WORKING GROUP ON MARINE LITTER (WGML; outputs from 2020 meeting)

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Contents

i Executive summary

The goal of the Working Group on Marine Litter (WGML) is to provide scientific guidance towards the international harmonisation of monitoring data for seafloor litter and microlitter. WGML functions as a knowledge base for other international organisations regarding seafloor litter and microlitter. WGML has mapped seafloor litter and microplastic monitoring approaches, discussed relevant issues, established an overview of national and international drivers and linkages, and distributed key information produced by WGML (e.g. guidelines, photoguides).

WGML activities focused on reviewing and assessing the quality and potential uses of current data in the ICES DATRAS (Trawl Surveys) and DOME (Marine Environment) databases. For seafloor litter, coverage by year and country was evaluated as being sufficient for future assessment of presence/absence, but some data gaps and irregularities were identified. Issues with the existing seafloor litter data and methods were reviewed and used to recommend improvements for future monitoring (e.g. harmonised sampling and categorisation). Seafloor litter monitoring has been 'piggybacking' on fish stock assessment programmes taking place regularly across many regions. However, this approach has some critical drawbacks: (i) limited to soft seafloor substrates; (ii) limited depths; (iii) limited to sampling gear and survey design of the fish stock assessment surveys; (iv) differences in catchability among gears, vessel speed, mesh size, cod ends and methods used among countries and regions, programmes, observers and studies. This seriously limits intercomparison and aggregation of seafloor litter data (no. of items) based on "bycatch litter data" obtained from the fisheries surveys. Although standardisation of seafloor litter data may be achievable at the local or national scale where harmonised sampling approaches are used, this is unlikely to be achieved across larger regions due to the critical drawbacks listed above.

Moreover, seafloor litter monitoring is mostly a secondary objective in fisheries surveys, therefore the interpretation, interest and attention given by observers differs from survey to survey and year to year, making the interpretation of temporal and spatial trend analyses difficult. Due to the high variability in the observed seafloor litter concentrations, WGML concludes that the current power of seafloor litter monitoring programmes is insufficient to follow temporal and spatial variations with a high degree of certainty (e.g. above 80% accuracy). Without solving these data issues, direct comparisons and harmonisation between surveys will restrict the international assessments to presence/absence outputs. Alternative, less/non-destructive methods should also be investigated for the future to avoid the destructive trawling approach currently used to obtain seafloor litter data. To assist in the classification of seafloor litter in the future, and to ensure standardisation in litter categories between data collection programmes, an updated photoguide of litter items was produced. Finally, WGML generated a seafloor litter guidance document containing information about sampling, data reporting and quality assurance/quality control (QA/QC), including the definition of litter categories and subcategories.

WGML activities on microplastics started with a review of the existing microplastic data registered in the DOME database. Very few datasets were present, thus WGML created an overview of existing microplastic datasets from members. Those were assessed based on their output format and ease of use. Two distinct types of monitoring (Compliance and Investigative) were defined that are currently taking place in different member countries. WGML discussed methods for microplastic sampling, processing and analysis, providing an overview of the development status and needs related to both compliance monitoring vs investigative case studies. WGML discussed microplastic presence/amounts in different marine environmental matrices (e.g. sediment/water/biota), as well as units for reporting data. WGML discussed QA/QC issues in relation

to microplastics data and how these might impact data quality. The group also mapped existing proficiency schemes addressing these issues.

A critical issue for ICES WGML is the lack of data being submitted to DOME, with much of the data generated by EU member states being submitted to The European Marine Observation and Data Network (EMODNET). WGML plans to interact more closely with EMODNET going forward to establish closers links and to support each other. Additionally, WGML promotes the submission of available and future microplastic data to the ICES DOME database in case countries/institutes would like WGML to review and provide QA/QC. Guidance for submitting microplastic data has been created by the ICES Data Centre.

ii Expert group information

Expert group name	Working Group on Marine Litter (WGML)
Expert group cycle	Multiannual
Year cycle started	2018
Reporting year in cycle	3/3
Chairs	Thomas Maes, UK and Norway
	Andy Booth, Norway
	Francois Galgani, France
Meeting venues and dates	23–27 April 2018, Copenhagen, Denmark (20 participants)
	21–24 October 2019, Paris, France (13 participants)
	12–13 and 19–20 October 2020, online (20 participants)

1 List of Outcomes and Achievements 2018–2020

General

- WGML mapped seafloor litter/microplastic monitoring approaches & issues amongst group members (Annex 3).
- WGML collaborated with the ICES Secretariat to improve uptake of our outputs (community page).
- WGML revised the overview of national and international drivers and linkages (Annex 4).
- WGML revised the combined road map on seafloor litter and microplastic for the next 1/5/10 years showing interactions with relevant project, organisations and institutes, key events and decision points (Section 4 and Annex 4).
- WGML updated their network folder with recent publications and documents relevant to WGML activities.
- WGML discussed existing QA/QC schemes and the potential for WGML monitoring. The group developed a 'Ring Test for Seafloor Litter', microplastic proficiency testing is progressing via Quasimeme (Quality Assurance of Information for Marine Environmental Monitoring in Europe) and a few other initiatives (Annex 5; WGML listed upcoming schemes).
- In 2020, discussion was started about the next 3 year cycle of WGML, including ToRs, chairing positions and membership.

Seafloor litter

- WGML reviewed the seafloor litter monitoring data presented by participants (Annex 6) and summarised general observations and any identified data issues.
- In 2018, WGML checked existing data entered into the ICES DATRAS database (surveys/areas/trawls/data availability), including the presence of specific categories (e.g. E2/A12). The findings were as follows:
    - Data quality and submissions are increasing for seafloor litter in DATRAS following international guidelines (started in 2012).
    - For the North Sea, most data are related to IBTS and generally performed with GOV gear.
    - For the Baltic Sea, most data are related to BITS and generally performed with TVS and TVL gear.
    - For western waters, most data are related to the surveys coordinated by the IBTSWG and generally performed by ottertrawls (GOV, BAK).
    - In general, coverage by year and country is improving, but some data gaps and data quality issues remain. In the period 2019–2020, WGML identified incorrect data registered in DATRAS and contacted those responsible to correct it. This process was completed in 2020.
- In 2018, WGML discussed power analysis. This was revisited annually.

- In 2019, WGML conducted a first European and regional assessment (Europe/Regional/Subcategories: counts, presence/absence). This included:
    - Discussion of weight (weight/check data/mass less than 1 g should not be recorded) and number (item count) issues and recommended database entry checks. It was concluded that weight values should not be mandatory as there are issues in accuracy related to wet weight vs. dry weight, use of different units, and the degree and type of fouling (e.g. mud or biofouling). WGML suggests to use g if weight is reported.
- Throughout 2018–2020, WGML reviewed existing manuals/guidelines and addressed specific questions on time trends, weight, categories and other sampling issues related to seafloor litter.
- WGML discussed marine litter sources and concluded that detailed source definition will be very difficult. Adding high level source definitions to individual items or groups of items (e.g. fishing, shipping, aquaculture, tourism) can be done retrospectively across the entire dataset. This should be part of the new ToRs for WGML.
- Throughout 2018–2020, WGML responded to questions from external groups and stakeholders (e.g. TGML, ICGML) in relation to seafloor litter sampling and categorisation.
- WGML developed and finalised the Photoguide for seafloor litter. Will be made available on the ICES website in 2021.
- WGML developed a ring test for identification of seafloor litter items and undertook a round with WGML members to evaluate it (Annex 7).
- WGML created simple data overviews of the existing seafloor litter data in the ICES database DATRAS (surveys/areas /trawls/data availability) and summarised general observations on the data.
- WGML developed checks and seafloor litter data submission guidelines for DATRAS (Annex 6).

Microplastic

- In the period 2018–2020, WGML reviewed the existing microplastic data registered in the DOME database. To date, very few datasets have been submitted (e.g. Estonia, Finland). Available data sets were assessed based on their output format and ease of use.
- WGML identified potential issues and challenges with improving the current quality and attributes regarding microplastic monitoring data. This focused on sampling, analysis and QA/QC guidelines, including upcoming proficiency schemes (Annex 5).
- Annually in the period 2018–2020, WGML updated the overview of microplastic monitoring across ICES WGML member states (Annex 3). Two distinct types of monitoring (Compliance and Investigative) were defined that are currently taking place in different member states. Compliance relates to routine spatial and temporal monitoring, using semi-harmonised methods to fulfil legislative requirements. Investigative relates to scientific study and method development targeting knowledge gaps. The latter data are typically not harmonized and do not focus on identifying spatial and temporal trends.
- WGML attempted to submit existing microplastic data to the ICES Data Centre for evaluation and testing of the DOME data system. This was partially successful, but several issues were highlighted. There is a reluctance to submit data before it has been published and there is also concern about the possibility of rising numbers over time that do not reflect actual changes in microplastic levels, but might be related to improvements in the sensitivity of methods used.

- Throughout 2018–2020, WGML discussed microplastic data streams (e.g. OSPAR/EMODNET) extensively. A critical issue for ICES is the lack of data being submitted, with much of the data generated by EU member states being submitted to EMODNET, driven by EU MSFD requirements. WGML evaluated the situation and have planned to interact more closely with EMODNET going forward to establish closers links and to develop a way forward that allows each organisation to support the needs of the other.
- WGML discussed methods for microplastic sampling, processing and analysis, providing an overview of the development status and needs related to both compliance monitoring vs investigative case studies.
- WGML discussed microplastic presence/amounts in different marine environmental matrices (e.g. sediment/water/biota), as well as units for reporting data.
- WGML discussed QA/QC issues and approaches and how these might impact data quality.
- ICES developed guidance on microplastic data submission to the DOME database (Annex 9).

2 Summary report on the Terms of Reference (ToR)

ToR a: The group received a small number of requests for external and internal advice (e.g. EU, Regional Seas Conventions, EU DG Environment, ICES Data Centre/Secretariat) during the period 2018–2020. In all cases, WGML provided timely responses and information to the best of their ability. Examples include:

- OSPAR wanted to know when ICES WGML had deadlines so they could align their work and outputs accordingly. Aim was to avoid duplication of efforts.
- OSPAR asked about methods for monitoring so that methods in both OSPAR and WGML could be aligned.
- EU MSFD approached WGML to align the categories and sub-categories across different matrices.

ToR b: WGML took into account new information and advice from GESAMP, the UN, EU directives and international frameworks regarding marine litter and microplastic, and fed this information into the ICES WGML Roadmap and Drivers. More detailed information can be found in Section 4 and Annex 4.

ToR c: WGML reviewed existing data in the ICES database and used this as a basis for updating ICES guidance for seafloor litter and, to a lesser degree, microplastic monitoring. The findings were also used to support expected ICES data needs and assessment outputs. An overview of the seafloor litter data in DATRAS, data issues and the European/regional assessment can be found in Annex 8. The group produced guidance documents for seafloor litter sampling, created a Photoguide, developed a seafloor litter ring test and revised data submissions and potential errors. This information is presented in Annexes 6 & 7.

ToR d: WGML integrated key dates with respect to seafloor litter and microplastic monitoring meetings, proficiency testing, project outcomes and other relevant initiatives into the Roadmap of ToR b. More detailed information can be found in Annexes 4 and 5. No publications were completed by the end of 2020, but a number of initiatives are currently in progress. These include an ICES Viewpoint (plus background report document) and a peer-reviewed manuscript on European seafloor litter assessment.

ToR e: WGML reviewed relevant outputs to take into account international developments in marine litter research and monitoring (Annex 4). In order to improve international coordination and communication, ICES WGML have reviewed ongoing developments in major research projects (e.g. JPI Oceans, EU H2020) and have brought in new knowledge from (i) international scientific literature and (ii) from key organisations (HELCOM, OSPAR, EU MSFD, etc.)

ToR f: WGML discussed potential quality assurance and quality control (QA/QC) options for marine litter monitoring and listed upcoming events. More details are given in Annex 5. Proficiency testing for microplastics conducted by other organisations (QUASIMEME, EU JRC) was followed closely and some WGML members participated actively. Knowledge was disseminated to the wider WGML group. There is a continued effort within seafloor litter monitoring to improve harmonisation and QA/QC with respect to seafloor litter sampling approaches (e.g. IBTS). This had a focus of trying to (i) assess the level of QA/QC and (ii) improve harmonisation of marine litter categorisation. To assist with this process, WGML developed a ring test scheme.

In addition, WGML mapped linkages with other ICES WGs, including where WGML members were also members of other WGs. WGML have been following the progress and outputs of other ICES WGs in relation to marine litter (e.g. Working Group on Biological Effects of Contaminants (WGBEC), Working Group on Marine Sediments in Relation to Pollution (WGMS) and Marine Chemistry Working Group (MCWG)). A meeting was organised with the chairs of WGMS to discuss ToRs and to avoid overlap and duplication of work. Discussions are ongoing about centralising all ICES microplastic activity in WGML with relevant members of other WGs transferring to or sitting in WGML. Some potential overlaps with other WGs exist, and WGML outputs and reports will be taken forward by members who sit on both WGML and these other ICES WGs. Specific groups include WGZE (Working Group on Zooplankton Ecology), WGEEL (Joint EIFAAC/ICES/GFCM Working Group on Eels), IBTSWG (International Bottom Trawl Survey Working Group), WGBEAM (Working Group on Beam Trawl Surveys), WGBIFS (Baltic International Fish Survey Working Group).

3 International roadmap and drivers

WGML International/National needs, drivers and timeline/roadmap

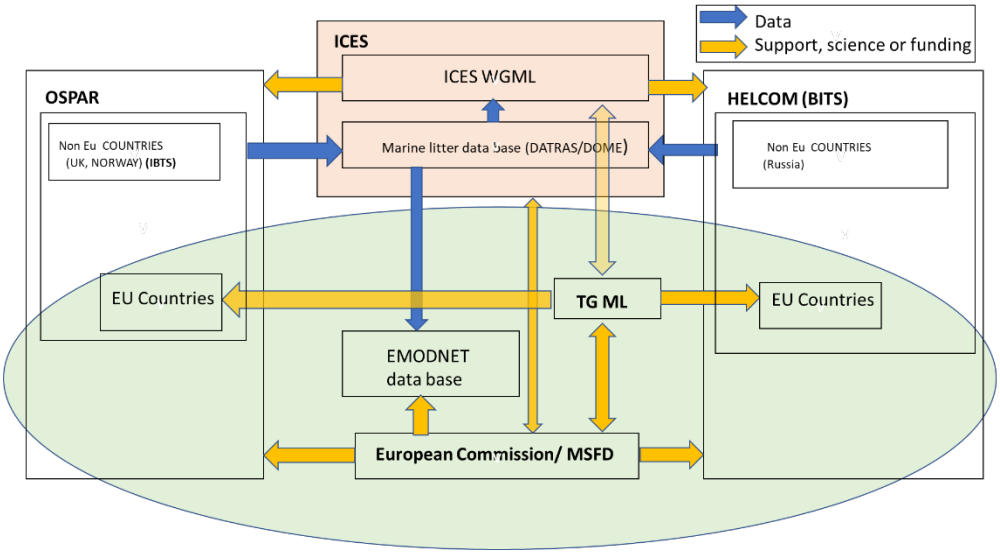
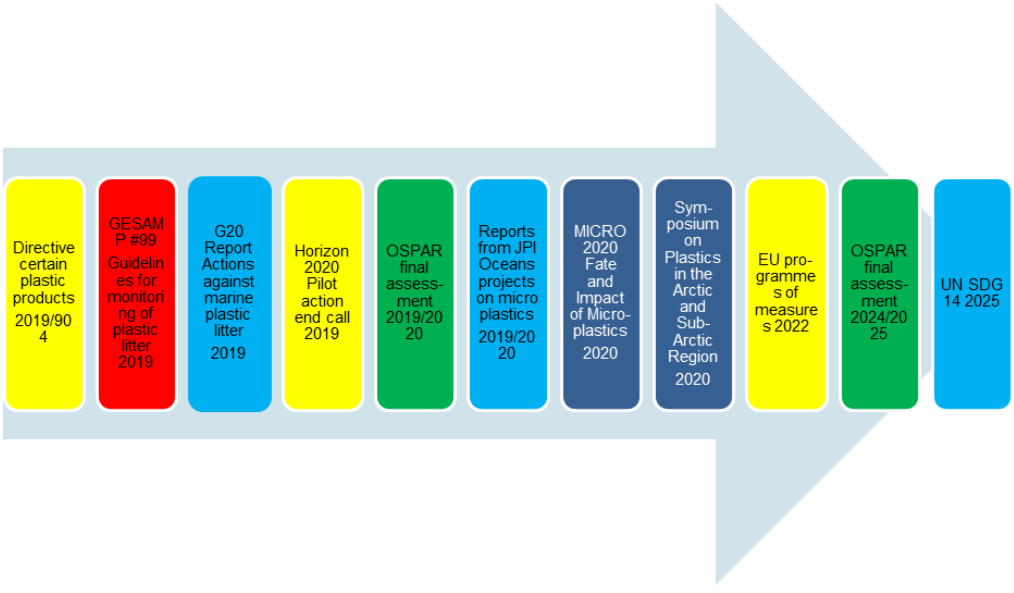


Figure 1 showing overview of drivers and linkages.



Key			
	OSPAR		Conferences
	GESAMP		EU
	International meetings		Other publications /organisations

Figure 2 outlining the ICES WGML roadmap (2018–2021). The figure is correct as of December 2019. Owing to COVID-19, maintaining an accurate and updated roadmap of activities was not possible in 2020 and beyond (e.g. some events are postponed without a new date).

Many initiatives have been launched at international fora (e.g. G7 and G20, the United Nations, the MARPOL Convention, EU TG Marine Litter) and regional seas conventions (e.g. OSPAR, HELCOM) and actions against marine litter are also included in the International Ocean Governance Agenda for the future of our oceans. Based on their published reports or action plans, WGML selected a list of drivers (Table 1) and has defined their supporting role for these events/targets. These primarily relate to (i) advice and guidance, (ii) assessments with DATRAS and DOME data, and (iii) focus on scientific issues around data collection, data submissions, sample analysis, data assessments and QA/QC.

Table 1. Selected drivers and deadlines.

	Driver	Year
EIHA	OSPAR	Annually
EU TGML D10	MSFD	Annually
ICG-ML	OSPAR	Every 6 months
PAME	Arctic council	Annually
MICRO conference	Microplastic R&D	Biannually
International Symposium on Plastics in the Arctic and Sub-Arctic Region	Plastic and microplastic R&D	2-4 March 2021 - Reykjavik, Iceland
7th International Marine Debris Conference (IMDC)	Plastic and microplastic R&D	Busan, South Korea, 2022
MSFD	Updates of the initial assessment, determination of GES and environmental targets due to be reported in October 2018	Completed 2018
GESAMP	Report on Guidelines for the Monitoring and Assessment of Plastic Litter in the Ocean	Completed January 2019
GESAMP	Report on marine litter sea-based sources.	Expected January 2021
JPI Oceans	Six new JPI Oceans projects on microplastic were launched in 2020. These will generate a large amount of knowledge related to microplastic that is relevant for monitoring.	Launched in 2020
WFD	Review of the WFD in 2019	Completed
MSFD	First thresholds validated for Beach litter	Completed 2020
OSPAR	Quality status report - final assessment	Expected in 2023
EU action plan for circular economy	Aspirational target of 30% reduction in marine litter by 2020 (= an aspirational target of reducing marine litter by 30% by 2020 for the ten most common types of litter found on beaches, as well as for fishing gear found at sea, with the list adapted to each of the four marine regions in the EU)	2020
MSFD	Updating the programmes of measures due to be reported in March 2022	2022
SDG 14	Includes marine debris and states that a significant reduction must be achieved by 2025.	2025
EU Waste Directive	Higher recycling target for plastics (55% by 2025), to be defined for 2030	2030
EU Mission STARFISH (H Europe 2021-2030)	Zero plastic emission, Plastic is 100% recyclable/degradable	2021-2030

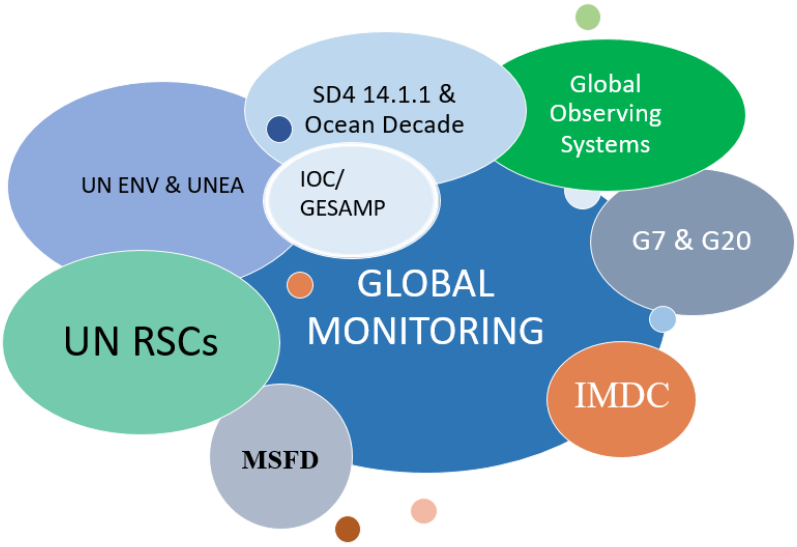


Figure 3 showing a summary of ongoing initiatives to support large scale monitoring of marine litter, including seafloor litter and microplastic.

