Ocean and Coastal Management 181 (2019) 104930

Contents lists available at ScienceDirect

Ocean and Coastal Management

journal homepage: www.elsevier.com/locate/ocecoaman

EMODnet marine litter data management at pan-European scale

Maria Eugenia Molina Jack[a,*], Maria del Mar Chaves Montero[a,1], François Galgani[b], Alessandra Giorgetti[a], Matteo Vinci[a], Morgan Le Moigne[c], Alberto Brosich[a]

[a] Istituto Nazionale di Oceanografia e di Geofisica Sperimentale, Division of Oceanography, Borgo Grotta Gigante, 42/C, 34010, Sgonico, TS, Italy
[b] IFREMER, Laboratoire LER/PAC, Immeuble Agostini, ZI Furiani, 20600, Bastia, France
[c] IFREMER, Service Valorisation de l'Information pour la Gestion Intégrée et la Surveillance, Centre Atlantique, Rue de l'Ile d'Yeu, BP 21105, 44311, Nantes Cedex 03, France

ARTICLE INFO

Keywords:
Marine litter
Plastic
Beaches
Seafloor
Micro-litter
Micro-plastics
Floating litter

ABSTRACT

Marine litter is a growing problem for environmental and human health and policies have included monitoring as an important tool to evaluate both trends and the efficiency of reduction measures. The Marine Strategy Framework Directive is the main driver in Europe for the monitoring of the marine environment; it has included the evaluation of marine litter in order to support policies and achieve good environmental status. This assessment depends on the availability of robust, homogeneous data-sets at the European scale. A data management plan for marine litter has been developed at European level within the existing EMODnet network to collect, homogenise and provide access to standardised data-sets and data products that may be used as a basis for marine litter assessment at pan-European scale. As a long term perspective, it also provides a scientific and technical basis for further global monitoring.

1. Introduction

Marine litter, defined as "any persistent, manufactured or processed material discarded, disposed of or abandoned in the marine and coastal environment" is recognised as a global threat to the marine environment (Barnes et al., 2009; Derraik, 2002; Dixon and Dixon, 2003). Marine litter can be originated from both marine and land-based activities, carried by rivers and dispersed with wind and waves depending on its density, and accumulate at the surface of the sea, on seafloor and beaches. It represents a risk of harm to marine organisms, which can be impacted through ingestion or entanglement, and eventually to human health by injuries on beaches, consumption of contaminated organisms and because of transfer of toxic chemical components (GESAMP, 2019; Mato et al., 2001; Teuten et al., 2009). Marine litter, and particularly its main component, plastics, have demonstrated to be highly pervasive and persistent (Barnes et al., 2009), representing a long term problem. Its impacts not only affect the environment, as there is a range of economic costs associated with clean-up expenses and losses to tourist revenue (Beaumont et al., 2019).

Although the problem is known since the 1960s, both the demand and production of plastics have continued to grow during the lasts decades (PlasticsEurope, 2018). Action is needed, but since it is a transboundary concern (UNEP, 2009) it requires a combined action.

In order to address the issue, the European Union (EU) included 'Marine Litter' as Descriptor 10 in the Marine Strategy Framework Directive (MSFD) adopted in 2008 (European Commission, 2017, 2008). The Descriptor 10 states that "the properties and quantities of marine litter should not cause harm to the coastal and marine environment", and considers the use of indicators to evaluate the marine litter pollution. A detailed marine litter assessment in terms of distribution and quantities is an essential step to define the strategies in order to reduce the impact of marine litter at European scale.

To perform such an assessment, it is essential to have a consistent data-set at European level. In the last years, a number of initiatives have been set up to assess marine litter within the framework of either monitoring programs, research activities or cleaning efforts. These initiatives use a variety of sampling methods that differ in the indicator of marine litter (e.g., total abundance, weight, surface density), reference list used to classify the marine litter (e.g., OSPAR, TG-ML or ICES), or spatial and temporal distribution of the sampling units. This variety leads to a large fragmentation of the data, which are heterogeneous in form and harvesting and management strategies, hence difficult to

