European Marine Strategy Framework Directive
Working Group on Good Environmental Status
(WG-GES)

Monitoring Guidance for Marine Litter in European Seas

Draft Report

CHAPTER 5

SEAFLOOR LITTER

July 2013

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Draft Guidance Report:

TSG-ML was tasked to deliver guidance so that European Member States could initiate programmes for marine litter monitoring. As monitoring must be operational by 2014, first guidance was required by mid-2013. The draft Guidance report provides the basis for the marine litter programme however since new information continues to be compiled TSG -ML can review and update this guidance later in 2013.

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5. Seafloor Litter

5.1. Introduction to Sea-floor Litter

Indicator 10.1 (Characteristics of litter in the marine and coastal environment) of Descriptor 10 includes the trends in the amounts of litter deposited on the seafloor, with analysis of its composition, spatial distribution and, where possible, source according to the Commission Decision (2010/477/EU).

Coordinated national or regional monitoring programmes for litter on the sea-floor within Europe have started in 2013 through experimental monitoring. The most common approaches to evaluate sea-floor litter distributions use opportunistic sampling. This type of sampling is usually coupled with regular fisheries surveys (marine reserve, offshore platforms, etc.) and programs on biodiversity, since methods for determining seafloor litter distributions (e.g. trawling, diving, video) are similar to those used for benthic and biodiversity assessments. The use of submersibles or *Remotely Operated Vehicles* (ROVs) is a possible approach for deep sea areas although this requires expensive equipment. Monitoring programmes for demersal fish stocks, undertaken as part of the International Bottom Trawl Surveys (IBTS), operate at large regional scale and provide data using an harmonized protocol, which may provide a consistent support for monitoring litter at the European scale on regular basis and within the MSFD requirements (see the 2011 GES TG ML report, "Marine Litter Technical Recommendations for the Implementation of MSFD Requirements).

5.2. Scope & key questions to be addressed

This Chapter evaluates existing methods for monitoring litter on the sea floor with respect to their capacity to fulfil the requirements of the MSFD. It proposes harmonised methods that can be applied to assess litter on regional seas which will ensure comparability of the results of seafloor assessments of litter within and between regions and at European scale. It presents the difficulties associated with applying the method and its limitations. A strategy is proposed, listing criteria, sites of interest and constraints. Complementary methodologies are also proposed for specific questions. Finally, it addresses data quality assurance and quality control requirements for trend and other analyses.

For shallow waters, the monitoring of litter on seafloor may not be considered for all coastal areas because of limited resources. In these areas the strategy is to be determined by each MS at national level, depending on the priority areas to be monitored. Opportunistic approaches may be used to minimize costs. Valuable information can be obtained from on-going monitoring of benthic species in protected areas, during pipeline camera surveys, cleaning of harbours and through diving activities. Additional monitoring might have to be put in place to cover all areas creating a consistent monitoring network. The sampling strategy should enable the generation of good detail of data, in order to assess most likely sources, the evaluation of trends and the possibility of evaluating the effectiveness of measures. The TSG-ML proposes simple protocols based on existing trawling surveys and two alternative protocols based on diving and video imagery which fit with the MSFD requirements and support harmonisation at European level, if applied trans-nationally.

Trawling (otter or beam trawl) is an efficient method for large scale evaluation and monitoring of sea-floor litter. The monitoring strategy for sea-floor can efficiently be based on on-going monitoring already developed at European level. Existing fisheries stock assessment programmes are covering most European seas on an annual basis, facilitating the harmonization across member states and the management of data. Key information can be obtained on typology, sources, localisation and trends.

Only some countries will have to consider deep sea areas in terms of monitoring of sea-floor litter. The strategy is to be determined by each MS at national level, depending on affected areas but previous results indicate that priority should be given to coastal canyons. Protocols based on video imagery are the only approaches to monitor deep sea areas. These protocols are based on the use of (ROVs)/submersibles. Because litter are accumulating and degrading slowly in deep sea waters, a multiyear evaluation will be sufficient.

Finally, research has shown to be also important to support the evaluation of litter on sea-floor. The priority topics include (i) the localisation of accumulation areas and supporting tools such as modelling to identify possible priority areas and to enable backtracking transportation schemes and sources, (ii) an analysis of existing data to characterise the most important sources, and (iii) the improvement of imaging tools (automated analysis, image resolution, etc.) for the deep sea video protocol.