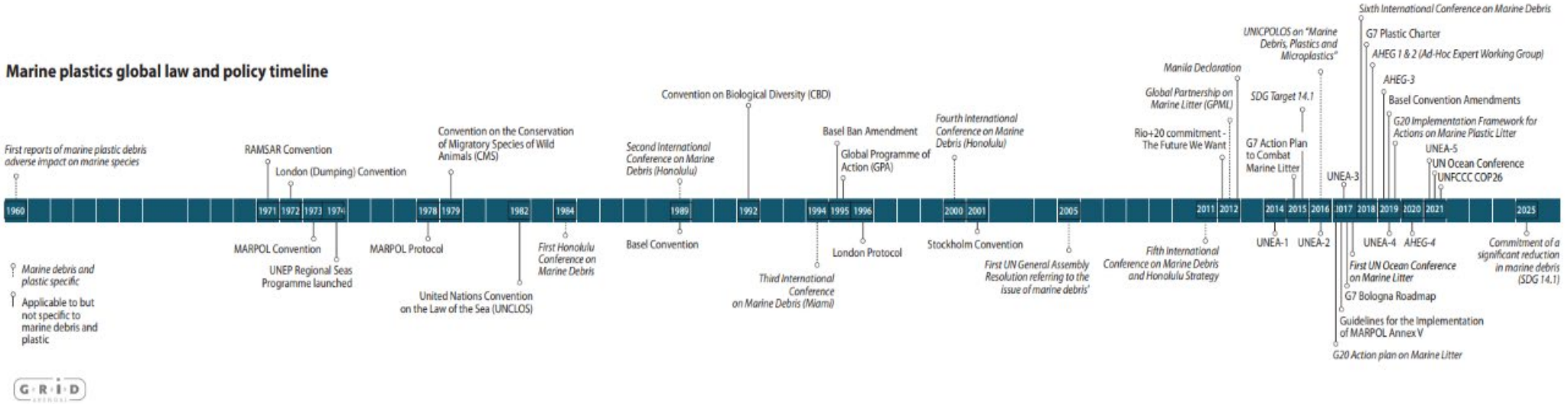


Figure 4 showing the United Nations Marine plastics global law and policy timeline.

4 Current status

Seafloor

- Seafloor litter data (in the DATRAS database) is currently collected through piggybacking on existing scientific surveys, including fish stock assessment surveys using benthic trawls. WGML has identified some significant limitations with the existing seafloor litter data and methods that result directly from this approach. WGML suggests that the existing seafloor litter data (and any future data produced using the approaches and methods) can, in the best case, be used to assess presence and absence, as well as changes within this over time. However, if quality and harmonisation of counting methods/protocols can be improved (e.g. through the presence of dedicated seafloor litter experts) a qualitative view of trends in numbers within specific surveys could potentially be determined.
- In order to make seafloor litter monitoring with fisheries trawls useful for the detection of the effectiveness of implemented measures, a dedicated seafloor survey designed by experts, responsible for sampling design (e.g. sampling equipment, locations, replicates, spatial and temporal monitoring), categorisation/identification/quantification and reporting of the seafloor litter data is required. For example, to improve the power of seafloor litter monitoring, more stations or longer datasets are required. However, such practices will also be extremely damaging for the marine environment and may not be worthwhile when taking into account the impact on benthic habitats and the carbon footprint associated with trawling (https://www.nature.com/articles/s41586-021-03371-z), alternative non-destructive methods need to be considered.
- WGML believes there is a danger that incorrect data utilisation can overestimate the value and quality of any assessment, for example, the development of indicators to detect fine changes in litter distribution resulting from measures (e.g. OSPAR common indicator for seafloor assessment, EU MSFD DC10.1/seafloor).
- Major legislative drivers and action programmes, such as those of the OSPAR RAP and EU MSFD D10, are planning to rely on the spatial and temporal seafloor litter trend assessments as key indicators to measure the success and effectiveness of litter mitigation measures. WGML have concluded that the power/quality of the available data is limited when datasets from different nations, vessels and surveys are combined and probably not sufficient to meet the expected needs (e.g. measuring small, incremental changes in litter concentrations over time as a result of implemented measures). On an individual survey basis, the data can be compared as less variables interplay.
- WGML acknowledges that without large investment in alternative methods, these issues will not be overcome and thus the value of the data obtained by trawl surveys will remain limited in scope. WGML also appreciates that this is not a new issue for newly established pollution issues and their associated monitoring programmes.
- WGML feels that it is important to highlight the positive aspects with the ongoing surveys, which include (i) delivering qualitative information on composition of litter and how this changes over time, (ii) raising awareness of the issue among involved stakeholders, and (iii) the removal of litter through the sampling approach.

- ICES has developed a guideline for the submission of seafloor litter data to the DATRAS database. This guideline is published in full as part of the ICES WGML Seafloor Litter Guideline (ICES to include link when it is available).

Microplastic

A number of issues related to microplastic and the role of ICES WGML were highlighted and discussed internally within WGML and across the ICES working groups, including the Chair of SCICOM. An overview of the issues and the suggested way forward are presented below:

- As a result of the requirements of EU MSFD Descriptor 10, the vast majority of microplastic data is currently submitted to EMODNET and no individual countries have a mandatory requirement for additional data submission to the ICES DOME database. This makes it difficult for WGML to conduct assessment and quality assurance on existing microplastic data.
- Some countries do have future plans to submit microplastic data to ICES DOME, with the expectation that this will also be entered into EMODNET via ICES. This would give WGML the opportunity to provide additional quality assurance and control of the data prior to any assessment.
- It is important for WGML to act as a pivotal intermediary to align ongoing activities and needs across regional seas conventions in Europe (OSPAR, HELCOM, Barcelona Convention and Black Sea Commission).
    - OSPAR contracting parties are planning to send their microplastic data to ICES DOME. At this point, the process has not been fully initiated and is waiting on the decision of OSPAR in relation to their candidate indicator of microplastics in sediments. ICES WGML is happy to act as a resource for OSPAR and suggests that OSPAR microplastic data is submitted to DOME where it can be subjected to additional quality assurance and control by WGML.
    - Similarly, HELCOM are also planning to recommend microplastic data submissions to EMODNET in the short term, but will consider using ICES DOME in the long term.
    - A possible route would for ACOM to be the committee to approach the regional seas conventions about a possible mandate for ICES DOME to receive microplastic data.
- WGML believes that it would be sensible to further align themselves with EU MSFD TGML to collaborate on outstanding scientific aspects (e.g. sampling, analytical techniques, statistical analysis) related to microplastics. In particular, it is suggested that ICES has a role using their technical and scientific capacity as a result of historical and ongoing fish stock assessments that form part of the wider ICES community. WGML and TGML share common members (including Chairs) that can facilitate improved discussion on this going forward.
- WGML does not feel that it should produce a specific microplastic monitoring guide. However, we are in a good position to review and assess existing (and future) guidelines to recommend those which have the best merits for specific purposes or applications.
- At the internal level, WGML feels that it needs to have a stronger focus, in line with its future mandate, on providing work for current microplastic experts within WGML, as well as attracting new members with competence in this area.

5 WGML way forward

Suggestions for continuation

General ToRs

- **Improve governance of marine litter and microplastic across ICES and its working groups and stakeholders.** Suggested focus areas:
    - It is recommended that WGML explores a new ToR related to its global role in monitoring and harmonisation with sister institutes (e.g. PICES).

Seafloor litter ToRs

- **Improvements of the seafloor litter assessments.** Suggested focus areas:
    - While WGML considers seafloor litter monitoring at the national level appropriate, low/unknown/variable catchability is still a problem in each survey. However, several issues related to harmonisation occur when trying to amalgamate datasets from different countries. Potential for improvements beyond presence and absence assessments for seafloor litter data should be considered.
    - A large problem with the data collection is to assess litter catchability of the different gears. WGML could strive to identify which of the international fish surveys has a higher degree of catchability and thus perhaps shows less variability over time.
    - One of the improvements could be adding higher level source definitions to individual items or groups of items (e.g. fishing, shipping, aquaculture, tourism). This can be done retrospectively across the entire dataset. The additional benefit could be the development of dedicated mitigation measures for specific sectors.
- **Assessment of specific ALDFG within the ICES region.** Suggested focus areas:
    - ICES is ideally positioned to address this issue based on its historical expertise with stock assessments and surveys using a range of equipment. ICES WGML could assess the sources, distribution, trends and impacts of specific ALDFG (Abandoned, lost or otherwise discarded fishing gear).
- **Improve QA/QC of seafloor litter data.** Suggested focus areas:
    - Develop a formal process for assessing data and flagging those needing correction.
    - A ringtest for seafloor litter monitoring should be organised based on the work previously initiated by WGML.
- **Alternative methods for data collection.** Suggested focus areas:
    - Trawling is limited to soft sediments and shallow waters, and maybe be phased out in the future. Additional/dedicated trawling is not recommended for litter as it is highly damaging to the marine benthic environment. Alternative monitoring approaches should be investigated, including digital and autonomous techniques overcome temporal and spatial gaps.

Microplastic ToRs

- **Align WGML with international expert groups.** Suggested focus areas:
    - WGML should offer to collaborate with EMODNET regarding data assessment and quality assurance.
- **Improve data streams to DOME.** Suggested focus areas:
    - Evaluate the current simplified format for microplastics data and its future needs.
    - Facilitate the interoperable flow of microplastic data between databases and organisations.
- **Methods for monitoring in relation to distribution and impacts.** Suggested focus areas:
    - Determine the best available techniques for different purposes in terms of methods for sampling, processing, analysis, reporting and assessment.
    - Evaluate the relevance of different matrices (water, sediment, biota) for use in microplastic monitoring.
    - Assess the relevance of using existing fisheries surveys to collect marine species (pelagic, benthic and deep sea) for monitoring of microplastic e.g. using their stomach contents. Could link into ICES BEWG.

WGML Workplan ideas/strategy ahead

The following issues and actions require further discussion to ensure that the WGML ToRs can be delivered during the next 3 year WGML cycle (2021–2023):

- **Development of a new strategy for ICES WGML regarding seafloor litter and microplastics.** The following four options related to the aim of WGML should be discussed:
    - Maintain existing situation with seafloor litter and microplastics being the main topics of WGML.
    - Split WGML into 2 groups, with one focused on seafloor litter and one focused on microplastics.
    - Disband WGML and move seafloor litter into a closely related WG (e.g. IBTSWG, WGBEAM) and microplastic into a closely related WG (e.g. WGBEC, MCWG, WGMS).
    - Refocus WGML towards new topics and needs (e.g. ALDFG, fragmentation, risk assessment, governance).
- **Future development of WGML.** Suggested focus areas:
    - Specify in more detail what type of assessment on seafloor litter can be made for each individual survey and what can be done with data from all surveys when combined.
    - Attract new experts and maintain existing ones.
    - Identify competence gaps and develop this expertise (e.g. modelling, digital monitoring, automated image recognition, data submission).
    - Utilise expertise available within the ICES network to facilitate knowledge exchange and collaboration across WGs. For example, WGML to work with MCWG and WGMS on a review of plastic additives in sediments supported by assessment of their toxicity by WGBEC.
- **Improvement of QA/QC across microplastics and seafloor litter data.** Suggested focus areas:
    - Establish a mandate with organisations such as Quasimeme and JRC/BAM. This could include the organisation of future meetings with invited experts from external organisations.

WGML has strong competence within the existing group for assessing the quality of MP data and monitoring programmes (including the applied sampling and monitoring techniques within them). Additionally, the ICES network has a large capacity for support of environmental/fisheries monitoring.

Recommendations

Seafloor

Improve data streams and QA/QC of the seafloor litter data submissions by:

a) Directing all litter data collected on environmental surveys to DOME.
b) Directing all litter data collected via fisheries surveys to DATRAS.
c) Taking part in proficiency schemes for seafloor litter (e.g. upcoming ICES WGML ringtest for seafloor litter).

Note: If users have questions regarding seafloor litter data collection and reporting these should be addressed directly to WGML.

Microplastic

Improve data streams and QA/QC of microlitter data submissions by:

a) Directing all microplastic data collected on environmental surveys to DOME.
b) Taking part in proficiency schemes for microlitter (e.g. QUASIMEME, EU JRC).

Note: If users have questions regarding microlitter data collection and reporting these should be addressed directly to WGML.

Annex 1: List of participants

Name	Institute	Country (of institute)	Email
Thomas Maes (chair)	GRID Arendal	Norway	thomas.maes@grida.no
Andy Booth (chair)	SINTEF Ocean	Norway	andy.booth@sintef.no
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Marie Storr-Paulsen	DTU Aqua	Denmark	msp@aqua.dtu.dk
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Annex 2: WGML resolution

2017/MA2/HAPISG08 The **Working Group on Marine Litter** (WGML), chaired by Thomas Maes, UK; Francois Galgani, France; and Andy Booth, Norway, will work on ToRs and generate deliverables as listed in the Table below.

Remark: 5-day meeting = 2 x 2.5 days split between seafloor litter and microplastic ToRs

	Meeting dates	Venue	Reporting details	Comments (change in Chair, etc.)
Year 2018	23–27 April	ICES HQ, Copenhagen, Denmark	Interim report by 31 May	
Year 2019	21–24 October	Paris, France		
Year 2020	12–13 & 19–20 October	online meeting/ by corresp.	Final report by 1 December to SCICOM	physical meeting cancelled - remote work

ToR descriptors

ToR	Description	Background	Science Plan codes	Duration	Expected Deliverables
a	Respond to requests for external and internal advice (e.g. EU, Regional Seas Conventions, ICES Data Centre/Secretariat) as required	Science or advisory requirements.	2.1; 3.1; 6.1	Y1-3	Advice and review document as required
b	Review and report on developments in MSFD, other EU directives and international frameworks regarding marine litter	Follow-up on future needs is key to constructively guiding and supporting the development process for monitoring, threshold development and impact assessment.	6.3;	Y1-3	Annual reporting
c	Review and propose guidance for seafloor litter and microplastic monitoring and assessment to support expected ICES data needs based on the review in ToR a	The aim is to provide guidance in solving problems for sampling, data comparability and ICES data submissions.	3.1; 3.2; 3.5;	Y1-3	Annual reporting consisting of guidelines and review of Standard Operating Procedures (SOP), scientific publication
d	Propose a possible strategy or road map for ICES to follow with respect to seafloor litter and microplastic research and monitoring	Required for standardisation of monitoring and subsequent assessments	3.1; 3.2; 6.3;	Y3	Seafloor litter monitoring and research strategy for attention of SCICOM, scientific publication

e	Interact with exisiting bodies, projects and organisations e.g. OSPAR, HELCOM, GESAMP, JPI Oceans to develop and report on international developments in marine litter research and monitoring	To avoid duplication of effort and improve international coordination and communication	4.1; 6.3	Y1-3	Annual reporting
f	Report new developments in quality assurance in marine litter monitoring in Europe, and provide information on other proficiency testing schemes with relevance to WGML.	Availability of high quality proficiency testing is vital to produce reliable results.	4.1; 6.3	Y1-3	Annual reporting, guidance for proficiency testing, ICES Cooperative Research Report (CRR) or Techniques in Marine Environmental Sciences (TIMES)

Summary of the Work Plan

Year 1	Respond to requests under ToR a, e & f Begin review paper to start to address ToRs c & d; Gather information on network of experts for topic to address ToR b, c & e Develop and set out matrix of knowledge gaps for remaining ToRs; Progress work towards completion of the remaining ToRs It will be important to revise current practices and activities in relation to seafloor litter and microplastic monitoring and assessment to take stock of different approaches in the light of international requirements and to make future recommendations for ICES e.g. sampling methods, protocol updates, monitoring programme guidelines, analytical methods, assessment methods, gear comparisons, data statistical power of monitoring programmes and QA/QC Produce Interim Report
Year 2	Respond to requests under ToR a Progress work towards completion of the remaining ToRs Continue review paper activity to address ToRs c & d Further develop matrix of knowledge gaps in relation to national and international knowledge and produce network map and advise documents as required Produce Interim Report
Year 3	Respond to requests under ToR a Finalise review papers ready for submission for ToRs c and d; finalise matrices and interpret output to address other ToRs Produce Final Report

Supporting information

Priority	The current activities of multiple WGs and external representatives will lead ICES into issues related to monitoring and fundamental research of marine litter. Consequently, such monitoring and research activities are considered to have a very high priority with respect to the issue of seafloor litter and MPs.
Resource requirements	The research programmes which provide the main input to this group are already underway (e.g. CleanAtlantic, Baseman, WeatherMIC, …) and national/EU resources are already committed. The ICES Data Centre has already invested in the setup of a database for seafloor litter (DATRAS) and microplastics (DOME). The additional resource required to undertake additional activities in the framework of this group is negligible.

Participants	The group is predicted to attract 20–25 members and guests. The group will focus on two main topics (seafloor litter/microplastics) and a 5 day meeting could be split equally to allow participants to attend all or half of the meeting depending on their interests and expertise.
Secretariat facilities	ICES Data Centre – data extractions
Financial	No financial implications.
Linkages to ACOM and groups under ACOM	There are currently no linkages with ACOM, but the EG will be ready to address advisory requests if these are forthcoming.
Linkages to other committees or groups	There will be close working relationships with HAPISG EG. The planned work is especially relevant to MCWG, WGMS, WGBEC and WGIBTS.
Linkages to other organizations	PICES, CIESM, EU, JPI Oceans, GESAMP, UN, RSC, G7, G20, …

Annex 3: Monitoring overviews of WGML members

This covers seafloor litter, microplastic and country specific marine litter monitoring programmes.

Informative overview of seafloor litter and microplastic monitoring programmes in ICES member states

Seafloor litter Monitoring

There is a good data base already on litter at the seafloor in DATRAS following international guidelines and starting in 2012 (compare Table "Overview of WGML member seafloor litter monitoring programmes 2006–2020"). Many European countries perform a regularly monitoring of seafloor litter in the North Sea and/or in the Baltic Sea and deliver their data to the ICES database DATRAS. From there all data are available for the public.

