EFH-DZ-4
Characterization of marine and coastal litter on 14 coastal wilaya

Overview of marine litter monitoring methodologies (EFH-DZ-4, Task 2)

Version	Document Title	Author	Review and Clearance
1	Overview of marine litter monitoring methodologies (EFH-DZ-4, Task 2)	Thomais Vlachogianni	Anis Ismail Michael Scoullos

THE SWIM AND H2020 SUPPORT MECHANISM PROJECT (2016-2019)

The SWIM and H2020 SM is a Regional Technical Support Program, funded by the European Commission, Directorate General (DG) NEAR (Neighborhood and Enlargement Negotiations), that includes the following Partner Countries (PCs): Algeria, Egypt, Israel, Jordan, Lebanon, Libya, Morocco, Palestine, [Syria] and Tunisia. However, in order to ensure the coherence and effectiveness of Union financing or to foster regional co-operation, eligibility of specific actions will be extended to the Western Balkan countries (Albania, Bosnia Herzegovina and Montenegro), Turkey and Mauritania. The Program is funded by the European Neighbourhood Instrument (ENI) South/Environment. It ensures the continuation of EU's regional support to ENP South countries in the fields of water management, marine pollution prevention and adds value to other important EU-funded regional programs in related fields, in particular the SWITCH-Med program, and the Clima South program, as well as to projects under the EU bilateral programming, where environment and water are identified as priority sectors for the EU co-operation. It complements and provides operational partnerships and links with the projects labelled by the Union for the Mediterranean, project preparation facilities in particular MESHIP phase II and with the next phase of the ENPI-SEIS project on environmental information systems, whereas its work plan will be coherent with, and supportive of, the Barcelona Convention and its Mediterranean Action Plan.

The overall objective of the Program is to contribute to reduced marine pollution and a more sustainable use of scarce water resources. The Technical Assistance services are grouped in 6 work packages: WP1. Expert facility, WP2. Peer-to-peer experience sharing and dialogue, WP3. Training activities, WP4. Communication and visibility, WP5. Capitalizing the lessons learnt, good practices and success stories and WP6. Support activities.

Disclaimer:

This document has been produced with the financial support of the European Union.
The contents are the sole responsibility of the implementing Consortium and can in no way be taken to reflect the views of the European Union.

TABLE OF CONTENTS

1 GENERAL INTRODUCTION 7

2 AIM AND SCOPE OF THIS DELIVERABLE 8

3 DEFINITIONS AND POLICY CONTEXT 8

4 MONITORING MARINE LITTER ON BEACHES 10

5 MONITORING MARINE LITTER ON THE SEA SURFACE 12

6 MONITORING MARINE LITTER ON THE SEAFLOOR 16

7 MONITORING MARINE LITTER IN BIOTA 19

8 REFERENCES/RESOURCES 21

LIST OF TABLES

Table 1. Observation width from different observation levels above the sea for a ship speed of 2knots. 13
Table 2. Suggested transect lengths and widths for underwater visual surveys, taking into consideration the environmental conditions and the litter densities. 16

LIST OF FIGURES

Figure 1. The Marine Litter Ecological Objective and the respective Indicators within the framework of the Barcelona Convention Ecosystem Approach and the Integrated Monitoring and Assessment Programme. 9
Figure 2. The Marine Litter Descriptor, Criteria, and respective Indicators within the framework of the EU MSFD. 9
Figure 3. The sampling unit for monitoring litter on beaches. 10
Figure 4. Visual inspection of microparticles under a microscope. 12
Figure 5. The ideal location of the observer for performing a floating litter survey. 14
Figure 6. A manta net sampling floating microplastics. 15
Figure 7. Litter items collected at an underwater visual survey with scuba. 17
Figure 8. Investigation of ingested litter by commercially found fish species with the use of a stereoscopic microscope. 20

ABBREVIATIONS

ATR	Attenuated Total Reflectance
COP	Conference of the Parties
D10	Descriptor 10
EC	European Commission
EO	Ecological Objective
EU	European Union
FTIR	Fourier-Transform Infrared Spectroscopy
GES	Good Environmental Status
GPS	Global Positioning System
H2020	Horizon 2020
ICZM	Integrated Coastal Zone Management
IMAP	Integrated Monitoring and Assessment Programme
LBS	Land-Based Sources
MSFD	Marine Strategy Framework Directive
NaCl	Sodium chloride
NAP	National Action Plan
NGO	Non-Governmental Organization
NKE	Non-Key Expert
ROVs	Remotely Operated Vehicles
SCUBA	Self-contained underwater breathing apparatus
TG	Technical Group
UNEP/MAP	United Nations Environment Programme/Mediterranean Action Plan

1 GENERAL INTRODUCTION

Marine litter -any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment- is globally acknowledged as a major societal challenge of our times due to its significant environmental, economic, social, political and cultural implications. Marine litter negatively impacts coastal and marine ecosystems and the services they provide, ultimately affecting people's livelihoods and well-being.