* Corresponding author.
E-mail addresses: mmolinajack@inogs.it (M.E. Molina Jack), mchavesmontero@inogs.it (M.d.M. Chaves Montero), francois.galgani@ifremer.fr (F. Galgani), agiorgetti@inogs.it (A. Giorgetti), mvinci@inogs.it (M. Vinci), Morgan.Le.Moigne@ifremer.fr (M. Le Moigne), abrosich@inogs.it (A. Brosich).
[1] Present address: Centro Euro-Mediterraneo sui Cambiamenti Climatici – CMCC, Climate Simulation and Prediction Division, Viale Berti Pichat, 6/2, 40127 Bologna, Italy.

https://doi.org/10.1016/j.ocecoaman.2019.104930
Received 14 May 2019; Received in revised form 23 July 2019; Accepted 23 August 2019
Available online 31 August 2019

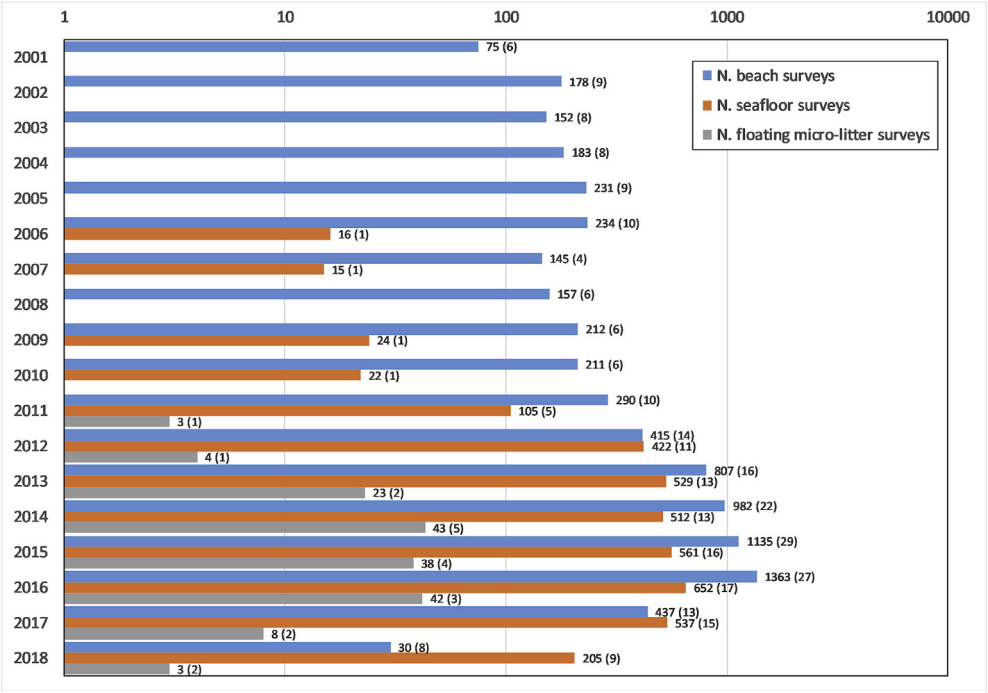

Fig. 1. Number of surveys by year of beach litter, seafloor litter and floating micro-litter data in EMODnet Chemistry. The number of countries providing data is indicated in brackets. Note the logarithmic scale. Data updated to June 2019.

compare. In this context, the use of a common structure for managing all the data is very relevant to have a comprehensive understanding of the available data, their comparability and which are the core requirements to address the heterogeneity of protocols and reporting in order to work at the European level.

The objective of this paper is to present the work done so far, why it is important and which are the expectations for the future. The text is organized as follows: section 2 provides a brief description of the EMODnet structure; section 3 illustrates the role of EMODnet in supporting the MSFD implementation and particularly in marine litter management; section 4 illustrates the marine litter data and derived products available in the EMODnet structure; section 5 describes the data workflow and methodology related to data quality checks and the generation of data products; in section 6 we offer a summary and discuss the future perspectives of the EMODnet in marine litter data management.

