Marine Litter

Technical Recommendations for the Implementation of MSFD Requirements

MSFD GES Technical Subgroup on Marine Litter

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Contents

List of Abbreviations

BITS	Baltic International Trawl Survey
BTS	Beam Trawl Survey
CSO	Combined sewer overflow
Com Dec(2010/477/EU)	Commission Decision on criteria and methodological standards on good environmental status of marine waters (2010/477/EU)
DCF	Data Center Framework
DG ENV	Directorate-General for the Environment
DG MARE	Directorate-General for Maritime Affairs and Fisheries
DIKE (WG)	Data, Information and Knowledge Exchange (Working group)
DPSIR	Driver, Pressure, State, Impact, Response
EAM	Ecosystem Approach Management
EcoQO	Ecological Quality Objective (OSPAR)
EMODNET	European Marine Observation and Data Network
EPA	U.S. Environmental Protection Agency
FAO	Food and Agriculture Organisation of the United Nations
FT-IR	Fourier Transform-Infra Red spectroscopy
GES	Good Environmental Status
GESAMP	Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection
HELCOM	Helsinki Commission Baltic Marine Environment Protection Commission
IBTS	International Bottom Trawl Survey
ICC	International Coastal Cleanup
ICES	International Council for the Exploration of the Seas (CIEM)
ICGML	Inter-sessional Correspondence Group - Marine Litter (OSPAR)
IFREMER	Institut Français de Recherche pour l'Exploitation de la Mer
IOC	Intergovernmental Oceanographic Commission
IUU fishing	Illegal, unreported and unregulated fishing
JRC - IES	European Commission Joint Research Centre - Institute for Environment and Sustainability
MEDITS	Mediterranean Trawl Survey
MEDPOL	Programme for the Assessment and Control of Marine Pollution in the Mediterranean region
MS	EU Member States
MSFD	Marine Strategy Framework Directive (2008/56/EC)
NGO	Non-Governmental Organisation
NOAA	National Oceanic and Atmospheric Administration
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
QA/QC	Quality assurance/Quality control
STFEFC	Scientific, Technical and Economic Committee for Fisheries
TSG ML	Technical Subgroup on Marine Litter under the Marine Strategy Framework Directive
UNEP	United Nations Environment Programme
WG GES	Working Group on GES in relation to the MSFD

1. Introduction

As a follow up to the Commission Decision on criteria and methodological standards on good environmental status (GES) of marine waters (Commission Decision 2010/477/EU), the Marine Directors requested the Directorate-General for the Environment (DG ENV) in 2010 to establish a technical subgroup under the Working Group on GES (WG GES) in relation to the Marine Strategy Framework Directive 2008/56/EC (MSFD) for further development of Descriptor 10 Marine Litter and Descriptor 11 Noise/Energy. For practical reasons the work was carried out by two separate groups. This report compiles the recommendations regarding Descriptor 10, Marine Litter.

The bases for the work of this group are the criteria and indicators listed in the Commission Decision 2010/477/EU under Descriptor 10:

> **Descriptor 10:** Properties and quantities of marine litter do not cause harm to the coastal and marine environment.
>
> The distribution of litter is highly variable, which needs to be taken into consideration for monitoring programmes. It is necessary to identify the activity to which it is linked including, where possible, its origin. There is still a need for further development of several indicators, notably those relating to biological impacts and to micro-particles, as well as for the enhanced assessment of their potential toxicity (21).
>
> 10.1. Characteristics of litter in the marine and coastal environment
>
> — Trends in the amount of litter washed ashore and/or deposited on coastlines, including analysis of its composition, spatial distribution and, where possible, source (10.1.1)
>
> — Trends in the amount of litter in the water column (including floating at the surface) and deposited on the sea- floor, including analysis of its composition, spatial distribution and, where possible, source (10.1.2)
>
> — Trends in the amount, distribution and, where possible, composition of micro-particles (in particular micro- plastics) (10.1.3)
>
> 10.2. Impacts of litter on marine life
>
> — Trends in the amount and composition of litter ingested by marine animals (e.g. stomach analysis) (10.2.1).
>
> This indicator needs to be developed further, based on the experience in some sub-regions (e.g. North Sea), to be adapted in other regions.

The mandate for the Technical Subgroup on Marine Litter (TSG ML) was drafted by DG ENV, IFREMER and JRC (European Commission Joint Research Centre), discussed by WG GES and issued by the European Marine Directors for the year 2011. It contained the following work items:

1. Identify and review existing data and on-going data collection on marine litter;

2. Describe data needs and methods for future assessment of marine litter;

3. Consider standards for recording of marine litter;

4. Develop proposals for the development of impact indicators for each of the regions;

5. Address how to develop objectives (characteristics of GES), environmental targets and associated indicators in relation to marine litter;

6. Discuss effectiveness of measures leading to reductions in marine litter, and;

7. Recommend proposals for further research priorities.

For the full mandate of the group, please see Annex 1.

The group's first task was to elaborate a strategy which should, in the short term, assist Member States (MS) in the implementation of the MSFD with regard to Descriptor 10. During the first meeting a strategy based on three major pillars was proposed and agreed:

- The use of a web-based communication tool for effective collaboration between the meetings;
- The development of a toolbox containing descriptions (tool sheets) of suitable/applicable monitoring approaches for the different indicators;
- The development of a roadmap indicating the needs for further development by the various stakeholders in science and policy.

1.1 Group organisation

In September 2010, MS and stakeholder delegates were invited to appoint experts for the TSG ML. In total, 42 people participated in the group (see Annex 2 for the detailed list of group members). Throughout the process further interested MS delegates joined the work.

The group was chaired by Francois Galgani (Ifremer, France), co-chaired by Georg Hanke (JRC, Institute for Environment and Sustainability) and Stefanie Werner (German Environment Agency, UBA, Germany) and supported by Henna Piha (JRC IES).

The group identified 11 tasks for organisation of discussions and information collection. For each task, a contact person was nominated and group members were allocated to take lead in preparing the task deliverables. However, all group members were invited to contribute to each task:

- Group organisation
- Task 1 Availability of data and methods
- Task 2 Beach
- Task 3 Water Column and Surface
- Task 4 Seafloor
- Task 5 Biota
- Task 6 Microplastics
- Task 7 Objectives and Targets
- Task 8 Sources
- Task 9 Reporting and Data Treatment
- Task 10 Research Needs
- Marine Litter Report 2011 (added for the final drafting process).

1.2 Collaboration and communication: Basecamp/Circa

The group reported to WG GES (consisting of representatives of Member States, Regional Sea Conventions and Stakeholders), the Marine Strategy Coordination Group, and the European Marine Directors. Prior to the final report, the group produced two intermediate reports and presentations to the meetings of the WG GES, which are available on CIRCA. As several group members were closely related to the implementation of the Descriptor 10 provisions in their home countries, the group served as a direct information exchange platform with many MS.

The work of the group was facilitated by Basecamp® (37signals LLC, Chicago, Illinois, USA), which is a web-based communication tool. It was provided through JRC and used for communication, drafting documents and compiling information. JRC provided a privacy policy document for the use of this external tool and regular back-up of the data.

The deliverables of the group were communicated via the European Commission communication tool CIRCA under the Marine Strategy interest group in the Environment section: (http://circa.europa.eu/Members/irc/env/marine/library?l=/implementation_coordinat/technical_subgroup&vm=detailed&sb=Title).

1.3 Meetings

The group convened three times. The kick-off meeting was held in Copenhagen, on 4 November 2010, back-to-back with a workshop on Marine Litter organised by ICES. The second meeting was held in Calvi, Corsica, France from 18-20 April 2011, with focus on discussions about a common understanding of the work items and drafting of tool sheets. The third meeting was held in Varna, Bulgaria from 12-14 October 2011, concentrating on final discussions and preparation of the final report.

2. Toolbox and Roadmap Concepts and Availability of Litter Monitoring Data

It is of prime importance that the assessments conducted under the MSFD of trends in occurrence of marine litter are comparable in order to achieve an equal level of GES across all European Seas. The first objective of the group was therefore to establish whether sufficiently harmonised monitoring methodologies for assessing the quantity of litter in the marine environment and in marine organisms were available, and to propose actions necessary to develop methods where they are currently lacking. While the proposed methodologies may be adapted to regional needs, they are the basis for trend assessments; hence it is essential that MS approach GES through the implementation of the MSFD Descriptor 10 in a harmonised way.

The group focused its work on developing **a toolbox** with applicable monitoring/quantification methods (**tools**) and **a roadmap** for the further implementation of MSFD Descriptor 10.

2.1 Toolbox concept

The first obligation for MS under the MSFD is the collection and consideration of available and new data for the initial assessment of the environmental status of their marine waters by mid-2012 (MSFD Art.8). Therefore information about existing monitoring tools and their properties as well as their limitations is of primary importance. For the indicators listed in the Commission Decision (2010/477/EU), tool sheets describing the appropriate methodologies for potential use have been prepared. The group prepared altogether 15 tool sheets describing the different methodologies for potential use. These tool sheets collect the main information about the methodologies, such as scope, matrices, and size ranges. They refer to existing guidelines and detailed descriptions if available and indicate also the maturity of the identified tool, including eventual shortcomings. These tool sheets are presented in Chapters 3-6 of this report under the relevant monitoring matrices. They provide a first set of methodologies for application by the MS for starting marine litter data collection.

2.2 Roadmap concept

While currently existing monitoring tools have been identified as a first priority, there are numerous issues in the Descriptor 10 implementation which need further attention. The elaboration of a roadmap which shows the options and needs for further development was therefore the second main task of the group. It has been tried, where possible, to differentiate between needs on different timescales and to identify the various actors who could be responsible for their development.

Also the need for further follow-up within the frame of the WG GES, to be carried out by the technical subgroup was identified. Therefore, in chapter 12 the roadmap for 2012 includes a list of priority tasks for preparation of a respective mandate. Further important milestones within the MSFD implementation are the start of monitoring programs in 2014 (Art. 11), the identification of programmes of measures in 2015, the implementation of those measures in 2016 (Art. 13) and the first revision of the Commission Decision (2010/477/EU) also expected by 2016. Throughout the whole process coordination of efforts, or at least mutual information exchange between the MS and stakeholders, should be guaranteed.

2.3 Availability of data and methods

The group reviewed the main available data sources on marine litter in the European Seas. For that purpose a data sheet was developed which requested extensive (38 categories) information about past and on-going litter monitoring or survey projects and programs: such as geographical information, data holder information, dataset size, covered matrices, and methodologies. The intention was to identify the spatial coverage and timing of marine litter assessments in Europe as well as the responsible persons and institutes. Datasets were received from approximately 40 organisations covering altogether 56 different monitoring projects. These ranged from monitoring programs by national authorities developed under the Regional Seas Conventions or initiatives by NGOs, to outcomes from research projects. This information has been used by the different tasks for their specific purpose.

Summary tables of current data availability regarding marine litter monitoring and surveys, according to the various compartments (beach, water column, sea floor, and biota) are presented in Annex 3. An excel sheet compiling all collected information is available on Circa:
http://circa.europa.eu/Members/irc/env/marine/library?l=/implementation_coordinat/technical_subgroup&vm=detailed&sb=Title.

The methodological approaches related to the reported datasets as well as other approaches collected from scientific publications, conference contributions and expertise of the group members have been identified. The outcome from this analysis was then used in the different tasks for the development of the tool sheets and the respective roadmap for further development needs.

3. Beach Litter

Litter on the coastline is one of the most obvious signs of marine litter pollution. Major land-based sources include tourism, recreation, illegal dumping, waste disposal sites, input from rivers, sewage and storm water outflows. Major sea-based sources are commercial shipping, fisheries activities, pleasure crafts and off-shore installations.

Surveys of litter stranded on the coastline are a primary tool for monitoring the load of litter in the marine environment and have been used world-wide to quantify and describe marine litter pollution. They can be used to measure the effectiveness of management or mitigation measures, identify the sources and activities leading to litter pollution and determine threats to marine biota and ecosystems (Cheshire et al., 2009).

For this reason, the amount of litter on the coastline is proposed as a main indicator for marine litter pollution (10.1.1) characterized as "trends in the amounts of litter washed ashore and/or deposited on coastlines, including analysis of its composition, spatial distribution and, where possible, source."

Although the term "Coastline litter" is used in the Commission Decision (2010/477/EU), it is common practice to use the term "Beach litter". This is the term that will be used in this report.

3.1 Availability of data

Up-to-date overviews of the results of litter surveys on the coastline are included in the Global Marine Overview (Cheshire et al., 2009). This includes the results of the reviews by Lozano and Mouat (OSPAR 2009) for the North-East Atlantic Region, Helsinki Commission (2007) for the Baltic region, BSC (2007) for the Black Sea region and information for the Mediterranean Sea. For this report an inventory has been prepared of beach litter data available in the EU area. These data are summarised in Annex 3, Table 1. For the full data set see:
http://circa.europa.eu/Members/irc/env/marine/library?l=/implementation_coordinat/technical_subgroup&vm=detailed&sb=Title.

Fig. 1. Beach in the UK. Photo: Steve Trewhella, Marine Conservation Society.

Fig. 2. Beach on the Swedish west coast. Photo: West Coast Foundation, Sweden.

3.2 Availability of methods

An initial identification of available methodologies resulted in a limited amount of reports for the EU region: OSPAR (Convention for the Protection of the Marine Environment of the North-East Atlantic) and HELCOM (Helsinki Commission Baltic Marine Environment Protection Commission). There was limited information on the Black Sea and Mediterranean region and overall there is limited information specifically on hands-on experience and data analyses. Therefore, the methodologies from UNEP (United Nations Environment Programme), EPA (U.S. Environmental Protection Agency)/Ocean Conservancy and NOAA (National Oceanic and Atmospheric Administration) are also considered here.

OSPAR: Guideline for monitoring marine litter on beaches in the OSPAR area

Monitoring of beaches in the OSPAR area has been running for 11 years. The number of participating countries and beaches varies per year with approximately 50 beaches in 10 countries surveyed in total. The methodology is practical and well documented although further development and harmonization is needed. Data has been analysed for several reports; a more advanced method of analysis is still being looked into.

HELCOM: HELCOM RECOMMENDATION 29/2 Guidelines on sampling and reporting of marine litter found on beach

The method is a less extensive version of the OSPAR method. As far as is known these guidelines have not yet been used (tested) in the HELCOM area

UNEP: UNEP/ICO Guidelines on Survey and Monitoring of Marine Litter (global).

These guidelines are based on studies of methods worldwide. They provide information on different monitoring methods varying from scientific to educational. The guidelines are well documented. There is, however, no record of the practical use of the guidelines.

EPA/Ocean Conservancy: National Marine Debris Monitoring Program (USA)

This programme was conducted for 10 years across the USA with 20 beaches per region in 9 regions. It is well organized and well documented, including the evaluation of method + analysis.

NOAA: Marine Debris Density Monitoring and Assessments NOAA Marine Debris Division (USA)

A pilot programme from 2009, it is currently undergoing rigorous testing. Well described method, including micro litter, working with transects.

3.3 Tool sheet development

An **analysis of the methods** described in 3.2 has been carried using an extensive list of assessment criteria and many discussions in TSG ML. This has led to the following observations and conclusions:

1. There doesn't seem to be a need for different individual (regional) methods. Once an EU-wide method is chosen this can be applied to all countries. The abundance and the types of litter recorded on beaches may vary between countries; however, this is not a barrier for a harmonized method.
2. One standard method for beach litter surveys should be implemented EU-wide for measuring whether objectives of the MSFD are met. ICES WKMAL REPORT 2010 (Galgani and Piha, 2010): there is a general agreement on using the same protocol in every country, which should be an advanced method and allow the assessment of trends with sufficient accuracy for the purpose of the MSFD.
3. Counting the number of individual items provides the best information for formulation of management measures at all levels (linking items to sources and uses). It is also the most practical method; other additional methods can be valuable: e.g. the assessment of the weight of the items found.
4. The detailed assessment of small pieces of micro litter particles (< 5 mm) should be carried out according to the methods provided in Chapter 7 on Microlitter.
5. Litter items should be registered on a standard survey sheet. A European list of standard litter items should be produced from which items can be selected for regional surveys. This will enable the comparison of the results of the surveys at a European level. All litter items should be given a unique identification code. A hierarchical categorization system should be developed which groups items according to their type, application and allocates them, where possible, to different sources.

6. The reporting of barcodes on litter items can provide some additional information on the country of origin of litter, although considerably more effort is required during the surveys and during analysis. However, as ships can purchase products in numerous ports of call, barcodes do not necessarily provide information on the source of litter.
7. Litter should be counted and removed from the beach during each survey. During the first survey this will provide a one off assessment of the standing stock of litter on that beach. Following surveys will provide information on litter flux.
8. The frequency of surveys should be adjusted to the needs for trend assessments within the MSFD time frame. Ideally counts should be carried out after each high tide. However this is in most cases not practical and very manpower intensive. It is therefore recommended to carry out a minimum frequency of four surveys per beach/year in order to be able to assess possible seasonal differences in litter pollution. At this moment there is no knowledge if a higher survey frequency would provide better data.
9. The cleaning of beaches (all year round, seasonally or incidentally) can influence the data. Although it is better to use beaches where cleaning does not take place, it is not necessary to exclude cleaned beaches from the assessment programme. It is, however, of utmost importance that the cleaning activities are well documented so that the information on beach cleaning can be taken into consideration when analysing the data. It is also very important that the local authorities responsible for cleaning the beaches are contacted before surveys begin and that there is a close cooperation between surveyors and those authorities.
10. Criterion for the selection of beaches can vary. Ideally beaches should be selected randomly. However, this is rarely practical when organising beach surveys. An attempt should be made to cover all aspects of the litter pollution problem within the region involved. A selection of beaches close to point sources such as towns or rivers and beaches reflecting diffuse sources such as shipping and fisheries should be chosen. The number of beaches chosen per country/region etc. should reflect the prevailing coast (length and geography). Sandy beaches are the easiest to survey, but, pebbly and rocky beaches can be included in the assessment programme. However, it must be noted that the results from such beaches will not be comparable to sandy beaches as there will be an underestimation of small items on pebbly beaches and accumulation processes will be different (especially on rocky coastlines). Here again documentation of the type of beach, local conditions and factors that can potentially affect the results of the surveys is of utmost importance.
11. When collecting data it is important to consider the following points as this will improve standardisation and the quality of data:
    - Detailed description of the methods to be applied including information on how to collect data. For example it is important to define clearly how pieces or broken litter items are recorded e.g. broken bottles or pieces of larger items identifiable as being part of a given item.
    - Photo guides of all items that are likely to be found on beach aid identification and standardisation of reporting.
    - Optimally the same person(s) should monitor a given beach for the duration of the monitoring programme to ensure that effort remains constant. However, this is seldom possible, and often volunteers are used for beach litter surveys. Overall, it is important that surveyors are well trained by people experienced in beach litter monitoring. Quality control measures should be implemented to check that surveyors are efficient at counting all litter items.
    - The physical characteristics and local conditions of the survey beach and adjacent region should be documented before surveys begin. Photographic documentation of the beach and individual litter items can be helpful. Survey conditions should be recorded during the survey (e.g. wind, snow or ice, special events, etc.)
12. A 100 m stretch of beach seems to be a practical length for surveys providing sufficient data for analysis. A minimum of two surveyors are recommended to carry out a given survey. However if the survey site is very heavily littered more surveyors may be required.
13. A method for analysing the data and producing an index for assessing achievement of set targets should be developed for the MSFD. OSPAR and The Ocean Conservancy have both applied different analysing methods. NOAA is currently working on this topic and a German R&D project will be looking at possibilities using the OSPAR data.

3.3.1 Common best practice methodology

Looking at the conclusions above and considering the different aspects of beach litter monitoring a proposal is developed for a tool for beach litter monitoring in the EU region, based on common best practice.

Starting points

- Properties and quantities of marine litter do not cause harm to the coastal and marine environment. Harm can be divided into three categories: ecological, economic and social.
- MSFD Task Group 10 recommends that the overriding objective would be a measurable and significant decrease in comparison with the initial baseline in the total amount of marine litter by 2020 (Galgani et al., 2010).

Recommendations for monitoring litter on beaches in the EU region

1. One standard method, at least on a regional seas level but preferably for the EU region.
2. Objective: a measurable and significant decrease in comparison with the initial baseline in the total amount of marine litter by 2020.

The following tools have been identified:

Beach Litter monitoring	(10.1.1_T1)
Beach Meso litter	(10.1.1_T2)

MSFD Marine Litter Monitoring TOOL SHEET

Tool name: Beach litter monitoring

Indicator for which the tool is to be applied: 10.1.1

Tool code: 10.1.1_T1

Tool description: Surveys of litter on beaches are a primary tool for monitoring the load of litter in the marine environment and have been used world-wide to quantify and describe marine litter pollution. Counting the number of individual items provides the best, easiest and cheapest information for formulation of management measures at all levels (linking items to sources and uses). It is also the most practical method; other additional methods can be valuable: e.g. the assessment of the weight of the items found.

Technical requirements: The beach litter monitoring surveys should take place on selected beaches which are marked by reference landmarks or GPS coordinates. The entire 100 m beach stretch should be surveyed from the tide line to the structures forming the border of the back of the beach (dunes, sea wall etc.). Litter items found on the beach should be registered using a standard list of items. All the items should be counted. The identification of items should be assisted by the use of a photo guide which is included in the guidelines. During the monitoring session the litter should be removed from the beach.

Size range: Although in line with the OSPAR methods no lower size limit is proposed, litter items smaller than 2.5 cm should be assessed additionally (in line with the NOAA protocol) using the method for meso-litter on beaches, described in Toolsheet 10.1.1_T2. The assessment of microplastics in beach sediments is also included in Chapter 7 (Task 6).

Spatial coverage: Survey area length 100 m; width determined by geography of the beach.

Survey frequency: At least four times a year.

Maturity of the tool: Comparable tools are in use.

Regional applicability of the tool: method can be applied in all regions of the EU. Regional differences in items and their sources will need to be taken into account.

Source related information: Material, items and categories are linked to sources. A hierarchical categorization system should be developed which groups items according to their type, application and allocates them, where possible, to different sources. This should be compatible with other indicators.

References:

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.

EPA/Ocean Conservancy. 2007. National Marine Debris Monitoring Program, final program report, data analysis & summary.

Galgani, F., Fleet, D., van Franeker, J., Katsanevakis, S., Maes, T.,Mouat, J., Oosterbaan, L., Poitou, I., Hanke, G.,Thompson, R., Amato, E., Birkun, A., Janssen, C Editor: Zampoukas. 2010. MSFD Task Group 10 Report Marine litter.

HELCOM. 2008. HELCOM Recommendation 29/2 Guidelines on sampling and reporting of marine litter found on the beach.

NOAA Marine Debris Division. Vision. 2010/2011. Marine Debris Density monitoring and Assessments (DRAFT).

OSPAR. 2010. Guideline for monitoring marine litter on beaches in the OSPAR area.

As visual surveys do have a practical lower size limit, it is proposed to close the gap between procedures representatively quantifying macrolitter (> 2.5 cm) and microlitter (< 5 mm), which is a size fraction most relevant for ingestion, by a specific methodology (Toolsheet 10.1.1_T2). A presentation of the proposal is included in the following:

MSFD Marine Litter Monitoring TOOL SHEET
Tool name: Sampling meso beach litter 5 mm - 25 mm size

Indicator for which the tool is to be applied for: 10.1.1

Tool code: 10.1.1_T2

Tool description: Sampling fragments of litter from beaches in the 'meso' size range (5 mm – 25 mm). Sediment is collected from within a 50 cm x 50 cm quadrat using a metal trowel or scoop to a depth of 3cm. Material is sieved (5 mm sieve) and fragments of litter removed and stored for further analyses. Further analyses should include counting the number of items, categorizing according to material type (plastic, glass, metal); use (where possible e.g. bottle cap closure), categorizing according to shape and colour. It may be necessary to use FT-IR spectroscopy (see tool sheets on microlitter) to confirm the identity of some pieces.

Technical requirements: Quadrat 50cm x 50cm, metal trowel or scoop, 5mm sieve.

Size range: Meso beach litter 5 mm – 25 mm size**.**

Spatial coverage: Tool can be used to sample meso litter on beaches from a series of replicate quadrats randomly distributed along the beach. The tool could most effectively be considered as an extension of the protocols used to sample larger items of beach litter which are described in Toolsheet 10.1.1_T1, alternatively it could be conducted at the same time as monitoring microlitter on beaches. Hence spatial extent for this monitoring approach will most logically be dictated by the overall number of beaches sampled for macro or microlitter.

Survey frequency: As for macro beach debris described in Toolsheet 10.1.1_T1

Maturity of the tool: Not yet used but similar protocols in use.

Regional applicability of the tool: Widely applicable but not yet used.

Source related information: Information could be complied in spatial data base and linked with hydrodynamic and meteorological conditions, analysis of sampled material, categories, shapes

References: None - Not previously used but in line with NOAA protocol: NOAA Marine Debris Division (2010/2011) – Marine Debris Density monitoring and Assessments (DRAFT).

3.4 Future needs and further development

A standardized, well documented methodology for monitoring beach litter is crucial for collecting data that can meet the MSFD objectives, needing a measurable and significant decrease in comparison with the initial baseline in the total amount of beach litter by 2020.

Harmonization is necessary at every level, resulting in the following recommendations:

3.4.1 Development needs and options within 2012

- Develop advice on monitoring strategy and implementation. Including:
  - The identification of regions with a similar litter profile. Taking into account litter sources, geographical, meteorological and hydrological conditions, as well as regional litter related activities, practices and measures.
  - Define the minimum amount of beaches (per country/region/EU) and number of surveys necessary to be able to measure whether the MSFD objectives are met for a given region within the defined timeframe.
  - Develop detailed guidelines for monitoring beach litter based on existing programmes. Including the monitoring of litter items < 2.5 cm and of microlitter in beach sediments. Taking into account regional differences in relation to items and sources. All aspects of monitoring, from choosing a beach to data collection as well as quality assurance and quality control (QA/QC) should be described in detail. The guidelines must also include: a

questionnaire on the characteristics of survey beaches, an itemized survey data sheet including a survey questionnaire and a photo guide of all litter items expected to be found on the beach.
  - A standard EU-wide list of litter items with unique identification codes should be developed. This should include the development of a hierarchical categorization system, which groups items according to their type and application and allocates them, where possible, to different sources.
  - If in some regions the standard 100 m length of beach cannot be adhered to for geographical reasons the inclusion of shorter lengths of coastline for data collection needs to be tested for comparability.
  - Exchange of experience between regions/road testing draft guidelines.

3.4.2 Development needs and options until 2016 and beyond

- Monitoring strategies
  - Monitoring more frequently than four times a year may provide better data. In France three beaches are monitored on a monthly basis. Comprehensive drift models should define source and destinations of litter regions, estimated residence times and average drift times.
- Socio economic impact
  - Evaluate the potential loss of income due to beach litter in relation to tourism.
  - Evaluate direct costs to industry, local authorities and governments, to ecosystems goods and services.
  - Assess socially acceptable levels of marine litter (including aesthetic impact) to the society.
  - Improve tools such as GIS; socio-economic models etc. enabling evaluations of sources of litter, social impact and contribution to management efforts.
  - Establish the impact of marine litter on human health.
  - Understand the effectiveness of measures intended to reduce the amount of marine litter.
- Develop a data handling and storage system, coordination, database, data entry, quality control etc.
- Set up a communication tool for exchanging information.
- Develop a table with conversion factors from number of items to weight of items.
- Develop a standard method for data analysis.
- Carry out further work on linking marine litter to sources.

4. Water Column and Surface Floating Litter

Floating items play an important role in the cycling of marine litter as they represent its mobile fraction and the pathway between different environmental compartments. Floating litter has therefore been selected as part of indicator 10.1.2 of the Commission Decision (2010/477/EU):

- Trends in the 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).

An understanding of the dynamics of floating litter is fundamental to developing appropriate strategies in order to manage marine litter in both a global and local context. The objects encountered as floating marine litter range from ship- or container -sized objects, fishing nets, drums, boxes, bottles, plastic bags, small consumer items, object fragments and microlitter particles down to the nano- and molecular scale. Almost 90 % of floating marine litter has been estimated to be items made of polymers of anthropogenic origin.

There is a wide range of potential harm caused by floating litter. Ingestion by and entanglement of marine biota such as seabirds, fish, turtles and marine mammals, with different object sizes affecting different species, is one impact from litter at the sea surface. This is further discussed in Chapter 6 of the report. As precursors of microlitter through physical degradation, floating items play an important role by triggering a whole range of other environmental effects, see Chapter 7. Floating litter also has the potential to provide a vector for the translocation of alien (invasive) species.

Pathways for the introduction are various, as floating litter in the marine environment can originate from riverine input, shoreline run-off, aerial input of low density objects or from sources at sea such as disposal or loss from ships or installations.

Objects with positive buoyancy might be floating due to the properties of their material (polymer material with positive buoyancy) or their design (bottles, containers, nets with floats, etc.). On the water surface they are transported with the surface currents, though considerable influence through wind action can affect the distribution of objects protruding from the surface.

It is assumed that these objects under influence from wave and weather action physically degrade and form smaller litter pieces, down to the so-called microlitter, defined as particles below 5 mm in size. The physical degradation can subsequently form particles in the micrometre range and below. The report deals with this fraction in Chapter 7. The degradation process can include the change in chemical composition and structure due to leaching of additives or polymer alteration by UV radiation.

Besides the obvious sinking of drums or bottles after damage, there are processes which can lead to a change in object density and thus cause an object to sink, e.g. biofouling (accumulation of organic material (Law et al., 2010)). Therefore the occurrence of litter in the water column (mid-water) would be limited to the steady state concentration of sinking litter. Nevertheless e.g. down welling events or the occurrence of litter having the same density as the surrounding seawater may lead to litter suspended in the water column as included under Indicator 10.1.2. This is regarded by the group as a matter for further research and the report will concentrate on litter floating at the surface, including litter which is temporarily mixed into the subsurface water through wave action.

