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EU Marine Beach Litter Baselines

Analysis of a pan-European 2012-2016 beach litter dataset

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MSFD Technical Group on Marine Litter

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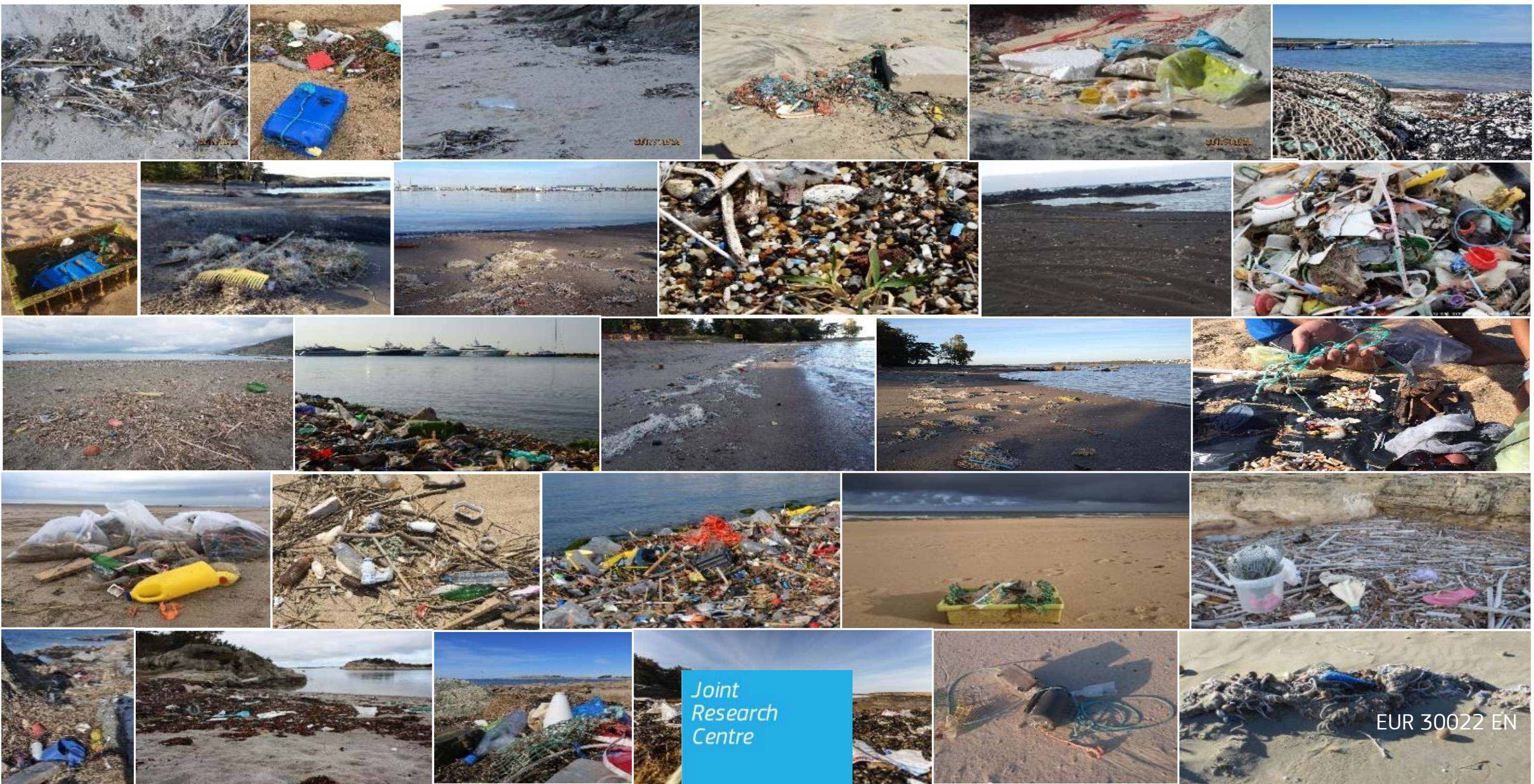

Title: **EU Marine Beach Litter Baselines**

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Contents

Abstract

Measures against marine litter require quantitative data for the assessment of litter abundance, trends and distribution. While beach litter monitoring has been ongoing in some European areas since years, so far it was yet not possible to obtain an overview and to analyse litter abundance, litter category distribution and trends at the different spatial scales from local to EU.

Therefore, the EU Marine Directors and the Marine Strategy Coordination Group mandated, in the context of the MSFD implementation, to the MSFD Technical Group on Marine Litter and the JRC, the compilation and analysis of an EU beach litter dataset. Aim was to derive EU Marine Beach Litter Baselines at different spatial levels. After collection of European beach litter data from EU Member States via the EMODNET chemistry module database, harmonisation of data formats and data clean-up, a 2012-2016 dataset was derived. Following the spatio-temporal aggregation of data and the identification of possible litter category analysis, different scenarios for baseline setting have been tested and evaluated.

The application of agreed scenario parameters has enabled the calculation of marine beach litter baselines for the years 2015 and 2016 at spatial scales ranging from country and country –region level to sub-regional, regional and EU level. Litter categories have been aggregated and allow analysis of group categories up to EU level, whereas the analysis of single categories could not include all received data due to non-comparable litter type category descriptions.

The resulting set of baselines enables the future monitoring of progress in reduction, as well as compliance checking developed using the dataset. Furthermore, it provides valuable information for future improving harmonised monitoring through updated guidance, common data treatment and agreed data reporting formats.

Beach litter abundance has been found to be very high in large areas of Europe, requiring joint and strong action in Europe and with the neighbours in shared marine basins.

Foreword

The Marine Directors of the European Union (EU), Acceding Countries, Candidate Countries and EFTA Countries have jointly developed a common strategy for supporting the implementation of the Directive 2008/56/EC, the “Marine Strategy Framework Directive” (MSFD). The main aim of this strategy is to allow a coherent and harmonious implementation of the Directive. Focus is on methodological questions related to a common understanding of the technical and scientific implications of the MSFD. In particular, one of the objectives of the strategy is the development of non-legally binding and practical documents, such as this report, on various technical issues of the Directive.

The MSFD Technical Group on Marine Litter led by the Directorate-General for Environment and chaired by IFREMER, the European Commission Joint Research Centre and the German Environment Agency, is delivering thematic technical reports such as Guidance for Monitoring of Marine Litter, Harm caused by Marine Litter, Identifying Sources of Marine Litter, and Riverine Litter Monitoring – Options and Recommendations. These thematic reports are targeted to those experts who are directly or indirectly implementing the MSFD in the marine regions.

This Technical Report should further support EU Member States in the implementation of monitoring programmes and planning of measures to act upon marine litter.

Acknowledgements

The authors would like to acknowledge the enormous field work that was the basis for the data analysis and scenario testing. Many hours have been provided by volunteers, sampling technicians and scientists to gather the original data. Major efforts have then been invested in managing these data, compiling and submitting them. Discussion input from individual TG Marine Litter group members is also gratefully acknowledged.

Authors

This report was prepared by JRC within the MSFD Technical Group on Marine Litter in close collaboration with EU Member States. The close collaboration with the EMODNET chemistry module consortium was fundamental in ingesting data and preparing the initial dataset. The data treatment, tidying-up, data analysis and scenario calculation have been performed together with Wageningen University and the Netherlands Rijkswaterstaat.

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1 Introduction

The European Union (EU) Marine Strategy Framework Directive (MSFD) provides for protection against harm caused by marine litter (ML) through Descriptor 10. Provisions include monitoring, assessment and measures in order to achieve or maintain Good Environmental Status (GES). The Communication on the European Strategy for Plastics in a Circular Economy provides the background for large scale activities on plastic waste reduction, as plastic constitutes a large part of marine litter (EC 2018a).

Measures against ML require quantitative data for the assessment of litter abundance, trends and distribution. While beach litter monitoring has been ongoing in some European areas since years, so far it was not yet possible to obtain an overview and to analyse litter abundance, litter category distribution and trends at the different spatial scales from local to EU.

Therefore, the EU Marine Directors and the Marine Strategy Coordination Group (MSCG) mandated, in the context of the MSFD implementation, to the MSFD Technical Group on Marine Litter (TG ML) and the Joint Research Centre (JRC), the compilation and analysis of an EU beach litter dataset. The data includes macro litter, the lower size being defined by the longest extension of the litter item or fragment being 2.5 cm. European beach litter data was collected via the European Marine Observation and Data Network (EMODNET) chemistry module database. Harmonisation of data formats, clean-up and spatio-temporal aggregation of data was done to provide correct and practical statistical scenarios, based on agreed data treatment and calculations, for the setting of beach litter baselines. This is the first time that litter data are being compiled on such a large scale to enable assessments.

The resulting information should support Member States (MS) in the implementation of the MSFD and the EU Strategy on Plastics.

2 Concept of marine litter baselines

This report should summarize information from the preparatory steps in marine litter baselines set-up and provide information about the steps following the data collection for scenario testing.

A baseline for ML is litter abundance information that can be used as a reference point in time in order to test the achievement of quantitative litter reduction goals. Some of these reduction goals, expressed as % reduction over time (from/to) have been discussed at EU level, by MS, different organisations and on a global scale.

The setting of ML baselines requires:

- Ideally, data collected using the same, or a comparable, monitoring protocol
- Data with sufficient spatial coverage
- Data with sufficient temporal coverage (both in duration and frequency)
- Data with sufficient "fit-for-purpose" quality
- An agreed data clean-up procedure
- An agreed baseline calculation method

In the current practice, European beach litter monitoring methods are not fully harmonised, and therefore some data aggregation and normalisation methods are necessary to obtain comparable results on an EU level (see methods and results in this report).

The concept of ML baselines is closely related to ML trend assessments, as baselines and trend assessments require data of appropriate quality and spatial/temporal coverage.

Overall, the discussion about ML baselines is a discussion about data availability and data quality.

Data should be acquired through harmonised monitoring methodologies in order to provide comparable data. This continues to be a challenge, though much progress has been made. The use of agreed guidelines is therefore fundamental in the acquisition of litter data for comparable assessments. Within the MSFD implementation process such guidelines, developed within the TG ML in close collaboration with Regional Sea Conventions (RSCs), have been provided (Galgani et al., 2013) and are currently being updated.

In addition, there are some variables regarding the monitoring and data treatment that need to be agreed upon. In particular, these are:

- The time period from which data is used for the calculation of baselines
- The temporal aggregation of data
- The spatial aggregation of data
- The mathematical procedure used for baseline calculation

As baselines will be used at different levels of organisation for evaluating the compliance with reduction goals, their setting is crucial in the whole process of reducing ML. While EU MS and RSCs are implementing their monitoring programmes, data sets are gradually becoming available. Most data have been derived from beach litter surveys.

Given these needs, JRC has, after a discussion on the overall strategy and roadmap within the MSFD GES group, started the ML baseline activity within the TG ML. It consists of a collaborative approach with the following steps:

1. Creating a ML data availability overview
2. Identification of priority test scenario(s)
3. Collection of data for scenario testing
4. Identification of options for baseline calculations
5. Testing of scenarios with different time coverage/spatial aggregation.
6. Discussion of outcome and identification of common principles for baseline setting

All steps have been performed in close collaboration with, and considering all available information from MS, RSCs, scientific literature and other sources. The discussion and set-up of baselines is closely related to ongoing discussions on monitoring, top litter item identification (Addamo et al. 2018) and litter thresholds (Van Loon at al. 2020).

3 Data

Scope of the data collection, as decided during an initial Baseline workshop (14+15.3.2018, Brussels), was a dataset including surveys from 2012-2016. Member State and other data providers, such as large-scale projects and non-governmental organizations (NGOs), were asked to first submit the data templates in order to evaluate data formats and then to submit data to JRC. The dataset used for scenario calculations contains 440902 values from 3069 surveys on 331 beaches, covering both urban and peri-urban beaches with a higher degree of impacts from local activities as well as rural beaches in more remote areas dominantly receiving litter washed ashore from the open sea. The last dataset to be considered was received on 24.10.2018 from Italy. A 2016 subset of the data has been analysed to provide information on the most abundant beach litter items in EU (Addamo et al. 2018, EC 2018b), in order to prepare the EU Directive on the Reduction of the impact of certain plastic products on the environment (2019/904/EU, EU 2019).

Raw data were collected by JRC, then submitted to and ingested by the EMODNET chemistry module consortium at OGS, Trieste, Italy. Data was then cleaned and corrected, completed, also in close collaboration with the data providers.

The dataset of European beach litter data for the period 1.1.2012 to 31.12.2016 was exported from EMODNET (https://www.emodnet-chemistry.eu) using a standardised data format. While the EMODNET dataset is including other data, the dedicated dataset for the baseline scenario analysis was exported from the EMODNET database to the following data structure:

Table 1: Dataset coding in EMODNET database

Data column	Possible values/Remark
region_name	OSPAR, HELCOM, MEDPOL, Black Sea
country_code	Two letter code, e.g. FR
country_name	Full country name
reference_list	OSPAR, UNEP, UNEP-Marlin, TG ML, IT
date	The actual monitoring/survey date
location_code	Beach code
location_name	Beach name
longitude	Of the monitoring beach. In Decimal Degrees (DD) format. See: https://en.wikipedia.org/wiki/Decimal_degrees
latitude	Idem
type_code	Code of the litter type/category/cluster. E.g. B12 (see Annex 1)
type_name	Description of the type code
abundance	The counted number of the specific litter type The abundance must be an integer value > 0, no blanks allowed.
selected?	True/-. This indicates if a record has been selected for analysis in this project, because it is clearly defined and useful.
remark_selection	Remark about True/-. E.g. explanation of a duplicate record

3.1 Data availability

Initially, a survey on the availability of beach litter data had been made in order to investigate the feasibility of the baseline analysis. Based on this, a request to MS and other stakeholders was made to provide all available data to JRC. During this stage also datasets from projects and NGOs or other parties have been received. While these have been included in the EMODNET data collection, they have been included in the baseline scenario analysis only if they had been endorsed by a EU MS because the baseline setting is part of the MSFD implementation and is thus closely linked to MS assessments and reporting. From some countries data have been received through the OSPAR beach litter database, after endorsement by the MS..

Data have been received from the following EU MS, indicating contact persons and data providers:

Belgium: Francis Kerckhof, Royal Belgian Institute of Natural Sciences

Bulgaria: Stela Barova and Violeta Slabakova, Black Sea Basin Directorate to the Ministry of Environment and Water, Department Marine Waters Protection and Monitoring

Croatia: Pero Tutnam, Institute of Oceanography and Fisheries

Denmark (Baltic Sea): Lone Munk Søderberg, Danish Ministry of the Environment and Food; Jakob Strand, Aarhus University, National Centre for Environment and Energy

Estonia: Marek Press, Keep the Estonian Sea Tidy Association, Agnes Unnuk and Katarina Oganjan, Ministry of the Environment of Estonia

Finland: Suikkanen Sanna, Finnish Environment Institute

France: Francois Galgani, French Research Institute for Exploitation of the Sea; Sophie Beauvais, French Biodiversity Agency; Camille Lacroix, French Centre of Documentation, Research and Experimentation on Accidental Water Pollution

Germany (Baltic Sea): Dennis Gräewe, State Agency for Environment, Nature Conservation and Geology, Mecklenburg-Vorpommern, Division Geology, Water and Soil, Department Water Quality Inland and Coastal Water; (North Sea) Stefanie Werner, German Federal Environment Agency

Italy: Oliviero Montanaro, Irene di Girolamo, Roberto Giangreco, Matteo Braida, Lorenza Babbini, Italian Ministry of Environment, Directorate General for Nature and Sea Protection

Ireland: Conall O'Connor, Department of Housing, Planning and Local Government

Greece: DeFishGear Project/MIO-ECSDE; Thomais Vlachogianni, Mediterranean Information Office for Environment, Culture and Sustainable Development

Latvia: Janis Ulme, Foundation for Environmental Education; Baiba Zasa, Ministry of Environmental Protection and Regional Development of the Republic of Latvia

Lithuania: Laura Lauciutė, Environment Protection Agency, Marine Research Department

Netherlands: Lex Oosterbaan and Willem van Loon, Rijkswaterstaat, Ministry of Infrastructure and Water Management

Poland: State Environmental Monitoring; Włodzimierz Krzymiński, Tamara Zalewska, National Research Institute, Institute of Meteorology and Water Management

Portugal: Isabel Moura, APA, Agência Portuguesa do Ambiente, Portugal, Sandra Moutinho, DGRM, Direção Geral de Recursos Naturais, Segurança e Serviços Marítimos

Romania: Elena Stoica, National Institute for Marine Research and Development 'Grigore Antipa'

Slovenia: Andreja Palatinus and Manca Kovač Viršek, Institute for Water of the Republic of Slovenia

Spain: Marta Martínez-Gil Pardo de Vera, Ministry for the Ecological Transition. Directorate for Coast and Sea Sustainability

Sweden (Baltic Sea): MARLIN Database; Eva Blidberg, Keep Sweden Tidy; Johanna Eriksson, Swedish Agency for Marine and Water Management; Per Nilsson, Swedish Institute for the Marine Environment

United Kingdom: Thomas Maes, Centre for Environment, Fisheries and Aquaculture Science (Cefas); Laura Foster, Marine Conservation Society

3.2 Spatial data coverage

All EU MS had been asked to provide data and, through the MSFD GES group, agreed to do so. Some MS had not started monitoring, thus did not provide data for 2012-2016.

Figure 1: Beach survey locations

3.3 Beach identification

The analysis of a large beach litter dataset requires the unambiguous identification and description of the surveys and the surveyed beaches (Figure 1). Numerous corrections have been made during the initial data ingestion and compilation phase. Each survey is defined by its start and end coordinates (expressed as WGS84 based coordinates in INSPIRE compatible format).

In the Italian dataset, multiple surveys of ca. 30 m have been made on the same day (Figure 2). These surveys have been summed up to a single survey with the cumulative length and litter counts (Figure 3).

Coordination data can nowadays be expected to be precise to a few meters' uncertainty. We can, however, not be sure on the initial input coordinate data (measured or derived). There are different coordinates that need to be considered: start/end of the survey and beach position metadata. Not always are all available. The beach identification coordinates can be ambiguous in case of very long beaches.

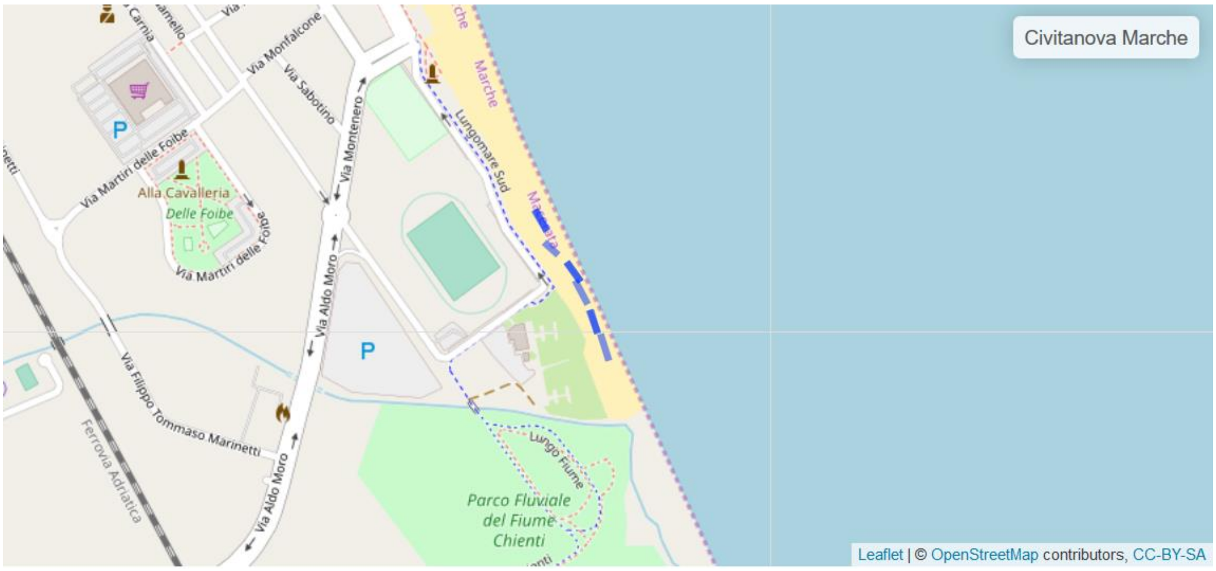

Figure 2: Multiple 30 m surveys

Figure 3: Surveys added to longer single survey

3.4 Temporal data coverage

While data coverage was overall improving from 2012 towards 2016, in some cases data have been provided through projects with limited duration, thus providing data only during a specific period (Table 2, Table 3, Figure 4).

