Plastic waste input from Guadalquivir River to the ocean

R. Quintana, D. González, A. Cózar, C. Vilas, E. González, F. Baldó and C. Morales

rocio.quintanasepulveda@alum.uca.es

UCA Universidad de Cádiz

EGU General Assembly 2020

IFAPA Instituto de Investigación y Formación Agraria y Pesquera

Aims of this study

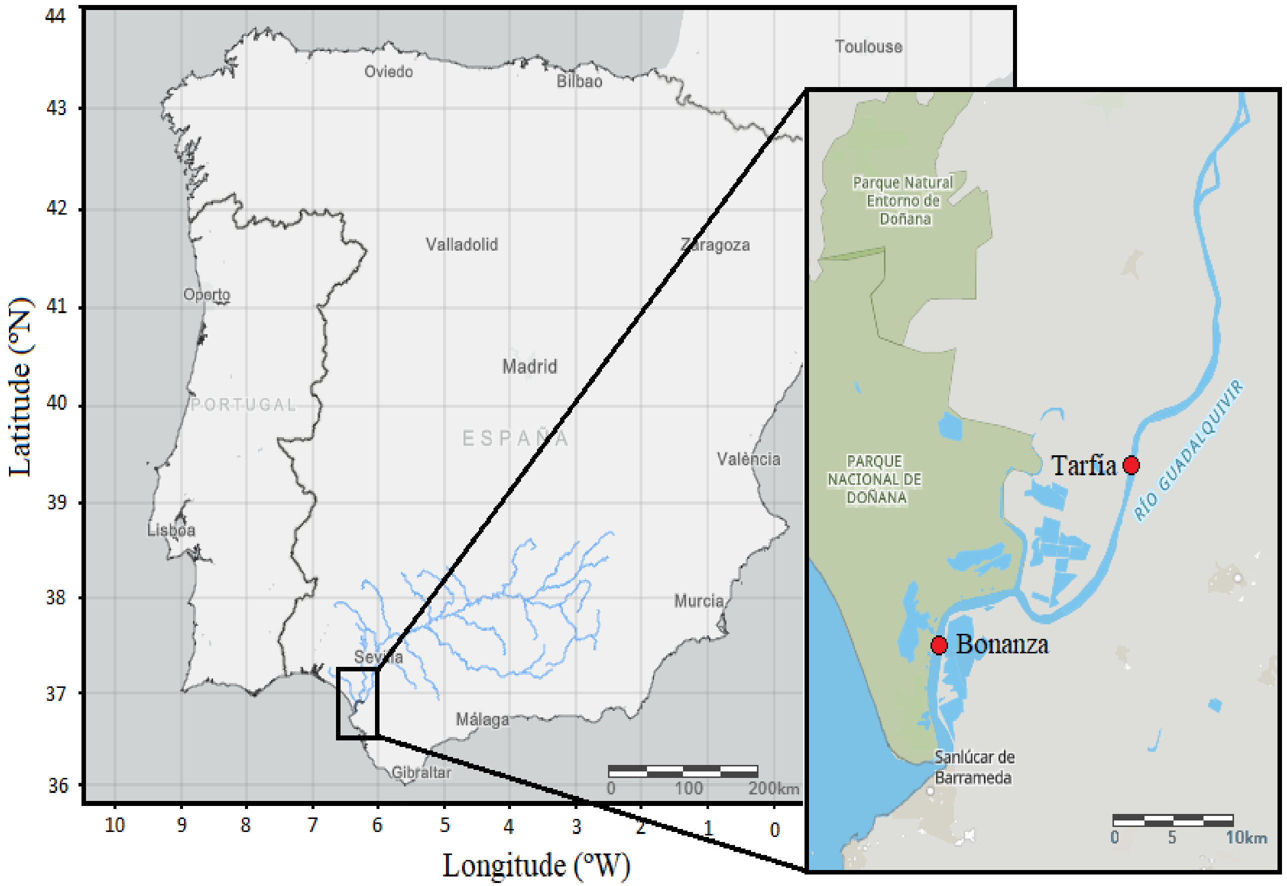
1. Establish the **monthly variation** of **plastic transport** in the Guadalquivir river during a two-year period.