The affected water depth is typically a few meters and will depend on the buoyancy of the objects and the sea state. Recent reports indicate that smaller particles might rapidly be mixed under water, but take longer time to re-surface (Prokurowski et al., 2011).

The monitoring of microlitter will be discussed here only for sampling methodologies where the size ranges for different monitoring methodologies overlap.

4.1 Availability of data

While visual observation of litter from ships is the most obvious methodology for quantification of floating litter in the marine environment there have been comparatively little surveys been reported. When cross-checking with scientific publications it becomes apparent that the survey methodologies are often slightly different and results therefore are difficult to compare. No multiannual time series of more than 5 years coverage have been reported. There are no surveys available which cover large areas or regional scale.

Selected information about the collected data availability on surface floating litter is given in Annex 3, which has been extracted from the data collection table referred to in Chapter 2.

4.2 Availability of methods

The methodologies for monitoring floating macroscopic litter are mostly observation methods. Surveys can be done with the naked eye or by using images from different kind of platforms such as fixed structures, ships, airplanes (Ribic et al., 1992, Veenstra and Churnside, 2011). No litter is actually collected and surveys will be subject to meteorological conditions. Protocols and reporting forms are available (Cheshire et al., 2009, NOAA, 2011, Thiel et al., 2011), but methodologies might need further development for the collection of data for trend assessments. For smaller litter items surface net trawls can be employed.

4.3 Tool sheet development

For the purpose of this report available techniques for quantification of floating litter have been reviewed. As agreed in the work plan for the MSFD GES TSG Marine Litter group, approaches currently in use have been identified and are presented as “tools” for the implementation of MSFD Descriptor 10. As they have not been developed specifically for MSFD purposes, they may need to be further developed or adapted to regional or local circumstances. Their degree of maturity is indicated and the roadmap highlights further development needs. Also new, promising tools are described in the roadmap section. The selection of an appropriate methodology will depend on the required object size range to be monitored.

Litter size dependent options:

- For object size > 30-40 cm aerial observation can be suitable.
- For 2.5 cm - 30-40 cm object size observation from ships can be suitable.

- For smaller objects (e.g. > 2.5 cm) trawl nets can be suitable, depending on sampling width and density of occurrence, see also Chapter 7 on microlitter.

4.3.1 Visual ship based observation

The visual observation from ships is the most often used methodology for the quantification of floating marine litter. The methodology is very much dependent on the observer's aim, the protocol, the ship and the observation conditions. As the results depend on these various external factors the comparison between different surveys and thus trend assessments are difficult. Harmonised protocols for reporting and detailed recording of observation conditions are crucial. It is likely that such surveys are being performed during already scheduled cruises for other purposes or on ships-of-opportunity.

Guidelines and scientific publications provide approaches for the quantification of marine litter. The UNEP (Cheshire et al., 2009) guidelines describe approaches for detailed monitoring of 5 x 5 km areas by subsampling through dedicated surveys, and also surveys along line transects, as they would be typical when using ships-of-opportunity.

US National Oceanographic and Atmospheric Administration (NOAA) developed protocols, called the Shipboard Observation Form for Floating Marine Debris (Arthur et al., 2011). They are based on methods used in studies of floating marine litter, previous shipboard observational studies conducted at sea by NOAA, and the experience and input of the yacht sailors. The goal of this form is to be able to calculate the density of marine litter within the transect area using a slightly modified version of the formula used by Matsumura and Nasu, 1997, Shiomoto and Kameda, 2005, and Thiel et al., 2003. Ecoocean is performing visual transect monitoring on the Mediterranean Sea since 2006 (Ecoocean, 2012).

Source attribution by identification and categorisation of floating objects can be difficult. Simplified classification systems have been proposed where litter is observed remotely, because it is often impossible to distinguish items based on material composition (Cheshire *et al.*, 2009). The operated classification system should be compatible with the one used for other Descriptor 10 indicators. It is important that litter categories are compatible among the different surveyed matrices.

The litter density should be calculated according to the strip transect method (Hinojosa and Thiel, 2009):

$D = n/((w/1000) \times L)$

- n = # of litter observed
- w = maximum distance perpendicular to the transect
- L = total length (in km) of the transect

It should be mentioned that observation targeting smaller items, e.g. down to 2.5 cm (compatible with shoreline survey size limits) can be done (Day and Shaw, 1987) but will have an influence on the observation corridor. The planning of surveys, use of protocols and briefing of observers should clearly identify the survey scope and recognise its limitations.

Although there is no theoretical upper size limit for the visual observations, typically larger objects are less abundant and may not be found representatively in a narrow observation transect.

<u>Survey location</u>

The selection of the observation transects depends on the aim of the survey. In an initial phase gradients and distribution patterns need to be understood. This information can then be used to select survey areas for trend assessments. Sampling locations can be e.g. in accumulation areas created by wind and currents, or reference areas with little variability. The selection of these sites can be supported by hydrographical (currents), meteorological (wind direction patterns) or source related information such as vicinity of estuaries or cities. Further work and agreement is needed in order to guide the selection of survey locations for the trend assessments.

<u>Survey timing</u>

The frequency of the surveys should be selected according to the needs for a statistically sound trend assessment. This will need an initial phase in order to understand patterns of variability in time. The timing of surveys will be much influenced through weather conditions and the availability of an observation platform.

The following 3 tools have been identified:

Surface observation from ship	(10.1.2_Water T1)
Surface observation from air	(10.1.2_Water T2)
Surface trawl net survey	(10.1.2_Water T3)

MSFD Marine Litter Monitoring TOOL SHEET

Tool name: Visual surface observation from ship

Indicator for which the tool is to be applied for: 10.1.2

Tool code: 10.1.2_Water T1

Tool description: Visual observation of a surface sample area by observers.

Technical requirements: Ship (of opportunity), observation without binoculars.

Size range: 2.5 cm (depending on survey set-up) – limited by observation area/item occurrence density.

Spatial coverage: Hours of observing transects (x m width of transect) at vessel speed.

Survey frequency: Several times a year, also depending on opportunities.

Maturity of the tool: In use for years, need for harmonisation and scientific studies on comparability between different observation set-ups and representativeness (Cameras can be an option for automatized surveys).

Regional applicability of the tool: Weather dependency, calm sea required.

Source related information: Coordinates linked with hydrodynamic and meteorological conditions, categories, shapes.

References:

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., Westphalen G. 2009. UNEP/IOC Guidelines on Survey and Monitoring of Marine Litter. UNEP Regional Seas Reports and Studies, No. 186; IOC.

Thiel, M., Hinojosa, I.A., Joschko, T., Gutow, L. 2011. Spatio-temporal distribution of floating objects in the German Bight (North Sea) , Journal of Sea Research 65: 368-37.

4.3.2 Surface observation from air

Aerial surveys can be a way forward in detecting larger litter items, while allowing for broad area surveys. A typical lower size limit for aerial surveys is ca. 30-40 cm, while satellite images have less resolution. These monitoring techniques are therefore suitable for the detection of larger objects, such as derelict fishing gear (floating nets) or large litter accumulation spots (Veenstra and Churnside, 2011).

The aerial surveys are very likely to be based on set-ups prepared for the evaluation of the abundance of marine fauna on the sea surface. The methodology has been applied in the German bight during cetacean surveys (Herr, 2009, Thiel *et al.*, 2011). This methodology has been applied in recent years in some countries to estimate the population abundance of marine mammals, sea turtles and fishes (Heide-Jorgensen *et al.,* 2010, Lauriano *et al.*, 2011, Palka, 2006, Panigada *et al.,* 2011). Also surveys on the Black Sea have been performed (BSC, 2007). The survey is usually designed using the 'distance sampling method' along parallel line transects (Buckland *et al.*, 2001, Thomas *et al.*, 2010). The platform is an aircraft equipped appropriate observation windows to enable a full view of the track line. Experience has shown that aerial litter surveys need method adaptation and their execution in addition to other tasks (such as cetacean monitoring) is subject to the availability of dedicated observers and an appropriate flight plan.

MSFD Marine Litter Monitoring TOOL SHEET

Tool name: Surface observation from air

Indicator for which the tool can be applied : 10.1.2

Tool code: 10.1.2_Water T2

Tool description: Visual observation of a surface sample area by observers from airplane.

Technical requirements: Airplane, slow speed, observation without binoculars.

Size range: min: 30-40 cm (depending on altitude) – max: limited by sample area.

Spatial coverage: Hours of observing transects (x m width of transect) at airplane speed and altitude.

Survey frequency: Several times a year, also depending on opportunities.

Maturity of the tool: In use for years, need for harmonisation and scientific studies on comparability between different observation set-ups and representativeness.

Regional applicability of the tool: Weather dependency.

Source related information: Coordinates linked with hydrodynamic and meteorological conditions, categories, shapes.

References:

Herr, H., Vorkommen von Schweinswalen (*Phocoena phocoena*) in Nord- und Ostsee – im Konflikt mit Schifffahrt und Fischerei? , Department of Biology, Hamburg University 2009

4.3.3 Surface net trawls

The trawling for surface floating litter is a method which, due to the distribution and frequency of occurrence is mostly suited to a representative sampling of meso and microlitter. Depending on the sampled survey area and trawl design also larger items could be sampled representatively. This depends on the opening of the employed net types and the expected object occurrence density and needs to be demonstrated in the sampling design.

The group considered a net mesh size of 333 µm, typically used for zooplankton sampling, as appropriate for marine litter monitoring. Smaller mesh sizes are indicated for specific purposes regarding microlitter.
Therefore trawl net and filtration techniques are mainly described in the chapter on microlitter. Initial datasets are needed in order to derive the upper size limit reasonably to be reported.

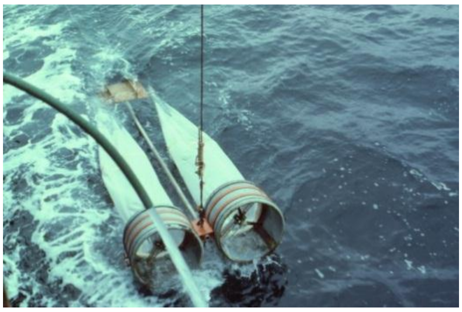
Trawl/Net types
The main types of surface trawls which can be used for surface monitoring are:

- Neuston
- Horizontal Bongo
- Manta (hi-speed/lo-speed)
- Inflatable Macro Litter trawls.

Different net sizes and trawl types have been used in litter surveys across the world, with mesh sizes ranging between 80 µm to 2 mm. The Manta trawl has two angled wings which keep it floating on the surface and a top lid that directs surface splash back into the trawl. It looks a bit like a manta ray hence its name. The trawl has a top opening and is lined by a mesh net which terminates in a small collection sock called the cod end. The manta trawl skims the surface layers and traps particles with sizes between this mouth aperture and the mesh size of the net used (Brown and Cheng, 1981). It has been used for surface water monitoring of meso- and microlitter (Algalita, 2004).

Neuston nets have a typical design featuring a large, rectangular metal net frame with a relatively long fine meshed net which allows sampling substantial water volumes at or near the surface. Different net openings, lengths and mesh sizes are available, they will mainly determine the speed of trawling and size limit of samples. Bongo nets are paired mesh nets attached to a metal frame which allow taking samples throughout the water column. The net openings can vary in diameter and have long, micro meshed nets and collecting bags attached to them, cod ends, where the particles are concentrated. Bongo samples are typically towed obliquely so that all depths (except the deepest point) are sampled twice. Specialised bongo nets with remotely closable mouths exist so samples can be taken at different selected depths. This means bongo nets are suitable for sampling both the surface and the water column. There are flow meters in the mouths of the nets so that the volume of water filtered can be calculated accurately.

Fig. 3. A high-speed Manta trawl. (© Crown copyright 2011, permission granted by Cefas)



Not all types of trawls have to be specifically developed for marine litter surveys; adaptation of existing structures may deliver low cost options.

The depth of the sampled water will depend on the net type used and the results will depend on the sea conditions also in the time prior to sampling, as surface floating particles may have been mixed into the upper water column.

Fig. 4. A double paired horizontal bongo net.

Also some methodologies for monitoring biota impacted by litter, e.g. by ingestion, are an indicator of floating marine litter (e.g. seabird ingested litter), but these described under Chapter 6 (Impact of litter on marine life) whereas the indicator 10.1.2 regards the unbiased physical quantification of litter presence.

MSFD Marine Litter Monitoring TOOL SHEET

Tool name: Surface trawl

Indicator for which the tool is to be applied for: 10.1.2

Tool code: 10.1.2_Water T3

Tool description: Towing of trawl net on surface.

Technical requirements: ship, trawl net.

Size range: 333 µm – e.g. 2.5 cm (max size for representative sampling depending on net type and survey design).

Spatial coverage: Examples: High speed trawl: 30 min at 6 knots (15.5 cm x 50 cm (20 cm in water)).

Low speed trawl: 15 min at 1-2 knots (100 cm x 30 cm)

Survey frequency: Likely to be based on existing cruises for fish stock assessment and limited by weather conditions.

Maturity of the tool: In use for years, further harmonisation and scientific studies on comparability of different designs and sampling representativity needed.

Regional applicability of the tool: Limited by prevailing weather conditions

Source related information: Coordinates linked with hydrodynamic and meteorological conditions, analysis of sampled material, categories, shapes.

References:

Algalita. 2004. Quality Assurance Project Plan - Assess Sources of Plastic and Trash in Urban and Coastal Waters, Marine Research Foundation, 148 N. Marina Drive Long Beach, CA 90803.

Maes, CEFAS. 2012. UK case studies manta trawl.

4.4 Future needs and further development

4.4.1 Development needs and options within 2012

Visual observations, in particular from ships are a methodology which can readily be employed. Depending on the selected observation transects research vessels or ships-of-opportunity, such as ferries, freight or cruise ships can be used.

- The development, endorsement and dissemination of a common Visual Shipboard Observation protocol for use in MSFD D10 implementation appears to be feasible and should be done on a short time scale. This will enable MS to gather comparable data of good quality for their assessments.
- Further discussion on the size range to be reported is needed. This regards in particular the main “target size range” which should be monitored. The lower size range will depend on the observation elevation and the transect width, as smaller items (e.g. down to 2.5 cm) can only be observed in a narrow corridor. There should also be an estimation of the representative sampling of larger items, which also depends on the statistical distribution.
- The initial assessments made by EU MS until then should be analysed for their approaches and this information should be exchanged among MS authorities on a common platform.
- Costs of different monitoring options should be estimated.
- While currently there is little knowledge about the distribution of litter items, a common view on the sampling strategy should be developed at EU level on a short time scale. This regards e.g. the approach for monitoring estuaries in relation to riverine input, or accumulation zones and background reference areas.
- The link between monitoring of floating marine litter and the identification of their sources should be further enhanced.

4.4.2 Development needs and options until 2016 and beyond

First assessments of surface floating litter should lead to an improvement in the assessment strategy over the next few years. Research efforts should provide insight into pathways and transportation pattern of litter. Monitoring efforts can then be focused on selected areas with known characteristics and monitoring programs of EU MS can provide data for reliable trend assessments.

Identified research priorities should be communicated to research funding organisations at national and EU level (Directorate-General for Research and Innovation).

The experts on Marine Litter involved in the implementation of MSFD should observe developments and promote promising approaches. The aim should be to achieve an improved knowledge of factors determining the distribution of litter at sea in time for the revision of the Commission Decision (2010/477/EU) and react by adjusting Descriptor 10 indicators, if needed.

Triggered by scientific research needs and the requirements for monitoring, some upcoming methodologies have been developed recently. They will need careful evaluation for their possible application for the purpose of MSFD marine litter monitoring in observing trends as indicators for successful measure implementation. Among the upcoming developments are the following:

4.4.2.1 Camera based systems

The use of camera based observation systems has great potential in harmonising visual observations of floating litter from different platforms. A system for the quantification of litter items on surface transects based on a high resolution camera and image recognition technology “JRC Sealittercam” is currently under development at the European Commission Joint Research Centre JRC. The system acquires images through a high resolution CCD camera pointing to the sea surface and evaluates images through image recognition (Hanke and Piha, 2011).

The Sealittercam was mounted on the bow at 16 m elevation on a Costa Crociere cruise ship. With a 50 mm lens a lower observation size limit of 2.5 cm can be achieved. Image recognition software parameters are currently being adjusted for identification of litter items. Automated systems have the advantage of covering very large areas and allow quality control of the results, including better possibility for object categorisation. The approach has been tested in 2010 and 2011 on transects in the Western Mediterranean Sea.

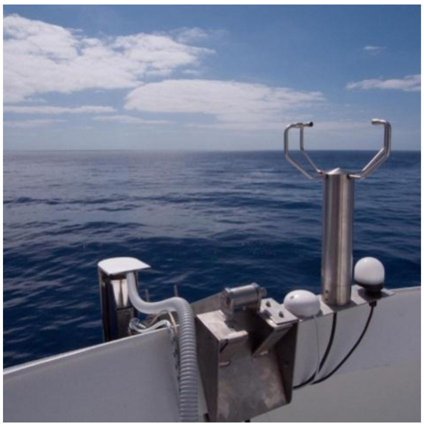


Fig. 5. Sealittercam developed by JRC.

4.4.2.2 Modelling approaches

Besides the development of new monitoring tools, the development of approaches using surface current modelling at relevant scales for forecast of accumulation areas with small scale models and targeted observations appears to be promising for further development. That could support the selection of appropriate beach locations, seafloor accumulation areas and surface water monitoring. This should involve national and regional agencies using e.g. models for oil spill distribution predictions and experiences as well as research efforts at EU scale and beyond. Exchange of information through an appropriate portal should be ensured.

4.4.2.3 Combined satellite, aerial imagery and modelling

Remote sensing with application of satellite radar, multispectral data and airborne remote sensing (particularly radar) can be used to identify eddies and convergence zones in the open sea. A multistage modelling and remote sensing approach is proposed for the identification of areas of the open ocean where litter items are more likely to congregate. A path forward may best be achieved through the refinement of existing procedures with the addition of a final search stage using airborne radar from an UAS simulator aircraft to detect zones of potential accumulation for direct search (Mace, 2011). NOAA and NASA have been planning tests of synthetic aperture radar (SAR) instrument that can see through cloud cover to detect ocean features that might accumulate marine litter. This particular SAR is designed to be mounted on an unmanned aerial vehicle (UAV), so it is called a UAVSAR. Maps of likely litter accumulation locations are prepared using sea surface temperature and photosynthetic chlorophyll data from satellite sensors. The litter estimated likelihood index (DELI) map that averages data before flights shows the areas they expect to contain more litter. These maps are used as a guide for planned flight tracks.

Temporal resolution is limited by orbit characteristics (for satellites), flight duration (for aircraft), and weather conditions. Polar orbiting satellites vary considerably but usually range from several days to a month or more, depending on swath width and altitude. Aircraft are generally limited to less than 10 h for piloted and less than 30 h for unmanned aerial systems (UAS). Area coverage is limited by the airspeed of the aircraft, making large areas difficult to survey at high repeat rates. Weather is a severe constraining factor for all optical measurements, but less so for observations in the microwave portion of the spectrum (Mace, 2011).

5. Litter on the Sea Floor

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 Commission Decision (2010/477/EU). There are currently no coordinated national or regional monitoring programmes for litter on the seabed within Europe. Only some experimental monitoring in some countries has been described (Galgani and Piha, 2010). However there are monitoring programs for demersal fish stocks undertaken as part of the International Bottom Trawl Surveys that can provide information on the amount and composition of litter on the seafloor. There is also no quality assurance program for litter monitoring on the sea floor.

The abundance and distribution of marine litter show considerable spatial variability. The geographical distribution of litter on the sea floor is strongly influenced by hydrodynamics, geomorphology and human factors. Under the weight of fouling by a wide variety of organisms, most litter will eventually sink to the bottom. Currents will enable transportation of litter to areas of accumulation, such as the seafloor. Moreover, there is notable temporal, particularly seasonal, variation with a tendency for accumulation and concentration along coastal and particular geographical areas. 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 deep sea floor, which influence both the distribution and densities. Nevertheless, considering existing data, it would appear that the Mediterranean Sea is 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 sea floor surveys. Finally, the data can be amalgamated to produce values for local, regional and basin and European level. UNEP has developed recommended protocols, considered by the International Council for the Exploration of the Sea – International Bottom Trawl Surveys Working Group (ICES/ IBTS WG) and OSPAR meetings (Galgani and Piha, 2010) but no methodological standards exist. A classification system using 6 categories is in use (Cheshire et al., 2009). The TSG ML recommends harmonizing categorizations between shorelines, water surface and sea floor evaluations. However the different compartments of sea floor require different monitoring approaches:

5.1 Availability of methods

5.1.1 Shallow waters

In shallow coastal areas (< 40 m depth), the abundance of marine litter is generally much greater 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. In shallow coastal areas, fishing activities of the coastal fleet significantly contribute to littering of the seafloor (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 or manta tow have also been applied for very shallow waters (usually < 10 m depth) and for larger forms of marine litter (nets/gear). These surveys were mostly based on plot sampling and especially strip transects where all items can be counted and type or size may be recorded (Table 1). There is however an underestimation of abundance. This is overcome by applying distance sampling, which is a group of methods for estimating abundance and/or population density (Buckland *et al*., 2001). The most commonly used Distance Sampling method for underwater surveys is line transect sampling. The standard software for modelling detectability and estimating density/abundance, based on distance sampling surveys, is DISTANCE (Thomas *et al*., 2006).

In areas with high litter densities, clear water and low sea bottom complexity (e.g. sandy bottoms) narrow strip transects may be preferred. In areas with low litter densities (where large sampling surfaces are needed to obtain a sufficiently high number of records), turbid waters, and/or high sea bottom complexity (e.g. rocky reefs, sea grass beds) imperfect detectability is an important issue and should not be ignored; line transects should be preferred and detectability should be estimated. The field protocols for line transect surveys of litter on the seabed are exactly the same as those for benthic sessile fauna, described in detail in Katsanevakis (2009). Table 1 provides some hints on the selection of the appropriate method and sampling unit depending on the expected density of marine litter.

Table 1. Proposed method and indicative sampling units depending on anticipated litter density and environmental conditions.

Litter density	Conditions	Method	**Sampling unit** (strips: length x width)
>1 items/m^2	Low turbidity - low habitat complexity	plot sampling	10 m x 2 m
>1 items/ m^2	all other cases	plot sampling	20 m x 1 m
0.1-1 items/ m^2	Low turbidity - low habitat complexity	plot sampling	20 m x 4 m
0.1-1 items/ m^2	Low turbidity - high habitat complexity	distance sampling	20 m x 4 m
0.1-1 items/ m^2	high turbidity	distance sampling	20 m x 4 m
0.01-0.1 items/ m^2	for every case	distance sampling	100 m x 8 m
<0.01 items/ m^2	for every case	distance sampling	200 m x 8 m

Linking shallow-water monitoring surveys to existing biological monitoring programs with SCUBA might improve cost-efficiency. Such biological monitoring based on strip or line transects is regularly conducted in many Marine Protected Areas or other sites within the framework of long-term monitoring projects. An additional effort to record marine litter together with the target benthic species could be possible; but will depend on the details of the surveys and its requirements.

In many regions underwater clean-ups are organized by diving clubs, local authorities, NGOs, citizens' initiatives, etc. For example, Project AWARE Foundation "Dive Against Debris" effort provides guidelines and field protocols for scuba divers to collect and report marine litter found underwater so that results from different surveys would be comparable as much as possible. Cooperation with such initiatives might be a good opportunity for some Member States for shallow-water litter monitoring but standardization and conformity with the common methodologies and tools proposed here should be achieved. It also has to be noted that to reduce variability and thus to be able to increase precision in the estimation of trends, surveyed sites should be fixed and not selected on a basis of opportunity. This might be an important issue when clean-up campaigns by volunteers and NGOs are used as a means for litter.

5.1.2 Shelves

Surveys of macro-litter loads on the seabed have been conducted mainly using trawl surveys. This method is the most adequate method to date, although quantities of litter are underestimated. It should be considered as a method for estimating relative litter densities rather than absolute densities. A constant trawl mouth width is required. General strategies to investigate seabed litter are similar to methodology for benthic ecology and place more emphasis on the abundance and nature (e.g. bags, bottles, and pieces of plastics) of items rather than their mass. Just like stranded litter, litter on the seabed aggregates locally in response to local sources and bottom topography.

As part of the assessment of the status of the fish stocks in the North Sea, Baltic Sea, western European waters and Mediterranean sea (i.e. Celtic Sea, Bay of Biscay and Eastern Atlantic from Shetlands to Gibraltar, European Mediterranean coasts), fisheries institutes of the bordering countries have for many years carried out research vessel surveys. At present four major international trawl surveys can be distinguished: the International Bottom Trawl Survey (IBTS, Table 2), the Baltic International Trawl Surveys (BITS), the Beam Trawl Survey (BTS) and Mediterranean Trawl Survey (MEDITS). Although initially these surveys were coordinated at the national level, over the years a number of these trawl surveys have evaluated into standardized international research programs. These programs in OSPAR/HELCOM/MEDPOL/BSC sub regions cover all shelves on a regular basis (annually). They are dedicated to fish stock assessment and may be used for litter data collection. The following programs may provide means for litter monitoring on the sea floor, including quality insurance.

Table 2. Summary of International Bottom Trawl Surveys (IBTS) cruises in Western Europe.

Country	Location	Number of hauls	Trawl width (m)	Trawl type (mesh)	Depth (m)
Bottom Trawl Survey					
Belgium	southern North sea	60	8	beam	<50
The Netherlands	South eastern North sea		8	beam (40 mm)	<50
Germany	South eastern North sea	60	7	beam (75 mm)	<50
England	Channel	91	4	beam (40 mm)	<50
France	Bay of Biscay			beam (40 mm)	< 200
IBTS North sea					
The Netherlands					
Belgium					
France (IBTS)	Southern North sea	80	20	GOV 36/47 (20 mm)	<50
England (IBTS)	North sea				
Scotland (IBTS)	North sea			36/47 GOV (20 mm)	20-500
Norway	North sea				
Denmark	North sea				
National Bottom Trawl Surveys					
Portugal	Portugal	76-85	15	Campell 1800/96 NCT (20 mm)	20-500
Spain(PGFS)	Porcupine	80		Baka trawl 40/52 (20 mm)	170-800
Spain (NGFS)	Northern Spain	120	21	Baka trawl 44/6 (20 mm)	15-700
Spain (SGFS)	Gulf of Cadix	75	21	Baka trawl 44/6 (20 mm)	35-700
Spain (Arsa-GC)				Baka trawl 44/6 (20 mm)	
France (EVHOE)	Biscay , Celtic	135	20	GOV 36/47 (20 mm)	30-600
France (CGFS)	Channel (CGFS)	105	20	GOV 36/47 (20 mm)	<50
England(CEFAS)	North Sea				
England (CEFAS)	Channel			PHHT (20 mm)	
England (CEFAS)	Celtic sea			PHHT (20 mm)	
Ireland (WCGS, ISCGS)	West Ireland, Celtic sea	70		rock-hopper (20 mm)	15-300
Ireland (NIGS)	Northern Ireland & St Georges	57		rock-hopper (20 mm)	15-300
Scotland (SWCS/VI A)	West Scotland	2-8/ICES square		36/47 GOV (20 mm)	20 to 500
Scotland (SGD6B)					

5.1.2.1 International Bottom Trawl Surveys IBTS

The IBTS consists of a number of national surveys stated in 1990 that aim at improving standardization and collaboration between surveys. Two areas can be distinguished that differ in terms of the length of trawl time and hence the degree to which standardization was achieved: IBTS North Sea and IBTS Western and Southern areas.

In the North Sea, The IBTS has been carried out twice per year since 1997 using a standardized protocol. In 1994, it was suggested to extend the remit of the ICES/IBTS Working Group to co-ordinate and standardize the surveys in the western and southern areas.

For southern and western seas, each country conducts surveys in adjacent areas with no overlap. Due to the variation in bottom types, each country uses a different gear. With the sampling protocols, however, a significant level of standardization is achieved and all countries are using the same sampling strategy. Details on protocols are available for each country (http://datras.ices.dk/Home/Descriptions.aspx#IBTS) and are described by IBTS (2004).

5.1.2.2 Baltic International Trawl Surveys BITS

The Baltic cod stock has been monitored annually since 1982 through bottom trawl surveys carried out by most countries surrounding the Baltic. The national research vessels have each surveyed part of the area with some overlap in coverage and applied a depth stratified sampling design. After agreement a common standard trawl gear and standard sampling procedures were implemented in 2000 resulting in the coverage of the whole Baltic Sea. The design and construction of the standard trawls (20 mm mesh) are given in ICES (2007) and can also be found in the BITS manual (ICES, 2011). The BITS is conducted as a depth-stratified survey. The standard haul is a 30-min haul with a towing speed of 3 knots.

5.1.2.3 Beam Trawl Survey BTS

During the 1980's, five countries bordering the North Sea and western waters of the UK had developed a range of beam trawl surveys. Despite the fact that a number of different gears and survey designs being used, sampling methods, data collection and storage, have been standardized to a considerable extent. Surveys are performed in the North Sea (Netherlands), Channel and Irish Seas (England), German Bight (Germany), southern North Sea (Belgium) and Bay of Biscay (France).

5.1.2.4 Mediterranean Trawl Survey MEDITS

The MEDITS program is an international survey conducted for fish stock assessments. It is financially supported by the European Commission (DG Mare) and the participating countries. It consists of bottom trawling along all Mediterranean shelves (Table 3). It also includes deeper sites (200-800 m) (MEDITS, 2007).

