

Activity: WES N-E-MO-2

Training on marine litter monitoring

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

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



MARINE LITTER MONITORING & KEY LEGISLATIVE FRAMEWORKS



**Water and
Environment Support**
in the ENI Southern Neighbourhood region

KEY LEGISLATIVE FRAMEWORKS

EU

Marine Strategy
Framework Directive

Plastics Strategy

Single-Use Plastics
Directive

Barcelona Convention

Ecosystem Approach

Regional Plan for
Marine Litter
Management in the
Mediterranean

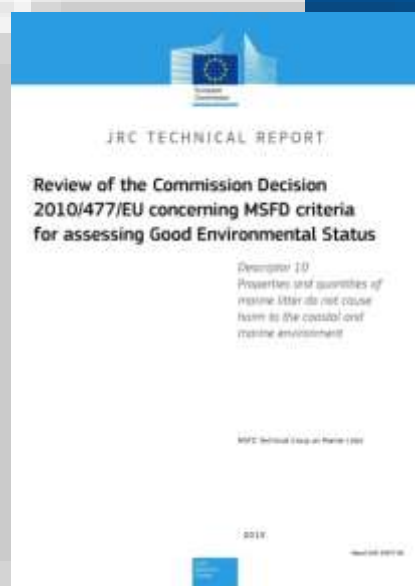
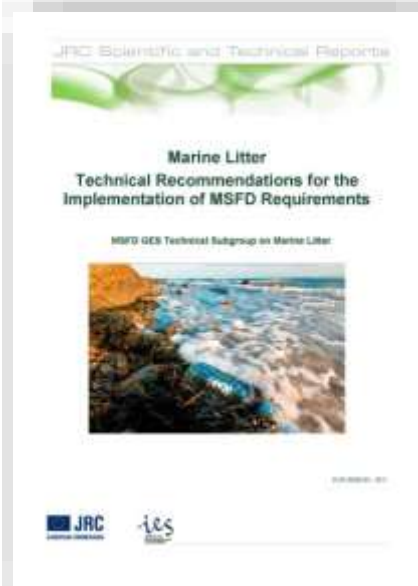


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KEY MARINE LITTER MONITORING GUIDELINES

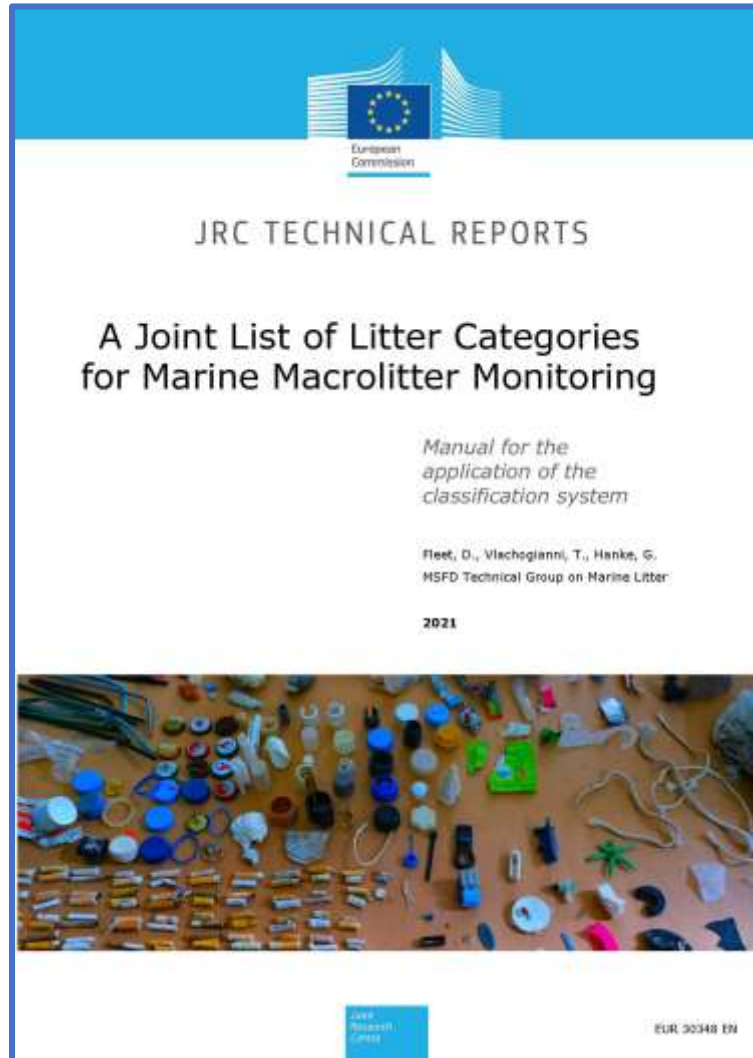


MSFD GES TECHNICAL GROUP ON MARINE LITTER



THE JOINT LIST OF LITTER CATEGORIES

6



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.

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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.

