Reproducible pipelines and readiness levels in plastic monitoring

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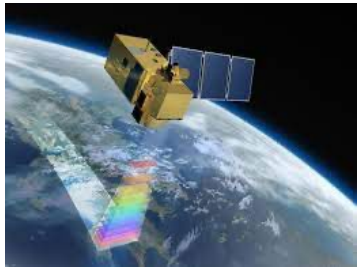
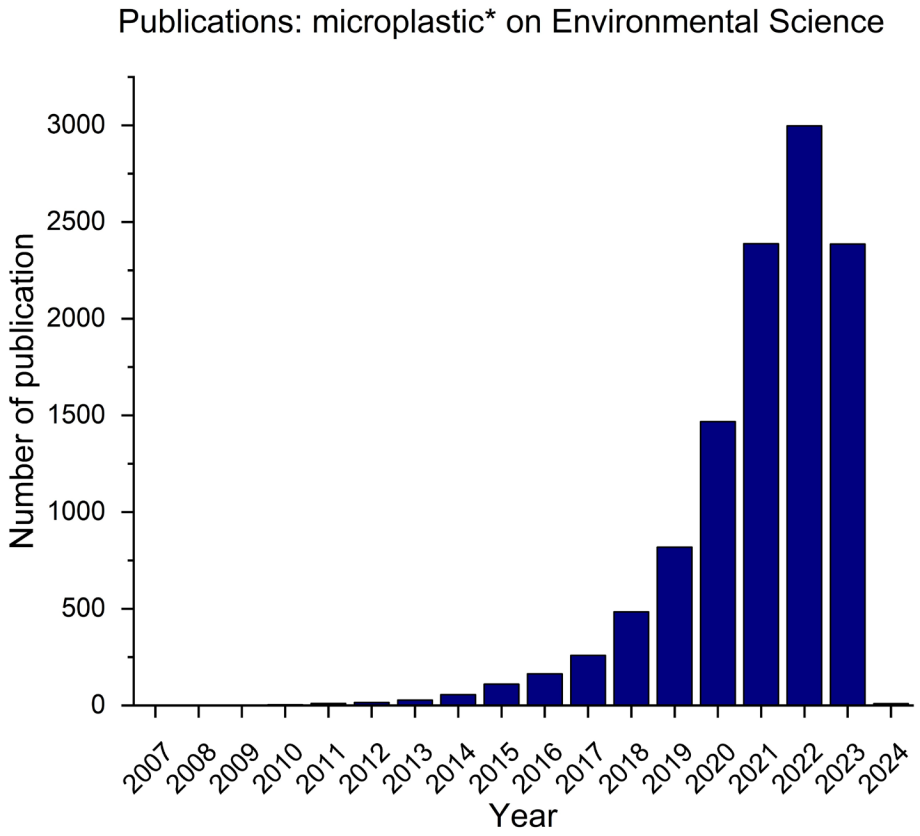
Plastics research is increasing exponentially

Still an evolving field with a large number of new or improved analytical methods (especially microplastics) provided on a monthly basis.

Various types of sampling and analysis.





So what is the problem?

Different approaches for analysis can hamper the setup and design of large-scale monitoring programmes and thus the assessment of plastic (and litter) pollution.

⇒ Differences between individual research teams, countries, and regions.

⇒ Consequences for monitoring, risk assessment, and legislation.

It is time to take major actions to evaluate our available approaches, optimise our methods to monitor plastic pollution, and begin to generate reproducible, robust and reliable data.

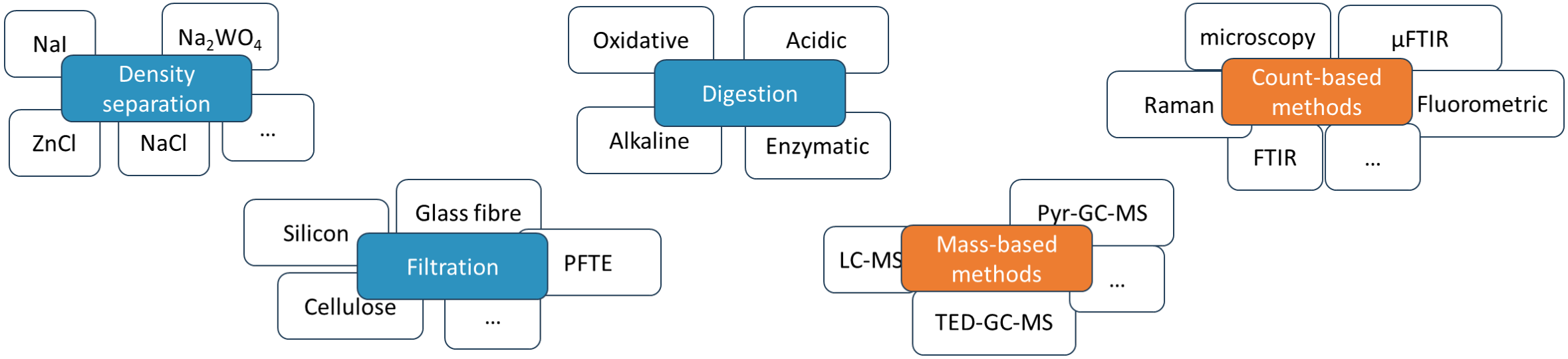
Is the solution harmonisation?

