New approach to assess the state-of-the-art for monitoring plastic pollution

Amy L. Lusher
(EUROqCHARM Scientific Project Manager)

EUROqCHARM Final Conference,
Brussels 11th October 2023

This project has received funding from the European Union's Horizon 2020 coordination and support action under grant agreement No. 101000805 (EUROqCHARM).
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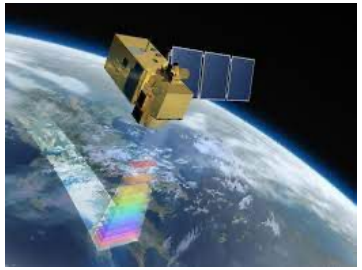
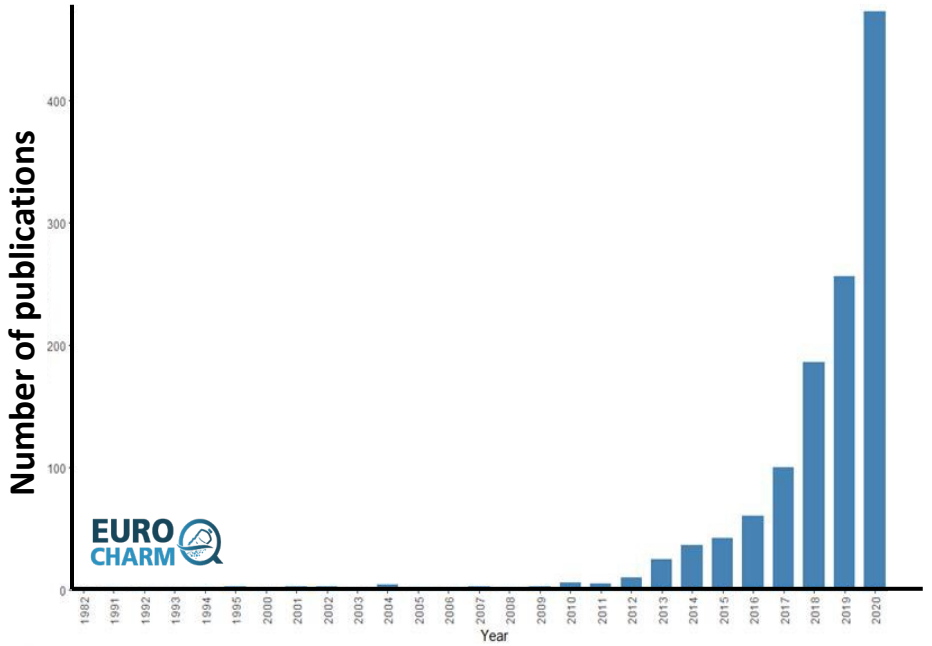
Norwegian Institute for Water Research

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.





Why do we need harmonisation?

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.

To reach substantial improvements in environmental sustainability and socio-economic development, it is essential to undertake major actions for the evaluation and optimisation of methods and approaches used to monitor plastic pollution.

Defining what we mean:

Monitoring is a key step in plastic pollution control and management.

Harmonisation of methods is paramount for monitoring

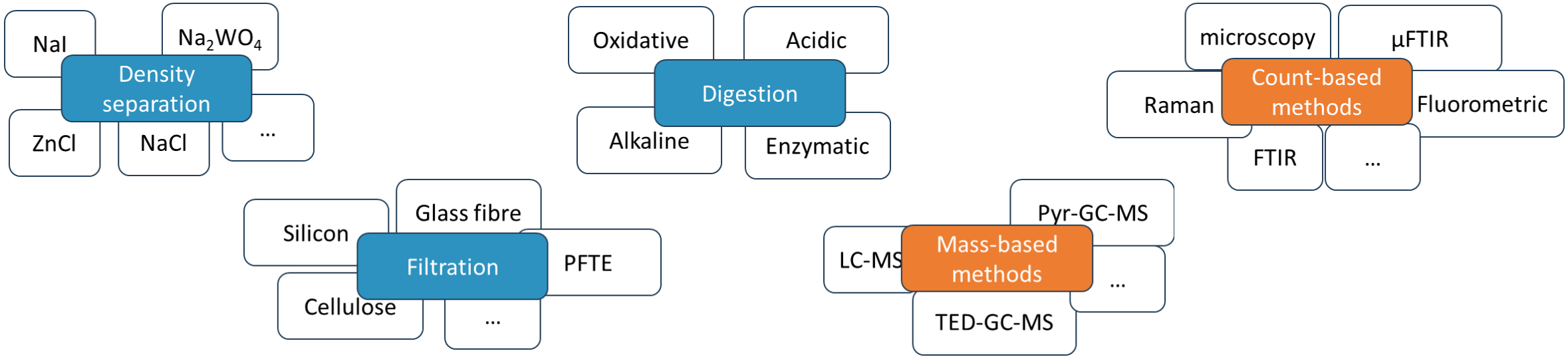
Defining what we mean:

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 is necessary to inform decisions on plastic litter, how we can generate comparable data, and to what level that 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

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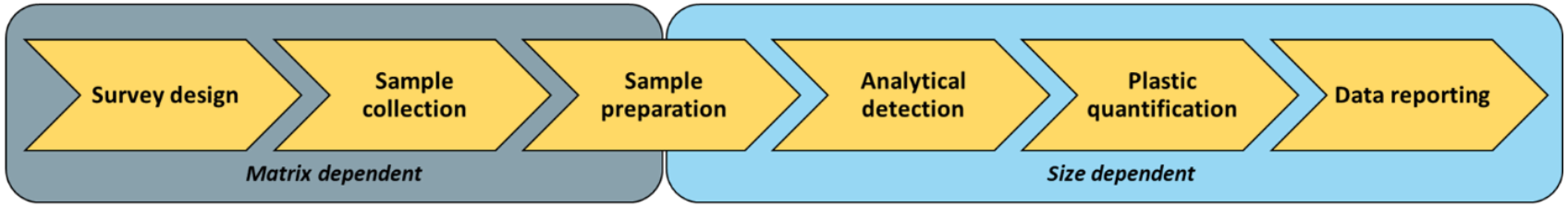
(1) Break the analytical elements into useable pieces: steps

RAPs



(Aliani et al., 2023)

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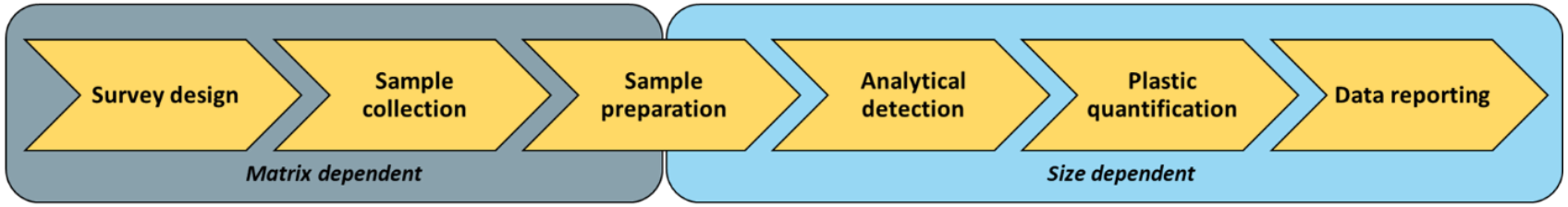
(1) Break the analytical elements into useable pieces: steps

RAPs



(Aliani et al., 2023)

(2) Assess the reproducibility of each approach and the requirement for further research/development, or recommend as suitable for monitoring programmes

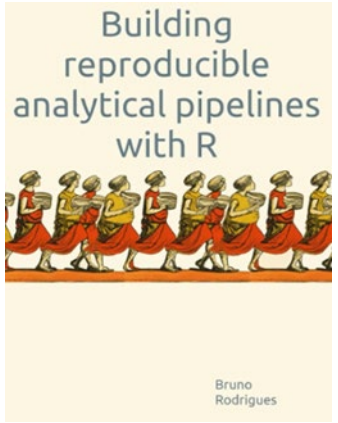
TRL /SWOT

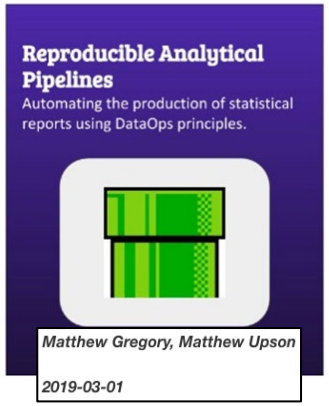
Reproducible Analytical Pipelines to define the workflow for plastic analysis

Reproducible Analytical Pipelines (RAPs) are statistical and analytical processes, first developed in software engineering.

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

Reproducible analysis is about breaking down the process into manageable steps.





