Water and Environment Support
in the ENI Southern Neighbourhood region

Activity: WES N-E-DZ-1

Training on marine litter monitoring & mitigation

Introduction to marine litter monitoring & overview of the state-of-the-art methods

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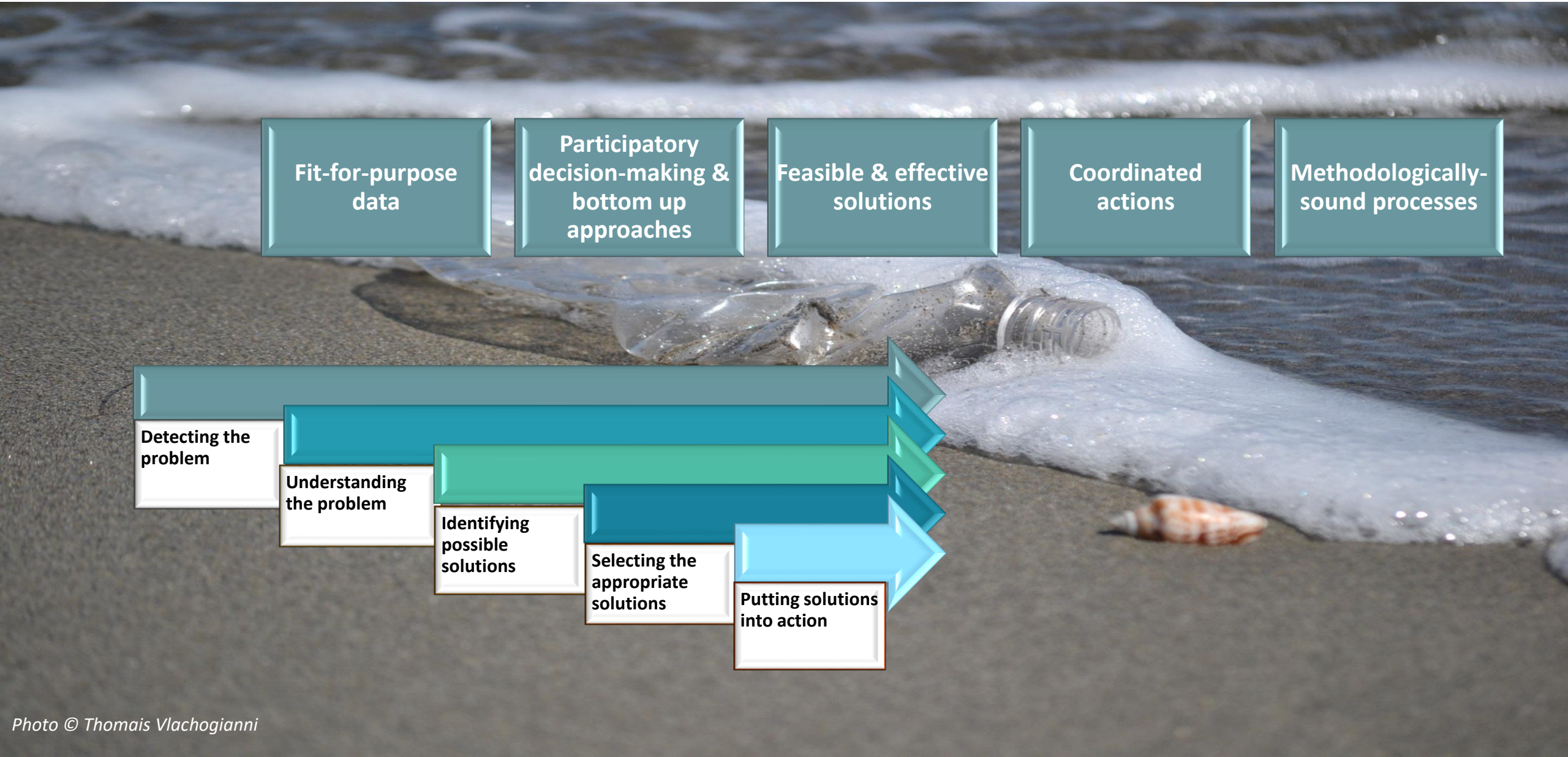
LDK Consultants Global EEIG

This Project is funded by the European Union

MARINE LITTER MONITORING WITHIN THE SCOPE OF THE MANAGEMENT CYCLE OF MARINE LITTER



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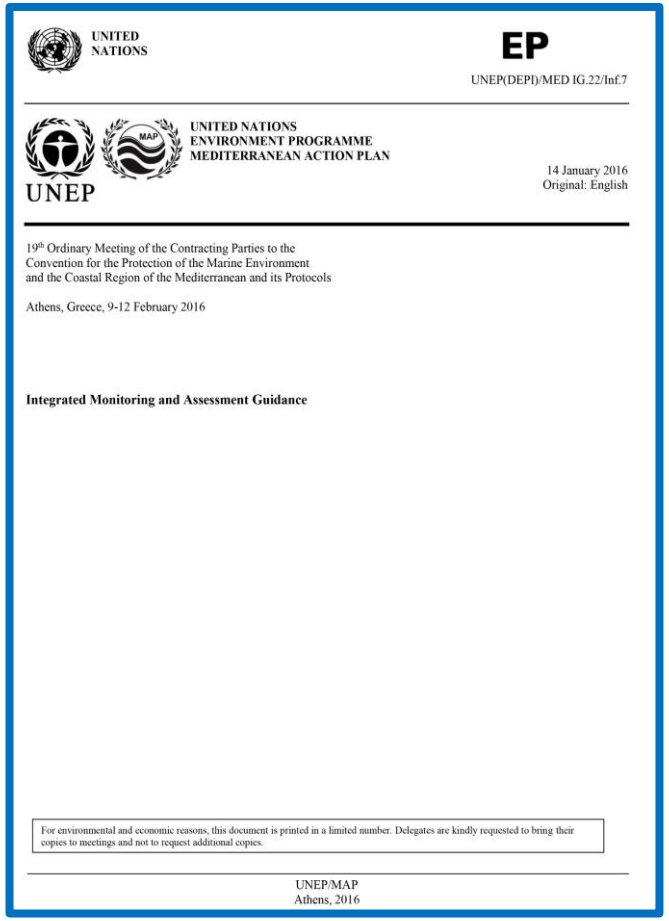
MARINE LITTER MONITORING & KEY LEGISLATIVE FRAMEWORKS

Water and Environment Support
in the ENI Southern Neighbourhood region

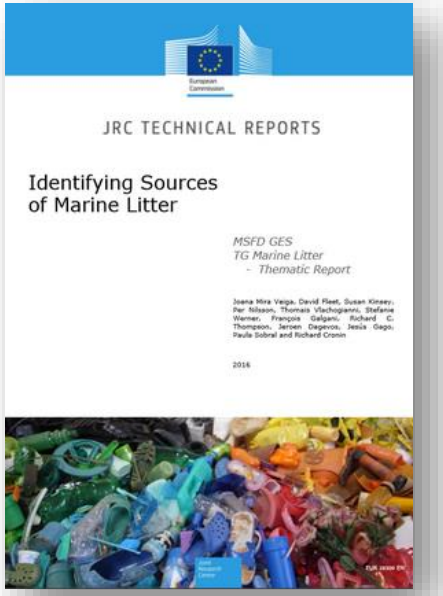
KEY LEGISLATIVE FRAMEWORKS

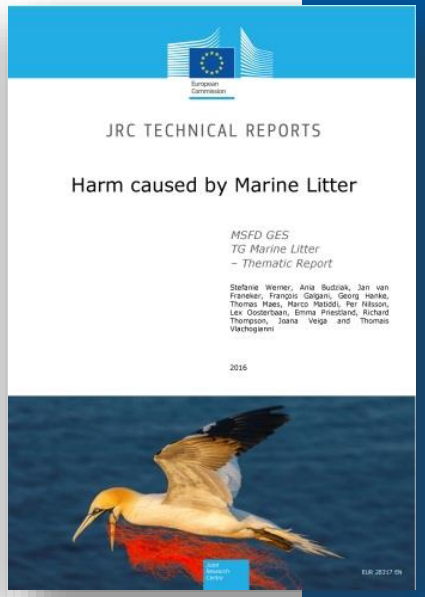
EU	Barcelona Convention
Marine Strategy Framework Directive	Ecosystem Approach
Plastics Strategy	Regional Plan for Marine Litter Management in the Mediterranean
Single-Use Plastics Directive	

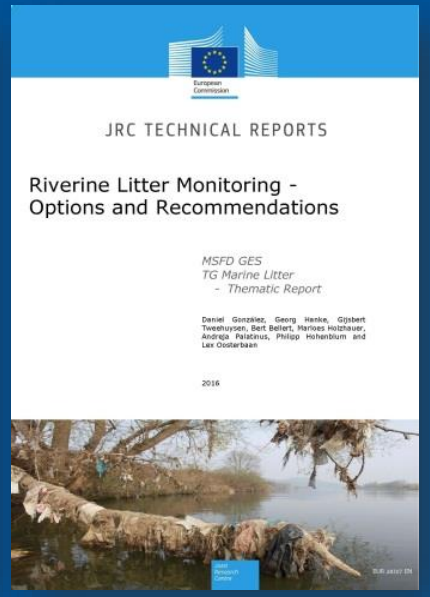
KEY MARINE LITTER MONITORING GUIDELINES

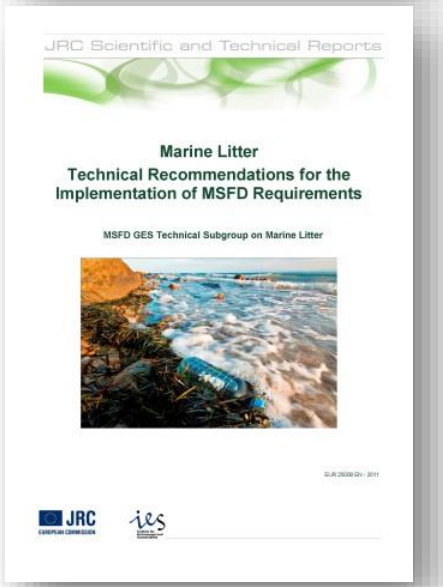


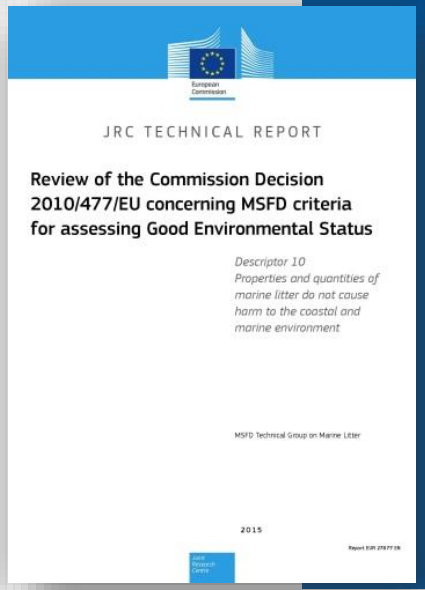
MSFD GES TECHNICAL GROUP ON MARINE LITTER



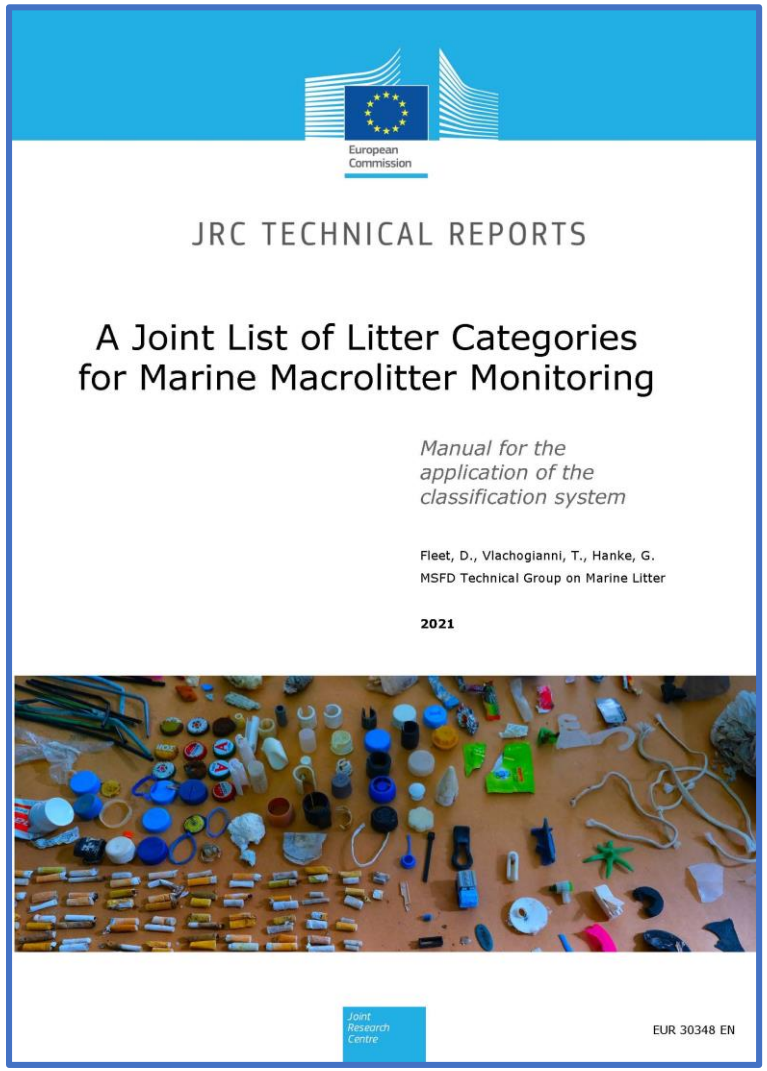








THE JOINT LIST OF LITTER CATEGORIES



WHAT IS MONITORING

Water and Environment Support
in the ENI Southern Neighbourhood region

Monitoring is a **long term, standardized** measurement, observation, evaluation and reporting of the environment in order **to define status** and **trends**.

Marine litter monitoring aims to provide information on the **types, quantities, distribution** and **impacts** of marine litter; to **identify the sources** of marine litter; and to **assess the effectiveness of management measures** to address the issue.

KEY TERMS & DEFINITIONS…

Survey

The process of **recording data** related to a **sampling unit** at a given time.

Survey site

A **section of coast, sea surface or seafloor** chosen for placing one or more sampling units.

Monitoring campaign

The long-term process of carrying out one or more surveys in one or more survey sites with a certain frequency and within a given time period.

Monitoring method

A detailed description of the **procedural method** for monitoring marine litter pollution, including a classification list of litter types.

Macrolitter

Litter items **larger than 25 mm** in the longest dimension, with no set upper limit.

Mesolitter

Litter items **from 5 mm to 25 mm** in the longest dimension.

Microlitter

Litter items **smaller than 5 mm** in the longest dimension, with no set lower limit

MONITORING & ASSESSMENT OF MARINE LITTER

- Beach
- Sea surface
- Seafloor
- Biota

MACROLITTER ITEMS > 2.5 CM

MICROLITTER ITEMS < 0.5 CM

Fit-for-purpose data → Comparable data → Reliable data

MAIN MONITORING METHODS FOR MARINE MACROLITTER

Methodology for monitoring MACROLITTER on the beach

Monitoring MACROLITTER on the seafloor with visual census

Methodology for monitoring MACROLITTER on the sea surface

Methodology for monitoring MACROLITTER on the seafloor with bottom trawl surveys

MAIN MONITORING METHODS FOR MARINE MICROLITTER

Beach sediments

Sea surface

Seafloor sediments

Biota

MARINE MACROLITTER MONITORING | KEY ELEMENTS

- **Monitoring Strategy**
  - Site selection
  - Frequency & timing
  - Sampling unit
- **Survey Protocols**
  - Litter ‘sampling’
  - Litter size classes & classification
  - Litter removal & disposal