Monitoring is a key step in plastic pollution control and management; harmonisation of methods is paramount to this.

Harmonisation also = flexibility to adapt to scientific, logistical, environmental and ethical constraints.

Objective of EUROqCHARM: To **exchange views** on what methods and data are necessary to **inform decisions** on plastic litter, investigate how we can generate **comparable data**, and to understand what level of data can be provided by the current protocols and **capacity to monitor** and observe plastics in the environment.

Addressing harmonisation in research and monitoring



- Which methods to use?
- How do we decide what is best without being biased by our own opinions?

→ Decisions for monitoring guidelines need to be informed by sound science, meet a minimum criteria, and allow data comparisons.

EUROqCHARM developed and tested a set of solutions

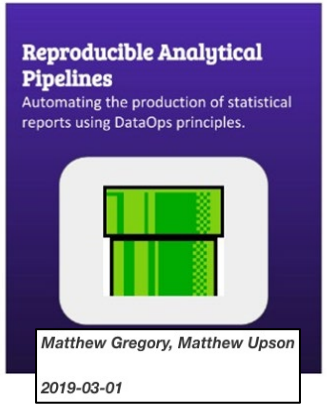
(1) Break the analytical elements into useable pieces: steps

RAPs – Reproducible Analytical Pipelines

(2) Assess the reproducibility of each approach, need for further research/ development, or recommend steps for monitoring programmes

TRL – Technological Readiness Levels with SWOT analysis

Reproducible Analytical Pipelines to define the workflow for plastic analysis



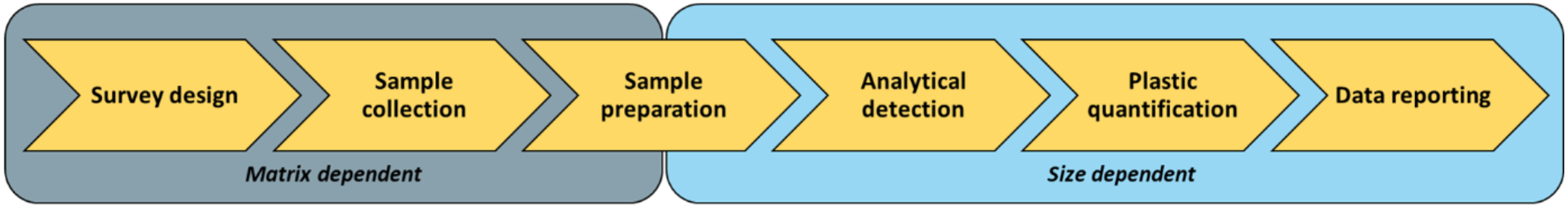
RAPs are statistical and analytical processes, first developed in software engineering.

Breaking down the process into manageable steps.

They ensure that analysis is reproducible, efficient, and have been indicated as a way of achieving highest standards.

We applied the concept of RAPs to plastic analysis and monitoring

Can we use RAPs to support plastic analysis and monitoring?