We applied the concept of RAPs to plastic analysis and monitoring

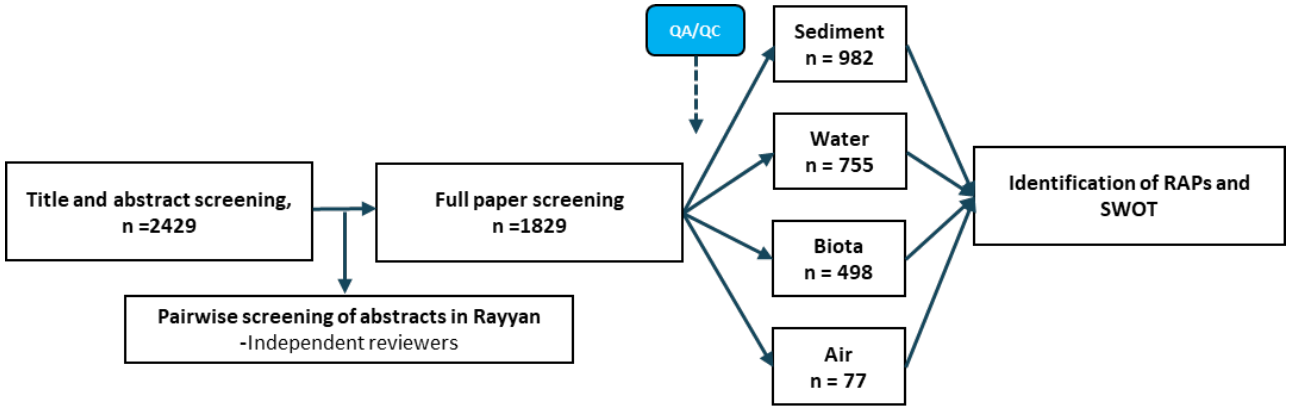
Can we use RAPs to support plastic analysis and monitoring?

Yes

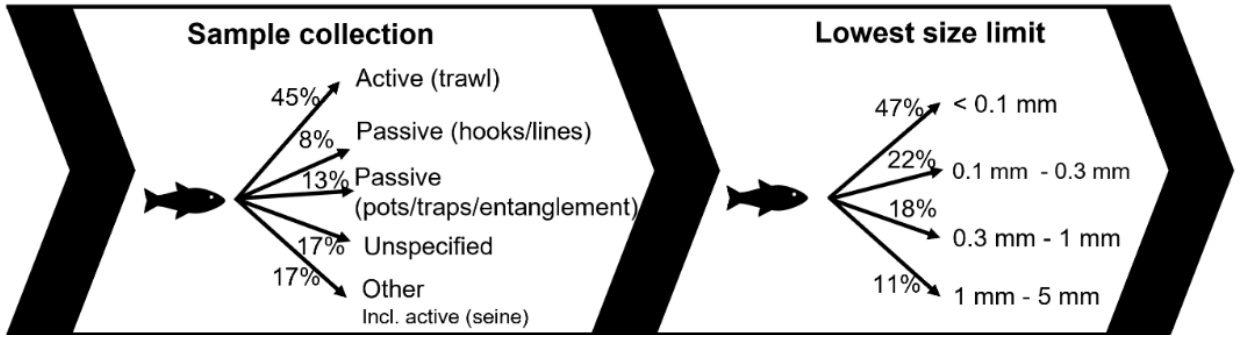
The analysis of plastic samples can be arranged in recurrent fundamental steps and **can represent the workflow of plastic analysis**.

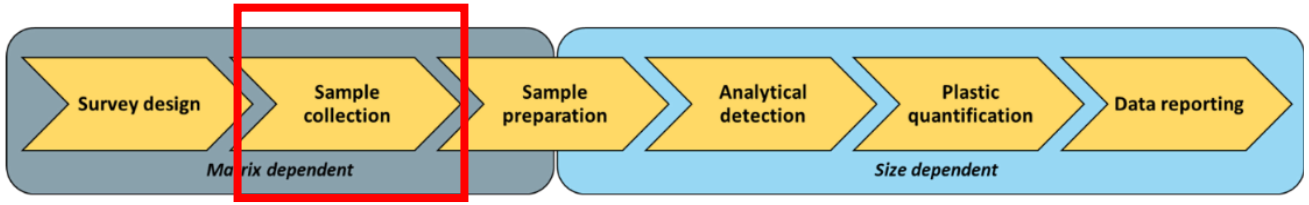
<u>In our application:</u>

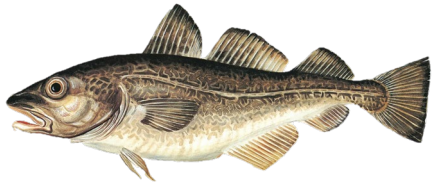
- We used a Systematic Literature review to identify the fundamental steps used for analysis.



