

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). This output reflects only the author's view and the European Union cannot be held responsible for any use that may be made of the information contained therein.





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 socioeconomic 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



EUROqCHARM Final Conference, Brussels 11th October 2023

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

EUROqCHARM Final Conference, Brussels 11th October 2023



EUROqCHARM developed and tested a set of solutions

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





RAPs

EUROqCHARM developed and tested a set of solutions

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



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

TRL /SWOT

RAPs





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



🎲 GOV.UK

Data in government

Organisations: <u>Civil Service</u>

Reproducible Analytical Pipelines

Using Data Science for Next-Gen Statistics

3rid Boissetter – Data Scientist. The Office for National Statistics and Dominic Bean – Data scientist. The Office for National Statistics. 14 February 2023 - Data Engineering. Data cience. Other tools. Python. Reproducible Analytical Pipelines

https://ukgovdatascience.github.io/rap_companion/

Bruno Rodrigues

Reproducible Analytical Pipelines Automating the production of statistical reports using DataOps principles.





EUROqCHARM Final Conference, Brussels 11th October 2023

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**.





Some examples of RAPs from EUROqCHARM









Some examples of RAPs from EUROqCHARM









EUROqCHARM Final Conference, Brussels 11th October 2023

Some examples of RAPs from **EUROqCHARM**







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.

Basic Research	Applied Research	Development	Implementation
1 Basic principles and research	4 Components validated in a laboratory	6 Prototype technology demonstrated in relevant environment	9 Technology refined and adopted
2 Application of concept formulated	environment	7 Prototype	
3 Experimental proof of concept	5 Integratedcomponentsdemonstrated in a	demonstrated in operational environment	
	laboratory environment	8 Technology proven in operational	
I	I	environment	Aliani, Lusher et al., EUROaCHARM D1.1 (2022)



EUROqCHARM Final Conference, Brussels 11th October 2023

SWOT analysis

Bivalves as a sampling matrix

Strengths		Weakness	ses
	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	-	Not suitable for meso- and macroplastic investigations Limited sampling opportunities in open sea Only for aqueous environments
Opportuni	ties	Threats	
-	Already used in other monitoring schemes (e.g. MSFD	-	Some species have a poor conservation status, especially freshwater bivalves



Some examples of TRLs from EUROqCHARM

TRL plastic (>1 mm) in biota

	TRL	Survey design	Sample collection	Sample preparation	Analytical detection	Plastic quantification	QA/QC	Data reporting
Basic research	1							
	3							
Applied research	4							
	5	Mammals						
Development	6	Fish, Reptiles			Chemical ID with FTIR (ATR, general and microscopy)			
	7			Alkaline digestion, oxidative digestion				Research protocols
	8							
Implementation	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 🔗

EUROqCHARM Final Conference, Brussels 11th October 2023

Some examples of TRLs from EUROqCHARM

TRL plastic (<1 mm) in biota

	TRL	Survey design	Sample collection	Sample preparation	Analytical detection	Plastic quantification	QA/QC	Data reporting
Basic research	1 2							
Applied research	4				Hyperspectral imaging			
	5	Plants, amphibian			Pyr-GC/MS Fluorometric		Field blanks, Positive controls	
	6	Non-bivalve invertebrates		Enzymatic digestion, acid digestion		h8\8	Air blanks	
Development	7	Bivalves, fish		Alkaline digestion, oxidative digestion, density separation	Optical microscopy, FTIR, μFTIR, Raman, μRaman	Items/individual, items/g, %	Air filtrations systems	
Implementation	8 9		Hand collection, nets, hooks/lines				Procedure blanks	



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.