Marine litter related information in the Mediterranean, remains limited, inconsistent and fragmented, however it is widely accepted that it is one of the most affected seas by marine litter worldwide. Effective measures to tackle marine litter in the region are seriously hampered by the lack of reliable scientific data. Within this context the need for accurate, coherent and comparable scientific data on marine litter in the Mediterranean countries is evident in order to set priorities for action and address marine litter effectively, thus ensuring the sustainable management and use of the marine and coastal environment of the region.

Within the framework of the SWIM-H2020 SM Algeria has asked for two Expert Facility Activities (EFH-DZ-4 and EFH-DZ-5) in order to:

- Characterize marine litter in the fourteen (14) coastal wilayas;
- Develop a national plan for marine litter management.

These activities will support the implementation in Algeria of the obligations and measures relevant to the Regional Plan for Marine Litter Management in the Mediterranean of the Barcelona Convention and will contribute to Integrated Coastal Zone Management (ICZM) within the framework of the implementation of the regional ICZM Protocol of the Barcelona Convention. These activities will support the implementation of the National Action Plan (NAP) against marine pollution caused by land-based activities recently updated within the framework of the Barcelona Convention. The objectives of the National Action Plan are to carry out a mid-term evaluation of the NAP1, to analyse the gaps and determine national operational targets to meet the commitments of the Regional Plan aimed at achieving Good Environmental Status (GES) in terms of three ecological objectives related to pollution from eutrophication, contaminants and marine litter. One of the projects envisaged within the NAP is the elaboration of a National Action Plan for Marine Litter Management, the first step of which is the characterization of marine litter. The assessment of marine litter on the Mediterranean coast of Algeria and the proposed management options based on the results would trigger positive changes in the design and implementation of the relevant national institutional, policy and regulatory frameworks, which should incorporate marine litter prevention and reduction measures. Furthermore, it will strengthen the regional coherence and cooperation in approaches to marine pollution prevention and control, and sustainable waste management.

The overall EFH-DZ-4 Activity entails the following tasks:

- Task 1: Setting up a Committee of Experts;
- Task 2: Carry out marine litter pilot surveys (including a workshop);
- Task 3: Characterization of marine litter: Assessment of marine litter (quantities, types and composition), Identification of pollution sources related to marine litter (including the origin of marine litter and the human-induced activities that generate litter).

The overall EFH-DZ-5 Activity entails the following tasks:

- Task 1: Involvement of the relevant sectors in the fight against marine litter pollution;
- Task 2: Elaboration of an Action Plan;
- Task 3: Preparation of legislative text on tackling marine litter.

2 AIM AND SCOPE OF THIS DELIVERABLE

The overarching aim of this document is to present a summary review of the state-of-the-art methods to monitor marine litter (macro-litter and micro-litter) in all marine compartments (beach, sea surface, seafloor, biota). This document takes stock of key documents on marine litter monitoring that have been developed to support the implementation of the Barcelona Convention Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast (IMAP) (UNEP/MAP-MEDPOL, 2017) and the EU Marine Strategy Framework Directive with regards to marine litter (Galgani et al., 2013). The compiled summary review aims to establish a common understanding within the project partnership on the recent advances made with regards to marine litter monitoring in order to define appropriate marine litter monitoring schemes and strategies.

3 DEFINITIONS AND POLICY CONTEXT

Within this document marine litter is defined as any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment. Marine litter can be classified in size classes as follows: macrolitter referring to items above 25mm in the longest dimension; mesolitter from 5mm to 25 mm; and microlitter from 1µm to 5mm. Sometimes the later size class is further broken down to large microplastics from 1mm to 5 mm and small microplastics from 1µm to 1mm.

The main legislative frameworks related to marine litter monitoring in the Mediterranean are the Barcelona Convention Ecosystem Approach (COP19 IMAP Decision IG.22/7) and the EU Marine Strategy Framework Directive (2008/56/EC, 2010/477/EC, 2017/848/EC).

Figure 1. The Marine Litter Ecological Objective and the respective Indicators within the framework of the Barcelona Convention Ecosystem Approach and the Integrated Monitoring and Assessment Programme.

Marine Litter and the Barcelona Convention Ecosystem Approach

Ecological Objective 10 (EO10): Marine and coastal litter do not adversely affect the coastal and marine environment.

IMAP Common Indicator 22:

Trends in the amount of litter washed ashore and/or deposited on coastlines (including analysis of its composition, spatial distribution and, where possible, source).

IMAP Common Indicator 23:

Trends in the amount of litter in the water column including micro plastics and on the seafloor.

IMAP Candidate Indicator 24:

Trends in the amount of litter ingested by or entangling marine organisms focusing on selected mammals, marine birds, and marine turtles.

Figure 2. The Marine Litter Descriptor, Criteria, and respective Indicators within the framework of the EU MSFD.

Marine Litter within the EU MSFD

Properties and quantities of marine litter do not cause harm to the coastal and marine environment (Descriptor 10)

Criteria D10C1 - Primary:

The composition, amount and spatial distribution of litter on the coastline, in the surface layer of the water column, and on the seabed, are at levels that do not cause harm to the coastal and marine environment.

