Race for Water Odyssey
Preliminary results from the Azores, Bermuda and Easter Island

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Synopsis

Race For Water Foundation is currently carrying out a worldwide boat expedition in order to assess plastic pollution in the world's ocean. The same NOAA[1] based scientific protocol is performed and will enable data comparison at large scale, in the ocean' 5 identified gyres, in terms of plastic debris concentration reached recently. Since stranded marine debris are - both in terms of quality and quantity - representative of what is in the ocean, on field samplings are carried out entirely on land, especially on the shorelines of islands.

Azores, Bermuda and Easter Island preliminary results indicates that microplastic concentration is very concerning, especially on Easter Island where values are at least tenfold higher than in the North Atlantic, with more than 10'000 microplastics per square meter on average. On the opposite, macrodebris concentrations are not significant because of regular clean-up operations done by local volunteers. Among the collected plastic debris, more than 80% on average is originated from land. Especially on Easter Island, pellet concentration is another specific concern because of the reached level, which is around 30%.

[1] National Oceanic and Atmospheric Administration, USA

Introduction

The Race For Water Odyssey a unique expedition aiming to visit the beaches of islands located in the oceans' 5 identified gyres (also called "vortex", it defines offshore high concentration of marine debris located in the North and South Atlantic, North and South Pacific, and South of Indian Ocean) in order to investigate the areas around the world affected by plastic garbage polluting the oceans, and highlight its consequences on the populations, in less than one year.

Since there is a global drifting movement created by the currents at the surface, floating marine debris in these vortexes – mainly composed of plastic – are found in a higher concentration than in the rest of the oceans. These floating debris are therefore washed ashore onto the exposed shorelines of these islands, which act as a sort of a natural barrier. For this reason, the types and the concentration of stranded marine debris found on these beaches is consecutively representative of the plastic pollution of the surrounding waters. This is why, the Race For Water Odyssey focused especially on an onshore sampling of washed ashore plastic marine debris.

In total, the Odyssey stopped on 8 different islands and/or archipelagoes including Azores, Bermuda, Easter Island, Hawaii, Guam, Palaos and Rodrigues. As a result of the boat capsizing in the Indian Ocean, two other stopovers (Chagos and Tristan Da Cunha) were not sampled by the team, but by local volunteers part of the Race For Water Foundation's network according, however, to the same protocol used by the Odyssey on all previous sampled beaches, in order to obtain comparable data.

During these scientific stopovers, the sampling protocol has been applied on two to five different shorelines, depending on the accessibility and on the scientific interests. These includes several criteria such as: the type of substrate, the morphology of the field, the direct proximity of outflows, estuaries or promontories, and the exposition of the shorelines, which can influence the representativity of the samplings. Clean-up activities taking place have also been reported, but were no grounds for exclusion.

Objectives and methodology

On that basis, the first goal of the Odyssey is to identify, to count, and to quantify on field the debris fractions above 2.5 cm (the so-called "macrodebris"), and to collect and analyse in laboratory the plastic fractions with a size ranging from 5mm to 2.5cm (the so-called "mesoplastics") and under 5mm (the so-called "microplastics") according the recent and standardized NOAA's[2] protocol, edited in 2013 [Lippiatt et al, 2013]. The systematic application of this protocol will enable us to get comparable qualitative and quantative data of all the gyres.

<u>Figure 1 :</u> Meso- and microplastics sampling on a « quadrat » (square area of 50cm, and 10cm depth), at Kamilo Point, Hawaii, 30 june 2015. Pictures F. Sciacca.

<u>Figure 2 :</u> Macrodebris sampling at Ngerong and Ulong beaches, Republic of Palao, 24 august 2015. Pictures P. Charaf.

In collaboration with Florian Faure, with the supervision of Prof. Felippe De Alencastro from the Central Environmental Laboratory (LCE) of the Ecole Polytechnique Fédéral de Lausanne (EPFL) in Switzerland, the consecutive laboratory analysis categorized and identified the types of sampled meso- and microplastics collected during the Odyssey. The main goal is to sort plastic marine debris according to its category (foam, films, fishing lines/lures, microbeads, pellets, hard fragments…), and type of plastic (LDPE, HDPE, PP, PS, PET, PVC…), and to identify the number and weight concentration per square metre of beach. The working procedure is summarized as follows.