		Obj.	ROV	USV	AUV	Ship	Handheld	Towed	GENERAL	TE
1		Obj.1			10 A					
	Multibeem soner	Obj.2			And the second				>1 km ²	
	system (MBSS)	Obj.3							> 2 m	
	Obj.4			-				-	1	
		Obj.1	Concernence (Second		1					
	120200000000000000000000000000000000000	Obj.2							< 1 km ²	
	2D imaging sonar	Obj.3			1				>1 cm	
		Cb1.4								1
		Obi 1								1
0.4	- AR	Obi 2							> 1 km ²	
2	Side scan sonar (\$\$5)	Chi 3	100000000000000000000000000000000000000		Conception in			20000000	25/00	
3	ň	Obi 4								
		Obi 1	Concession of the	0.007.07.07.07	Concernation (Concernation)			Same	and the second second	í
	Semiflatic sparture	Obi 2			8				>1km ²	
	sonar (SAS)	Ohi 3			1				>2 cm	
		Chil								
		Obt 1			-					1
	Single beam somar	Chi 2							of Lond	1
	system (CHIRP	Obi 3					-		28.00	
	modulated)	Obu							*o cm	
-	-	001.4								-
	100000 00000	0011	-				-			
	VIS Hyperspectral	0012							- inter-	4
	maging	0013							1 mm-15 cm	-
		061.4								-
J.,	Constraint and the second second	0011				10.00.00y 20, 2020				
A State of the sta	Journ	Contents li al of Ocea journal homepa	ists available at Science n Engineering age: www.elsevier.com	aDirect g and Sc /locate/joes	cience		4.		<11km ³ 1 mm - 15 cm	
view	Journ. Article	Contents li al of Ocea journal homepu	ists available at Science n Engineering age: www.elsevier.com	aDirect g and Sc /locate/joes	cience	to an	-1		<11m ² 1 mm-15 cm	
view	Journ. Article tematic review of sta	Contents li al of Ocea journal homepu ate-of-the-	sts available at Science n Engineering age: www.elsevier.com art technolog	aDirect g and Sc /locate/joes ies for n	cience				<1 km ³ 1 mm - 15 cm <1 km ³ 1 mm - 1 cm	
view sys asti	Journ. Article tematic review of sta c seafloor litter	Contents I al of Ocea journal homepu ate-of-the-	sts available at Science n Engineering age: www.elsevier.com art technolog	aDirect g and Sc /locate/joes ies for n	cience nonitoring	an a			<1 km ² 1 mm-15 cm <1 km ² 1 mm-3 cm	
view sys asti	Journ. Article tematic review of sta c seafloor litter as Sandra**, Lisa L Devrie;	Contents I al of Ocea journal homepu ate-of-the- se ^a , Andy M.	art technolog Booth ^b , Bavo De	aDirect g and Sc /locate/joes ies for n Witte ^c , Ge	cience nonitoring rt Everaert ^a ,	a d			<11mi 1 mm-15 cm <11mi 1 mm-3 cm	
view sys asti	Journ. Article tematic review of stat ic seafloor litter as Sandra ¹⁴ , Lia L. Devrie ago ¹ , Francois Galgani ¹⁴ , Without Heart Jens Berenill, Chein	Contents I al of Ocea journal homepu ate-of-the- se ^a , Andy M. obus Langed	sts available at Science n Engineering age: www.elsevier.com art technolog Booth ^b , Bavo De ck ^a , Amy Lusher	aDirect g and Sc /locate/joes ies for n Witte ^c , Ge f, Thomas	cience nonitoring rt Everaert ^a , Maes ^s ,	a d			<11mil 1mm-15 cm <11mil 1mm-3 cm	
view sys asti us C ns P	Journ. Article tematic review of sta cc seafloor litter as Sandra*, Lisa I. Devrie ago!, Francois Galgani*, K Virtet*, Josie Russel®, Chris	Contents I al of Ocea journal homepu ate-of-the- se ^a , Andy M. obus Langed topher K. Pha	sts available at Science n Engineering art technolog Booth ^b , Bavo De cck ² , Amy Lusher m ¹	iDirect g and Sc /locate/joes ies for n Witte ^c , Ge	cience nonitoring rt Everaert ^a , Maes ^a ,				<1 km² 1 mm-15 cm <1 km² 1 mm-3 cm <1 km² 2 mm-3 cm	
view sys asti atthio ns P nders M	Journ Article tematic review of stt c seafloor litter as Sandra ⁴⁴ , Lisa I. Devrie ago ⁴⁷ , Francois Calgani ⁴⁷ , K Hiret, Jose Russel ¹⁹ , Chris Hiret, Jose Russel ¹⁹ , Chris	Contents I al of Ocea journal homepu ate-of-the- se ^a , Andy M. obus Langedo topher K. Phi axobsenstrat I, 8400	ats available at Science n Engineering age: www.elsevier.com art technolog Booth ¹⁰ , Bavo De cck ²⁰ , Amy Lusher Im ¹ . Countrie, Rejum	eDirect g and Sc flocaterjoes ites for n Witte ^e , Ge	cience nonitoring rt Everaert ^a , Maes ^a ,				<11mm ² 1 mm-15 cm <11mm ² 1 mm-3 cm <11mm ² = 10 cm	