- ✓ amount of litter washed ashore and/or deposited on coastlines, including analysis of its composition, spatial distribution and, where possible, source (10.1.1)
- ✓ amount of litter in the water column (including floating at the surface) and deposited on the seafloor, including analysis of its composition, spatial distribution and, where possible, source (10.1.2)

Criteria D10C2 - Primary:

The composition, amount and spatial distribution of micro-litter on the coastline, in the surface layer of the water column, and in seabed sediment, are at levels that do not cause harm to the coastal and marine environment.

- ✓ amount, distribution and, where possible, composition of microparticles (in particular microplastics) (10.1.3)

Criteria D10C3 - Secondary:

The amount of litter and micro-litter ingested by marine animals is at a level that does not adversely affect the health of the species concerned.

- ✓ amount and composition of litter ingested by marine animals (10.2.1)

Criteria D10C4 - Secondary:

The number of individuals of each species which are adversely affected due to litter, such as by entanglement, other types of injury or mortality, or health effects.

4 MONITORING MARINE LITTER ON BEACHES

Macrolitter

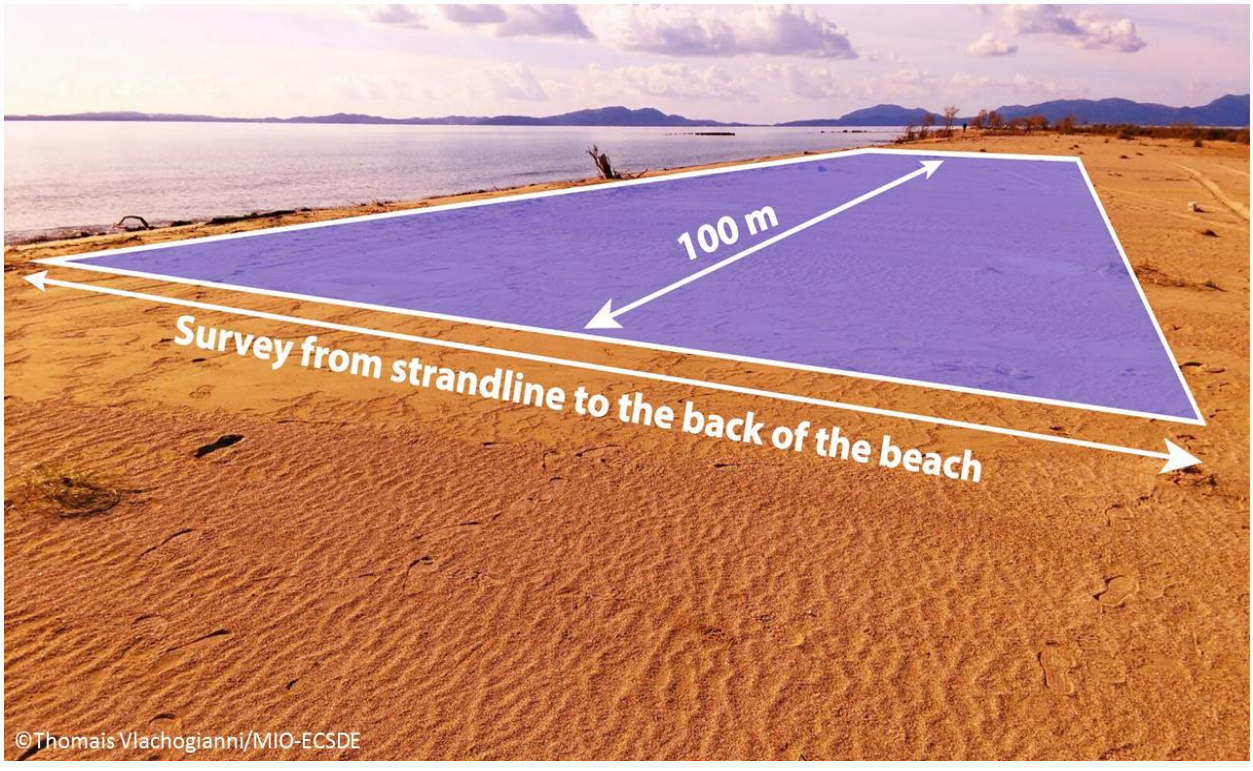
Beach surveys for macrolitter (items > 2.5 cm) assessment are the most common mode of marine litter monitoring in the Mediterranean. Beach litter surveys focus on the collection and visual identification and classification of litter items found at a shoreline site. The protocols applied may differ in terms of sampling units (size and positioning), frequency and timing of the surveys, size limits and classes of litter items to be surveyed, classification list and quantification units.

The guidance documents that have been produced within the IMAP and the MSFD recommend the following methodological approach:

Site selection. The survey sites are selected taking into consideration the following criteria: they have a minimum length of 100 m; they are characterized by a low to moderate slope (~1.5-4.5 º); they have clear access to the sea (not blocked by breakwaters or jetties); they are accessible to survey teams throughout the year; they are ideally not subject to cleaning activities. Furthermore, the selected beaches are situated in the vicinity of ports or harbours, river mouths, coastal urban areas, tourism destinations; and in relatively remote areas.

Frequency and timing of the surveys. Surveys are carried out at intervals of three months in autumn (mid-September to mid-October), winter (mid-December to mid-January), spring (April) and summer (mid-June to mid-July).