5.3. Background and state of the art

The sea-floor from inter-tidal to abyssal depths has been identified as an important sink for marine litter. With observations made by divers, through video footage from ROV's as well as sampling by bottom trawls, data has been obtained from varying depths and at many places, although the methodologies used were different.

The abundance and distribution of marine litter show considerable spatial variability. Near metropolitan areas, in the Mediterranean, densities may exceed 100.000 items/km^2. The geographical distribution of litter on the sea floor is strongly influenced by hydrodynamics, geomorphology and human factors. Litter made of high density polymers or, in some cases, under the weight of fouling by a wide variety of organisms, will sink to the bottom. In shallow coastal areas (< 30 m depth), the abundance of marine litter is generally much greater than on the continental shelf. In these coastal areas, activities related to fishing and tourism significantly contribute to littering of the seafloor with notable temporal, particularly seasonal, variations. Interpretation of temporal trends is therefore complicated by annual variations in litter transport, such as seasonal changes in flow rate of rivers and related turbidity currents. Other seasonal factors include the intensity of currents, swell and upwelling and the conformation of sea bed, which influence both the distribution and densities. Nevertheless, considering existing data, it would appear that the Mediterranean Sea may be the most affected part of the European Seas.

Due to the persistence of some litter materials, the monitoring of litter on the sea floor must consider accumulation processes for past decades. Timescales of observation should therefore be adapted, requiring multiannual frequencies for deep sea floor surveys. Finally, the data can be amalgamated to produce values for local, regional and European level.

In this chapter, protocols are provided for monitoring:

(i) Shallow coastal waters
(ii) Margin / continental plate (<800m)
(iii) deep sea floor

Shallow coastal areas

The abundance of marine litter is generally much greater in shallow waters than on the continental shelf or on the deep seafloor, with the exception of some accumulation zones in the open sea (Katsanevakis, 2008). This is especially true in bays due to weaker currents; litter disposed locally is more likely to accumulate on the bottom. Furthermore wave or upwelling-induced cleaning of the seafloor is of less importance in small bays, where usually there is much less transport (Katsanevakis and Katsarou, 2004).

The most commonly used method to estimate marine litter density in shallow coastal areas is to conduct underwater visual surveys with SCUBA, although snorkelling has also been applied for very shallow waters (usually < 10 m depth) and for larger forms of marine litter (nets/fishing gear). To overcome an underestimation of abundance, Distance Sampling, which is a group of methods for estimating abundance and/or population density (Buckland *et al*., 2001) is more often applied. The most commonly used Distance Sampling method for underwater surveys is line transect sampling, with recent development enabling the modelling of detectability and the estimation of density/abundance (Thomas *et al*., 2006). This approach is particularly efficient in areas with low litter densities , turbid waters, and/or high sea bottom complexity (e.g. rocky reefs, sea grass beds) when imperfect detectability should not be ignored; The field protocols for line transect surveys of litter on the sea-floor are the same as those for benthic sessile fauna, described in detail in Katsanevakis (2009).

Continental Plate

Collection of data on litter on continental plate (0-200m) was started in the 1990's in both NE Atlantic (within IBTS program) and Mediterranean sea (within MEDITS program) but on experimental basis. The

IBTS Working Group (ICES/ IBTS WG) has recently developed a unique protocol for marine litter assessments using trawling programmes, which was taken up by the International Council for the Exploration of the Sea in the IBTS programme in the NE Atlantic. This protocol harmonizes the procedures for collecting and reporting marine litter data which is collected on the back of existing fish stock surveys. This protocol has been discussed within the TSG-ML and modified to provide an accurate methodology applicable for MSFD monitoring (facilitating the evaluation of sources, trends, data analysis, etc.).

Deep Sea-floor

Only some areas/countries are concerned with deep sea floor along the European coasts including submarine canyons, seamounts, cold seeps, open slopes and deep basins, such as present in Norway, UK, Ireland, France, Spain, Portugal, Italy, and Greece. Monitoring in those deep sea areas is largely restricted by sampling difficulties and costs. Litter that reaches the seabed may already have been transported for considerable distances, only sinking when weighed down by fouling. The consequence is an accumulation in bays and canyons, often around large cities, rather than at open sea. These densities are a consequence of residual ocean circulation patterns and more locally to the morphology of the sea bed (around rocks and/or in depressions or channels) and the extension of deep submarine extensions of coastal rivers. For monitoring, the use of trawls in deep-sea areas is restricted to flat and smooth bottoms. For slopes and rocky bottoms, more specialised equipment is necessary. ROVs, which are less complicated than submersibles and generally cheaper, are recommended for litter surveys of deep see-floor.