Table 2: Number of surveys/country

Country name	2012	2013	2014	2015	2016
Belgium	3	7	7	9	8
Bulgaria	0	0	0	24	8

Country name	2012	2013	2014	2015	2016
Croatia	0	0	4	12	0
Denmark	1	2	2	15	16
Estonia	18	18	30	30	10
Finland	22	24	26	29	27
France	40	37	32	31	63
Germany	47	94	115	100	91
Greece	0	0	6	9	6
Ireland	2	16	16	16	16
Italy	0	0	0	60	117
Latvia	31	32	34	35	36
Lithuania	16	16	0	0	0
Netherlands	15	16	16	18	14
Poland	0	0	0	47	64
Portugal	0	28	37	34	36
Romania	0	0	0	7	2
Slovenia	32	29	3	15	0
Spain	5	103	105	96	100
Sweden	42	42	40	45	47
United Kingdom	68	140	155	63	114

Table 3: Survey numbers per year in subregions

Region name	Subregion name	2012	2013	2014	2015	2016
Baltic Sea	Baltic Sea	136	188	207	254	244
Black Sea	Black Sea	0	0	0	31	10
Mediterranean Sea	Adriatic Sea	32	29	7	45	38
Mediterranean Sea	Ionian Sea and the Central Mediterranean Sea	0	0	6	20	28

Region name	Subregion name	2012	2013	2014	2015	2016
Mediterranean Sea	Western Mediterranean Sea	0	53	56	84	131
North East Atlantic Ocean	Bay of Biscay and the Iberian Coast	9	77	80	79	86
North East Atlantic Ocean	Celtic Seas	68	119	118	58	119
North East Atlantic Ocean	Greater North Sea, incl. the Kattegat and the English Channel	97	129	142	116	113
North East Atlantic Ocean	Macaronesia	0	9	12	8	6

Note the large differences of surveys in different areas. While the Eastern Mediterranean Sea is not covered at all, the Black sea is covered by a total of 41 surveys in 2015 and 2016.

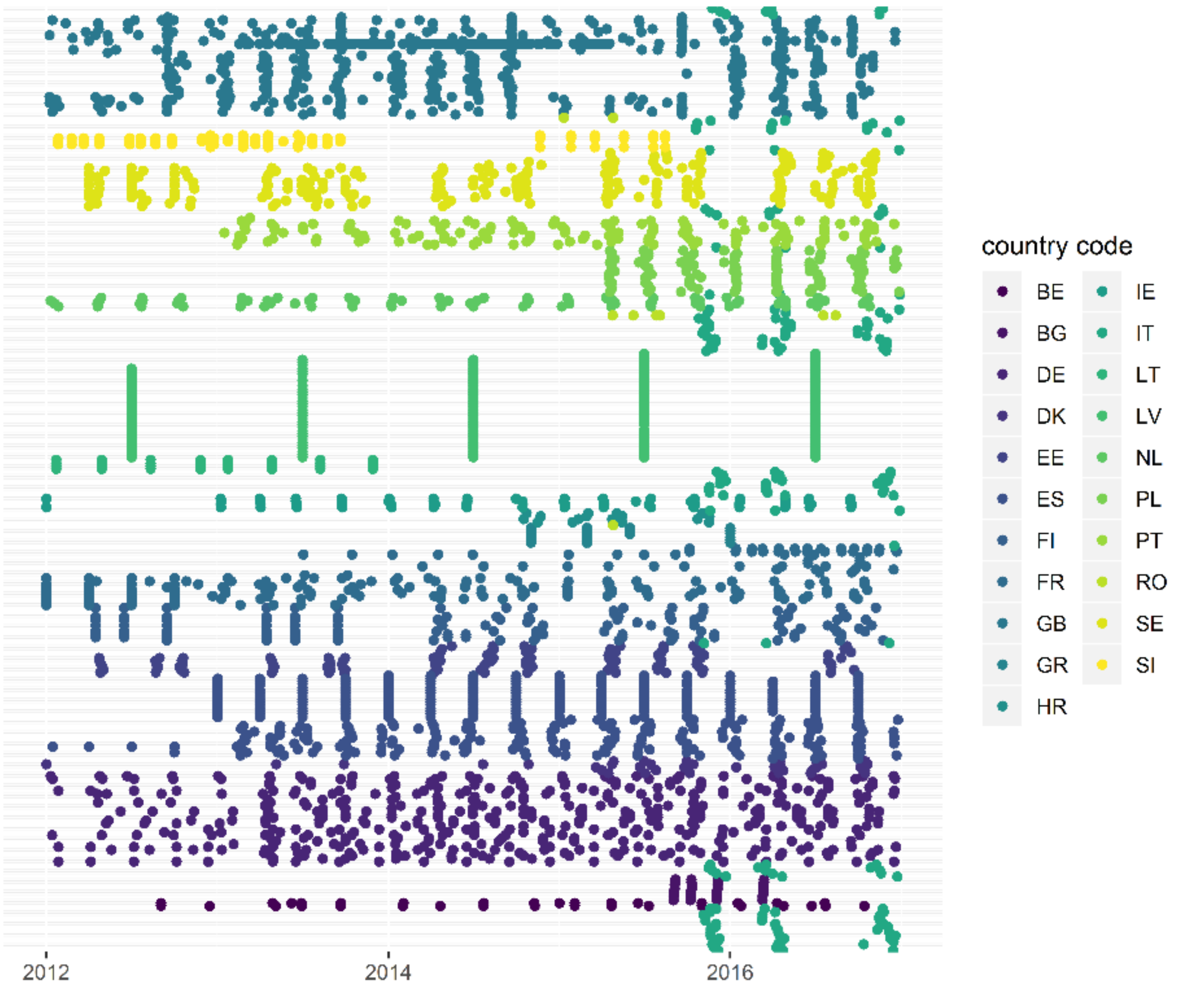

Figure 4: Plot of survey dates from 2012-2016

The survey data provided by MS show regular and increasing survey activity in most EU countries from 2012-2016 (Figure 5, Figure 6, Figure 7).

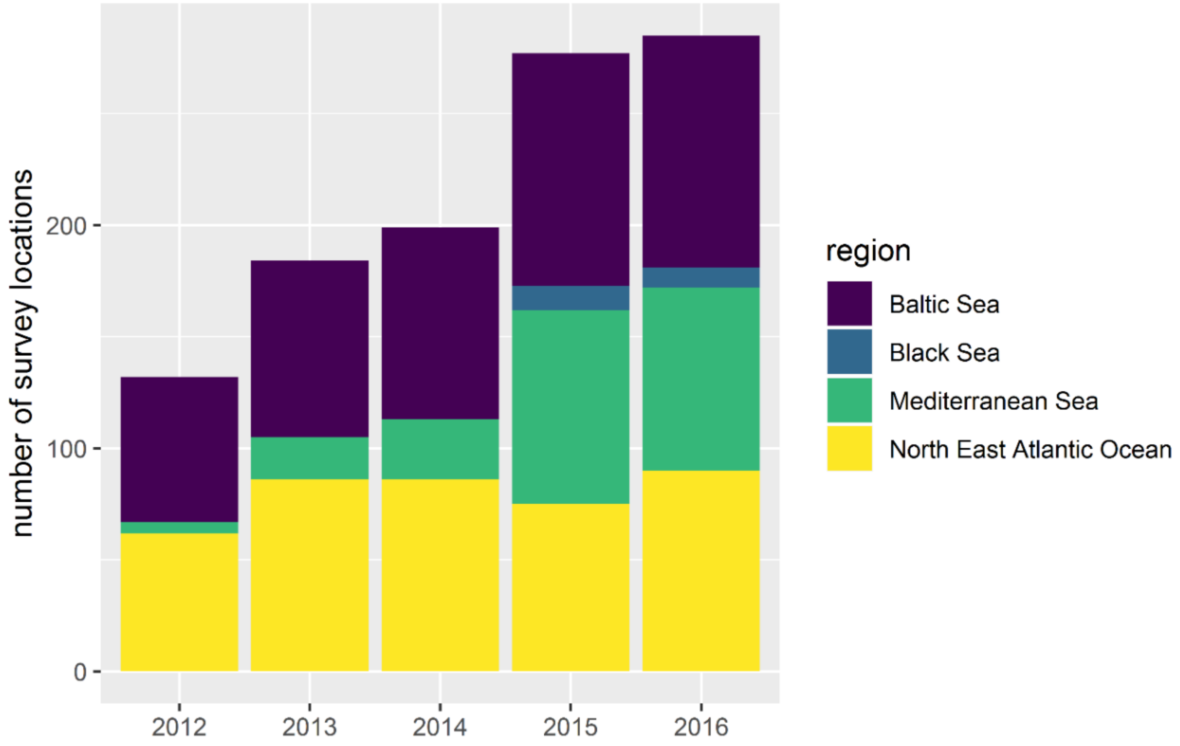

Figure 5: Number of surveys in different years per region

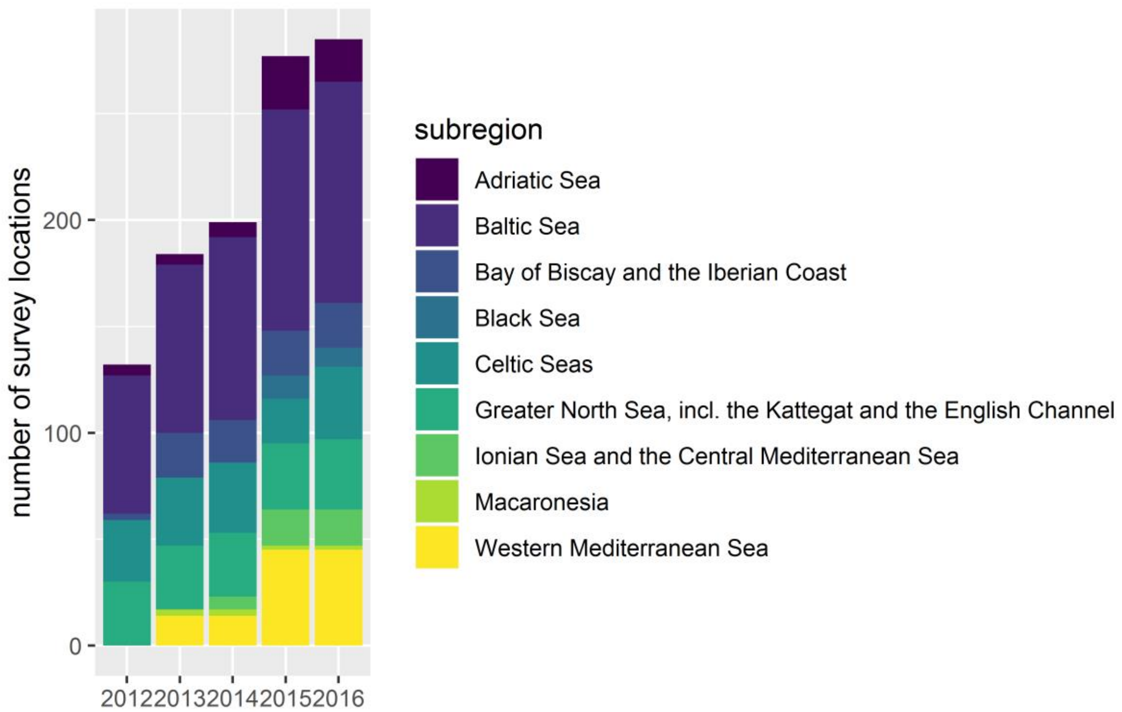

Figure 6: Number of surveys per year at subregion level

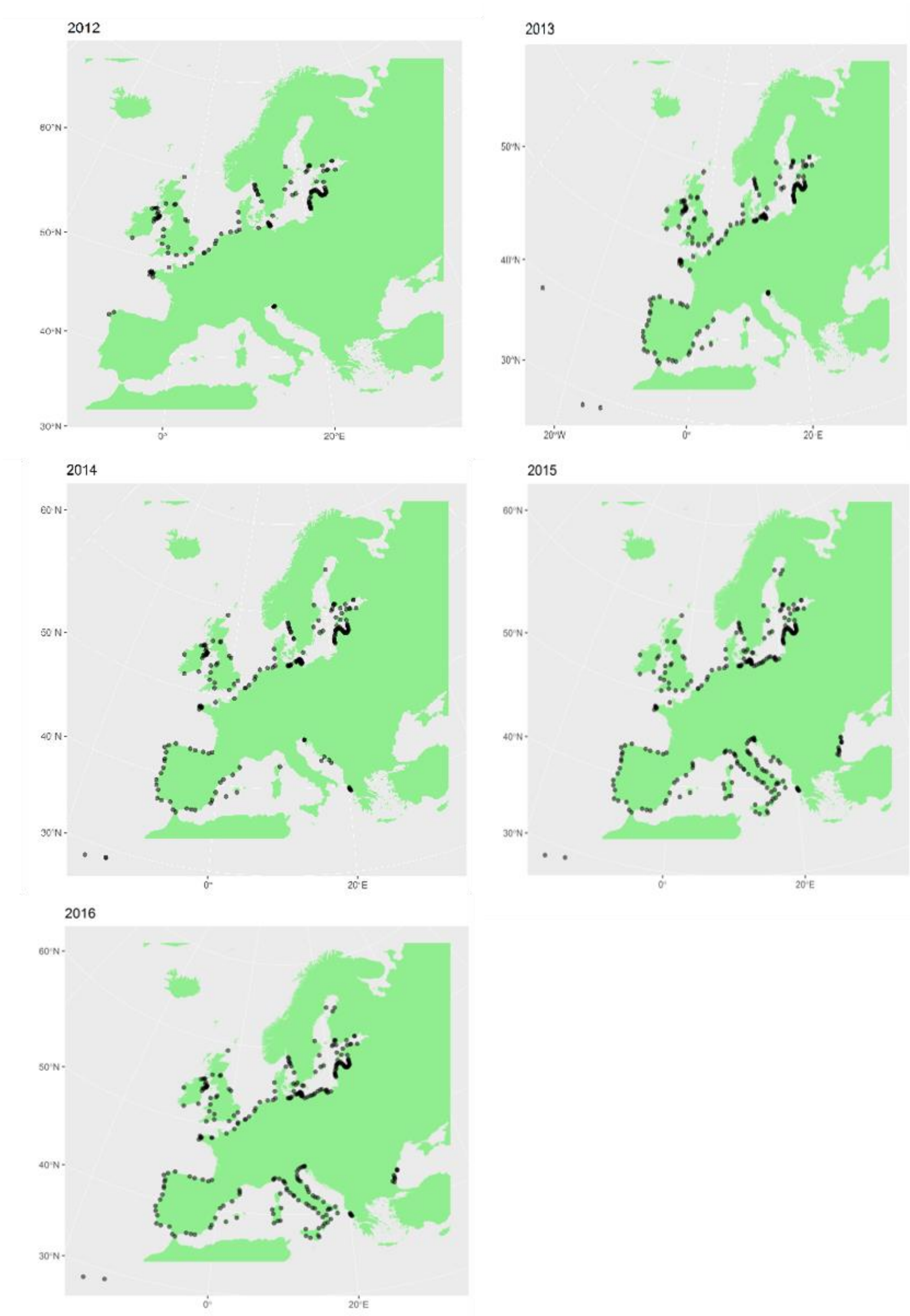

Figure 7: Maps showing data coverage development from 2012 to 2016

4 Preparation of the dataset for scenario analysis

4.1 Data quality

Quality assurance (QA) and quality control (QC) are crucial when utilising quantitative data for assessments that may have far-reaching consequences in terms of policy decisions and implementation. There are specific challenges in beach litter monitoring as it is based on observations and different protocols are in use.

The quality of beach macro litter monitoring data is depending on the organisation and performance of the litter surveys. Common understanding, agreed protocols, training and implementation of monitoring strategies are fundamental.

Also, the data recording, transmission and treatment is of great importance. Elements of QA/QC are:

- Qualification of the monitoring organisation (*how to assess*?)
- Use of approved monitoring protocols (*by whom*?)
- Raw data review (outlier and probability checks, which criteria)
- Metadata (coordinates (INSPIRE), etc.)

As the dataset resulted from surveys based on different protocols and litter category descriptions, comparability was not given for all data, therefore the dataset needed to be cleaned before proceeding to data analysis. It is here assumed that data provided by MS have undergone thorough quality checks and do not contain erroneous data. This concerns the extreme values that have been found, see discussion further down.

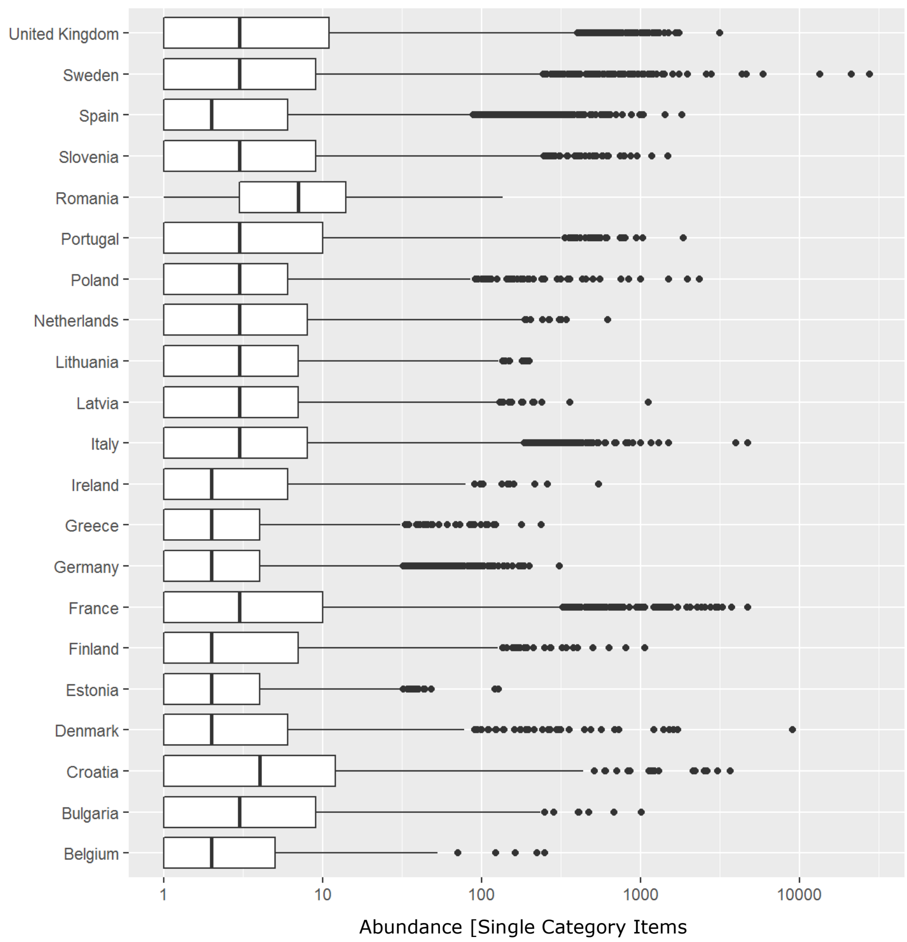

Figure 8: Plots of all raw litter abundance data for single categories (removed zero values to enable logarithmic plot)

Distribution of raw litter data across national surveys in 2012-2016, and the presence of high value "outliers", while representing real data, indicate non comparable approaches e.g. concerning small litter size fractions and specific litter types (Figure 8).

For the initial analysis of the dataset the following categories have been flagged in terms of data comparability, coverage and scope and have thus not been considered in the analysis:

- Cigarette butts (3986 records)

Data coverage is incomplete, monitoring has been done often on short survey lengths that may not have been representative:

- Paraffin/wax (7517 records)

Monitoring includes different material type; physical fractionation may lead to assessment by counts that are not comparable:

- Litter types < 2.5 cm (2762 records)

Incomplete coverage, as meso litter may require a harmonised monitoring approach.

Here the detailed data clean-up actions that have been performed, resulting in a cleaned Total Abundance (TA), are given. In this clean-up process, the poorly monitored or incomparable data records have been removed.

(a) Identical duplicates were removed from the EMODNET master dataset in this project, because these are obvious errors. In case of duplicate location and date with different type abundances, EMODNET informed that these records can either be (a) replicate 100 m samples (e.g. in case of country *), or (b) in one case (country *) are research data about abundances found at respectively 10, 20, 30, ...100 m beach stretches. In case (a), the replicate records were averaged in this study. In case (b), only the 100 m data were selected for data analysis in this study.

(b) In principle, only 100 m data are analysed in this project. However, when possible, deviating surveys lengths were normalised to 100 m, in order to keep as much European data in the data analysis as possible. It is expected that 10 m data will be excluded from analyses, because these are usually targeted at a few very abundant types (e.g. cigarette butts), and extrapolation to 100 m can be erroneous. Survey data from 1000 m usually only contain types > 50 cm and will therefore probably be excluded from the analysis.

The possible normalisation of survey data from 10 to 1000 m surveys was investigated by making so-called Type Spectra, in which the mean abundance per type for all reported types was plotted for a specific survey length (e.g. 300 m). These Type Spectra will show the average composition of the types per survey length and will give evidence whether a specific survey length should be included or excluded in the analysis.

(c) Several types < 2.5 cm (meso litter 0.5-2.5 cm and possibly large micro-litter 1-5 mm) are excluded from the analysis. This is done because these items are likely to be counted in an incomparable way (depending on surveyor accuracy and counting effort), leading to a decreased comparability of the European beach litter data. In addition, analysis of 10 m stretches can be used for these small and very abundant items, and extrapolation to 100 m may be unreliable. It is recommended that monitoring is done according to MSFD ML monitoring guidance.

(d) Paraffin, wax and other pollutants are excluded from the analysis, because they are often counted on small beach stretches, leading to incomparable results.

(e) Part of the Slovenian data, which appeared, after consultation with Slovenia, to be research data with a particular monitoring method, are excluded from the analysis.

Cigarette butts are monitored per 10 m in the UNEP Marlin protocol (HELCOM, 2018). Extrapolation of these results to 100 m could give erroneous results if the 10 m stretch would not be representative (e.g. a hot spot). Therefore, these results are not comparable on a European scale, and will not be analysed.

(f) The types Other-wood and Other-paper are removed from the dataset, just like other organic biodegradable material.

Being an operationally defined methodology, beach litter assessments need strict protocols to provide good and comparable data. Based on human observations the quality of the data cannot be assured or assessed by methodologies in use e.g. for chemical substances monitoring. The data quality has two elements:

(a) Deviations from the actual litter abundance on the beach by observation errors, missing of items, misidentification of categories, etc.

