Marine Debris Tracker Data Analysis

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Introduction

In recent decades there has been a significant increase of scientific interest towards marine pollution, marine debris and its potential consequences on the environment. Marine plastic debris has been acknowledged as one of the most important threats to marine life ever (Derraik, 2002) and the United Nations Environment Program (UNEP) has classified it as one of the most critical issues ever faced by the human race. Marine debris is known to harm a wide variety of species via entanglement and ingestion (Laist, 1987) and to act as a way to help the spread of marine invasive species throughout the oceans (Winston, 1982; Winston et al., 1997; NOAA MDP, 2017). Recent work by Geyer et al. (2017) provides an estimate for the amount of plastic ever produced in approximate 8,300 million tonnes, with at least 6,300 million tonnes of plastic waste as a result of it. Knowing that approximately 80% of plastic debris enters the ocean via land-based sources (Andrady, 2011) there is a high probability for all that waste to end up in the ocean.

Some models suggest the amount of existing accumulated plastic debris in the oceans to be around 150 million tonnes, with a yearly increase of approximately 5 to 12 million tonnes (Jambeck et al., 2015). If the whole society does not take action and this trend continues, it is expected that by 2050 the oceans will contain more plastic, by weight, than fish (Ellen MacArthur Foundation, World Economic Forum, McKinsey & Company, 2016).

The Marine Debris Tracker Initiative was born in 2010 as a result of a partnership between the National Oceanic and Atmospheric Administration (NOAA) Marine Debris Program (MDP) and Georgia, North Carolina and South Carolina universities. The will to use new technologies to add relevant information to the NOAA's MDP led to the development of a mobile application called Marine Debris Tracker (MDT) (SAMDI, 2010). Other than act as a data collector tool, the Marine Debris Tracker application, or "app" as commonly referred, was designed to raise awareness about marine debris and its impacts to marine life.

The app allows users to record observations of marine debris items by offering a simple set of fields that users can fill with the particular information of the observed item, such as the material of the debris item and the quantity of it. Since its first release, the app has been used by individuals and grass-roots organisations alike, becoming a support tool in single and collective clean-up efforts as it has replaced the traditional manual way to record and classify marine debris data.

Data Acquisition

Although the MDT website offers an interactive form[1] to download data for specific periods of time, the dataset being analysed in this report is obtained through a self-made Python script. Due to difficulties found on the website form when querying

[1] View and get data http://www.marinedebris.engr.uga.edu/newmap/

data from relatively long periods of time, and although the data could probably be requested via email to a member of the MDT team, to build a programmatically approach seems a sensible solution that can be used multiple times and be publicly available in Github[2].

MDT allows users to retrieve observations from multiple debris lists (see fig. 1), due to the fact that organisations are able to create their own lists for their particular users. An example of this is the "Volvo Ocean Race" list, where race participants could upload their debris observations while sailing the globe. For this particular study, the fetched dataset belongs to the general list "Marine Debris Items" which is supposed to be the most complete one as it is the default one and the majority of app users use.

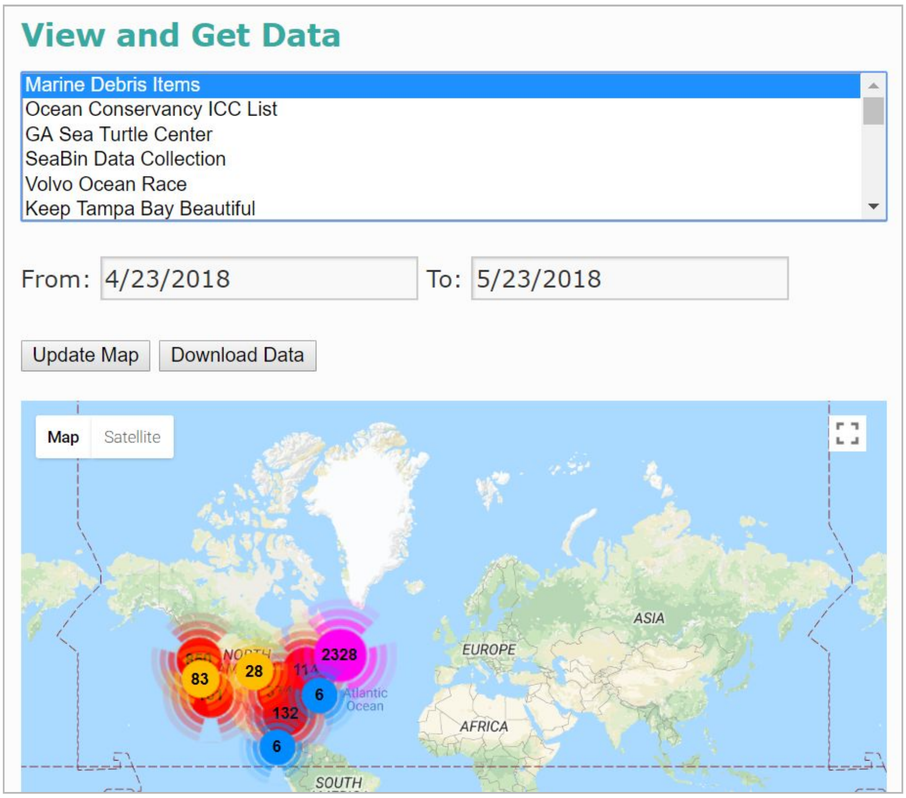

Figure 1. Download form with list and date selectors.

Data Refinement

The fetched dataset contains observations (records) dated between the years 2011 and 2018, which is still incomplete as this study is developed during the months of April and May of 2018.

As the date of each observation is a basic piece of information, each observation without a date is removed from the dataset. For the remaining observations, the date is used to extract the year and the month of each record, as they are the only needed fields for the plots and graphs produced for this analysis.

[2] Github repository https://github.com/jordij/samdi-get

Two new fields are added to each observation; *grade* and *size*. Both are calculated from the field *quantity* as a way to separate *quantity* values in levels, which is needed for plotting and mapping purposes (see table 1).

