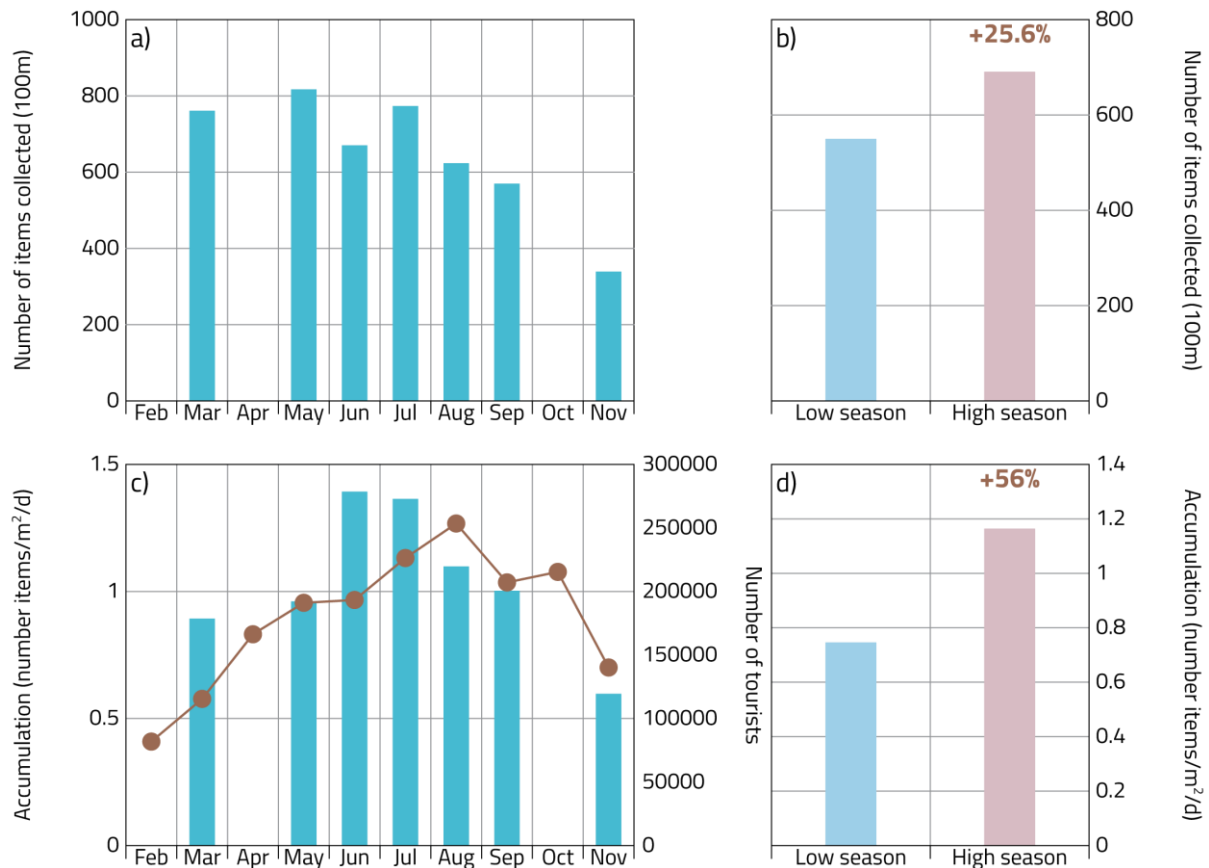


Figure D.IV.3-2: total number and accumulations rates of items collected at the beach of Marsaxlokk. a) number of items collected during each survey on the fixed 100m portion of beach; b) comparison of the average number of items collected per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season; c) accumulation rates of the marine litter (left axis, blue bars) and the monthly number of tourists¹⁶ in Malta (right axis, brown line and dots); and d) comparison of the accumulation rates of marine litter per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season.

c) Composition of the marine litter

The marine litter collected on the beach of Marsaxlokk (Fig. D.IV.3-3) was classified into 8 major categories of material type (see Part B.III.2.c). It is largely dominated by the artificial polymer materials (average=89.16% \pm 6.62; min=77.10% in March and max=97.57% in August), followed by the glass/ceramics (average=5.49% \pm 4.09; min=0.17% in August and max=12.52% in March), the metal (average=2.10% \pm 1.15; min=1.06% in June and max=4.41% in March), the processed/worked wood (average=1.34% \pm 0.86; min=0.00% in August and max=2.65% in May), the paper/cardboard (average=0.88% \pm 0.85; min=0.00% in September and max=2.42% in March), the rubber (average=0.68% \pm 0.56; min=0.00% in September and max=1.71% in March), the cloth/textile (average=0.27% \pm 0.31; min=0.00% in November and max=0.76% in June) and the unidentified and/or chemicals (average=0.09% \pm 0.24; min=0.00% in September and max=0.64% in November).

During the low season (Fig. D.IV.3-3), the marine litter is largely dominated by the artificial polymer materials (83.76%), followed by the glass/ceramics (9.29%), the metal (2.84%), the paper/cardboard (1.53%), the rubber (1.01%), the processed/worked wood (0.96%), the unidentified and/or chemicals (0.32%) and the cloth/textile (0.28%).

¹⁶ Data source: monthly number of tourists welcomed on Malta in 2016, Malta Tourism Authority: <http://www.mta.com.mt/>

During the high season (Fig. D.IV.3-3), the marine litter is largely dominated by the artificial polymer materials (91.32%), followed by the glass/ceramics (3.97%), the metal (1.80%), the processed/worked wood (1.49%), the paper/cardboard (0.62%), the rubber (0.55%) and the cloth/textile (0.26%).

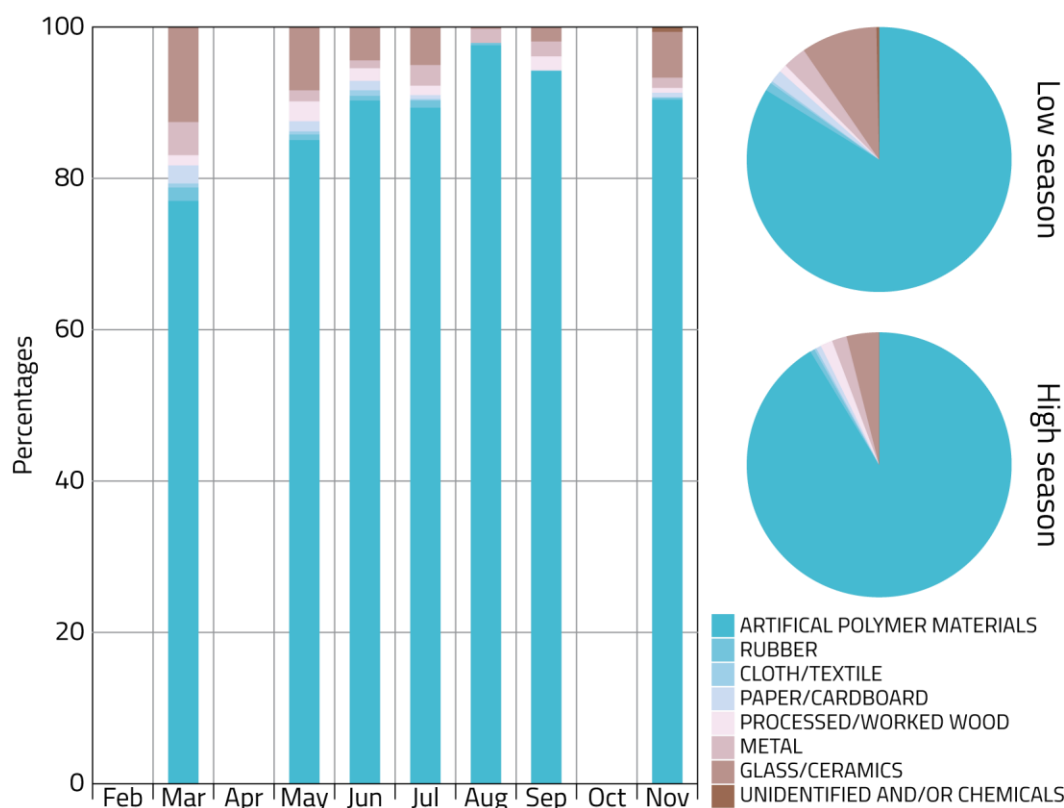


Figure D.IV.3-3: composition of the marine litter collected at the beach of Marsaxlokk. Left: histogram showing the monthly percentages of the 8 major categories of material type. Right: pie charts showing the average composition of the marine litter during the low (top) and high (bottom) seasons. The color scale (lower right) indicates the type of material.

d) The 10 items with the highest accumulation rates

In this section, we consider the items with the highest averaged accumulation rates, which are not necessarily the most abundant items collected during the marine litter monitoring performed on the beach of Marsaxlokk (Fig. D.IV.3-4). These items account for 78.55% of the total marine litter items (4591) collected in 2017. They are dominated by the cigarette butts (0.2662 items/m²/day; 23.42% of the total marine litter items collected), followed by the mesoplastics (0.1242 items/m²/day; 11.19% of the total marine litter items collected), the macroplastics (0.1133 items/m²/day; 11.63% of the total marine litter items collected), the microplastics (0.0966 items/m²/day; 8.31% of the total marine litter items collected), the caps/lids (0.0715 items/m²/day; 6.84% of the total marine litter items collected), the strings and cords (diameter less than 1 cm) (0.0406 items/m²/day; 4.37% of the total marine litter items collected), the cutlery/trays/straws (0.0369 items/m²/day; 3.28% of the total marine litter items collected), the crisp/sweet packets and lolly sticks (0.0335 items/m²/day; 3.29% of the total marine litter items collected), the bottles (0.0318 items/m²/day; 3.49% of the total marine litter items collected) and the foam sponge (0.0251 items/m²/day; 2.74% of the total marine litter items collected). In this top 10, the artificial polymer materials largely dominate as they are represented by 9 items, accounting for 75.07% of the total marine litter items collected.

In this top 10, 5 items (cigarette butts, caps/lids, cutlery/trays/straws, crisp/sweet packets and lolly sticks and glass bottles) accounting for 40.32% of the total marine litter items collected, can be

attributed to the shoreline source, including poor waste management practices, tourism and recreational activities (see Part B.III.2.c). To this, can possibly be added 2 items (mesoplastics and microplastics) presenting a clear seasonal pattern (see Appendix, Fig. E.V-3) and accounting for additional 19.5% of the total marine litter items collected.

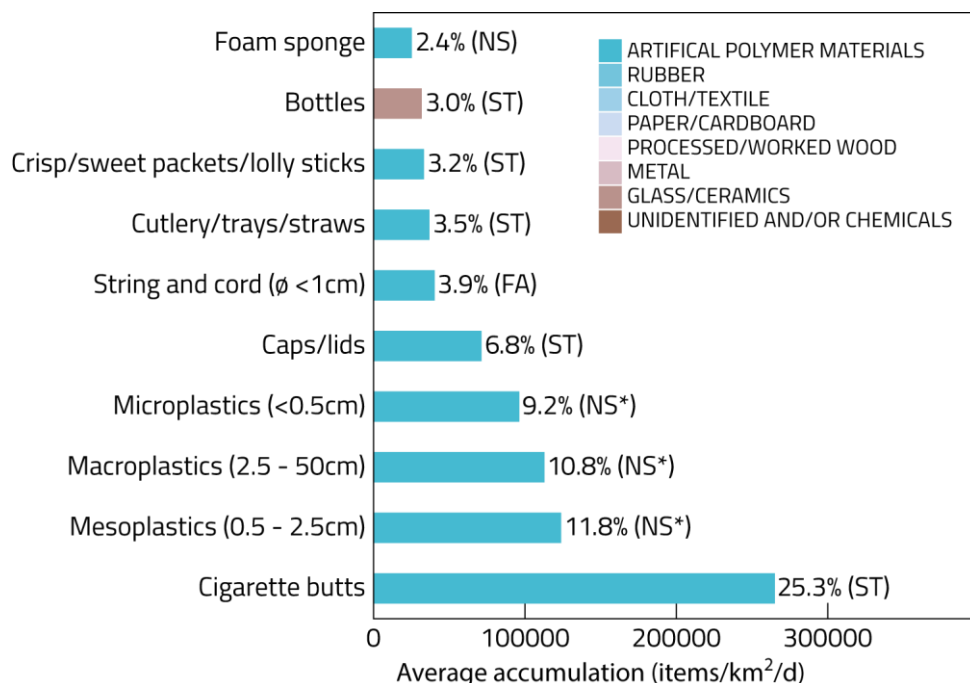


Figure D.IV.3-4: list of the 10 items with the highest accumulation rates collected at the beach of Marsaxlokk. The percentages next to each item refers to their relative abundance with respect to the total collected. The possible source of the items is given into parenthesis: ST=shoreline, including poor waste management, tourism and recreational activities; FA= fishing and aquaculture; and NS=non-sourced. The asterisk (*) associated to the non-sourced items (NS) shows that this specific item presents a clear seasonal increase. The color scale (upper right) indicates the type of material.

4. Summary

The 21 marine litter surveys conducted in Malta in 2017 have revealed that:

- If only the number of items collected is considered, the touristic beach of Golden Bay is the most affected by the marine litter (6784 items collected; average: 969.1 items/survey; 1415.4 items/survey during the low season; 790.6 items/survey during the high season), followed by the remote beach of Marsaxlokk (4591 items collected; average: 655.8 items/survey; 554.3 items/survey during the low season; 696.4 items/survey during the high season) and the beach of Gnejna, mainly used by locals (4552 items collected; average: 650.3 items/survey; 963.7 items/survey during the low season; 524.9 items/survey during the high season). For the 3 beaches, no seasonal variability was observed from the number of items collected.
- If the accumulation rate of the marine litter is considered, the remote beach of Marsaxlokk is the most affected by marine litter accumulation (average: 1.0518 items/m²/day; 0.7509 items/m²/day during the low season; 1.1721 items/m²/day during the high season), followed by the touristic beach of Golden Bay (average: 0.8252 items/m²/day; 0.7260 items/m²/day during the low season; 0.8649 items/m²/day during the high season) and the beach of Gnejna, mainly used by locals (average: 0.4494 items/m²/day; 0.5001 items/m²/day during the low season; 0.4291 items/m²/day during the high season). The 3 beaches presented recognizable seasonal variations with a relative increase of the accumulation rates of 19% (Golden Bay) and

56% (Marsaxlokk), and a relative decrease of 14% (Gnejna) and during the high season with respect to the low season.

- The items collected are mainly composed of artificial polymer materials: they represent 94.27% (Golden Bay), 95.06% (Gnejna) and 89.16% (Marsaxlokk) of the total marine litter items collected.
- On the touristic beach of Golden Bay, 5 items (cigarette butts, cutlery/trays/straws, caps/lids, crisp/sweet packets and lolly sticks and drink bottles), most likely related to tourism and recreational activities, are representing 47.76% of the total marine litter items collected. To this, can possibly be added 3 items (mesoplastics, microplastics and other paper items), accounting for additional 23.34% as they presented a recognizable seasonal variation.
- On the beach of Gnejna, mainly used by locals, 5 items (cigarette butts, caps/lids, cutlery/trays/straws, crisp/sweet packets and lolly sticks and bottle caps), most likely related to tourism and recreational activities, are representing 48.03% of the total marine litter items collected. To this, can possibly be added 1 item (other paper items), accounting for additional 1.48% as they presented a recognizable seasonal variation.
- On the remote beach of Marsaxlokk, 5 items (cigarette butts, caps/lids, cutlery/trays/straws, crisp/sweet packets and lolly sticks and bottles), most likely related to tourism and recreational activities, are representing 40.32% of the total marine litter items collected. To this, can possibly be added 2 items (mesoplastics and microplastics), accounting for additional 19.5% as they presented a recognizable seasonal variation.
- The cleanliness of the beaches is considered as moderate/clean for the low/high season in Golden Bay (Clean-Coast Index of 7.3/4.1), moderate/ clean for the low/high season in Gnejna (CCI of 5.9/3.2) and moderate/dirty for the low/high season in Marsaxlokk (CCI of 9.8/12.1).
- Finally the accumulation index of the beaches is considered as very high/very high for the low/high season in Golden Bay (Accumulation Index of 5.86/5.94), very high/very high for the low/high season in Gnejna (AI of 5.70/5.63) and very high/extremely high for the low/high season in Marsaxlokk (AI of 5.88/6.07).

V. Crete

1. Touristic beach: Rethymno

a) Characteristics of the beach

The touristic beach of Rethymno is an urban beach, located in the municipality of Rethymno in the central north western side of Crete, facing the sea to the NE. It has a total length of $\pm 450\text{m}$, a width of $\pm 36\text{m}$ and is composed at 100% of sand with a smooth slope of 3%. The monitored fixed portion of the beach has a surface of 2531 m^2 . It has a pier situated on each sides. The beach is mainly used for recreational activities during the high season (swimming, sunbathing and local people) and the low season (local people). It is accessible by vehicles/boats and for pedestrians. The area situated directly behind the beach, has many services and facilities provided to the beach users. The coordinates of the fixed 100m portion selected for the monitoring are: 35.3694N, 24.4771E (starting point) and 35.3686N, 24.4776E (ending point) (Fig. D.V.1-1). Drink and food outlets are situated directly on the beach and harbors can be found on each side of the beach. The beach is cleaned once a week all year long.



Figure D.V.1-1: location map showing the beach of Rethymno and the selected 100m portion of beach monitored (red area).

b) Seasonality of the marine litter

The touristic beach of Rethymno was sampled for marine litter in March, May, June, July, August, September and November of 2017. A total of 12271 items (corrected for distance, see Part B.III.2.a) were collected on the same 100m portion of beach during the 7 monitoring, representing an average of 1752.9 items (± 480.1 items, $n=7$) per survey. The lowest number of items was recorded in June (1280 items) while the highest number was recorded in March (2500 items) (Fig. D.V.1-2a). In general, the amount of marine litter collected during each survey is quite variable and changes from one month to another. No clear seasonal pattern was visible (Fig. D.V.1-2a). When only the number of items collected is considered (Fig. D.V.1-2b), their average number per survey during the low season (October – April) was of 1916.1 (± 826.1 items, $n=2$) and of 1687.7 (± 395.5 items, $n=5$) during the high season (May – September). Then, the amount of marine litter collected per survey during the high season was on average 11.9% lower than during the low touristic season (Fig. D.V.1-2b). When the accumulation rates (see Part B.III.2.b) are considered, a seasonal pattern can be observed (Fig. D.V.1-2c), despite the high values recorded in March. The lowest value observed was of 0.0194 items/m²/day (19418 items/km²/day) in November and the highest was of 0.2997 items/m²/day (299750 items/km²/day) in August (Fig. D.V.1-2c). The seasonal pattern of the marine litter seems to follow the monthly number of tourists welcomed on Crete (Fig. D.V.1-2c): higher accumulation rates are observed during the touristic season and lower accumulation rates are observed during the off season. During the low season, the average accumulation rate is of 0.0800 items/m²/day (± 0.0613 , $n=2$) and of 0.1498 items/m²/day (± 0.0933 , $n=5$) during the high season. These results show that, on average the accumulation rates of the marine litter are slightly higher during the high season (+87%, Fig. D.V.1-2d) than during the low season.

Finally, the beach of Rethymno can be considered as dirty during both the low and high seasons, according to the Clean-Coast Index (see Part B.III.2.d) exhibiting values of respectively 15.1 and 13.3 (Fig. C.II-4a). The accumulation index shows that the accumulation of the marine litter can be considered as high during the low season (AI=4.90) and very high during the high season (AI=5.18) (Fig. C.II-4b).

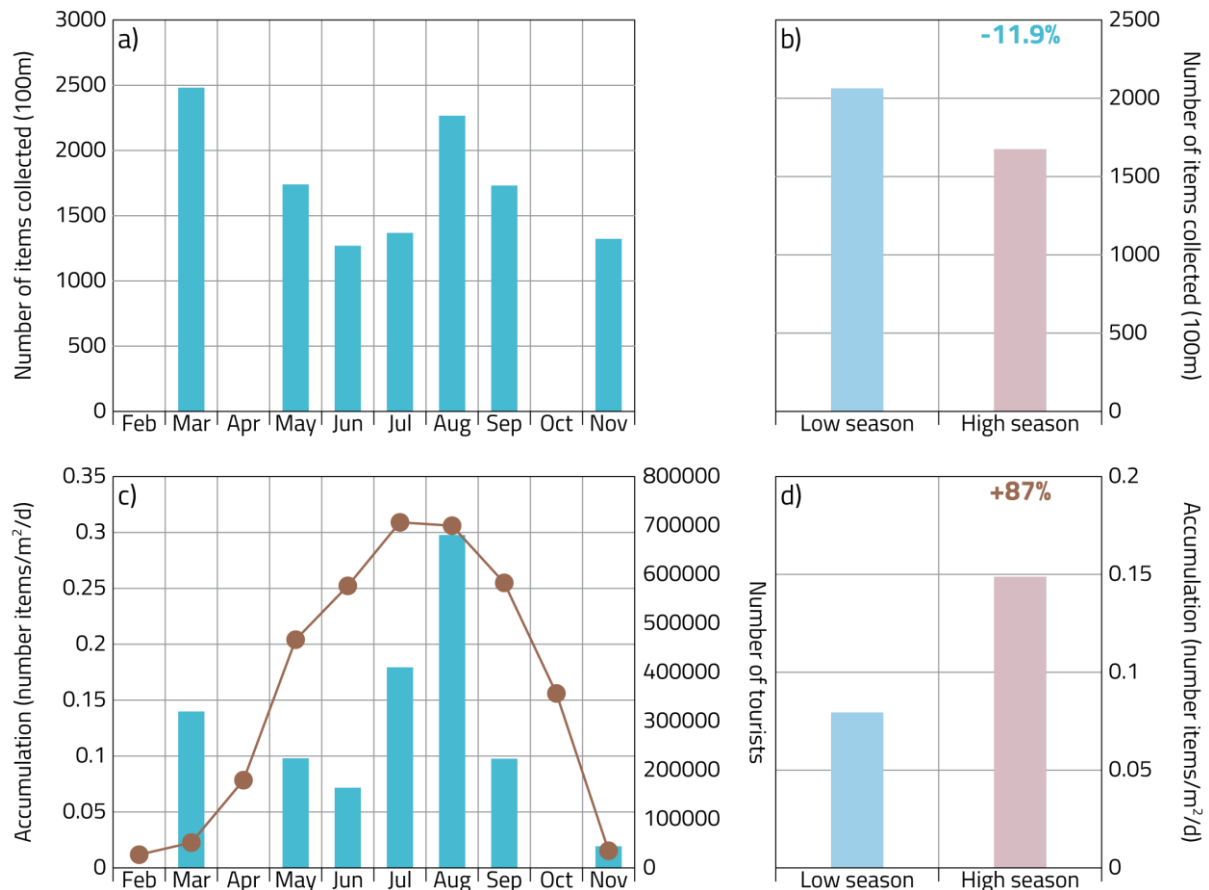


Figure D.V.1-2: total number and accumulations rates of items collected at the beach of Rethymno. a) number of items collected during each survey on the fixed 100m portion of beach; b) comparison of the average number of items collected per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (blue font) refers to the decrease with respect to the low season; c) accumulation rates of the marine litter (left axis, blue bars) and the monthly number of tourists¹⁷ in Crete (right axis, brown line and dots); and d) comparison of the accumulation rates of marine litter per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season.

c) Composition of the marine litter

The marine litter collected on the beach of Rethymno (Fig. D.V.1-3) was classified into 8 major categories of material type (see Part B.III.2.c). It is largely dominated by the artificial polymer materials (average=90.62% \pm 8.07; min=77.15% in August and max=98.12% in November), followed by the glass/ceramics (average=5.00% \pm 7.62; min=0.00% in november and max=18.59% in August), the paper/cardboard (average=1.62% \pm 1.10; min=0.00% in June and max=3.42% in July), the unidentified and/or chemicals (average=0.79% \pm 0.93; min=0.00% in November and max=2.59% in June), the metal (average=0.78% \pm 0.32; min=0.12% in September and max=1.08% in March), the rubber (average=0.47% \pm 0.65; min=0.00% in November and max=1.46% in July), the processed/worked wood (average=0.44% \pm 0.42; min=0.00% in November and max=1.09% in May) and the cloth/textile (average=0.28% \pm 0.39; min=0.00% in November and max=1.00% in March).

During the low season (Fig. D.V.1-3), the marine litter is largely dominated by the artificial polymer materials (89.68%), followed by the glass/ceramics (6.54%), the paper/cardboard (1.23%), the metal (1.03%), the rubber (0.68%), the cloth/textile (0.50%), the unidentified and/or chemicals (0.20%) and the processed/worked wood (0.12%).

¹⁷ Data source: monthly number of tourists welcomed in Crete in 2016.

During the high season (Fig. D.V.1-3), the marine litter is largely dominated by the artificial polymer materials (90.99%), followed by the glass/ceramics (4.39%), the paper/cardboard (1.78%), the unidentified and/or chemicals (1.02%), the metal (0.68%), the processed/worked wood (0.57%), the rubber (0.38%) and the cloth/textile (0.19%).

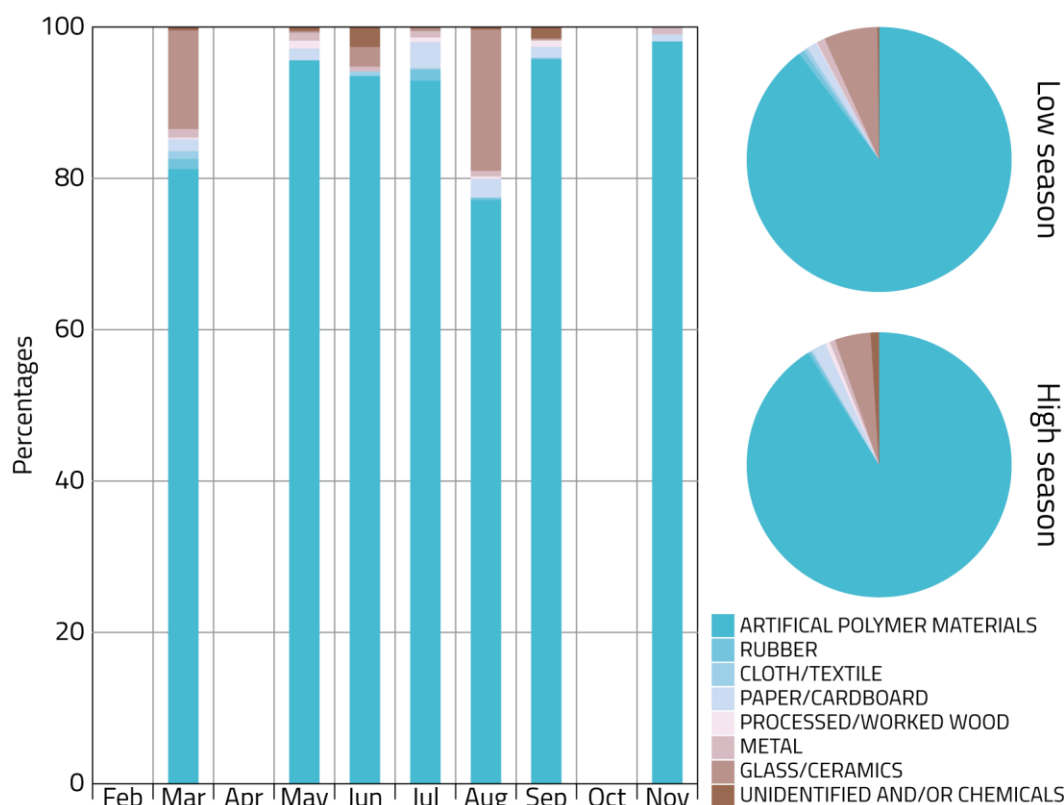


Figure D.V.1-3: composition of the marine litter collected at the beach of Rethymno. Left: histogram showing the monthly percentages of the 8 major categories of material type. Right: pie charts showing the average composition of the marine litter during the low (top) and high (bottom) seasons. The color scale (lower right) indicates the type of material.

d) The 10 items with the highest accumulation rates

In this section, we consider the items with the highest averaged accumulation rates, which are not necessarily the most abundant items collected during the marine litter monitoring performed on the beach of Rethymno (Fig. D.V.1-4). These items account for 80.8% of the total marine litter items (12271) collected in 2017. They are dominated by the cigarette butts (0.0442 items/m²/day; 32.92% of the total marine litter items collected), followed by the mesoplastics (0.011 items/m²/day; 9.14% of the total marine litter items collected), the macroplastics (0.0099 items/m²/day; 5.36% of the total marine litter items collected), the cutlery/trays/straws (0.0097 items/m²/day; 8.7% of the total marine litter items collected), the other glass items (0.0082 items/m²/day; 3.71% of the total marine litter items collected), the crisp/sweet packets and lolly sticks (0.0061 items/m²/day; 4.82% of the total marine litter items collected), the caps/lids (0.0054 items/m²/day; 4.51% of the total marine litter items collected), the strings and cords (diameter less than 1 cm) (0.0046 items/m²/day; 4.3% of the total marine litter items collected), the small plastic bags, e.g., freezer bags (0.0039 items/m²/day; 2.9% of the total marine litter items collected) and the cotton bud sticks (0.0031 items/m²/day; 4.45% of the total marine litter items collected).

In this top 10, the artificial polymer materials largely dominate as they are represented by 9 items, accounting for 77.10% of the total marine litter items collected.

In this top 10, 5 items (cigarette butts, cutlery/trays/straws, crisp/sweet packets and lolly sticks, caps/lids and small plastic bags) accounting for 53.85% of the total marine litter items collected, can be attributed to the shoreline source, including poor waste management practices, tourism and recreational activities (see Part B.III.2.c). To this, can possibly be added 3 items (mesoplastics, macroplastics and other glass items) presenting a clear seasonal pattern (see Appendix, Fig. E.VI-1) and accounting for additional 18.21% of the total marine litter items collected.

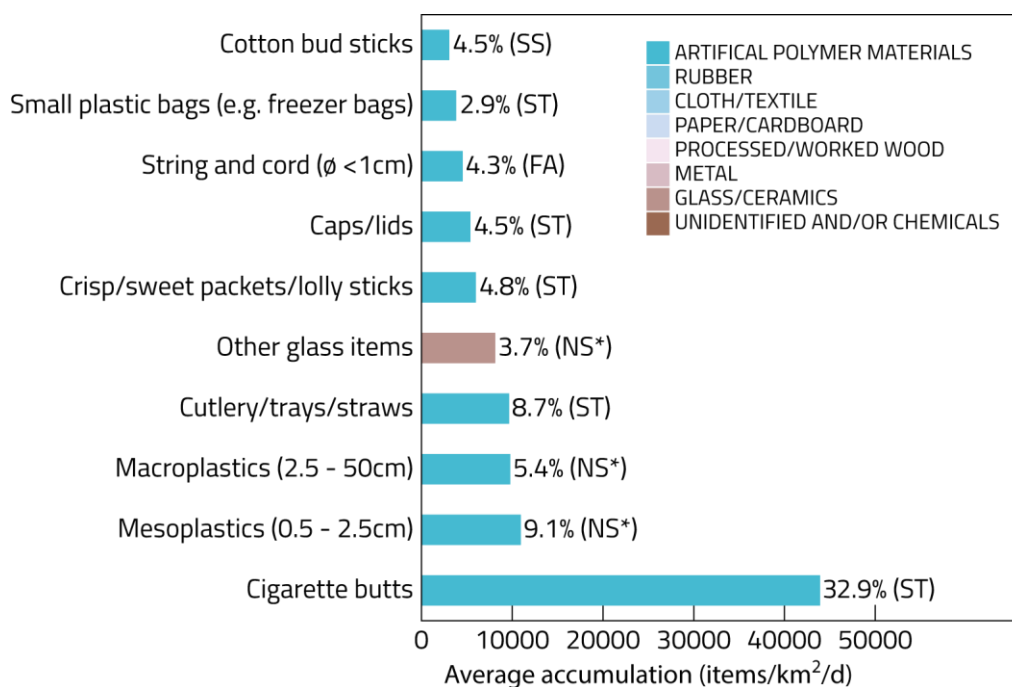


Figure D.V.1-4: list of the 10 items with the highest accumulation rates collected at the beach of Rethymno. The percentages next to each item refers to their relative abundance with respect to the total collected. The possible source of the items is given into parenthesis: ST=shoreline, including poor waste management, tourism and recreational activities; FA= fishing and aquaculture; SS= sanitary and sewage related litter; and NS=non-sourced. The asterisk (*) associated to the non-sourced items (NS) shows that this specific item presents a clear seasonal increase. The color scale (upper right) indicates the type of material.

2. Beach mainly used by locals: Arina

a) Characteristics of the beach

The beach of Arina was selected as it is a popular beach mainly used by locals. It is a semi-urban beach, located in the municipality of Vathianos Kampos in the central north eastern side of Crete, facing the sea to the north. It has a total length of $\pm 455\text{m}$, a width of $\pm 75\text{m}$ and is composed at 100% of sand with a smooth slope of 2%. The monitored fixed portion of the beach has a surface of 3173 m^2 . The beach is mainly used for recreational activities all year long (swimming, sunbathing and local people). It is accessible by vehicles and for pedestrians. In the area situated directly behind the beach, few services and facilities provided to the beach users are found. The coordinates of the fixed 100m portion selected for the monitoring are: 35.3310N, 25.2391E (starting point) and 35.3314N, 25.2401E (ending point) (Fig. D.V.2-1). Drink and food outlets are situated directly on the beach and the closest harbor is situated 8 km away to the west. The beach is cleaned once a day from April to October.



Figure D.V.2-1: location map showing the beach of Arina and the selected 100m portion of beach monitored (red area).

b) Seasonality of the marine litter

The beach of Arina, mainly used by locals, was sampled for marine litter in March, May, June, July, August, September and November of 2017. A total of 24689 items (corrected for distance, see Part B.III.2.a) were collected on the same 100m portion of beach during the 7 monitoring, representing an average of 3527.0 items (± 1204.4 items, $n=7$) per survey. The lowest number of items was recorded in July (1731 items) while the highest number was recorded in March (5370 items) (Fig. D.V.2-2a). In general, the amount of marine litter tends to decrease from March to July and increase again from July to November, leading to an inverse seasonal pattern (Fig. D.V.2-2a). When only the number of items collected is considered (Fig. D.V.2-2b), their average number per survey during the low season (October – April) was of 4670.0 (± 989.8 items, $n=2$) and of 3069.8 (± 1008.2 items, $n=5$) during the high season (May – September). Then, the amount of marine litter collected per survey during the high season was on average 34.3% lower than during the low touristic season (Fig. D.V.2-2b). When the accumulation rates (see Part B.III.2.b) are considered, a seasonal pattern can be observed (Fig. D.V.2-2c). The lowest value observed was of 0.0116 items/m²/day (11577 items/km²/day) in March and the highest was of 0.1301 items/m²/day (130071 items/km²/day) in August (Fig. D.V.2-2c). The seasonal pattern of the marine litter seems to follow the monthly number of tourists welcomed on Crete (Fig. D.V.2-2c): higher accumulation rates are observed during the touristic season and lower accumulation rates are observed during the off season. During the low season, the average accumulation rate is of 0.0167 items/m²/day (± 0.0099 , $n=2$) and of 0.0613 items/m²/day (± 0.0396 , $n=5$) during the high season. These results show that, on average the accumulation rates of the marine litter are much higher during the high season (+266%, Fig. D.V.2-2d) than during the low season. Finally, the beach of Arina can be considered as very dirty during the low season and dirty during the high season, according to the Clean-Coast Index (see Part B.III.2.d) exhibiting values of respectively 29.4 and 19.3 (Fig. C.III-4a). The accumulation index shows the accumulation of marine litter can be considered as high during both the low and high seasons (AI=4.22 and 4.79) (Fig. C.III-4b).

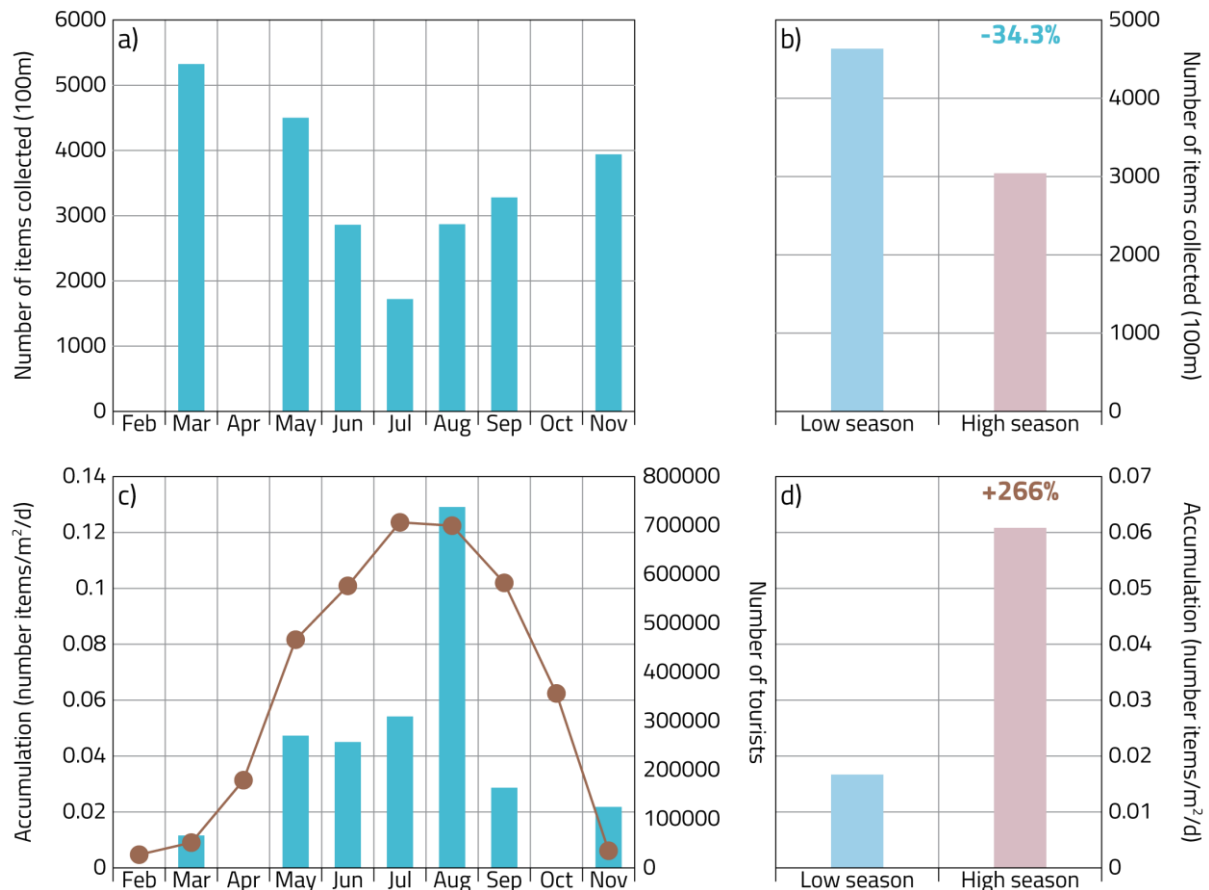


Figure D.V.2-2: total number and accumulations rates of items collected at the beach of Arina. a) number of items collected during each survey on the fixed 100m portion of beach; b) comparison of the average number of items collected per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (blue font) refers to the decrease with respect to the low season; c) accumulation rates of the marine litter (left axis, blue bars) and the monthly number of tourists¹⁸ in Crete (right axis, brown line and dots); and d) comparison of the accumulation rates of marine litter per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season.

c) Composition of the marine litter

The marine litter collected on the beach of Arina (Fig. D.V.2-3) was classified into 8 major categories of material type (see Part B.III.2.c). It is largely dominated by the artificial polymer materials (average=97.01% \pm 0.97; min=95.76% in September and max=98.97% in November), followed by the paper/cardboard (average=0.72% \pm 0.63; min=0.05% in November and max=1.61% in November), the glass/ceramics (average=0.60% \pm 0.29; min=0.24% in March and max=1.03% in September), the unidentified and/or chemicals (average=0.39% \pm 0.17; min=0.11% in May and max=0.58% in September), the metal (average=0.38% \pm 0.18; min=0.00% in November and max=0.58% in September), the processed/worked wood (average=0.31% \pm 0.28; min=0.00% in November and max=0.71% in March), the cloth/textile (average=0.30% \pm 0.29; min=0.00% in November and max=0.71% in May) and the rubber (average=0.28% \pm 0.17; min=0.00% in November and max=0.46% in July).

During the low season (Fig. D.V.2-3), the marine litter is largely dominated by the artificial polymer materials (98.07%), followed by the unidentified and/or chemicals (0.52%), the processed/worked wood (0.35%), the glass/ceramics (0.34%), the cloth/textile (0.24%), the metal (0.23%), the rubber (0.18%) and the paper/cardboard (0.07%).

¹⁸ Data source: monthly number of tourists welcomed on Crete in 2016.

During the high season (Fig. D.V.2-3), the marine litter is largely dominated by the artificial polymer materials (96.59%), followed by the paper/cardboard (0.97%), the glass/ceramics (0.71%), the metal (0.44%), the unidentified and/or chemicals (0.34%), the cloth/textile (0.33%), the rubber (0.33%) and the processed/worked wood (0.29%).