For the North Sea and North East Atlantic most data are related to IBTS and delivered by Denmark, France, Germany, Netherlands, Norway, Sweden, England and Scotland. These data are collected from fishing trawls performed with the same type of gear (GOV (http://www.ices.dk/sites/pub/Publication%20Reports/ICES%20Survey%20Protocols%20(SISP)/SISP1-IBTSVIII.pdf)), although the ground gears used for some surveys differ. The other part of the North Sea data is related to beamtrawl surveys coordinated by WGBEAM, amongst others by Belgium, Netherlands, England and Germany. For the Baltic Sea data are delivered by Denmark, Estonia, Germany, Latvia, Lithuania, Poland, Russia and Sweden and are related mainly to BITS. In the Baltic Sea the gears TVS and TVL are mostly used. Even if the coverage by year and country is quite good some data gaps are still remaining.

Belgium, France and Germany produce additional data on marine litter on the seafloor using fishery trawls on a monitoring basis. These additional data are not related to the fisheries surveys and are therefore not able to be included in DATRAS. These additional data are supposed to be stored in ICES DOME because it is related to ecological or biological monitoring. At the moment DOME is testing a first trial format for those submissions.

Microplastic monitoring

Preliminary monitoring of micro litter in sediments, fish or water is performed by some countries on a regular basis, please see information for each country below. Many countries have ongoing research programmes covering the North Sea and the Baltic Sea which might form the basis of future microlitter monitoring activities. As there are many research-level activities across Europe that concern microplastic, more monitoring data are expected to come in the future. Monitoring data on microplastic can be submitted to DOME, which has already established a specific database for recording such data and has a mechanism for transferring it further into EMODNET.

Overview of WGML member seafloor litter monitoring programmes.

Trawl litter submission within DATRAS - Number of hauls[a,b]. Data retrieved from https://datras.ices.dk/Data_products/Submission_Status.aspx.

Nation	Area	Gear	Survey	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006
GFR[c]	Baltic	TVS	BITS q1	59	47	59	55	60	59	60	60	0						
DEN	Baltic	TVL	BITS q1	41	54	47	50	54	53	0	50	53	56					
DEN	Baltic	TVS	BITS q1	61	54	52	0	0	49	49	48	49	48					
LTU	Baltic	TVS	BITS q1	6	6	6	5	5	0	0	0	0						
LAT	Baltic	TVL	BITS q1	17	25	25	28	30	0	0	0	0						
POL	Baltic	TVL	BITS q1	57	68	69	81	49	0	0	0	0						
SWE	Baltic	TVL	BITS q1	46	43	35	51	47	49	45	50	52						
GFR[c]	Baltic	TVS	BITS q4	0	51	52	53	58	48	55	44	51						
DEN	Baltic	TVS	BITS q4	0	66	56	0	0	53	48	47	49	49					
DEN	Baltic	TVL	BITS q4	0	49	49	51	43	16	51	54	0	52					
EST	Baltic	TVS	BITS q4	0	10	10	10	10	9	0	0	0						
LTU	Baltic	TVS	BITS q4	0	6	6	6	5	4	0	0	0						
LAT	Baltic	TVL	BITS q4	0	11	17	21	14	14	0	0	0						
POL	Baltic	TVL	BITS q4	0	59	54	55	51	32	0	0	0						

SWE	Baltic	TVL	BITS q4	0	25	26	29	31	29	29	25	30						
GFR[c]	North Sea	BT7	BTS q3	0	32	38	39	53	60	17	38	32	10					
ENG	North Sea	BT4A and BT4A	BTS q3	0	186	181	179	186	71	0	0	0						
NED	North Sea	BT8	BTS q3	0	144	156	126	72	76	71	69	72						
BEL	North Sea	BT4A	BTS q3	0	56	57	54	0	0	20	57	56	56					
FRA	Channel	GOV	EVHOE q4	0	0	155	26	161	150	147	128	108						
FRA	Western waters	GOV	FR-CGFS q4	0	0	73	71	75	76	0	0	0						
IRL	NE Atlantic	GOV	IE-IGFS q4	0	161	153	149	172	46	170	176	172						
GFR[c]	North Sea	GOV	NS-IBTS q1	0	0	36	58	36	0	0	0	0						
DEN	North Sea	GOV	NS-IBTS q1	35	47	49	43	41	41	36	39	0						
FRA	North Sea	GOV	NS-IBTS q1	0	54	61	62	67	83	74	66	59						
SCO	North Sea	GOV	NS-IBTS q1	55	58	57	58	57	53	49	56	56						
NED	North Sea	GOV	NS-IBTS q1	0	64	56	55	53	45	56	59	0						
NOR	North Sea	GOV	NS-IBTS q1	0	0	18	23	20	17	22	23	0						
SWE	Skagger-rak/Kattegat	GOV	NS-IBTS q1	39	45	47	47	46	47	48	46	46						

GFR[c]	North Sea	GOV	NS-IBTS q3	0	0	28	7	25	15	21	12	22	18				
DEN	North Sea	GOV	NS-IBTS q3	56	53	55	50	59	59	51	47	0					
ENG	North Sea	GOV	NS-IBTS q3	0	0	78	77	76	67	74	74	75					
SCO	North Sea	GOV	NS-IBTS q3	0	84	94	76	98	91	84	84	84					
NOR	North Sea	GOV	NS-IBTS q3	0	0	0	50	39	11	16	14	0					
SWE	Skagger-rak/Kattegat	GOV	NS-IBTS q3	0	45	45	46	45	46	45	45	47					
POR	NE Atlantic	NCT	PT-IBTS q3 & q4	0	0	0	0	85	90	81	93	0	86	87	93	0	63	61
SCO	NE Atlantic	GOV	ROCKALL q3	0	44	41	41	48	42	47	31	36					
SPA	Gulf of Cadiz	BAK	SP-ARSA q1	0	0	41	37	0	0	40	40	33					
SPA	Gulf of Cadiz	BAK	SP-ARSA q4	0	0	45	44	0	0	45	43	37					
SPA	Bay of Biscay	BAK	SP-NORTH q4	0	109	113	112	112	115	115	114	112					
SPA	Porcupine	PORB	SP-PORC q3	0	79	80	80	80	0	79	80	79					
SCO	NE Atlantic	GOV	SWC-IBTS q1	57	62	60	61	63	62	62	67	64					
SCO	NE Atlantic	GOV	SWC-IBTS q4	0	62	56	55	60	58	0	25	66					

a Total number of hauls reported by the submitting country, including hauls with '0' litter

b Data retrieved from ICES DATRAS on 21 October 2020

c 'GFR' is the ICES code for Germany

Country specific monitoring programmes overview for WGML members

SWEDEN (last updated 2020)

Seafloor litter monitoring in Sweden

Seafloor litter monitoring in Sweden conducted by the Swedish University of Agricultural Science, Institute of Marine Research.

Sampling of sea floor litter is done during the DCF NS-IBTS survey in Q1 and Q3 in Skagerrak and Kattegat. It is also done in Q1 and Q4 during the DCF Bits survey in the Baltic. Sampling of sea floor litter is also done closer to the coast in Skagerrak and Kattegat in a national programme every Q3. Litter sampled within DCF surveys is registered on board and litter sampled in the national programme is registered in the lab.

- Today analysis and report of seafloor litter is per year, per km^2 and for specific areas within Skagerrak/Kattegat and the Baltic. The results include:
  - Number of stations sampled
  - Number of stations without litter
  - Graphs of mean weight of litter per km^2 per litter category A-plastic, B-metal etc.
  - graphs of mean number of litter items per km^2 per litter category, A-plastic, B-metal etc.

Seafloor litter data from IBTS and Bits is uploaded to the DATRAS database. Seafloor litter data from IBTS, Bits and from coastal trawling in Skagerrak and Kattegat is also sent to the Swedish Agency for Marine and Water Management. Results from analysis of IBTS, Bits and coastal trawling data is reported to the Swedish Agency for Marine and Water Management. The quality control is based on documents in the DATRAS Litter reporting format xls file and information in Bits and IBTS manuals as well as information in the WGML-report from 2018. Data from sea floor litter sampling within IBTS and Bits have been reported to DATRAS since 2012. The national sea floor litter sampling started in 2015.

Micro plastic monitoring and research in Sweden

In 2020 sediment samples for analysis of micro litter have been collected in tandem with the collection of sediment for analysis of pollutants. However, it is not yet finally decided that micro-litter in sediments will be part of the regular national monitoring programme. Previously Sweden has funded several different research projects regarding specific issues on micro litter, for example comparisons of different methods for analysis.

Micro litter sampling within DCF conducted by the Swedish University of Agricultural Science, Institute of Marine Research is done during the DCF NS-IBTS survey in Q1 in Skagerrak and Kattegat. This is done during the MIK-trawling which is designed for sampling of herring larvae. Litter is registered on board and data is sent and analysed by Bastian Huwer at DTU Aqua.

BELGIUM (last updated 2020)

Seafloor litter monitoring and research in Flanders & Belgium

Routine macrolitter monitoring on the seafloor by Belgium is done within two different sampling surveys by ILVO. Litter is recorded within the bottom trawl survey, making use of a 4m beam trawl with 40 mm mesh size at the cod end. This monitoring campaign includes 5 stations within the Belgian part of the North Sea but also 57 stations at other parts of the Southern North Sea. Litter is also collected within environmental monitoring campaigns at the Belgian part of the North Sea, which are held twice a year. Within environmental monitoring, 8m bottom trawl is used with 20 mm mesh size at the cod end. Data from 2012 onwards will be made publicly available within the ICES databases (DATRAS and DOME). Data reporting within MSFD is coordinated by the Royal Belgian Institute of Natural Sciences (RBINS). The Marine Plastics project aims at assessing this monitoring data, taking into account the different anthropogenic pressures at the Belgian Part of the North Sea.

The PLUXIN project aims to map and tackle the plastic flow from rivers and harbours into the North Sea, and to understand the behaviour of plastic in our watercourses. The plastic flux calculation will provide the T0-value for the monitoring of the inflow of plastic into the marine environment in Flanders (OVAM). Besides the traditional sampling techniques, different sensor systems (RGB, multi-spectral, hyperspectral) and sensing set-ups/platforms (UAV, fixed poles & near-surface set-ups) are evaluated in the PLUXIN project to define to which extent plastics near the water surface can be detected and quantified based on remotely sensed data.

Other macrolitter monitoring in Belgium includes beach litter (OD Nature/RBINS), plastics in Fulmar stomachs (INBO) and plastics in marine mammals (OD Nature/RBINS).

Microplastic monitoring and research in Flanders & Belgium

Currently, there is no routine monitoring of microplastics in the marine environment for Belgium. Different research groups were involved with microplastic analysis in fresh or salt water, sediment and biota within different research projects. Within the framework of monitoring, several research projects in Belgium (e.g. JPI Oceans Andromeda, EFMZV Marine Plastics, VLAIO PLUXIN) will ensure that the techniques, detection and monitoring of plastic particles are accelerated in Belgian waters. Analytical methods for microplastic detection are developed in close cooperation between ILVO, VLIZ and RBINS. For national monitoring obligations (including for MSFD), the tasks are shared between ILVO (biota) and RBINS (water, sediment). At VLIZ the focus is on research, method development, risk assessment and modeling approaches.

Within Belgium, following knowledge gaps and research needs for micro- and nanoplastics were identified:

- Focused and multidisciplinary research related to the problems in Belgium, using existing international knowledge**, cost-effective methods and technologies;**
- To gather international knowledge and to develop international methods and technologies to sample**, identify and quantify the smallest fraction of microplastics and nanoplastics;**
- To establish **a comprehensive and long-term monitoring programme in both the marine environment** and in the Belgian watercourses to the sources, presence, behaviour and transport routes, and the effects of litter and microplastics. This may be part of, but should not be limited to, monitoring provided for under EU legislation. This monitoring is crucial for the follow-up of policy actions on this issue;

- The development of a battery of monitoring and testing techniques, based on the already wide (internationally available) range of (simple) measurement and evaluation techniques that can be used in these monitoring programmes. These techniques should be able to efficiently measure the amount and nature of litter/microplastics in water, sediment, biota (critical biological indicators) and food (human health). Including the **need for automatic monitoring systems** (multi-platforms with sensors) for the monitoring of microplastics in the aquatic environment;
- Very little is known about the **ecosystem effects of microplastics** (and nanoplastics). There is a need for additional research at the level of populations and communities and how they interact with their environment;
- The development of a **risk assessment framework** and the necessary techniques/models to quantitatively assess the risks of micro and nanoplastics for humans and the environment. In doing so, due consideration should be given to **environmentally relevant concentrations and relevant reference particles**;
- The establishment of **limit values ('safe limits')** linked to the spatial variability in the occurrence of micro and nanoplastics in the environment;

Information on marine litter and microplastic research and monitoring in Belgium is included in the annual policy brief (NL): http://www.vliz.be/nl/imis?module=ref&refid=322438

Project presentations

Andromeda (JPI Oceans) – presented by Bavo De Witte:

https://www.jpi-oceans.eu/andromeda

Project partners: MIO (France, coordinator), ILVO (Belgium), Ifremer (France), Sintef (Norway), NILU (Norway), VLIZ (Belgium), University of Malta (Malta), University of Gothenburg (Sweden), UFZ (Germany), Marei Centre (Ireland), IEO (Spain), Taltech (Estonia), McGill (Canada), WUR (The Netherlands, Merinov (Canada)

The JPI Oceans project Andromeda was presented. Within ANDROMEDA, **in situ MP detection, efficient sampling and cost-effective laboratory methods** will be developed and optimized to analyze microplastics. Approaches will be based on **hyperspectral imaging, chemical markers and fluorometric detection techniques**. **Advanced analysis techniques** making use of μFTIR, Raman imaging and SEM-EDX (amongst others) will be applied to quantify and characterize micro- and nanoplastics down to 1 μm, 0.2 μm or lower. Specific tasks will focus on challenging types of microplastics such as **microfibers, tire wear particles (TWPs) and paint flakes**. UV, hydrolytic and thermo-oxidative methods to study **accelerated plastic degradation** at the lab-scale will be developed and used to prepare partially degraded **reference materials**. Comprehensive degradation studies will be conducted to study in detail the mechanisms of UV and microbial degradation, as well as to investigate the influence of parameters such as temperature, pH and hyperbaric pressure, where attention will be paid to additive chemical leaching. Quality assurance will be a central theme in all aspects of the project.

PLUXIN (VLAIO) – presented by Lisa Devriese:

https://www.pluxin.be/nl

Project partners: VLIZ (coordinator), VITO, UGent, UAntwerpen, KULeuven

A first prerequisite to take effective plastic remediation measures is to know where and when action should be taken. However, to date there is a critical knowledge gap about the **whereabouts of plastics** and about their **flux towards the marine** environment. This information is crucial to fast track cost-efficient plastic remediation measures. A central objective in the PLUXIN project is to develop a two-dimensional-horizontal (2DH) **plastic dispersal model**. The model will be calibrated and validated with experiments and field sampling data. In this context, plastics will be identified from remote sensing reflectance data through image recognition algorithms ('Machine Learning'), hence resulting in an **automated plastic detection** method. This information in combination with in situ sampling will validate the 2DH-model.

The **overall objectives of the PLUXIN project** are (1) to develop an optimized protocol for in situ plastic sampling and processing; (2) to quantify the plastic flux from rivers and harbours to the marine environment; and (3) to automatically detect plastic through remote sensing. As such, the project incorporates a number of objectives linked to the knowledge gaps above. The PLUXIN project consists of four scientific work packages aiming:

- to study experimentally the behavior of plastic litter in the water column by determining their vertical flux as a function of polymer type, shape, size, degree of biofouling, and lab-based and natural weathering;
- to get a model-based quantification of plastic flux from inland waters towards the coastal region. We will get insight into where the plastic travels, where it washes ashore and where it is deposited in the sediment, as well as how this relates to the physical-chemical characteristics of the plastic litter;
- to perform field observations on the horizontal and vertical distribution of plastic litter in the water column and their presence in the sediments. A simultaneous integrated sampling campaign will be organized to sample both micro- and macroplastic in different environmental compartments.
- to assess experimentally to which extent plastics near the water surface can be detected and quantified based on remotely sensed data. The suitability of different image classification methods, as spectral feature analyses combined with innovative machine learning techniques, will be assessed. Various experiments, performed under controlled lab and mesocosm conditions, using different sensor systems (RGB, multi-spectral, hyperspectral) and sensing set-ups/platforms (UAV, fixed poles & near-surface set-ups), are foreseen.

AQUA-LIT (EMFF) – presented by Lisa Devriese:

https://aqua-lit.eu/

Project partners: Geonardo (coordinator), VLIZ, EurOcean, FRCT, IEO, Nausicaa

The AQUA-LIT website provides an **overview of the available knowledge on marine litter originating from the aquaculture sector** and reported in the marine environment of the North Sea region, the Mediterranean region, and the Baltic region. In order to understand the potential sources of aquaculture litter, the website provides a profound **overview of the different types of aquaculture facilities** in these areas and the **important stakeholders related to this sector.**

AQUA-LIT considers crucial to:

- Understand better how aquaculture activities (separate from fishing activities) are littering the ocean through monitoring and quantification frameworks.
- Provide littering preventive measures that help reduce the input of litter from the aquaculture industry and that can be applied as the sector keeps expanding.
- Provide mechanisms that help reduce the existing marine debris coming from aquaculture activities, including the testing of best available techniques for aquaculture installations.
- Provide solutions for recycling the collected plastic waste, aiming towards a more circular economy, and
- Examine what policies need to be adapted or put in place to underpin these practical actions.

All deliverables of the AQUA-LIT projects are available online! The upcoming toolbox will provide existing, upcoming and already implemented tools, case studies, best practices, a database and links between. The toolbox will be accessible via an online platform and a mobile app and will become available by the termination of the project in 2020.

GERMANY (last updated 2020)

Seafloor litter monitoring and research in Germany

Germany routinely records macrolitter on the seafloor from bottom trawl surveys conducted by the Thünen-Institute of Fisheries Ecology, Thünen-Institute of Sea Fisheries and Thünen-Institute of Baltic Sea Fisheries. Among these activities are IBTS in the North Sea (Q2), BITS in the Baltic Sea (Q1 and Q3) and surveys alongside the monitoring of chemical and biological effects of fish under MSFD. Collection and recording of macrolitter on the seafloor are carried out according to the protocol given in the IBTS manual. All found litter items are counted, recorded, categorised following the IBTS (sub-)categories, sized and photographed. Hauls without litter are reported. This kind of litter monitoring has been performed for more than 20 years with similar gears and since 2011 it follows the IBTS protocol and MSFD requirements.

The Thünen-Institute of Fisheries Ecology recently works on an in-house extension of some parts of the IBTS protocol. The main aim is to gather more interesting and relevant parameters of the litter items to enhance the possibilities of their analyses and provide a deeper scientific insight into the distribution, patterns and sources of marine macrolitter.

Since 2018 macrolitter which was entangled in the nets is recorded as well. Before just the macrolitter in the fish catch was taken into account. First data assessments showed an overall increase in the total amount of litter items and changes in the distribution of certain (sub-)categories with macrolitter. The macrolitter entangled in the nets and in the fish catch is recorded separately to identify the changes following this new implemented approach. Data is merged prior to provision to ICES DATRAS. During the WGML meeting in 2019 the wish for a harmonized approach of ICES member states was addressed and found its way in the IBTS manual.

Additional data is produced using fishery trawls as a monitoring basis. As these additional data are not directly related to IBTS fishery surveys it is not possible to include them in ICES DATRAS. Germany expresses its wish to deliver data from its ongoing environmental monitoring programme to ICES DOME as it is related to ecological and biological monitoring and in order to connect (micro-)litter metadata with pollution and biological effect data covered by ICES DOME. The option and format to implement such data into ICES DOME is currently tested in a first trail by ICES DOME. German data from BITS and IBTS are already available via ICES DATRAS.

Recently two scientific publication on marine macrolitter were published peer-reviewed by the Thünen-Institutes:

Based on parts of the German data of marine litter in fishery trawls a manuscript was published (Kammann *et al.*, 2018). It was shown that plastic represents 80% of the total litter in both, North Sea and western Baltic Sea, which is in accordance with other studies. Furthermore, the diversity of litter material increases in near-shore regions and quantitative differences in litter items/km^2 were recognised between regions. However, as different gears were used in North Sea and Baltic Sea, they may have influenced the absolute litter catch.