Benthic litter assessments need to be planned with defined protocols, including the definition and specification of the survey location, choice of sampling units, methodology for collection, classification and quantification of litter and a process for data integration, analysis and reporting of results.

5.4. Protocol for shallow sea-floor (< 20m)

The most commonly used method to estimate marine litter density in shallow coastal areas is to conduct underwater visual surveys with SCUBA/snorkelling. These surveys are best based on line transect surveys of litter on the sea-floor, which is derived from UNEP (Cheshire, 2009). The protocol is actually in use for evaluation of benthic fauna. It requires SCUBA equipment and trained observers. Only litter items above 2.5 cm are considered, between 0 and 20 m (to 40 meters with skilled divers).

5.4.1. Technical requirements

Frequency

The minimum sampling frequency for any site should be annually. Ideally it is recommended that locations are surveyed every three months (allowing an interpretation in terms of seasonal changes).

Transects

Surveys are conducted through 2 line transects for each site. Unbiased design-based inference requires allocating the transects randomly in the study area or on a grid of systematically spaced lines randomly superimposed. However, with a model-based approach like density surface modelling (DSM), it is not required that the line transects are located according to a formal and restrictive survey sampling scheme, although good spatial coverage of the study area is desirable. Line transect are defined with a nylon line, marked every 5 meters with resistant paints, that is deployed using a diving reel while SCUBA diving.

Individual litter within 4 m of the line (half of the width –Wt - of the line transects) are recorded. For each observed litter item, when possible, the corresponding line segment of occurrence and its perpendicular distance from the line (yi - for the estimation of detection probability, measured with the use of a 2 m plastic rod), and litter size category (wi) are recorded. The nature of the bottom/habitat is also recorded. The length of the line transects vary between 20 and 200 m, depending on the depth, the depth gradient, the turbidity, the habitat complexity and the litter density (Katsavenakis, 2009). Results are expressed in litter density (items/m^2 or items/ 100 m^2).

Litter density	Conditions	Method	Sampling Unit (strips: length x width)
0.1-1 items/m2	Low turbidity - high habitat complexity	distance sampling	20 m x 4 m
0.1-1 items/m2	high turbidity	distance sampling	20 m x 4 m
0.01-0.1 items/m2	for every case	distance sampling	100 m x 8 m
<0.01 items/m2	for every case	distance sampling	200 m x 8 m

Table 6: Spatial sampling units for litter evaluation on the sea floor (shallow waters) depending on density of items and sea conditions (Katsanevakis, 2009)

Detectability

In distance sampling surveys, detectability is used to correct abundance estimations (Katsavenakis, 2009). The probability that any particular item that is in the covered region is detected, i.e., the 'detection probability', is denoted by (*pa)*, and the estimator (d) of abundance becomes d = N/ Ac *pa*, where (N) is the number of detected items, and (Ac) is the surface area covered by the survey. The extra effort in a line transect survey is to record the perpendicular distance of each item from the line. This set of distances is used to estimate detection probability *pa* (Buckland *et al*., 2001; Katsanevakis, 2009). The standard software for modelling detectability and estimating density/abundance, based on distance sampling surveys, is DISTANCE (Thomas *et al*., 2006).

5.4.2. Use of volunteers in shallow waters surveys

Recreational and professional scuba divers can provide valuable information on litter they see underwater and they are uniquely positioned to support benthic litter monitoring efforts. They can access, have the skills and the equipment needed to collect, record, and share information about litter they encounter underwater. Many dive clubs and dive shops organize underwater cleanups, often in partnerships with NGOs or local governments. Many of these events, when managed, can be a valuable source of information and possibly be a part of a regular survey, monitoring or even assessment efforts while using volunteers.

For example, Project AWARE's "Dive Against Debris" programme provides guidelines and field protocols for scuba divers on how to collect and report marine litter found underwater (Project AWARE 2013). Divers are encouraged, but currently not required, to conduct surveys at the same dive site on a regular (once a quarter/per season) basis. Divers remove the litter in a self-selected area within a site that they measured or estimate, they record information about types and amounts litter on a data card, and later report that information into a public, online database.

For some Member States use of volunteer divers might be a good opportunity for shallow-water litter monitoring but standardization and conformity with the common methodologies and tools proposed here should be achieved. Fixed sites, common frequency and sampling methodology can be easily established by each Member State and training, material distribution etc. can be done relatively easily when partner NGOs or research institutions are involved.