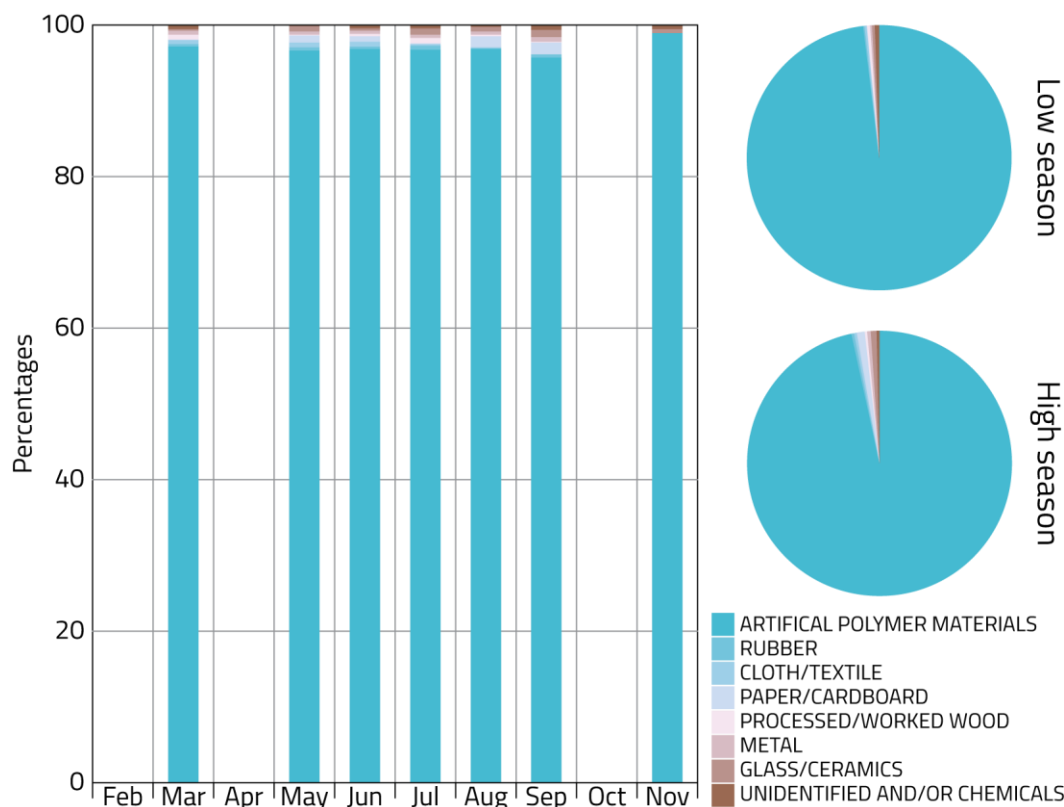


Figure D.V.2-3: composition of the marine litter collected at the beach of Arina. Left: histogram showing the monthly percentages of the 8 major categories of material type. Right: pie charts showing the average composition of the marine litter during the low (top) and high (bottom) seasons. The color scale (lower right) indicates the type of material.

d) The 10 items with the highest accumulation rates

In this section, we consider the items with the highest averaged accumulation rates, which are not necessarily the most abundant items collected during the marine litter monitoring performed on the beach of Arina (Fig. D.V.2-4). These items account for 88.95% of the total marine litter items (24689) collected in 2017. They are dominated by the mesoplastics (0.0122 items/m²/day; 31.17% of the total marine litter items collected), followed by the cigarette butts (0.008 items/m²/day; 10.55% of the total marine litter items collected), the pellets (0.0067 items/m²/day; 14.45% of the total marine litter items collected), the macroplastics (0.0056 items/m²/day; 8.13% of the total marine litter items collected), the caps/lids (0.0022 items/m²/day; 5.56% of the total marine litter items collected), the cotton bud sticks (0.002 items/m²/day; 4.27% of the total marine litter items collected), the other plastic/polystyrene items (0.0017 items/m²/day; 7.06% of the total marine litter items collected), the cutlery/trays/straws (0.0016 items/m²/day; 2.8% of the total marine litter items collected), the small plastic bags, e.g., freezer bags (0.0016 items/m²/day; 1.83% of the total marine litter items collected) and the microplastics (0.0011 items/m²/day; 3.14% of the total marine litter items collected).

In this top 10, all the items are exclusively artificial polymer materials, accounting then for 88.95% of the total marine litter items collected.

In this top 10, 4 items (cigarette butts, caps/lids, cutlery/trays/straws and small plastic bags) accounting for 20.74% of the total marine litter items collected, can be attributed to the shoreline source, including poor waste management practices, tourism and recreational activities (see Part B.III.2.c). To this, can possibly be added 3 items (mesoplastics, macroplastics and microplastics) presenting a clear seasonal pattern (see Appendix, Fig. E.VI-2) and accounting for additional 42.44% of the total marine litter items collected.

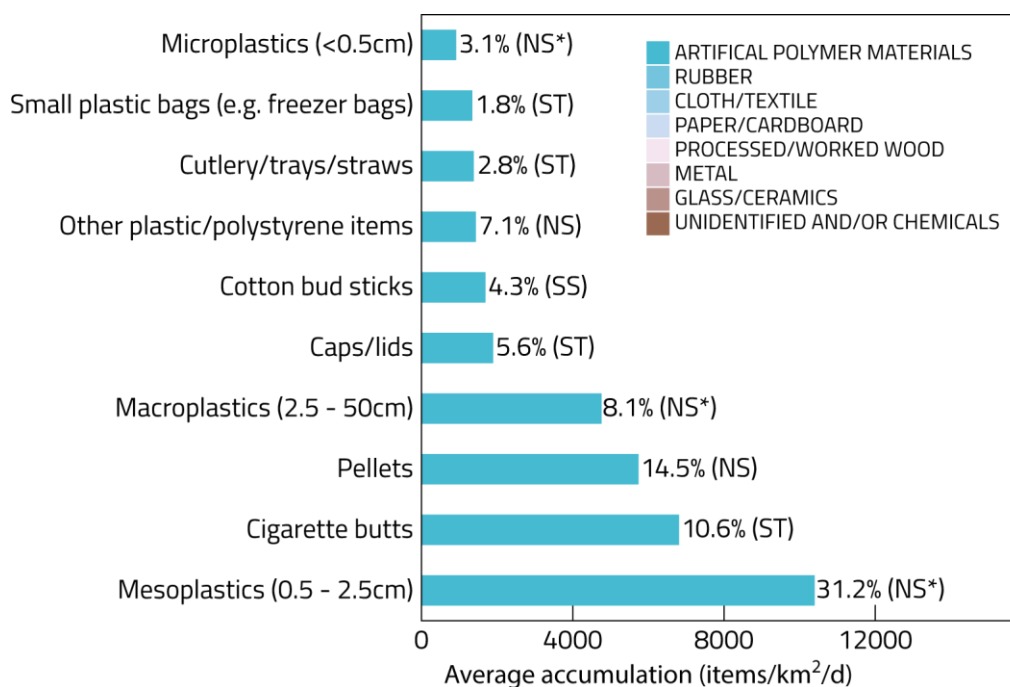


Figure D.V.2-4: list of the 10 items with the highest accumulation rates collected at the beach of Arina. The percentages next to each item refers to their relative abundance with respect to the total collected. The possible source of the items is given into parenthesis: ST=shoreline, including poor waste management, tourism and recreational activities; SS= sanitary and sewage related litter; and NS=non-sourced. The asterisk (*) associated to the non-sourced items (NS) shows that this specific item presents a clear seasonal increase. The color scale (upper right) indicates the type of material.

3. Remote beach: Tsoutsouras

a) Characteristics of the beach

The remote beach of Tsoutsouras is a rural beach, located in the municipality of Tsoutsouras Krasas in the central south eastern side of Crete, facing the sea to the south. It has a total length of ± 460 m, a width ranging from 20m to 35m and is composed at 100% of coarse sand with a slope of 11%. The monitored fixed portion of the beach has a surface of 2541 m². The beach is mainly used for recreational activities during the high season (swimming and sunbathing). It is only accessible for pedestrians. The area situated directly behind the beach is a rural area with no services and facilities provided to the beach users. The coordinates of the fixed 100m portion selected for the monitoring are: 34.9838N, 25.3053E (starting point) and 34.9842N, 25.3043E (ending point) (Fig. D.V.3-1). The closest harbor is situated 38 km away to the east. No cleaning activities are conducted on the beach.



Figure D.V.3-1: location map showing the beach of Tsoutsouras and the selected 100m portion of beach monitored (red area).

b) Seasonality of the marine litter

The remote beach of Tsoutsouras was sampled for marine litter in March, May, June, July, August, September and November of 2017. A total of 43 items (corrected for distance, see Part B.III.2.a) were collected on the same 100m portion of beach during the 7 monitoring, representing an average of 6.1 items (± 2.2 items, $n=7$) per survey. The lowest number of items was recorded in July (3 items) while the highest number was recorded in August (9 items) (Fig. D.V.3-2a). In general, the amount of marine litter collected during each survey is quite variable and changes from one month to another. No clear seasonal pattern was visible (Fig. D.V.3-2a). When only the number of items collected is considered (Fig. D.V.3-2b), their average number per survey during the low season (October – April) was of 6.0 (± 2.8 items, $n=2$) and of 6.2 (± 2.3 items, $n=5$) during the high season (May – September). Then, the amount of marine litter collected per survey during the high season was on average 3.3% higher than during the low touristic season (Fig. D.V.3-2b). When the accumulation rates (see Part B.III.2.b) are considered, a seasonal pattern can be observed (Fig. D.V.3-2c). The lowest value observed was of 0.00001 items/m²/day (9 items/km²/day) in April and the highest was of 0.0001 items/m²/day (114 items/km²/day) in August (Fig. D.V.3-2c). The seasonal pattern of the marine litter seems to follow the monthly number of tourists welcomed on Crete (Fig. D.V.3-2c): higher accumulation rates are observed during the touristic season and lower accumulation rates are observed during the off season. During the low season, the average accumulation rate is of 0.00002 items/m²/day (± 0.00001 , $n=2$) and of 0.0001 items/m²/day (± 0.00003 , $n=5$) during the high season. These results show that, on average the accumulation rates of the marine litter are higher during the high season (+289%, Fig. D.V.3-2d) than during the low season. It is important to note that the beach of Tsoutsouras was the less affected of all the beaches monitored by marine litter.

Finally, the beach of Tsoutsouras can be considered as very clean during both the low and high seasons, according to the Clean-Coast Index (see Part B.III.2.d) exhibiting values of respectively 0.05 and 0.05 (Fig. C.IV-4a). The accumulation index shows that the accumulation of marine litter can be considered as very low during both the low and high seasons (AI=1.25 and 1.84) (Fig. C.IV-4b).

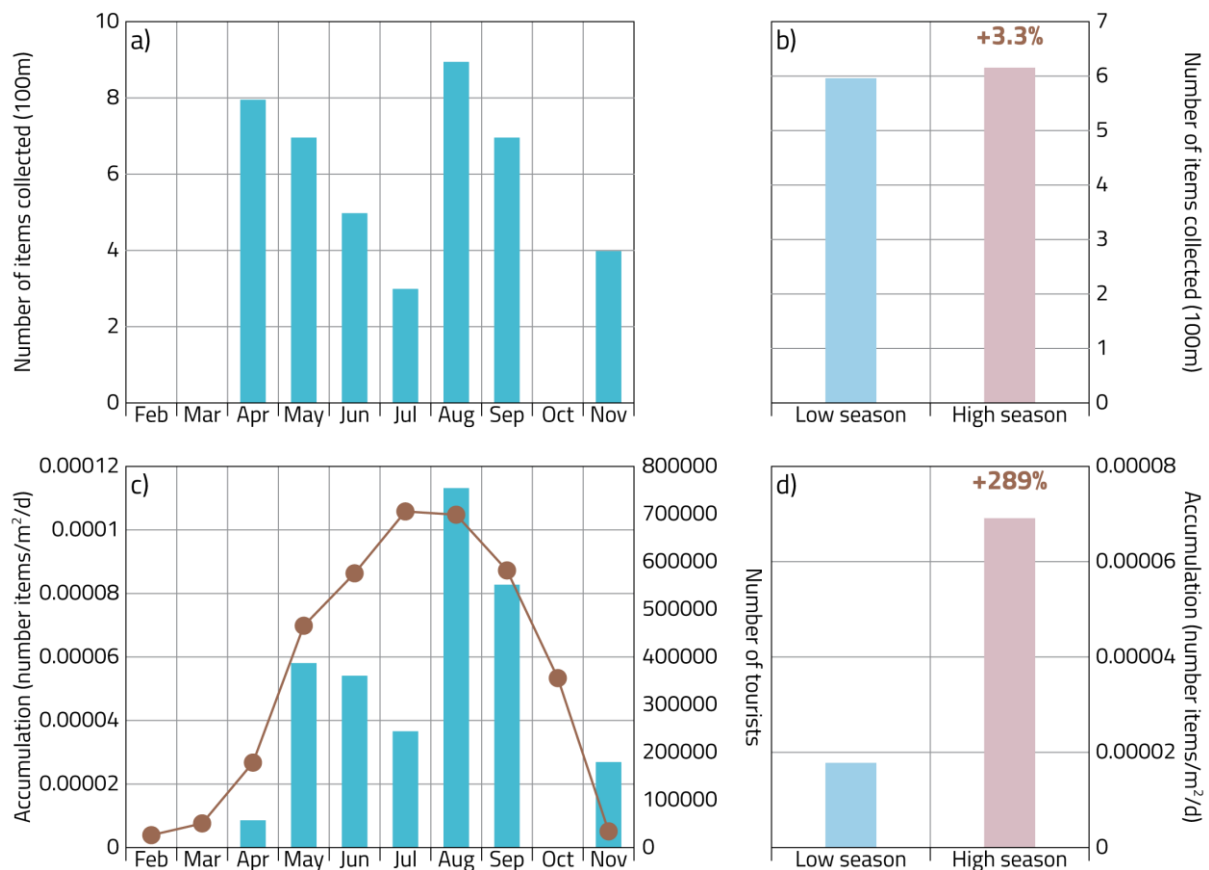


Figure D.V.3-2: total number and accumulations rates of items collected at the beach of Tsoutsouras. a) number of items collected during each survey on the fixed 100m portion of beach; b) comparison of the average number of items collected per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season; c) accumulation rates of the marine litter (left axis, blue bars) and the monthly number of tourists¹⁹ in Crete (right axis, brown line and dots); and d) comparison of the accumulation rates of marine litter per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season.

c) Composition of the marine litter

The marine litter collected on the beach of Tsoutsouras (Fig. D.V.3-3) was classified into 8 major categories of material type (see Part B.III.2.c). It is largely dominated by the artificial polymer materials (average=81.62% \pm 19.74; min=57.14% in May and max=100.00% in July), followed by the processed/worked wood (average=9.54% \pm 14.85; min=0.00% in november and max=40.00% in June), the paper/cardboard (average=4.76% \pm 12.60; min=0.00% in November and max=33.33% in August) and the metal (average=4.08% \pm 10.80; min=0.00% in November and max=28.57% in May). The amount of marine litter was so low that no cloth/textile, glass/ceramics, rubber and unidentified and/or chemicals were found on the beach.

During the low season (Fig. D.V.3-), the marine litter is largely dominated by the artificial polymer materials (93.75%) and followed by the processed/worked wood (6.25%).

During the high season (Fig. D.V.3-), the marine litter is dominated by the artificial polymer materials (76.76%), followed by the processed/worked wood (10.86%), the paper/cardboard (6.67%) and the metal (5.71%).

¹⁹ Data source: monthly number of tourists welcomed on Crete in 2016.

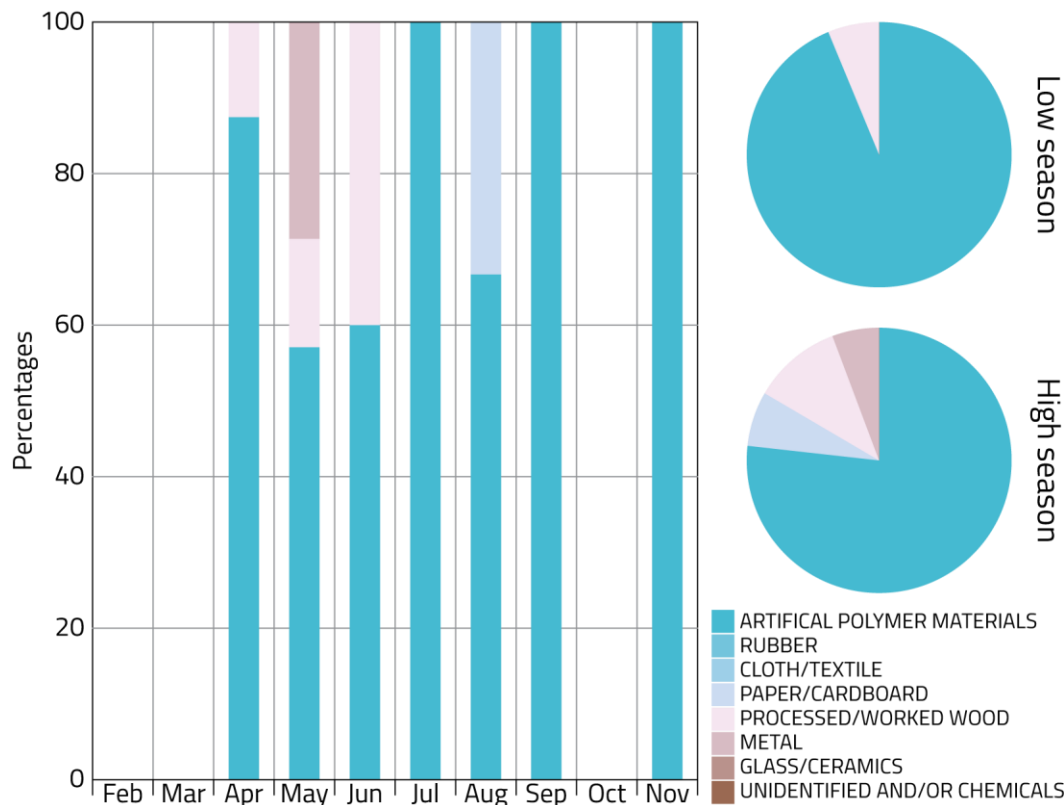


Figure D.V.3-3: composition of the marine litter collected at the beach of Tsoutsouras. Left: histogram showing the monthly percentages of the 8 major categories of material type. Right: pie charts showing the average composition of the marine litter during the low (top) and high (bottom) seasons. The color scale (lower right) indicates the type of material.

d) The 10 items with the highest accumulation rates

In this section, we consider the items with the highest averaged accumulation rates, which are not necessarily the most abundant items collected during the marine litter monitoring performed on the beach of Tsoutsouras (Fig. D.V.3-4). These items account for 95.35% of the total marine litter items (43) collected in 2017. They are dominated by the bags (e.g. shopping) (0.000013 items/m²/day; 25.58% of the total marine litter items collected), followed by the drink bottles, containers and drums (0.000013 items/m²/day; 27.91% of the total marine litter items collected), the plastic/polystyrene pieces >50cm (0.000007 items/m²/day; 9.3% of the total marine litter items collected), the other paper items (0.000005 items/m²/day; 6.98% of the total marine litter items collected), the plastic bag ends (0.000005 items/m²/day; 6.98% of the total marine litter items collected), the food containers (e.g. fast food containers) (0.000003 items/m²/day; 4.65% of the total marine litter items collected), the other wood >50cm (0.000003 items/m²/day; 6.98% of the total marine litter items collected), the strings and cords (diameter less than 1 cm) (0.000002 items/m²/day; 2.33% of the total marine litter items collected), the other wood <50cm (0.000001 items/m²/day; 2.33% of the total marine litter items collected) and the aerosol/spray cans (0.000001 items/m²/day; 2.33% of the total marine litter items collected).

In this top 10, the artificial polymer materials largely dominate as they are represented by 6 items, accounting for 76.74% of the total marine litter items collected.

In this top 10, 3 items (bags drink bottles and food containers) accounting for 58.14% of the total marine litter items collected, can be attributed to the shoreline source, including poor waste management practices, tourism and recreational activities (see Part B.III.2.c).

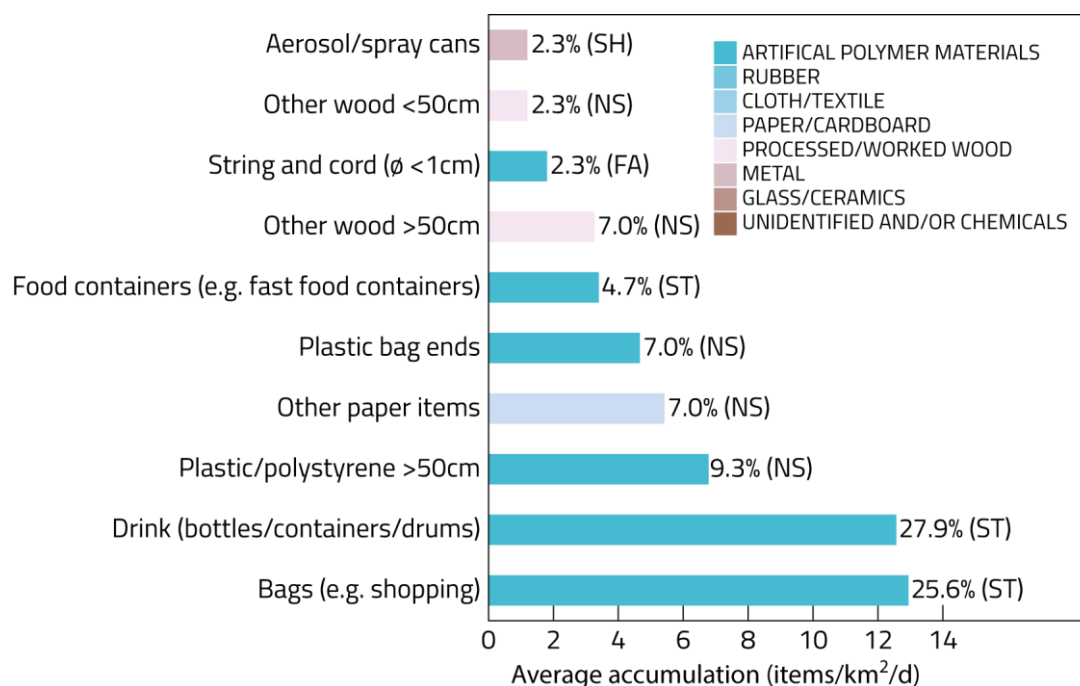


Figure D.V.3-4: list of the 10 items with the highest accumulation rates collected at the beach of Tsoutsouras. The percentages next to each item refers to their relative abundance with respect to the total collected. The possible source of the items is given into parenthesis: ST=shoreline, including poor waste management, tourism and recreational activities; FA= fishing and aquaculture; SH=shipping; and NS=non-sourced. The color scale (upper right) indicates the type of material.

4. Summary

The 21 marine litter surveys conducted in Crete in 2017 have revealed that:

- If only the number of items collected is considered, the beach of Arina, mainly used by locals is the most affected by the marine litter (24689 items collected; average: 3527.0 items/survey; 4670.0 items/survey during the low season; 3069.8 items/survey during the high season), followed by the touristic beach of Rethymno (12271 items collected; average: 1752.9 items/survey; 1916.1 items/survey during the low season; 1687.7 items/survey during the high season) and the remote beach of Tsoutsouras (43 items collected; average: 6.1 items/survey; 6.0 items/survey during the low season; 6.2 items/survey during the high season). For the 3 beaches, no seasonal variability was observed from the number of items collected.
- If the accumulation rate of the marine litter is considered, the touristic beach of Rethymno is the most affected by marine litter accumulation (average: 0.1299 items/m²/day; 0.0800 items/m²/day during the low season; 0.1498 items/m²/day during the high season), followed by the beach of Arina, mainly used by locals (average: 0.0486 items/m²/day; 0.0167 items/m²/day during the low season; 0.0613 items/m²/day during the high season) and the remote beach of Tsoutsouras (average: 0.00005 items/m²/day; 0.00002 items/m²/day during the low season; 0.00007 items/m²/day during the high season). The 3 beaches presented recognizable seasonal variations with a relative increase of the accumulation rates of 87% (Rethymno), 266% (Arina) and 289% (Tsoutsouras) during the high season with respect to the low season.
- The items collected are mainly composed of artificial polymer materials: they represent 90.62% (Rethymno), 97.01% (Arina) and 81.62% (Tsoutsouras) of the total marine litter items collected.

- On the touristic beach of Rethymno, 5 items (cigarette butts, cutlery/trays/straws, crisp/sweet packets and lolly sticks, caps/lids and small plastic bags), most likely related to tourism and recreational activities, are representing 53.85% of the total marine litter items collected. To this, can possibly be added 3 items (mesoplastics, macroplastics and other glass items), accounting for additional 18.21% as they presented a recognizable seasonal variation.
- On the beach of Arina, mainly used by locals, 4 items (cigarette butts, caps/lids, cutlery/trays/straws and small plastic bags), most likely related to tourism and recreational activities, are representing 20.74% of the total marine litter items collected. To this, can possibly be added 3 items (mesoplastics, macroplastics and microplastics), accounting for additional 42.44% as they presented a recognizable seasonal variation.
- On the remote beach of Tsoutsouras, 3 items (bags, drink bottles and food containers), most likely related to tourism and recreational activities, are representing 58.14% of the total marine litter items collected.
- The cleanliness of the beaches is considered as dirty/dirty for the low/high season in Rethymno (Clean-Coast Index of 15.1/13.3), very dirty/dirty for the low/high season in Arina (CCI of 29.4/19.3) and very clean/very clean for the low/high season in Tsoutsouras (CCI of 0.05/0.05).
- Finally the accumulation index of the beaches is considered as high/very high for the low/high season in Rethymno (Accumulation Index of 4.90/5.18), high/high for the low/high season in Arina (AI of 4.22/4.79) and very low/very low for the low/high season in Tsoutsouras (AI of 1.25/1.84).

VI. Mykonos

1. Touristic beach: Platis Gyalos

a) Characteristics of the beach

The touristic beach of Platis Gyalos is an urban beach, located in the municipality of Platis Gyalos in the south western side of Mykonos, facing the sea to the south. It has a total length of $\pm 295\text{m}$, a width of $\pm 22\text{m}$ and is composed at 70% of sand and 30% of pebbles with a smooth slope. The monitored fixed portion of the beach has a surface of 1611 m^2 . It has a pier situated on the western side. The beach is mainly used for recreational activities during the high season (swimming, sunbathing and local people) and the low season (local people). It is accessible by vehicles/boats and for pedestrians. The area situated directly behind the beach, has many services and facilities provided to the beach users. The coordinates of the fixed 100m portion selected for the monitoring are: 37.4141N, 25.3428E (starting point) and 37.4142N, 25.3439E (ending point) (Fig. D.VI.1-1). Drink and food outlets are situated directly on the beach and the closest harbor is situated 8 km away to the west. The beach is cleaned once a day during the high season.



Figure D.VI.1-1: location map showing the beach of Platis Gyalos and the selected 100m portion of beach monitored (red area).

b) Seasonality of the marine litter

The touristic beach of Platis Gyalos was sampled for marine litter in April, May, June, July, August, September and November of 2017. A total of 738 items (corrected for distance, see Part B.III.2.a) were collected on the same 100m portion of beach during the 7 monitoring, representing an average of 123.0 items (± 30.9 items, $n=7$) per survey. The lowest number of items was recorded in June (95 items) while the highest number was recorded in November (179 items) (Fig. D.VI.1-2a). In general, the amount of marine litter collected during each survey is quite stable from April to September and increases in November. No clear seasonal pattern was visible (Fig. D.VI.1-2a). When only the number of items collected is considered (Fig. D.VI.1-2b), their average number per survey during the low season (October – April) was of 146.8 (± 45.5 items, $n=2$) and of 111.1 (± 18.3 items, $n=5$) during the high season (May – September). Then, the amount of marine litter collected per survey during the high season was on average 24.3% lower than during the low touristic season (Fig. D.VI.1-2b). When the accumulation rates (see Part B.III.2.b) are considered, a seasonal pattern can be observed (Fig. D.VI.1-2c). The lowest value observed was of 0.0025 items/m²/day (2527 items/km²/day) in April and the highest was of 0.0298 items/m²/day (29795 items/km²/day) in July (Fig. D.VI.1-2c). The seasonal pattern of the marine litter seems to follow the monthly number of tourists welcomed on Mykonos (Fig. D.VI.1-2c): higher accumulation rates are observed during the touristic season and lower accumulation rates are observed during the off season. During the low season, the average accumulation rate is of 0.0031 items/m²/day (± 0.0017 , $n=2$) and of 0.0238 items/m²/day (± 0.0113 , $n=5$) during the high season. These results show that, on average the accumulation rates of the marine litter are much higher during the high season (+665%, Fig. D.VI.1-2d) than during the low season. Finally, the beach of Platis Gyalos can be considered as very clean during both the low and high seasons, according to the Clean-Coast Index (see Part B.III.2.d) exhibiting values of respectively 1.8 and 1.4 (Fig. C.II-4a). The accumulation index shows that the accumulation of marine litter can be considered as moderate during the low season (AI=3.49) and high during the high season (AI=4.38) (Fig. C.II-4b).

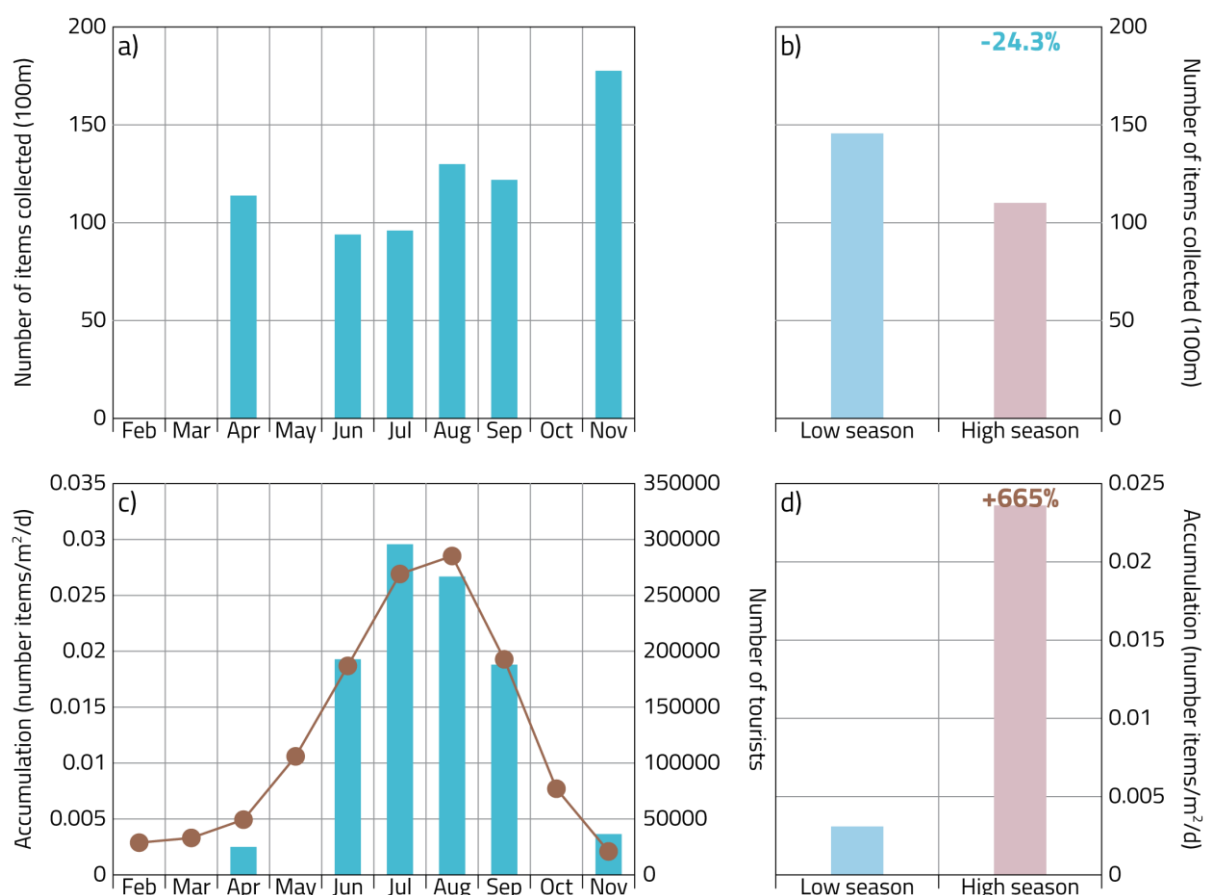


Figure D.VI.1-2: total number and accumulations rates of items collected at the beach of Platis Gyalos. a) number of items collected during each survey on the fixed 100m portion of beach; b) comparison of the average number of items collected per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (blue font) refers to the decrease with respect to the low season; c) accumulation rates of the marine litter (left axis, blue bars) and the monthly number of tourists²⁰ in Mykonos (right axis, brown line and dots); and d) comparison of the accumulation rates of marine litter per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season.

c) Composition of the marine litter

The marine litter collected on the beach of Platis Gyalos (Fig. D.VI.1-3) was classified into 8 major categories of material type (see Part B.III.2.c). It is dominated by the artificial polymer materials (average=77.83% \pm 8.26; min=66.85% in November and max=89.47% in April), followed by the metal (average=8.52% \pm 4.73; min=4.17% in July and max=16.85% in November), the paper/cardboard (average=7.03% \pm 4.54; min=2.63% in April and max=15.63% in July), the processed/worked wood (average=5.39% \pm 5.22; min=0.00% in June and max=14.62% in August), the cloth/textile (average=0.44% \pm 1.07; min=0.00% in November and max=2.63% in April), the glass/ceramics (average=0.42% \pm 0.70; min=0.00% in August and max=1.69% in November) and the rubber (average=0.37% \pm 0.92; min=0.00% in September and max=2.25% in November).

During the low season (Fig. D.VI.1-3), the marine litter is dominated by the artificial polymer materials (78.16%), followed by the metal (10.62%), the paper/cardboard (4.97%), the processed/worked wood (2.97%), the cloth/textile (1.32%), the rubber (1.12%) and the glass/ceramics (0.84%).

²⁰ Data source: monthly number of arrivals at Mykonos airport in 2017, https://www.jmk-airport.gr/uploads/sys_nodeIng/2/2891/Mikonos_FY_Traffic_2017vs2016.pdf

During the high season (Fig. D.VI.1-3), the marine litter is dominated by the artificial polymer materials (77.67%), followed by the paper/cardboard (8.07%), the metal (7.47%), the processed/worked wood (6.60%) and the glass/ceramics (0.20%).

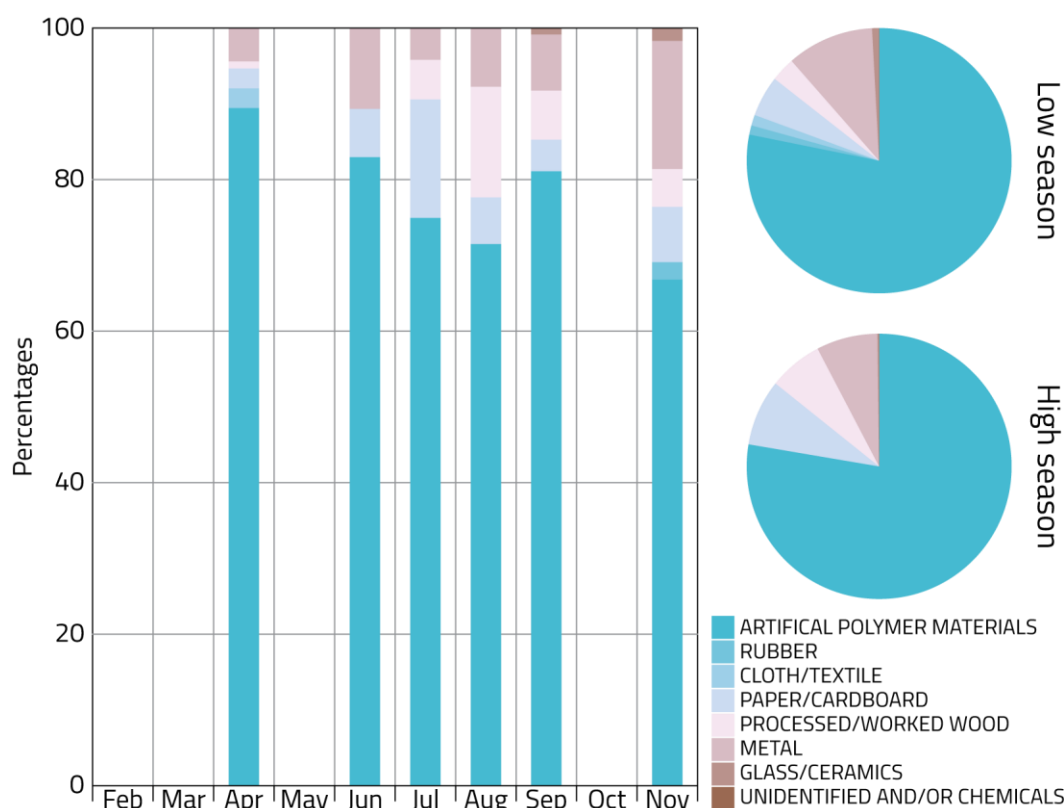


Figure D.VI.1-3: composition of the marine litter collected at the beach of Platis Gyalos. Left: histogram showing the monthly percentages of the 8 major categories of material type. Right: pie charts showing the average composition of the marine litter during the low (top) and high (bottom) seasons. The color scale (lower right) indicates the type of material.

d) The 10 items with the highest accumulation rates

In this section, we consider the items with the highest averaged accumulation rates, which are not necessarily the most abundant items collected during the marine litter monitoring performed on the beach of Platis Gyalos (Fig. D.VI.1-4). These items account for 67.3% of the total marine litter items (738) collected in 2017. They are dominated by the cigarette butts (0.0052 items/m²/day; 27.66% of the total marine litter items collected), followed by the caps/lids (0.0014 items/m²/day; 8.17% of the total marine litter items collected), the crisp/sweet packets and lolly sticks (0.001 items/m²/day; 5.31% of the total marine litter items collected), the bottle caps (0.0008 items/m²/day; 4.63% of the total marine litter items collected), the food containers (e.g. fast food containers) (0.0007 items/m²/day; 3.54% of the total marine litter items collected), the corks (0.0006 items/m²/day; 2.86% of the total marine litter items collected), the drink bottles, containers and drums (0.0006 items/m²/day; 4.5% of the total marine litter items collected), the macroplastics (0.0006 items/m²/day; 5.04% of the total marine litter items collected), the cutlery/trays/straws (0.0005 items/m²/day; 3.27% of the total marine litter items collected) and the ice lolly sticks/chip forks (0.0005 items/m²/day; 2.32% of the total marine litter items collected).

In this top 10, the artificial polymer materials largely dominate as they are represented by 7 items, accounting for 57.49% of the total marine litter items collected.

In this top 10, 9 items (cigarette butts, caps/lids, crisp/sweet packets and lolly sticks, bottle caps, food containers, corks, drink bottles, cutlery/trays/straws and ice lolly sticks/chip forks) accounting for 62.26% of the total marine litter items collected, can be attributed to the shoreline source, including poor waste management practices, tourism and recreational activities (see Part B.III.2.c). To this, can possibly be added 1 item (macroplastics) presenting a clear seasonal pattern (see Appendix, Fig. E.VII-1) and accounting for additional 5.04% of the total marine litter items collected.

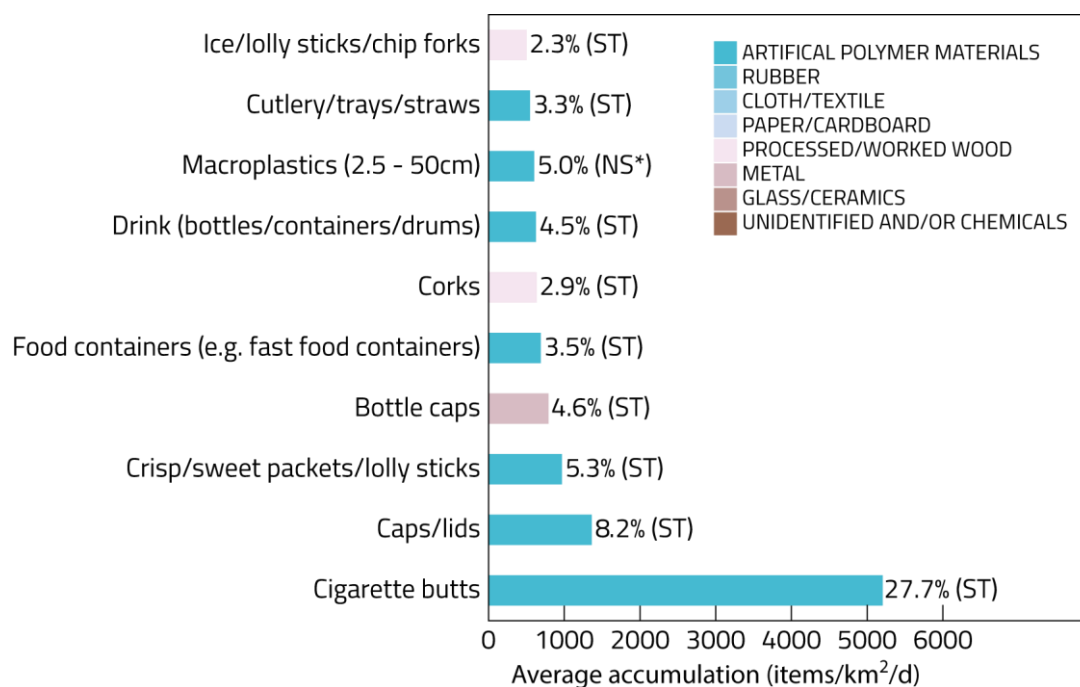


Figure D.VI.1-4: list of the 10 items with the highest accumulation rates collected at the beach of Platis Gyalos. The percentages next to each item refers to their relative abundance with respect to the total collected. The possible source of the items is given into parenthesis: ST=shoreline, including poor waste management, tourism and recreational activities and NS=non-sourced. The asterisk (*) associated to the non-sourced items (NS) shows that this specific item presents a clear seasonal increase. The color scale (upper right) indicates the type of material.