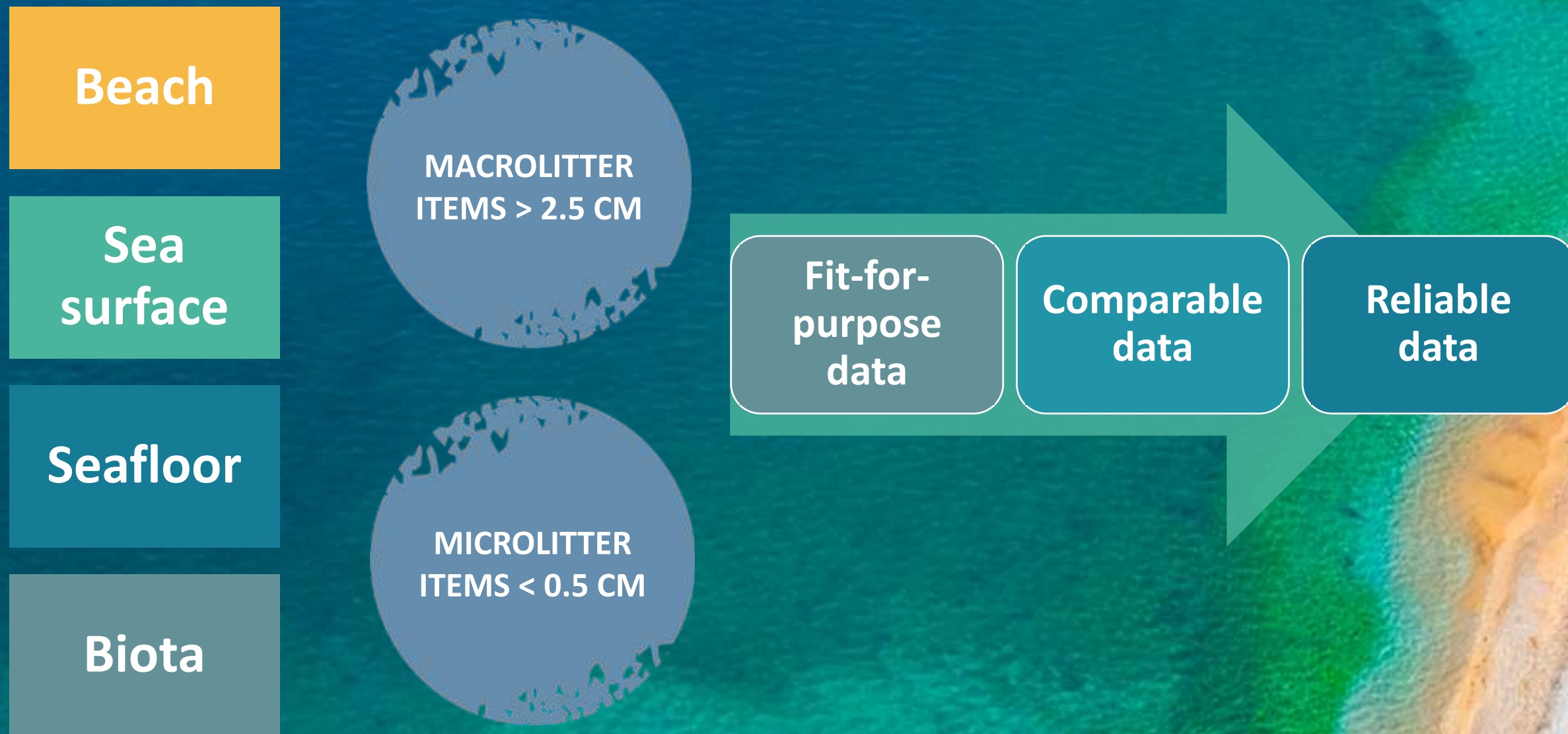
Mesolitter

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



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

THE MONITORING METHODS ADDRESSED BY WES

Monitoring marine litter on the sea surface with visual census

Monitoring marine litter on the sea floor with visual census by scuba divers



© Milica Mandić

THE MONITORING METHODS ADDRESSED BY WES



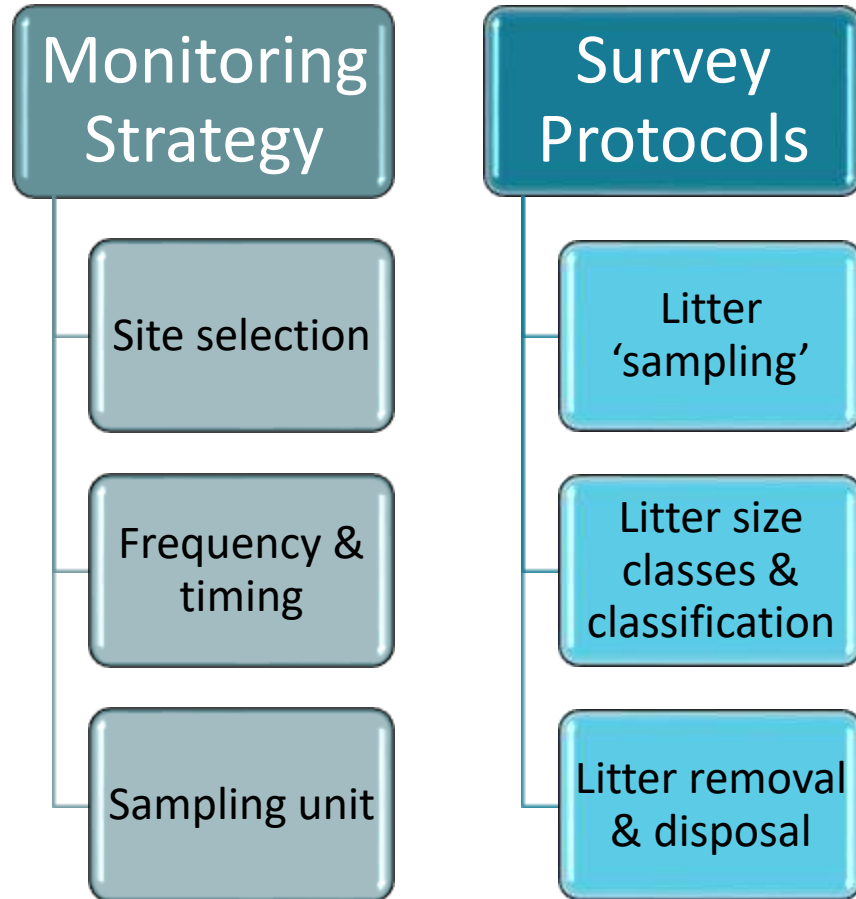
**Water and
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in the ENI Southern Neighbourhood region