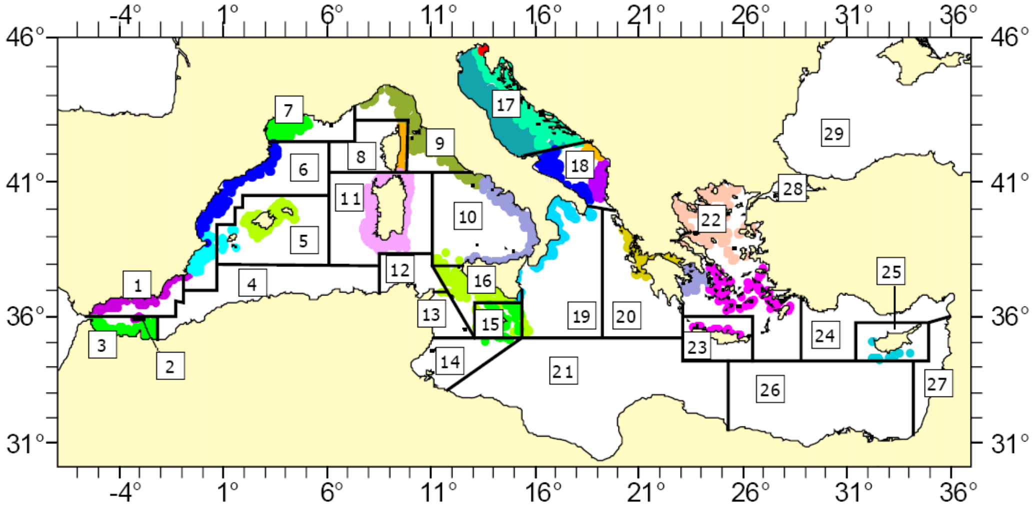


Fig. 6. General map of the area covered by the MEDITS programme.

Table 3. MEDITS, trawling experiments in Mediterranean European countries. Non-European countries such as Morocco, Croatia, Montenegro, and Albania are participating in the MEDITS program. (Coordinator: M.T. Spedicato)

Country	GSA geographical sub-area	Number of surveys	Area
Cyprus	25	26	Cyprus
France	7	95	Gulf Lion, Corsica
Greece	20	32	Eastern Ionian sea
Greece	22	21	Aegean sea
Greece	22	65	North Aegean Sea
Greece	22	61	South Aegean sea
Italy	9	120	N Tyrrhenian sea
Italy	10	70	S Tyrrhenian sea
Italy	11	98	Sardinia
Italy	16	120	Strait Sicily
Italy	17	121	North Adriatic
Italy	19	70	South Adriatic
Italy	19	70	Ionian sea (NW)
Malta	15	45	Malta
Slovenia	17	2	North Adriatic
Spain	1,2	46	Alboran sea
Spain	5	60	Balearic islands
Spain	6	92	Northern Spain

The sampling gear is a bottom trawl (GOC73, horizontal opening of 20 m). The hauls are made in the same position from year to year at fixed strata limits: 10 - 50 m, 50 - 100 m, 100 - 200 m, 200 - 500 m, 500 - 800 m. The *Posidonia oceanica* grasslands are excluded from the sampling scheme and should never been trawled. The haul duration is fixed at 30 minutes on depths less than 200 m and 60 minutes at depths > 200 m. The cod end mesh size is 20 mm. Hauls are made at constant depth (+/- 5%) and rectilinear.

5.1.2.5 Black Sea program

In the Bucharest Bilateral Coordination Meeting (February 2010) Bulgaria and Romania agreed to conduct a common demersal trawl surveys in Romanian and Bulgarian areas (Appendix IX, Commission Decision 2008/949/EC). Mainly to define the stock biomass indices and respectively the annual quota for turbot fishery, they are undertaking surveys on annual basis, using the same methodology and where the same type of litter data could be collected. This program is linked to the MEDITS program with harmonized methodology and Black sea is quoted as number 29 of the MEDITS areas.

5.1.2.6 "Fishing for Litter" initiatives

"Fishing for Litter" initiatives have been implemented to remove litter mainly from the seabed of the North Sea (OSPAR, 2007). It is an activity where fishing vessels brings ashore litter caught in their nets as part of their fishing activities. The initiative is coordinated by KIMO International (The Netherlands, United Kingdom, Isle of Man, and Faeroes) and promotes a responsible attitude within the fishing industry towards this problem. NABU has launched a first “Fishing for Litter” project in the Baltic Sea in 2011. Besides environmental benefits, the fishing industry in particular will benefit from the initiative through the reduced risks of damages to fishing gear and contamination of catches. KIMO Baltic has also begun a scheme. Total figures for the FFL schemes operated by KIMO in 2010/11 are as follows: 390 vessels, 40 harbors, 700 tonnage collected.

To date, most studies have measured amounts of litter collected but not on regular bases. Litter has been collected by the boats involved in the initiative, which is run in the North Sea. In the Baltic Sea 20 vessels have joined the initiative so far. Data may be of importance locally to evaluate composition and sources of litter but will not be included in large scale monitoring network to assess litter on the sea floor.

5.1.3 Deep sea floor

Studies that investigate seabed litter typically focus on continental shelves, while research into the deeper seabed, which forms about half the planet's surface, is restricted by sampling difficulties and cost. Large-scale evaluations of deep seabed litter distribution and densities anywhere are scarce. Of the areas investigated along European coasts to date (Galgani *et al*., 2000), Mediterranean sites tend to show the greatest densities. In general, bottom litter tends to become trapped in areas of low circulation and high sediment accumulation in contrast to floating litter, which accumulates in frontal areas. 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 of plastics litter in bays and canyons rather than the open sea. Some accumulation zones in the Atlantic Sea and the Mediterranean Sea have very high litter densities despite being far from coasts. These densities relate to the consequence of large-scale residual ocean circulation patterns and locally to the morphology of the sea bed (around rocks and/or in depressions or channels). Deep submarine extensions of coastal rivers also influence the distribution of seabed litter. In some areas, local water movements transport marine litter away from the coast to accumulate in zones of high sedimentation. Continental shelves have locally lower concentrations of litter since most of the anthropogenic litter in the outer shelf originates from coasts to shelves that are washed offshore by currents associated with river plumes. Investigations using submersibles at depths beyond the continental shelf have revealed substantial quantities of litter mainly in canyons adjacent to large cities (up to 112 items per kilometre and 70% plastics). Only some areas/countries are concerned along the European coasts including Norwegian trench, France, Spain, Portugal, Italy, and Greece. For evaluation of litter and monitoring, the use of trawl in deep-sea areas will be restricted to flat and smooth bottoms. For slopes and rocky bottoms, special means are necessary including Remotely Operated Vehicles (ROVs) and submersibles that are very expensive to operate. ROVs are simpler and generally cheaper and must be recommended for litter surveys. There are some available protocols where litter is counted on routes. The route survey results are expressed as item/km. Litter occurrence density quantification should be performed taken the survey width into account so that they can be compared to other methods.

5.2 Tool sheet development

Following the activity of the group focusing on developing toolboxes with applicable monitoring/quantification methods for the further MSFD Descriptor 10 implementation, tool sheets have been developed and agreed to support the monitoring of litter on the sea floor (Table 4).

Altogether four monitoring tools are presented for litter monitoring on the sea floor:

SCUBA surveys for shallow seabed – Plot Sampling	(10.1.2_Seafloor T1)
SCUBA surveys for shallow seabed – Distance Sampling	(10.1.2_ Seafloor T2)
Trawling surveys	(10.1.2_ Seafloor T3)
Submersibles	(10.1.2_ Seafloor T4).

Table 4. Summary of methods available for litter evaluation on sea floor.

Component	Shallow waters	Continental shelves and canyon bottoms	Deep sea floor
Depth	0 – 40 m	40 – 800 m	200 - 2500 m
Areas to be monitored	Coastal	Shelves	Priorities must be considered and given to deep sea areas close to sources (costal, urban, affected by litter).
Approach	Diving	Trawling	Submersibles (ROVs - Autonomous or manned submersibles)
Existing program	E.g. Project AWARE dive against debris, NGO initiative	MEDITS related programs (including Black Sea), IBTS related (IBTS, EVHOE, CGFS, ….) Cruises (OSPAR/ICES)	Irregular dives (France)
Areas not concerned			Baltic countries, North Sea countries, North Adriatic, etc.
Areas largely concerned	All Mediterranean countries, Baltic	Any shelf	Mediterranean (Spain, France, West and south east Italy, Greece, Cyprus), Portugal, England (Partly)
Sample size	10-2000 m^2	1-5 ha	0.1-2 km routes / dive
Units	Density (items/ha)	Density (items/ ha , per categories)	Items (per categories) / km route
Categories	Plastic, paper and cardboard glass and ceramics, metal, leather/clothes, others, fishing gear	Plastic, paper and cardboard glass and ceramics, metal, leather/clothes, others fishing gear	Plastic, paper and cardboard glass and ceramics, metal, leather/clothes, others, fishing gears
	Compatible among indicators	Compatible among indicators	Compatible among indicators
Frequency	Every year	Every 1-3 years	Every 5-10 years
Inter calibration	Possible	Possible	Difficult
Research needed			Search for accumulation areas

MSFD Marine Litter Monitoring TOOL SHEET

Tool name: SCUBA surveys for shallow seabed – Plot Sampling

Indicator for which the tool is to be applied: 10.1.2

Tool code: 10.1.2_Seafloor T1

Tool description: The most commonly used method to estimate marine litter density in shallow coastal areas is to conduct underwater visual surveys with SCUBA, although snorkeling or manta tow has also been applied for very shallow waters (usually < 10 m depth). These surveys were mostly based on plot sampling and especially strip transects, where all items can be counted and type or size may be recorded. In strip transects, the plots are long, narrow strips and the diver-observer travels along the centerline searching marine litter and counting all items within the strip. The survey design comprises of k randomly positioned strips or a grid of k systematically spaced strips randomly superimposed on the study area. The average density of litter in the study area is estimated as $\hat{d} = \frac{n}{A_c}$, where n is the number of detected individuals, and A_c is the surface area covered by the survey.

In plot sampling, the critical assumption is that all items present in the surveyed area Ac are detected. However, this assumption cannot be tested using the survey data, and to ensure that it holds to a good approximation, it may be necessary to use narrow strips, which is problematic for low litter densities and increases the variance of density estimators. If the assumption that all items present in the surveyed areas are detected is not met, there is underestimation of abundance.

Technical requirements: SCUBA equipment, trained observers.

Size range: > 2.5 cm

Spatial coverage:

Litter density	Conditions	Method	Sampling Unit (strips: length x width)
>1 items/m^2	Low turbidity - low habitat complexity	plot sampling	10 m x 2 m
>1 items/m^2	all other cases	plot sampling	20 m x 1 m
0.1-1 items/m^2	Low turbidity - low habitat complexity	plot sampling	20 m x 4 m

Depth 0-40 m

Survey frequency: Annually.

Maturity of the tool: In use.

Regional applicability of the tool: Very relevant in clear waters (e.g. Mediterranean), problematic in turbulent and turbid waters, and in complex habitats (e.g. rocky reefs, seagrass beds).

Source related information: Categories are recorded and thus some limited source information can be inferred.

References:

Katsanevakis, S. and Katsarou, A. 2004. Influences on the distribution of marine litter on the seafloor of shallow coastal areas in Greece (Eastern Mediterranean). Water, Air and Soil Pollution 159: 325–337.

MSFD Marine Litter Monitoring TOOL SHEET

Tool name: SCUBA surveys for shallow seabed – Distance Sampling

Indicator for which the tool is to be applied: 10.1.2

Tool code: 10.1.2_Seafloor T2

Tool description: In plot sampling, the critical assumption is that all items present in the surveyed area A_c are detected. However, this assumption cannot be tested using the survey data, and to ensure that it holds to a good approximation, it may be necessary to use narrow strips, which is problematic for low litter densities and increases the variance of density estimators. If the assumption that all items present in the surveyed areas are detected is not met, there is underestimation of abundance. This is overcome by applying distance sampling, which is a group of methods for estimating abundance and/or population density (Buckland et al., 2001). In distance sampling surveys, it is acceptable that we fail to detect some of the items that are in the covered region, as detectability is actually estimated and used to correct abundance estimations. The probability that any particular individual that is in the covered region is detected, i.e., the 'detection probability', is denoted by p_a, and the estimator of abundance becomes $\hat{d} = \frac{n}{A_c p_a}$. 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 p_a (Buckland et al., 2001; Katsanevakis, 2009). The most commonly used Distance Sampling method for underwater surveys is line transect sampling. The standard software for modelling detectability and estimating density/abundance, based on distance sampling surveys, is DISTANCE (Thomas et al., 2006).

In areas with high litter densities, clear water and low sea bottom complexity (e.g., sandy bottoms) narrow strip transects may be preferred. In areas with low litter densities (where large sampling surfaces are needed to obtain a sufficiently high number of records), turbid waters, and/or high sea bottom complexity (e.g. rocky reefs, sea grass beds) imperfect detectability is an important issue and should not be ignored; line transects should be preferred and detectability should be estimated. The filed protocols for line transect surveys of litter on the seabed are exactly the same as those for benthic sessile fauna, described in detail in Katsanevakis (2009).

Technical requirements: SCUBA equipment, trained observers

Size range: > 2.5 cm

Spatial coverage:

Litter density	**Conditions**	**Method**	**Sampling Unit (strips: length x width)**
0.1-1 items/m^2	Low turbidity - high habitat complexity	distance sampling	20 m x 4 m
0.1-1 items/m^2	high turbidity	distance sampling	20 m x 4 m
0.01-0.1 items/m^2	for every case	distance sampling	100 m x 8 m
<0.01 items/m^2	for every case	distance sampling	200 m x 8 m

Depth 0-40 m

Survey frequency: annually

Maturity of the tool: In use for benthic fauna

Regional applicability of the tool: It can be applied in every region.

Source related information: Categories are recorded and thus some limited source information can be inferred.

References:

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

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

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. http://www.ruwpa.st-and.ac.uk/distance/.

MSFD Marine Litter Monitoring TOOL SHEET

Tool name: Trawling surveys

Indicator for which the tool is to be applied: 10.1.2

Tool code: 10.1.2_Seafloor T3

Tool description: Surveys of macro-litter loads on the seabed have been conducted mainly using trawl surveys. This method is the most adequate method to date, although quantities of litter are underestimated. It should be considered as a method for estimating relative litter densities rather than absolute densities. A constant trawl mouth width is required. General strategies to investigate seabed litter are similar to methodology for benthic ecology and place more emphasis on the abundance and nature (e.g. bags, bottles, pieces of plastics) of items rather than their mass. Just like stranded litter, litter on the seabed aggregates locally in response to local sources and bottom topography.

Technical requirements: trawler [20 mm mesh size for otter trawls; 40 mm mesh size for beam trawls].

Size range: > 2 cm for otter trawls; > 4 cm for beam trawls.

Spatial coverage: Sample area size 1-5 ha, 20-800 m depth, fixed locations.

Survey frequency: Annually.

Maturity of the tool: In use.

Regional applicability of the tool: It can be applied in every region on soft bottoms.

Source related information: Categories are recorded, minimum7+1 categories [7 (plastic, paper & cardboard, glass, ceramics, metal, leather/clothes, others) + 1 (fishing gears)]. Categories should be compatible with other surveys.

References:

Galgani F., Jaunet S., Campillo A., Guenegan X. & His E.,1995b. 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., 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).

MSFD Marine Litter Monitoring TOOL SHEET

Tool name: Submersibles (manned and unmanned)

Indicator for which the tool is to be applied: 10.1.2

Tool code: 10.1.2_Seafloor T4

Tool description: Only some areas/countries are concerned along the European coasts including Norwegian trench, France, Spain, Portugal, Italy, Greece. For evaluation of litter and monitoring, the use of trawl in deep-sea areas will be restricted to flat and smooth bottoms. For slopes and rocky bottoms, special means are necessary including ROVs and submersibles that are very expensive to operate. ROVs are simpler and largely cheaper and must be recommended for litter surveys. There are some available protocols where litter is counted on routes. These routes surveys must be in the km range and results are expressed as item/km).

Technical requirements: ROVs, submarines.

Size range: > 2.5 cm

Spatial coverage: Sample size 0.5-2 km routes/ dive, depths: 50-2500 m.

Survey frequency: On irregular basis, every 5-10 years.

Maturity of the tool: In use.

Regional applicability of the tool: Priority regions: Mediterranean (Spain, France, West and south east, Italy, Greece, Cyprus), Portugal, UK (Partly), Norwegian trench. Priority sites: large cities, accumulation areas.

Source related information: Categories are recorded, minimum7+1 categories [7 (plastic, paper & cardboard, glass, ceramics, metal, leather/clothes, others) + 1 (fishing gears)].

References:

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.

5.3 Future needs and further development

To improve the monitoring of litter on the sea floor, the following recommendations were considered as important for data collection and management, harmonization and trends evaluation and more generally for a better evaluation of GES:

5.3.1 Development needs and options within 2012

Shallow seafloor monitoring

Develop a monitoring strategy for shallow waters (sites, depths, priority areas). Diving surveys to monitor marine litter are scarce in European waters and there is a need for further development of the monitoring. The concept of priority areas is important and the issue of selection of sites and their representation will have to be discussed in developing a strategy adapted to shallow coastal waters. Alternatives to diving methods will have to be evaluated. There is need to link the strategy to ongoing seafloor habitat surveys and to investigate possible contribution by NGO initiatives (e.g. Project AWARE, http://www.projectaware.org/project/dive-against-debris).

Bottom trawl surveys

Available program in OSPAR/HELCOM/MEDPOL/BSC areas covering all shelves on regular basis (annually). Rationalize, implement, improve the existing IBTS, BITS and MEDITS (including BSC) marine litter protocols and extend them to other regions covered by these programs, will enable a coverage of most European seafloor areas between 40 m and 800 m. Monitoring of Litter through seafloor trawls must be co-organized and coordinated within the two groups ICES/IBTS covering NE Atlantic and Baltic Sea and MEDITS covering Mediterranean and Black Sea. Inclusion of litter monitoring through IBTS/MEDITS programs will need to be organized within the EU through STEFC (Scientific, Technical and Economic Committee for Fisheries) and its Subgroup Research Needs (SGRN) with the support of the Data Center Framework (DCF) from DG MARE (Directorate-General for Maritime Affairs and Fisheries). The development of a central database for European trawl survey data (DATRAS) may be used for collection of trawl survey data preceding a more specific litter data management system.

Seafloor litter reporting categories

Following recommendations from OSPAR, UNEP/IOC, ICES/WKMAL and the TSG ML discussions, it is the opinion of the group that for classification of marine litter in general, an hierarchical approach should be developed and used. Very general categories should split up into more detailed identification, where possible. For sea floor surveys categories are including: plastic, paper and cardboard, wood (processed), metal, glass and ceramics, cloth (textile), rubber, others. This system should be compatible across the different survey types, see: Chapter 8.5, Availability of source identification methods. The same approach should be applied in all European areas.

5.3.2 Development needs and options until 2016 and beyond

Long term improvement of sea floor monitoring is related to research needs and should include the development of innovative methods (e.g. imaging or sonar detection), semi automation and rationalisation of monitoring.

Monitoring of deep sea is actually on irregular basis because it is very expensive. Therefore very specific deep-sea areas where no trawling exists and which are especially affected by litter should be prioritized (Norwegian trench, Cap Breton canyon, canyon of Lisbon, large towns in the Mediterranean and deeps subjected to inputs).

6. Impacts of Litter on Marine Life

Marine organisms may be impacted by litter in various ways. At least 43 % of existing cetacean species, all species of marine turtles, approximately 36 % of the world's seabird species, and many species of fish have been reported to ingest marine litter (Katsanevakis, 2008). Ingestion of marine litter may occur either because of misidentification of litter items as natural prey, as shells from sepia for calcium carbonate supply, or accidentally during feeding and normal behaviour (Gregory, 2009). Serious effects of ingested litter are the blockage of the digestive tract and internal injuries by sharp objects, which may be a cause of mortality. Other harmful effects include the blockage of gastric enzyme production, diminished feeding stimulus, nutrient dilution, reduced growth rates, lowered steroid hormone levels, delayed ovulation and reproductive failure, and absorption of toxins (Azzarello and Van-Vleet, 1987; Ryan, 1988; Van Franeker and Bell, 1988; Sievert and Sileo, 1993; Auman *et al*., 1997; McCauley and Bjorndal, 1999; Derraik, 2002; Thompson *et al*., 2009, Teuten et al., 2007; Teuten et al., 2009). Entanglement in marine litter has been reported for numerous species (Katsanevakis, 2008) and can cause limited mobility and restricted movement (leading to starvation), suffocation, laceration, subsequent infection, and possible mortality in marine life (Honolulu Strategy, draft 2011)

According to the 1998 U.S. Marine Mammal Commission´s last published report in 1999, 136 marine species have been reported in entanglement incidents, including six of the seven species of sea turtle, 51 out of the world´s 312 species of seabirds, and 32 species of marine mammals. Of the 120 marine mammals species listed on the IUCN list, 54 (45 %) were reported to have interacted (ingestion and/or entanglement) with marine litter.

With accounting for around one tenth of the entire litter in the world`s oceans (Cheshire et al., 2009) derelict or discarded fishing gear ranks as the most problematic marine litter. These estimated 640000 tons of fishing gear lost, abandoned or discarded annually may continue to fish for years and even decades (a process referred to as 'ghost' fishing). While the impact of lost fishing gear in shallow waters are better known and documented, impacts on deep water environments have also been observed (McElwee et al., 2011 in press). For example the decline of deep water sharks in North Atlantic has been linked to ghost fishing in the North Atlantic (Hareide et al., 2005, Large et al., 2009). Please see Annex 4 for an overview of the issue.

Other known impacts of marine litter include alteration, damage and degradation of benthic habitats and communities (Katsanevakis et al., 2007) such as coral reef abrasion from derelict fishing gear or smothering from plastic bags. Litter can disrupt the assemblages of organisms living on or in the sediment (Uneputty and Evans 1997; Donohue et al., 2001, Chiappone et al., 2002). Marine litter items can assist in alien species invasions (Winston, 1982; Barnes, 2002; Barnes and Milner, 2005). Chemicals incorporated in, or attracted to plastics floating in seawater have a broad range of potentially toxic, carcinogenic and hormone disturbing effects (Thompson et al., 2009). Evidence from passive samplers indicate associated release and sorbance of chemicals on polymers, thus plastics and micro-plastics have a potential to possibly cause long term effects as they may act as a vector for transferring toxic chemicals to the food chain.

Evidence from passive samplers indicate associated release and sorbance of chemicals on polymers, thus plastics and micro-plastics have a potential to possibly cause long term effects as they may act as a vector for transferring toxic chemicals to the food chain.

In the Commission Decision (2010/477/EU), the impacts of litter on marine life are addressed with indicator 10.2.1 "Trends in the amount and composition of litter ingested by marine animals". Although the indicator is based on assessing trends in ingested litter, the Commission Decision (2010/477/EU) also requests for the improvement of knowledge concerning the impacts of litter on marine life in general.

6.1 Availability of data

In the EU, monitoring programs focusing on the trends of ingested marine litter or on its impacts have been scarce. The most comprehensive data set available is that on northern fulmars (*Fulmarus glacialis*). Northern fulmar monitoring has been conducted in the Dutch North Sea since the early 1980s, and since around 2002 in the German North Sea, Danish Skagerrak area, Norwegian North Sea/Skagerrak area, Swedish west coast, Belgian North Sea / Channel, UK North Sea and around Faroe Islands. Fairly isolated data are available on ingested litter in other seabird species, cetacean, seals, sea turtles, plankton, crustacean and fish. Formal programs and methodologies are not in place or only poorly developed and suitable numbers of individuals are not collected making it hard to draw robust conclusions. Entanglements have been studied from beached seabirds in only very few places, mostly in the German and Dutch North Sea coasts (Camphuysen, 2008). The most representative data set with regards to seabird entanglement rate originates from Germany, where this has been monitored in approximately 30 sites from the beginning of the 1990s (Fleet et al., 2010).

6.2 Availability of methods

In general, the following characteristics in an indicator species to be used to assess trends in the amount and composition of ingested marine litter can be identified:

- an abundant species;
- easily attainable (e.g. via Beached Bird Surveys);
- foraging exclusively at sea;
- a species known to have a sufficiently high incidence of ingested litter to monitor change even in times or areas of lower pollution.

Currently the only mature methodology for indicator 10.2.1 is the OSPAR Ecological Quality Objective (EcoQO) for litter particles in stomachs of northern fulmars. It is used to assess temporal trends, regional differences and compliance with a set target for acceptable ecological quality. For each litter category/subcategory the incidence, abundance by number, and abundance by mass is assessed. Trend assessment is based on statistical tests of linear regressions of ln-transformed data for the mass of plastics against year of collection in individual stomachs.

The methodology has been developed for the North Sea but it is applicable to most of the North East Atlantic. It is however not directly applicable to the Baltic, Mediterranean, Black Sea, and southern parts of the North East Atlantic, which are outside of the range of northern fulmars. The methodology itself is directly comparable on studies in ingestion in other seabird species.

EcoQO monitoring trials in the south eastern North Atlantic and western Mediterranean (Azores; Canary Islands; Selvagens; Spain Mediterranean; Malta Sea) have been carried out with Cory's Shearwater. This species doesn't offer full coverage of the Mediterranean and does not occur in the Baltic or the Black Sea. Methodologies will have to be adapted and fine-tuned to fit other potential indicator groups such as marine turtles.

Sea turtles are considered as a candidate to act as an ingestion indicator in the Mediterranean and nearby Atlantic areas, not however being suitable for the Black Sea or Baltic Sea regions, as their distribution does not cover these seas. On the basis of latest scientific studies, the loggerhead *Caretta caretta* seems to be the best indicator for the Mediterranean Sea, although more information on this topic must be collected. Several litter such as plastic, fish hooks, rubber, aluminum foil, tar, ropes and monofilament line have been found in its stomach contents (Tomàs et al., 2002, Lazar and Gracăn, 2011) and in its faeces (Casale et al., 2008, Armanasco et al., 2010).

6.3 Tool sheet development

Altogether three monitoring tools are presented for the monitoring of ingested litter:

Fulmar	(10.2.1_T1)
Shearwater	(10.2.1_T2)
Sea turtle	(10.2.1_T3)

The fulmar tool is classified as mature and the shearwater tool close to mature. The sea turtle tool is classified as under development indicating that enough information exists for the group to be able to suggest a monitoring approach for this species.

Additionally, the group has identified three other animal groups that could be suitable for ingested litter monitoring, but which require significant further development in order to be applied as tools for indicator 10.2.: fishes, seals, and crustaceans. These are presented and discussed in the following section 6.4.

MSFD Marine Litter Monitoring TOOL SHEET

Tool name: Fulmar

Indicator for which the tool is to be applied for: 10.2.1

Tool code: 10.2.1_T1

Tool description: The methodology of this tool is the OSPAR Ecological Quality Objective (EcoQO) for litter particles in stomachs of northern fulmars (*Fulmarus glacialis*). The stomach contents of beached northern fulmars are used to measure trends in marine litter.

Technical requirements: The technical requirements are described in detail in documents related to the fulmar EcoQO methodology: Van Franeker & Meijboom (2002), OSPAR (2008), Van Franeker *et al.* (2011a, 2011b). For each litter category/subcategory the (1) incidence; (2) abundance by number (count of number of items), and (3) abundance by mass (weight in grams) is assessed. Trend assessment is based on statistical tests of linear regressions of ln-transformed data for the mass of plastics against year of collection in individual stomachs.

Size range: >= 1 mm (stomach contents are rinsed over 1 mm mesh sieve)

Spatial coverage: Dead birds are collected from beaches (for methodology see Van Franeker 2004).

Survey frequency: Continuous sampling. A sample size of 40 birds or more is recommended for a reliable annual average for a particular area. However, also years of low sample size can be used in the analysis of trends as these are based on individual birds and not on annual averages. For reliable conclusions on change or stability in ingested litter quantities, data over periods of 4 to 8 years (depending on the category of litter) is needed.

Maturity of the tool: Mature and in use.

Regional applicability of the tool: The tool is applicable to the MSFD marine regions where fulmars occur; the Greater North Sea, the English Channel, and the Celtic Seas.

Quality assurance / quality control: The methodology referred to in this report is based on an agreed OSPAR methodology which has been developed over a number of years.

Source related information: In this tool the following categories are used:

1 Plastics
1.1 Industrial plastic pellets
1.2 User plastics
1.2.1 sheetlike user plastics
1.2.2 threadlike user plastics
1.2.3 foamed user plastics
1.2.4 fragments
1.2.5 other (including e.g. cigarette filters)
2 Rubbish other than plastic
2.1 Paper; incl. multi-layer laminates that are dominated by paper as in tetrapacks, and foils of aluminium-like materials
2.2 Kitchen food
2.3 Various rubbish (incl. manufactured wood, paint chips, metal, glass, etc.)
2.4 Fish hook
Further optional categories of stomach contents
3 Pollutants
3.1 slag/coal
3.2 oil/tar
3.3 paraffine/ chemical
3.4 feather lump (of oil or chemical fouled feathers)
4 Natural food remains
5 Natural non-food remains

The tests on significance of trends are suggested to be carried out for “total plastics”, “industrial plastics” and “user plastics”.

References

OSPAR Commission. 2008. Background document for the EcoQO on plastic particles in stomachs of seabirds.

van Franeker, J.A. & Meijboom, A. 2002. Litter NSV - Marine litter monitoring by Northern Fulmars: a pilot study. ALTERRA-Rapport 401. Alterra, Wageningen, 72pp.

van Franeker, J.A., et al. 2011a. Monitoring plastic ingestion by the northern fulmar *Fulmarus glacialis* in the North Sea, Environmental Pollution (2011), doi:10.1016/j.envpol.2011.06.008

van Franeker, J.A.; & the SNS Fulmar Study Group. 2011b. Fulmar Litter EcoQO monitoring along Dutch and North Sea coasts in relation to EU Directive 2000/59/EC on Port Reception Facilities: results to 2009. IMARES Report C037/11 (in prep).