Quantity	Grade	Size
≥ 1	[1, 5)	0.25
≥ 5	[5, 10)	0.5
≥ 10	[10, 20)	0.75
≥ 20	[20, 30)	1
≥ 30	[30, 40)	2
≥ 40	[40, 50)	3
≥ 50	[50, 100)	5
≥ 100	[100, 1000)	6
≥ 1000	[1000, Infinite)	8

Table 1. New **grade** and **size** columns.

Because the value of the original field *quantity* presents a huge variation range, it varies between 1 and 38,875, it is rather difficult to plot graphs using it as a variable to drive the colour palette. The same principle applies to plotting observations in a map where the shape or the size of the mapped observation depend on the *quantity* value. The new *grade* and *size* fields do help solve this issue.

After these basic refinement steps, the final dataset ends up being composed of 20 columns but not all of them are relevant for this particular analysis. A final composition of the dataset fields is provided (see table 2 and table 3).

Used fields						
longitude	latitude	quantity	description	date	month	year
itemname	grade	size				

Table 2. Used fields (dataset columns).

Unused fields					
listname	timestamp	itemlist_id	location	material_id	radius
item_id	id	iteminstance_description	altitude		

Table 3. Unused fields (dataset columns).

Global Overview

The slightly refined dataset contains a total of 208,071 observations or rows, with a total *quantity* value (the addition of all observations quantity values) of 1,008,166. The first impression is that these numbers are relatively large, and they are going to provide a good baseline of data to perform the analysis. Slicing the observations by year (see table 4) clearly shows that the number of reported observations of marine debris increases year after year.

Year	Observations	Total quantity	Max quantity	Avg quantity per obs.
2011	4,047	226	1,000	5.6
2012	7,038	108,154	38,875	15.4
2013	17,515	138,866	15,496	7.93
2014	11,195	139,126	8,281	12.4
2015	33,466	190,956	13,500	5.71
2016	40,339	165,827	2,464	4.11
2017	65,334	178,418	2,667	2.73
2018	29,137	64,170	2,500	2.2
Total	208,071	1,008,166		4.84

Table 4. Yearly statistical analysis.

Increased quantities are recorded until the year 2015, and they seem to stabilize for the next two years, but if the trend is going to persist for what is left of the current year 2018, a significant increase could be achieved by the end of it. In just the first four months of 2018, from January to April, 64,170 items are reported via 29,137 observations.

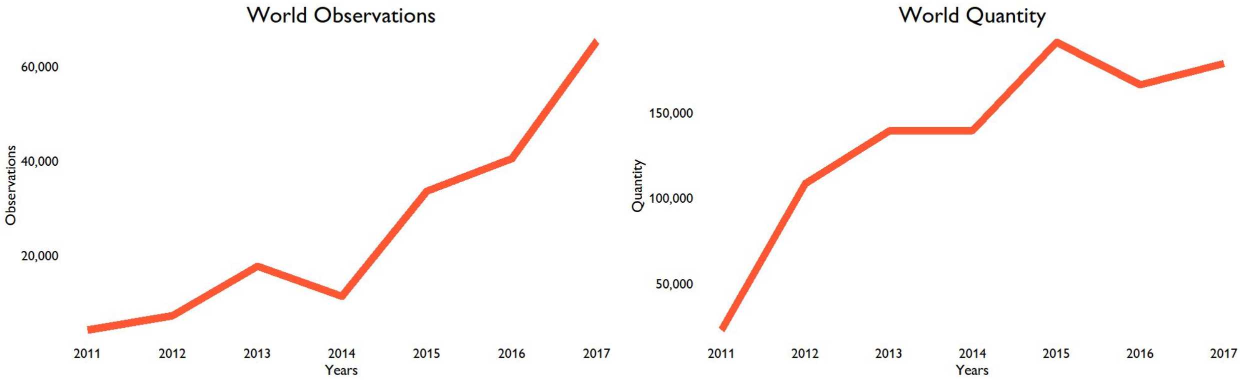

Figure 2. World number of debris observations and quantity per year during 2011-2017.

When plotting these numbers by excluding the partial results of the year 2018 (see fig. 2), the increasing tendency is clearly reflected on both the number of observations and the quantity. It is interesting to see what the tendency is going to be at the end of the year 2018.

But all these numbers do not tell much in terms of origins of the observations and their associated type of debris. Plotting the whole dataset in a world map, with different colors and point sizes depending on the *grade* and *size* of each observation provides a general picture of the submitted observations (see fig. 3).