2. Beach mainly used by locals: Fokos

a) Characteristics of the beach

The beach of Fokos was selected as it is a popular beach mainly used by locals. It is a semi-rural beach, located in the municipality of Fokos in the north eastern side of Mykonos, facing the sea to the NW. It has a total length of $\pm 203\text{m}$, a width of $\pm 49\text{m}$ and is composed at 60% of sand and 40% of pebbles with a smooth slope. The monitored fixed portion of the beach has a surface of 3800 m^2 . The beach is mainly used for recreational activities during the high season (swimming, sunbathing and local people) and the low season (local people). It is accessible by vehicles and for pedestrians. In the area situated directly behind the beach, very few services and facilities provided to the beach users are found. The coordinates of the fixed 100m portion selected for the monitoring are: 37.4815N, 25.4101E (starting point) and 37.4807N, 25.4103E (ending point) (Fig. D.VI.2-1). The closest harbor is situated 14 km away to the west. The beach is cleaned once every 2 weeks from April to October.



Figure D.VI.2-1: location map showing the beach of Fokos and the selected 100m portion of beach monitored (red area).

b) Seasonality of the marine litter

The beach of Fokos, mainly used by locals, was sampled for marine litter in April, May, June, July, August, September and November of 2017. A total of 637 items (corrected for distance, see Part B.III.2.a) were collected on the same 100m portion of beach during the 7 monitoring, representing an average of 106.1 items (± 23.6 items, $n=7$) per survey. The lowest number of items was recorded in June (69 items) while the highest number was recorded in November (133 items) (Fig. D.VI.2-2a). In general, the amount of marine litter collected during each survey slightly increases from June to September and is higher during April and November. No seasonal pattern was visible (Fig. D.VI.2-2a). When only the number of items collected is considered (Fig. D.VI.2-2b), their average number per survey during the low season (October – April) was of 130.9 (± 3.6 items, $n=2$) and of 93.7 (± 17.6 items, $n=5$) during the high season (May – September). Then, the amount of marine litter collected per survey during the high season was on average 28.4% lower than during the low touristic season (Fig. D.VI.2-2b). When the accumulation rates (see Part B.III.2.b) are considered, a seasonal pattern can be observed (Fig. D.VI.2-2c). The lowest value observed was of 0.0011 items/m²/day (1077 items/km²/day) in November and the highest was of 0.0279 items/m²/day (27895 items/km²/day) in August (Fig. D.VI.2-2c). The seasonal pattern of the marine litter seems to follow the monthly number of tourists welcomed on Mykonos (Fig. D.VI.2-2c): higher accumulation rates are observed during the touristic season and lower accumulation rates are observed during the off season. During the low season, the average accumulation rate is of 0.0011 items/m²/day (± 0.0006 , $n=2$) and of 0.0186 items/m²/day (± 0.0113 , $n=5$) during the high season. These results show that, on average the accumulation rates of the marine litter are by far higher during the high season (+1574%, Fig. D.VI.2-2d) than during the low season.

Finally, the beach of Fokos can be considered as very clean during both the low and high seasons, according to the Clean-Coast Index (see Part B.III.2.d) exhibiting values of respectively 0.7 and 0.5 (Fig. C.III-4a). The accumulation index shows that the accumulation of marine litter can be considered as moderate during the low season (AI=3.05) and high during the high season (AI=4.27) (Fig. C.III-4b).

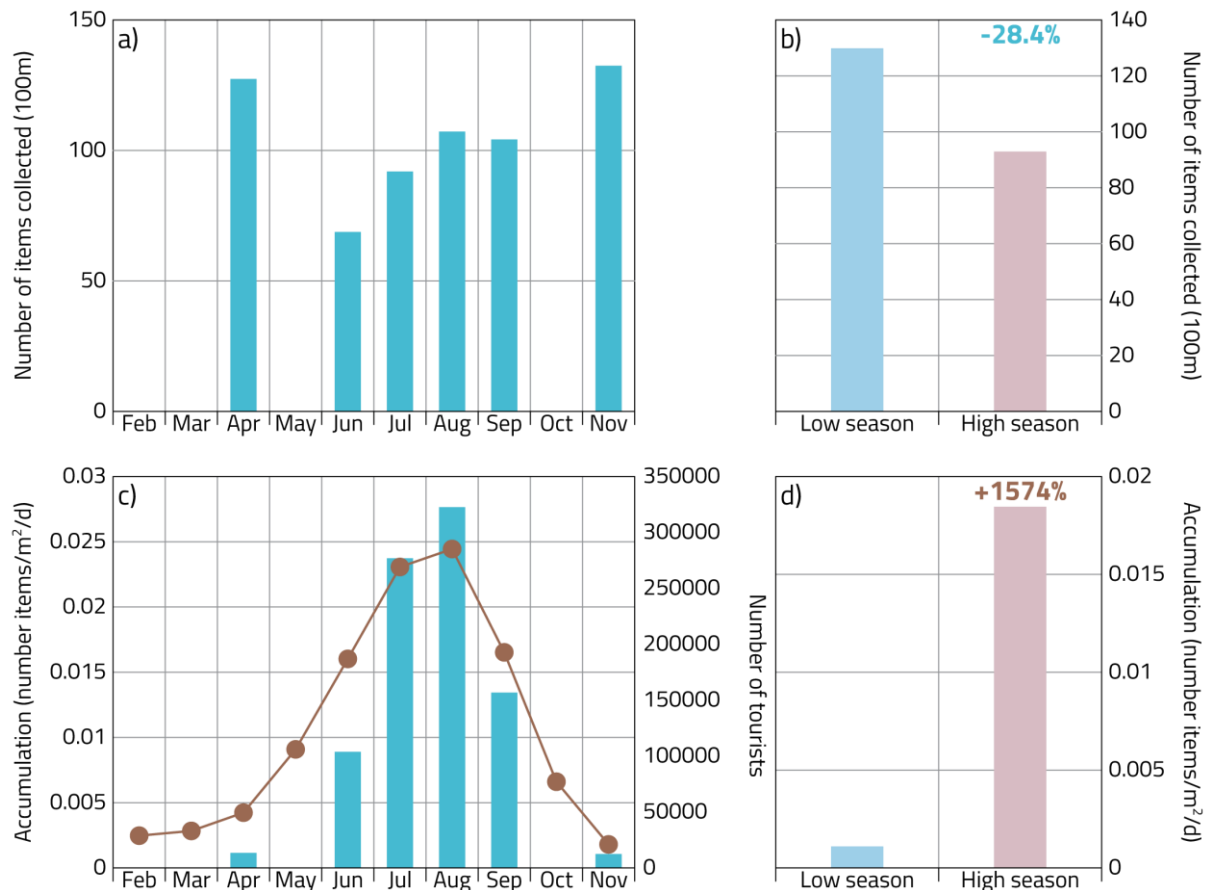


Figure D.VI.2-2: total number and accumulations rates of items collected at the beach of Fokos. a) number of items collected during each survey on the fixed 100m portion of beach; b) comparison of the average number of items collected per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (blue font) refers to the decrease with respect to the low season; c) accumulation rates of the marine litter (left axis, blue bars) and the monthly number of tourists²¹ in Mykonos (right axis, brown line and dots); and d) comparison of the accumulation rates of marine litter per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season.

c) Composition of the marine litter

The marine litter collected on the beach of Fokos (Fig. D.VI.2-3) was classified into 8 major categories of material type (see Part B.III.2.c). It is dominated by the artificial polymer materials (average=71.31% \pm 12.76; min=63.21% in August and max=96.83% in April), followed by the metal (average=12.03% \pm 6.28; min=0.79% in April and max=17.56% in November), the paper/cardboard (average=9.85% \pm 6.85; min=1.59% in April and max=20.59% in June), the processed/worked wood (average=4.38% \pm 3.48; min=0.00% in April and max=10.38% in August), the rubber (average=1.26% \pm 1.32; min=0.00% in November and max=2.94% in June), the glass/ceramics (average=1.05% \pm 0.95; min=0.00% in June and max=2.29% in November) and the cloth/textile (average=0.13% \pm 0.31; min=0.00% in September and max=0.76% in November).

During the low season (Fig. D.VI.2-3), the marine litter is largely dominated by the artificial polymer materials (83.15%), followed by the metal (9.18%), the paper/cardboard (3.47%), the processed/worked wood (2.29%), the glass/ceramics (1.15%), the rubber (0.40%) and the cloth/textile (0.38%).

²¹ Data source: monthly number of arrivals at Mykonos airport in 2017, https://www.jmk-airport.gr/uploads/sys_nodelng/2/2891/Mikonos_FY_Traffic_2017vs2016.pdf

During the high season (Fig. D.VI.2-3), the marine litter is dominated by the artificial polymer materials (65.39%), followed by the metal (13.46%), the paper/cardboard (13.04%), the processed/worked wood (5.43%), the rubber (1.69%) and the glass/ceramics (1.00%).

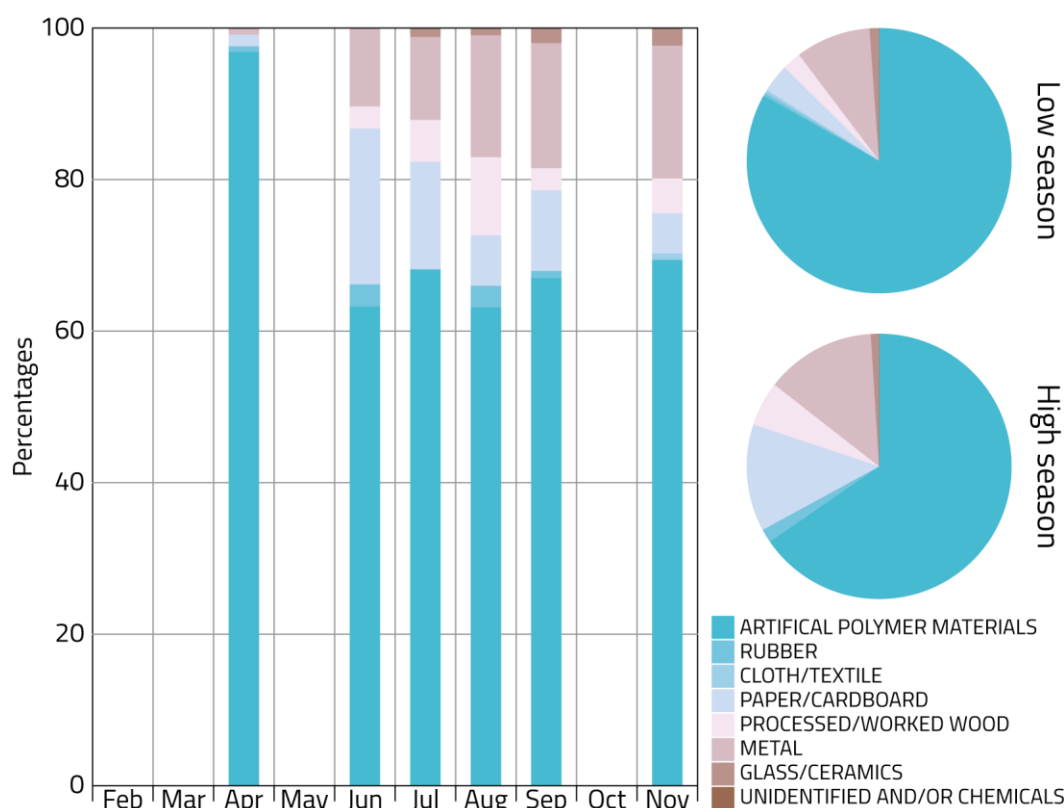


Figure D.VI.2-3: composition of the marine litter collected at the beach of Fokos. Left: histogram showing the monthly percentages of the 8 major categories of material type. Right: pie charts showing the average composition of the marine litter during the low (top) and high (bottom) seasons. The color scale (lower right) indicates the type of material.

d) The 10 items with the highest accumulation rates

In this section, we consider the items with the highest averaged accumulation rates, which are not necessarily the most abundant items collected during the marine litter monitoring performed on the beach of Fokos (Fig. D.VI.2-4). These items account for 67.2% of the total marine litter items (637) collected in 2017. They are dominated by the cigarette butts (0.0028 items/m²/day; 16.64% of the total marine litter items collected), followed by the caps/lids (0.0012 items/m²/day; 17.92% of the total marine litter items collected), the bottle caps (0.0011 items/m²/day; 7.04% of the total marine litter items collected), the food containers (e.g. fast food containers) (0.0006 items/m²/day; 5.44% of the total marine litter items collected), the ice lolly sticks / chip forks (0.0006 items/m²/day; 2.4% of the total marine litter items collected), the cutlery/trays/straws (0.0006 items/m²/day; 2.72% of the total marine litter items collected), the cigarette packets (0.0005 items/m²/day; 3.04% of the total marine litter items collected), the drink cans (0.0005 items/m²/day; 2.72% of the total marine litter items collected), the cups (0.0005 items/m²/day; 6.08% of the total marine litter items collected) and the crisp/sweet packets and lolly sticks (0.0004 items/m²/day; 3.2% of the total marine litter items collected).

In this top 10, the artificial polymer materials and the metal are represented respectively by 6 and 2 items, accounting for 52.00% and 9.76% of the total marine litter items collected.

In this top 10, the 10 items accounting for 67.2% of the total marine litter items collected, can be attributed to the shoreline source, including poor waste management practices, tourism and recreational activities (see Part B.III.2.c).

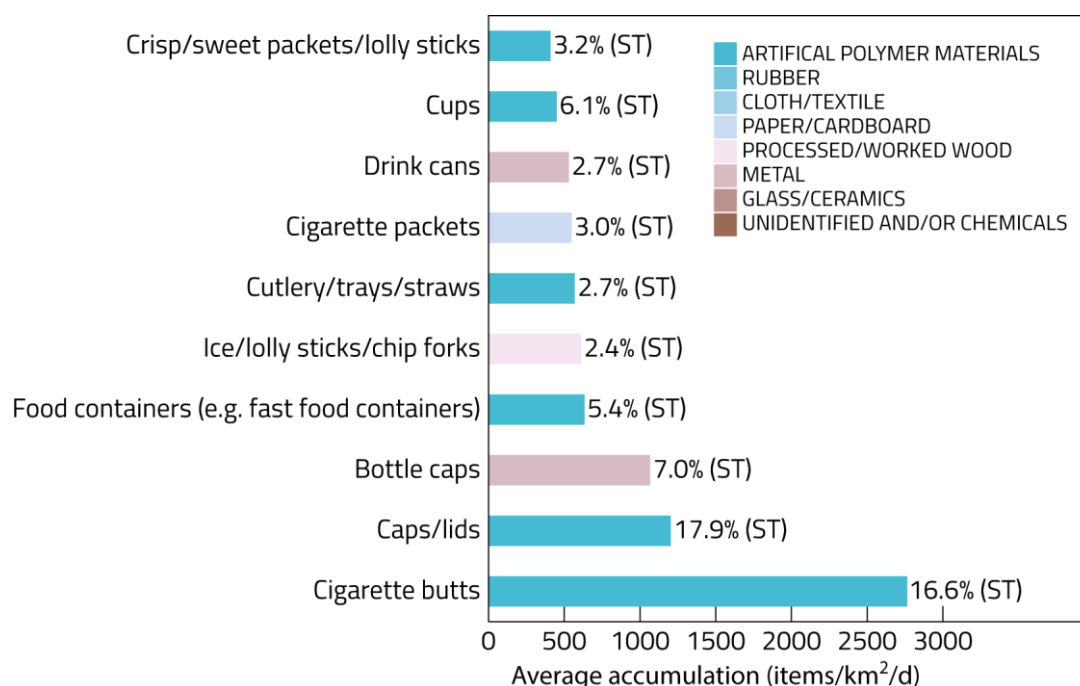


Figure D.VI.2-4: list of the 10 items with the highest accumulation rates collected at the beach of Fokos. The percentages next to each item refers to their relative abundance with respect to the total collected. The possible source of the items is given into parenthesis: ST=shoreline, including poor waste management, tourism and recreational activities. The color scale (upper right) indicates the type of material.

3. Remote beach: Merchia

a) Characteristics of the beach

The remote beach of Merchia is a rural beach, located in the municipality of Merchia in the north eastern side of Mykonos, is facing the sea to the NW. It has a total length of $\pm 132\text{m}$, a width of $\pm 35\text{m}$ and is composed at 70% of pebbles and 30% of sand with a smooth slope. The monitored fixed portion of the beach has a surface of 2147 m^2 . The beach is mainly used for recreational activities during the high season (swimming and sunbathing). It is accessible by vehicles and for pedestrians. The area situated directly behind the beach is a semi-rural area with no services and facilities provided to the beach users. The coordinates of the fixed 100m portion selected for the monitoring are: 37.4719N, 25.4284E (starting point) and 37.4711N, 25.4289E (ending point) (Fig. D.VI.3-1). The closest harbor is situated 15 km away to the east. The beach is cleaned once a month during the high season.



Figure D.VI.3-1: location map showing the beach of Merchia and the selected 100m portion of beach monitored (red area).

b) Seasonality of the marine litter

The remote beach of Merchia was sampled for marine litter in April, May, June, July, August, September and November of 2017. A total of 612 items (corrected for distance, see Part B.III.2.a) were collected on the same 100m portion of beach during the 7 monitoring, representing an average of 101.9 items (± 44.2 items, $n=7$) per survey. The lowest number of items was recorded in June (39 items) while the highest number was recorded in November (153 items) (Fig. D.VI.3-2a). In general, the amount of marine litter collected during each survey is quite low in April and June, and increases from July to November (Fig. D.VI.3-2a). Then no seasonal pattern was visible. When only the number of items collected is considered (Fig. D.VI.3-2b), their average number per survey during the low season (October – April) was of 104.4 (± 68.2 items, $n=2$) and of 100.7 (± 41.2 items, $n=5$) during the high season (May – September). Then, the amount of marine litter collected per survey during the high season was on average 3.6% lower than during the low touristic season (Fig. D.VI.3-2b). When the accumulation rates (see Part B.III.2.b) are considered, a seasonal pattern can be observed (Fig. D.VI.3-2c). The lowest value observed was of 0.0001 items/m²/day (126 items/km²/day) in April and the highest was of 0.0051 items/m²/day (5123 items/km²/day) in July (Fig. D.VI.3-2c). The seasonal pattern of the marine litter seems to follow the monthly number of tourists welcomed on Mykonos (Fig. D.VI.3-2c): higher accumulation rates are observed during the touristic season and lower accumulation rates are observed during the off season. During the low season, the average accumulation rate is of 0.0010 items/m²/day (± 0.0008 , $n=2$) and of 0.0037 items/m²/day (± 0.0023 , $n=5$) during the high season. These results show that, on average the accumulation rates of the marine litter are much higher during the high season (+283%, Fig. D.VI.3-2d) than during the low season.

Finally, the beach of Merchia can be considered as very clean during both the low and high seasons, according to the Clean-Coast Index (see Part B.III.2.d) exhibiting values of respectively 0.9 and 0.9 (fig. C.IV-4a). The accumulation index shows that the accumulation of marine litter can be considered as low during the low season (AI=2.99) and moderate during high season (AI=3.57) (Fig. C.IV-4b).

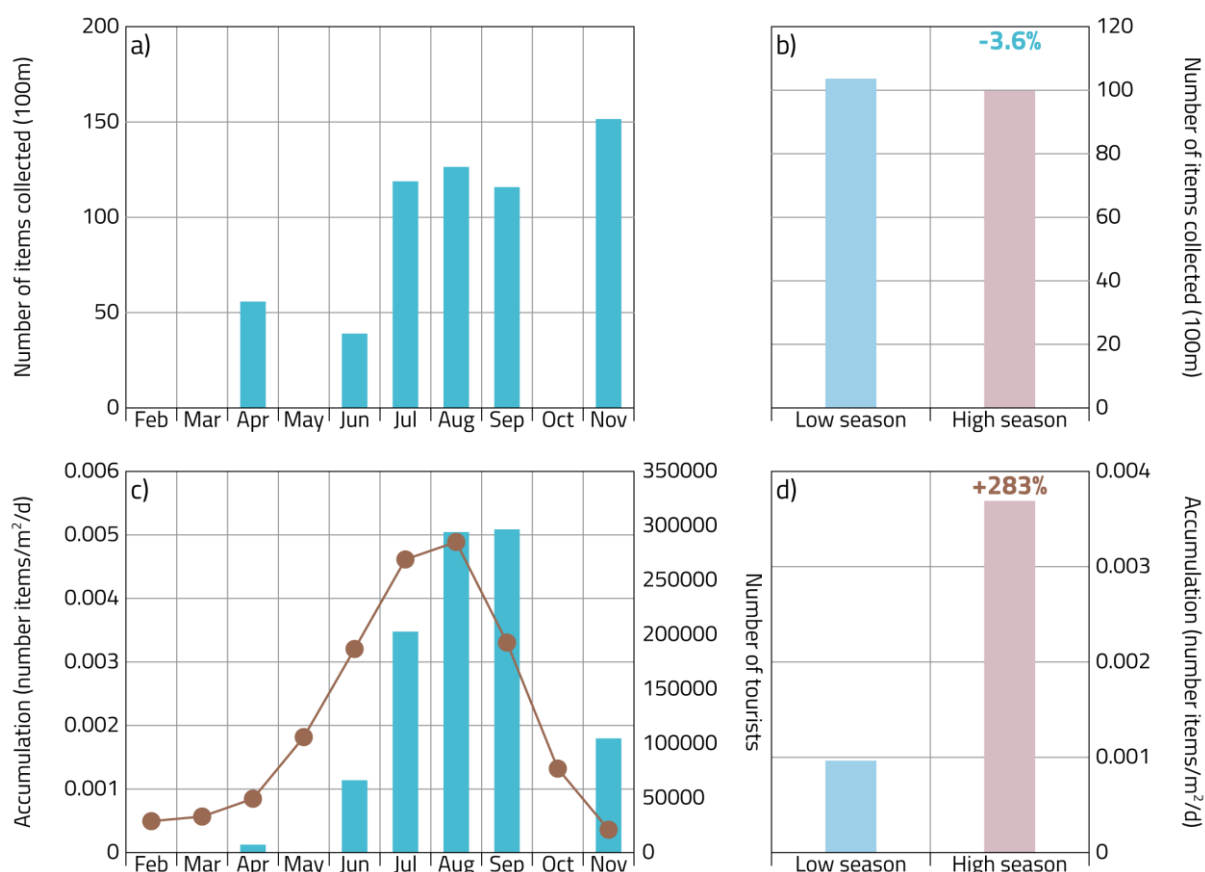


Figure D.VI.3-2: total number and accumulations rates of items collected at the beach of Merchia. a) number of items collected during each survey on the fixed 100m portion of beach; b) comparison of the average number of items collected per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (blue font) refers to the decrease with respect to the low season; c) accumulation rates of the marine litter (left axis, blue bars) and the monthly number of tourists²² in Mykonos (right axis, brown line and dots); and d) comparison of the accumulation rates of marine litter per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season.

c) Composition of the marine litter

The marine litter collected on the beach of Merchia (Fig. D.VI.3-3) was classified into 8 major categories of material type (see Part B.III.2.c). It is dominated by the artificial polymer materials (average=75.52% \pm 12.01; min=65.49% in July and max=96.23% in April), followed by the metal (average=11.56% \pm 7.26; min=1.89% in April and max=17.27% in September), the paper/cardboard (average=8.51% \pm 3.97; min=1.89% in April and max=13.51% in June), the processed/worked wood (average=3.75% \pm 3.43; min=0.00% in June and max=8.85% in July), the glass/ceramics (average=0.29% \pm 0.45; min=0.00% in November and max=0.91% in September), the rubber (average=0.23% \pm 0.57; min=0.00% in September and max=1.39% in November) and the cloth/textile (average=0.14% \pm 0.34; min=0.00% in November and max=0.83% in August).

During the low season (Fig. D.VI.3-3), the marine litter is largely dominated by the artificial polymer materials (83.18%), followed by the metal (9.28%), the paper/cardboard (4.76%), the processed/worked wood (2.08%) and the rubber (0.69%).

During the high season (Fig. D.VI.3-3), the marine litter is dominated by the artificial polymer materials (71.69%), followed by the metal (12.70%), the paper/cardboard (10.38%), the processed/worked wood (4.58%), the glass/ceramics (0.44%) and the cloth/textile (0.21%).

²² Data source: monthly number of arrivals at Mykonos airport in 2017, https://www.jmk-airport.gr/uploads/sys_nodeIng/2/2891/Mikonos_FY_Traffic_2017vs2016.pdf

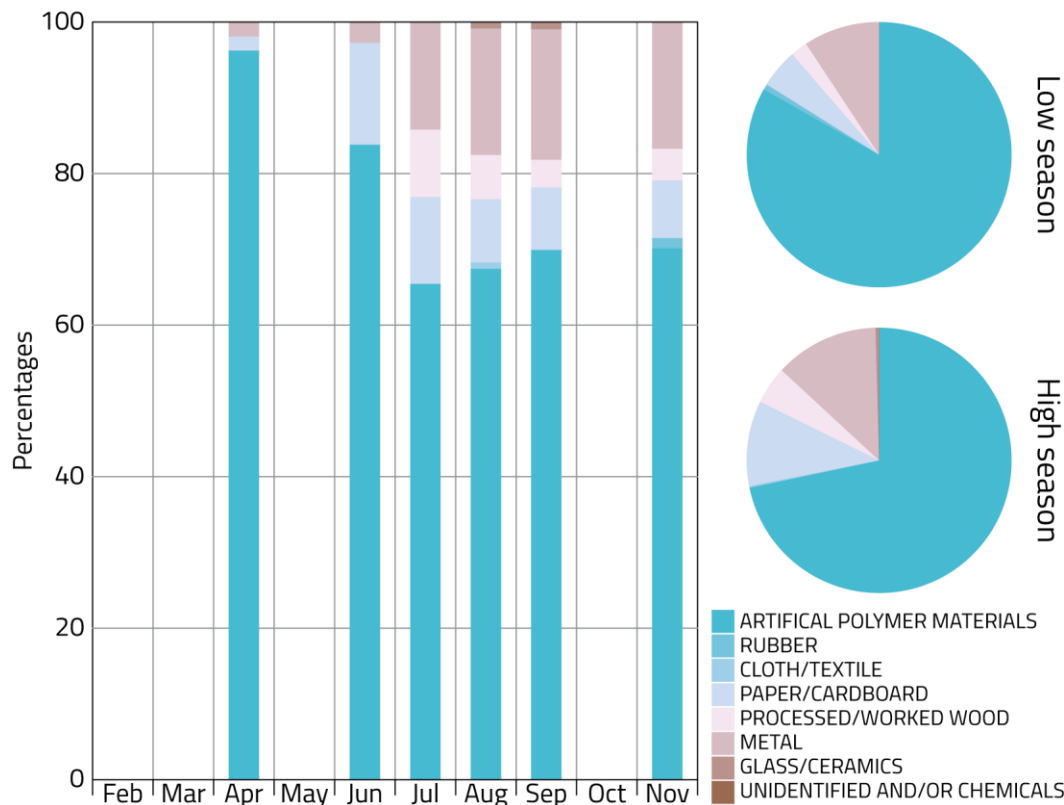


Figure D.VI.3-3: composition of the marine litter collected at the beach of Merchia. Left: histogram showing the monthly percentages of the 8 major categories of material type. Right: pie charts showing the average composition of the marine litter during the low (top) and high (bottom) seasons. The color scale (lower right) indicates the type of material.

d) The 10 items with the highest accumulation rates

In this section, we consider the items with the highest averaged accumulation rates, which are not necessarily the most abundant items collected during the marine litter monitoring performed on the beach of Merchia (Fig. D.VI.3-4). These items account for 68.28% of the total marine litter items (612) collected in 2017. They are dominated by the cigarette butts (0.0006 items/m²/day; 17.68% of the total marine litter items collected), followed by the caps/lids (0.0003 items/m²/day; 13.17% of the total marine litter items collected), the bottle caps (0.0002 items/m²/day; 6.24% of the total marine litter items collected), the crisp/sweet packets and lolly sticks (0.0002 items/m²/day; 9.19% of the total marine litter items collected), the cups (0.0001 items/m²/day; 4.85% of the total marine litter items collected), the cigarette packets (0.0001 items/m²/day; 4.51% of the total marine litter items collected), the plastic bag ends (0.0001 items/m²/day; 3.99% of the total marine litter items collected), the cutlery/trays/straws (0.0001 items/m²/day; 2.6% of the total marine litter items collected), the food containers (e.g. fast food containers) (0.0001 items/m²/day; 3.12% of the total marine litter items collected) and the drink bottles, containers and drums (0.0001 items/m²/day; 2.95% of the total marine litter items collected).

In this top 10, the artificial polymer materials largely dominate as they are represented by 8 items, accounting for 57.54% of the total marine litter items collected.

In this top 10, 9 items (cigarette butts, caps/lids, bottle caps, crisp/sweet packets and lolly sticks, cups, cigarette packets, cutlery/trays/straws, food containers and drink bottles) accounting for 64.31% of the total marine litter items collected, can be attributed to the shoreline source, including poor waste management practices, tourism and recreational activities (see Part B.III.2.c). To this, can possibly be

added 1 items (plastic bag ends) presenting a clear seasonal pattern (see Appendix, Fig. E.VII-3) and accounting for additional 3.99% of the total marine litter items collected.

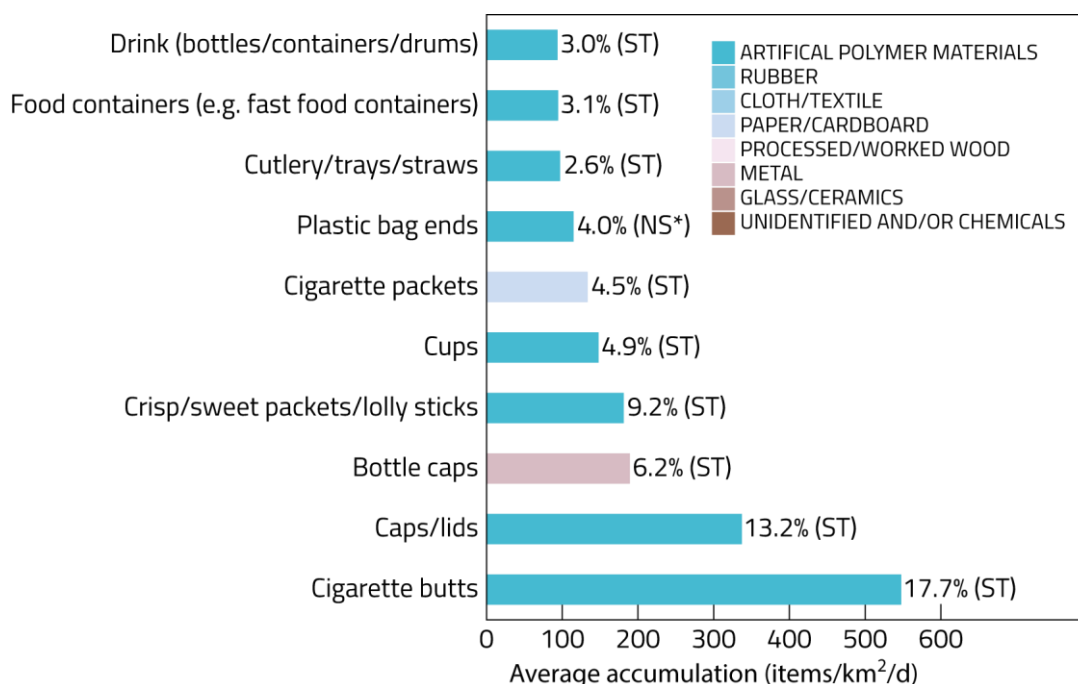


Figure D.VI.3-4: list of the 10 items with the highest accumulation rates collected at the beach of Merchia. The percentages next to each item refers to their relative abundance with respect to the total collected. The possible source of the items is given into parenthesis: ST=shoreline, including poor waste management, tourism and recreational activities and NS=non-sourced. The asterisk (*) associated to the non-sourced items (NS) shows that this specific item presents a clear seasonal increase. The color scale (upper right) indicates the type of material.

4. Summary

The 18 marine litter surveys conducted in Mykonos in 2017 have revealed that:

- If only the number of items collected is considered, the touristic beach of Platis Gyalos is the most affected by the marine litter (738 items collected; average: 123.0 items/survey; 146.8 items/survey during the low season; 111.1 items/survey during the high season), followed by the beach of Fokos, mainly used by locals (637 items collected; average: 106.1 items/survey; 130.9 items/survey during the low season; 93.7 items/survey during the high season) and the remote beach of Merchia (612 items collected; average: 101.9 items/survey; 104.4 items/survey during the low season; 100.7 items/survey during the high season). For the 3 beaches, no seasonal variability was observed from the number of items collected.
- If the accumulation rate of the marine litter is considered, the touristic beach of Platis Gyalos is the most affected by marine litter accumulation (average: 0.0169items/m²/day; 0.0031items/m²/day during the low season; 0.0238 items/m²/day during the high season), followed by the beach of Fokos, mainly used by locals (average: 0.0128 items/m²/day; 0.0011 items/m²/day during the low season; 0.0186 items/m²/day during the high season) and the remote beach of Merchia (average: 0.0028 items/m²/day; 0.0010 items/m²/day during the low season; 0.0037 items/m²/day during the high season). The 3 beaches presented recognizable seasonal variations with a relative increase of the accumulation rates of 665% (Platis Gyalos), 1574% (Fokos) and 283% (Merchia) during the high season with respect to the low season.

- The items collected are mainly composed of artificial polymer materials: they represent 77.83% (Platis Gyalos), 71.31% (Fokos) and 75.52% (Merchia) of the total marine litter items collected.
- On the touristic beach of Platis Gyalos, 9 items (cigarette butts, caps/lids, crisp/sweet packets and lolly sticks, bottle caps, food containers, corks, drink bottles, cutlery/trays/straws and ice lolly sticks/chip forks), most likely related to tourism and recreational activities, are representing 62.26% of the total marine litter items collected. To this, can possibly be added 1 item (macroplastics), accounting for additional 5.04% as they presented a recognizable seasonal variation.
- On the beach of Fokos, mainly used by locals, 10 items (cigarette butts, caps/lids, bottle caps, food containers, ice lolly sticks/chip forks, cutlery/trays/straws, cigarette packets, drink cans, cups and crisp/sweet packets and lolly sticks), most likely related to tourism and recreational activities, are representing 67.20% of the total marine litter items collected.
- On the remote beach of Merchia, 9 items (cigarette butts, caps/lids, bottle caps, crisp/sweet packets and lolly sticks, cups, cigarette packets, cutlery/trays/straws, food containers and drink bottles), most likely related to tourism and recreational activities, are representing 64.31% of the total marine litter items collected. To this, can possibly be added 1 item (plastic bag ends), accounting for additional 3.99% as they presented a recognizable seasonal variation.
- The cleanliness of the beaches is considered as very clean/very clean for the low/high season in Platis Gyalos (Clean-Coast Index of 1.8/1.4), very clean/very clean for the low/high season in Fokos (CCI of 0.7/0.5) and very clean/very clean for the low/high season in Merchia (CCI of 0.9/0.9).
- Finally the accumulation index of the beaches is considered as moderate/high for the low/high season in Platis Gyalos (Accumulation Index of 3.49/4.38), moderate/high for the low/high season in Fokos (AI of 3.05/4.27) and low/moderate for the low/high season in Merchia (AI of 2.99/3.57).

VII. Rhodes

1. Touristic beach: Tsampika

a) Characteristics of the beach

The touristic beach of Tsampika is a semi-urban beach, located in the municipality of Archangelos in the central western side of Rhodes, facing the sea to the SW. It has a total length of $\pm 1200\text{m}$, a width of $\pm 30\text{m}$ and is composed at 95% of sand and 5% of pebbles with a smooth slope of 1%. The monitored fixed portion of the beach has a surface of 2813 m^2 . The beach is mainly used for recreational activities during the high season (swimming and sunbathing). It is accessible by vehicles/boats and for pedestrians. The area situated directly behind the beach, has many services and facilities provided to the beach users. The coordinates of the fixed 100m portion selected for the monitoring are: 36.2276N, 27.1478E (starting point) and 36.2283N, 27.1483E (ending point) (Fig. D.VII.1-1). Drink and food outlets are situated directly on the beach and the closest harbor is situated 28 km away to the north. The beach is cleaned annually by the local authorities.



Figure D.VII.1-1: location map showing the beach of Tsampika and the selected 100m portion of beach monitored (red area).

b) Seasonality of the marine litter

The touristic beach of Tsampika was sampled for marine litter in February, May, June, July, August, September and November of 2017. A total of 1792 items (corrected for distance, see Part B.III.2.a) were collected on the same 100m portion of beach during the 7 monitoring, representing an average of 255.9 items (± 53.5 items, $n=7$) per survey. The lowest number of items was recorded in May (160 items) while the highest number was recorded in June (310 items) (Fig. D.VII.1-2a). In general, the amount of marine litter collected during each survey is quite stable from February to November, with slightly lower values in May and September. A seeming seasonal pattern was visible (Fig. D.VII.1-2a). When only the number of items collected is considered (Fig. D.VII.1-2b), their average number per survey during the low season (October – April) was of 279.9 (± 2.9 items, $n=2$) and of 246.3 (± 62.4 items, $n=5$) during the high season (May – September). Then, the amount of marine litter collected per survey during the high season was on average 12.0% lower than during the low touristic season (Fig. D.VII.1-2b). When the accumulation rates (see Part B.III.2.b) are considered, a clear seasonal pattern can be observed (Fig. D.VII.1-2c). The lowest value observed was of 0.0003 items/m²/day (341 items/km²/day) in February and the highest was of 0.0044 items/m²/day (4374 items/km²/day) in August (Fig. D.VII.1-2c). The seasonal pattern of the marine litter seems to follow the monthly number of tourists welcomed on Rhodes (Fig. D.VII.1-2c): higher accumulation rates are observed during the touristic season and lower accumulation rates are observed during the off season. During the low season, the average accumulation rate is of 0.0009 items/m²/day (± 0.0006 , $n=2$) and of 0.0032 items/m²/day (± 0.0014 , $n=5$) during the high season. These results show that, on average the accumulation rates of the marine litter are much higher during the high season (+256%, Fig. D.VII.1-2d) than during the low season.

Finally, the beach of Tsampika can be considered as very clean during both the low and high seasons, according to the Clean-Coast Index (see Part B.III.2.d) exhibiting values of respectively 1.9 and 1.7 (Fig. C.II-4a). The accumulation index shows that the accumulation of marine litter can be considered as low during the low season (AI=2.96) and moderate during the high season (AI=3.51) (Fig. C.II-4b).