2. Provide a **first estimate** of **plastic waste** flowing from the Guadalquivir river into the ocean.

3. **Categorization and description** of the **plastic waste abundance**, ranging from microplastics of just 1mm to larger macroplastic particles and objects.

4. Compare **size and weight distribution** of plastic in the Guadalquivir river with those already described in coastal waters of the Mediterranean Sea and in open waters. Aiming at improving our understanding of the fragmentation dynamics and transport pathways from land to sea.

Study Site: Guadalquivir River



Study Period

January 1st 2014 - December 18th 2015

Sampling was carried out every month during the new moon, constituting a total of 25 consecutive samplings.

Sampling Points

Bonanza - 8km from the river mouth

Tarfía - 32km from the river mouth

Sampling

Samples were taken from a boat anchored on the eastern bank of the Guadalquivir estuary and equipped with three nets with an opening of 2.5 (width) × 3 (depth) meters.

Duration

Every 6 hours during a full day, aiming to cover the entire tidal cycle. A total of 4 samples for each sampling point.

Between 1.00 to 1.30 hours

Filtered Volume

60,000 m^3

Methodology

Plastic items were weighted, counted and measured (area) by imaging analysis using the **ImageJ Fiji®** system.

TOTAL
200 samples
19,371 items

MICROPLASTIC	**MESOPLASTIC**	**MACROPLASTIC**
200 samples	147 samples	79 samples
11,774 items	5,995 items	1,602 items

Each item was classified into **5 categories**:
Film, Fragment, Fishing line, Foam and Pellet

Concentration ($g \cdot m^3$) and **plastic transport** ($kg \cdot day^{-1}$) were obtained using the following expressions:

- $$\text{Concentration} = \frac{\text{Weight (g)} * \text{Dilution Factor}}{\text{Filtered Volume(} m^3\text{)}}$$
- $$\text{Plastic Transport} = C_W \left(\frac{g}{m^3}\right) * \frac{1\ Kg}{1000\ g} * Q \left(\frac{m^3}{s}\right) * \frac{3600\ s}{1\ h} * \frac{24\ h}{1\ day}$$

River flow data (Q) from SWAT model provided by Gomiz-Pascual et al., 2016.

To obtain a **monthly value**, the data of the eight samples corresponding to each monthly sampling are averaged.

For the **annual load**, the expression used:

- $$\text{Annual Load} \left(\frac{kg}{year}\right) = \frac{\sum \text{Plastic transport}}{\text{Number of samplings}} * 365 \text{ days}$$

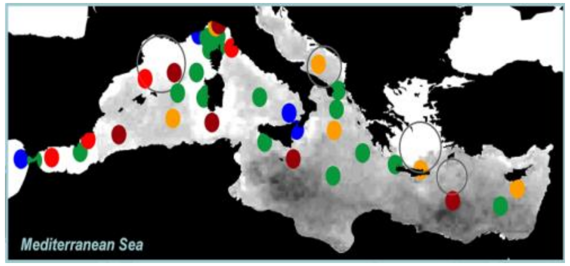
The annual load is carried out in weight ($kg \cdot year^{-1}$) and in number of items ($\# \cdot year^{-1}$).

Methodology

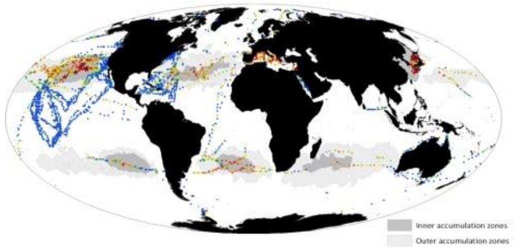
Size-distribution analysis

- A total of **19,371 plastic particles** were classified into **27 size-classes**, where the limits of each size class were established following a series of 0.1 logarithm of linear length.