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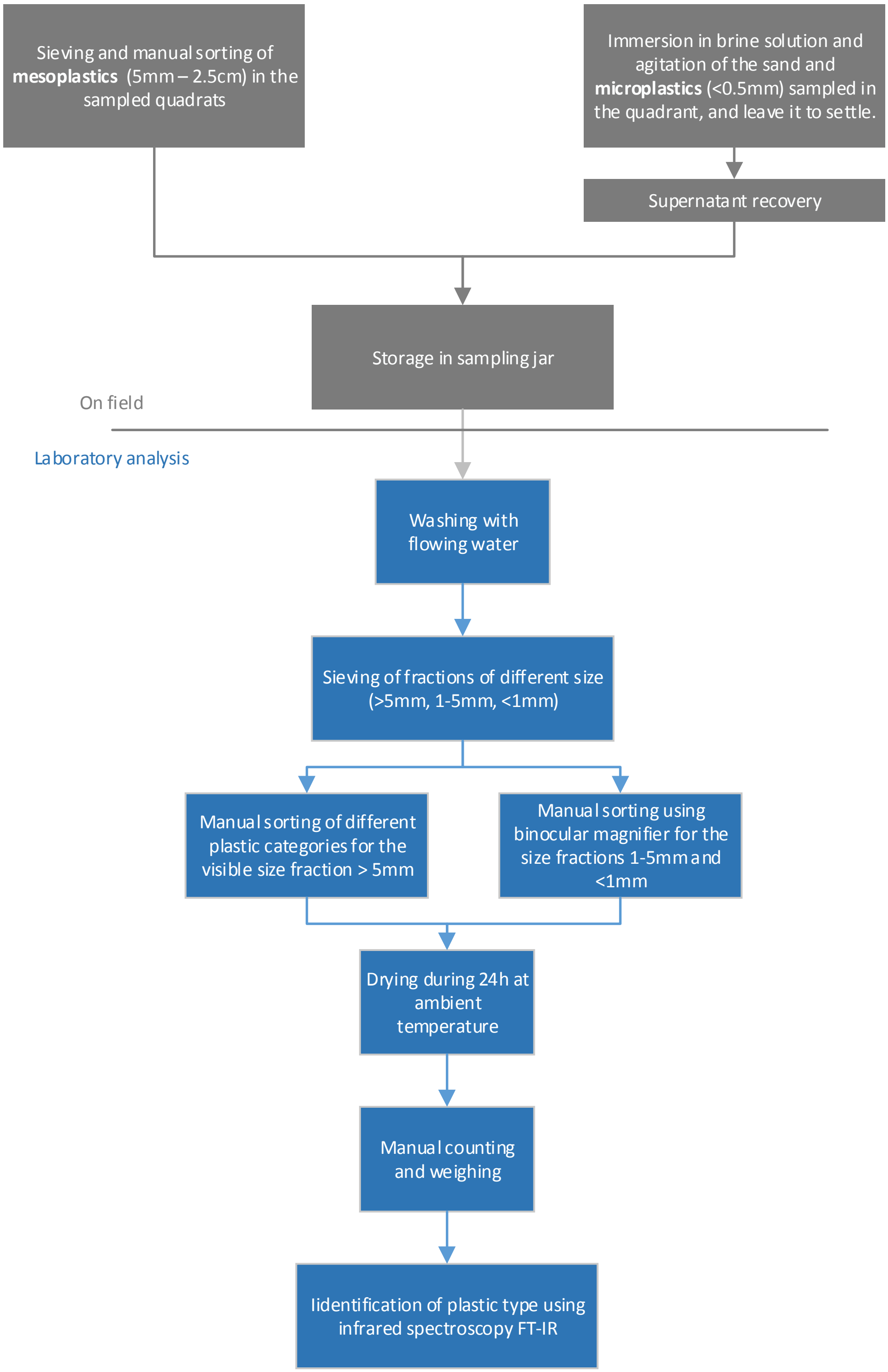
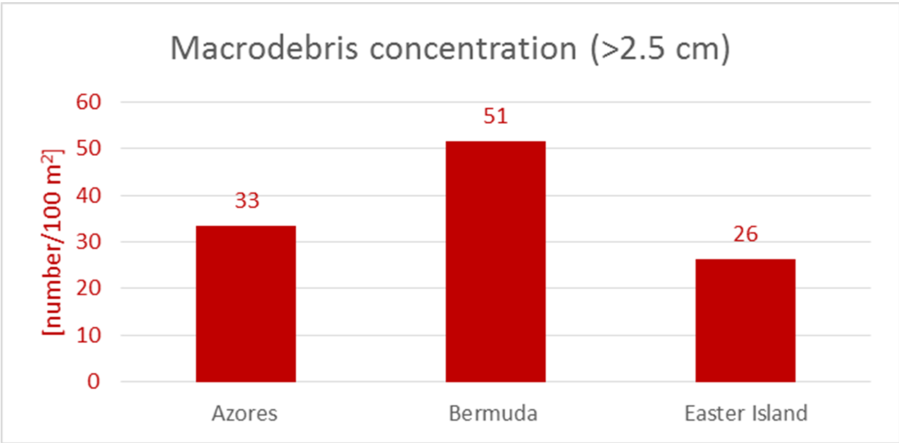
[2] National Oceanic and Atmospheric Administration, USA