THE JOINT LIST:
A LIST FOR ALL MARINE COMPARTMENTS

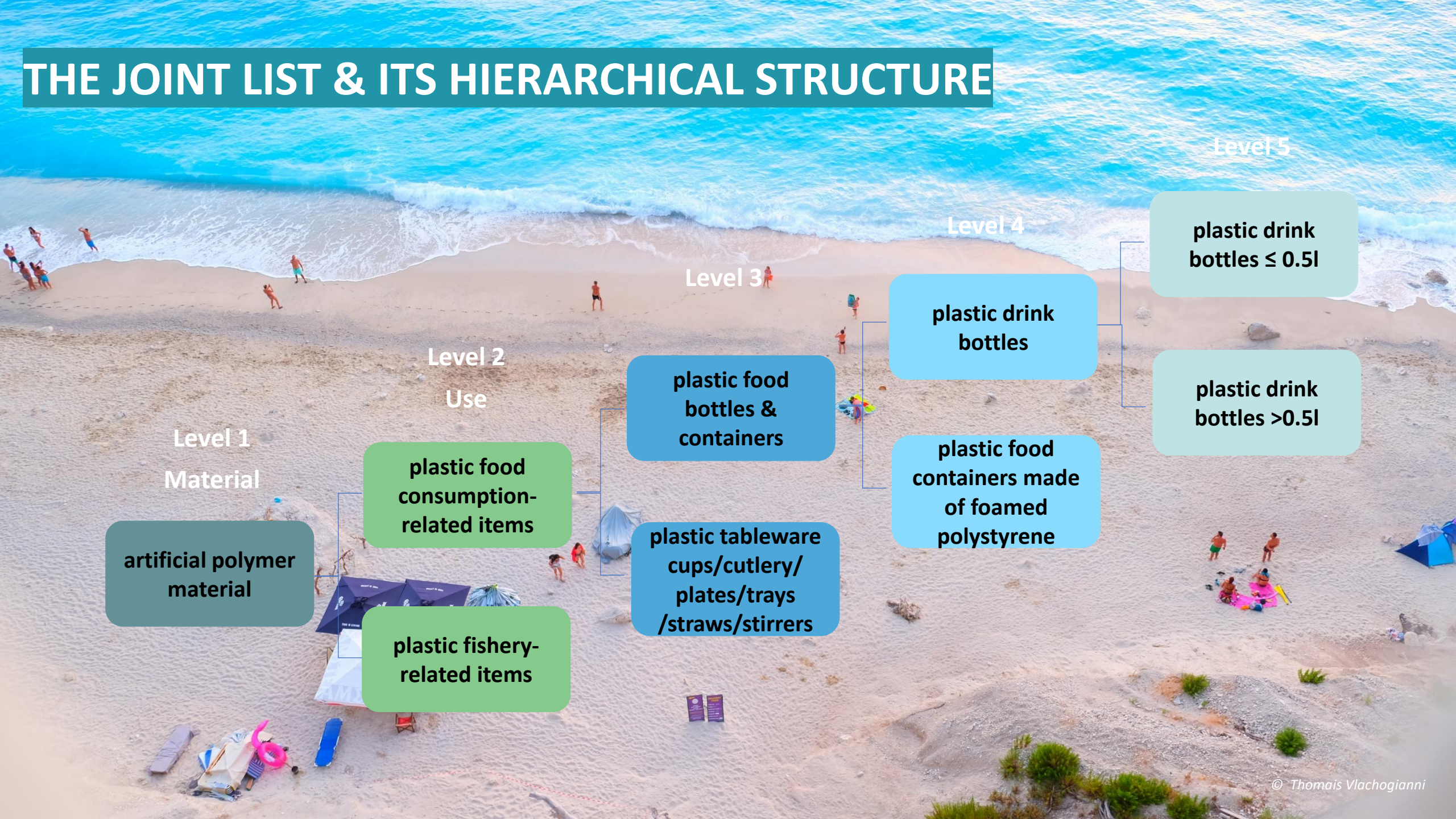
Beach

Sea surface

Seafloor

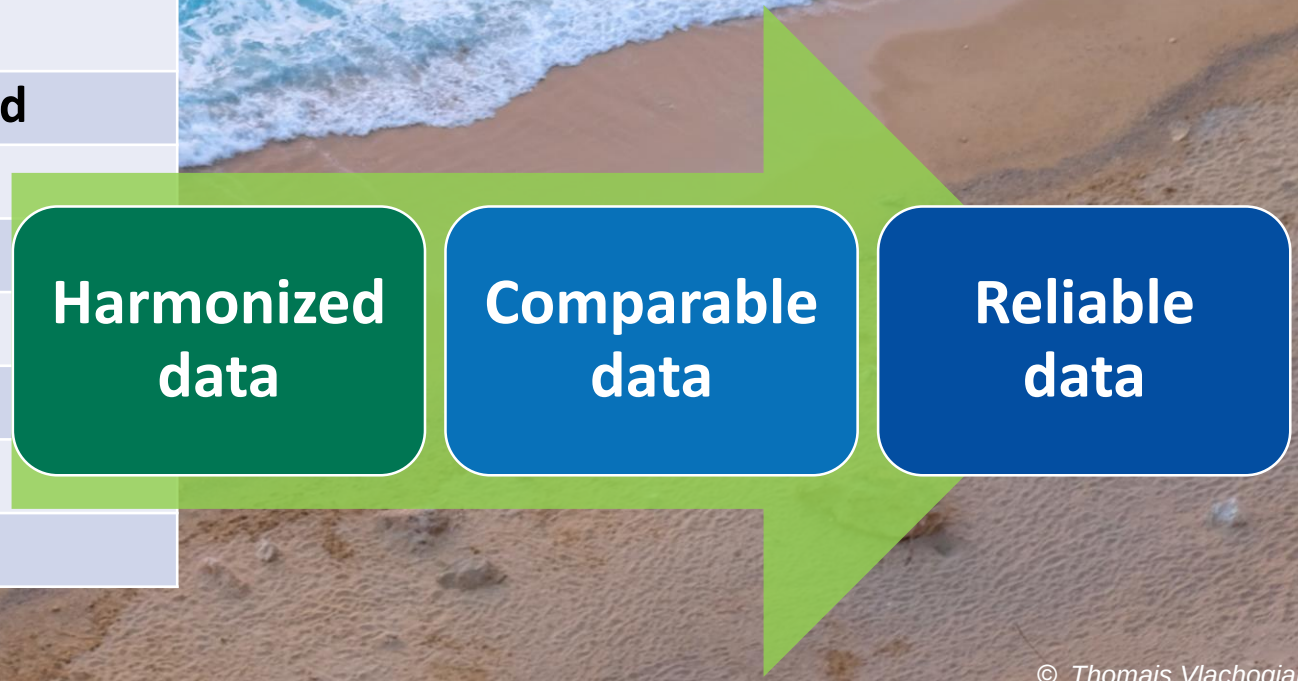
Biota

THE JOINT LIST & ITS HIERARCHICAL STRUCTURE



THE USE CATEGORIES

Type-code	Name
ag_	agriculture related
aq_	aquaculture related
cl_	clothing
co_	building & construction related
fc_	food consumption related
fi_	fisheries related
hy_	personal hygiene and care related
md_	medical related
nn_	undefined use
re_	recreation related
sm_	smoking related
vk_	vehicle related
hu_	hunting related



HOW DOES THE LIST LOOK LIKE?

Litter type-codes	Litter type
pl_	artificial polymer materials
pl_fc_	plastic food consumption related items
pl_fc_b&c_	plastic food consumption related bottles and containers
pl_fc_b&c_dbot_	plastic drink bottles
pl_fc_b&c_dbot_lage	plastic drink bottles > 0.5 l
pl_fc_b&c_dbot_smll	plastic drink bottles ≤ 0.5 l

Photo © Thomais Vlachogianni

THE J-CODE LIST

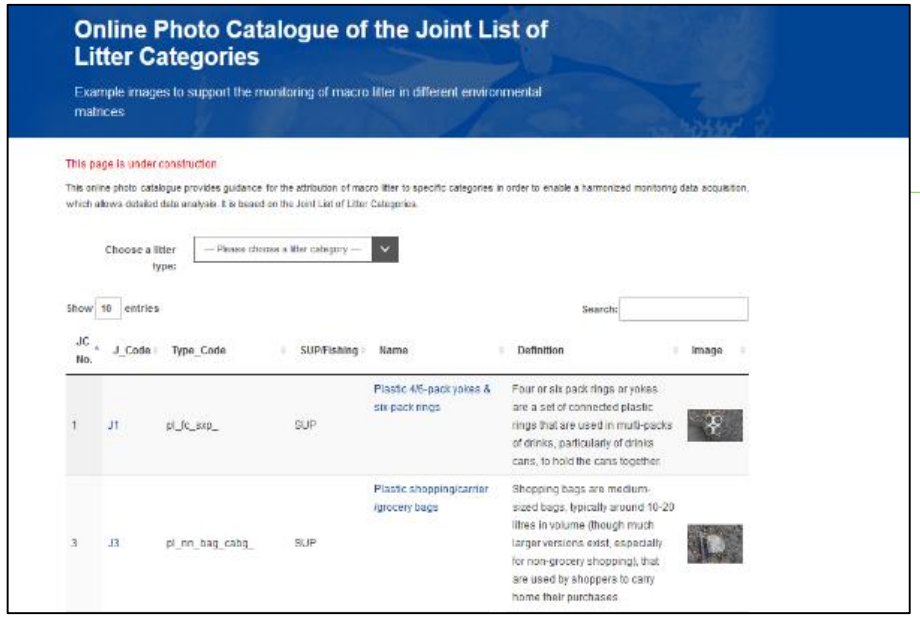
ARTIFICIAL POLYMER MATERIALS			
Code	Items name	Item counts	Total
J220	plastic sheeting from greenhouses		
J221	plastic irrigation pipes		
J222	other plastic items from agriculture		
J90	plastic flower pots		
J223	trays for seedlings of foamed plastic		
J46	plastic oyster trays		
J45	plastic mussels/oyster mesh bags, net sack, socks		
J47	plastic sheeting from mussel culture (Tahitians)		
J102	plastic flip-flops		
J136	footwear made of plastic - not flip flops		
J40	plastic gloves (household/dishwashing, gardening)		
J41	plastic gloves (industrial/professional applications)		
J252	single-use plastic gloves		
J69	plastic hard hats/helmets		
J256	foamed plastic insulation including spray foam		
J89	plastic construction waste (not foamed insulation)		
J8	plastic drink bottles >0.5 l		
J7	plastic drink bottles ≤ 0.5 l		
J224	plastic food containers made of foamed polystyrene		
J21	plastic caps/lids drinks		
J225	plastic food containers made of hard non-foamed plastic		
J1	plastic 4/6-pack yokes & six-pack rings		
J226	cups and cup lids of foamed polystyrene		
J227	cups and lids of hard plastic		
J228	plastic cutlery		
J229	plastic plates and trays		
J230	plastic stirrers		
J231	plastic straws		
J30	plastic crisps packets/sweets wrappers		
J31	plastic lolly & ice-cream sticks		
J85	plastic commercial salt packaging		
J58	fish boxes - foamed polystyrene		

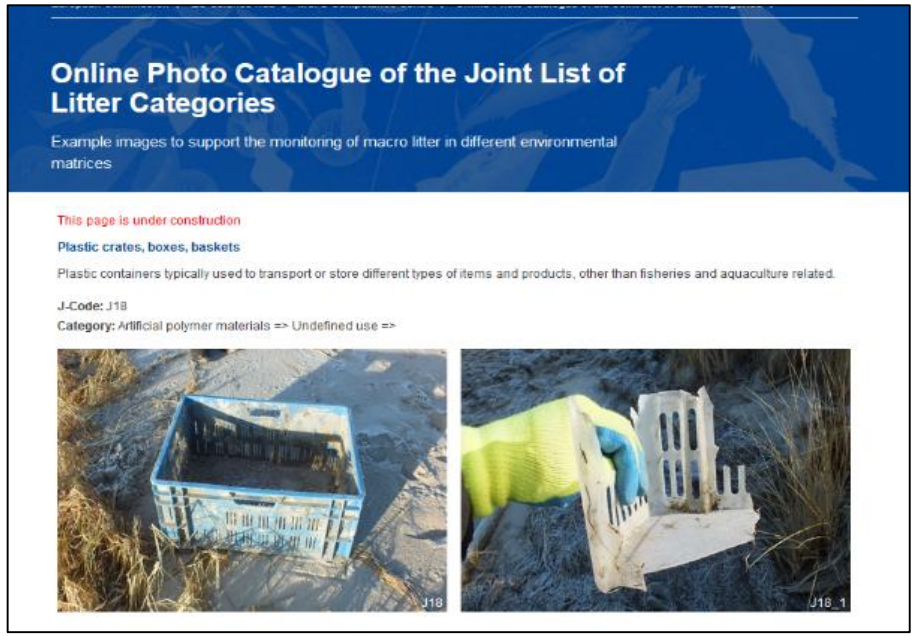
METAL			
Code	Items name	Item counts	Total
J194	metal cables		
J175	metal drinks cans		
J176	metal food cans		
J181	metal tableware (e.g. plates, cups & cutlery)		
J184	metal lobster/crab pots		
J182	metal fisheries related weights/sinkers, and lures		
J180	metal appliances (refrigerators, washers, etc.)		
J187	metal drums & barrels		
J174	metal aerosol/spray cans		
J188	other metal cans		
J190	metal paint tins		
J178	metal bottle caps, lids & pull tabs from cans		
J195	metal household batteries		
J177	metal foil wrappers, aluminium foil		
J199	other metal pieces > 50cm		
J198	other metal pieces 2.5cm ≥ ≤ 50cm		
J186	metal industrial scrap		
J191	wire, wire mesh, barbed wire		
J179	metal disposable BBQs		
J193	metal vehicle parts / batteries		

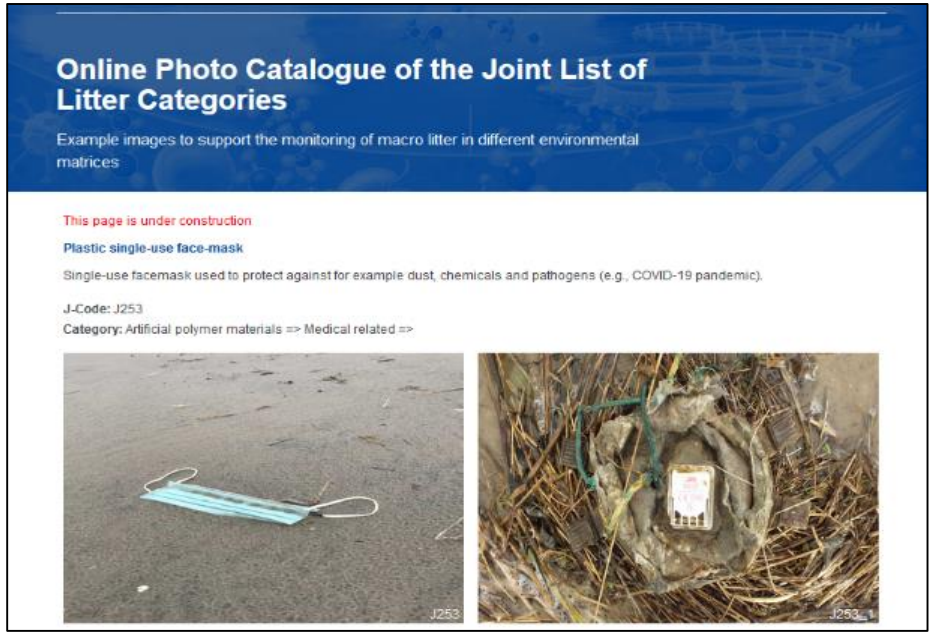
183 litter types

LITTER ITEMS DESCRIPTIONS

Litter type	Description
Plastic shopping/carrier/grocery bags	Shopping bags are medium-sized bags, typically around 10–20 litres in volume (though much larger versions exist, especially for non-grocery shopping), that are used by shoppers to carry home their purchases. Shopping bags can be made of a variety of plastics; polyethylene (LDPE, LLDPE, etc.) is the most common one. They usually have handles.
Plastic mussels/oysters mesh bag, net sack, sock	A special bag or sack made of extruded net which is used for growing (underwater) mussels, oysters and other shellfish species. These bags can have different sizes and shapes, e.g., sack-like or tubular, and the mesh net can have a different thickness.
Plastic gloves (household/dishwashing, gardening)	Gloves used to perform household chores such as dishwashing, gardening, etc. They are typically made of different polymers including latex, nitrile rubber, polyvinyl chloride. Less heavy-duty than industrial gloves.
Plastic string and filaments exclusively from dolly ropes	Strings and filaments from blue, black or orange string that are used to protect bottom trawling nets against wear and tear. A dolly rope consists of around 30 strings; each string has around 25 threads.
Plastic mesh bags for vegetable, fruit and other products	A special mesh bag made of polypropylene, polyethylene or high-density polyethylene used for packaging and transporting agricultural products such as vegetables, fruit, bird feed, etc.
Plastic injection gun containers/cartridges	A cartridge made of plastic for devices that are used to inject grease, silicone, or other fluids.







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THE IMAP LIST

ID	PLASTIC/POLYSTYRENE
G1	4/6-pack yokes, six-pack rings
G3	Shopping bags incl. pieces
G4	Small plastic bags, e.g. freezer bags incl. pieces
G5	Plastic bag collective role; what remains from rip-off plastic bags
G7/G8	Drink bottles
G9	Cleaner bottles & containers
G10	Food containers incl. fast food containers
G11	Beach use related cosmetic bottles and containers, e.g. Sunblocks
G14	Engine oil bottles & containers <50 cm
G15	Engine oil bottles & containers >50 cm
G16	Jerry cans (square plastic containers with handle)
G17	Injection gun containers (including nozzles)
G13	Other bottles & containers
G18	Crates and containers / baskets
G19	Car parts
G21/24	Plastic caps and lids (including rings from bottle caps/lids)
G26	Cigarette lighters
G28	Pens and pen lids
G29	Combs/hair brushes/sunglasses
G30/31	Crisps packets/sweets wrappers/ Lolly sticks
G32	Toys and party poppers
G33	Cups and cup lids
G34/35	Cutlery and trays/Straws and stirrers
G36	Fertiliser/animal feed bags
G37	Mesh vegetable bags
G40	Gloves (washing up)
G41	Gloves (industrial/professional rubber gloves)
G42	Crab/lobster pots and tops
G43	Tags (fishing and industry)
G44	Octopus pots
G45	Mussels nets, Oyster nets including plastic stoppers
G46	Oyster trays (round from oyster cultures)
G47	Plastic sheeting from mussel culture (Tahitians)
G49	Rope (diameter more than 1cm)
G50	String and cord (diameter less than 1 cm)

131 litter types

- ❑ Plastic/Polystyrene
- ❑ Rubber
- ❑ Cloth
- ❑ Paper/Cardboard
- ❑ Processed/Worked Wood
- ❑ Metal
- ❑ Glass
- ❑ Ceramics
- ❑ Sanitary Waste
- ❑ Medical Waste
- ❑ Paraffin/Wax
- ❑ Faeces