view sys asti atthicus C nns P nders M nders M nders No	Journ. Article tematic review of static cs scafloor litter as Sandra', Lis I. Devrie Sago', Francois Galgani', K. Tritte', Josie Russell', Christ Construction of the static construction of the static static construction of the static	Contents I al of Ocea journal homepu ate-of-the- ate-of-the- bus Langed topher K. Pha axobenetizat 1, 8409 m. Noneog F Fod (100). Martin 6, 36309 Vigo. Spain	ats available at Science n Engineering age: www.elsevier.com art technolog Booth ¹⁰ , Bavo De ckc ¹⁰ , Amy Lusher un ¹ Ocerade, Regium Reverse (INO-Marine), Jacob	aDirect g and Sc //ocate/joes ies for n Witte ^c , Ge (, Thomas senstraat 1, 8400	cience nonitoring rt Everaert ³ , Maes ⁵ ,				<11m ⁷ 1 mm - 15 cm 	
view sys asti us C ns P ders M ders Ra ders Ra	Journa Anticle tematic review of sta c scafloor litter as Sandra ^{1,4} , Lie J. Devrie Argo ¹ , Francois Galgani ¹ , K. Hirte ¹ , Joie Russien, Rienra and Russien, Russien, Russien and Russien, Russien and Russien, Russien and Russien, Russien and Russ	Contents II al of Ocea journal homeps ate-of-the- se ^a , Andy M. obus Langedd topher K. Pha cobsenstrat 1, 840 m. Norway Tool (110), Marther 9, 1650 yeb, Spain	ats available at Science n Engineering age: www.elsevier.com art technolog Booth ^b , Bavo De ckc ^k , Amy Lusher m ¹ Corende, Refum Corende, Refum Way	aDirect g and Sc //ocate/joes ies for n Witte ^c , Ge (, Thomas) senstreat 1, 8400	cience nonitoring rt Everaert ^a , Maes ^a ,				<11mi 1 mm-15 cm - - - - - - - - - - - - - - - - - - -	
riew sys asti us C ns P sters h ttp Octoor to Nate MER (wegian D-Aren D-Aren 2., Pakk	Journ Article tematic review of stat. ice scalloor litter ago', Francois Calgani', K. iret, Jose Reusel', Chris Merker Marker, Marker Merker Marker, Marker Marker, Marker Marker, Marker Marker Marker, Marker Marker, Marker	Contents II al of Ocea journal homepu ate-of-the- se ⁴ , Andy M. obus Langed topher K. Phr obus Langed topher K. Phr obus Langed topher K. Phr obus Langed topher S. Phr obus	ats available at Science n Engineering are technolog Booth ^b , Bavo De' ck ² , Amy Lusher m ¹ Couende, Régum Merueré (NIGO Marite), Jacob vwy	aDirect g and Sc /locate/joes ies for n Witte ^e , Ge (, Thomas eventmant 1, 8400	cience nonitoring rt Everaert ³ , Maes ⁸ , Outende, Relgium				*11m ² 1 mm - 15 cm *11m ² 1 mm - 3 cm *11m ² *10 cm *11m ² *11m ² *2 cm	
riew sys asti atthio us C ns P aders & thro Nate SMER, U wegian 22, Pakker 23, Pakker 24, Pakker 24, Pakker 25, Pakker 26, Pakker 26	Journ. Article tematic review of stst ic seafloor litter as Sandra *, Lis I. Devrie Sago ¹ , Francois Galgani ¹ , K Tritte ¹ , José Russel ¹ , Chris and Sandra *, Lis I. Devrie Sago ¹ , Francois Galgani ¹ , K Tritte ¹ , José Russel ¹ , Chris and Parken State (1974) and	Contents II al of Ocea journal homepu ate-of-the- ses ¹ , Andy M. bobus Langed bobus Langed Food (100). Marite <i>i</i> and <i>i</i> and <i>i</i> and <i>i</i> and <i>i</i> and <i>i</i> and <i>i</i> and <i>i</i> and <i>i</i> and <i>i</i> and <i>i</i> and <i>i</i> and <i>i</i> and <i>i</i> an,	ats available at Science n Engineering age: www.elsevier.com art technolog Booth ¹ , Bavo De ck ² , Amy Lusher m ¹ m ² Beoeth ² , Bavo De ck ² , Amy Lusher m ² m ² wereade, Refers Researd, (Dio Marine), Jacob wer core, Jernag	aDirect g and Sc /locate/joes ies for n Witte ^c , Ge (, Thomas senstreat 1, 8400	cience nonitoring rt Everaert ⁴ , Maes ⁸ , Outende, Relgium				<11m ² 1 mm-15 cm <11m ² 1 mm-3 cm <11m ² >10 cm <11m ² >10 cm <11m ² >10 cm	
riew sys asti us of ns P sters bo ders R ders R der	Journ. Article tematic review of sta c seafloor litter as Sandra ²⁴ , Lisa I. Devrie ago ²⁵ , Francois Calgan ¹ , K. Hiret ¹ , Jose Russel ¹ , Chris Hiret ¹ , Jose Russel ¹ , Chris Harte Index 1, 448 And Andreas and Mithy Mark International Conference and Mark Mark International Conference and Conference and Co	Contents II al of Ocea journal homepu ate-of-the- se ⁴ , Andy M. obust Langed tobust Langed tobust Langed obust Anged Science (Content) Fried (100), Marite a Science (Content) Fried (100), Marite a Science (Content) Fried (100), Marite (Content),	ats available at Science n Engineering art technolog Booth ¹⁰ , Bavo De ock ¹⁰ , Bavo De ock ¹⁰ , Any Lusher Im ¹ Ocerede, Rejtan Researd, Rojtan Researd, Horn, Jond	sDirect g and Sc /locate/joes ites for n Witte ^c , Ge (, Thomas senstreat 1, 8400	cience nonitoring rt Everaert ³ , Maes ⁴ , Outmde, Régum				<11mi 1 mm-15 cm - - - - - - - - - - - - - - - - - - -	
