

INTRODUCTION

Estuaries

- Highly productive, biodiverse transitional ecosystems
- Essential ecological functions and social-cultural services
- Ecological assessment based on Water Framework Directive (WFD) metrics (physical, chemical and biological parameters)
- Microplastics (MPs; emerging contaminants) are not yet included in this assessment



Accumulation of plastics resulting from industrial and urban activities

Discharge of MPs from WWTPs due to incomplete retention

Transport of MPs and other pollutants from rivers to ocean

Accumulation of MPs in marinas, derived from nautical activities, boat maintenance and cleaning

AIMS



- Evaluate the ecological status of the Douro Estuary
- Characterize the occurrence of MPs in the area adjacent to the Marina da Afurada

METHOD

In situ:

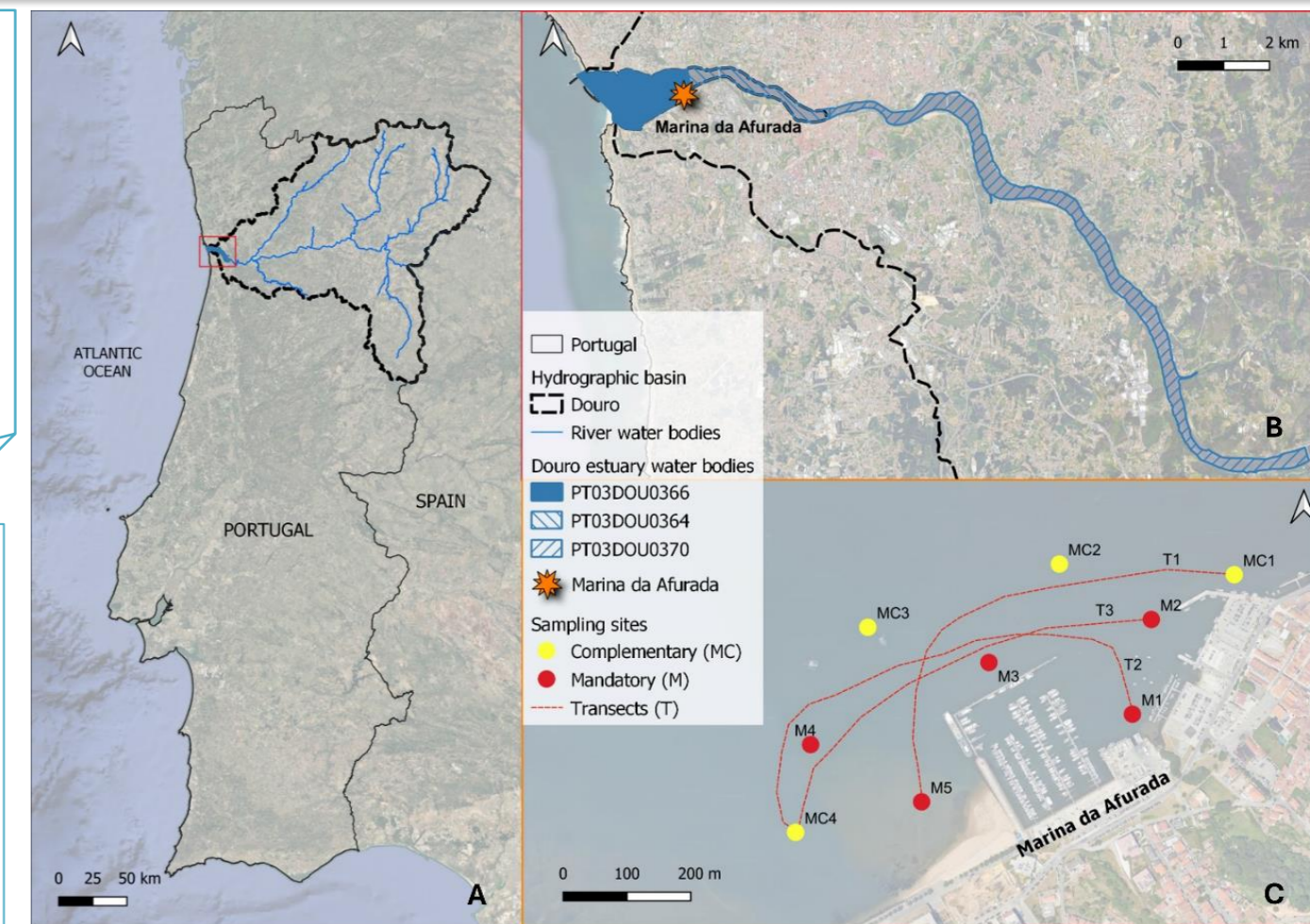
- Measurement of physical and chemical parameters
- Sampling:

Subsurface water
Water
Sediment



Laboratory procedures:

- Mp's evaluation (type, colour, size)
- Determination of:
 - nutrient and chlorophyll a concentrations
 - organic matter and granulometry
- Benthic macroinvertebrates assessment (BAT - Benthic Assessment Tool)



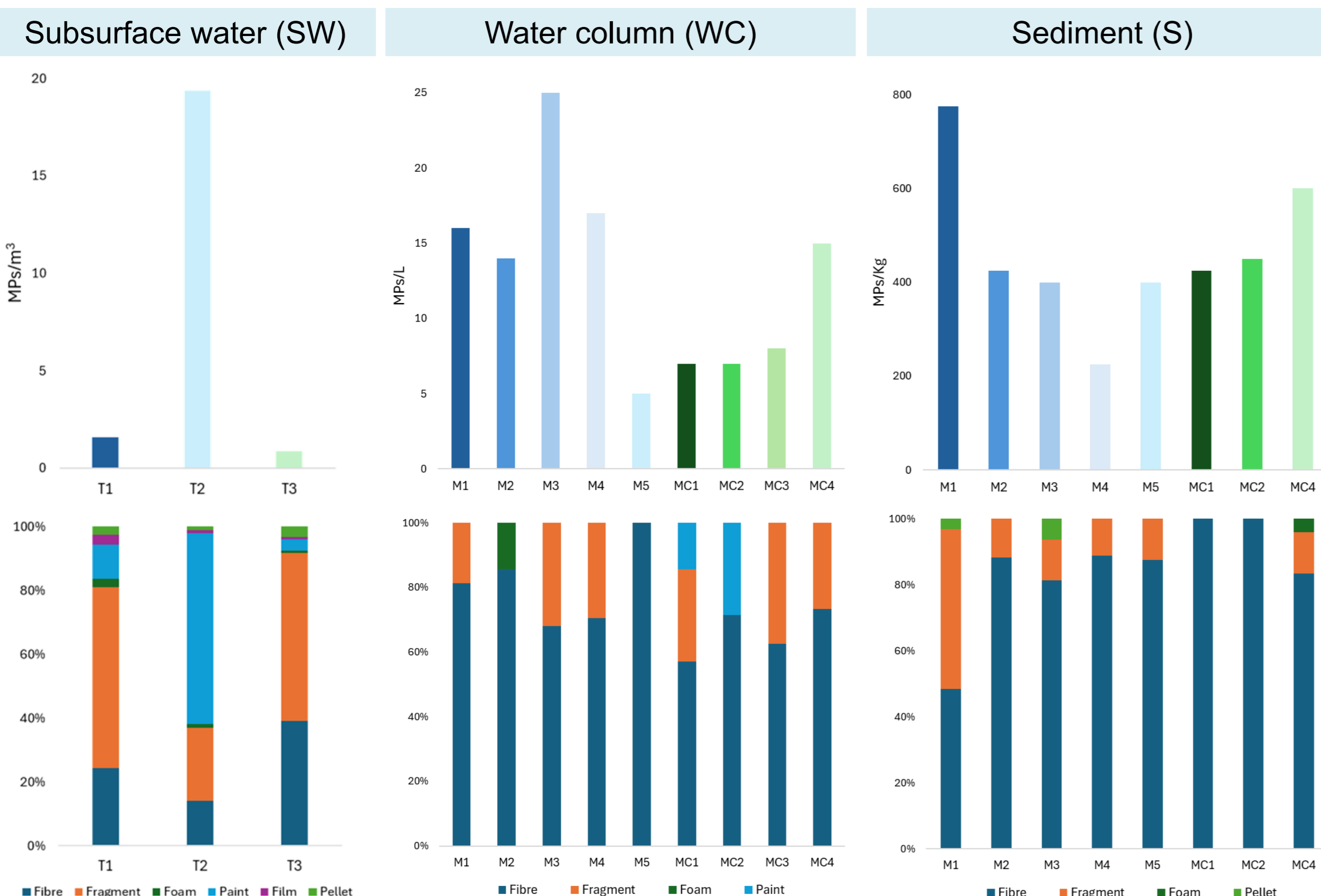
Data analysis

- Descriptive analysis
- Multivariate analysis considering S samples and measured parameters

*Sediment collection at MC3 was not feasible due to the sediment characteristics

RESULTS & DISCUSSION

MPs evaluation



Results indicate that **Marina da Afurada acts as a sink for MPs within the Douro Estuary**, with patterns consistent with previous studies carried in the estuary and marinas worldwide^{1,2}.

Overall, higher abundances of MPs were observed at sites closer to the marina, and in sediment samples, reflecting its low hydrodynamic conditions, retention capacity and significant anthropogenic pressures.

- **SW samples:** highest contamination level at T2; all types of MPs were detected; predominance of paint particles, associated to **nautical activities and vessel coating degradation**³.
- **WC samples:** highest abundance at M3 (25 MPs/m³); prevalence of fibres (> 57 %).
- **S samples:** MP abundance higher at M1 (775 MPs/Kg), with equal frequency of fibres and fragments (48 %); fibres predominance at other sampling sites (> 81 %), likely **associated with land-based sources**².
- Blue MPs were the most observed particles across all matrices. Black MPs were also predominant in WC samples, whereas transparent and gray MPs were frequently observed in S samples.
- Larger MPs (1-2.5 mm and 2.5-5 mm) predominated in WC and S samples, whereas MPs of lower size categories were more abundant in SW samples.

