The distribution, abundance and characteristics of plastic debris along the Coast of Grândola, Portugal

Andrey Zhukov

Bachelor's thesis in Natural Resources

Degree Programme in Sustainable Coastal Management

Raseborg 2017

Bachelor's thesis

Author: Andrey Zhukov

Degree Programme: Sustainable Coastal Management

Specialization: Natural Resources

Supervisor: Maria Kihlström

Title: The distribution, abundance and characteristics of plastic debris along the Coast of Grândola, Portugal

---

Date 12/06/2017 Number of pages 64 Appendices 2

Abstract

Coastal clean-up campaign on the coast of Grândola is an annual practice organized by the non-governmental Portuguese organization, Brigada do Mar. With the objective of developing the marine litter monitoring on the Portuguese coast, the Portuguese Marine Litter Association participated in the project with the aim of collecting primary data about the state of coastal marine litter pollution on the coast of Grândola.

A close collaboration between the Grândola Municipality, Brigada do Mar and the Portuguese Marine Litter Association was set up, in order to gather information about marine litter in the coastal area of the region. The coast of Grândola was surveyed in five sampling areas along the coastline. The survey includes numbers, characteristics and abundance data. Plastic, making up 94,24 % of the registered marine litter, is a predominant material type in the marine litter of Grândola. The quantity of marine litter items differs between the sampling areas. The highest number of items (1000) were collected near the small village of Comporta. Among the microplastics, small broken plastic pieces are the most widespread. This study is important, not only to survey the current state of the marine litter on the coast, but also to promote awareness in the society and provide information for the institutes and local government.

Keywords: plastic, marine litter, microplastics, marine debris, Portugal

---

Acknowledgements

First of all, I would like to thank head of our programme Anna Granberg for being inspiring mentor during the course period. I would like to thank my supervisor Maria Kihlström for her patience and readiness in the thesis writing stage. I would also like to give kind regards to Paula Sobral from Nova University of Lisbon for that great chance to work together in environmental projects in Portugal and special gratitude for meeting me with Brigada do Mar team. I also would like to thank Ana Rita Seirôco and Simão Acciolli for their warm welcome in the cleaning campaign and the opportunity to collect samples for this thesis. Finally, I want to thank my dear parents for supporting me all my life.

Table of Contents

List of abbreviations

EU – European Union

GESAMP – The Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection

NAFTA – North American Free Trade Agreement

NGO – Non-governmental Organization

PEMRG – PlasticEurope Market Research Group

PCPs – Personal Care Products

PP – Polypropylene

PS - Polysterene

TGL-ML – Technical Subgroup on Marine Litter under Marine Strategy Framework Directive

UNEP – United Nations Environmental Programme

1 Introduction

Nowadays, plastic is an essential material in human use. It is impossible to imagine our regular life without products made of plastic. It serves in diverse industries and widely spread from local households to global international industries. Plastics show great variety in form, size, applicability, reusability, degradability, etc.
The mass production of plastic started in the 1950's and has grown very rapidly. The statistics show, that in 2014 about 311 million tons of plastic were produced on the planet. For example, in the early nineties only about 150 million tons were produced, which is twice less than nowadays. The trends also show that production will only increase in the near future (UNEP 2016).

Plastic use is an anthropogenic factor that affects the ecosystem development. Everything that have been used eventually ends up in nature and affects its structure. Any anthropogenic material has its own biodegradation time. As for the plastics, the biodegradation period can last from 100 to 1000 years, depending on the conditions, and might not even biodegrade at all. For example, plastic bottles made with polyethylene terephthalate will never biodegrade (O'Connor 2011).

Plastic is considered a toxic substance, which can be dangerous for the marine and terrestrial creatures, as well as for humans. It can cause physical harm to marine animals and seabirds who ingest plastic particles. It can cause entanglement, starvation, suffocation, infection and drowning. It has been calculated that plastic affects at least 267 species worldwide, where statistics show that it influences 86 % of all types of sea turtles, 44 % of all seabirds and 43 % of all marine mammal species on the planet (Laist, 1997). Furthermore, floating plastic can transport pathogens and hazardous substances for long distances (Y. Mato et al. 2005). It can also transfer invasive species into new habitats (Barnes 2002).

Today plastic pollution is a global problem. Since plastic is being mass produced all around the world and is also very lightweight, it easily spreads from terrestrial areas to the ocean and from the water to the coasts. According to Greenpeace, 100 million plastic items are produced annually and 10 % of them end up in the ocean

(Greenpeace 2006). Due to the oceans' currents, plastic debris forms great garbage patches. At least five giant gyres have been discovered:

- Indian Ocean Gyre
- North Atlantic Gyre
- South Atlantic Gyre
- North Pacific Gyre
- South Pacific Gyre

These plastic islands are growing annually in size and concentration. The researchers at the Algalita Marine Research Foundation report that the one of the Pacific Gyre increased five-fold between 1997 and 2007 (Moore 2006). Japanese scientific reports document a 10-fold increment in 10 years of pelagic floating plastic near the coast and later a 10-fold increase every 2-3 years in the nineties (Ogi, Fukumoto 2000). In the early 1990s, plastic debris increased 100 times in the Southern Ocean (Copello, Quintara 2003).

According to scientists, today the mass of the biggest garbage island is more than three and a half million tons, while its area is more than a million square kilometers. In 2001, the plastic mass exceeded the mass of zooplankton in the island zone six times (Seltenrich 2015).

2 Aims

The Portuguese coastline suffers from marine litter and is considered very vulnerable to plastic accumulation. There have been done several studies and articles on this subject in Portugal. For example, "Local marine litter survey - A case study in Alcobaça municipality, Portugal", by Frias J., Antunes, J., Sobral, P.
The objective of this work is to identify and classify plastic debris on the specific Portuguese coastline located in Grândola Municipality.
This study focuses on a primary marine debris assessment on the long coastline with a closer look at the microplastics problem. The research aims to provide information

about the current situation of marine litter on the coast and evaluate the state of the microplastics on the coastline of Grândola.
Based on the assessment, some figures of the current situation of marine debris will be calculated and some characteristics, such as abundance and distribution, will be described.

The study can be used by local authorities, non-governmental organizations, private bodies in social awareness actions, and by universities and researchers who works with the topic of marine debris.

The main goals of the study are following:

- Describe the current situation of marine debris on the coast of Grândola
- Assess and characterize type, abundance and distribution of the marine plastic debris
- Provide a first assessment for the current state of microplastics on the shoreline

3 Theoretical framework of the study

Reviewing the literature is very important to understand the scale of the marine litter problem and current situation with the plastic debris in the ocean. The problem is considered global and stays very much an actual topic. This overview shows the current state of the problem and indicates the environmental issues with a growing volume of marine litter in the ocean. It also emphasizes plastics and the microplastics production and utilization. The review also points out the sources of the coastal marine litter pollution.

3.1 Plastic

3.1.1 What is Plastic?

Plastic is one of the great inventions of the twentieth century. The development of plastic materials started from natural materials in the nineteenth century and evolved with the progress and availability of chemical modification of natural materials. Modern plastics have been recognized for around 100 years with the development of completely synthetic materials where the key breakthrough have been done by Leo Baekeland in 1907, who created Bakelite, the first real synthetic, mass-produced plastic. (PlasticEurope)

Plastics are produced from the processing of natural organic products such as crude oil, natural gas, cellulose, coal and salt. The production of plastic is a very complex technological process. One common technique is a distillation process in an oil refinery. It is used to separate crude oil into lighter groups which are called fractions. These fractions are used for different purposes. One of these fractions is Naphtha, the vital element in the plastic production.

There are two prevalent methods in the plastics production, which are polymerization and polycondensation. In addition, there are many types of final products that can be divided into the two big groups of thermoplastics and thermosets (Table 1).

Table 1. List of two main plastic groups: thermoplastics and thermosets

Examples of plastic final products	
Thermoplastics	Thermosets
Acrylonitrile butadiene styrene – ABS Polycarbonate - PC Polyethylene - PE Polyethylene terephthalate - PET Polyvinyl chloride - PVC Polymethyl methacrylate - PMMA Polypropylene - PP Polystyrene - PS Expanded Polystyrene - EPS	Epoxide (EP) Phenol-formaldehyde (PF) Polyurethane (PUR) Polytetrafluoroethylene - PTFE Unsaturated polyester resins (UP)

Thermoplastics is made from polymer resins. It has a liquid structure when heated and hard structure when it is cooled and can also be frozen. The flexible quality makes thermoplastic reusable; it can be reheated and reshaped many times. This type of plastic is very widespread in everyday life and comes in many varieties. There are a lot of different types of thermoplastics produced. The most common are:

- Polyethylene (plastic shopping bags, cosmetic bottles)
- Polycarbonate (drinking bottles, compact discs, food containers)
- Acrylonitrile butadiene styrene (toys, sport equipment)

Thermosets are synthetic materials with changed chemical structure. They have been processed to create a new a three-dimensional structure. After the plastic objects are done after heating and formation, the molecules cannot be restructured. This important quality provides great heat and pressure persistence and helps maintain the form unchanged. Thermosets are also highly widespread in diverse fields: electronic chips, fiber-reinforced composites, polymeric coatings, spectacle lenses, dental fillings, etc. The plastics can be recoverable by way of energy

recovery, feedstock recycling and grinding. These are all possible options (PlasticEurope).

3.1.2 Microplastics

The plastic particles can be classified into three size categories, microplastics (less than 5 mm), mesoplastics (5–10 mm) and macroplastics (>10 mm), (Collignon et. al., 2013).

The small plastic particles which are less than 5 mm in diameter have been defined as microplastics (GESAMP 2015). The microplastics can be classified into two major types: primary and secondary. Other types can also be recognized, as there are no strong definition for microplastics, but these can be seen as something between primary and secondary microplastics.

The primary type is a specially manufactured microscopic plastic for various purposes. It is, for example, widespread in cosmetics and air blasting technology. There are a lot of forms such as pellets, fibers, capsules and microbeads (UNEP 2016).

Secondary microplastics are derived from the breakdown of larger plastic debris. The origin of the small particles can be both from sea as well as from land. The process of plastic breakdown begins when it is exposed to sunlight (NOAA 2015).
Other sources of microplastics can be defined as by-products or dust emission during wear and tear of the industrial machines. Examples of these are dust from ship maintenance activities, waste treatment, synthetic textiles, ropes or paint. This type of microplastics derives from human activities. The Norwegian Environment Agency considers these plastic particles as a primary microplastics (Mepex 2014).

3.2 Plastic production & consumption

3.2.1 Production of plastic

The mass production started in the nineteenth century after the introduction of thermoplastics. The trend for the plastic production is a continuous growth from the beginning to now that is expected to continue in the future. For example, in 2015 the various industries produced 322 million tons against 230 million in 2005, meaning that the production quantity increased 1.4 times between those ten years. (PlasticEurope 2016). The world distribution of the plastic materials production look like follows (considering only thermoplastics and polyurethanes): China is the global leader with 27,8 % of overall production, followed by Europe and the NAFTA countries with 18,5 %. The rest of Asia fabricates about 16,7 %. Other countries produce relatively much less plastic than the countries mentioned (PlasticsEurope (PEMRG) / Consultic). The plastic production trend in the world and in Europe is shown in Figure 1.

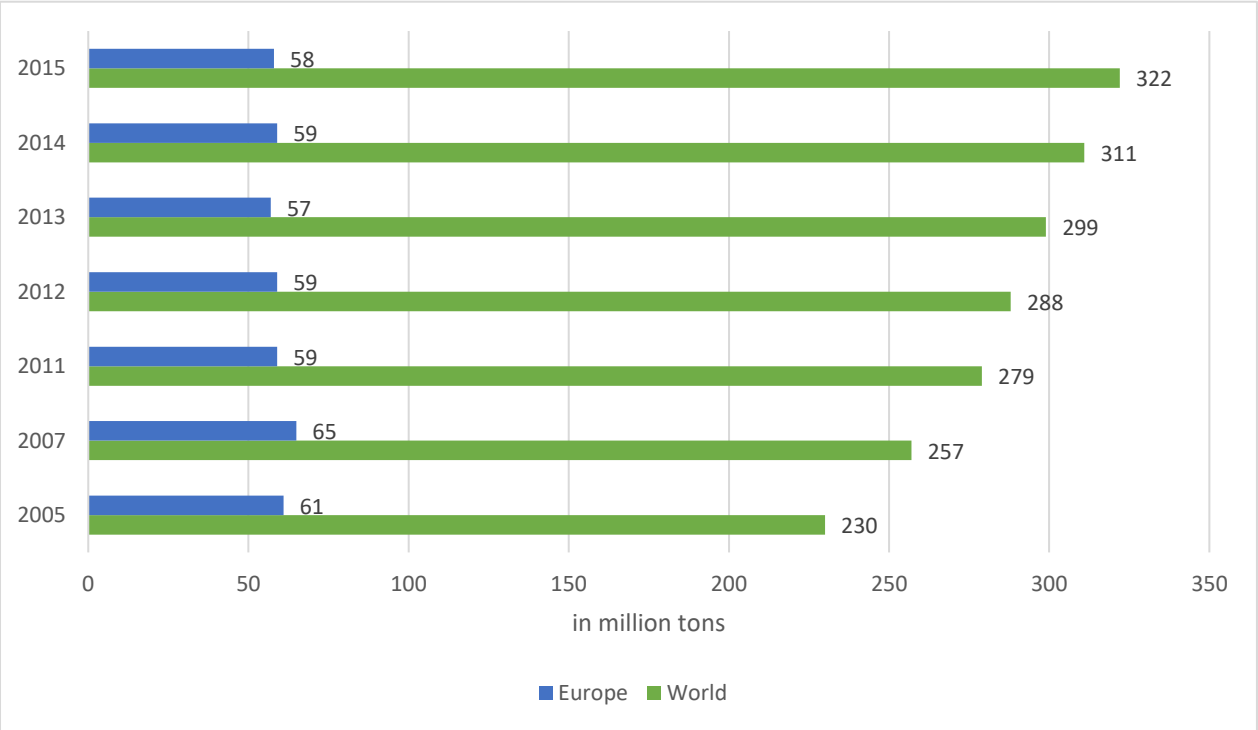

Figure 1. World and EU plastic production data (PlasticEurope 2016).*

** The 28 European Union countries as well as Norway and Switzerland*

In 2015, the total European plastic demand was 49 million tons, of which six countries stood for 70 % of the demand. These countries are Germany (24,6 %), Italy (14,3 %), France (9,6 %), Spain (7,7 %), The United Kingdom (7,5 %) and Poland (6,3 %) (PlasticsEurope (PEMRG) / Consultic / myCeppi). Considering the main market sectors, the distribution in European countries (EU-28+Norway/Switzerland) looked like follows: packaging (39,9 %), building & construction (19,7 %), automotive (8,9 %), electrical & electronic (5,8 %), agriculture (3,3 %) and other market categories including consumer and household goods, furniture, sport, health and safety (22,4 % in total).