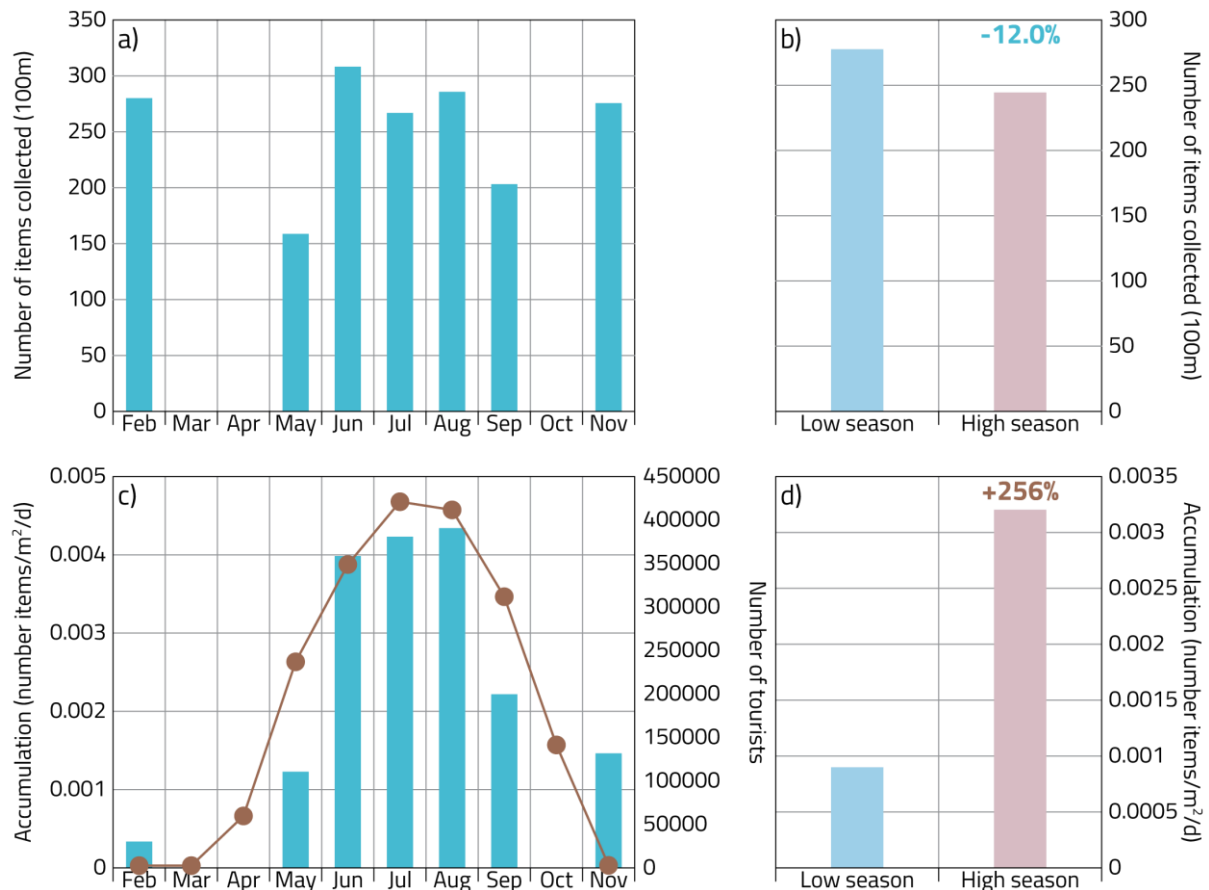


Figure D.VII.1-2: total number and accumulations rates of items collected at the beach of Tsampika. a) number of items collected during each survey on the fixed 100m portion of beach; b) comparison of the average number of items collected per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (blue font) refers to the decrease with respect to the low season; c) accumulation rates of the marine litter (left axis, blue bars) and the monthly number of tourists²³ in Rhodes (right axis, brown line and dots); and d) comparison of the accumulation rates of marine litter per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season.

c) Composition of the marine litter

The marine litter collected on the beach of Tsampika (Fig. D.VII.1-3) was classified into 8 major categories of material type (see Part B.III.2.c). It is largely dominated by the artificial polymer materials (average=86.14% \pm 4.08; min=82.33% in August and max=92.78% in February), followed by the metal (average=4.64% \pm 3.02; min=1.08% in February and max=10.19% in May), the paper/cardboard (average=4.02% \pm 2.55; min=0.72% in February and max=8.33% in July), the unidentified and/or chemicals (average=3.11% \pm 4.25; min=0.00% in June and max=11.72% in November), the glass/ceramics (average=1.12% \pm 0.86; min=0.38% in July and max=2.89% in February), the rubber (average=0.52% \pm 0.55; min=0.00% in September and max=1.44% in February) and the cloth/textile (average=0.46% \pm 0.48; min=0.00% in November and max=1.08% in February).

During the low season (Fig. D.VII.1-3), the marine litter is largely dominated by the artificial polymer materials (87.96%), followed by the unidentified and/or chemicals (5.86%), the glass/ceramics (1.81%), the metal (1.46%), the paper/cardboard (1.28%), the rubber (1.09%) and the cloth/textile (0.54%).

During the high season (Fig. D.VII.1-3), the marine litter is largely dominated by the artificial polymer materials (85.41%), followed by the metal (5.91%), the paper/cardboard (5.12%), the unidentified

²³ Data source: International tourists arrivals at main greek airports – Rhodes – for 2014.

and/or chemicals (2.01%), the glass/ceramics (0.84), the cloth/textile (0.42%) and the rubber (0.29%).

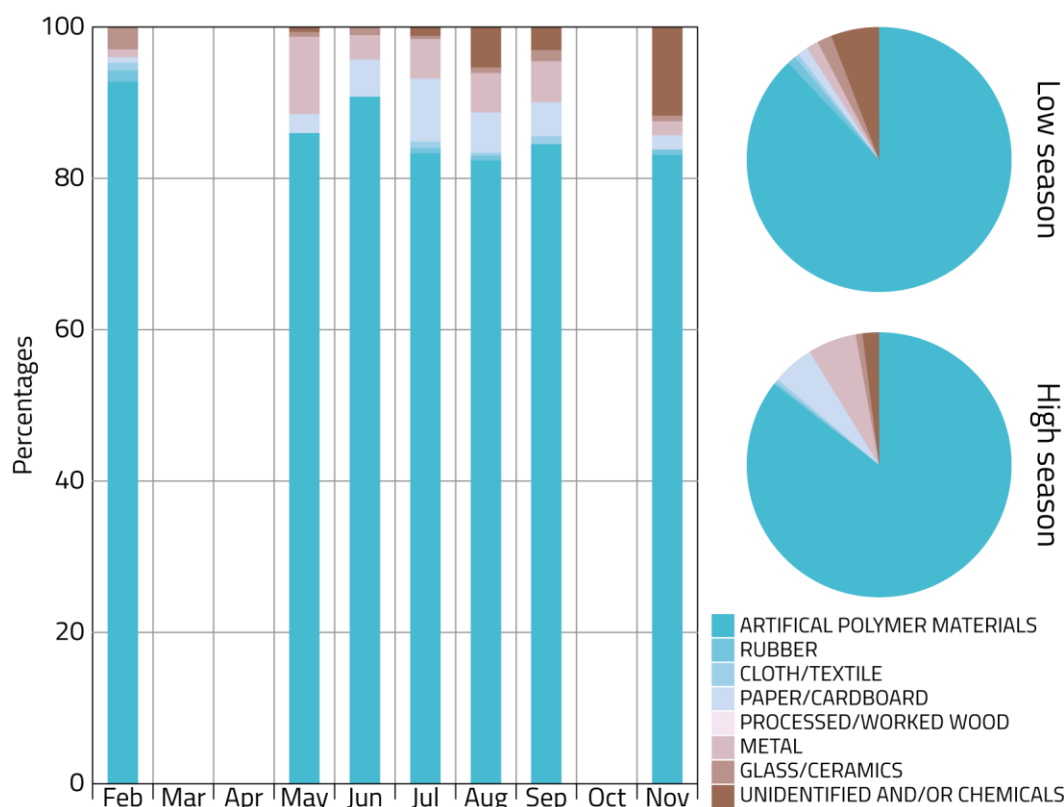


Figure D.VII.1-3: composition of the marine litter collected at the beach of Tsampika. Left: histogram showing the monthly percentages of the 8 major categories of material type. Right: pie charts showing the average composition of the marine litter during the low (top) and high (bottom) seasons. The color scale (lower right) indicates the type of material.

d) The 10 items with the highest accumulation rates

In this section, we consider the items with the highest averaged accumulation rates, which are not necessarily the most abundant items collected during the marine litter monitoring performed on the beach of Tsampika (Fig. D.VII.1-4). These items account for 81.31% of the total marine litter items (1792) collected in 2017. They are dominated by the cigarette butts (0.0007 items/m²/day; 21.19% of the total marine litter items collected), followed by the mesoplastics (0.0006 items/m²/day; 27.27% of the total marine litter items collected), the caps/lids (0.0003 items/m²/day; 12.67% of the total marine litter items collected), the drink bottles, containers and drums (0.0001 items/m²/day; 4.72% of the total marine litter items collected), the others pollutants (0.0001 items/m²/day; 3.24% of the total marine litter items collected), the food containers (e.g. fast food containers) (0.0001 items/m²/day; 2.95% of the total marine litter items collected), the drink cans (0.0001 items/m²/day; 2.33% of the total marine litter items collected), the microplastics (0.0001 items/m²/day; 3.81% of the total marine litter items collected), the cigarette lighters (0.0001 items/m²/day; 1.65% of the total marine litter items collected) and the cups (0.00004 items/m²/day; 1.48% of the total marine litter items collected). In this top 10, the artificial polymer materials largely dominate as they are represented by 8 items, accounting for 75.74% of the total marine litter items collected.

In this top 10, 7 items (cigarette butts, caps/lids, drink bottles, food containers, drink cans, cigarette lighters and cups) accounting for 46.99% of the total marine litter items collected, can be attributed to the shoreline source, including poor waste management practices, tourism and recreational activities (see Part B.III.2.c). To this, can possibly be added 1 item (mesoplastics) presenting a clear seasonal

pattern (see Appendix, Fig. E.VIII-1) and accounting for additional 27.27% of the total marine litter items collected.

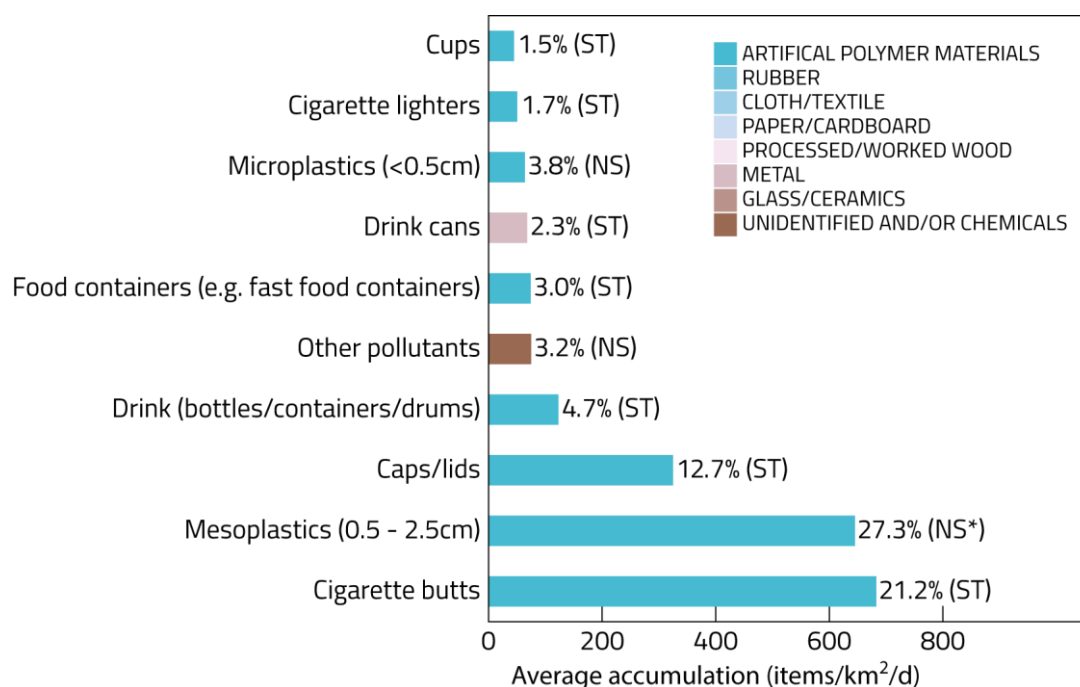


Figure D.VII.1-4: list of the 10 items with the highest accumulation rates collected at the beach of Tsampika. The percentages next to each item refers to their relative abundance with respect to the total collected. The possible source of the items is given into parenthesis: ST=shoreline, including poor waste management, tourism and recreational activities and NS=non-sourced. The asterisk (*) associated to the non-sourced items (NS) shows that this specific item presents a clear seasonal increase. The color scale (upper right) indicates the type of material.

2. Beach mainly used by locals: Afandou

a) Characteristics of the beach

The beach of Afandou was selected as it is a popular beach mainly used by locals. It is a semi-rural beach, located in the municipality of Afandou in the central western side of Rhodes, facing the sea to the SW. It has a total length of $\pm 6200\text{m}$, a width of $\pm 15\text{m}$ and is composed at 60% of pebbles and 40% of sand with a smooth slope of 2%. The monitored fixed portion of the beach has a surface of 2049m^2 . The beach is mainly used for recreational activities during the high season (swimming, sunbathing and local people) and the low season (local people, fishing). It is accessible by vehicles/boats and for pedestrians. In the area situated directly behind the beach, no services and facilities provided to the beach users are found. The coordinates of the fixed 100m portion selected for the monitoring are: 36.2728N, 28.1700E (starting point) and 36.2736N, 28.1705E (ending point) (Fig. D.VII.2-1). Drink and food outlets are situated directly on the beach and the closest harbor is situated 2 km away to the east. The beach is cleaned annually by the local authorities.



Figure D.VII.2-1: location map showing the beach of Afandou and the selected 100m portion of beach monitored (red area).

b) Seasonality of the marine litter

The beach of Afandou, mainly used by locals, was sampled for marine litter in February, May, June, July, August, September and November of 2017. A total of 1292 items (corrected for distance, see Part B.III.2.a) were collected on the same 100m portion of beach during the 7 monitoring, representing an average of 184.6 items (± 48.7 items, $n=7$) per survey. The lowest number of items was recorded in November (117 items) while the highest number was recorded in August (255 items) (Fig. D.VII.2-2a). In general, the amount of marine litter collected during each survey decreases from February to November with 2 increases in June and August. No seasonal pattern was visible (Fig. D.VII.2-2a). When only the number of items collected is considered (Fig. D.VII.2-2b), their average number per survey during the low season (October – April) was of 161.1 (± 61.9 items, $n=2$) and of 194.1 (± 47.0 items, $n=5$) during the high season (May – September). Then, the amount of marine litter collected per survey during the high season was on average 20.5% higher than during the low touristic season (Fig. D.VII.2-2b). When the accumulation rates (see Part B.III.2.b) are considered, a clear seasonal pattern can be observed (Fig. D.VII.2-2c), despite the decrease recorded in July. The lowest value observed was of 0.0003 items/m²/day (348 items/km²/day) in February and the highest was of 0.0054 items/m²/day (5432 items/km²/day) in August (Fig. D.VII.2-2c). The seasonal pattern of the marine litter seems to follow the monthly number of tourists welcomed on Rhodes (Fig. D.VII.2-2c): higher accumulation rates are observed during the touristic season and lower accumulation rates are observed during the off season. During the low season, the average accumulation rate is of 0.0006 items/m²/day (± 0.0004 , $n=2$) and of 0.0032 items/m²/day (± 0.0018 , $n=5$) during the high season. These results show that, on average the accumulation rates of the marine litter are much higher during the high season (+420%, Fig. D.VII.2-2d) than during the low season.

Finally, the beach of Afandou can be considered as very clean during both the low and high seasons, according to the Clean-Coast Index (see Part B.III.2.d) exhibiting of respectively 1.6 and 1.9 (Fig. C.III-4a). The accumulation index shows that the accumulation of the marine litter can be considered as low during the low season (AI=2.80) and moderate during the high season (AI=3.51) (Fig. C.III-4b).

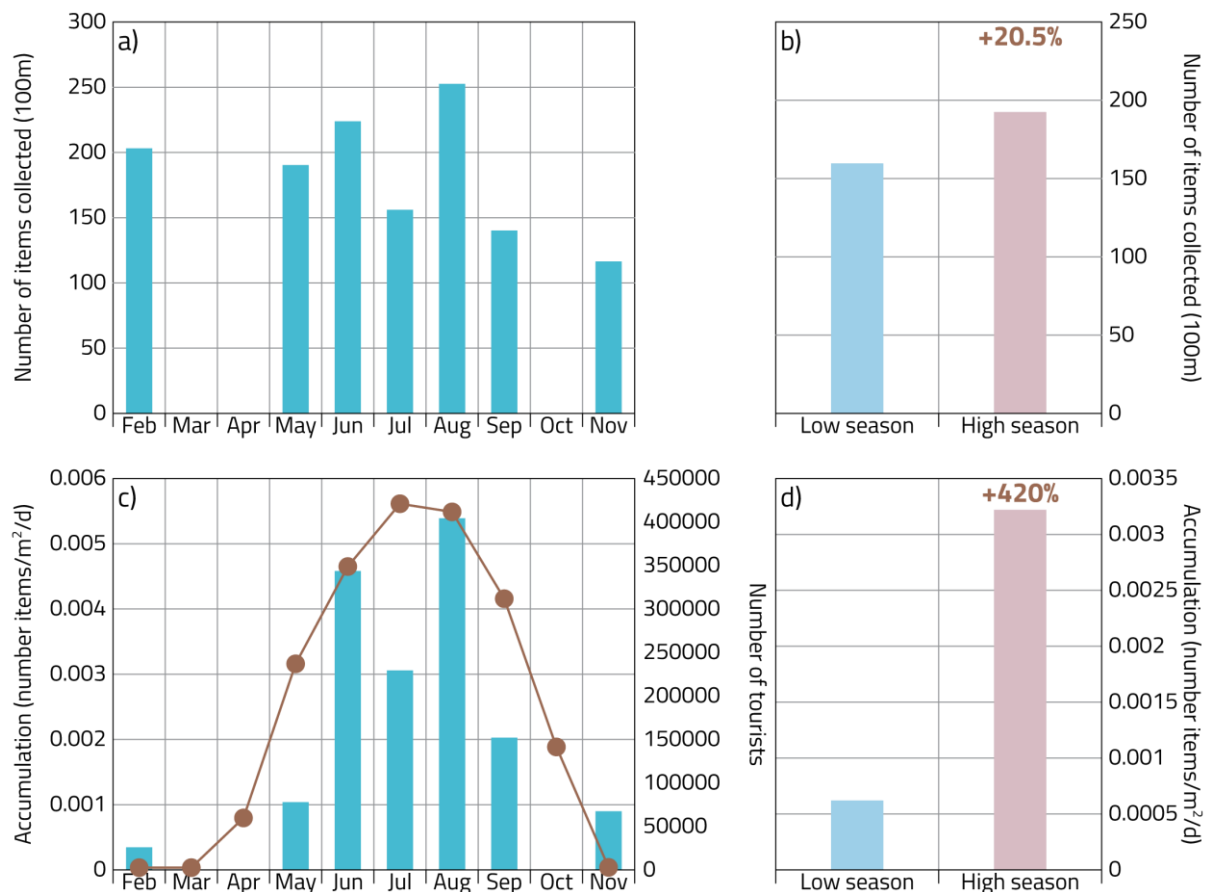


Figure D.VII.2-2: total number and accumulations rates of items collected at the beach of Afandou. a) number of items collected during each survey on the fixed 100m portion of beach; b) comparison of the average number of items collected per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season; c) accumulation rates of the marine litter (left axis, blue bars) and the monthly number of tourists²⁴ in Rhodes (right axis, brown line and dots); and d) comparison of the accumulation rates of marine litter per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season.

c) Composition of the marine litter

The marine litter collected on the beach of Afandou (Fig. D.VII.2-3) was classified into 8 major categories of material type (see Part B.III.2.c). It is largely dominated by the artificial polymer materials (average=84.94% \pm 4.10; min=76.76% in September and max=89.12% in May), followed by the metal (average=6.15% \pm 2.58; min=2.07% in May and max=10.56% in September), the paper/cardboard (average=5.03% \pm 2.70; min=0.49% in February and max=9.15% in September), the glass/ceramics (average=1.28% \pm 0.92; min=0.00% in June and max=2.11% in September), the unidentified and/or chemicals (average=1.25% \pm 2.07; min=0.00% in November and max=5.18% in May), the cloth/textile (average=0.77% \pm 0.67; min=0.00% in June and max=1.69% in November) and the rubber (average=0.58% \pm 0.94; min=0.00% in November and max=2.43% in February).

During the low season (Fig. D.VII.2-3), the marine litter is largely dominated by the artificial polymer materials (86.79%), followed by the metal (5.21%), the paper/cardboard (3.63%), the glass/ceramics (1.82%), the rubber (1.21%), the cloth/textile (1.09%) and the unidentified and/or chemicals (0.24%). During the high season (Fig. D.VII.2-3), the marine litter is largely dominated by the artificial polymer materials (84.19%), followed by the metal (6.53%), the paper/cardboard (5.58%), the unidentified

²⁴ Data source: International tourists arrivals at main greek airports – Rhodes – for 2014.

and/or chemicals (1.65%), the glass/ceramics (1.07%), the cloth/textile (0.64%) and the rubber (0.33%).

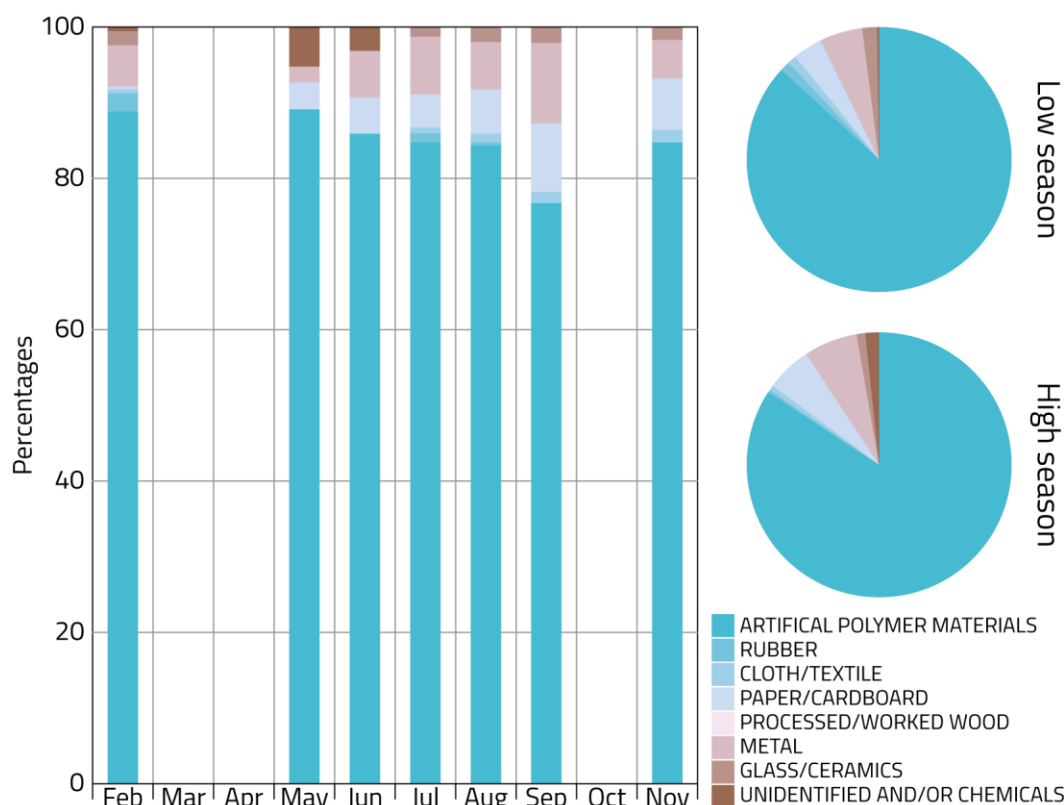


Figure D.VII.2-3: composition of the marine litter collected at the beach of Afandou. Left: histogram showing the monthly percentages of the 8 major categories of material type. Right: pie charts showing the average composition of the marine litter during the low (top) and high (bottom) seasons. The color scale (lower right) indicates the type of material.

d) The 10 items with the highest accumulation rates

In this section, we consider the items with the highest averaged accumulation rates, which are not necessarily the most abundant items collected during the marine litter monitoring performed on the beach of Afandou (Fig. D.VII.2-4). These items account for 78.08% of the total marine litter items (1292) collected in 2017. They are dominated by the mesoplastics (0.0007 items/m²/day; 30.15% of the total marine litter items collected), followed by the drink bottles, containers and drums (0.0005 items/m²/day; 15.23% of the total marine litter items collected), the caps/lids (0.0003 items/m²/day; 9% of the total marine litter items collected), the cigarette butts (0.0002 items/m²/day; 8.23% of the total marine litter items collected), the drink cans (0.0001 items/m²/day; 3.15% of the total marine litter items collected), the food containers (e.g. fast food containers) (0.0001 items/m²/day; 2.31% of the total marine litter items collected), the cups (0.0001 items/m²/day; 2.69% of the total marine litter items collected), the microplastics (0.0001 items/m²/day; 3.92% of the total marine litter items collected), the food cans (0.0001 items/m²/day; 1.92% of the total marine litter items collected) and the cartons e.g., tetrapack (0 items/m²/day; 1.46% of the total marine litter items collected).

In this top 10, the artificial polymer materials largely dominate as they are represented by 7 items, accounting for 71.54% of the total marine litter items collected.

In this top 10, 8 items (drink bottles, caps/lids, cigarette butts, drink cans, food containers, cups, food cans and cartons e.g. tetrapack) accounting for 78.06% of the total marine litter items collected, can be attributed to the shoreline source, including poor waste management practices, tourism and

recreational activities (see Part B.III.2.c). To this, can possibly be added 2 items (mesoplastics and microplastics) presenting a clear seasonal pattern (see Appendix, Fig. E.VIII-2) and accounting for additional 34.07% of the total marine litter items collected.

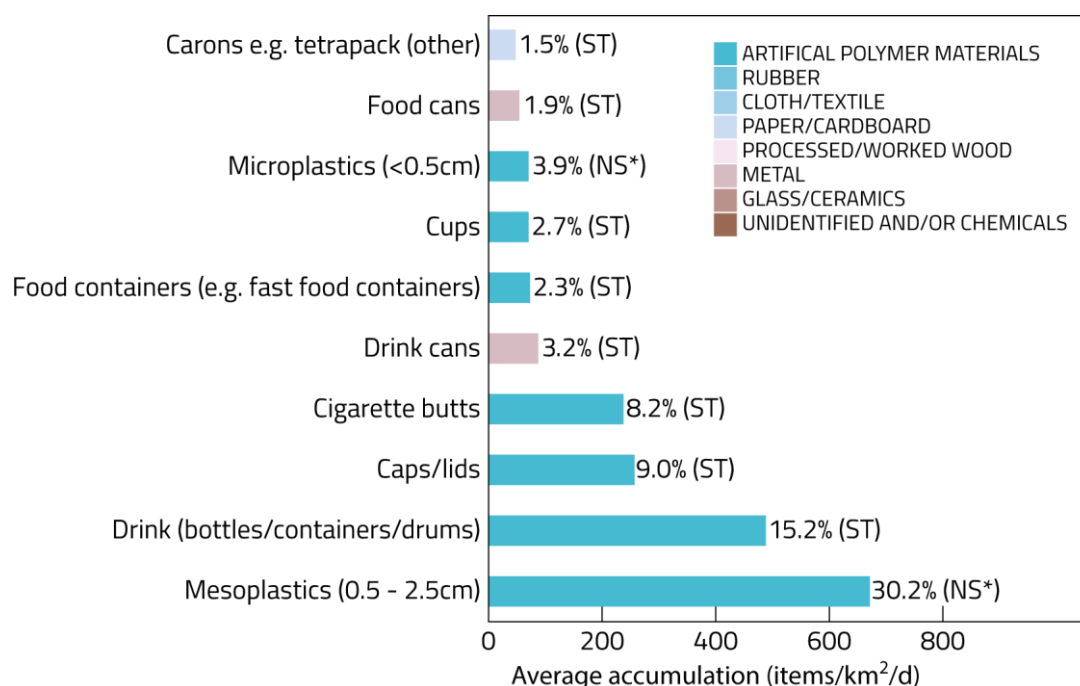


Figure D.VII.2-: list of the 10 items with the highest accumulation rates collected at the beach of Afandou. The percentages next to each item refers to their relative abundance with respect to the total collected. The possible source of the items is given into parenthesis: ST=shoreline, including poor waste management, tourism and recreational activities and NS=non-sourced. The asterisk (*) associated to the non-sourced items (NS) shows that this specific item presents a clear seasonal increase. The color scale (upper right) indicates the type of material.

3. Remote beach: Gennadi

a) Characteristics of the beach

The remote beach of Gennadi is a semi-rural beach, located in the municipality of Gennadi in the south eastern side of Rhodes, facing the sea to the SW. It has a total length of ± 10 km, a width of ± 40 m and is composed at 60% of sand and 40% of pebbles with a smooth slope of 2%. The monitored fixed portion of the beach has a surface of 3998 m². The beach is mainly used for recreational activities during the high season (swimming and sunbathing) and the low season (fishing). It is accessible by vehicles/boats and for pedestrians. The area situated directly behind the beach is a semi-rural area with very limited services and facilities provided to the beach users. The coordinates of the fixed 100m portion selected for the monitoring are: 36.0252N, 27.9334E (starting point) and 36.0259N, 27.9339E (ending point) (Fig. D.VII.3-1). Drink and food outlets are situated directly on the beach and the closest harbor is situated 2 km away to the east. The beach is cleaned annually by the local authorities.



Figure D.VII.3-1: location map showing the beach of Gennadi and the selected 100m portion of beach monitored (red area).

b) Seasonality of the marine litter

The remote beach of Gennadi was sampled for marine litter in March, May, June, July, August, September and November of 2017. A total of 557 items (corrected for distance, see Part B.III.2.a) were collected on the same 100m portion of beach during the 7 monitoring, representing an average of 79.6 items (± 42.1 items, $n=7$) per survey. The lowest number of items was recorded in May (29 items) while the highest number was recorded in June (151 items) (Fig. D.VII.3-2a). In general, the amount of marine litter collected during each survey is quite variable from March to November. No clear seasonal pattern was visible (Fig. D.VII.3-2a). When only the number of items collected is considered (Fig. D.VII.3-2b), their average number per survey during the low season (October – April) was of 69.2 (± 28.6 items, $n=2$) and of 83.7 (± 48.8 items, $n=5$) during the high season (May – September). Then, the amount of marine litter collected per survey during the high season was on average 20.9% higher than during the low touristic season (Fig. D.VII.3-2b). When the accumulation rates (see Part B.III.2.b) are considered, a clear seasonal pattern can be observed (Fig. D.VII.3-2c), despite the decrease recorded in July. The lowest value observed was of 0.0001 items/m²/day (69 items/km²/day) in March and the highest was of 0.0012 items/m²/day (1225 items/km²/day) in June (Fig. D.VII.3-2c). The seasonal pattern of the marine litter seems to follow the monthly number of tourists welcomed on Rhodes (Fig. D.VII.3-2c): higher accumulation rates are observed during the touristic season and lower accumulation rates are observed during the off season. During the low season, the average accumulation rate is of 0.0001 items/m²/day (± 0.0001 , $n=2$) and of 0.0007 items/m²/day (± 0.0005 , $n=5$) during the high season. These results show that, on average the accumulation rates of the marine litter are much higher during the high season (+464%, Fig. D.VII.3-2d) than during the low season.

Finally, the beach of Gennadi can be considered as very clean during both the low and high seasons, according to the Clean-Coast Index (see Part B.III.2.d) exhibiting values of respectively 0.3 and 0.4 (Fig. C.IV-4a). The accumulation index shows that the accumulation of marine litter can be considered as low for both the low and high seasons (AI=2.08 and 2.83) (Fig. C.IV-4b).

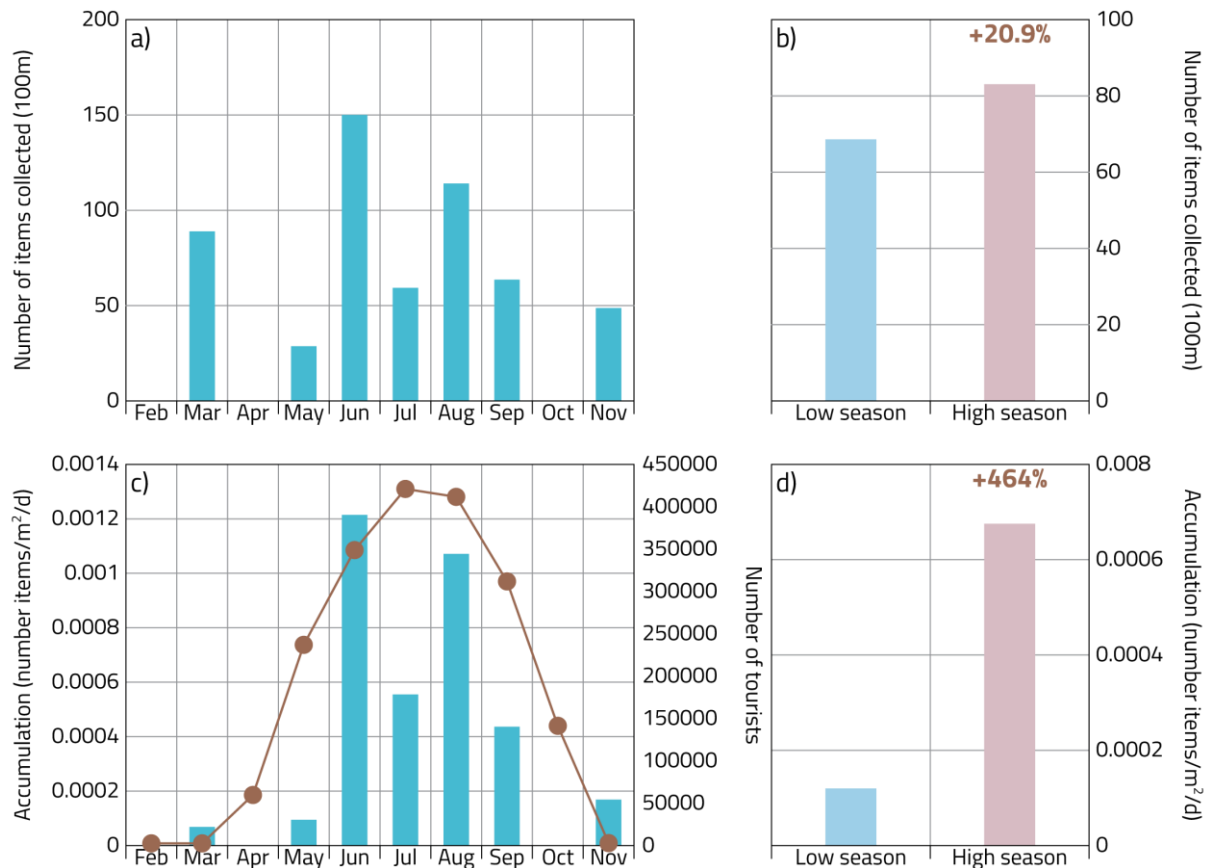


Figure D.VII.3-2: total number and accumulations rates of items collected at the beach of Gennadi. a) number of items collected during each survey on the fixed 100m portion of beach; b) comparison of the average number of items collected per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season; c) accumulation rates of the marine litter (left axis, blue bars) and the monthly number of tourists²⁵ in Rhodes (right axis, brown line and dots); and d) comparison of the accumulation rates of marine litter per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season.

c) Composition of the marine litter

The marine litter collected on the beach of Gennadi (Fig. D.VII.3-3) was classified into 8 major categories of material type (see Part B.III.2.c). It is largely dominated by the artificial polymer materials (average=83.16% \pm 5.01; min=78.57% in March and max=93.66% in June), followed by the paper/cardboard (average=6.09% \pm 4.96; min=1.41% in June and max=14.81% in May), the metal (average=4.02% \pm 3.71; min=0.00% in May and max=10.71% in July), the glass/ceramics (average=3.45% \pm 1.70; min=0.00% in June and max=5.00% in September), the rubber (average=1.46% \pm 2.33; min=0.00% in November and max=5.95% in March), the unidentified and/or chemicals (average=1.25% \pm 2.32; min=0.00% in November and max=5.95% in March) and the cloth/textile (average=0.58% \pm 0.99; min=0.00% in September and max=2.17% in November).

During the low season (Fig. D.VII.3-3), the marine litter is dominated by the artificial polymer materials (79.50%), followed by the paper/cardboard (6.63%), the glass/ceramics (4.55%), the rubber (2.98%), the unidentified and/or chemicals (2.98%), the metal (2.28%) and the cloth/textile (1.09%).

During the high season (Fig. D.VII.3-3), the marine litter is largely dominated by the artificial polymer materials (84.62%), followed by the paper/cardboard (5.87%), the metal (4.71%), the glass/ceramics (3.01%), the rubber (0.85%), the unidentified and/or chemicals (0.56%) and the cloth/textile (0.37%).

²⁵ Data source: International tourists arrivals at main greek airports – Rhodes – for 2014.

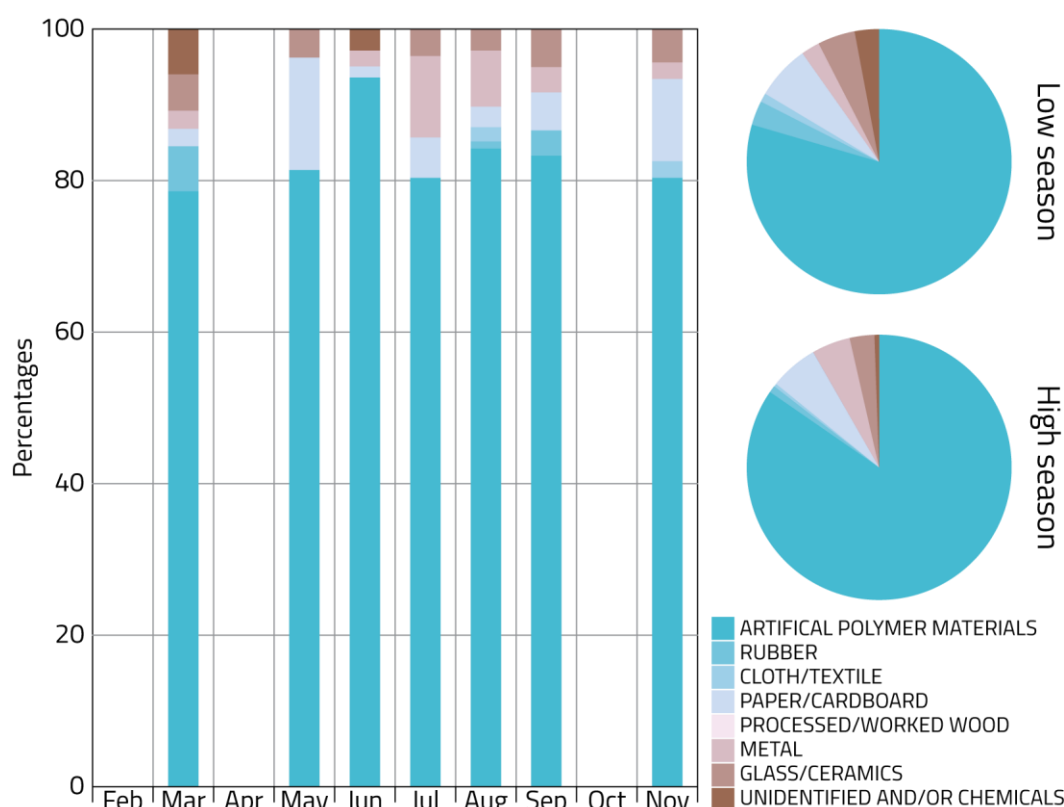


Figure D.VII.3-3: composition of the marine litter collected at the beach of Gennadi. Left: histogram showing the monthly percentages of the 8 major categories of material type. Right: pie charts showing the average composition of the marine litter during the low (top) and high (bottom) seasons. The color scale (lower right) indicates the type of material.

d) The 10 items with the highest accumulation rates

In this section, we consider the items with the highest averaged accumulation rates, which are not necessarily the most abundant items collected during the marine litter monitoring performed on the beach of Gennadi (Fig. D.VII.3-4). These items account for 79.35% of the total marine litter items (557) collected in 2017. They are dominated by the mesoplastics (0.0002 items/m²/day; 37.48% of the total marine litter items collected), followed by the cigarette butts (0.0001 items/m²/day; 15.87% of the total marine litter items collected), the caps/lids (0.00004 items/m²/day; 9.56% of the total marine litter items collected), the microplastics (0.00002 items/m²/day; 3.25% of the total marine litter items collected), the small plastic bags, e.g., freezer bags (0.00002 items/m²/day; 3.25% of the total marine litter items collected), the cigarette packets (0.00001 items/m²/day; 2.68% of the total marine litter items collected), the drink cans (0.00001 items/m²/day; 1.72% of the total marine litter items collected), the food cans (0.00001 items/m²/day; 1.53% of the total marine litter items collected), the bottles (0.00001 items/m²/day; 2.49% of the total marine litter items collected) and the pellets (0.00001 items/m²/day; 1.53% of the total marine litter items collected).

In this top 10, the artificial polymer materials largely dominate as they are represented by 6 items, accounting for 70.94% of the total marine litter items collected.

In this top 10, 7 items (cigarette butts, caps/lids, small plastic bags, cigarette packets, drink cans, food cans and glass bottles) accounting for 37.1% of the total marine litter items collected, can be attributed to the shoreline source, including poor waste management practices, tourism and recreational activities (see Part B.III.2.c). To this, can possibly be added 2 items (mesoplastics and microplastics) presenting a clear seasonal pattern (see Appendix, Fig. E.VIII-3) and accounting for additional 40.73% of the total marine litter items collected.

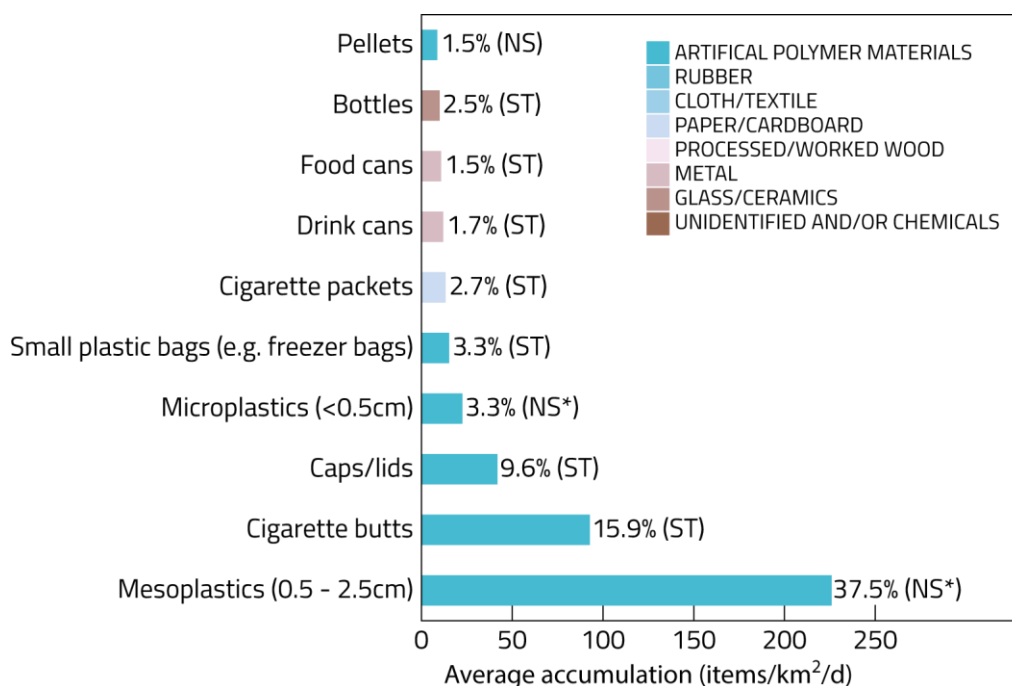


Figure D.VII.3-4: list of the 10 items with the highest accumulation rates collected at the beach of Gennadi. The percentages next to each item refers to their relative abundance with respect to the total collected. The possible source of the items is given into parenthesis: ST=shoreline, including poor waste management, tourism and recreational activities and NS=non-sourced. The asterisk (*) associated to the non-sourced items (NS) shows that this specific item presents a clear seasonal increase. The color scale (upper right) indicates the type of material.

