What's that Floating in my Soup?
Characterisation of Floating Debris in the Great Pacific Garbage Patch

Fatimah Sulu-Gambari, Matthias Egger, Laurent Lebreton

The Ocean Cleanup Foundation, Rotterdam, The Netherlands

Background

Large debris in ocean garbage patches contribute significantly to marine plastic pollution and are not well characterised. Buoyant plastics accumulate offshore in the five ocean subtropical gyres; the largest is the Great Pacific Garbage Patch (GPGP) in the North Pacific Ocean.

There, plastics float in a loosely concentrated 'soup', degrading over time in the saltwater, under UV radiation, with the help of wind and wave action. They serve as substrates for trace metal and organic pollutant adsorption, and the growth of microbes and larger potentially-invasive organisms.

Objective

There is currently limited data on large floating plastics in ocean gyres. Majority of data collected on plastics in the garbage patches is based on trawled sampling techniques that exclude objects larger than 0.5m.

In this study, we establish a protocol for the handling and logging of large floating plastic debris accumulated in subtropical gyres. This protocol will help discern the nature and duration of the journey of plastic debris from sources, whether land- or sea-based, to the gyre.

Significance

It is important to understand what types of debris accumulate in the garbage patches, their land- or marine-based origins and the point sources from which they enter the ocean. Where the objects were once produced, what practices (commercial or industrial), market sectors and even types of socio-cultural or -economic behaviour contribute to their accumulation, and how far they have travelled, is also pivotal insight into why and how they end up in the patches.

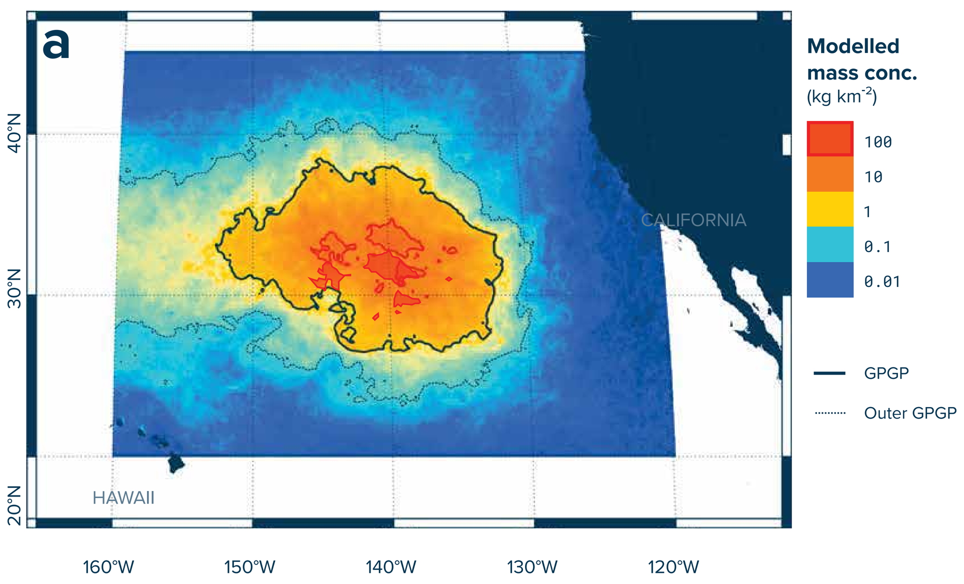
This information, coupled to data on the persistence and perseverance of plastics in the marine environment, is necessary for creating effective and efficient mitigation strategies.