riew sys asti us C ns P aders & tro Note tro Note Note tro Note tro Note tro Note tr	Journ Article tematic review of stat. ice scalloor litter as Sandra ^{1,1} , Lis 1. Devrie ago ¹ , Francois Calgan ¹ , K. Urter, Ljose Revelle ¹ , Chris Form Instein, Velle June Verstein Reviewen and State S	Contents II al of Ocea journal homepu- ate-of-the- se ² , Andy M. bobus Langed topher K. Pha makenetizet J. 8400 m. Ninow, Spain Content of Content of Content a JSEO Work, Spain Content of Content of Content Science (Content of Content of Content Science (Content of Content of Content Science (Content of Content of Content of Content Science (Content of Content	ats available at Science n Engineering art technolog Booth ^b , Bavo De' ck ² , Amy Lusher m ¹ Ocerneic, Rigtum Reventi, Riston Marine, Jacob way r	aDirect g and Sc /locate/joes ies for n Witte ^c , Ge ¹ , Thomas	cience nonitoring rt Everaert [*] , Maes [*] ,	-			<pre>*11m² 1 mm-15 cm - - *11m² *11m² *10 cm - - *11m² *2 cm - - - *11m²</pre>	
view sys asti us C ns P ders M ders M	Journ. Article tematic review of stat. ice scafloor litter as Sandra *, Lis I. Devrie Sago ¹ , Francois Galgani ¹ , K. Thite', José Russel ¹ , Chris Sago ¹ , Francois Galgani ¹ , K. Thite', José Russel ¹ , Chris and Michael Sandra (1998) and Sand	Contents in all of Occea journal homepu atte-of-the- se ⁴ , Andy M. obust Langed topher K. Pha boshoment for a stranged topher K. Pha boshoment for a stranged to the stranged K. Universided et al. A B S T R A C Passic listic Passic listic mark	ats available at Science n Engineering are technolog Booth ³ , Bavo De' Ack ³ , Amy Lusher m ¹ Occerde, Réglum Resorts (100-Merine), Jacob very over, Horen, Forngal r en, woldty documented in	aDirect g and Sc /locate/joes ies for n Witte ^c , Ge ^f , Thomas senstroat 1,8400	cience nonitoring rt Everaert ⁴ , Maes ⁶ , stjaar Outrad, stjaar	dvide concerns, reg			4 11mi 1 mm-15 cm - - - - - - - - - - - - - - - - - - -	
riew sys asti utthi. us O ns P aders M dres A dres	Journ. Article tematic review of stat cs scalloor litter as Sandra ²⁴ , Lisa I. Devrie ago?, Francois Calgani, K. Trett, Jose Russell, Chris Hirtel, Jose Russell, Chris Hirtel, Jose Russell, Chris Mark, Marken Mark, Sandra Jose Mark, Marken Mark, Sandra Jose Harten Internet Christian and Christian del Tarbiguest 1, 488 Article Nation del Tar	Contents in all of Occaa journal homepu atte-of-the- the- the- the- the- the- the- the-	ats available at Science In Engineering art technolog Booth ¹⁰ , Bavo De occ*, ² Amy Lusher Im ¹ Oceracie, Régum Revarde (2000 Marine), Jacob way grees, Herts, Portugal r en widdy documented in on the automemory for	aDirect g and Sc /locate/joes ies for n Witte ^c , Ge ⁽ , Thomas senstruat 1, 8400	cience nonitoring rt Everaert ³ , Maes ¹ , Ournde Region	devide concerns rep			<11m ² 1 mm-15 cm - - - - - - - - - - - - - - - - - - -	
view sys asti asti into de EMER a bolarn into de tro Nois EMER a tro Nois E tro Nois E T	Journ. Article tematic review of str. ic scalloor litter as Sandra ^{1,1} , Lis 1, Devrie to scalloor litter ago', F, narce is calgani ¹ , K. Harris M. (1997). And Sandra Sandra ago, J. Jance is calgani ¹ , K. Harris M. (1997). And Sandra Sandra Martinet, Jose Review 1997). And Tarrison A. (1997). And Tarrison A. (1997)	Contents In al of OCcea journal homepu atte-of-the- se ² , Andy M. obust Langed tobust	ats available at Science In Engineering age: www.elsevier.com art technolog Booth ⁵ , Bavo De ckc ⁴ , Amy Lusher m ¹ Deck ⁴ , Amy Lusher m ¹ www.elsevier.jusher ensemble