Figure 3. *The sampling unit for monitoring litter on beaches.*



Sampling unit. In each survey, the sampling unit used is a 100-metre stretch from the strandline to the back of the beach. The back of the beach is 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). Two (2) sections of a 100-metre stretch on the same beach are monitored, separated at least by a distance of 50m.

Litter size limits and classes to be surveyed. During the surveys, all macroscopic beach litter items larger than 2.5 cm in the longest dimension are collected and counted, ensuring the inclusion of caps, lids and cigarette butts.

Identification and classification of litter. All items found on the sampling unit are collected and are categorized in accordance with the 'MEDPOL Beach Litter Survey Form' or the 'MSFD TG10 Master List of Categories of Litter Items'.

Quantification of litter. Results are expressed as counts of litter items per square meter (m^2) or counts of litter items per 100-metre stretch of beach.

Microlitter

Microparticles, mainly microplastics, comprise a very heterogeneous assemblage of pieces that vary in size, shape, colour, specific density, polymer type, and other characteristics. Within the framework of the Marine Strategy Framework Directive, the Technical Group on Marine Litter (MSFD TG10) has developed guidelines on monitoring microplastics in beach sediments (Galgani et al., 2013).

Sampling. Microplastics should be monitored at the front of the shore (strandline) and where possible on sandy shores (0.1 - 0.0125 mm diameter). Separate samples should be collected to monitor two size classes of microplastics: large microplastics with size in the range of 1-5 mm; small microplastics with size in the range of 20 μm - 1 mm. Samples should be collected from the upper 5 cm of the beach sediment. A minimum of five replicate samples should be collected starting from the strandline. Each replicate should be separated by at least 5 m. In addition the replicates should be distributed in a stratified random manner so as to be representative of the entire beach or of a specific beach section. Regarding large microplastics (1 – 5 mm), they should be sampled by stacking together a 5 mm sieve with a 1 mm sieve to achieve sample volume reduction. Small microplastics (20 μm - 1 mm) should be collected from the top 5 cm of sand, using a metal spoon. The collection of approximately 250 ml of sediment is recommended. The sediment should be stored in metal or glass containers.

Sample processing. Density separation is being recommended for the extraction of the microplastics with the use of a concentrated saline NaCl solution (1.2 g/ml).

Sample analyses. Microplastics are commonly identified either by using Fourier-Transform Infrared Spectroscopy (FTIR) with ATR (Attenuated Total Reflectance) or Raman Spectroscopy. The latter is a relatively easier and faster semi-automated technique. Most Raman instruments are able to match the sample spectra to a spectral library to identify the specific polymer. Raman Spectroscopy does not work well with smaller or dark-coloured microplastics and FTIR Spectroscopy may have to be used. The identification of microplastics can be performed also with visual inspection under a microscope, however this method is prone to serious errors.

Classification and quantification. Microparticles are characterized by size, type (fragments, pellets, filaments, films, foam, granules, styrofoam), shape and colour. Results are being expressed in number of microplastics or microparticles per cm^3 of strandline.

Figure 4. *Visual inspection of microparticles under a microscope.*

5 MONITORING MARINE LITTER ON THE SEA SURFACE

Macrolitter

For macrolitter on the sea surface, visual observation is the most common methodology used and relies on competent and dedicated observers. The floating macrolitter surveys can be carried out from different types of vessels, ranging from small- or medium-sized boats to large ships, including platforms of opportunity such as ferries and cargo ships. In many cases, these surveys are carried out simultaneously with other research surveys such as cetacean observations.

The guidance documents that have been produced within the IMAP and the MSFD recommend the following methodological approach:

Site selection. The selected areas should include: 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 or commercial traffic. Incoming currents from neighbouring areas or outgoing currents should be considered.

Frequency and timing of the surveys. At least two surveys, one in autumn (mid-September to mid-October) and one spring (April) should be carried out. Ideally the visual observations should be carried out after a minimum duration of calm sea, so that there is no bias by litter objects which have been mixed into the water column by recent storms or heavy sea. In addition, the wind speed should be less than 2 Beaufort.

Survey area. The survey area is defined by the transect width and length. The transect length will be determined from the latitude and longitude of the transect start and end points obtained by GPS. Typically a transect width of 10 m is expected, however depending on the observation level of the surveyor for the predefined ship speed of 2knots (3.7 km/h) the following transect widths might be used:

Table 1. *Observation width from different observation levels above the sea for a ship speed of 2knots.*

Observation level of the surveyor above the sea	Observation width (ship speed = 2knots)
1 m	6 m
3 m	8 m
6 m	10 m
10 m	15 m

Visual observation considerations. The observation from boats should ensure the detection of litter items in the size range of 2.5 cm to 50 cm, therefore the speed of the boat should not be higher than 3 knots. The observation, quantification and identification of floating litter items must be made by a dedicated observer who does not have other duties at the same time. The transect length should correspond approximately to 1 h of observation for each survey. The ideal location for observation is often the bow area of the boat. The observation direction must be perpendicular to the boat track (see Figure 5). The surveyor should conduct the survey from the glare-free side of the vessel and to avoid the hours of the day when the sun is low on the horizon (sunrise and sunset), since visibility is not good enough due to glare and/or reflection.