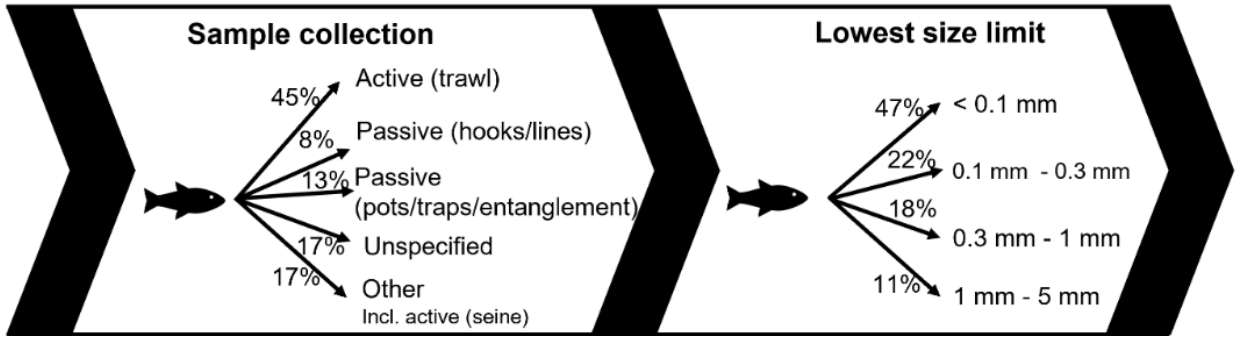


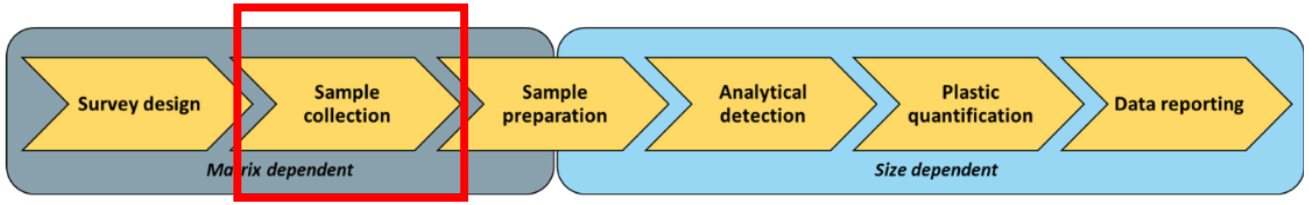
In our application:

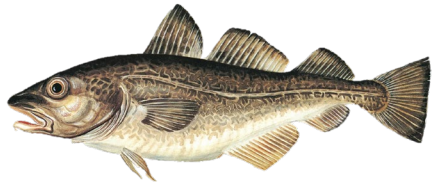
(Aliani et al., 2023)

- We used a Systematic Literature review to identify the fundamental steps used for analysis.