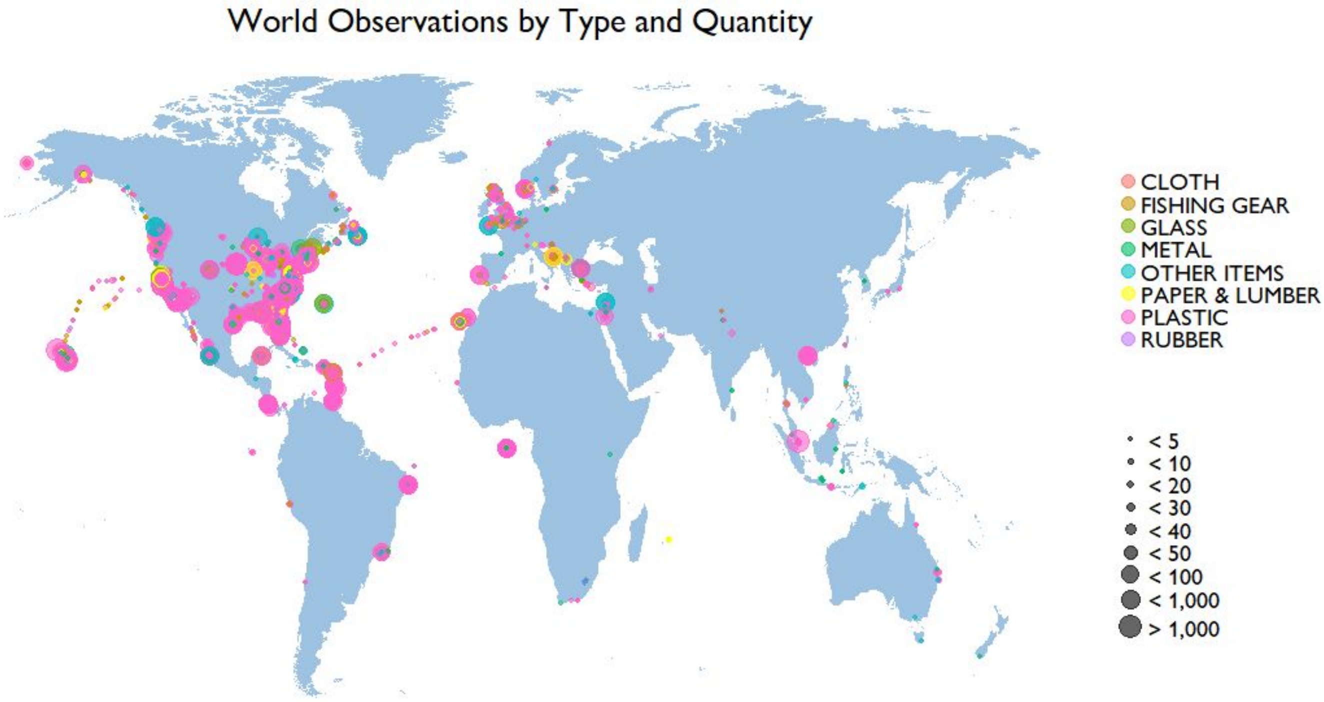

Figure 3. Observations by debris type and quantity around the world.

U.S. Analysis

Despite having observations from all over the world, the majority of them are located in the North America. This is why the rest of this analysis focuses on the United States solely (excluding the states of Hawaii and Alaska). Using a bounding box results in a separation of a U.S. based dataset (see table 5) and reveals a total number of observations of 193,778, approximately 93.13% of the original dataset.

Year	Observations	Total quantity	Max quantity	Avg quantity per obs.
2011	3,985	21,228	785	5.33
2012	6,995	108,020	38,875	15.4
2013	17,196	138,451	15,496	8.05
2014	10,473	135,275	8,281	12.9
2015	29,956	165,321	13,500	5.52

2016	36,621	149,061	2,464	4.07
2017	59,881	168,703	2,667	2.82
2018	28,671	63,208	2,500	2.2
Total	193,778	949,267		4.84

Table 5. United States yearly statistical analysis.

Although the numbers are slightly lower than the ones from the world-wide dataset (see table. 4), the relations between them are very similar.

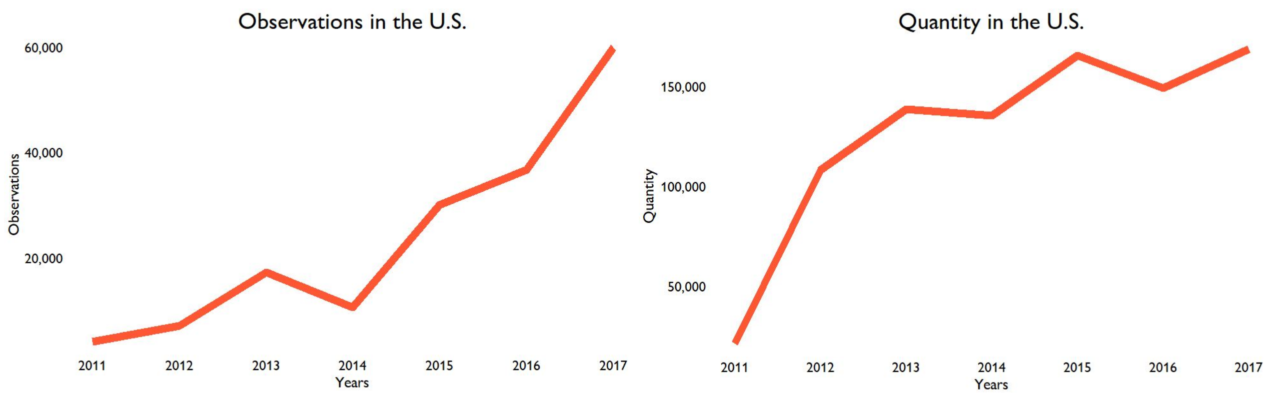

Figure 4. Number of observations and quantity per year in the U.S.

When excluding the data from the current year 2018, the annual plots for the number of observations and associated quantities (see fig. 4) also show almost identical results than those obtained from the whole dataset (see fig. 2). When performing another subset operation to obtain the U.S. observations of the **plastic** type (see fig. 5) the results are again similar. This emphasizes the importance of plastic observations, a similar outcome to the world map (see fig. 3).

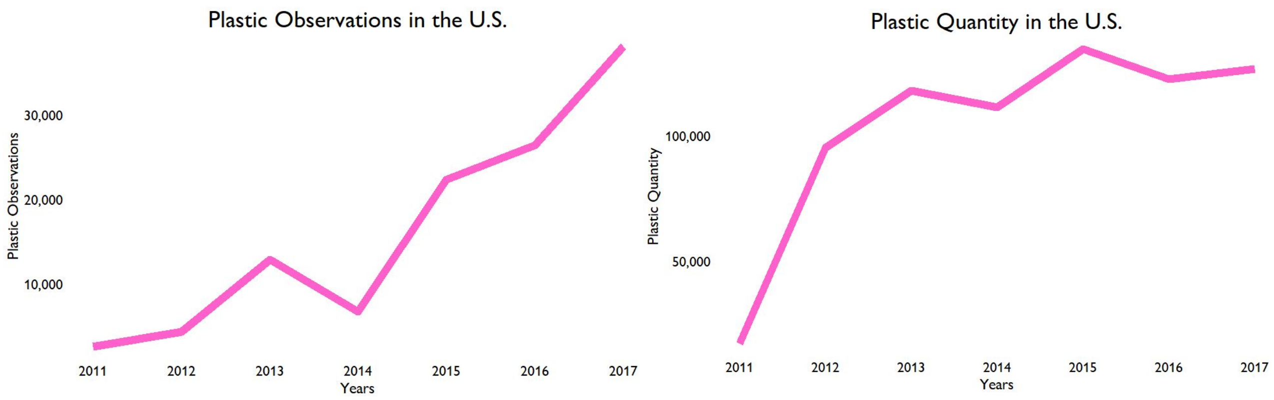

Figure 5. Number of plastic observations and quantity per year in the U.S.