(b) Deviations of the actual observed litter as proxy for the litter accumulation over the period that is being assessed. This includes all factors which hinder the observations from being representative, such as meteorological events, intense littering, clean-ups, etc.

While observation errors can be minimised by training, protocols and on-site collaboration, it is more difficult to ensure the representativity of a single survey. Also, the influence of data deriving from unplanned beach clean-ups must be considered and avoided.

The surveys are being made on beaches that have different characteristics with regards to their use. Some may be remote, hardly accessible from land, while others may be in urban areas or areas with a large touristic influence. Not for all beaches the metadata on their use typology, distance to urban centres or touristic affluence (number of visitors) is known or reported. It is assumed that current beach selections provide a range across different types. This should be verified and implemented for future beach selections.

Therefore, aggregation of surveys and beaches is used to provide a statistical reduction of noise in the dataset and hence results.

Therefore, it is at present not possible to quantify a scientifically derived measurement of uncertainty for beach litter surveys. The evaluation of the data being “fit-for-purpose” is therefore based on a thorough implementation of approaches and protocols.

4.2 Survey lengths

The length of the monitoring surveys is based on agreements made in order to allow harmonised assessments, as provided through guidance and protocols. Survey length depends on the observed objects’ size ranges and reasonable invested time for surveys. Surveys extension is reported as linear length in m, with the whole beach width (i.e. beach “depth”, as distance to vegetation or another beach limitation) being surveyed. The beach width should be reported as part of the essential metadata.

The availability of beach width (“depth”) data, in addition to the 100 m survey length extension, enables the calculation of beach litter concentrations per square meter for specific purposes.

Surveys included lengths ranging from 10 m to ca. 3000 m. Some of the survey lengths have been used for specific purposes, e.g. 10 m surveys for cigarette butts and specific MARLIN/OSPAR surveys of 1000 m length for items > 50 cm.

While the vast majority of the surveys was performed with a harmonised length of 100 m, some surveys, though considering all litter categories (see survey length/category spectra graph), have been performed with intermediate length between 10 and 100 m, but also with longer length, up to 3000 m (see Figure 9).

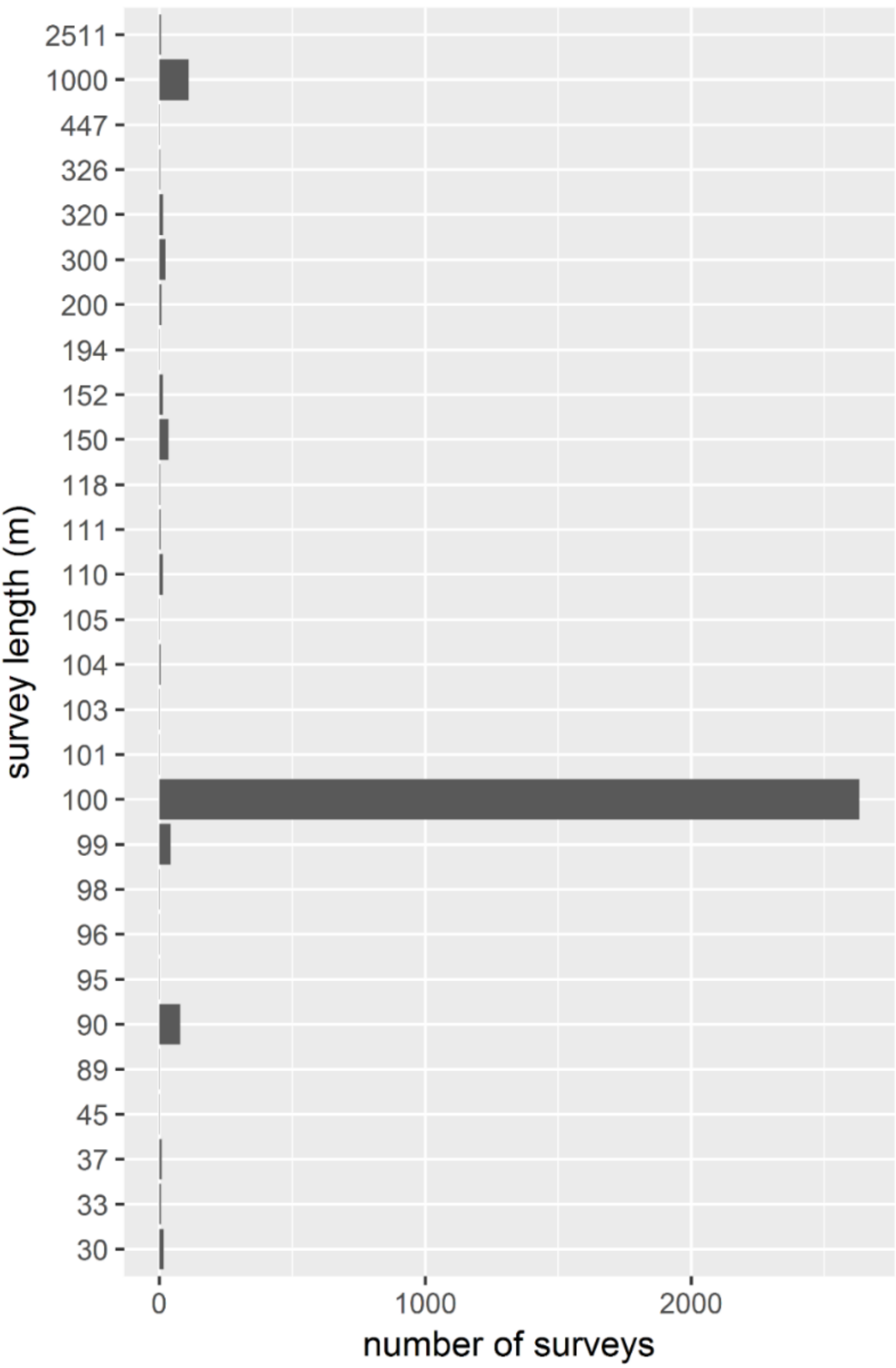

Figure 9: Original survey length distribution

In order to decide if data from different survey lengths can be normalised to 100 m and be kept within the data analysis, so-called type spectra were made in which the average (mean) qualitative and quantitative composition of all survey data from a specific survey length are shown. These type spectra show that the type composition and abundances from 90 to 850 m are reasonably comparable. The 10 m surveys contain only cigarette butts and are therefore not comparable with 100 m survey data.

Surveys of 1000 m length, targeted specifically for large objects > 50 cm, as performed previously by OSPAR had already been excluded from the initial dataset.

The analysis of the survey length showed that different survey lengths had been employed in different areas (Figure 10, Figure 11). In particular, longer surveys have been used on the Black Sea coast and in Poland, while surveys shorter than 100 m have been used in Italy.

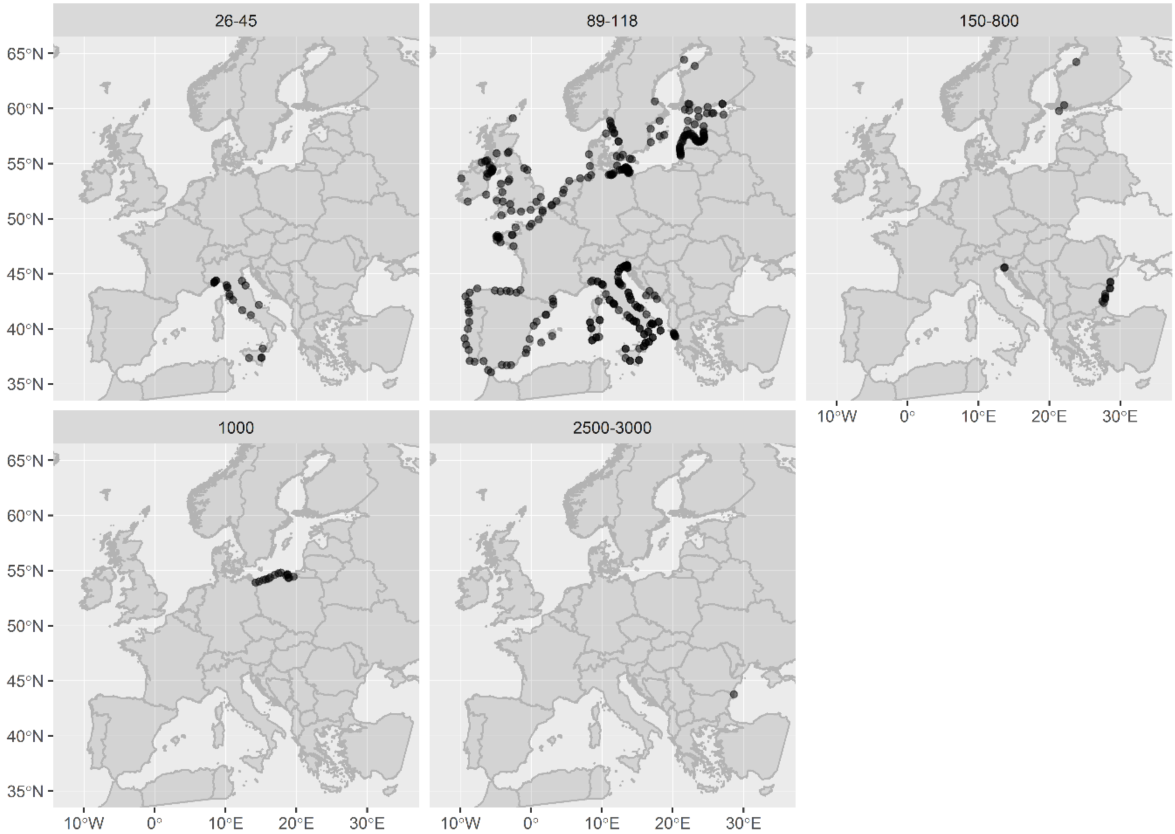

Figure 10: Spatial distribution of employed beach litter survey length

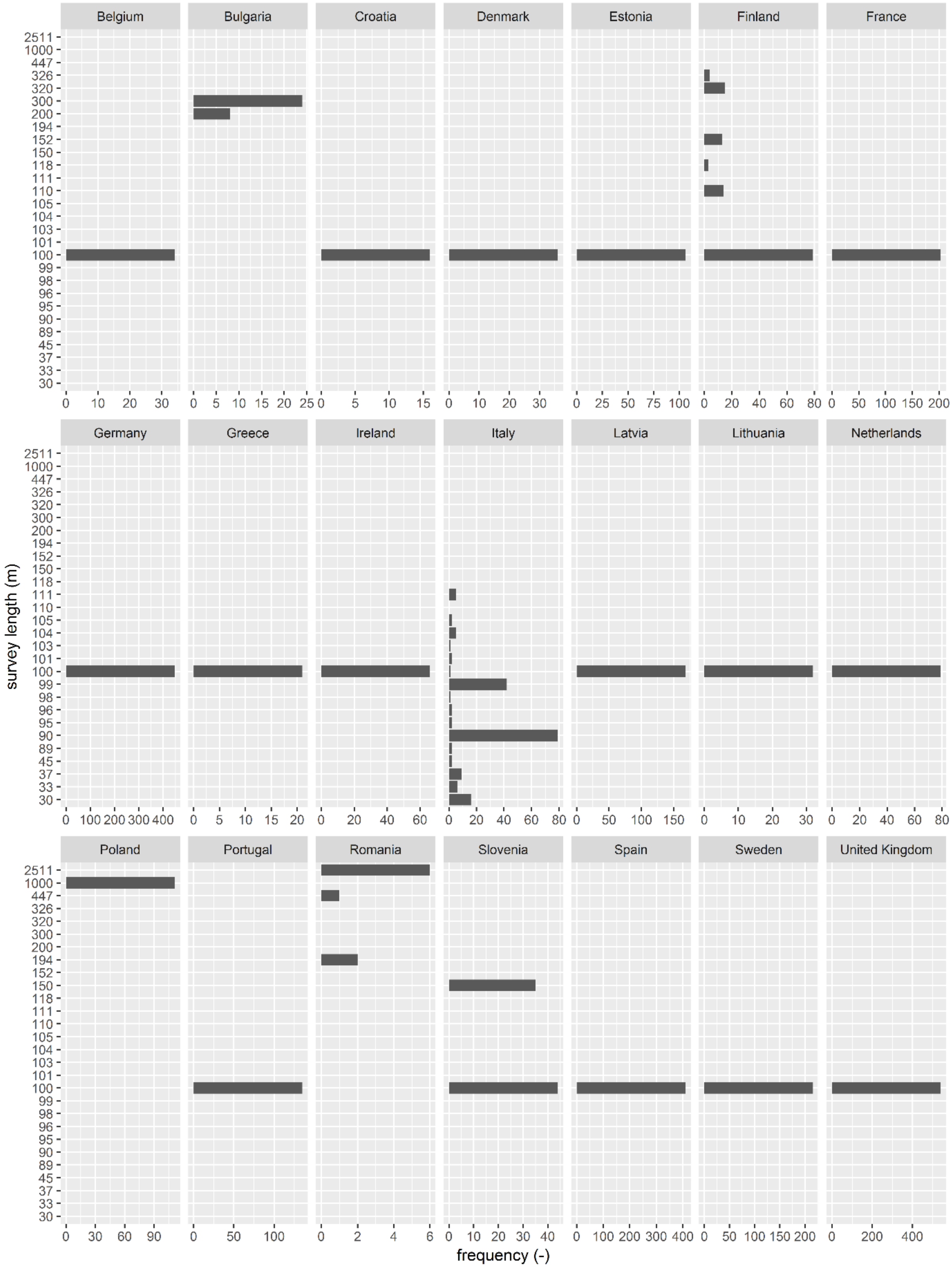

Figure 11: Survey length distribution per country

The litter category spectra of the surveys have been analysed in order to ensure the inclusion only of surveys which considered all categories. This was necessary as some specific short surveys had been dedicated only to cigarette butts. It was found that the surveys of different length considered the whole category spectrum

(B-codes), thus normalisation of all survey lengths, except 10 m surveys (dedicated to cigarette butts) to 100 m has been performed.

It is crucial that the length of surveys is well-defined and measured because it is directly influencing the quantitative result. It could be expected that the detail of observation differs between surveys of e.g. 50 m and those of more than 2000 m.

4.3 Litter categories

Beach litter macro litter is identified by description of material and item or fragment identity. Based on agreed lists, litter objects are then attributed to specific categories (types). These categories have been set-up based on practical consideration and findings on beaches. While the OSPAR category list has been in use since many years, other lists have been set-up later. For the purpose of MSFD implementation (Galgani et al., 2013), a list has been set-up in order to allow improved detail and comparability. This list has been revised and the resulting Joint List of Litter Categories (Fleet et al., 2020) should be used for future monitoring.

Currently there are thus 5 different lists in use, each with different levels of litter category aggregation and total category number. This denotes that the analyses across results derived from the use of different lists need to be aggregated to the list of lowest resolution. Unfortunately, in some cases it has been chosen to aggregate individual items differently, thus only very coarse analyses can consider all results.

Across Europe, a total of 562 categories in the different lists have been identified (Table 4). They are mainly deriving from 4 approaches to harmonise litter monitoring, with added diversity due to different interpretation of the lists. While much progress for a harmonisation towards better comparability of data has been made, still the different completeness, item grouping and description in the lists creates some hindrances in data comparison and analysis.

Table 4: Number of categories in different litter category lists

ITA	59
OSPAR	128
TG ML	216
UNEP	77
UNEP_MARLIN	82

Table 5: The number of records (individual category result numbers) from each category list

ITA	13983
OSPAR	250108
TG ML	50880
UNEP	6004
UNEP_MARLIN	43011

In order to solve this problem of different litter reference lists, an aggregated harmonised category list, referred to as the B(aseline)-list, was constructed. In this B-list, the OSPAR, TGML, UNEP and UNEP_MARLIN type lists have been merged, leading to a new reduced and harmonised list of approx. 130 types/categories (see Annex 1). In this harmonisation process, the resolution of the OSPAR and TG ML lists was inevitably reduced to the resolution of the UNEP and UNEP_MARLIN lists.

In order not to reduce the resolution of the litter type list further, the Italian litter types (ITA) were projected onto this B-list, leading to a partial harmonisation of the Italian list with the B-list. The following three categories have been aggregated and analysed:

- SUP: Single Use Plastics: This group contains all items that have been identified as Single Use Plastics (Cigarette butts' exception).
- FISH: Fishery related litter items: These include all litter items that are originating likely from fisheries and aquaculture.
- TA: Total Abundance: This group includes all quantified litter items that have been identified as part of the quantified litter items, i.e. excluding certain categories for which no reliable data are available (see Annex 1). TA thus includes SUP and FISH categories.

TA, SUP and FISH groups were constructed for all the reference lists described above (see Appendix 1). It appears that these three groups can be constructed and analysed relatively well.

Note that for TA, cigarette butts, paraffin/wax and litter < 2.5 cm (considered by OSPAR only) were excluded, in order to obtain more robust values for TA. Furthermore, cigarette butts were not included in the SUP group.

Overall, the detailed analysis of the available beach litter data revealed numerous issues that hindered data comparability. SUP, FISH and TA category groups have been analysed across all countries, as well as plastic bags, while other categories could only be analysed without Italian data, due to mismatches in the aggregated single litter categories.

While harmonisation efforts are ongoing, it is important to consider these findings in future surveys, by implementation of a Joint Litter Category List.

4.4 Dataset

After identification of issues, cleaning and tidying-up of the original data, a final dataset for beach litter scenario analysis was derived. This dataset was prepared in a list type format, optimised for the application of data analysis scripts and additionally in a so-called "wide format", which enables the data viewing and analysis through excel.

Table 6: Survey numbers

Region name	Subregion name	2012	2013	2014	2015	2016
Baltic Sea	Baltic Sea	136	188	207	254	244
Black Sea	Black Sea	0	0	0	31	10
Mediterranean Sea	Adriatic Sea	32	29	7	45	38
	Ionian Sea and the Central Mediterranean Sea	0	0	6	20	28
	Western Mediterranean Sea	0	53	56	84	131
North East Atlantic Ocean	Bay of Biscay and the Iberian Coast	9	77	80	79	86
	Celtic Seas	68	119	118	58	119

Region name	Subregion name	2012	2013	2014	2015	2016
	Greater North Sea, incl. the Kattegat and the English Channel	97	129	142	116	113
	Macaronesia	0	9	12	8	6

Table 7: Litter records in the final beach litter baseline dataset

Country	Region name	2012	2013	2014	2015	2016	Total
BE	North East Atlantic Ocean	231	539	539	693	616	2618
BG	Black Sea	0	0	0	2544	848	3392
DE	Baltic Sea	2387	6160	7777	6391	5929	28644
DE	North East Atlantic Ocean	1232	1078	1078	1309	1078	5775
DK	Baltic Sea	0	0	0	636	636	1272
DK	North East Atlantic Ocean	77	154	154	780	886	2051
EE	Baltic Sea	1206	1206	2010	2010	670	7102
ES	Mediterranean Sea	0	3927	4081	3619	3696	15323
ES	North East Atlantic Ocean	385	4004	4004	3773	4004	16170
FI	Baltic Sea	1474	1608	1742	1943	1809	8576
FR	Mediterranean Sea	0	154	231	636	2756	3777
FR	North East Atlantic Ocean	3080	2695	2233	1925	2849	12782
GB	North East Atlantic Ocean	5236	10780	11935	4851	8778	41580
GR	Mediterranean Sea	0	0	636	954	636	2226
HR	Mediterranean Sea	0	0	424	1272	0	1696
IE	North East Atlantic Ocean	154	1232	1232	1232	1232	5082
IT	Mediterranean Sea	0	0	0	3540	6903	10443
LT	Baltic Sea	1232	1232	0	0	0	2464
LV	Baltic Sea	2077	2144	2278	2345	2412	11256
NL	North East Atlantic Ocean	1155	1232	1232	1386	1078	6083
PL	Baltic Sea	0	0	0	4982	6784	11766

Country	Region name	2012	2013	2014	2015	2016	Total
PT	North East Atlantic Ocean	0	2156	2849	2618	2772	10395
RO	Black Sea	0	0	0	742	212	954
SE	Baltic Sea	1206	1206	1072	1608	1608	6700
SE	North East Atlantic Ocean	1788	1788	1788	1567	1711	8642
SI	Mediterranean Sea	2112	1914	198	990	0	5214
Total		25032	45209	47493	54346	59903	231983

5 Scenarios for beach litter baselines

Baselines of marine beach litter will be differing, depending on the analysed area, the period and the analysed categories. It had therefore been decided to collect data, derive a specific dataset and then to perform scenario analysis in order to explore baselines using different approaches. The scenarios are characterised by the consideration of different parameters that are specified here below.

5.1 Spatial scale selection

Baseline analyses can be done at different spatial scales. The definition of the borders for grouping at a specific scale is provided by political (country borders/EU membership) or geographic (sea basin) factors.

For different purposes, baselines at different spatial scales are needed. The spatial resolution of the analysis will reflect the level at which common littering effects and thus common implementation of management measures will be needed. The theoretical spatial scenario options include:

- Global level
- EU level
- Regional sea level (including non-EU countries, RSC level)
- Subregional level
- MS level (national)
- Country region level (area)
- Local level (beach or set of beaches)

The selection of a spatial aggregation level is related to the spatial scope of the analysis, as for trends, threshold setting and other purposes. It is linked to the spatial dimension of litter mitigation and measures. Monitoring should thus enable the assessment of need for measures and the validation of their success. For beach litter the spatial aggregation is further influenced by the cross-boundary nature of ML, as it can be transported also over larger distances. Concerning the geographical scale level, differences in beaches with higher local impact i.e. from urban and tourist activities on the beaches compared to more remote reference areas could not be taken into account in this analysis, as relevant metadata were not always available.