Some examples of RAPs from EUROqCHARM







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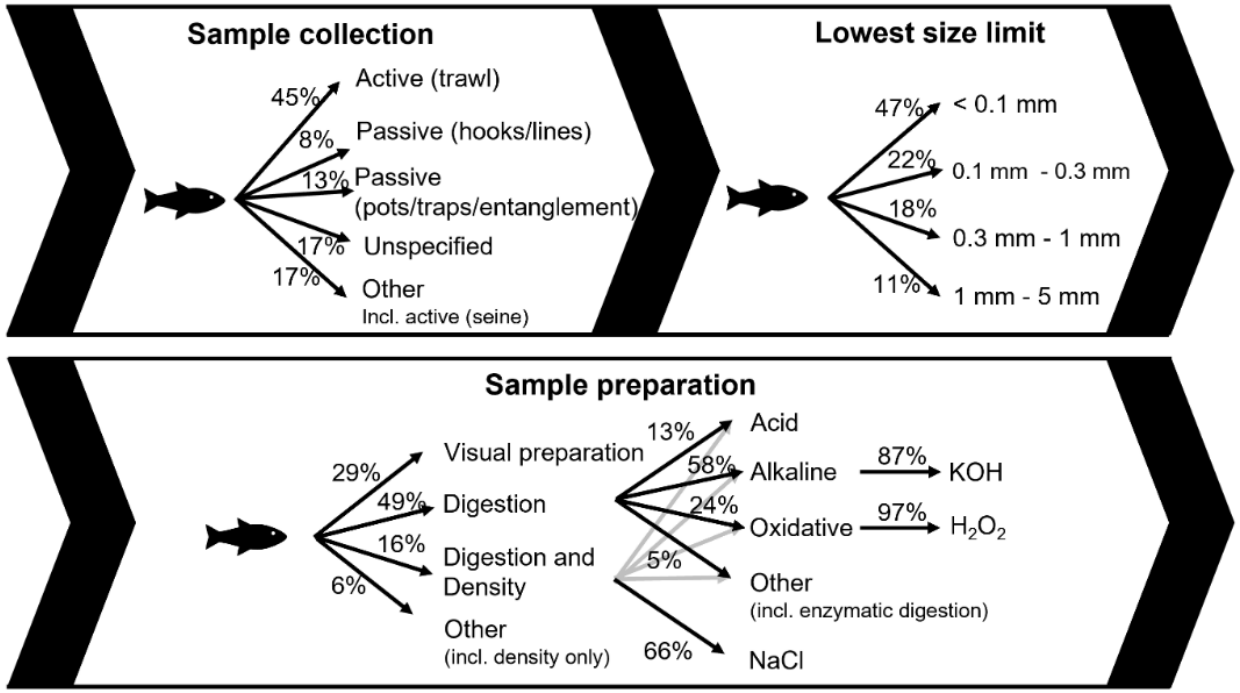