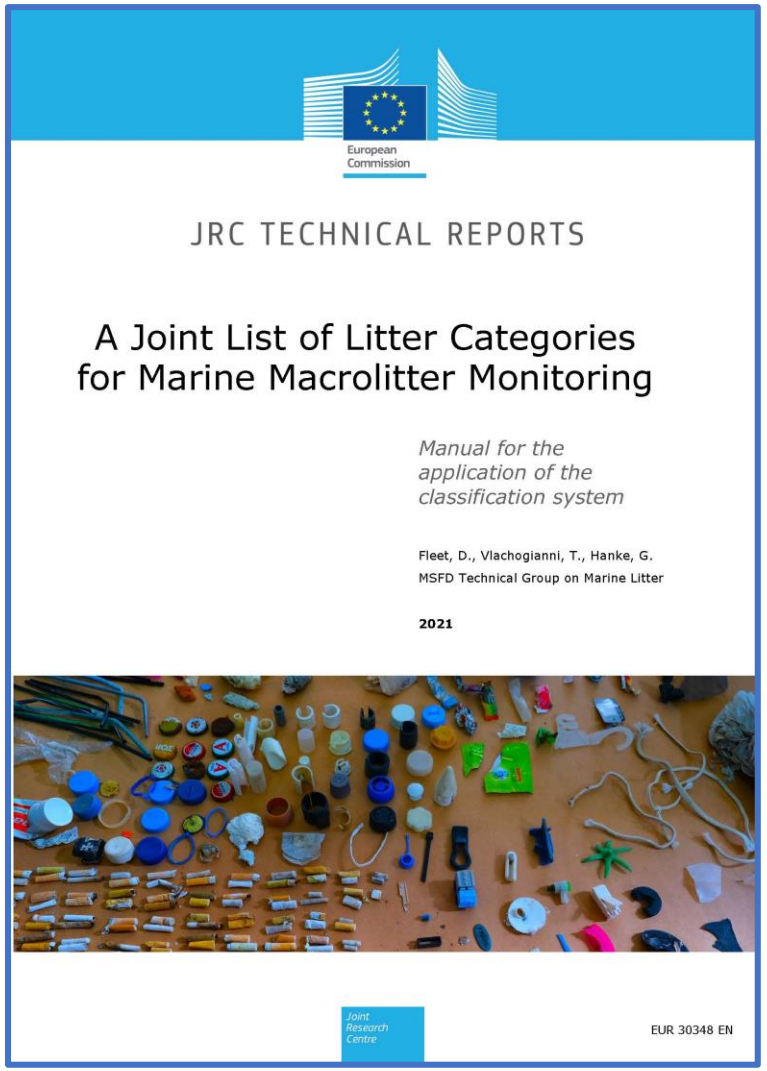
THE JOINT LIST VS THE IMAP LIST

Policy context	Litter size	Materials / main categories	List & item categories
EU MSFD	> 2.5 cm + 15 categories even if < 2.5 cm	AP, R, C/T, P, WW, M, G/CE, CH, OF	Joint list (Fleet 2021) 183 categories
Barcelona Convention	> 5 mm	AP, R, C, P, WW, M, G, C, SW, MW, F, PW	IMAP list 131 categories:

THE CLASSIFICATION LIST FOR ALL SURVEYS

Survey Protocols

- Litter ‘sampling’
- Litter size classes & classification
- Litter removal & disposal



THE JOINT LIST
183 litter types

THE IMAP LIST
131 categories

THE PLASTIC BUSTERS RESOURCES

Union for the Mediterranean
Union pour la Méditerranée
الاتحاد من أجل المتوسط

Interreg Mediterranean
EUROPEAN UNION
PLASTIC BUSTERS MPAs

ENI CBCMED
Cooperating across borders in the Mediterranean

Project funded by the EUROPEAN UNION

REGIONE AUTÒNOMA DE SARDIGNA
REGIONE AUTONOMA DELLA SARDEGNA

Plastic Busters CAP

PLASTIC BUSTERS TOOLKIT & ELEARNING MODULE

Self-paced distance learning course
Plastic Busters MPAs module on how to monitor the presence and effects of MARINE LITTER
https://envirolearning.net/catalog/info/id:153

METHODOLODY FOR MONITORING MACROLITTER ON BEACHES

Photos © Thomais Vlachogianni

MARINE MACROLITTER MONITORING ON BEACHES | KEY ELEMENTS

Monitoring Strategy

- Site selection
- Frequency & timing
- Sampling unit

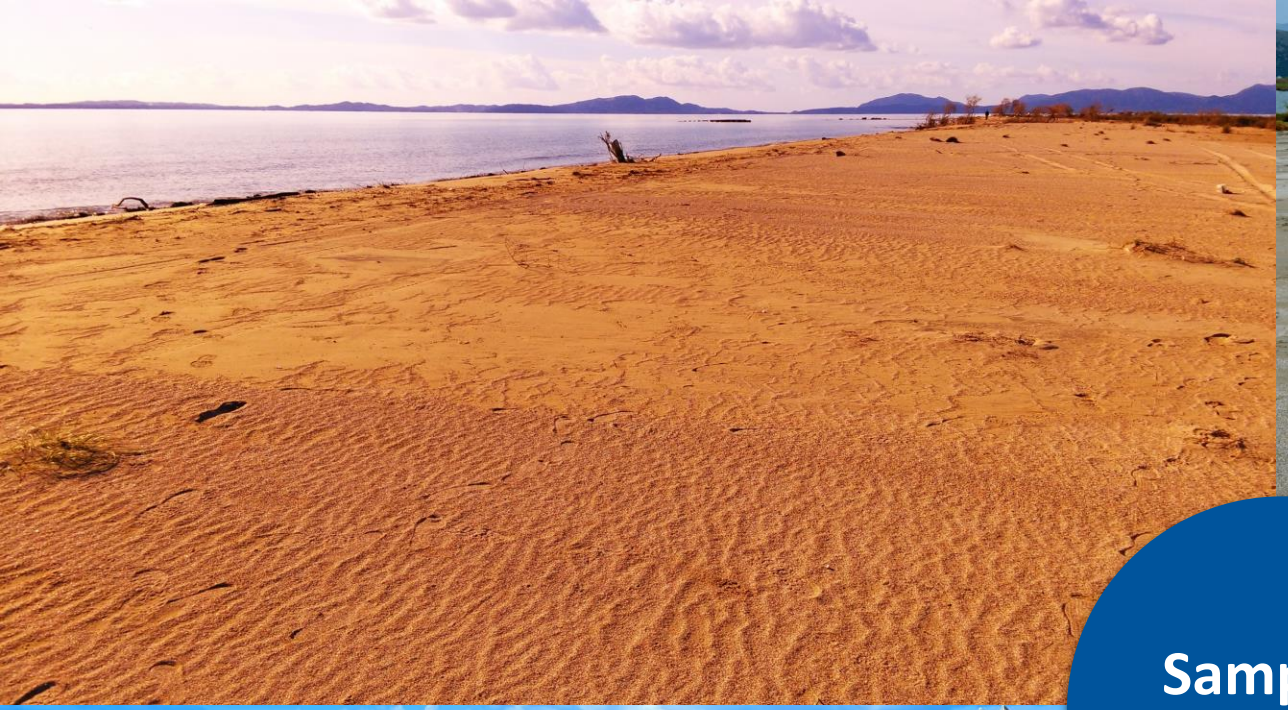
Survey Protocols

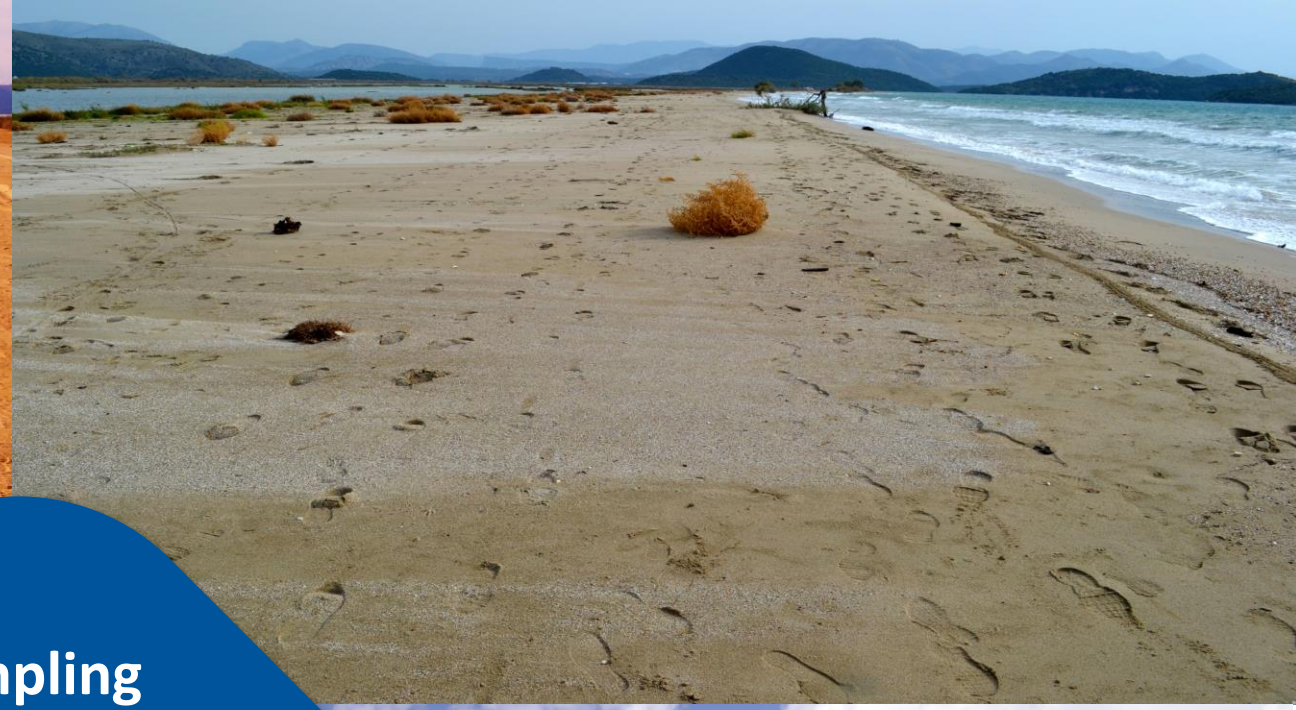
- Litter sampling
- Litter size classes & classification
- Litter removal & disposal

SITE SELECTION

Site location	Site features
✓ In the vicinity of ports or harbors; ✓ In the vicinity of river mouths; ✓ In the vicinity of coastal urban areas; ✓ In the vicinity of tourists destinations; ✓ In relatively remote areas.	✓ Having a minimum length of 100 m; ✓ Low to moderate slope; ✓ Clear access to sea; ✓ Accessible to survey teams throughout the year; ✓ Ideally the site should not be subject to cleaning activities; ✓ Survey activities posing no threat to endangered or protected species.





Sampling locations

Photos © Thomais Vlachogianni

BEACH TYPOLOGY	ENVIRONMENT	ACCESSIBILITY	HABITATION, ACCOMMODATION	SERVICES AND FACILITIES
URBAN	Located in front of urban areas, with a wide range of well-established public services (shopping areas, business districts, etc.).	Accessible by both public and private transport.	Large population and large-scale residential and tourist accommodation.	Extensively developed range of services and facilities provided to beach users.
SEMI-URBAN	Located in the surroundings of the urban areas, adjacent to or within a small coastal town with small-scale community services.	Accessible by both public and private transport.	Small residential populations and/or many beach users during the bathing season; presence of accommodation facilities (hotels, B&B, campsites).	A reduced range of services and facilities provided to beach users.
REMOTE/NATURAL	Remote and natural environment; located away from small towns or villages; predominance of natural elements and absence of community services.	Accessible via private transport, boat or by walking; including those which are closed to the public.	Absence of residential population, housing or tourist accommodations.	Absence of services and facilities provided to beach users.

Main characteristics of different beach typologies representing different levels of urbanisation (MSFD TGML, 2022)

FREQUENCY AND TIMING OF SURVEYS

Frequency:
4 surveys/year

Autumn:
October

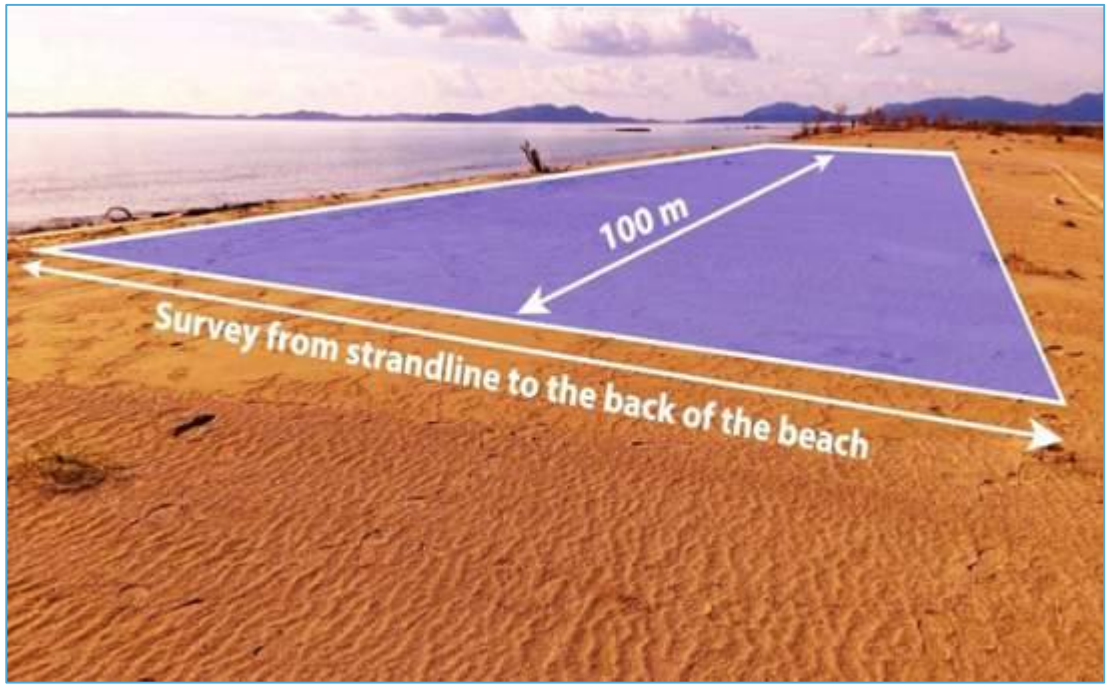
Winter:
January

Spring:
April

Summer:
July

Photos © Thomais Vlachogianni

THE SAMPLING UNIT



The sampling unit should be a 100-metre stretch of beach along the strandline and reaching to the back of the beach.

The back of the beach needs to be explicitly identified using coastal features such as the presence of vegetation, dunes, cliff base, road, fence or other anthropogenic structures such as seawalls (either piled boulders or concrete structures).

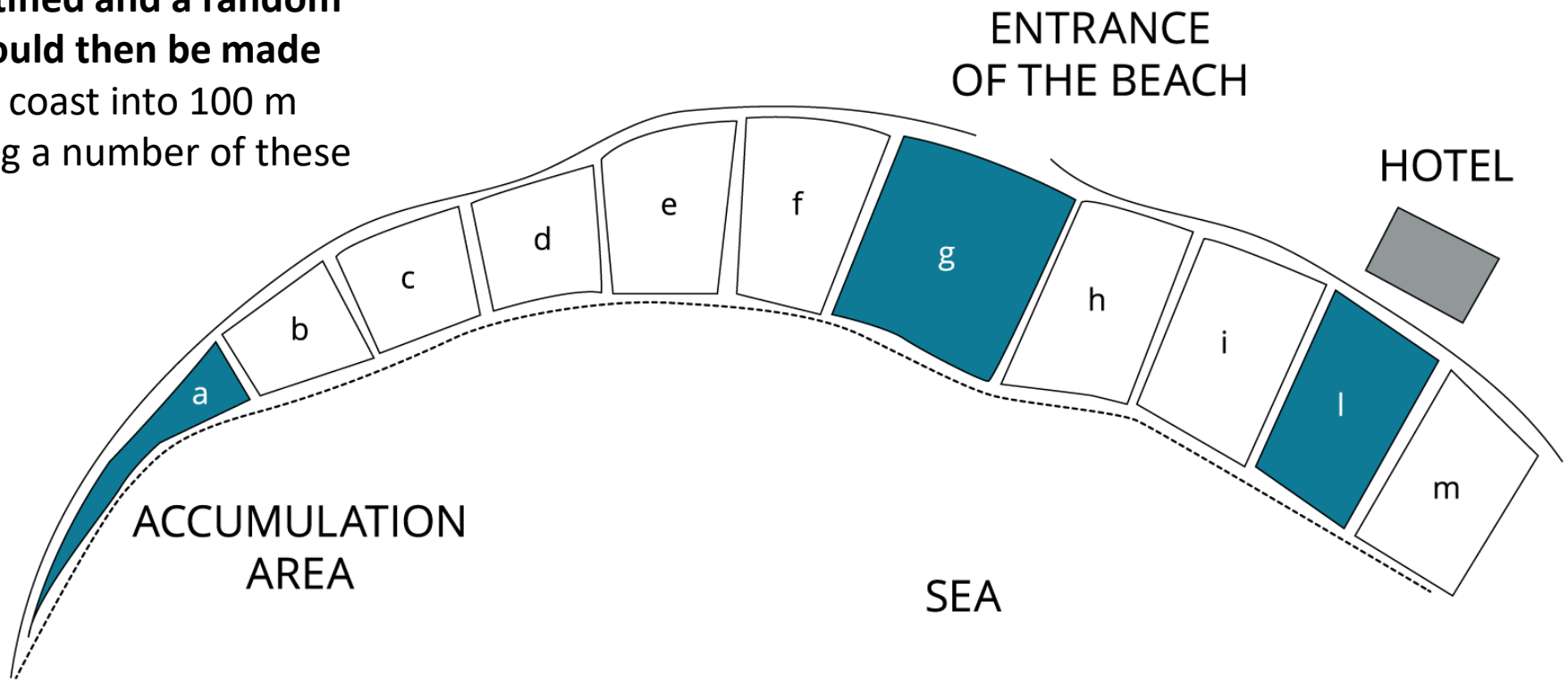
THE SAMPLING UNIT | GENERAL CONSIDERATIONS

Sampling units should represent the **general characteristics** of the survey site and the **general state of litter** in the survey site.
The sampling units **should not be placed on the edges of a beach or on parts of the beach that have a higher potential to accumulate litter.** In addition, the sampling units **should not be placed in potential litter hotspots** such as areas near the entrance of the beach or near coastal parking lots or directly in front of hotels.

Photo: Thomais Vlachogianni

THE SAMPLING UNIT SELECTION

Based on these considerations **a set of potential sampling units should be identified and a random selection of sampling units should then be made from this set** (e.g., dividing the coast into 100 m sections and randomly choosing a number of these sections as sampling units).