<u>Figure 3 :</u> Block diagram of the sampling and laboratory analysis of meso- (5mm-2.5cm) and microplastics (<5mm) collected in the quadrat (square area of 50cm, and 10 cm depth).

Preliminary results

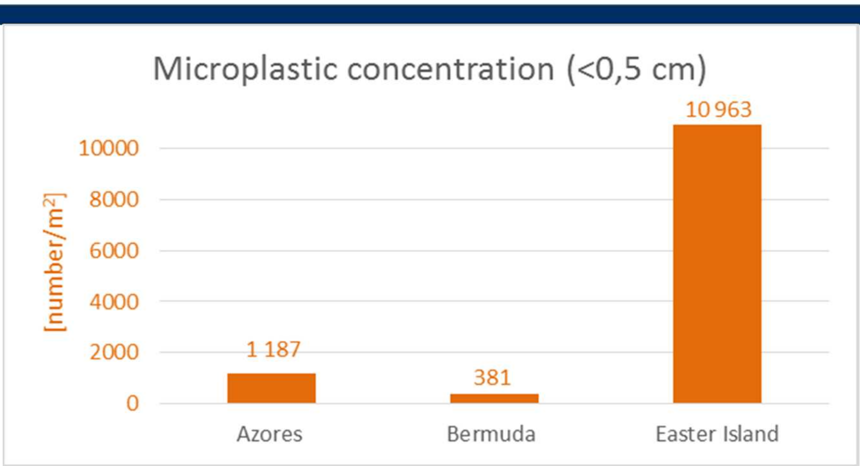
This document presents the preliminary results of the first three stopovers (Azores, Bermuda and Easter Island). Definition of plastic types will be done in the subsequent laboratory phase and is therefore not included in this preliminary report.



<u>Figure 4 :</u> Macrodebris concentration (>2.5cm) in number per 100 square metre of beach (a square of 10 metres). Macrodebris concentrations are globally low. There is high data variance, even between shorelines of the same island, but the main cause is local clean-up operations.

Of the waste collected, plastic made up nearly 69% of all macrodebris in the Azores, 79% in Bermuda and 92% on Easter Island. The average concentration of macrodebris per area of beach is globally low, but these data are directly impacted by the local clean operations. Concentration is highly variable from beach to beach in any given place. The beaches sampled in Bermuda show the highest waste average with 51 macro debris on a 100 square meter area.

The concentration of macrodebris by weight present a different trend however with Easter Island outstripping Bermuda and the Azores. Indeed, the respective concentration in gram per hundred square meter is 94 gr in the Azores, 240 gr in Bermuda, and 1609 gr on Easter Island. These preliminary results demonstrate that there is no correlation between macrodebris quantity and weight. Specifically, Easter Island demonstrates that certain large items of debris, such as rope or containers, can significantly impact concentration on the smaller beaches. These results are relative however because the concentration of large waste is highly variable and dependent on the frequency of beach cleaning operations which are systematic across all three islands albeit with varying regularity.



<u>Figure 5 :</u> Microdebris concentration (<0.5cm) in number per square metre of beach. Corresponding macrodebris concentration in weight are 16 [g/m²] on the Azores, 3 [g/m²] on Bermuda and more than 150 [g/m²] on Easter Island. In comparison, macroplastic (>5mm) concentration in weight are much lower with 1 [g/m²] on the Azores, 2 [g/m²] on Bermuda and more than 16 [g/m²] on Easter Island. The point is that microplastics are not collected during clean-up operations and therefore constitute an interesting historical dataset of plastic deposition on the shorelines.