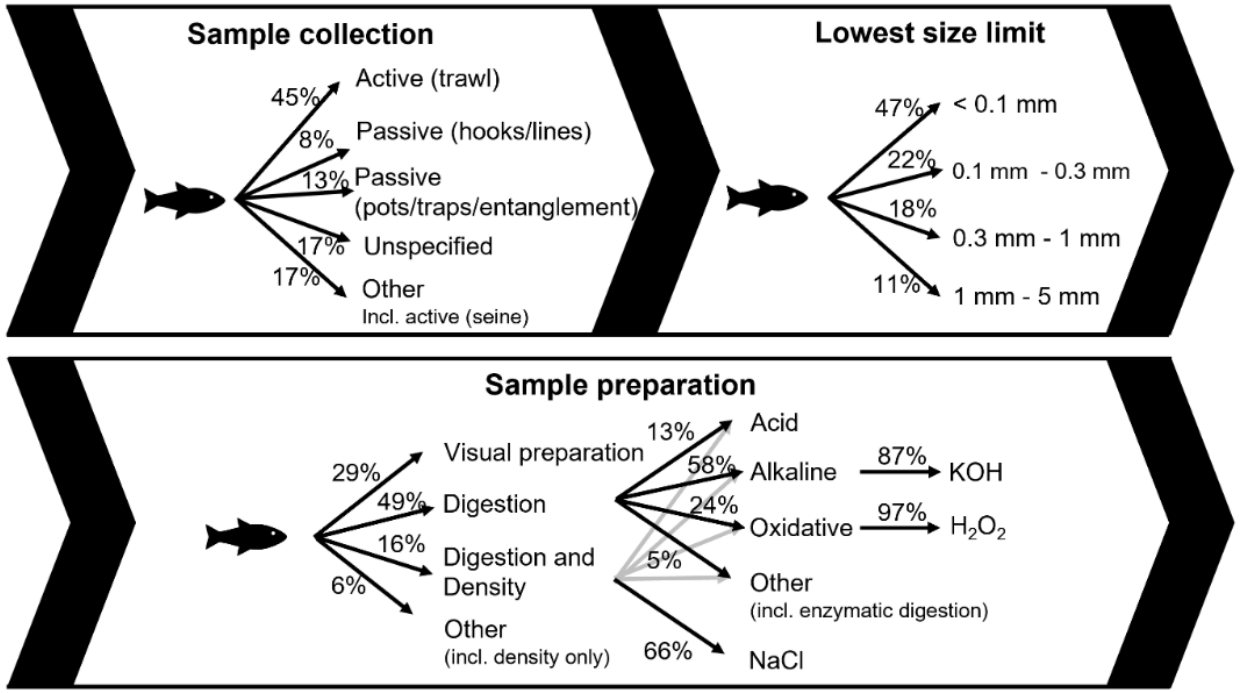
Some examples of RAPs from EUROqCHARM

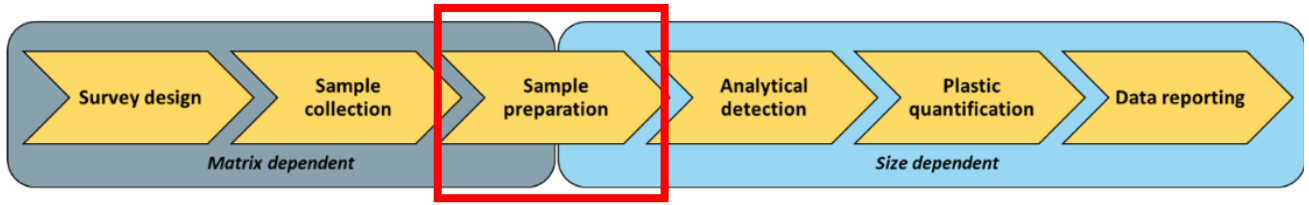


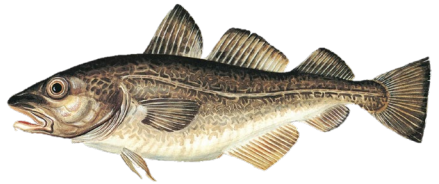




Some examples of RAPs from EUROqCHARM







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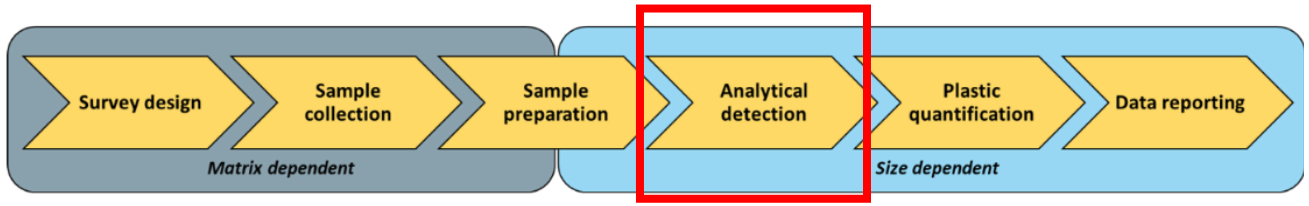
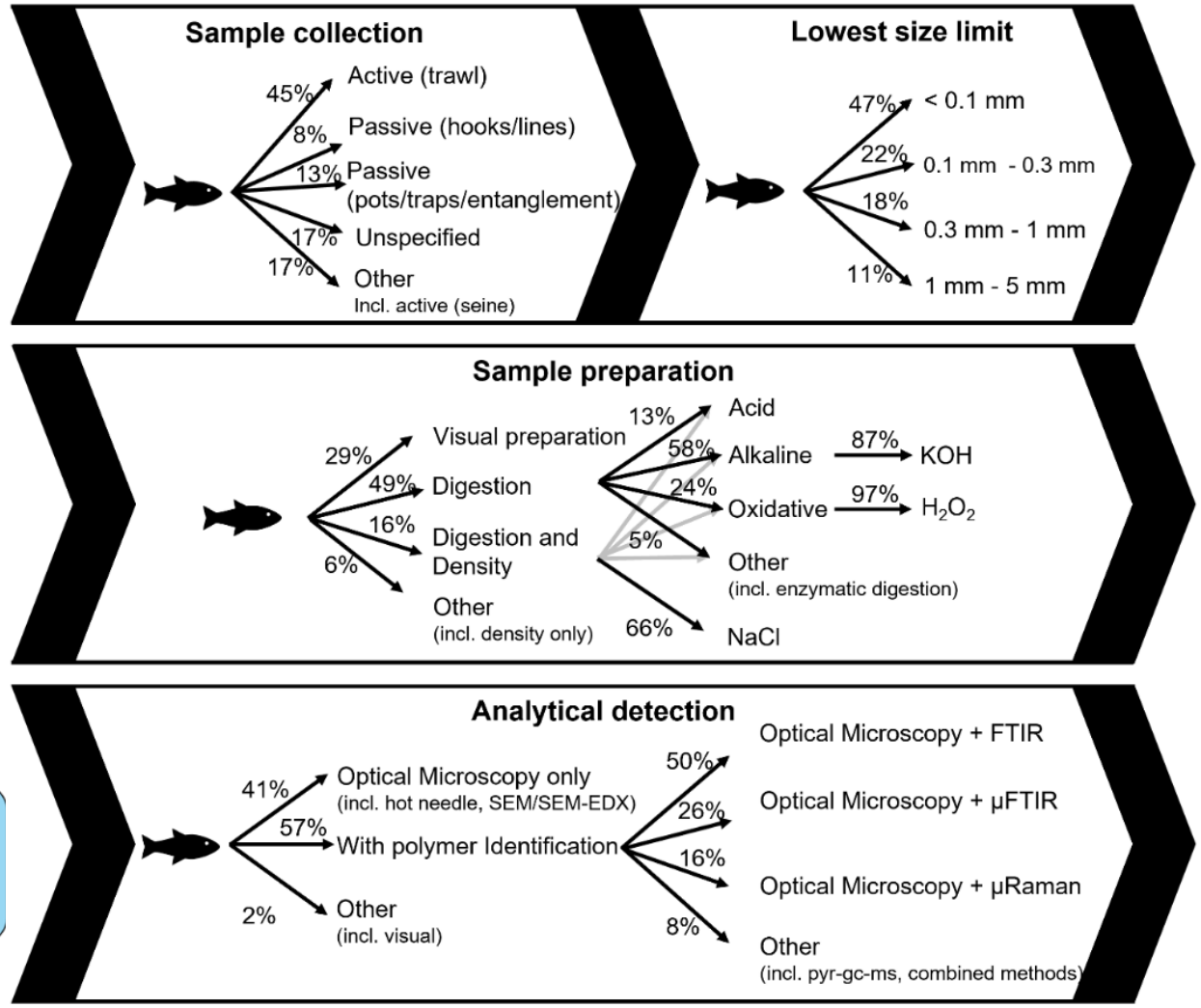
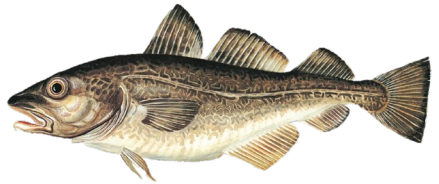