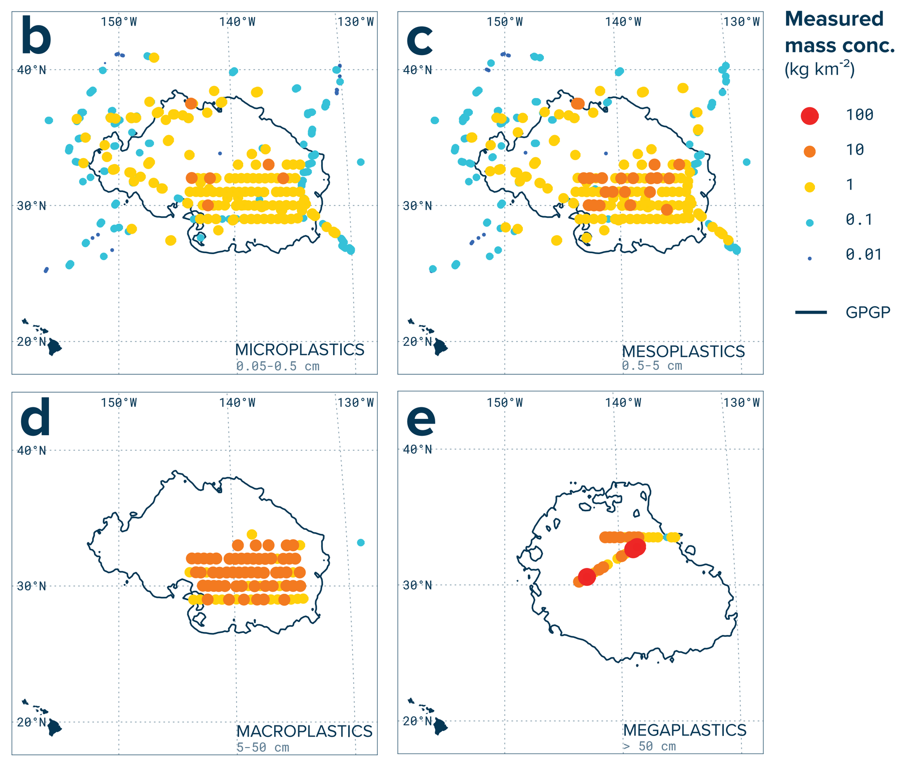
Approach

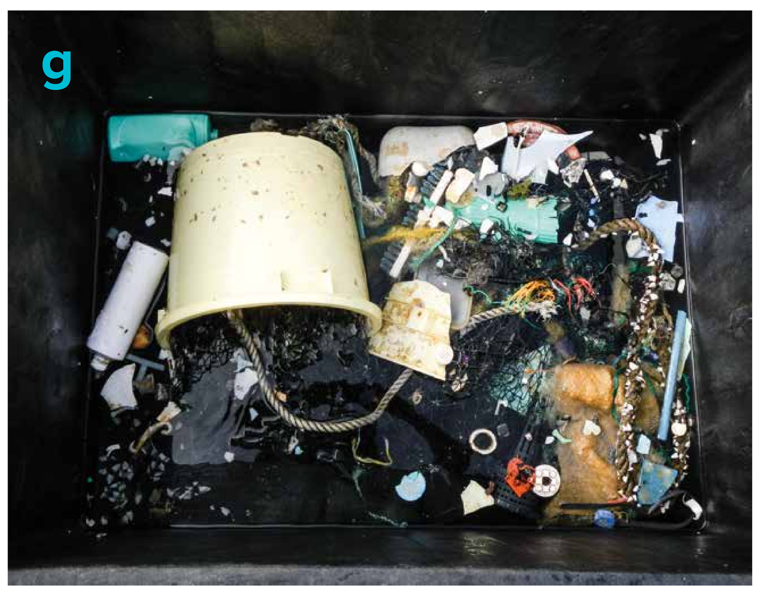
Identifying large debris accumulating in oceanic subtropical gyres is important for characterisation of floating plastic pollution. This is because the identification of visual clues on buoyant plastics can tell us about the origin and age of the debris, and in turn, the origin and duration of the pollution problem.

We know that 8% of the GPGP is comprised of microplastics and thus larger objects constitute the greater fraction of the total plastic mass, which we know little about (figure 1). Therefore by identifying the origin and ages of these larger objects, we gain a broader understanding of the formation of garbage patches, with which we can shape mitigation strategies.

In 2018, plastic was concentrated in and around our System 001, which was deployed in the North Pacific gyre (figure 1a) over a four-month period. System 001 aka 'Wilson', is a passive aggregation device for floating debris (figure 2a, b). The aggregated plastics (~ 100kg) were transported by sea freight to Europe for sorting, logging and eventual recycling (figure 2c).







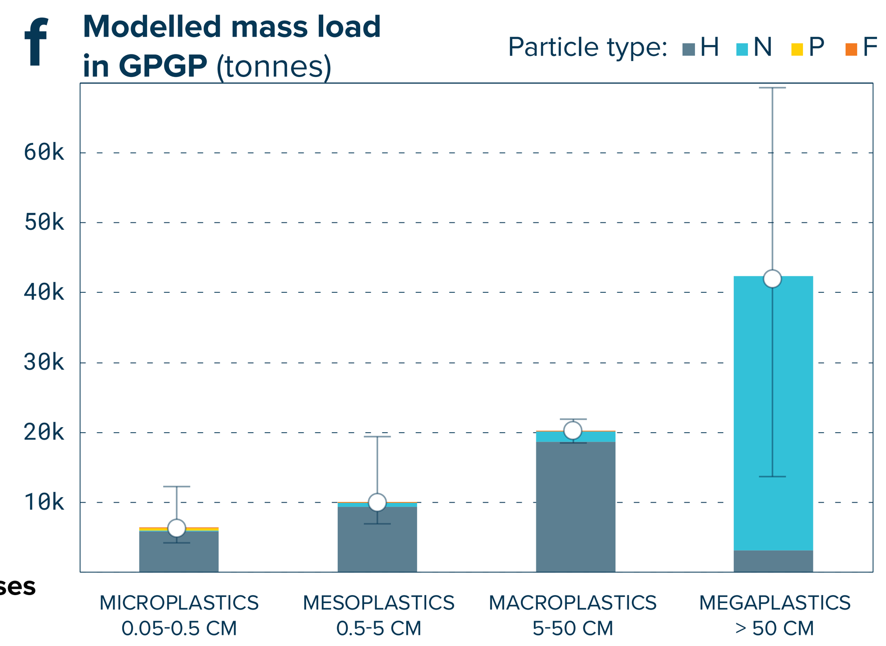


Figure 1: Adapted from Lebreton, et al. 2018
a-e. Modelled and measured mass concentration in GPGP in 2015
f. Plastic mass distribution in GPGP in 2015, between size (bar) and type (colour) classes
g. Trawled debris in 2015 mega expedition

Plastics were pre-sorted into categories comprising hard plastics, nets and ropes, pellets and foam (H, P, N, F) and into size classes, following the classification system introduced in Lebreton, et al. 2018.