The similarity reflects the influence of the plastic type in the whole U.S. dataset. Sorting the observations by type confirms plastic as the main type of observed debris in the U.S. by far (see fig. 6 and 7), both by number of observations and by quantity.

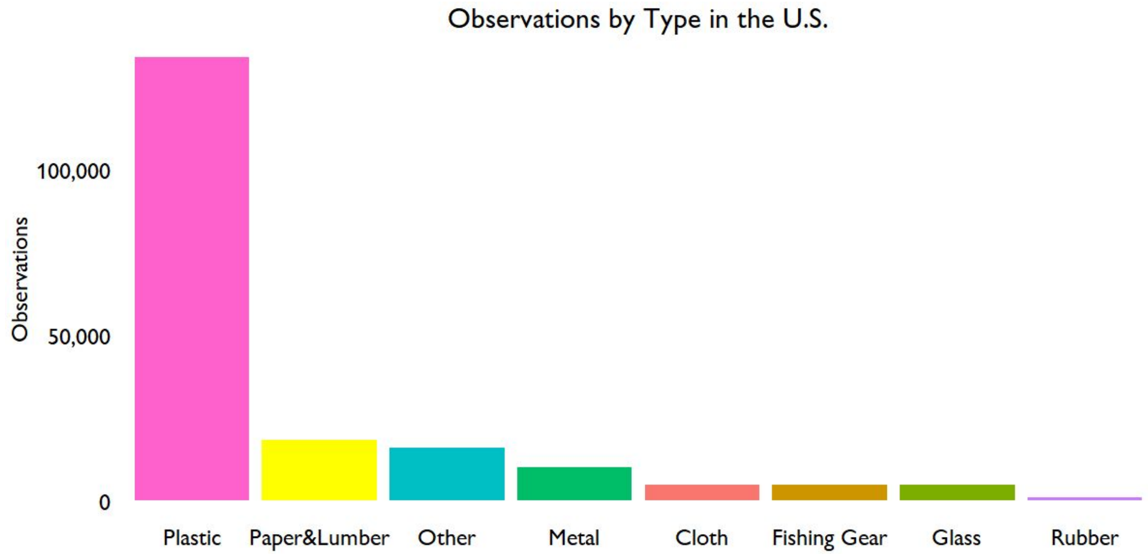

Figure 6. Number of observations by type in the U.S. between 2011 and 2018.

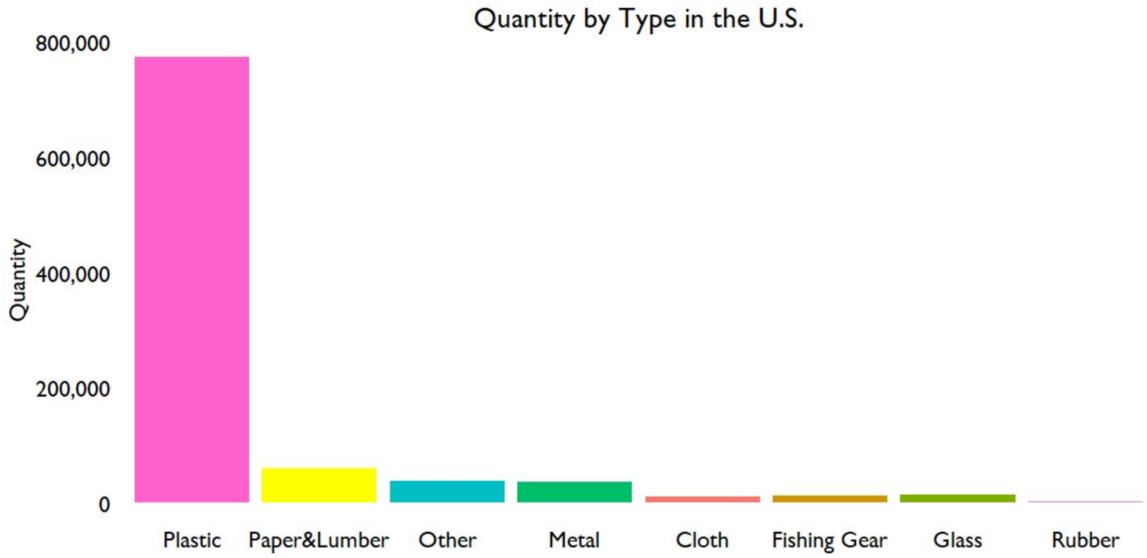

Figure 7. Quantity by type in the U.S. between 2011 and 2018.

Knowing plastic is the main type of debris observed by the app users in the U.S., there is a need to confirm this as a recurring fact and not the result of a "bad" year where users just submitted high quantities of plastic debris.

Plotting the observations by type and in percentages on a yearly basis (see fig. 8) reveals high homogeneity, in terms of proportions, across the years. It does include the year 2018 even though there are only four months of data available.