Table 8: Regional, Subregional and National spatial scale attribution

Region	Subregion	Country
North East Atlantic Ocean	Greater North Sea, incl. the Kattegat and the English Channel	BE
Black Sea	Black Sea	BG
Baltic Sea	Baltic Sea	DE
North East Atlantic Ocean	Greater North Sea, incl. the Kattegat and the English Channel	DE
Baltic Sea	Baltic Sea	DK
North East Atlantic Ocean	Greater North Sea, incl. the Kattegat and the English Channel	DK
Baltic Sea	Baltic Sea	EE
Mediterranean Sea	Western Mediterranean Sea	ES
North East Atlantic Ocean	Bay of Biscay and the Iberian Coast	ES

Region	Subregion	Country
North East Atlantic Ocean	Macaronesia	ES
Baltic Sea	Baltic Sea	FI
Mediterranean Sea	Western Mediterranean Sea	FR
North East Atlantic Ocean	Bay of Biscay and the Iberian Coast	FR
North East Atlantic Ocean	Celtic Seas	FR
North East Atlantic Ocean	Greater North Sea, incl. the Kattegat and the English Channel	FR
North East Atlantic Ocean	Greater North Sea, incl. the Kattegat and the English Channel	GB
North East Atlantic Ocean	Celtic Seas	GB
Mediterranean Sea	Ionian Sea and the Central Mediterranean Sea	GR
Mediterranean Sea	Adriatic Sea	HR
North East Atlantic Ocean	Celtic Seas	IE
Mediterranean Sea	Adriatic Sea	IT
Mediterranean Sea	Ionian Sea and the Central Mediterranean Sea	IT
Baltic Sea	Baltic Sea	LT
Baltic Sea	Baltic Sea	LV
North East Atlantic Ocean	Greater North Sea, incl. the Kattegat and the English Channel	NL
Baltic Sea	Baltic Sea	PL
North East Atlantic Ocean	Bay of Biscay and the Iberian Coast	PT
North East Atlantic Ocean	Macaronesia	PT
Black Sea	Black Sea	RO
Baltic Sea	Baltic Sea	SE
North East Atlantic Ocean	Greater North Sea, incl. the Kattegat and the English Channel	SE
Mediterranean Sea	Adriatic Sea	SI

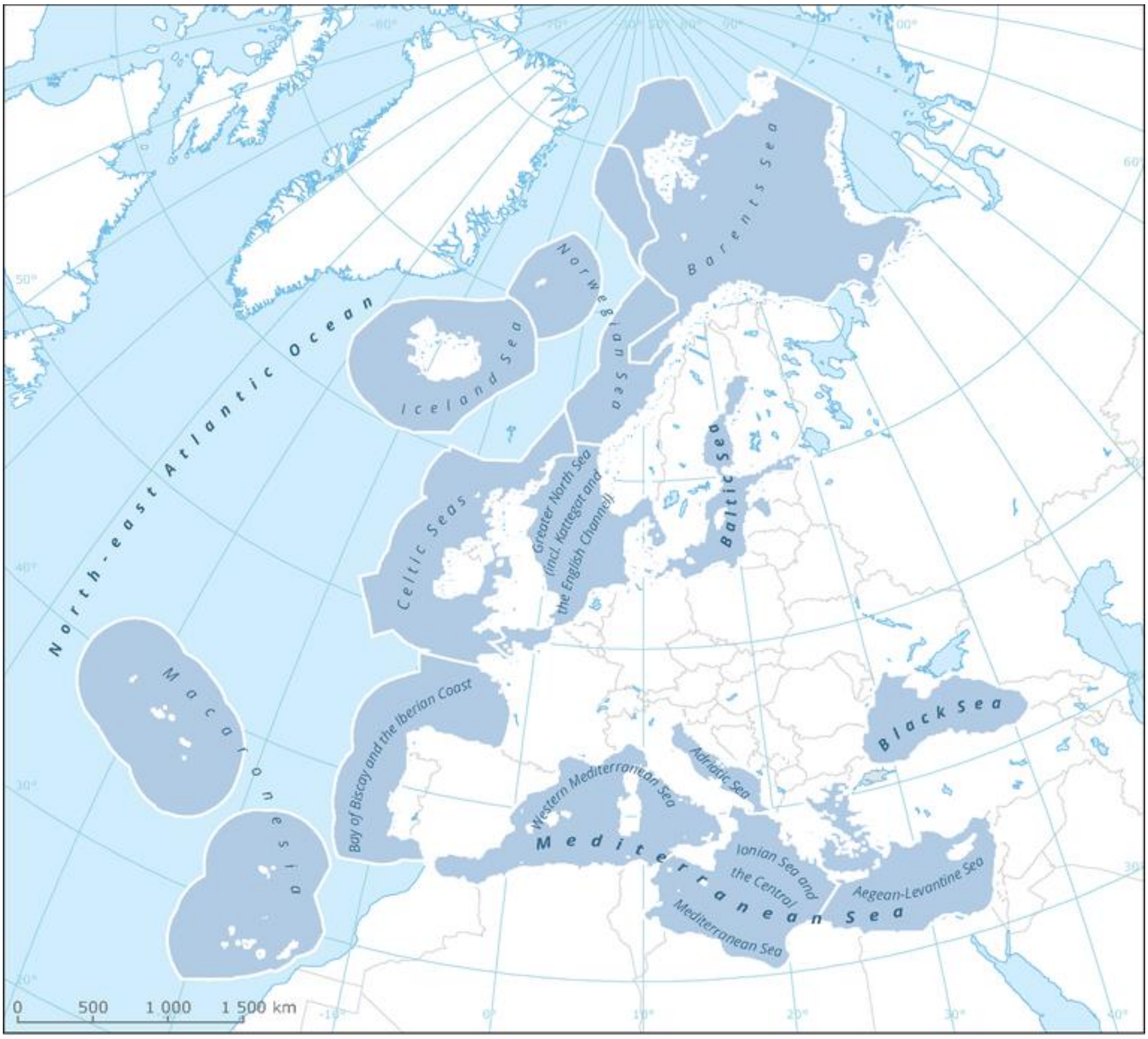

Figure 12: Map of MSFD Regions and Subregions (EEA)

5.2 Temporal scale selection

The temporal coverage of baseline scenario calculations is limited by the data availability and temporal data resolution. Within the scenario analysis the minimum resolution has been defined as 1 year. More detailed analyses, down to seasonal scale would be possible. Initially, data from 2012-2016 have been collected, but coverage in early years was low, except for the OSPAR area (Schulz et al. 2017). Given that the monitoring coverage was increasing from 2012 to 2015, data from 2015 and 2016 was considered specifically for further baseline scenario analysis.

As in some cases data was available either only for 2015 or 2016, both years have been kept and result are presented for the individual years and for a combined 2015-2016 averaged dataset.

5.3 Litter category selection

Litter categories are closely linked to the data need, deriving from policy measures against litter. In that context most abundant items are of importance, grouped specific categories, such as SUPs and FISH and also TA considering other litter categories. The possibility to analyse single and aggregated data depends again on the availability of data and on their potential grouping in different litter category lists.

Besides the three group litter categories, SUP, FISH and TA (see description in chapter 4.3), single or less aggregated data have been derived for selected abundant categories. The B-codes are specified in Annex 1.

- B2 Plastic bags and parts/remains
- B3 Drink/cleaner/food bottles
- B4 Fast food containers
- B9 Plastic caps, lids and rings
- B15 Crisps packets, sweet wrappers, lolly sticks
- B18 Cutlery, trays, straws, stirrers
- B27 Rope, string, cord (all diameter)
- B28 Net and pieces of net, fishing line/net (tangled), monofilament line (angling)
- B41 Plastic and polystyrene pieces 2.5 <> 50 cm

A baseline can be set for the total abundance of all litter items recorded on the survey site, for the abundance of groups of litter category groups, which are from a given source or activity, and for the abundance of individual litter types. For supra-regional assessments the litter types should be taken from a common list of litter types, such as the MSFD Technical Group Litter Category.

5.4 Scenario analysis summary

After definition of the parameters, evaluation of the available data and analysis, the following parameters have been chosen for the baseline scenario analysis:

Table 9: Parameters for beach litter scenario analysis

Parameter	Metric
Spatial Scale	National, Subregional, Regional, EU scale
Temporal Scale	2015, 2016, 2015 + 2016, 1-year resolution
Litter Category	B-codes (aggregated from different lists): TA (with description of contained categories), Litter category groups (SUP, FISH, Other litter (fragments, etc.), Selected single litter categories (aggregated))

6 Data treatment

A crucial step in baseline scenario analysis is the selection and application of statistical and mathematical tools for their calculation. The operations included in that step are averaging and aggregating, weighting across different areas and the treatment of extreme data points.

This includes the preparatory work to test and apply methodologies in order to analyse the structure and properties of the dataset, in order to then apply a specific technique for data analysis.

6.1 Averaging of data

The aggregation of data at different temporal/spatial scales requires the averaging of data. There are different methodologies which can be employed for this. The most straightforward method is the calculation of a mean value, i.e. dividing the total number of litter items/100 across different surveys divided by the number of surveys. Other methodologies, such as median, trimean, a trimmed mean (i.e. a mean after elimination of extreme values), midhinge or q1+q2+q3 method enable data treatment that considers extreme values to a lesser extent (Table 10).

Table 10: Scoring analysis of criteria for averaging method selection

Criterion	Mean	Median	Trimmed mean	Trimean	Midhinge	q1+q2+q3
Good quantitative reflection of litter situation	7.5	5	9	6.5	7	7.5
Robustness for assessment	4	10	6	10	10	10
Statistical correctness	9	9	5	9	9	9
Simple, transparent, well-known, practical	10	10	5	8	8	8
Total scores (unweighted)	30.5	34	25	33.5	34	34.5

After consideration of advantages and disadvantages of the different methods, calculations have been made by using mean, median and trimean in order to compare results from these different calculation scenarios (Table 11). Considering the implications of various factors, such as the robustness of the method against extreme values but also the transparency of the calculation method, the TG ML agreed to use the median as the calculation method to average beach litter data across surveys. Examples for the application of different statistical data aggregating methods:

Table 11: Median, Mean and Trimean results of data aggregation at EU level

Year	Group	Mean	Median	Trimean
2015	TA	545	154	231
2015	FISH	101	16	30
2015	SUP	202	53	87
2016	TA	532	148	206

Year	Group	Mean	Median	Trimean
2016	FISH	111	20	31
2016	SUP	157	58	74
2015-2016	TA	575	149	256
2015-2016	FISH	107	22	31
2015-2016	SUP	201	58	89

A comparison of aggregation results at EU level shows the impact of the different calculation methods (Figure 13, Figure 14). As extreme numbers are being considered less by using the median, final aggregated numbers are considerably lower than those derived from averaging to mean values.

Figure 13: Plastic bags, comparison of data aggregated at national level using mean, median and trimean for the calculation of averages within countries per region

Figure 14. Fishing nets and lines, comparison of mean, median and trimean for the calculation of averages within countries per region

The data aggregation process through the different levels is shown in Figure 15, the sequence of the aggregations including the following steps:

1. Starting with 'litter items', each pertaining to a specific day and a specific location (raw data);
2. Litter items are aggregated to litter groups (TA, SUP, FISH, BAGS);
3. Litter items/groups are temporally aggregated to annual (2015, 2016) and 2015-2016 medians;
4. Litter items/groups are spatially aggregated from specific locations to the country-subregion level (note: some countries (e.g. France) have observations at more than one subregion)
5. For the spatial aggregation level "country-subregion", the data are further aggregated to subregions, regions and finally to European level.

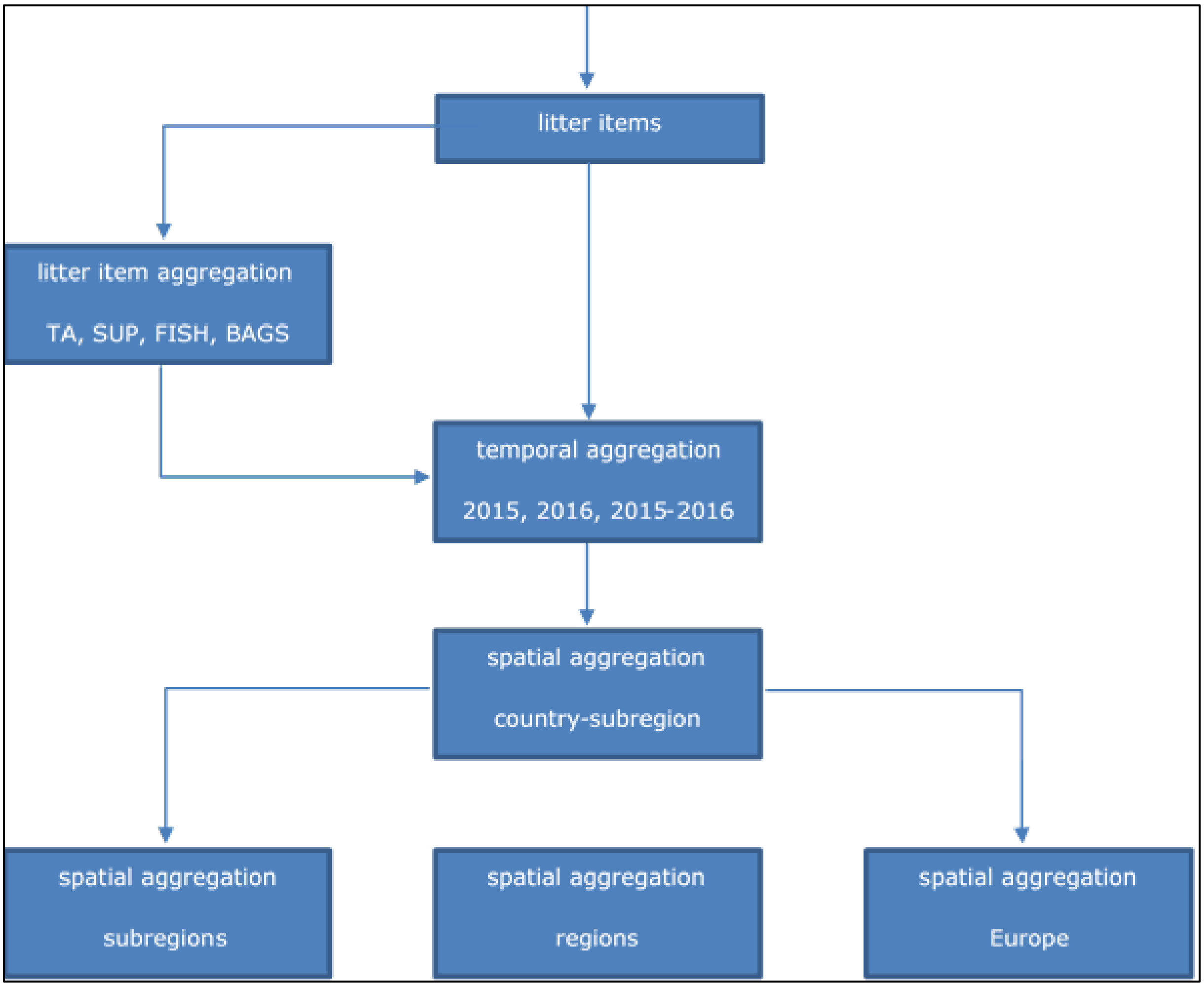

Figure 15: Litter data aggregation procedure

6.2 Extreme values

Beach litter data are characterised by a high variability, with values ranging from zero to tens of thousands of litter objects or fragments within 100 m coastline. It frequently occurs that a few surveys exhibit values that are much higher than for most of the surveys (see Figure 16).

Such extraordinary high values can be caused e.g. by particular events, such as high touristic affluence, spills from shipping containers, specific wind/wave action, etc. They may thus represent true data and indicate a specific litter source or pathway that needs to be considered in policy implementation.

While it can be assumed that data have been screened for being realistic and correct, some values appear very high, e.g. > 1900 plastic parts > 50 cm (B42)/100 m during a single survey. It is therefore suggested to perform an additional probability and validation check in such cases.

Examples of such values are e.g. “rope, string, cord” (B27), with a maximum value in a single survey of 27462 items/100 m, followed by a second survey of 6204 items/100 m, then 1881 items/100 m and gradually decreasing further. Examples with lower absolute numbers include “flip-flops” sandals, category B64, where the first two ranked values are 60 and 46 items/100 m, then 12/100 m and only 5 and less/100 m further down. Other examples are a case with 251 condoms/100 m survey, with the next ranking value being 16/100 m, and 57 paintbrushes/100 m, followed by 21 and 6/100 m.

In total, 18 litter categories have been identified for which the highest-ranking survey is more than 5 times higher than the third ranking survey, and/or the first survey is 10 times higher than the tenth survey. Often categories with low overall counts are concerned, but in some cases the absolute numbers are high, so that even the total abundance values can be influenced considerably.

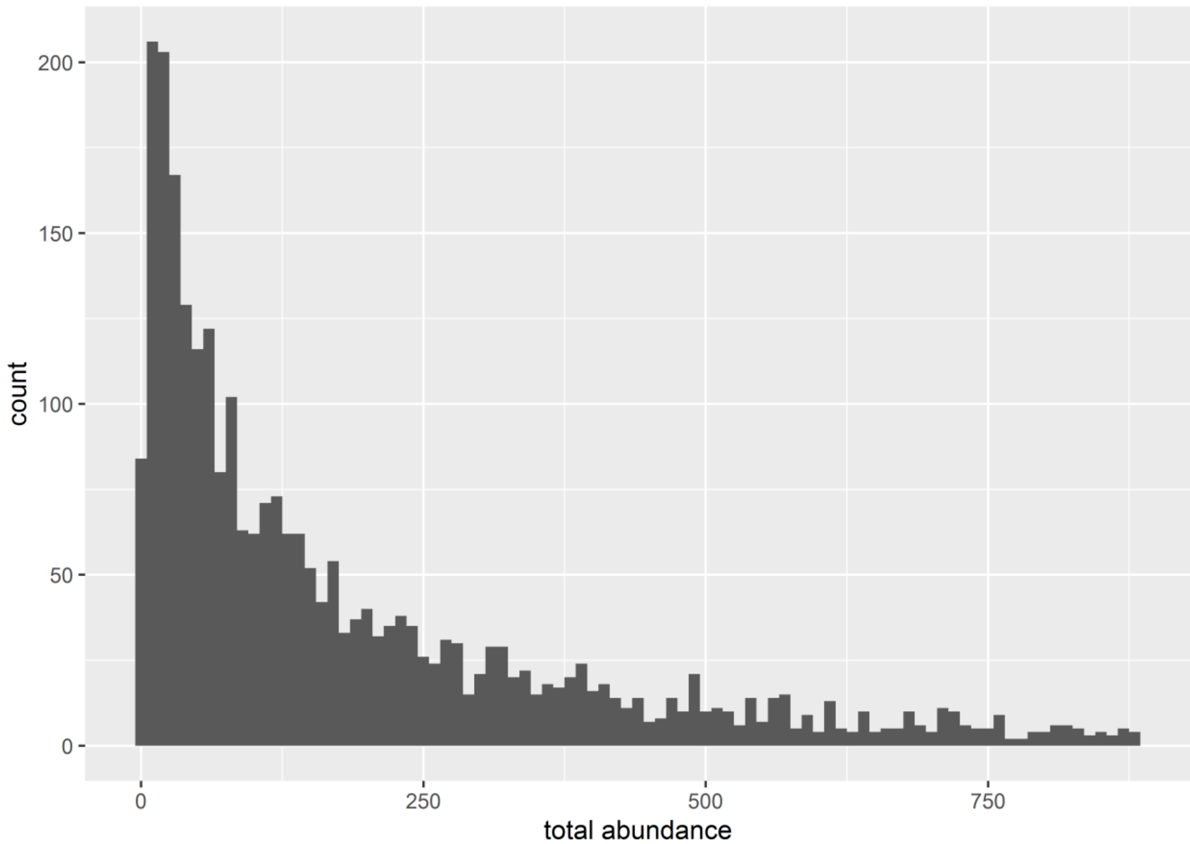

Figure 16: Beach litter data distribution

The occurrence of such rare high values provides a specific challenge, as these single events can influence the average data of a whole country or region. Once a final data validation has been made, it is then necessary to flag such high values and investigate potential reasons for extreme values.

The methodology for the identification of extreme values can be either expert judgement, or be based on statistical and modelling approaches, such as the application of Tukey's box plots to detect potential outliers. For skewed distributions, the adjusted box plot is more appropriate (Hubert & Vandervieren, 2008). The use of adjusted boxplot statistics is one option to identify potential outliers (see Figure 17). Another option is modelling, by assuming an appropriate statistical distribution. Litter abundances are count data. For count data, often a Poisson distribution or a negative binomial distribution (NB) is assumed. The Poisson distribution is restricted in the sense that its variance is always equal to its mean. The NB-distribution is more flexible as its variance can also be greater than the mean. Hence, we assume the NB-distribution. The modelling approach for the identification of extreme values is then performed by fitting the NB-distribution to the data by means of maximum likelihood and tagging all values in the right tail as potentially extreme values if the probability that they belong to the fitted NB-distribution is less than, e.g. 0.001.