© Thomais Vlachogianni

Monitoring marine microlitter on the sea surface with manta trawling

MARINE MACROLITTER MONITORING | KEY ELEMENTS



THE JOINT LIST: A LIST FOR ALL MARINE COMPARTMENTS

Beach

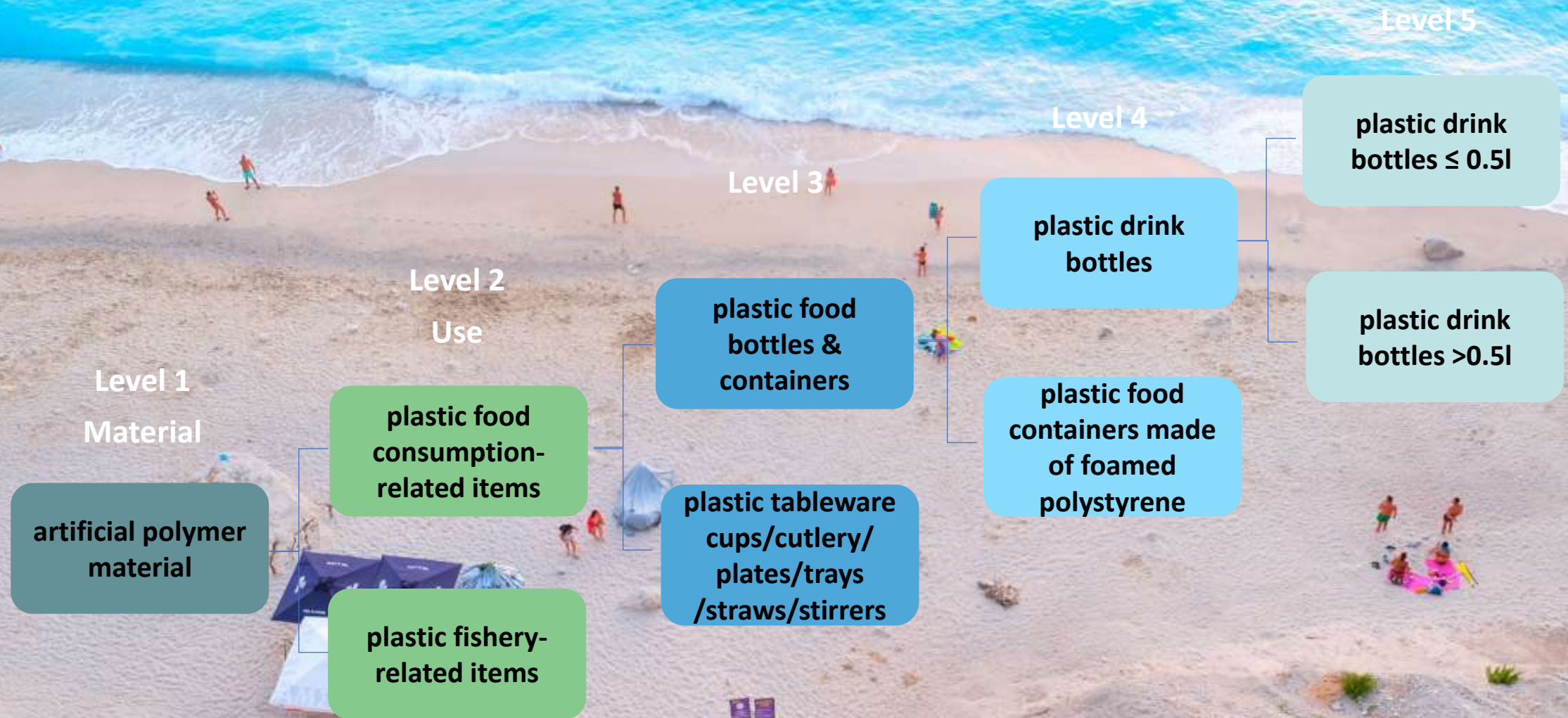
Sea
surface

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

**Harmonized
data**

**Comparable
data**

**Reliable
data**

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

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.

Online Photo Catalogue of the Joint List of Litter Categories

Example images to support the monitoring of macro litter in different environmental matrices

This page is under construction

This online photo catalogue provides guidance for the attribution of macro litter to specific categories in order to enable a harmonized monitoring data acquisition, which allows detailed data analysis. It is based on the Joint List of Litter Categories.

Choose a litter type:

Please choose a litter category

Show 10 entries

Search

JC No.	J_Code	Type_Code	SUP/Fishing	Name	Definition	Image
1	J1	pl_kc_sap_	SUP	Plastic 45-pack yokes & six pack rings	Four or six pack rings or yokes are a set of connected plastic rings that are used in multi-packs of drinks, particularly of drinks cans, to hold the cans together	
3	J3	pl_nn_bag_cabg_	SUP	Plastic shopping/canteen/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	

45	J45	pl_ad_sht_sock_	Fishing gear	Plastic mussel/oyster mesh bags, net sack, socks	A special bag or sock made of extruded net which is used for growing (underwater) oysters and other shellfish species. These bags can have different sizes and shapes e.g., sack-like and tubular and the mesh net can have different sizes.	
85	J85	pl_f_bag_hdsa_saf_	Fishing gear	Plastic commercial salt packaging	Heavy-duty sacks and other containers used for packaging and shipping salt	
92	J92	pl_f_hls_	Fishing gear	Plastic bait containers/packaging	Plastic packaging (pouches, bags) and plastic containers suitable for storing, transporting, selling fishing baits	
191	J191	pl_nn_bag_dogb_		Plastic dog/pet faeces bag	A plastic bag used for picking up and removing the faeces of a dog or other pet	
139	J139	cl_re_hps_		Cloth/teddy backpacks & tote bags	Teddy receptacles with an opening at the top, shoulder straps or a handle, used for carrying things	
147	J147	pp_nn_bag_		Paper bags	A small bag made of paper, commonly used as shopping bags, packaging, etc.	

Online Photo Catalogue of the Joint List of Litter Categories

Example images to support the monitoring of macro litter in different environmental matrices



This page is under construction

Plastic crates, boxes, baskets

Plastic containers typically used to transport or store different types of items and products, other than fisheries and aquaculture related.