Microplastic concentration (<5mm) was highly variable between beaches on the same island. But tests demonstrated that the Easter Island beaches (Ovahe and Anakena) show 10 times the concentration of plastic than the Azores beaches (Norte, Porto Pim, Almoxarife, Conceição) both in terms of quantity and weight per square metre sampled. Contrary to the macrodebris results, Bermuda appears less exposed to microplastic pollution than the Azores and Easter Island.

In terms of data gathered on the microdebris mass, the figures correlate with a resulting average weight of 13.5mg in the Azores, 7.8mg in Bermuda and 13.7mg per microplastic on Easter Island. Beyond the consistency of the data, the most striking conclusion is that the concentration in mass of microplastics per square metre is much higher than that of macro plastics. Although it is important to note that these results are relative as the concentration of macrodebris is dependent on beach cleaning operations, whereas micro debris is rarely cleaned up. Nevertheless, these concentrations refer to microplastics sampled until a depth of 10 cm only, and in most cases microplastics were still identified beyond the limit.

The concentration of macro debris is directly connected to local awareness of waste management. Locally generated waste needs to be considered in some cases. In other words, the geographic location of the islands studied by R4WO relative to continents or urban hubs could be a parameter that explains why there is a higher concentration of macro debris on islands close to continents. Conversely, distance from continents and proximity to ocean gyres - where waste debris have a long residence time in the water and therefore more opportunities to break down - could be a parameter that explains the greater concentration of fragmented debris, or micro plastic, on Easter Island. Indeed, the more marine debris stays in the water, the more it is broken down by the solar UV light, the physical and biological degradation. Due to the small number of islands studied and sampled at this stage of the research, these theories require further analysis to be confirmed.