4. Summary

The 21 marine litter surveys conducted in Rhodes in 2017 have revealed that:

- If only the number of items collected is considered, the touristic beach of Tsampika is the most affected by the marine litter (1792 items collected; average: 255.9 items/survey; 279.9 items/survey during the low season; 246.3 items/survey during the high season), followed by the beach of Afandou, mainly used by locals (1292 items collected; average: 184.6 items/survey; 161.1 items/survey during the low season; 194.1 items/survey during the high season) and the remote beach of Gennadi (557 items collected; average: 79.6 items/survey; 69.2 items/survey during the low season; 83.7 items/survey during the high season). For the 3 beaches, no seasonal variability was observed from the number of items collected.
- If the accumulation rate of the marine litter is considered, the touristic beach of Tsampika is the most affected by marine litter accumulation (average: 0.0026 items/m²/day; 0.0009 items/m²/day during the low season; 0.0032 items/m²/day during the high season), followed by the beach of Afandou, mainly used by locals (average: 0.0025 items/m²/day; 0.0006 items/m²/day during the low season; 0.0032 items/m²/day during the high season) and the remote beach of Gennadi (average: 0.0005 items/m²/day; 0.0001 items/m²/day during the low season; 0.0007 items/m²/day during the high season). The 3 beaches presented recognizable seasonal variations with a relative increase of the accumulation rates of 256% (Tsampika), 420% (Afandou) and 464% (Gennadi) during the high season with respect to the low season.
- The items collected are mainly composed of artificial polymer materials: they represent 86.14% (Tsampika), 84.94% (Afandou) and 83.16% (Gennadi) of the total marine litter items collected.
- On the touristic beach of Tsampika, 7 items (cigarette butts, caps/lids, drink bottles, food containers, drink cans, cigarette lighters and cups), most likely related to tourism and recreational

activities, are representing 46.99% of the total marine litter items collected. To this, can possibly be added 1 item (mesoplastics), accounting for additional 27.27% as they presented a recognizable seasonal variation.

- On the beach of Afandou, mainly used by locals, 8 items (drink bottles, caps/lids, cigarette butts, drink cans, food containers, cups, food cans and cartons e.g. tetrapack), most likely related to tourism and recreational activities, are representing 78.06% of the total marine litter items collected. To this, can possibly be added 2 items (mesoplastics and microplastics), accounting for additional 34.07% as they presented a recognizable seasonal variation.
- On the remote beach of Gennadi, 7 items (cigarette butts, caps/lids, small plastic bags, cigarette packets, drink cans, food cans and glass bottles), most likely related to tourism and recreational activities, are representing 37.1% of the total marine litter items collected. To this, can possibly added 2 items (mesoplastics and microplastics), accounting for additional 40.73% as they presented a recognizable seasonal variation.
- The cleanliness of the beaches is considered as very clean/very clean for the low/high season in Tsampika (Clean-Coast Index of 1.96/1.7), very clean/very clean for the low/high season in Afandou (CCI of 1.6/1.9) and very clean/very clean for the low/high season in Gennadi (CCI of 0.3/0.4).
- Finally the accumulation index of the beaches is considered as low/moderate for the low/high season in Tsampika (Accumulation Index of 2.96/3.51), low/moderate for the low/high season in Afandou (AI of 2.80/3.51) and low/low for the low/high season in Gennadi (AI of 2.08/2.83).

VIII. Cyprus

1. Touristic beach: Sunrise

a) Characteristics of the beach

The touristic beach of Sunrise is an urban beach, located in the municipality of Protaras in the south western side of Cyprus, facing the sea to the NE. It has a total length of $\pm 170\text{m}$, a width of $\pm 20\text{m}$ and is composed at 95% of sand and 5% of pebbles with a slope of 5%. The monitored fixed portion of the beach has a surface of 2157 m^2 . The beach is mainly used for recreational activities during the high season (swimming, sunbathing and local people). It is only accessible for pedestrians. The area situated directly behind the beach, has many services and facilities provided to the beach users. The coordinates of the fixed 100m portion selected for the monitoring are: 35.0159N, 34.0546E (starting point) and 35.0167N, 34.0540E (ending point) (Fig. D.VIII.1-1). The closest harbor is situated 3 km away to the north. The beach is cleaned 2 to 3 times per day during the high season.



Figure D.VIII.1-1: location map showing the beach of Sunrise and the selected 100m portion of beach monitored (red area).

b) Seasonality of the marine litter

The touristic beach of Sunrise was sampled for marine litter in March, May, June, July, August, September and November of 2017. A total of 5813 items (corrected for distance, see Part B.III.2.a) were collected on the same 100m portion of beach during the 7 monitoring, representing an average of 830.4 items (± 504.0 items, $n=7$) per survey. The lowest number of items was recorded in March (112 items) while the highest number was recorded in November (1588 items) (Fig. D.VIII.1-2a). In general, the amount of marine litter collected during each survey continuously increases from March to November with a sharp increase in May and a small decrease in September. A seeming seasonal pattern was visible (Fig. D.VIII.1-2a), although minimized by the high values recorded in November. When only the number of items collected is considered (Fig. D.VIII.1-2b), their average number per survey during the low season (October – April) was of 850.0 (± 1044.1 items, $n=2$) and of 822.6 (± 328.9 items, $n=5$) during the high season (May – September). Then, the amount of marine litter collected per survey during the high season was on average 3.2% lower than during the low touristic season (Fig. D.VIII.1-2b). When the accumulation rates (see Part B.III.2.b) are considered, a clear seasonal pattern can be observed (Fig. D.VIII.1-2c). The lowest value observed was of 0.0030 items/m²/day (3000 items/km²/day) in March and the highest was of 0.1840 items/m²/day (183967 items/km²/day) in June (Fig. D.VIII.1-2c). The clear seasonal pattern of the marine litter seems to follow the monthly number of tourists welcomed on Cyprus (Fig. D.VIII.1-2c): higher accumulation rates are observed during the touristic season and lower accumulation rates are observed during the off season. During the low season, the average accumulation rate is of 0.1223 items/m²/day (± 0.1078 , $n=2$) and of 0.3136 items/m²/day (± 0.0847 , $n=5$) during the high season. These results show that, on average the accumulation rates of the marine litter are higher during the high season (+156%, Fig. D.VIII.1-2d) than during the low season.

Finally, the beach of Sunrise can be considered as moderately clean during both the low and high seasons, according to the Clean-Coast Index (see Part B.III.2.d) exhibiting values of respectively 7.8 and 7.5 (Fig. C.II-4a). The accumulation index shows that the accumulation of marine litter can be considered as very high during both the low and high seasons (AI=5.09 and 5.50) (Fig. C.II-4b).

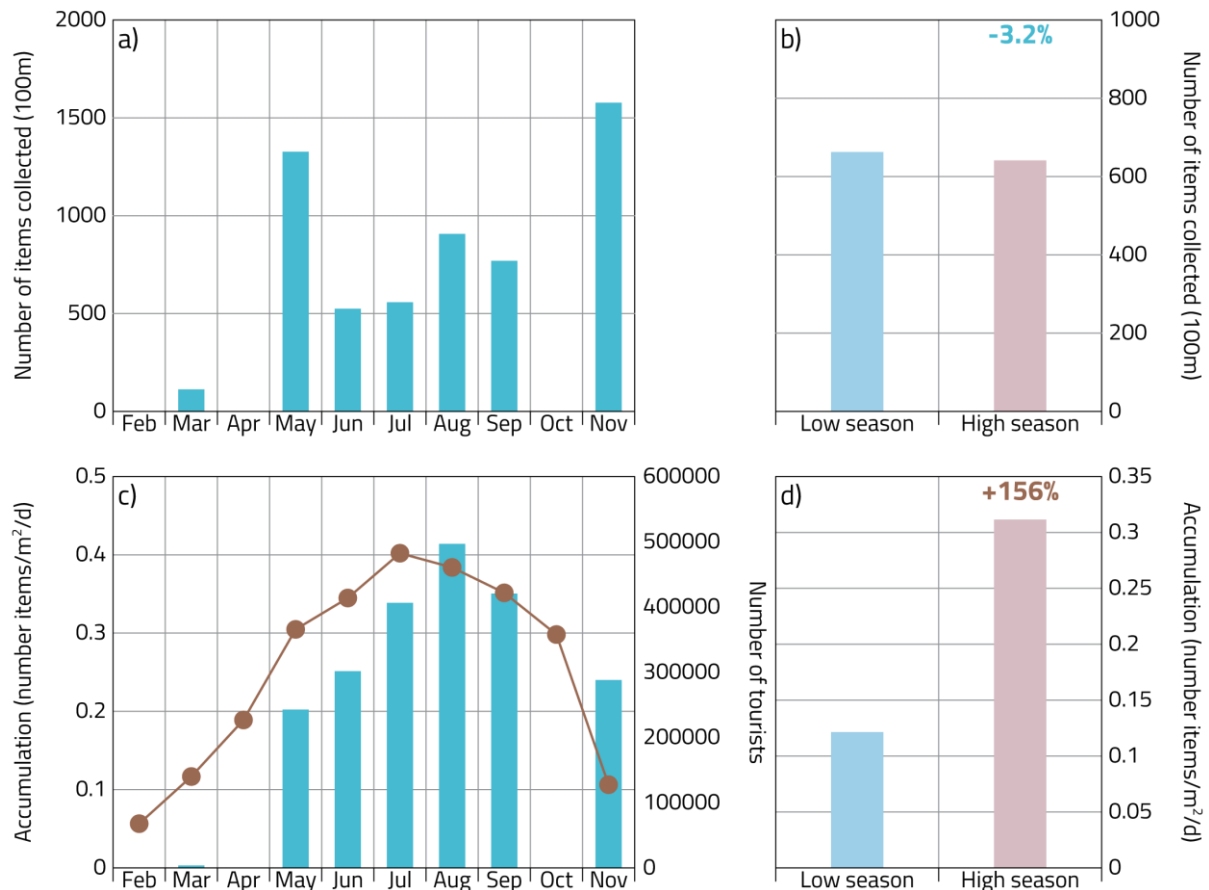


Figure D.VIII.1-2: total number and accumulations rates of items collected at the beach of Sunrise. a) number of items collected during each survey on the fixed 100m portion of beach; b) comparison of the average number of items collected per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (blue font) refers to the decrease with respect to the low season; c) accumulation rates of the marine litter (left axis, blue bars) and the monthly number of tourists²⁶ in Cyprus (right axis, brown line and dots); and d) comparison of the accumulation rates of marine litter per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season.

c) Composition of the marine litter

The marine litter collected on the beach of Sunrise (Fig. D.VIII.1-3) was classified into 8 major categories of material type (see Part B.III.2.c). It is largely dominated by the artificial polymer materials (average=93.22% \pm 6.19; min=80.00% in March and max=98.22% in August), followed by the unidentified and/or chemicals (average=2.45% \pm 4.95; min=0.00% in June and max=13.64% in March), the paper/cardboard (average=1.75% \pm 1.07; min=0.67% in August and max=3.15% in September), the metal (average=1.23% \pm 0.83; min=0.33% in August and max=2.70% in June), the glass/ceramics (average=0.75% \pm 0.99; min=0.00% in September and max=2.73% in March), the processed/worked wood (average=0.26% \pm 0.36; min=0.00% in September and max=0.91% in March), the rubber (average=0.17% \pm 0.20; min=0.00% in July and max=0.58% in June) and the cloth/textile (average=0.16% \pm 0.21; min=0.00% in November and max=0.52% in September).

During the low season (Fig. D.VIII.1-3), the marine litter is largely dominated by the artificial polymer materials (88.91%), followed by the unidentified and/or chemicals (7.14%), the glass/ceramics (1.40%),

²⁶ Data source: arrivals of tourists by country of usual residence and month in 2016, http://www.cystat.gov.cy/mof/cystat/statistics.nsf/services_71main_en/services_71main_en?OpenForm&sub=1&sel=2#

the metal (1.13%), the paper/cardboard (0.87%), the processed/worked wood (0.52%) and the rubber (0.03%).

During the high season (Fig. D.VIII.1-3), the marine litter is largely dominated by the artificial polymer materials (94.94%), followed by the paper/cardboard (2.11%), the metal (1.27%), the unidentified and/or chemicals (0.58%), the glass/ceramics (0.50%), the rubber (0.22%), the cloth/textile (0.22%) and the processed/worked wood (0.16%).

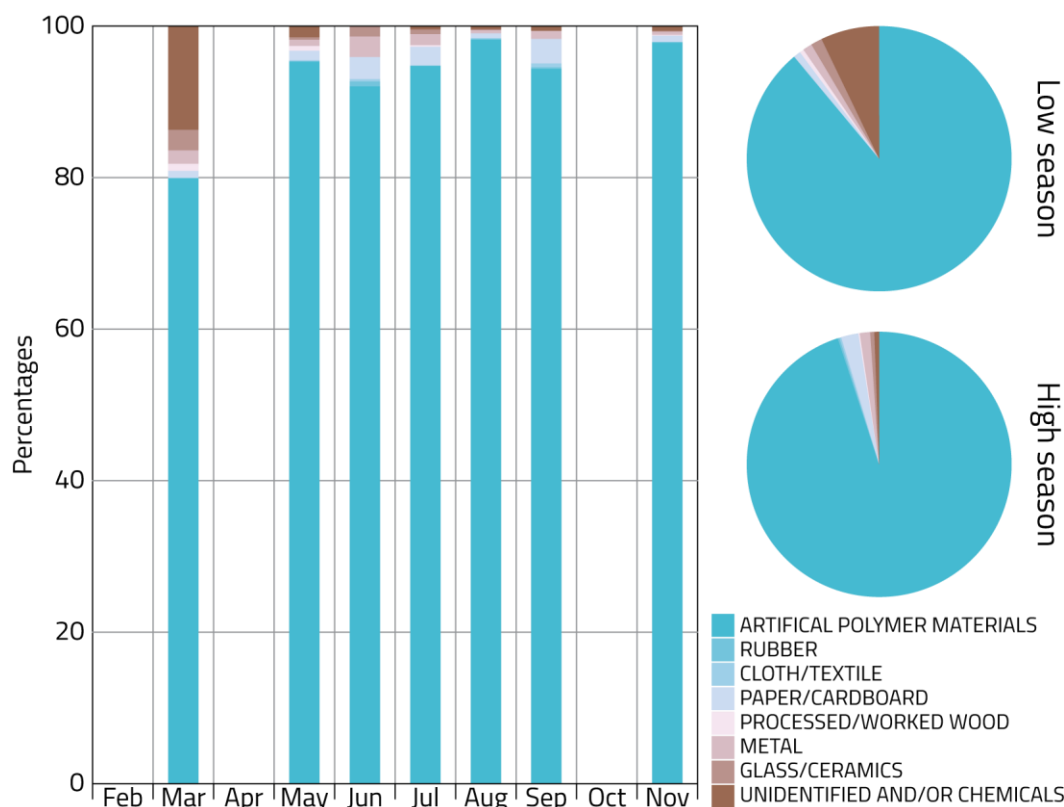


Figure D.VIII.1-3: composition of the marine litter collected at the beach of Sunrise. Left: histogram showing the monthly percentages of the 8 major categories of material type. Right: pie charts showing the average composition of the marine litter during the low (top) and high (bottom) seasons. The color scale (lower right) indicates the type of material.

d) The 10 most abundant items

In this section, we consider the items with the highest averaged accumulation rates, which are not necessarily the most abundant items collected during the marine litter monitoring performed on the beach of Sunrise (Fig. D.VIII.1-4). These items account for 93.83% of the total marine litter items (5813) collected in 2017. They are dominated by the mesoplastics (0.0885 items/m²/day; 34.31% of the total marine litter items collected), followed by the cigarette butts (0.0581 items/m²/day; 19.88% of the total marine litter items collected), the pellets (0.046 items/m²/day; 23.04% of the total marine litter items collected), the microplastics (0.0224 items/m²/day; 8.05% of the total marine litter items collected), the cutlery/trays/straws (0.0081 items/m²/day; 2.39% of the total marine litter items collected), the macroplastics (0.0044 items/m²/day; 2.13% of the total marine litter items collected), the other paper items (0.0043 items/m²/day; 1.35% of the total marine litter items collected), the other sanitary items (0.0034 items/m²/day; 1% of the total marine litter items collected), the cups (0.0031 items/m²/day; 0.7% of the total marine litter items collected) and the caps/lids (0.0031 items/m²/day; 0.98% of the total marine litter items collected).

In this top 10, the artificial polymer materials largely dominate as they are represented by 9 items, accounting for 93.83% of the total marine litter items collected.

In this top 10, 4 items (cigarette butts, cutlery/trays/straws, cups and caps/lids) accounting for 23.95% of the total marine litter items collected, can be attributed to the shoreline source, including poor waste management practices, tourism and recreational activities (see Part B.III.2.c). To this, can possibly be added 3 items (mesoplastics, microplastics and other paper items) presenting a clear seasonal pattern (see Appendix, Fig. E.IX-1) and accounting for additional 43.71% of the total marine litter items collected.

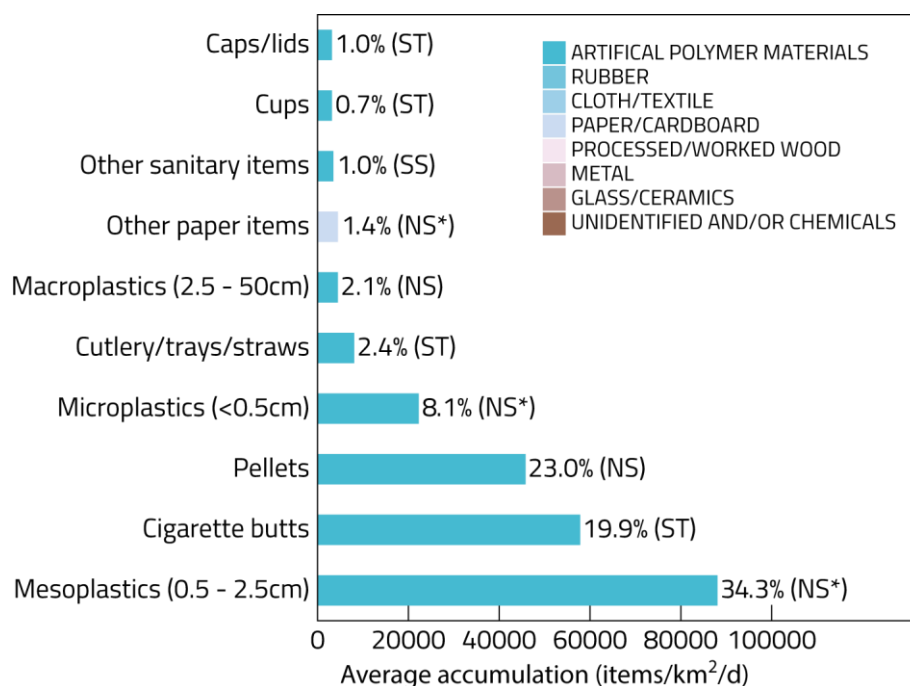


Figure D.VIII.1-4: list of the 10 items with the highest accumulation rates collected at the beach of Sunrise. The percentages next to each item refers to their relative abundance with respect to the total collected. The possible source of the items is given into parenthesis: ST=shoreline, including poor waste management, tourism and recreational activities; SS= sanitary and sewage related litter; and NS=non-sourced. The asterisk (*) associated to the non-sourced items (NS) shows that this specific item presents a clear seasonal increase. The color scale (upper right) indicates the type of material.

2. Beach mainly used by locals: Faros

a) Characteristics of the beach

The beach of Faros was selected as it is a popular beach mainly used by locals. It is a semi-urban beach, located in the municipality of Perivolía in the south eastern side of Cyprus, facing the sea to the east. It has a total length of $\pm 310\text{m}$, a width of $\pm 60\text{m}$ and is composed at 80% of sand and 20% of pebbles with a slope of 15%. The monitored fixed portion of the beach has a surface of 4316 m^2 . The beach is mainly used for recreational activities during the high season (swimming, sunbathing and local people) and the low season (local people). It is only accessible for pedestrians. In the area situated directly behind the beach, few services and facilities provided to the beach users are found. The coordinates of the fixed 100m portion selected for the monitoring are: 34.8201N, 33.6049E (starting point) and 34.8210N, 33.6049E (ending point) (Fig. D.VIII.2-1). Drink and food outlets are situated directly on the beach and the closest harbor is situated 12 km away to the north. The beach is cleaned daily during the high season.



Figure D.VIII.2-1: location map showing the beach of Faros and the selected 100m portion of beach monitored (red area).

b) Seasonality of the marine litter

The beach of Faros, mainly used by locals, was sampled for marine litter in March, May, June, July, August, September and November of 2017. A total of 2689 items (corrected for distance, see Part B.III.2.a) were collected on the same 100m portion of beach during the 7 monitoring, representing an average of 384.1 items (± 155.6 items, $n=7$) per survey. The lowest number of items was recorded in March (68 items) while the highest number was recorded in November (541 items) (Fig. D.VIII.2-2a). In general, the amount of marine litter collected during each survey continuously increases from March to November. No seasonal pattern was visible (Fig. D.VIII.2-2a). When only the number of items collected is considered (Fig. D.VIII.2-2b), their average number per survey during the low season (October – April) was of 304.8 (± 334.3 items, $n=2$) and of 415.9 (± 63.0 items, $n=5$) during the high season (May – September). Then, the amount of marine litter collected per survey during the high season was on average 36.4% higher than during the low touristic season (Fig. D.VIII.2-2b). When the accumulation rates (see Part B.III.2.b) are considered, a seeming seasonal pattern can be observed (Fig. D.VIII.2-2c). The lowest value observed was of 0.0010 items/m²/day (985 items/km²/day) in March and the highest was of 0.1840 items/m²/day (183967 items/km²/day) in June (Fig. D.VIII.2-2c). The seasonal pattern of the marine litter does not follow exactly the monthly number of tourists welcomed on Cyprus (Fig. D.VIII.2-2c): higher accumulation rates are observed at the beginning of the touristic season and lower accumulation rates are observed during the off season. During the low season, the average accumulation rate is of 0.0040 items/m²/day (± 0.0030 , $n=2$) and of 0.1072 items/m²/day (± 0.0574 , $n=5$) during the high season. These results show that, on average the accumulation rates of the marine litter are higher during the high season (+156%, Fig. D.VIII.2-2d) than during the low season. Finally, the beach of Faros can be considered as very clean during both the low and high seasons, according to the Clean-Coast Index (see Part B.III.2.d) exhibiting values of respectively 1.4 and 1.9 (Fig. C.III-4a). The accumulation index shows that the accumulation of marine litter can be considered as moderate during the low season (AI=3.60) and very high during the high season (AI=5.03) (Fig. C.III-4b).

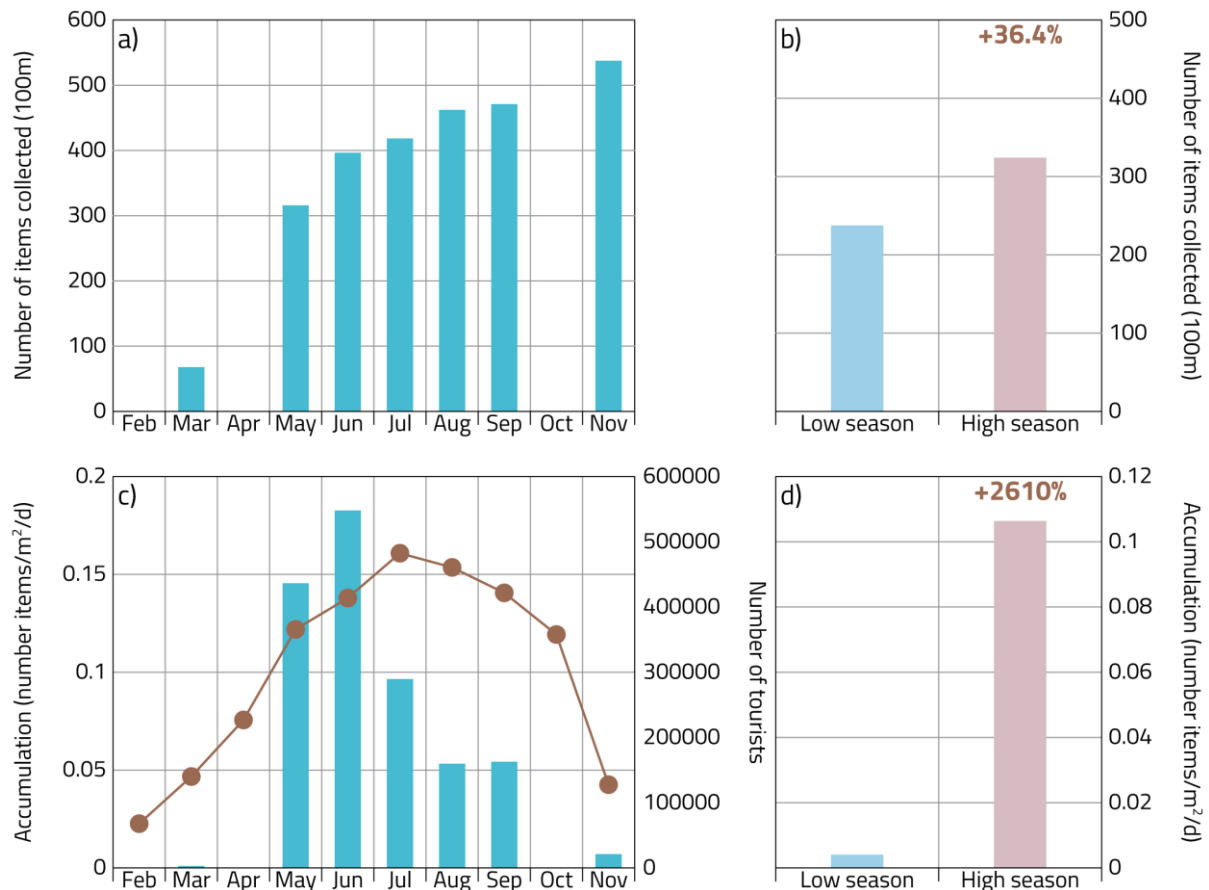


Figure D.VIII.2-2: total number and accumulations rates of items collected at the beach of Faros. a) number of items collected during each survey on the fixed 100m portion of beach; b) comparison of the average number of items collected per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season; c) accumulation rates of the marine litter (left axis, blue bars) and the monthly number of tourists²⁷ in Cyprus (right axis, brown line and dots); and d) comparison of the accumulation rates of marine litter per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season.

c) Composition of the marine litter

The marine litter collected on the beach of Faros (Fig. D.VIII.2-3) was classified into 8 major categories of material type (see Part B.III.2.c). It is largely dominated by the artificial polymer materials (average=93.87% \pm 3.60; min=86.76% in March and max=97.21% in November), followed by the metal (average=3.35% \pm 3.20; min=0.72% in July and max=10.29% in March), the paper/cardboard (average=1.82% \pm 1.13; min=0.19% in November and max=3.53% in June), the unidentified and/or chemicals (average=0.28% \pm 0.24; min=0.00% in May and max=0.65% in August), the processed/worked wood (average=0.25% \pm 0.36; min=0.00% in November and max=1.01% in June), the glass/ceramics (average=0.21% \pm 0.28; min=0.00% in August and max=0.64% in September), the cloth/textile (average=0.18% \pm 0.40; min=0.00% in November and max=1.08% in August) and the rubber (average=0.04% \pm 0.10; min=0.00% in November and max=0.25% in June).

During the low season (Fig. D.VIII.2-3), the marine litter is largely dominated by the artificial polymer materials (91.99%), followed by the metal (6.08%), the paper/cardboard (1.56%), the glass/ceramics (0.19%) and the unidentified and/or chemicals (0.19%).

²⁷ Data source: arrivals of tourists by country of usual residence and month in 2016, http://www.cystat.gov.cy/mof/cystat/statistics.nsf/services_71main_en/services_71main_en?OpenForm&sub=1&sel=2#

During the high season (Fig. D.VIII.2-3), the marine litter is largely dominated by the artificial polymer materials (94.63%), followed by the metal (2.25%), the paper/cardboard (1.92%), the processed/worked wood (0.35%), the unidentified and/or chemicals (0.32%), the cloth/textile (0.26%), the glass/ceramics (0.22%) and the rubber (0.05%).

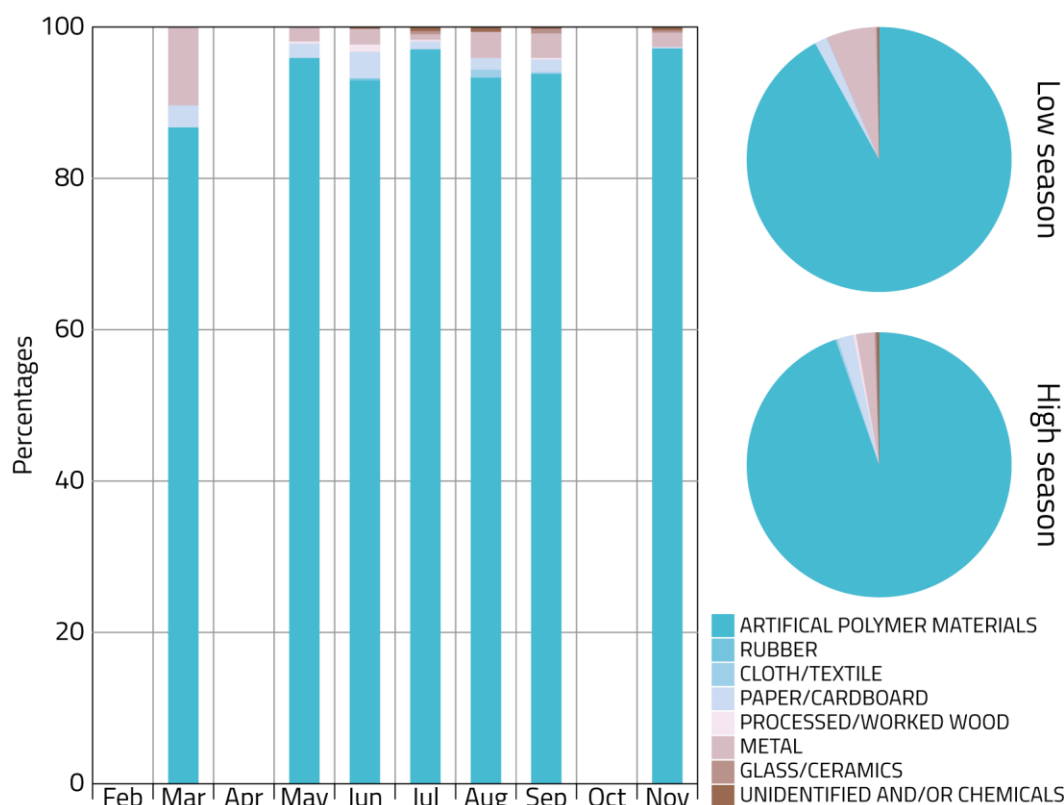


Figure D.VIII.2-3: composition of the marine litter collected at the beach of Faros. Left: histogram showing the monthly percentages of the 8 major categories of material type. Right: pie charts showing the average composition of the marine litter during the low (top) and high (bottom) seasons. The color scale (lower right) indicates the type of material.

d) The 10 items with the highest accumulation rates

In this section, we consider the items with the highest averaged accumulation rates, which are not necessarily the most abundant items collected during the marine litter monitoring performed on the beach of Faros (Fig. D.VIII.2-4). These items account for 91.92% of the total marine litter items (2689) collected in 2017. They are dominated by the mesoplastics (0.0432 items/m²/day; 53.16% of the total marine litter items collected), followed by the cigarette butts (0.0107 items/m²/day; 17.17% of the total marine litter items collected), the microplastics (0.0093 items/m²/day; 10.48% of the total marine litter items collected), the pellets (0.0019 items/m²/day; 2.96% of the total marine litter items collected), the cutlery/trays/straws (0.0018 items/m²/day; 2.21% of the total marine litter items collected), the caps/lids (0.0017 items/m²/day; 2.13% of the total marine litter items collected), the other paper items (0.0012 items/m²/day; 1.27% of the total marine litter items collected), the other plastic/polystyrene items (0.0008 items/m²/day; 0.75% of the total marine litter items collected), the other sanitary items (0.0007 items/m²/day; 0.9% of the total marine litter items collected) and the drink cans (0.0007 items/m²/day; 0.9% of the total marine litter items collected).

In this top 10, the artificial polymer materials largely dominate as they are represented by 8 items, accounting for 89.75% of the total marine litter items collected.

In this top 10, 4 items (cigarette butts, cutlery/trays/straws, caps/lids and drink cans) accounting for 22.41% of the total marine litter items collected, can be attributed to the shoreline source, including poor waste management practices, tourism and recreational activities (see Part B.III.2.c). To this, can possibly be added 3 items (mesoplastics, microplastics and other plastic/polystyrene items) presenting a clear seasonal pattern (see Appendix, Fig. E.IX-2) and accounting for additional 64.39% of the total marine litter items collected.

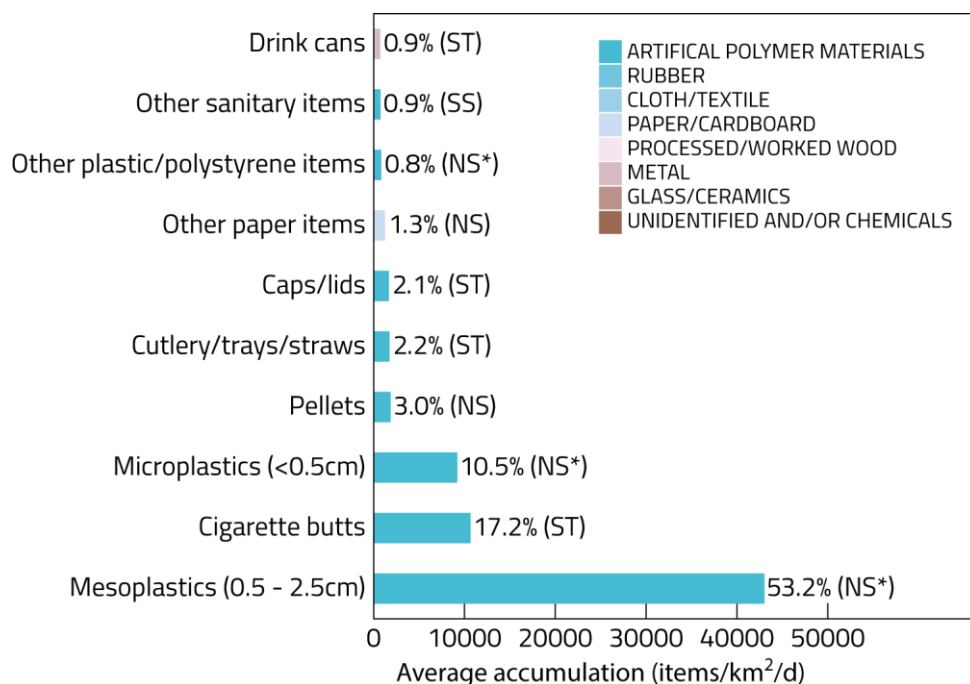


Figure D.VIII.2-4: list of the 10 items with the highest accumulation rates collected at the beach of Faros. The percentages next to each item refers to their relative abundance with respect to the total collected. The possible source of the items is given into parenthesis: ST=shoreline, including poor waste management, tourism and recreational activities; SS= sanitary and sewage related litter; and NS=non-sourced. The asterisk (*) associated to the non-sourced items (NS) shows that this specific item presents a clear seasonal increase. The color scale (upper right) indicates the type of material.

3. Remote beach: Timi

a) Characteristics of the beach

The remote beach of Timi is a semi-rural beach, located in the municipality of Timi in the south western side of Cyprus, facing the sea to the SW. It has a total length of $\pm 120\text{m}$, a width of $\pm 30\text{m}$ and is composed at 50% of sand, 30% of pebbles and 20% of rocks with a slope of 20%. The monitored fixed portion of the beach has a surface of 2300 m^2 . The beach is mainly used for recreational activities during the high season (swimming, sunbathing, local people and fishing). It is accessible by vehicles. The area situated directly behind beach is a semi-rural area with no services and facilities provided to the beach users. The beach is located behind the international airport of Paphos. The coordinates of the fixed 100m portion selected for the monitoring are: 34.7099N, 32.4879E (starting point) and 34.7091N, 32.4883E (ending point) (Fig. D.VIII.3-1). The closest harbor is situated 13 km away to the NW. The beach is cleaned 2 to 3 times per year.



Figure D.VIII.3-1: location map showing the beach of Timi and the selected 100m portion of beach monitored (red area).

b) Seasonality of the marine litter

The remote beach of Timi was sampled for marine litter in March, May, June, July, August, September and November of 2017. A total of 2070 items (corrected for distance, see Part B.III.2.a) were collected on the same 100m portion of beach during the 7 monitoring, representing an average of 295.7 items (± 123.1 items, $n=7$) per survey. The lowest number of items was recorded in March (43 items) while the highest number was recorded in November (408 items) (Fig. D.VIII.3-2a). In general, the amount of marine litter collected during each survey continuously increases from March to November with a slight decrease in August. No seasonal pattern was visible (Fig. D.VIII.3-2a). When only the number of items collected is considered (Fig. D.VIII.3-2b), their average number per survey during the low season (October – April) was of 225.5 (± 257.9 items, $n=2$) and of 323.7 (± 51.7 items, $n=5$) during the high season (May – September). Then, the amount of marine litter collected per survey during the high season was on average 43.5% higher than during the low touristic season (Fig. D.VIII.3-2b). When the accumulation rates (see Part B.III.2.b) are considered, a clear seasonal pattern can be observed (Fig. D.VIII.3-2c). The lowest value observed was of 0.0012 items/m²/day (1168 items/km²/day) in March and the highest was of 0.0104 items/m²/day (10373 items/km²/day) in July (Fig. D.VIII.3-2c). The seasonal pattern of the marine litter seems to follow the monthly number of tourists welcomed on Cyprus (Fig. D.VIII.3-2c): higher accumulation rates are observed during the touristic season and lower accumulation rates are observed during the off season. During the low season, the average accumulation rate is of 0.0024 items/m²/day (± 0.0016 , $n=2$) and of 0.0049 items/m²/day (± 0.0033 , $n=5$) during the high season. These results show that, on average the accumulation rates of the marine litter are higher during the high season (+104%, Fig. D.VIII.3-2d) than during the low season. Finally, the beach of Timi can be considered as very clean during the low season and clean during the high season, according to the Clean-Coast Index (see Part B.III.2.d) exhibiting values of respectively 1.9 and 2.8 (Fig. C.IV-4a). The accumulation index shows that the accumulation of marine litter can be considered as moderate during both the low and high seasons (AI=3.38 and 3.69) (Fig. C.IV-4b).