2. The pan-European structure of EMODnet

EMODnet (European Marine Observation and Data Network) is a European initiative funded by DG MARE. It is divided into 7 thematic areas, each focused on a specific topic (e.g., geology, physics, chemistry or human activities). Among them, EMODnet Chemistry started in 2009, intending to support the MSFD implementation with a data management plan aiming to unlock the fragmented and inaccessible environmental chemical monitoring data. Based on the adoption and fitting for purpose of SeaDataNet data management infrastructure (Giorgetti et al., 2018), it is formed by a consortium of institutes and research institutions from 27 countries, plus 3 international organizations (ICES, Black Sea Commission, UNEP/MAP) and relies on the network of National Oceanographic Data Centres (NODCs). From the beginning of the project, EMODnet Chemistry was focused on data of nutrients and contaminants, while marine litter was included among the target parameters only in its third phase, in 2017. In the last two years, a joint task group to develop a common data structure for marine litter on the European scale has been performed. The possibility of having a central gate to sparse data, with a unique access procedure, which is revised and homogeneous, represents itself an innovation for the litter management practice. Additionally, the provision of visual products and summarised data, which can support litter management decisions, complements a work that may be helpful in different environments.

Two central EMODnet databases were specified and set-up, one for beach litter, modelled following the OSPAR Beach litter database (OSPAR-MCS) approach and taking into account the MSFD Technical Group on Marine Litter (TG-ML) and UNEP/MAP requirements, and one for seafloor litter, modelled according to the ICES-DATRAS (Database of Trawl Surveys) approach and taking into account TG-ML and the Mediterranean project MEDITS requirements.

3. How is EMODnet helping the MSFD implementation

A trust-building process with institutions involved in litter monitoring and assessment has allowed EMODnet Chemistry to develop the first pan-European marine litter database. The collation of fragmented data has been possible due to the creation of a unified data model and the definition of common data formats that pick up the most relevant information and standardises it. EMODnet formats for beach and seafloor litter data are based on existing and consolidated monitoring protocols but adapted to accept data from a majority of European initiatives on litter collection. For micro-litter the approach is different, using a standard SeaDataNet format already used within EMODnet Chemistry to manage other types of chemical data.

As a result, EMODnet Chemistry holds litter data spanning from 2001 to 2018 in the case of beach litter (Addamo et al., 2018), from 2006 to 2018 for seafloor litter and from 2011 to 2018 for floating micro-litter. In total it counts 7237 beach surveys, 3600 seafloor surveys and 164 floating micro-litter surveys (Fig. 1), the most comprehensive collection of homogenised data available at pan-European scale.

This collection represents a good resource that can be used as a base for marine litter assessments at a trans-boundary level. Indeed, part of EMODnet litter data have been already used for evaluating litter distributions on the seafloor for the EU plastic assessment (European

Commission, 2018), to create the basic data-set to compute beach litter baselines (ongoing) and it has been used as a basis for the current updating of the TG-ML litter reference list.

Furthermore, the visualization products provide an easy tool to display the available litter data and allow partial comparison of homogenised European data through summarised metrics displaying sensitive information as total abundances, litter composition or abundance of relevant litter types. They are hence a straightforward way to promote access to data interesting for a wide variety of stakeholders.

4. Data and data products availability

EMODnet marine litter formats and instructions for data gathering are available in the EMODnet Chemistry portal (Galgani et al., 2017a, 2017b). Marine litter raw data are accessible through the EMODnet Chemistry web portal at http://www.emodnet-chemistry.eu/data_access.html. Data are accessible depending on the specific data policy applied by the originator, following the specific rules related to data policy established by SeaDataNet to achieve a balance between the rights of the originators and the need for widespread access (SeaDataNet, 2007). In general, data availability is significantly higher from 2012 onwards. This relevant increase is reasonably expected due to the 2012 and 2014 deadlines for the initial assessment of the environmental status and the monitoring programme implementation fixed by MSFD (European Commission, 2008).

In particular, for beach litter data the input from OSPAR Convention highly affects the content of the database, representing around 60% of the surveys gathered from 13 countries belonging to the Convention. Indeed the OSPAR region started beach litter data monitoring in 2001 gathering more than 15 years of data publicly available (OSPAR, 2009). Additionally, the synergy with MSFD TG-ML, that has materialised in a joint endeavour JRC-EMODnet for the collation of data for Baselines and then Thresholds computation, has allowed to collate monitoring data from 30 countries across Europe assuring a good spatio-temporal coverage for the period 2012–2016 (Addamo et al., 2018).