Using the data of 6828 litter items yielded by 2377 survey trawl hauls on the Baltic seafloor during six years of BITS conducted by seven nations a publication was compiled (Zablotski & Kraak, 2019). Results including the fact that the plastic share in the Baltic benthic litter (35%) was below the world average (70%). Natural products, mostly residuals of burnt coal (or clinker), were found to be the most common litter category (42–57%). This category seemed to be mainly ignored in the past. The results highlight the importance of using several evaluation metrics, particularly counts of items and encounter probability.

Kammann *et al.* (2018) Marine litter at the seafloor - abundance and composition in the North Sea and the Baltic Sea. Mar Pollut Bull 127:774-780

Zablotski & Kraak (2019) Marine litter on the Baltic seafloor collected by the international fish-trawl survey. Mar Pollut Bull 141:448-461.

Microplastic monitoring and research in Germany

Microplastic in the marine environment are currently not routinely monitored in Germany. Various research groups in Germany carried out academic microplastic projects in different natural compartments such as marine and fresh waters, shorelines, sediments and biota. A national monitoring framework is still missing.

The Thünen-Institute of Fisheries Ecology is carrying out an academic research project (PlasM) at the moment. The first main aim of this study is the characterisation and quantification of microplastic in ecological and economical important fish species of the North and Baltic Sea. . The gastrointestinal tracts of the fishes are dissected. Afterwards they undergo a multistep extraction method including alkaline digestion by potassium hydroxide, oxidation by hydrogen peroxide and a density separation using zinc chloride in order to concentrate the microplastic and deposit the natural components. The extracted samples are filtered onto aluminium oxide filters subsequently. Final characterisation and quantification analyses are carried out by means of micro-FTIR spectroscopy.

Results of the microplastic uptake of the species *Limanda limanda* will be connected to routinely monitored data of fish diseases for the same individuals. Next to the scientific outcomes this study will help in identifying suitable target species for a future routinely monitoring of microplastic in marine fishes. Besides the academic path of identification via micro-FTIR this study aims to find possible monitoring approaches for microplastic in marine fishes. Monitoring approaches need to be quicker and less costly, so larger sample numbers can be monitored in a routinely manner. In addition, it should be economically viable for the involved institutions. The staining with Nile Red is a method which grants the abovementioned requirements while promising reliable data. The application of the Nile Red staining method for the identification of microplastic was tested for marine fish samples. The results basically verified this approach to be suitable for marine biota samples, but need further optimisation.

The second main aim of the PlasM project is the investigation of possible effects of oral microplastic uptake on the health status of affected fishes. For this, laboratory exposure experiments are planned to study e.g. the retention time and immunological effects of microplastic in sticklebacks (*Gasterosteus aculeatus*). Fluorescence techniques will be applied to visualize and count microplastic uptake. Realistic particles that are commonly present in the marine environment will be used for a risk assessment in concentrations that match with those found in the marine environment. The exposure experiments will focus on the effects of microplastic fibres, the most common form of microplastic in marine environments.

NORWAY (last updated 2020)

Seafloor litter monitoring and research in Norway

Seafloor litter monitoring in Norway is conducted by the Institute for Marine Research (IMR). Litter as bycatch from bottom trawls from ICES IBTS cruises in the North Sea are recorded according to the IBTS protocol and reported to ICES DATRAS database. Litter as bycatch from bottom trawls in the Norwegian-Russian ecosystem survey in the Barents Sea are recorded according to common guidelines agreed between IMR and PINRO and reported to Norwegian Marine Data Centre. This monitoring has been ongoing since 2010 (Grøsvik *et al.* 2018). Observations of seafloor litter based on video surveys by the MAREANO mapping programme, have been recorded since 2006 (Buhl-Mortensen & Buhl-Mortensen 2017, 2018). These data are stored in the IMR database 'Marbunn' and are reported through the interactive map-service on the MAREANO website (www.MAREANO.no). For all other surveys than seafloor litter monitoring, the data are held in national database and IMR uses its own set of litter codes. These non-ICES coordinated surveys don't conform to the C-TS or C-TS-REV formats and are much simpler, with general categories of metal, glass, plastic.

Other macrolitter monitoring in Norway, including Svalbard and Jan Mayen, includes beach litter (MOSJ programme) and litter in sediments (MAREANO programme). Some data on plastics in Fulmar stomachs from Svalbard are available for selected years (Norwegian Polar Institute) and for plastics in fish and mussels (Norwegian Institute for Water Research).

Microplastic monitoring and research in Norway

Norway does not currently have any form of governmental monitoring programme on microplastic, as no standardized methods for microplastic analysis are developed and available yet. Nevertheless, a number of mapping projects are ongoing with the aim to provide information on the amount of microplastic in different types of environment, and to provide reference values for bigger particles. These R&D projects have been funded to develop and acquire the necessary information for establishing a microplastics monitoring programme, mainly with support from the Norwegian Environment Agency.

The MAREANO project has performed two pilot studies with monitoring microplastics in sediment along the Norwegian continental shelf and in areas around Svalbard. Results are reported to the MAREANO programme.

IMR has started a monitoring programme with collection of samples from sediments, biota and water from monitoring programs in the Barents Sea. Methods for analyses are still under development and testing. Results will be reported to the Norwegian Marine Data Centre.

The Norwegian Environment Agency announced in late 2020 a national funding competition for establishing microplastic monitoring. This should lead to a monitoring programme being established in 2021–2022 and continuing forward.

In addition to the above, different research groups are involved with microplastic analysis in water, sediment, sea ice and biota within different research projects, including previous and ongoing JPI Oceans projects. Several institutes are involved in national and international research projects on environmental microplastic analysis and ecosystem impacts, including Akvaplan-niva, IMR, NIVA, Nofima, NORUT, Norwegian Polar Institute, and SINTEF Ocean. Microplastic researchers with a Nordic/arctic perspective collaborate within the Fram Centre for Climate and the Environment and also to the development of microplastic monitoring guidelines for the Arctic Monitoring and Assessment Programme (AMAP).

Identified needs

Macrolitter and microplastic needs for environmental monitoring and research:

- Gathering knowledge and developing standardized/harmonized methods and technologies to sample, identify and quantify the smallest fraction of plastic litter (microplastic and nanoplastics).
- suitable monitoring programs for marine and freshwater environments to identify sources, distribution, and transport pathways, as well as ecosystem effects of microplastic.
- development of risk assessment frameworks and associated techniques to quantitatively assess the risks for humans and the environment.
- Linked ecological and socio-economic studies to evaluate the impact of policy measures concerning litter or microplastic.
- Funding to support marine litter and microplastic monitoring and research.

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NETHERLANDS (last updated 2020)

Seafloor litter monitoring and research in the Netherlands

Routine macrolitter monitoring on the seafloor by the Netherlands is done in the first Quarter of the year during the IBTS using the GOV and following the international IBTS survey manual including the description of how to collect the seafloor litter data. This monitoring has been done since 2013 and is yearly reported to Rijkswaterstaat (O'Donoghue &van Hal, 2018, van Hal & de Vries 2013, van der Sluis & van Hal, 2014, van Hal 2015, 2016, 2017, 2019, Volwater & van Hal, 2020). The monitoring has developed in time, first year separation was made between the litter from the net and litter from the codend. The years after counting improved, were multiple items of the same subcategory (Fishing line and Synthetic rope) were registered as a single item in 2013 and 2014. Later these were all counted separately.

In the third Quarter macrolitter monitoring on the seafloor is done during the Dutch Beam Trawl Survey (BTS) covering a large part of the North Sea up to 58.5N. This survey is done with an 8m beam trawl having 40 mm mesh size. Seafloor litter is collected since 2012 on this survey. On an irregular basis seafloor litter is collected during other survey activities performed by Wageningen Marine Research, most of this are inshore surveys. These data are held in a national database.

In 2019, following the accident with the container vessel MSC Zoe losing a part of her cargo, additional monitoring on the regular fish surveys was done (Volwater & van Hal, 2019).

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Microplastic monitoring and research in The Netherlands

Within the national monitoring programme for chemical contaminants in marine sediments the Dutch Ministry for Infrastructure and the Environment - Rijkswaterstaat (RWS) started a study on the occurrence of microplastic in the Wadden Sea, North Sea and Zeeuwse Delta. The monitoring is conducted from 2017 until (at least) 2020. The first year, 2017, focuses on method development.

The project is divided in two parts: 1) the development of an accurate and robust analytical method, 2) the application and optimization of the analytical method for the RWS monitoring.

Part 1: For the development of the analytical method 24 samples of 1 L wet sediment have been collected in 2017 from the Dutch Wadden Sea and North Sea. The sediments are from 4 locations (Noordwijk2, Vlissingen, Doovebalg-west and Bocht van Watum); and sampled in triplicate with boxcore or shovel (from tidal mud flats).

The method of analysis complies with the OSPAR recommendations:

- Required amount of sediment: 50–200 g wet weight.
- Extraction: zinc chloride (density 1.6 g/ml).
- Filtration: optimal filter.
- Cleanup of the filtrate with necessary agents.
- Analysis: microscopy of filter
- Reporting limit: 100 um + size-classes (max. length): 100–300, 300–1000, 1000–5000 um.
- Shapes: sphere, fiber, film/foil, pellet
- Color: transparent/translucid, grey, white, black, blue, green, orange, yellow, red
- Validation: sufficient part of the samples (for false positives) by second technician, random chosen, complete with FTIR.
- Quality control: Blank extraction-analysis per measuring series. Extraction and analysis of a reference material (150 um) to simple blank sediment, per measuring series.

End product

Part 1: Report of the micro-plastic analytical method + measurement uncertainty. Photo attachment of representative micro plastic fractions (shape and size). Evaluation on the OSPAR approach and determination of points for improvement and recommendations for final method.

Data reporting and end products: a. sample code b. Sample description (from detailed metadata provided by RWS). c. amount of material per sample for analysis (gram dry weight) d. number of particles per size class + form class, as specified above. e. Showing FTIR analysis (composition plastics in some samples). f. if applicable an explanation: special observations in the extraction and analysis of the specific sample. g. the file name (s) of one or more pictures of the micro plastics from this monster. h. quality control, based on blank and std addition. i. method of prescription. Including: extraction methods, analytical methods, quality assurance + measurement uncertainty of the method.

Part 2: Optimization and application of the method for the multiannual monitoring of microplastic.

Planned monitoring programme

In 2018, 13 sediment samples will be collected. For the North Sea and coastal zone locations: TERSLG235, TERSLG100, TERSLG10, ROTTMPT50, Noordwk20, Noordwk70, Goere6, WAlCRN2 and WALCRN20. In addition, four locations in the Wadden Sea (in overlap with the 2017 programme).

In 2019, 12 sediment samples will be collected. For the Zeeland Delta locations: DREISR, ROGGPND, VEERHVMZD, haringvliet, WILHMNDGGPT, MARLGOT, TERNZBIWPT2, SCHAARVODDL. In addition four locations in the Wadden Sea (in overlap with the 2017 programme). In addition four locations in the Wadden Sea (in overlap with the 2017 programme).

In total in the period 2018 to 2020, 31 samples from different locations will be collected (given the potential changes in the multiannual planning of the chemistry programme). Results and methods improvements will be reported as mentioned above.

FINLAND (last updated 2020)

Seafloor litter monitoring and research in Finland

Bottom trawling is not conducted on Finnish seafloors, and the murky waters of the northern Baltic make it challenging to conduct visual underwater monitoring. The Finnish Environment Institute (SYKE) has carried out one small pilot study at four sites in Helsinki by scuba diving following UNEP method for underwater litter survey. Each site was monitored by visually observing litter items from three 15 m long transects. One transect covered approx. 30 m2, one site 90 m2 and the whole survey 360 m2. The survey was published in Finnish as a report in 2014 (Majaneva & Suonpää 2015). In addition, a project on ALDG (KAPYYSI) was carried out in 2018–2020 by SYKE and the Finnish Fisherman's Association (SAKL). The project collected information on potential areas for lost fishing gear and carried out retrieval of lost gear. More than 100 transects (a total distance of more than 300 km) were hauled. About 10% of the of the hauls resulted in of some remains of fishing gear or fishery related material: lines, anchors, ropes, chain, cables, weights, remains of nets or nets. Currently, a pilot project to develop suitable methods for assessing the amount of seafloor litter in the Finnish waters is being planned.

Microplastic monitoring and research in Finland

The Finnish Environment Institute (SYKE) took first microlitter samples from the surface waters in 2013 using a manta trawl equipped with a flow meter. Since then, pilot monitoring has been carried out during monitoring cruises at different seasons until 2019; during these cruises, altogether 39 offshore sampling sites have been visited in the Gulf of Finland, the Bothnian Sea and the Bothnian Bay, and methods for sampling different matrices and sample processing have been tested.

Finland's national microlitter monitoring programme started officially in June 2020. Sampling is done every other year and covers 12 offshore stations and at least 5 coastal stations. The sampling is conducted in May during national COMBINE II monitoring cruise together with e.g. zooplankton and benthos sampling. In addition to surface water sampling with a manta trawl, GEMAX corer is used to sample the uppermost 5 cm of the sediment. Density separation and the enzymatic purification method by Löder *et al.* (2017) is applied for sample processing with some modifications. Extracted particles are stained with Nile red, and analyzed with epifluorescence microscope. An automated image analysis is currently under development.

Smaller scale investigative research on microplastic abundance in water, sediment, shoreline and biota (fish, >500 specimens of mainly perch, roach, three-spined sticklebacks) has also been conducted on coastal areas around Finland in summer 2017. In addition, the microplastic load of common pelagic offshore fish (herring, sprat and three-spined stickleback, approx. 600 individuals) has been studied (Budimir *et al.* 2018).

Microlitter sampling with different techniques includes also the use of multinet equipped with 100 μm mesh size from different parts of the northern Baltic in 2018 (unpublished) and the comparison between bulk sampling (30L water sampler) and vertical plankton net (10 μm) in the Gulf of Finland (Uurasjärvi *et al.* 2020). In January 2020 snow and sea ice samples were collected from the Bothnian Bay.

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DENMARK (last updated 2020)

Seafloor litter monitoring and research in Denmark

Routine macrolitter monitoring on the seafloor is conducted by Denmark in the North Sea in quarter 1. and quarter 3. during the IBTS using the GOV and following the international IBTS survey manual including the description of how to collect the seafloor litter data. This monitoring has been done since 2013 and is on annual basis reported to ICES DATRAS. In the Baltic the seafloor litter is routinely monitored on the BITS survey (Baltic international trawl survey) in quarter 1 and quarter 4. The monitoring are following the same litter as in the North Sea. Litter sampling has in both Baltic and North Sea been conducted since 2011.

Long term monitoring of microlitter in the Danish environment is not currently carried out. However, there have been a number of case studies of microplastic litter conducted by different institutes in Denmark.

Contents of microplastic particles were investigated in sediment sampled in the North Sea in 2015 by Aarhus University as a national monitoring activity funded by the Danish EPA. This study looked at microplastic the size range of 20–5000 μm from 10 stations. Samples were collected using HAPS bottom corer with a diameter of 13.5 cm corresponding to a surface area of 0.0143 m^2. Microplastic were visually identified based on their relatively homogenous texture and structure using a stereo microscope (20–50x magnification). Later this study has been followed by a parallel study on 10 sediment samples collected in the Inner Danish waters.

As a national monitoring activity funded by the Danish EPA studies on microplastic in the stomachs of herring and cod from the North Sea and Baltic Sea was carried out by DTU Aqua in 2016. Two specific fish species, cod and herring were examined. The aim was to analyse the stomach contents of 100 fish from each species caught in coastal and offshore waters of the North Sea and the Baltic Sea with the focus on particles > 100 μm in size and using the sampling already planned as part of DTU Aqua fish monitoring activities (International Bottom Trawl Survey). Microplastic samples were identified using a combination of visual identification and the hot needle technique. Sub-samples were also taken for polymer identification using Ramen spectroscopy. Another more case-oriented study showed no increase in marine microplastic concentration in herring from the Baltic Sea over the last three decades.

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Microplastic monitoring and research in Denmark

Various research projects on sources, detection methods, occurrence, fate and impact of microplastic in the environment is at the moment going on at the different Danish universities. To mention some projects that Aarhus University is involved in:

- Research project on sources, occurrence and fate of plastic debris in a Danish coastal fjord (Roskilde Fjord) covering studies on water column, sediment and mussels. Cooperation between Aarhus University, Roskilde University and Plastic Change. Funded by the VELUX foundation.
- Research project (SIMAG) on microplastic in sediments in West Greenland and in a gradient from a more local urban area towards mores pristine waters. Focus on particle sizes >100 μm where polymer composition has been verified with μFT-IR. The dominant polymer groups in the sediment were found to be polyesters, acrylates, rubber and PVC. The SUMAG project also included studies on beach litter and fulmars in Greenland. Funded by the Danish EPA
- Synthesis project which aims to gather knowledge about potential framework for risk screening of microplastic, detection methods and the fate of microplastic in Denmark. The project also intends to facilitate networking and knowledge exchange between research groups at different Danish universities and relevant stakeholders. Funded by the VELUX foundation.
- Method development projects to improve identification methods of microplastic using μFTIR images for mapping microplastic. This includes work with on developments of more automated methods for the processing of data produced by μFTIR imaging of microplastic. Collection of relevant μFT-IR as well as ATR generated samples of different types of environmental plastic will also feed into developments of high-quality reference libraries. Collaboration with e.g. Ålborg University, The technical University in Denmark and Gothenburg in Sweden and SYKE in Finland.

UK (last updated 2020) - except Scotland

Seafloor litter monitoring and research in the UK (Except Scotland)

Since 1992, the Centre for Environment, Fisheries and Aquaculture Science (Cefas), a UK Government organisation, has been collecting seafloor litter data on environmental and fisheries stock assessment surveys. Such research provides spatial and temporal trend assessments of the abundance of seafloor litter within North West European seas and acts as a baseline against which litter reduction mitigation measures can be assessed. We recently published an assessment of 25 years of seafloor litter data (1992–2017), gathered during 39 scientific surveys at 2461 stations in the coastal seas of North West Europe. We divided the analysis in two main parts: an analysis of the trends of the major litter categories and plastic sub-categories during the 1992–2017 period (presence/absence) and a spatial analysis in 2011 (number of items), the last year in which all surveys took place, thus providing a comparison of the inshore (within 12 nautical miles of land) and offshore (>12 nautical miles) regions of the Celtic and Greater North Seas.

Highlights of the study included:

- Widespread distribution of litter items on the seabed, up to 1835 items km−2;
- Over the 25-year period, 63% of the trawls contained at least one plastic litter item;
- No significant temporal trend in total number of litter items km−2;
- Significant trends in plastic bags (down) and fishing debris (up);
- Potential influence of behavioral changes on litter abundance.

Since 2012, the UK has implemented a seafloor litter monitoring programme to fulfil international drivers and requirements e.g. OSPAR, MSFD. The data is gathered on board the trawling surveys by trained staff, QA/QCed by the Cefas marine litter experts and submitted to ICES Datras on a yearly basis. The data, together with those of other countries, has been used in the intermediate OSPAR common indicator assessment for seafloor litter: https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/pressures-human-activities/marine-litter/composition-and-spatial-distribution-litter-seafloor/.

Microplastic monitoring and research in UK (Except Scotland)

In relation to microplastic, the UK has published the results of several case studies to look at the presence of microplastic in the water and sediments. Microplastic contamination was determined in sediments of the Southern North Sea and floating at the sea surface of North West Europe. Floating concentrations ranged between 0 and 1.5 microplastic/m^3, whereas microplastic concentrations in sediments ranged between 0 and 3146 particles/kg dry weight sediment. In sediments, mainly fibers and spheres were found, whereas at the sea surface fragments were dominant. At the sea surface, concentrations of microplastic are lower and more variable than in sediments, meaning that larger sample sizes and water volumes are required to find detectable concentrations. We have calculated the widths of the confidence intervals (CI) for different sample sizes, to give a first indication of the necessary sample size for a microplastic survey at the water surface. Higher concentrations of floating microplastic were found near estuaries. In sediments, estuaries and areas with a high organic carbon content were likely hotspots. Standardization of monitoring methods within marine regions is recommended to compare and assess microplastic pollution over time.