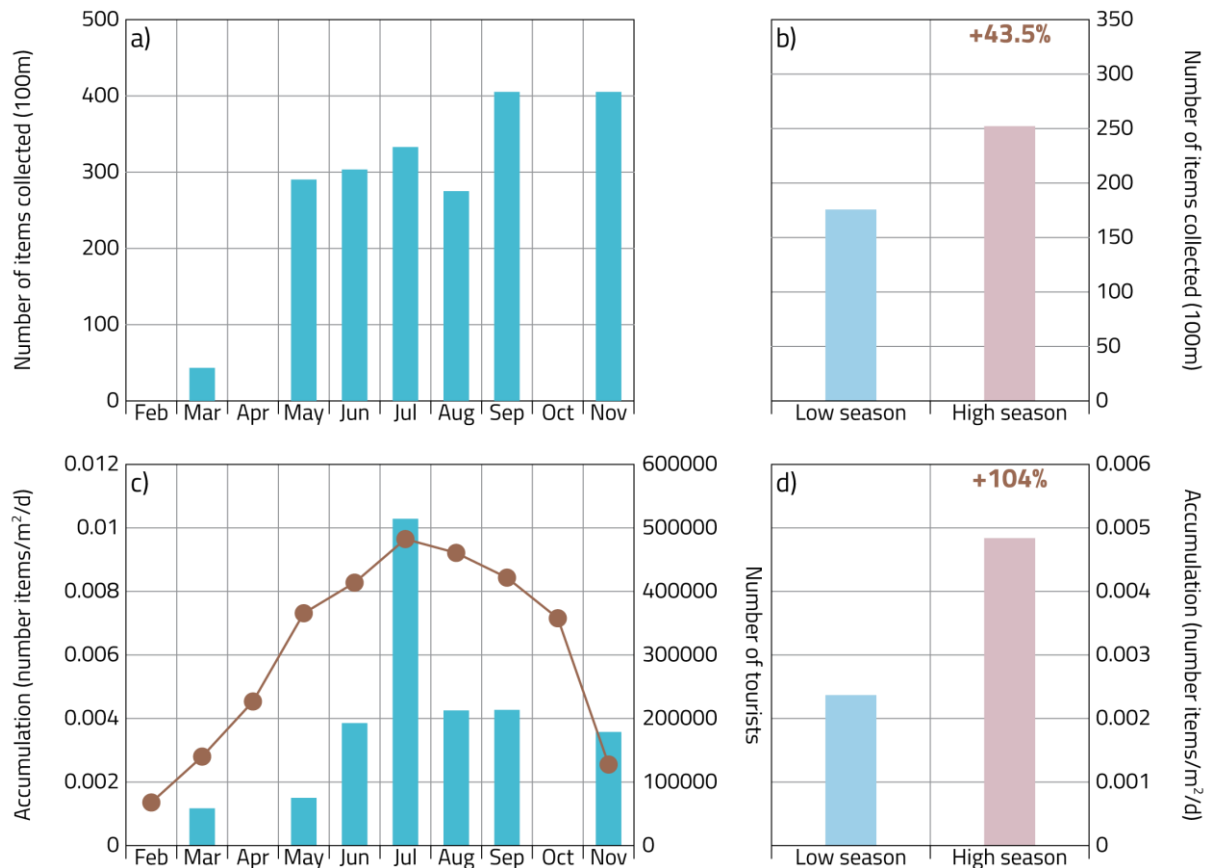


Figure D.VIII.3-2: total number and accumulations rates of items collected at the beach of Timi. a) number of items collected during each survey on the fixed 100m portion of beach; b) comparison of the average number of items collected per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season; c) accumulation rates of the marine litter (left axis, blue bars) and the monthly number of tourists²⁸ in Cyprus (right axis, brown line and dots); and d) comparison of the accumulation rates of marine litter per survey during the low season (blue bar) and the high season (brown bar), the percentage reported (brown font) refers to the increase with respect to the low season.

c) Composition of the marine litter

The marine litter collected on the beach of Timi (Fig. D.VIII.3-3) was classified into 8 major categories of material type (see Part B.III.2.c). It is largely dominated by the artificial polymer materials (average=89.44% ±11.36; min=65.12% in March and max=96.06% in November), followed by the metal (average=4.15% ±7.44; min=0.25% in September and max=20.93% in March), the glass/ceramics (average=2.36% ±2.52; min=0.36% in August and max=6.98% in March), the paper/cardboard (average=1.82% ±1.18; min=0.00% in March and max=3.09% in May), the rubber (average=0.81% ±1.71; min=0.00% in November and max=4.65% in March), the processed/worked wood (average=0.72% ±0.92; min=0.00% in November and max=2.33% in March), the cloth/textile (average=0.56% ±0.64; min=0.00% in November and max=1.72% in May), the unidentified and/or chemicals (average=0.15% ±0.39; min=0.00% in November and max=1.03% in May).

During the low season (Fig. D.VIII.3-3), the marine litter is largely dominated by the artificial polymer materials (80.59%), followed by the metal (11.57%), the glass/ceramics (4.10%), the rubber (2.33%), the processed/worked wood (0.39%) and the paper/cardboard (0.25%).

²⁸ Data source: arrivals of tourists by country of usual residence and month in 2016, http://www.cystat.gov.cy/mof/cystat/statistics.nsf/services_71main_en/services_71main_en?OpenForm&sub=1&sel=2#

During the high season (Fig. D.VIII.3-3), the marine litter is largely dominated by the artificial polymer materials (92.98%), followed by the paper/cardboard (2.45%), the glass/ceramics (1.66%), the metal (1.18%), the cloth/textile (0.78%), the processed/worked wood (0.54%), the unidentified and/or chemicals (0.21%) and the rubber (0.20%).

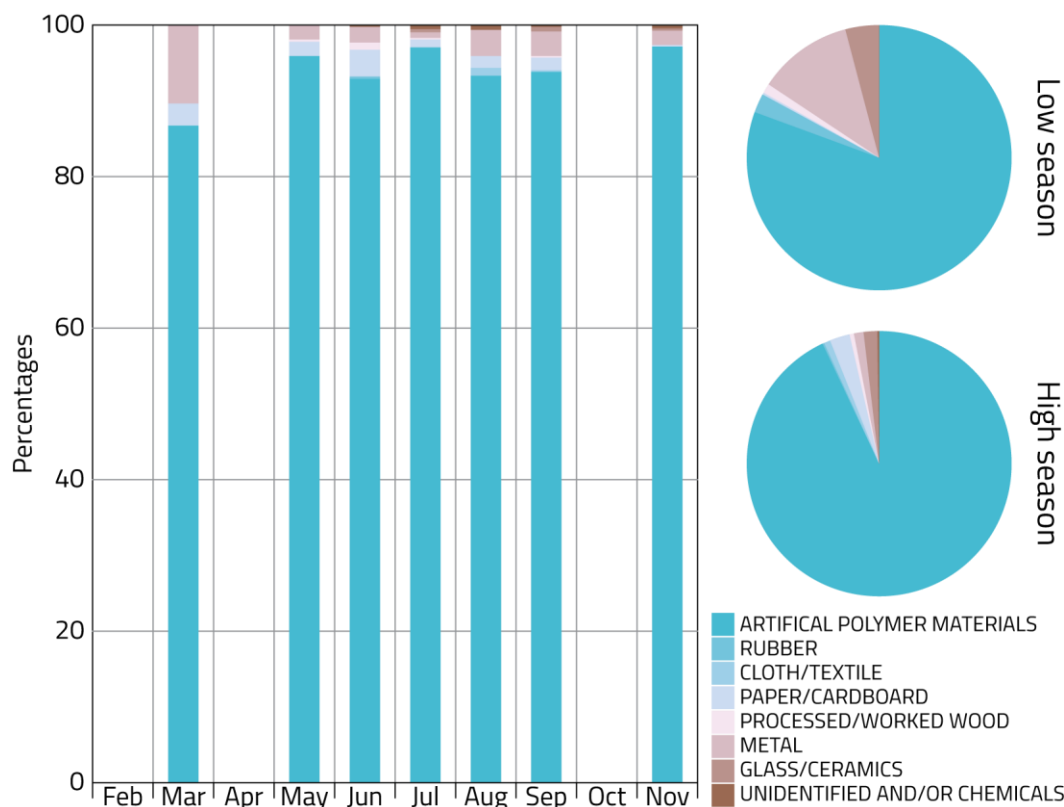


Figure D.VIII.3-3: composition of the marine litter collected at the beach of Timi. Left: histogram showing the monthly percentages of the 8 major categories of material type. Right: pie charts showing the average composition of the marine litter during the low (top) and high (bottom) seasons. The color scale (lower right) indicates the type of material.

d) The 10 items with the highest accumulation rates

In this section, we consider the items with the highest averaged accumulation rates, which are not necessarily the most abundant items collected during the marine litter monitoring performed on the beach of Timi (Fig. D.VIII.3-4). These items account for 85.63% of the total marine litter items (2070) collected in 2017. They are dominated by the mesoplastics (0.0023 items/m²/day; 55.05% of the total marine litter items collected), followed by the microplastics (0.0007 items/m²/day; 15.73% of the total marine litter items collected), the caps/lids (0.0002 items/m²/day; 3.3% of the total marine litter items collected), the drink bottles, containers and drums (0.0001 items/m²/day; 2.38% of the total marine litter items collected), the macroplastics (0.0001 items/m²/day; 1.89% of the total marine litter items collected), the cigarette butts (0.0001 items/m²/day; 1.89% of the total marine litter items collected), the other plastic/polystyrene items (0.0001 items/m²/day; 1.26% of the total marine litter items collected), the foam sponge (0.0001 items/m²/day; 1.36% of the total marine litter items collected), the pellets (0.0001 items/m²/day; 1.46% of the total marine litter items collected) and the cups (0.0001 items/m²/day; 1.31% of the total marine litter items collected).

In this top 10, all the items are exclusively artificial polymer materials, accounting then for 85.63% of the total marine litter items collected.

In this top 10, 4 items (caps/lids, drink bottles, cigarette butts and cups) accounting for 8.88% of the total marine litter items collected, can be attributed to the shoreline source, including poor waste management practices, tourism and recreational activities (see Part B.III.2.c). To these items could possibly added 4 items (mesoplastics, microplastics, macroplastics and other plastic/polystyrene items) presenting a clear seasonal pattern (see Appendix, Fig. E.IX-3) and accounting for additional 73.93% of the total marine litter items collected.

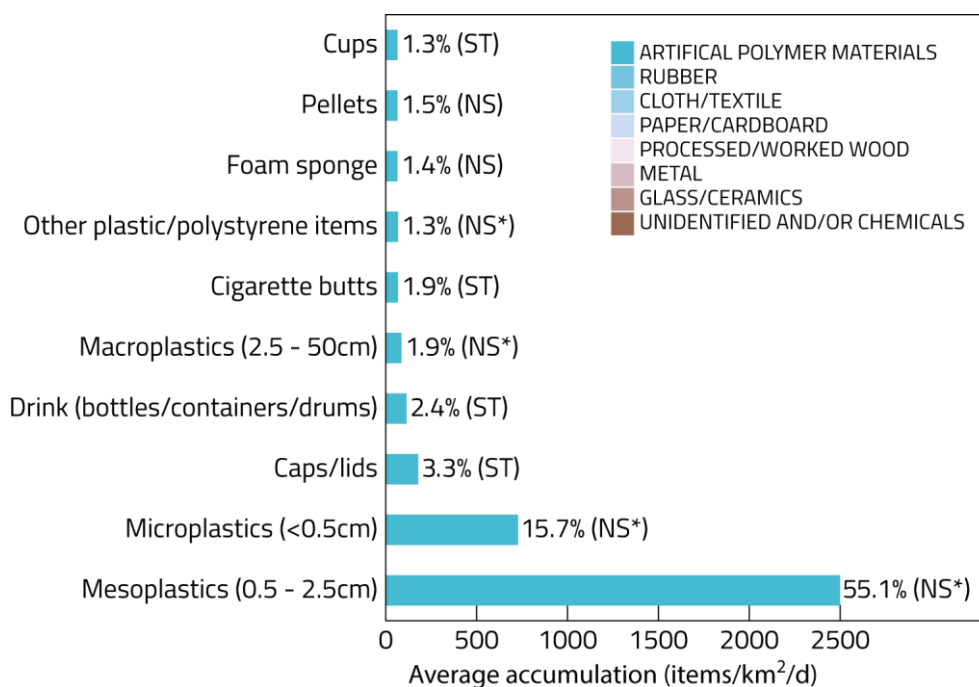


Figure D.VIII.3-4: list of the 10 items with the highest accumulation rates collected at the beach of Timi. The percentages next to each item refers to their relative abundance with respect to the total collected. The possible source of the items is given into parenthesis: ST=shoreline, including poor waste management, tourism and recreational activities and NS=non-sourced. The asterisk (*) associated to the non-sourced items (NS) shows that this specific item presents a clear seasonal increase. The color scale (upper right) indicates the type of material.

4. Summary

The 21 marine litter surveys conducted in Cyprus in 2017 have revealed that:

- If only the number of items collected is considered, the touristic beach of Sunrise is the most affected by the marine litter (5813 items collected; average: 830.4 items/survey; 850.0 items/survey during the low season; 822.6 items/survey during the high season), followed by the beach of Faros, mainly used by locals (2689 items collected; average: 384.1 items/survey; 304.8 items/survey during the low season; 415.9 items/survey during the high season) and the remote beach of Timi (2070 items collected; average: 295.7 items/survey; 225.5 items/survey during the low season; 323.7 items/survey during the high season). For the 3 beaches, no seasonal variability was observed from the number of items collected.
- If the accumulation rate of the marine litter is considered, the touristic beach of Sunrise is the most affected by marine litter accumulation (average: 0.2590 items/m²/day; 0.1223 items/m²/day during the low season; 0.3136 items/m²/day during the high season), followed by the beach of Faros, mainly used by locals (average: 0.0777 items/m²/day; 0.0040 items/m²/day during the low season; 0.1072 items/m²/day during the high season) and the remote beach of Timi (average: 0.0042 items/m²/day; 0.0024 items/m²/day during the low season; 0.0049 items/m²/day during the high season). The 3 beaches presented recognizable

seasonal variations with a relative increase of the accumulation rates of 156% (Sunrise), 2610% (Faros) and 104% (Timi) during the high season with respect to the low season.

- The items collected are mainly composed of artificial polymer materials: they represent 93.22% (Sunrise), 93.87% (Faros) and 89.44% (Timi) of the total marine litter items collected.
- On the touristic beach of Sunrise, 4 items (cigarette butts, cutlery/trays/straws, cups and caps/lids), most likely related to tourism and recreational activities, are representing 23.95% of the total marine litter items collected. To this, can possibly be added 3 items (mesoplastics, microplastics and other paper items), accounting for additional 43.71% as they presented a recognizable seasonal variation.
- On the beach of Faros, mainly used by locals, 4 items (cigarette butts, cutlery/trays/straws, caps/lids and drink cans), most likely related to tourism and recreational activities, are representing 22.41% of the total marine litter items collected. To this, can possibly be added 3 items (mesoplastics, microplastics and other plastic/polystyrene items), accounting for additional 64.39% as they presented a recognizable seasonal variation.
- On the remote beach of Timi, 4 items (caps/lids, drink bottles, cigarette butts and cups), most likely related to tourism and recreational activities, are representing 8.88% of the total marine litter items collected. To this, can possibly be added 4 items (mesoplastics, microplastics, macroplastics and other plastic/polystyrene items), accounting for additional 73.93% as they presented a recognizable seasonal variation.
- The cleanliness of the beaches is considered as moderate/moderate for the low/high season in Sunrise (Clean-Coast Index of 7.8/7.5), very clean/very clean for the low/high season in Faros (CCI of 1.4/1.9) and very clean/clean for the low/high season in Timi (CCI of 1.95/2.8).
- Finally the accumulation index of the beaches is considered as very high/very high for the low/high season in Sunrise (Accumulation Index of 5.09/5.50), moderate/very high for the low/high season in Faros (AI of 3.60/5.03) and moderate/moderate for the low/high season in Timi (AI of 3.38/3.69).

Part E: APPENDIX

I. General Results

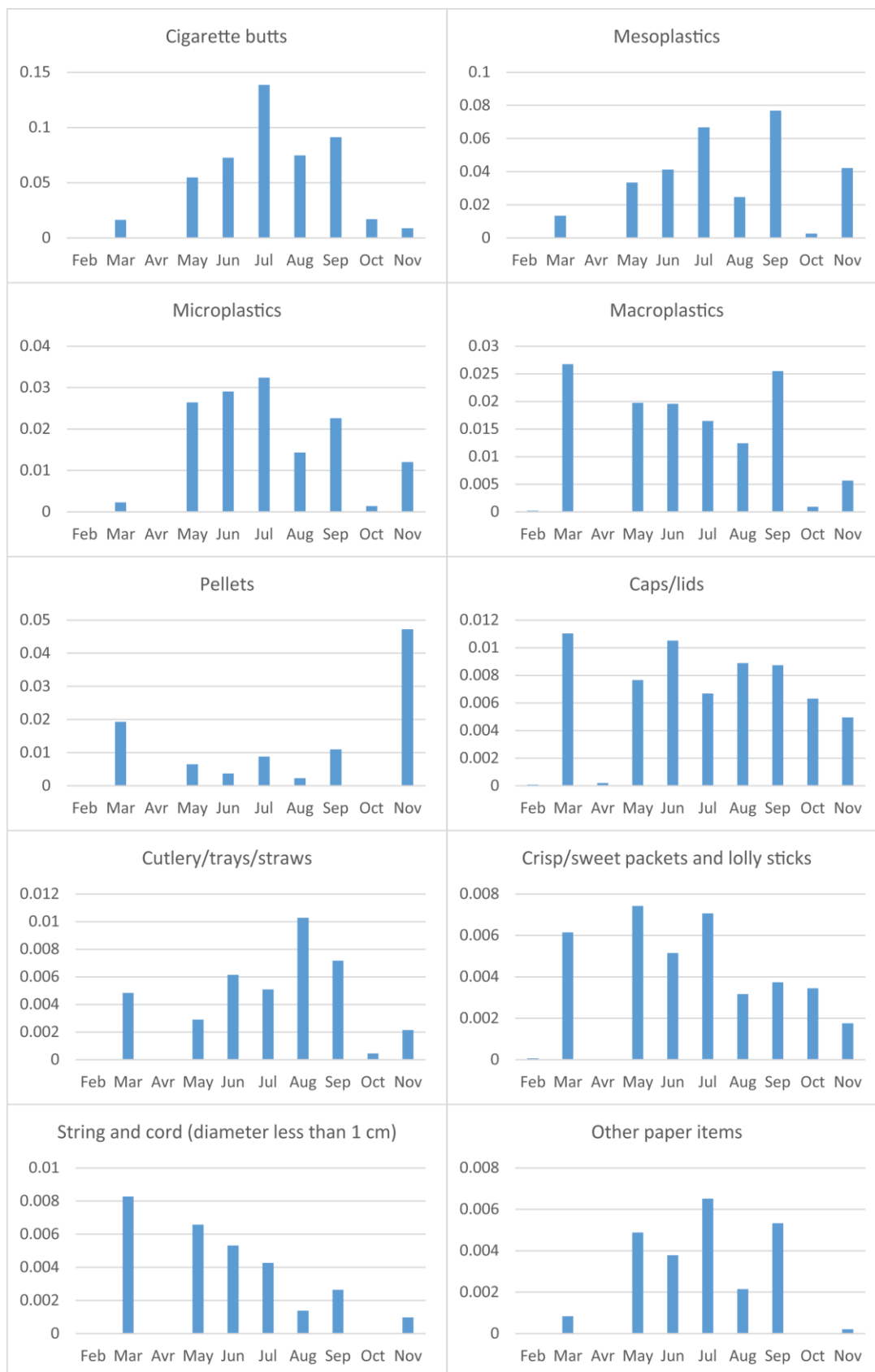


Figure E.I-1: seasonal variations of the 10 items with the highest accumulation rates (items/m²/day) collected the 24 beaches.

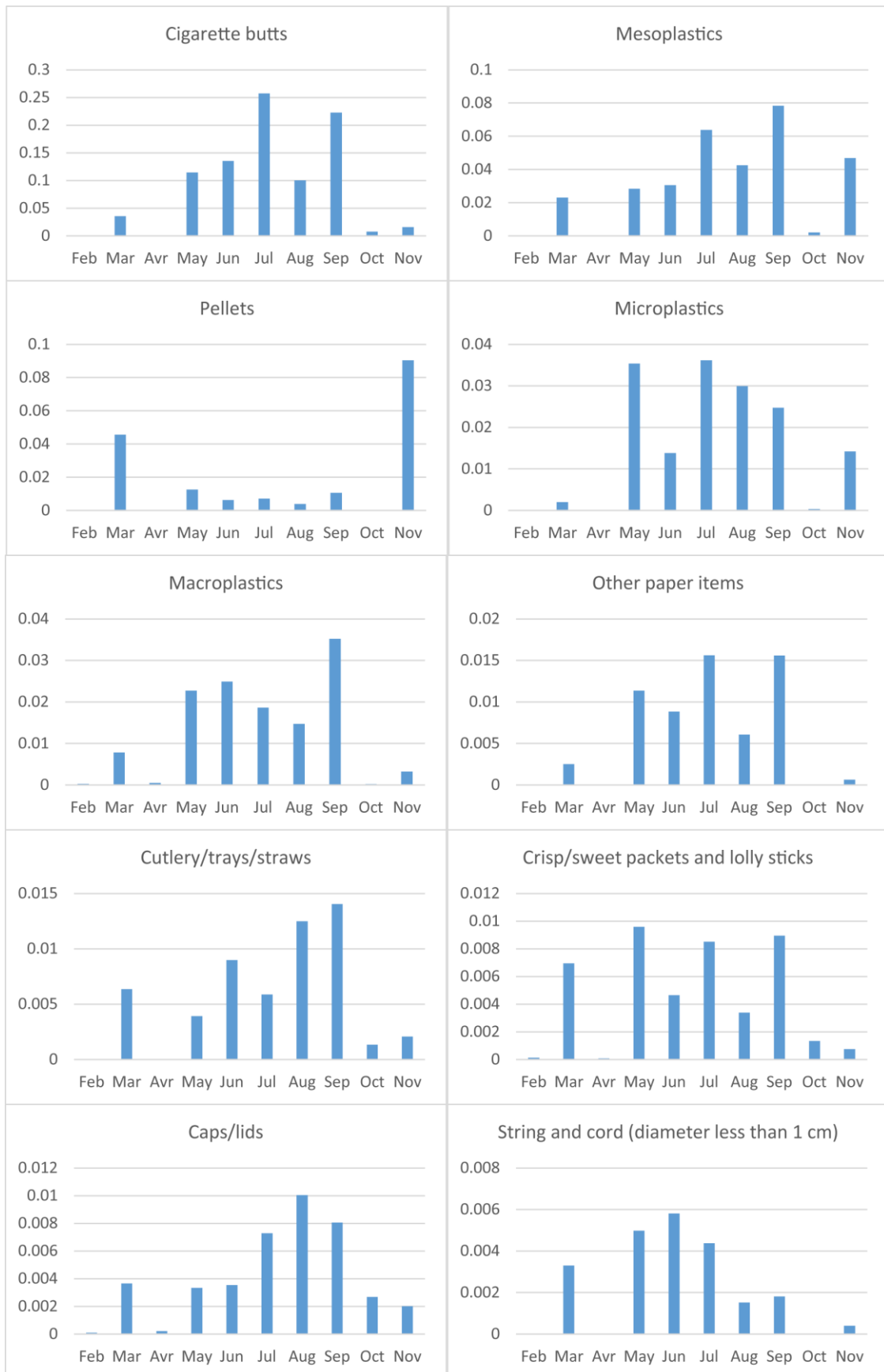


Figure E.I-2: seasonal variations of the 10 items with the highest accumulation rates (items/m²/day) collected on the 8 touristic beaches.

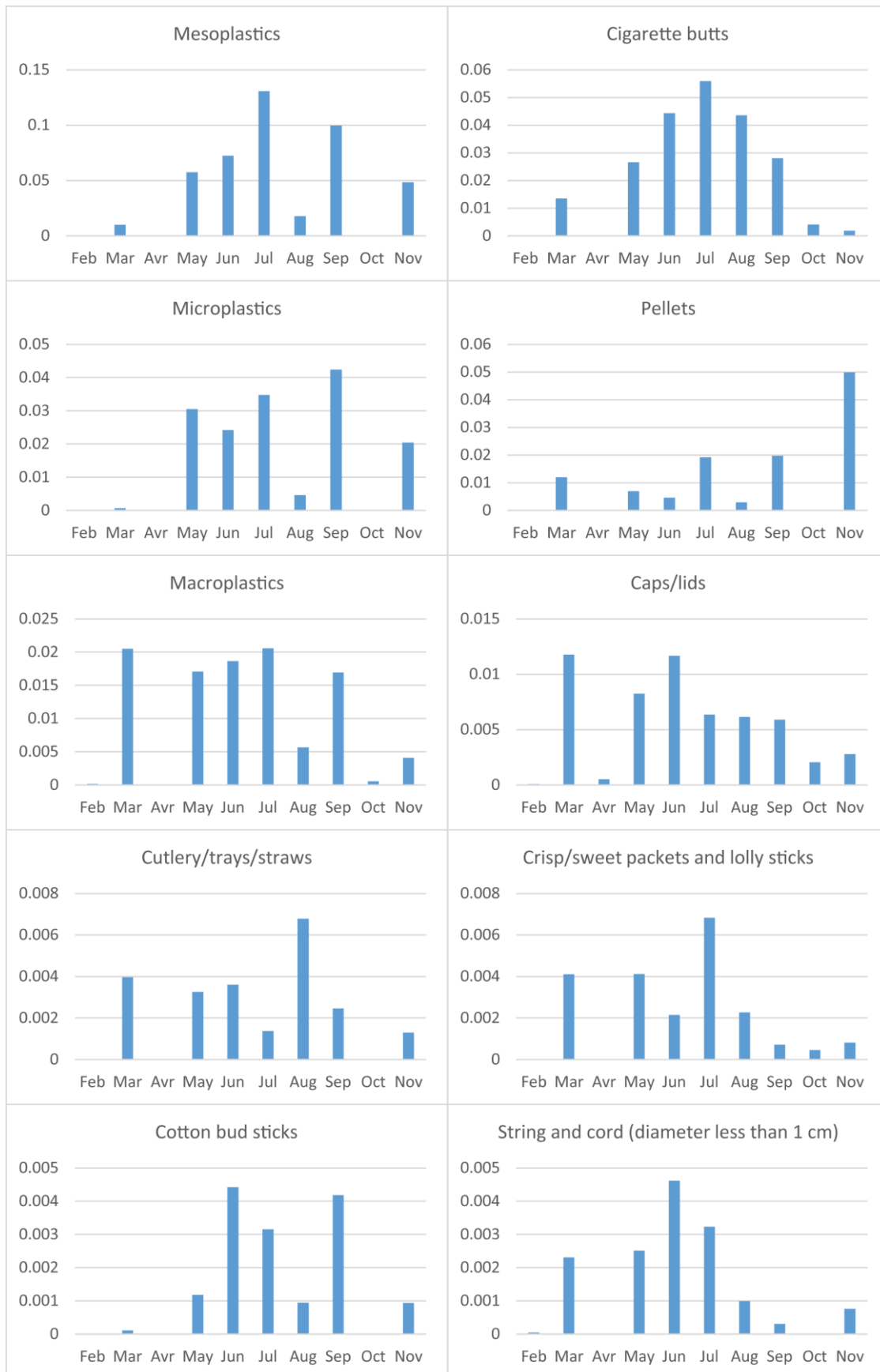


Figure E.I-3: seasonal variations of the 10 items with the highest accumulation rates (items/m²/day) collected on the 8 beaches mainly used by locals.

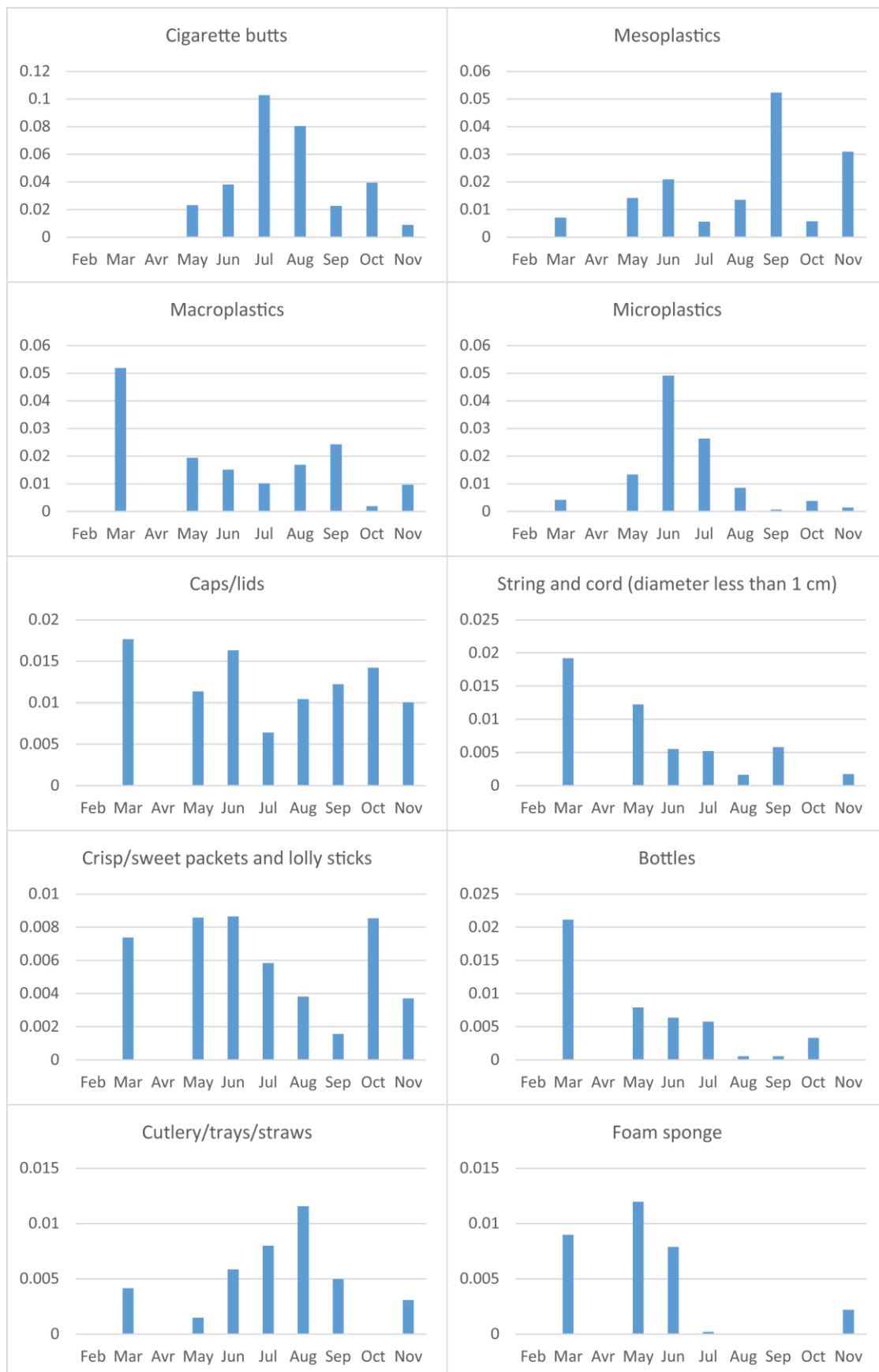


Figure E.I-4: seasonal variations of the 10 items with the highest accumulation rates (items/m²/day) collected on the 8 remote beaches.

II. Mallorca

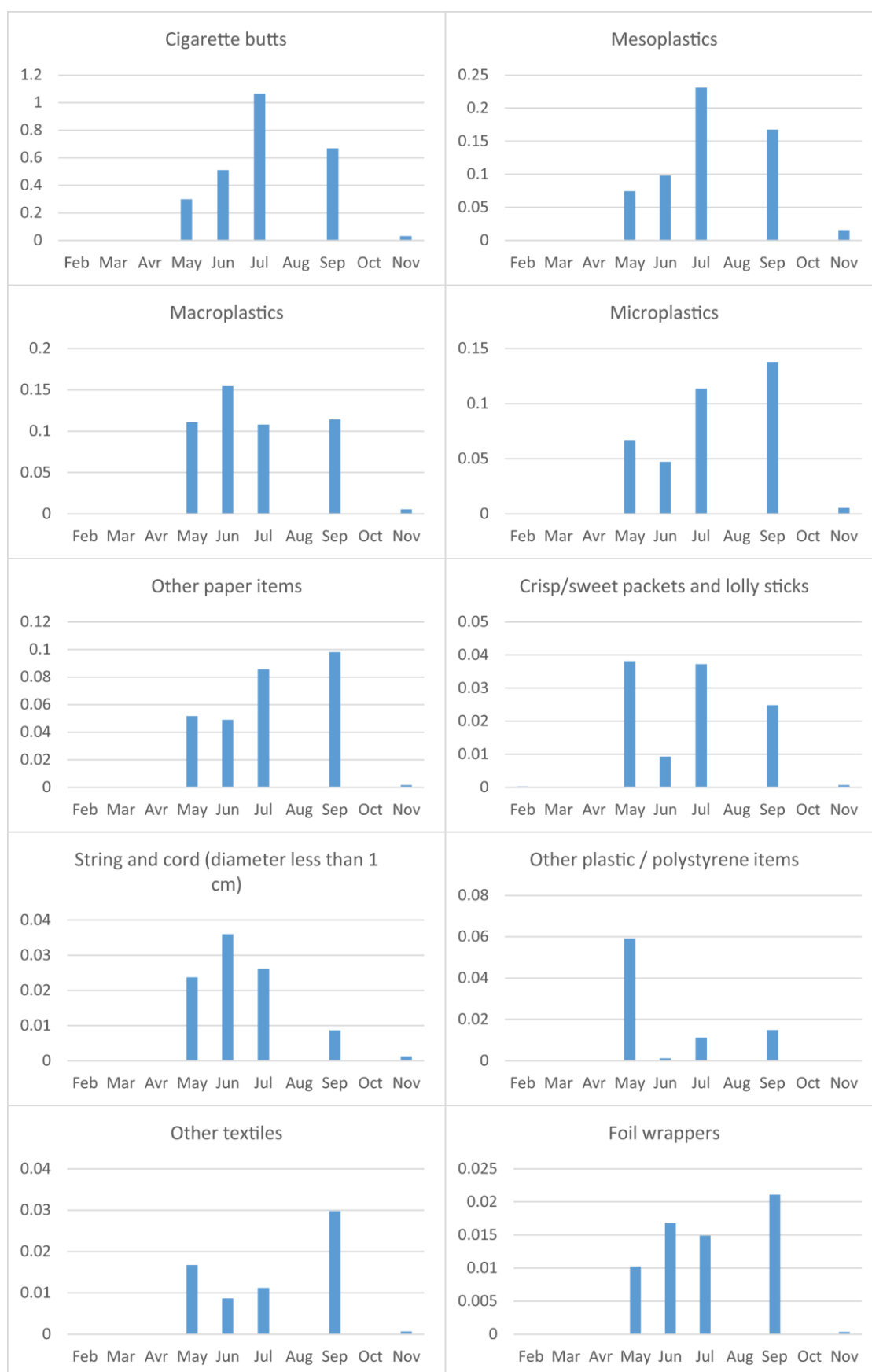


Figure E.II-1: seasonal variations of the 10 items with the highest accumulation rates (items/m²/day) collected on the beach of Torá.

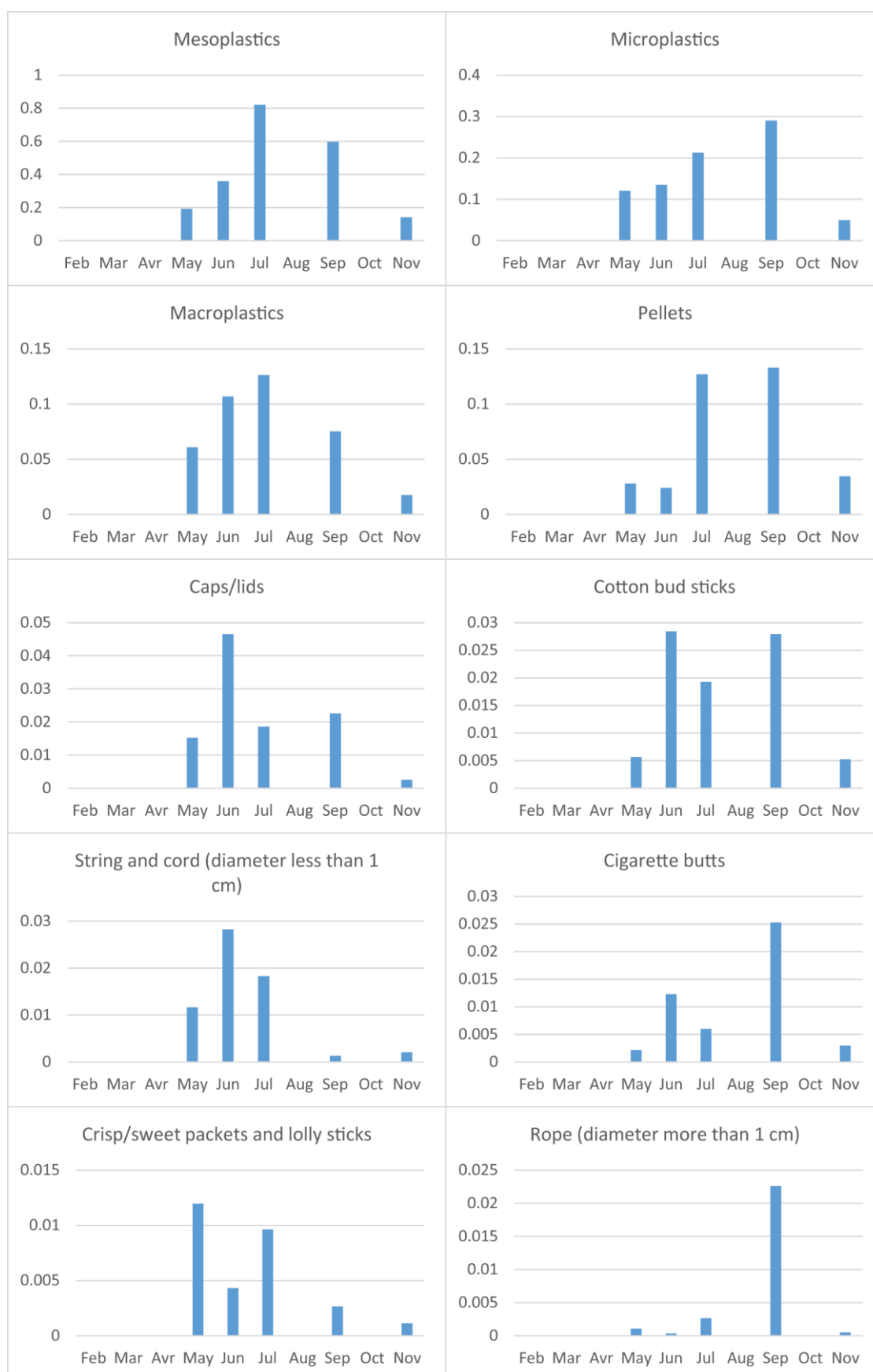


Figure E.II-2: seasonal variations of the 10 items with the highest accumulation rates (items/m²/day) collected on the beach of Es Caragol.

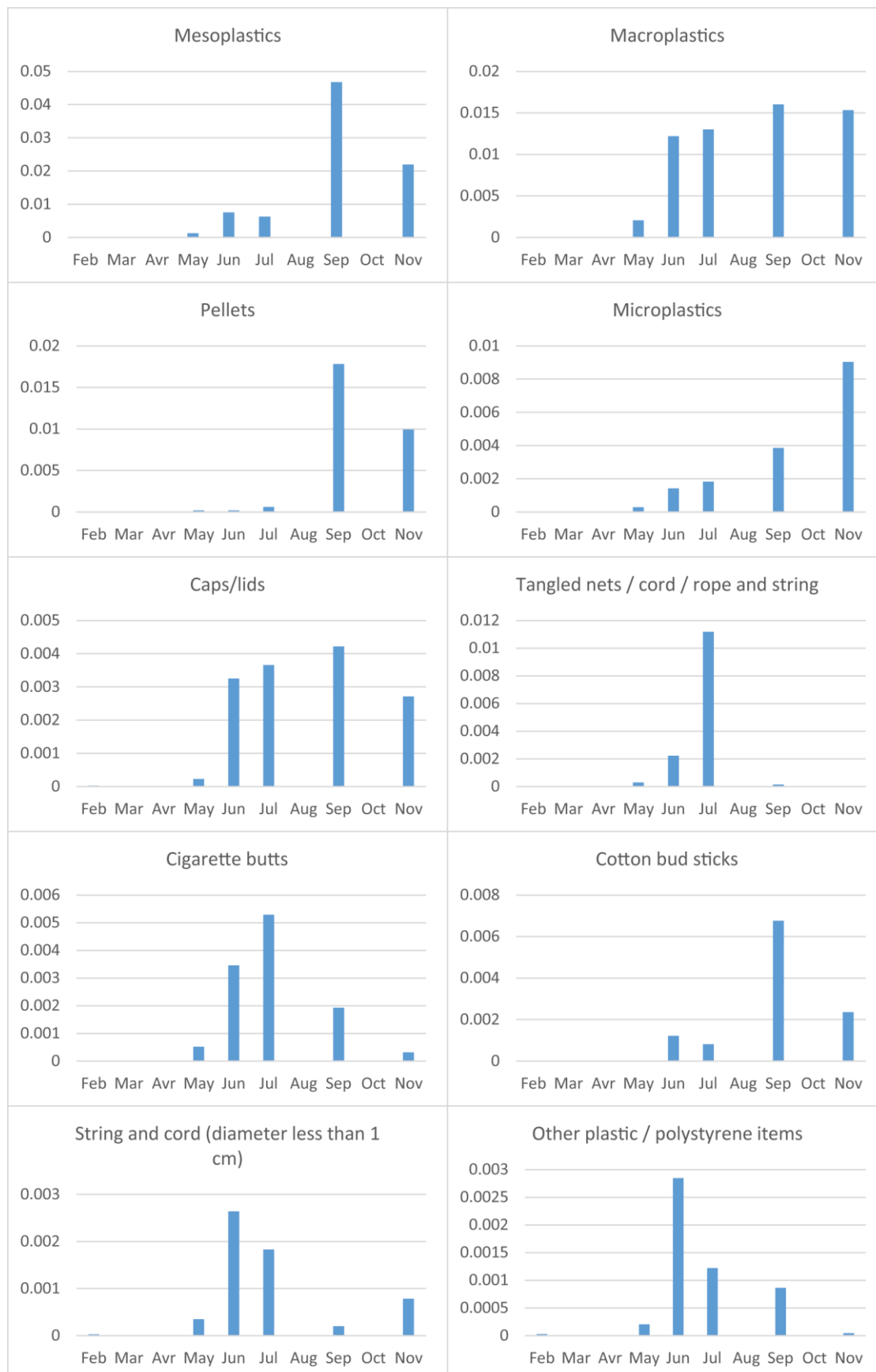


Figure E.II-3: seasonal variations of the 10 items with the highest accumulation rates (items/m²/day) collected on the beach of Sa Canova.