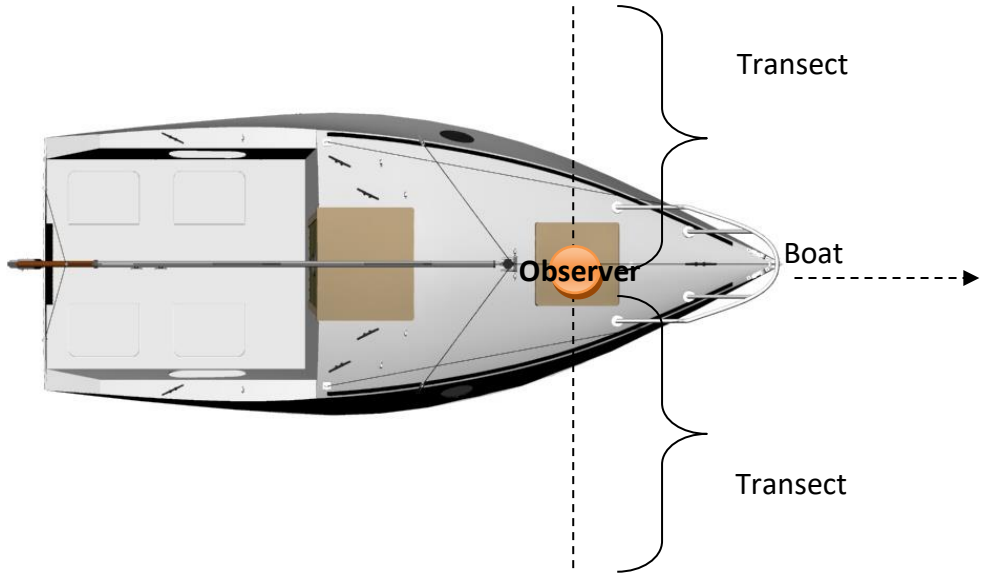
Litter size limits and classes to be surveyed. Litter items in the size range of a 2.5 cm (in the longest dimension) to 50 cm should be monitored and reported. However, in order to understand the relevance of larger than 50 cm items in the statistical evaluation of data, these should be also recorded. Given that visual observation will not permit the correct measuring of object sizes, the following size range classes should be reported for each recorded litter item:

A. 2.5cm-5cm
B. 5cm-10cm
C. 10cm-20cm
D. 20cm-30cm
E. 30cm-50cm
F. >50cm

Identification and classification of litter. All items observed on the survey area should be classified and recorded in accordance with the 'MSFD TG10 Master List of Categories of Litter Items'. The occurrence of groups of floating litter items should be recorded along with their location as these could provide useful information with regards to accumulation areas.

Quantification of litter. The unit in which litter should be assessed on the sea surface is number of items and it should be expressed as counts of litter items per square kilometre (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.

Figure 5. *The ideal location of the observer for performing a floating litter survey.*