5.5. Protocol for Sea-floor (20-800m)

From all the methods assessed, trawling (otter trawl) has been shown to be the most suitable for large scale evaluation and monitoring (Goldberg, 1995, Galgani *et al*., 1995, 1996, 2000). Nevertheless there are some restrictions in rocky areas and in soft sediments, as the method may be restricted and/or underestimate the quantities present. This approach is however reliable, reproducible, allowing statistical processing and comparison of sites. As recommended by UNEP (Cheshire, 2009), sites should be selected to ensure that they (i) Comprise areas with uniform substrate (ideally sand/silt bottom); (ii) consider areas generating/accumulating litter, (iii) avoid areas of risk (presence of munitions), sensitive or protected areas; (iv) do not impact on any endangered or protected species.

Sampling units should be stratified relative to sources (urban, rural, close to riverine inputs) and impacted offshore areas (major currents, shipping lanes, fisheries areas, etc.).

General strategies to investigate seabed litter are similar to methodology for benthic ecology and place more emphasis on the abundance and nature of items (e.g. bags, bottles, pieces of plastics) rather than their mass. The occurrence of international bottom trawls surveys such as IBTS (Atlantic), BITS (Baltic) and MEDITS (Mediterranean/Black Sea) provide useful and valuable means for monitoring marine litter. These are using common gears depending on region (GOV nets in Atlantic, MEDITS net in the Mediterranean) and provide some harmonized and common conditions of sampling (20 mm mesh, 30-60 min tows, large sampling surface covered) and hydrographical and environmental information (surface & bottom temperature, surface & bottom salinity, surface & bottom current direction & speed, wind direction & speed, swell direction and height). More than 20 sampling units are sampled within each region as recommended by UNEP (Cheshire, 2009).

Therefore, the TSG-ML strongly recommends to use these on-going and continuous programmes to collect data on marine litter in the sea-floor. This will enable to compare data from one country to another and to evaluate transnational transportation.

5.5.1. Technical requirements

The protocol for sampling and trawling margins (20-800m) has been standardized for each region:

Atlantic and Baltic Seas

For Atlantic and Baltic regions, the protocol is derived from the IBTS /BITS protocols (see the protocol manual, ICES/IBTS, 2012). The sampling grids are based on statistical rectangles of one degree longitude x 0.5 degree latitude (# 30 x 30 nautical miles). Each rectangle is usually fished by ships of two different countries (two hauls per rectangle) or a single country fishing more than once in every rectangle (Skagerrat and Kattegat, Sweden). All countries have a standard haul duration to 30 minutes (defined as the moment when the vertical net opening and door spread are stable), using the same 36/47 GOV-trawl with 20 mm mesh nets (ICES/IBTS, 2012) and sampling at 3.5-4 knots between 0 and 200 m depth.

Mediterranean and Black Seas

For the Mediterranean Region, the protocol is derived from the MEDITS protocol (see the protocol manual, Bertan *et al*., 2007). The protocol is also a reference protocol for associated countries, including Romania and Bulgaria in the Black Sea. The hauls are positioned following a depth stratified sampling scheme with random drawing of the positions within each stratum. The number of positions in each stratum is proportional to the surface of these strata and the hauls are made in the same position from year to year. The following depths (10 – 50; 50 – 100; 100 – 200; 200 – 500; 500 - 800 m) are fixed in all areas as strata limits. The total number of hauls for the Mediterranean Sea is 1385; covering the shelves and slopes from 11 countries in the Mediterranean.

The haul duration is fixed at 30 minutes on depths less than 200m and at 60 minutes at depths over 200m (defined as the moment when the vertical net opening and doorspread are stable), using the same GOC 73 trawl with 20 mm mesh nets (Bertran *et al*, 2007) and sampling between May and July, at 3 knots between 20 and 800 m depth.

Detecting trends

Consistency of results is based on sampling strategy and monitoring efforts. Long term monitoring of litter on the sea floor has been performed in some EU countries such as UK, Germany, Spain and France. In some cases such as the margins of gulf of Lion (France), trends studies (70 Stations, depth 40-800m,) indicated a statistically significant decrease [Abundance (10-4) = 0.038 x (Year) + 1.062 (R2 =0.36)] enabling the measurement of 15% decrease in 15 years.

However, Power Analysis of IBTS related sampling by Cefas indicates that detection of a 10% change over 5 or 10 years is unlikely without massive sample sizes. However, 50% changes over 5 or 10 years look to be readily detectable with current designs based on fish stock surveys such as IBTS.