As for demand per polymer, Polypropylene (PP) and Polyethylene (PE) are the most popular in the plastic materials production and make up about 50 % of overall production. PP is used for food packaging, snack wrappers, hinged caps, microwave proof containers, pipes, banknotes etc. PE is used for the production of reusable bags, agricultural film, food packaging film, toys, bottles, pipes, etc. (PlasticEurope 2016).

3.2.2 Management of plastic waste

Plastic has become a very widespread material on the planet in a hundred years, which also poses waste management issues. Due to inappropriate disposal, low recycling rates and inherent slow degradability, plastic causes concern.

In order to achieve self-sustainability goals, plastic recycling technologies need to be established. The modern recycling methods can be classified into three groups: mechanical, chemical and energetic recycling (Manrich et al., 2009).

The mechanical way of plastic recycling is the simplest one, which demands low investment compared to the other methods. This implies reprocessing of plastic waste into new products, for which it needs to be sorted (Manrich et al., 2009). For example, thermosets and thermoplastics cannot be reprocessed the same way because thermosets do not re-melt. Moreover, thermoplastics should also be divided into groups, otherwise the properties of the reprocessed plastic become very poor (Goodship, Vannessa 2007). This means, that in order to create good reprocessed plastics it has to be sorted.

Chemical recycling uses heat or chemical treatment to reprocess plastic waste. The common practices are hydrolysis and pyrolysis. Usually plastic breaks down into basic chemical components, which can be used for new polymers or other products. However, the chemical method is very expensive and requires a huge investment (Manrich et al., 2009).

The energy recycling method has been excluded from a normal type of plastic recycling and use as a form of energy recovery (Manrich et al., 2009).

Nowadays, a huge part of the plastic waste still ends up in landfills. The rate of this varies from country to country. For example, among the European countries only a few has less than 10 % utilization of plastic waste in landfills. Examples of these are countries like Germany, Sweden, the Netherlands and Norway. A moderate level, represented by 10 to 50 % of plastic waste utilization in landfills can be found in The United Kingdom, France, Portugal, Finland and Italy. There are some countries where plastic waste ends up in landfills in rates above 50 %, like Spain, Poland, Greece and Bulgaria (Plastic Europe). The figures mean that there is still an active utilization process of plastic as landfill going on.

The European Union has an active ongoing project, “Zero plastics to landfill by 2025”, aiming to stop the use of recyclable and other recoverable waste in landfills. In order to do that, EU supports innovations in plastic recycling and seeks to improve the separate collection of bio-waste and dry-recyclables (Plastic Europe).
The alternative for non-recyclable or waste which cannot be recycled sustainably, should be utilization as an energy source.

3.3 Sources of plastic debris in the ocean and on the coasts

There are many possible sources for the plastics in the ocean. It’s very challenging to classify all of them. However, the general sources of plastic pollution can be characterized in figure 2.

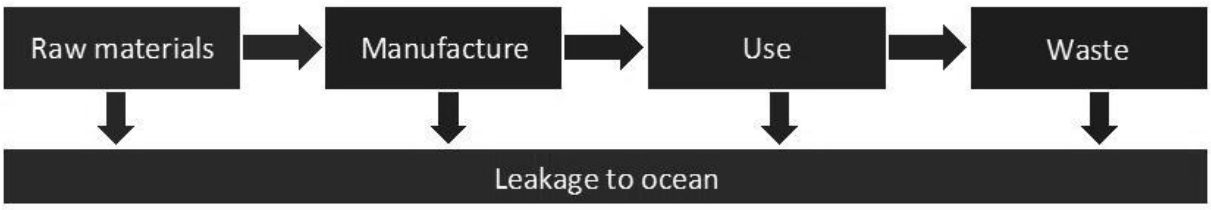

Figure 2. Potential leakage points of the plastic to the ocean (original by P. J. Kershaw).

This picture demonstrates that plastic can be discharged to the ocean at every stage of its life-cycle, from production to use and utilization. This also increases the complexity of the recycling process for plastic. Moreover, plastic enters the ocean in different forms and sizes, from microplastics to macroplastics.
The land-based pathways for macroplastics are shown in figure 3.

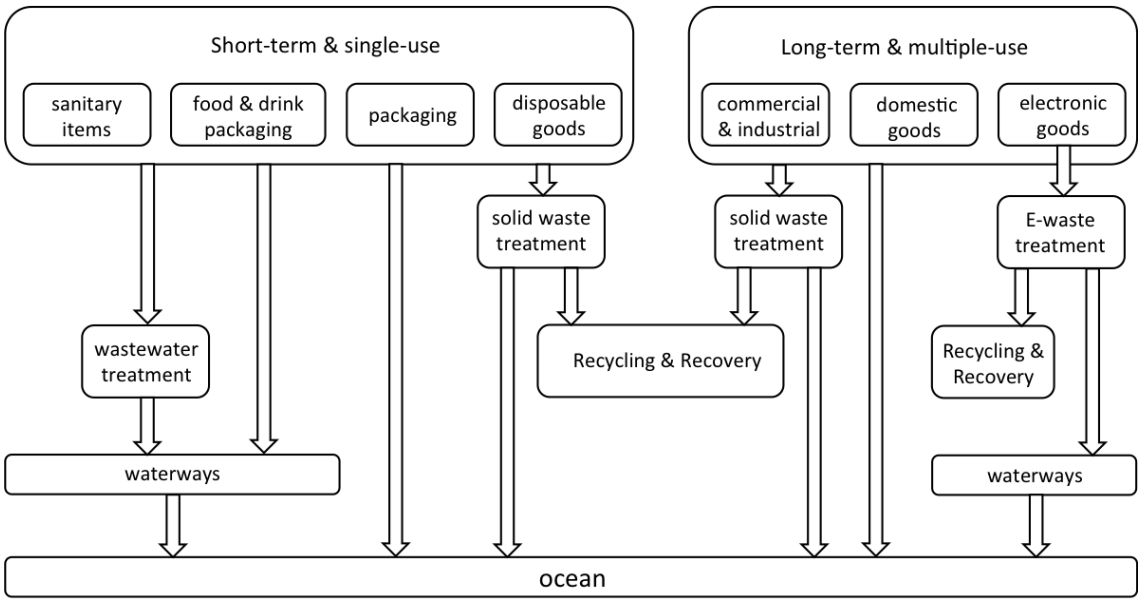

Figure 3. Land-based sources of macroplastics and pathways to the ocean (original by P. J. Kershaw)

This figure illustrates the main pathways from land-based macroplastics. Each sector becomes a point source for plastics to the ocean. Potential land-based sources by sector and common entry points are presented in table 2, in accordance with a GESAMP report from 2016:

Table 2. Potential land-based sources of macroplastics by sector, examples of plastic waste and common entry points to the ocean (UNEP 2016)

Sector	Description	Entry Points
Retail	Packaging, consumer goods, household goods	Rivers, coastal areas, atmosphere
Food & Beverages	Single-use packaging	Rivers, coastal areas, atmosphere
Household	Packaging, consumer goods, household goods	Rivers, coastal areas, atmosphere
Tourism	Packaging, consumer goods, household goods	Rivers, coastal areas, atmosphere
Plastic recycling	Packaging, consumer goods, household goods	Rivers, coastal areas, atmosphere
Construction	EPS, packaging	Rivers, coastal areas, atmosphere
Agriculture	Films/sheets, pots, pipes	Rivers, coastal areas, atmosphere
Land-based transportation	End-of-life vehicles and tires	Rivers, coastal areas

Macroplastic litter also reaches the ocean from sea-based sources. The scheme of the most typical entry pathways is shown in figure 4.

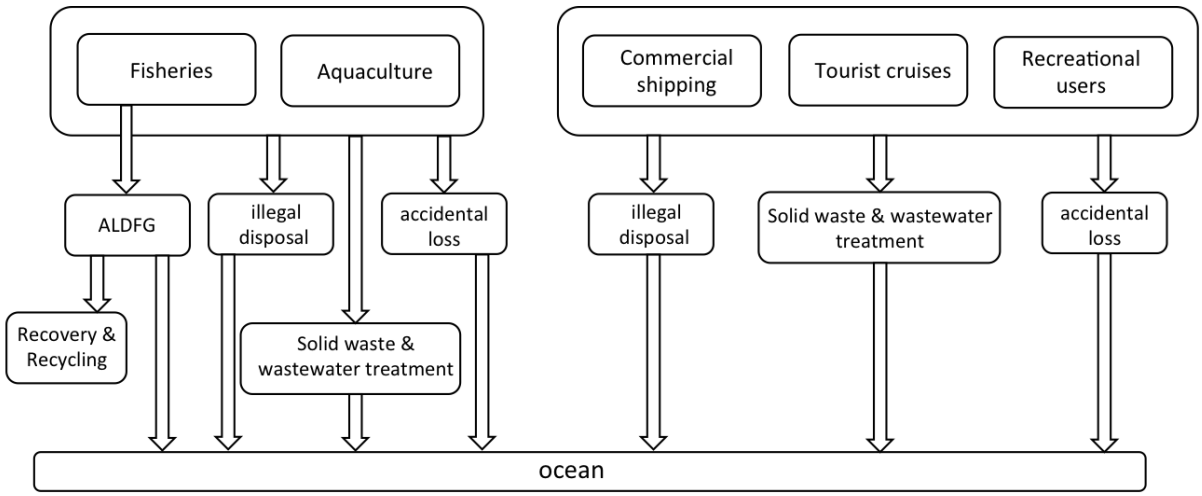

Figure 4. Sea-based sources of macroplastics and pathways to the ocean (original by P. J. Kershaw)

Fisheries and aquaculture continuously produce macroplastic litter. For example, abandoned, lost or otherwise discarded fishing gear (ALDFG), is one of the most constant sources of marine plastic litter. Fishing gear can be lost accidentally or dumped on purpose. It's almost impossible to control fishery ships. The most typical items which end up in the ocean are all kinds of fishing gear, strapping bands, storage boxes, packaging and personal goods. Fisheries use plastic products very widely (UNEP 2016).

As for other ships, the impact from them is also significant. Due to the complexity of maritime laws and jurisdiction, disposal from the ships is still common practice. Accidents can also happen with loss of cargo. For example, containers usually contain plastic pellets, plastic packaging, etc.
Cruise ships are also generating tons of litter and very few of them have appropriate waste management. Thousands of people on one ship is a direct source of plastic and non-plastic litter to the ocean. Recreational tourism on the open water is another pathway for marine litter.
The common sources of macroplastics in the sea-based sector is summarized in table 3.

Table 3. Sea-based sources of macroplastics

Sector	**Description**	**Entry Points**
Fisheries	Fishing gear, strapping bands, storage boxes, packaging, personal goods	Coastal, Marine
Aquaculture	Buoys, lines, nets, structures, storage boxes, packaging, personal goods	Coastal, Marine
Shipping/ Offshore industry	Cargo, packaging, personal goods	Coastal, Marine
Ship-based tourism	Packaging, personal goods	Coastal, Marine

The microplastics has a more complex scheme of entry pathways than macroplastics. It's very hard to quantify all particles which reach the ocean from the atmosphere

or from the waterways. And there is no official data on how much microplastics enters the ocean. However, the typical entry points are summarized in figure 5.

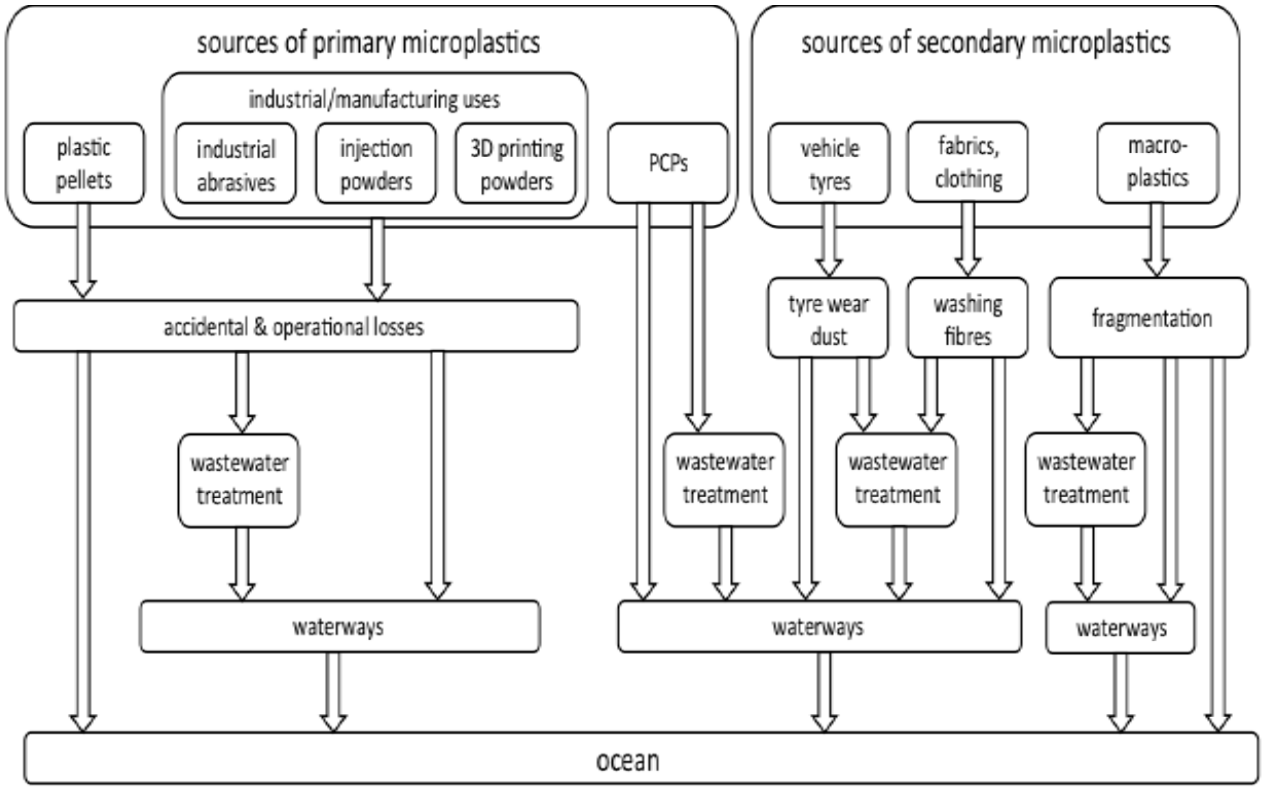

Figure 5. Land-based sources of microplastics and pathways to the ocean (original by P. J. Kershaw)

The microplastics can enter the ocean at any stage of its existence. The main sources of land-based microplastics are cosmetics and personal care products, textiles and clothing, terrestrial transportation, plastic products, as well as waste from ship maintenance and ship dismantling.

More possible land-based sources of microplastics are illustrated in the table 4.