Data identified as belonging to regular monitoring are the majority in the beach litter database, complemented by 5% of the information that is coming from research and clean-up activities. This percentage will increase thanks to the collaboration with EEA Marine Litter Watch that is collating information from citizen science projects.

Concerning seafloor litter, data collated by ICES are preponderant in the database, and constitute more than 90% of the surveys, from 16 countries. The trawl survey protocols have included the collection of litter data since 2011, in order to comply with MSFD (ICES, 2018, 2017, 2012) and the availability of a public web service highly facilitated the ingestion of data into EMODnet Chemistry database. Additional sources of information are expected to improve the coverage especially in the Mediterranean and the Black Sea, which now is restricted to data from France and Romania.

The collection of micro-litter is less extensive than the other ones. The initiatives to survey micro-litter in the water body are less consolidated and official monitoring of micro-plastics along Europe haven't been undertaken yet (European Commission, 2019), therefore data sources are limited.

In general, the collection provides information about all types of marine debris. Plastics categories are a large part of the litter found, therefore constitute the major part of the problem. The database allows the isolation of plastic categories and can benefit from the definition of supra categories (i.e., aggregation of litter types sharing specific characteristics or usage as single-use plastics) to help in their assessment.

Aggregated data collections and visualization products are public domain and freely available for all users with acknowledgment of the source at http://www.emodnet-chemistry.eu/products.

5. Workflow for data management and methodology for products generation

EMODnet tackled the marine litter task from an integrative perspective to unifythe largest possible existing information. The data management plan relies on a first data assessment with an analysis of the state-of-the-art of the different monitoring, where we identified marine litter legislation applied at European level and the instruments implemented by the diverse countries to collect and store marine litter information. This analysis constitutes the base for the definition of EMODnet marine litter formats, following consolidated formats adapted to allow the combination of the information from the different data sources. One of the strengths of EMODnet litter formats and hence of the data collections are the utilisation of standard vocabularies widely used in European consolidated data infrastructures and the definition of additional common terms for several attributes regarding metadata and data (as in the cases of beach and seafloor litter).

Marine litter data enters the EMODnet network through diverse systems: direct contact with data providers, NODC's, EMODnet Ingestion (https://www.emodnet-ingestion.eu/). All the collected information is ingested into the developed databases and storage systems only after a semi-automated validation process that allows them to detect and correct formatting and semantic errors. During the validation process, checks of file data formats and vocabularies compliance are performed to guarantee the consistency of the data-sets before the ingestion into the database. The data are validated with respect to the EMODnet marine litter formats, which describe the type of information that can be ingested and how it should be conveyed (i.e., field names, data format, acceptable values) and most importantly allow the data to be presented in a homogeneous form. A feedback loop with the originators is established to facilitate the clarification of possible ambiguous and/or missing information or the correction of detected errors, therefore allowing the continuous improvement of the data-sets.

During the validation process, the check of potential duplicates is a non-trivial step. It is performed at various levels taking into account coordinates, date of the survey and types and quantities of items found. Additional controls on the coordinates and the coherence of the information related to the survey lengths are also carried out before the ingestion process.

If additional errors are highlighted during products generation, these are notified to the data providers in order to correct them and improve the quality of the data-sets.

The development of visualization products on a European scale has proven to be a real challenge, due to the heterogeneities in the data sources, sampling protocols and reference lists used. The methodology used in the generation of visualization products is described in Le Moigne et al. (2019). The same set of products have been created for beach and seafloor litter: (i) a location map; (ii) maps to display the total litter abundance per year; (iii) maps to display the material categories percentage per year; (iv) maps to display the abundance per beach or trawl per year for specific items: plastic bags related items, fishing related items. In addition, maps to display the abundance of smoking-related items have been produced for beach litter only.

Data used in the products have been homogenised and filtered in order to allow comparisons among countries. Consequently, they might not be comparable with source data. As an example, a normalisation on the survey length and the number of surveys per year has been performed for beach litter products. Additionally, modifications or exclusions allowed comparisons between different the litter reference lists used for data reporting. For seafloor litter outputs, processing has been applied only on the harmonisation of the reference list used.