Data recording and Management

A template for data recording sheet based on this system has been integrated in the IBTS Manual[24] and will be included in the protocol for the MEDITS protocols[25]. Data on litter should be collected these templates and the items categories listed for Sea-floor (Annex 5.1). Other elements from the haul operations should be also recorded – See ICES Survey Protocols for Atlantic/Baltic and MEDITIS for the Mediterranean/Black Sea.

Data on litter should be reported as items/ha or items/km2 before further processing and reporting. In some cases, when the horizontal opening of the trawl is not evaluated for each tow, it will be necessary to calculate surfaces using mean opening of the trawl, as provided by the technical manual.

Monitoring of litter on continental margins must be co-organized and coordinated within the two groups ICES/IBTS (NE Atlantic and Baltic Sea) and MEDITS (Mediterranean and Black Sea). Inclusion of litter monitoring through IBTS/MEDITS programmes will need to be organized within the EU through the STEFC (Scientific, Technical and Economic Committee for Fisheries) and its Subgroup on Research Needs (SGRN), with the support of the Data Center Framework (DCF) from DG MARE (Directorate-General for Maritime Affairs and Fisheries). The use of a central database for European trawl survey data (MEDITS, IBTS, ICES, DATRAS, etc.) may be used for collection of trawl survey data preceding a more specific litter data management system. Organisation of litter data management is still being considered at the EU level (WISE/EMODNET) or regional institution (OSPAR, HELCOM, BSC, MEDPOL).

5.6. Litter categories for sea-floor

Because marine litter degradation is affected by light, oxygen and wave action, the persistence of marine litter on the sea floor and deep sea floor is increased with notable outcomes on the nature of litter found. Another important factor influencing the composition of benthic litter is related to the type of activity. Typically, the analysis of sources indicated the importance and differences between ship based litter, as in the Southern North Sea, and land based litter such as in the Mediterranean. The definition of categories will have to take this in account when defining a protocol. Although marine litter is strongly affected by transportation, fishing has been shown as a main source of litter in some fishing or aquaculture grounds. Similarly specific types of marine litter were also found in areas affected by tourism, around beaches, as in the Mediterranean Sea. This may affect the strategy for monitoring selected areas, such as shallow waters.

A standardized litter classification system has been defined before monitoring the sea floor (Annex 5.1; see also Chapter 8). These categories were defined in accordance with types of litter found at regional level, enabling common main categories for all regions. The main categories have a hierarchical system including sub categories. It considers 5 main categories of material (Plastics, metal, rubber, glass/ceramics, natural products) and additional ones: 1 for NE Atlantic (miscellaneous) or 4 for Mediterranean (wood, paper/cardboard, other, unspecific). There are various subcategories for a more detailed description of litter items. Other specific categories may be added by Member States and additional description of the item may provide added-value, as long as the main categories and sub-categories are maintained. Furthermore, the weight, picture and note of potential attached organisms may further complement the classification of items.

Other parameters

Site information and trawling sampling characteristics such as date, position, type of trawl, speed, distance, sampled area, depth, hydrographical and meteorological conditions should be recorded

Data-sheets should be filled out for each trawl and compiled by survey. If multiple counts (transects/observers) are run at any given site then a new sheet should be used for each trawl shot. After each survey data must be aggregated for analysis and reporting.

[24] http://www.ices.dk/sites/pub/Publication%20Reports/ICES%20Survey%20Protocols%20(SISP)/SISP1-IBTSVIII.pdf (ANNEX 15)

[25] http://www.sibm.it/SITO%20MEDITS/principaleprogramme.htm

5.7. Complementary protocol for sea-floor – Video camera

Large-scale evaluations of marine litter in the deep sea-floor are scarce because of available resources to collect data. Special equipment is necessary including ROVs and/or submersibles that may be very expensive to operate, especially in deep sea areas.

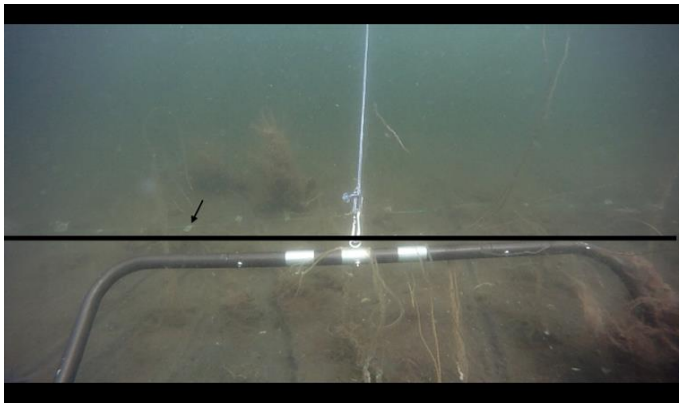
Towed video camera for shallow waters (Lundqvist, 2013) or ROVs for deeper areas are simpler and generally cheaper and must be recommended for litter surveys. There are some available protocols where litter is counted on routes and expressed as item/km, especially when using submersibles/ROVs at variable depths above the deep sea floor (Galgani *et al.*, 1996) but technology enables the evaluation of densities trough video-imagery using a standardized approach especially for shallow waters.