Table 4. Potential land-based sources of microplastics by sector, examples of plastic waste and common entry points to the ocean (UNEP 2016)

Sector	**Primary microplastics**	**Secondary microplastics**	**Entry points**
Tourism		Fragmented packaging, household goods, consumer goods	Wastewater, rivers, coastal, atmosphere
Food and drink		Fragmented single-use packaging	Wastewater, rivers, coastal, atmosphere
Plastic producers	Plastic resin pellets		Wastewater, rivers, coastal
Retail		Fragmented packaging, household goods, consumer goods	Wastewater, rivers, coastal
Households	Personal care and cosmetic products	Fragmented packaging, household goods, consumer goods	Wastewater, rivers, coastal
Terrestrial transportation		Tyre wear dust	Wastewater, rivers
Cleaning ships' hulls, buildings	Abrasive powders		Wastewater, rivers, coastal
Manufacturing	Powders for injection molds, powders for 3D printing		Wastewater, rivers
Plastic recyclers		Fragmented packaging, household goods, consumer goods	Wastewater, rivers
Construction		Fragmented EPS, packaging	Wastewater, rivers, coastal
Agriculture		Fragmented films/sheets, pots, pipes	Rivers, coastal, atmosphere

As for the sea-based sources of microplastics, it mainly comes from diverse maritime activities, such as shipping, fisheries, aquaculture and cruise ship tourism. The scheme of the sources is summarized in figure 6.

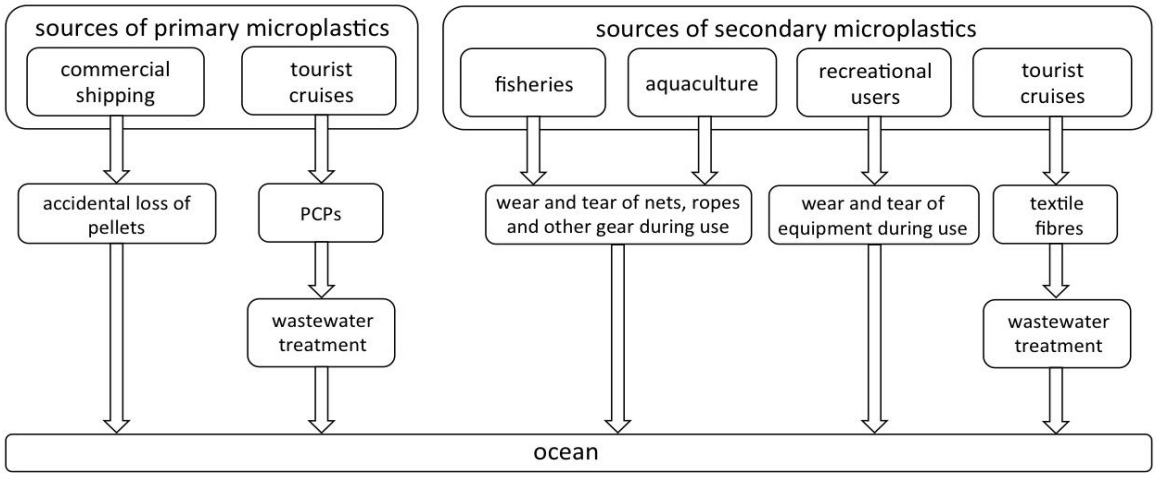

Figure 6. Sources of sea-based primary and secondary microplastics (original by P J Kershaw)

The primary microplastics can come from cargo loss in the open water. It also can reach the ocean directly from cruise ships and its wastewater treatment systems. Secondary microplastics come from all kinds of maritime activities and operational use of nets, fishing gear, ropes and buoys in fisheries and aquaculture. Additionally, there are a lot of other fragments and fibers from diverse maritime operational use, as well as routine wear and tear of equipment.

The variety of plastic entry points makes the task of marine litter assessment very complex and challenging. It is very important to estimate the scale of the problem from different angles and estimate the problem both from the sea and from the land. This project concentrates only on the coastal debris. The analysis of the marine litter is aiming to characterize possible pathways for entry and clarify the current situation on the coast of Grândola.

4 Materials and Methods

4.1 Parties, cooperation and participation

The methodology used was proposed by professor Paula Sobral from Nova University of Lisbon, who is also in charge of the Portuguese Marine Litter Association. The sampling work has been done during the coastal cleaning campaign of Brigada do Mar on the coast of Grândola. This non-governmental organization provides probably one of world's the biggest coastal cleaning actions every year (Brigada do Mar). The sampling action was possible because of the close collaboration of all those parties including the Novia University of Applied Sciences exchange student.
The full list of the parties which participated in the sampling activity:

- Portuguese Association of Marine Litter
- Brigada do Mar
- Nova University of Lisbon
- Novia University of Applied Sciences, Finland

4.2 Sampling method and activity

During the sampling, the objective was to identify and assess the categories of plastics, as well as size, type and abundance of marine debris along the coast. The selected method that was deemed the most suitable was provided by Professor Paula Sobral from Nova University of Lisbon. This method is suitable to understand the common type of marine debris on the long coast and provides information of distribution, abundance and characteristics of plastic debris along the Coast of Grândola. It also provides an opportunity to assess the current abundance of microplastics.

Samples of marine debris were collected during the voluntary beach cleaning campaign of Non-Governmental Organization (NGO) Brigada do Mar in May of 2016. It is the one of the biggest coastal cleaning events for marine litter in the world this

year (Brigada do Mar). Sampling was done along the coast of Grândola which is approximately 45 km long.
There were two principal types of assessment. The first one was a coastal litter assessment survey with debris classification and registration in the survey sheets. The second one was a sampling of shallow water sand, which was made to assess the current situation of microplastics on the coast.

To provide the first part of the assessment, five different sampling areas were chosen along the coast to assess the amount and type of litter. Each area has a length of 100 meters, the width being determined by the sand terrain, starting from the sea line and limited by the dunes or cliffs. Within every sampling area, all the litter that can be found with the naked eye was collected, counted, recognized, registered and written down on the survey sheets.

To provide the second part of the assessment, inside every sampling area, five quadrats of 0,5x0,5 m were randomly selected in order to assess the amount of microplastics. The squares are preferably marked and selected on the last visible tidal line. All the sand from the marked quadrants - approximately a 2 cm layer, was collected with a metallic shovel into a sieve. The sieve was used to filter and separate the debris from the sand. It was sieved in by using a situ 2.5 x 3.5 mm mesh size. After the filtration process, the plastic particles and all the debris stayed in the sieve. In this way, 25 samples have been taken from 5 different locations. Later the samples were analyzed and counted in the laboratory.

The laboratory part was done in the Nova University of Lisbon. Samples were separated by type of debris and placed in petri dishes, as shown in figure 7 below. All plastic pieces collected were counted and classified according to the classification system adopted by Ogi & Fukumoto (2000): class 1 (≤1 mm), class 2 (>1 mm and ≤2 mm), class 3 (>2 mm and ≤3 mm), class 4 (>3 mm and ≤4 mm), class 5 (>4 mm and ≤5 mm), class 6 (>5 mm and ≤6 mm), class 7 (>6 mm and ≤7 mm), class 8 (>7 mm and ≤8 mm), class 9 (>8 mm and ≤9 mm), class 10 (>9 mm and ≤10 mm), class 11 (>1 cm e ≤ 2,5 cm) and class 12 (>2,5 cm). The results can be found in the

appendices. The materials which were used in the laboratory are the following: petri dishes, tweezers, microscope, paper.

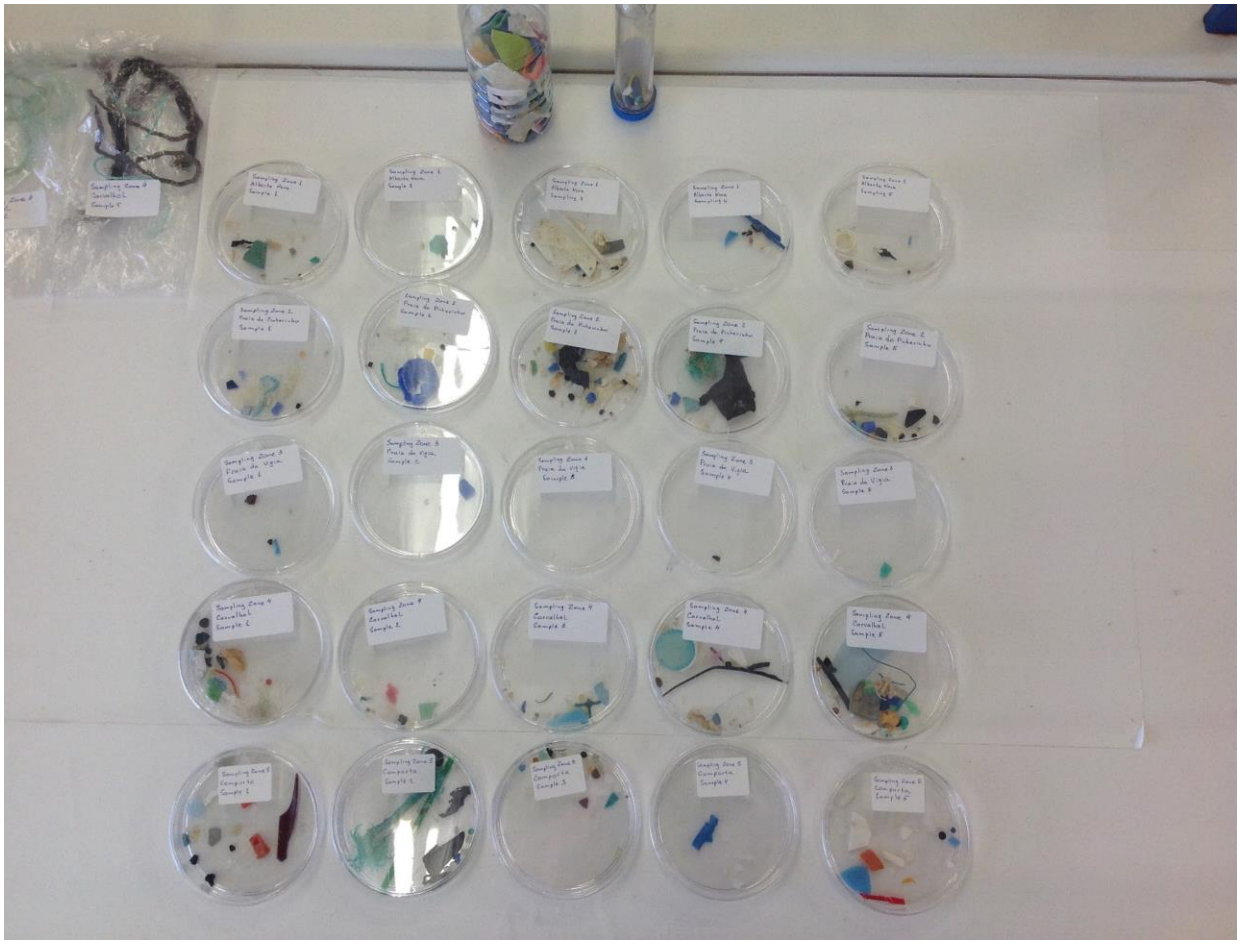

Figure 7. Microplastic samples in petri dishes

4.3 Location

The sampling took place all along the coast of Grândola. The selected coast is 45 kilometers long and goes from Melides up to Troia. Five sampling spots were chosen near the following areas (Figure 8):

- Praia da Alberta Nova 38.175842855125666, -8.781561367213726,
- Praia do Pinheirinho 38.23434552177787, -8.774855928495526,
- Praia da Vigia, 38.1334279,-8.7924842
- Praia do Carvalhal, 38.34117547608912, -8.78831491805613
- Praia da Comporta, 38.40058791451156, -8.813692890107631

The coordinates are in The World Geodetic System (WGS) 1984 geographic coordinate system.

Every sampling zone is located near the public beaches and next to the small villages. This fact provides better understanding about the marine debris on the coast because it can be originated from the sea as well as from the beach dwellers and local communities. In the coastal litter assessments, it's very important to take into consideration different aspects of debris origin and occurrence.

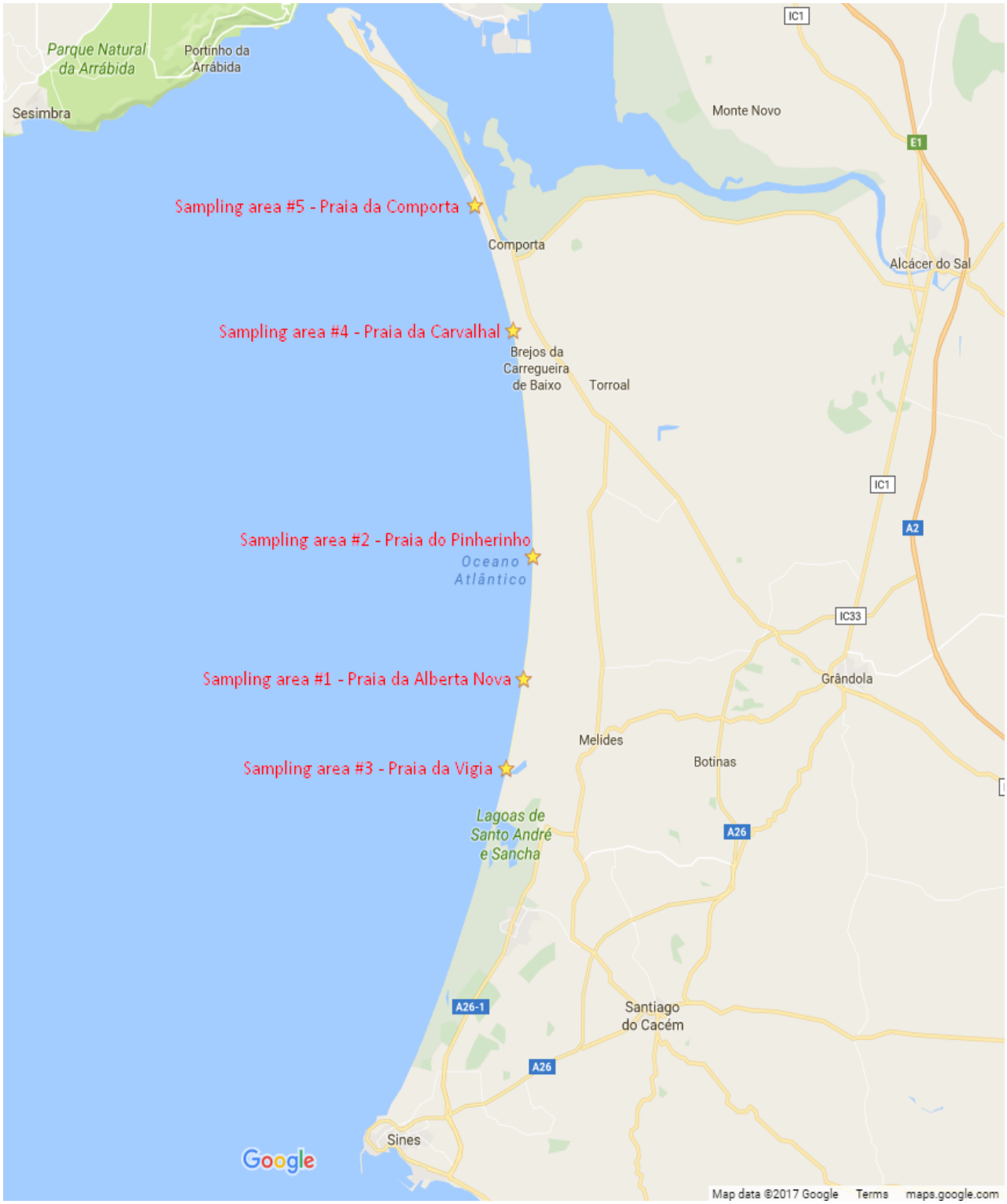

Figure 8. Sampling areas on the coast of Grândola (map: Google Maps)

5. Results

5.1 Background information

No previous studies have been discovered about the marine litter and microplastics on the coast of Grândola. There is no current scientific information about the state and characteristics of marine litter on the coast. The following results are primary figures and have been done following the methodology which was described in the previous section.