Cefas presented a new approach for analysis of microplastic in environmental samples, based on selective fluorescent staining using Nile Red (NR), followed by density-based extraction and filtration. The dye adsorbs onto plastic surfaces and renders them fluorescent when irradiated with blue light. Fluorescence emission is detected using simple photography through an orange filter. Image-analysis allows fluorescent particles to be identified and counted. Magnified images can be recorded and tiled to cover the whole filter area, allowing particles down to a few micrometres to be detected. The solvatochromic nature of Nile Red also offers the possibility of plastic categorisation based on surface polarity characteristics of identified particles. This article details the development of this staining method and its initial cross-validation by comparison with infrared (IR) microscopy. Microplastic of different sizes could be detected and counted in marine sediment samples. The fluorescence staining identified the same particles as those found by scanning a filter area with IR-microscopy. The method has been applied for the large-scale mapping of microplastics in environmental samples (i.e. sediment, biota and surface waters) for other areas including the Pacific region and South Africa (Bakir *et al.*, 2020a, 2020b). The Nile red method was found to be a promising approach for the large-scale mapping of microplastics in a monitoring context.

In 2017, the UK has setup a specific monitoring programme, mainly to look at microplastic in sediments, but also to investigate the potential for microplastic monitoring in biota. The first year

we have focussed on the method development, sample collection and collaborations with other international experts to fine-tune the approach together with OSPAR. We will follow the procedure as outlined in the OSPAR Microplastic Candidate Indicator (Annex 11). We have now started the analysis of sediment samples and biota.

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Scotland (last updated 2020)

Seafloor litter monitoring and research in Scotland

Sea-floor litter data collection has continued throughout this term of the working group with data from 308 trawls for 2018, 310 trawls for 2019 and (up to the time of writing) 112 trawls for 2020 added to ICES DATRAS. We have also undertaken an analysis of the sea-floor litter data in the waters around Scotland. This used litter count data downloaded from DATRAS and evaluated annual spatial distributions using a generalized additive mixed-effect model utilising soap-film smoothers and temporal changes using a linear mixed effects model. The results of this analysis are described in Scotland's Marine Assessment 2020 (http://marine.gov.scot/sma/assessment/sea-floor-litter).

Microplastic monitoring and research in Scotland

Marine Scotland Science (MSS) has had a programme running since 2014 looking at the quantities of microplastics present in Scotland's seas. Sea surface water samples are collected with a 333 µm neuston net mounted on a catamaran swimmer body (Neuston Net acc. to David/Hempel Model 300). The samples are collected on MSS' CSEMP cruises. Until now the operational requirements of the cruise have meant samples were collected as and when there was free time. Sampling will be more targeted in coming years. Sea surface sampling is also affected by wind and sea conditions. Nevertheless MSS has collected 398 samples since 2014. Samples are mainly processed at sea by rinsing cod end over a sieve stack (5 mm and 125 µm sieves). The 125 µm sieve is used as although the net is 333 µm mesh material smaller than this has been collected, quite often stuck to seaweed or other floating material. Material in the top 5 mm sieve is collected and counted as is any suspected microplastic in the 125 µm sieve (spheres, pellets, fragments, fibres, film and polystyrene). The sieves are examined under a lighted magnifying plate and are checked by two people. Around 10% of plastics are confirmed by micro FTIR. The data from this project will be used in the 2020 Scottish Overall Assessment though it is recognised that it is not monitoring *per se*.

Sediments have been collected from our CSEMP contaminant monitoring sites since 2016 and analysis of these has now begun using the Nile Red method and micro FTIR. Data from these has been delayed by COVID-19 pandemic. Biota (mainly gastro-intestinal tract but also some gills) have also been collected on our CSEMP cruises – flatfish,roundfish and some shellfish. These will be analysed in 2021 with a view to picking species most suited to monitoring.

FRANCE (last updated 2020)

Seafloor litter monitoring and research in France

Seafloor litter monitoring in France is conducted by IFREMER. Sampling is done during the IBTS –NS- IBTS surveys in the Channel, western Brittany (southern Celtic Sea) and the Bay of Biscay. Litter sampled within DCF surveys is registered on board.

Today analysis and report of seafloor litter is per year, per km2 or Hectare. Data from navigation logs are automatically extracted through the IFREMER/Tutti system and litter data are processed through the French litter database QUADRIGE/DALI before being uploaded to the ICES DATRAS database. The results include the number of stations sampled, Number of stations without litter, data on mean weight of litter per km2 per litter category A-plastic, B-metal etc. and data of mean number of litter items per km2 per litter categories following the IBTS protocol, MSFD compatible.

Data are used for the reporting of MSFD, and, on irregular basis, to support the French ministry of environment in monitoring the efficiency of reduction measures.

Data from seafloor litter sampling within IBTS and Bits have been reported to DATRAS since 2012. The national sea floor litter sampling started in 2015.

Microplastic monitoring and research in France

In recent years, a number of R&D projects have been also funded to develop and acquire the necessary information for such a monitoring programme. IFREMER is the coordinator of any microplastic monitoring programme at sea and for sediment, when CEDRE is in charge of Microplastics on beaches.

The National microlitter monitoring programme started officially in 2012, along the French Atlantic and Mediterranean Coasts. Microlitter sampling within DCF is conducted during the IBTS –NS- IBTS surveys in the Channel, western Brittany (southern Celtic Sea) and the Bay of Biscay. Collection is done through the use of manta trawl, following the MSFD guidance protocol, Samples are conditioned on board and all samples (from all cruises) are analysed in a single laboratory (IFREMER). Data is used to report for MSFD.

Corers are about to be used to sample the uppermost 5 cm of the sediment (TGML, 2013). The reference extraction method using KOH (TGML, 2013) is applied for sample processing with some modifications. Extracted particles are counted visually but a protocol is under implementation to use Nile red, with epifluorescence microscope analysis, on regular basis.

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POLAND (last updated 2020)

Seafloor litter monitoring in Poland conducted by National Marine Fisheries Research Institute (NMFRI)

The monitoring of the southern part of the Baltic Sea has been done since 2015 in quarters 1 (Q1) and 4 (Q4). Marine litter from the bottom of the sea were collected in the framework of the Baltic International Trawl Surveys programme (BITS) realized by the National Marine Fisheries Research Institute (NMFRI, Poland) within the Polish Multiannual Fisheries Data Collection Programme on R/V Baltica.

The standard fish control-catch procedure is described in detail in the Manual for the Baltic International Trawl Surveys. The fish control-catch sites are randomly selected by the WGBIFS from the fixed list of sites sampled within the BITS programme. The rigging cod ground trawl type TV-3#930 (without bobbins and additional chains fastened to the footrope) is in use during the operations. Mesh bar length of 10 mm in the codend allowed sampling macro-litter and larger fractions of meso-litter. Fish control-hauls are conducted at 3 knots vessel speed. The standard trawling-time is 30 minutes, however, the time is modified in case of unexpected logistical reasons.

The sampling and reporting of marine litter were additional tasks of BITS surveys, recommended and partly coordinated by the Baltic International Fish Survey Working Group. The litter BITS Q1 and Q4 survey data were entered into DATRAS database.

Other seafloor litter monitoring programmes carried on in Poland

As an initiative of three fishing associations in cooperation with the National Marine Fisheries Research Institute (NMFRI) Institute, over 150 fishing vessels have collected lost fishing gear and marine litter. The fishermen are creating a database using a mobile android application "MIR przyłowy". The data provider is NMFRI. The project is financed by European Maritime and Fisheries Fund (EMFF) via the government project "Rybactwo i Morze" ("Fishing and the Sea").

Microplastic research conducted by National Marine Fisheries Research Institute (NMFRI)

The NMFRI does not conduct the microplastic monitoring but participates in the BONUS MICROPOLL project (2017–2020). The aims of the project are:

1. assessment of the occurrence of microplastics in the Baltic Sea;
2. assessment of microplastics emission to the Baltic Sea;
3. identification and mapping of micro-plastic emission sources to the Baltic Sea;
4. assessment of the impact of microplastics on marine organisms;
5. developing effective methods for monitoring microplastics in the marine environment and ways to reduce their emissions into the Baltic Sea.

During the programme NMFRI conducted:

1. Assessment of microplastics transport in the Vistula River. The sampling was conducted every month for a year in the river mouth and in its vicinity. The samples were taken with a Manta 300 μm mesh net in the water column vertically and in the horizontal hauls.
2. The field experiment on the assessment of microbiological biofilm development on the surface of microplastics - Sopot site.
3. Laboratory experiments on the impact of microplastics on Baltic invertebrates.
4. Laboratory experiments on the impact of microplastics in the early fish life stages (rainbow trout and sea trout).

Other microplastic monitoring programmes carried on in Poland

Another institution that monitors litter and microplastics in Poland is Polish Institute of Meteorology and Water Management - National Research Institute (IMGW-PIB). The monitoring deals with the microplastics in the sea water and sediments, collected once a year from 4 locations on the Baltic Sea and in the Vistula Lagoon and Szczecin Lagoon. Both monitorings have been carried in frame of the State Environmental Monitoring since 2014. (information obtained thanks to the kindness of the Dr. Er. Tamara Zalewska, Professor of IMGW-PIB Tamara.Zalewska@imgw.pl).

SPAIN (last updated 2020)

Seafloor litter monitoring and research in Spain

Routine macrolitter monitoring on the seafloor is conducted by IEO (Instituto Español de Oceanografía) in the spanish waters during the IBTS using the BAKA and following the international IBTS survey manual including the description of how to collect the seafloor litter data. This monitoring has been done since 2013 and is on annual basis reported to ICES DATRAS. Other methods are evaluated under the framework of projects (the use of images from ROVs, glidders, etc) like Cleanatlantic (www.cleanatlantic.eu).

Additional data is also produced by IEO using fishery trawls as a monitoring basis. As these additional data are not directly related to IBTS fishery surveys it is not possible to include them in ICES DATRAS but IEO is working with this data to produce reports on the issue. Also other data source are under evaluation like fishing for litter programmes or specific clean ups by divers.

Data are used for the reporting of MSFD, and also to support the Spanish ministry of environment in monitoring the efficiency of reduction measures.

Microplastic monitoring and research in Spain

IEO is the coordinator of the microplastic monitoring programme at sea and for sediments, and CEDEX is in charge of Microplastics on beaches.

The water sampling is done through the use of manta trawl, following the MSFD guidance protocols and the improvements made in the framework of projects like BASEMAN, Samples are conditioned on board and all samples (from all cruises) are analysed in a single laboratory (IEO, Vigo). Data is used to report for MSFD.

The sediment corers used are sampled in the uppermost 5 cm of the sediment (TGML, 2013). The reference extraction method using KOH (TGML, 2013) is applied for sample processing with some modifications developed in the BASEMAN project. Extracted particles are counted visually and a number between 5–10% of total particles are identified chemically using FTIR, Raman or similar techniques.

Also work on microplastics in biota is developed by IEO and other labs. Actually no specie has been selected but some articles have been publised dealing with species found in spanish national waters.

Various research projects on sources, detection methods, occurrence, fate and impact of microplastic in the environment are actually going on at the different spanish universities and research institutions like CSIC. In this sense is important to mention the JPI Oceans projects (2020.2023) ANDROMEDA, iplastics and RESPONSE with spanish participation,

To mention some articles that IEO has published recently on the issue:

-From the coast to the shelf: Microplastics in Rías Baixas and Miño River shelf sediments (NW Spain). O Carretero, J Gago, L Viñas. *Marine Pollution Bulletin*

-Microplastic ingestion by pelagic and benthic fish and diet composition: A case study in the NW Iberian shelf. AV Filgueiras, I Preciado, A Cartón, J Gago. Marine Pollution Bulletin 160, 111623

-Microplastics in the Bay of Biscay: An overview. A Mendoza, JL Osa, OC Basurko, A Rubio, M Santos, J Gago, F Galgani, C Pena-Rodríguez. *Marine Pollution Bulletin* 153, 110996

-Plastic debris accumulation in the seabed derived from coastal fish farming. L Krüger, N Casado-Coy, C Valle, M Ramos, P Sánchez-Jerez, J Gago, O Carretero, A Beltrán-Sanahuja, C Sanz-Lázaro. *Environmental Pollution* 257, 113336

-Observations and idealized modelling of microplastic transport in estuaries: The exemplary case of an upwelling system (Ría de Vigo, NW Spain). M Díez-Minguitoa, M Bermúdez, J Gago, O Carretero, L Viñas. *Marine Chemistry* 222, 103780

-The Bay of Biscay as a trapping zone for exogenous plastics of different sizes. L Rodríguez-Díaz, JL Gómez-Gesteira, X Costoya, M Gómez-Gesteira, J Gago. *Journal of Sea Research* 163, 101929

-Ingestion of plastic debris (macro and micro) by longnose lancetfish (Alepisaurus ferox) in the North Atlantic Ocean. J Gago, S Portela, AV Filgueiras, MP Salinas, D Macías. *Regional Studies in Marine Science* 33, 100977

-Plackett Burman desing for microplastics quantification in marine sediments. AV Filgueiras, J Gago, I García, VM León, L Viñas. *Marine Pollution Bulletin*

-Microplastics in Seawater: Recommendations from the Marine Strategy Framework Directive Implementation Process. Jesus Gago, Francois Galgani, Thomas Maes, Richard C. Thompson: Frontiers in Marine Science 11/2016; 3., DOI:10.3389/fmars.2016.00219

Annex 4: Detailed summary of linkages and drivers

EU Mission STARFISH

Within its next Horizon Europe framework to be launched early 2021 by the EU DG R & I, a mission, named Mission STARFISH, dedicated to Ocean sciences has been launched with 5 main objectives to support the regeneration of EU seas and waters (https://ec.europa.eu/info/publications/mission-starfish-2030-restore-our-ocean-and-waters_en). Part of the working plan is to limit pollution with a focus on Marine litter, including the reduction of emissions, objectives of 100% recyclability or degradability, and the tagging of fishing gear to avoid losses and support recovery.

G7 and G20

G7 Action Plan to combat Marine Litter (G7, 2015).

The G7 countries

- Commit to the improvement of countries' systems as a key goal of the action plan, to prevent, reduce and remove marine litter, including the below listed priority actions.
- Recognize that support through international development assistance and investments are important to combat marine litter and encourage both.
- Support development and implementation of national or regional action plans to reduce waste entering inland and coastal waters and ultimately becoming marine litter, as well as to remove existing waste.
- Share best practices, especially with developing countries, and encourage a similar call to action in other international fora.
- Recognize that, where available, the use of existing platforms and tools for cooperation will reduce duplication and take advantage of progress made (e.g. the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA), the Global Partnership on Marine Litter (GPML) and the Regional Seas Conventions and Action Plans) and therefore support their use.
- Promote individual and corporate behaviour change through public awareness and education to address marine litter.
- Recognize that prevention is key to long-term success in addressing and combating marine litter and that industries and consumers have an important role to play in reducing waste.
- Recognize that the need for removal actions is important, due to the vast amounts of litter already in the marine environment.
- Support the use of a broad range of policy toolkits and available instruments, including economic incentives, market-based instruments, and public private partnerships to support implementation of actions to effectively combat marine litter.

In 2019, the G7 was under the presidency of France who organized two dedicated workshops in Metz (G7 Ministries of Environment) and Paris (Ministries of Research) with recommendations to:

- Support monitoring through Regional Sea Conventions (RSCs) with a coordination by UNEP.
- Support biomonitoring to address impacts of marine litter, supporting the creation of a dedicated technical group to implement such a monitoring.

G20 Action Plan on Marine Litter (G20, Germany, 2017).

The G20 maintains that the tools to reduce marine litter have to be as diverse as the challenge of marine litter itself. There is no 'one size fits all' solution. We **reiterate the need to:**

- address pollution from land based sources,
- address pollution from sea based sources, including key waste items from the fishing and aquaculture industry as well as from the shipping sector,
- address financial resources for cost-effectiveness analyses as well as measures for marine litter prevention or reduction,
- put in place effective actions e.g. to facilitate the implementation of the polluter pays approach, e.g. 'extended producer responsibility' or deposit schemes - already in place in some G20 countries as appropriate and develop new sources of funding for effective waste management systems, as well as stimulate innovation;
- address education and outreach, and
- address additional research requirements.

In 2019, the G20 was under the presidency of Japan, also supporting global monitoring, including microplastic, based on the recommendations from the GESAMP group.

In 2020, Japan launched an initiative to upscale the assessment of floating microplastics to global level. The coordination (Ministry of Japan) launched a technical guidelines and started to compile data from any country/institute.

UN Environment Assembly (UNEA4)

The resolutions and decisions called for accelerated action and strengthened partnerships to, inter alia: combat the spread of marine plastic litter and microplastic; eliminate exposure to lead paint and promote sound management of used lead-acid batteries; improve air quality globally; address water pollution; manage soil pollution; and control pollution in areas affected by terrorist operations and armed conflict.

In 2020, The Scientific Advisory committee (SAC) is compiling scientific information and prepare a review to support the "ad hoc expert group" in their future decision on harmonized reduction measures.

UN Decade of Ocean Science (2021–2030) – SDG14

To Support the initiative, the IOC started a group (14.1.1) to address both eutrophication and plastic pollution. The group is actually defining the most appropriate indicators to support a strategy dedicated to the global monitoring of the ocean.

Drivers:

- SDG14 includes marine debris', support global monitoring through appropriate and relevant indicators and states that a significant reduction must be achieved by 2025. Each regional sea convention, including the Atlantic and Arctic, organized regional meeting to prepare recommendations, including sessions on "cleans seas" largely dedicated to Marine litter.

IOC/GESAMP

As part of the IOC's initiatives and strong linking with SDG14, the 2019 OceanObs meeting (OO19) was organized to implement the global observing systems. A breakout session was organisized for Marine litter pollution with key recommendations in terms of global monitoring:

- A comprehensive global observing & information system is necessary to evaluate sources/sinks, abundance, trends, risks and the efficiency of reduction measures, and finally to get the problem under control.
- To achieve fundamental understanding of the issues of marine debris, develop efficient in situ observation technology, remote sensors, models and monitoring strategies, involving citizen scientists when possible.
- Build an integrated, standardized and harmonized collaborative network, using commonly accepted methods & definitions, whose structure (variables, coverage, and products) answers fundamental scientific questions and societal demands.

In 2019, the Joint publication by GESAMP, IOC and UN Environment on monitoring harmonisation and standardisation was published to support RSCs in implementing their monitoring

The Global Partnership on Marine Litter

The Global Partnership on Marine Litter (GPML) was launched in June 2012 at Rio + 20 in Brazil. The GPML, besides being supportive of the Global Partnership on Waste Management, seeks to protect human health and the global environment by the reduction and management of marine litter as its main goal, through several specific objectives. A new group, WG 43 , supported by UNEP and IMO, was launched in 2019 to prepare a re-port to be published in 2020 on the sea based sources of marine litter.

EU – Plastic Strategy

Opportunities and challenges linked to plastics are increasingly global and addressing them will significantly contribute to achieving the 2030 Sustainable Development Goals.

Drivers:

- Major aim to reduce marine litter.
- Consideration of recyclability/biodegradability and bio- based plastics.
- Vision/actions on microplastic.
- Strategy for most-found items.

EU - Marine Strategy Framework Directive (MSFD)

The main goal of the Marine Directive is to achieve Good Environmental Status of EU marine waters by 2020. The Directive defines Good Environmental Status (GES) as: "The environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive". For Descriptor 10, the Good Environmental Status (by 2020) is defined as: "the properties and quantities of marine litter do not cause harm to the coastal and marine environment".