5.7.1. Shallow sea-floor using towed video

During some circumstances diving may be unsuitable, difficult or impossible, e.g. because of inadequate conditions, such as intense boat traffic, cold water temperatures, etc., because the legal requirements for diving are very strict, or because there is a lack of diving personal with the proper scientific/technical requirements. Using towed video may then be suitable alternative.

The principles for monitoring with towed video are essentially the same as for the diving protocol, but transects are filmed and analysed either immediately during the filming or afterwards in the lab/office.

The method is based on the protocol developed by Lundqvist (2013), as tested for recording the number of litter objects on shallow (<20m) seafloor biotopes (soft, hard and sand/stone bottoms). The equipment used consisted of a steel rig with two consumer type video cameras (mounted for filming obliquely forward and straight down (see Photo 1). A *Gopro* type camera (Woodman Labs, Inc. 2012)[26] equipped with a waterproof camera house or other similar brands are recommended with filmed sequences stored on memory card, and analysed afterwards.



Picture 1: (Right) - The rig with two video cameras for monitoring seafloor litter. The rig was towed after a small open boat (after Lundqvist, 2013)**; (Left) -** The method used by Lundqvist for estimating the width of a video transect. The arrow shows one of the markings (2 cm across) on the line used to calculate the width. The distance between two markings is 0.2 m and at the black line across the picture the estimated transect width is 2.55 m.

The width of the transect is estimated using a line placed perpendicular to the tow direction and marked at every 0.2 m (Fig X2). The types of litter must be then recorded using the categories defined for the sea-floor (Annex 5.1) but whenever possible, a more detailed description of the item should be added.

In turbid waters, cameras could be used down to approximately 20 m depth without any additional light source (Lundqvist, 2013). In total, it takes approximately 60 minutes to perform one transect in the field and then analyse it on land, including the preparation and disassembly of the system (camera and sleigh). The total area monitored during one workday (8h) (including boat transport, analysis, etc.) can be on

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average 2900 m^2/day. If the system has some limits (require access to a boat and it is weather sensitive, less suitable for habitats with thick vegetation coverage, technical malfunctions are only seen afterwards), this method has major advantages such as (1) the inexpensive and standard equipment (<1000 €), (2) the system does not require high technical expertise, (3) the method is fast and requires only 1-2 persons in the field, (4) it allows for independent analysis of videos and other uses of the same films (e.g. habitat mapping, estimation of resources), (5) enables random (non-biased) transect, as the operator does not see the actual transects until afterwards, and the analyse of only subset to meet basic monitoring requirements, and finally (6) the system is a viable option if legal requirements or conditions limit diving.

5.7.2. Deep sea-floor using video

For deep sea-floor, data collection is to be performed on irregular basis, using mainly opportunistic circumstances, considering and counting only litter larger than 2.5 cm, along submersibles/ROVs routes of minimum 0.5 km.

Bathymetrically, the proportion of area with anthropogenic litter may increase with increasing distance along a broad offshore front, from inner to outer shelf. Priority must then be given to coastal canyons, or on other areas that are known to generate or accumulate marine litter. Categories are recorded following the list of main categories provided in Annex 5.1 and the data-sheet mentioned in section 5.5.1 – Data Recording and Management..

For shallow waters and deep sea floor (range 200-4000m), results are expressed as items/100 m or items/km or items/ha or km^2 when surface are measured (towed camera).

5.8. Quality Assessment /Quality Control

Several contracting parties from OSPAR and MEDPOL have indicated they will use their fish stock surveys for benthic litter monitoring and thus this method might be adopted as a common indicator. This is considered to be an adequate approach although quantities of litter might be underestimated, given restriction ion some areas. The adoption of a common protocol will lead to a significant level of standardization among the countries that apply it as their sampling strategy.

Data on litter in shallow sea-floor are collected through protocols already validated for benthic species.