MSFD Marine Litter Monitoring TOOL SHEET

Tool name: Shearwater

Indicator for which the tool is to be applied for: 10.2.1

Tool code: 10.2.1_T2

Tool description: The methodology of this tool is basically the same as the OSPAR Ecological Quality Objective (EcoQO) for litter particles in stomachs of northern fulmars (*Fulmarus glacialis*). The stomach contents of beached or otherwise found dead individuals of Kühls Shearwaters *(Calonectris diomedea / scopoli)* are used to measure trends in marine litter. Potentially other shearwater species *(Puffinus spp.)* may be considered.

Technical requirements: The technical requirements are described in detail in documents related to the fulmar EcoQO methodology: Van Franeker & Meijboom (2002), OSPAR (2008), Van Franeker *et al.* (2011a, 2011b). For each litter category/subcategory the (1) incidence; (2) abundance by number (count of number of items), and (3) abundance by mass (weight in grams) is assessed. Trend assessment is based on statistical tests of linear regressions of ln-transformed data for the **mass** of plastics against year of collection in individual stomachs.

Size range: >=1 mm (stomach contents are rinsed over 1 mm mesh sieve)

Spatial coverage: Dead birds are collected from beaches (for methodology see Van Franeker 2004) or from any land or sea based location. Trial studies at the moment use a mix of longline victims of chicks that died during fledging, and of corpses found in/near colonies. Fledged chicks would be the best sample type, but is probably not possible in many locations.

Trial studies are being conducted using birds from Azores, Canaries, Selvagens and western Mediterranean. In principle, the species occurs in the southern part of the Atlantic OSPAR area and in the Mediterranean. But although the species is reasonably common in the Mediterranean, suitable sampling locations seem hard to find.

Survey frequency: Continuous sampling. It is not yet known whether a sample size of about 40 birds, would be suitable in this species for assessing a reliable annual average for a particular area. However, also years of low sample size can be used in the analysis of trends as these are based on individual birds and not on annual averages.

Maturity of the tool: Method itself is mature, but feasibility of establishing a proper sampling network is in trial phase, not mature.

Regional applicability of the tool: The tool is applicable to the MSFD marine regions where shearwaters occur; southeastern North Atlantic and Mediterranean.

Quality assurance / quality control: The methodology referred to in this report is based on an agreed OSPAR methodology. Application to shearwaters is tested in particular on the Azores for several years, but data still have to analysed and results evaluated, which has been developed over a number of years.

Source related information: Please see the **fulmar tool** (10.2.1_T1) for the categories to be used.

References

OSPAR Commission. 2008. Background document for the EcoQO on plastic particles in stomachs of seabirds.

van Franeker, J.A. & Meijboom, A. 2002. Litter NSV - Marine litter monitoring by Northern Fulmars: a pilot study. ALTERRA-Rapport 401. Alterra, Wageningen, 72pp.

van Franeker, J.A., et al. 2011a. Monitoring plastic ingestion by the northern fulmar *Fulmarus glacialis* in the North Sea, Environmental Pollution, doi:10.1016/j.envpol.2011.06.008.

van Franeker, J.A.; & the SNS Fulmar Study Group. 2011b. Fulmar Litter EcoQO monitoring along Dutch and North Sea coasts in relation to EU Directive 2000/59/EC on Port Reception Facilities: results to 2009. IMARES Report C037/11 (In prep).

MSFD Marine Litter Monitoring TOOL SHEET

Tool name: Sea turtle
Indicator for which the tool is to be applied for: 10.2.1
Tool code: 10.2.1_T3
Tool description: The gastrointestinal tract contents of dead sea turtles, loggerhead (*Caretta caretta*) are used to measure trends in marine litter. The animal should be collected once stranded on the beach or straight from the sea, as accidental bycatch collected by fisherman, coast guard, or NGO volunteers. Carcasses should be labelled with information on location, date, finder's personal details, and any possible relevant information. After that first step the animal or sample should be frozen in a plastic bag and transported to an authorized laboratory for dissection (if only the stomach and gut are collected, data should be added with a necropsy form). The gastrointestinal tract is best divided into esophagus, stomach and intestine using particular attention to not mix contents. These components must be opened, after which the contents are rinsed with cold water in a sieve 1mm mesh to remove smaller organic material. Fecal pellet analysis is another possibility to collect litter in sea turtles but the methodology is under development.

Technical requirements: All items are sorted using the categorization as in Fulmar protocol analysis. For each category of plastics (industrial pellet or user plastic), rubbish (other than plastic), pollutant (industrial or chemical waste remain) or natural non-food remain, in the different parts of the gastrointestinal tract, incidence (presence/absence), abundance by number (count of number of items), and abundance by mass (weight of air-dry material) are recorded. Further details are possible, for example recording colours (number of items with the same colour). Different items found could be photographed above a graph paper foil.

Size range: >=1 mm (stomach contents are rinsed over 1 mm mesh sieve)

Spatial coverage: Dead turtles are collected from beaches or straight from the sea

Survey frequency: Continuous sampling, but it could be possible to have samples only during spring and summer period, in particular from May to October.

Maturity of the tool: Under development.

Regional applicability of the tool: The tool is applicable to the MSFD marine regions where sea turtles occur; the Mediterranean Sea.

Quality assurance / quality control: Under development.

Source related information: Please see the **fulmar tool** (10.2.1_T1) for the categories to be used.

References:

Armanasco, A., Botteon, E., Nannarelli, S. and Savini, D. 2010. Fecal pellet analysis of Caretta Caretta out patients of the Linosa island turtle rescue center (Sicily, AD) 41°Congressodella Società Italiana di Biologia Marina, Rapallo 7-11 Giugno 2010.

Casale P., Abbate G., Freggi D., Conte N., Oliverio M., Argano R., 2008. Foraging ecology of loggerhead sea turtles *Caretta caretta* in the central Mediterranean Sea: evidence for a relaxed life history model. Marine Ecology Progress Series 372:265–276.

Lazar, B. and Gračan, R. 2011. Ingestion of marine debris by loggerhead sea turtles, *Caretta caretta*, in the Adriatic Sea. Marine Pollution Bulletin 62:43–47.

Tomás, J., Guitart, R., Mateo, R. and Raga, J.A. 2002. Marine debris ingestion in loggerhead sea turtles, *Caretta caretta*, from the Western Mediterranean. Marine Pollution Bulletin 44:211–216.

Van Franeker, J.A.; & the SNS Fulmar Study Group 2011. Fulmar Litter EcoQO monitoring along Dutch and North Sea coasts in relation to EU Directive 2000/59/EC on Port Reception Facilities: results to 2009.. IMARES Report C037/11 (in prep).

6.4 Future needs and further development

6.4.1 Ingested litter

For MS to be able to evaluate the status of their marine regions with regard to litter, the most urgent need is to develop an integrated set of monitoring tools for ingested litter that covers all the four regional seas. Currently such tools cannot yet be recommended for the Baltic Sea and the Black Sea due to the lack of data on potential indicator species in these areas that would have adequate amounts of litter in their stomachs. It is pivotal that MS establish pilot studies for monitoring programs that provide information that supports the further development of tools for assessing trends in ingested litter. This is also the only plausible way to assess whether or not ingested marine litter is causing harm to biota.

Importantly, the comparability of trend results obtained from the indicator species' in the different marine regions must be ensured. As no single indicator species can cover all European waters, the selected indicator species should ideally have some spatial and/or ecological overlap with those from bordering areas. Consideration should be given to using different trophic levels. For example, it could be that ecologically similar fish species in all waters with a low frequency of plastic ingestion can be used for a rough general comparison of pollution levels in different regional seas, but that the monitoring of spatial-temporal trends within regional seas requires other species.

In addition to the animal groups for which ingestion tool sheets have been prepared, we propose three animal groups, which we regard to have potential for ingested litter monitoring in the future, particularly in the Baltic and the Black sea. Additionally, as an essential parallel activity to developing the monitoring of ingested litter, we highlight the importance and need of separate experimental studies for the assessment of harm/impacts of litter on marine organisms.

Fish

To evaluate the applicability of fish for ingested litter monitoring, studies surveying the occurrence of litter in fish in the different marine regions is needed. The group encourages MS to assess the applicability of already ongoing fisheries analysis in their country also for litter monitoring purposes and/or the establishment of small-scale research projects focusing solely on this issue. Ultimately MS should aim at a dedicated program for analysis of litter ingested by fish, based on harmonised methods. Species, which fulfill the requirements identified in section 6.2., such as sand eel, sprat, herring, and sardines, should be considered. Preliminary results of European surveys on litter ingested by fish have not shown clear candidate species so far, as incidence levels even in polluted areas have often found to be low. The standard fisheries stomach research (which may miss smaller particles) very rarely shows ingested litter, with incidence usually far below 1 %. This was observed even in species suspected to easily pick up litter like the Mackerel (*Scomber scombrus*) (Foekema et al., 2011; Lopez-Lopez 2011, unpublished reports). Dedicated studies around the North Sea that included very careful inspections for small particles occasionally showed somewhat higher incidences up to c. 10% in some species in polluted areas (Foekema et al., 2011; unpublished reports). Such levels are not very suitable for monitoring within regions, but could be useful as a general comparison between the four European seas. Further work on fish is certainly required and should include other species and also different life stages of fishes. Possibly ingestion of small litter is more common in juvenile fishes, which may be of high relevance to the issue of harm as well as potential economic impact. Studies in the northern Pacific (Boerger et al., 2010, Davison and Asch, 2011) and in the Southern Ocean (Eriksson and Burton, 2003) suggest that myctophid fish species ("lanternfishes") may have high incidences of ingested plastics. These species are not commonly captured and have not yet been included in European surveys but should be looked at as soon as possible.

In conclusion it seems that many fish in the European areas are not very suitable as ingestion indicators, but available information is fragmentary and much more dedicated work is urgently needed.

Seals and whales

In Germany, the occurrence of ingested litter in marine mammals (Pinnipedia and Cetacea) has been studied by the former Research and Technology Centre (FTZ West coast, now Institute of Terrestrial and Aquatic Wildlife Research) following the protocols developed for marine top predators (Pierce and Boyle, 1991). During the examination of defrosted stomachs, intact or partially digested food items are identified and measured. Remaining stomach contents are separated using a series of sieves with mesh sizes of 0.5-2 mm. Another method which is applied e.g. in Sweden, is to flush stomachs and intestines of hunted and beached seals with water and pass the contents through strainers. The smallest sieves used in this method have a mesh size of 0.5 mm.

In Sweden, the digestive track of Grey seals, Harbour seals and Ringed seals are analysed annually by the Swedish Museum of Natural History in a diet project taking also note of litter. Over the years, several hundred Baltic grey seals and approximately a hundred Ringed and Harbour seals have been analysed, but the occurrence of ingested litter has been negligible. At the FTZ West coast in Germany, only one harbour seal out of 24 contained litter in its stomach. A study of over 100 stomachs of seals that died in the Netherlands during the 2002 virus disease showed about 12 % incidence of litter (van Franeker, unpublished), but this was a special situation and without further work, it is not known if stomach contents reflect a normal pattern. Extensive studies of seal faeces from the Dutch Waddensea have not shown litter to be present (unlike e.g. Eriksson and Burton, 2003). Reportedly, stomachs of seals from the Icelandic area only very rarely show marine litter.

An exception to the above findings are the results obtained by Eriksson and Burton (2003), where they found plastics remains in about 85 % of the scats in the Southern Ocean Fur Seals. The authors suggested that plastic remains were not consumed by seals directly but instead were ingested by pelagic fish that were consumed by the seals. Maybe the fish species consumed by Baltic seals are not very prone to ingest plastic, but this needs to be verified.

Beaching numbers in some toothed whales (Odontoceti) could be high enough to evaluate potential suitability for indicating trends. However, the species known to be more prone to ingestion like Cuvier´s beaked whales (Macleoad, 2009) and Sperm Whales (Jacobsen et al., 2010) are rare on European coasts. Out of 47 analysed harbour porpoises from 1998-2006 by the FTZ West coast (according to the protocol mentioned above) two animals had plastic and nylon in their stomachs. Regular studies of stomach contents of Harbour porpoises from the Netherlands (e.g. 64 animals in Leopold and Camphuysen 2006) only very rarely show ingested marine litter.

Plastic accumulates in Risso`s dolphin habitat in the Mediterranean (Aliani et al., 2003). Of the 100 Risso´s dolphins stranded or rescued along the coasts of Italy between 1986 and 2005, one reportedly had many plastic bags and a ping-pong ball in its stomach and the stomach and oesophagus of another were occluded by plastic bags (Bearzi et al., 2011). Of the 59 Risso´s dolphins stranded in France between 1072 and 2003 (including along the Atlantic coast), 2 had ingested plastic bags (Dhermain, 2004). Those proportions do not reflect actual rates of ingestion because only a minority of stranded animals were dissected.

In conclusion, it seems that for marine mammals either the known incidence of ingested plastic is too low to use this group for ingestion monitoring, or it concerns species that occur in too low frequencies to be used in a monitoring system. Studies of litter in stomach contents of marine mammals are certainly recommended, also from the viewpoint of knowledge of harm, but not as a monitoring tool.

Crustaceans (Norwegian Lobster or similar)

Crustaceans are widely distributed animals, and should be surveyed for their potential to act as indicators in all the MSFD marine regions. However the occurrence of litter in crustaceans has yet received little attention. Plastic contamination has been found to be high in the crustacean *Nephrops norvegicus* in the Clyde Sea, where 83 % of the animals sampled contained plastics (predominantly filaments) in their stomach. Tightly tangled balls of plastic strands were found in 62 % of the animals studied but were less prevalent in animals which had recently moulted (Murray and Cowie 2011). Variations in litter accumulations related to age or moulting stage of crustaceans could complicate their use for monitoring and further studies in this and other crustacean species need to verify these findings.

6.4.2 Entanglement

The entanglement of marine species in marine litter has been frequently described as a serious mortality factor.

Long-term observations on the German North Sea island Helgoland from 1976-1985 suggested that 29 % of the observed mortality of beached gannets could be caused by plastic-litter and fishing gear; the actual entanglement rate among beached birds was 13% (Schrey and Vauk, 1987). A study conducted on the British island Grassholm, Wales, where approximately 40000 pairs of gannets breed, accounted for 470 g plastic on average in each nest, equating to an estimated colony total of 18.5 tonnes. A total of 525 individuals were found entangled over eight years (1996-1997 and 2005-2010), the majority of which were nestlings (Votier et al., 2011).

Fifteen species of sea- and water birds were recorded as victims of entanglement with litter on the German North Sea coast in the 1980s. The most common victim was the Gannet, with 20 % of all corpses of this species found to be entangled (Hartwig et al., 1985, 1992). An increase in entangled dead beached seabirds from 0.23 ± 0.11% for the years 1992-2003 to 0.35 ± 0.06 % for the years 2004-2007 was reported for Dutch beaches (Camphuysen, 2008). Up to 6.5 % of Gannets beached in the Netherlands shows entanglement (Camphuysen, 2008). The values for sea- and water birds beached on the German North Sea coast in the period 1992-2007 and included in the German North Sea beached bird database are 0,26 ± 0,11 % entangled (n entangled = 230; n total = 87074). As in the Netherlands, the Gannet remains the species most frequently found entangled on German North Sea coasts and 12 % of all gannets recorded are entangled (Wadden Sea Ecosystem No. 25, 2009).

In conclusion, it seems that entanglement rates among beached birds, except for gannet, are often too low for monitoring purposes of marine litter. Wherever beached birds surveys are carried out protocols should include the aspect of entanglement to monitor trends in entanglement rates especially of Gannets. In addition, entanglement rate may provide a useful tool to be used for the assessment of harm in breeding bird colonies, such as gannets, kittiwakes, and cormorants (Votier et al., 2010). In the case of the kittiwakes colony in the so-called "Jammerbucht" in North-West-Denmark studies were carried out quantifying the percentage of nests containing plastic litter being used as nesting material. In 1992, 39 % of the 466 nests in that season contained plastic, whereas in 2005, 57 % out of 311 nests contained plastic (Heckroth and Hartwig, 2005). This is an issue to be considered.

Entanglement rates of marine mammals are probably high, but are extremely complicated to assess as found in the detailed study of death causes for harbour porpoises by Leopold and Camphuysen (2006). In most cases, no proper protocol has yet been developed. Additionally, in beached animals, usually entanglement in marine litter cannot be distinguished from entanglement in active fishing gear. As for the beached birds, protocols should always include a section for entanglement in order to assess harm.

6.4.3 Development needs and options within 2012

The group identifies that as a priority and feasible goal for 2012, a common protocol for the monitoring of ingested litter in fish needs to be developed. This is not an uncomplicated task, as the size of items to be looked at has to be specified, as well as which species should be considered. Currently recording of litter of stomachs in standard fisheries research does not allow for the identification of microlitter, which may be causing harm to the fish, and hence the techniques is not useful for the purposes of assessing GES. Additionally a protocol for a harmonised assessment of entanglement rate in breeding bird colonies needs to be developed, taking into account the number of birds attending a certain breeding colony and the number of birds dying from entanglement.

6.4.4 Development needs and options until 2016 and beyond

To a great extent, the long term development needs for the assessment of the impacts of litter on biota, depend on the effectiveness with which MS begin to implement the proposed monitoring tools and to provide information on the occurrence of litter in biota. The interaction of chemical pollutants related to marine litter in the aquatic food chains needs further attention. The implementation of further research aspects concerning both monitoring and assessment of harm are of key importance, in which harm from ingestion should cover both physical and chemical consequences. Derelict fishing gear deserves particular attention and the need for activity collecting information on the current state considering all involved stakeholders under the WG GES should be considered. The aim would be to exchange information at EU level and enable thus for a common approach under the MSFD.

Once MS have begun to implement these methods, the results have to be brought together, analysed, and protocols further developed from there. This is an iterative process, and hence the group sees that to ascertain the best use of the information provided by MS during the coming years, a coordinated approach would be needed to collecting and processing the data.

7. Microlitter

Microlitter is specifically considered in the Commission Decision (2010/477/EU): "Trends in the amount, distribution and, where possible, composition of micro-particles (in particular micro- plastics) (10.1.3)''.

When first described the term microplastic was used to refer to truly microscopic particles in the region of 20 µm diameter (Thompson et al., 2004). However the definition has since been broadened to include particles smaller than 5 mm (Arthur et al., 2009). In effect microparticles are no different to any other type of litter; they are merely pieces of litter at the small end of the size spectrum. Microparticles of a range of common material types including glass, metal, plastic and paper litter are undoubtedly present in the environment. However the most comprehensive date we have is for microscopic particles of plastic. Microplastics are widely dispersed in the environment and are present in the water column, on beaches and on the seabed, and it is likely that microparticles of other materials such as metal and glass are also present across a range of locations and habitats. Hence microparticles are relevant to Chapters 3, 4, 5 and 6 of this report and some of the sampling approaches described in these Chapters, for example the Manta trawl for surface litter will undoubtedly capture buoyant microplastics as well as larger items of litter. Microplastics are also treated separately, here in Chapter 7, because their size may also necessitate more specific methodology for collection and compared to larger items microparticle sampling invariably requires additional steps for identification.

Sampling strategies – avoiding gaps and avoiding duplication in sampling effort

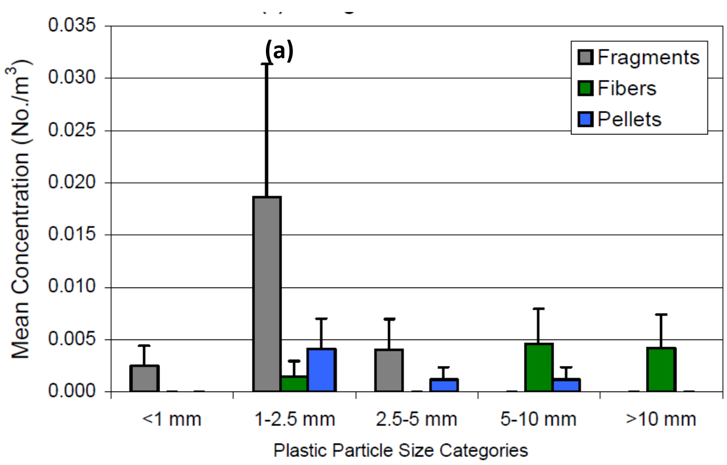
Since marine litter is present in the environment in a range of sizes effectively forming a continuum from very large items such as fishing nets to microscopic particles it is inevitable there will be some overlap in sampling protocols and this can be harnessed to achieve greater efficiency, for example by surveying for macro litter and microlitter simultaneously. There is also potential for gaps in coverage across the size spectra of litter to result according to the combinations of approaches used. For example, approaches to monitor beach litter described in Chapter 3 follow well established OSPAR protocols. In this protocol there is a minimum cut off point for categorization at 2.5 cm, and while the protocol has the option for smaller particles to be recorded (category for items < 2.5 cm amalgamated together) in practice this data has limited accuracy because of the large size of the area being examined compared to the relatively small size of the litter, i.e. it is inevitable that when surveying at the scale of a beach that monitoring will not be able to adequately capture all of the very small items. However, sampling of beaches for microlitter, described here in Chapter 7, only considers pieces smaller than 5 mm. Hence there is a gap in coverage (OSPAR >2.5 cm, microplastic < 5 mm) representing the size range < 2.5 cm and > 5 mm. This size range represents an important fraction of marine litter that is numerically abundant and has the potential to be ingested by marine organisms. Hence the TSG Marine Litter decided an additional protocol should be included in this report to allow coverage of 'meso' scale litter - size range < 2.5 cm and > 5 mm. A tool sheet for meso beach litter is included here. In terms of efficiency of data collection, information on meso litter could either be collected at the same time as surveying for larger items of beach litter which are described in Chapter 3 or while sampling for microparticles which are described here in Chapter 7. Protocols for beach litter represented an obvious and inevitable gap in sampling; similar gaps in data collection could occur when sampling surface waters, the seabed or biota and will depend the sampling devices or approaches used (net, trawl, grab, etc.) and this should be an important consideration when selecting monitoring approaches for marine litter in order to give good representation across size categories; avoiding gaps and also avoiding duplication of effort.

7.1 Availability of data

Considering the broad definition of microplastics proposed by NOAA (i.e. particles < 5 mm), it is evident that microplastics are not a new phenomenon. For example, the presence of small plastic pre-production pellets in coastal waters (5 mm) was first reported in the early 1970s (Carpenter et al., 1972) and since then pellets and fragmented plastic litter have been reported worldwide (Barnes et al., 2009) Plastic pellets and plastic fragments are frequently found either floating on the sea surface, deposited on the sea bed, or in the intertidal sediment.

Microplastics can enter the marine environment directly (e.g. pre-production pellets and/or granules used as abrasives in cleaning products) or indirectly (fragmentation of larger plastic litter). Plastics are progressively fragmenting in the environment and are also transported as pellets (<5 mm) and powders (<1 mm) prior to manufacture into everyday items. The sizes of microplastics reported varies from study to study from 1.6 µm to 5 mm (Barnes et al. 2009). There is no widely accepted "lower bound" in size as the limit of detection is dependent on the sensitivity of the sampling technique used (e.g. mesh size of the net or size of the filter) and plastic particles as small as 1.6 µm have been detected (Ng and Obbard, 2006). When considered in terms of numerical abundance, as opposed to weight, there is evidence that microparticles of plastic are the most numerous type of plastic litter. An investigation of micro-litter in plankton samples collected during NOAA surveys in the Southeast Bering Sea (2006) and off the U.S. West Coast (2006-2007) showed that plastic fragments, mostly resulting from the degradation of larger litter, accounted for the majority of the particles in the plankton samples, and that most of these fragments were less than 2.5 mm in size (Figs. 7a, b) (Doyle et al., 2011). Similarly in estuarine sediments in the UK, small fragments were the most abundant type of plastic litter present (Browne et al., 2010).

Microplastics enter the environment from both primary and secondary sources (Fig. 8). Primary sources of microplastics include particulates which are produced either for direct use, such as for industrial abrasives, exfoliants, and cosmetics or as precursors (resin pellets) for the production of consumer products. For example, microplastics can be used as exfoliants in cosmetics, replacing natural exfoliating materials with median sizes ranging from 196 to 375 µm (Fendall Sewell, 2009). A typical concentration of PE beads in formulations is 0.5 – 5 % and it is estimated that approximately 260 tonnes are currently formulated per year in the US alone (with an estimated per capita consumption of 0.88 g/person/year) (GESAMP 2010). These microplastics are then transported by waste water to wastewater treatment plants where a portion is likely to be captured in oxidation ponds or sewage sludge. However, due to their small size material will pass through the filtration system and enter the marine environment. Fendall and Sewell (2009) reported the implication of microplastics used as "scrubbers" in cosmetic products, usually up to 0.5 mm (500 µm) in diameter, being released into the natural environment at sizes that are readily available for ingestion by organisms (Thompson et al., 2004b, Browne et al., 2008, Graham and Thompson, 2009) .



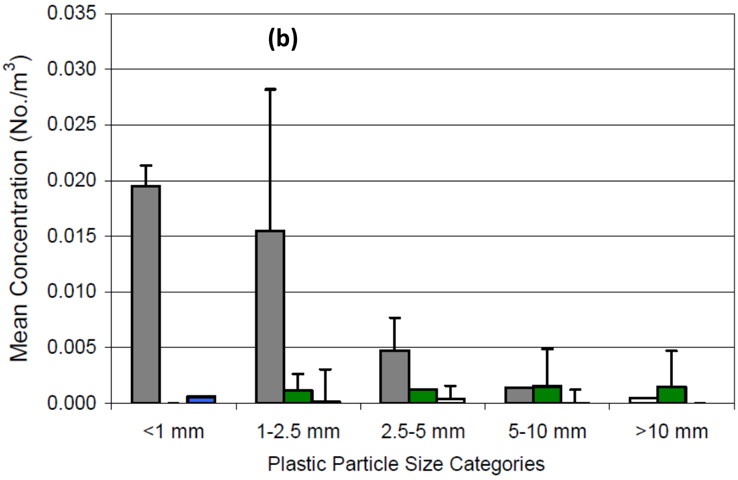


Fig. 7. Abundance of plastic particles (mean ± SE) according to plastic particle size categories in samples, combined from (a) Bering Sea cruises (2006), and (b) US west coast cruises (2006-2007).

Pre-production pellets accidentally released by spillage from industry can enter the aquatic environment by three distinct routes (US EPA 1993, IMO 2011): 1) Combined sewer overflow (CSO) and storm water discharges: Spilled pellets may be carried by rainwater into storm water drains, which in turn transport the water into municipal wastewater systems (Fig. 8). The pellets may then be discharged into the aquatic environment through storm water discharges or, where the sewage and storm sewers are combined, through CSO discharges; 2) Pellets may also be spilled directly into waterways, such as during cargo handling operations at ports or during cargo transport at sea.

Secondary sources relate to formation of microplastics in the environment due to the degradation of larger plastic material, are described as secondary microplastics. The relative importance of primary and secondary sources of microplastics to the marine environment is not known. Also, predicting the rate of formation of secondary microplastic is difficult, as no systematic study of the disintegration processes of plastics under realistic conditions has been conducted (Arthur et al., 2009).

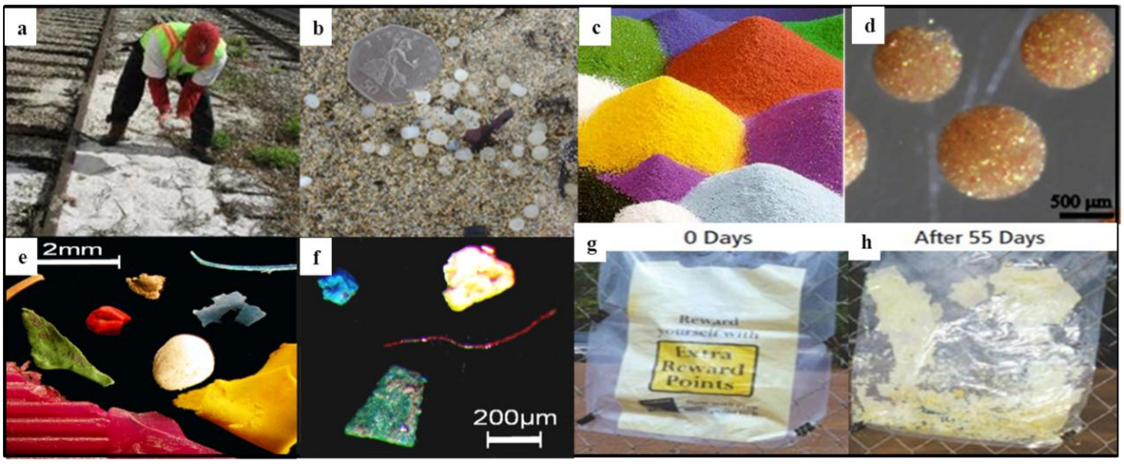


Fig. 8. Primary (from direct sources, a-f) and secondary (from indirect, g-h) microplastics. a: pre-production plastic pellets layering the ground around railroad tracks, b: pre-production pellets found on a sandy beach c: powdered plastic for thermosetting, , d: microbead facial scrubs, e-f: plastic fragments from beaches in the UK resulting from degradation of larger litter, g-h: a “degradable” plastic bag fragmenting into smaller pieces (Algalita 2011; Piwania Technologies Pvt. Ltd. 2010; Proud2BeGreen 2010; SAS 2008).