Further work is underway on the harmonization of a number of methods which have not yet been fully developed (such as, e.g. those for microplastic and floating litter) and the specification of protocols in the light of national experiences and considerations, the possible establishment of a network for microplastic measurements, and further discussions and advise on a database with litter information from MS states which can serve as a baseline for marine litter.

The MSFD is now completing the second 6-year cycle of implementation, with updates of the assessment, determination of GES (revision of art 8 n 2020–2021) and environmental targets due to be submitted in 2021 and reported in October 2023 for finalization in 2024, followed by updating of monitoring programmes, and updating the programmes of measures due to be reported in March 2022.

Deadline for submission of proposals: June 2018. The purpose of the open call for proposals is to support the next 6-year cycle of MSFD implementation. The proposals should have practical outcomes which clearly contribute to the implementation of the MSFD. The successful implementation of the proposals should directly contribute to regional or subregional cooperation needs of Member States' competent authorities in their implementation of the Directive. The proposals can contribute directly to the efforts of the regional organisations, such as the Regional Sea Conventions (RSCs), as long as these are directly linked to MSFD implementation requirements. The proposals should support those (sub)regions where Member States have jointly identified certain shortcomings and are committed to address them together in a coherent manner

Drivers:

- Updating of monitoring programmes due to be reported in October 2020.
- Updating the programmes of measures due to be reported in March 2022.
- Next cycle starting 2020.

EU TGML

The EU TGML supports member states in their implementation of the MSFD. It addresses many different tasks, some of them directly to support monitoring:

Review of Guidance for the Monitoring of Marine Litter:

While the TG Marine Litter Guidance on the Monitoring of Marine Litter is being widely used and has led to a considerable improvement of harmonisation, further progress and research results require a review of the guidance. That review is underway by TGML, in close collaboration with Member State experts, research projects and scientific experts on specific topics.

MSFD Marine Litter Item Category Masterlist:

The monitoring of marine macro litter is based on its identification according to a list of commonly found items. The harmonisation of this list is crucial to a comparable assessment of macro litter and has been referenced in the Commission Decision 2017/848/EU. The list has been revised in 2019 within TGML, in close collaboration with Member State experts, and is now officially available together with the photoguide:

- Joint List of Litter Categories for Marine Macrolitter Monitoring - https://ec.europa.eu/jrc/en/publication/joint-list-litter-categories-marine-macrolitter-monitoring.
- Online Photo Catalogue of the Joint List of Litter Categories - https://mcc.jrc.ec.europa.eu/main/photocatalogue.py?N=41&O=457&cat=all.

Baseline and thresholds:

TGML was also mandated to define baselines and thresholds. The group has initiated the process, considering beach litter in 2019, and both seafloor litter and microplastic in the coming years. The first official threshold for beach litter in European has been validate by the MSCG coordination group in September 2020 (https://ec.europa.eu/jrc/en/publication/european-threshold-value-and-assessment-method-macro-litter-coastlines).

Interactions:

- EU TGML D10 meeting November 2020
- Review of Guidance for the Monitoring of Marine Litter: 2020
- MSFD Marine Litter Item Category Masterlist: 2020/2021
- Seafloor litter and microplastic baselines and Thresholds: 2020–2022

EU – Water Framework Directive (WFD)

In the context of the Water Framework Directive Member States must report on the presence of litter/microplastic, if they are taking measures to address it.

Drivers:

Review of the WFD by 2019.

OSPAR

As part of its monitoring and assessment programme, OSPAR currently assesses beach litter, seabed litter and plastic particles in Fulmar stomachs as indicators. These allow the abundance, trends and composition of marine litter in the OSPAR Maritime Area to be determined for different marine compartments (floating, seafloor and coast).

OSPAR is currently also working to develop new indicators, including ingestion of plastic particles by turtles and microplastic in sediments. The turtle indicator is being developed by the INDICT project and will cover the Bay of Biscay and Iberian Coast, (as well as the western Mediterranean). The microplastic indicator will address levels in marine sediments and will cover the whole OSPAR Maritime Area. After the OSPAR intermediate assessment (2017), OSPAR will publish a final assessment by 2020.

In 2014 OSPAR agreed to develop a Regional Action Plan (RAP) for Marine Litter, along with an implementation plan, to achieve its objective to significantly reduce amounts of marine litter. The RAP focuses on both sea-based and land-based sources of litter, as well as considering removal actions and education and outreach. It will be implemented over the period 2014–2021.

The OSPAR objective and this RAP are supportive of the Rio+20 global commitment to "take action to, by 2025, based on collected scientific data, achieve significant reductions in marine debris to prevent harm to the coastal and marine environment" in the "The Future We Want" and with the 2013 UNGA resolution A/RES/68/70 in which States noted concern on marine debris.

Drivers:

- OSPAR microplastic indicator
- OSPAR final assessment by 2020
- OSPAR litter expert group (ICG-ML): Develop and agree regionally coordinated SMART reduction/operational targets linked to relevant actions as contained in this implementation plan, starting from 2015, including those linked to sources

The next ICG-ML meeting will take place in June 2021.

OECD - Workshop on Managing Contaminants of Emerging Concern in Surface Waters:

Scientific developments and cost-effective policy responses, 5 February 2018:

https://www.oecd.org/water/Summary%20Note%20-%20OECD%20Workshop%20on%20CECs.pdf

"Key messages of the workshop will inform an OECD report on policies to manage CECs. Draft versions of the report, including preliminary policy recommendations, will be circulated for comment to delegates of the JM and WPBWE and workshop participants. The final report will be released at the end of 2018."

PAME - Protection of the Arctic Marine Environment Working Group (PAME)

PAME is one of six working groups encompassed by The Arctic Council. Founded as part of the 1991 Arctic Environmental Protection Strategy, it assimilated into the structure of the Council following the signing of the 1996 Ottawa Declaration by the 8 Arctic States. The group compiles

representatives from each state, (Canada, Denmark (representing both Greenland and the Faroe Islands), Finland, Iceland, Norway, Russia, Sweden, and the United States) as well as its Permanent Participants (The Aleut International Association, The Arctic Athabaskan Council, The Gwich'in Council International, The Inuit Circumpolar Council (ICC), The Russian Association of Indigenous Peoples of the North (RAIPON), and the Saami Council) representing the region's indigenous populations, and a number of observers. The Working Group claims to operate across the domains of Arctic shipping, maritime pollution, marine protected areas, ecosystem approaches to management, resource exploitation and development, and associations with the marine environment. Where necessary, it is tasked with producing guidelines and recommendations for policy improvement, with projects approved every two years by the council. The Secretariat for PAME is located in Akureyri, Iceland.

The overarching objectives for PAME were formally outlined in the 2009 meeting held in Oslo, Norway. These objectives are:

- To improve knowledge and respond to emerging knowledge of the Arctic Marine Environment.
- To determine the adequacy of applicable international/regional commitments and promote their implementation and compliance.
- To facilitate partnerships, programme and technical cooperation and support communication, reporting and outreach both within and outside the Arctic Council.

PAME is in the process of developing a Regional Action plan on marine litter in the Arctic, as an extension of a preliminary study on Arctic marine litter and micro-plastics which was carried out between 2017 and 2019. The development of the Regional Action Plan on Marine litter is co-led by Canada, the Kingdom of Denmark, Finland, Iceland, Norway, Sweden, USA, AIA and OSPAR with close collaboration with other working groups.

The Regional Action Plan will address both sea and land-based activities, focusing on Arctic-specific marine litter sources and pathways that will play an important role in demonstrating Arctic States' stewardship efforts towards reducing the negative impacts of marine litter, including microplastics, to the Arctic marine environment.

The Regional Action Plan may be updated in subsequent years to address new and emerging information and priorities; therefore, the structure will be realistic and adaptable.

Project Objectives:

- Develop a first version of a Regional Action Plan on Marine Litter in the Arctic based on the Desktop Study on Marine Litter (Phase I) and other resources and information, as relevant and specific to the Arctic.
- Collaborate with other Arctic Council Working Groups working on marine litter activities, such as AMAP's work on monitoring, CAFF's work on impacts of marine litter on wildlife, ACAP's work on solid waste management, and others as relevant to marine litter in the Arctic to ensure that this work is adequately reflected in the first version of the Regional Action Plan.
- Continue the development of outreach and communication material.

PAME's Desktop Study on Marine Litter in the Arctic concluded that "Developing a Regional Action Plan (RAP) on marine litter in the Arctic is timely, recognizing that the RAP can be modified over time based on the state of knowledge. Developing a monitoring programme as part of, or in parallel to, the development of a RAP is particularly valuable to establish a baseline of

marine litter, understand changes in distribution and composition, and inform decision-making."

AMAP – Arctic Monitoring and Assessment Programme

In 2017, AMAP released an assessment on Chemicals of Emerging Arctic Concern in which marine plastics, microplastics and their toxicity were examined, and identified as an emerging research area in the Arctic. AMAP is currently preparing the first monitoring plan on microplastics and litter in the entire Arctic ecosystem. AMAP has established Expert Group on Microplastics and Litter, which is chaired by Jan Rene Larsen (AMAP) and co-chaired by Jennifer Provencher (Carleton University, Canada) and Eivind Farmen (Norwegian Environment Agency). While PAME is currently developing a new Regional Action Plan on marine litter in the Arctic, it was decided that AMAP would support this effort by focusing on the monitoring aspect of the growing issue of litter and microplastics.

AMAP's Expert Group on Microplastics and Litter: AMAP has a mandate to monitor and assess the status and trends of contaminants in the Arctic. In the Spring of 2019, AMAP decided to step up its efforts on the plastic issue and established an Expert Group on microplastics and litter. The Expert Group currently is working on developing a comprehensive monitoring plan and technical guidelines for monitoring microplastics and litter in the Arctic. It will be the first time that all parts of the Arctic ecosystem are examined for traces of this type of pollution. While PAME's Regional Action Plan is focused on the marine environment, AMAP's Expert Group is interested in monitoring and assessing the presence and effects of litter and microplastics in the air, in rivers, lakes, on land, all the way to the bottom of the sea.

The Expert Group aims to:

- Design a programme for the monitoring of microplastics and litter in the Arctic environment.
- Develop necessary guidelines supporting the monitoring programme.
- Formulate recommendations and identify areas where new research and development is necessary from an Arctic perspective.
- The current leads of the Expert Group on Microplastics and Litter can be found under Contacts (see below). AMAP maintains a list of members of its expert groups who are nominated through an open process and contribute to this work in their capacity and independent experts. All AMAP reports are subject to an independent peer-review process.

International Symposium on Plastics in the Arctic and Sub-Arctic Region (2–4 March 2021 - Reykjavik, Iceland)

This symposium aims for exchanges of views and to inform about the threat of plastic to ocean life and possible reactions (https://www.arcticplastics2020.is).

Recently there has been an increasing worldwide discussion about plastic which fragments slowly and pollutes the environment. It has been estimated that about 9 million tons of plastic have been produced since around 1950 and about 90% of this is still present in the environment. The problem is greater than anyone could comprehend only a few years ago. This has also led to demands from both the public and politicians about actions to mitigate the problems that it is causing.

The symposium will evaluate the present status of plastic pollution in Arctic and Subarctic waters and discuss:

- how extensive is the plastic pollution and of what nature?
- where from and how it is transported to or in arctic and subarctic?
- how breakdown processes are operating in the arctic and subarctic?
- how the different groups and sizes of plastic are affecting organisms in the arctic and subarctic?
- which are the possible mitigation methods and how can they be put to force?

Annex 5: Recommendations for a QA/QC Framework for microplastic monitoring and analysis

Quality assessment and quality control within microplastic monitoring

The creation of quality assured data is essential for every monitoring scheme. For monitoring of microplastics, ICES WGML identifies different categories of quality assessment and quality control that should be taken into account:

- Background contamination - the reduction, as well as the measuring, of background contamination during every step of the process, i.e. from sampling, sample transport to analysis. This includes e.g. the reduction of air contamination, clothing restrictions, lab cleaning procedures, the recording of the sampling environment, and field blanks.
- The detailed reporting of sampling strategy, sampling method, sample transport and analysis within protocols.
- Method validation, including the parameters accuracy and precision, limit of quantification, specificity (how well the method allows discrimination between plastics and other types of material), robustness (how resistant is the plastic towards the method, what is the effect of small method changes) and cut-off size (minimum size the method can measure).
- Negative control samples, including the whole procedure from sampling to detection or part of the procedure.
- Positive control samples, using different shapes, sizes, colours and polymer types of microplastics.
- Polymer identification techniques
- Personnel training procedures
- Instrument calibration
- Data reporting QC
- Participation to proficiency testing schemes

Within every microplastic analysis protocol, ICES WGML advises to include a detailed description of these QA/QC elements. More specifics on each point of this QA/QC overview can be found in multiple public documents, such as (non-exhaustive list):

- ICES WGML report 2018, Annex 6.
- Hermsen *et al.*, 2018. Quality criteria for the analysis of microplastic in biota samples: a critical review, Environmental Science and Technology, 52(18), 10230-10240.
- Gago *et al.*, 2018. Standardised protocol for monitoring microplastics in seawater. JPI-Oceans Baseman project.
- Frias *et al.*, 2018. Standardised protocol for monitoring microplastics in sediments. JPI-Oceans Baseman project.
- Bessa *et al.*, 2019. Harmonised protocol for monitoring microplastics in biota. JPI-Oceans Baseman project.
- Cowger *et al.*, 2020. Reporting Guidelines to Increase the Reproducibility and Comparability of Research on Microplastics. Applied Spectroscopy 74 (9), 1066-1077.

- Lusher *et al.*, 2020. Isolation and Extraction of Microplastics from Environmental Samples: An Evaluation of Practical Approaches and Recommendations for Further Harmonization. Applied Spectroscopy 74 (9), 1049-1065.
- Brander *et al.*, 2020. Sampling and Quality Assurance and Quality Control: A Guide for Scientists Investigating the Occurrence of Microplastics Across Matrices. Applied Spectroscopy 74 (9), 1099-1125.
- Provencher *et al.*, 2020. Proceed with caution: The need to raise the publication bar for microplastics research. Science of the Total Environment 748, 141426.

Proficiency testing schemes and reference materials

International efforts are being made towards the harmonization of analytical procedures for microplastic analysis through the development of interlaboratory comparison studies. Valuable information on method comparison and QA/QC can also be gathered by participation in proficiency testing schemes and by taking into the account the result of previous interlaboratory exercises (non-exhaustive list):

- Quasimeme – Microplastics Analysis Development Exercise (First round: spring 2019).
- JRC proficiency test on microplastics in food, feed and environmental samples.
- JRC proficiency test on microplastics in drinking water (completed in 2020) and sediments (planned for 2021).
- Isobe *et al.*, 2019. An interlaboratory comparison exercise for the determination of microplastics in standard sample bottles. Marine Pollution Bulletin, 146, 831-837, https://doi.org/10.1016/j.marpolbul.2019.07.033.
- The Southern California Coastal Water Research Project, will examine precision, repeatability, cost and other issues associated with five commonly used methods for measuring microplastics in aquatic environments: Raman spectroscopy, Fourier-transform infrared spectroscopy (FTIR), stereoscopy, stereoscopy with staining, and Pyrolysis-GCMS (gas chromatography/mass spectrometry) (https://www.sccwrp.org/).
- Cadiou *et al.*, 2020. Lessons learned from an intercalibration exercise on the quantification of microplastic particles in sediment and water samples, Marine Pollution Bulletin, 154, https://doi.org/10.1016/j.marpolbul.2020.111097.
- Upcoming work on comparing monitoring methods for microplastics in the marine environment is also planned within the JPI Oceans project Andromeda.

Other schemes were proposed as proficiency testing and interlaboratory comparisons including Quasimeme and JRC/BAM exercises. To date, interlaboratory comparison studies included water, sediment, and biota matrices (see Table below).

Table summarising past and current on interlaboratory studies on the analysis of microplastics.

Exercise	Organiser	Round	Matrices	Deadline for returning	Final report	Number of participants	Workshop planned?	Link to website
QUASIMEME/NORMAN Interlaboratory Study on the Analysis of Microplastics in Environmental Matrices (1st round)	Quasimeme	1	Water	September 2019	December 2019	34	Yes, date tbc	http://www.quasimeme.org/
QUASIMEME/NORMAN Interlaboratory Study on the Analysis of Microplastics in Environmental Matrices (2nd round)	Quasimeme	2	Sediment, biota (fish)	January 2021	April 2021	tbc	Yes, planned May 2021	http://www.quasimeme.org/
Microplastics in drinking water and sediments	JRC and BAM	1	Drinking water	September 2020	tbc	131	Yes, date tbc	https://ec.europa.eu/jrc/en
Southern California Coastal Water Research Project	SCCWRP	-	tbc	-	-	-	-	https://www.sccwrp.org/
An interlaboratory comparison exercise for the determination of microplastics in standard sample bottles	Exercise included in Environmental Risk Assessment of Microplastics in the Marine Environment supported by the Ministry of the Environment, Japan	-	Seawater	-	Publication Isobe *et al.*, 2019	12	-	https://doi.org/10.1016/j.marpolbul.2019.07.033

Given the rapidly evolving nature of the microplastic research field, the above set of QA/QC recommendation is subject to further revision in the future.

Microplastic assessment – overview

Within microplastic assessment, multiple decisions have to be made: a broad range of analytical methods are available, giving a different degree of information, but also cost-effectiveness. Choices have to be made regarding monitoring or research scheme and sampling procedure. Within each step, QA/QC are essential and should be taken into account throughout the entire procedure.

Type of monitoring and research, objectives and matrix

To set up the microplastic assessment, best fit for purpose, researchers should be aware of which type of monitoring and research is requested: if it is important to determine a status or condition, to identify trends or reach specific research goals this will influence the way forward. This will also be strongly dependent on the objectives of the assessment. Different objectives can be identified, which will define the degree of information required, e.g. if detailed polymer information is necessary or not.

Identified objectives may be:

- Identification of abundance
- Identification of occurrence
- Identification of sources
- Identification of pathways
- Identification of food chain accumulation
- Set Ecological Quality Standard

Marine matrices that can be analyzed to achieve these goals are water, sediments and/or biota. Performance criteria for microplastic analysis may be put forward in order to select the best sampling and analysis approach.

Monitoring or sampling scheme

After identifying goals and objectives, researchers should decide on the monitoring/sampling scheme. It is important to consider what the best selected sample will be: should the researcher sample surface water or deeper water, top layer sediment, mixed sediments or different layers, the entire organism or the edible part of an organism. Spatial and temporal variability of the monitoring scheme should also be considered. Whereas a specific study may want to identify small temporal changes, other studies may put their focus on spatial variability. Both natural and analytical variability should be taken into account to meet the requested statistical power needed, to achieve an appropriate level of sensitivity/detection, and to determine the amount of replicate samples and subsamples. Use of pilot studies to estimate variability is therefore essential. The presence of quality controlled international data on microplastic occurrence within the ICES databases may play an important role in estimating variability and performing power analysis.

Sampling and transport

Depending on the selected matrix, different sampling techniques should be employed: nets and pumps are appropriate for water analysis; corers, grabs or shovels for sediment analysis; different fishing techniques or manual sampling for biota sampling.

Due to the ubiquitous presence of microplastic in the environment, stringent background reduction measures should be taken during sampling, subsampling and transport. Possible background reduction measures may be:

- Avoid the use of plastic materials within the sampling procedure, the division into subsamples and the use of sampling containers or sampling packaging.
- Precleaning of all materials used during sampling and transport is mandatory. Filtered water can be used. Use of solvents such as ethanol may even perform better since solvents reduce surface tension and enhance cleaning efficiency.
- In the case of water sampling by net, the net should be thoroughly cleaned before sampling.
- All containers should be sealed as much as possible during and directly after sampling.
- All persons involved in sampling should undergo appropriate training, with special focus on QA/QC measures.
- If a plastic material cannot be avoided during the sampling procedure (e.g. net material), a subsample of the plastic used should be taken and used to identify any contamination in the main sample (e.g. false positives).
- Record the color of clothes (fibres), as well as the color of the research vessel (paint).
- Where possible, field blanks should be taken to account for background contamination at the sampling site.
- To estimate airborne contamination during handling, filters should be set for the time of sampling to estimate this effect.