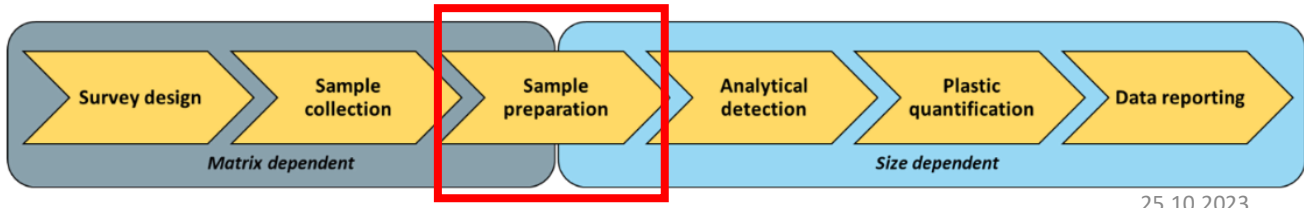

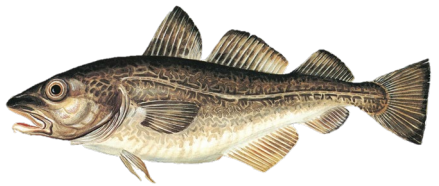

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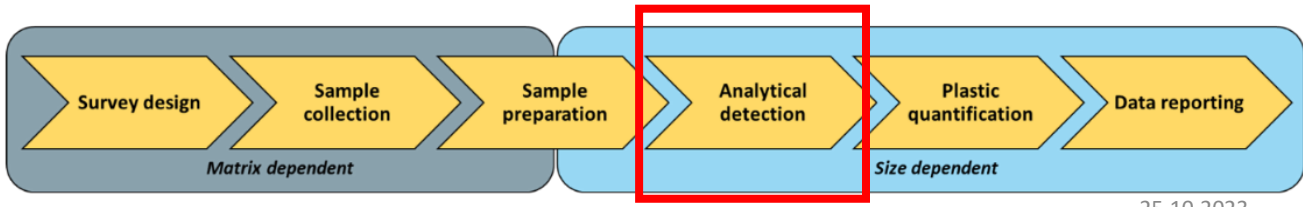
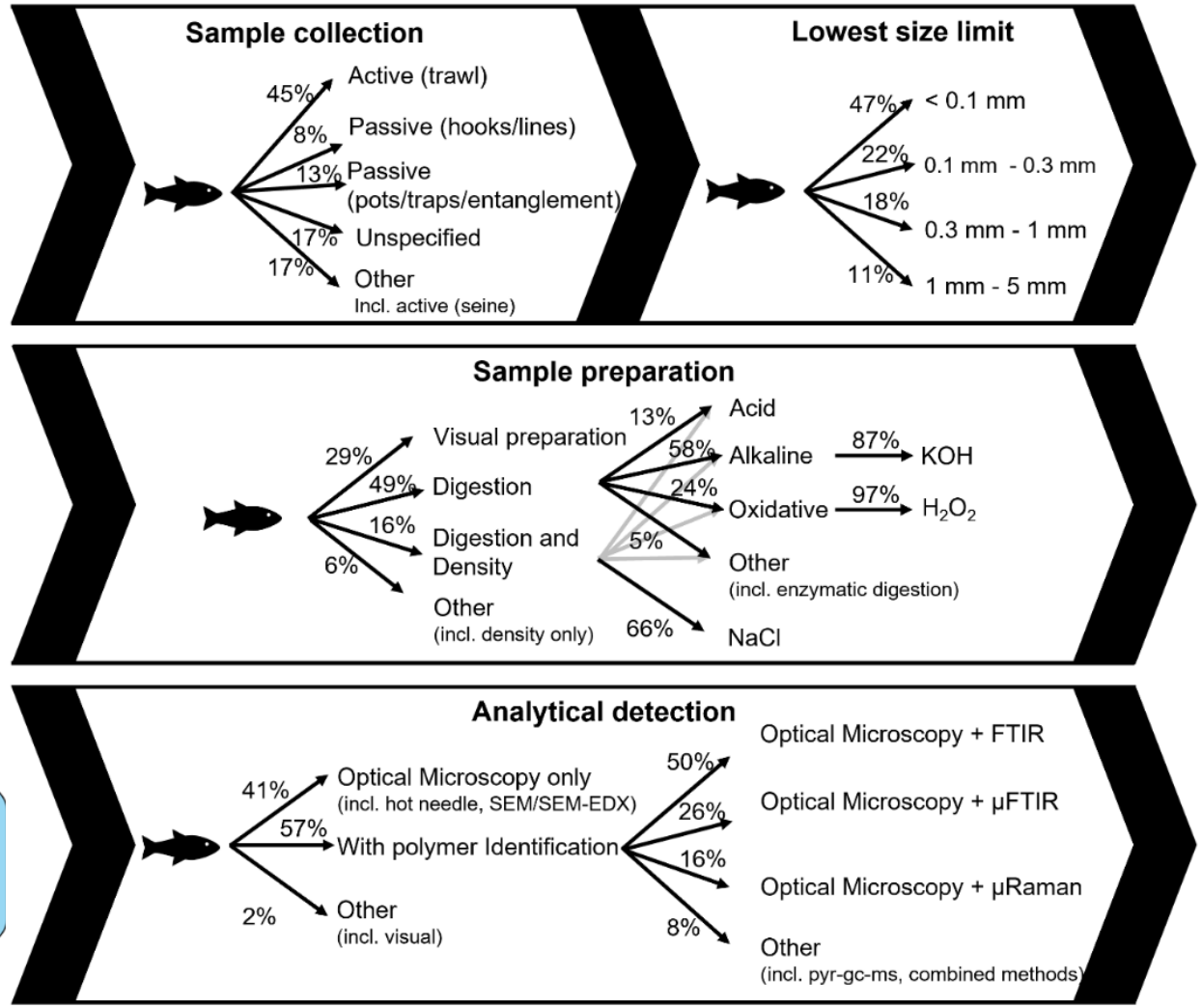
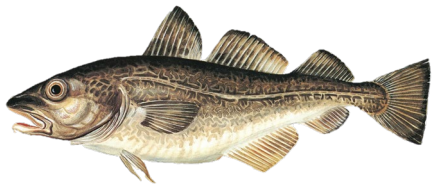