Oceanographic modelling and net sampling indicates accumulation of plastic, including microplastic litter, litter, in gyres, which are large systems of rotating ocean currents Fig. 9 (Law et al., 2010) with some of the greatest densities of plastic being furthest from land. Hence, the buoyancy and high mobility of plastic items in the marine environment results in a widespread distribution and microplastics have accumulated on shorelines worldwide (Fig. 10) (Browne et al., 2011). The abundance of microplastics is variable but in some locations they can represent the major component of marine litter in terms of numerical quantity but not by weight. Browne et al. (2010) found 65 % of litter sampled from intertidal habitats in Plymouth, UK, was microplastic. Martins and Sobral (2011) report 72 % microplastics in litter from 5 beaches in Portugal. The most prevalent polymer types were polyester (35 %), PVC (26 %) and polyamide (18 %). Other types of polymers commonly encountered in the marine environment, both in the sediment and water column, include PE, PP and

PS (Table 1). Changes in the overall density of a plastic item, for example as a consequence of fouling, will affect buoyancy and therefore deposition and accumulation on the sea-floor. However, the fate of plastic particles that become dense enough to sink below the sea surface is less clear (Law et al., 2010). In a study in SW England Thompson et al. (2004) reported greater abundance of microplastics in subtidal rather than in intertidal sediments. Browne et al. (2011) reported on microplastics in the subtidal zone in the vicinity of disused sewage sludge dumping grounds with greater abundance than in subtidal reference sites but generally lower densities than those reported in the intertidal.

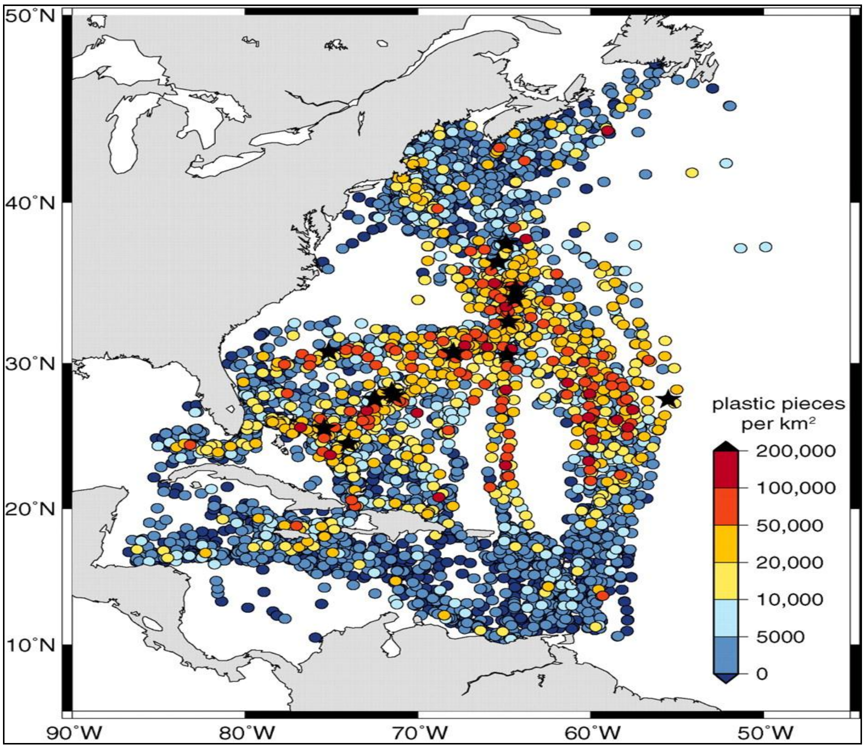


Fig. 9. Distribution of plastic marine litter collected in 6136 surface plankton net tows (1.0 x 0.5 m mouth with a 335 μm mesh net) on annually repeated cruise tracks from 1986 to 2008 in the western North Atlantic Ocean and Caribbean Sea. Black stars indicate tows with measured concentration greater than 200,000 pieces per km^2 (Law et al. 2010).

Fig 10. Global extent of microplastic in sediments from 18 sandy shores and identified as plastic by Fourier transform infrared spectrometry. The size of filled-circles represents number of microplastic particles found (Browne et al., 2011).

Temporal trends in the abundance of microplastics have been obtained using archived plankton samples collected by the Continuous Plankton Recorders (CPR). This is a plankton sampling instrument designed to be towed at a depth of approximately 10m from merchant ships on their normal sailings. The aim of the CPR Survey is to monitor the near-surface plankton and it has been used extensively throughout the North Atlantic and North Sea to collect samples on a regular basis (~monthly). The CPR works by filtering plankton from the water over long distances (up to 500 nautical miles). Water enters the device through 127 mm^2 and particulate material is then collected on a moving filter band of silk (270 µm mesh size) (Richardson et al., 2006). As well as plankton, the CPR will capture small pieces of plastic. This approach has been used to examine temporal patterns in abundance. Here, four samples were examined from each decade since 1960. Silk screens were viewed under a microscope and any unusual fragments identified using Fourier transform infrared spectroscopy (FT-IR). Microscopic plastic in CPR samples revealed a significant increase in abundance when samples from the 1960s and 1970s were compared to those from the 1980s and 1990s (Fig. 11) (Thompson et al., 2004).

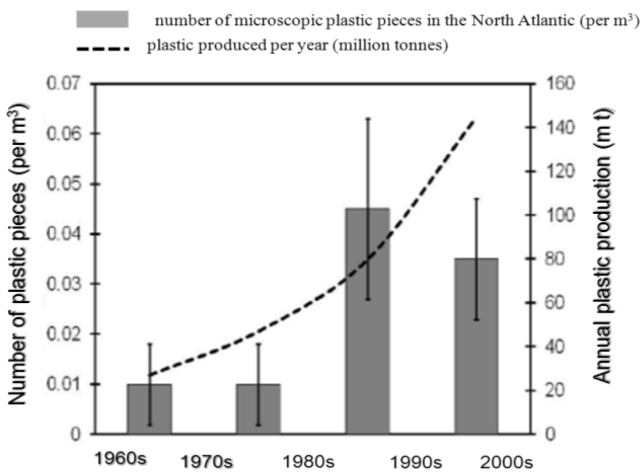


Fig. 11. Microscopic plastics (< 5 mm) in surface waters, collected with continuous plankton recorder and identified by FT-IR, revealed a significant increase in abundance when samples from the 1960s and 1970s were compared with the 1980s and 1990s ($F_{3,3} = 14.42$, $p < 0.05$) (modified after Thompson et al., 2004).

7.2 Availability of methods

Despite the relatively recent use of the term microplastics to describe small items of marine litter there have been over 60 published articles considering this litter either on the sea surface, on shorelines or in marine sediments. There is a lack of consistency in the methods adopted and the sampling strategy used; however three main strategies emerge from these studies: selective sampling, screening or filtering to reduce the volume of the sample, and bulk sampling. The majority of intertidal sampling has been from the strand line which is the location where buoyant macro litter tends to accumulate in the intertidal; while samples in the water column are mostly from surface waters and hence will also be biased entirely toward floating litter. Sampling from the sea bed typically follows approaches used to separate fragments from intertidal sediments. A critical step in all of these approaches is the extent to which the material obtained is/can be identified as plastic. For larger microplastic fragments (~5 mm) it is possible to identify plastic litter with reasonable certainty by visual examination based on color and shape. However this becomes increasingly difficult with pieces less than 1 mm in size such that only around one third of the material which might be separated from a sample according to colour and shape by visual examination actually are plastic. Hence, a further analytical step to determine the identity of plastic is essential. This has typically been achieved by Fourier Transform-Infra Red spectroscopy (FT-IR, see later).

Sampling from the intertidal zone is typically achieved by collecting replicated samples of sediment typically with a small metal scoop or trowel. Sampling is normally from the top few centimetres of sediment (although some studies have sampled to below 1 m and found microplastics). Material should be transferred to a glass or metal container (preferably not plastic if microplastic is to be sampled). Care must be taken to ensure cleanliness of sampling procedures and handling at all times. The most common approach is then to extract plastic particles from the sediment using a density separation typically by agitating the sand in concentrated sodium chloride solution. The supernatant, containing any plastic is then separated onto filter paper, which is then examined under a dissecting microscope. Small fragments are either identified by visual examination or preferably are removed for further analyses using FT-IR.

Sampling from subtidal seabed sediments has been achieved using an Ekman Grab and a Van Veen grab. In principle any type of grab or core would suffice provided potential sources of contamination can be eliminated. After collection material should preferably be stored in glass or metal if the sample is to be analysed for microplastics. Care must be taken to ensure cleanliness of sampling procedures and handling at all times. The most common approach is then to extract plastic particles from the sediment using a density separation typically by agitating the sand in concentrated sodium chloride solution. The supernatant, containing any plastic is then separated onto filter paper, which is then examined under a dissecting microscope. Small fragments are either identified by visual examination or preferably are removed for further analyses using FT-IR.

Sampling from the water column has been achieved using the Continuous plankton recorder and via a range of nets and trawls typically used to sample planktonic organisms including: manta trawls, bongo nets and plankton nets. There is some uncertainty about the relative efficiency of these approaches as none have specifically been designed to sample plastic. The CPR is widely used in monitoring programs in the NE Atlantic and there is archived material, from which plastic can be quantified, going back over several decades. However this approach has limitations because of the small aperture of the CPR and its sub surface depth in the water column (10 m). Since the aperture size of the CPR limits its use to microplastic it is described in a tool sheet within this section. Manta trawls offer a good approach to collect surface litter and have been used in the UK and the USA (see Chapter 4). Bongo nets and plankton nets can be used to sample at various depths according to the configuration of the equipment. Since manta trawls and nets can be used to sample macro plastic and microplastic, they are covered in Chapter 4, Water Column and Floating litter. Pieces can be removed by unaided visible examination and with the use of low power dissecting microscope As discussed earlier fragments of plastic around 5mm in size can be reasonably reliably identified by unaided visual examination however accuracy of identification is substantially lower for fragments of less than 1mm. Hence for smaller fragments further analysis for example using FT-IR spectroscopy is required.

Small fragments of unidentified material that is suspected to be plastic can be identified using FT-IR. This technique matches a spectra from the unknown material with that of known materials held in a data base. Using this approach a range of common polymers have been identified (Fig. 12). The analysis is reliable and reproducible and gives a quality index indicating the degree of match between the known and the unknown material. The approach requires expensive equipment (FT-IR linked to a microscope) a trained operator and is time consuming, however it remains the most widely used reliable method for identification of small fragments from the environment. Caution should be exercised when evaluating data on quantities of microplastic where formal identification using approaches such as FT-IR has not been undertaken.

Three tools have been identified for the monitoring of microlitter:

Microlitter Intertidal Sediment	(10.1.3_T1)
Microlitter Subtidal Sediment	(10.1.3_T2)
Microlitter CPR	(10.1.3_T3)

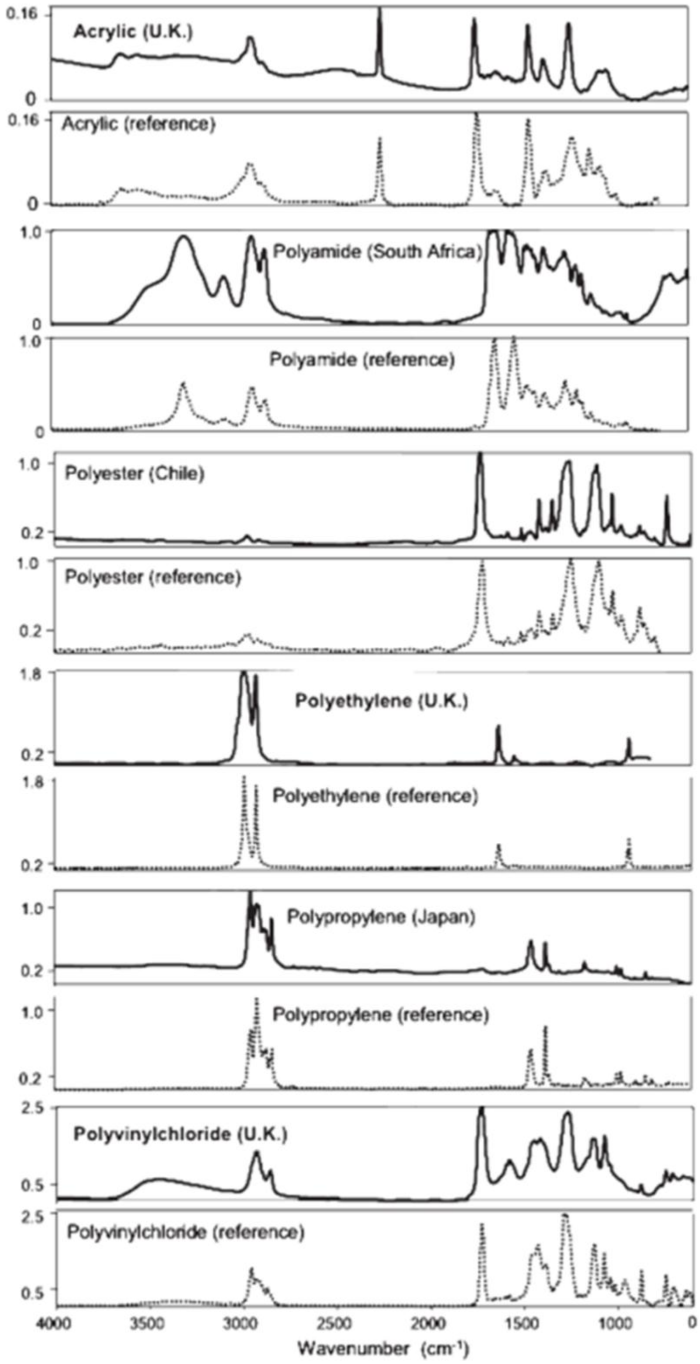


Fig. 12. Examples of Fourier transform infrared spectra of microplastic and corresponding reference material from ATR spectral database, vertical axis represents transmission in standard optical density units. (Bruker Optics ATR-Polymer Library - a Collection of Synthetic Fibres, Copyright 2004 Bruker Optic GmbH). From Browne et al., 2011.

TOOL SHEET

Tool name: Sampling microplastics from intertidal sediments

Indicator for which the tool is to be applied for: 10.1.3

Tool code: 10.1.3_T1

Tool description: Quantification of microplastics from intertidal sediments

Technical requirements:

Containers for sediment and small scoop to collect (not plastic)

Glass separating funnel, vacuum filtration system

Binocular microscope

FT-IR spectroscopy for formal identification of polymers

Size range: Microplastics down to around 20µm can be separated onto filter paper.

Spatial coverage: No restrictions the method has been used to a limited extent on shorelines world wide

Survey frequency : At discretion of research team.

Maturity of the tool: Used since 2004.

Regional applicability of the tool: Broadly applicable but extraction of plastics form from fine particulates e.g. mud or silt can be difficult.

Source related information: Need for harmonisation.

References:

Thompson et al. 2004. Lost at sea, where is all the plastic? *Science* 304: 838. For details see http://www.sciencemag.org/content/304/5672/838/suppl/DC1

TOOL SHEET

Tool name: Sampling microplastics from subtidal sediments

Indicator for which the tool is to be applied for: 10.1.3

Tool code: 10.1.3_T2

Tool description: Quantification of microplastics from subtidal sediments

Technical requirements: Grab or core to collect sediment sample from vessel

Containers for sediment (not plastic)

Glass separating funnel, vacuum filtration system

Binocular microscope

FT-IR spectroscopy for formal identification of polymers

Size range: Microplastics down to around 20µm can be separated onto filter paper.

Spatial coverage: No restrictions, the method has been used to a limited extent on intertidal shorelines worldwide, but only one report of subtidal sampling.

Survey frequency: Depending on the needs for trend assessments.

Maturity of the tool: Approach developed in 2004.

Regional applicability of the tool: Broadly applicable but extraction of plastics from fine particulates e.g. mud, silt can be difficult.

Source related information: Subject to development of a harmonised approach.

References:

Thompson et al. 2004. Lost at sea where is all the plastic? *Science* 304: 838. For details see http://www.sciencemag.org/content/304/5672/838/suppl/DC1

TOOL SHEET
Tool name: Continuous Plankton Recorder

Indicator for which the tool is to be applied for: 10.1.3

Tool code: 10.1.3_T3

Tool description: Towing CPR and subsequent quantification of microplastics from water column.

Technical requirements: Vessel minimum requirements SAHFOS CPR's are towed by voluntary vessels at approximately 6-10 m depth ranging from 5-25 knots. Vessel needs a tow point with a minimum of 1.5 tonne safe working load and a suitable mooring winch drum. CPR

Size range: Mesh size is 270 µm and upper limit of capture approx. 4 cm. Fragments much smaller (~20 µm) than 270 µm can be captured if they become trapped amongst mesh.

Spatial coverage: Northern European and Worldwide coverage. 25 CPR devices are deployed each month which approximates to 10000 nautical miles of seawater sampled per month. This is normally examined as a sample representing 10 nm sections, representing 3 m^3 of sea water.

Survey frequency : Likely to be based on existing cruises organized by Sir Alister Hardy Foundation for Ocean Science (SAHFOS http://www.sahfos.ac.uk/).

Maturity of the tool: Well characterized for plankton and used over 70 years. Used to quantify microplastic over last decade including examination of archived material back to 1960s.

Regional applicability of the tool: Limited by water depth, must be greater than 12 m.

Source related information: Information complied in spatial data base can be linked with hydrodynamic and meteorological conditions, analysis of sampled material, categories, shapes.

References:

Batten SD, Clark R, Flinkman J, Hays G, John E, John AWG, Jonas T, Lindley JA, Stevens DP, Walne A. 2003a. CPR sampling: the technical background, materials and methods, consistency and comparability. Progress in Oceanography 58:193-215.

Batten SD, Walne AW, Edwards M, Groom SB. 2003b. Phytoplankton biomass from continuous plankton recorder data: an assessment of the phytoplankton colour index. Journal of Plankton Research 25:697-702.

Reid PC, Colebrook JM, Matthews JBL, Aiken J. 2003. The Continuous Plankton Recorder: concepts and history, from plankton indicator to undulating recorders. Progress in Oceanography 58:117-173.

Richardson AJ, Walne AW, John AWG, Jonas TD, Lindley JA, Sims DW, Stevens D, Witt M. 2006. Using Continuous Plankton Recorder data. Progress in Oceanography 68:27-74.

7.3 Future needs and further development

There is a need to standardize sampling approaches in order to monitor the abundance of microplastic for MSFD. This needs to consider both the sampling design in terms of number and size of replicates, spatial area and frequency of coverage as well as the methodological approach; type of net or core and method of identification used. Given this is an emerging area with numerous recent studies it is not reasonable to prescribe set methodologies at this time and the development of standard approaches and protocols should be seen as a goal over the next 4 years.

7.3.1 Development needs and options within 2012

Review of existing published approaches considering sampling design, methods of sample collection and identification of microparticles is a high priority. This review should consider methods optimization by examining the relationships between sampling effort and variability. It should also consider the availability of existing equipment and existing monitoring programs into which sampling of microplastics could readily and practically be incorporated. So within 2012 identification and recommendation of protocols to provide consistent, reliable and relatively easily obtainable data on spatial and temporal trends in microplastic are needed. Since patterns of distribution and the movement of particles between compartments, for example sea surface to seabed is far from clear; it will be important to evaluate methods to sample shorelines, sea surface and seabed.

7.3.2 Development needs and options until 2016 and beyond

Following on from 7.3.1 selected methods should be initiated to monitor microplastics by MS. In parallel there should be inter-calibration EU level workshops to ensure the comparability of those participating in data collection. This will help both to refine and standardize, from a practical perspective, the approaches identified in 1.3.1.

There is also a need for research to develop and subsequently validate new methods to identify and quantify microparticles. These methods could include image recognition equipment to facilitate rapid identification (as is currently used for plankton and particulate characterisation (Mikkelsen et al., 2005, Sieracki, 2010) and separation and/or development of bulk chemical approaches to provide either an absolute value or an index of extent to which a sediment or water sample is contaminated with microparticles and to indicate the type of particles involved (e.g. polymer type).

The development of filtration systems for the quantification of microlitter particles in water appears promising. Large water volumes can be sampled on filter screens and subsequently analysed using techniques to identify microlitter (e.g. FT-IR). The use of filtration instead of net tows allows the sampling from ships of opportunities through onboard pumping and filtration systems, e.g. also in connection with in-line analytical systems, such as Ferrybox Systems (http://www.ferrybox.org/) in order to provide the necessary metadata.

As this is an emerging field and our understanding of the rates of accumulation of microplastics and the extent to which microplastics might cause harm in the environment is limited. The expert group advocates a precautionary approach and recommends that the development and calibration of methods and initiation of wider scale monitoring should commence straight away. However, this task needs to be guided by developments in our level of understanding about the potential for harm; if new research changes our perspective then this information should be used to help indicate priorities. A key step is therefore to re-evaluate the state of the art at 2016 in terms of the knowledge base on spatial distribution of microplastics, rates of accumulation and the potential for harm; this will inform longer term priorities beyond 2016.

Marine litter monitoring under the MSFD aims to identify trends in the amount of litter and its properties. This includes changes in the relative proportions of litter types in terms of sources and uses. However it is also implicit within the descriptor that this consideration should include trends in the size and shape of particles. There is already evidence that microplastics are widespread, increasing in abundance and that in some locations they are numerically the most abundant type of litter. Hence it is important in our understanding of the fate of litter in the environment and its impacts to establish patterns of degradation of litter and any associated movement of litter between compartments in the marine environment. For example rates of fragmentation of large items of litter in to smaller pieces and how such changes in size influences the potential for transport.

Hence the longer term needs are to gain a holistic understanding of marine litter by integrating data collected from surface waters, seabed, sea shore and biota and by integrating knowledge of temporal and spatial tends across types and sizes of litter; doing so will not only help establish the effectiveness of policy measures to reduce marine litter it will also indicate the priorities beyond 2020.

8. Sources of Marine Litter

8.1 Introduction

In the Commission Decision (2010/477/EU) for Descriptor 10 Marine Litter, sources of litter are referred to in relation to two of the criteria for the descriptor:

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

These criteria are important for source identification as they provide the greatest amount of information on individual litter items that can be linked back to the sources of litter. This is also important for setting Targets and Objectives as, in order to develop operational targets linked to measures, it is important to identify what are the important sources of litter in a (sub) region so they can be addressed.

Identifying the source of many litter items is a complex task as marine litter enters the ocean from point and diffuse sources both land-based and ocean-based, and can travel long distances before being deposited onto shorelines or settling on the bottom of the ocean, sea or bay. Marine litter can be transported indirectly to the sea or coast by rivers, drains, sewage outlets and storm water outflows, road run-off or can be blown there by winds. Land-based sources include tourism and recreational use of the coast, general public litter, fly tipping, local businesses, industry, harbours and unprotected waste disposal sites. Ocean-based sources for marine litter include merchant shipping, ferries and cruise liners, commercial and recreational fishing vessels, military fleets and research vessels, pleasure craft, offshore installations such as oil and gas platforms, drilling rigs and aquaculture sites.

Factors such as ocean current patterns, climate and tides, and proximity to urban centres, industrial and recreational areas, shipping lanes, and fishing grounds also influence the types and amount of litter that are found on the open ocean or collected along beaches and waterways or under water.

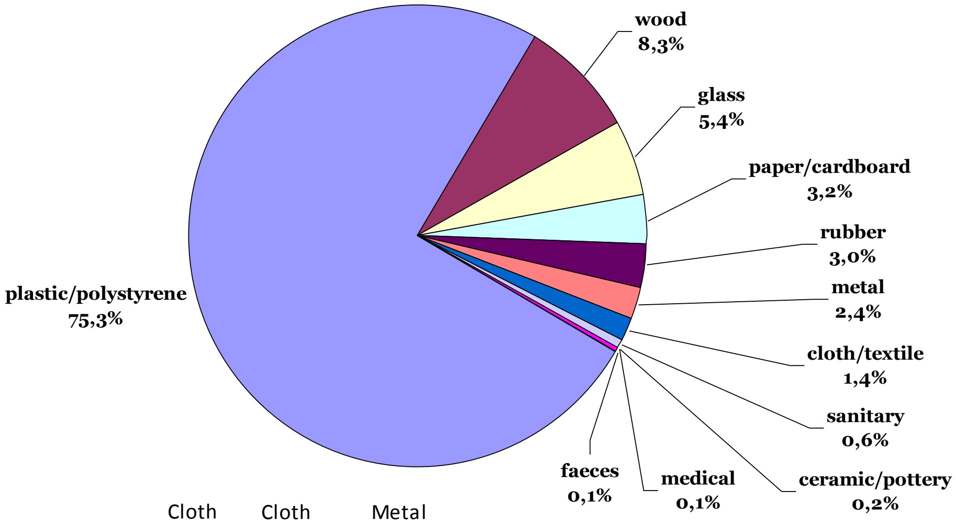
Sources of litter can be characterised in several ways. One common method is to classify marine litter sources as either land-based or ocean-based, depending on how the litter enters the water.

These broad categories can be further broken down into sources such as recreational litter, shipping litter and fishing litter. Some items can be attributed with a high level of confidence to certain sources such as some fishing items, sewage-related debris (SRD) and some tourist litter. Such so called use-categories provide valuable information for setting targets and reduction measures as they are the most easily linked to measures.

The production or the geographical source of litter can also be identified through barcodes and backtracking models. Whilst these types of sources provide additional data, with the increasing globalisation of markets this information is of less use for implementing effective measures and targets than use categories.

International and national legislation prohibits the disposal of all plastics into the sea. Nevertheless assessments of the composition of beach litter in different marine regions, e.g. of the North Sea (Fig. 13a) and the Mediterranean Sea (Fig. 13b) show that synthetic materials make up the largest proportion of overall litter pollution. Plastic litter can take hundreds if not thousands of years to break down, and it may never truly biodegrade. The category plastic includes all synthetic materials. Packaging, fishing nets, pieces of fishing nets and small pieces of unidentifiable plastic and polystyrene make up the majority of the litter items recorded, in this category. However, some synthetic materials are recorded in the litter use-categories “sanitary” and “medical”.

(a)



(b)

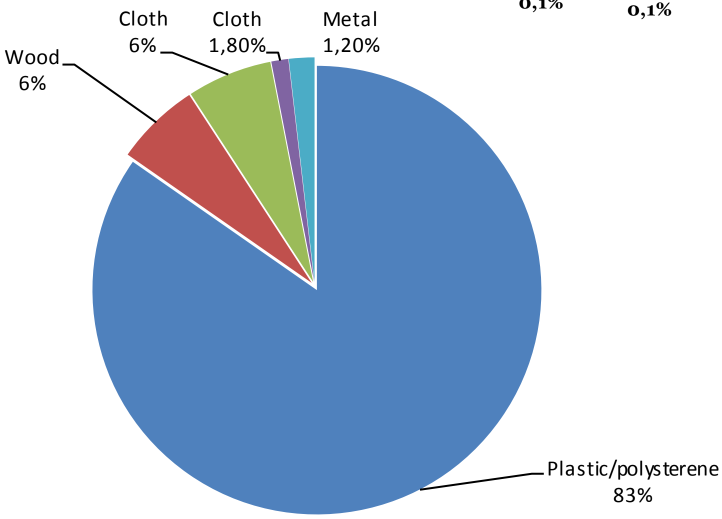


Fig. 13. Composition based on the number of items of marine litter collected during (a) the OSPAR “Beach Litter Monitoring Program” along the southern North Sea coast (2002-2008); (b) the ICC campaign in the Mediterranean (2002-2006).

Information on sources of litter encountered in the water column, on the water surface and deposited on the sea- floor can be obtained from monitoring of litter on the seabed using fishing nets and observations of litter on the water surface from ships or airplanes. Whether or not visual observations from ships and airplanes will provide the necessary detail to define sources is still unclear. Seabed monitoring is likely to use the existing fisheries research trawls, such as IBTS or MEDITS, or divers recording litter items in similar format to the beach litter monitoring with a reduced number of litter items recorded. A common approach to the categorisation of litter in the different compartments is needed.

8.2 Availability of data

For trends in the amount of litter washed ashore and/or deposited on coastlines, beach litter monitoring provides the most comprehensive data on individual litter items. Large data sets are already held by, amongst others, the Ocean Conservancy through their International Coastal Clean-Up (25+ yrs.) the UK's Marine Conservation Society's Beachwatch (18+ yrs.), the North Sea Beach litter monitoring programmes of three German NGOs (20+ yrs.) and the EU OSPAR marine litter monitoring programme (10+ yrs.).

8.3 Regional specific source information

8.3.1 Mediterranean

Even the remotest parts of the Mediterranean are affected by marine litter. The findings of the "Assessment of the status of marine litter in the Mediterranean" (2009) undertaken by UNEP/MAP MEDPOL in collaboration with the Mediterranean Information Office for Environment, Culture and Sustainable Development (MIO-ECSDE), the Hellenic Marine Environment Protection Association (HELMEPA), and Clean up Greece Environmental Organization, illustrate that although useful data on types and quantity of marine litter exists in the region, it is inconsistent and geographically restricted mainly to parts of the North Mediterranean.

Fig. 14. Sources of marine litter in the Mediterranean.

Previous deductions that most of the Mediterranean marine litter is from land-based sources, rather than ships, were confirmed (Fig. 14). Marine litter found on Mediterranean beaches originates from shoreline and recreational activities and is composed mainly of plastics (bottles, bags, caps/lids, etc.), aluminium (cans, pull tabs) and glass (bottles) (52 %, based on item counts). This figure is in line with the global average in the same period (2002-2006). Marine litter from smoking related activities accounts for 40 % (collected items) which is considerably higher than the global average. Recording of litter floating on the surface of the Mediterranean sea verified the overwhelming presence of plastics in the Mediterranean Sea both in terms of number of items observed and mass estimation. Plastics accounted for about 83% of marine litter items, while all other major categories (textiles, paper, metal and wood) accounted for about 17 % (no. of items observed). Beach Clean ups in Greece 2004–2008 (Clean up Greece) revealed that plastics is the major part of litter collected by volunteers in beach areas, followed by paper (MEDPOL, 2010).