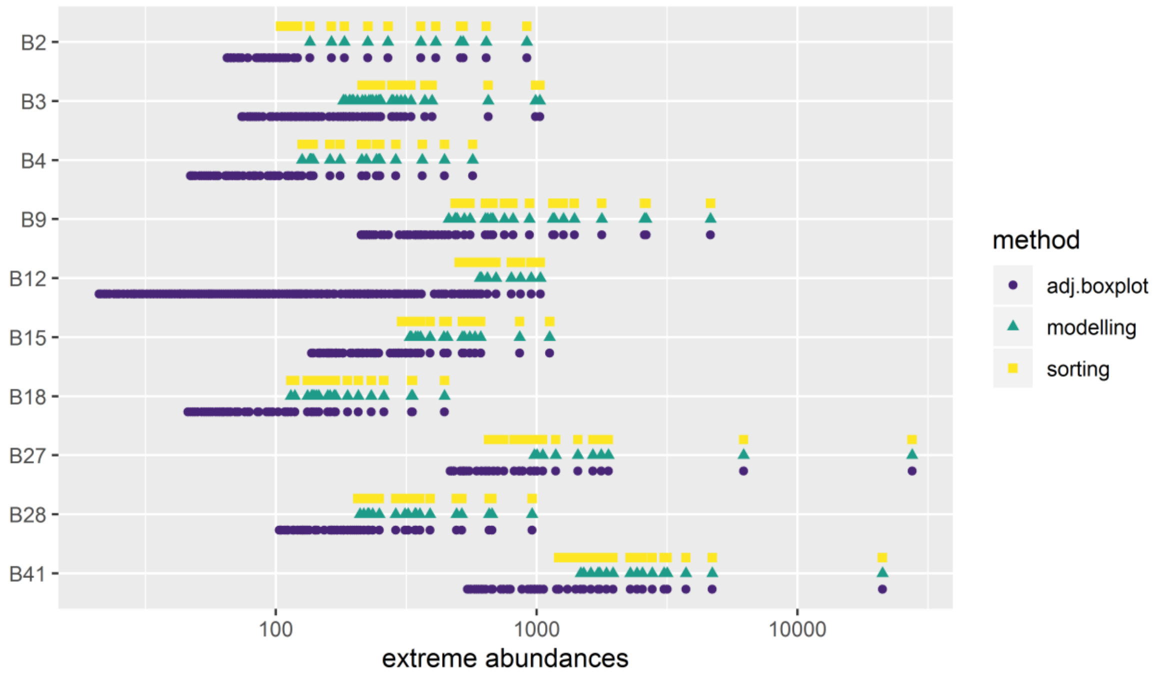

Figure 17: Comparison of testing results for the detection of extreme values

The parallel use of three calculation methods, mean, median and trimean, on selected examples enabled a comparative analysis and an informed choice of a final agreed methodology among the experts in the TG ML. It was agreed to leave the extreme data in the dataset, while highlighting the need to check to verify extreme data case by case and to apply the median for calculating of averages. This allows the use of all data while not skewing results through single extraordinary high litter count surveys.

6.3 Spatial weighting

As European coastal countries have different coastline length it was discussed if the results should be weighted according to a countries coastline length when aggregating data to a higher spatial level. This could e.g. be of interest if the coasts are considered as litter entry points to the sea and thus a longer coastline accordingly should have a larger impact.

Following discussion during the TG ML annual meeting 2019 and a consultation with TG ML experts, it was concluded not to apply weighting to the beach litter survey results when aggregating them. While spatial weighting might be used for other purposes, it would not provide a benefit for assessing the environmental status on the beaches. Furthermore, the complexity of the calculations would reduce the transparency in deriving beach litter baselines. The description of a methodology for spatial weighting, which has not been considered here, is provided for potential future use in another application, in Annex 2.

7 Beach litter abundances

Based on the previous data analysis, treatment and selection of scenario parameters, calculations have been performed and resulted in litter counts/100 m shoreline. These are litter abundance values for different scenarios, based on the aforementioned data treatment and selection methods.

7.1 Mean beach litter abundances

An overview across all data has been provided by calculating an average on aggregated categories (TA (B-categories), SUP and FISH) for the years 2012-2016 (Figure 18).

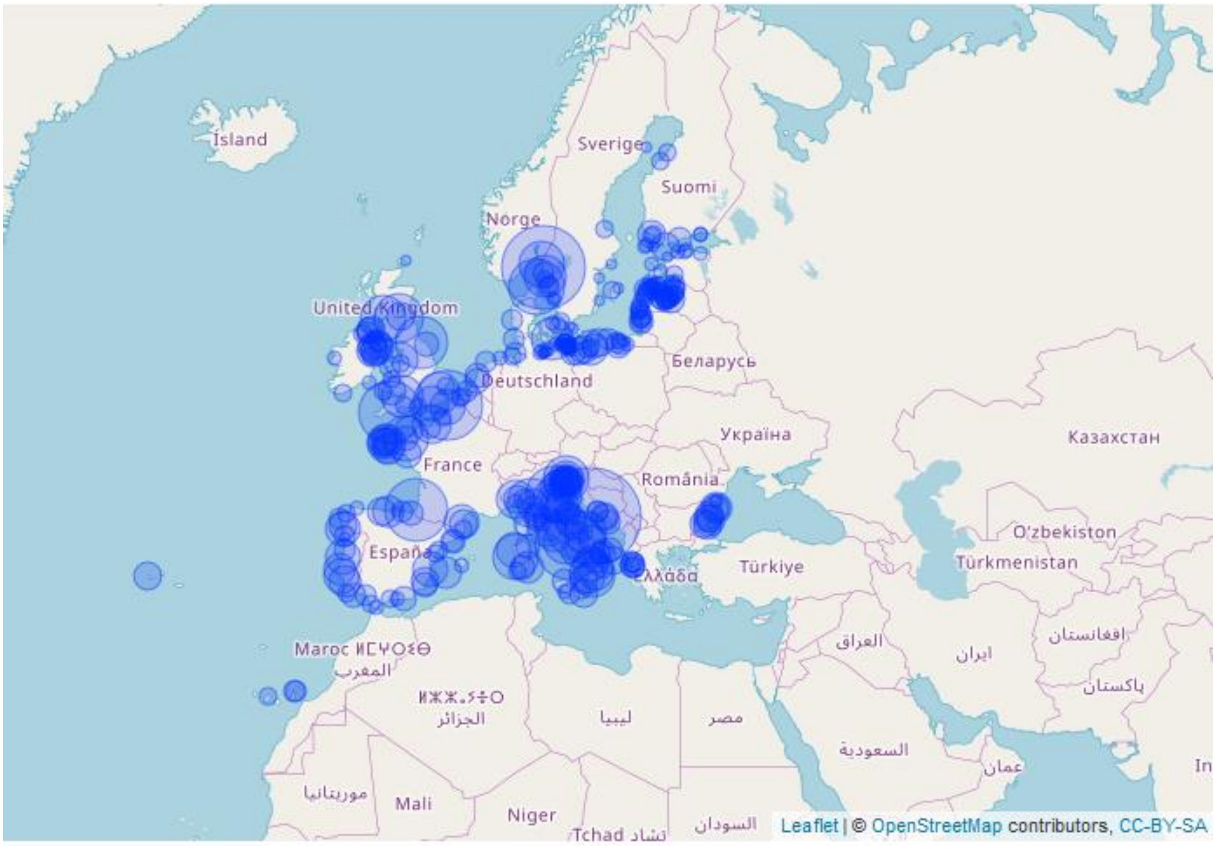

Figure 18: Map of mean beach litter abundances across the EU

7.2 Litter abundances for individual beaches

The availability of surveys on the same beaches for longer sequences of monitoring provides the possibility to assess the temporal development of litter on that beach.

Selected examples of temporal development of litter group categories on a few beaches are shown below (Figure 19, Figure 20, Figure 21). They have been chosen to demonstrate the variability in the litter abundance development for SUP, TA and FISH. Such plots can be made for all beaches. In some cases, the developments appear to indicate trends, but this needs to be confirmed by additional data for recent years and by the application of statistical methods for trend detection.

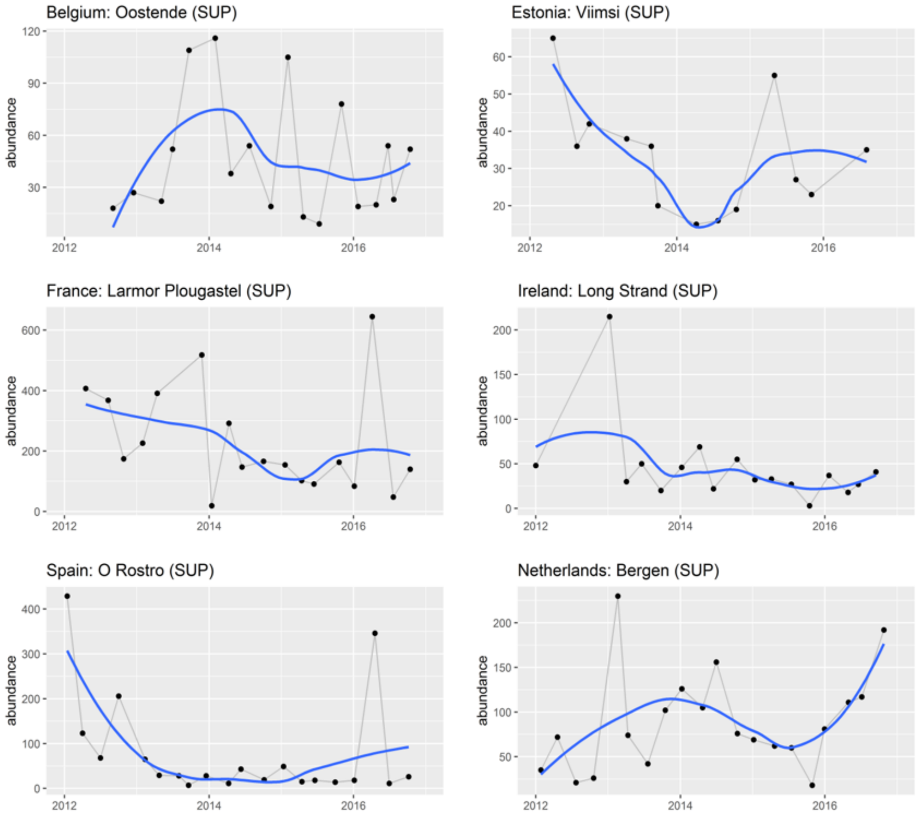

Figure 19: Single-use plastics

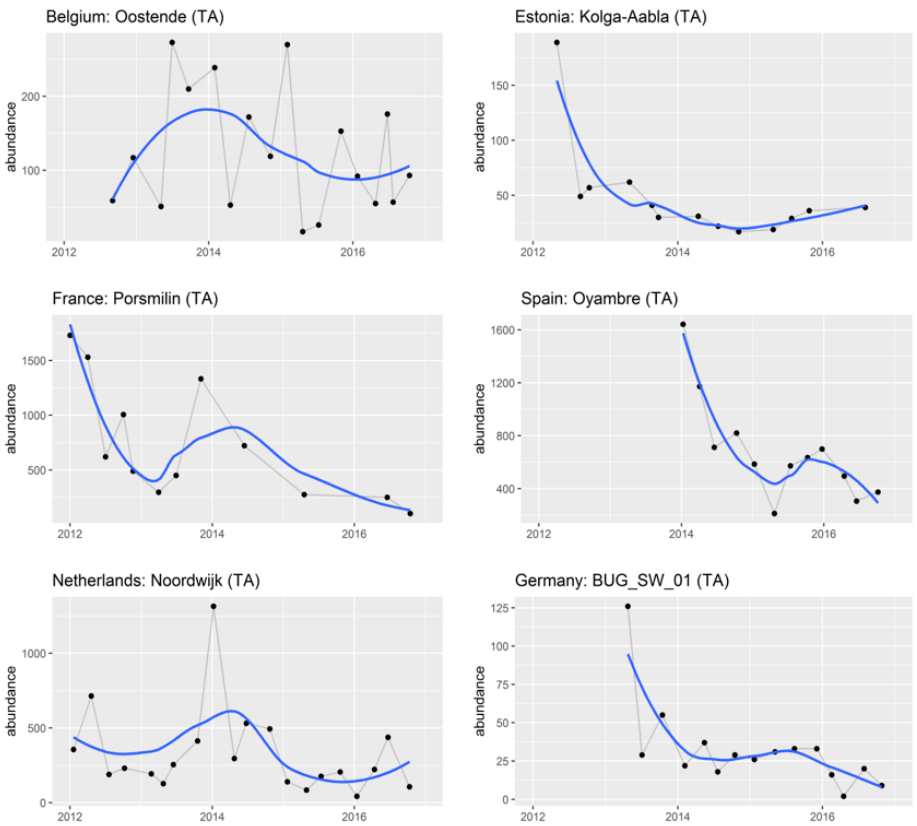

Figure 20: Total Abundance

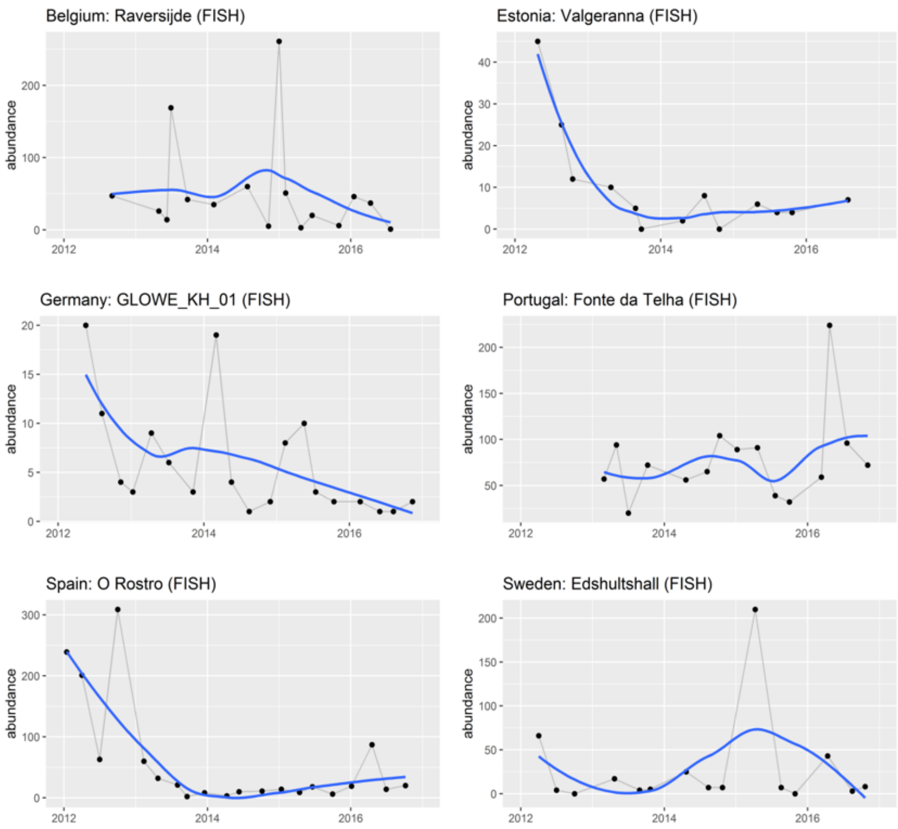

Figure 21: Fishery related litter

Analysis of the cleaned dataset, with most hindrances being removed, provides for each beach a plot of litter abundance counts on a time axis indicating the survey dates between 2012-2016. From these data, spatial and time aggregation, as well as different category aggregations, according to different baselines scenarios, can be developed and mapped.

Individual beach plots enable an assessment of trends, data variability and the potential influence of single surveys on a large-scale average. They allow the assessments of individual beach developments in order to understand dynamics of litter occurrence.

Please note here that the levels of litter abundance can be very diverse and thus the y-axis of the plots covers a range of two orders of magnitude, as shown in the initial dataset analysis. There are often single outstanding surveys which might be attributed to particular events. In numerous cases the pre-2014 litter abundance was higher than in the later years, potentially indicating a success of earlier implemented measures.

8 Baseline results

Spatial aggregation scenarios in EU subregions are presented here as the outcome from combining all available and approved data with a set of parameters, which would result in different scenarios. While all possibilities would produce a very high number of scenarios, here the selected outcome, as described in the previous chapters, median values, non-weighted, from 2015-2016 against mapped B-codes are presented.

8.1 Country level group baselines

Data have been aggregated from different beaches and surveys in 2015 + 2016 at national level. For countries with beaches in two different regions these results are presented separately. Countries are sorted according to their region (Figure 22, Table 12).

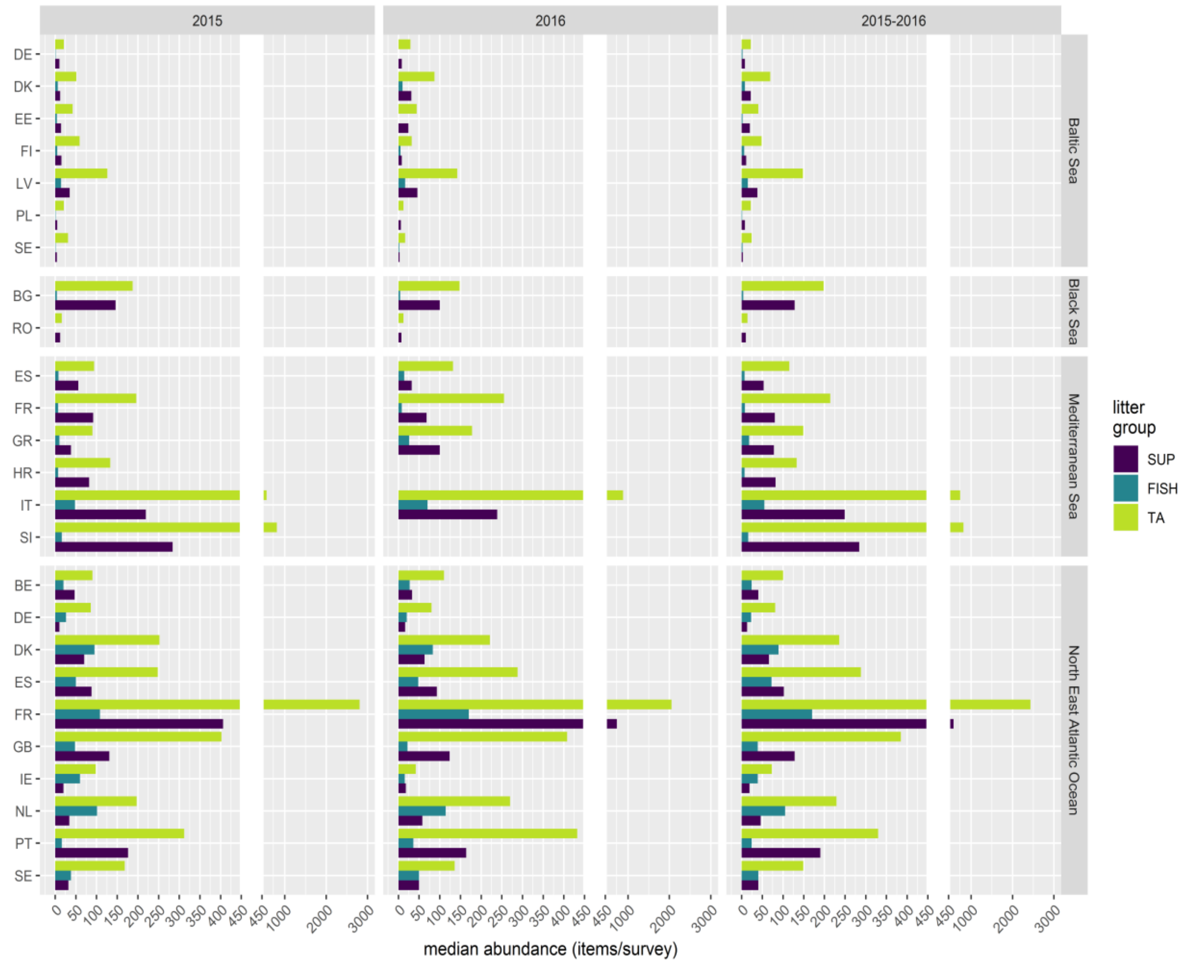

Figure 22: Abundance per litter category group (SUP/FISH/TA) as median in single countries and country-regions

Table 12: Litter abundance at EU country beaches (Categories B2, B3, B4, B9, B12, B18, B27, B28, SUP, Fish, TA) as items/100 m survey (see Annex 1 for code explanation, n.a. = non available; n = number of surveys)

Country	Region	Subregion	Period	n	B2	B3	B4	B9	B12	B18	B27	B28	FISH	SUP	TA
Belgium	North East Atl. Ocean	Greater North Sea, Kattegat + Engl. Channel	2015-2016	17	4	4	2	8	0	2	2	17	24	40	100
Bulgaria	Black Sea	Black Sea	2015-2016	32	8	15	1	33	23	4	2	2	4	128	198
Germany	Baltic Sea	Baltic Sea	2015-2016	160	1	1	0	1	1	0	1	0	2	8	22
Germany	North East Atl. Ocean	Greater North Sea, Kattegat + Engl. Channel	2015-2016	31	5	1	1	3	0	0	18	2	23	13	81
Denmark	Baltic Sea	Baltic Sea	2015-2016	12	2	1	3	3	n.a.	0	7	1	8	22	69
Denmark	North East Atl. Ocean	Greater North Sea, Kattegat + Engl. Channel	2015-2016	19	4	4	2	12	n.a.	2	81	6	89	66	236
Estonia	Baltic Sea	Baltic Sea	2015-2016	40	4	2	5	5	0	0	0	1	2	20	40
Spain	Med. Sea	Western Mediterranean Sea	2015-2016	95	6	5	1	12	8	2	4	1	7	53	115
Spain	North East Atl. Ocean	Bay of Biscay and the Iberian Coast	2015-2016	87	3	7	2	10	8	2	42	4	72	102	288
Spain	North East Atl. Ocean	Macaronesia	2015-2016	14	4	8	0	8	32	1	6	2	10	58	136
Finland	Baltic Sea	Baltic Sea	2015-2016	56	1	0	2	3	0	1	1	1	6	11	48
France	Med. Sea	Western Mediterranean Sea	2015-2016	32	4	6	2	14	12	2	1	4	8	80	214