- Two databases have been used in order to **compare** the **size distribution** of the Guadalquivir river with other marine systems:



Mediterranean Sea
(Cózar et al., 2015)



Open Ocean
(Cózar et al., 2014)

Weight-distribution analysis

- To obtain the weight distribution, it is necessary to obtain the **individual weights** of each particle. In order to achieve this, **equations** adapted to the **category** of each item have been used, relating the weight according the area.

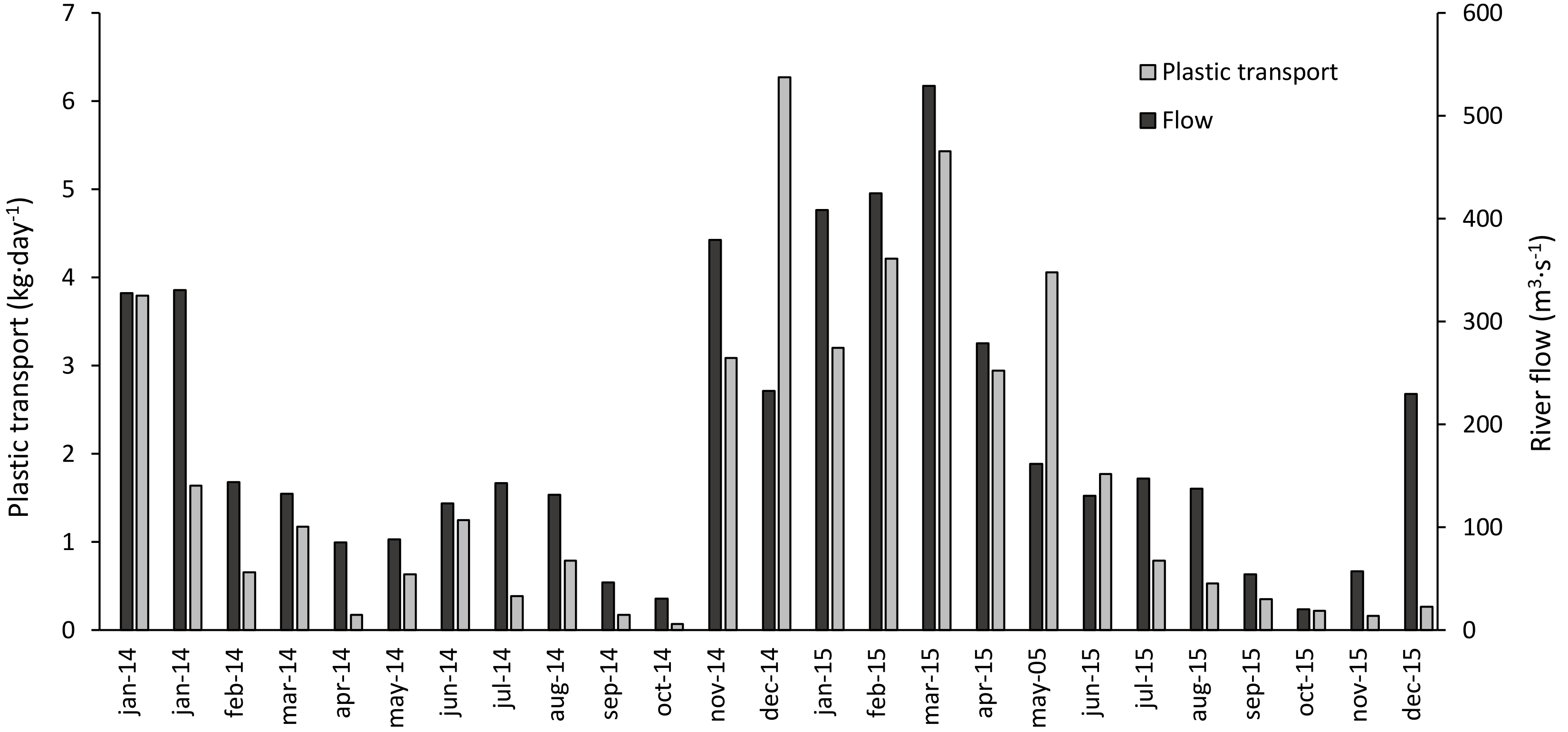
- Once the weights were obtained, 27 size-classes (i) have been used with increasing widths according to a logarithmic increase:

$$\text{Normalized Weight Concentration}\left(\frac{\frac{\text{g}}{\text{m}^3}}{\text{cm}}\right) = \frac{\text{Concentration}\left(\frac{\text{g}}{\text{m}^3}\right)}{\text{w}_\text{i}\ (\text{cm})}$$

- Where w_i is the width of each size class.

- In this case, the weight distribution has been **compared** with data obtained in the **Mediterranean Sea** (Cózar et al., 2015).

Results: Temporal Variation and Annual Load

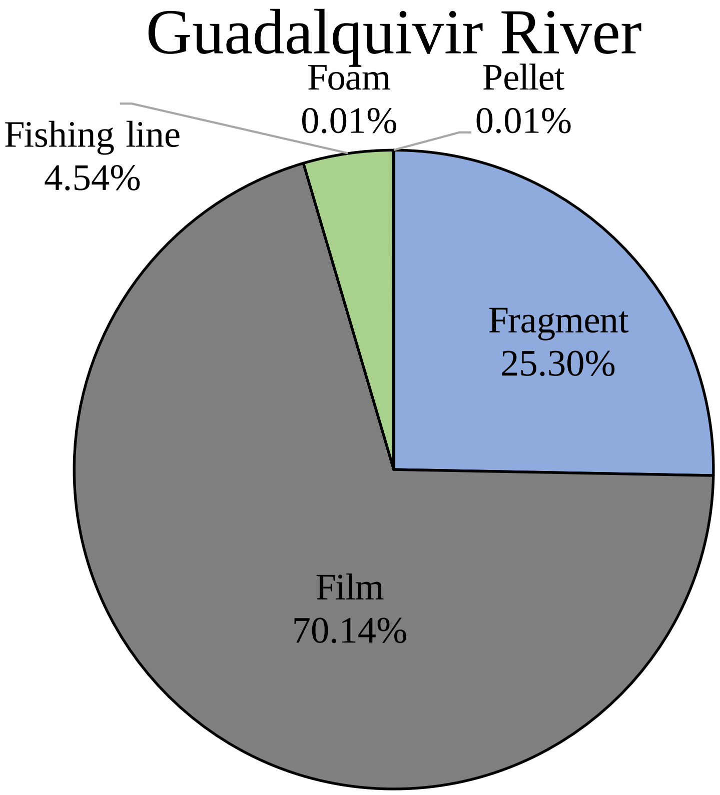


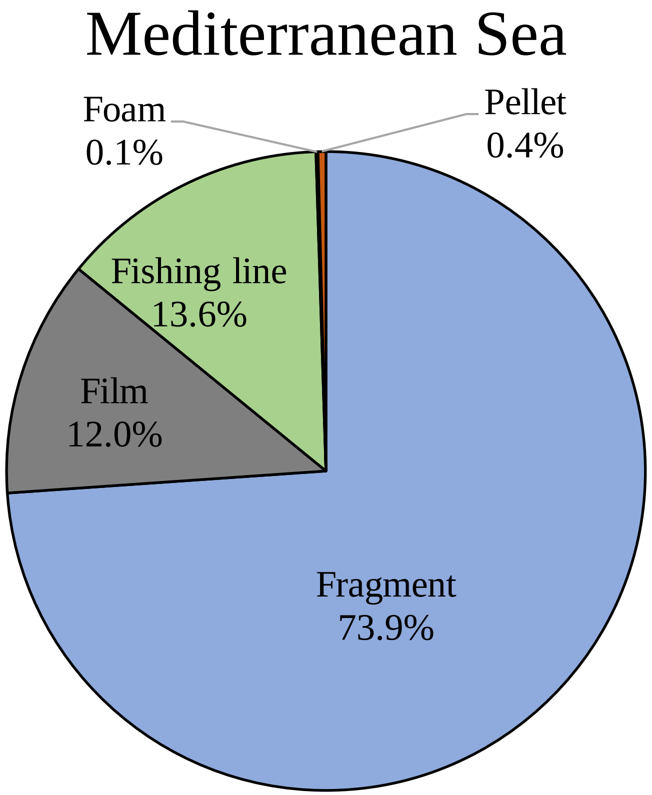
- $\mathbf{R^2 = 0.6852}$ p-value = 0.0001
- **Higher plastic transport** can be observed in winter, reaching maximum values during the months of **January** and **February.**
- **Lower plastic transport** occur in summer-autumn, with minimum values during the months of **August**, **September** and **October**.