6. Summary and perspectives

Marine litter is a global problem that requires global action. It is also a very sensitive issue, which has raised in just a few years a public

concern, which is being translated into fast political action through specific regulation. The development of successful mitigation strategies requires a careful evaluation of the problem, which can only be achieved with homogeneous, consistent data-sets allowing cross-border assessment. EMODnet provides a stable structure that facilitates the collection and sharing of data. Furthermore, specific actions have been taken to provide information homogeneously. The heterogeneity of the source data represents a challenge both in terms of standardization of the data management procedures and comparison of the data. During the development of the structure, it was evident that there is a big necessity to keep working in the homogenization of sampling and reporting methods to obtain comparable data. Despite all, the marine litter data within the EMODnet Chemistry structure allow a partial comparison of data across countries within the European region. Visualization products are used as a tool for earlier evaluation of the database content. They are also a useful tool for education, communication, and gap-analyses purposes.

With this activity, EMODnet Chemistry has demonstrated its capacity to enhance the use of environmental information by creating services that valorise the data giving central access and ensuring their quality while keeping track of the metadata and favouring the acknowledgment of the data providers.

Given the success of the current system, the next phases of EMODnet will consider the expansion of the data-set and of the litter data types, i.e. floating macro litter data, imaging data-sets of seafloor litter and micro-litter in sediment. More generally, global monitoring will need a harmonized framework for the collection of coherent data from different regions, to identify changes in concentrations over time, and providing tools for management and effective reduction measures. Building such a system is a multi-step process. EMODnet may provide scientific and technical background and an efficient platform for such a global, rationalized and integrated observing system.

Acknowledgments

This work would have never reached such a wide impact without the collaboration with and scientific advice by Georg Hanke. All EMODnet Chemistry partners and subcontractors are acknowledged for contributing with data and valuable expertise.

This work was supported by Directorate-General for Maritime Affairs and Fisheries (DG MARE) under the Service Contract number EASME/EMFF/2016/1.3.1.2-Lot4/SI2.749773.

References

Addamo, A.M., Brosich, A., Chaves Montero, M.M., Giorgetti, A., Hanke, G., Molina Jack, M.E., Vinci, M., 2018. Marine Litter Database Lessons Learned in Compiling the First Pan-European Beach Litter Database. Publications Office of the European Union. https://doi.org/10.2760/68866.

Barnes, D.K.A., Galgani, F., Thompson, R.C., Barlaz, M., 2009. Accumulation and fragmentation of plastic debris in global environments. Philos. Trans. R. Soc. Biol. Sci. 364, 1985–1998. https://doi.org/10.1098/rstb.2008.0205.

Beaumont, N.J., Aanesen, M., Austen, M.C., Börger, T., Clark, J.R., Cole, M., Hooper, T., Lindeque, P.K., Pascoe, C., Wyles, K.J., 2019. Global ecological, social and economic impacts of marine plastic. Mar. Pollut. Bull. 142, 189–195. https://doi.org/10.1016/J.MARPOLBUL.2019.03.022.

Derraik, J.G., 2002. The pollution of the marine environment by plastic debris: a review. Mar. Pollut. Bull. 44, 842–852. https://doi.org/10.1016/S0025-326X(02)00220-5.

Dixon, T.R., Dixon, T.J., 2003. Marine litter surveillance. Mar. Pollut. Bull. 12, 289–295. https://doi.org/10.1016/0025-326x(81)90078-3.

European Commission, 2019. Environmental and Health Risks of Microplastic Pollution. Publications Office of the European Union. https://doi.org/10.2777/65378.

European Commission, 2018. Commission Staff Working Document Impact Assessment, Reducing Marine Litter: Action on Single Use Plastics and Fishing Gear, Accompanying the Document Proposal for a Directive of the European Parliament and of the Council on the Reduction of the Impact of Certain Products on the Environment. SWD/2018/254 final - 2018/0172 (COD).

European Commission, 2017. Commission Decision (EU) 2017/848 of 17 May 2017 laying down criteria and methodological standardised methods for monitoring and assessment, and repealing Decision 2010/477/EU. Off. J. Eur. Union L125, 43–74.

European Commission, 2008. Directive 2008/56/EC of the european parliament and of the council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (marine Strategy framework directive). Off. J. Eur. Union L164, 19–40.