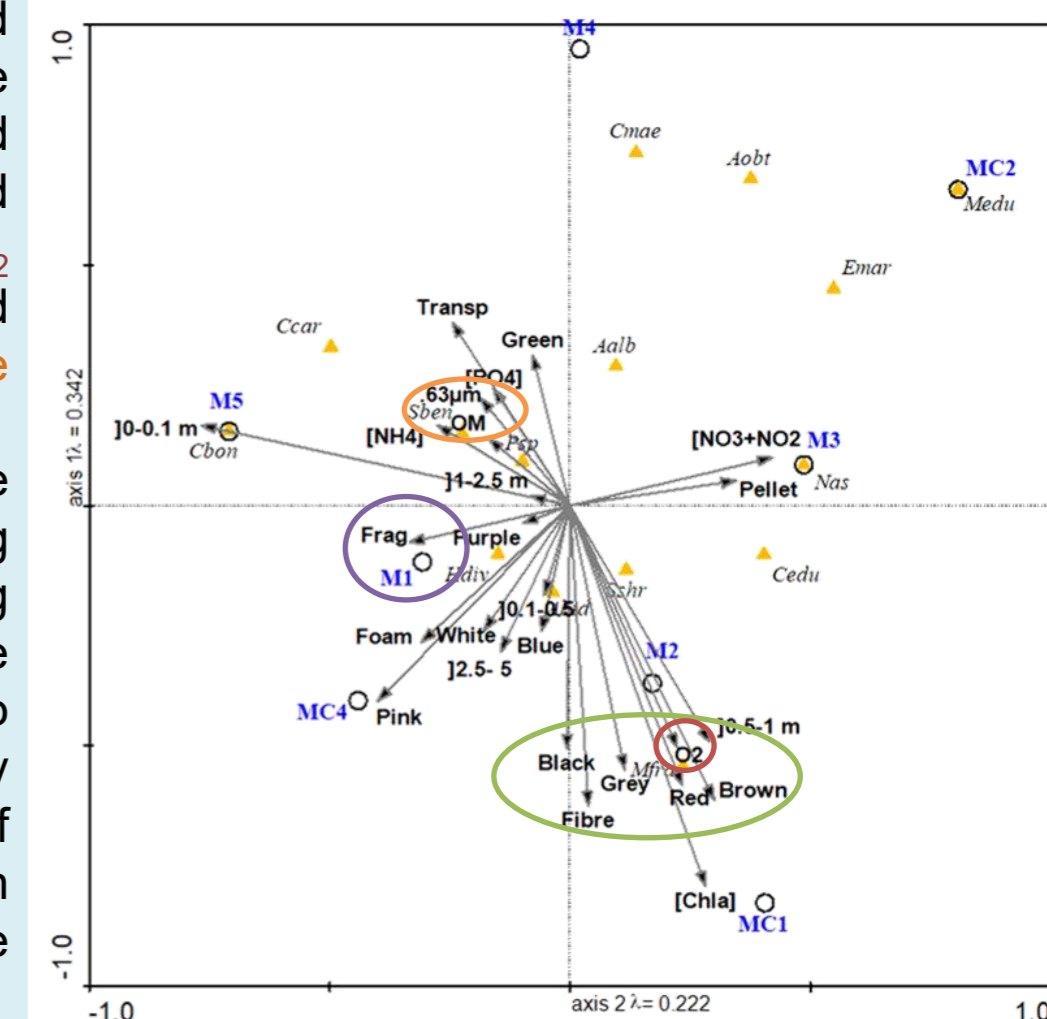
Ecological Assessment

- Slightly elevated O₂ values (%) (from 82.7 at M1 to 88.2 % at MC1)
- High nutrient concentrations at some sites (NO₃+NO₂ at M1 (1.25 mg N/L), and MC2 (1.15 mg N/L), NH₄ at M1 (0.31 mg N/L), and PO₄ at MC3 (0.15 mg P/L)), related to inputs from urban discharges and accumulation through the hydrographic basin⁴.
- Lower BAT values at M5, MC1, and MC4 (benthic macroinvertebrate assessment) (0.62, 0.65, and 0.55, respectively).
- Higher level of organic matter (%) at M1 (15.59 %), associated with very fine sand (higher retention of organic matter).

Sampling site	Physical-Chemical classification	Biological classification	Ecological Status	Organic matter (%)	Granulometry
M1	Good	Excellent	Good	15.6	Very fine sand
M2	Good	Excellent	Good	1.09	Gravel
M3	Good	Excellent	Good	1.50	Very coarse sand
M4	Good	Excellent	Good	2.77	Very coarse sand
M5	Good	Good	Good	1.53	Very coarse sand
MC1	Good	Good	Good	0.63	Very coarse sand
MC2	Good	Excellent	Good	0.48	Gravel
MC3	Good	Excellent	Good	n.d.	n.d.
MC4	Good	Good	Good	0.76	Gravel

Multivariate analysis

- **S samples** showed a clear **dominance of fibres and various colours**, although **fragments** also predominated at site **M1**.
- Although MP variables exerted a greater influence on the ordination axes, physical and chemical parameters showed that site **M1** presented low O₂ (%) values, likely associated with a **higher % of OM and fine sediments**.
- Moreover, **M1** is located at the marina entrance, being subjected to vessel cleaning and other discharges. These conditions are conducive to biofilm formation, thereby enhancing the deposition of MPs in sediments, which explains the higher abundance observed at this site.



CONCLUSION

- ✓ Douro estuary functions as a generally balanced system with a **Good ecological status**.
- ✓ **Marina da Afurada acts as a local sink for MPs and nutrients** derived from anthropogenic activities (e.g. nautical activities, urban discharges, inputs from Douro River).
- These findings reinforce the **need to incorporate MPs into long-term, future estuarine monitoring and management frameworks**, since the presence of these pollutants can interfere with the natural trophic structure and nutrient recycling of these ecosystems.

REFERENCES

1. <https://doi.org/10.1016/j.heliyon.2023.e19642>
2. <https://doi.org/10.1016/j.cscee.2020.100056>
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