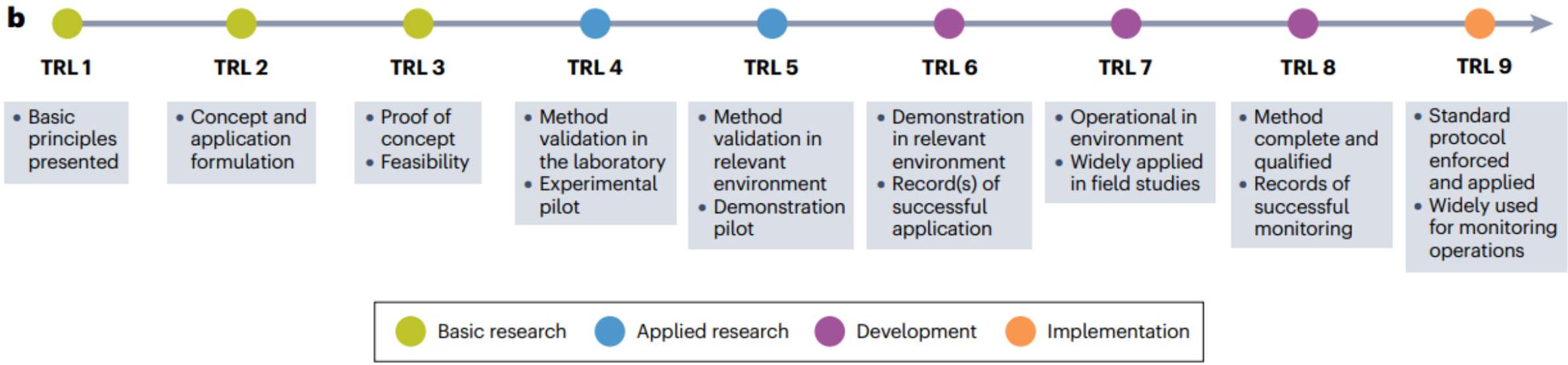




Technological Readiness Level (TRL)

The TRL scale was developed with space technologies in mind (i.e. ESA / NASA).

TRL used for the first time in plastic monitoring to sustain an innovative and robust discussion about monitoring methods.



Aliani, Lusher et al., (2023)

Some examples of TRLs from EUROqCHARM

Basic research

Applied research

Development

Implementation

TRL plastic (>1 mm) in biota

TRL	Survey design	Sample collection	Sample preparation	Analytical detection	Plastic quantification	QA/QC	Data reporting
1							
2							
3							
4							
5	Mammals						
6	Fish, Reptiles			Chemical ID with FTIR (ATR, general and microscopy)			
7			Alkaline digestion, oxidative digestion				Research protocols
8							
9	Birds	Hand collection, nets, hooks/lines	Visual separation	Visual	Guidelines for shapes and colour Items/individual, g/individual, %		International protocols (e.g., OSPAR)

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Some examples of TRLs from EUROqCHARM