J-Code: J18

Category: Artificial polymer materials => Undefined use =>



Online Photo Catalogue of the Joint List of Litter Categories

Example images to support the monitoring of macro litter in different environmental matrices



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Plastic single-use face-mask

Single-use facemask used to protect against for example dust, chemicals and pathogens (e.g., COVID-19 pandemic).

J-Code: J253

Category: Artificial polymer materials => Medical related =>



<https://mcc.jrc.ec.europa.eu/main/photoscatalogue.py?N=41&O=457&cat=all>

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

25



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

Interreg
Mediterranean



PLASTIC BUSTERS
MPAs



ENI
CBCMED
Cooperating across borders
in the Mediterranean



Project funded by the
EUROPEAN UNION



REGIONE AUTONOMA DE SARDEGNA
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>



METHODOLOGY 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
<ul style="list-style-type: none">✓ 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.	<ul style="list-style-type: none">✓ 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**



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

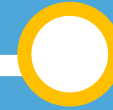
Frequency:
4 surveys/year



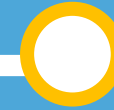
Autumn:
October



Winter:
January



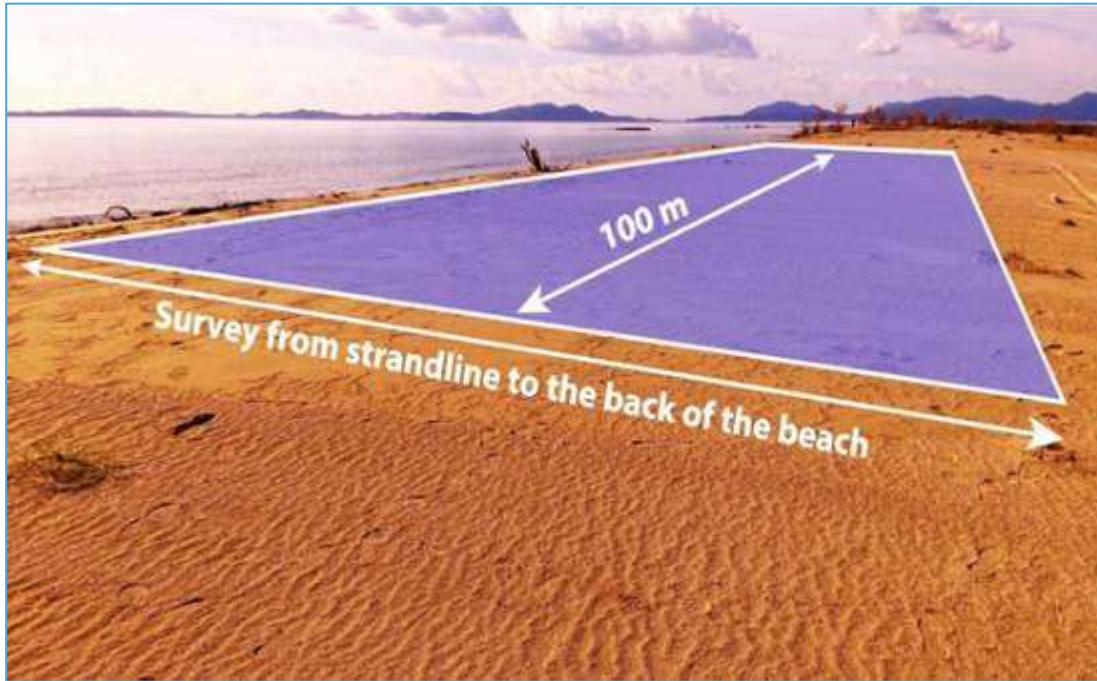
Spring:
April



Summer:
July



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

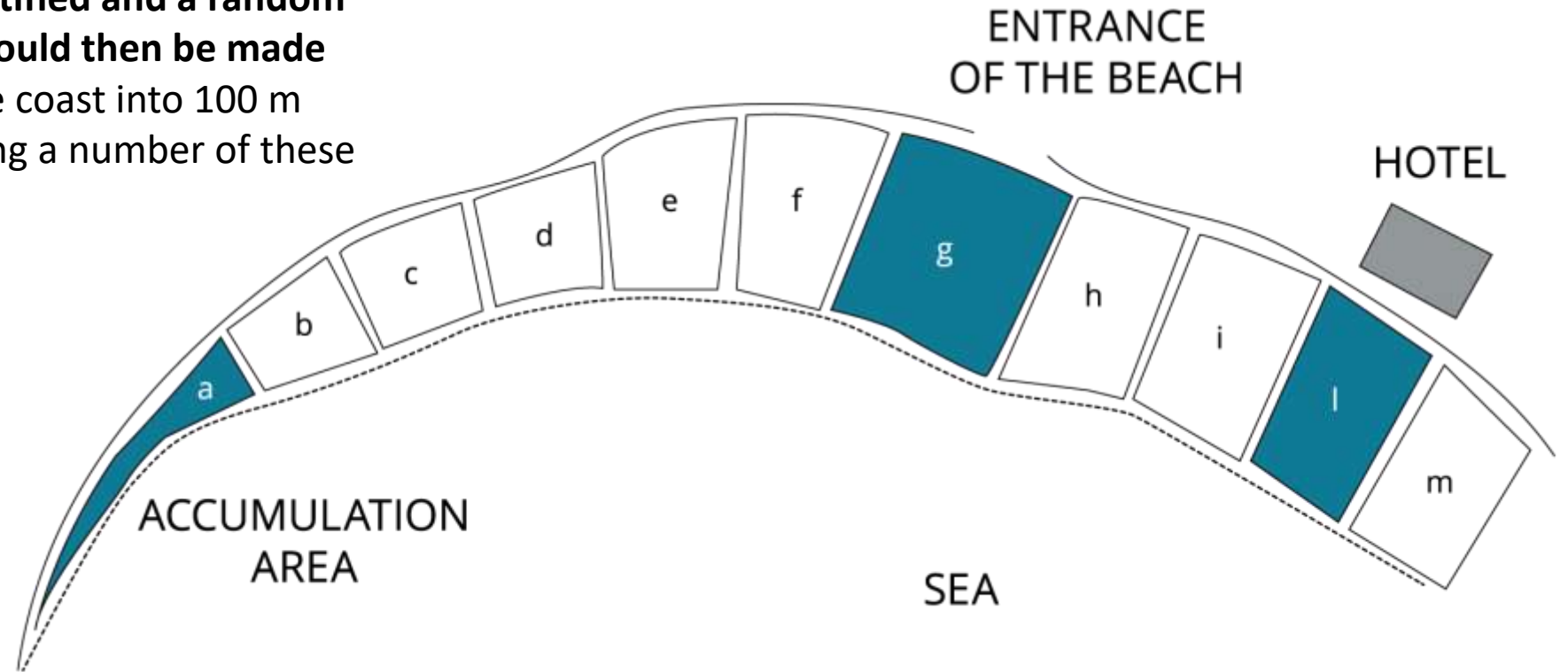
Sampling units should represent the **general characteristics** of the survey site and the **general state of litter** in the survey site.