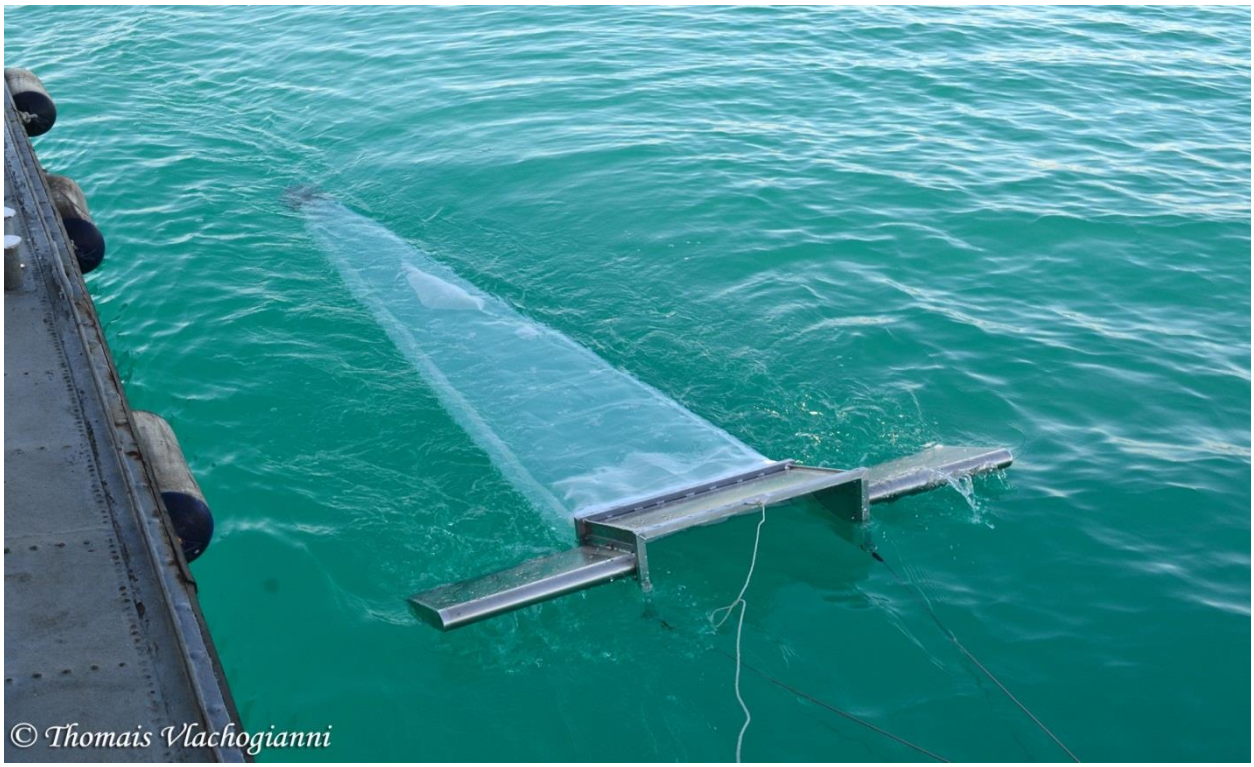
Microlitter

The most commonly used approach for monitoring floating micro-litter entails the use of a Neuston nets and manta nets that sample the microlitter.

Sampling. The MSFD Technical Group on Marine Litter recommends a manta net with 333 μm mesh size and a length of 6 m in order to ensure inter-comparability of obtained results. A 30-min sampling duration is suggested, at a vessel speed kept under 3 knots. Start and end position points should be recorded from the ship's GPS. All toes should be conducted from the ship's side and beyond the ship's wake. After

the completion of each tow the net has to be washed thoroughly with seawater in order to collect all particles in the cod end. The sample collected in the cod end should be rinsed with seawater on a 300μm metallic sieve and transferred in glass jars in 70% ethanol solution for analysis.

Figure 6. *A manta net sampling floating microplastics.*



Sample analysis. Microplastics are commonly identified either by using Fourier-Transform Infrared Spectroscopy (FTIR) with ATR (Attenuated Total Reflectance) or Raman Spectroscopy. The latter is a relatively easier and faster semi-automated technique. Most Raman instruments are able to match the sample spectra to a spectral library to identify the specific polymer. Raman Spectroscopy does not work well with smaller or dark-coloured microplastics and FTIR Spectroscopy may have to be used. The identification of microplastics can be performed also with visual inspection under a microscope, however this method is prone to serious errors.

Classification and quantification. Microparticles are characterized by size, type (fragments, pellets, filaments, films, foam, granules, styrofoam), shape and colour. Results are being expressed in number of microplastics or microparticles per square kilometre (items/km^2).

6 MONITORING MARINE LITTER ON THE SEAFLOOR

Macrolitter

The most widespread approaches to monitor litter deposited on the seafloor include underwater visual surveys with scuba/snorkeling, bottom trawl surveys and image acquisition surveys with the use of submersibles or Remotely Operated Vehicles (ROVs). The latter methodological approach requires expensive equipment and thus underwater visual surveys with scuba/snorkeling and bottom trawl surveys are the ones recommended by the guidance documents produced within the framework of IMAP and the MSFD.

Underwater visual surveys with scuba/snorkeling at shallow seafloor (0-20 m)

Site selection. Sites should be selected to ensure that they: consider areas that might accumulate litter; avoid areas of risk (presence of munitions and other hazardous waste), sensitive or protected areas; do not exert impacts on any endangered or protected species; avoid areas with strong currents or waves; avoid navigation routes of vessels that might put divers in danger. Sites should be chosen following a two-fold approach: (i) selecting sites that meet certain criteria (e.g. are close to ports, river mouths, cities, etc.); (ii) choosing randomly from a large number of sites.

Survey area & sampling unit. The survey area is defined by the transect width and length. Surveys are conducted through two (2) line transects for each sampling site. The line transects are defined with a nylon line, marked every 5 meters with resistant paints, that is deployed using a diving reel while scuba diving. Distances should be determined either by laying out a 100 m tape measure or alternatively by laying a 100 m length of weighted rope across the bottom. 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 50 m to 200 m and the width from 4 m to 8 m, depending on the depth, the depth gradient, the turbidity, the habitat complexity and the litter density (see table below).

Table 2. *Suggested transect lengths and widths for underwater visual surveys, taking into consideration the environmental conditions and the litter densities.*

Debris Density	Environmental Conditions	Sampling Unit (length x width)
0.1 – 1 items / m^2	Low turbidity & high habitat complexity	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

Frequency and timing of the surveys. At least two surveys in autumn and spring should be carried out. The proposed surveys periods are: autumn (September-October) and spring (April).

Size classes to be surveyed. The following size range classes will be reported for each recorded litter item:

A. < 5cm*5cm = 25cm^2
B. < 10cm*10cm = 100cm^2
C. < 20cm*20cm = 400cm^2
D. < 50cm*50cm = 2500cm^2
E. < 100cm-100cm = 10000cm^2 = 1m^2
F. > 100cm-100cm = 10000cm^2 = 1m^2

Identification of litter and classification of litter. When conducting underwater visual surveys with scuba, lighter litter items should be collected (while larger items should be just marked), brought ashore and entered in the recording sheet. All items observed on the survey area should be classified and recorded in accordance with the 'MSFD TG10 Master List of Categories of Litter Items'.