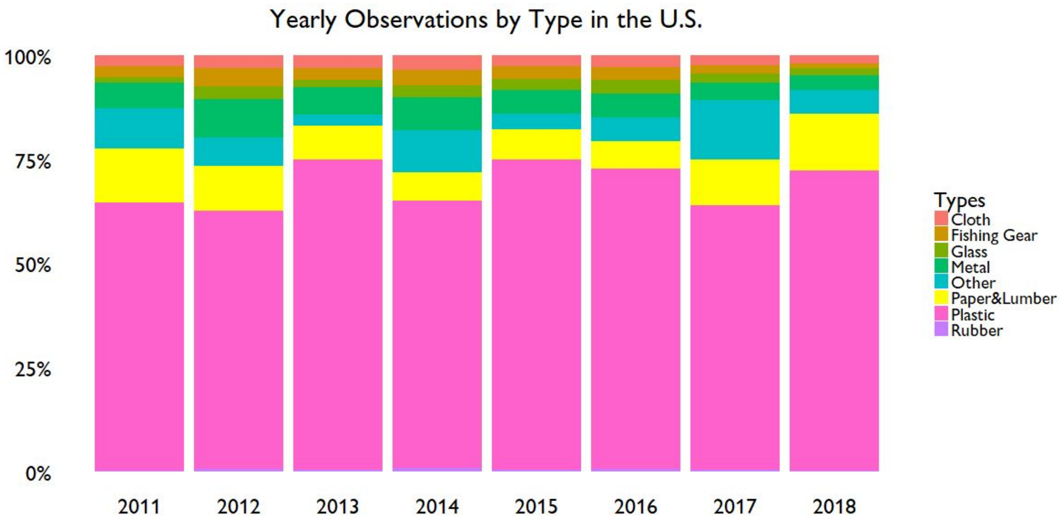

Figure 8. Yearly percentage of observation types in the U.S.

A closer look into Plastic

The plastic debris observations are originally classified by a long list of subtypes and materials. This classification has been simplified (see table 6), resulting in a new classification that groups the different subtypes by similarity and purpose of the debris materials.

Original subtype	**New subtype**
Cigarette lighters/tobacco packaging, Cigarette or tobacco packaging, Cigarettes	**Cigarettes**
Aerosol cans, Aluminum or tin cans	**Cans**
Buoys and floats, Crab/Lobster/Fish trap parts, Fishing nets, Fishing lures and lines, Rope or Net Pieces (non-nylon)	**Fishing gear**
Plastic Bottle, Plastic Bottle or Container Caps, Straws, Plastic Food Wrappers, Foam or Plastic Cups, Plastic Utensils, Six-pack rings	**Food and drink**
Styrofoam packaging, Balloons and/or string, Personal care products, Other Plastic Jugs or Containers, Fireworks, Toys (plastic), Non-food related plastic packaging, Chemicals and chemical containers, Rubber Gloves	**Other**

Table 6. New classification for the plastic debris type.

The distribution of these types of observations shows a majority of them to be “food and drink” related debris items (see fig. 9). Although a distribution based on quantity (see fig. 10) shows cigarette-related items being almost twice as much as all food and drink ones. This is due to the high amounts of collected cigarette butts during big clean-up events in some coastal and inland areas (e.g. Great Lakes), especially during the year 2013 (see fig. 11).

It becomes clear though, that by getting rid of all cigarette-related items plus the food and drink ones it would translate into a very significant reduction in the amount of observed plastic debris.

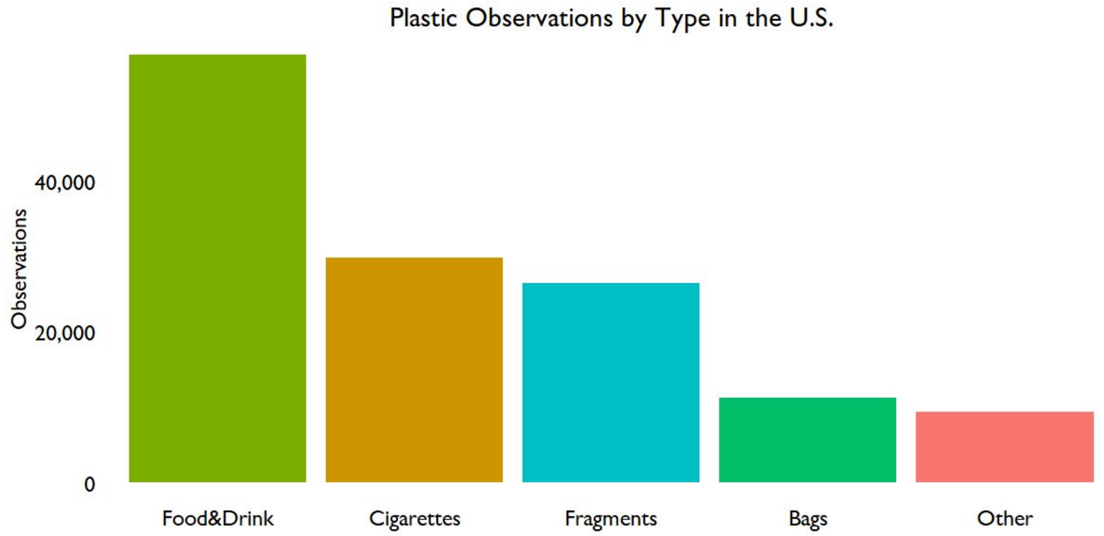

Figure 9. U.S. plastic observations by type between 2011 and 2018.