Country	Region	Subregion	Period	n	B2	B3	B4	B9	B12	B18	B27	B28	FISH	SUP	TA
France	North East Atl. Ocean	Bay of Biscay and the Iberian Coast	2015-2016	8	4	96	54	75	90	9	52	54	118	570	2430
France	North East Atl. Ocean	Celtic Seas	2015-2016	43	2	10	10	40	0	2	57	9	96	79	323
France	North East Atl. Ocean	Greater North Sea, Kattegat + Engl. Channel	2015-2016	11	7	33	19	73	5	3	70	18	170	220	622
UK	North East Atl. Ocean	Celtic Seas	2015-2016	102	6	9	2	13	0	3	21	5	39	50	193
UK	North East Atl. Ocean	Greater North Sea, Kattegat + Engl. Channel	2015-2016	75	2	6	3	14	6	1	12	13	22	128	385
Greece	Med. Sea	Ionian Sea + Central Mediterranean Sea	2015-2016	15	2	18	2	21	1	4	2	2	18	78	149
Croatia	Med. Sea	Adriatic Sea	2015-2016	12	17	7	6	20	8	3	4	1	7	82	133
Ireland	North East Atl. Ocean	Celtic Seas	2015-2016	32	4	1	1	1	0	0	39	1	39	19	73
Italy	Med. Sea	Adriatic Sea	2015-2016	56	23	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	55	249	538
Italy	Med. Sea	Ionian Sea + Central Mediterranean Sea	2015-2016	33	20	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	51	133	334
Italy	Med. Sea	Western Mediterranean Sea	2015-2016	88	19	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	44	202	730
Latvia	Baltic Sea	Baltic Sea	2015-2016	71	14	1	1	6	7	2	7	7	15	38	148

Country	Region	Subregion	Period	n	B2	B3	B4	B9	B12	B18	B27	B28	FISH	SUP	TA
Netherlands	North East Atl. Ocean	Greater North Sea, Kattegat + Engl. Channel	2015-2016	32	4	3	2	12	2	2	95	12	105	46	229
Poland	Baltic Sea	Baltic Sea	2015-2016	111	0	1	0	0	1	0	0	0	1	8	22
Portugal	North East Atl. Ocean	Bay of Biscay and the Iberian Coast	2015-2016	70	17	7	4	20	39	6	22	5	24	190	330
Romania	Black Sea	Black Sea	2015-2016	9	2	2	1	1	3	1	0	0	0	10	14
Sweden	Baltic Sea	Baltic Sea	2015-2016	48	1	0	0	0	0	1	0	0	2	3	24
Sweden	North East Atl. Ocean	Greater North Sea, Kattegat + Engl. Channel	2015-2016	44	8	5	4	5	0	1	20	13	40	40	149
Slovenia	Med. Sea	Adriatic Sea	2015-2016	15	43	0	26	10	44	2	2	6	16	284	805

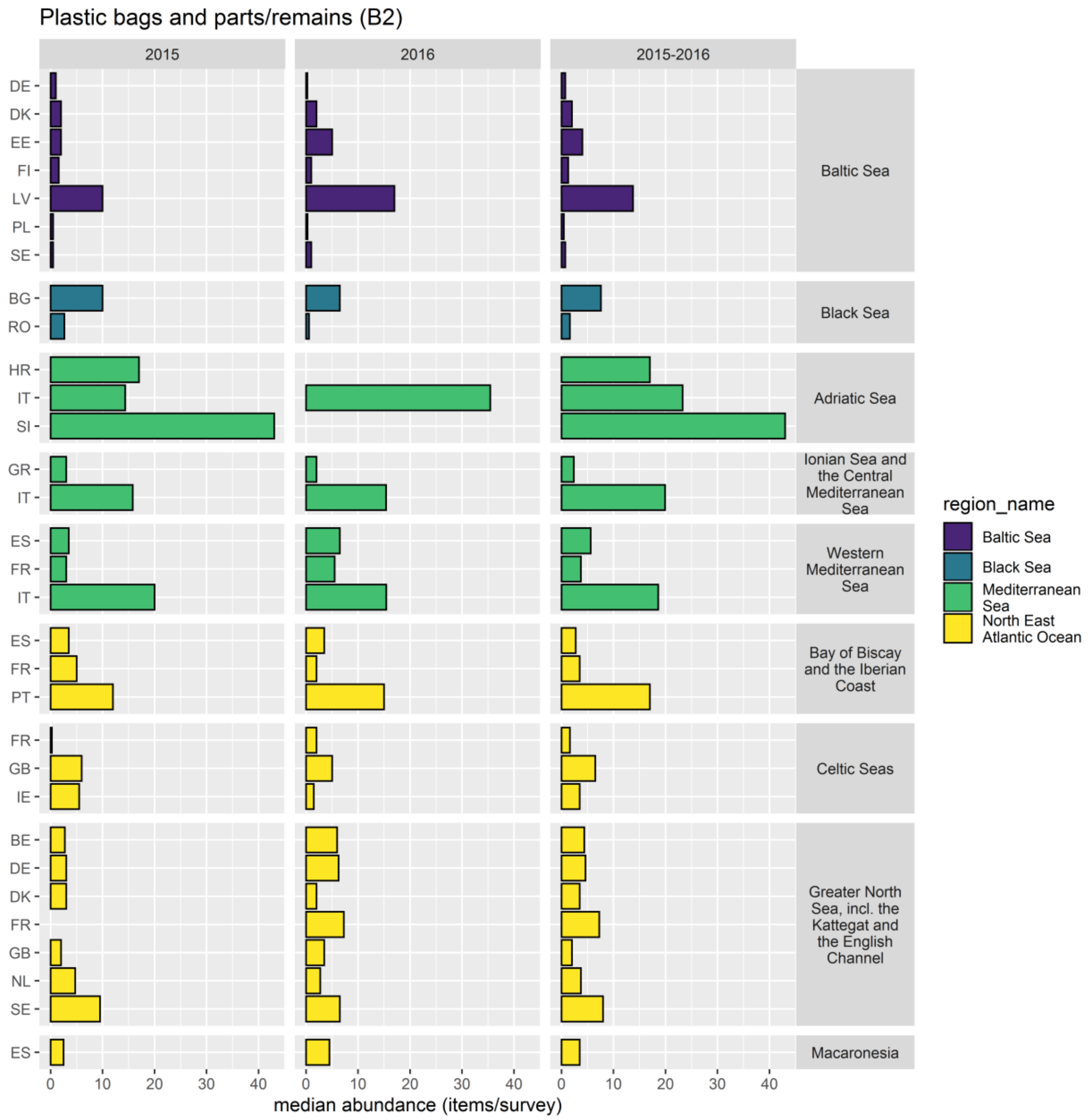

Figure 23: Abundance of litter category group – plastic bags and part/ remains (B2)

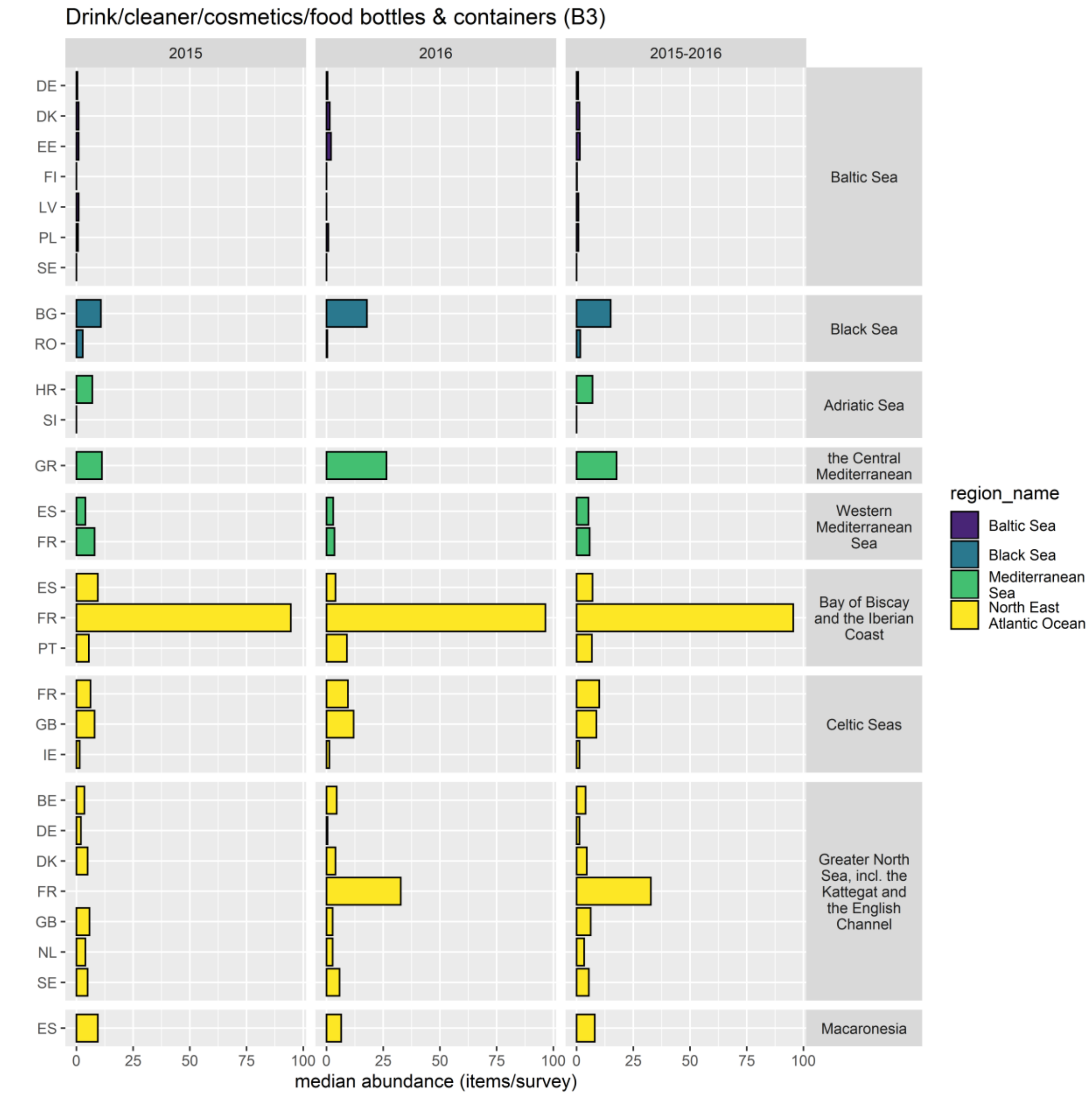

Figure 24: Country level litter category baselines – drink/cleaner/cosmetics/food bottles & containers (B3)

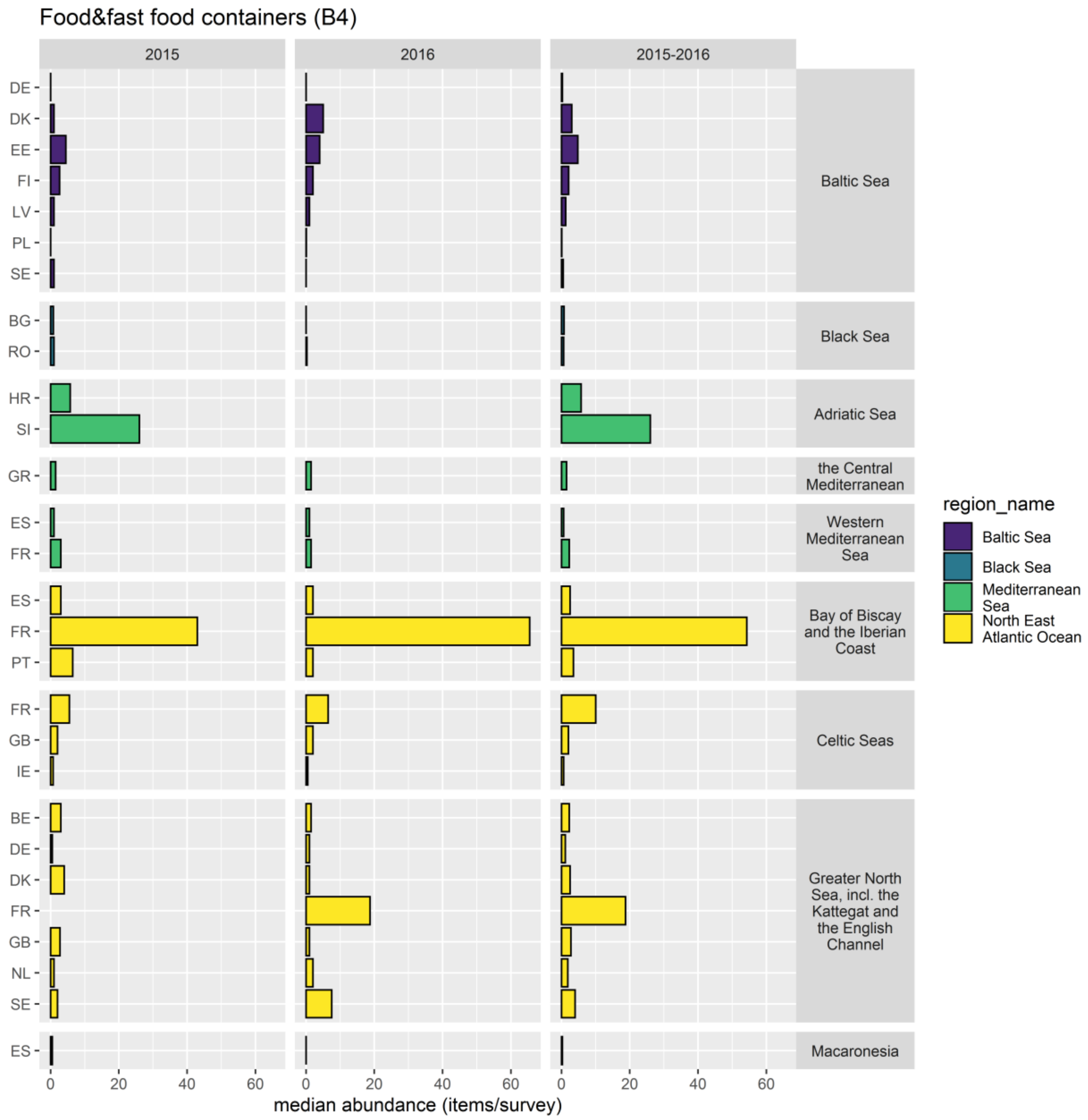

Figure 25: Country level litter category baselines – food & fast food containers (B4)

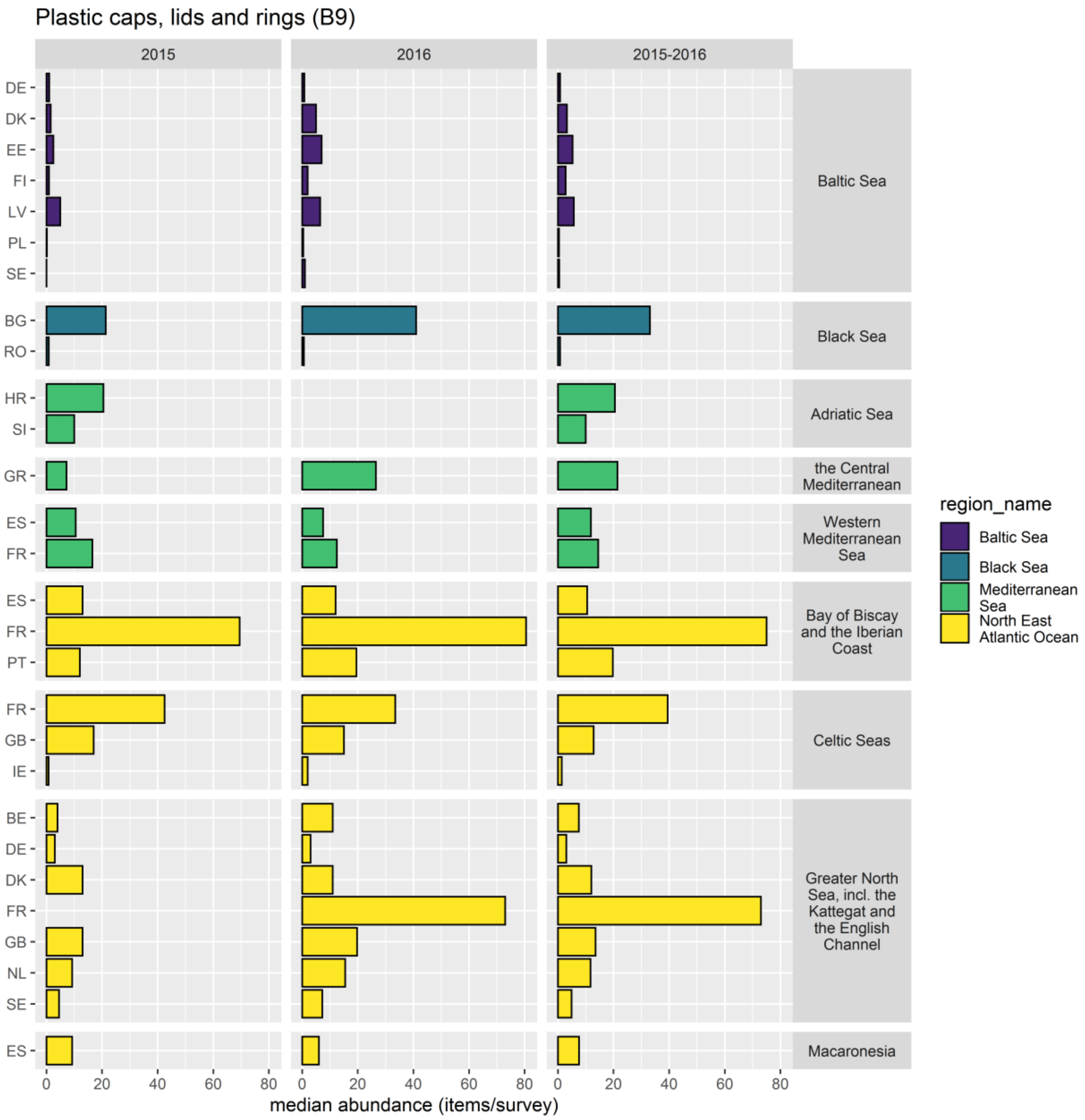

Figure 26: Country level litter category baselines – plastic caps, lids and rings (B9)

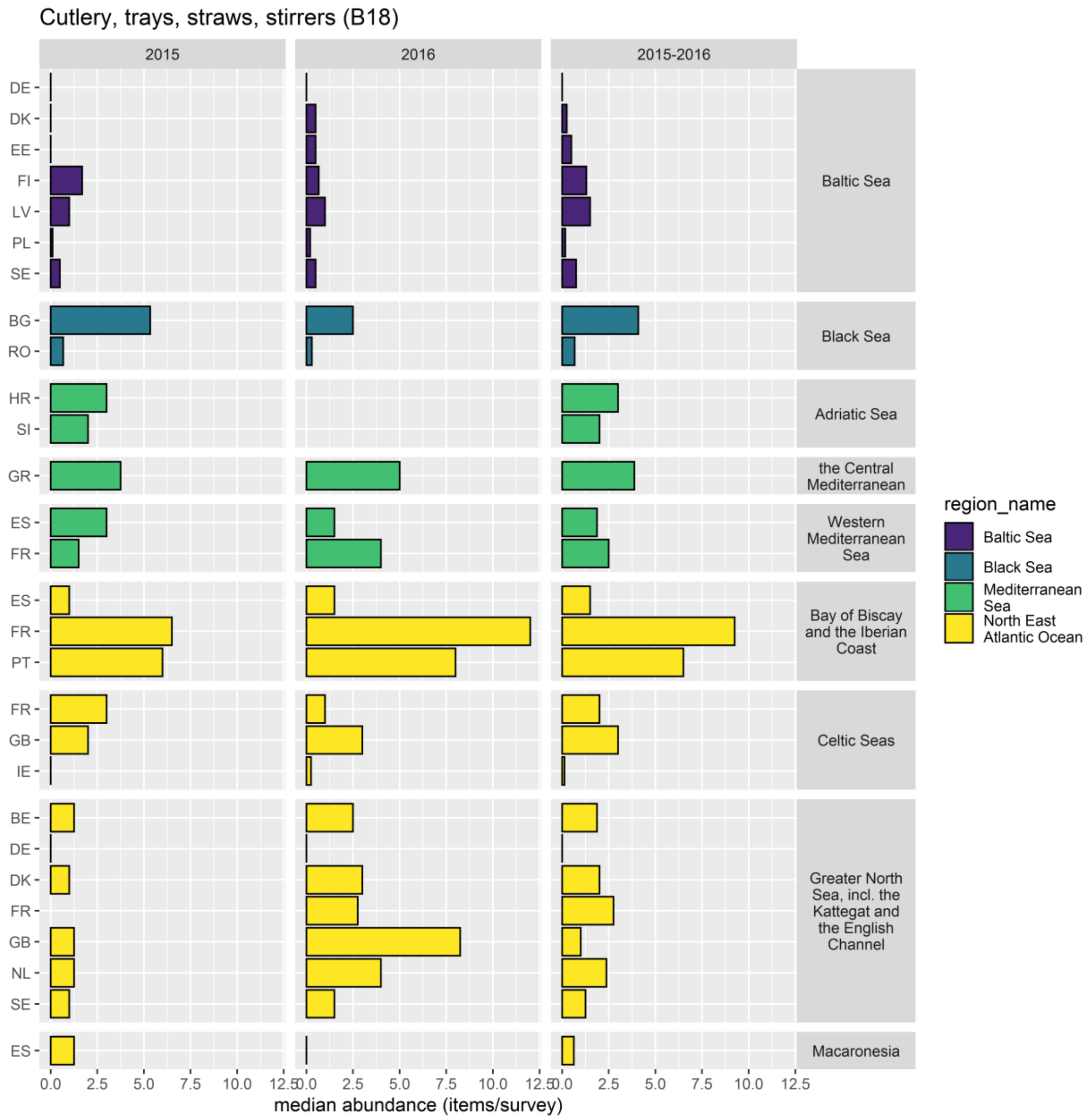

Figure 27: Country level litter category baselines – cutlery, trays, straws, stirrers (B18)