It is important to note that on the coast of Grândola, one of the Portuguese non-governmental organizations Brigada do Mar yearly arranges a coastal cleaning campaign. The statistics which this voluntary organization collects are only the tonnage of collected marine litter. During its 8 years of action, Brigada do Mar has counted more than 200 tons of marine litter that has been removed from the coast (Brigada do Mar).

The sampling sites stayed in natural conditions about a year following the last cleaning campaign in 2015 by the NGO. This also means that the results reflect contamination of the coast on yearly basis and the situation with marine litter could be different if there had been no cleanings done in the coastal area.

5.2 Marine debris assessment survey

The full survey lists are found in the appendices of this work. The following results are shown according to a site-by-site principle and only the most common litter is shown in the figures. It helps to create a better understanding on the current situation and see the pattern all along the coast.

The first assessment was performed near the official public beach which is called Praia da Alberta Nova (38.175842855125666, -8.781561367213726), the location is

also shown in figure 9 below. The area is located close to the small village Melides and is surrounded by recreational facilities such as a golf course and resorts.

Figure 9. Sampling area #1 – Praia Alberta Nova (map: Google Maps)

The most common litter on that site was debris made of plastic. Snack packages from crisps and sweets were the most common type of litter making up 15.3 % of the overall registered debris. Pieces of plastic from 2.5 cm to 50 cm are also widespread with 12.4 %, as well as pieces from plastic bags 12.2 %. Pieces from cords and strings are a little less prevalent making up 11.4 % of the debris. The fifth most common litter was plastic lids from beverage bottles (5.3 %).

The numbers of items of the most commonly registered litter from the first sampling area are shown in figure 10.

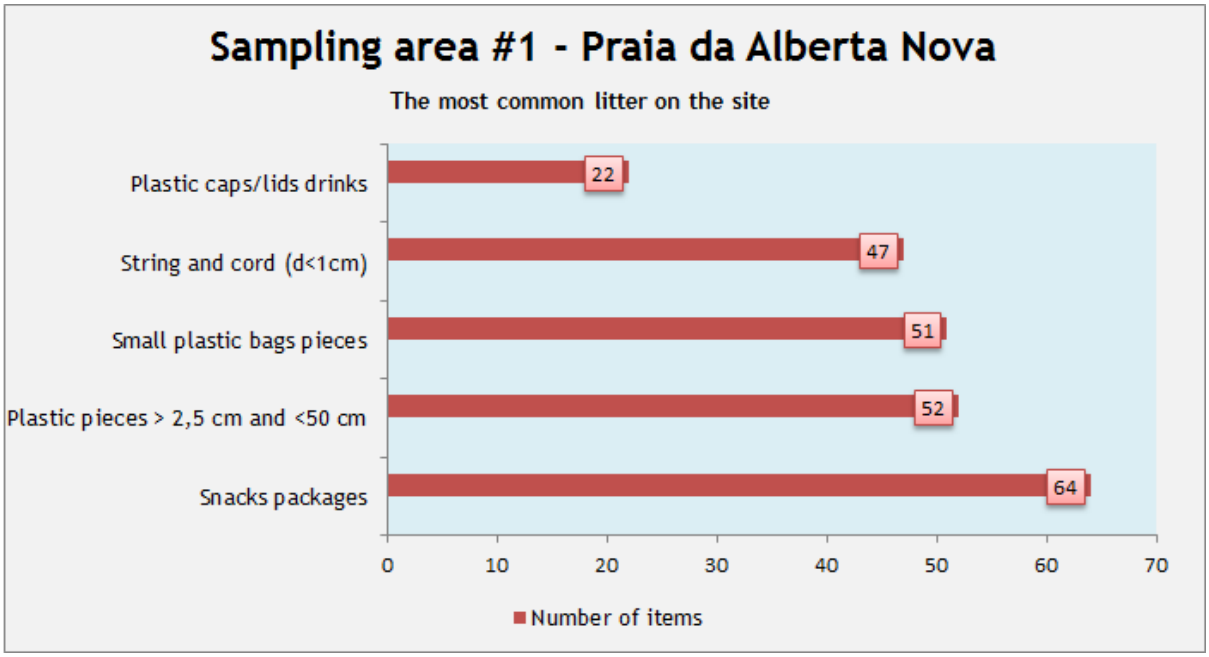

Figure 10. The most common litter on sampling area #1 – Praia da Alberta Nova

Praia do Pinheirinho (38.23434552177787, -8.774855928495526) was the second sampling site of the research. The sampling area is located next to an official public beach and close to the Golf and Beach Resort, see figure 11.

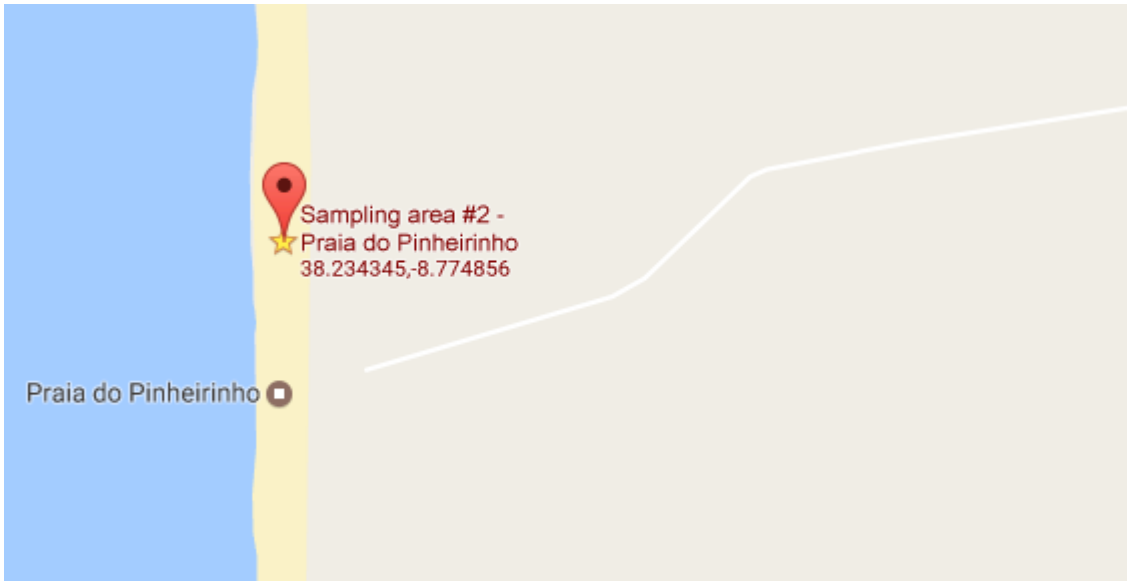

Figure 11. Sampling area #2 – Praia do Pinherinho (map: Google Maps)

The results are very similar to the first spot with a predominance of plastic debris. However, the most typical marine litter on this site is small pieces of plastic with a diameter of less than 2.5 cm (10.8 %). Plastic bags including pieces (9.6 %), plastic

pieces from 2.5 cm to 50 cm (9.0 %), cords with a diameter of less than 1cm (6.3 %) are also on top of the list of the most common litter on the spot as well as on the first site. Only cotton bud sticks (6.0 %) are representing a new type of the most widespread litter on the coast.

The numbers of items of most the commonly registered litter from this sampling area are shown in figure 12.

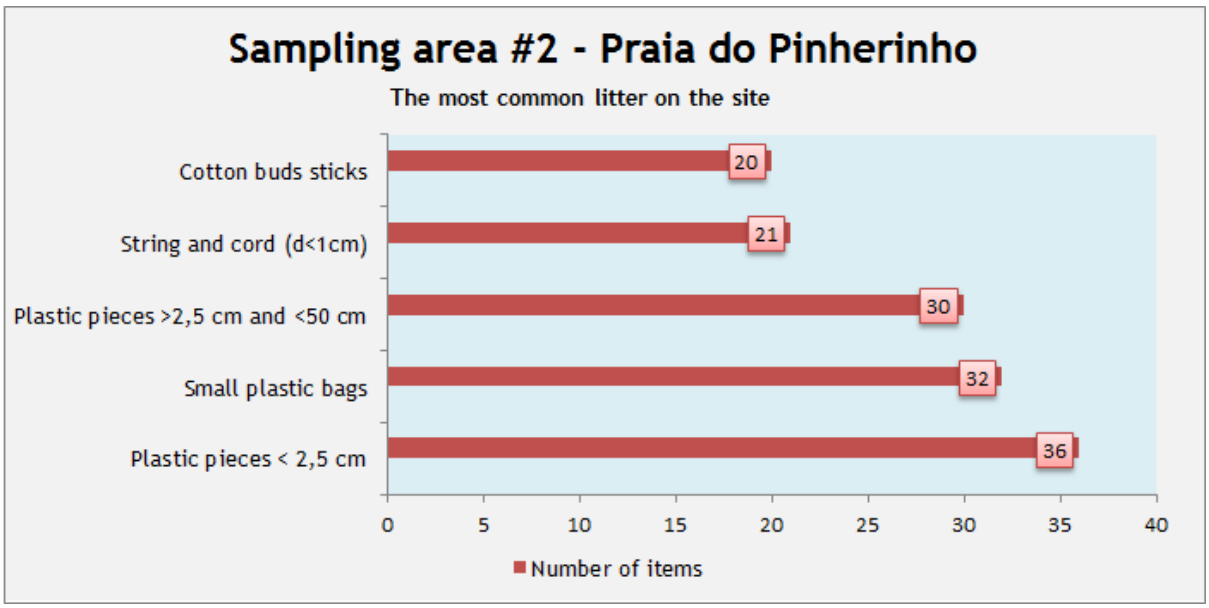

Figure 12. The most common litter on sampling area #2 - Praia do Pinherinho

The next spot was near the Praia da Vigia (38.1334279, -8.7924842), figure 13, which serves as an official public beach for the local inhabitants. The Melides Lagoon is located near the sampling area which can be an additional source of terrestrial litter.

Figure 13. Sampling area #3 – Praia da Vigia (map: Google Maps)

In this sampling area, there were 540 marine litter items registered, where debris made of plastic make up 90.7 %. The most typical categories of plastics were cord and string (15.9 %), pieces of plastic from 2.5 cm to 50 cm (8.7 %), plastic lids from bottles (7.4 %), small plastic pieces less than (6.7 %) and plastic bags (6.3 %). The pattern of the most common marine litter remained the same as at the previous sampling sites.

The numbers of items of the most commonly registered litter from this sampling area are shown in figure 14.

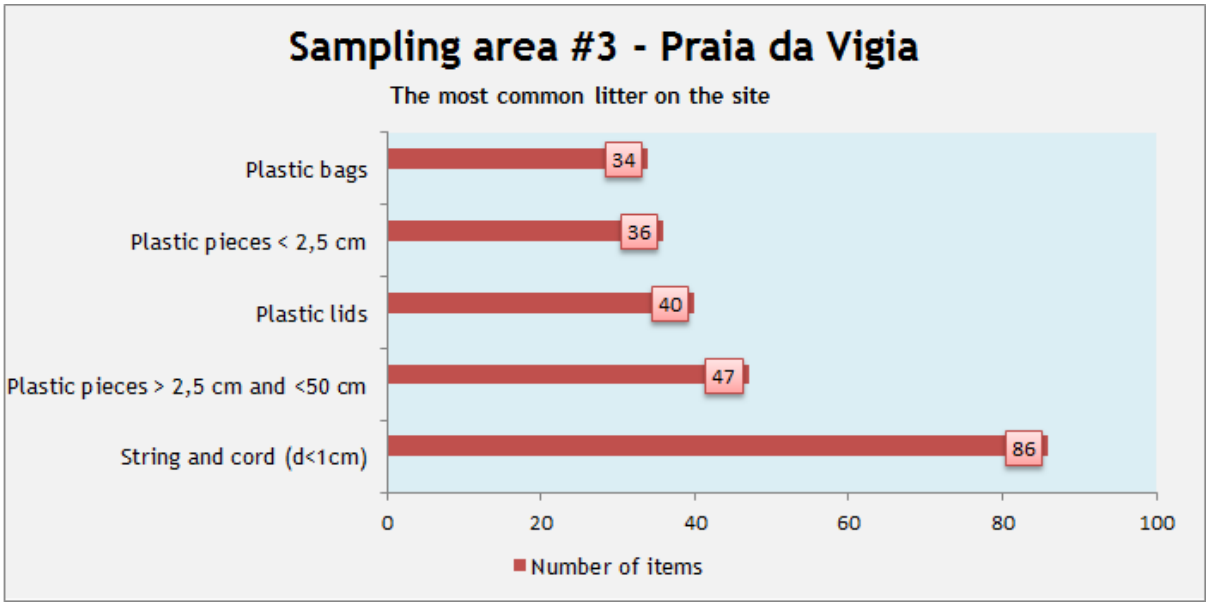

Figure 14. The most common litter on sampling area #3 - Praia da Vigia

Praia do Carvalhal (38.34117547608912, -8.78831491805613) was the fourth sampling site, located between the two official public beaches Praia da Torre and Praia dos Brejos. The location is presented in figure 15.

Figure 15. Sampling area #3 – Praia da Vigia (map: Google Maps)

There were 1000 items of marine litter registered in Praia do Carvalhal, more than on any other sampling area. Plastic debris also make up the majority as a material type (95.9 %) and again occur in the top of the most common marine litter items. Small plastic pieces which are less than 2.5 cm (17 %), string and cord (14.4 %), plastic pieces with sizes from 2.5 cm to 50 cm (8.9 %), cotton bud sticks (8.8 %) and

snack packages (7.3 %) can be found among the majority of the litter of the sampling area. The marine litter pattern has not changed up north. Other materials also doesn't show up in any significant amounts on this sampling site.