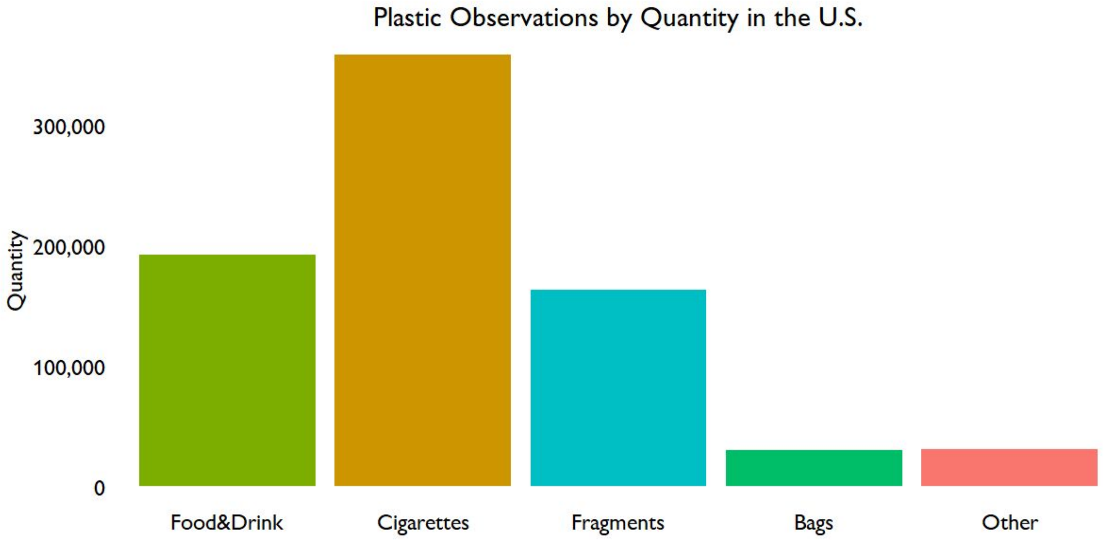

Figure 10. U.S. plastic obs. by quantity and type between 2011 and 2018.

Yearly-based percentages (see fig. 11) show homogenous results, with the subtype "food and drink" being the main one except on the year 2013, for the reasons previously mentioned. It is interesting to see how the tendency stays the same in the year 2018 even though only four months of data are available so far.

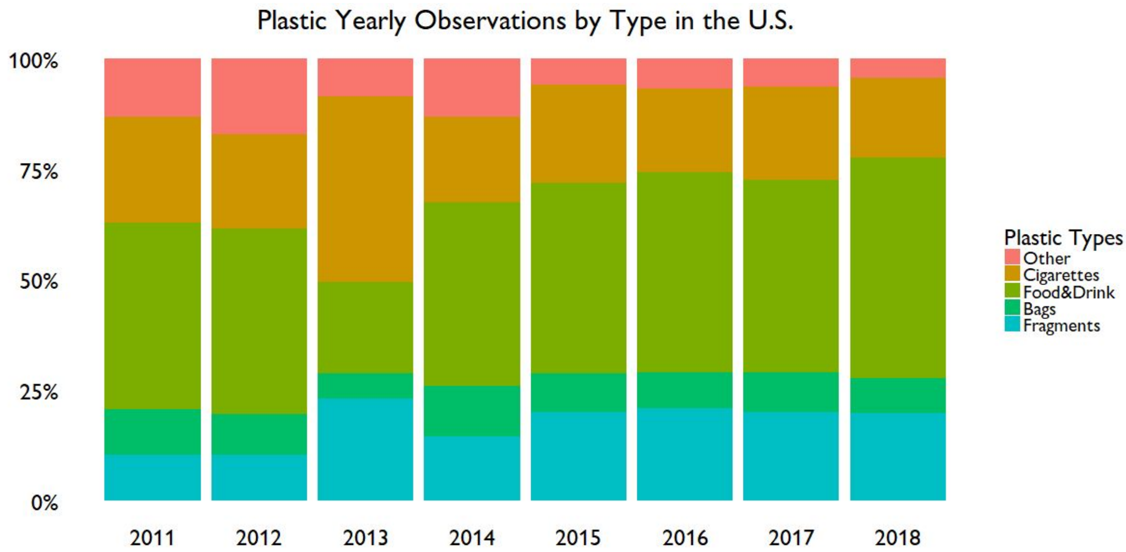

Figure 11. Yearly percentage of plastic observation types in the U.S.

Geographical distribution

Most of the continental U.S. observations being based in coastal areas provided with an opportunity to take a closer look to both the east and the west coast states (see fig. 12). The geographical distribution in the west indicates that most of the observations are located in the state of California, while in the east they are more equally dispersed.

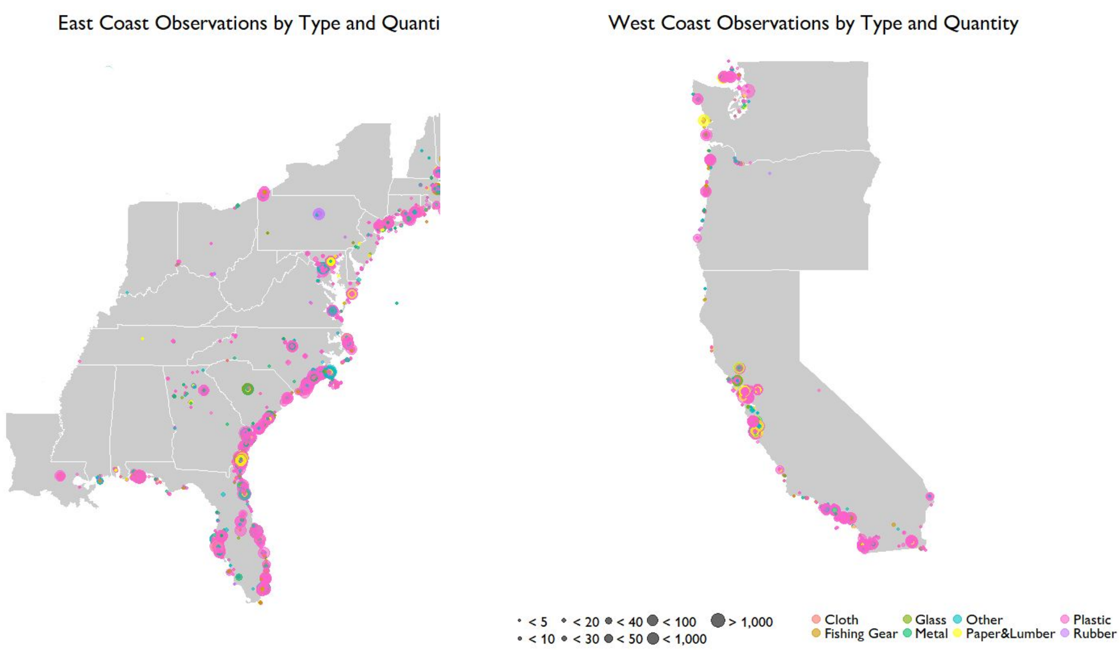

Figure 12. East and West coast observations by type and quantity.