Data recording and management should be undertaken through an online, relational database system under the control and direction of local managers. The responsibility for review and approval of uploaded data should be than undertaken by regional/country coordinators. This would ensure a high level of consistency within each region as well as create a hierarchy of quality assurance on data acquisition. Until now, no quality assurance programme has been considered for litter monitoring on the sea-floor. For IBTS and MEDITS, sampling data are collected in the DATRAS database and participate in data quality checking for hydrographical and environmental conditions. This process may also support quality insurance for data on litter. Currently, there are on-going discussions on how to organize and harmonize a specific system to collect, validate and organize data through a common platform, enabling the review and validation of data. ICES is considering data for OSPAR area, while MEDITS has included litter data to be analysed within a specific sub-group. The occurrence of WISE/EMODNET with modules dedicated to MSFD indicators may also be considered to develop a specific module for indicators from descriptor 10, including litter on sea floor.

5.9. Conclusions: Key messages to MSFD implementation process

Considering “windows of opportunity” may be the best approach to monitor litter on the sea-floor.

There may be other opportunities to couple marine litter surveys with other regular surveys (monitoring in marine reserve, offshore platforms, etc.) or programmes on biodiversity.

Monitoring programmes such as IBTS operate at larger, regional scale and not only may be a good opportunity to couple monitoring of marine litter but also provide a regional, comparable approach, as required by the MSFD.

5.10. References

Bertrand, J., A. Souplet, L., Gil de Soula, G., Relini, C., Politou. 2007. *International bottom trawl survey in the Mediterranean (Medits), Instruction manual, Version 5*. pp. 62. Last accessed 13 June 2013 online at: http://www.sibm.it/SITO%20MEDITS/file.doc/Medits-Handbook_V5-2007.pdf

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Borchers, D.L. and Thomas, L. 2001. *Introduction to distance sampling: Estimating abundance of biological populations*. Oxford University Press, New York. pp. 448.

Cheshire, A.C., Adler, E., Barbière J., Cohen, Y., Evans, S., Jarayabhand, S., Jeftic, L., Jung, R.T., Kinsey, S., Kusui, E.T., Lavine, I., Manyara, P., Oosterbaan, L., Pereira, M.A., Sheavly, S., Tkalin, A., Varadarajan, S., Wenneker, B. and Westphalen, G. 2009. *UNEP/IOC Guidelines on Survey and Monitoring of Marine Litter.* UNEP Regional Seas Reports and Studies, No. 186; IOC.

DATRAS. 2010. *Development of a central database for European trawl survey data DATRAS*, Database TRAwl Surveys , Final report, Project number QLRT-2001-00025. Last accessed 13 June 2013 online at: http://datras.ices.dk/Home/Default.aspx

Galgani, F., Jaunet, S., Campillo, A., Guenegan, X. and His, E. 1995. *Distribution and abundance of debris on the continental shelf of the North-western Mediterranean Sea*. Mar. Pollut. Bull. 30, 713–717. (doi:10.1016/0025-326X (95)00055-R).

Galgani, F., Souplet, A. and Cadiou, Y. 1996. *Accumulation of debris on the deep sea floor off the French Mediterranean coast.* Marine Ecology Progress Series 142: 225–234.

Galgani, F., Leaute, J. P., Moguedet, P., Souplet, A., Verin, Y., Carpentier, A., Goraguer, H., Latrouite, D., Andral, B., Cadiou, Y., Mahe, J. C., Poulard, J. C., Nerisson, P. 2000. *Litter on the Sea Floor along European Coasts.* Marine Pollution Bulletin 40(6):516-527. doi:10.1016/S0025-326X(99)00234-9).

Galgani, F. and Piha, H. 2010. *ICES WKMAL Report 2010 - Report of the Joint Workshop on Marine Litter (WKMAL).* Citation: Report of the Joint MEDPOL/Black Sea/JRC/ICES Workshop on Marine Litter (WKMAL) p. 1-20 Publisher: International Council for the Exploration of the Sea Publication Year: 2010 JRC Publication-N°: JRC61822. Last accessed 13 June 2013 online at: http://publications.jrc.ec.europa.eu/repository/handle/111111111/15217

Goldberg, E.D. 1995. *Emerging problems in the coastal zone for the twenty-first century*. Marine Pollution Bulletin. 31, 152-158.