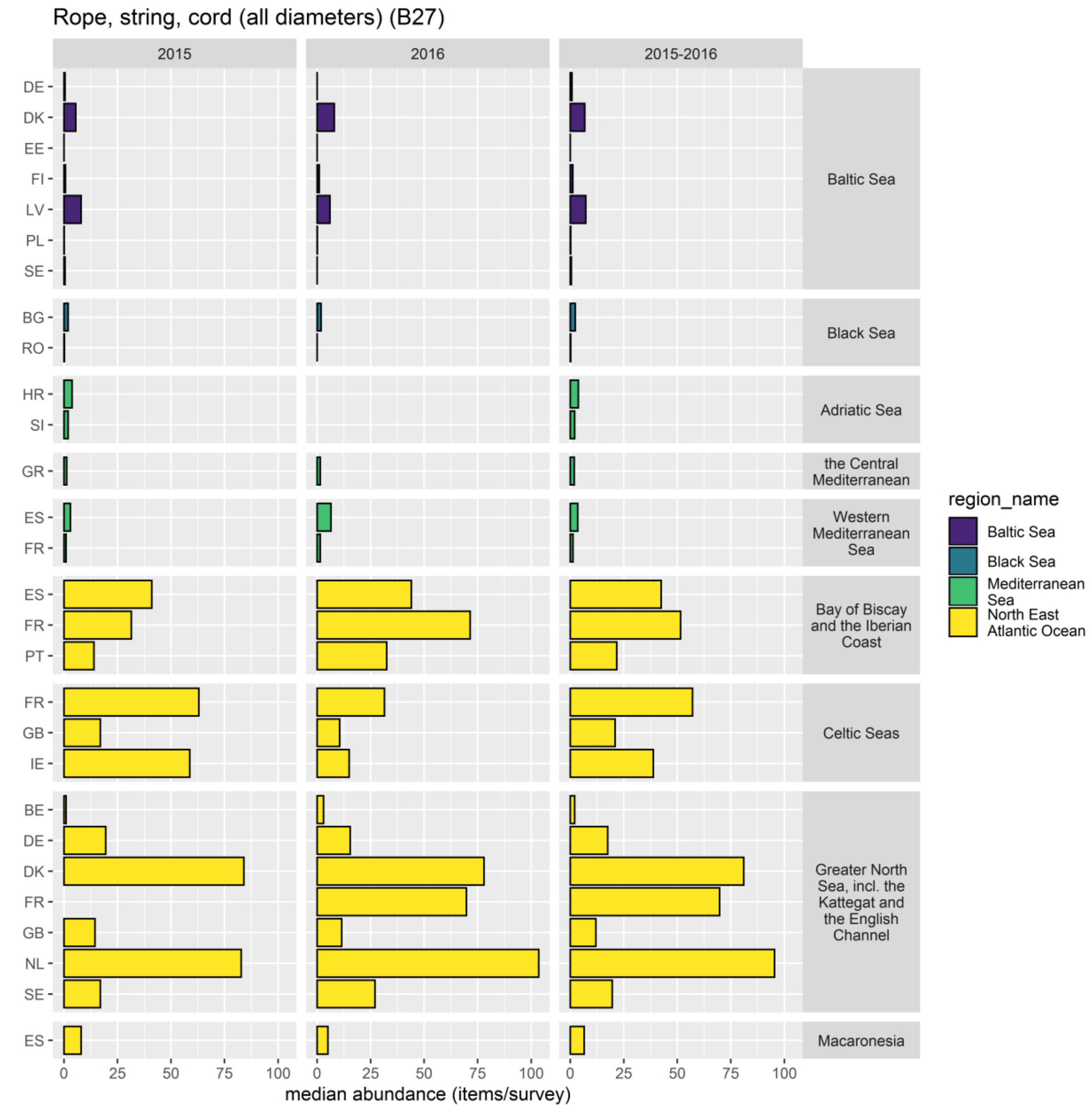

Figure 28: Country level litter category baselines – rope, string, cord (all diameters) (B27)

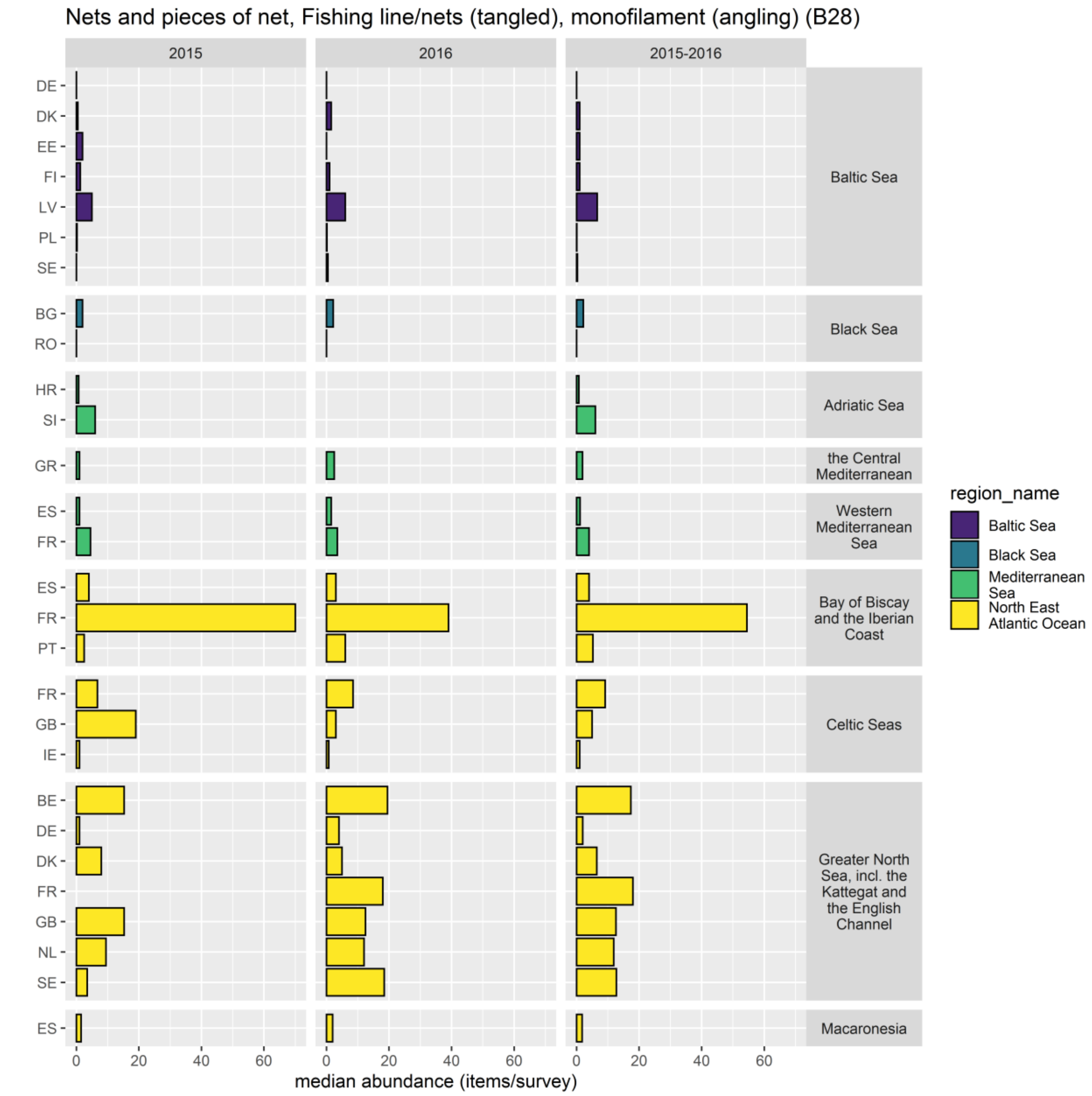

Figure 29: Country level litter category baselines – nets and pieces of nets, fishing line/nets (tangled), monofilament (angling) (B28)

8.2 Subregional level baselines

Designated subregions have been used to aggregate beach litter data (Figure 30, Figure 31, Figure 32, Figure 33, Figure 34, Figure 35, Figure 36, Figure 37, Table 13). Note that the Baltic Sea and the Black Sea do not have MSFD subregions.

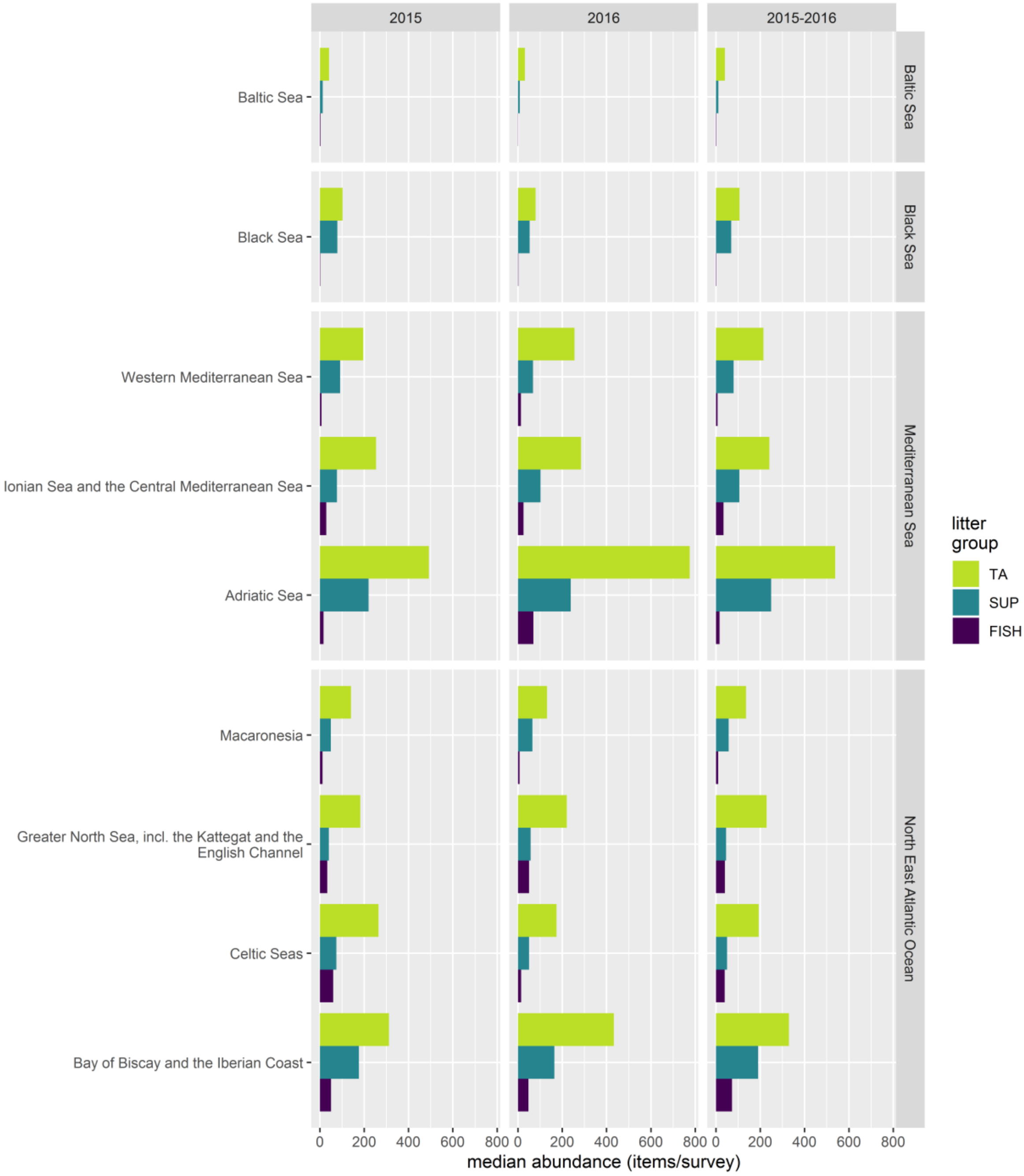

Figure 30: Abundance of litter category groups (SUP, FISH, TA) in subregions

Table 13: Litter groups SUP, FISH and TA in subregions across EU in 2015 + 2016 [items/100 m beach]

Year	Region	Subregion	SUP	FISH	TA
2015	Baltic Sea	Baltic Sea	12	4	42
2015	Black Sea	Black Sea	79	2	102
2015	Med Sea	Adriatic Sea	219	16	492
2015	Med Sea	Ionian Sea and the Central Med Sea	77	29	253

Year	Region	Subregion	SUP	FISH	TA
2015	Med Sea	Western Mediterranean Sea	92	8	196
2015	NEAO	Bay of Biscay and the Iberian Coast	176	50	312
2015	NEAO	Celtic Seas	74	60	264
2015	NEAO	Greater North Sea	40	34	183
2015	NEAO	Macaronesia	50	12	140
2016	Baltic Sea	Baltic Sea	8	2	32
2016	Black Sea	Black Sea	53	2	80
2016	Med Sea	Adriatic Sea	239	70	775
2016	Med Sea	Ionian Sea and the Central Med Sea	102	26	285
2016	Med Sea	Western Mediterranean Sea	68	14	255
2016	NEAO	Bay of Biscay and the Iberian Coast	164	48	432
2016	NEAO	Celtic Seas	50	15	174
2016	NEAO	Greater North Sea	58	50	221
2016	NEAO	Macaronesia	66	8	132
2015+16	Baltic Sea	Baltic Sea	11	2	40
2015+16	Black Sea	Black Sea	69	2	106
2015+16	Med Sea	Adriatic Sea	249	16	538
2015+16	Med Sea	Ionian Sea and the Central Med Sea	106	34	241
2015+16	Med Sea	Western Mediterranean Sea	80	8	214
2015+16	NEAO	Bay of Biscay and the Iberian Coast	190	72	330
2015+16	NEAO	Celtic Seas	50	39	193
2015+16	NEAO	Greater North Sea	46	40	229
2015+16	NEAO	Macaronesia	58	10	136

NEAO = North East Atlantic Ocean; Med Sea = Mediterranean Sea

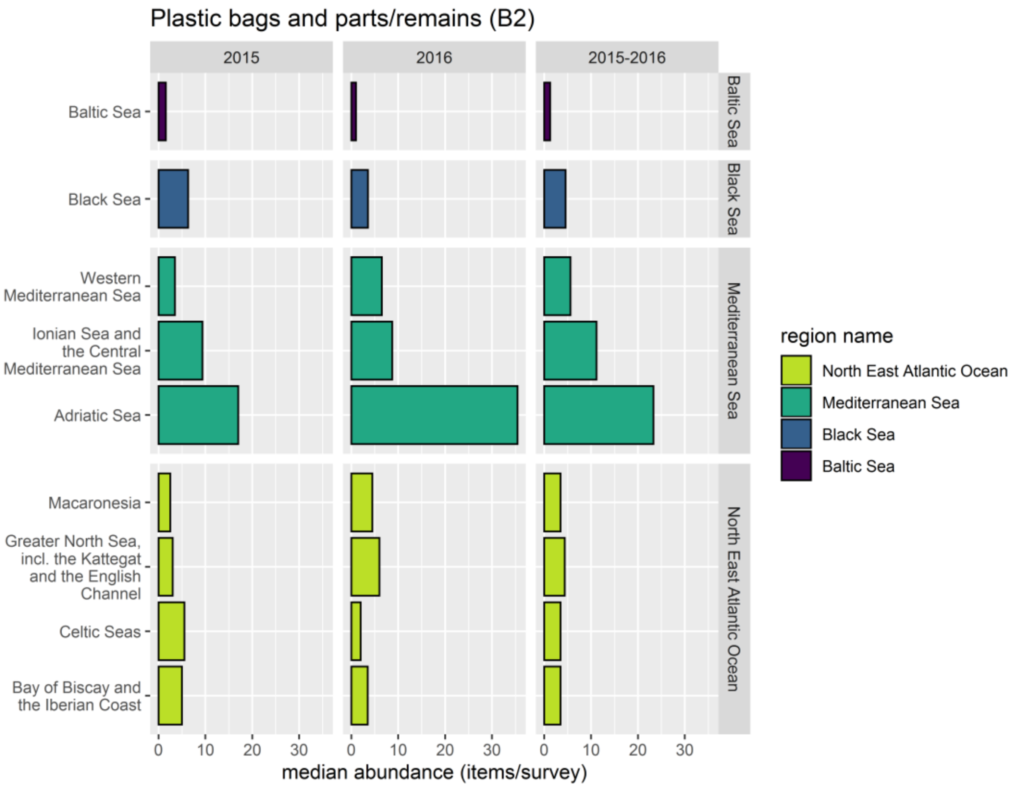

Figure 31: Subregional Litter Category baselines – plastic bags and parts/remains (B2)

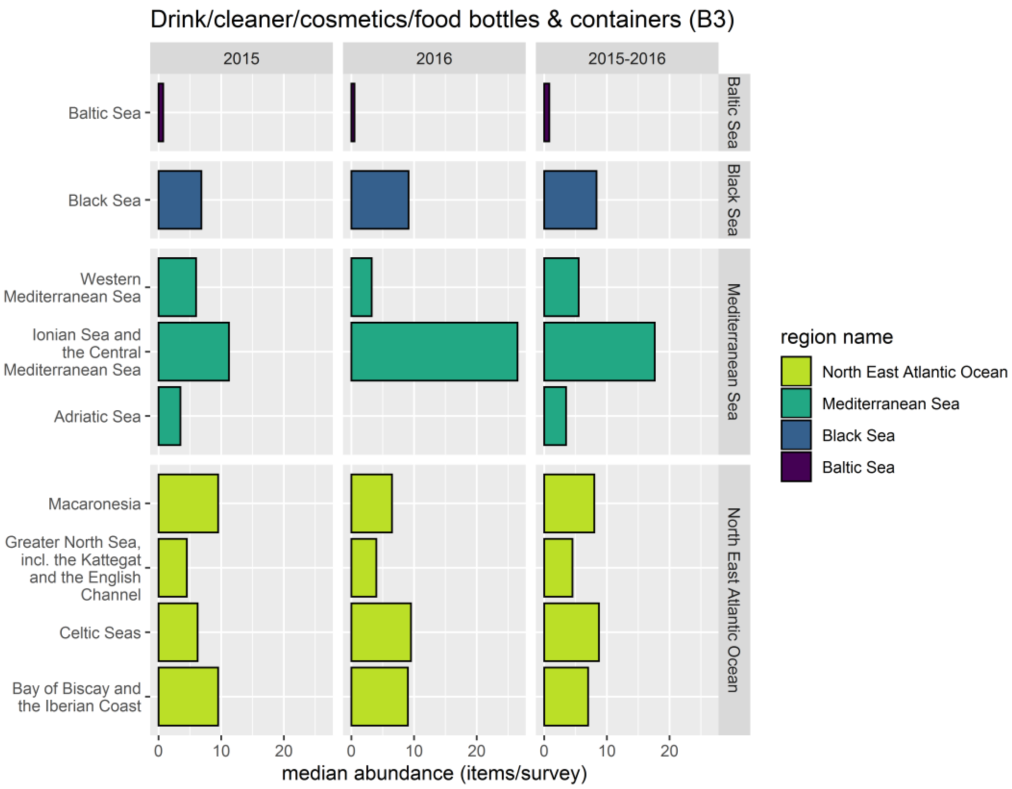

Figure 32: Subregional Litter Category baselines – drink/cleaner/cosmetics/food bottles & containers (B3)