HEAVILY LITTERED BEACHES

In **heavily littered** survey sites (i.e., where a 100-m stretch of beach requires more than one day of work to be surveyed), **a smaller sampling unit** (at least a 50-metre stretch of coastline covering the area from the water edge to the back of the beach), **representative** of the situation, can be monitored. Note that the results must be **normalized** to 100-m stretch when reported, to obtain comparable results.

LITTER SIZE CLASSES TO BE SURVEYED

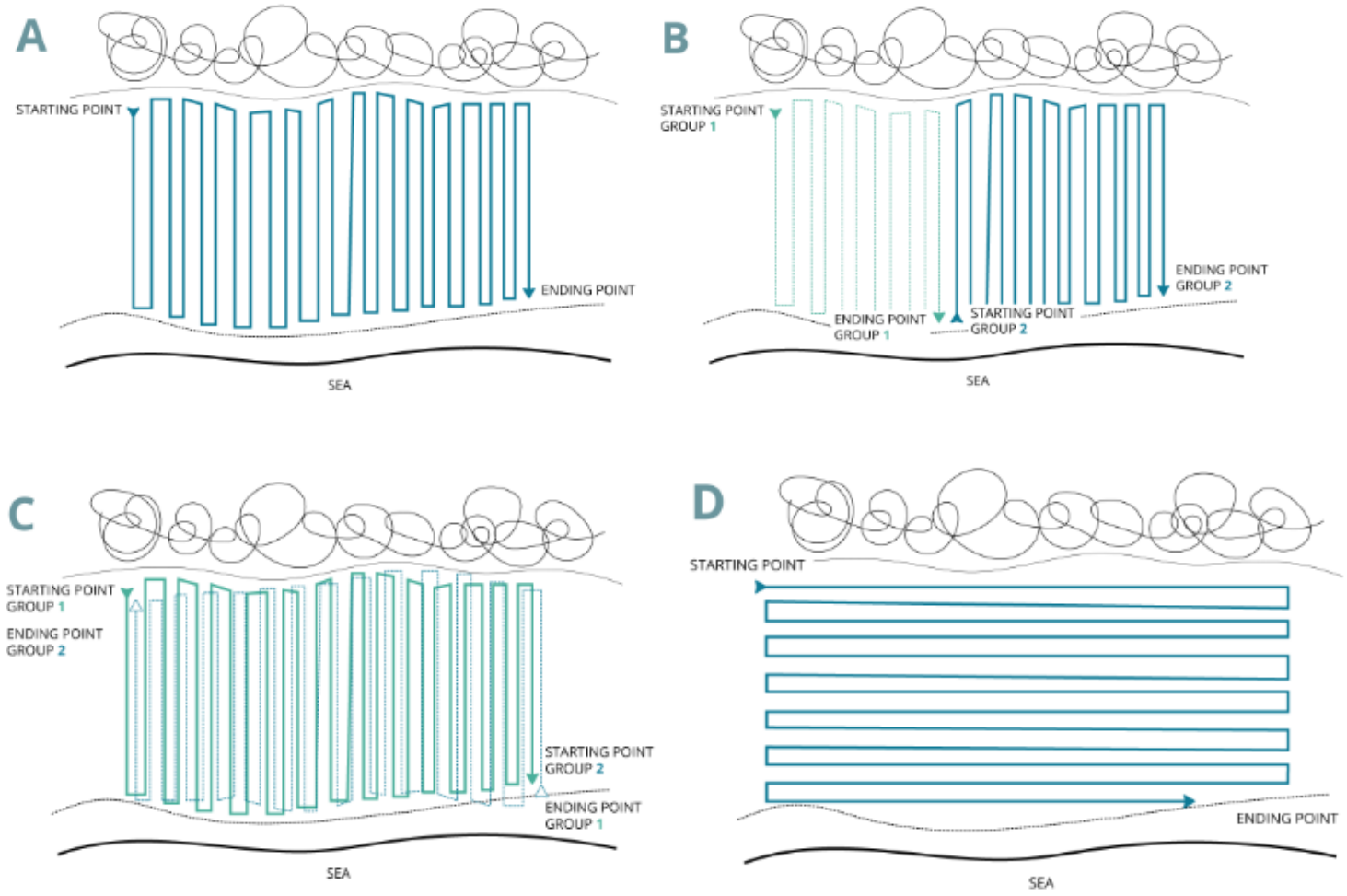
Plastic straws

Plastic caps

Cigarette butts

In case such items are found in extremely high numbers, a 1-metre (rather than a 100-metre) beach transect should be used instead, saving effort and time.

EXAMPLES OF LITTER SAMPLING APPROACHES (TGML, 2022)



LITTER ITEMS CLASSIFICATION

On-site classification

Classification in a lab

AT THE FIELD

FIELD TIPS

Photos © Th. Vlachogianni

Items that easily break or get entangled and are weathered must be sorted and classified on-site to avoid errors

To speed up the survey, the items can be first grouped in categories according to the Joint List and then to be counted together.

Arranging the litter types on the field list according to the most frequent items found can facilitate the recording of the litter items found.

Unusual or not recognizable litter items can be photographed for further evaluation.

ADDITIONAL CONSIDERATIONS

events that may lead to unusual types and/or amounts of litter (e.g. shipping container losses, overflows of sewage treatment systems, etc.)

difficult weather conditions (e.g. heavy winds or rain, etc.)

replenishment/nourishment of the beach; etc.

Photo © Thomais Vlachogianni


High-resolution camera


Hand-held GPS unit with extra batteries


100-metre tape measure (fiberglass proferred)


Flag markers/stakes


Rubbish bags


Protective gloves


Rigid container and sealable lid to collect sharp items such as needles, etc.


Clipboard for each surveyor


Recording sheets (printed on waterproof paper)


Pencils and pens


First aid kit (to include sunscreen, bug spray, drinking water)

MATERIALS & EQUIPMENT

Methodology for monitoring marine MACROLITTER on the sea surface with visual census

SITE SELECTION CRITERIA

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in the ENI Southern Neighbourhood region

- Low density areas (e.g. open sea)
- High density areas (e.g. close to ports)
- Other selected areas e.g. in estuaries, in the vicinity of cities, in local areas of touristic, recreational or commercial traffic



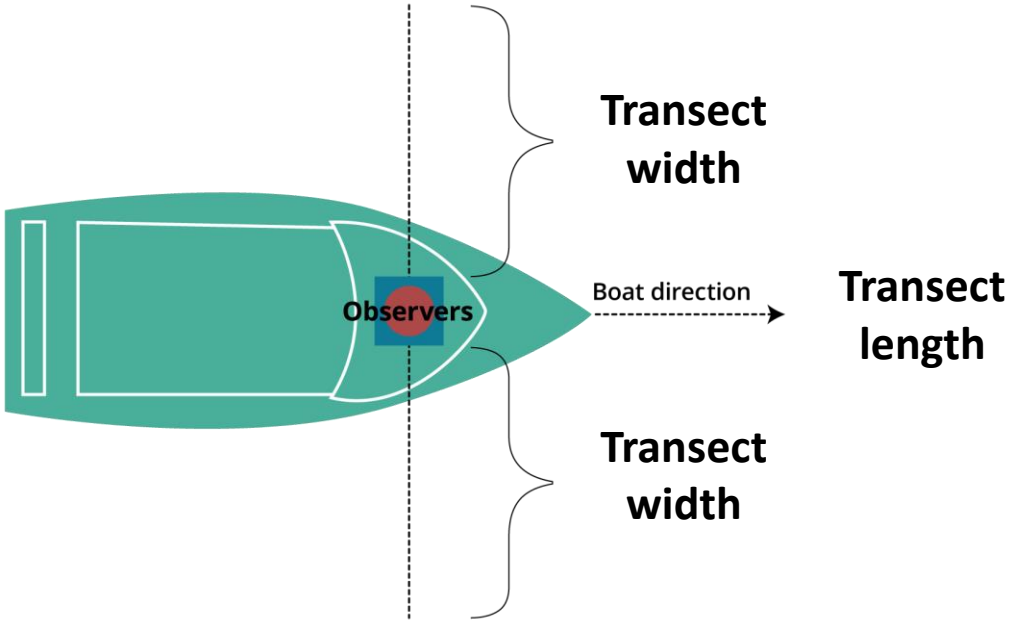


MONITORING MARINE LITTER ON THE SEA SURFACE WITH VISUAL CENSUS

Water and Environment Support
in the ENI Southern Neighbourhood region

Spring: April

Autumn: October



MONITORING MARINE LITTER ON THE SEA SURFACE WITH VISUAL CENSUS

Water and Environment Support
in the ENI Southern Neighbourhood region

- ✓ **The transect width** recommended to be used **for small-scale vessels is 3 m on each side of the boat (6 m in total if two observers are deployed)** and for **medium-scale vessels 5 m on each side of the boat (10 m in total if two observers are deployed).**
- ✓ The transect length should correspond approximately to 1 h of observation for each survey with a boat speed of 4-6 knots.

MONITORING MARINE LITTER ON THE SEA SURFACE WITH VISUAL CENSUS

Water and Environment Support
in the ENI Southern Neighbourhood region

MONITORING MARINE LITTER ON THE SEA SURFACE WITH VISUAL CENSUS

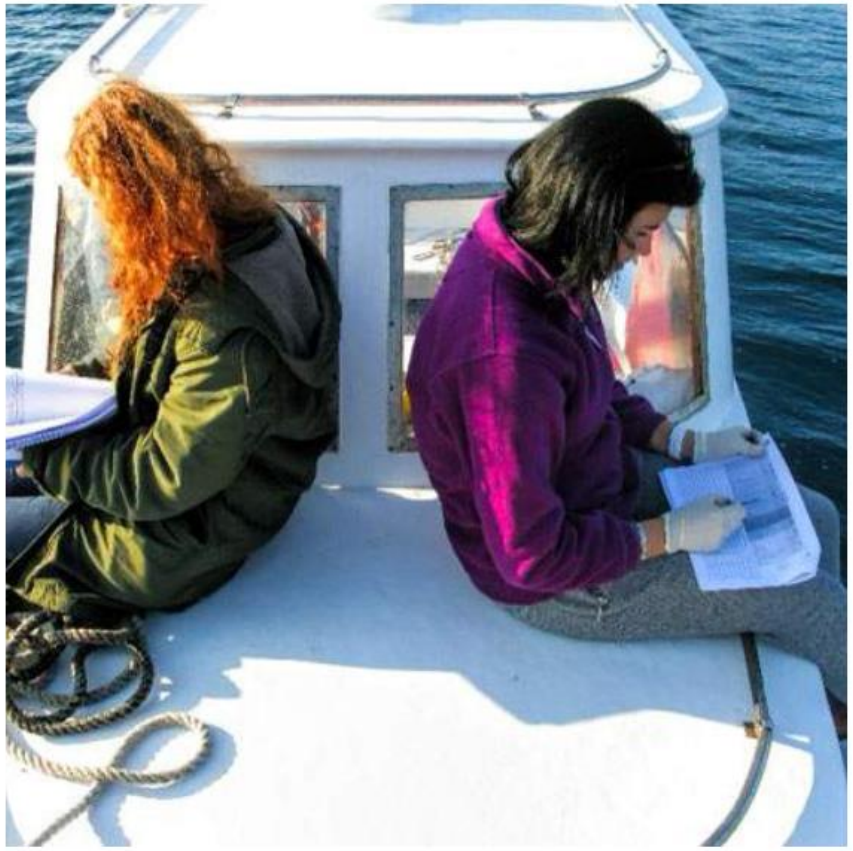


Photo © HEIS

MATERIALS & EQUIPMENT

The unit in which litter is assessed on the sea surface is 'number of items' and it is expressed as counts of litter items per square kilometer (litter items/km^2). In order to compute the exact surveyed area, **GPS coordinates must be recorded regularly (every min)** to obtain an accurate measurement of the travelled transect. A handheld GPS unit might be handy in this respect.

METHODOLOGY FOR MONITORING MARINE MACROLITTER ON THE SEAFLOOR WITH VISUAL CENSUS

MONITORING MARINE LITTER ON THE SEA SEAFLOOR WITH VISUAL CENSUS

Water and Environment Support
in the ENI Southern Neighbourhood region

Spring: April

Autumn: October

MONITORING MARINE LITTER ON THE SEA SEAFLOOR WITH VISUAL CENSUS

Water and Environment Support
in the ENI Southern Neighbourhood region

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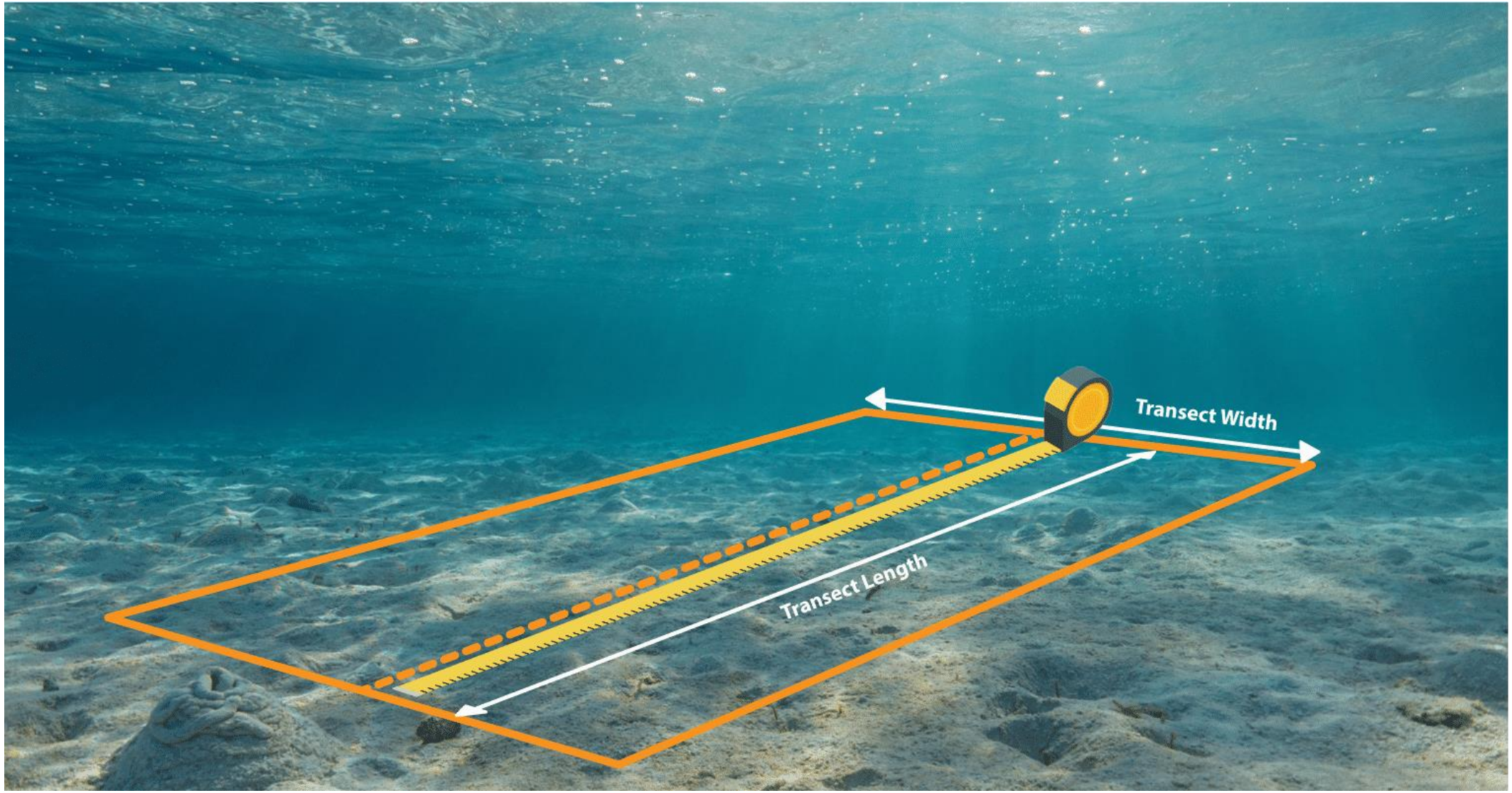
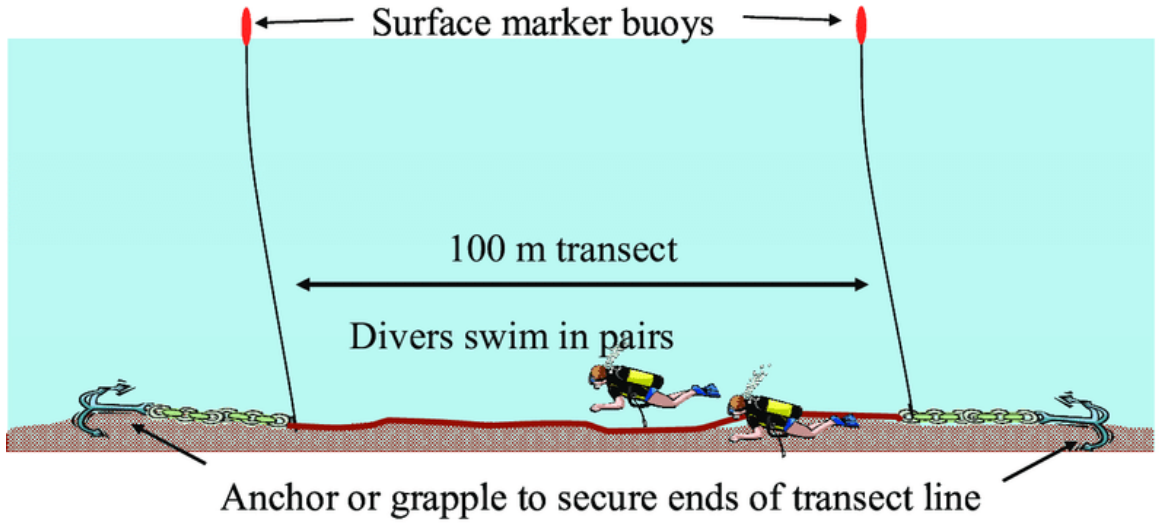


MONITORING MARINE LITTER ON THE SEA FLOOR WITH VISUAL CENSUS | SAMPLING



Litter Density	Environmental Conditions	Sampling Unit (length x width)
0.1 – 1 items / m^2	Low turbidity	20 m x 4 m
0.1 – 1 items / m^2	High turbidity	20 m x 4 m
0.01 – 0.1 items / m^2	In every case	100 m x 8 m
< 0.01 items / m^2	In every case	200 m x 8 m

- ✓ The survey area is defined by the transect width and length.
- ✓ The start and end point of each transect should be identified with marker buoys and recorded using a GPS.
- ✓ The length of the line transects could vary between 50m-100m and the width from 4m-8m, depending on the depth, the depth gradient, the turbidity, the habitat complexity and the litter density.
- ✓ Digital photos should be taken for all items with an underwater camera; lighter litter items should be collected and brought ashore, while larger items should just be marked.
- ✓ The unit in which litter should be recorded is number of items and it should be expressed as counts of litter items per square kilometer (litter items/km^2).