december of the science www.ensemble december of the science rest widely documented in the switching in the market switching document of the different science and the switching document of the different science the switching document of the switching document of the switching document of th	Direct g and Sc Accate/joes ies for n Witte ^c , Ge ⁴ , Thomas senstroot 1, 8400	cience nonitoring rt Everaert [*] , Maes [*] , Ouonde, Région	devide concerns rep eccemulates at the representation of the representation of the representation of the representation of the representation of the representation of the repre			<pre><11m7 1mm-15 cm </pre> < 11m7 1mm-3 cm < 11m7 > 10 cm < 2 cm > 11m7 > 10 cm > 10 cm > 10 cm	
riew sys asti atthiu us C ns P aders & tro Naie EMER (D-Aren Sa, Pikk into de s attro Naie EMER (C Sa, Sa tro Naie EMER (C Sa tro Naie E Sa tro Naie E Sa Sa Sa Tro Naie E Sa Sa Sa Sa Tro Naie E Sa Sa Sa Sa Sa Sa Sa Sa Sa Sa Sa Sa Sa	Journa Anticle tematic review of sta cs scalador litter as Sandra ¹⁴ , Lis I, Devrie Gago, ¹ , Francois Galgari ¹ , K Hiret, ¹ , Jose Raudone Gengu, ¹ Hirtet, ¹ Jose Raudone Compute and the state of the st	Contents In al of OCcea journal homepu ate-of-the- se', Andy M. obous Langed topber K. Phi- methylic and the second methylic a	ats available at Science n Engineering are twown.elsevier.com art technolog Booth ³ , Bavo De Cck ² , Amy Lusher mi Ocaende. Brigum Resort (2020-Merine), Jocob wwy core, Horta, Portugal r en widely documented in on the factor, Writh document, Brita, Portugal	ADirect g and Sc ilocate/joes ies for n Witte ^c , Ge , ¹ Thomas wristriant 1, 8400 our ecoans, loo n, A large program and quantify se how several life for a ret information of the set information of the set	cience nonitoring rt Everaert [*] , Maes [*] , oursed, kejson adag to growing work	Avide concrets rep concretions at the 5 metal implication of regented by the (0000), and the 1			<11mi 1 mm-15 cm · · · · · · · · · · · · · · · · · · ·	
view sys asti atthio us C msers Mattro Nai Mattro Nai M	Journ Article tematic review of stat to scalador litter as Sandra ¹⁴ , Lisa I. Devrie ago ¹⁶ , Francois Calgan ¹⁴ , K. to scalador litter as Sandra ¹⁴ , Lisa I. Devrie ago ¹⁶ , Francois Calgan ¹⁴ , K. Hirt ¹ , Jose Russel ¹⁸ , Artis teris Instant, Artis and Artis and Mithel Coll Tangato and Artis and Artis and Artis and Artis and Artis and Artis and Artis and Artis and Artis Arti	Contents In al of OCcea journal homepu ate-of-the- ie', Andy M, obus Langed topher K, Phi And Content and Anno Annowski	ats available at Science an Engineering art technolog Booth ¹⁰ , Bavo De occ*, ² Amy Lusher Im ¹ Ouerade, Régum Revarde (RIO-Marine), Jacob way gaves, Herts, Pengal r en widdy documented in one track, Weith	Direct g and Sc flocate/joes ies for n Witte -, Ge , Thomas westraat 1,8400 our occans, lot the stage prop and quantify as the stage prop and the stage prop and the stage prop and quantify as the stage prop and quanti	cience nonitoring rt Everaert*, Maes*, Ournel, Rejun	decide concerne rep economicante e la concerne de l	anding monthy here or a second s		<11m ² 1 mm-15 cm - - - - - - - - - - - - - - - - - - -	
view syss asti atthic us O ns P nders & cas P addrs & BMR (us O ns P nders & cas P addrs & BMR (us O ns P nders & cas P addrs & cas P nders	Journ. Article tematic review of stat. (cs scalloor litter as Sandra*, Lisa I, Devrie (cs scalloor litter) as Sandra*, Lisa I, Devrie (cs scalloor litter) as Sandra*, Lisa I, Devrie (cs scalloor litter) as Compared and Compared and Compared (cs (cs (cs hordown), Compared and Compared (cs (cs hordown), Compared and Compared (cs (cs hordown), Compared and Compared (cs (cs hordown), Cs (cs hordown),	Contents In al of OCcea journal homepu atte-of-the- se ⁴ , Andy M. obous Langed bous Langed bous Langed bous Langed bous Langed to A distantiation in Reveal in 84 other attesting the second in 84 ot	ats available at Science n Engineering are technology Booth ⁵ , Bavo De bck ⁴ , Amy Lusher