Galgani, F., Giorgetti, A., Le Moigne, M., Brosich, A., Vinci, M., Lipizer, M., Molina Jack, M.E., Holdsworth, N., Schlitzer, R., Hanke, G., Moncoiffe, G., Schaap, D., Giorgi, G., Addamo, A.M., Chaves Montero, M.M., 2017a. Guidelines and Forms for Gathering Marine Litter Data. https://doi.org/10.6092/15c0d34c-a01a-4091-91ac-7c4f561ab508.

Galgani, F., Giorgetti, A., Vinci, M., Le Moigne, M., Moncoiffe, G., Brosich, A., Lipizer, M., Holdsworth, N., Schlitzer, R., Hanke, G., Schaap, D., Addamo, A.M., 2017b. Proposal for Gathering and Managing Data Sets on Marine Micro-litter on a European Scale. https://doi.org/10.6092/8ce4e8b7-f42c-4683-9ece-c32559606dbd.

GESAMP, 2019. Guidelines for the Monitoring and Assessment of Plastic Litter in the Ocean. GESAMP Reports & Studies.

Giorgetti, A., Partescano, E., Barth, A., Buga, L., Gatti, J., Giorgi, G., Iona, A., Lipizer, M., Holdsworth, N., Larsen, M.M., Schaap, D., Vinci, M., Wenzer, M., 2018. EMODnet Chemistry Spatial Data Infrastructure for marine observations and related information. Ocean Coast Manag. 166, 9–17. https://doi.org/10.1016/j.ocecoaman.2018.03.016.

ICES, 2018. Interim Report of the Working Group on Marine Litter (WGML). International Council for the Exploration of the Sea.

ICES, 2017. Manual for the Baltic International Trawl Surveys (BITS). Ser. ICES Surv. Protoc. SISP 7 - BITS. International Council for the Exploration of the Sea. https://doi.org/10.17895/ices.pub.2883.

ICES, 2012. Manual for the International Bottom Trawl Surveys. Ser. ICES Surv Protoc. SISP 1-IBTS VIII. International council for the Exploration of the Sea.

Le Moigne, M., Daniel, J., Quimbert, E., Chaves Montero, M.M., Molina Jack, M.E., Vinci, M., Barth, A., Holdworth, N., Giorgetti, A., Galgani, F., 2019. Visualization Products for Beach and Seafloor Litter Data. https://doi.org/10.6092/ef4901d2-642a-4881-ba81-6b2607f5485e.

Mato, Y., Isobe, T., Takada, H., Kanehiro, H., Ohtake, C., Kaminuma, T., 2001. Plastic resin pellets as a transport medium for toxic chemicals in the marine environment. Environ. Sci. Technol. 35, 318–324. https://doi.org/10.1021/es0010498.

OSPAR, 2009. Marine Litter in the North-East Atlantic Region: Assessment and Priorities for Response. (London, United Kingdom).

PlasticsEurope, 2018. Plastics—The Facts 2018: an Analysis of European Latest Plastics Production, Demand and Waste Data. [WWW Document]. URL. www.plasticseurope.org/application/files/6315/4510/9658/Plastics_the_facts_2018_AF_web.pdf accessed 3.1.19.

SeaDataNet, 2007. SeaDataNet Data Policy and User Licence. [WWW Document]. URL. www.seadatanet.org/Data-Access/Data-policy accessed 10.7.19.

Teuten, E.L., Saquing, J.M., U Knappe, D.R., Barlaz, M.A., Jonsson, S., Björn, A., Rowland, S.J., Thompson, R.C., Galloway, T.S., Yamashita, R., Ochi, D., Watanuki, Y., Moore, C., Hung Viet, P., Seang Tana, T., Prudente, M., Boonyatumanond, R., Zakaria, M.P., Akkhavong, K., Ogata, Y., Hirai, H., Iwasa, S., Mizukawa, K., Hagino, Y., Imamura, A., Saha, M., Takada, H., 2009. Transport and release of chemicals from plastics to the environment and to wildlife. Trans. R. Soc. B 364, 2027–2045. https://doi.org/10.1098/rstb.2008.0284.

UNEP, 2009. Marine Litter: A Global Challenge. UNEP, Nairobi.