The number of the most commonly registered marine litter items from this sampling area are shown in figure 16.

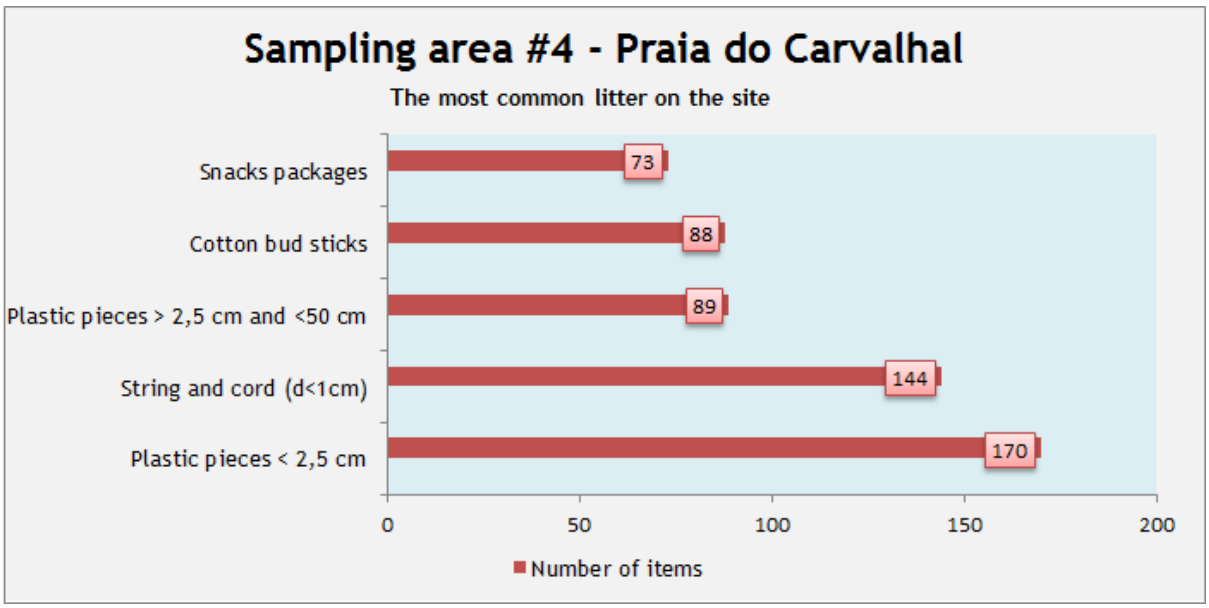

Figure 16. The most common litter on sampling area #4 - Praia do Carvalhal

The last sampling procedure took place near the official beach of a small village called Comporta and next to the official beach Praia da Comporta (38.40058791451156, -8.813692890107631).

Figure 17. Sampling area #5 - Praia da Comporta (map: Google Maps)

In the fifth sampling area, 667 marine litter items were registered. The marine litter type pattern remains the same as at the previous spots with plastic items in absolute majority (94,9 %). Any other type of marine litter materials occurred with no more than 10 items per type. This means non-plastic materials once again have negligibly small rates comparing to the plastics.

In the top of the most typical items, there were no big differences either. Plastic pieces less than 2.5 cm are the most identifiable debris in the sampling area #5 (18.3 %). String and cord (18 %) also have significant rates and stayed a typical type of litter on all the sites. Cotton bud sticks are the third popular type of items (15 %) followed by plastic pieces from 2.5 cm to 50cm (12.4 %) in size. The fifth popular items were different kinds of plastic lids which were hard to identify whether they came from beverage bottles or domestic chemicals or something else (4.3 %)

The number of the most commonly registered marine litter items from this sampling area are shown in figure 18.

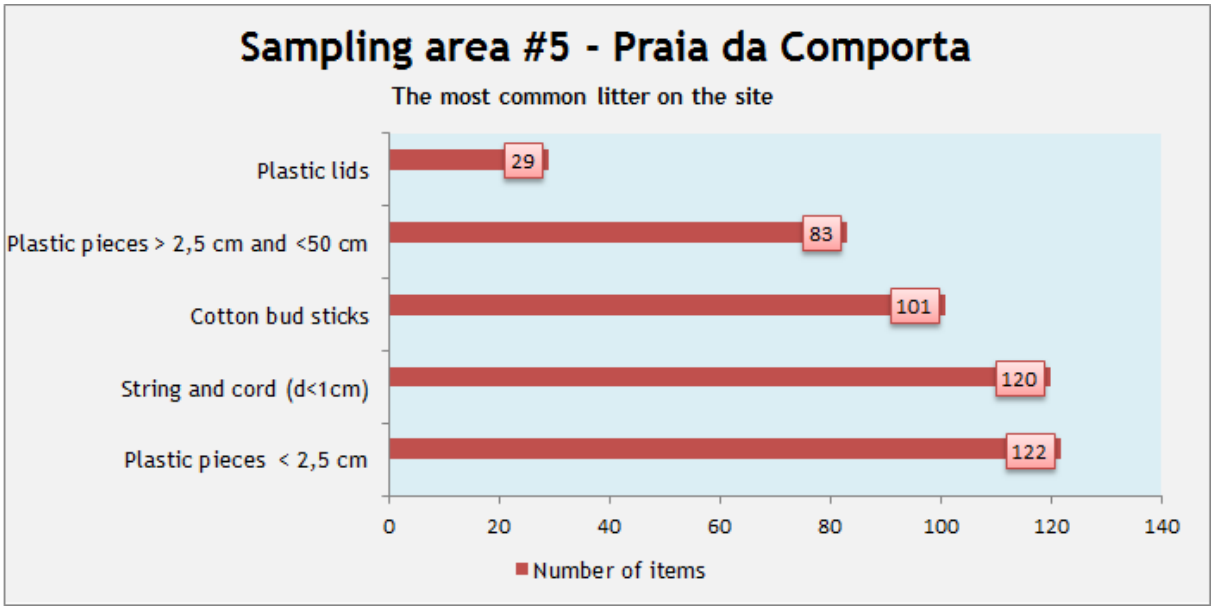

Figure 18. The most common litter on sampling area #5 - Praia da Comporta

A general overview of the collected debris on the coast shows that plastic litter is the dominating type and makes up about 94,3 % of all the types of found items. From 5 sampling areas, there were more than 3000 items of marine debris collected in total. Out of these, 2958 were identifiable and registered on marine litter assessment sheets. Figure 19 shows that other types of materials have minor rates about 1 % maximum per capita and are almost negligible. The total quantity of non-plastic items does not exceed 200 items. The statistics illustrates predominance of plastics as marine debris all along the coast.

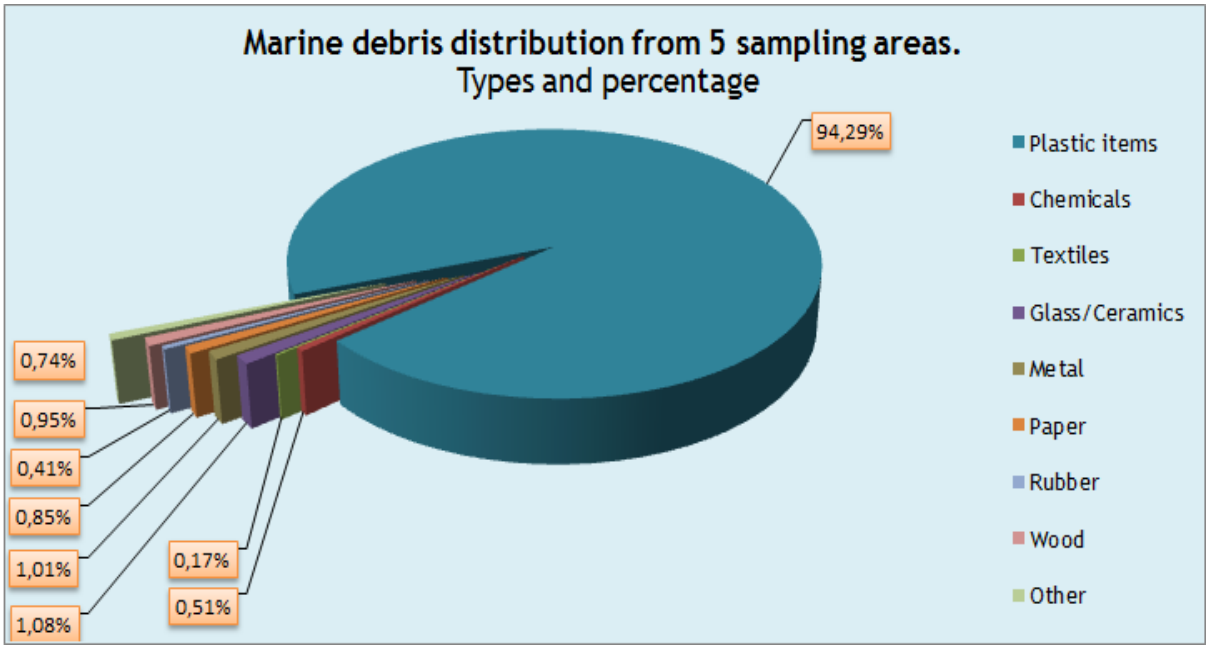

Figure 19. Marine debris distribution from 5 sampling areas, in terms of material type.

Not surprisingly the plastics group form the most abundant type of litter, which has been discovered.

Table 5 shows type, quantity of the most common coastal litter and percentage of the total items that have been registered from the 5 sampling areas.

Table 5. Type and quantity of the most common coastal litter and percentage from total registered items from all sampling areas

Type of litter	Number of items	% total items
String and cord (d<1cm)	418	14.13
Plastic pieces < 2,5cm	364	12.31
Plastic pieces > 2,5cm e <50cm	301	10.18
Cotton bud sticks	209	7.07
Crisps packets/sweet wrappers	137	4.63

The litter types which are illustrated in figure 20, can be found all along the coast and was discovered in dozens in all sampling areas.

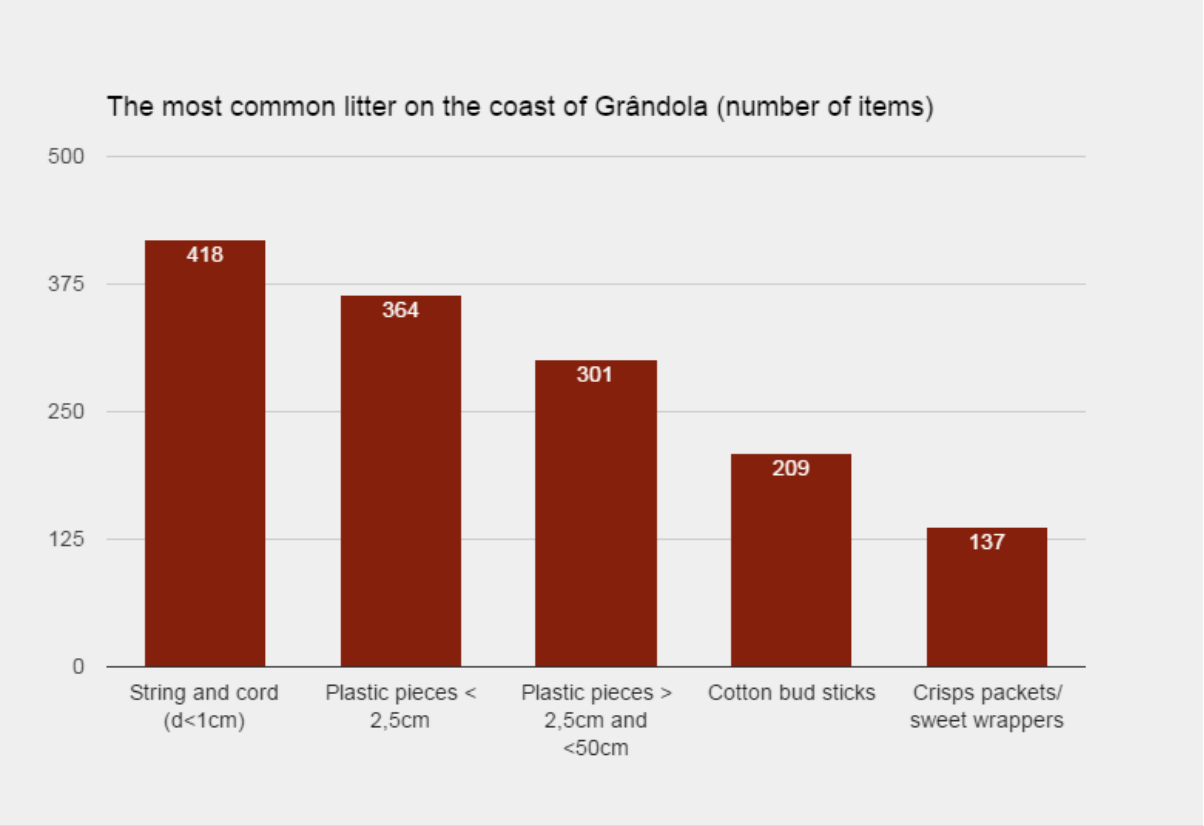

Figure 20. The most common litter items on the coast of Grândola

5.3 Microplastics

The second part of the research was the assessment of the abundance of microplastics following the described methodology. As a result, there were 25 samples taken on the 5 sampling areas and later all the items were analyzed, categorized and counted in the laboratory.

In the end, 536 marine litter items were recognized from 25 samples. Among the registered items, 7 types of items were identified. The first type is small plastic pieces which have different kind of size, color and shape and it can be named as the prevalent type of collected microplastics. The second widespread group is plastic pellets, which also shows significant rates from site-to-site. Other types that were recognized were styrofoam, sponge, fibers and pieces of wood.

The results from the sampling areas are illustrated in the graphics below (figures 21-25). The Y axis represents the quantity of each item type.