By using the counties boundaries for the states on both coasts allows to map the observations and their associated quantities to visually identify the counties with the most submitted observations and highest quantities (see fig. 13).

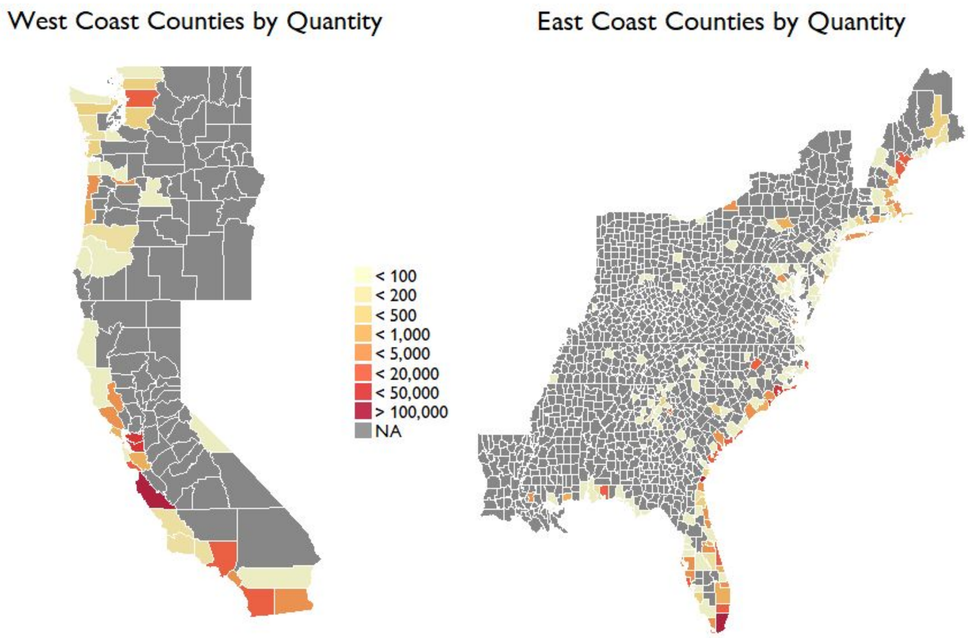

Figure 13. East and West coast counties heatmaps by quantity.

California counties are, as suspected, the ones with more quantity of debris observed (see table 7) along the west coast, with five counties in the top six. On the east coast the highest quantity, by far, is located in the county of Glynn, in Georgia.

West Coast		**East Coast**	
County	Quantity	County	Quantity
Monterey	89,220	Glynn	257,853
Alameda	38,008	Miami-Dade	65,812
Contra Costa	32,940	New Hanover	46,456
Los Angeles	15,111	Onslow	30,607
Snohomish	13,526	Santa Rosa	16,945
San Diego	10,627	Carteret	16,649
Santa Cruz	10,157	Beaufort	12,192
Orange	4,135	York	10,456
Imperial	2,957	Chatham	10,343
Multnomah	2,802	Cumberland	8,251

Table 7. West and East top ten coast counties with highest quantity of observed debris.

It is important to acknowledge that these group of counties can not be denominated as the most polluted ones but are the ones where people using the app submitted the highest quantities of debris.

California, a case study

In 2016 the people of the State of California voted in favor of proposition 67, a ban on single-use plastics proposed by the state's lawmakers back in 2014. After this ban some organisations (CAW, 2017) detected a significant decrease on plastic debris in coastal areas, especially on the annually-held Coastal Clean-Up Day[3].

Year	Observations	Total quantity	Max quantity	Avg quantity per obs.
2012	1,047	4,528	216	4.32
2013	1,562	45,362	3,092	29
2014	1,258	53,689	8,281	42.7
2015	1,338	5,444	214	4.07
2016	6,062	25,054	872	4.13
2017	23,055	41,895	120	1.82
2018	17,993	32,946	691	1.83
Total	52,315	949,267		12.55

Table 8. California yearly statistical analysis.

However, there is no sign of any positive effect within the MDT observations located in such state (see fig. 14) as plastic observations lead the yearly distribution by type before and after 2016. The most significant fact is that despite the relatively low number of observations during the years 2013 and 2014 (see table 8), these very same years recorded observations with the highest quantities. While a substantial increase on submitted observations in the last two years is probably going to lead to the highest number of observations in the year 2018.

Yearly-based percentages (see fig. 15) show very similar results to the ones obtained at a country scale (see fig. 8) with the highest percentages consistently being related to plastic debris year after year.

[3] Coastal Clean-up Day https://www.coastal.ca.gov/publiced/ccd/ccd.html

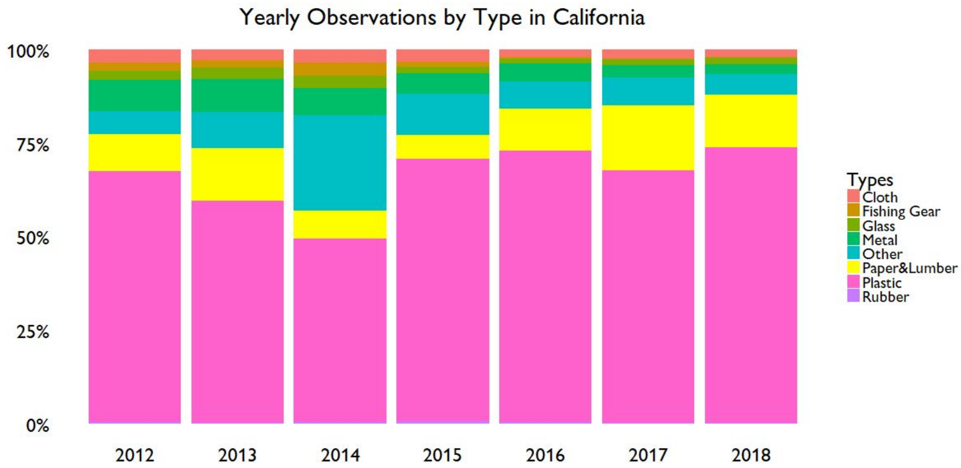

Figure 14. Yearly observations by type in California.