Litter items classification

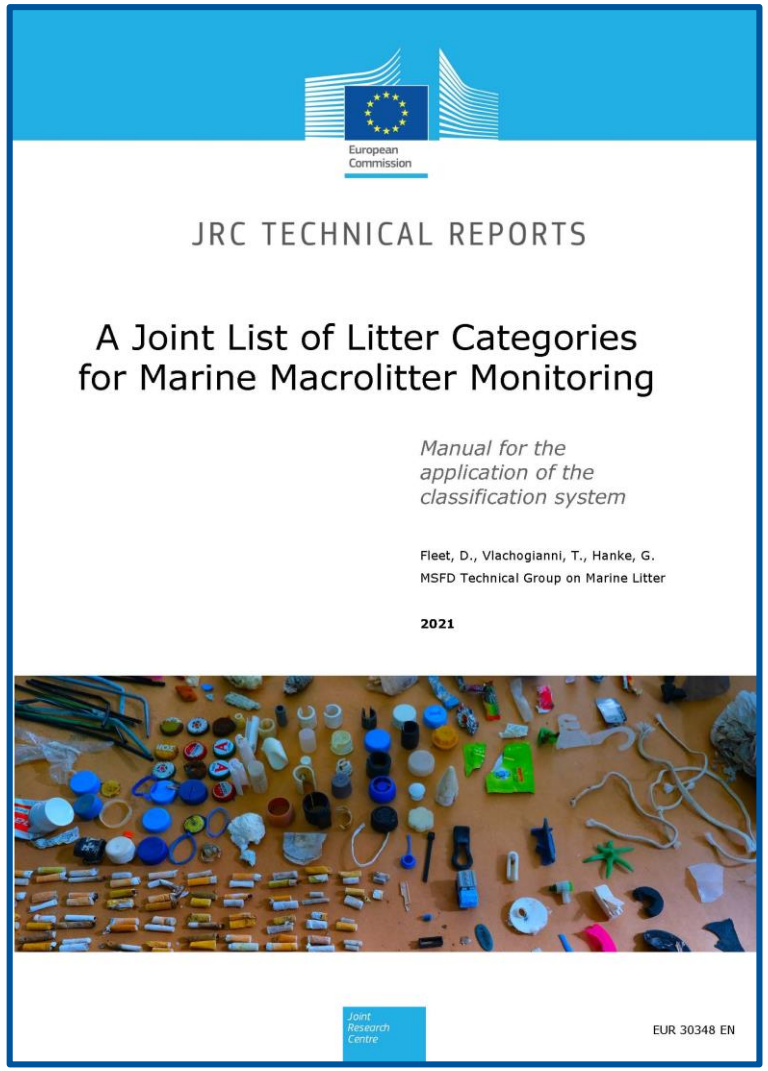
Photo © P.Consoli

Photo © Institute of Marine Biology of the University of Montenegro

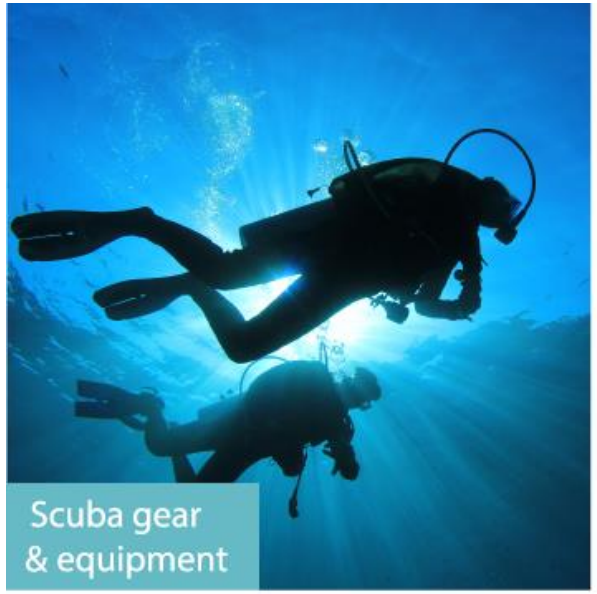
Photo © P.Consoli

Photo © M.Mandic

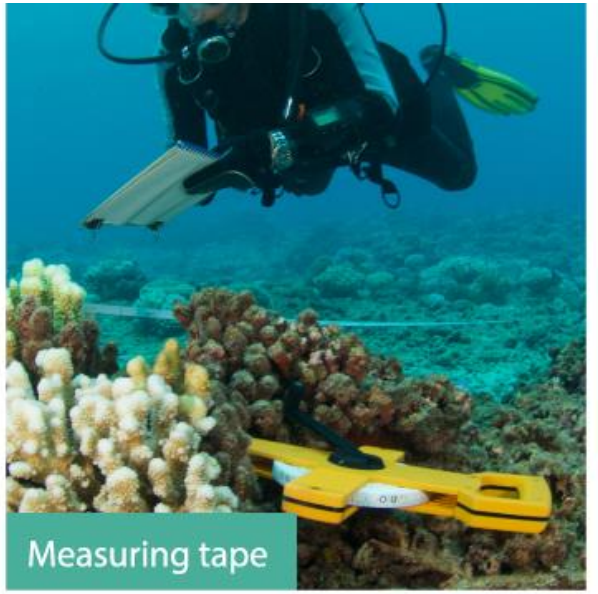
Photo © Th.Vlachogianni



Materials & equipment


Scuba gear & equipment

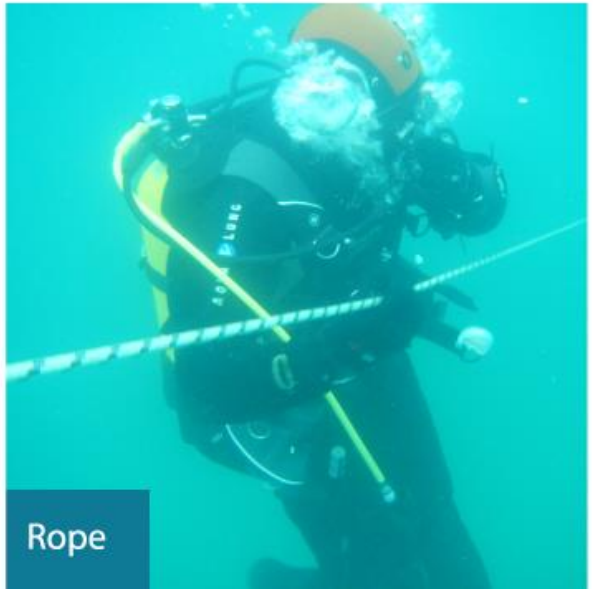

Mesh sack


Measuring tape


Underwater digital camera


GPS


Water proof recording sheets and pens

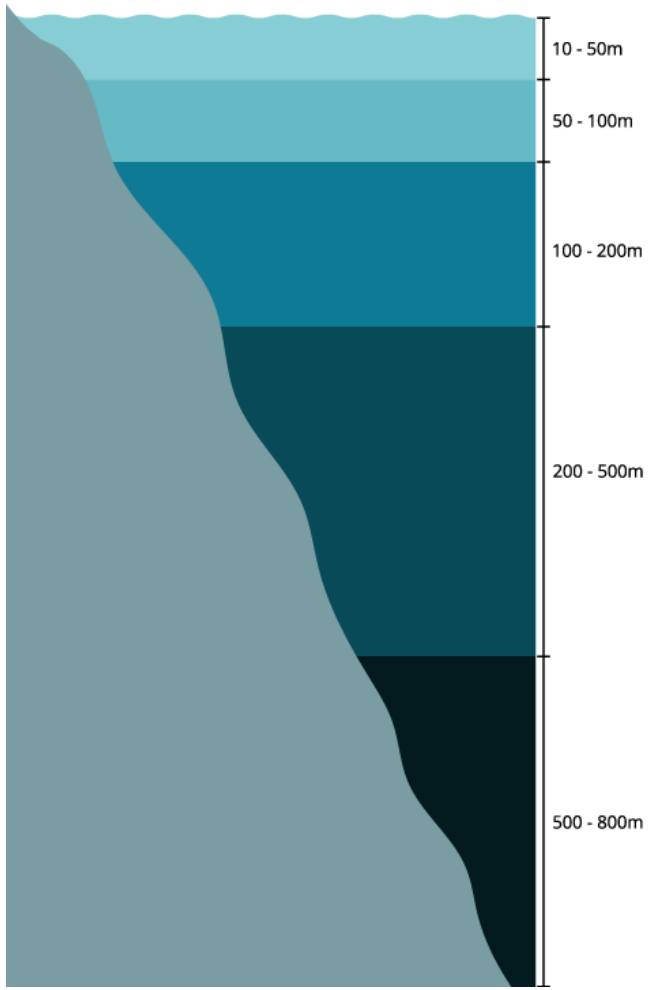

Rope

METHODOLOGY FOR MONITORING MARINE MACROLITTER ON THE SEAFLOOR WITH BOTTOM TRAWLING

MONITORING MARINE LITTER ON THE SEA SEAFLOOR
WITH bottom trawl surveys | timing & sampling approach

Spring:
April

Autumn:
October

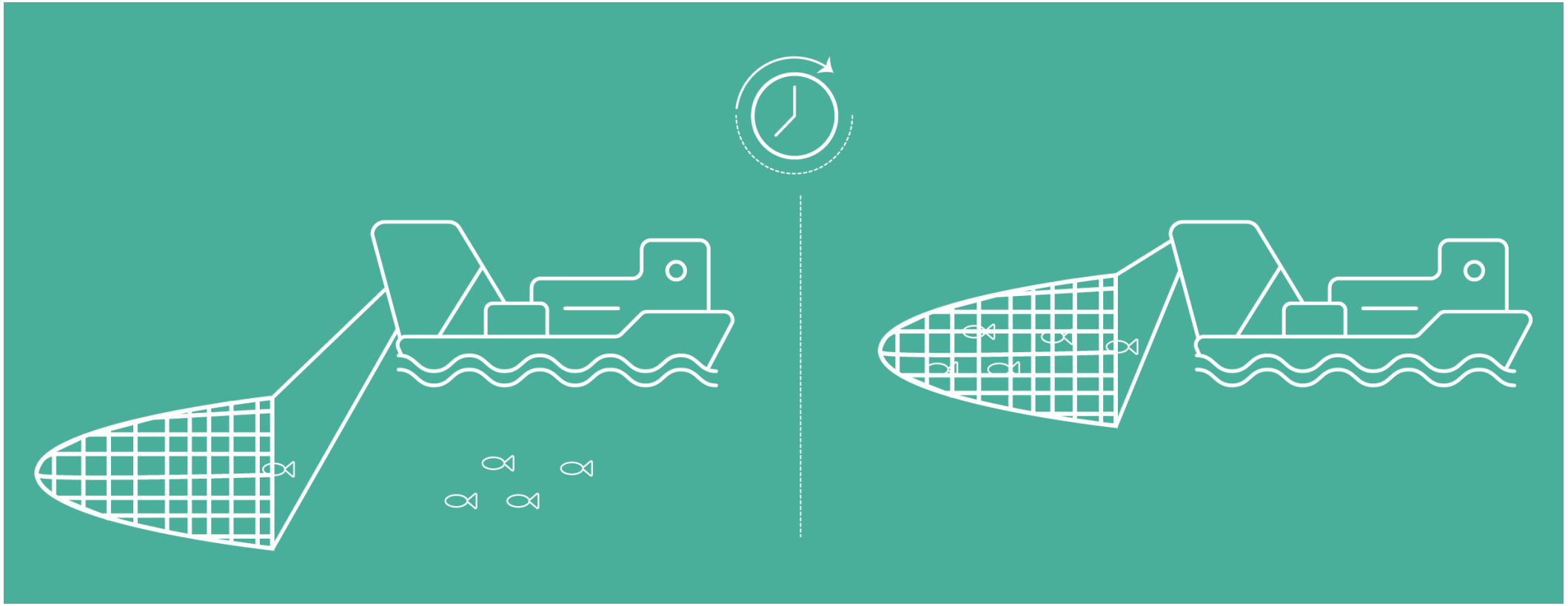


With regards to the sampling area, the MEDITS survey uses a depth stratified sampling scheme with random selection of trawling sites (same positions each year) within each stratum. Within this methodology, the following strata are sampled: **10-50, 50-100, 100-200, 200-500 and 500-800 m.**

Trawling operation | speed & duration

The vessel speed should be 3 knots during the haul. However, if the skipper indicates that a slightly different speed is appropriate for optimal gear operation (depends on net characteristics) the vessel speed can be altered accordingly. **In any case, vessel speed, hauling depth and geographical position should be continuously monitored during the haul (e.g. every 5 min). The haul duration is fixed at 30 min.**

Trawling operation | start & end definition



The start of the haul is defined as the moment at which the trawl geometry (vertical and horizontal) is stabilized. In the absence of electronic equipment (acoustic devices like SCANMAR, etc.) the actual start time will be indicated by the skipper. **The end of the haul is defined as the moment at which warp hauling begins.**

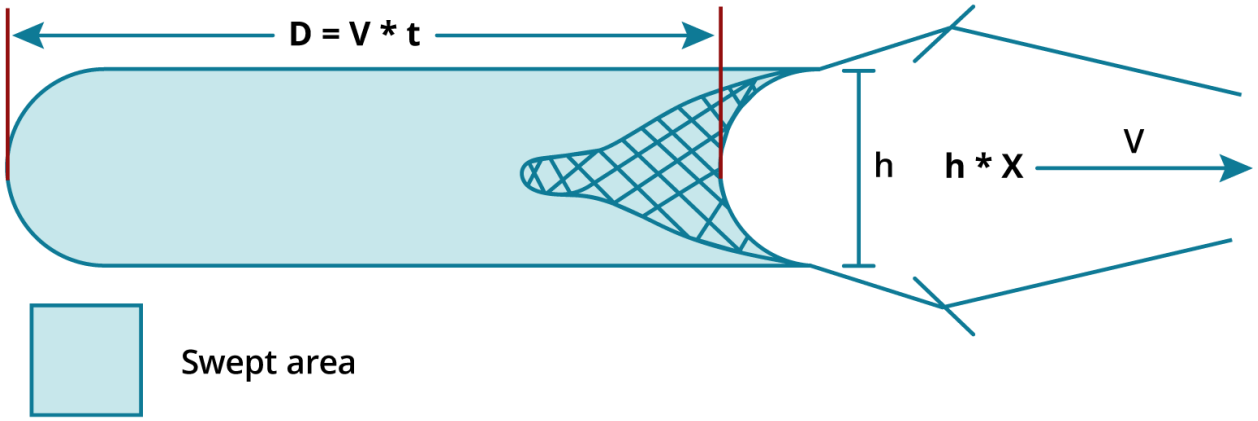
Litter items classification

Photo © M.Prevenios, HCMR

Photo © G.Kroqi

Photo © G.Kroqi

Litter density calculation



The unit in which litter should be recorded is the **number of items** and it should be expressed as counts of litter items per square kilometer (litter items/km^2).

The swept area (a) can be estimated by:

a = D * h * X **where D = V * t**

Where:

V is the velocity of the trawl over the ground when trawling;
h is the length of the head-rope;
D is the cover of distance;
t is the time spent trawling;
X is that fraction of the head-rope length, which is equal to the width of the path swept by the trawl.
The value of X varies from 0.4 to 0.66 for tropical waters and a value of **X = 0.5 has been suggested as the best compromise value for the Mediterranean Sea** (Sparre and Venema, 1992).