Current legal and illegal waste handling practices contribute to the presence of marine litter. The inadvertent release of litter from coastal landfills and garbage from water transports; recreational beach and roadside litter and the illegal dumping of domestic and industrial garbage into coastal and marine waters are practices contributing to the marine litter problem.

Marine litter is enhanced by high numbers of tourists, which visit the region especially in the summer months. In some tourist areas more than 75 % of the annual waste production is generated in summer season. According to statistics from holiday destinations in the Mediterranean tourists generate an average of 10-15% more waste than inhabitants. Regarding beaches, there is a big gap between holiday resorts and public beaches. Whereas private tourist beaches tend to be cleaned regularly, litter pollution on public beaches is seen as a problem.

8.3.2 Southern North Sea

The large diversity of items found on German North Sea coasts and the composition of the litter recorded during the OSPAR-Beach Litter Project, as well as during the German surveys over the period 1991-2002, indicate that shipping, the fisheries industry and offshore installations are the main sources of litter found on German and Dutch beaches (Flee*t et.*

al., 2009). The relative proportions of litter originating from these different sources cannot be determined exactly. The larger proportion of litter recorded on German North Sea beaches certainly originate from shipping with a considerable proportion of this originating in the fisheries industry (Fleet, 2003). This has not changed since the 1980s when Vauk and Schrey (1987) stated that major sources of litter in the North Sea were commercial shipping and fisheries. According to van Franeker and Meijboom (2002) these are supplemented by coastal recreational activities, the offshore industry - although the latter is thought to be a minor source because of strict waste management practices - and litter entering the North Sea by wind, currents, or river-transport from land based sources. Litter also enters the southern North Sea from the English Channel, as records of litter identified as originating on the French Atlantic coast have shown (Fleet, 2003). From the study on Texel in 2005 it was concluded that various indicators show that around 90% of the litter originated from shipping and fisheries (Van Franeker, 2005).

The results of the regional analysis of the OSPAR Beach Litter data indicate that one of the main sources of pollution is the fisheries industry in the form of lost or discarded nets. The data from the Dutch and German beached bird surveys show also that litter from fisheries activities is the main cause of entanglements providing a direct connection between litter discard and environmental infringement.

Various forms of packaging also account for a large proportion of the litter recorded on the OSPAR beaches in the region. So called professional items (nets, rope, oil cans, strapping bands, etc.) accounted for 39 % of the identifiable litter on these beaches and consumer items (bottles, food cans, plastic bags, etc.) for a further 26 %.

During the “Schoon Strand” survey on Texel in 2005 the origin of 119 litter items was identified by registering the language used on labels. The majority of the labels were Dutch (42 %) and large proportions were English, German and French (Fig. 15). As ships can buy supplies in foreign harbours this does not necessarily indicate the state of origin of the people disposing of litter.

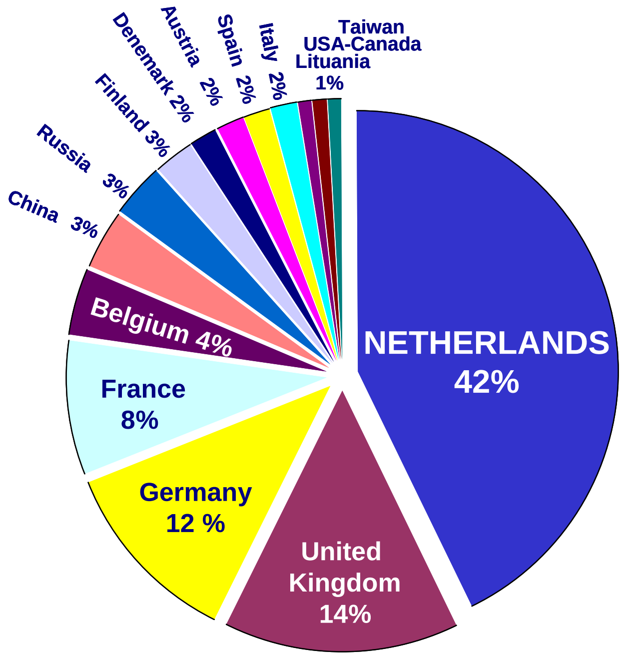


Fig. 15. Proportions of countries of origin as derived from barcodes or label information on litter items found on Texel, April 2005 (translated from Van Franeker, 2005)

8.3.3 Baltic Sea

A marine litter project of HELCOM co-funded by UNEP collected all readily available information on marine litter in the Baltic Sea by searching the literature and contacting relevant organizations who could provide the data on marine litter. The project also distributed a questionnaire in which information was collected on the amounts, types and sources of marine litter in the Baltic Sea countries (HELCOM/UNEP 2007).

Marine litter enters the seas from both land-based sources and from ships and other installations at sea. Marine litter can be brought indirectly to the sea or coast with rivers, sewage, storm water or winds. Recognized sea-based sources for marine litter are shipping (commercial, recreational and other) and fishing industry. Possible land-based sources are riverine transport of litter, tourism or recreational visitors to the coast, landfills and waste dumps located in the coast, sewage overflows and other industrial discharges.

The sources indicated in the study 1994 (Tuomisto 1994) were the following: in the Gulf of Bothnia and in Åland most litter pieces that could be identified originated from cruise liners between Finland and Sweden, and recreational boating. In the western Gulf of Finland the origin of the litter pieces could be recognized from the text on them in almost 30 % of the pieces. The litter was mainly from cargo ships. 40 % of the litter was from Russia and Baltic countries and 21 % was Polish origin. In the eastern Gulf of Finland the biggest part of the litter originated also from shipping industry. Litter pieces from fishing activities were abundant everywhere in the Baltic Sea.

Main land-based source indicated by five countries is tourism and recreational use of the coasts. Fishing by the rivers and intentional waste dumping were also mentioned as major land-based sources for litter. According to the answers given by five countries, major sea-based sources in the Baltic Sea are commercial shipping (fishing boats, cargo ships, tankers, passenger ships) and pleasure craft. The importance as a source varies in different areas of the Baltic Sea.

8.3.4 Black Sea

Marine litter originates from various land- and sea-based sources as a result of manifold human activities. Floating marine litter and marine litter items suspended in the water are transported by currents and winds throughout the sea. Widespread distribution of illegal, unreported and unregulated (IUU) fishing in the Black and Azov Seas can be considered as a peculiar source of marine litter.

The results of aerial surveys suggested that major quantity of marine litter comes to the Russian Black Sea in late spring and early summer. It was supposed that the level of marine litter pollution depends mainly on the river run-off in this area. Just river and rain torrents (which wash down the land-based solid waste) are considered as a principal source/supplier of marine litter in the territorial waters of Russia.

Important data on permanent sources of marine litter have been published by Turkish specialists. Solid waste management is one of the main environmental problems in the Black Sea Region (BSC, 2007). They reported that at the southern coast of the Black Sea most municipal and industrial solid wastes, mixed with hospital and hazardous wastes, are still dumped on the nearest lowlands and river valleys or directly on the seashore or even at sea. Such practice is spread also in Georgia. Most uncontrolled coastal landfills and dumping sites are not protected from waves and, thus, serve as stationary sources of unknown (but admittedly large) quantities of marine litter. The continuing accumulation of solid wastes on the coast may cause a growth of marine litter in the marine environment due to spontaneous removal of the wastes from the dumps into the sea by erosive factors such as waves, rains and winds. At the same time, the sea currents and winds play a role of marine litter dissemination factors contributing to the transport of floating litter. Therefore, the land-based solid wastes continue to constitute major resource of marine litter for the Black Sea in whole. This problem most likely represents transboundary region-wide top priority.

8.4 Microparticles

Although sources for microparticles are not specifically mentioned in the Commission Decision on criteria and methodological standards, some sources are well known and should be mentioned here. This will enable MS to address the problem of microparticles in the marine environment according to the precautionary principle although the scale of pollution resulting, from known sources is as yet largely unknown.

Microparticles are considered as all litter items less than 5 mm in diameter. This size range is known to include plastic pellets used as raw material in the plastics industry, small pieces of plastic resulting from the degradation of larger plastic items in the marine or coastal environment or the shredding of galley waste on commercial ships, small plastic granules used as abrasives in cleaning products and scrubbing agents as well as artificial fibres. It is suspected that that rubber from the abrasion of car tyres on roads, road wear particles, oil and paint remains are also part of the microlitter fraction.

A large part of the microparticles found in the marine environment are the result of degradation due to UV-radiation, mechanical forces in the seas (e.g. wave action, grinding on shorelines), or through biological activity (e.g. boring, shredding and grinding by marine organisms) of larger litter items of all litter entering the marine and coastal environment. The sources of these larger litter items are as diverse as the sources for marine litter in general. A detailed discussion, related to microparticle monitoring can be found in Chapter 7.

8.4.1 Sewage related sources

Plastic granules used in scrubs and abrasives in household and personal care products enter the marine environment via sewage discharge from land and possibly, to a much smaller extent, from sewage from pleasure boats. Sewage is also a source of artificial fibres, which result from abrasion of clothing and other materials during household washing activities. Discharge of macerated wastes, e.g. sewage sludge is mentioned as a source by GESAMP (2010).

A recent study has shown that a major source of microplastic fibres may be particles shed when clothing is washed. (Browne et al., 2011).

8.4.2 Shipping and offshore installations

The sources of plastic pellets and powders, which are transported by ship in bulk, are loss of cargo during transport by commercial shipping and losses during cargo handling in harbours. Food items can be shredded and disposed of at sea and can reportedly contain galley waste items being shredded together with the food waste. Microparticles of paint, probably from the operation of ships have been found in Swedish waters. These can result from maintenance work during operation of the ships at sea as well as in harbours and docks. Offshore installations could also be the source of this type of microparticle. Other possible microparticles from shipping include fly ash from combustion of organic material (soot from shipping exhausts) and particles resulting from oil spills (Norén et al., 2009, 2010).

8.4.3 Run off from land

Shot-blasting of ship hulls and industrial cleaning products respectively, grinding or milling waste via run off and urban wastewater treatment are listed as sources by GESAMP (2010).

Investigations of microparticles in the marine environment in Sweden (Norén et al., 2009, 2010) indicate that other sources of microparticles are road-wear particles (possibly asphalt, bitumen, or mineral fillers) and rubber from the abrasion of rubber tyres.

8.5 Availability of source identification methods

Methodologies for source assessment are mostly based on the identification and reporting of monitored litter. Due to the difference in the monitoring approaches, as e.g. collection on beaches, observation from ship/airplane, dredging from seafloor, the possibilities for identification of objects vary between the different environmental compartments. The group recommends that the categories for reporting should be compatible between different survey types so that outcomes are comparable. A hierarchical structured system, where more detailed information can be given, if available, is therefore recommended and should be developed. It is important that, wherever possible, this system is compatible with existing time series and surveys outside the EU.

The most common method used for beach litter is to count a number of individual items e.g. bottle tops, fishing nets, cotton bud sticks and then assign these to a category e.g. tourism, fishing, sewage related litter.

The OSPAR beach litter surveys record 120 different items that can be used to identify the source category. However one of the difficulties of all data sets is that many items can originate from more than one source and others cannot be attributed to any one source in particular, for example plastic/polystyrene pieces 2.5 cm > < 50 cm. To overcome this issue and to identify trends for source categories OSPAR has identified indicator items that relate directly to a particular source category (see also 9.6). Whilst this does allow trends to be calculated for source categories it needs to be done with care as changing practices within a category might lead to the reduction in the numbers of an indicator item but not the contribution of that category to the overall litter load. For example a change in fishing gear type might lead to the reduction of an indicator item, but not to the overall level of litter attributable to the fishing sector. However, this is still a valuable tool in linking items to sources but should be closely monitored to ensure the indicator items remain relevant.

The above approach does not, however, supply information on the proportion of marine litter originating from a given source. In order to obtain this information, which is important for setting appropriate measures, the following approach is necessary.

The OSPAR ICGML is developing a system of hierarchical litter categorisation, where the main categories are based on material and subcategories are based on source and/or application.

Below is the items list from the OSPAR Beach Litter Programme database, which designates each item, as far as is possible, to different categories of material, application, use and source.

Table 5. OSPAR Beach Litter categorization.

1	Material	Glass, metal, paper/cardboard, rubber, wood, plastic/polystyrene, cloth/textile, sanitary, medical
2	Application	Packaging, user item, other
3	Use	Consumer, professional, other
4	Source	Shipping, fishing, tourism, sanitation, other

Although it is still under development and the terms used may need to be changed or better defined, this will provide information on the proportion/amount of litter originating from a given source. If filled in conscientiously it could enable the analysis of data at the 4 different levels, which could help the targeting of measures.

The table above is constructed for the OSPAR-region as a whole. Ideally it should be filled in at the sub-regional level, because sources for individual items can differ even between sub-regions. This method could also be adapted for other regional seas and their sub-regions as long as care is taken to ensure that results are still comparable.

Categories currently used in monitoring of benthic litter (CEFAS, UK):

A: Plastic	**B: Sanitary waste**	**C: Metals**	**Related size category**
A1. Bottle	B1. diapers	C1. Cans (food)	A: <5*5 cm= 25 cm^2
A2. Sheet	B2. cotton buds	C2. Cans (beverage)	B: <10*10 cm= 100 cm^2
A3. Bag	B3. cigarette butts	C3. Fishing related	C: <20*20 cm= 400 cm^2
A4. Caps/ lids	B4. condoms	C4. Drums	D: <50*50 cm= 2500 cm^2
A5. Fishing line (monofilament)	B5. syringes	C5. appliances	E: <100*100 cm= 10000 cm^2= 1 m^2
A6. Fishing line (entangled)	B6. sanitary towels/ tampon	C6. car parts	F: >100*100 cm = 10000 cm^2= 1 m^2
A7. Synthetic rope	B7. other	C7. cables	
A8. Fishing net		C8. other	
A9. Cable ties			
A10. Strapping band			
A11. crates and containers			
A12. other			
D: Rubber	**E: Glass/ Ceramics**	**F: Natural products**	**G: Miscellaneous**
D1. Boots	E1. Jar	F1. Wood (processed)	G1. Clothing/ rags
D2. Balloons	E2. Bottle	F2. Rope	G2. Shoes
D3. bobbins (fishing)	E3. piece	F3. Paper/ cardboard	G3. other
D4. tyre	E4. other	F4. pallets	
D5. glove		F5. other	
D6. other			

It can be concluded that the reporting of Marine Litter for source attribution needs still further development, as the efficiency of measures towards specific litter categories will have to be verified along the same categories for different environmental compartments.

9. Good Environmental Status, Objectives and Targets

9.1 Introduction

The accumulation of persistent organic pollutants on litter items, and the release of toxic components during the decomposition of synthetic materials, the transport of non-indigenous species by litter, and the capability of marine litter to cause physical damage to habitats through suffocation and abrasion as well as the ingestion of litter by marine animals links Descriptor 10 closely to Descriptors 1 (Biodiversity), 2 (Non-indigenous species), 4 (Food web), 6 (Sea floor integrity) and 8 (Contaminants and pollution effects). Whereas for some Descriptors such as D8 (Contaminants and pollution effects) or D5 (Eutrophication) advanced assessment methods are available and internationally set targets exist, there are some underdeveloped descriptors such as marine litter (D10) or energy (D11), where the ability to quantify impacts is not fully developed, making it hard to set quantitative targets and determine GES at this time.

9.2 Definition of GES

"Properties and quantities of marine litter do not cause harm to the coastal and marine environment."

Building upon the above-mentioned MSFD definition for Descriptor 10, GES could be seen to be achieved, when:

1. Litter and its degradation products present in, and entering into EU waters do not cause harm to marine life and damage to marine habitats.

There is a direct reference to marine litter in the OSPAR North-East Atlantic Environment Strategy: “substantially reduce marine litter in the OSPAR maritime area to levels where properties and quantities do not cause harm to the marine environment.” The MSFD recalls in the preamble, paragraphs 27 and 44 the general principles of EU environmental law that have to be taken into account, in particular the precautionary principle. Establishing and isolating the extent of harm caused by marine litter at a population, community or ecosystem level will be difficult to confirm because of the wide range of factors affecting this level of biological organisation. Hence it is essential to consider harm at the individual level, and estimating the numbers of individuals affected is likely to offer the most feasible and representative conclusions about biological impacts.

While the TSG ML sees its mandate and expertise to deal with the ecological consequences of marine litter, this descriptor is far more than others (with the exception of Descriptor 9) directly related to human health (such as cutting on sharp litter items, entanglement of divers) and socioeconomic issues (such as cleaning of beaches and fishing nets or entanglement of ship propellers). Nevertheless, using the trend indicators as listed in the Commission Decision (2010/477/EU) to observe and assess trends in litter occurrence in the different ocean compartments will also help to predict for socio-economic consequences. The following aspects need to be taken into account by responsible forums, but are directly related to a comprehensive definition of GES for D 10:

2. Litter and its degradation products present in, and entering into EU water do not pose direct or indirect risks to human health.
3. Litter and its degradation products present in, and entering into EU waters do not lead to negative socio-economic impacts.

Additionally a direct link to Descriptor 2 (Introduction of alien species) can be made. While litter has the potential to transport and disperse Alien Species, this impact has not been considered as an indicator under Commission Decision 2010/477/EU.

Reaching GES may thus be understood as a continuous reduction of inputs with the aim to reduce the total amount of marine litter by 2020 towards a level that does not cause harm to the coastal and marine environment. Removal activities will assist in reaching this goal. To achieve GES as described above, some important points have to be considered:

9.3 General considerations for achievement of GES

The definition of baseline, target and initial GES levels must consider the different approaches under discussion and will need decisions at the MS level. Defining GES should be possible on the basis of litter levels in a pristine area (such as the Arctic seas). Calculating a mean litter level for an area could provide a baseline level for evaluating GES and measured trends in litter levels.

The production of litter, especially of plastics, continues to increase. Hence, it will not be possible to reduce litter levels to zero by 2020. The main short-term objective in terms of the implementation of the MSFD for Descriptor 10 consists of the prevention of further input of marine litter into the marine environment.

Economic costs of marine litter include benefits lost to society by the impact of litter e.g. loss of income in tourism, cost to communities for regular cleaning of beaches for the purposes of tourism, the cost of damage to ships and installations, the cost for the fishing industry due to “ghost fishing” (entrapment of marine life in discharged gear) and the cost of coastal clean-ups. A general reduction of marine litter will certainly have positive consequences on the economic sectors affected.

9.4 Indicator specific considerations for achievement of GES

Litter indicators must be considered as part of a general process to evaluate the GES of the marine environment. The MSFD requires a holistic assessment of the impacts of different pressures (such as litter, fisheries, noise, eutrophication, and contaminants) on the different components of the marine ecosystem. More than one indicator will be required to assess GES for litter pollution to cover the different compartments of the marine environment and the different aspects of litter pollution including the damage it causes (e.g. smothering of corals, microplastics in organisms, and entanglement of marine life). Metrics are not yet available for evaluating most of the biological impacts that litter may have. Further research is needed to obtain such metrics. In their absence, trend indicators based on, for example, the amount of litter on the sea floor or on beaches could be considered for evaluating GES. It needs to be determined if additional indicator species can be found for other marine regions (such as sea turtles for the Mediterranean) and which additional ecological impacts need to be covered in addition to ingestion as required by the COM Dec (2010/477/EU) (e.g. entanglement).

The reduction of litter inputs from the sources of origin (domestic, industrial, shipping, and aquaculture activities) in national sea areas will contribute to reaching a regional GES. Although not all introduction pathways have yet been identified, it seems likely that some sources of litter will lie outside national jurisdiction and that the national GES cannot be achieved only through national measures.

The amount of litter present in the different marine compartments is, amongst other things, dependent on regional topography, including sea-bed topography and the prevailing currents, winds and tidal cycles. Increasing knowledge on the amount and dynamics of litter in the marine environment will help to determine whether targets need to be defined at the regional level.

9.5 Setting Environmental Targets

Although sufficient information is available to show negative impacts of marine litter on individuals, it is not generally feasible for assessment systems to provide information on the extent of harm at the population, community or ecosystem level and it is actually unlikely that we can find an assessment system that can show effects at a population or ecosystem level. Therefore a precautionary approach to reducing the impacts of marine litter needs to be introduced in the short-term.

The approach applied could be comparable with the targets for eutrophication and/or contaminants set in the past by the International North Sea conferences and adopted by OSPAR and HELCOM. Analogous to the reductions of nutrient input (political 50 %-goal) and contaminants from riverine inflow (also in the order of 50 % and for four particularly problematic substances 70 %) within 10 years (1985-1995) a first trend-setting (political) target value should now be defined for the reduction of the input of marine litter.

Strategies for Hazardous Substances set by the Fourth International North Sea Conference and adopted by Regional Sea Conventions (e.g. HELCOM, OSPAR, BARCELONA (MEDPOL)) pursue the objective of preventing pollution of the maritime area by continuously reducing discharges, emissions and losses, with the ultimate aim of achieving concentrations in the marine environment near background values for naturally occurring substances and close to zero for synthetic (mad-made) substances as a generation target. These principles could apply to litter, especially plastics which are man-made synthetic substances with hazardous chemical properties that potentially transfer into the food chain. Therefore as an analogous generation target for specific types of marine litter (such as synthetic materials) known to be harmful or damaging marine life and habitats, causing socio-economic impacts and/or risk human health, should no longer occur in the marine environment (e.g. the fourth MSFD assessment cycle in 2030). In order to achieve this, a classification according to the potential harm on different species and habitats for different materials (such as plastics, glass, metal etc.) and litter categories (e.g. nylon nets, plastics from households and industry, sanitary items) needs to be carried out. Even though it is reasonable to say that plastics, as a major part of the problem of marine litter, are completely unnatural, it would not be reasonable to argue that the ultimate goal of the MSFD should be zero percent of plastic in the marine environment. There will always be a residual of earlier pollution that cannot be cleaned, and there will always be some unavoidable accidental spillage. In the OSPAR EcoQO system for the North Sea such remaining levels of pollution have been acknowledged in target definitions. Targets for the different compartments of the marine environment need to be set on the basis of the national initial assessments according to Article 10 of the MSFD depending on the initial level of pollution within the area considered (similar to eutrophication). An appropriate target for clean areas would be the maintenance of this status and for areas assessed to have unacceptable levels of litter pollution to ultimately achieve clean area status.

For litter on beaches, for which appropriate monitoring is already in place in some regions, it is proposed that the reduction goal of the Task Group 10 of a general measurable and significant reduction of marine litter until 2020 is adopted in the first instance.

In setting such targets for reduction of marine litter under the MFSD, it is important to have a perspective of their feasibility. The case of industrial plastics may be indicative. During the mid-1980's beached Fulmars from the Dutch coast had 6.8 ±1.1 industrial plastic pellets in their stomach (average ± standard error; n=69 birds). As such losses are a direct economic loss to the industry, changed methods in production and transport processes resulted in a rapid decrease of industrial granules in the marine environment. By the second half of the 1990s the abundance of plastics in Fulmar stomachs was reduced by almost half to an average of 3.6 ± 0.5 pellets per stomach (1995-99, 222 birds) (Van Franeker et al., 2011). Similar reductions of industrial plastic pollution in seabird stomachs have been reported from the Pacific by Vlietstra and Parga (2002) and from the south Atlantic by Ryan (2008). These changes show that reductions in abundance of marine litter in the order of 50% per decade are a feasible target when adequate measures are taken.

In order to prevent items becoming marine litter, it is important to tackle the problem at the source. In the first two of the four indicators under Descriptor 10 (litter on coastlines, litter in the water column and on the sea floor), sources of litter are referred to. These indicators are important for source identification because monitoring of these compartments of the marine environment will provide the greatest amount of information on individual litter items that can be linked back to sources of litter. In order to develop operational targets, linked to measures, it is important to identify the important sources of litter in a region or sub region so that they can be addressed by appropriate measures.

9.6 Developing Operational Targets

Article 10 of the MSFD, Establishment of environmental targets, provides for environmental targets that will guide progress towards GES. Annex IV of the directive outlines characteristics to be taken into account in the setting of these environmental targets including 2(c) "*operational targets relating to concrete implementation measures to support their achievement*".

The difference between environmental targets mirroring the desired state of the marine environment in terms of the occurrence of marine litter and specific operational targets, which can support the achievement of environmental targets, has to be distinguished. Specific operational targets can help in terms of reduction of the amounts of litter being present or entering the marine environment by tackling the sources. They can be set to assess the effectiveness of measures implemented to reduce input from specific sources such as fishing tackle from fisheries. Operational targets cannot substitute environmental targets, but will be helpful in terms of defining measures. Once measures are implemented, their success must be evaluated. Not only the effectiveness of the individual measures implemented to reduce litter but also the level of any corresponding environmental targets must be evaluated.

So called use-categories, such as fishing or tourism, provide the most useful information for setting targets and reduction measures. For trends in the amount of litter washed ashore and/or deposited on coastlines, beach litter monitoring provides the most comprehensive information on individual litter items. However, one of the difficulties is that many items can originate from more than one source and others cannot be attributed to any one source in particular, for example pieces of plastic and polystyrene, where it is unclear what the original object was, or food wrappers, where they could have come off a vessel or from land. To overcome these problems and to identify trends for source categories, the OSPAR beach litter monitoring programme has identified indicator items, which relate directly to a particular source category, as outlined below.

Table 6. OSPAR Beach Litter source categorization.

Source	*Indicators*
Fisheries, including aquaculture	Jerry cans. Fish boxes. Fishing line. Fishing weights. Rubber gloves. Floats/buoys. Ropes/cords/nets <50 cm, and >50 cm, respectively. Tangled nets/cords. Crab/lobster pots. Octopus pots. Oyster nets and mussel bags. Oyster trays. Plastic sheeting from mussel culture ("Tahitians").
Galley waste from shipping, fisheries and offshore activities *(non-operational waste)*	Cartons/tetrapaks. Cleaner bottles. Spray cans. Metal food cans. Plastic gloves. Plastic crates.
Sanitary and sewage-related waste	Condoms. Cotton bud sticks. Sanitary towels/panty liners/backing strips. Tampons/Tampon applicators.
Shipping, including offshore activities *(operational waste)*	Strapping bands. Industrial packaging. Hard hats. Wooden pallets. Oil drums (new and old). Light bulbs/tubes. Injection gun containers.
Tourism and Recreational activities	4-6-pack yokes. Plastic shopping bags. Plastic bottles/containers for drinks. Metal bottles/containers for drinks. Plastic food containers. Glass bottles. Crisp/sweets packets and lolly sticks.

Beach litter monitoring also provides valuable data on other litter items, which is particularly helpful in developing measures targeting use-categories.

In order to set operational targets, the most important use-categories in each marine region or sub-region must be identified. This information should be contained within the initial assessment developed by each MS. However, as litter monitoring implementation varies greatly throughout the EU, this will be more difficult for some regions than for others.

Therefore operational targets can be used to link measures to sources. As an example, a MS might define as an environmental target for marine litter a general reduction of X % of litter per 100 m of coast or per m^2m^2 of seabed by 2020 or/and a reduction in impacts by X % by 2020 in priority habitats. To ensure that these targets are met it is important to set additional targets that address the main sources in a region or sub region thus contributing to the overall target. For example, if fishing related litter is a major source of litter, a MS might want to develop a target to reduce the number lost fishing gear (see Annex 1) by X %. This could be achieved for example by introducing a measure to mark all fishing gear and retrieve lost fishing gear. As another example cigarette butts from beach visitors (see Annex 5) are a significant source of beach litter in the Mediterranean therefore a MS might want to develop a target to reduce the number found on beaches by X+20 %. This could be achieved by introducing a national measure to raise public awareness or to ban smoking on beaches, for example.

However, some litter items may require a much broader suite of measures to address them. For example, in the OSPAR region, plastic bottles are one of the most commonly recorded items but, as demonstrated in Annex 6, there are many different sources. Therefore to achieve a reduction or target, a regional or EU wide suite of measures would have to be developed and implemented.

In order to restrict litter related to the fishing and shipping industry, which are major sources in some regions, measures such as better schooling of ship crews and correlated work at the IMO level are needed. Recently Annex V under MARPOL was revised with prohibition for any waste disposal at sea from ships and fishing vessels, with some exceptions. Control of any illegal disposal and enforcement of the MARPOL regulations at sea will now be easier and even more important for the reduction of pollution. Under this requirement waste separation on board ships as well waste reception facilities on land will increase in importance. Likewise, the current review of the EC Directive on Port Reception Facilities (2000/59/EC) gives the opportunity to further discourage dumping of ship waste at sea.

One of the difficulties in target setting for some regions will be the lack of data for developing a baseline. Given the variability of litter data, which is influenced greatly by season, weather conditions and water currents, a 5-year running mean is considered appropriate to provide a baseline in terms of an average level of pollution. In some regions, where there have not been any formal litter monitoring programs, this will be more difficult. However, data from NGOs or voluntary monitoring programs are often available and can be used.

In order to be able to set operational targets the important source categories in the region or sub-region must first be identified. This information should be contained within the initial assessment developed by each MS. However as litter monitoring implementation varies greatly throughout the EU this will be more difficult for some regions.

9.7 Examples of potential targets

Indicator 10.1.1: "Trends in the amount of litter washed ashore and/or deposited on coastlines, including analysis of its composition, spatial distribution and, where possible, source."

There is not so much information available in EU marine waters to set quantitative thresholds related to the reduction of marine litter washed ashore and/or deposited on coastlines. Despite this, quantitative reduction targets for beach litter based on the baseline data available from current monitoring programmes should be considered. Despite natural fluctuations (annual variability, effects of storms etc.) that may affect quantities washed ashore, trends and inflicted harm, trend-based targets may be appropriate until the evidence supports other procedures. Data could be derived from existing national and regional monitoring programmes, which could be harmonized at EU level using recently published guidelines (MCS, OSPAR, MEDPOL, HELCOM, UNEP/IOC) on survey and monitoring of marine litter as well as the recommendations made in this report. More work is needed to check local applicability and feasibility (confidence, monitoring implications, spatial scale, etc.); however, the following targets may be considered.