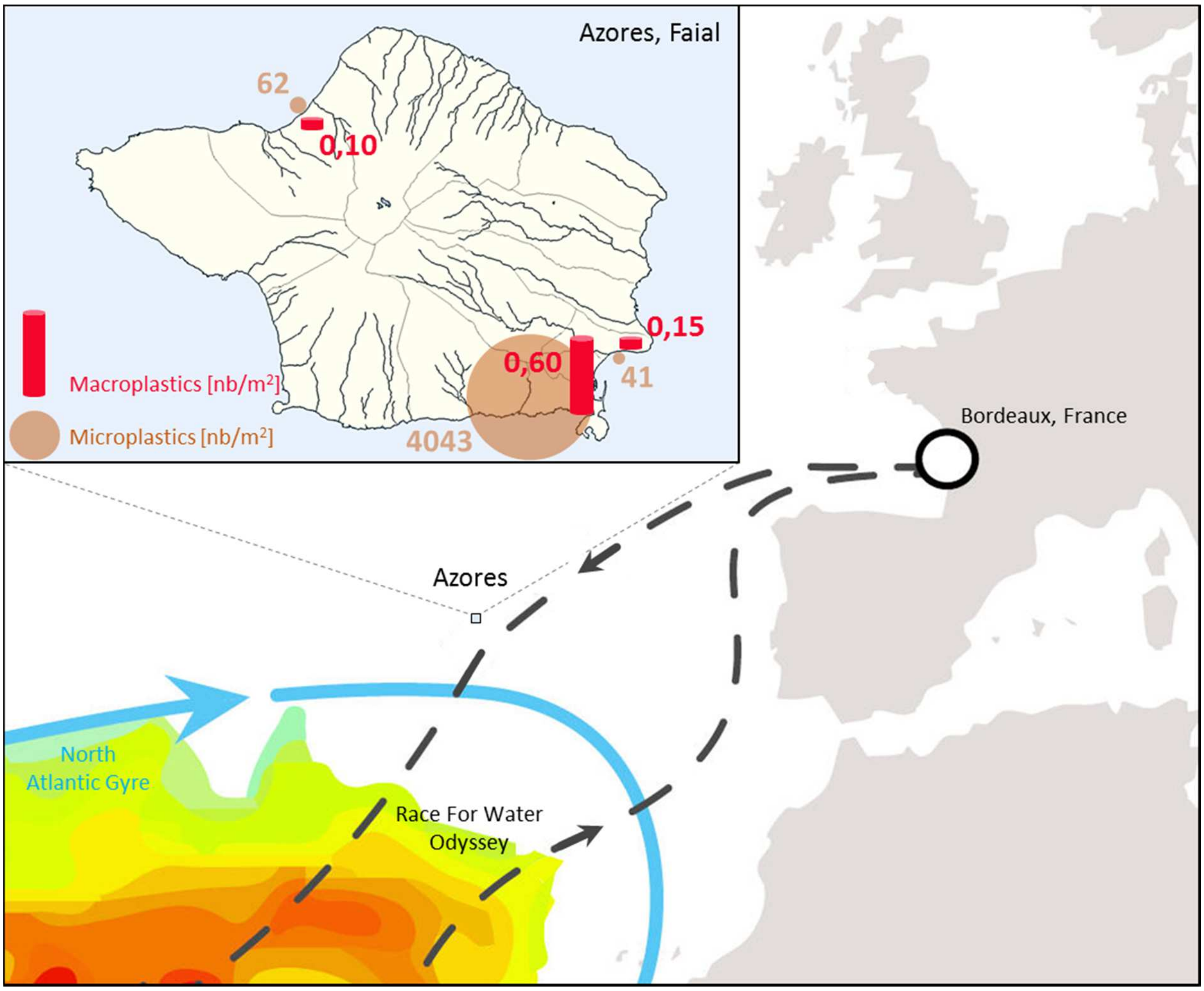
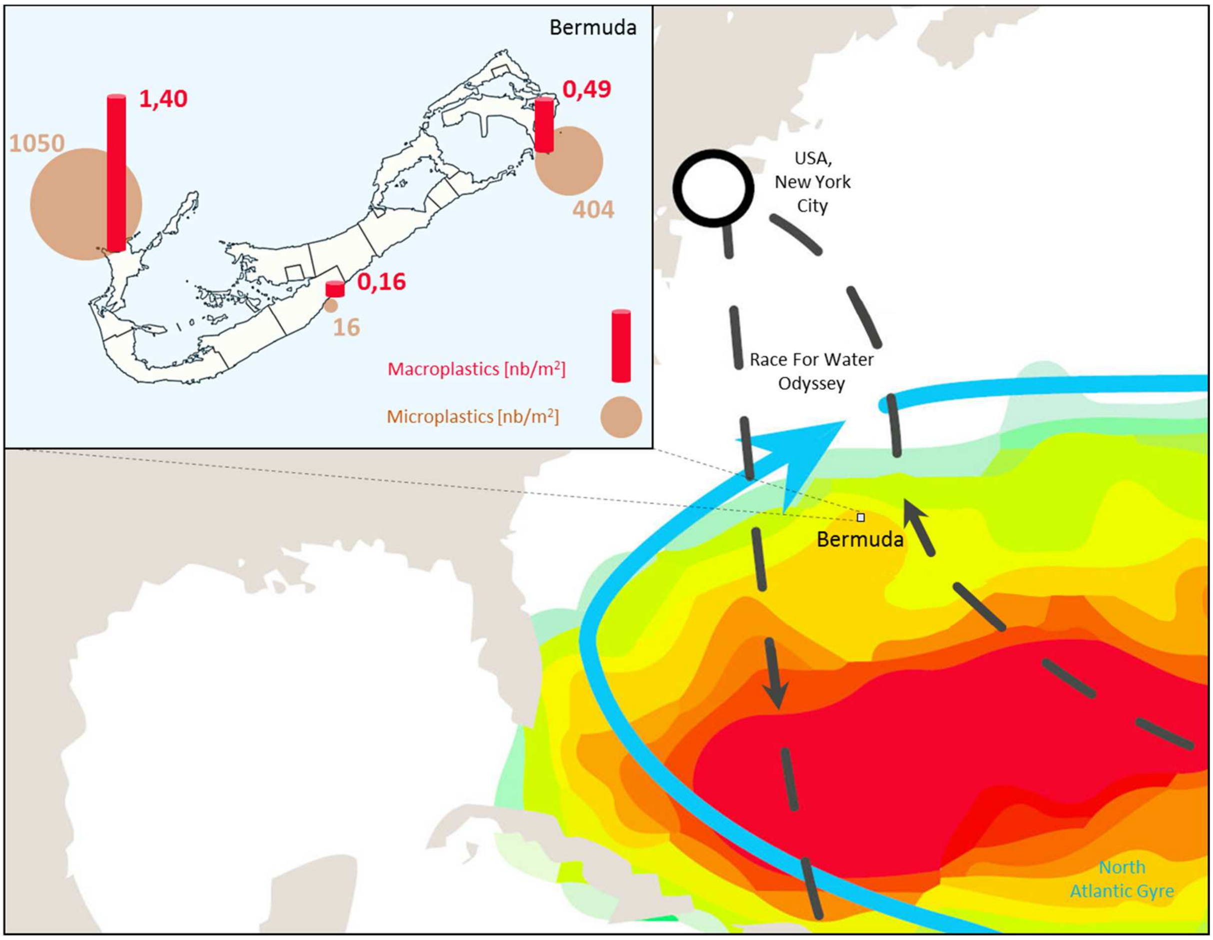