m ¹ m ² core, Hora, Portgal r enwide's documented in way core, Hora, Portgal r enwide's documented in the analytic of the Sol Development Coal 14 (Sol Development Coal 1	Direct g and Sc and Sc and Sc and Sc ies for n Witte ^c , Ge ⁽ , Thomas and quantify a and quantify a and quantify a interval 1,8400 our occass, leg ⁽ , 1000) ⁽ , 1000)	cience nonitoring rt Everaert*, Maes*, Oomdo, Adjun abege to growing work abege to growing work abege to growing and abege to growing a	Ander concerner rep accession of the second second second construction of the second second second term of the second second second second (COSNN) and the Is overview of the second second second second control (COSNN) and the Is overview of the second second second second second second second second second second second second second second second se			<11m ² 1 mm - 15 cm 	
view syss asti atthic us O ns P nders & maders & wegins finto bde kinto bde t T I 1 de histor the bistor the b	Journa Article tematic review of sta cs scafloor litter as Sandra ²⁴ , Lisa I. Devrie Gago ²⁵ , Francois Galgan ¹ , K. Tiret ¹ , Jose Russel ²¹ , Chris Hirt ¹ , Jose Russel ²¹ , Chris Harte Index (122), Imarches Galgan ² , K. Tiret ¹ , Jose Russel ²¹ , Chris Harte Index (122), Imarches Calgan ² , K. Tiret ¹ , Jose Russel ²¹ , Chris Harte Index (122), Imarches Calgan ² , K. Tiret ¹ , K. And Christophiller, M. Christophiller, M. Christophiller, M. Christophiller, M. Christophiller, M. Christophiller, M. Christophiller, M. Christophiller, M. Christophiller, M.	Contents In all of OCcea journal homepo atte-of-the- se', Andy M., obous Langed topher K. Phr schematiker, Phr Hoff (TD), March 1, 520 Vol. 5, 200 A B S T R C C A B S T R C C C C A B S T R C C C C C C C C C C C C C C C C C C	ats available at Science an Engineering art technolog Booth ^{1,1} , Bavo De Cock ² , Amy Lusher m ¹ Ocernic, Rejam Resourch (200-Merine), Jocob www www cares, Herns, Horngal r envidely documented in one in a ande services r envidely documented in one in a safet services construct rechnologe r envidely documented in on the a safet services document and address us to probability and a services and a structure rechnologies to in publication. A set on public	aDirect g and Sc (locater)oes ites for n Witte', Ge (, Thomas and quartify es and quartify es and quartify es base several lifetor inter are 1 (kt2). This system that are eligible to directive a procession of a constant of the several manufactor of the several s	cience construction constructio	devide concerns reg excerns the resolution of the second transmission of the second second second devide concerns reg excerns the second second second devide concerns reg excerns the second second second second devide concerns reg excerns the second second second second devide second second second second second devide second second second second second second devide second second second second second devide second second second second second second devide second s			4 11mi 1 mm - 15 cm - - - - - - - - - - - - - - - - - - -	
view Syss asti tribus Conservations inter Market Syss asti tribus Conservations and the Market System and Conservations and the Market System and Conservations and the Market System and Conservations and the Market System and Conservations and Co	Journ. Article tematic review of stat. ics scalloor litter as Sandra ^{1,4} , Lis I. Devrie ago ^{1,4} , Francois Calgan ^{1,4} , K. Hite ^{1,4} , Jose Russel ^{1,4} , Ortho Barbach Parlos (2019), Charlos territorita (2019), Charlos territor	Contents In al of OCcea journal homepu ate-of-the- se', Andy M, obus Langed topber K, Phi- ne Mangara ater and the second topher K, Phi- ne Mangara S, Short S, Salar A B STRAC The STRAC The STRAC A STRAC	ats available at Science an Engineering art technolog art technolog bock ² , Amy Lusher m ¹ Doarde, Rigum Research (RIVO-Marine), Jacob way cores, Horts, Portugal r widdy documented in dollers are overshowned and address are in a need to monitor static factor of the Sal	aDirect g and Sc //ocate/joes ies for n Witte ^c , Ge /, Thomas weistraat 1, 8400	cience nonitoring rt Everaert ² , Maes ² , Ournel, Rejum ander the second secon	devide concerns rep comulates at the constraints of the second (CBAN) and the la (CBAN) and the la (CB	Anting the second		4 11m ² 1 mm-15 cm - - - - - - - - - - - - - - - - - - -	