The following are potential targets currently under discussion:

- *[XX%] overall reduction in the number of visible (> 2.5 cm) [new] litter items on coastlines from 2012 levels (as submitted in the initial assessments) by 2020.*
- *[XX%] reduction in the number of plastic/fishing/sanitary litter items on coastlines from 2012 levels (as submitted in the initial assessments) by 2020.*

Indicator 10.1.2: "Trends in the amount of litter in the water column (including floating at the surface) and deposited on the sea-floor, including analysis of its composition, spatial distribution and, where possible, source."

Different protocols enable the evaluation of floating litter but few data have been collected on regular basis. Methods enabling large scale surveys (aerial surveys, camera-based systems etc.) need refining whereas traditional methods (net collection and observations from ships) will restrict GES evaluation and target setting to areas on a local/regional scale. Selected areas will also need to be chosen for the evaluation of shallow waters through diving operations. At the moment seabed litter has only been surveyed at a few sites in the EU and data are sparse, making assessment difficult. The situation is even worse with regard to water column surveys. This means there is insufficient knowledge or criteria to assess impacts and levels on a national or regional seas basis, although new evidence suggests that marine litter accumulates in certain locations due to underlying hydrodynamics. Consequently a trend target is being considered. Data would be derived from monitoring programmes existing and to be established in order to improve the temporal and spatial scale. Opportunistic sampling of seabed litter takes place on the back of on-going fish stock assessment and contaminant surveys. However, the protocols used give limited insight into the full extent of the marine litter problem. The following are potential targets currently under discussion as candidates. More work is needed to check their feasibility (confidence, monitoring implications, spatial scale etc.).

- Overall reduction [XX %] in the number of litter items per square meter on nationally defined affected areas for surface litter

- Overall reduction [XX %] in the number of litter items per square meter on the sea bed as measured by trawling, and by diving in selected shallow waters, from 2012 (as submitted in the initial assessments) levels by 2020.
- Overall reduction [XX %] in the number of fishing related litter items on the sea bed as measured by trawling on shelves and by diving in selected shallow waters, from 2012 (as submitted in the initial assessments) by 2020.

Indicator 10.1.3: "Trends in the amount, distribution and, where possible, composition of micro-particles (in particular micro-plastics)."

This parameter is not currently measured on regular basis and no baseline is available. This means there is at present insufficient information available for most waters to set quantitative or qualitative targets. Before any target can be set, sufficient monitoring should be carried out and a baseline established. Limited spatial data are available from time series derived from Continuous Plankton Recorder (CPR) datasets. However CPR samples at approximately 10 m depth and so will not sample floating debris. Surface and water column sampling with a manta trawl or filtration systems would enable the assessment of its effectiveness at capturing micro-particles at the surface larger than 333 µm. The occurrence of microparticles in sediments must also be considered.

Indicator 10.2.1: "Trends in the amount and composition of litter ingested by marine animals (e.g. stomach analysis)."

OSPAR has defined its target for acceptable ecological quality concerning litter in the North Sea i.e. "less than 10 % of Northern Fulmars should be allowed to have more than 0.1g plastic in their stomach" (undated target for the Greater North Sea). As monitoring species for ingestion elsewhere in EU waters still have to be established, copying the OSPAR EcoQO to GES is not directly possible for areas where fulmars do not occur. Similar to beach litter options and for the time being, it may be better in MSFD to describe GES in terms of e.g. x % annual reduction in the abundance of ingested litter. It is important to quickly find suitable monitoring species and to establish the reference value against which such reduction should be measured.

9.8 Temporal and spatial scale of targets

Due to the long degradation time of many litter categories (plastics, metal, glass and rubber) reduced inputs will, on the short term, possibly not lead to a measurable reduction of total litter levels in the marine environment. However, measurable reductions in at least the floating fraction of intact litter items could be achieved in the short term through appropriate measures. In addition, microplastics are partly introduced directly though cosmetic and cleaning products, as a replacement for sand in sandblasting or in form of pre-production pellets for further processing. A further accumulation of this type of micro-particles can be avoided through appropriate measures, e.g. through substitutions within the products themselves.

Any assessment of marine litter should consider short term variations caused by meteorological and/or hydrodynamic events and seasonal fluctuations which will influence our ability to detect underlying trends. Human activities – such as seasonal tourism or fishing – can also affect GES evaluation and should be taken into account when planning monitoring schemes.

Changes in patterns of production and consumption over the last 30-40 years have led to a significant increase in the use of plastics and synthetics thus changing the nature of litter ending up in the marine environment. Further consideration is necessary with respect to expected future trends in application of plastic products, their impacts, and the effects of regulatory, technological, or social changes. Marine litter and especially some materials such as plastics or metals take a long time to degrade. Even with the ideal scenario of a stop of all inputs it will take a long time before the marine environment is free of litter. Large items degrade into smaller ones, therefore even if all input is stopped and the occurrence of large items decreases, at the same time the abundance of small items could possibly increase. Thus, due to the persistence of some materials the time scales for monitoring of marine litter must be chosen in a way to cover both, times of accumulation as well as recovery.

Consideration should be given as to whether the timescales of observations should therefore be adapted to ensure multiannual frequency of surveying. This is especially true for deep sea areas where evidence suggests litter may be accumulating.

The aggregation of assessments for the evaluation at sub-regional or even regional scale will be different for the various parameters to be considered. For example beached litter surveys can be applied to the European spatial scale while deep sea-floor monitoring is more relevant at smaller scales and over longer periods.

10. Reporting and Data Treatment

The reporting process of data and information under the MSFD (Art 19.3) is being addressed by the Working Group DIKE (Data, Information Knowledge Transfer) and steered by DG ENV with the support of its consultant, MRAG/UNEP-

WCMC/Scott Wilson, and the EEA. The separation between primary data and interpreted information offers a basis for interpreting the Directive's phrase 'data and information' in Art 19.3. The 'information' will be captured in the reporting sheets, whilst the underlying data will largely be made available via other mechanisms, including INSPIRE and EMODNET, with GMES as a potential source of data. Both elements (data and information) will fall under the auspices of WISE-Marine.

The WISE reporting system, managed by the EEA and used for WFD and other water Directives, will have a new element (WISE Marine) to accommodate MSFD reporting. The system is established also as a platform for informing the general public through an initiative to visualise the data and to communicate on the state of the environment (WISE viewer). The integration of marine data and information will be overseen by the WISE Steering Group, which, as from October 18th 2011, has become a joint WISE and WISE-Marine steering group.

The WISE-Marine Implementation Plan is currently being developed, but once the WG DIKE agrees on the content of the reporting sheets, EEA will operate ReportNet, its report management system that stores the information reported under several Directives, in order to receive the data and information from MSFD reporting as well. While the linkages between the different existing data systems relevant for the MSFD (at national, regional or other levels) and how they will operate within WISE are still being defined, WISE is moving towards a distributed network system, with the intention that the data will be held at national level.

Regarding the expectations for 2012 reporting, the Commission is fully conscious that MS have tackled or are tackling the Initial Assessments (IA), the determination of GES and the establishment of targets in different ways. Reporting sheets are therefore being developed to secure coherence between the different elements that MS have to report on (Art. 8, 9 and 10), while allowing for the necessary degree of flexibility to accommodate the different Initial Assessments (IA) that Member States (MS) have produced. Moreover, they will also need to allow the Commission to assess the status of implementation by Member States and comparison across regions.

These reporting sheets are being developed in a phased-approach, as agreed at the second WG DIKE meeting, in 11th May 2011. It was concluded that the debate on the framework and level of detail would best be facilitated through the development of pilot reporting sheets, considering in particular how to quantify and visualise what the pressures and impacts are and distinguishing the minimum information for reporting from other optional elements. The pilot testing of reporting sheets occurred during the summer by a volunteer group of MS (Denmark, Finland, France, Germany, Greece, The Netherlands, UK and Portugal).

The objective of this exercise, based on five reporting sheets representative of the different elements of the Directive (pressures and impacts, state characteristics, GES, targets, regional cooperation), was to achieve agreement on the overall conceptual approach to the reporting system, as well as on the overall structure and content. This would then allow for the development of the remaining reporting sheets in a quicker and smoother way. The outcomes of the draft reporting sheets were presented and discussed during the WG DIKE meeting on 5th and 6th September 2011.

A second, revised version of the reporting sheets will be released in time for the next WG DIKE meeting on 7th and 8th November 2011. The reporting sheet on marine litter was not part of the pilot sheets and therefore it will only be presented and discussed during the November WG DIKE meeting. Comments from both meetings (September and November) will be collected in order to prepare proposals on reporting sheets for the approval of Marine Directors at their meeting on 8th and 9th December 2011.

11. Research Needs

11.1 Research Strategy in support to MSFD Descriptor 10

The MSFD definition of Good Environmental Status and the objectives by 2020 and related monitoring require a thorough understanding of mechanisms and processes associated with litter at sea. This requires considerable research with underlying objectives:

- Clarify any fundamental research gaps required to link quantities of litter and associated harm in the context of GES.
- Within the MSFD context, research must be conducted at the region/sub region to give a scientific and technical basis for large scale monitoring.
- Research must define priority (highly affected) areas.
- Harmonisation and coordination of common and comparable monitoring approaches are required.
- Research will support guidelines to assess GES on a regional/European scale.

11.2 Factors influencing the localisation of litter at sea and on the coast

An important aspect of litter research to be established is the evaluation of links between hydrodynamic factors such as velocity, turbidity, turbulence, density of water masses, residual circulation and other forcing variables. These factors will determine the behaviour of the different types of litter in the marine environment (varying according to nature, size and composition). This will give us a better understanding of transport dynamics and accumulation zones. Close links also exist between the presence of litter in marine environment and the prevailing anthropic, meteorological and geographical conditions. Further development and improvement of modelling tools must be considered for the evaluation and identification of both sources and fate of litter in the marine environment and will include different aspects:

- To identify, evaluate and precise sources of litter, including maritime transport, industrial and urban activities, rivers and diffuse inputs.
- To investigate how, why and by whom litter is disposed of from shipping and the types of ships involved (merchant, navy, fishing, etc.).
- To support calculations, properties (floatability, density, effects of wind, fouling properties, and degradation rates) and behaviour of each large category of litter at sea must be evaluated.
- External constraints such as weather, sea depth, temperature driven variations affecting transport must be evaluated.
- Comprehensive models should define source and destinations of litter regions, estimated residence times and average drift times.
- Drift calculations will differ between different types of material being exposed to wind, wave and current forces in different ways. Drift simulations should comprise all situations and time scales, including backtrack simulations.
- Patterns of regional connectivity in the sense that certain receptor regions are particularly exposed to litter. This must include cross borders transportation.
- Establishment of numerical beach-litter hindcast/forecast models
- Geomorphologic factors (e.g. slope, canyons, bays, capes, beaches) are key elements determining litter distribution and must be studied in more detail because they will affect the fate and accumulation rate of litter on the seafloor. Furthermore sedimentation will determine the rate of smothering and must be considered when evaluating litter sinks.
- Finally, accumulation areas of importance (closed bays, gyres, and specific deep sea zones where litter accumulates) must be identified in MSFD region/sub regions.

11.3 The degradation process

The persistence through time is key characteristic of some forms of marine litter. We need a better understanding about rates of degradation of litter in the environment and this should include examination of so called "biodegradable" materials with enhanced degradation properties as there is concern they may break down into non degradable fragments. Microlitter particles are a recently described phenomenon and our knowledge of the accumulation and environmental consequence of this material are relatively limited. Research has shown that microlitter particles of a range of common polymers are present on shorelines worldwide and that the abundance of this material has increased significantly in the water column in recent decades. It seems likely that this material is accumulating as a consequence of the fragmentation of larger items of litter together with direct inputs of small particles. It therefore seems likely that the quantity of microlitter in the environment will continue to increase even if inputs of larger items of litter begin to decline. Further research needs then to be undertaken in order to:

- Evaluate rates of degradation of different types of litter (plastics, degradable materials, bio plastics, etc.) and related leachability of pollutants.
- Lower detection limits: Develop appropriate methodology to quantify nanoparticles.
- Understand fate and effects of litter related chemicals (Phthalates, bisphenol A, etc. in marine organisms), establish environmental consequences.
- Identify sources for direct inputs of industrial and personal hygiene products related microlitter particles.
- Establish the environmental consequences of microlitter to establish potential physical and chemical impacts on wildlife, marine living resources and the food chain.

11.4 The ecological impact on marine organisms

Studies are needed to quantify the impact of marine litter on marine organisms at a population and community level. Ingestion of, and entanglement in marine litter may be important mortality factors for many marine species. However, there is a lack of knowledge of effects at the population level. There are a few studies demonstrating that entanglement in marine litter is a serious mortality factor for some marine species. There are also a few studies trying to quantify the population level effect of ghost fishing (see Annex 4.). However, these studies are not estimates of litter-related mortality for the vast majority of affected species. Understanding the ecological impact of litter on marine organisms and ecosystems will need upstream research, relating quantities of ingested litter to lethal or sublethal effects and modelling effects under different environmental conditions. Further research needs then to be undertaken in order to understand:

- How litter ingested by marine organisms affects their physiological condition and chemical burdens, reduce survival and reproductive performance and ultimately affect their populations or communities.
- How litter may affect habitats, directly or indirectly.
- The validation and/or transposition of target species for monitoring effects of litter ingestion and entanglement along the European coasts is required.
- Link the impact of ingested litter to the amount of litter at sea.
- Identify biological communities living in the "Litter ecosystem". Evaluate the risk for transportation of invasive species.
- Study dose/response relationships in relation with types and quantities of marine litter to enable science based definition of threshold levels. Develop models enabling simulations scenarios.

11.5 The socio economic impact

Anthropogenic inputs may have changed and sources are maybe shifting between tourism fishing, shipping and marine industry. More research towards a clear evidence base is necessary to ensure efficient policy decisions. It is essential that common methodologies are developed to collect both social and economic data. This must be addressed to develop comparable datasets for evaluation at the EU level. The evaluation of direct costs and loss of income to industry and local authorities should be evaluated on a yearly basis and using harmonized protocols with overall responsibility for marine litter, as part of a national marine litter strategy in each MS. In relation to the economic costs of marine litter, further research needs then to be undertaken in order to:

- Evaluate the potential loss of income due to beach litter in relation to tourism.
- Evaluate the potential loss of fish stocks due to abandoned and lost fishing gear.
- Evaluate direct costs to industry, local authorities and governments, to ecosystems goods and services.
- Assess socially acceptable levels of marine litter to the public and industry.
- Improve tools such as GIS, socio-economic models etc. enabling evaluation of sources of litter, social impact and contributing to management efforts.
- Establish the impact of marine litter on human health.
- Develop an indicator for the aesthetic impact of litter.
- Understand the effectiveness of measures intended to reduce the amount of marine litter.

11.6 Novel methods and automated monitoring devices

Repeatability, optimisation, robustness and reliability of methods will require further research to develop large scale measurements and rapid interpretation of litter data. Further research needs then to be undertaken in order to:

- Litter floating on the sea surface recorded trough aerial surveys need to be further developed before data can be used for monitoring purposes especially for litter conglomerates.
- Develop high resolution geo-referenced images and consider the future high resolution satellite images and other approaches using automated image analysis that may offer a high quality platform for surface litter monitoring at sea.
- Develop automated monitoring systems (ship-based camera monitoring, Stationary platforms transferring images, etc.).
- Develop automated samplers and measuring devices (FITC detectors of polymers) to quantify microlitter in water and sediment samples. Simultaneous quantification of micro and larger items in surface and subsurface must be considered.
- Develop technologies (acoustics) to detect derelict fishing gear at sea.
- Harmonize the tools for geostatistics of social sciences with those of oceanographical sciences.

11.7 Rationalisation of monitoring

There is a need to further increase coverage of survey sites, further development of data analysis and quality insurance in all regions. There are currently no coordinated national or regional monitoring programmes for surface water, water column, seabed or microparticles within Europe. This must be done as part of existing programs (e.g. Water Framework

Directive (2000/60/EC), International bottom trawl surveys, CPR, regional monitoring programs) but this would require further development:

- **Develop comparable and coherent monitoring standards and baselines, harmonize protocols within MS**
- Precise Temporal/spatial scales for the MSFD indicators.
- Transpose reliable protocols from one to other regions/sub regions (Fulmar EcoQO) including intercalibrations between regional and overlapping indicators species.
- Set up a data management system, quality assurance.
- Evaluate new approaches for monitoring (smart phones observations/ counts by citizens, litter evaluation by satellites, etc.).

11.8 Recommendations for research priorities

The implementation of the Marine Strategy Framework Directive is a long term process with the goal of achieving good environmental status by 2020. Research to underpin this will have to be engaged quickly in particular to support the start of monitoring by 2014.A number of short term priorities can be identified:

1) Behaviour (floatability, density, effects of wind, fouling, degradation rates) and factors affecting the fate of litter (weather, sea altitude, temperature driven variations, slopes, canyons, bays, etc.) affecting transport must be evaluated.
2) Comprehensive models should define source and destination regions of litter (especially accumulation areas, permanent gyres, deep sea zones), estimated residence times, average drift times and must consider transborder transportation, from/to MSFD region/sub regions.
3) Evaluate rates of degradation of different types of litter, quantify degradation products (to nanoparticles) and evaluate environmental consequences of litter related chemicals (Phthalates, bisphenol A, etc.) in marine organisms.
4) Identify sources for direct inputs of industrial microlitter particles.
5) Establish the environmental consequences of microlitter to establish potential physical and chemical impacts on wildlife, marine living resources and the food chain.
6) Evaluate effects (on metabolism, physiology, on survival, reproductive performance and ultimately affect populations or communities).
7) Evaluate the risk for transportation of invasive species.
8) Study dose/ response relationships in relation with types and quantities of marine litter to enable science-based definition of threshold levels.
9) Evaluate direct costs to industry, fishing industry, local authorities and governments to ecosystems goods and services.
10) Develop automated monitoring systems (ship-based cameras, microlitter quantification etc.) and impact indicators (aesthetic impact, effects on human health, and harm to environment).
11) Rationalisation of monitoring (standards/baselines; data management/quality insurance; extend monitoring protocols to all MSFD sub regions)

Amongst these priorities, point 10 and 11 are critical for monitoring.

12. Conclusions and general roadmap

12.1 Conclusions

The implementation of provisions under MSFD Descriptor 10 as described in the Commission Decision (2010/477/EU) is in its first step depending on the availability of appropriate monitoring tools. The group has investigated the monitoring approaches for marine litter and provides a list of currently 15 monitoring tools which could be considered for that purpose:

Table 7. Identified tools for Marine Litter assessments

MSFD Indicator	Tool Code	Tool name
10.1.1	10.1.1_T1	Beach Litter
10.1.1	10.1.1_T2	Beach Mesolitter
10.1.2	10.1.2_Water T1	Surface observation from Ship
10.1.2	10.1.2_Water T2	Surface observation from Air
10.1.2, 10.1.3	10.1.2_Water T3	Surface net trawl survey
10.1.2	10.1.2_Seafloor T1	Seafloor Shallow _Plot Sampling
10.1.2	10.1.2_Seafloor T2	Seafloor Shallow _ Distance Sampling
10.1.2	10.1.2_Seafloor T3	Seafloor trawl
10.1.2	10.1.2_Seafloor T4	Seafloor sub
10.2.1	10.2.1_T1	Fulmar
10.2.1	10.2.1_T2	Shearwater
10.2.1	10.2.1_T3	Sea turtle
10.1.3	10.1.3_T1	Microlitter Intertidal Sediment
10.1.3	10.1.3_T2	Microlitter Subtidal Sediment
10.1.3	10.1.3_T3	Microlitter CPR

There are gaps in the regional applicability and differences in the maturity of some tools. There is need for further harmonization and collaborative activities in order to allow EU MS the future reporting of environmental trends and thus the verification of measures against marine litter.

Marine Litter monitoring under the MSFD is aiming at the detection of trends in the amount of litter. It can be assumed that through collective harmonization efforts the quality of available data will increase and the necessary feedback between implemented measures against the introduction of marine litter and the quantities measured at sea will be possible.

This will require on-going efforts for common basic strategies, data quality assurance and control as well as a common database which allows the evaluation of data at regional scale. The close collaboration with neighbouring, also non-EU countries will be of prime importance for reduction of marine litter.

During its mandate, the TSG Marine Litter has provided information on most of the issues requested. The needs for further activities in preparation of the MSFD Descriptor 10 implementation have been identified. While these longer term development needs have been treated in the according roadmap chapters for the different issues, a number of items with short terms priority has been identified as part of a roadmap 2012 and listed in the following chapter.

12.2 Roadmap 2012

The MSFD TSG Marine Litter has identified potential priority work items for support to the implementation of Descriptor 10 during 2012:

Monitoring strategies

While monitoring tools have been identified, the selection of monitoring sites and timing should also be subject to a harmonized approach across regions and EU. There is need to develop recommendations for spatial, including also off-shore areas and temporal distribution of monitoring efforts across the different indicators.

Monitoring implementation

The implementation of marine litter monitoring tools needs a common approach on EU level. The available tools are now being further refined and this should be accompanied at EU level for issues such as protocol availability, data quality assurance and control, comparability of results and integration of marine litter monitoring with other monitoring efforts.

New monitoring tools

While a basic set of tools for monitoring marine litter is available, commercial and research activities provide new options, which should be evaluated at EU level in order to help MS to harmonize their implementation.

Costs related to monitoring

Across all indicators the related monitoring costs should be estimated. This would include the costs of sampling, also using platforms of opportunity, reporting networks and analysis.

Harm

There is no final consolidated common understanding about what is harm in regard to marine litter and how it can be assessed within the MSFD implementation. There is a need to collect and assess evidence and approaches for harm assessment done currently at research level.

Harmonized protocols for assessments

There are environmental impacts which are not being recommended for monitoring under the current MSFD indicators, but which are encouraged for pilot monitoring. In order to ensure these surveys are coordinated and coherent from the outset, common protocols for EU wide assessments are needed.

Examples are:

- Protocols for entanglement
- Protocols for litter ingested by fish

Litter categories

The development of a common reporting system for categories of marine litter harmonized between different indicators is needed. This should be done in close collaboration with the Regional Sea Conventions.

Sources

The identification of sources through monitoring must be further enhanced. Technical options, including backtracking modeling should be evaluated and communicated.

Sources weighting

The evaluation of source strengths should be harmonized and an approach should be developed.

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Annex 1. Terms of Reference for the Technical Subgroup on Marine Litter (TSG ML)

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
ENVIRONMENT
Directorate D – Water, Chemicals and Cohesion
ENV.D.2 - Marine

Document WG GES
DOC 2
(Agenda point 3)

Brussels, 22 October 2010

DRAFT
Terms of Reference for the Technical subgroup on underwater noise and marine litter - Version 5 October 2010

Organisation of the Technical subgroup on noise and litter

i) EU level process

The implementation of the Marine Strategy Framework Directive is assisted, at EU level, by:

- the development of more detailed elements on some key aspects of the Directive, including the criteria and methodological standards for the GES descriptors. The Directive includes provisions for these to be agreed through a procedure involving a Regulatory Committee (MSFD Art. 25);
- complementary activities which Member States and the Commission agree to undertake to facilitate implementation.

In February 2009, Member States and the Commission agreed to work in an informal structure, the Common Implementation Strategy, which consists of

- Marine Directors
- Marine Strategy Coordination Group
- Working Group on Good Environmental Status
- Working Group on Data, Information and Knowledge Exchange
- Working Group on Economic and Social Assessment

After the Draft Decision on criteria and methodological standards on good environmental status of marine waters was developed received the positive opinion of the Regulatory Committee in May 2010, the Marine Directors agreed to establish one technical subgroup under the WG GES for further development of the descriptors noise and litter. After discussion at the WG GES, the draft ToR will be presented to the Marine Directors at their next meeting.

The work of the technical subgroup on litter and noise will be reported to the Working Group on Good Environmental Status where all relevant actors (Member States, neighbouring countries, international organisations such as regional sea conventions and marine scientific organisations, stakeholder organisations) can provide structured feedback. This is the main forum where the outcomes of the subgroups' work are addressed for further approval in the working structure described above.

ii) Organisation of the work of the technical subgroup

Setup of the technical subgroup (TG)

The technical subgroup consists of persons who can attribute scientific knowledge and experience to the group.

Combining two work fields

Noise and litter are to a large extent two different work fields with each its own constituency. The pressure from litter originates from maritime activities and from land-based activities. The impact of litter is linked to contaminants, to the food web and to marine organisms which indigested small particles. The pressure by underwater noise comes mainly from shipping, surveys, exploration and exploitation and building activities at sea. The impact of noise is mainly to marine mammals and possibly fish larva's. Because the different nature of these two issues , the technical subgroup will consist in practice of two parts: one for litter, one for underwater noise (and other forms of energy). The meetings will be held back-to-back to ease organizational matters.

Membership

The Member States and the stakeholders decide on the partipation of members to the technical subgroup. In doing so, it is recommended that they take into account, where practicable, the following criteria:

a. Demonstrated expertise applicable to the task,

b. Demonstrated experience in providing practical scientific advice,

c. Ensuring the range of expertise necessary for the task

In addition, one objective would be to ensure the range of regional knowledge necessary for the task. The participation of experts from regional organisations (HELCOM, OSPAR, Barcelona, and Bucharest) is particularly important, as well as other competent organisations (e.g. IMO, MAP), NGO's (e.g. KIMO, Seas at Risk) and industries (e.g. OGP, Plastic Europe).

Chairing the meeting

The Netherlands and the UK are willing to co-chair the work on underwater noise. France, Germany and JRC offered to co-chair the subgroup on marine litter. Both ICES and JRC have shown interest in participating in the subgroups as a continuation of their task in developing the technical reports on the various MSFD descriptors.

The work and meetings of the technical subgroup

Most of the work of the technical subgroup will be by correspondence, the exact nature of this will be decided within the technical subgroup. The technical subgroup will have a maximum of two physical meetings during 2011, to ensure work is planned and coordinated efficiently.

Additional to their involvement in the management of the process, the Commission will address with the JRC the possibility of an assessment of what information is available with regard to marine litter, having regard to the four identified indicators in the Decision on criteria and methodological standards on Good Environmental Status.

On 29th September 2010 MS and stakeholders were invited to appoint experts for the two technical subgroups on underwater noise and marine litter.

Related activities in the field of litter

ICES is organizing on 2-4 November 2010 a joint MEDPOL/Blacksea/ICES workshop on marine litter. In the ToR of this workshop

- Review the status of Marine Litter based on the work done by the Task Group on Marine Litter which provided scientific input to the European Commission for the Marine Strategy Framework Directive and the Commission (draft) decision on criteria on good environmental status under Article 9(3) of the MSFD.
- Identify existing data on marine litter
- Identify on-going data collection on marine litter
- Describe data needs for future assessment of marine litter (taking into account the Commission Decision)
- Consider standards for recording of marine litter
- If relevant, prepare draft ToRs for a Study Group on marine litter

The technical subgroup on marine litter can build upon the result of this workshop. Therefore, the first meeting of the technical subgroup on litter will be held on the afternoon of 4th November in Copenhagen after the closure of the ICES workshop.

Observers

Representatives of the Regional Seas Conventions (HELCOM, OSPAR, Barcelona, and Bucharest) will be invited to appoint one observer to follow the work of the technical subgroup.

TERMS OF REFERENCE OF THE TECHNICAL SUBGROUP

The technical subgroup will address the following issues:

2.1 Marine Litter:

1. **Identify and review existing data and on-going data collection on marine litter**

In the Decision on criteria and methodological standards on GES, 4 indicators have been identified:

- Trends in the amount of litter washed ashore and/or deposited on coastlines, including analysis of its composition, spatial distribution and, where possible, source (10.1.1)
- Trends in the amount of litter in the water column (including floating at the surface) and deposited on the sea-floor, including analysis of its composition, spatial distribution and, where possible, source (10.1.2)
- Trends in the amount, distribution and, where possible, composition of micro-particles (in particular micro-plastics) (10.1.3)
- Trends in the amount and composition of litter ingested by marine animals (e.g. stomach analysis) (10.2.1).

For each of these indicators, the existing data and on-going data collection will be identified and reviewed.

2. **Describe data needs for future assessment of marine litter**

Based on the required data and the available data, an advice on the need for data for future assessment can be made. Geographical and temporal distribution of the data needs should be taken into consideration.

3. **Consider standards for recording of marine litter**

For the monitoring of litter at the coast, guidelines have been developed and are in place in most regions of Europe. For the monitoring of litter in the water column, including micro plastics, pilot methods are available (trawling, video mapping, algae monitoring). The subgroup will develop proposals for the standardization of monitoring litter in the water column including floating litter and deposited on the seas bed. Regional hydrographical conditions will be taken into account.

4. **Proposals for the development of impact indicator for each of the regions**

In the North Sea, an indicator which expresses the impact of marine litter is available. This indicator measures ingested litter in Nordic Fulmar. Similar indicators for other regions need to be developed. The subgroup will develop proposals for such indicators.

5. **Objectives and targets**

The technical subgroup provides a common platform for addressing how to develop objectives (characteristics of GES), environmental targets and associated indicators in relation to marine litter. This common reflection can then be taken further within each marine region and subrgion (where possible in the context of regional sea conventions) and at national level.

6. **Research needs**

There is still a need for further development of several indicators, notably those relating to impacts on marine life, degradation processes at sea, the study of litter-related micro particles, the study of chemicals associated with litter, the factors influencing the distribution and densities of litter at sea (human factors, hydrodynamics, geomorphology etc.) and the determination of thresholds. The assessment and monitoring of socio-economic harm will also need to be addressed.
The subgroup should recommend proposals for further research priorities in this respect.