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.



Photo © Thomais Vlachogianni

LITTER SIZE CLASSES TO BE SURVEYED



Plastic straws



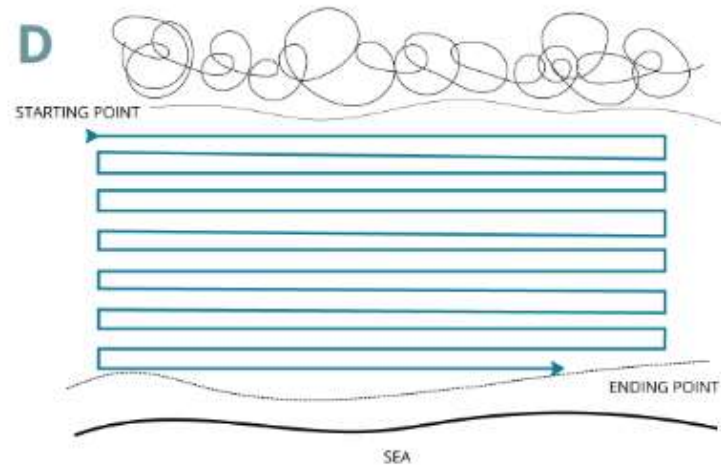
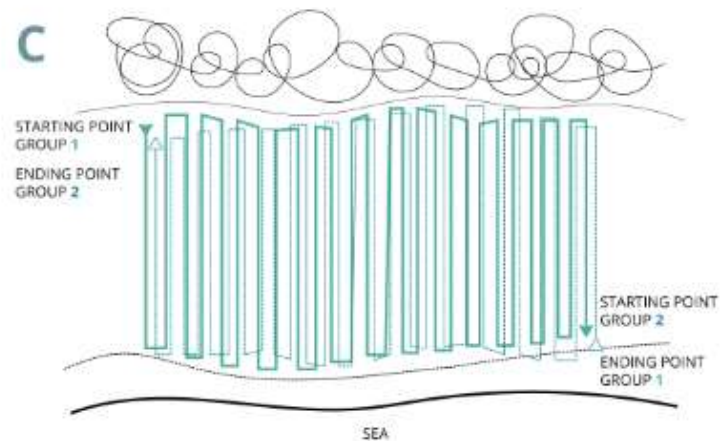
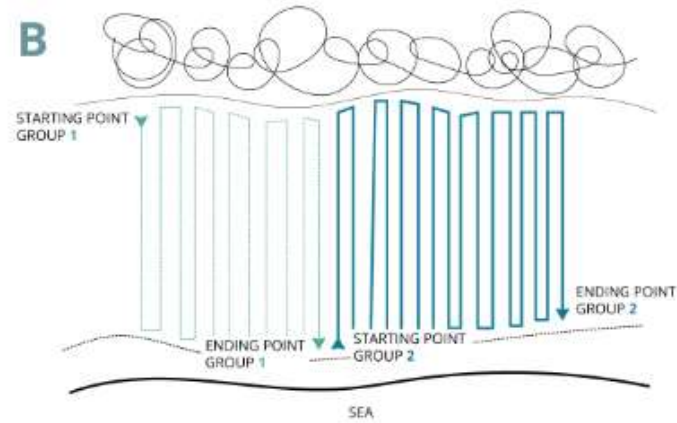
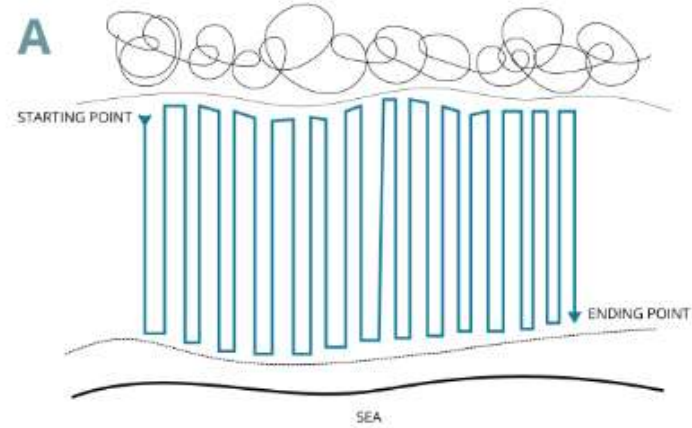
Plastic caps



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.