Laboratory analysis

After sample transport and storage, samples are analyzed in the laboratory. Harmonization of methods is important, although research/monitoring goals and cost-effectiveness are critical parameters to take into account when selecting the most appropriate method. Multiple research papers have described different analytical methods, extraction techniques, density separation approaches, digestion media and filtration steps. A thorough comparison of methods is beyond the scope of this report. It is, however, important to note that users should be aware of the limitations of their selected method(s). For example, within density separation, the selected salt will define the efficiency of the separation process but also affect the analysis cost. For biota analysis, different digestion media have different impacts on the matrix, as well as the plastic itself. The optimum combination is therefore case-dependent. When identifying and determining the amount of microplastic in a sample, differences in the number of particles will occur when using different techniques, such as light microscope counting, use of fluorescent dyes, microFTIR or Raman or other advanced techniques. Again, differences in research goals and the cost-effectiveness of a particular method will influence the choice.

Independent of the analysis method selected, stringent background reduction measures should be taken. Possible background reduction measures may be:

- Preclean labware
- Filter all solutions that are added to the sample
- Cover all glassware
- Use clean air room or laminar flow cabinet if possible
- Check air contamination by tapes or exposing filters

- Frequently clean the place where analysis is performed
- Avoid synthetic clothes within the laboratory
- Minimize the number of people allowed in the laboratory
- Dust filters may be applied to reduce air contamination
- Avoid plastic labware
- Minimize transfer steps

Analytical method QA/QC

To assess the quality of the analytical procedure, multiple QA/QC steps should be taken into account. Advisable procedures are:

- Use of procedural blanks. As background contamination is a large issue within microplastic analysis, laboratories should apply procedural blanks in order to estimate the impact of background contamination. Procedural blanks may make use of a microplastic-free sample, e.g. filtered water for seawater analysis or fish filet for biota analysis. Otherwise, the procedure can run without the use of a matrix.
- Use of spiked samples. Spiked samples may be used as positive controls. Microplastic reference materials are commercially available or laboratories may use custom-made microplastic (e.g. cryomilled). The use of different shapes and sizes is advisable.
- Microplastic specificity. Even when the polymer type is not routinely determined, it is advisable to check to what extent the procedure selected allows for identification of microplastic from other non-plastic particles and which types of microplastic can be identified. FTIR- and Raman-based techniques can be helpful here.
- Quantification limit. Since background contamination is difficult or even impossible to exclude completely, results from analyses at levels comparable with background contamination levels can be questionable to report. It is therefore advisable to apply a limit of quantification of ten times the level of the procedure blanks, while the limit of detection is normally considered to be three times the background.

Annex 6: Interpretational issues related to sea-floor litter data and its assessment

The ICES WGML interim report of 2018 identified a variety of data and sampling issues associated with seafloor data. This annex briefly identifies, through critique, some interpretational uncertainties inherent in analysis results and is included to serve as a focus for discussions around what can be inferred from such data.

The ICES seafloor litter exchange data has been used to statistically model the spatial distribution of sea-floor litter counts in the seas around Scotland. Litter item counts were modelled spatially using a soap-film smoother generalized additive mixed effect model and annual litter item mean values modelled temporally using a linear mixed effect model. The statistical models generate results which are subject to multiple interpretations as summarised below.

Modelled spatial distribution

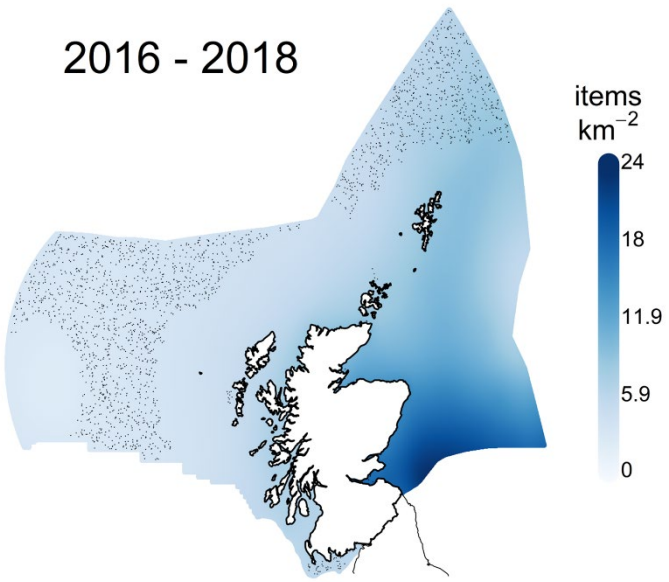

Figure showing a modelled spatial distribution of seafloor macro-litter densities within the Scottish Zone. Stippled areas are distant from survey trawls.

Questions include:

- Are estimates of density biased? For example, to what extent does the efficiency of gear litter capture and retention affect density estimates?
- Is the spatial distribution a consequence of survey design and/or implementation? For example, to what extent does the use of different ground-gears at different geographical locations affect the spatial distribution?
- Is the spatial distribution a consequence of associated variables? For example, to what extent do the number of fish captured influence the capture and retention of litter?
- Is the spatial distribution a statistical modelling artefact? For example, is the apparent halo of increased litter density along the north and northwest coast of mainland Scotland a modelled edge effect?

- Are estimates from un-surveyed areas informative?
- Taking the above questions into account, to what extent does the modelled spatial distribution represent the actual litter distribution? What additional investigations are required to check this?

Modelled temporal trend

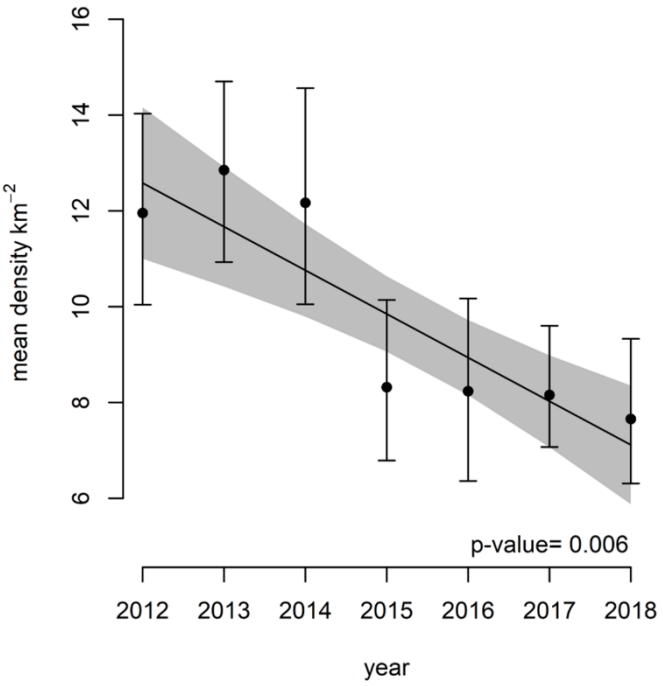

Figure showing a modelled temporal change in litter density within the Scottish Zone.

Questions include:

- Is the apparent decrease in density a consequence of changes in sampling or counting methodology? For example, has seafloor litter data guidance changed throughout the period?
- Is the apparent decrease in density a consequence of survey design and/or implementation? For example, could the movement of litter to un-sampled areas deeper than 500 m generate an apparent decrease? Could repeated annual sampling in similar locations generate an apparent decrease which is not representative of unsampled locations?
- Is the apparent decrease in density a consequence of gear sampling bias? For example, could litter fragmentation over time to sizes less efficiently captured and/or retained by gear account for the apparent decrease?
- Is the apparent decrease in litter density year-on-year consistent? For example, is there actually a step-change reduction in apparent litter density not addressed by the linear model between 2014 and 2015?
- Is the temporal trend a statistical modelling artefact? For example, is a linear model using seven years of data sufficient to infer a decrease in litter densities?
- Taking the above questions into account, to what extent does the modelled temporal trend represent increased rates of litter degradation and/or removal relative to inputs? What additional investigations are required to check these results?

Annex 7: Ring test seafloor categorisation

WGML developed a ring test for identification of seafloor litter items and undertook a round with WGML members to evaluate it.

Details are given below.

ICES WGML

Seafloor Litter Pilot Ring Test

ITEM NUMBER	SEAFLOOR LITTER CATEGORY
001	
002	
003	
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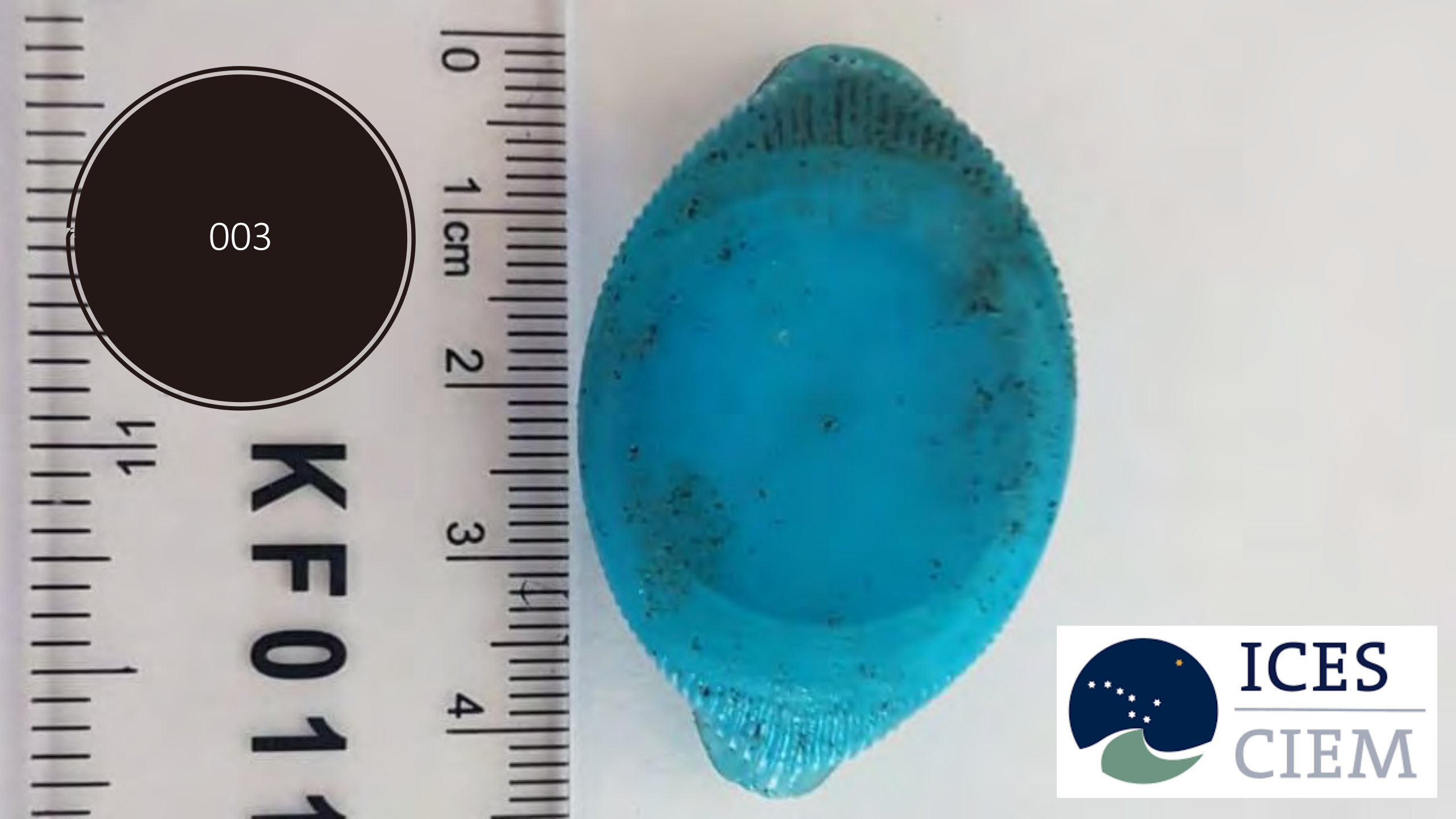
001


002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004


005

006

ICES
CIEM


007


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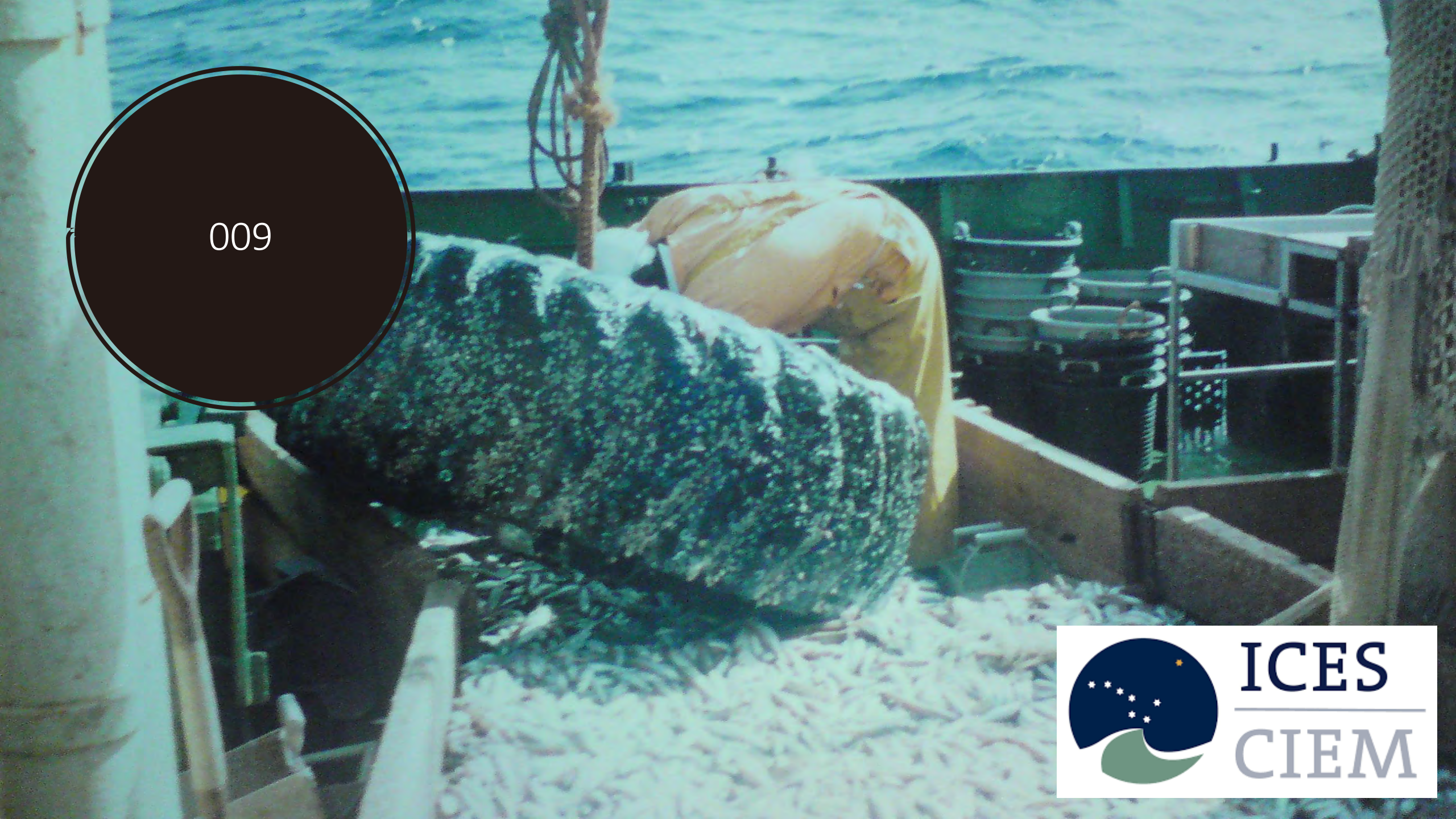
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www.pepsi.co.uk
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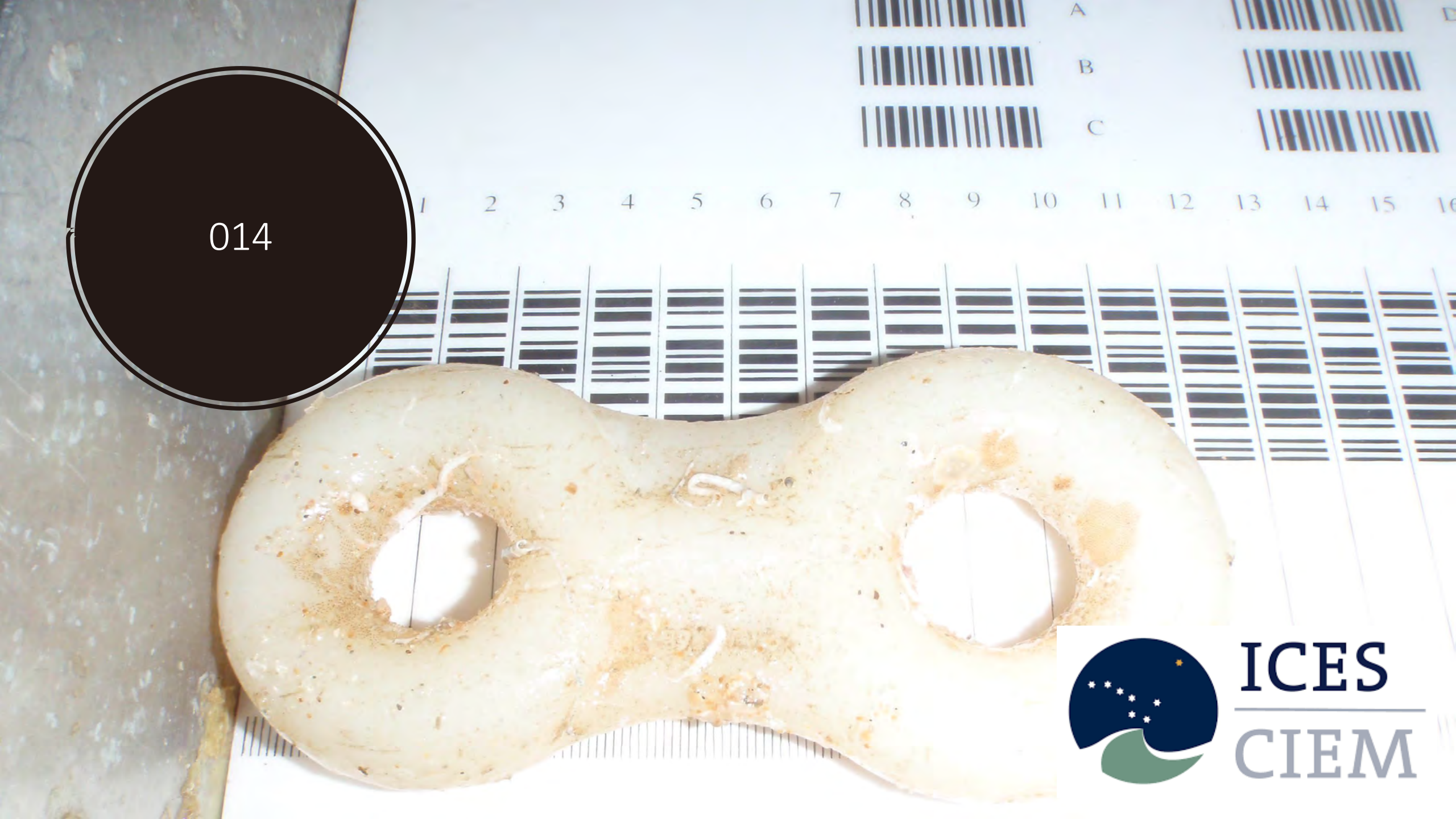
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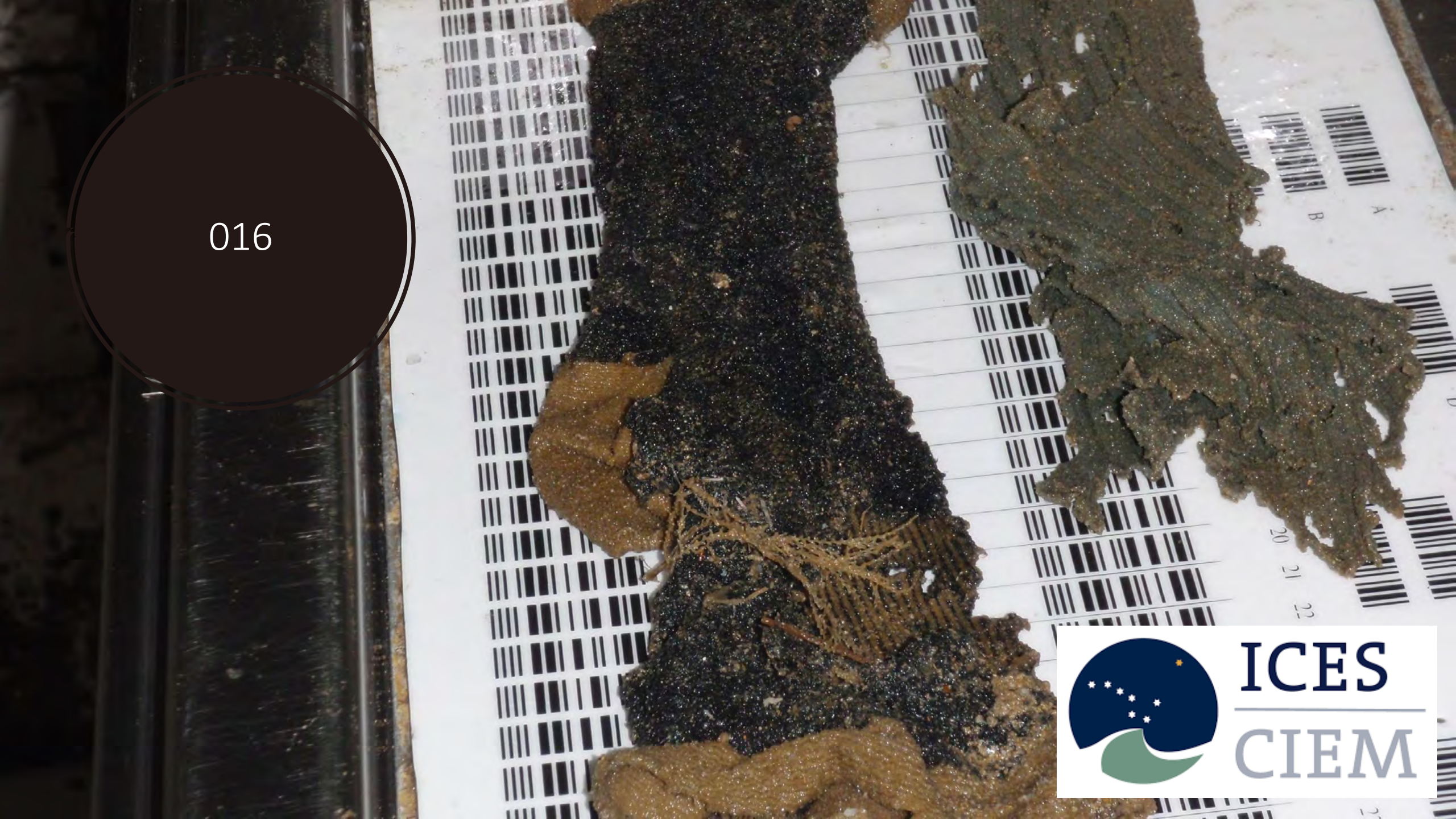
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All Rights Reserved.
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167 kJ /
39 kcal
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That's all Folks!