ICES/IBTS. 2012. *Manual for the International Bottom Trawl Surveys , Revision VIII*. The International Bottom Trawl Survey Working Group , SERIES OF ICES SURVEY PROTOCOLS , SISP 1-IBTS VIII, pp. 72. Available online at: http://www.ices.dk/sites/pub/Publication%20Reports/ICES%20Survey%20Protocols%20(SISP)/SISP1-IBTSVIII.pdf

Katsanevakis, S. 2009. *Estimating abundance of endangered marine benthic species using Distance Sampling through SCUBA diving: the Pinna nobilis (Mollusca: Bivalvia) example*. In: Columbus, A.M., Kuznetsov, L., (eds) Endangered Species: New Research. Nova Science Publishers, New York. pp. 81–115.

Lundqvist, J. (2013) – Monitoring marine debris, Report of university of Gothenburg, Faculty of sciences, 22 pages

NOWPAP. 2007. *Guidelines for Monitoring Marine Litter on the Seabed of the Northwest Pacific Region.* Prepared by NOWPAP and MERRAC.

Thomas, L., Laake, J.L., Rexstad, E., Strindberg, S., Marques, F.F.C., Buckland, S.T., Borchers, D.L., Anderson, D.R., Burnham, K.P., Burt, M.L., Hedley, S.L., Pollard, J.H., Bishop, J.R.B. and Marques, T.A. 2006. *Distance 6.0. Release Beta 3.* Research Unit for Wildlife Population Assessment, University of St. Andrews: St. Andrews, UK. Last accessed 13 June 2013 online at: http://www.ruwpa.st-and.ac.uk/distance/

Timmers, M.A., Kistner, C.A. and Donohue, M.J. 2005. *Marine Debris of the Northwest Hawaiian Islands: Ghost Net Identification*. Sea Grant Publication: UNIHI-SEAGRANT-AR-05-01.

Annex 5.1 - Categories and sub-categories of litter items for Sea-Floor

Litter categories from the OSPAR/ICES / IBTS for North East Atlantic and Baltic

A: Plastic	B: Metals	C: Rubber	D: Glass/ Ceramics	E: Natural products/ Clothes	F: Miscellaneous
A1. Bottle	B1. Cans (food)	C1. Boots	D1. Jar	E1. Clothing/ rags	F1. Wood (processed)
A2. Sheet	B2. Cans (beverage)	C2. Balloons	D2. Bottle	E2. Shoes	F2. Rope
A3. Bag	B3. Fishing related	C3. bobbins (fishing)	D3. piece	E3. Other	F3. Paper/ cardboard
A4. Caps/ lids	B4. Drums	C4. tyre	D4. other		F4. pallets
A5. Fishing line (monofilament)	B5. appliances	C5. other			F5. other
A6. Fishing line (entangled)	B6. car parts				
A7. Synthetic rope	B7. cables				
A8. Fishing net	B8. other				
A9. Cable ties					
A10. Strapping band					
A11. crates and containers					
A12. Plastic diapers					
A13. sanitary towel/tampon					
A14. Other					

Related size categories

A: <5*5 cm= 25 cm²

B: <10*10 cm= 100 cm²

C: <20*20 cm= 400 cm²

D: <50*50 cm= 2500 cm²

E: <100*100 cm= 10000 cm²= 1 m²

F: >100*100 cm = 10000 cm2= 1 m2

Litter categories from MEDITS litter for Mediterranean and Black Sea

A. Plastic	B. Rubber	C. Metals	D: Glass/ Ceramics	E. textils / natural fibers	F. Wood (processed)	G. Paper / cardboard	H. Other (specify)	I. Unspecified
A1.Bags	B1. Tyres	C1. Beverage cans	D1. Bottles	E1. Clothing (clothes, shoes)				
A2. Bottles	B2. Other (gloves, shoes, etc.)	C2. Other food cans/wrappers	D2. Pieces of glass	E2. Large pieces (carpets, etc)				
A3. Food wrappers		C3. Middle size containers	D3. Ceramic jars	E3. Natural ropes				
A4. Sheets		C4. Large metallic objects	D4. Large objects (specify)					
A5. Other plastic objects		C5. Cables						
A6. Fishing nets		C6. Fishing related						
A7. Fishing lines								
A8. Other fishing related								
A9. Ropes/strapping bands								
A10. Sanitaries (diapers, etc.)								

Related size category

A: <5*5 cm= 25 cm^2

B: <10*10 cm= 100 cm^2

C: <20*20 cm= 400 cm^2

D: <50*50 cm= 2500 cm^2

E: <100*100 cm= 10000 cm^2= 1 m^2

F: >100*100 cm = 10000 cm2= 1 m2