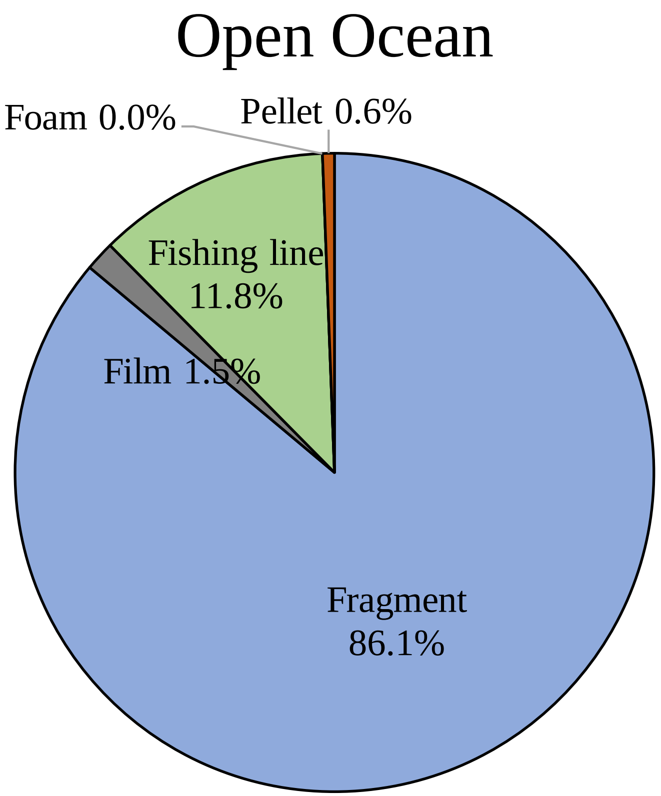
Plastic Transport	Mass (kg·year^{-1})	Items (#·year^{-1})
2014	565	312,597,379
2015	725	381,604,054
Total	**645**	**347,100,717**

- The difference in plastic transport can be explained by the **high variability** of the **river flow** during our study period, ranging from **168.98 m^3·s^{-1}** in **2014** to **215.18 m^3·s^{-1}** in **2015**.