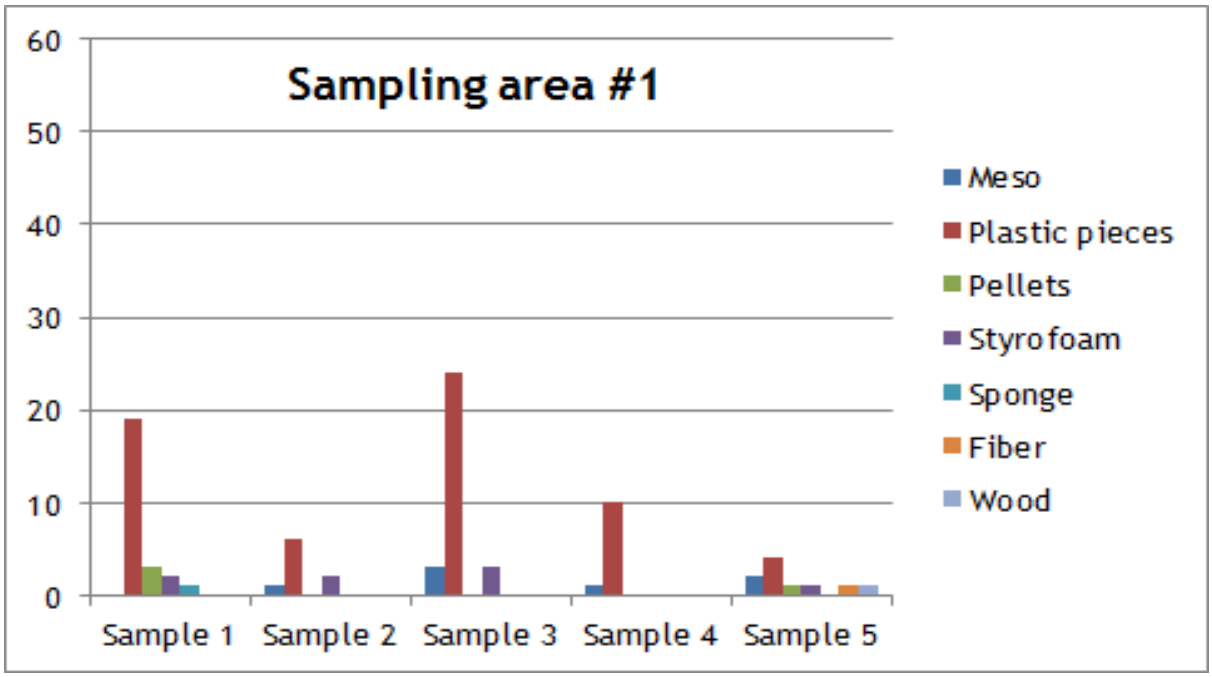

Figure 21. The microplastics from sampling area #1 – Praia da Alberta Nova

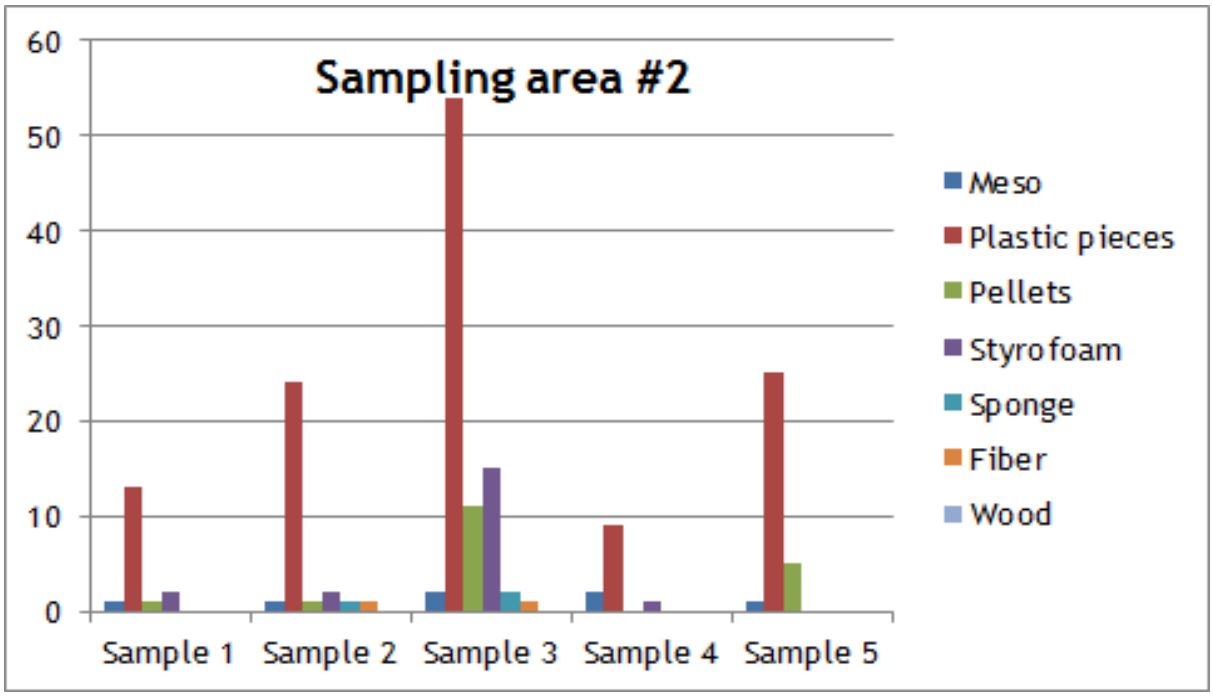

Figure 22. The microplastics from sampling area #2 – Praia do Pinherinho

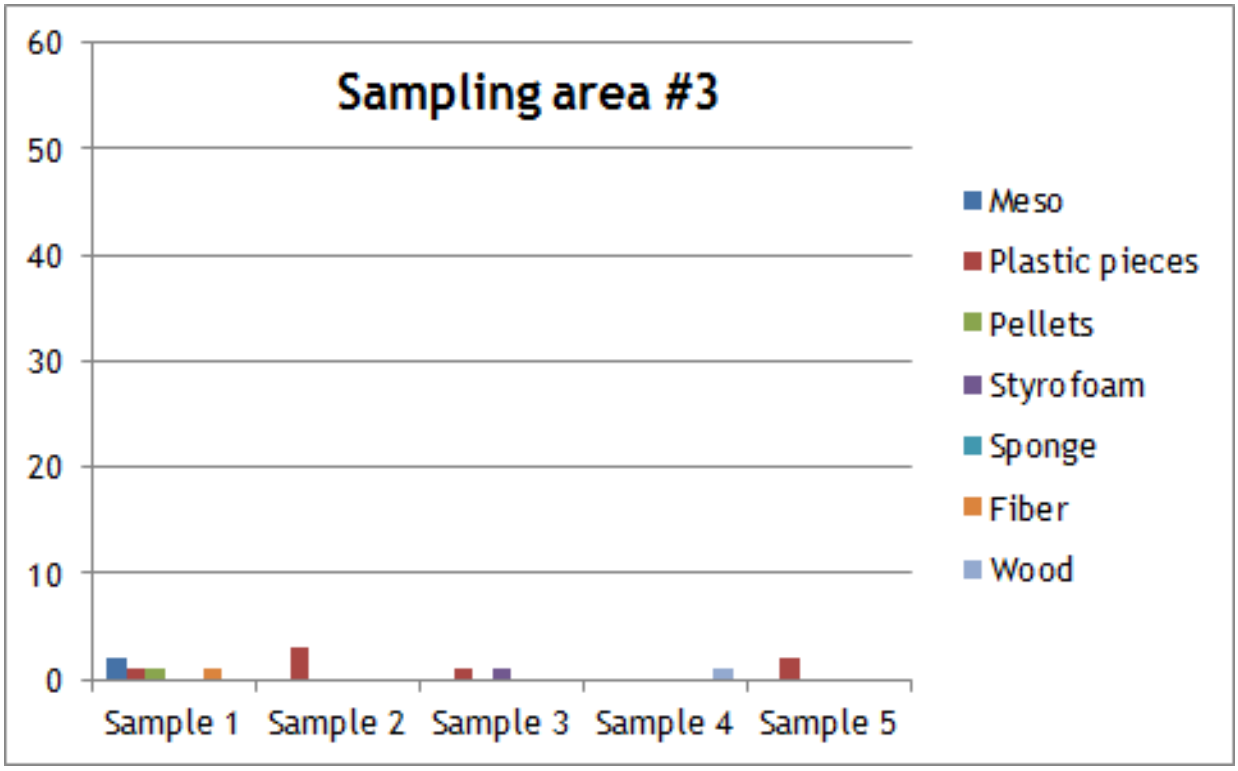

Figure 23. The microplastics from sampling area #3 – Praia da Vigia

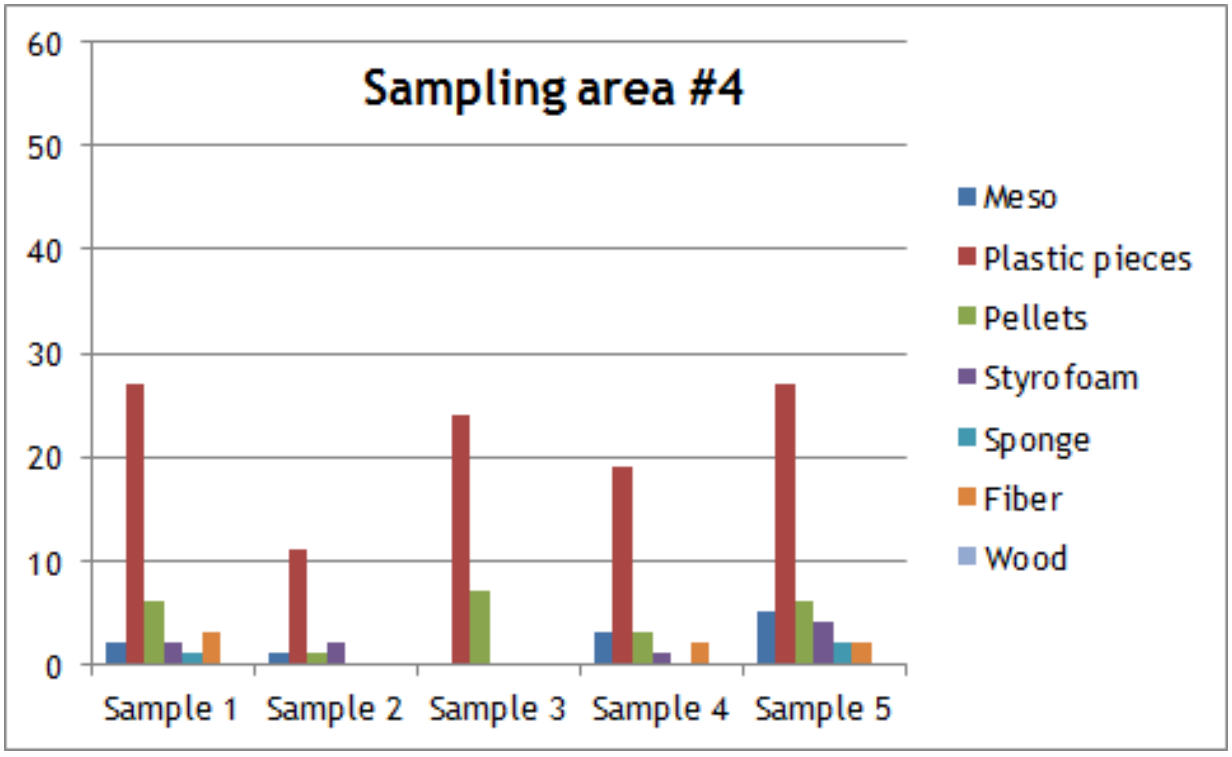

Figure 24. The microplastics from sampling area #4 – Praia da Carvalhal

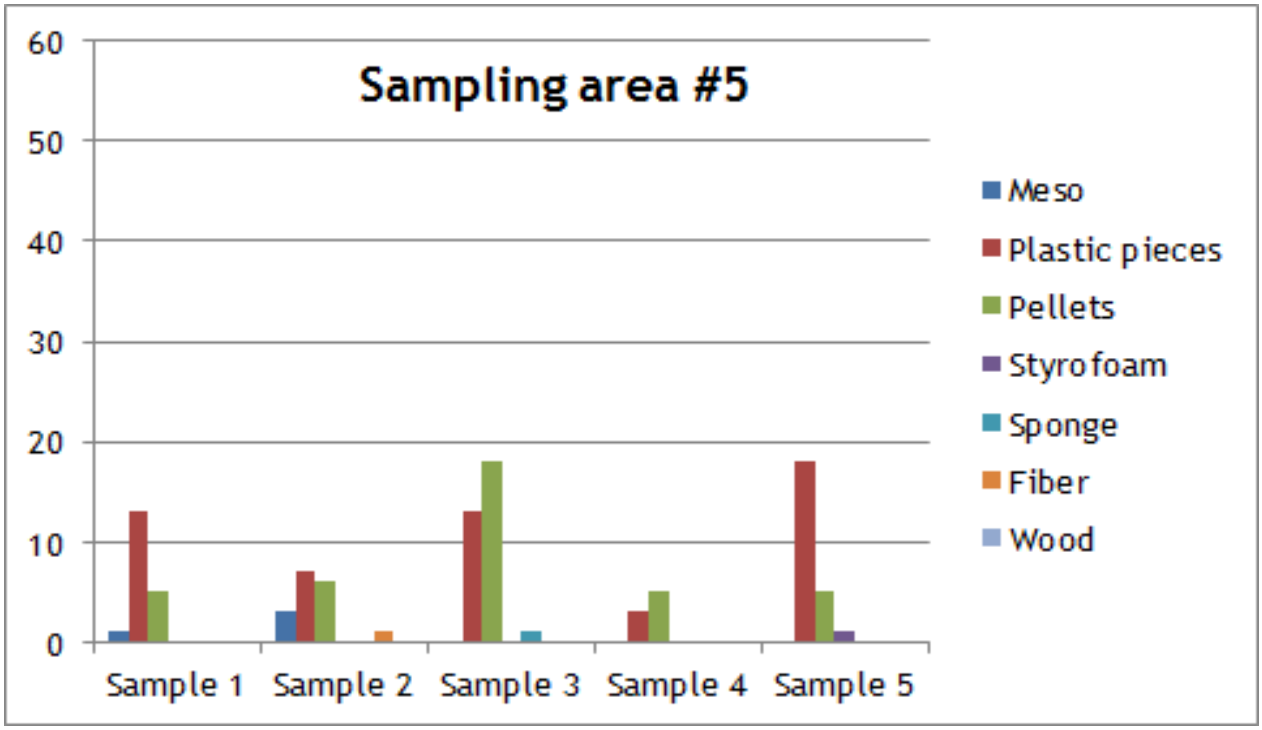

Figure 25. The microplastics from sampling area #5 – Praia da Comporta

The graphics show that plastic pieces have the highest total concentration per sampling area and occurred in the highest numbers on each spot. Plastic pellets are also a very common type of micro litter and can be considered as a microplastics. In general, microplastics were found on each sampling area in significant amounts and show predominant abundance on the coast compared to other types of litter.

5.4 Critical analysis

The marine litter assessment task is very challenging. In every research, there are several things that can be done differently, which in turn creates a lot of variables. The first thing is choice of sampling area. The coast is more than 45 km long and each sampling site can be chosen differently. It is important to notice that the coast has crowded (official beaches) and deserted areas which can each time affect the final results. The sandy area has a very varying width from the sea line to the dunes or cliffs. The measured distance can vary with the use of different methodologies. An error also can be a made during metering the sampling area.

As for microplastics, there are even more variables. It can be done following the tidal line on the sand, but this changes several times during the day, making it also very challenging determine the most suitable place to take samples.