Materials & equipment


Bucket or box


Tape measure


Plastic bags to collect the litter


Digital scales for weighing litter ideally with a 1g precision)


Hand-held GPS unit with extra batteries


Clipboard for the surveyor and recording sheets

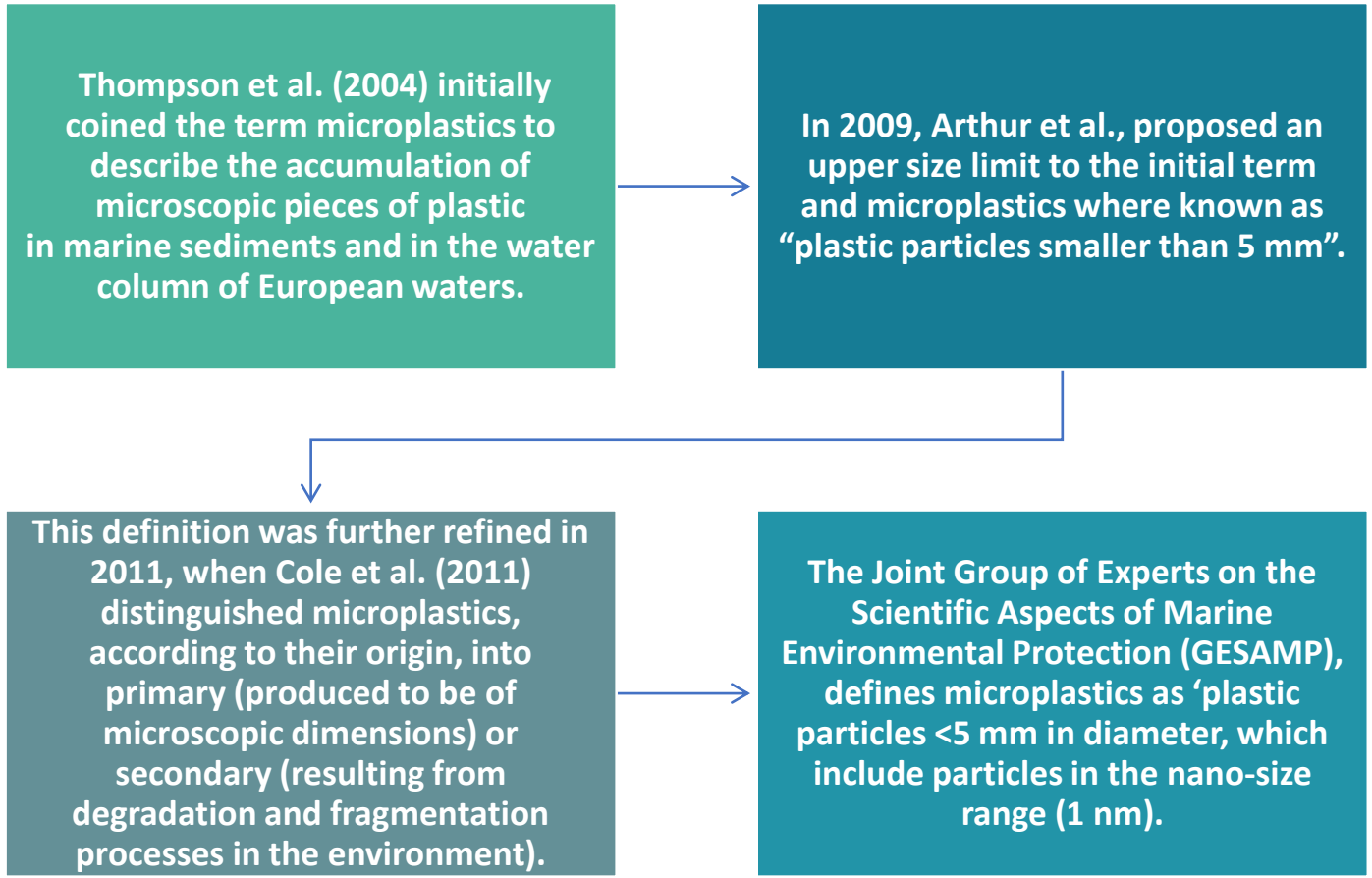

Pencils and pens


First aid kit (to include sunscreen, bug spray, drinking water)

MICROLITTER IN THE MEDITERRANEAN

The Mediterranean Sea is one of the most studied regions in the world in terms of microplastic contamination

MICROPLASTICS: FINDING A CONSENSUS ON THE DEFINITION

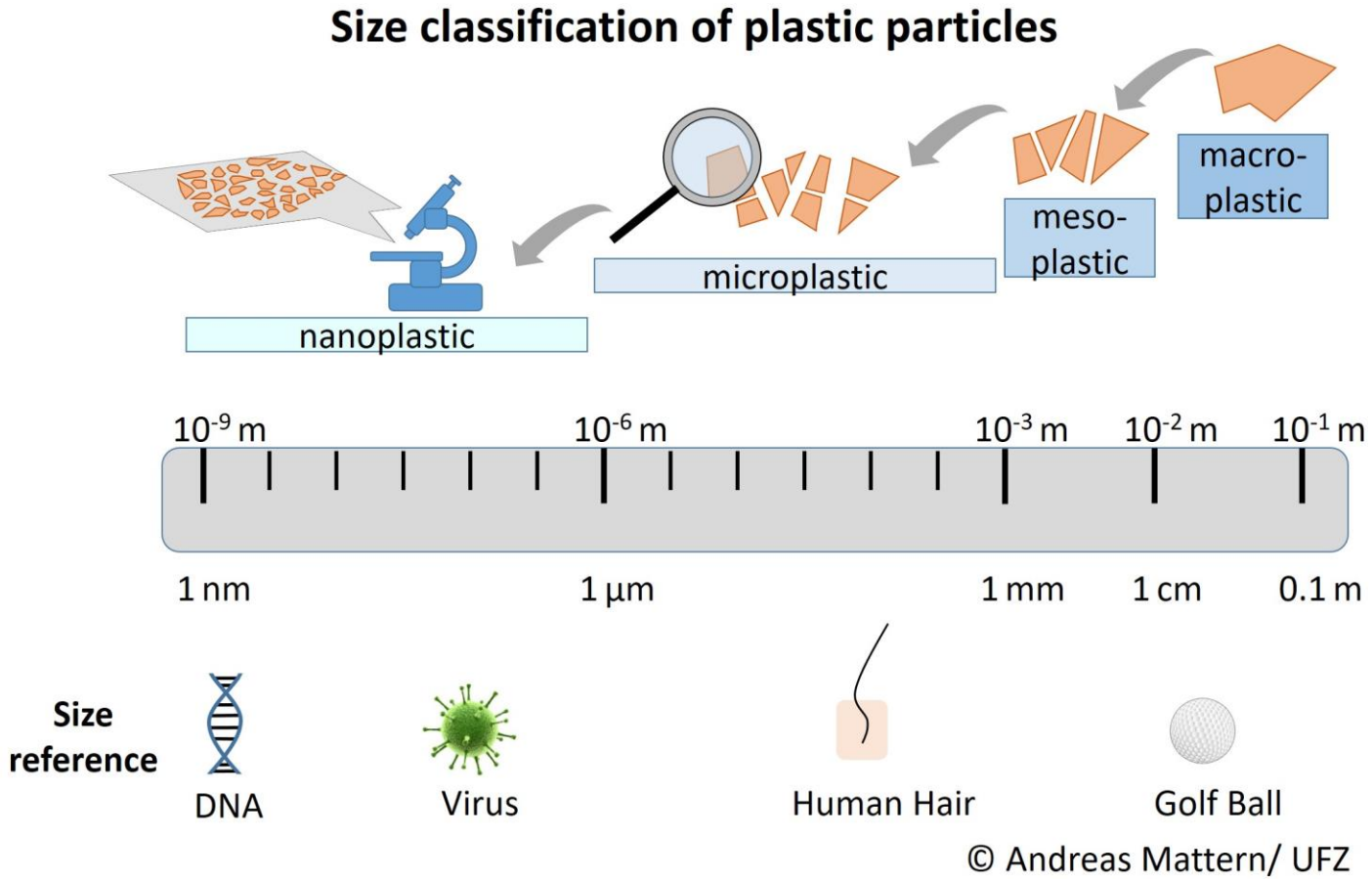


- There is still no clear consensus on a definition that is extensive enough to encompass all necessary criteria to describe ‘microplastics’. This technicality causes several methodological challenges.
- Regarding size, there is still no agreement on the upper and lower size limits to microplastics, even though the most used definition is the one proposed by Arthur et al.

https://doi.org/10.1016/j.marpolbul.2018.11.022

SIZE CLASSIFICATION OF PLASTIC PARTICLES

Microplastics are any synthetic solid particle or polymeric matrix, with regular or irregular shape and with size ranging from 1 µm to 5 mm, of either primary or secondary manufacturing origin, which are insoluble in water Source: Frias and Nash, 2019.



CLASSIFYING MICROPLASTICS BY SHAPE & COLOR

Microplastic type	Definition	Potential sources
Fragment	Hard, jagged plastic particle	Bottles; hard, sturdy plastics
Line/fiber	Thin or fibrous, straight plastic	Fishing line/nets; clothing or textiles
Pellet	Hard, rounded plastic particle	Virgin resin pellets; facial cleansers
Film	Thin plane of flimsy plastic	Plastics bags, wrappers, or sheeting
Foam	Lightweight, sponge-like plastic	Foam floats, Styrofoam, cushioning

Microplastic colour is considered important, for studies concerning marine organisms, as some species are thought to potentially ingest microplastics based on a colour preference behaviour

SIZE IS IMPORTANT

- Different sizes of plastic particles or larger plastic objects need different types of equipment to sample them in the ocean and different analytical techniques in the laboratory.
- Size also determines the likely impact on ocean life and human activities such as fisheries.

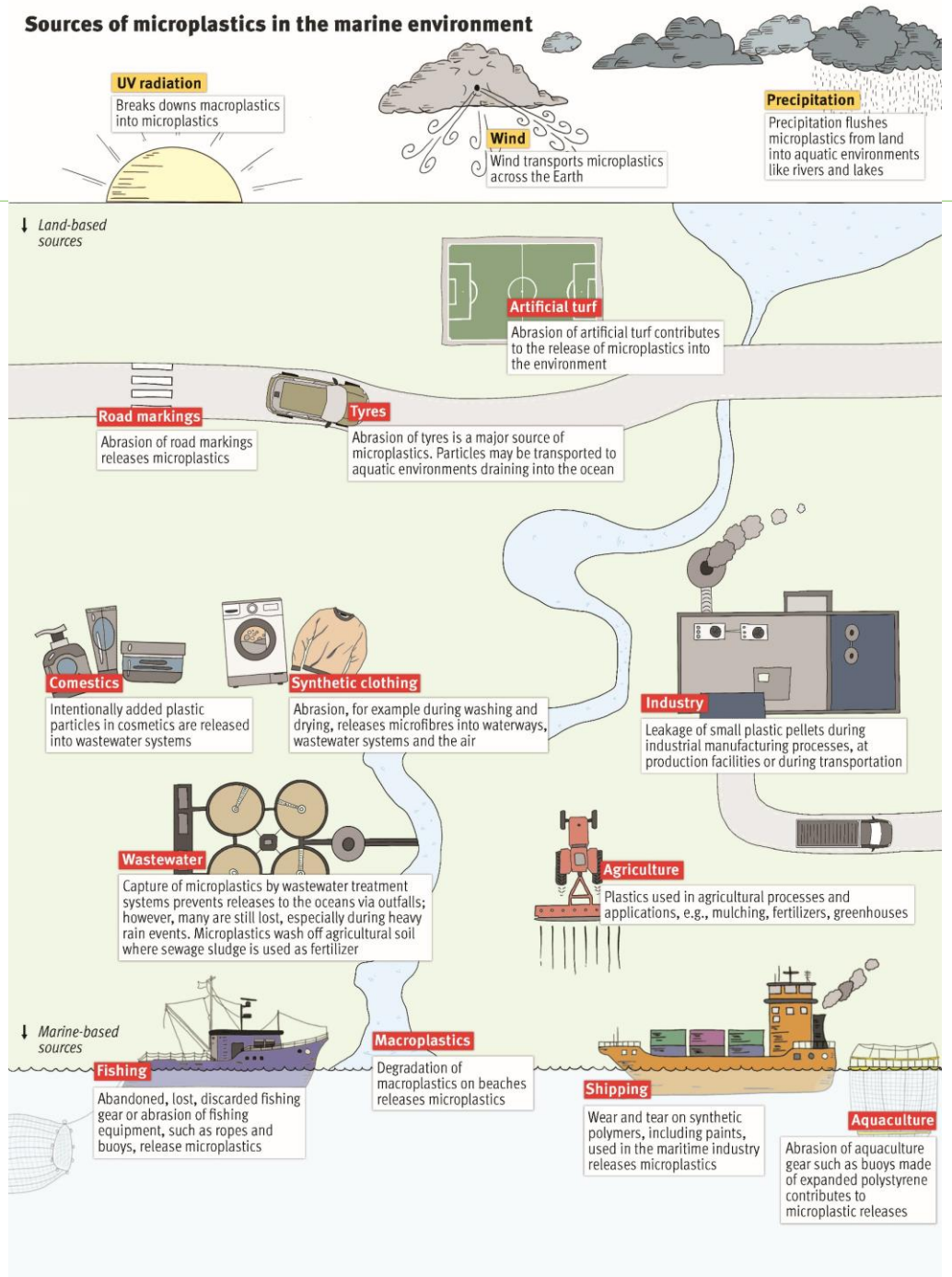
TYPES OF MICROPLASTICS

Primary microplastics

manufactured for the purpose of being added to (or used in the production of) other products

Secondary microplastics

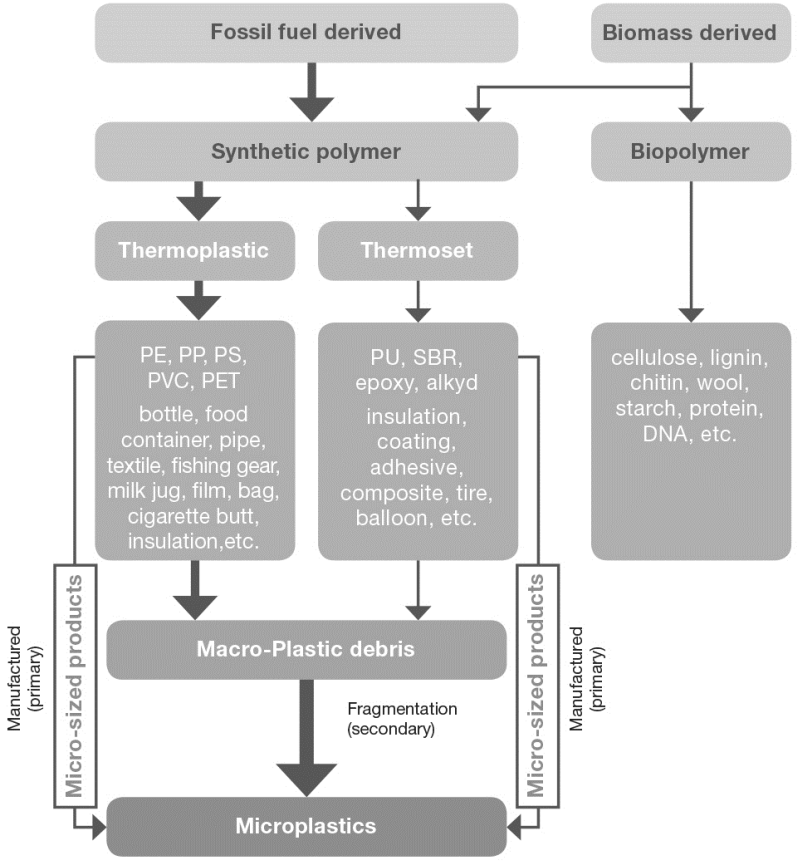
created by the fragmentation and degradation of macroplastics



MICROPLASTICS TERMS & DEFINITIONS IN THE RPMMM

- Primary microplastics: tiny particles designed for direct commercial use (such as cosmetics, detergents and paints components), or for indirect use (such as pre-production pellets).
- Secondary microplastics: the fraction of microplastics in the marine environment which results from the breakdown of larger plastic items into numerous tiny fragments due to mechanical forces and/or photochemical processes, as well as from other degradation sources such as water bottles, fibres in wastewater from washing clothes and particles of rubber lost from tyres due to normal wear.

MICROPLASTICS CLASSIFICATION OVERVIEW



PE - polyethylene
PP - polypropylene
PS - polystyrene
PVC - poly(vinyl chloride)
PET - poly(ethylene terephthalate)
PU - polyurethane
SBR - styrene-butadienne rubber

MICROLITTER MONITORING APPROACHES

Beach sediments

Sea surface

Seafloor sediments

Biota

MICROLITTER STUDIES IN MEDITERRANEAN BEACH SEDIMENTS

Location	Size	Sampling			Extraction					Identification	Reference
		Beach zone	n	Depth (cm)	Drying duration/ Temp	Extraction process	Stirring time/ speed	Settling time	Repeat extractions		
Slovenian coast	250µm-5mm	Entire beach	3	5	24 h/60 °C	1.2 kg/L NaCl	2 min manually	30 min	2	Visual (microscope)	Laglbauer et al., 2014
Slovenian coast	250 µm-5mm	Sublittoral zone	3	ND	24 h/60 °C	1.2 kg/L NaCl	2 min manually	30 min	2	Visual (microscope)	Laglbauer et al., 2014
North-western Adriatic coast, Italy	≤5mm	High tide mark	6	5	48 h/50 °C	Optical	-	-	-	FTIR-ATR	Munari et al., 2017
Mediterranean coastline, Morocco	1.25-4.75 mm	Entire beach	3	5	1 h/65 °C	Optical	-	-	-	-	Alshawafi et al., 2017
Northern coast of Crete isl.	≥2mm	Entire beach	12-18	10	-	Optical	-	-	-	-	Karkanorachaki et al., 2018
Mediterranean Sea (Esp, Fr, It, Gr, Tr, Is)	0.3- 5mm	High tide line	5	5	48 h/60 °C	1.2 kg/L NaCl	2 min/ 900 rpm	8 h	3	Visual (microscope) and Raman spectroscopy	Lots et al., 2017
Northern Tunisian coast	≥1mm	ND	3	2-3	air	1.2 kg/L NaCl	5 min manually	ND	ND	FTIR-ATR	Abidli et al., 2018
Kea isl., Aegean Sea	1-2 mm	Upper beach	3-4	3	ND	1.2 kg/L NaCl	ND	ND	ND	FTIR-ATR	Kaberi et al., 2013
Kea isl., Aegean Sea	2-4 mm	Upper beach	3-4	3	ND	Optical	-	-	-	Visual and FTIR-ATR	Kaberi et al., 2013
Samos isl., Greece	≥1.2 µm	Beach and sublittoral zone	27	0-5, 5-10, 10-15 cm	ND	1.2 kg/L NaCl	ND	ND	ND	ND	De Ruijter et al., 2018

Source: Vlachogianni, et al., 2018. State-of-the-art methods to monitor marine litter and its impacts on biodiversity. Interreg Med Plastic Busters MPAs project.