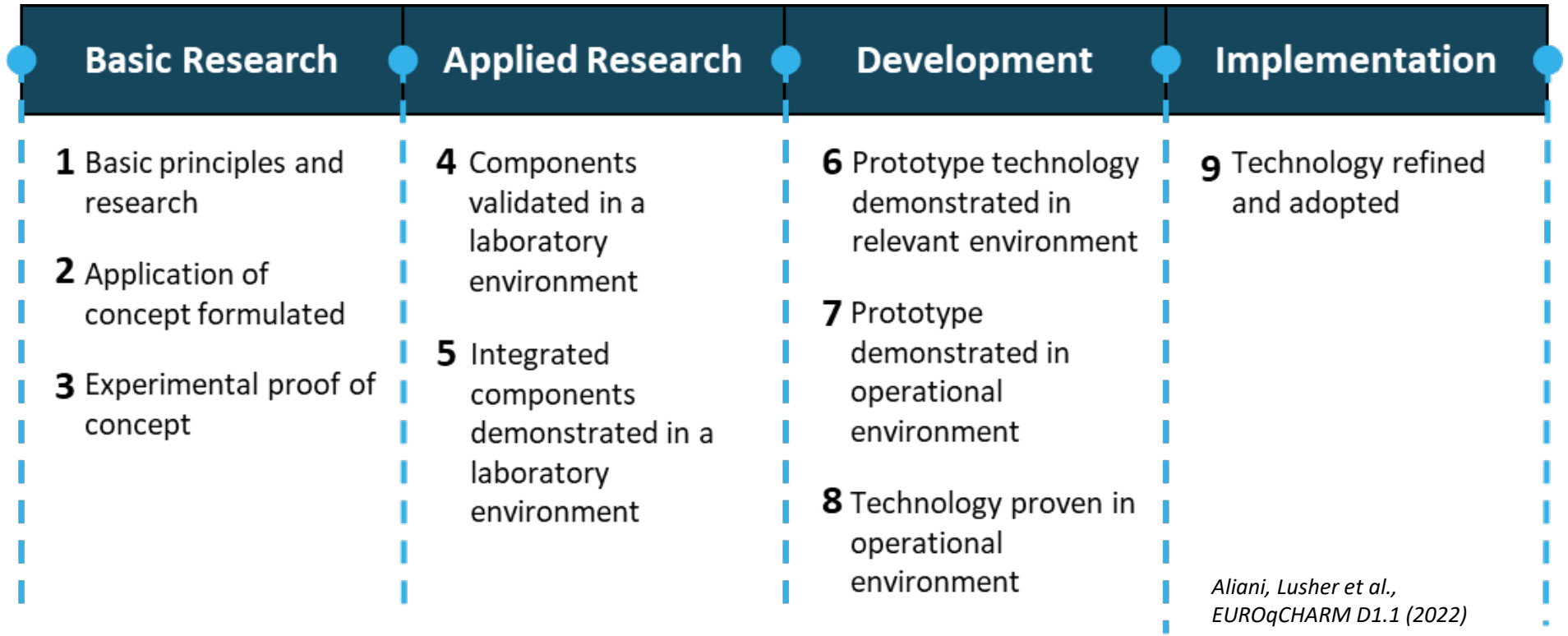




Technological Readiness Level (TRL)

The TRL scale was developed with space technologies in mind where the environment does not change and the more physical the nature of a discipline, the better TRL can be applied .