III. Sicily

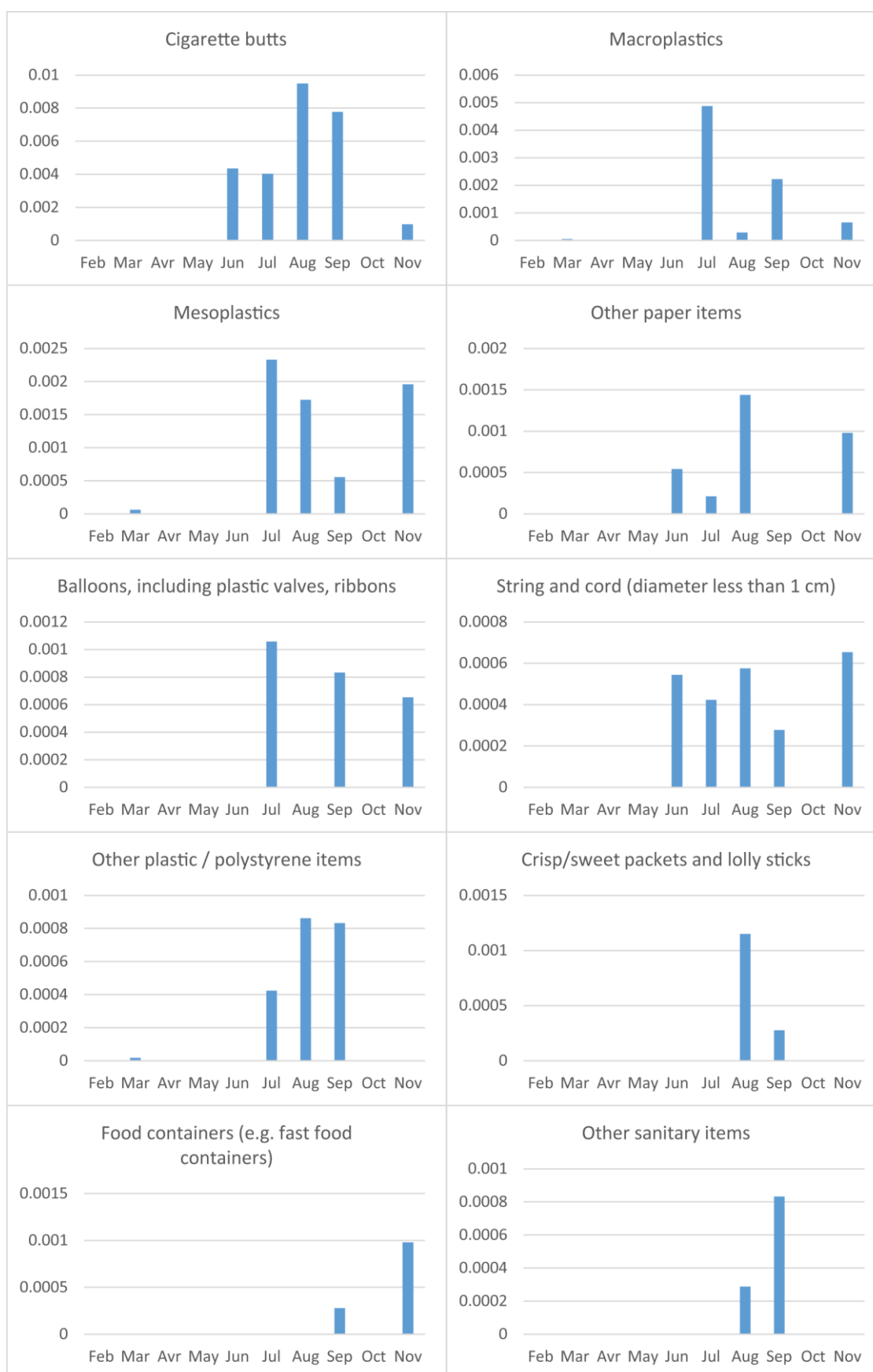


Figure E.III-1: seasonal variations of the 10 items with the highest accumulation rates (items/m²/day) collected on the beach of Giardini Naxos.

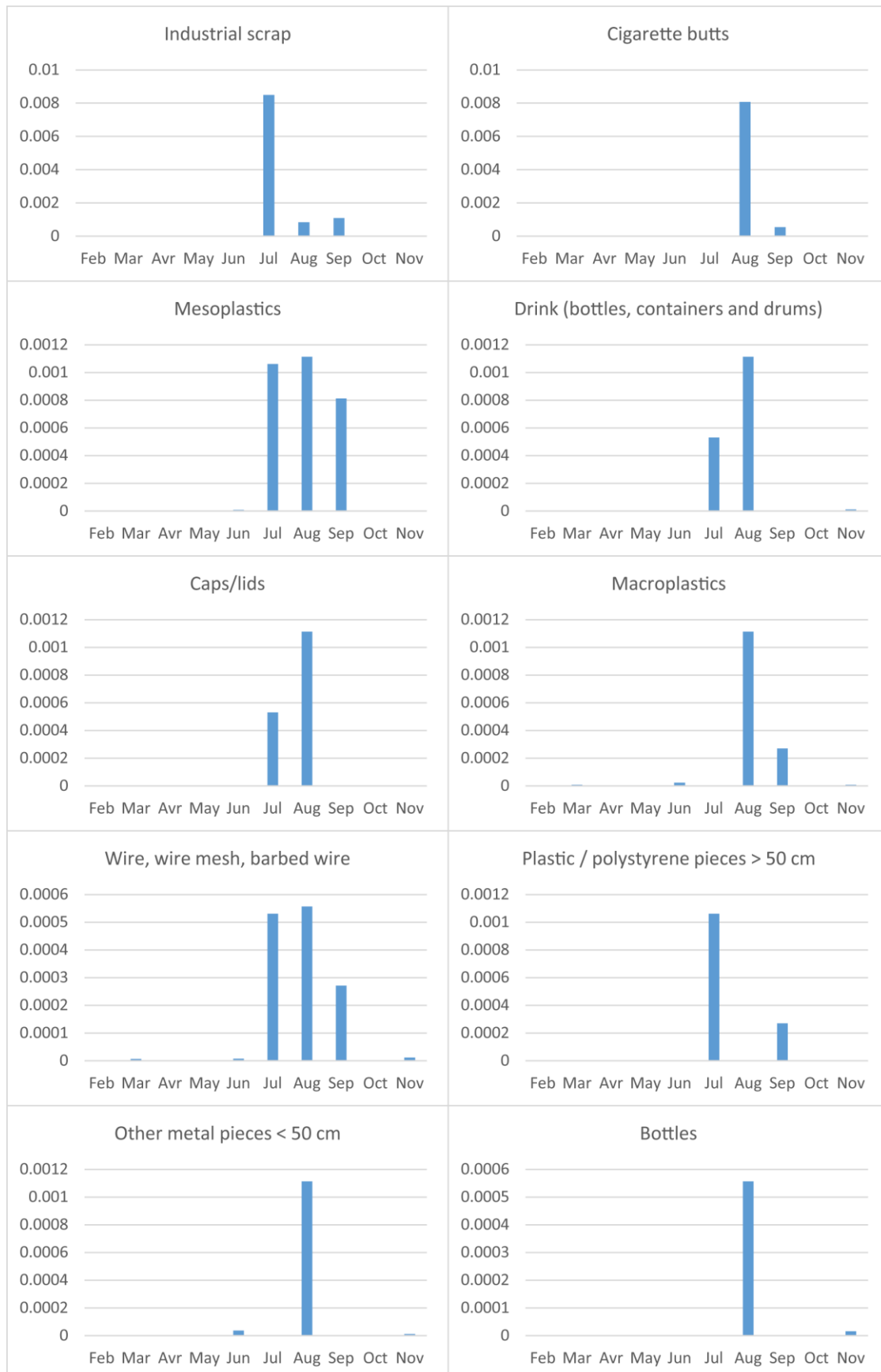


Figure E.III-2: seasonal variations of the 10 items with the highest accumulation rates (items/m²/day) collected on the beach of Letojani.

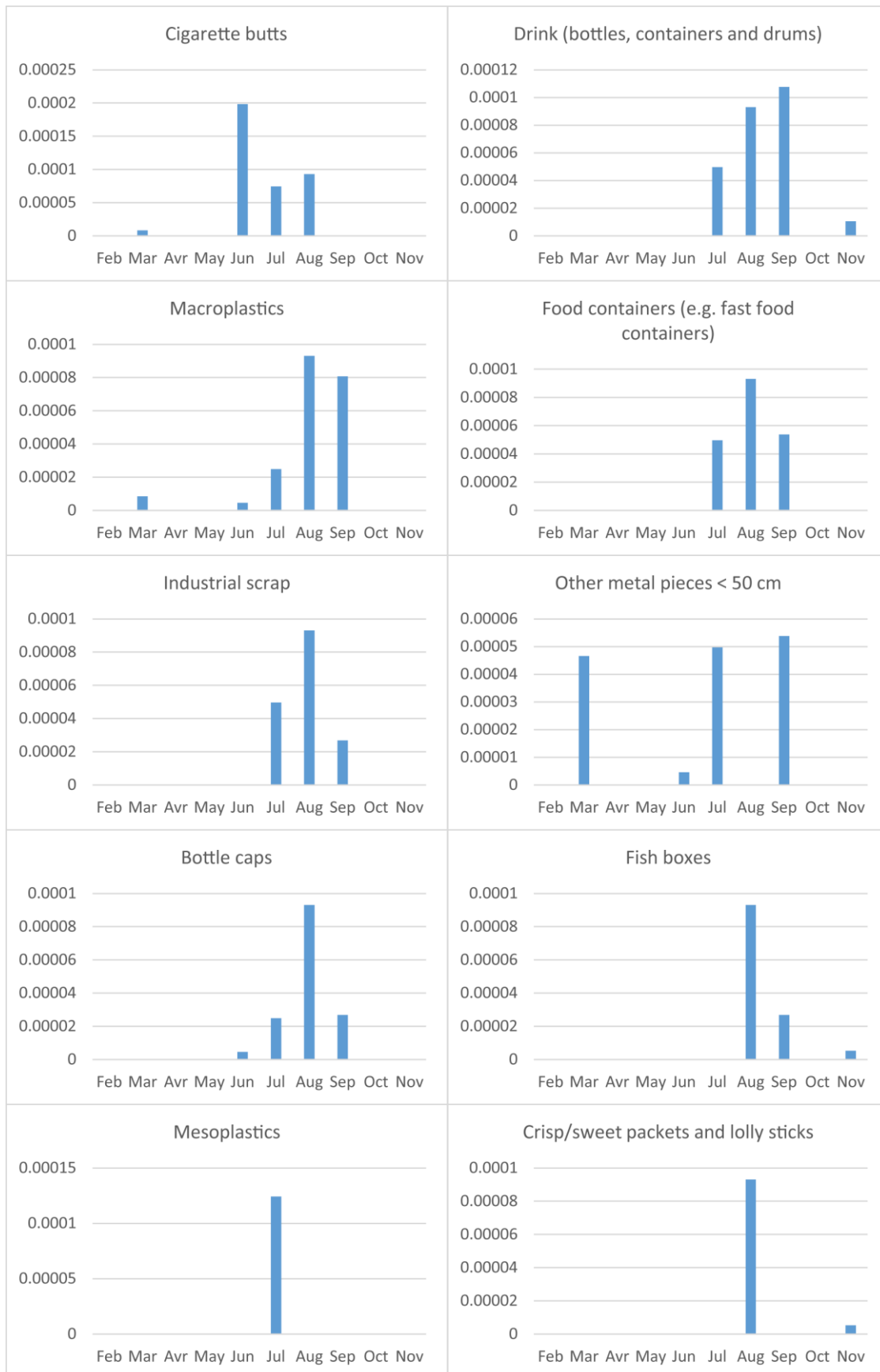


Figure E.III-3: seasonal variations of the 10 items with the highest accumulation rates (items/m²/day) collected on the beach of Fondaco Parrino.

IV. Rab

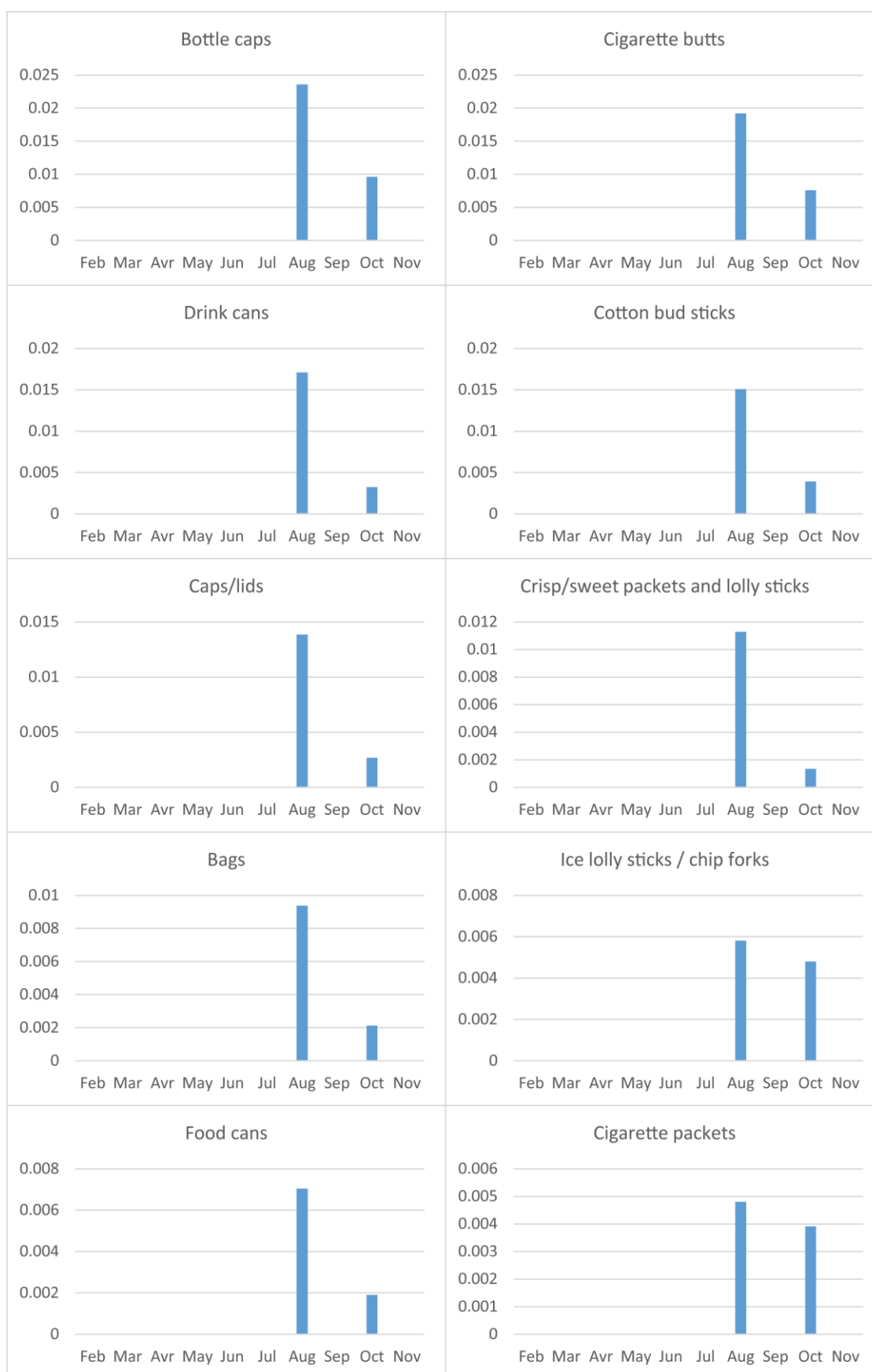


Figure E.IV-1: seasonal variations of the 10 items with the highest accumulation rates (items/m²/day) collected on the beach of Rajska.

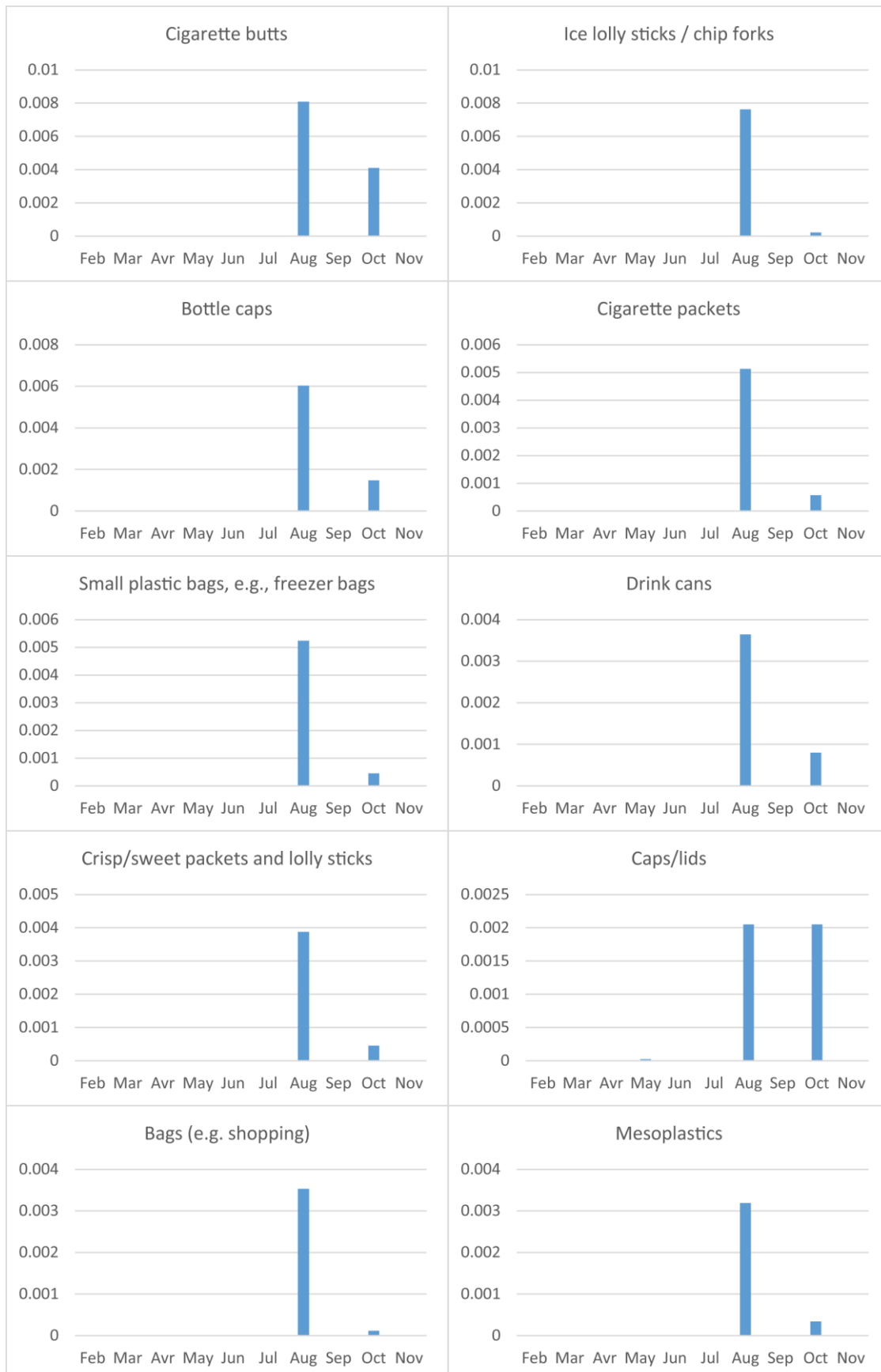


Figure E.IV-2: seasonal variations of the 10 items with the highest accumulation rates (items/m²/day) collected on the beach of Kampor.

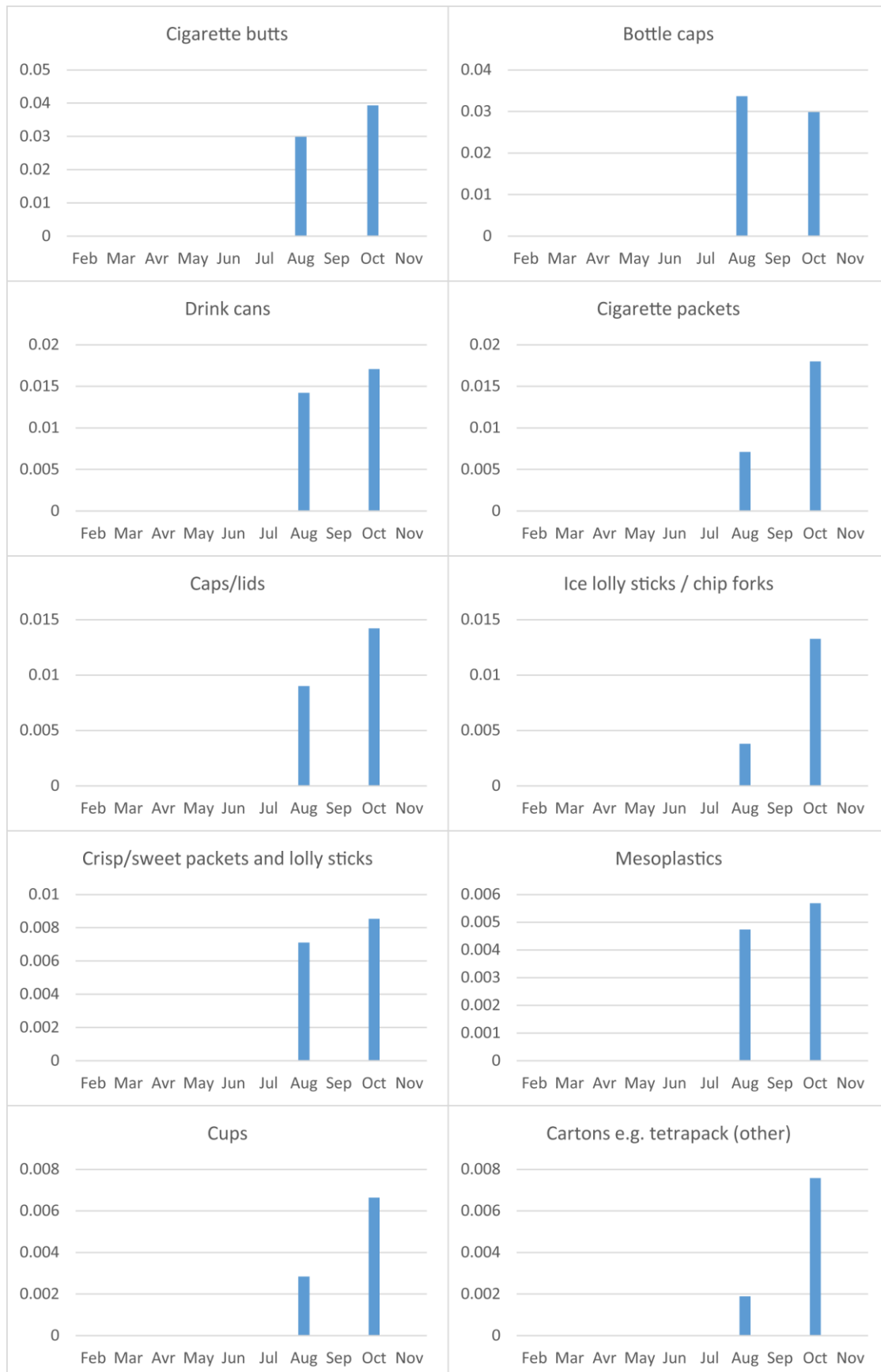


Figure E.IV-3: seasonal variations of the 10 items with the highest accumulation rates (items/m²/day) collected on the beach of Pudarica.

V. Malta

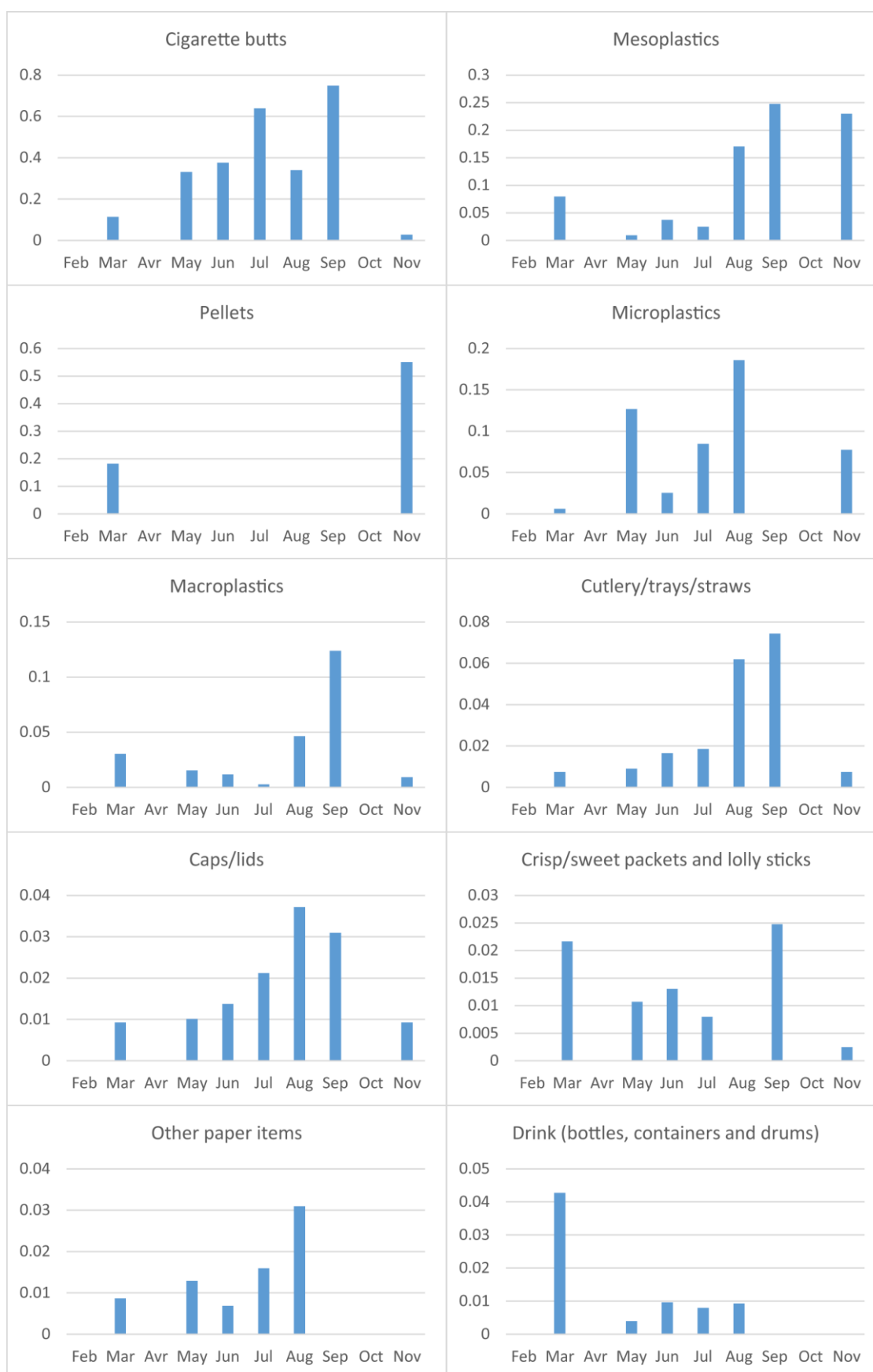


Figure E.V-1: seasonal variations of the 10 items with the highest accumulation rates (items/m²/day) collected on the beach of Golden Bay.

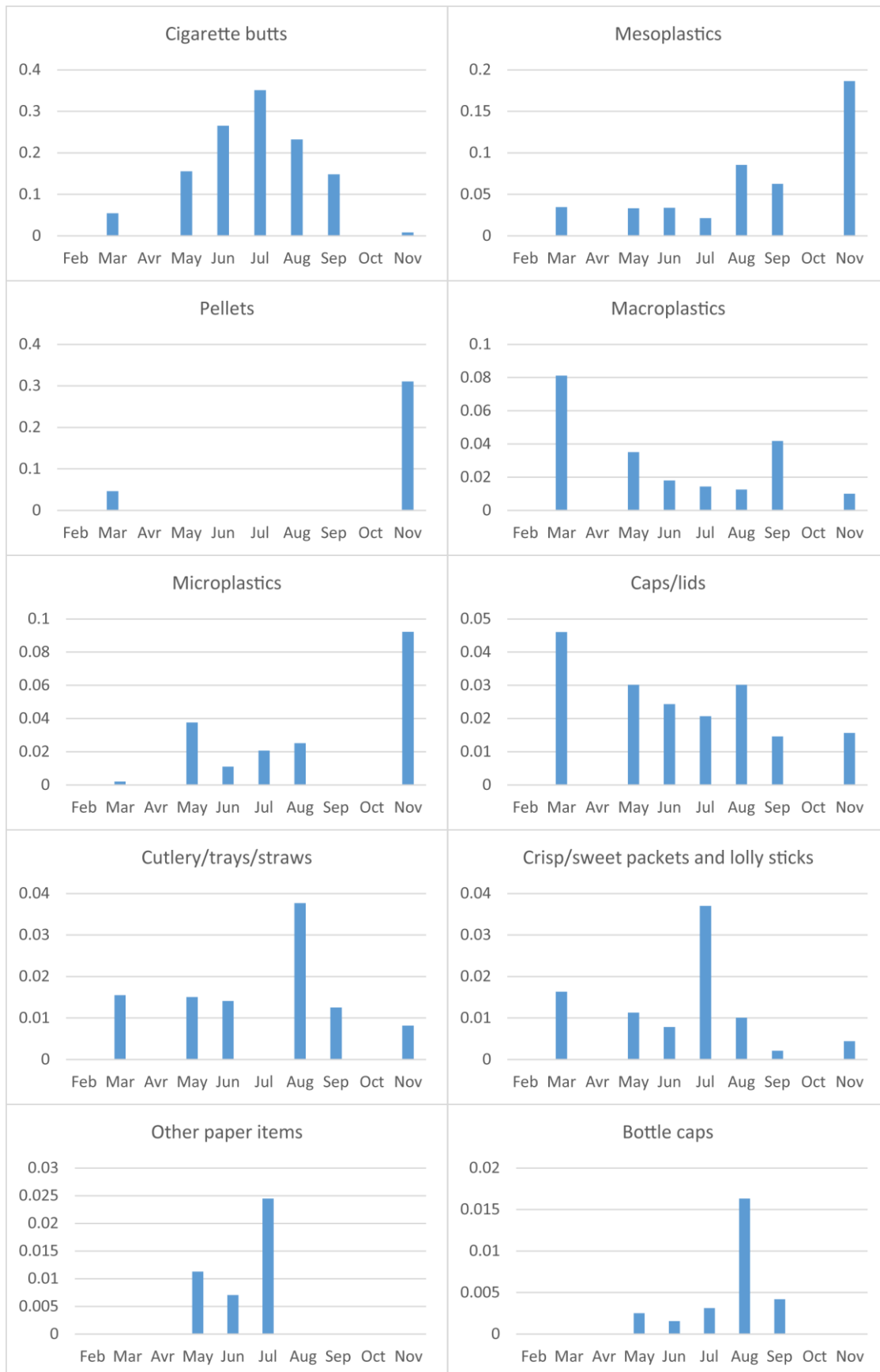


Figure E.V-2: seasonal variations of the 10 items with the highest accumulation rates (items/m²/day) collected on the beach of Gnejna.

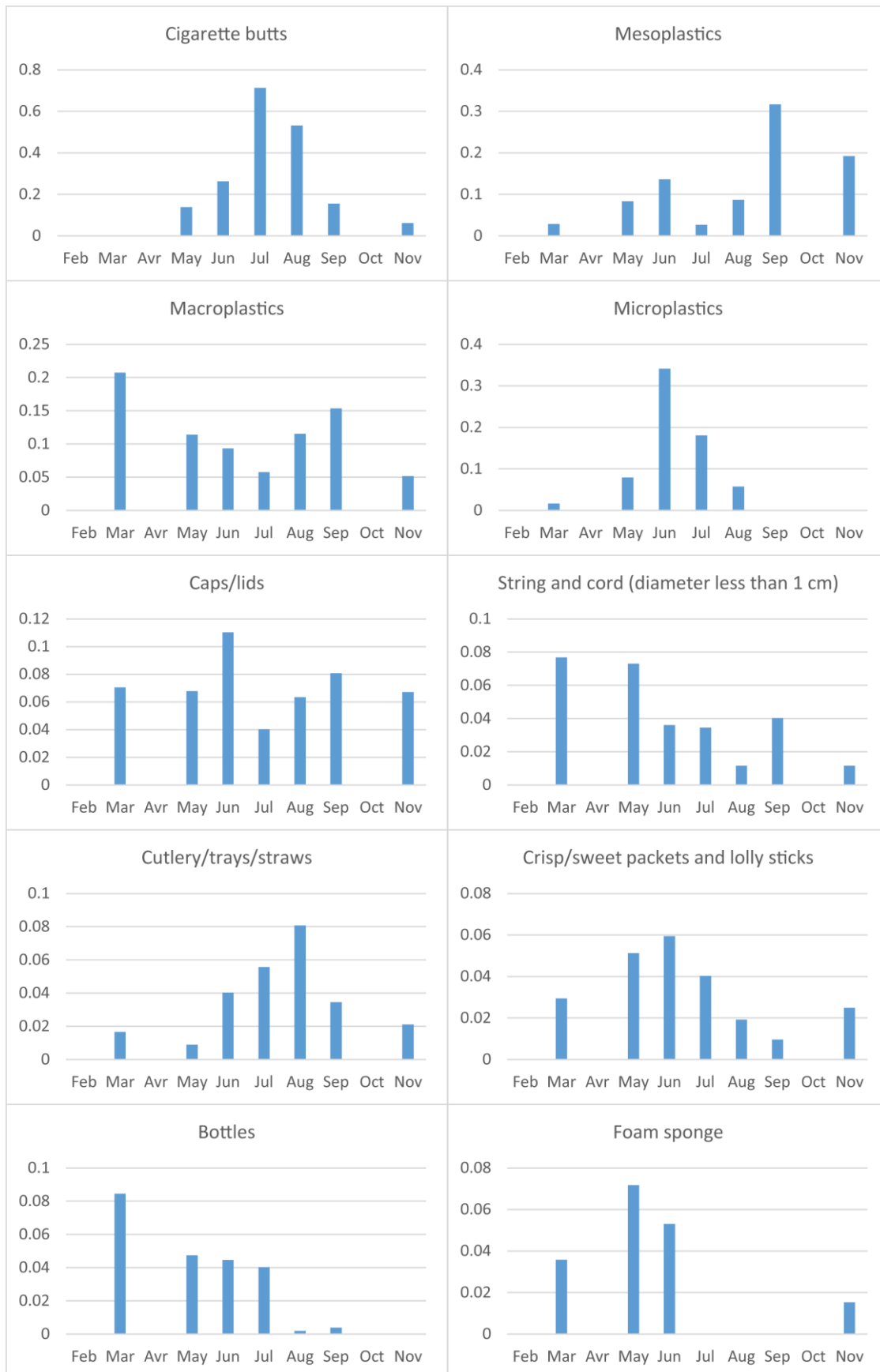


Figure E.V-3: seasonal variations of the 10 items with the highest accumulation rates (items/m²/day) collected on the beach of Marsaxlokk.

VI. Crete

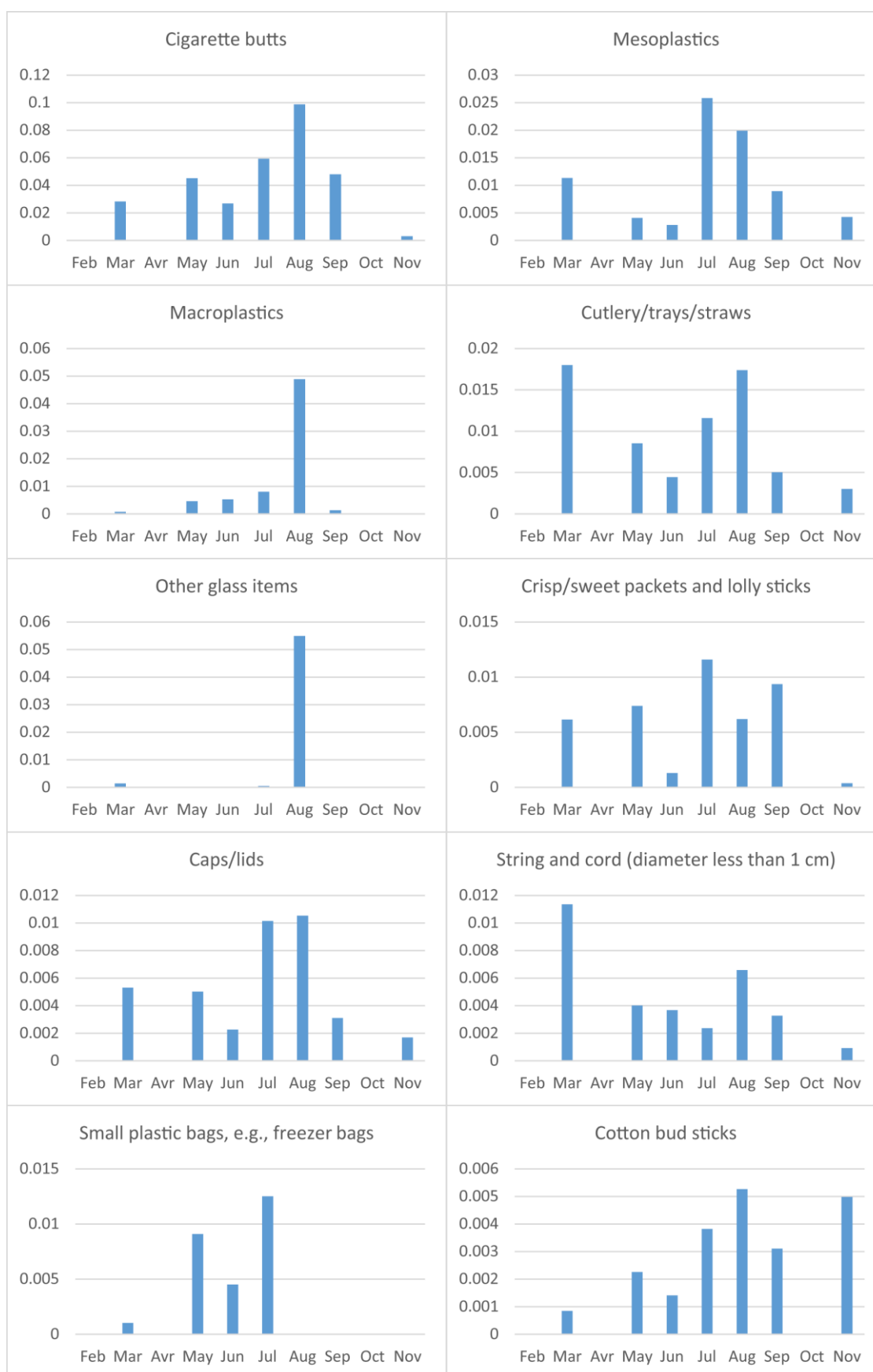


Figure E.VI-1: seasonal variations of the 10 items with the highest accumulation rates (items/m²/day) collected on the beach of Rethymno.