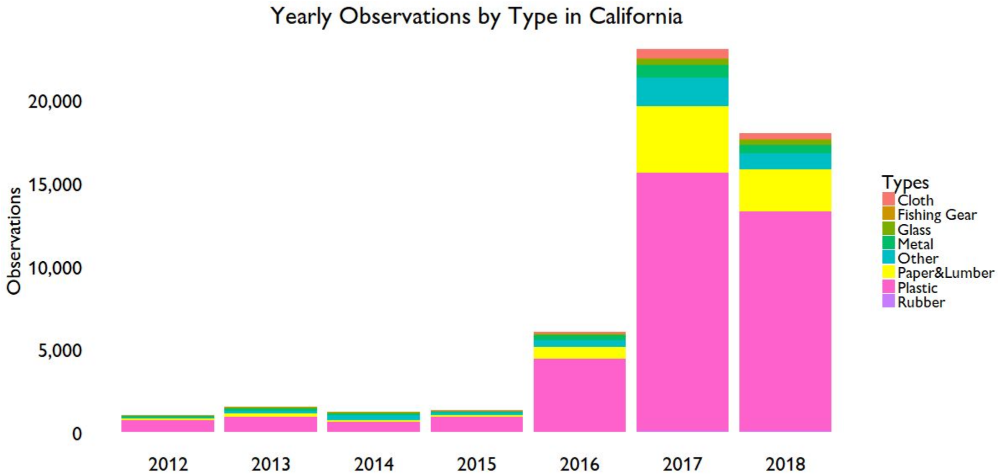

Fig 15. Yearly percentage of observation types in California.

The hypothesis of a reduction in observed plastic debris after the ban does not seem to hold against these results. Plotting the plastic debris observations subtypes (see fig. 16) delivers once again a very similar picture to the one obtained at a country level and shows very similar percentages of plastic bags, one of the items affected by the ban put in place.

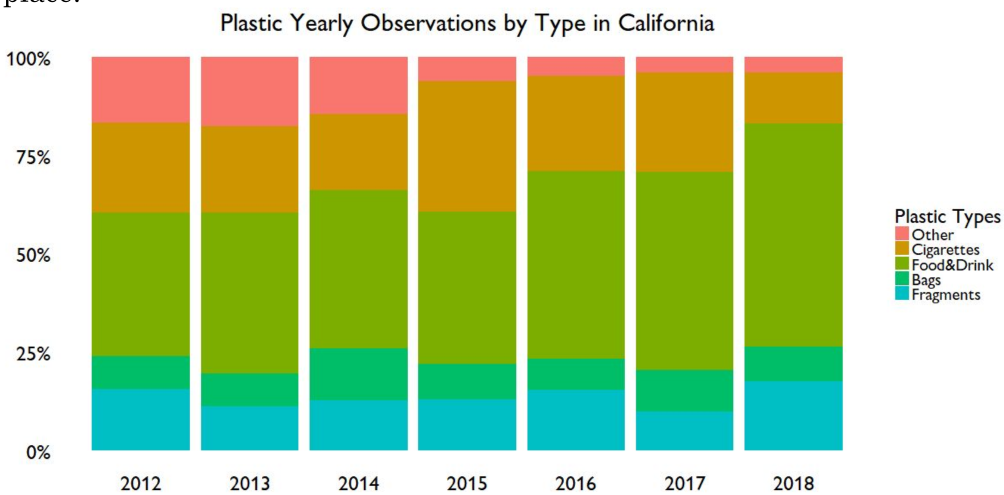

Figure 16. Yearly percentage of plastic observation types in California.

It is safe to admit that, unfortunately, and within the data from this particular dataset, single-use plastics quantities among submitted observations have not been affected by the California ban.

Conclusions

The results provided by this analysis do not aim to identify the most polluted areas in terms of marine debris. This is not feasible because the Marine Debris Tracker submissions do not happen everywhere and in the same frequency. It can rather be regarded as a behavioral study as it shows the areas where the app is most used (highest number of observations) or where largest clean-up operations have happened (observations with highest quantity).

It is clear that the country with most observations is the United States and that is completely logical as the Marine Debris Tracker was born out of a North American partnership within North American institutions. The number of observations at a country level has been steadily increasing which is good news as it will help expand the current dataset and hopefully provide observations from areas that currently do not have any. Although the app usage analytics are not available for this study, it seems plausible to assume that the increasing number of observations is due to an increase of app users. As one of the specific motivations of the MDT programme is to raise awareness among the public, this increase in usage implies more education and awareness, which is great.

Recreational areas (e.g. California, Miami) show the highest activity, likely due to the fact that large clean-up events, such as the annual Coastal Clean-up Day, happen in those areas. It is good to see the app being used by the organisations driving these events as they provide high amounts of valuable data for the locations they operate in, which can definitely help more locally-based studies such as the one performed by Rosevelt et al., (2013) in the bay of Monterey, California.

In terms of debris type, it has become rather clear that plastic is the main culprit. If we as a society, are able to get rid of single-use plastic items (bags, cups, takeaways boxes etc.) and cigarettes paraphernalia, half of the problem would be solved. Bans like the one in the state of California must lead the way and hopefully have a positive impact in the near future. Although with this specific dataset this impact has not been demonstrated, it is expected that given more time, and probably more data, it will.

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