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



Aliani, Lusher et al., EUROqCHARM D1.1 (2022)

Technological Readiness Level (TRL)

TRL 1
Basic principles presented

TRL 2
Concept and application formulation

TRL 3
- Proof of concept
- Feasibility

TRL 4
- Method validation in the laboratory
- Experimental pilot

TRL 5
- Method validation in a relevant environment
- Demonstration pilot

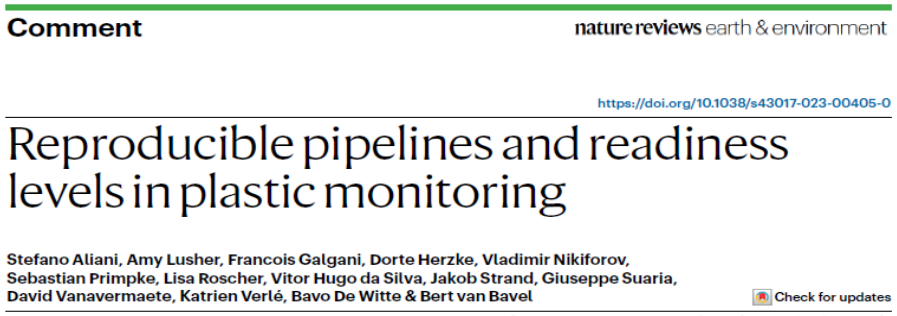
TRL 6
- Demonstration in a relevant environment
- Record(s) of successful applications

TRL 7
- Operations in the environment
- Widely applied in field studies

TRL 8
- Method complete and qualified
- Records of successful monitoring

TRL 9
- Standard protocol enforced and applied
- Widely used for monitoring operations

- Basic Research
- Applied research
- Development
- Implementation


Comment

nature reviews earth & environment

https://doi.org/10.1038/s43017-023-00405-0

Reproducible pipelines and readiness levels in plastic monitoring

Stefano Aliani, Amy Lusher, Francois Galgani, Dorte Herzke, Vladimir Nikiforov, Sebastian Primpke, Lisa Roscher, Vitor Hugo da Silva, Jakob Strand, Giuseppe Suaria, David Vanavermaete, Katrien Verlé, Bavo De Witte & Bert van Bavel

Check for updates

SWOT analysis

Bivalves as a sampling matrix

Strengths

- Mostly sessile organisms, allowing assessment of local pollution
- Wide geographical distribution
- Ingest microplastics
- Social-Economic relevance
- Marine and freshwater bivalves
- Can be caged for site-specific monitoring

Weaknesses

- Not suitable for meso- and macroplastic investigations
- Limited sampling opportunities in open sea
- Only for aqueous environments

Opportunities

- Already used in other monitoring schemes (e.g. MSFD D8)

Threats

- Some species have a poor conservation status, especially freshwater bivalves

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							
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)

EURO CHARM

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 - are often required to obtain scientific data and 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.*