MICROLITTER STUDIES IN THE MEDITERRANEAN SEA SURFACE

Photo: Thomais Vlachogianni

Location	Sampling						Identification	References
	Compartment	Net	Mesh size	Mouth	Vessel speed	Time		
North Western Mediterranean Sea Tuscan coast	Sea surface/Water column	Surface samples: Manta-net Vertical hauls: WP2 plankton net	Manta trawl net: 330 µm WP2 net: 200 µm	Manta trawl: 0.5 × 0.25 m WP2: 0.57 m diameter	Manta trawl: 2 – 3 knots WP2: 0 knots	Manta trawl: 20 min WP2: up to 100 m	FTIR	Baini et al., 2018
Western Mediterranean Sea PelagosSanctuary	Sea surface	Manta-net	330 µm	0.5 × 0.25 m	3 – 4 knots	30 min	FTIR	Fossi et al., 2017
Western Mediterranean SeaGulf of Lion	Sea surface	Manta-net	780 µm	0.5 x 0.15 m	2.5 knots	20 min	Visual (microscope)	Schmidt et al., 2017
Aegean-Levantine Sea, Turkish	Sea surface	Manta-net	333 µm	0.4 x 0.2 m	-	-	FTIR	Güven et al., 2017
Aegean-Levantine Sea	Sea surface	Manta-net	333 µm	0.2 × 0.6 m	2 knots	15 min	Visual (microscope)	van der Hal et al., 2017
Western Mediterranean Sea (Ligurian Sea)	Sea surface	Neuston net	200 µm	0.6 x 0.2 m	2.5 knots	60 min	FTIR	Pedrotti et al., 2016
Western Mediterranean Sea and Adriatic Sea	Sea surface	Neuston net	200 µm	1 × 0.5 m	1.5 – 2 knots	5 min	FTIR-ATR	Suaria et al., 2016
Whole Mediterranean	Sea surface	Manta-net	333 µm	0.6 x 0.25 m	3.13 knots	15 - 30 min	Visual (microscope)	Ruiz-Orejón et al., 2016
Adriatic Sea	Sea surface	Neuston net	300 µm	0.6 × 0.15 m	3 knots	20 min	Chemical analysis	Gajšt et al., 2016
Western Mediterranean Sea	Sea surface	Neuston net	200 µm	0.6 x 0.25 m	1.5 knots	20 min	Visual (microscope)	Fossi et al., 2016
Aegean-Levantine Sea Turkey	Sea surface	Manta-net	333 µm	0.6 × 0.25 m	2 knots	20 min	Visual (microscope)	Gündoğdu and Çevik, 2017
Western Mediterranean Sea AsinaraNational Park PelagosSanctuary	Sea surface	WP2	200 µm	57 cm diameter	0.772 m/s	20 min	Visual (microscope)	Panti et al., 2015
Whole Mediterranean	Sea surface	Neuston net	200 µm	1.0 × 0.5 m	2 – 3 knots	15 min	Visual (microscope)	Cózar et al., 2015
Western Mediterranean Sea	Sea surface	Manta-net	330 µm	0.6 × 0.15 m	1.4 m/s	45 - 90 min	Visual (microscope)	Faure et al., 2015
Western Mediterranean Sea (Corsica)	Sea surface	WP2 0.2 mm	200 µm	0.6 x 0.25 m	2.5 km/h	20 min	Visual (microscope)	Collignon et al., 2014
Western Mediterranean Sea (Sardinian coast)	Sea surface	Manta-net	500 µm	-	2 knots	20 min	Visual (microscope)	de Lucia et al., 2014
Adriatic and Ionian Seas	Sea surface	Manta-net	330 µm.	0.6 × 0.24 m	< 3 knots	30 min	Visual (stereomicroscope); ATR-FTIR spectroscopy	Zeri et al., 2018

Source: Vlachogianni, et al., 2018. State-of-the-art methods to monitor marine litter and its impacts on biodiversity. Interreg Med Plastic Busters MPAs project.

INDICATIVE FLOATING MICROPLASTICS DENSITIES

Location	Habitat	Date	Density	References
North Western Mediterranean Sea Tuscan coast	Sea surface/Water column	2013-2014	Surface: 69,161.3 ± 83,243.9 items/km^2 Vertical: 0.16 ± 0.47 Items/m^3	Baini et al., 2018
Western Mediterranean Sea Pelagos Sanctuary	Sea surface	2014	82,000 ± 79,000 items/km^2	Fossi et al., 2017
Western Mediterranean Sea (Ligurian Sea)	Sea surface	2013	125,930 ± 132,485 Items/km^2 ± SD	Pedrotti et al., 2016
Western Mediterranean Sea and Adriatic Sea	Sea surface	2013	400,000 ± 740,000 items/km^2 1.00 ± 1.84 Items/m^3	Suaria et al., 2016
Adriatic Sea- Slovenian coastal waters	Sea surface	2014	472,000 ± 201,000 Items/km^2 ± SD	Gajšt et al., 2016
Gulf of Trieste	Sea surface	2014- 2015	444,182 ± 563,190 items/km^2	Zeri et al., 2018
Western Mediterranean Sea	Sea surface	2012	0.31 ± 1.17 Items/m3 ± SD	Fossi et al., 2016
Western Mediterranean Sea, Asinara National Park, Pelagos Sanctuary	Sea surface	2012–2013	0.17 ± 0.32 Items/m^3 ± SD	Panti et al., 2015
Whole Mediterranean	Sea surface	2013	243,853 Items/km^2	Cózar et al., 2015
Western Mediterranean Sea (Sardinian coast)	Sea surface	2013	0.15 ± 0.11 Items/m^3	de Lucia et al., 2014
Ligurian and Sardinian Sea	Sea surface	2011	0.62 ± 2.00 Items/m^3 ± SD	Fossi et al. 2012
Western Mediterranean Sea	Sea surface	2010	116,000 Items/km^2	Collignon et al., 2012
Archipelago of Zadar	Sea surface	2015	127,135 ± 294,847 particles/km^2	Palatinus et al., 2019

MICROLITTER STUDIES IN MEDITERRANEAN SEAFLOOR SEDIMENTS

Location	Sampling	Depth	Laboratory analysis	References
32"22.90 N 31"43.130 E	25 cm^2 Core sampling, 1-5mm	1176-4848	Density (NaCl) separation, visual counts, 4 categories (fibres, pellets, films, spherical)	Van cauwernberghe et al., 2013
NW basin, canyons & slope	Canyons/slopes/abyssal plain, ROV/core sampling, 0.32-5mm	300-3500	Density (NaCl) separation, visual counts, fibers & particles separation, FTIR analysis	Woodall et al., 2014
Eolian Islands	Undisturbed sediment (5 cm depth) collected by scientific scuba divers, using wide mouth glass jars	30	Surface sediment, sieving, visual observation, MSFD categories (5)	Fastelli et al., 2016
Malta	0.1-m2 van Veen grab at eight sampling stations	4-22	Density (NaCl) separation, visual counts, 3 categories (fibrous, rounded and irregular)	Romeo et al., 2015
Croatia	sediment collected by scientific scuba divers, using wide mouth glass jars in 10 sites. Three replicates for each site	3-15	Density (NaCl) separation of sieved fractions, MSFD categories (5)	Blăsković et al., 2017
Balearic Islands	Superficial core sampling (0-3.5 cm) with scuba diving, 1- 5 mm	8-10 m	Density (NaCl) separation of sieved fractions, MSFD categories (5)	Alomar et al., 2016

Source: Vlachogianni, et al., 2018. State-of-the-art methods to monitor marine litter and its impacts on biodiversity. Interreg Med Plastic Busters MPAs project.

COMPOSITION OF FLOATING MICROPLASTICS

The detected plastic types are diverse but some are predominant on the sea surface because of their widespread use and their buoyancy:

- poly(ethylene) (PE) frequent in food packaging (e.g. in films and bottle caps)
- poly(propylene) (PP), used as packaging material and plastic parts in various industries
- poly(amides) (PA) and poly(styrene) (PS)

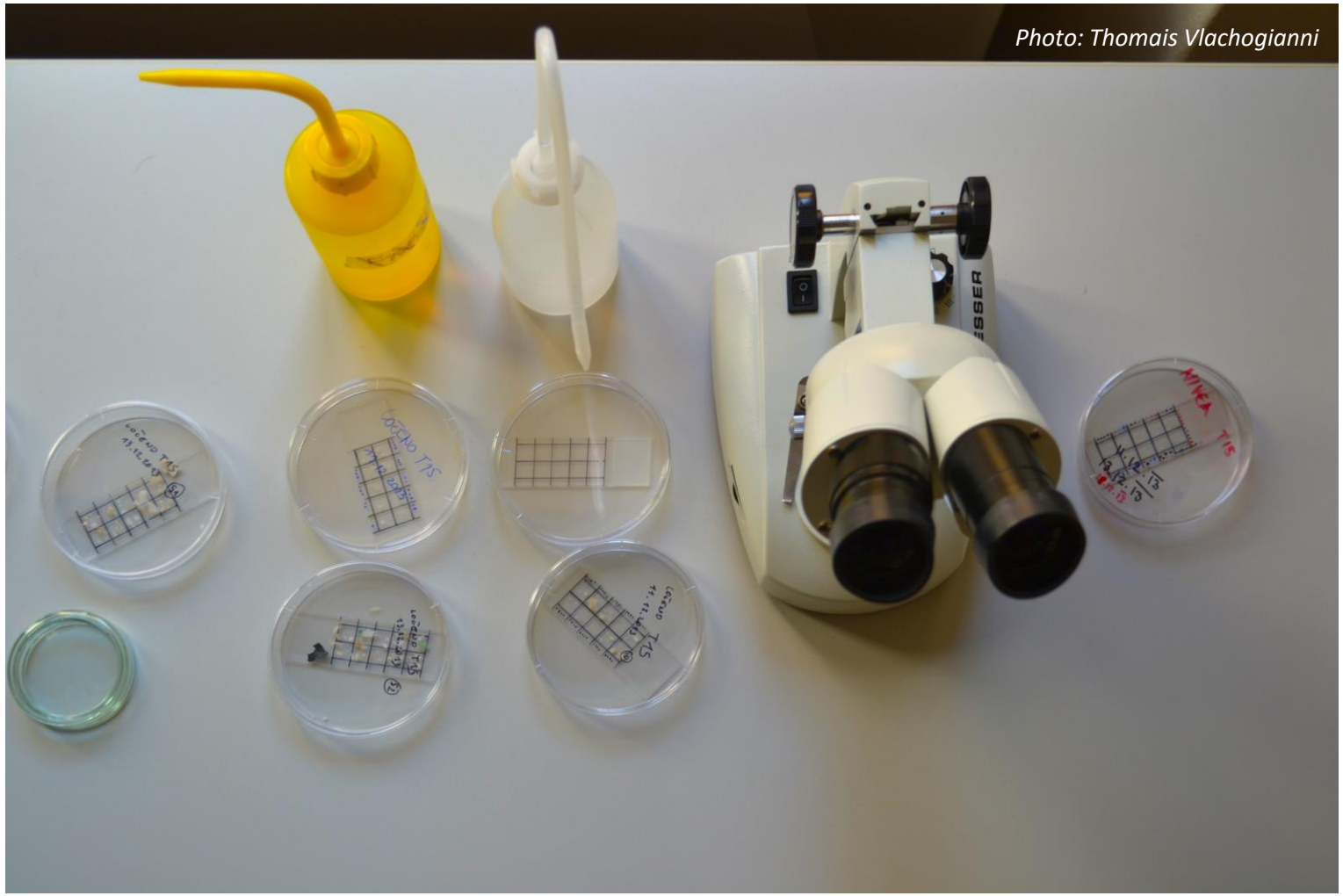
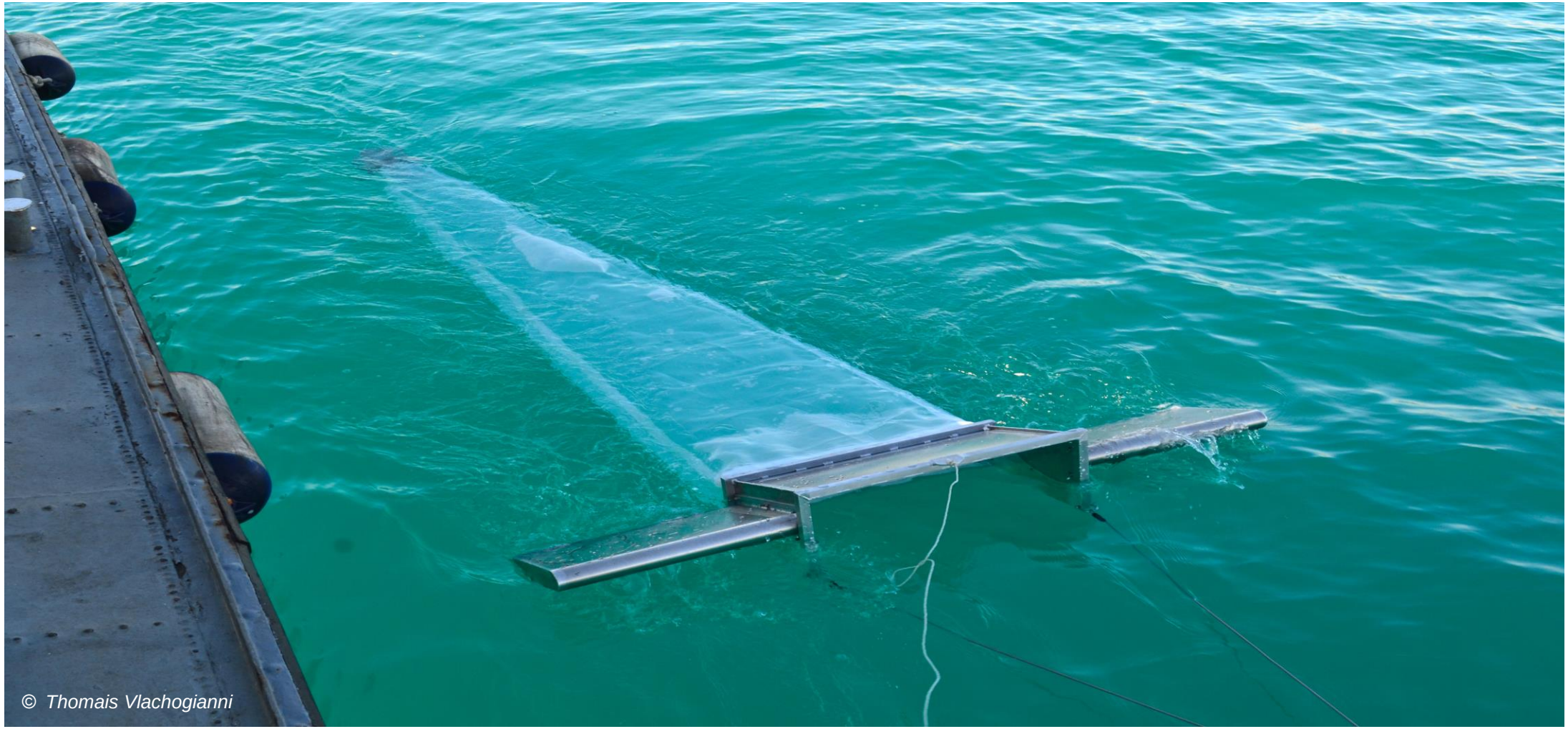


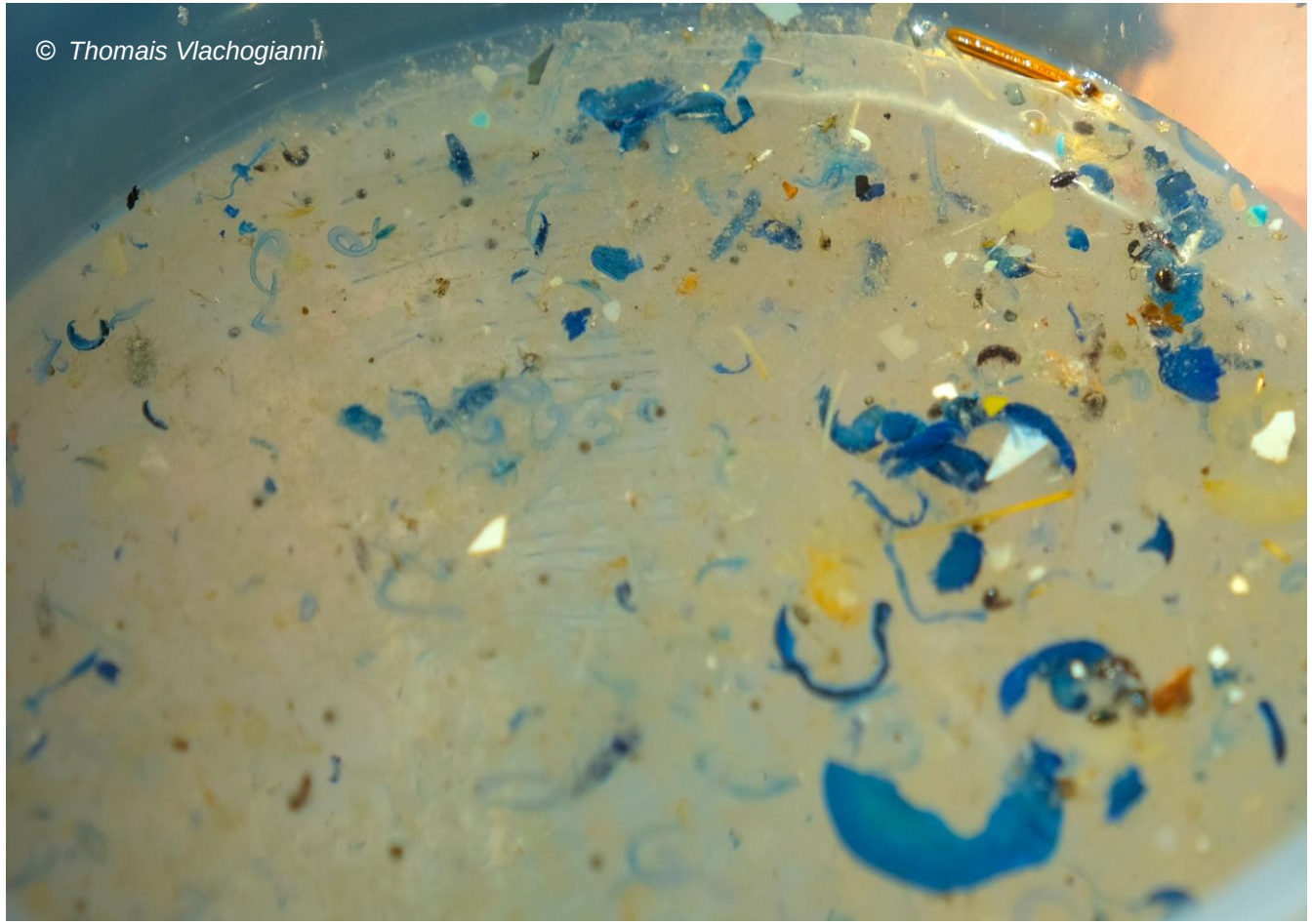
Photo: Thomais Vlachogianni

MONITORING MARINE MICROLITTER ON THE SEA SURFACE WITH MANTA TRAWLING



MARINE MACROLITTER MONITORING | KEY ELEMENTS

- **Monitoring Strategy**
  - Site selection
  - Frequency & timing
  - Sampling unit
- **Survey Protocol**
  - Litter ‘sampling’
  - Sample processing
  - Microplastics identification & classification