Annex 8: Overall seafloor litter assessment

These are what we think we could do in terms of an overall assessment of litter levels from the seafloor surveys.

We have litter data from 14 surveys. Whilst we haven't done an extensive investigation of these data. Over the last 3 years, WGML have noted and corrected (where possible) the following problems with the data.

- Some countries record weights and counts, some record only counts and some record only weights. WGML has created a new count variable for where the count is zero, but where there is a positive weight. In such instances, count is recorded as "1". WGML has, however, also retained the original count variable.
- Most surveys record weights.
- In some cases, no weight or count value was recorded. These values have been checked and updated where relevant.
- WGML's view is that not a single survey counts litter items properly. We have not considered this separately by year, but over all the years surveyed. One option is to stop counting litter items, this has not been achieved yet, so it may be difficult to operationalise. Instead, WGML recommends relying on weight and on presence/absence data.
- If there is a zero count, the count variable (LT_Items) is sometimes recorded as -9 and sometimes as 0. WGML recommends that '-9' should only be used if there was no trawl and '0' should only be used if there was no litter present in a trawl.
- There are 10 different gear types. Different gear types have different abilities to catch litter and the problem is that the gear types can be confounded with country or region effects.
- Some surveys record weight as Kg and some as g. WGML recommends using Kg for all future data inputs in order to harmonise reporting units.
- The NMarea (whether a haul is within 12 NM of the country) and the region (OSPAR/MSFD region) were not reliably reported previously. This has now been corrected in the original data files.
- WGML recommends using common reporting formats across different trawl surveys (e.g. the PT-IBTS and IE-IGFS surveys need to be put into the same column format as the other surveys and to have their own data files).

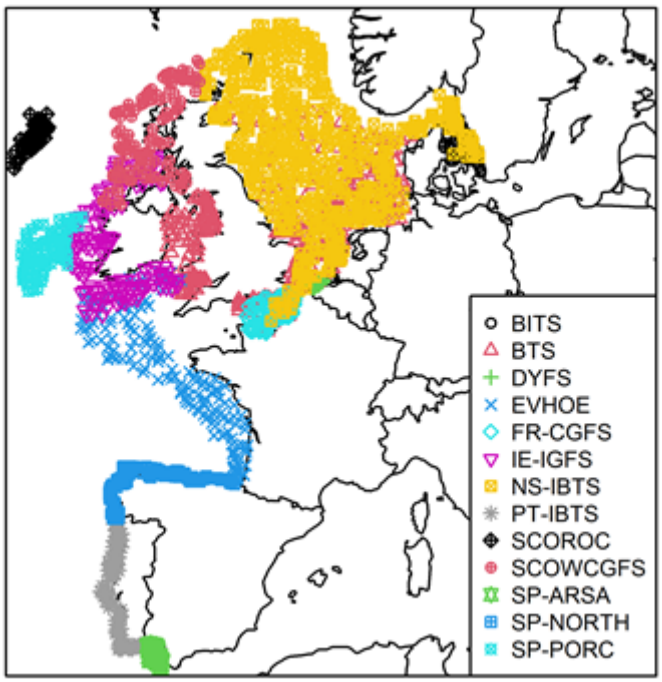

Figure summarising smoothed maps for the three regions (GNS, CS and BB) combined for 2019 of the probability hauls contain a litter item, from 2012–2019.

Some of these issues are relatively easy to address, others are more deep-rooted. At present, our only option is to use presence-absence data. WGML aims to produce maps of the probability that a haul contains a chosen item (e.g. plastic, plastic bags). The precision of this map will be low in some areas – e.g. where BAK gears have been used and where there is no data from other gears nearby.

WGML proposes to model the data as one big data file. For ease of explanation, WGML will assume that it is modelling that a trawl contains a plastic item; Pr(P). A Generalised Additive Model can be fitted to explain Pr(P) with a logistic link to make sure that Pr(P) does not go outside the range (0,1). WGML suggests using explanatory variables as factors, including:

- Gear
- Quarter
- Latitude / Longitude – as a bivariate GAM smoother (perhaps with restricted degrees of freedom)
- Area of haul or duration of haul depending on variability

The figure below shows a similar assessment that was done for the OSPAR Quality Status Report in 2021. In the future, WGML is considering producing a similar sort of plot, but for the whole of the ICES region. Such a map could form the basis of a strong publication – bringing together the work done by all the participating countries.

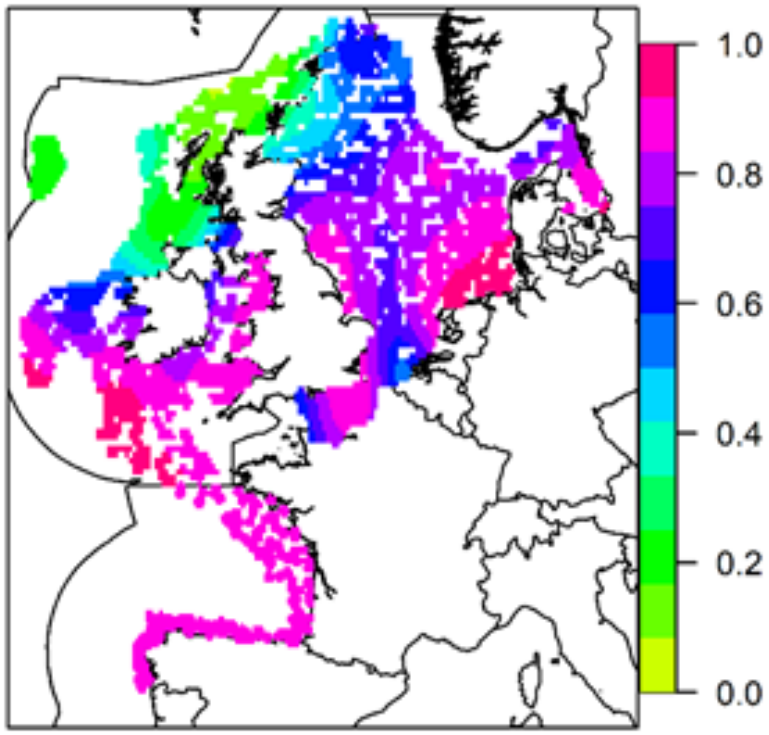

Figure showing the locations of surveys in 2018 (2016 for PT-IBTS survey).

Latest update from OSPAR and HELCOM (March 2021)

OSPAR and HELCOM assessments have been made on data collected by contracting parties as part of the OSPAR and HELCOM Regional Action Plans for seafloor litter (e.g. OSPAR assessment: https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/pressures-human-activities/marine-litter/composition-and-spatial-distribution-litter-seafloor/). Litter has been collected in line with the OSPAR CEMP guidelines and IBTS/BITS protocols. Assessments were performed using data is stored annually by the ICES datacentre and extracted from the ICES website (https://datras.ices.dk/Data_products/Download/Download_Data_public.aspx). There were three main problems found for data collection schemes:

i. Countries not recording zero hauls
ii. Combining Litter and Haul files
iii. The combination of files on recording details of the haul and details of the litter items. This has now been rectified.

The seafloor litter assessment is based on the surveys programmes BTS (UK, BT4A, BT4AI, BT7 and BT8 nets), EVHOE and FR-CGFS (France, GOV net), IE IGFS (Ireland, GOV net), NS-IBTS (GOV net), PT-IBTS (Portugal, NCT net), SCORO and SCOWCGFS (Scotland, GIV net), SP-ARSA and SP North (Spain, MAK net), DYFS (BT6 net) and SP Porc (Spain, and TV3 trawl [small or large] in the Baltic Sea).

In OSPAR region, the assessment comprised all the main categories (plastics, glass, metal, etc.) and items relating to fisheries that are composed of mixed materials (plastic, rubber, and metals). Plastic bottles and bags were also chosen because they represent items that have been subject to Government legislation.

In the Baltic sea (HELCOM litter page; https://helcom.fi/action-areas/monitoring-and-assessment/monitoring-manual/litter/), the data were classified into major categories in all years (plastic, metal, glass/ceramics, rubber, other) and are mutually exclusive. The category 'Natural' was not considered further. Three further categories were also investigated (a litter item will appear in one of these categories only if it already appears in one the above categories):

i. Fishing (fishing line [monofilament + entangled] + rubber bobbins + rope [natural and synthetic] + fishing related metals + fishing net)
ii. Plastic bags
iii. Plastic bottles

Further work is ongoing to designate litter into categories presenting an ingestion or entanglement risk.

The OSPAR assessment (2021, In Preparation) concluded that:

- The significance of seafloor litter data from fishing surveys must be better defined (what is collected, and where, and whether our data is useful for picking out spatial and temporal trends).
- Different hauls have different abilities to capture such litter (e.g. beam trawls vs GOV trawls).
- It must be recognized that haul data is almost certainly an underestimate of the amount of litter on the seafloor and different types of trawling gear will have different levels of bias.
- The bias does matter if we want to know exactly how much litter is on the seafloor. Thus, fishing surveys may not be a good way to answer this question.
- A zero-litter return from a haul may be a "false zero" if the haul has missed litter that is present on the seafloor.
- For spatial and temporal trends, fishing surveys can provide useful information, understanding that the amount of litter caught in our surveys is proportional to the true amount on the seafloor and surveys are performed with comparable means.
- There may be year-to-year changes in litter composition that are not due to some underlying trend, but local conditions (weather, currents) that are varying.
- There is a need to fully understand the 'life cycle' of litter items when they reach the seafloor and accumulate (buried or not, decomposing or not, process and pathways involved for an item to become marine litter, process by which litter becomes trapped, role of biofouling, etc.).
- Information on seafloor litter only comes from sandy areas where bottom fishing is done. We do not have these data from rocky regions.
- The trawl will not collect small items such as cigarette butts, bottle tops or pieces of plastic sheeting, so the number of these items will be underestimated in the surveys.

The OSPAR assessment also concluded on how litter assessments could be improved:

- Taking advantage of the existing literature and experiences on how fisheries scientists allow for the effects of haul types and changes in the make-up of gears over time.
- Consider using only the best data for particular regions, limiting the spatial spread of data that is not comparable.
- Continue work in ICES WGML and the OSPAR Seafloor Litter Expert Groups to ensure harmonisation of methods, specifically for counts so this data can be used for future assessments.

- Look at any possible relation to litter sources (urban areas, river inputs, fishing grounds, shipping lanes etc.) using the seafloor litter data.
- Decide whether sub-sampling is a viable approach for very high counts (e.g. when there are 100s of litter items in a single trawl).
- Evaluate the use of models (prediction and conversion of data from different fishing gears, zero-inflated models to model count data, linear or non-linear models, consideration of spatial correlations and confidence intervals) for better estimations.
- Harmonize counting methods and look at litter weights.

The following points could improve future assessments:

- What is the 'lifecycle' of litter on the seafloor? We need a better understanding of how hydrodynamics, geomorphology and human factors influence the geographical distribution of litter on the seafloor.
- How do different types of sediment impact the behaviour of the litter and how much litter gets collected by the trawl?
- How do seasonal patterns, weather and changes in currents effect the litter distribution?
- How do sources relate to litter densities?
- How is litter transported? Is it (i) transported to deeper areas and thus not sampled nor counted, (ii) transported outside, or (iii) kept within an area, alternating between the seafloor and the shores?
- Whether it is possible to compare (i) different fisheries surveys (relates to gear types and methodologies), (ii) different depths (impact of gear behaviour), (iii) varying survey station design (e.g., random stratified or fixed position), and (iv) catchability of gears and conversion factors (e.g. Baka and GOC nets).
- Understanding of fisheries assessments and how they account for variables such as gear type, area swept, haul, survey design etc.
- How much of the litter on the seafloor gets collected during trawls? Building on O'Donoghue and Van Hal (2018) estimation of 5%.
- Work on the assessment beyond the OSPAR region to enable comparisons. This would require further work that looks into data, as well as methodology discussions between regional seas conventions.
- Do areas with high/low commercial trawling intensities affect the distribution and amounts of litter on the seafloor?

Annex 9: Microlitter Data Submission Guidelines

Microlitter data can be reported to the ICES DOME database as well as all other types and sizes of litter data. "Litter" includes macro-, meso- and microlitter monitoring data.

Formats

The format required for reporting microlitter data is based on the Environment Reporting Format version 3.2.5. This format can be submitted in two versions, the original hierarchical structure of the ERF3.2 format, or the Simplified Format version. Both versions can be downloaded at http://www.ices.dk/data/Documents/ENV/Environment_Formats.zip .

For existing data flows, where monitoring data are already reported using the ERF3.2 hierarchical format, one can simply add microplastic data to existing files by adding records with microlitter parameters under the appropriate sample matrix.

For new data flows, the most convenient for the user is the Excel-based Simplified Format. The format, examples and instructions can be downloaded at http://www.ices.dk/data/Documents/ENV/Environment_Formats.zip.

The Simplified Formats were developed to meet the needs of those data submitters who have no possibility to use the ERF3.2 hierarchical format or who have only Excel-stored data. One advantage of the Simplified Format is that multiple years can be reported in one file whereas ERF3.2 hierarchical format requires one year/one file.

The "Simplified Format for litter" is used for macro-, meso- and microlitter on the seafloor (MATRX=SF), in the water column (MATRX=WC), on the water surface (MATRX=SW) or on a beach (MATRX=BE) (note that these formats/database are not for OSPAR beach data). This format allows for reporting information in fields such as litter reference lists (LTREF), type of plastic (TYPPL), size (LTSZC) and other properties (LTPRP) of the litter.

For microlitter data which need to be linked to the specific sample matrix that was analysed in biota, sediment or water (for example, in the stomach of a fish (MATRX=ST) or in a specific grain size fraction (ex. MATRX=SED1000) in sediment), report the microlitter parameters together with the other sample parameters in the "Simplified Format for Contaminants&Microlitter". This means that the fields for general litter above, LTREF, TYPPL, LTSZC, and LTPRP, are not available but parameter codes can be created by the Data Centre to include any combination of these litter field options if necessary. For example, if one knows the type of microplastic that was found in the stomach, a code can be created to reflect this information which would otherwise be reported in field TYPPL.

Codes needed to report data can be found at vocab.ices.dk. Microlitter codes can be found in the parameter code list (PARAM) where litter codes begin with "LT". Microlitter codes can be found from LT239 onward. Contact accessions@ices.dk for new codes.

See the Simplified Format Instructions for more information. Help may also be found in the DOME FAQ Document available at:

http://www.ices.dk/data/Documents/ENV/DOME%20Frequently%20asked%20questions.docx

An evaluation of microplastic data on DOME

ICES have identified microplastic data collected by Estonia and submitted to DOME as being of potential high quality. A statistician at the ICES WGML meeting undertook a short review of the data's potential utility.

The individual is an experienced statistician, but inexperienced regarding micro-litter and the particular data. The comments below are therefore the response of an uninitiated user and are of value in that they indicate the accessibility of the data to the scientific community as a whole rather than micro-litter specialists.

ICES sent the statistician relevant data for evaluation. The data file structure appears complex and the statistician found it difficult to find accessible and comprehensive information on the general structure of the files and the meaning of all codes. The statistician was never entirely sure which values pertained to sampled values rather than sampling codes. While the statistician was sure that with expert guidance all this would become comprehensible, without such support it is unlikely a user would be certain that they are interpreting the data as intended.

The statistician could not find an R script to assemble the data into a simple spreadsheet giving date of sampling, latitude and longitude, classification of microplastic, and estimated density (or any other necessary ancillary information). Given sufficient time, the statistician would have been able to produce an R script to extract the most basic information, but would have worried about what other important information had not been included.

In the statisticians view it is necessary to:

- Produce a simple guide to the data, possibly comprising an annotated data file, easily visible and accessible to an inexperienced user.
- Produce an R script which is publicly accessible and assembles the data from these repository files into an easily understood and useful data-file.

Such actions would improve the accessibility of the data and would also facilitate further investigation into the quality and potential utility of the DOME microlitter data.