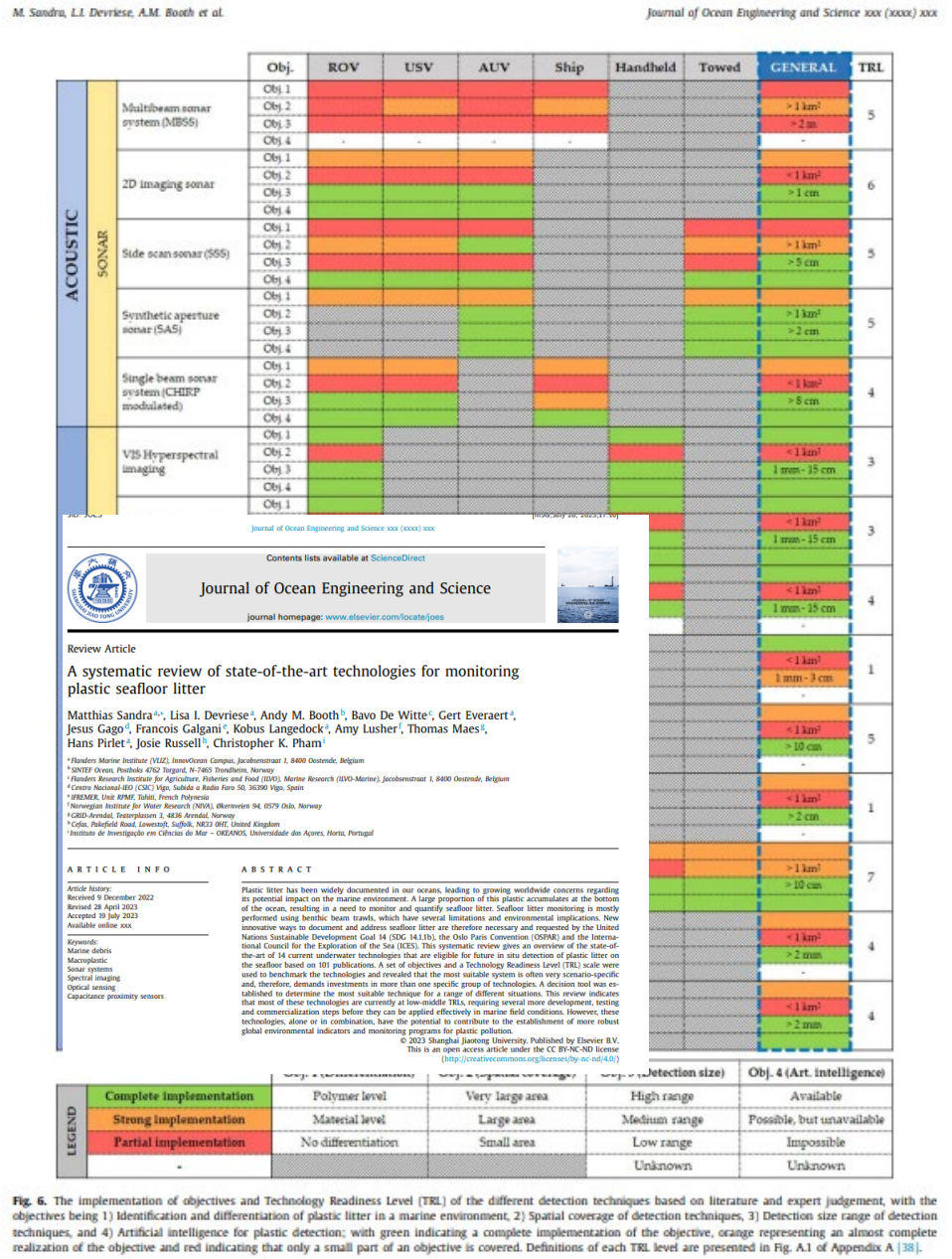
5. **No sample preparation protocol for microplastic particles (addressing also particle <1 mm) has successfully passed a rigorous interlaboratory testing experiment.**

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.

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.



M. Sandra, L.I. Devriese, A.M. Booth et al. Journal of Ocean Engineering and Science xxx (xxxx) xxx

			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								

Journal of Ocean Engineering and Science xxx (xxxx) xxx

Contents lists available at ScienceDirect

Journal of Ocean Engineering and Science

journal homepage: www.elsevier.com/locate/joes

Review Article

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

Matthias Sandra[a,*], Lisa I. Devriese[a], Andy M. Booth[b], Bavo De Witte[c], Gert Everaert[a], Jesus Gago[d], Francois Galgani[e], Kobus Langedock[a], Amy Lusher[f], Thomas Maes[g], Hans Pirlet[a], Josie Russell[h], Christopher K. Pham[i]

[a] Flanders Marine Institute (VLIZ), InnovOcean Campus, Jacobsenstraat 1, 8400 Oostende, Belgium
[b] SINTEF Ocean, Postboks 4762 Torgard, N-7465 Trondheim, Norway
[c] Flanders Research Institute for Agriculture, Fisheries and Food (ILVO), Marine Research (ILVO-Marine), Jacobsenstraat 1, 8400 Oostende, Belgium
[d] Centro Nacional-IEO (CSIC) Vigo, Subida a Radio Faro 50, 36390 Vigo, Spain
[e] IFREMER, Unit RPMF, Tahiti, French Polynesia
[f] Norwegian Institute for Water Research (NIVA), Økernveien 94, 0579 Oslo, Norway
[g] GRID-Arendal, Teaterplassen 3, 4836 Arendal, Norway
[h] Cefas, Pakefield Road, Lowestoft, Suffolk, NR33 0HT, United Kingdom
[i] Instituto de Investigação em Ciências do Mar – OKEANOS, Universidade dos Açores, Horta, Portugal

ARTICLE INFO

Article history:
Received 9 December 2022
Revised 28 April 2023
Accepted 19 July 2023
Available online xxx

Keywords:
Marine debris
Macroplastic
Sonar systems
Spectral imaging
Optical sensing
Capacitance proximity sensors

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. 4 (Art. Intelligence)
LEGEND	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

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].

Thank you for listening

Amy.Lusher@niva.no
@AmieLusher
www.EUROqCHARM.eu

Questions?