Figure 2: a. System 001 in the North Pacific gyre
b. Plastic collecting in 'Wilson'
c. Debris from the patch at the harbour of Rotterdam

Table 1: Main characteristics of interest for large floating debris

Object			State		Colour	Biofouling				Plas c		Origin (Produc on)								Inside GPGP	Size class (cm)
Recognisable	Debris type	Source object	Condi on	Form		Fouling organisms	Type (General)	Degree coverage (0-360)	Photo organism(s)	Type	Polymer ID	Place	Language	Produc on year	Produc on month	Photo code insert/ cipher wheel	Brand (if applicable)	Logo	Photo of logo		
Yes	Plas c (rigid)	Jerry can	Intact	Original	Blue	Yes	Bivalves (Mussels)	> 270	Figure 3a	Hard plas c	HDPE	NA	NA	NA	NA			No	NA	Yes	> 15
Yes	Plas c (rigid)	Basket	Intact	Original	Yellow	Yes	Bivalves (Mussels)	> 270	Figure 3c	Hard plas c	HDPE	NA	Japanese	NA	NA	Figure 3c		Yes	Figure 3d	Yes	> 50

Parameters of interest (table 1 column headings) were collected for 448 items and logged. A couple of populated rows are shown here.

Recognisable plastics were separated from those that were unrecognisable and then further sorted into whole, partly-intact and fragmented objects.

Partly-intact objects and fragments larger than 10cm at their widest dimension were then included, along with whole objects, in the characterisation step (table 1).

Figure 3: Objects characterised in Table 1
a. Blue fouled jerry can
b-d. Yellow fouled basket with production tags and (Japanese language) branding

Figure 4: Macro- and megaplastics collected by 'Wilson' in GPGP
a. Largest object of the analysed items, a barrel (> 50cm)
b. Plastic resin identification code on an object
c. Crate with commercial logo from a Japanese-owned brand
d. Fouling by hydroids on barrel in a.
e. Dessicated crab exoskeleton in netting
f. Fouling by mussels on the same barrel

Findings

The debris collected in 2018 comprised 98% hard plastics, 60% of which were identifiable macroplastics; we can compare this to 99% recognisable hard macro- and megaplastics caught in the expedition in 2015, 12% of which were identifiable.

The polymer composition, deduced from visual observation of markings and tags, identified as polyethylene (PE, 26%, figure 4b) > polypropylene (PP, 2%) > polyethylene terephthalate (PET, 1%; drink bottles). The polymer composition of most objects (70%), could not be identified solely using visual cues*.

The largest size fraction was 5-50 cm (39%; figure 4a) and most plastics (90%) were found in their original form (i.e. not melted, nor modifed), but a greater proportion of fragmented (57%), than intact debris (26%) identified, may support the idea that objects have either persisted in the gyre long enough to fragment and/or have been transported there from faraway sources, possibly with intermittent beaching events, giving them time to wear.

Evidence of persistence is also provided by the presence of fouling, where 64% of objects served as substrates (figure 4d-f). Some objects could also be characterised by production dates, the oldest of which was 1994 (an even older object, a crate produced in 1977, was logged in 2015). The most reccurent language on objects with identifiable branding (6%) was Japanese (4%; e.g. figure 3d), which may provide insight into production origins. The prevalence of buoyant objects of Japanese production origin in the gyre could be also attributed to transportation during extreme events, including the 2011 tsunami, where tens of thousands of tonnes of potentially-buoyant debris were released into the ocean.

*Polymer types can subsequently be identified with additional spectroscopic analysis techniques.

2015

- Pieces of analysed debris: > 160,000
- Most prevalent objects: Oyster spacers
- Most represented colour: White
- Largest size range: > 50cm
- Most prevalent polymer type: PE
- Most recurring language: Japanese
- Earliest production date: 1977
- Largest object: Crate (> 50cm)

2018

- Pieces of analysed debris: 448
- Most prevalent objects: Eel traps, bottle caps
- Most represented colour: Black
- Largest size range: 15-50cm
- Most prevalent polymer type: PE
- Most recurring language: Japanese
- Earliest production date: 1994
- Largest object: Barrel (> 50cm)

References

[1] Jambeck, J. R. & Johnsen, K. Citizen-Based Litter and Marine Debris Data Collection and Mapping. *Computing in Science & Engineering*, **17**, 20-26 (2015)
[2] Lebreton, L. et al. Evidence that the Great Pacific Garbage Patch is rapidly accumulating plastic. *Scientific Reports*, **8**, 4666 (2018)
[3] Lebreton, L. et al. A Global Mass Budget for Positively Buoyant Macroplastic Debris in the Ocean. *Scientific Reports* **9**, 12922 (2019)

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fatimah.sulugambari@theoceancleanup.com