Quantification of litter. The unit in which litter should be recorded is number of items and it should be expressed as counts of litter items per square kilometre (items/Km^2).or items per square metre (items/m^2).

Figure 7. *Litter items collected at an underwater visual survey with scuba.*

Bottom trawl surveys (200-800 m)

Site selection. Sites should be selected to ensure that they: comprise areas with uniform substrate (ideally sand/silt bottom); consider areas that might accumulate litter; avoid areas of risk (presence of munitions), sensitive or protected areas; do not exert impacts on any endangered or protected species. Sites should be chosen following a two-fold approach: (i) selecting sites that meet certain criteria (e.g. are close to ports, river mouths, cities, etc.); (ii) choosing randomly from a large number of sites.

Survey area. With regards to the sampling area, a depth stratified sampling scheme with random selection of trawling sites (same positions each year) within each stratum should be used. The sampling strata are the depth zones: 10-50, 50-100, 100-200, 200-500 and 500-800 m. The number of stations in each stratum is proportional to the surface of these strata. The size of the sampling area should be defined by each surveying team on the basis of the resources available for this task.

Frequency and timing of the surveys. At least two surveys, one in autumn and one in spring should be carried out. The proposed surveys periods are: autumn (September-October) and spring (April). The hauls should be ideally performed during daylight. The daylight period is defined as the time between 30 minutes after sunrise and 30 minutes before sunset.

Trawling operation. Given that surveys might be performed with otter trawl fishing fleets or research vessels which use different gear, it is evident that handling operations and parameters (such as type of mesh, mesh size of cod end, etc.) during the surveys cannot be standardized. Nevertheless, the following recommendations should be followed as close as possible:

- **Haul position & orientation:** The hauls should be positioned following a stratified sampling design, including at least three strata from the following ones: 10-50, 50-100, 100-200, 200-500 and 500-800 m. The hauls should be made over the same position in each sampling survey. The depth variations during the haul will not exceed ± 5% relative to the initial depth. The discrepancies to this target should be recorded. As far as possible, the hauls will be rectilinear.
- **Haul 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 will 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 minutes on depths less than 200 m and at 60 minutes at depths over 200m.
- **Haul start and 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.
- **Gear characteristics:** Cod-end mesh size and head rope length should be recorded.

Size classes to be surveyed. The following size range classes should be reported for each recorded litter item:

A. < 5cm*5cm = 25cm^2
B. < 10cm*10cm = 100cm^2
C. < 20cm*20cm = 400cm^2
D. < 50cm*50cm = 2500cm^2
E. < 100cm-100cm = 10000cm^2 = 1m^2
F. > 100cm-100cm = 10000cm^2 = 1m^2

Identification of litter and classification of litter. When conducting underwater visual surveys with scuba, lighter litter items should be collected (while larger items should be just marked), brought ashore and entered in the recording sheet. All items observed on the survey area should be classified and recorded in accordance with the 'MSFD TG10 Master List of Categories of Litter Items'.

Quantification of litter. The unit in which litter will be recorded will be number of items and it will be expressed as counts of litter items per square kilometre (items/Km^2).

Microlitter

Microplastics monitoring on the seafloor is commonly performed by recovering a sample of relatively undisturbed surface sediment from the seafloor using any of the following instruments: Van Veen grab sampler, multi-corer, box core, etc. A small sample of sediment, ideally 250 ml is transferred to a metal or glass container for subsequent density separation and FTIR Spectroscopy (see para on microplastics in Chapter 6).

7 MONITORING MARINE LITTER IN BIOTA

Monitoring marine litter in relation to biota refers mainly to monitoring ingestion of litter by different species and entanglement of different species in marine litter items. The most widespread approach for monitoring marine litter in biota focuses on determining the ingested items by marine species.

The guidance documents produced within the framework of IMAP and the MSFD describe the following protocols for ingested litter: protocol for monitoring litter ingested by sea turtles (stranded *Caretta caretta*) and protocol for monitoring litter ingested by fishes. Given the diversified approaches for processing and analysing biota samples and the ongoing work towards harmonizing marine litter monitoring in biota, the present document will not address in detail this issue but will provide a general overview of the overall approach.

The methodological approach for sampling strategies vary according to the species, the size of the organisms and the desired analytical level. Generally, the whole organism is analysed when small invertebrates/fish species are being investigated, whereas for larger organisms the gastrointestinal tract or faecal pellets are the main samples to be analysed. Once the samples are processed, the marine litter

items are identified and classified in accordance with the 'MSFD TG10 Master List of Categories of Litter Items'.

The results of the analysis of marine litter ingestion are expressed as follows:

- Presence/absence of litter in the whole organism/ gastrointestinal tract /faecal pellets;
- Occurrence (%) of individuals that have ingested marine litter among a subpopulation/population/species;
- The abundance (N) and weight (g) of marine litter (macro- and micro-litter) ingested per individual (N items/individual; g/individual) as a total and per category of litter.