2.2 Underwater noise and other forms of energy

1. **Identify and review existing data and monitoring methods on underwater noise**

The work should be based on a review of experiences within MS for different sources and the knowledge within the scientific community in this field. It should be related to the two identified indicators in the Commission decision:

- Proportion of days and their distribution within a calendar year over areas of a determined surface, as well as their spatial distribution, in which anthropogenic sound sources exceed levels that are likely to entail significant impact on marine animals measured as Sound Exposure Level (in dB re 1μPa^{2}·s) or as peak sound pressure level (in dB re 1μPa$_{peak}$) at one metre, measured over the frequency band 10 Hz to 10 kHz (11.1.1)
- Trends in the ambient noise level within the 1/3 octave bands 63 and 125 Hz (centre frequency) (re 1μPa RMS; average noise level in these octave bands over a year) measured by observation stations and/or with the use of models if appropriate (11.2.1).

2. Develop proposals for methodological standards to monitor loud impulsive sounds

The proposed methodological standard must be feasible and implemented with reasonable efforts. It should describe what type of instruments to be used for which frequencies, how to monitor Source Level and Exposure Level, sampling method, filtering, statistical analysis methods, etc. The proposal should take into account differences in physical features in the European seas with respect to configuration, depth, morphology.

3. Develop proposals to monitor low frequency continuous sounds

The proposed monitoring must be feasible and implemented with reasonable efforts. It should describe what type of instruments to be used for which frequencies, how to monitor Source Level and Exposure Level, sampling method, filtering, statistical analysis methods, etc. But also other methods including the use of models to develop ' sound maps' need to be considered. The proposal should take into account differences in physical features in the European seas with respect to configuration, depth, morphology.

4. Assess the need to develop indicators for other forms of energy

Underwater noise has been highlighted though out the Directive and also in the Decision on criteria and methodological standards on GES. But also the other forms of energy such as thermal energy, electromagnetic fields and light need to be assessed. Questions need to be answered such as: What are the potential impacts? How to monitor the pressure? Is there a need to develop this into a GES indicator? What are appropriate indicators?

5. Objectives and targets

The technical subgroup provides a common platform for addressing how to develop objectives (characteristics of GES), environmental targets and associated indicators in relation to underwater noise and other forms of energy. This common reflection can then be taken further within each marine region and subregion (where possible in the context of regional sea conventions) and at national level.

6. Research needs

Additional scientific and technical progress is still required to support the further development of criteria related to this descriptor, especially in relation to the impacts of relevant noise and frequency levels on marine life.

REPORTING

Interim reports will be required prior to the meetings of the WG on GES. These brief reports should indicate the status of the subgroup work. The final report by itself can be short. It should explicitly address the issues identified in the ToR. The substance of the work will be in annexes; these can be much more detailed.

Annex 2. Members of the Technical Subgroup on Marine Litter (TSG ML)

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Annex 3. Summary tables of marine litter monitoring data in Europe (Results from questionnaire survey by MSFD TSG Marine Litter)

Table 1. Availability of beach litter monitoring data in Europe.

Methodological description	No of surveys (transect length)	Country (-ies) involved	Organisation running the surveys	Area description	Data amount	Start - end of programme	Monitoring frequency	Survey timing
Beach litter; transect survey	432 (74 m-1627 m)	SI	Republic of Slovenia Ministry of the Environment and Spatial Planning	Slovenian coast	24 samplings x 18 transects x 3 categories	1/1/2009-12/1/2010	1/month	
Beach litter	7	RO	Mare Nostrum	95% of coast beween Navodari and Vama Veche		2004-ongoing	1/year	
Beach litter; transect survey	ca. 1800	DE	Schutzstation Wattenmeer e.V.	German North Sea coast of Schleswig-Holstein	ca. 355000	1992-ongoing	12-15/winter	Every two weeks in the period September to April
Beach litter; transect survey	ca. 2500	DE	Schutzstation Wattenmeer e.V.	German North Sea coast of Schleswig-Holstein		1993-ongoing	14-15/year (winter) with the exception of Westerhever where counts are irregular	Every two weeks in the period September to March
Beach litter; transect survey	ca. 1000	DE	Verein Jordsand zum Schutze der Seevögel und der Natur e.V.	German North Sea coast of Hamburg	ca. 235000	1980, 1983, 1989 & 1991-ongoing	10/month	Surveys every three days in the period May-September on 100 m transects
Beach litter; transect survey	ca. 2700	DE	Der Mellumrat	German North Sea coast of Niedersachsen	ca. 601000	Mellum North and Mellum South: 1991-ongoing; Minseneroog: 1995-ongoing	Mellum North and Mellum South: 10/month from 2003 4/month Minseneroog: 4/month	Mellum North & Mellum South: surveys every three days from 2003 1/week mostly in the period March-October on 100m – Minsener Oog West once a week on 100m mostly in the period March-October
Beach Litter	8 (500 m)	Countries bordering the Baltic Sea	WWF			1998-2005		

Methodological description	No of surveys (transect length)	Country (-ies) involved	Organisation running the surveys	Area description	Data amount	Start - end of programme	Monitoring frequency	Survey timing
Beach litter; transect survey	3 (100 m)	DE	NABU	German Baltic Coast of Schleswig-Holstein (Island Fehmarn)		2011-ongoing	4/year	Surveys in spring, summer, autumn, and when possible in winter
Beach litter; transect survey	12	DE	Verein Jordsand zum Schutze der Seevögel und der Natur e.V.	German Baltic Coast of Schleswig-Holstein		1986; 1996	6/year	
Beach litter; transect survey	6	Countries bordering the Mediterranean Sea	ICC and National NGO's	Coastal areas of Mediterranean countries		2002-2006		
Beach litter; coastal cleanup	22	EL	Cleanup Greece (Greek NGO)	Beaches in Greece		2000-2010	15/year	Every June
Beach litter; transect survey	400	UK	Marine Conservation Society (MCS)	The UK Coast including Scotland, England, Wales, Northern Ireland, Channel islands, Isle of Man, and some Republic of Ireland sites	400	1994-ongoing	4/year/beach	
Beach litter; transect survey	54 (150 m)	SI	ECOVITAE, Slovenia	Slovenian coast	6 x 33 = 198	2007	1/month	
Beach litter; transect survey	63 (150 m)	SI	Republic of Slovenia Ministry of the Environment and Spatial Planning	Slovenian coast	7 samplings x (77+5) categories=574	2010-ongoing	1/month untill May 2011; 1/2 months May 2011 onwards	
Beach litter; transect survey	ca. 570 (1000 m)	BE, FR, DE, IE, NL, PT, ES, UK	OSPAR programme	NE-Atlantic	ca. 60,000	2002-ongoing	3-4/year	Surveys in spring, summer, autumn, and when possible in winter

Methodological description	No of surveys (transect length)	Country (-ies) involved	Organisation running the surveys	Area description	Data amount	Start - end of programme	Monitoring frequency	Survey timing
Beach litter; transect survey	ca. 900 (100 m)	DE (2002-), NL (2001-), ES (2001-), UK (2001-), BG (2002-2006), DK (2001-2006), PT (2002-2006), SE (2001-2009), FR (2006), IE (2008; 2009)	OSPAR programme	NE-Atlantic	ca. 500000	2001-ongoing	3-4/year	Surveys in spring, summer, autumn, and when possible in winter
Underwater and shoreline cleanup	1741 in 2010 (numbers change annually)	85 countries in 2010 (numbers vary annually)	Project AWARE Foundation		Data from 1741 sites	1993 with PAF data passed onto Ocean Conservancy. Project AWARE Foundaiton have kept the data reported by its volunteers only for 2009 and 2010	1/year	Different areas every year

Table 2. Availability of surface/water column marine litter monitoring data in Europe.

Methodological description	No of surveys (transect length)	Country (-ies) involved	Organisation running the surveys	Area description	Data amount	Start - end of the programme	Monitoring frequency	Survey timing
Surface litter; trawl survey	107 tows of # 40 000 m2	FR, UK	IFREMER	Eastern Channel	83 in 1998, 107 in 2010	1998, 2010-ongoing	107 in 2010	Autumn
Surface litter; trawl survey	1	UK (FR, BE, NL, DE)	CEFAS	North Sea, Channel and Irish Sea	more than 100 stations	2011-ongoing	1 study	Winter period (Feb-March)
Floating litter; count survey	40-50 counts	IT, FR	Ecocean		40-50 counts	2006-ongoing		Different areas every year
Floating litter; aerial survey		DE	FTZ Westküste	German North and Baltic Sea areas	In period 2002-2006 ca. 48000 km North Sea - 36000 km Baltic Sea	2002-ongoing		
Fishing for litter		DE	NABU	German Baltic Coast of Schleswig-Holstein		2011		

Table 3. Availability of sea floor marine litter monitoring data in Europe.

Methodological description	No of surveys (transect length)	Country (-ies) involved	Organisation running the surveys	Area description	Data amount	Start - end of the programme	Monitoring frequency	Survey timing
Underwater and shoreline cleanup	1741 in 2010 (numbers change annually)	85 countries in 2010 (numbers vary annually)	Project AWARE Foundation		Data from 1741 sites	1993 with PAF data passed onto Ocean Conservancy. Project AWARE Foundaiton have kept the data reported by its volunteers only for 2009 and 2010	1/year	Different areas every year
Sea floor litter; trawl survey	One/multiple annual surveys since 1992	UK (FR, BE, NL, DE)	CEFAS	North Sea, Channel and Irish Sea	More then 100 stations	1992-ongoing	1 cruise from 1992-1999, 2 from 2000-2009, 6 from 2010-	All year round
Sea floor litter; trawl survey	103 tows of #40 000m2	FR, UK, IE	IFREMER	Bay of Biscay, Celtic sea	90 tows in 1998, 103 tows in 2010	1994, 1998, 2010-ongoing	103 in 2010	Autumn

Methodological description	No of surveys (transect length)	Country (-ies) involved	Organisation running the surveys	Area description	Data amount	Start - end of the programme	Monitoring frequency	Survey timing
Sea floor litter; trawl survey	88 tows (3-50 000 m2)	FR	IFREMER	Gulf of lion, East Corsica (continental shelves of the French Mediterranean)	88 tows every year	1994-ongoing	88/year	Every May/June
Sea floor litter; trawl survey	4	EL	University of Patras, Greece	Four Greek Gulfs (Patras, Corinth, Echinades and Lakonikos)	54 hauls	2000-2003	Annually from May to October	
Sea floor litter; trawl survey	79	DE	R&D Project of UBA	German territorial waters		1983-1988		
Sea floor litter; trawl survey	ca. 2500 trawls, 23 sites	DE	AWI Bremerhaven	German territorial waters		Since 1990 (1992 additional sites in Waddensee)-ongoing (Waddensee)	1/year	
Sea floor litter; trawl survey	14	TR	Istanbul University	Western part of the Turkish Black Sea coast	4 hauls in 2007, 10 in 2008	2007-2008	4 in 2007, 10 in 2008	Oct 2007, Feb and April 2008, different areas
Sea floor litter; transect survey	36 (50 m width)	DE	AWI Bremerhaven	German North Sea territorial waters		2006-2008		
Sea floor litter; SCUBA survey	210 ROV dives	FR	AAMP/COMEX	French Mediterranean coast	210 ROV dives	2010	Irregular	Different areas every year
Sea floor litter; SCUBA survey	59 sites (1600 m2 strip transects/site)	EL	University of Athens, financed by PADI Foundation	Southern Greece (Aegean and Ionian Seas)	59 sites, a single survey in 2003	2003	1 survey	

Table 4. Availability of marine microlitter monitoring data in Europe.

Methodological description	No of surveys (transect length)	Country (-ies) involved	Organisation running the surveys	Area description	Data amount	Start - end of the programme	Monitoring frequency	Survey timing
Floating microlitter; trawl survey	40 tows	IT, FR	EXPedition MED	North occidental basin, Mediterranean	40 manta trawl tows	2010-ongoing	1/year	Different areas every year

Methodological description	No of surveys (transect length)	Country (-ies) involved	Organisation running the surveys	Area description	Data amount	Start - end of the programme	Monitoring frequency	Survey timing
Floating microlitter	Survey by ships in 3 months period	Ships under the ownership of Greek companies	HELMEPA	Mediterranean sea from Gibraltar to south of Cyprus and Adriatic to Suez Canal		2/1/2008-4/1/2008	Continuous	
Surface microlitter; trawl survey	19 stations	SE	n-Research, Sweden		19 sites, covers complete coast of Sweden	2008	1/year	
Microlitter on beaches	20 sampling points (top 5cm of 50x50cm and 2x2m square areas) on 2 beaches	PT	IMAR FCT-UNL	Lisbon area	12-15 counts	2008-2010	Irregular	End of February - April.
Microlitter on beaches	12-15 stations	FR	SOS mal de seine		12-15 stations	2009-ongoing	Not yet on regular basis	Different areas every year
Microlitter on beaches	One survey on 5 beaches, (top 5 cm of 50x50cm and 2x2m square areas, 3x2m transects between tidal marks	PT	IMAR FCT-UNL	Western coast (north to south)		2010-ongoing	Irregular	March 2010

Table 5. Availability of monitoring data of ingested litter in /entanglement of biota in Europe.

Methodological description	No of surveys (transect length)	Country (-ies) involved	Organisation running the surveys	Area description	Data amount	Start - end of the programme	Monitoring frequency	Survey timing
Ingested litter in fulmars	Not applicable; continuous	NL	Dutch Seabird Group and IMARES	Dutch North Sea	20 to over 100 birds/year	1979-ongoing	Continuous searches for sampling of birds; partly linked to BBS program	

Methodological description	No of surveys (transect length)	Country (-ies) involved	Organisation running the surveys	Area description	Data amount	Start - end of the programme	Monitoring frequency	Survey timing
Ingested litter in fulmars; EcoQO	Not applicable; continuous	DE	FTZ and IMARES	German North Sea	Data annually from 2002; with incidental earlier info	2002 with incidental earlier data--ongoing	Continuous searches for sampling of birds; partly linked to BBS program	
Ingested litter in fulmars; EcoQO	Not applicable; continuous	DK	Skagen bird Group, SUC and IMARES	Danish Skagerak area	Data annually from 2003	2003-ongoing	Continuous searches for sampling of birds; partly linked to BBS program	
Ingested litter in fulmars; EcoQO	Not applicable; continuous	NO	Lista Bird Group and IMARES	Norwegian North Sea / Skagerak area	Data annually from 2003	2003-ongoing	Mostly monthly searches for sampling linked to BBS	
Ingested litter in fulmars; EcoQO	Not applicable; continuous	SE	currently none	Swedish west coast	Few data only: 6 birds for 2003	No regular program (few data only for year 2003)		
Ingested litter in fulmars; EcoQO	Not applicable; continuous	BE	INBO Belgium and IMARES	Belgian North Sea / Channel	Data annually from 2002	2002-ongoing	Mostly monthly searches for sampling linked to BBS	
Ingested litter in fulmars; EcoQO	Not applicable; continuous	FR	Groupe Ornithologique Normand and rehab; IMARES	Belgian North Sea / Channel	Data annually from 2004 (but some years few data)	2004-ongoing	Mostly monthly searches for sampling linked to BBS	
Ingested litter in fulmars; EcoQO	Not applicable; continuous	UK	SOTEAG and DEFRA	UK North Sea	Data annualy from 2002 or 2003	2003-ongoing	Mostly monthly searches for sampling linked to BBS	
Ingested litter in fulmars; EcoQO	Not applicable; continuous	FAROE Islands		Around Faroe Islands	Data annually after 2003; variable for special purpose studies	2003 (with incidental earlier data)-ongoing	Variable samples from scientific sampling; hunted birds; and fisheries bycatch	
Ingested litter in shearwaters	Not applicable; varies by location	Azores, Canary Islands, Selvagens, ES, MT		Southeastern N. Atlantic and western Mediterranean	Variable by location (best data from Azores)	mostly 2004	At Azores basically annually (fledged chicks); elsewhere very different	

Methodological description	No of surveys (transect length)	Country (-ies) involved	Organisation running the surveys	Area description	Data amount	Start - end of the programme	Monitoring frequency	Survey timing
Ingested litter in sea turtles	54 loggerhead sea turtles	HR, SI	University of Zagreb, Faculty of Science, Dep. Biology, Croatia	Eastern Adriatic Sea (Slovenia and Croatia)	From 2001-2004	2001-2004		May-October
Ingested litter in fish	First trial; no survey structure	NL	IMARES	North Sea		2010 trial only	Not applicable; ad hoc trial	
Ingested litter in seals	Irregular; no true survey	NL	IMARES	Dutch Wadden and North Sea		2002 trial only	Not applicable (ad hoc collection of dead Seals)	
Ingested litter in seals	24 harbour seals	DE	FTZ Westküste	German North Sea coast		1997-2007		
Ingested litter in harbour porpoises	47 individuals	DE	FTZ Westküste	German North Sea coast		1998-2006		
Ingested litter in plankton	30 mins 5m tows; 25 mins 10 m tows	Portugal	IMAR FCT-UNL	60-80 miles offshore Central coast of Portugal	180 tows	2010-ongoing	Irregular	
Entanglement rate; dead beached seabirds	ca. 2000	Germany		German North Sea coast		(1976) 1983 - 1988, 1990		
Entanglement rate; dead beached seabirds	Regular; linked to BBS	NL	NZG-NSO	Dutch North Sea		1970-ongoing	Mostly monthly BBS	
Entanglement rate; dead beached seabirds	ca. 3600	DE	The Schleswig-Holstein Agency for Coastal Defence, National Park and Marine Conservation	German North Sea coast of Schleswig-Holstein	ca. 31000	1991-ongoing	2/month	
Entanglement of seabirds	ca. 4320	DE	The Lower Saxony Water Management, Coastal Defence and Nature Conservation Agency	German North Sea coast of Lower Saxony	ca. 62000	1992-ongoing	2/month	

Annex 4. Overview of the issue of derelict fishing gear.

Every abandoned, deliberately discarded or lost at sea fishing gear can be considered as marine litter as internationally defined by UNEP who recognises the immediate and direct interconnection between marine litter and lost/abandoned fishing gear and related debris (UNEP, 2005). Fishing gear can be lost at sea for several reasons e.g. bad weather conditions, accidental cutting of buoys by vessels, or illegally disposed of and abandoned at sea. The Food and Agricultural Organization of the United Nations considers ghost fishing to be of great concern generating additional mortality in overexploited marine ecosystems (UNEP, 2009). Ghost nets are often considered perpetual “killing machines” that never stop fishing (Esteban, 2002). Some studies have been performed to quantify the decay of efficiency of ghost nets, these parameters depend on many factor such as the type and depth of seabed where the net remains, the velocity of biofouling development, visibility or transparency of water etc. (Kaiser et al., 1996; Erzini et al., 1997, Saldanha et al., 2003).

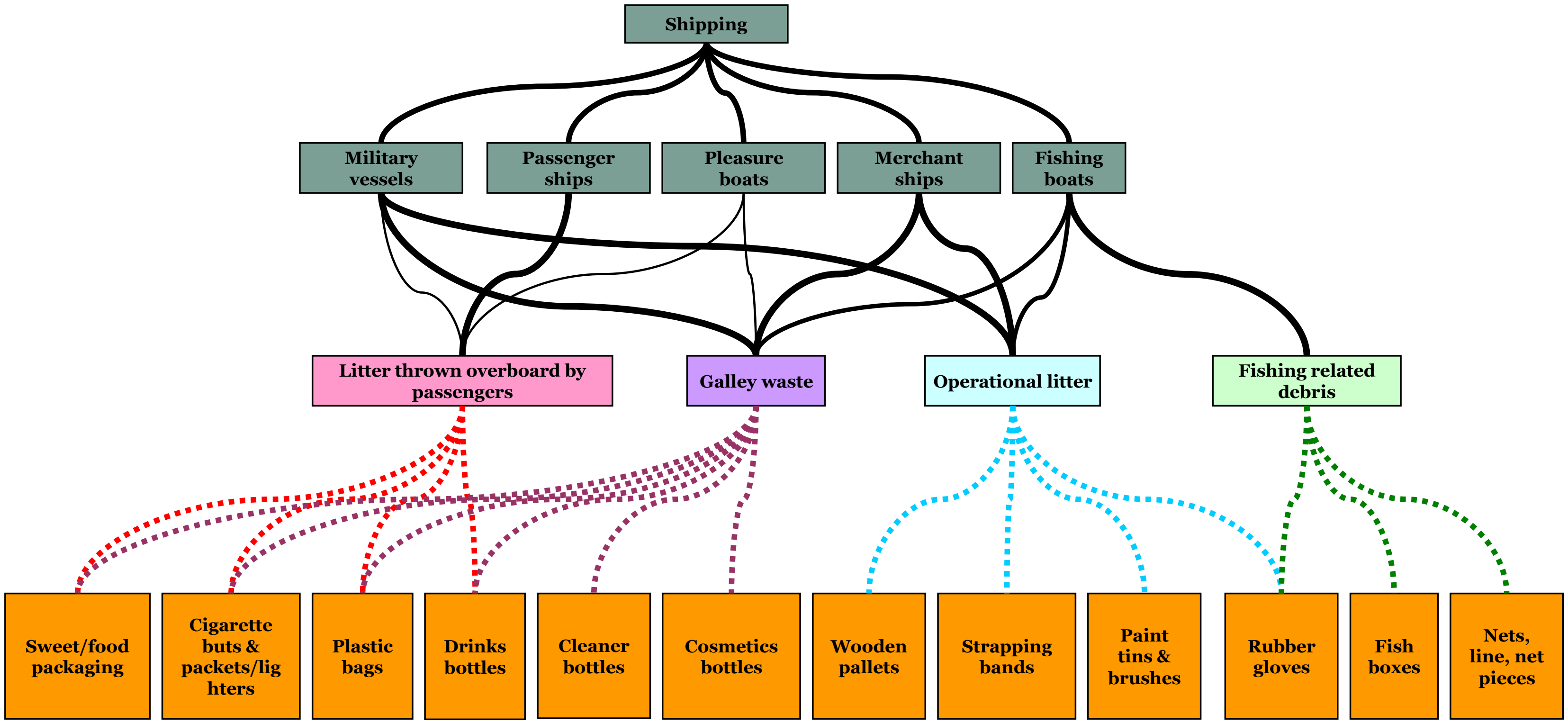
Overall catch rates of lost/abandoned fishing gear vary so greatly that a global estimate would be meaningless (Brown et al., 2005). Sancho et al. (2003) considered lost tangle nets to catch around 5 % of the total commercial catch. Fish and crustaceans such as lobsters and crabs are frequently caught in lost or discarded fishing gear. The major damage seems to be caused by cages traps, placed on the sea bottom, in which there is a self baiting phenomenon. Lost traps continue to attract fish and crustaceans, which enter them in search of food or shelter.

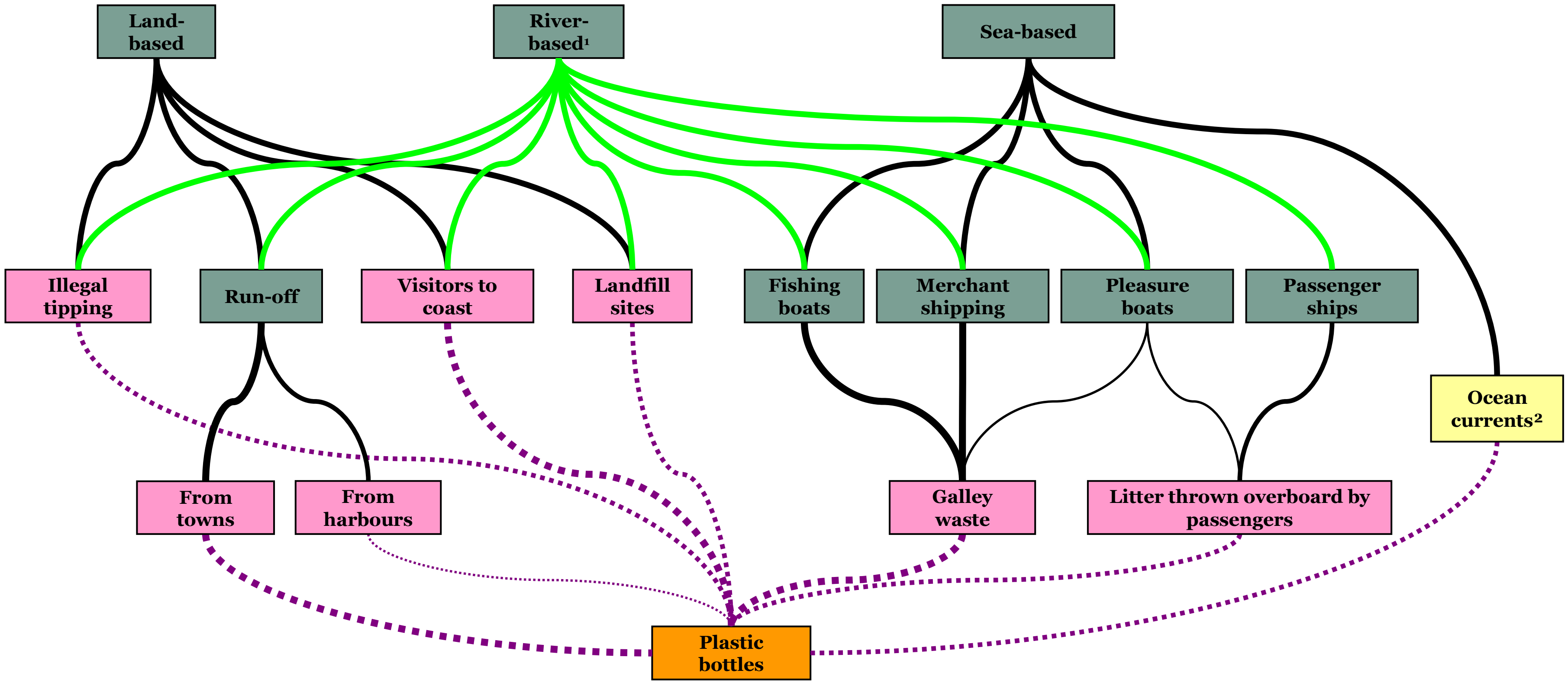
Other fishing gear such as drift and trammel nets may actively kill a great number of marina fauna. Driftnets are among the simplest and oldest methods of fishing. A vertical sheet of netting, held in place by floats and a weight-line attached to the bottom of the net, is hung from the water's surface. Tethered to a buoy or the side of a fishing vessel, the net is then left to drift passively for hours or even days, entangling any fish that swims into it. As they are unattended and roaming, they fish indiscriminately, not only catching threatened species but undersized and protected fish/marine mammals as well. A UN moratorium came into force in 1991 prohibiting the use of most types of driftnets. The EU responded initially by banning the use of driftnets over 2.5km in length within the Mediterranean, but illegal drift-netting continued, mainly by Italian fleets. The EU subsequently introduced a total ban in 2002 on the use of driftnets in fisheries targeting ten species, a move that was reiterated in 2003 by the International Commission for the Conservation of Atlantic Tuna (ICCAT). Although banned under the UN moratorium for over a decade and despite the strong public and political perception that the driftnet problem has been solved, legal loopholes and weak enforcement means that illegal driftnets continue to be used by Italian, French, Moroccan, Turkish and Algerian fleets (Oceana, 2005).

Lost/abandoned fishing gear continues to trap passing fish ‘unintentionally’ as well as endangered and protected species. Floating and suspending parts of abandoned fishing gear entangle wildlife such as marine mammals, sea turtles, sea birds and fish, often attracted by fish that have been caught or entangled in the nets and fishing lines (Laist, 1995, Laist and Liffman, 2000).

Due to the resistance to degradation of synthetic materials (nylon, polyethylene and polypropylene), once discarded or lost, fishing gear remain in the marine environment, with negative economic and environmental impacts. Worldwide lost/abandoned fishing gear is becoming an increasing problem. It is assumed that hundreds of thousands tonnes of undegradable fishing nets are abandoned or lost in the world oceans every year. Worldwide, this phenomenon is having an impact on the sustainability of already stressed fisheries. Ghost fishing kills thousands of fish that might otherwise have found their way to the market. An estimated US$ 250 million in marketable lobster is lost each year from ghost fishing (UNEP, 2005). Furthermore, derelict fishing gear in the form of nets and ropes, invisibly floating just below the water’s surface, can cause significant risks to vessel operations. Nets, ropes and other derelict gear, can entangled vessel propellers and rudders resulting in costly repairs, significant loss of operational time, and endangering boater and crew safety (Johnson, 2000). Moreover, lost/abandoned fishing gear, like other marine debris, has the capacity to travel for very long distances and through different habitats, transporting with them invasive species from one sea area to another.

Annex 5. Sources of litter.





Major pathways of plastic bottles into the European marine environment (the thickness of the line indicates the suspected importance of a given pathway)
[1] Litter enters the marine environment via rivers. The pathways of litter into rivers are the same as the pathways for land-based sources
[2] Ocean currents transport litter into European waters. The sources of litter in ocean currents are land-, sea- & river-based.

Annex 6. Major pathways of plastic bottles into the European marine environment.

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Abstract

A technical subgroup under the Working Group on GES for the further development of Descriptor 10 Marine Litter was established within the implementation strategy for the Marine Strategy Framework Directive 2008/56/EC (MSFD) and the Commission Decision on Criteria and Methodological Standards on Good Environmental Status (GES) of Marine Waters (Commission Decision 2010/477/EU). The group consisted of 42 experts and was chaired by Ifremer, EC JRC IES and the German Environment Agency.

The group developed an overview about existing data and methodologies for the monitoring of marine litter. Appropriate monitoring methodologies have been identified for beach, surface water, biota and microlitter, and altogether 15 monitoring tools have been described in relation to the indicators for Marine Litter. Sources of marine litter, issues on targets and objectives relevant to MSFD as well as research needs have been discussed and a roadmap for the further implementation of Descriptor 10 has been developed.

The mission of the JRC is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies. As a service of the European Commission, the JRC functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.

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