High-resolution camera



Hand-held GPS unit with extra batteries



100-metre tape measure (fiberglass preferred)



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



**Water and
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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



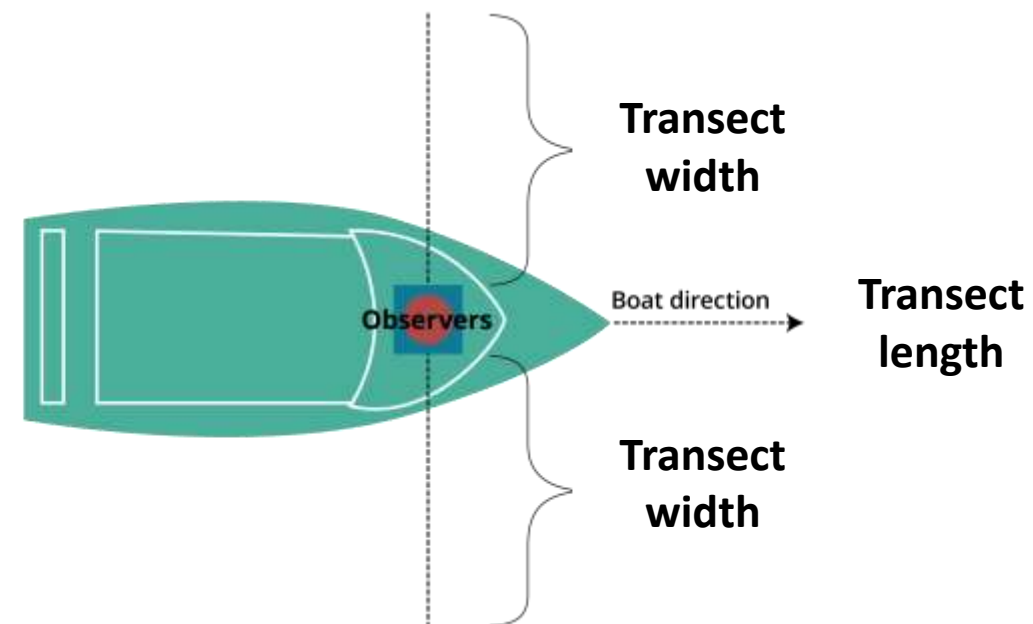
**Water and
Environment Support**
in the ENI Southern Neighbourhood region

Spring:
April

Autumn:
October



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MONITORING MARINE LITTER ON THE SEA SURFACE WITH VISUAL CENSUS



**Water and
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- ✓ **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
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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/km²). 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



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MONITORING MARINE LITTER ON THE SEA SEAFLOOR WITH VISUAL CENSUS



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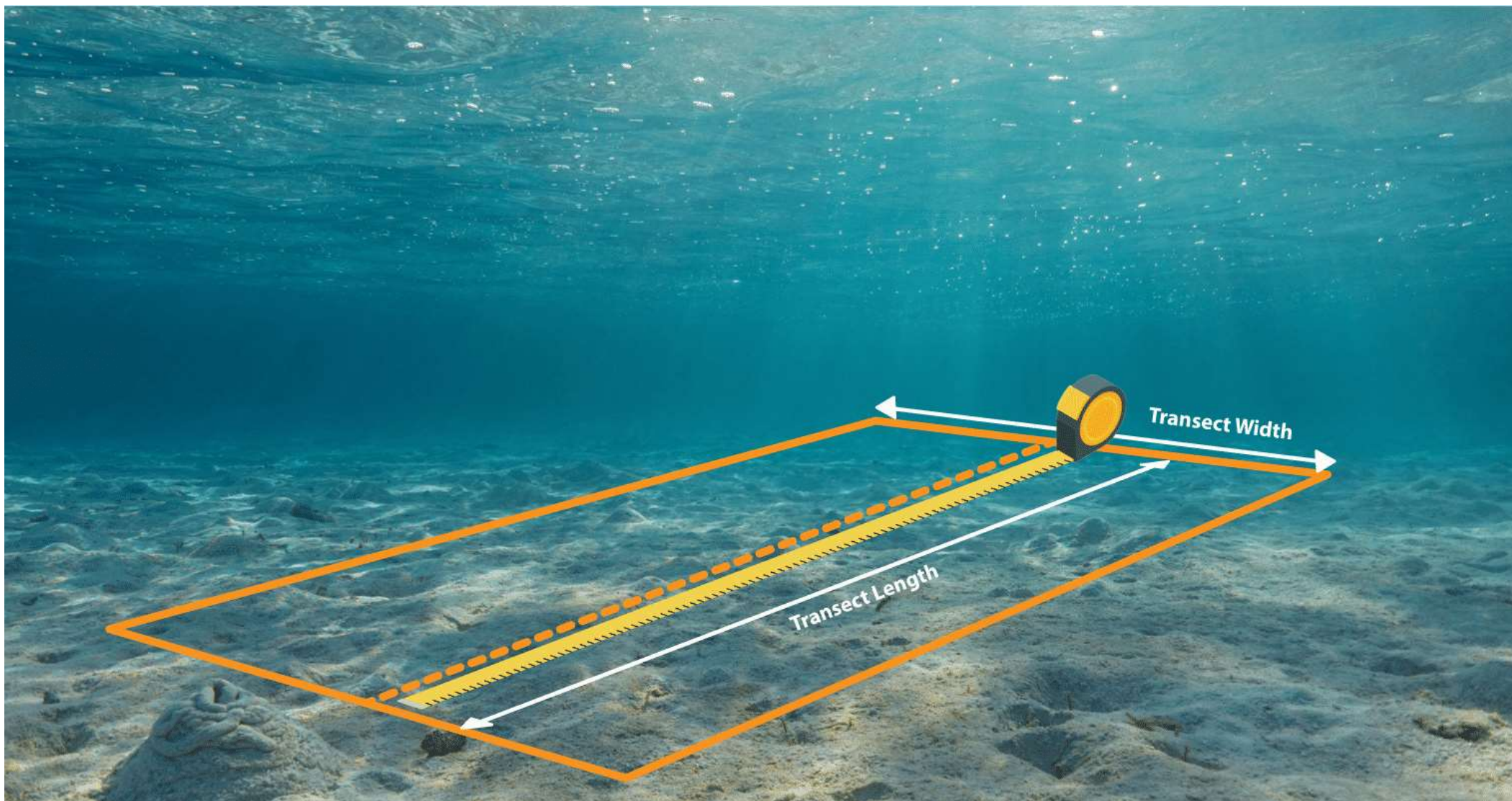