SITE SELECTION CRITERIA

- Low density areas (e.g. open sea)
- High density areas (e.g. close to ports)
- Other selected areas e.g. in estuaries, in the vicinity of cities, in local areas of touristic, recreational or commercial traffic

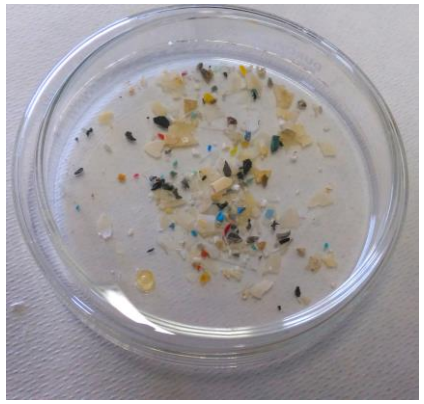


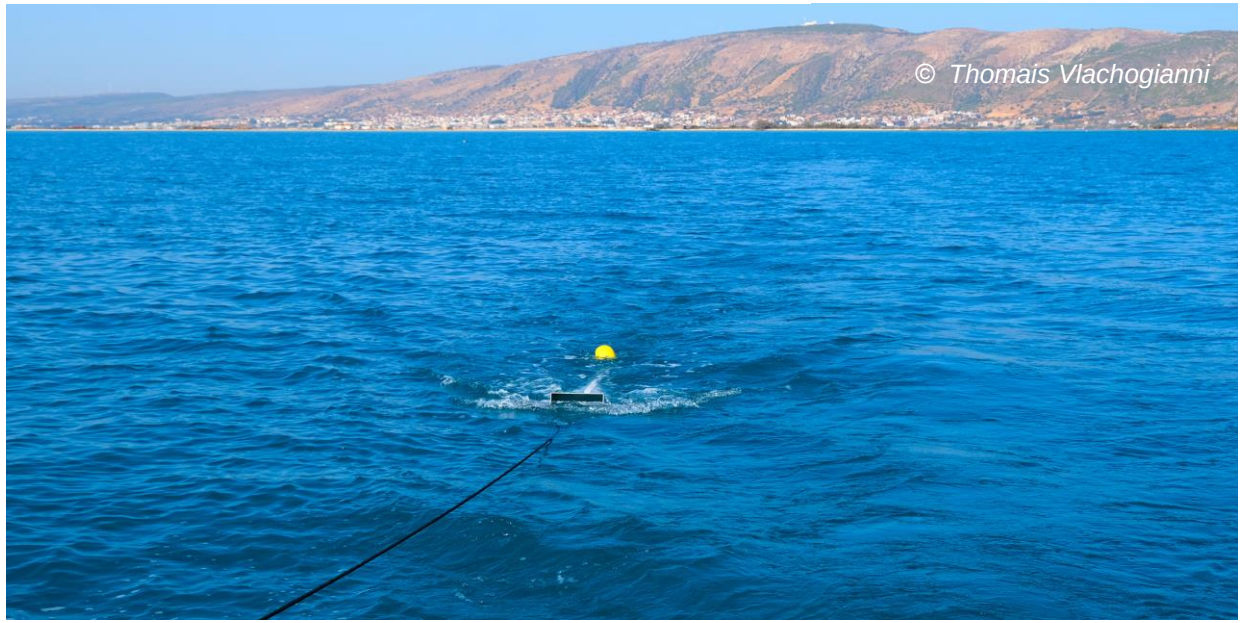


FREQUENCY & TIMING OF THE SURVEYS

Spring:
April

Autumn:
October





THE SAMPLING UNIT

Manta trawl equipped with a flowmeter
Mouth opening: 60 x 15 cm
Mesh size: 330 µm
Sampling duration: 30 minutes
Vessel speed: 1.5 – 2.5 knots

- ✓ The sampling should be conducted using small to medium-sized vessels in low wind conditions (0-2 Beauforts).
- ✓ All tows should be conducted from the ship's side and beyond the ships' wake.
- ✓ Both the starting and ending positions should be recorded with GPS, along with the track.

THE SAMPLING PROCEDURE – STEP-BY-STEP






- ✓ The **sample collected in the cod-end** should be **rinsed** with seawater on a **300 µm metallic sieve** and transferred to glass jars filled with seawater.
- ✓ Any **natural debris items**, such as leaves, twigs, seaweed, etc., should be **rinsed separately** above the sieve and removed from the sample.
- ✓ The samples should be **stored in 70% ethanol solution** for further analysis.

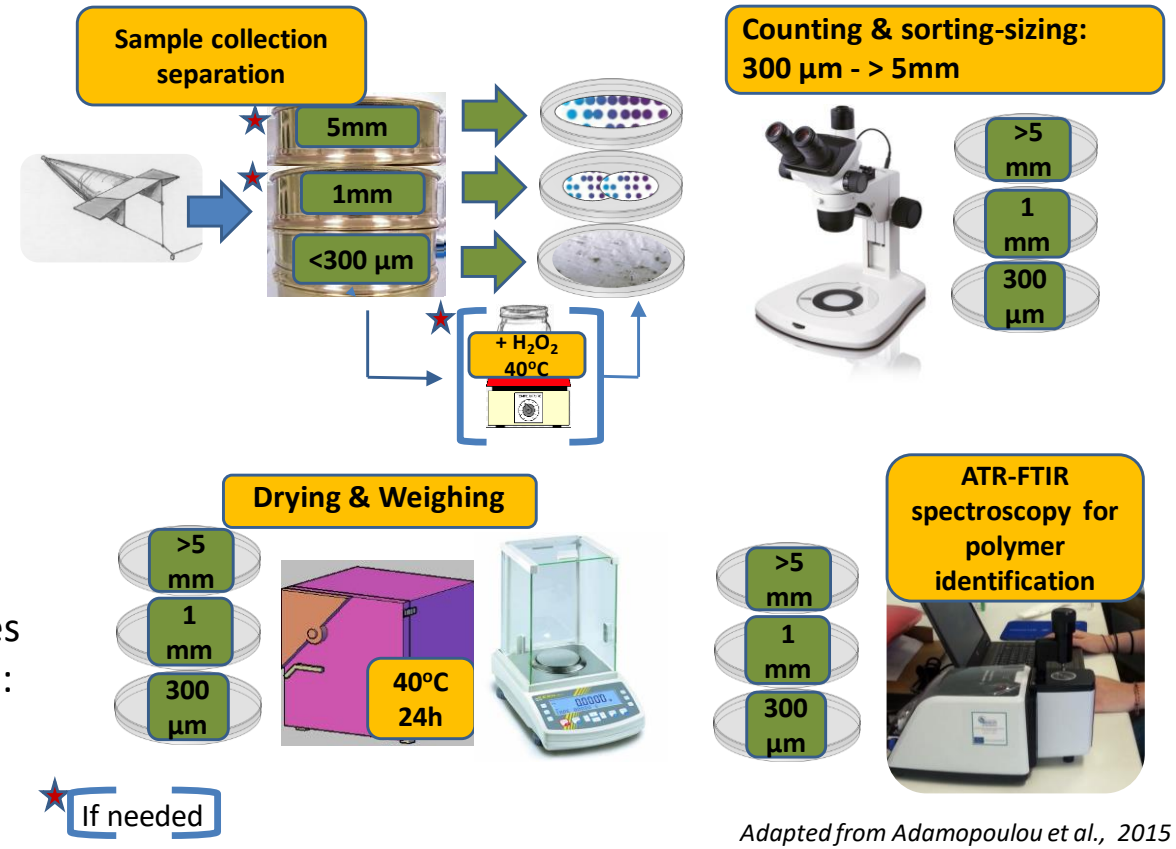
SAMPLE PROCESSING

Microlitter is classified in:

- ✓ **Large Microlitter LML (1mm-5mm)**
- ✓ **Small Microlitter SML (300µm – 1mm)**

- ✓ In case of samples **poor in natural particles and organic material**, transfer the sample into a petri dish and observe under a stereomicroscope. Measure the particles' longest dimension using an image analysis software, count and classify into the sizes classes. For the determination of weight, transfer the characterized MPs into three pre-weighted petri dishes according to size classes, dry at 40°C and weigh.

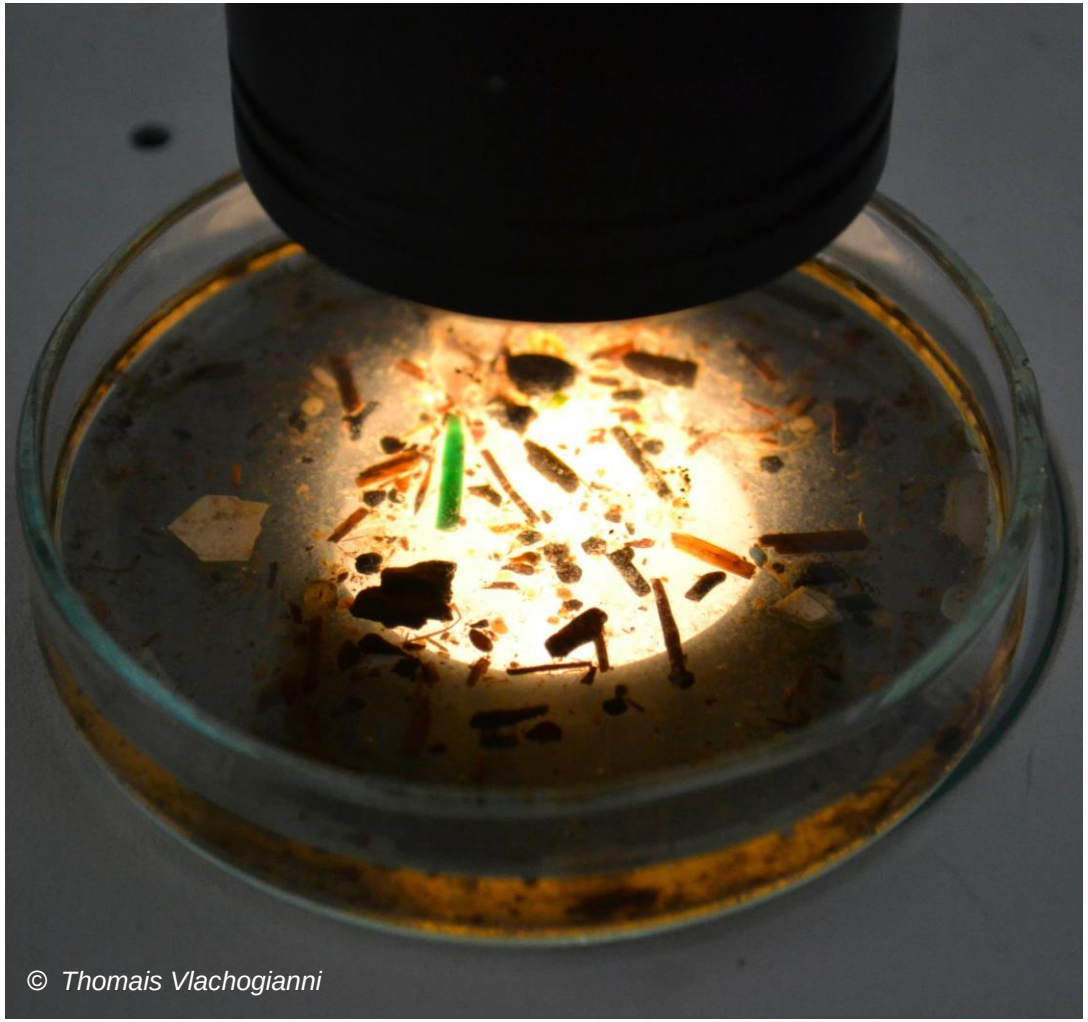
- ✓ In case of **high natural organic matter content** in the samples (LML or SML) a step of peroxide digestion precedes filtration: Add 15% hydrogen peroxide (H2O2) with 1:1 (sample:H2O2) volume ratio and boil on a hot plate (approx.40ºC) until the digestion is complete (no natural organic material should be visible). Collect the digested material with deionised water and continue with filtration, drying and mass determination.



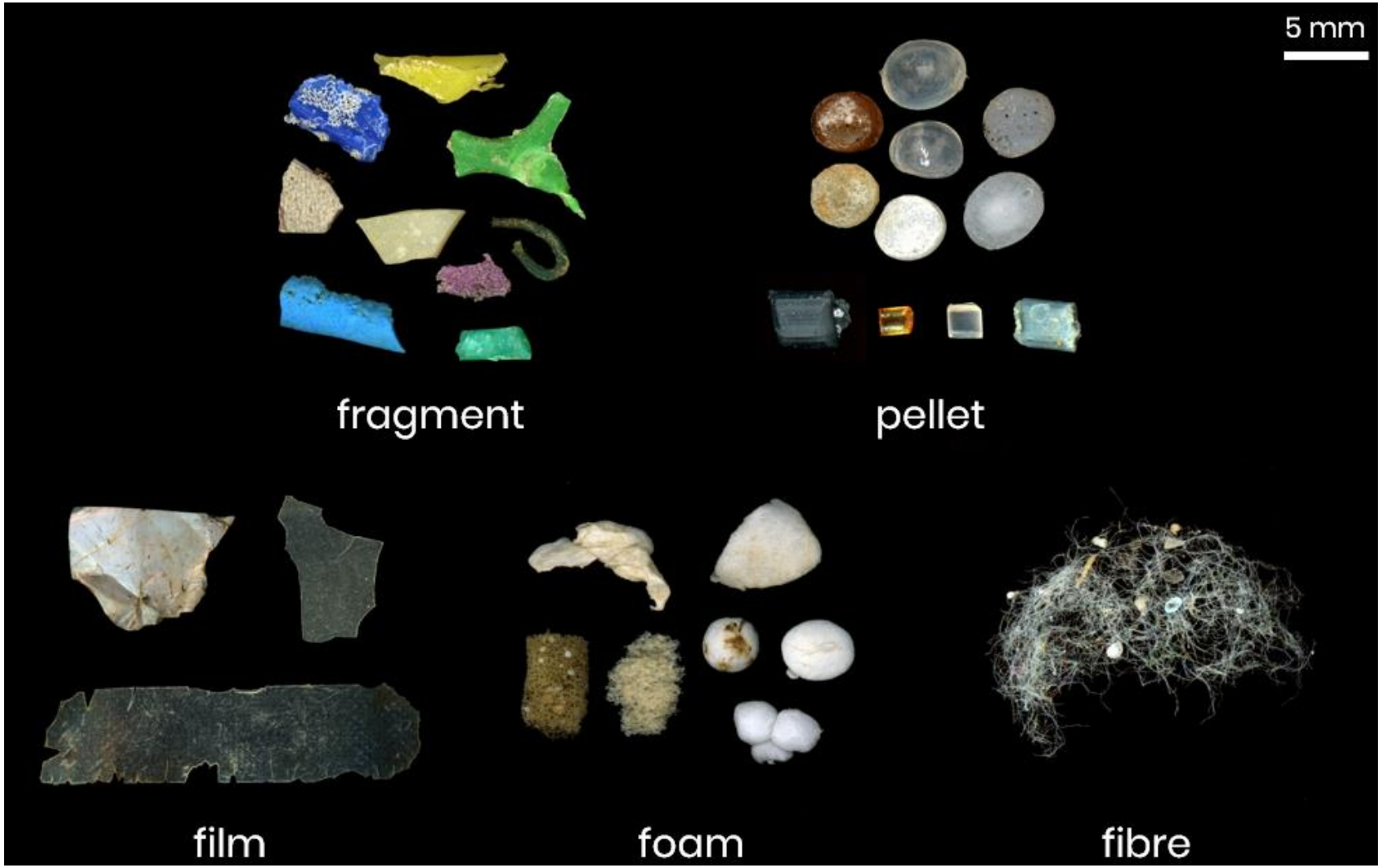
Adapted from Adamopoulou et al., 2015

SAMPLE ANALYSIS

- ✓ Microplastics sorted, counted and characterized by **type** on the basis of the following categories: pellet, fragment (granule, flake), fibre, film, filaments, microbeads, foam (expanded polystyrene-PS), in line with the MSFD TGML guidelines.
- ✓ The most common **colours** of microplastics identified are the following: black, blue, white, transparent, red, green, multicolour, other.
- ✓ For the identification of the **polymer type** it is recommended to use an ATR-FTIR spectrometer or Raman spectroscopy or Pyrolysis-Gas chromatography-mass spectroscopy (Py-GCMS). FT-IR spectroscopy is mostly used in microplastic studies and in particular ATR-FTIR is considered fast, low cost and adequate for analyzing particles >300 µm, in size like the ones collected with manta nets.



MICROPLASTICS SORTED BY TYPE



MICROPLASTICS – REPORTING UNITS

Microlitter counts (N) are reported as follows:

- N per km^2 or N per m^2, based on the start - end transect coordinates and the dimensions of the manta net mouth.
- N per Km^3 or N per m^3, based on flow meter indication and relevant formula.

Microlitter mass is reported as follows:

- g per km^2 or g per m^2
- g per Km^3 or g per m^3

Water and
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Thank you for your attention!

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