view Syss asti us Conserved MEF Oco ders Marter MEF Oco ders Mef Oc	Journe Antide Control to the second second control of the second	Contents In al of OCcea journal homep: http://www.com/occean acceanting/files/ accea	ats available at Science an Engineering art technology art technology Booth ³ , Bavo De ock ³ , Any Des Ack ³ , Amy Lusher m ¹ Ocerada, Régun Neurard (IIIO-Marine), Jacob way overs, Hora, Jordgal r en widely documented in word and the Spatian science of the Sol of	Direct g and Scotterion ies for n Witter's Ge f, Thomas witter is a special direct and construct is a special direct the special direct special specia	cience nonitoring rt Everaert ⁴ , Maes ⁶ , Outrad, Mjan dig to growing work about the software about the software back of the software software back of the software back of the	dvide concern rep termination of the second second second termination of the second second second second second repeated by the second second second second second second repeated by the second second second second second second repeated by the second second second second second second second second sec	arding the second		4 11mi 1 mm-15 cm - - - - - - - - - - - - - - - - - - -	
view sys asti atthio atthio asti atthio asti atthio atthio asti atthio asti atthio atthio asti atthio atthi	Journ. Article tematic review of stor ice scaffoor litter as Sandra ^{1,4} , Lisa I. Devrie Sayo ^{1,4} , Francois Galgan ^{1,4} , K Hert ¹ , Jose Russel ¹ , Chris Hert ¹ , Jose Russel ¹ , Chris Hert ¹ , Jose Russel ¹ , Chris Hert ¹ , Sandra ^{1,4} , Valo Rush Andra Martine, Sandra ^{1,4} , Valo Rush Hert ¹ , Jose Russel ¹ , Chris Hert ¹ , Sandra ^{1,4} , Valo Rush Hert ¹ , Kangal ^{1,4} , Valo Rush Hert ^{1,4} , Valo Rush Hert ^{1,4} , Valo Rush Hert ^{1,4} , Valo Rush Hert ^{1,4} , Kangal ^{1,4} , Valo Rush Hert ^{1,4} ,	Contents In al of OCcea journal homepo atte-of-the- se', Andy M., Obous Langed topher K. Phr Bobus Lan	ats available at Science an Engineering art technolog Booth ^{1,0} , Bavo De Morth ^{1,0} , Bavo De Morth ^{1,0} , Bavo Les Cottante, Reguan Research (2004 Merine), Jonot www www www www www www www w	Applied g and Scotterior lies for n Witter', G thomas Witter', Thomas Witter', Thomas Witter', Law Witter', L	cience construction constructio	devide concerns rep exceeding of the concerns of the concerns of the concerns of the concerns of the concerns of the concerns of the concerns of the concerns	anding the second secon		4 11mi 1 mm - 15 cm - - - - - - - - - - - - - - - - - - -	
view sys astii atthia sus D ins P ins of the surron Name surron Na	Journ. Article tematic review of stat cs scalloor litter cs scalloor litter as Sandra ²⁴ , Lisa 1. Devrie ago ²⁶ , Francois Calgan ¹⁴ , K Hiet ¹ , Jose Russel ²⁸ , Chris Hert ¹ , Jose Russel ²⁸ , Chris Arte instance (VIZ). Innotores (argun, 14 Hiet ¹ , Jose Russel ²⁸ , Chris Hert ¹ , Jose Russel ²⁸ , Chris Hert ¹ , Horte Russel ²⁸ , Chris Hert ¹ , Kallen Kallen, 14 Hiet ¹ , Kallen Hert ¹ , Kall	Contents In al of OCcaa journal homepo atte-of-the- ex-, Andy M., Obous Langed tophore K. Phr. Books La	ats available at Science an Engineering art technolog Booth ¹ , Bavo De Key, Any Lusber Im ¹ Oarnde, Rejam Research (1020-Marine), Jacob way way way way way art, Hens, Parngal r en woldy documented in on the anale sensities the technologies and available the technologies and available the technologies and available the technologies are correspondent the technologies are correspondent technologies are correspondent and in constantial the host sensities are and and the sensities on the technologies and available technologies are correspondent technologies are correspondent technologies and available technologies and available technologie	Applied g and Scotterion and Scotterion disc for n Witter', G Thomas wester 1, 8600 wester 1, 86000 wester 1, 86000 wester 1, 86000 wester 1, 86000	cience constructions construct	devide concerns rep eccemations and the second seco	anding the second secon	an size)	<pre><11mi 1 mm-15 cm - - - - - - - - - - - - - - - - - - -</pre>	