On the marine litter identification stage several issues can occur. For example, the standards and guidelines for marine litter registration differ from each other. Moreover, sometimes it is very challenging to identify a sample. They also can be undetected during registration and not collected. Even more, the human factor can influence the results and some mistakes are possible.

Concerning the methodology, a lot of different available options can be applied, for the macro litter as well as for the microplastics. This is especially true considering the microplastics analyses. The sampling spots and the sampling instruments can be different each research in a matter of size, material and type. For example, the sieves can have different size and structure. The spots are different each time and depend on tidal line, which differ during the day.

Laboratory analyses can be done in a more comprehensive manner using powerful microscopes and specific methodologies to analyze the chemical composition of the microplastic samples.

6 Discussion

This research is a first attempt to assess the state of the marine litter on the coast of Grândola. It is important to notice that no previous data on the area are known to have been collected. This work is in that sense primary data about the current situation of the marine litter in the area. The local non-governmental organization Brigada do Mar, which provides coastal cleaning each year, assesses only a tonnage of marine litter.

The assessment of amount and categorization of marine litter may help to understand possible sources for it and its origin. The data from this research provides an opportunity to evaluate the most common items that accumulate on the coastline of the region. It can also help in future microplastics researches.

Marine litter abundance depend on several physical factors such as the orientation of the coast, distance to sources and form of debris. Abiotic factors are also important to take into consideration, like water currents, wind direction and waves (Debrot et al., 1999).

It is clear, that the coastline is a dynamic system and has many variables during the year and some conditions can be very different over the years. It means that assessing seasonal variations requires a well-established monitoring plan for the coastline.

The results from the marine litter assessment show that plastic is the predominant material type. All the other types of debris are almost negligible compared to the plastic. The pattern of litter type remains more or less the same throughout the coastline.

The quantity of marine litter items differs between the sampling areas. The most polluted site was discovered near Comporta, where 1000 items were collected and registered. The least contaminated area was Praia do Pinherinho, where only 334 items were found. These results are dependent on many factors as already

mentioned above - wind direction, waves, beach orientation, source distance, etc. The last factor, but not the least, is the width of the sandy area from the dunes to the tidal line, which varies from one site to another.

The sources for the discovered marine litter are many. Starting with the most common items are string and cord, which comes from the fisheries. It can be from local fishermen and from industrial fisheries. Moreover, there were also other items connected to fishery activities. For example plastic traps, octopus pots, nets and ropes are clearly pointing to the small local fisheries. Aside from this, many items were found on the shore like lighting sticks, fishing gear, boxes for fish bait, etc.

Plastic of different size is the biggest group of marine litter. The group has the largest overall abundance. The sources for plastic litter can be very diverse. The visual analysis shows that there is a high probability that it was brought from the sea by the wind, currents and waves. Some part, such as plastic pellets, may be brought from local industries. Another possible source can be local communities and tourists. Abandoned items made of plastic break down into small pieces over time and become a part of this group.

The next common item of marine litter on the coast is cotton bud sticks. They still can be flushed down into the toilets and then end up in the marine environment, as their structure allows them to pass wastewater treatment systems. Cotton buds also pass sewage systems during the storm overflows in the systems (Cotton bud project).

The coast is also a very popular destination during the summer time for recreational activities and summer vacations. Consequently, visitors to the beach become one more significant cause of the marine litter pollution. This research shows that snack packages are present among the five most common items. There were other types of litter found that may belong to beach visitors such as plastic cups, bottles, lids, sunscreen protectors, etc.

As for the microplastics, the results of this research demonstrate that occurrence of the small plastic pieces and plastic pellets is quite common all along the coast. There

were no data found to compare the microplastics situation with previous years or researches. This work only shows the current abundance of the microplastics in the sampling areas and provides primary information.
This thesis can be a starting point for future marine debris research on the coast of Grândola. For example, new methodologies can be applied and more data can be collected to compare the situation over time.

Considering macroplastics, there are several other methods that can be applied. One such method is chemical analysis of the samples, for concentrations of persistent organic pollutants absorbed to plastic pellets (Frias et al., 2013).

This study is also important to promote environmental awareness in society on the issues of marine and coastal litter and can help with necessary information for local authorities.

One more thing can be suggested from this work. Establishing a permanent marine litter monitoring program to observe the changes over time.

References

Allsopp M., Walters A., Santillo D., Johnston P., *Plastic Debris in the World's Oceans*, Greenpeace report, 2006.

Brigada do Mar. *O Projecto* http://www.brigadadomar.org/o-projecto.html (retrieved: 03.02.2017).

Collignon A., Hecq J., Galgani F., Collard F., Goffart A., *Annual variation in neustonic micro- and meso-plastic particles and zooplankton in the Bay of Calvi (Mediterranean; Corsica)*, Marine Pollution Bulletin, Volume 79, Issues 1-2, 15 February 2014, Pages 293-298, ISSN 0025-326X.

Cotton bud project. *How do they end up on our beaches?* http://www.cottonbudproject.org.uk/how-they-get-there.html (retrieved: 07.03.2017).

David Barnes, *"Biodiversity: Invasions by Marine Life on Plastic Debris,"* Nature, 6883 (April 25, 2002): 808-809.

Debrot, D.O., Tiel, A.B., Bradshaw, J.E. (1999) - *Beach debris in Curaçao*. Marine Pollution Bulletin, 38(9):795–801. DOI: 10.1016/S0025-326X(99)00043-0.

EU (The Joint Research Centre Institute for the European Commission) (2013) *Guidance on Monitoring of Marine Litter in European Seas*. The Publications Office of the European Union, Luxembourg

Frias J.P.G.L., Antunes J.C., Sobral P., *Local marine litter survey - A case study in Alcobaça municipality*, Portugal Journal of Integrated Coastal Zone Management 13(2):169-179 (2013)

GESAMP (2015). *"Sources, fate and effects of microplastics in the marine environment: a global assessment"* (Kershaw, P. J., ed.). (IMO/FAO/UNESCO-

IOC/UNIDO/WMO/IAEA/UN/UNEP/UNDP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection). Rep. Stud. GESAMP No. 90, 96 p.

Goodship, Vannessa. *Introduction to Plastics Recycling* (2). Shrewsbury, US: iSmithers Rapra Publishing, 2007.

H. Ogi, Y. Fukimoto, *"A Sorting Method for Small Plastic Debris Floating on the Sea Surface and Stranded on Sandy Beaches,"* Bulletin of the Faculty of Fisheries, Hokkaido University 5 (2), 2000, 71-93.

Laist D.W., *"Impacts of marine debris: entanglement of marine life in marine debris including a comprehensive list of species with entanglement and ingestion records,"* in Coe, J.M. Rogers, D.B. (eds), Marine Debris: Sources, Impacts, and Solutions: Springer-Verlag, New York, (1997) 99-139.

Manrich, Sati, and Santos, Amélia S.F.. *Plastic Recycling*. New York, US: Nova, 2009.
Mepex. Sources of microplastic pollution to the marine environment, 2014

Moore C., *Algalita Marine Research Foundation, presentation at California District Attorney's Association*, Sept. 2006.

Moore C., Lattin G., Zellers A., *"A Brief Analysis of Organic Pollutants Sorbed to Pre- and post- Production Plastic Particles from the Los Angeles and San Gabriel River Watersheds,"* presented at the Plastic Debris, Rivers to Sea Conference, September 2005, Redondo Beach, CA. Plastic Debris Project.

NOAA. *What are microplastics? ,* (2015)
http://oceanservice.noaa.gov/facts/microplastics.html (retrieved: 12.01.2017).

O'Connor, K. (2011) *How Long Does It Take a Plastic Bottle to Biodegrade?*
http://www.postconsumers.com (retrieved: 03.02.2017).

PlasticEurope. *Plastics - the Facts*, 2016 http://www.plasticseurope.org/Document/plastics---the-facts-2016-15787.aspx (retrieved: 13.02.2017).

PlasticsEurope. *What is plastic?* http://www.plasticseurope.org/what-is-plastic.aspx (retrieved: 03.01.2017).

S. Copello, F. Quintara, *"Marine Debris Ingestion by Southern Giant Petrels and its Potential Relationships with Fisheries in the Southern Ocean,"* Marine Debris Bulletin, 46 (2003): 1513-1515.

Seltenrich N., *"New Link in the Food Chain? Marine Plastic Pollution and Seafood Safety,"* Environmental Health Perspectives, vol. 123, no. 2, February 2015.

UNEP (2016) *Marine plastic debris and microplastics – Global lessons and research to inspire action and guide policy change*. United Nations Environment Programme, Nairobi.

Y. Mato et al., *"Toxic Chemicals Contained in plastic resin pellets in the marine environment- spatial difference in pollutant concentrations and the effects of resin type,"* Kanyo Kagakukaishi 15 (2002): 425-423.

Appendices

Appendix I - Survey sheets

List of categories of Litter Items

Sampling site #1 - Praia da Alberta Nova

Date	**13 May 2016**	Start	**11-00**
Area	**Alberta Nova**	Finish	**12-30**
Length	**100 m**		
Monitoring			

TSG_ML General Code	General Name	Number of items
	Plastics	
G3	Shopping bags incl. pieces	21
G4	Small plastic bags, e.g. freezer bags incl. pieces	51
G7	Drink bottles ≤0,5L	10
G8	Drink bottles >0,5L	3
G9	Cleaner bottles & containers	2
G10	Food containers incl. fast-food containers	9
G18	Crates and containers / baskets	1
G21	Plastic caps/lids drinks	22
G23	Plastic caps/lids unidentified	17
G26	Lighters	3
G27	Cigarette butts and filters	2
G28	Pen and pen lids	1
G30	Crisps packets / sweet wrappers	64
G31	Lolly sticks	3
G32	Toys and party poppers	4
G33	Cups and cup lids	9
G34	Cutlery and trays	1
G44	Octopus pots	1
G49	Rope (diameter >1 cm)	6
G50	String and cord (diameter <1 cm)	47
G55	Fishing line (entangled)	3
G58	Fish boxes – expanded polystyrene	10
G60	Light sticks (tubes with fluid)	1

G62	Float for fishing nets	1
G67	Sheets, industrial packaging, plastic sheeting	2
G70	Shotgun cartridges	3
G73	Foam sponge	13
G74	Foam packaging / insulation / polyurethane	16
G78	Plastic pieces < 2,5 cm	22
G79	Plastic pieces > 2,5 cm and <50 cm	52
G92	Bait containers / packaging	1
G95	Cotton bud sticks	8
G96	Sanitary towels / panty liners / backing strips	1
G100	Medical / Pharmaceuticals containers / tubes	1
G35	Straws and stirrers	6
G24	Plastic rings from bottles caps / lids	4
G61	Other Fishing related	1
	Slack / coal	
G212	Slack / coal	2
	Cloth / textile	
G145	Other textiles (incl. rags)	2
	Glass / ceramics	
G200	Bottles incl. pieces	1
G204	Construction materials (brick, cement, pipes)	1
	Metal	
G177	Foil wrappers, aluminum foil	5
G196	Large Metallic Objects	1
	Paper / cardboard	
G151	Cartons / Tetra packs (others)	4
G156	Paper fragments	2
	Wood	
G171	Other <50 cm	1
G172	Other >50 cm	2
	Other	
G215	Food waste	1

Sampling site #2 - Praia do Pinheirinho

Date	**14 May 2016**	Start	**10-30**
Area	**Pinheirinho**	Finish	**11-30**
Length	**100 m**		
Monitoring			

TSG_ML General Code	General Name	Number of items
	Plastics	
G3	Shopping bags incl. pieces	5
G4	Small plastic bags, e.g. freezer bags incl. pieces	32
G6	Bottles	7
G7	Drink bottles ≤0,5L	9
G8	Drink bottles >0,5L	16
G9	Cleaner bottles & containers	3
G10	Food containers incl. fast-food containers	5
G18	Crates and containers / baskets	3
G21	Plastic caps/lids drinks	19
G23	Plastic caps/lids unidentified	8
G28	Pen and pen lids	1
G30	Crisps packets / sweet wrappers	18
G31	Lolly sticks	4
G33	Cups and cup lids	13
G34	Cutlery and trays	1
G42	Crab / lobster pots and tops	3
G49	Rope (diameter >1 cm)	3
G50	String and cord (diameter <1 cm)	21
G59	Fishing line / monofilament (angling)	1
G60	Light sticks (tubes with fluid)	2
G66	Strapping bands	1
G73	Foam sponge	4
G74	Foam packaging / insulation / polyurethane	18
G78	Plastic pieces < 2,5 cm	36
G79	Plastic pieces > 2,5 cm and <50 cm	30
G80	Plastic pieces > 50 cm	2
G91	Biomass holder from sewage treatment plants	1
G92	Bait containers / packaging	3
G95	Cotton bud sticks	20

G35	Straws and stirrers	10
G24	Plastic rings from bottles caps / lids	3
G12	Other Cosmetic Containers	1
G14	Oil Container	1
G90	Flower pots	1
G124	Other plastic unidentified	6
	Glass / ceramics	
G200	Bottles incl. pieces	5
G201	Jars incl. pieces	1
	Metal	
G174	Aerosol / Spray cans industry	1
G175	Cans (beverages)	1
G178	Bottle caps, lids & pull tabs	1
	Paper / cardboard	
G150	Cartons /Tetrapack (milk)	1
G151	Cartons /Tetrapack (others)	7
	Rubber	
G134	Other rubber	1
	Processed wood	
G161	Processed timber	2
G172	Other >50 cm	1
	Other	
G215	Food waste	2

Sampling site #3 - Praia da Vigia

Date	**14 May 2016**	Start	**15-30**
Area	**Vigia**	Finish	**16-30**
Length	**100 m**		
Monitoring			

TSG_ML General Code	General Name	Number of items
	Plastics	
G3	Shopping bags incl. pieces	34
G4	Small plastic bags, e.g. freezer bags incl. pieces	12
G7	Drink bottles ≤0,5L	26
G8	Drink bottles >0,5L	11
G9	Cleaner bottles & containers	9
G10	Food containers incl. fast-food containers	5
G13	Other plastic bottles & containers	1
G15	Engine oil bottles & containers > 50 cm	1
G18	Crates and containers / baskets	4
G21	Plastic caps / lids drinks	40
G23	Plastic caps / lids unidentified	15
G26	Cigarette lighters	3
G27	Cigarette butts and filters	2
G28	Pens and pen lids	4
G30	Crisps packets / sweet wrappers	26
G31	Lolly sticks	4
G32	Toys and party poppers	3
G33	Cups and cup lids	7
G41	Gloves (industrial / professional rubber gloves)	1
G42	Crab / lobster pots and tops	2
G49	Rope (diameter > 1 cm)	4
G50	String and cord (diameter < 1 cm)	86
G53	Nets and pieces of net (< 50cm)	4
G58	Fish boxes – expanded polystyrene	1
G60	Light sticks (tubes with fluid) incl. packaging	1
G62	Floats for fishing nets	8
G61	Other Fishing related	2
G65	Buckets	1
G66	Strapping bands	4