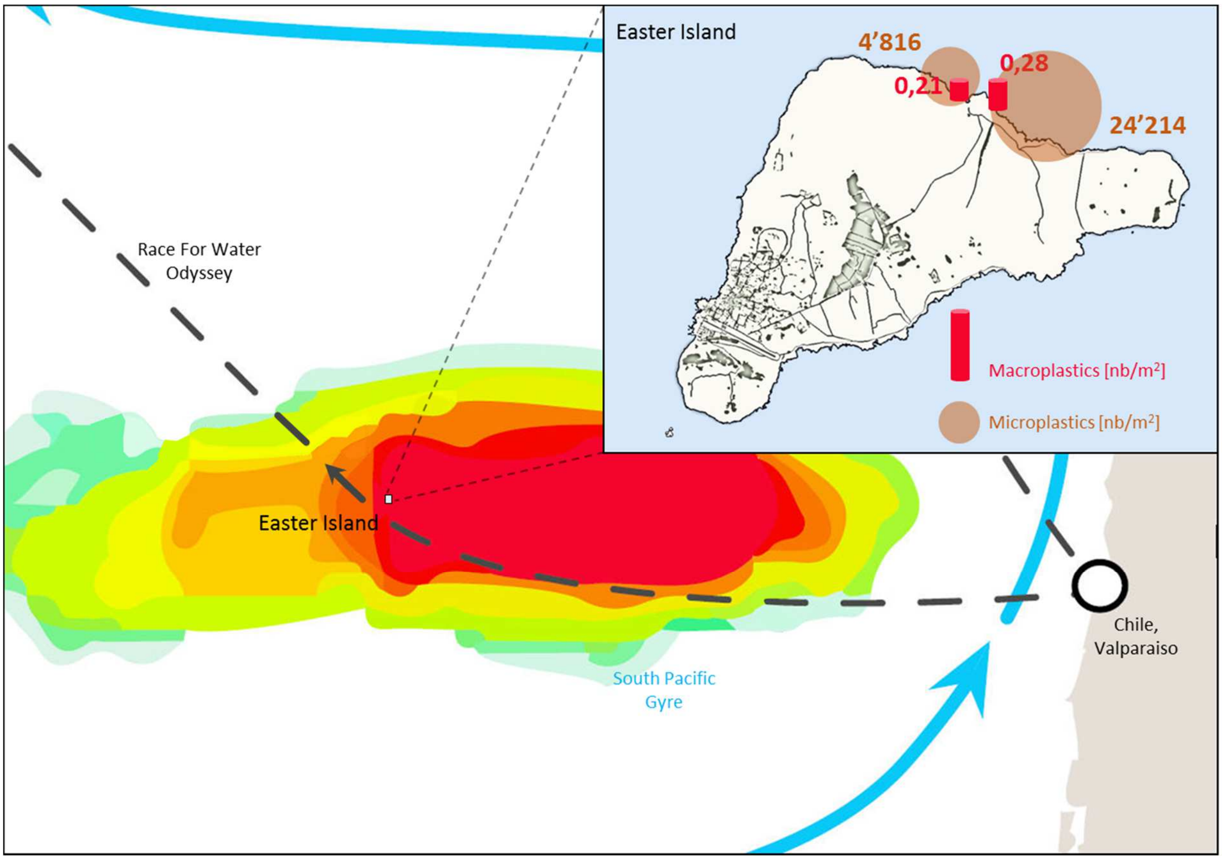
Figure 6 : Macrodebris (red circle) and microplastics (orange circle) concentration per square metre of beach (until 10cm depth) on Faial Island, Azores. Circle size is proportional to concentration, but with different scale according to the considered category.