TRL plastic (<1 mm) in biota

Basic research

Applied research

Development

Implementation

TRL	Survey design	Sample collection	Sample preparation	Analytical detection	Plastic quantification	QA/QC	Data reporting
1							
2							
3							
4				Hyperspectral imaging			
5	Plants, amphibian			Pyr-GC/MS Fluorometric		Field blanks, Positive controls	
6	Non-bivalve invertebrates		Enzymatic digestion, acid digestion		µg/g	Air blanks	
7	Bivalves, fish		Alkaline digestion, oxidative digestion, density separation	Optical microscopy, FTIR, µFTIR, Raman, µRaman	Items/individual, items/g, %	Air filtrations systems	
8						Procedure blanks	
9		Hand collection, nets, hooks/lines					

Outcomes of the RAP / TRL assessments:

1. **Only few matrices and size classes have high TRL in all steps of RAPs**: e.g., protocols for measuring macroplastic/litter in different environments are mature and are suitable for monitoring programs.

2. Challenge of setting up monitoring programs for macroplastic/litter relates to **representative sampling of spatially unevenly distributed materials**.

3. Setting up monitoring programs for microplastics comes with the same challenges of representative sampling, on a different scale. **Additional challenge of assessing the microplastic contents in complex matrices**

4. Processing protocols - and several variations thereof - usually relate to projects with a time horizon of a few years and a limited number of samples. *Before such procedures can be integrated into large monitoring programs**, rigorous quality control through intercalibration** testing must be performed.*

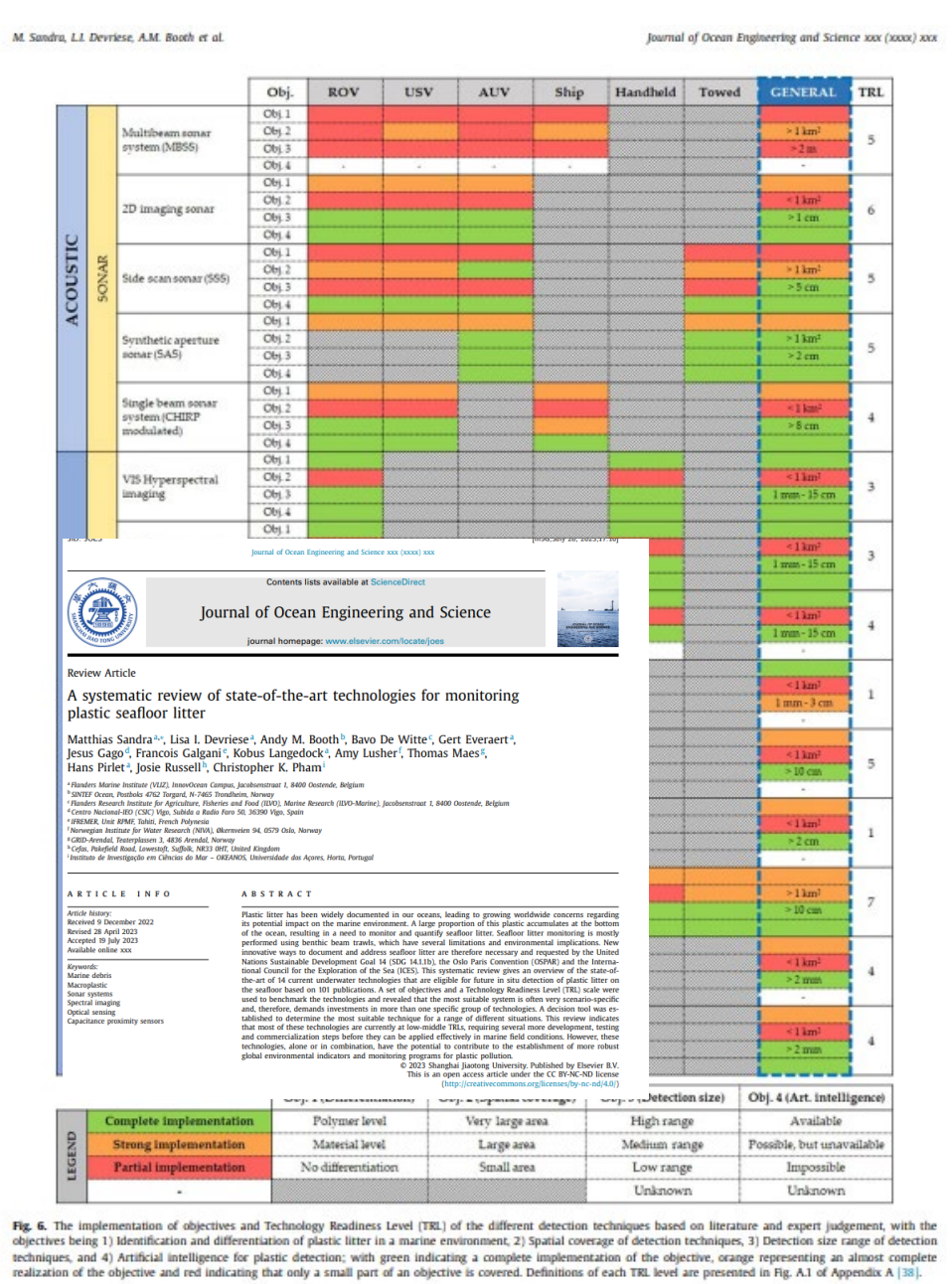
5. **No sample preparation protocol for microplastic particles (addressing also particle <1 mm) has successfully passed a rigorous interlaboratory testing experiment.**