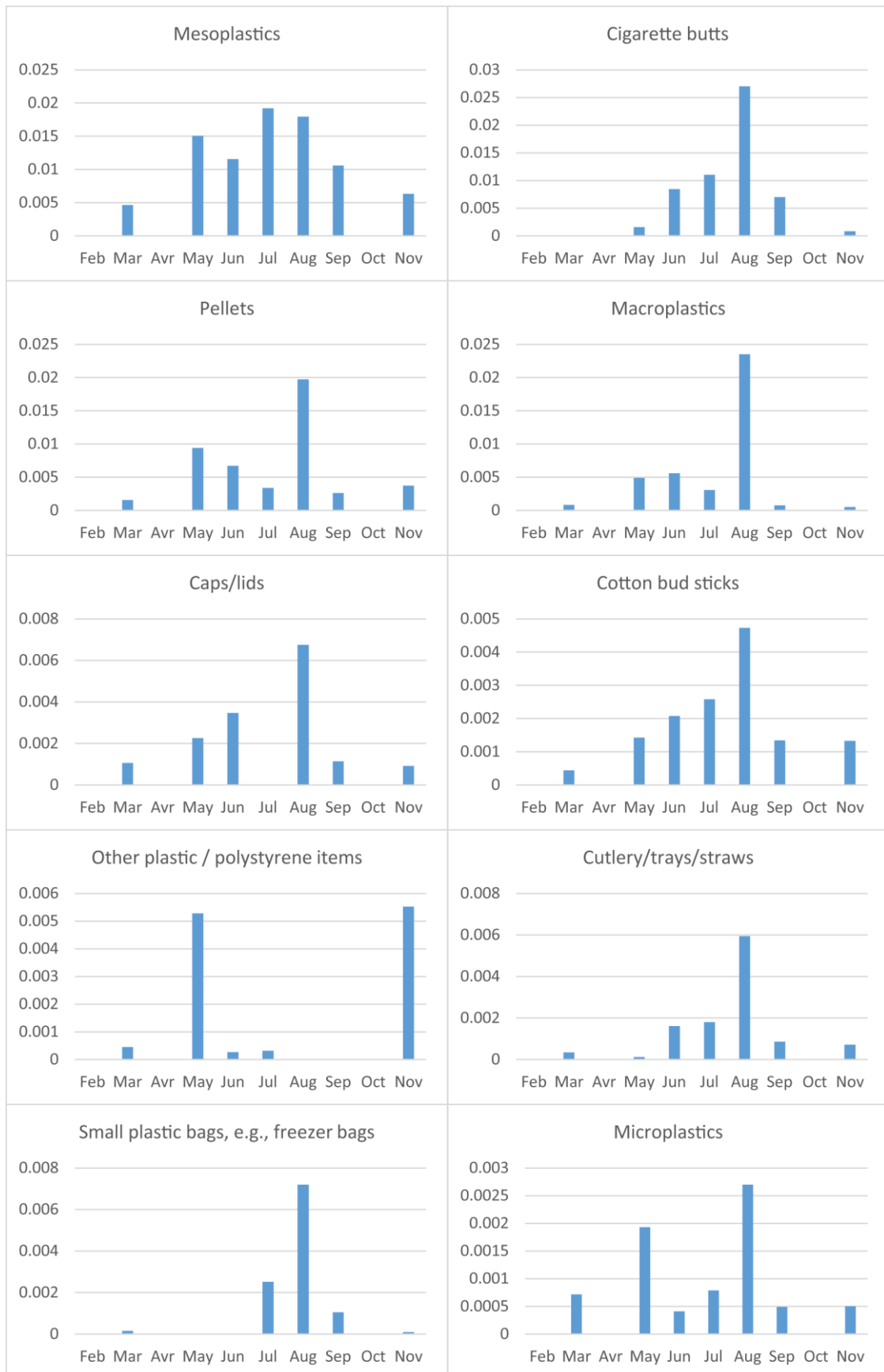


Figure E.VI-2: seasonal variations of the 10 items with the highest accumulation rates (items/m²/day) collected on the beach of Arina.

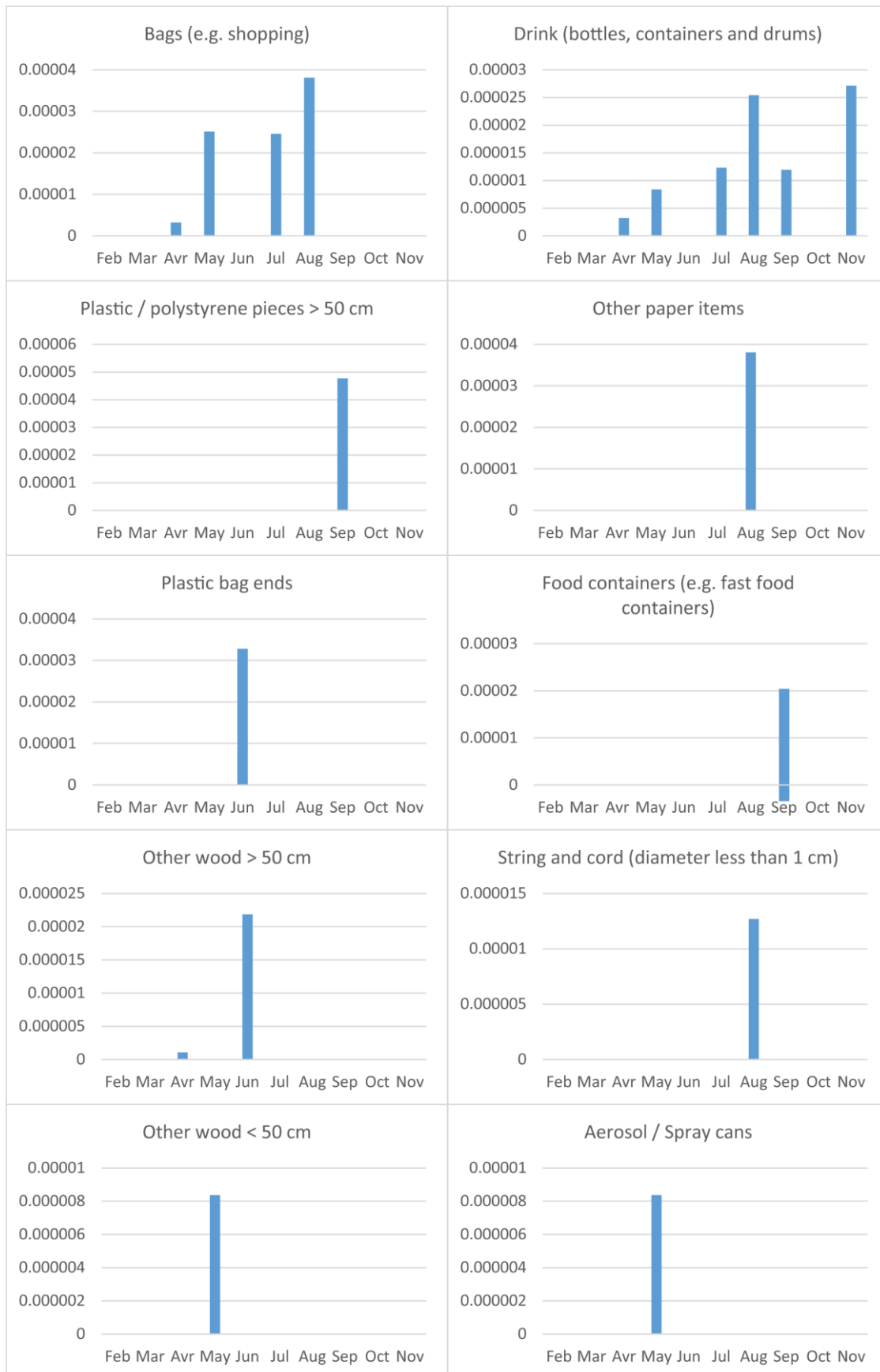


Figure E.VI-3: seasonal variations of the 10 items with the highest accumulation rates (items/m²/day) collected on the beach of Tsoutsouras.

VII. Mykonos

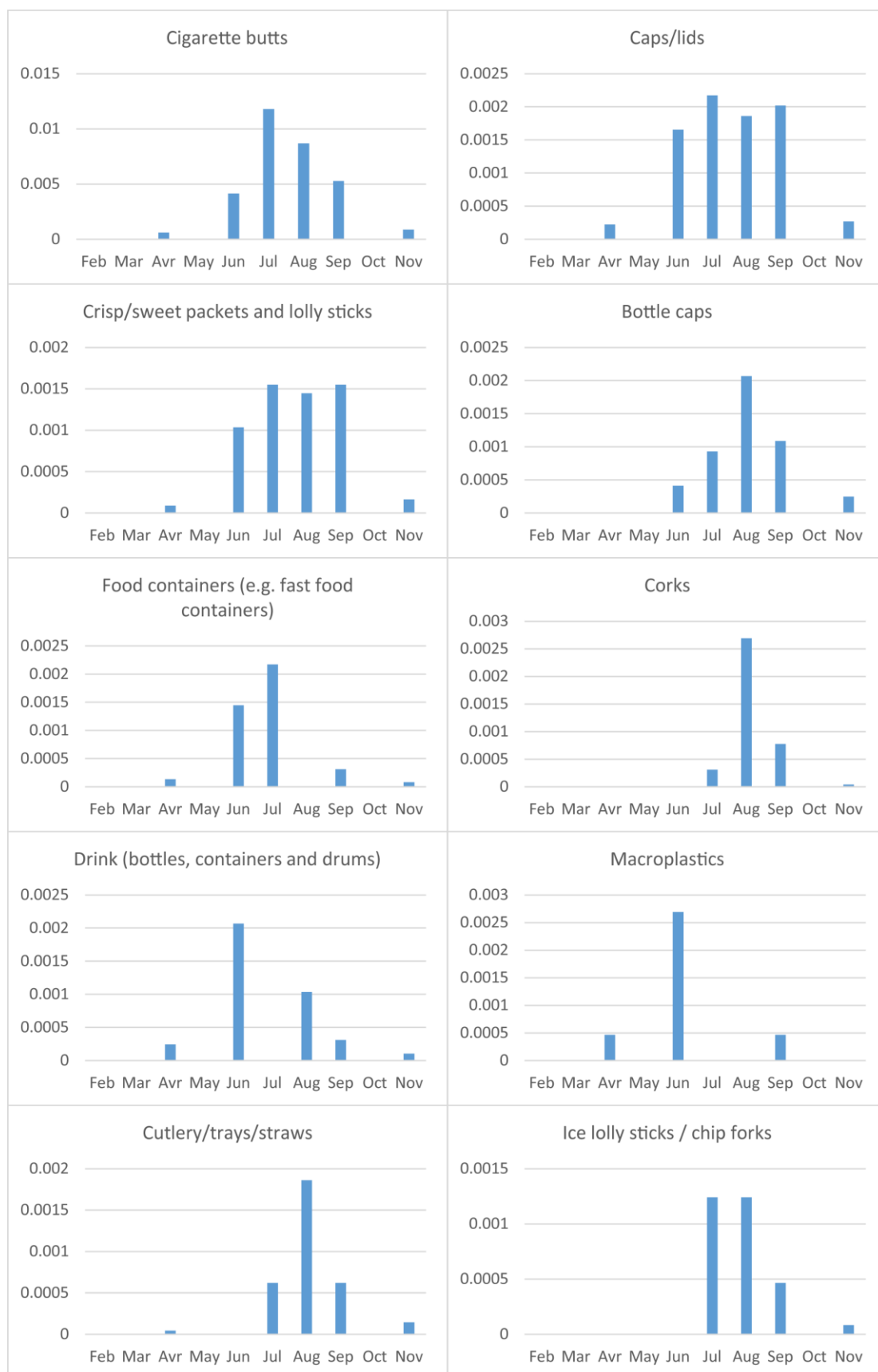


Figure E.VII-1: seasonal variations of the 10 items with the highest accumulation rates collected (items/m²/day) on the beach of Platis Gyalos.

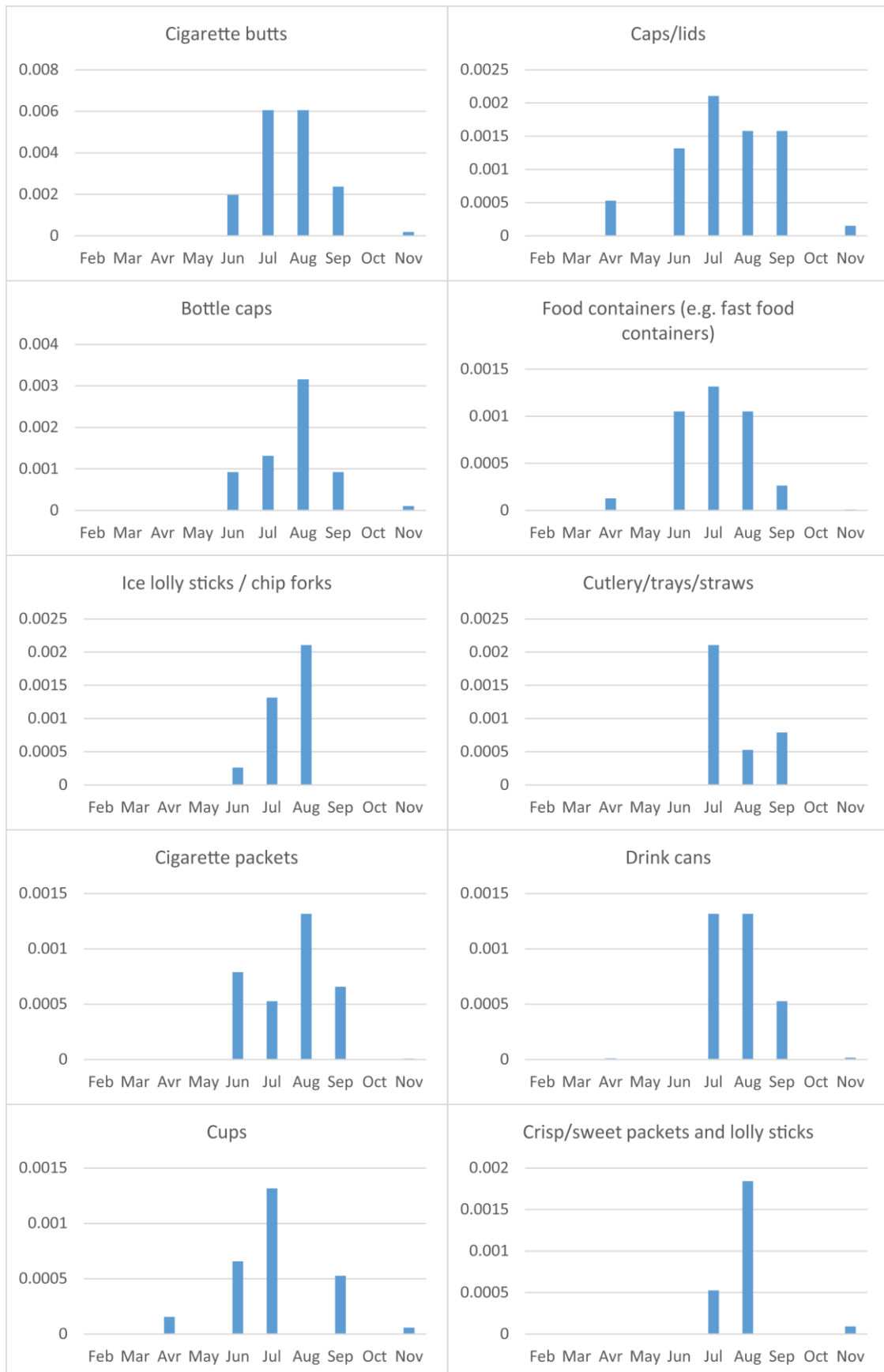


Figure E.VII-2: seasonal variations of the 10 items with the highest accumulation rates (items/m²/day) collected on the beach of Fokos.

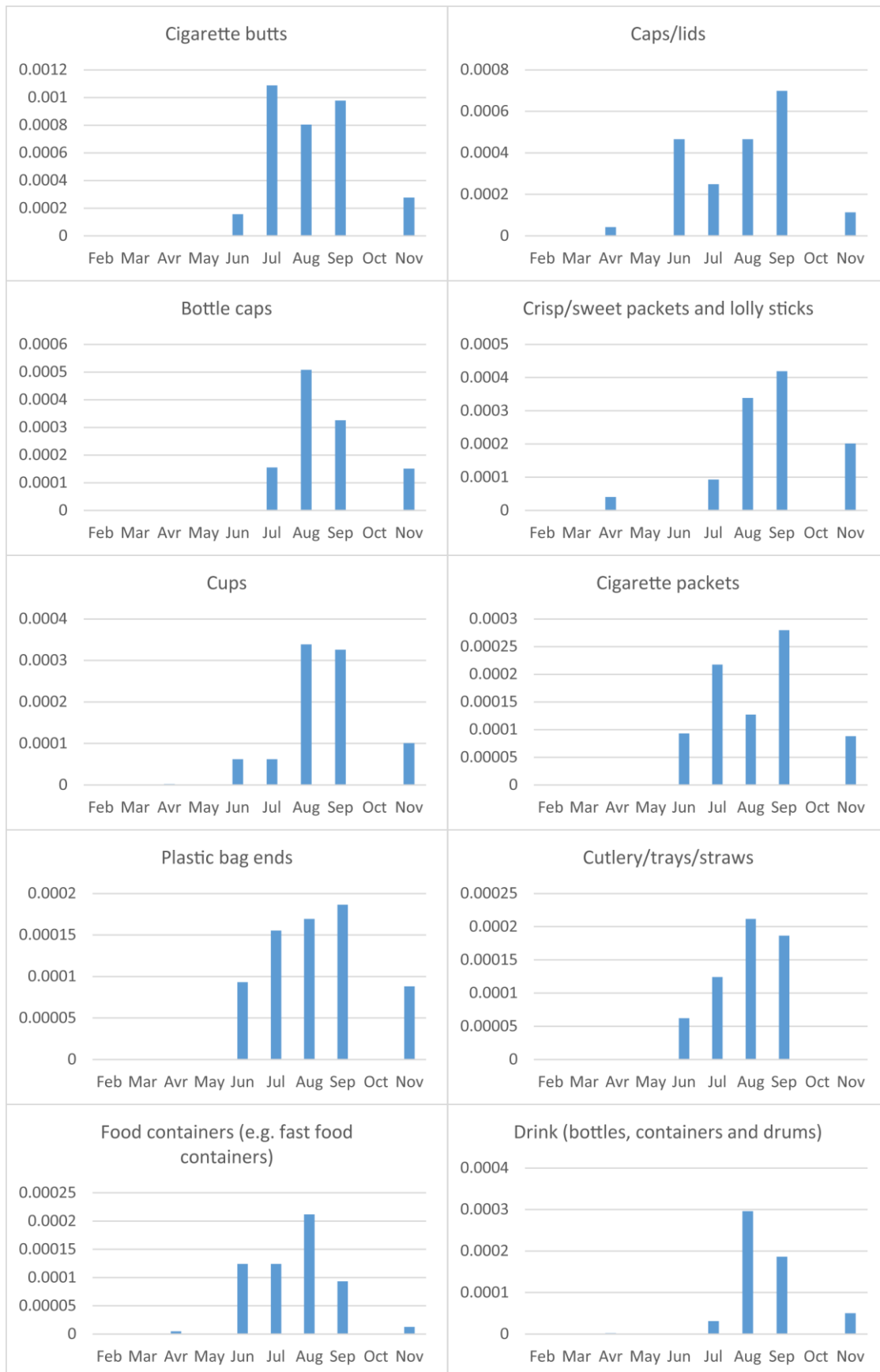


Figure E.VII-3: seasonal variations of the 10 items with the highest accumulation rates (items/m²/day) collected on the beach of Merchia.

VIII. Rhodes

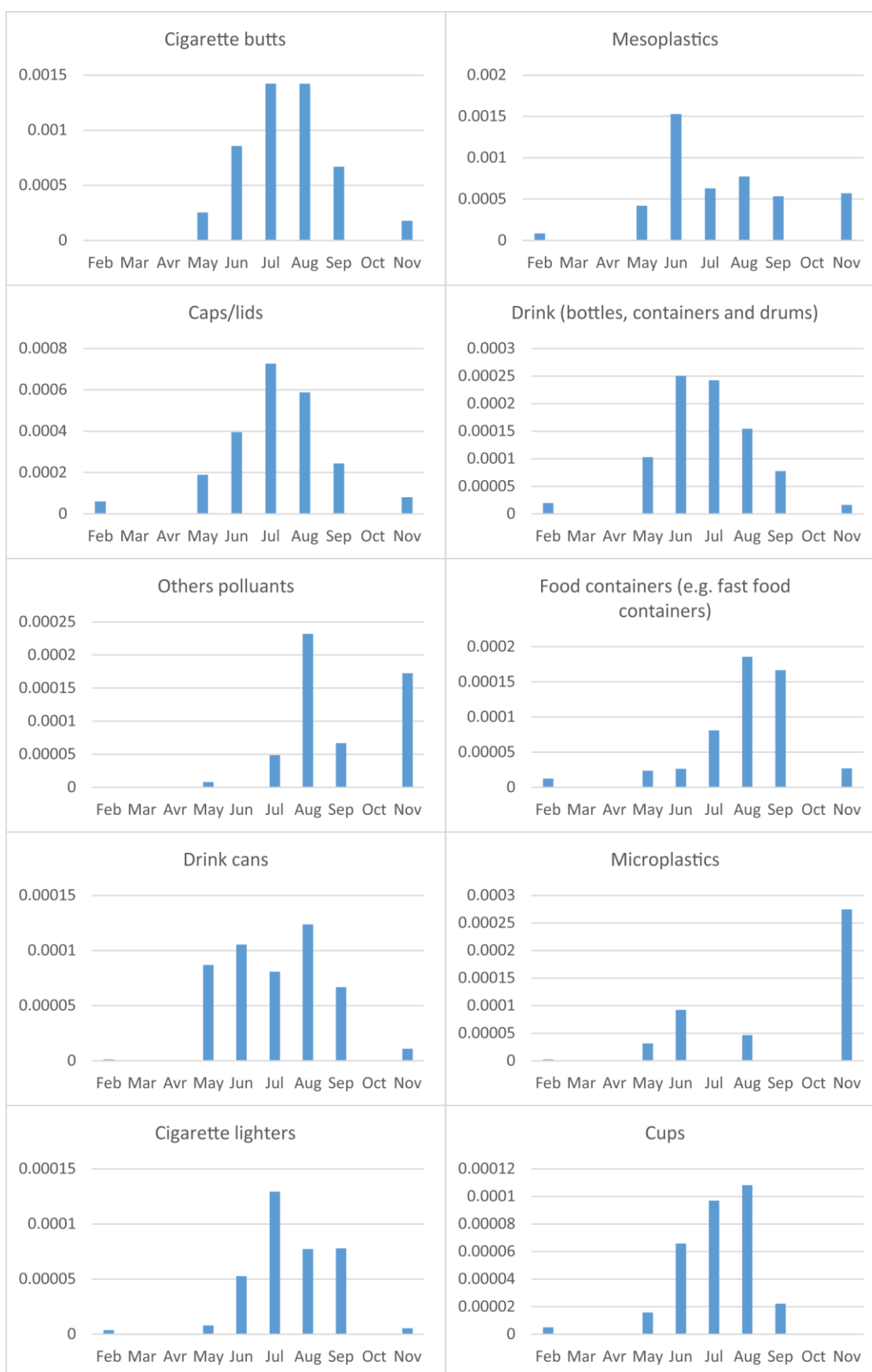


Figure E.VIII-1: seasonal variations of the 10 items with the highest accumulation rates (items/m²/day) collected on the beach of Tsampika.

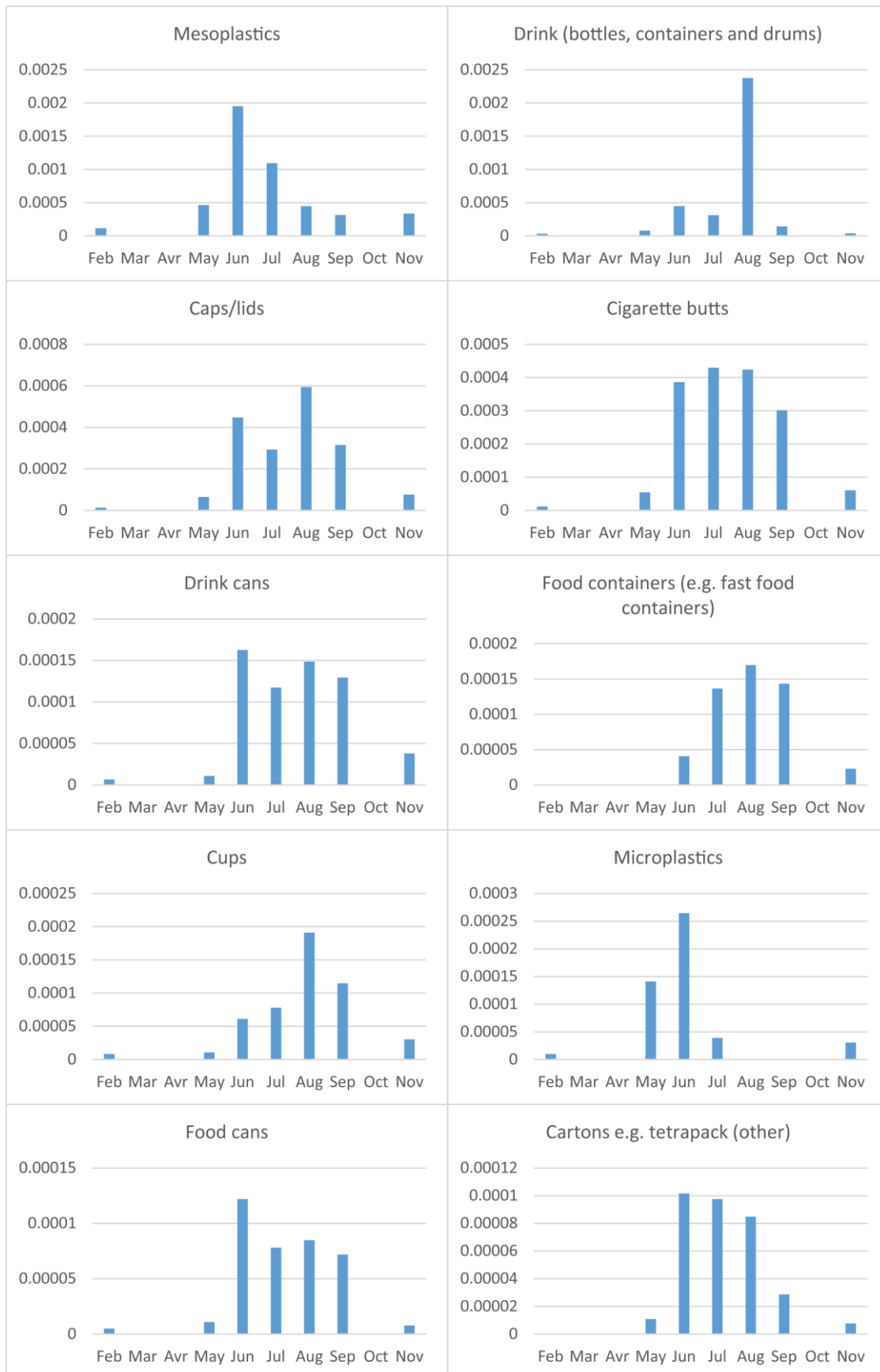


Figure E.VIII-2: seasonal variations of the 10 items with the highest accumulation rates (items/m²/day) collected on the beach of Afandou.

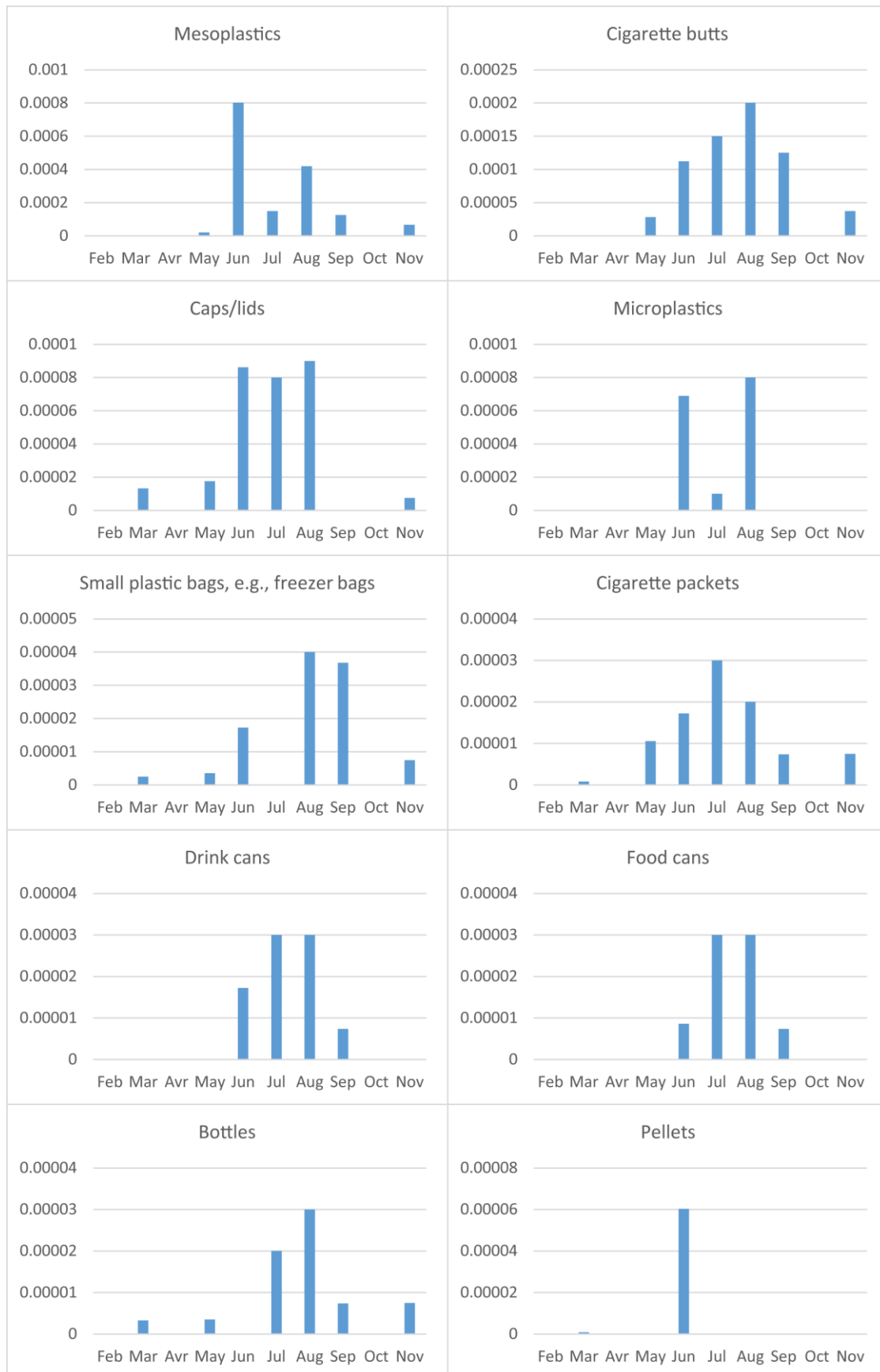


Figure E.VIII-3: seasonal variations of the 10 items with the highest accumulation rates (items/m²/day) collected on the beach of Gennadi.

IX. Cyprus

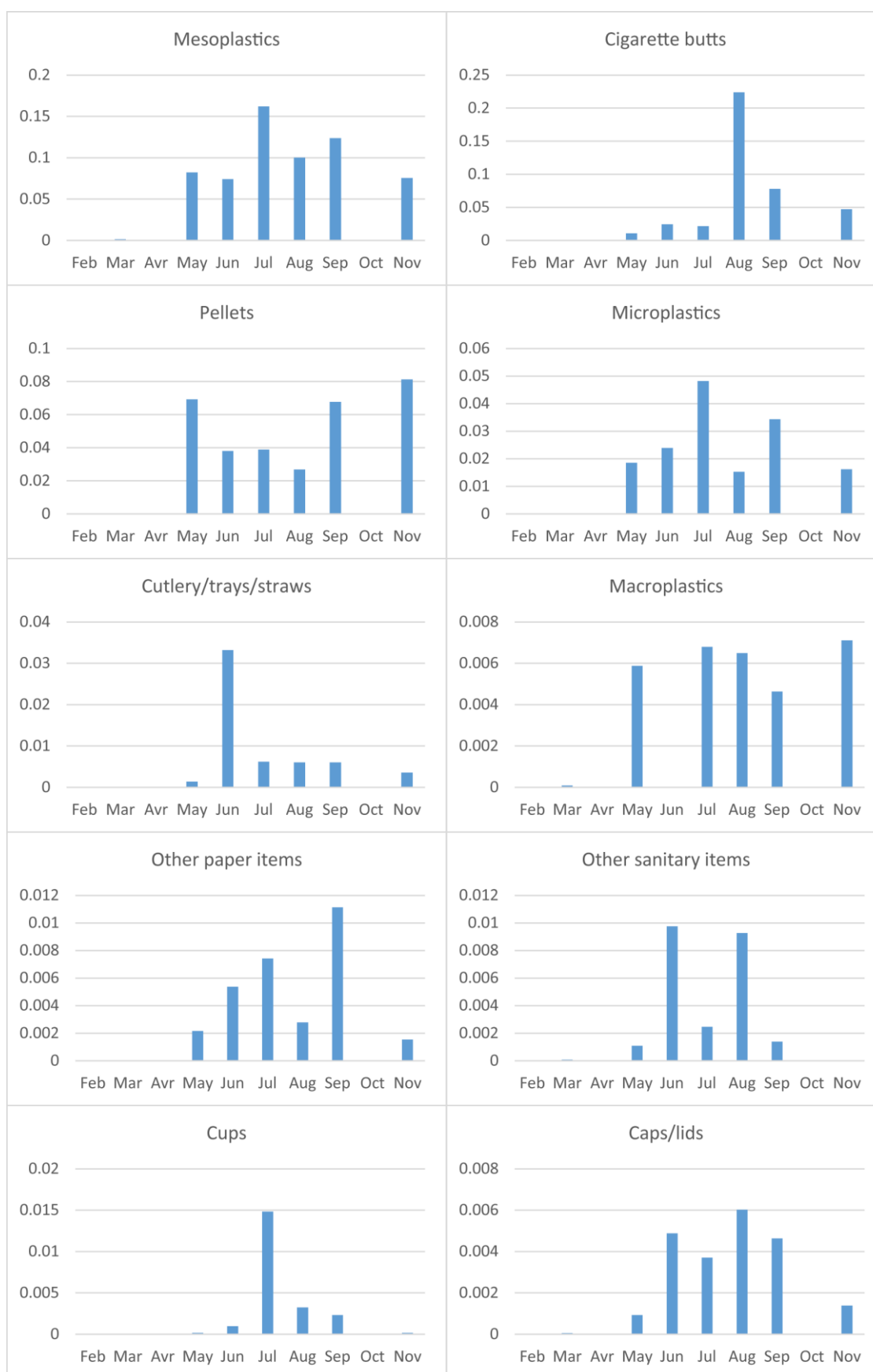


Figure E.IX-1: seasonal variations of the 10 items with the highest accumulation rates (items/m²/day) collected on the beach of Sunrise.

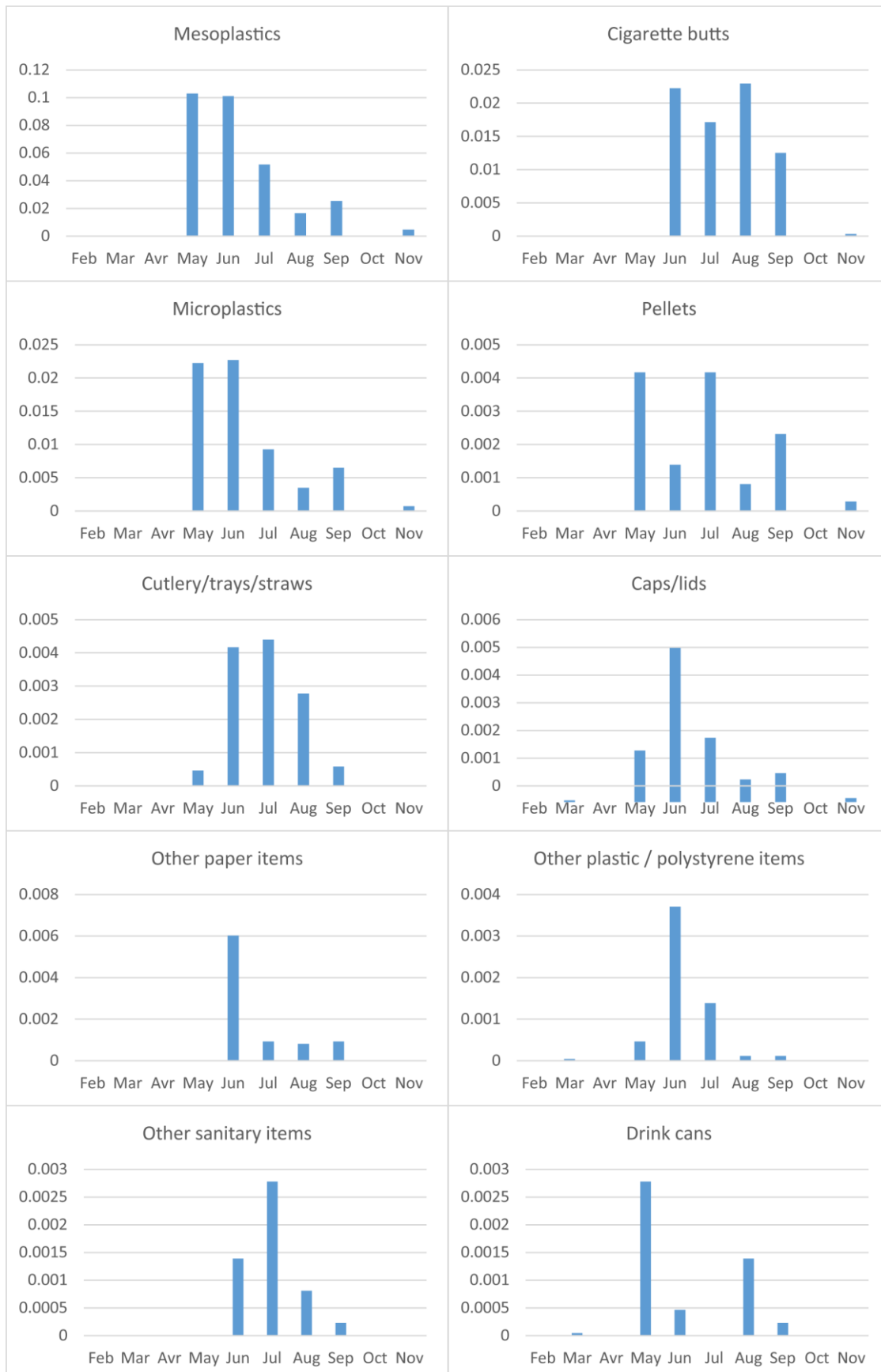


Figure E.IX-2: seasonal variations of the 10 items with the highest accumulation rates (items/m²/day) collected on the beach of Faros.

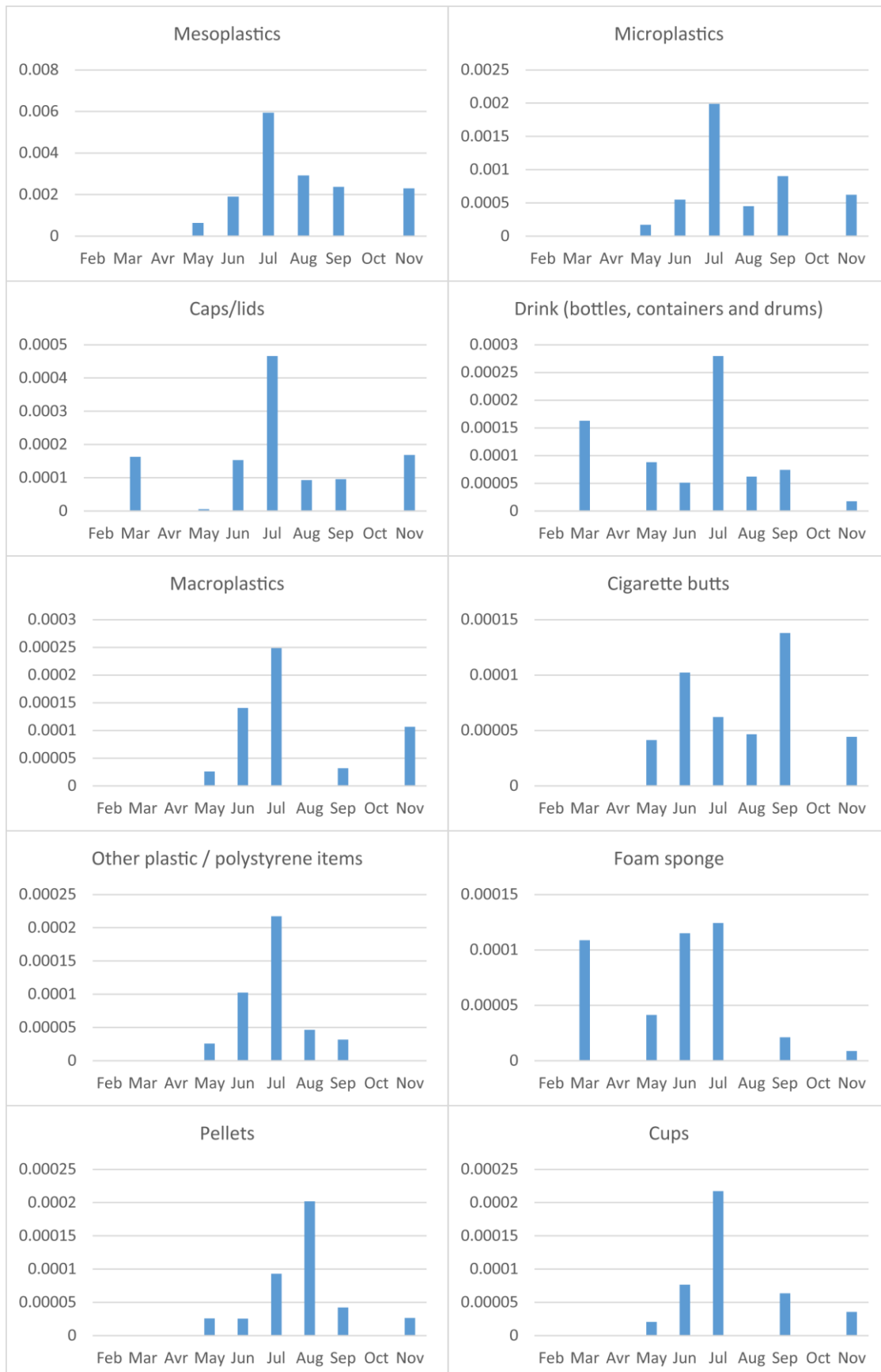


Figure E.IX-3: seasonal variations of the 10 items with the highest accumulation rates (items/m²/day) collected on the beach of Timi.