Figure 8. *Investigation of ingested litter by commercially found fish species with the use of a stereoscopic microscope.*

8 REFERENCES/RESOURCES

Fortibuoni, T., Ronchi, F., Mačić, V., Mandić, M., Mazziotti, C., Peterlin, M., Prevenios, M., Prvan, M., Somarakis, S., Tutman, P., Bojanić Varezić, B., Kovac Virsek, M., Vlachogianni, T., Zeri C., 2019. A harmonized and coordinated assessment of the abundance and composition of seafloor litter in the Adriatic-Ionian macroregion (Mediterranean Sea). Marine Pollution Bulletin, 139, 412-426.

Galgani, F., Hanke, G., Werner, S., Oosterbaan, L., Nilsson, P., Fleet, D., Kinsey, S., Thompson, R.C., Van Franeker, J., Vlachogianni, T., Scoullos, M., Mira Veiga, J., Palatinus, A., Matiddi, M., Maes, T., Korpinen, S., Budziak, A., Leslie, H., Gago, J., Liebezeit, G., 2013. Guidance on Monitoring of Marine Litter in European Seas. Scientific and Technical Research series, Report EUR 26113 EN.

IPA-Adriatic DeFishGear project, 2014. Methodology for Monitoring Marine Litter on Beaches (Macro-Debris >2.5 cm).

IPA-Adriatic DeFishGear project, 2014. Methodology for Monitoring Marine Litter on the Sea Surface-Visual observation (> 2.5 cm).

IPA-Adriatic DeFishGear project, 2014. Methodology for Monitoring Marine Litter on the Seafloor (continental shelf) – bottom trawl surveys.

IPA-Adriatic DeFishGear project, 2014. Methodology for Monitoring Marine Litter on the Seafloor (Shallow coastal waters 0 – 20 m) - Visual surveys with SCUBA/snorkelling.

Lippiatt S, Opfer S, Arthur C., 2013. Marine Debris Monitoring and Assessment. NOAA Technical Memorandum NOS-OR&R-46.

UNEP/MAP IG.21/9. Regional Plan on Marine Litter Management in the Mediterranean in the Framework of Article 15 of the Land Based Sources Protocol. UNEP(DEPI)/MED IG.21/9, ANNEX II – Thematic Decisions, pp.143-173.

UNEP/MAP, 2015. Marine Litter Assessment in the Mediterranean. ISBN No: 978-92-807-3564-2.

UNEP/MAP-MEDPOL, 2017. Beach Litter Survey Form (UNEP(DEPI)/MED WG.439/20/L.1)

UNEP/MAP-MEDPOL, 2017. UNEP(DEPI)/MED WG. WG.439/12. IMAP Common Indicator Guidance Facts Sheets (Pollution and Marine Litter).

Veiga, J.M., Fleet, D., Kinsey, S., Nilsson, P., Vlachogianni, Th., Werner, S., Galgani, F., Thompson, R.C., Dagevos, J., Gago, J., Sobral, P., Cronin, R., 2016. Identifying sources of marine litter. MSFD GES Technical Subgroup on Marine Litter (TSG-ML). Thematic Report, JRC Technical Report.

Vlachogianni, Th., Fortibuoni, T., Ronchi, F., Zeri, Ch., Mazziotti, C., Tutman, P., Varezić, D.B., Palatinus, A., Trdan, S., Peterlin, M., Mandić, M., Markovic, O., Prvan, M., Kaberi, H., Prevenios, M., Kolitari, J., Kroqi, G., Fusco, M., Kalampokis, E., Scoullos, M., 2018. Marine litter on the beaches of the Adriatic and Ionian Seas: An assessment of their abundance, composition and sources. Marine Pollution Bulletin, 131(A), 745–756.

Vlachogianni, Th., Fossi M.C., Anastasopoulou, A., Alomar, C., Aparicio, A., Baini, M., Caliani, I., Campani, T., Casini, S., Consoli, P., Deudero, S., Galgani, F., Kaberi H., Panti, C., E. Romeo, T., Tsangaris, C., Zeri, C., 2018. State-of-the-art methods to monitor marine litter and its impacts on biodiversity. Interreg Med Plastic Busters MPAs project.

Vlachogianni, Th., Zeri, Ch., Ronchi, F., Fortibuoni, T., Anastasopoulou, A., 2017. Marine Litter Assessment in the Adriatic and Ionian Seas. IPA-Adriatic DeFishGear Project, MIO-ECSDE, HCMR and ISPRA. pp. 180 (ISBN: 978-960-6793-25-7).

Werner, S., Franeker, J.V., Galgani, F., Maes, T., Matiddi, M., Nilson, P., Oosterbaan, L., Priestland, E., Thompson, R., Veiga, J.M., Vlachogianni, Th., 2016. Harm caused by marine litter. MSFD GES Technical Subgroup on Marine Litter (TSG-ML). Thematic Report, JRC Technical Report.

Zeri, C., Adamopoulou, A., Bojanic Varezic, D., Fortibuoni, T., Kovac Virsek, M., Krzan, A., Mandic, M., Mazziotti, C., Palatinus, A., Peterlin, M., Prvan, M., Ronchi, F., Siljic, J., Tutman, P., Vlachogianni, Th., 2018. Floating plastics in Adriatic waters (Mediterranean Sea): From the macro- to the micro-scale. Marine Pollution Bulletin, 136, 341-350.