G68	Fiber glass / fragments	1
G71	Shoes / sandals	4
G73	Foam sponge	6
G74	Foam packaging / insulation / polyurethane	15
G78	Plastic pieces < 2,5 cm	36
G79	Plastic pieces > 2,5 cm e <50 cm	47
G95	Cotton bud sticks	26
G96	Sanitary towels / panty liners / backing strips	6
G102	Flip-flops	2
G35	Straws and stirrers	10
G24	Plastic rings from bottles caps / lids	2
G124	Other plastic / polystyrene items (identifiable)	14
	Chemicals	
G212	Slack / coal	1
G213	Paraffin / wax	1
	Textile	
G145	Other textiles (incl. rags)	2
	Glass / ceramics	
G200	Bottles incl. pieces	6
G205	Fluorescent light tubes	1
	Metal	
G174	Aerosol / Spray cans industry	1
G176	Cans (food)	1
G177	Foil wrappers, aluminum foil	3
G178	Bottle caps, lids & pull tabs	4
G198	Other metal pieces <50 cm	1
	Paper / cardboard	
G151	Cartons /Tetrapack (others)	2
G156	Paper fragments	1
	Rubber	
G125	Balloons and balloon sticks	2
G134	Other rubber pieces	1
	Processed wood	
G159	Corks	5
G161	Processed timber	1
G171	Other wood < 50 cm	9
	Other	
G216	Various rubbish	8

Sampling site #4 - Praia do Carvalhal

Date	**17 May 2016**	Start	**15-00**
Area	**Comporta**	Finish	**16-00**
Length	**100 m**		
Monitoring			

TSG_ML General Code	General Name	Number of items
	Plastics	
G3	Shopping bags incl. pieces	21
G4	Small plastic bags, e.g. freezer bags incl. pieces	13
G7	Drink bottles ≤ 0,5L	45
G8	Drink bottles > 0,5L	53
G10	Food containers incl. fast-food containers	21
G11	Beach use related cosmetic bottles and containers	1
G12	Other Cosmetic bottles & containers	1
G15	Engine Oil bottles & containers > 50 cm	3
G18	Crates and containers	2
G21	Plastic caps / lids drinks	46
G23	Plastic caps / lids unidentified	39
G26	Cigarette lighters	4
G27	Cigarette butts and filters	1
G28	Pens and pen lids	2
G29	Combs / hair brushes / sunglasses	1
G30	Crisps packets / sweet wrappers	73
G31	Lolly sticks	8
G32	Toys and party poppers	3
G33	Cups and cup lids	18
G34	Cutlery and trays	2
G37	Mesh vegetable bags	1
G42	Crab / lobster pots and tops	4
G44	Octopus pots	2
G49	Rope (diameter > 1 cm)	2
G50	String and cord (diameter < 1 cm)	144
G53	Nets and pieces of net (< 50cm)	4
G55	Fishing line (entangled)	2
G58	Fish boxes – expanded polystyrene	2
G60	Light sticks (tubes with fluid) incl. packaging	3
G62	Floats for fishing nets	3

G66	Strapping bands	6
G70	Shotgun cartridges	2
G71	Shoes / sandals	2
G73	Foam sponge	11
G74	Foam packaging / insulation / polyurethane	32
G78	Plastic pieces < 2,5 cm	170
G79	Plastic pieces > 2,5 cm e <50 cm	89
G95	Cotton bud sticks	88
G96	Sanitary towels / panty liners / backing strips	4
G97	Toilet fresheners	2
G100	Medical / pharmaceuticals containers / tubes	2
G35	Straws and stirrers	10
G24	Plastic rings from bottle caps / lids	10
G124	Other plastic / polystyrene items (identifiable)	7
	Chemicals	
G212	Slack / coal	1
G213	Paraffin / wax	6
	Textiles	
G145	Other textiles (incl. rags)	1
	Glass / ceramics	
G200	Bottles incl. pieces	6
G201	Jars incl. pieces	1
G202	Light bulbs	2
	Metal	
G175	Cans (beverage)	2
G177	Foil wrappers, aluminum foil	1
	Paper / cardboard	
G151	Cartons / Tetrapack (others)	3
G158	Other paper items	1
	Rubber	
G125	Balloons and balloon sticks	3
G131	Rubber bands	1
G133	Condoms (incl. packaging)	1
G134	Other rubber pieces	1
	Processed wood	
G159	Corks	3
	Other	
G216	Various rubbish	8

Sampling site #5 - Praia da Comporta

Date	**18 May 2016**	Start	**15-30**
Area	**Comporta**	Finish	**16-30**
Length	**100 m**		
Monitoring			

TSG_ML General Code	General Name	Number of items
	Plastics	
G3	Shopping bags incl. pieces	11
G4	Small plastic bags, e.g. freezer bags incl. pieces	7
G7	Drink bottles ≤ 0,5L	8
G8	Drink bottles > 0,5L	6
G9	Cleaner bottles & containers	3
G10	Food containers incl. fast-food containers	9
G15	Engine Oil bottles & containers > 50 cm	3
G18	Crates and containers	3
G21	Plastic caps / lids drinks	13
G23	Plastic caps / lids unidentified	29
G27	Cigarette butts and filters	1
G28	Pens and pen lids	1
G30	Crisps packets / sweet wrappers	28
G31	Lolly sticks	4
G32	Toys and party poppers	6
G33	Cups and cup lids	3
G34	Cutlery and trays	1
G37	Mesh vegetable bags	1
G42	Crab / lobster pots and tops	1
G50	String and cord (diameter <1 cm)	120
G53	Nets and pieces of net (< 50cm)	3
G55	Fishing line (entangled)	2
G60	Light sticks (tubes with fluid) incl. packaging	3
G61	Other Fishing related	1
G62	Floats for fishing nets	2
G66	Strapping bands	2
G70	Shotgun cartridges	1
G73	Foam sponge	5
G74	Foam packaging / insulation / polyurethane	5

G78	Plastic pieces < 2,5 cm	122
G79	Plastic pieces > 2,5 cm e <50 cm	83
G82	Polystyrene pieces >2,5 cm e <50 cm	5
G95	Cotton bud sticks	101
G96	Sanitary towels / panty liners / backing strips	1
G35	Straws and stirrers	14
G24	Plastic rings from bottle caps / lids	11
G124	Other plastic / polystyrene items (identifiable)	14
	Chemicals	
G212	Slack / coal	2
G213	Paraffin / wax	2
	Glass / ceramics	
G200	Bottles incl. pieces	5
G202	Light bulbs	1
G205	Fluorescent light tubes	2
	Metal	
G174	Aerosol / Spray cans industry	4
G175	Cans (beverage)	2
G177	Foil wrappers, aluminum foil	2
	Paper / cardboard	
G146	Paper / cardboard	1
G151	Cartons / Tetrapack (others)	2
G156	Paper fragments	1
	Rubber	
G125	Balloons and balloon sticks	1
G131	Rubber bands	1
	Processed wood	
G161	Processed timber	4
	Other	
G216	Various rubbish	4

Appendix II – Microplastics assessment

List of categories of the microplastics according to Ogi & Fukumoto (2000)

Sampling Zone 1		Microplastics categories	Number of items
Sample 1		Class 1	
Total objects	25	Class 2	
Meso plastic	0	Class 3	1
Micro plastic	19	Class 4	2
Pellets	3	Class 5	3
Styrofoam	2	Class 6	2
		Class 7	3
		Class 8	3
		Class 9	1
		Class 10	1
		Class 11	3
Sample 2		Class 1	
Total objects	9	Class 2	
Meso plastic	1	Class 3	
Micro plastic	6	Class 4	1
Pellets	0	Class 5	2
Styrofoam	2	Class 6	1
		Class 7	
		Class 8	
		Class 9	
		Class 10	2
		Class 11	3
Sample 3		Class 1	
Total objects	30	Class 2	1
Meso plastic	3	Class 3	1
Micro plastic	24	Class 4	2
Pellets	0	Class 5	3
Styrofoam	3	Class 6	4
		Class 7	2
		Class 8	5
		Class 9	1
		Class 10	1
		Class 11	4

Sample 4		Class 1	
Total objects	11	Class 2	
Meso plastic	1	Class 3	
Micro plastic	10	Class 4	1
Pellets	0	Class 5	1
Styrofoam	0	Class 6	2
		Class 7	1
		Class 8	
		Class 9	2
		Class 10	1
		Class 11	2
Sample 5		Class 1	
Total objects	10	Class 2	
Meso plastic	2	Class 3	
Micro plastic	4	Class 4	1
Pellets	1	Class 5	
Styrofoam	1	Class 6	1
		Class 7	1
		Class 8	
		Class 9	
		Class 10	
		Class 11	1

Sampling Zone 2		Microplastics categories	Number of items
Sample 1		Class 1	
Total objects	17	Class 2	
Meso plastic	1	Class 3	1
Micro plastic	13	Class 4	
Pellets	1	Class 5	1
Styrofoam	2	Class 6	2
		Class 7	
		Class 8	2
		Class 9	
		Class 10	2
		Class 11	5

Sample 2		Class 1	
Total objects	30	Class 2	
Meso plastic	1	Class 3	3
Micro plastic	24	Class 4	3
Pellets	1	Class 5	4
Styrofoam	2	Class 6	1
		Class 7	1
		Class 8	
		Class 9	6
		Class 10	2
		Class 11	4
Sample 3		Class 1	
Total objects	85	Class 2	
Meso plastic	2	Class 3	1
Micro plastic	54	Class 4	6
Pellets	11	Class 5	8
Styrofoam	15	Class 6	5
		Class 7	3
		Class 8	6
		Class 9	6
		Class 10	2
		Class 11	17
Sample 4			
Total objects	12	Class 1	
Meso plastic	2	Class 2	
Micro plastic	9	Class 3	
Pellets	0	Class 4	1
Styrofoam	1	Class 5	1
		Class 6	
		Class 7	
		Class 8	1
		Class 9	2
		Class 10	
		Class 11	4
Sample 5		Class 1	
Total objects	31	Class 2	
Meso plastic	1	Class 3	2

Micro plastic	25	Class 4	2
Pellets	5	Class 5	3
Styrofoam	0	Class 6	3
		Class 7	4
		Class 8	2
		Class 9	3
		Class 10	2
		Class 11	4

Sampling Zone 3		Microplastics categories	Number of items
Sample 1		Class 1	
Total objects	5	Class 2	
Wood	2	Class 3	
Glass	1	Class 4	
Micro plastic	1	Class 5	
Styrofoam	0	Class 6	
		Class 7	
		Class 8	
		Class 9	
		Class 10	
		Class 11	1
Sample 2		Class 1	
Total objects	3	Class 2	
Meso plastic	0	Class 3	
Micro plastic	3	Class 4	
Pellets	0	Class 5	1
Styrofoam	0	Class 6	
		Class 7	
		Class 8	
		Class 9	
		Class 10	
		Class 11	2
Sample 3		Class 1	
Total objects	2	Class 2	
Meso plastic	0	Class 3	
Micro plastic	1	Class 4	
Pellets	0	Class 5	1
Styrofoam	1	Class 6	

		Class 7	
		Class 8	
		Class 9	
		Class 10	
		Class 11	
Sample 4		Class 1	
Total objects	1	Class 2	
Meso plastic	0	Class 3	
Micro plastic	0	Class 4	
Pellets	0	Class 5	
Styrofoam	1	Class 6	
		Class 7	
		Class 8	
		Class 9	
		Class 10	
		Class 11	
Sample 5		Class 1	
Total objects	2	Class 2	
Meso plastic	0	Class 3	
Micro plastic	2	Class 4	
Pellets	0	Class 5	
Styrofoam	0	Class 6	
		Class 7	
		Class 8	
		Class 9	1
		Class 10	
		Class 11	1

Sampling Zone 4		Microplastics categories	Number of items
Sample 1		Class 1	
Total objects	43	Class 2	
Meso plastic	2	Class 3	
Micro plastic	27	Class 4	3
Pellets	6	Class 5	4
Styrofoam	2	Class 6	2
		Class 7	2
		Class 8	
		Class 9	4

		Class 10	1
		Class 11	11
Sample 2		Class 1	
Total objects	15	Class 2	
Meso plastic	1	Class 3	
Micro plastic	11	Class 4	2
Pellets	1	Class 5	3
Styrofoam	2	Class 6	
		Class 7	
		Class 8	
		Class 9	1
		Class 10	1
		Class 11	4
Sample 3		Class 1	
Total objects	31	Class 2	
Meso plastic	0	Class 3	6
Micro plastic	24	Class 4	3
Pellets	7	Class 5	5
Styrofoam	0	Class 6	1
		Class 7	1
		Class 8	
		Class 9	
		Class 10	1
		Class 11	7
Sample 4		Class 1	
Total objects	29	Class 2	
Meso plastic	3	Class 3	1
Micro plastic	19	Class 4	2
Pellets	3	Class 5	1
Styrofoam	1	Class 6	3
		Class 7	
		Class 8	2
		Class 9	2
		Class 10	2
		Class 11	7
Sample 5		Class 1	

Total objects	45	Class 2	
Meso plastic	5	Class 3	2
Micro plastic	27	Class 4	5
Pellets	6	Class 5	4
Styrofoam	4	Class 6	2
		Class 7	3
		Class 8	3
		Class 9	1
		Class 10	1
		Class 11	6

Sampling Zone 5		Microplastics categories	Number of items
Sample 1		Class 1	
Total objects	19	Class 2	
Meso plastic	1	Class 3	
Micro plastic	13	Class 4	1
Pellets	5	Class 5	
Styrofoam	0	Class 6	
		Class 7	3
		Class 8	
		Class 9	2
		Class 10	1
		Class 11	6
Sample 2		Class 1	
Total objects	17	Class 2	
Meso plastic	3	Class 3	
Micro plastic	7	Class 4	
Pellets	6	Class 5	1
Styrofoam	0	Class 6	1
		Class 7	1
		Class 8	
		Class 9	
		Class 10	
		Class 11	4
Sample 3		Class 1	
Total objects	32	Class 2	
Meso plastic	0	Class 3	
Micro plastic	13	Class 4	

Pellets	18	Class 5	3
Styrofoam	0	Class 6	
		Class 7	1
		Class 8	2
		Class 9	1
		Class 10	
		Class 11	6
Sample 4		Class 1	
Total objects	8	Class 2	
Meso plastic	0	Class 3	1
Micro plastic	3	Class 4	
Pellets	5	Class 5	
Styrofoam	0	Class 6	1
		Class 7	
		Class 8	
		Class 9	
		Class 10	
		Class 11	1
Sample 5		Class 1	
Total objects	24	Class 2	
Meso plastic	0	Class 3	
Micro plastic	18	Class 4	3
Pellets	5	Class 5	2
Styrofoam	1	Class 6	
		Class 7	
		Class 8	
		Class 9	2
		Class 10	3
		Class 11	8