view syss astri mthio sysse intro Naio system into de historia is yeste trained de the historia is yeste trained de trained de train	Journ. Article tematic review of stu cs scalloor litter as Sandra ^{1,4} , Lisa I. Devrie ago ^{1,4} , Francois Calgan ^{1,4} , K. Hitt ¹ , Jose Russel ¹ , Actin terristick, Actin terristick, Terristick, Actin terristick, Actin t	Contents In al of OCcaa journal homepo atte-of-the- se', Andy M., bobus Langed hobbus	ats available at Science an Engineering art technolog art technolog Booth ¹⁰ , Bavo De ck ²¹ , Any Lusher Im ²¹ Ocarade, fagual Reverse, furba Marine, Jacob way way cores, Horts, Purtgal r en widely documented in the materie avoid science restrict and sciences and restrict and restri	Applied the second seco	cience nonitoring rt Everaert*, Maes*, Ourned. Rejuin affinite provide statution affinite aff	Ander cancernt rep commission of the second	anting the second secon	m size)	(1)mi 1 mm-15 cm - - - - - - - - - - - - - - - - - - -	
view syss astii taus C madens & tron Nais madens & tron Nais tron Naistron	Journ. Article tematic review of stat. ice scalloor litter as Sandra ^{1,4} , Lis I. Devrie ago ^{1,4} , Francois Calgan ^{1,4} , K. Hitt ¹ , Jose Russel ¹ , Chris Bernheit (1997), Bernheit (1997), Bernheit Bernheit (1997), Bernheit Hitter (1997), Bernheit Hitter (1997), Bernheit Bernheit (1997), Bernheit Bernheit (1997), Bernheit Bernheit (1997), Bernheit Bernheit (1997), Bernheit Bernheit Bernheit (1997), Bernheit Bernheit Bernheit Bernheit Bernheit (1997), Bernheit Bernhei	Contents I al of OCcea journal homepu atte-of-the- set', Andy M. obsus Langed bobus Langed to the set of the content in Newsy in Newsy in Sector 19, 1990 in Sector 1990, Nature in Sec	ats available at Science an Engineering are twown elsevier com- art technology Booth ⁵ , Bavo De bck ² , Amy Lusher m ¹ Booth ² , Bavo Lusher m ¹ Research Regim Research Regim Research Regim are statistic and the science research and the	And the second s	cience nonitoring rt Everaet*, Maes*, Ouende, Rijken afort a proving work for the second of the seco	Andre concerns rep eccentration of the second second second term of the second second second second second (SOPAN) and the Is operating the second second second second second (SOPAN) and the Is operated by the second second second second second second second second second second second second second second second se	Anting the second secon	on size)	<1 km ² 1 mm - 15 cm <1 km ² 1 mm - 15 cm <1 km ² > 10 cm <1 km ² > 20 cm <20 cm <20 cm <20 cm <20 cm	linges wails
view sys asti atthia us of the system of the	Journ Anticle Conserved of state conserved of state	Contents I al of OCcea journal homeps atte-of-the- se', Andy M. obus Langed bobus Langed to the second second n, Norway Contentiant I. How Second N. Statistic Second N. Statistic Second Secon	ats available at Science In Engineering are technology Booth ³ , Bavo De ock ³ , Any Des Ch ² , Any Lusher Int are technology Booth ³ , Bavo De ock ³ , Any Lusher Int are available (are technology are them for the order technology order, Hern, Jongal T T T T T T T T T T T T T	All the second s	cience nonitoring rt Everaert*, Maes*, Outnob. Bijam dig to growing word able the safety of the safe	Ander concern reported in the second	anding the second secon	on size) po sn size) ze ze	4 1 km ² 1 mm - 15 cm - - - - - - - - - - - - - - - - - - -	vvaila e

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. A1 of Appendix A [38].



Thank you for listening

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

Questions?