Locally, the concentration of waste is extremely variable and is based on geographic location. This finding is logical as waste patterns rely on ocean currents. In this context, the southern tip of Faial Island, which has a southwest facing beach, acts as a natural waste trap for debris drifting from west to east. The Norte beach has some particular characteristics; it faces northwest, is sloped and has a regular swell with powerful waves and a sandy beach. This may explain the low quantity of microplastics. It is also regularly cleaned. On Do Norte and Conceição beaches, large plastic debris (>2.5cm) is widespread. The nearby landfill site in the case of Do Norte and an urban centre near Conceição could explain the locally generated macroplastic found on these two beaches. Frequent cleaning of Almoxarife beach may explain the absence of any macroplastics.



<u>Figure 7 :</u> Macrodebris (red circle) and microplastics (orange circle) concentration per square metre of beach (until 10cm depth) on Bermuda. Circle size is proportional to concentration, but with different scale according to the considered category.

In Bermuda, R4WO recorded the highest amount of micro- and macrodebris on Somerset Long Bay beach in the southwest. Local residents contest this saying that the majority of the waste comes in from the east. The conflict between the R4WO results and local testimony is likely due to a recent clean-up operation on the beaches in the east of the island. In addition to the local testimony, the fact that Well Bay beach, situated on the north eastern coast, forms a small south westerly facing cove that acts as a waste trap for debris drifting from southwest to the northeast may explain the significant concentrations of debris despite a recent clean up. According to local experience, Well Bay beach is the most affected by marine debris.



<u>Figure 8 :</u> Macrodebris (red circle) and microplastics (orange circle) concentration per square metre of beach (until 10cm depth) on Easter Island. Circle size is proportional to concentration, but with different scale according to the considered category

Sampling on Easter Island is less representative than the other two locations as only two beaches, Ovahe and Anakena, were studied on the northeast coast of the island. This was due to the steep and rocky nature of the rest of the coastline. Ovahe beach faces east and Anakena faces northwest, the concentration of waste suggested that the debris flow is from east to west.

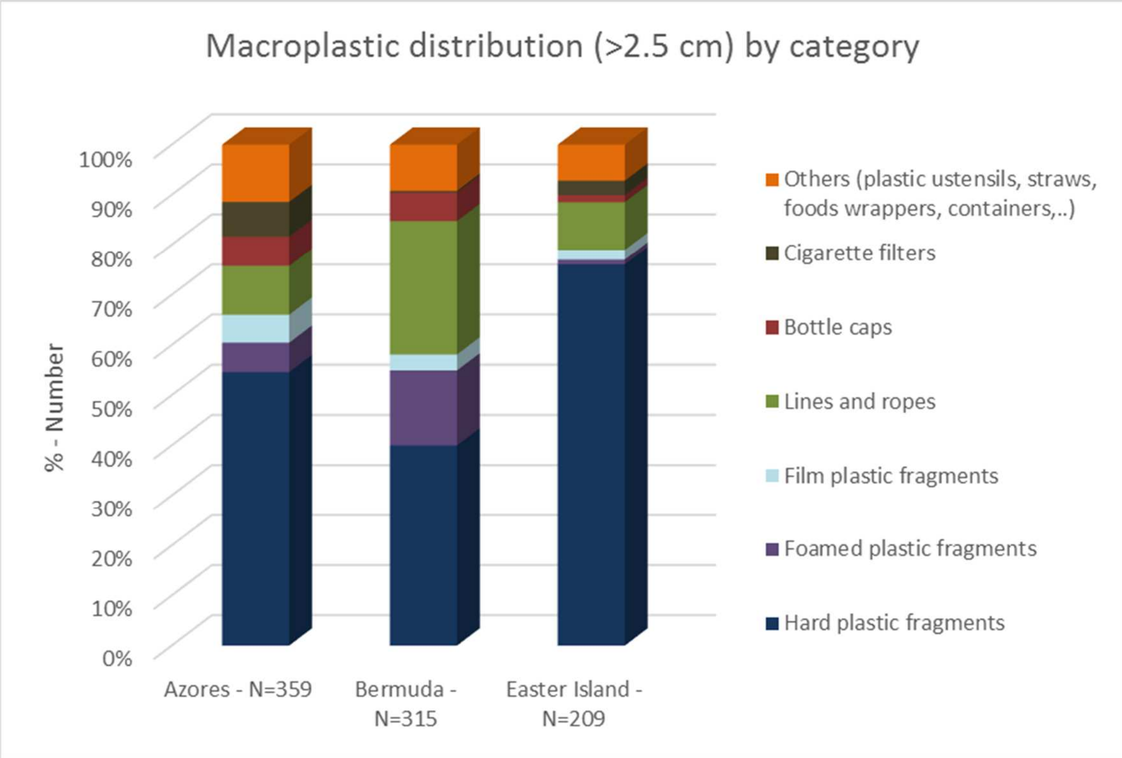


Figure 9 : Macroplastics (>2.5cm) distribution according to plastic debris categories.