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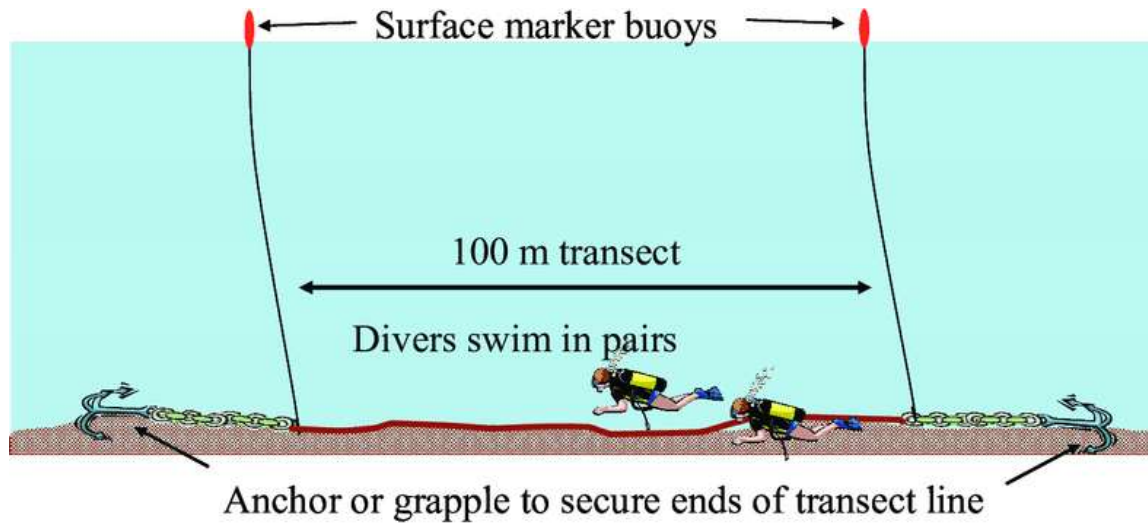
MONITORING MARINE LITTER ON THE SEA SEAFLOOR WITH VISUAL CENSUS



**Water and
Environment Support**
in the ENI Southern Neighbourhood region



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/km²).

Litter items classification



Photo © P.Consoli



Photo © Institute of Marine Biology of the University of Montenegro



Photo © P.Consoli



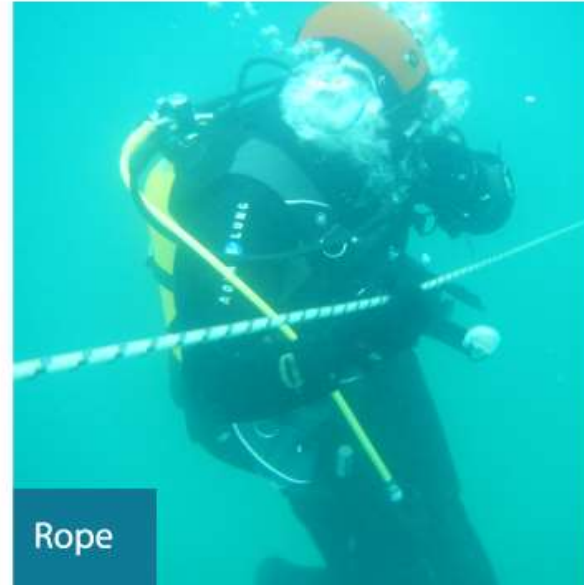
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Materials & equipment