Recommendations for monitoring guidelines

- Guidelines should be informed based on a critical, unbiased assessment of methods.
- Must be cost-effective to ensure they are maintained.
- Prioritisation to address the most significant risks and associated indicators,
- Encourage cooperation.
- Consider opportunities to integrate innovative and opportunistic approaches after validation.
- Build on existing monitoring activities, but must acknowledge plastics are not the same as traditional contaminants (i.e. POPs).

Next steps

- Adoption of RAP and TRL approach by expert working groups.
- Use TRLs to further R&D into promising methods.
- Use TRLs to identify monitoring methods and priorties for possible future adaptations of monitoring guidelines.



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			Obj.	ROV	USV	AUV	Ship	Handheld	Towed	GENERAL	TRL
ACOUSTIC	SONAR	Multibeam sonar system (MBSS)	Obj. 1								5
			Obj. 2							> 1 km²	
			Obj. 3							> 2 m	
			Obj. 4	-	-	-	-			-	
		2D imaging sonar	Obj. 1								6
			Obj. 2							< 1 km²	
			Obj. 3							> 1 cm	
			Obj. 4								
		Side scan sonar (SSS)	Obj. 1								5
			Obj. 2							> 1 km²	
			Obj. 3							> 5 cm	
			Obj. 4								
		Synthetic aperture sonar (SAS)	Obj. 1								5
			Obj. 2							> 1 km²	
			Obj. 3							> 2 cm	
			Obj. 4								
		Single beam sonar system (CHIRP modulated)	Obj. 1								4
			Obj. 2							< 1 km²	
			Obj. 3							> 8 cm	
			Obj. 4								
		VIS Hyperspectral imaging	Obj. 1								3
			Obj. 2							< 1 km²	
			Obj. 3							1 mm - 15 cm	
			Obj. 4								
			Obj. 1								3
			Obj. 2							< 1 km²	
			Obj. 3							1 mm - 15 cm	
			Obj. 4								4
			Obj. 1								
			Obj. 2							< 1 km²	
			Obj. 3							1 mm - 15 cm	
			Obj. 4							-	
			Obj. 1								1
			Obj. 2							< 1 km²	
			Obj. 3							1 mm - 3 cm	
			Obj. 4							-	
			Obj. 1								5
			Obj. 2							< 1 km²	
			Obj. 3							> 10 cm	
			Obj. 4							-	
			Obj. 1								1
			Obj. 2							< 1 km²	
			Obj. 3							> 2 cm	
			Obj. 4							-	
			Obj. 1								7
			Obj. 2							> 1 km²	
			Obj. 3							> 10 cm	
			Obj. 4								
			Obj. 1								4
			Obj. 2							< 1 km²	
			Obj. 3							> 2 mm	
			Obj. 4							-	
			Obj. 1								4
			Obj. 2							< 1 km²	
			Obj. 3							> 2 mm	
			Obj. 4								

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Review Article

A systematic review of state-of-the-art technologies for monitoring plastic seafloor litter

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ABSTRACT

Plastic litter has been widely documented in our oceans, leading to growing worldwide concerns regarding its potential impact on the marine environment. A large proportion of this plastic accumulates at the bottom of the ocean, resulting in a need to monitor and quantify seafloor litter. Seafloor litter monitoring is mostly performed using benthic beam trawls, which have several limitations and environmental implications. New innovative ways to document and address seafloor litter are therefore necessary and requested by the United Nations Sustainable Development Goal 14 (SDG 14.1.1b), the Oslo Paris Convention (OSPAR) and the International Council for the Exploration of the Sea (ICES). This systematic review gives an overview of the state-of-the-art of 14 current underwater technologies that are eligible for future in situ detection of plastic litter on the seafloor based on 101 publications. A set of objectives and a Technology Readiness Level (TRL) scale were used to benchmark the technologies and revealed that the most suitable system is often very scenario-specific and, therefore, demands investments in more than one specific group of technologies. A decision tool was established to determine the most suitable technique for a range of different situations. This review indicates that most of these technologies are currently at low-middle TRLs, requiring several more development, testing and commercialization steps before they can be applied effectively in marine field conditions. However, these technologies, alone or in combination, have the potential to contribute to the establishment of more robust global environmental indicators and monitoring programs for plastic pollution.

