



First assessment of per- and polyfluoroalkyl substances (PFAS) in loggerhead turtle (*Caretta caretta*) blood along the Tuscan coast (NW Mediterranean), 2024–2025

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Background

PFAS are persistent, mobile and bioaccumulative organofluorine contaminants of increasing concern in marine ecosystems.

Why *Caretta caretta*?

Loggerhead turtles are long-lived, coastal and trophically generalist marine reptiles, making them useful sentinels of coastal contamination.

Aim

To provide a first targeted assessment of PFAS in whole-blood samples of *Caretta caretta* stranded or rescued along the Tuscan coast during 2024–2025.

16 turtles | 18 PFAS | Tuscan coast 2024–2025

Sampling locations

Sixteen loggerhead turtles (*Caretta caretta*) stranded or rescued along the Tuscan coast were sampled between 2024 and 2025. The map shows the origin of each individual and provides the spatial framework for interpreting PFAS contamination patterns (Fig. 1).



Figure 1. Spatial distribution of the stranded loggerhead turtles analyzed.

Analytical workflow

Whole-blood samples were extracted using a modified QuEChERS protocol (Unpublished data) and analysed by UHPLC-HRMS on an Orbitrap Q-Exactive platform. Quantification was performed by isotope dilution using labelled internal standards (Fig. 2).

Target compounds

18 PFAS, including PFOS, PFOA, PFASAs, PFCAs of different chain length and FOSA.

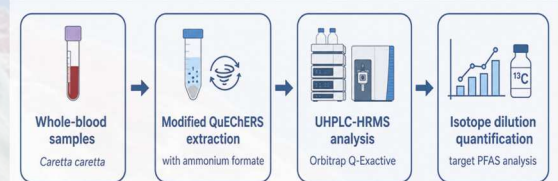


Figure 2. Analytical workflow used for PFAS determination in *Caretta caretta* whole-blood samples.

Key results

- Perfluorooctanesulfonic acid (PFOS) and Perfluorooctanoic acid (PFOA) were detected in all specimens (Fig. 3).
- Perfluorooctanesulfonic acid (PFOS) constitutes the majority of the PFAS present (Fig. 4).
- Total PFAS ranged from **0.14 to 3.59 µg/kg** (Fig. 4).
- Total PFAS showed a positive correlation with body mass ($r = 0.69$) (Fig. 5).
- Dead turtles showed higher concentrations than live individuals (Fig. 6).
- Spatial patterns suggested higher PFAS burdens in turtles from more anthropogenically impacted coastal sectors.

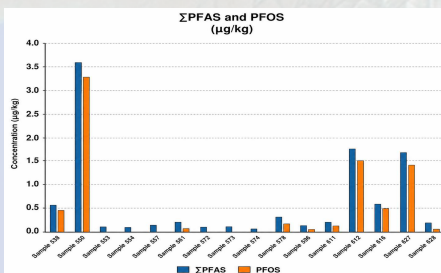


Figure 4. ΣPFAS and PFOS concentrations (µg/kg) in whole-blood samples of individual loggerhead turtles (*Caretta caretta*) collected along the Tuscan coast.

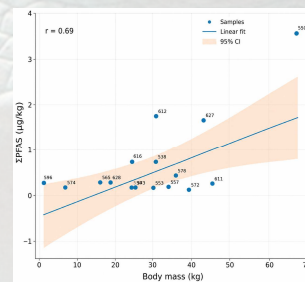


Figure 5. Relationship between total PFAS concentration (ΣPFAS, µg/kg) in blood and body mass (kg) in *Caretta caretta*. The solid line represents the linear regression, and the shaded area indicates the 95% confidence interval. A positive correlation was observed between ΣPFAS and body mass ($r = 0.69$).

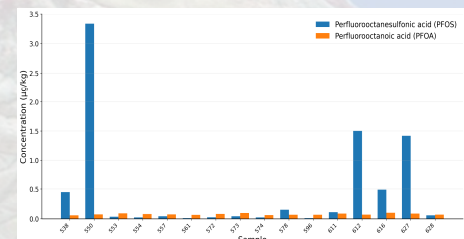


Figure 3. PFOS and PFOA concentrations (µg/kg) in whole-blood samples of individual loggerhead turtles (*Caretta caretta*) from the Tuscan coast.

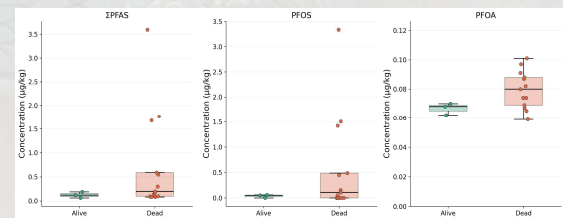


Figure 6. Comparison of ΣPFAS, PFOS, and PFOA concentrations (µg/kg) in whole-blood samples from live ($n = 3$) and dead ($n = 13$) *Caretta caretta* individuals collected along the Tuscan coast. Boxplots summarize the distribution of values, and dots indicate individual samples. Higher concentrations were generally observed in dead turtles.

Conclusion

This study provides the first integrated dataset on PFAS exposure in *Caretta caretta* along the Tuscan coast. The detection of PFOS and PFOA in all individuals, the size-related increase in total PFAS burden and the spatial signal associated with anthropogenic coastal pressure support the use of loggerhead turtles as sentinels of organofluorine contamination in nearshore Mediterranean ecosystems.

REFERENCES:

- Guarranti C. et al., 2013. Perfluorinated compounds in blood of *Caretta caretta* from the Mediterranean Sea. *Marine Pollution Bulletin*, 73(1), 98–101.
- Moretti S. et al., 2024. Occurrence and pattern of legacy and emerging per- and polyfluoroalkyl substances (PFAS) in eggs of loggerhead turtle *Caretta caretta* from western Mediterranean. *Environmental Pollution*, 343, 123257.
- González Curbelo M. Á. et al., 2014. Use of ammonium formate in QuEChERS for high-throughput analysis of pesticides in food by fast, low-pressure gas chromatography and liquid chromatography tandem mass spectrometry. *Journal of Chromatography A*, 1358, 75–84.
- Puthigai S. K. et al., 2025. Skin sampling as a proxy for screening per- and polyfluoroalkyl substances (PFAS) exposures in endangered sea turtles. *Marine Pollution Bulletin*, 218.