METHODOLOGY FOR MONITORING MARINE MACROLITTER ON THE SEAFLOOR WITH BOTTOM TRAWLING

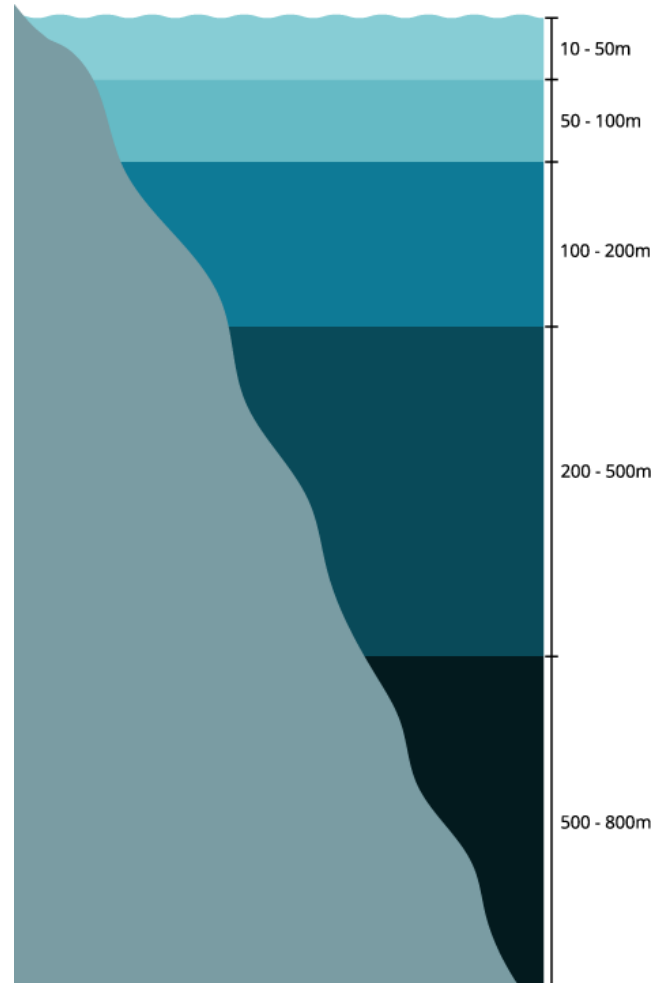


MONITORING MARINE LITTER ON THE SEA SEAFLOOR

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.**

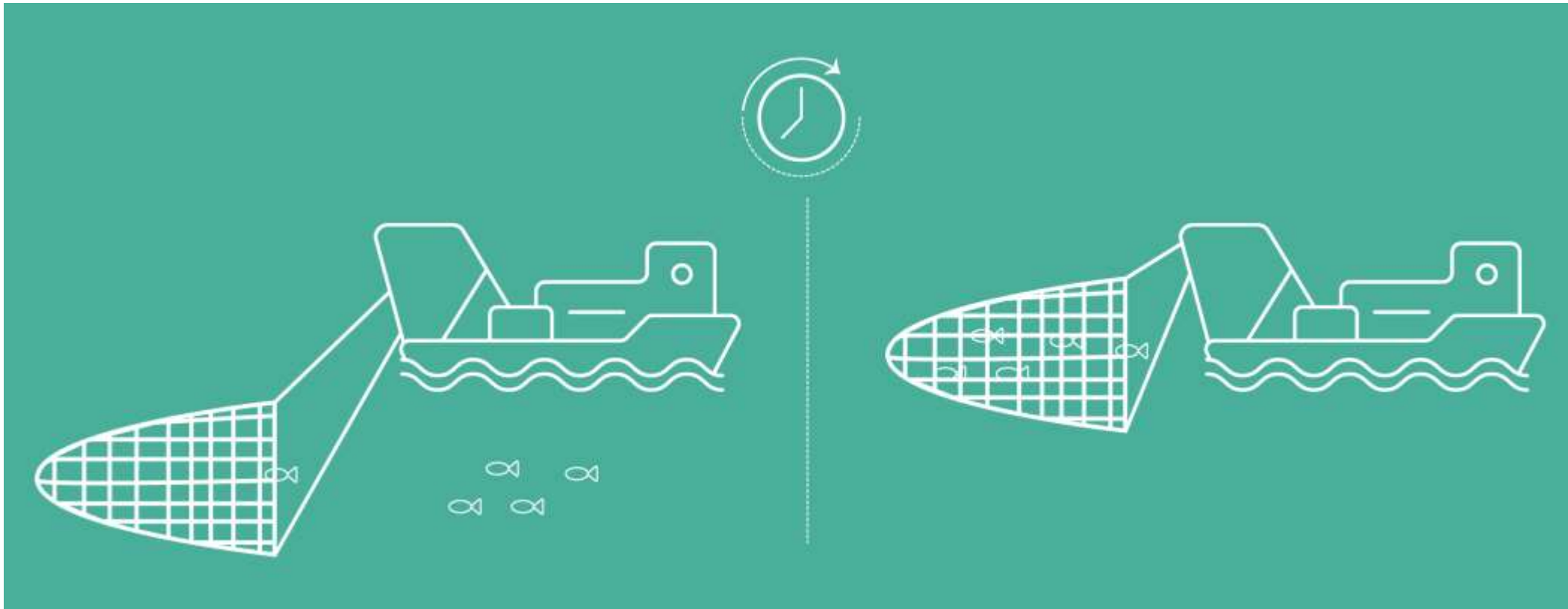
Trawling operation | speed & duration



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

61



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



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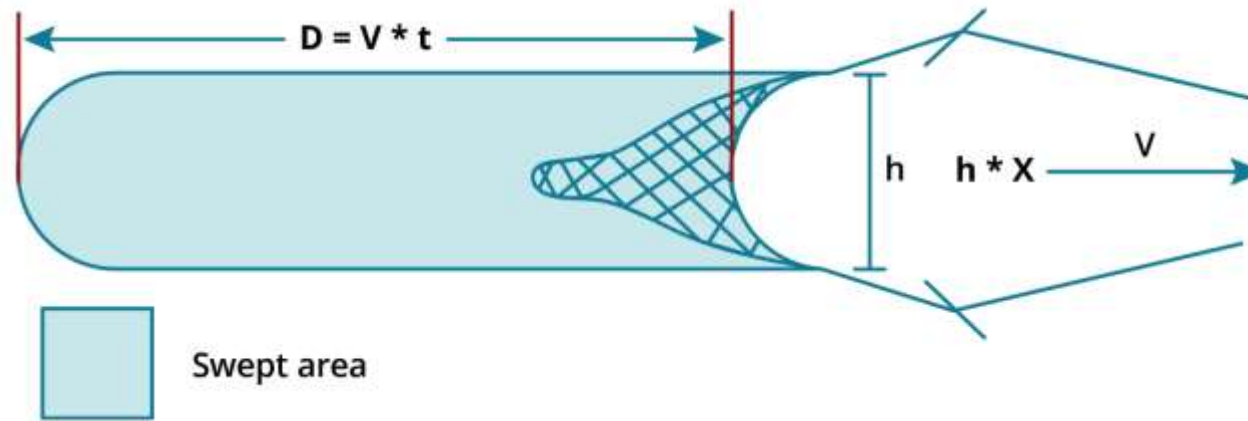


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Litter density calculation



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/km²).

The swept area (a) can be estimated by:

$$a = D * h * X \quad \text{where } D = V * t$$

Where:

V is the velocity of the trawl over the ground when trawling;

h is the length of the head-rope;

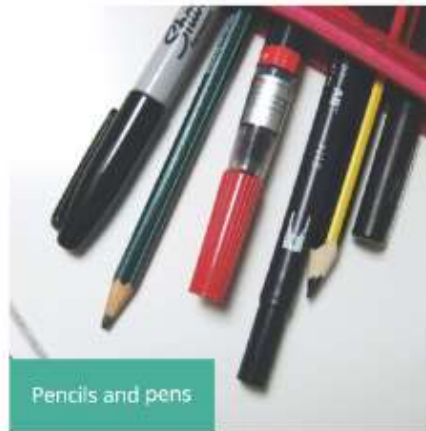
D is the cover of distance;

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).

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Thank you for your attention!

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