	Obj. 3 (Detection size)	Obj. 4 (Art. Intelligence)
Complete implementation	Polymer level	Very large area	High range	Available
Strong implementation	Material level	Large area	Medium range	Possible, but unavailable
Partial implementation	No differentiation	Small area	Low range	Impossible
-			Unknown	Unknown

LEGEND

Fig. 6. The implementation of objectives and Technology Readiness Level (TRL) of the different detection techniques based on literature and expert judgement, with the objectives being 1) Identification and differentiation of plastic litter in a marine environment, 2) Spatial coverage of detection techniques, 3) Detection size range of detection techniques, and 4) Artificial intelligence for plastic detection; with green indicating a complete implementation of the objective, orange representing an almost complete realization of the objective and red indicating that only a small part of an objective is covered. Definitions of each TRL level are presented in Fig. A.1 of Appendix A [38].

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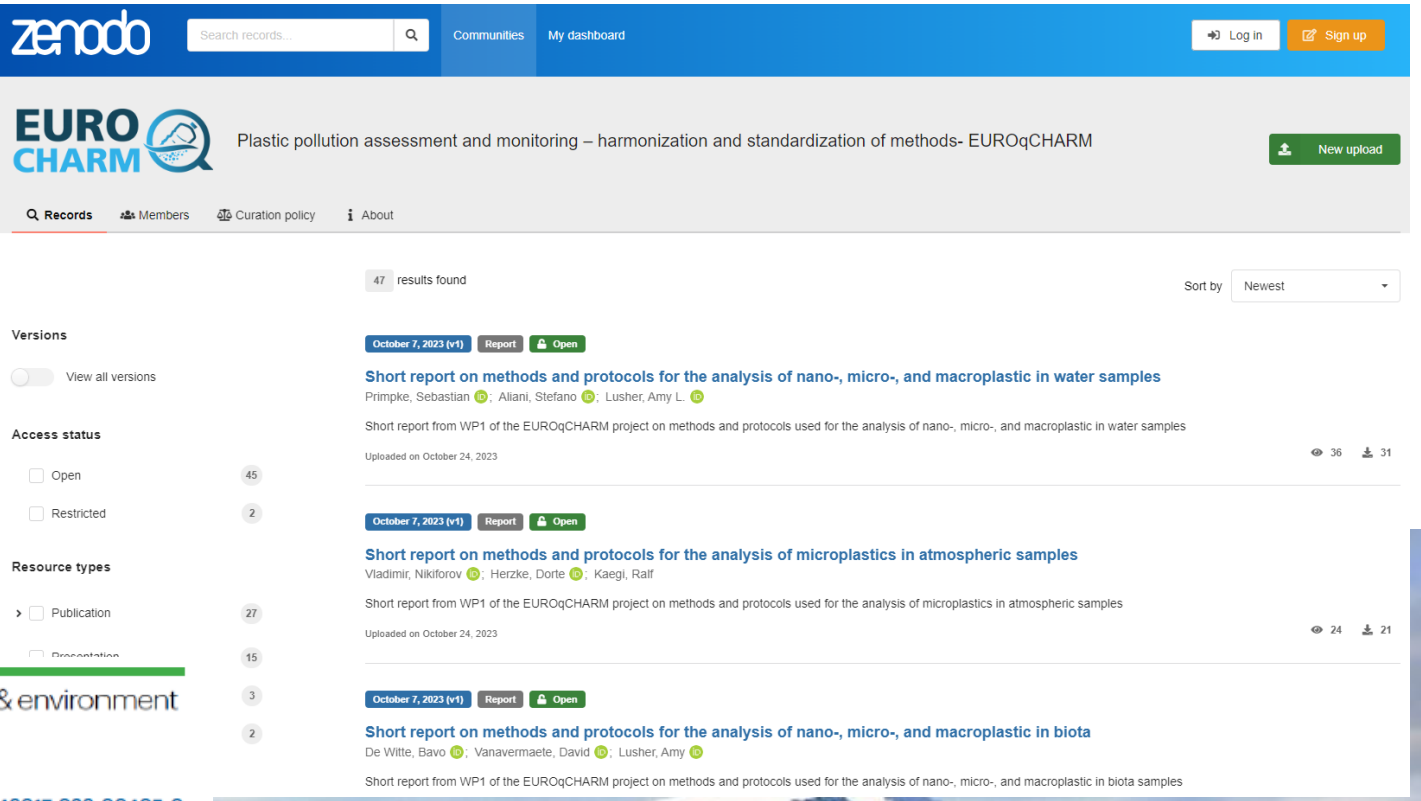
Thank you for listening



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