Plastic Composition

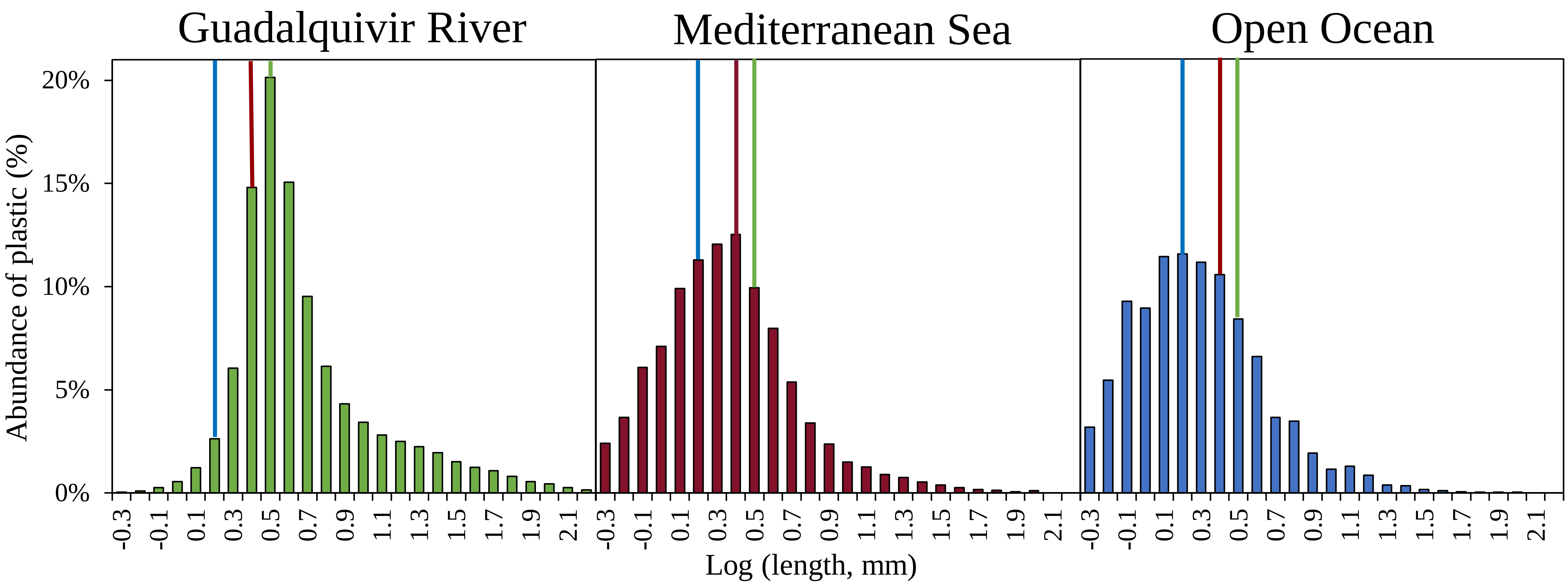






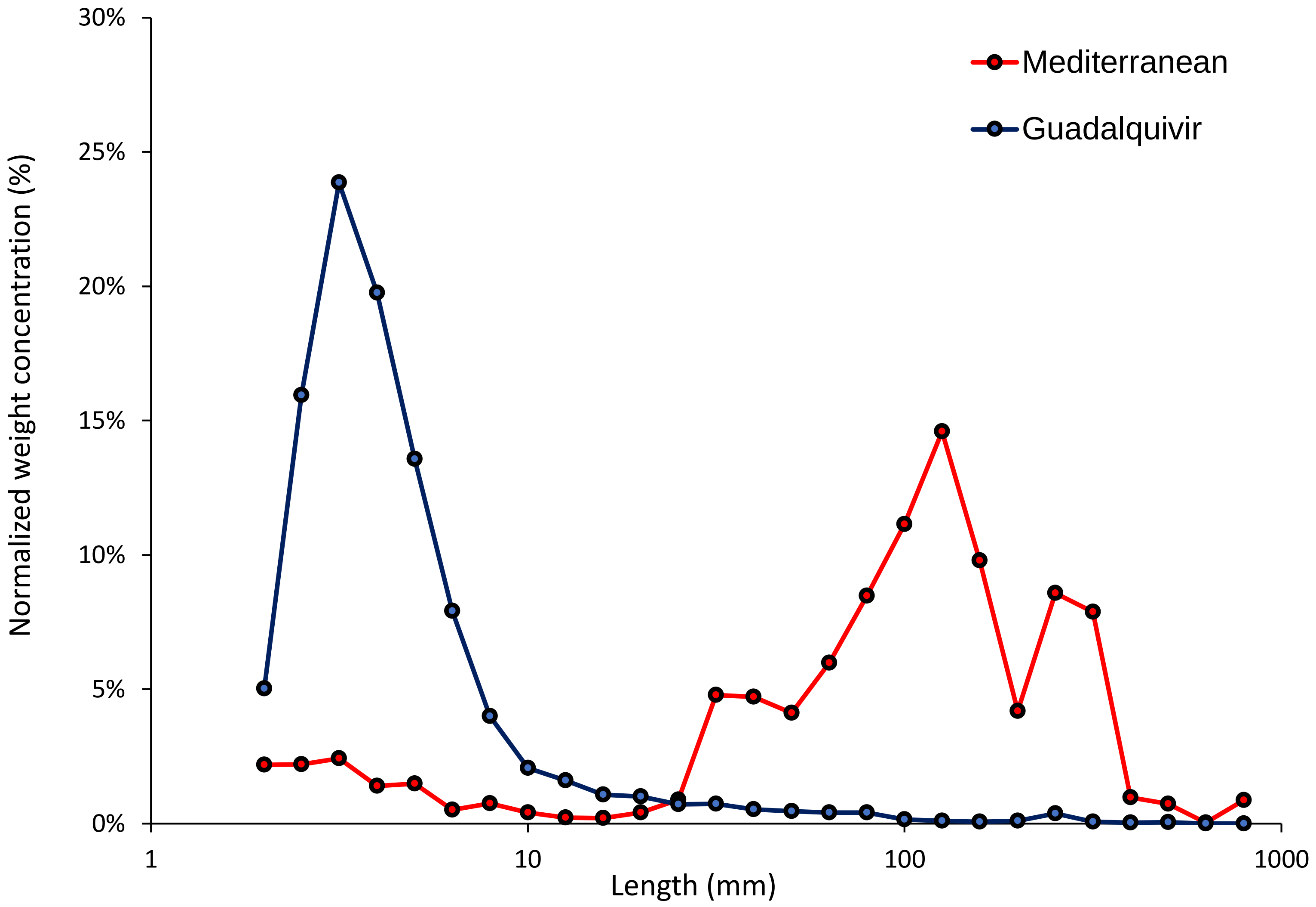
- The **highest percentage** of plastic items in the Guadalquivir river corresponds to **film** with **70.14%.**
- **Film**-type plastics with **higher surface-to-volume ratio** tend to be more affected by surface pollution, ballasting and fragmentation processes.
- Facilitating a **faster removal** from the ocean surface than other plastic types.

Size distribution



- **Particle size decreases** as one moves away from the coast.
- **Plastic fragmentation** is directly related to **exposure time** in the environment, so particles located further from the land will be exposed to the sun for a longer period of time. Therefore, they will have suffered more fragmentation than particles that have been recently dumped inland.
- The selective process towards maximum abundance in smaller sizes may be associated with **removal mechanisms** of floating particles by **ballasting**.

Weight distribution



- **Small fragments** in Guadalquivir river comprised most of the plastic **mass waste** into the sea.

- Most microplastics are formed directly from the fragmentation of large plastic items, which are normally trapped on riverbanks for longer periods of time.

- Due to a higher photo and thermo-oxidation on land, the aging and subsequent **fragmentation** of plastic is much **faster inland** than at sea.

- Once fragmented into smaller pieces, they are **easily transportable** through the basin until it reaches the river water, which acts as a garbage collector in the catchment basin.

Conclusion

- **Plastic transport** through the Guadalquivir river **ranged** between **two orders of magnitude** for monthly variations.

- Estimates of **plastic transport** were 565 $\mathrm{kg{\cdot}year^{-1}}$ for 2014 and 725 $\mathrm{kg{\cdot}year^{-1}}$ for 2015, with an average value of **645 $\mathbf{kg{\cdot}year^{-1}}$**. In number, the average annual load of plastic particles consisted of **347 million items**.

- There is a **predominance** of **film-type** plastic representing a 70% of the total. Microplastics in the size range from **2.5 to 4.0 mm** represented half of the total sampled items.

- **Small fragments** in Guadalquivir river comprised **most** of the **plastic waste mass** compared to marine waters. **Aging** and **fragmentation processes** of plastic are **accelerated inland**, being smaller pieces easily transportable through the basin.

Photo by César Vilas