Of the macroplastics collected on the beaches, between 40 and 74% was hard plastic. The second major category was fishing line and pieces of plastic rope, then foam and bottle caps, plastic film and cigarette filters. Fishing and boating activity is logically at the source of the bits of rope and fishing line and Bermuda is more exposed to this type of debris than the Azores and Easter Island.

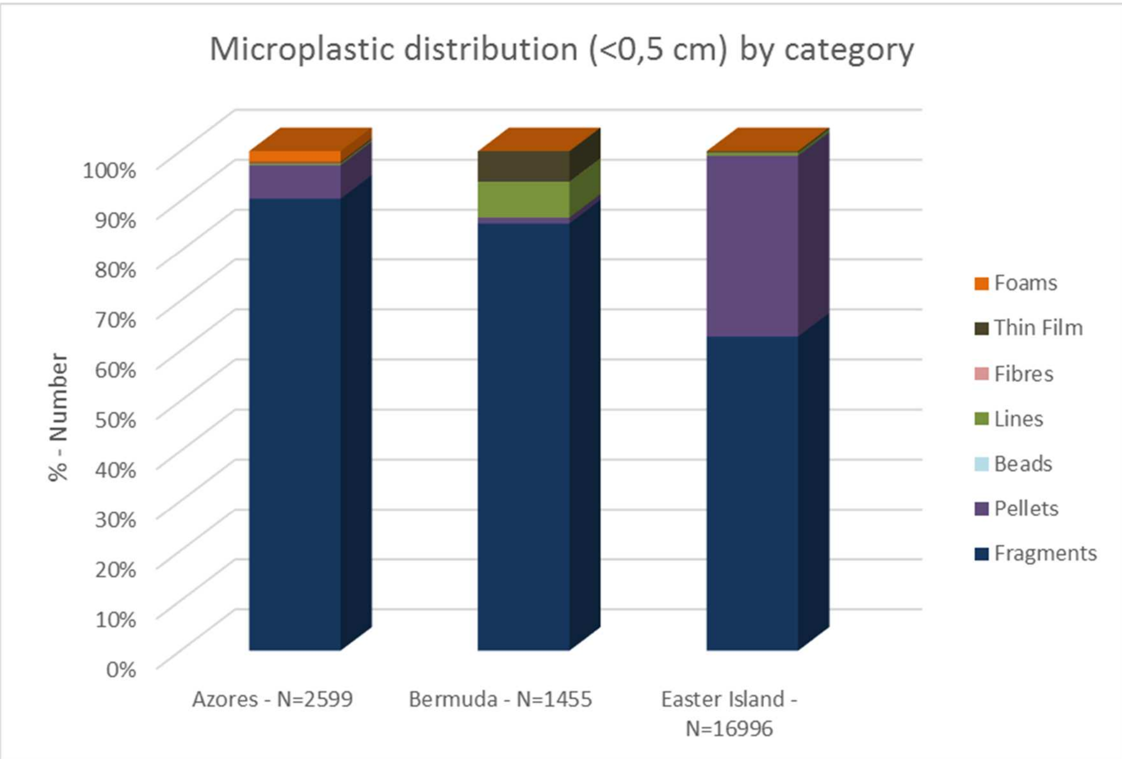


Figure 10 : Microplastics (<0.5cm) distribution according to plastic debris categories.

The microplastic findings were also dominated by hard plastic, which is logical given that the macro plastic findings were also in majority hard plastic (bottle caps, containers, utensils) and the microplastics result from the degradation of the macroplastics. These microplastic findings most likely originate from human activities on the continent. In Bermuda, fishing line ranks second after the hard plastic. A significant part of the debris therefore comes from the sea. In the Azores and on Easter Island however, the next largest category after hard plastic waste is pellets. Pellets are at the origin of all industrial plastic production, they are a primary microplastic as opposed to the microplastic that derives from the breakdown of larger plastic waste. On Easter Island the concentration of plastic pellets is high, making up over 36% of the total. The pellets could be the result of container ships losing their cargo in bad weather; they could also originate from the continent through badly managed production, transformation or storage. Pellets discharged into an uncontrolled environment can easily end up in rivers carried by rain runoff, for example, and then in the seas and oceans.