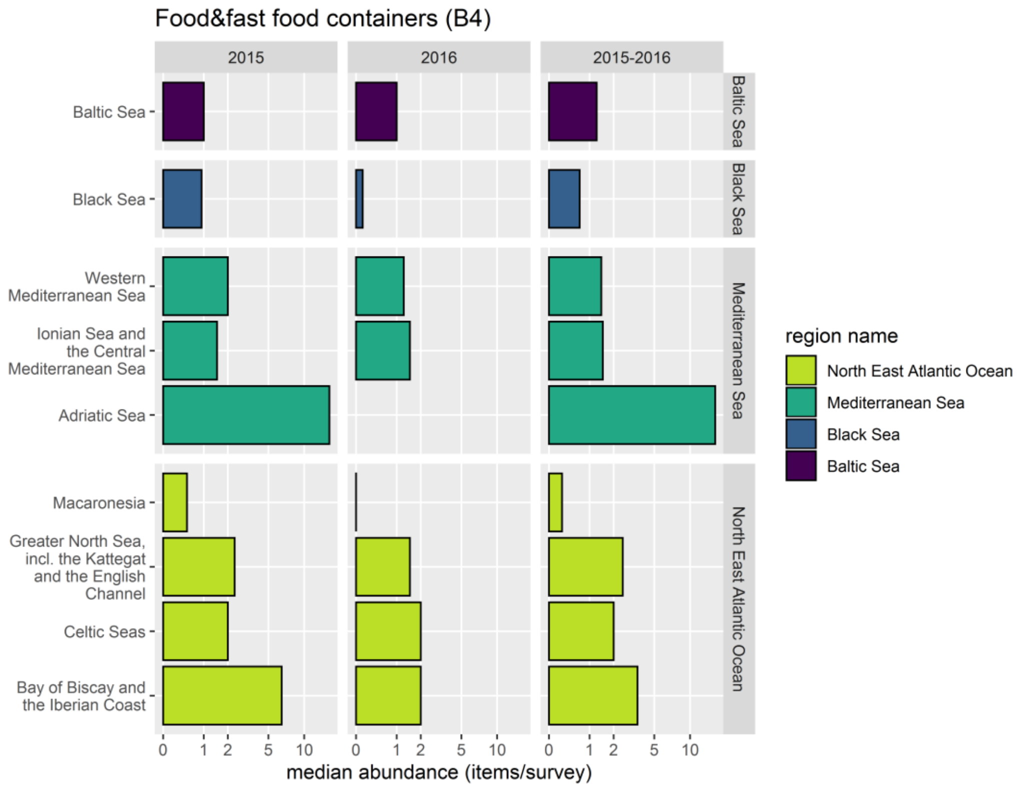

Figure 33: Subregional Litter Category baselines – food & fast food containers (B4)

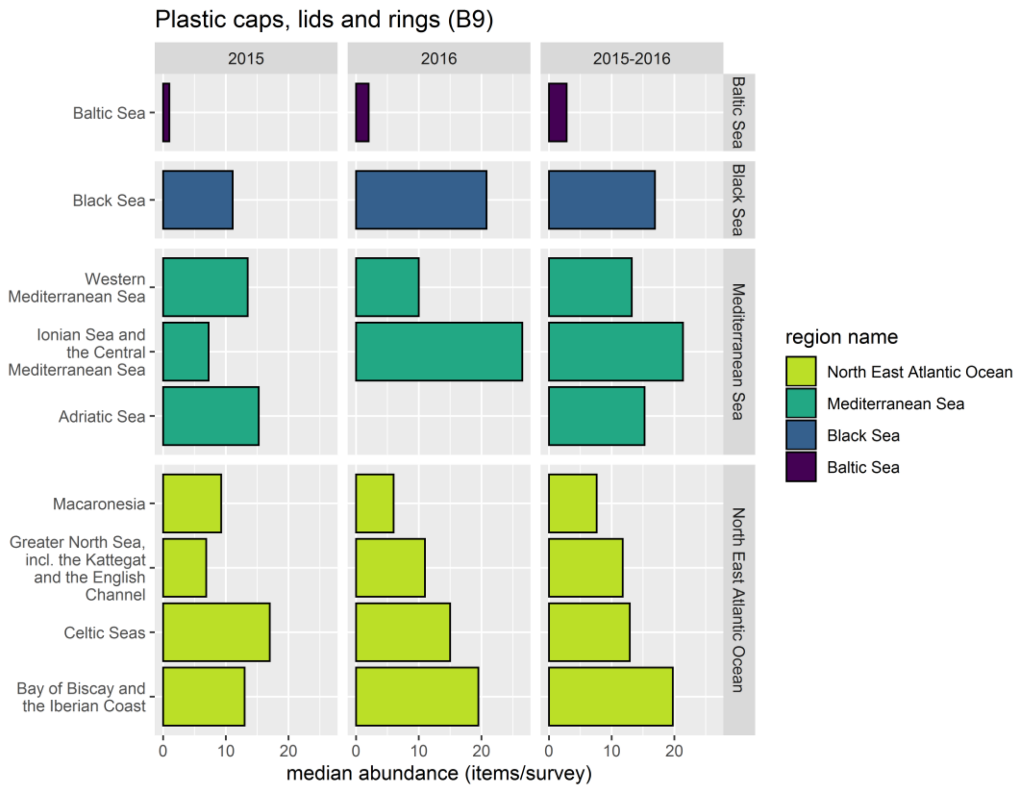

Figure 34: Subregional Litter Category baselines – plastic caps, lids and rings (B9)

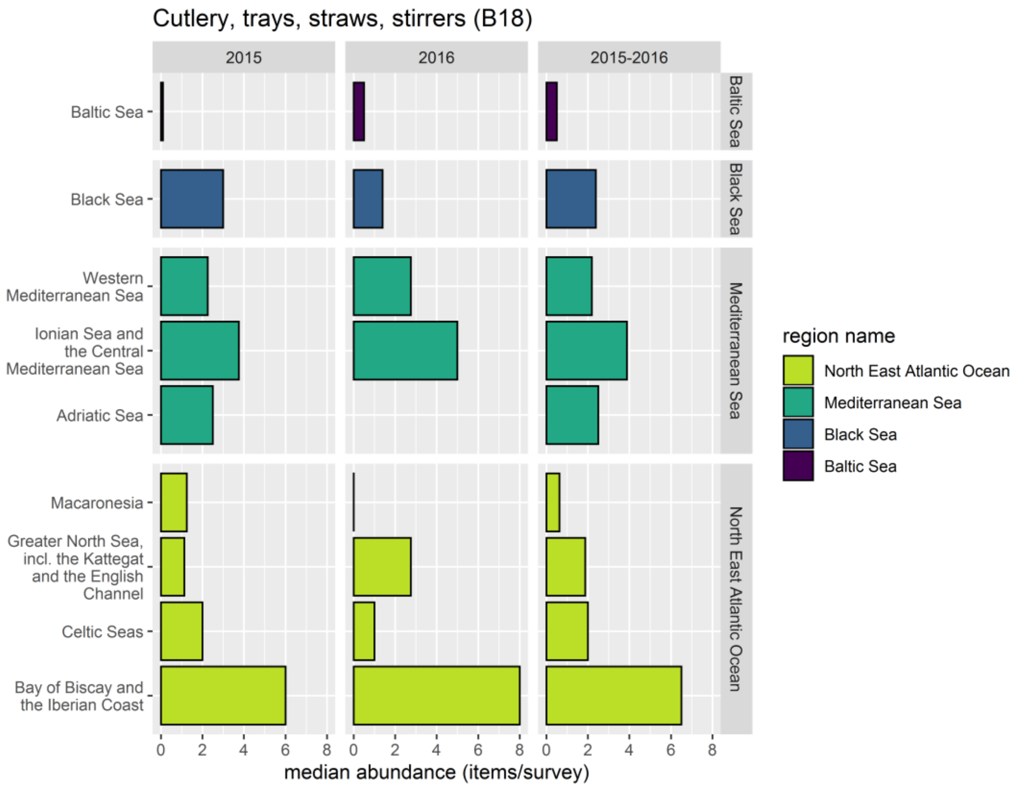

Figure 35: Subregional Litter Category baselines – cutlery, trays, straws, stirrers (B18)

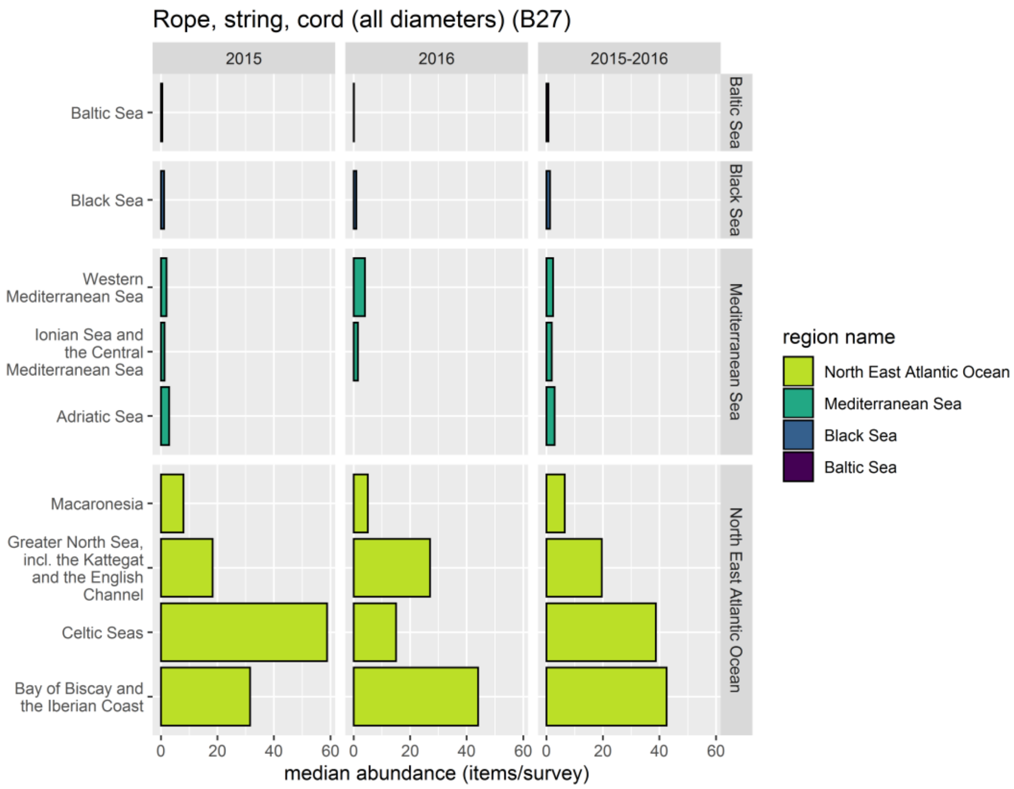

Figure 36: Subregional Litter Category baselines – rope, string, cords (all diameters) (B27)

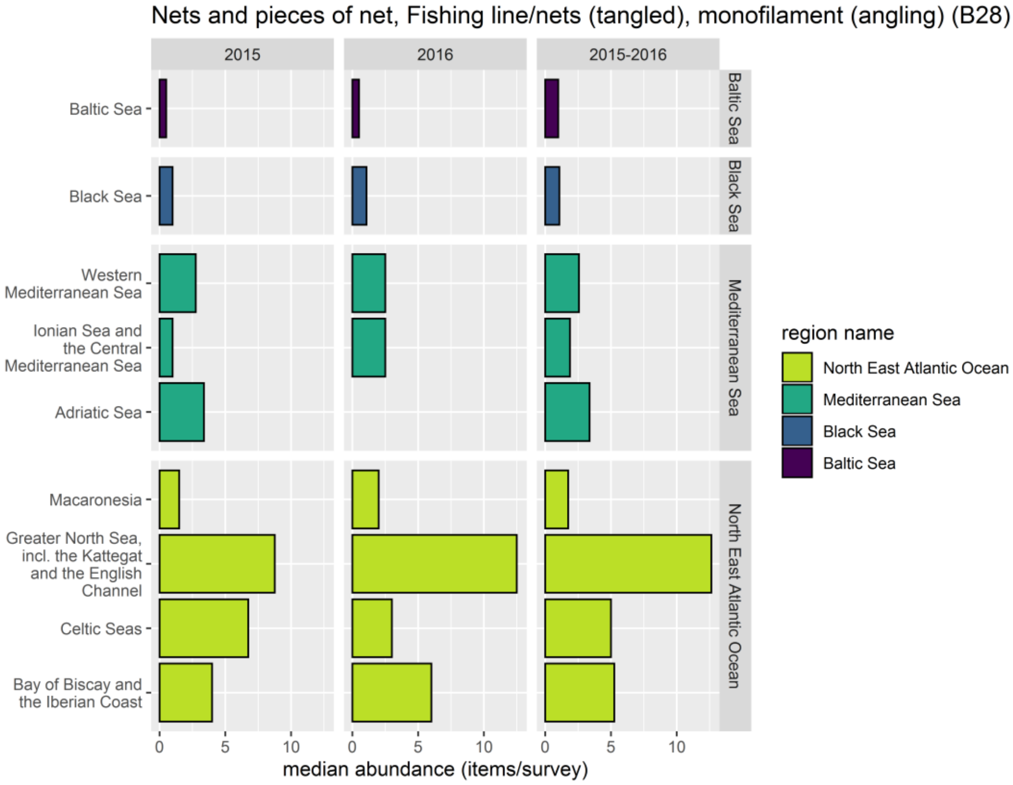

Figure 37: Subregional Litter Category baselines – nets & pieces of nets, fishing line/nets (tangled), monofilament (angling) (B28)

8.3 Regional level baselines

Data have been aggregated to the level of the four Regional Seas that include EU waters.

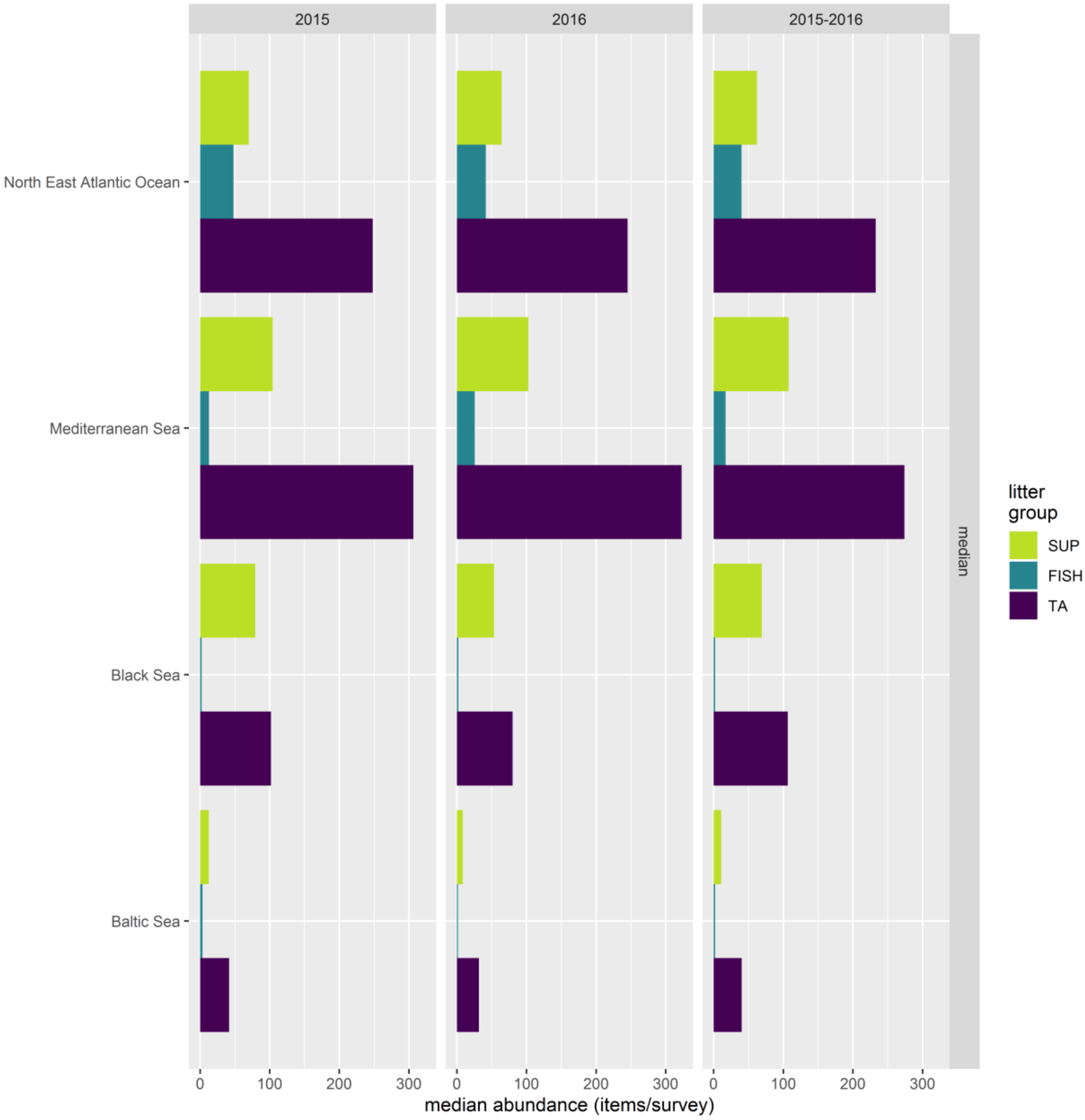

Figure 38: Abundance of litter category groups (SUP/FISH/TA) as median at regional seas level

Table 14: **Litter groups SUP, FISH and TA in regions across EU in 2015 + 2016 [items/100 m beach], n= number of surveys**

Year	Region	n	SUP	FISH	TA
2015	Baltic Sea	254	12	4	42
2015	Black Sea	31	79	2	102
2015	Mediterranean Sea	149	104	13	306
2015	North East Atlantic Ocean	261	70	48	248
2016	Baltic Sea	244	8	2	32
2016	Black Sea	10	53	2	80
2016	Mediterranean Sea	197	102	26	323
2016	North East Atlantic Ocean	324	64	42	245
2015-2016	Baltic Sea	498	11	2	40
2015-2016	Black Sea	41	69	2	106
2015-2016	Mediterranean Sea	346	108	17	274
2015-2016	North East Atlantic Ocean	585	62	40	233

Figure 39: Regional level categories

8.4 EU level baselines

Aggregation at EU level provides single numbers for each year (and the combined 2015 + 2016 dataset) (Figure 40, Table 15).

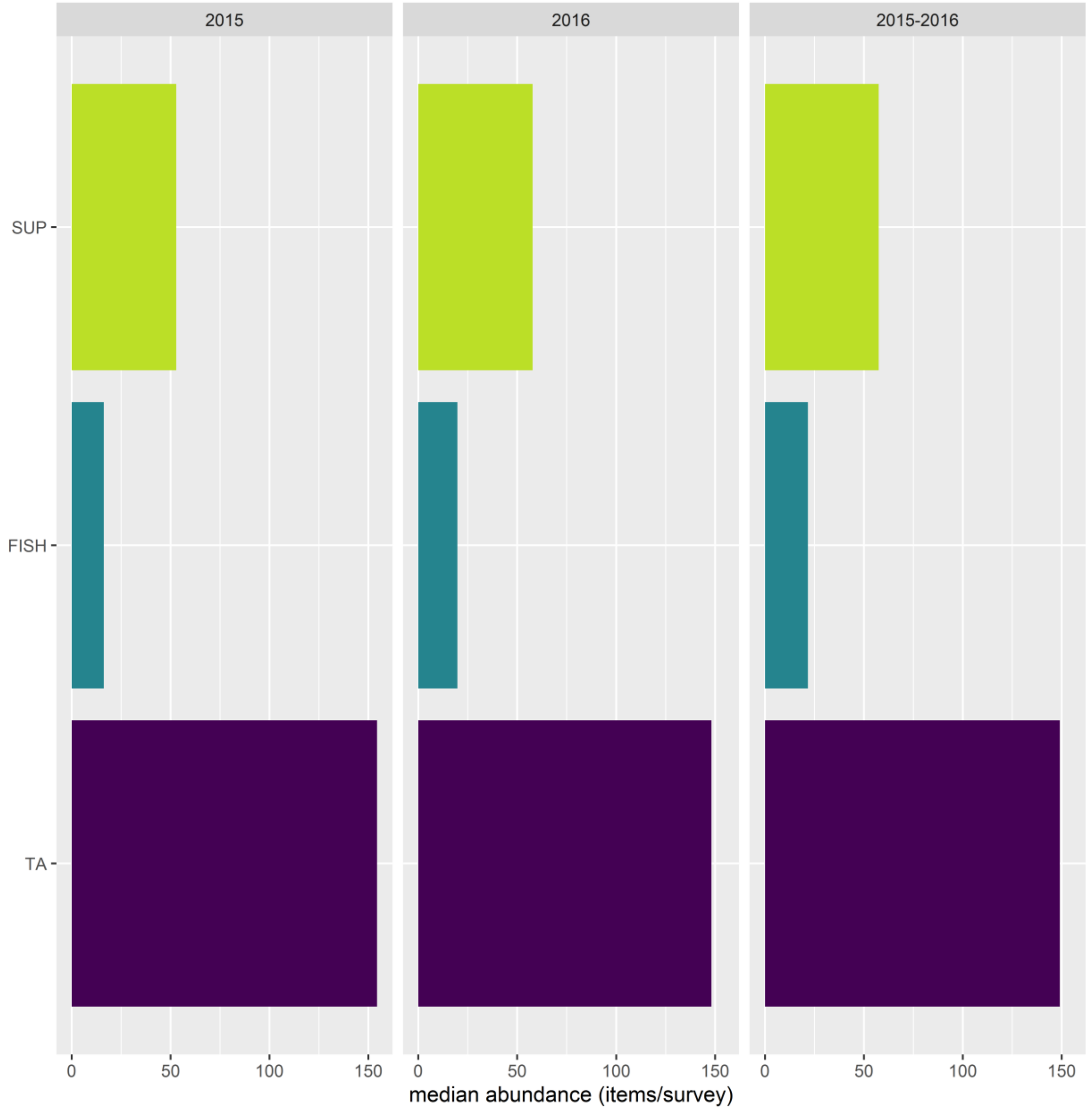

Figure 40: Litter abundance SUP, FISH, TA median across EU in 2015, 2016 and 2015 + 2016

Table 15: Median litter abundance in EU for SUP, FISH, TA as items/100 m

Year	SUP	FISH	TA
2015	53	16	154
2016	58	20	148
2015-2016	58	22	149

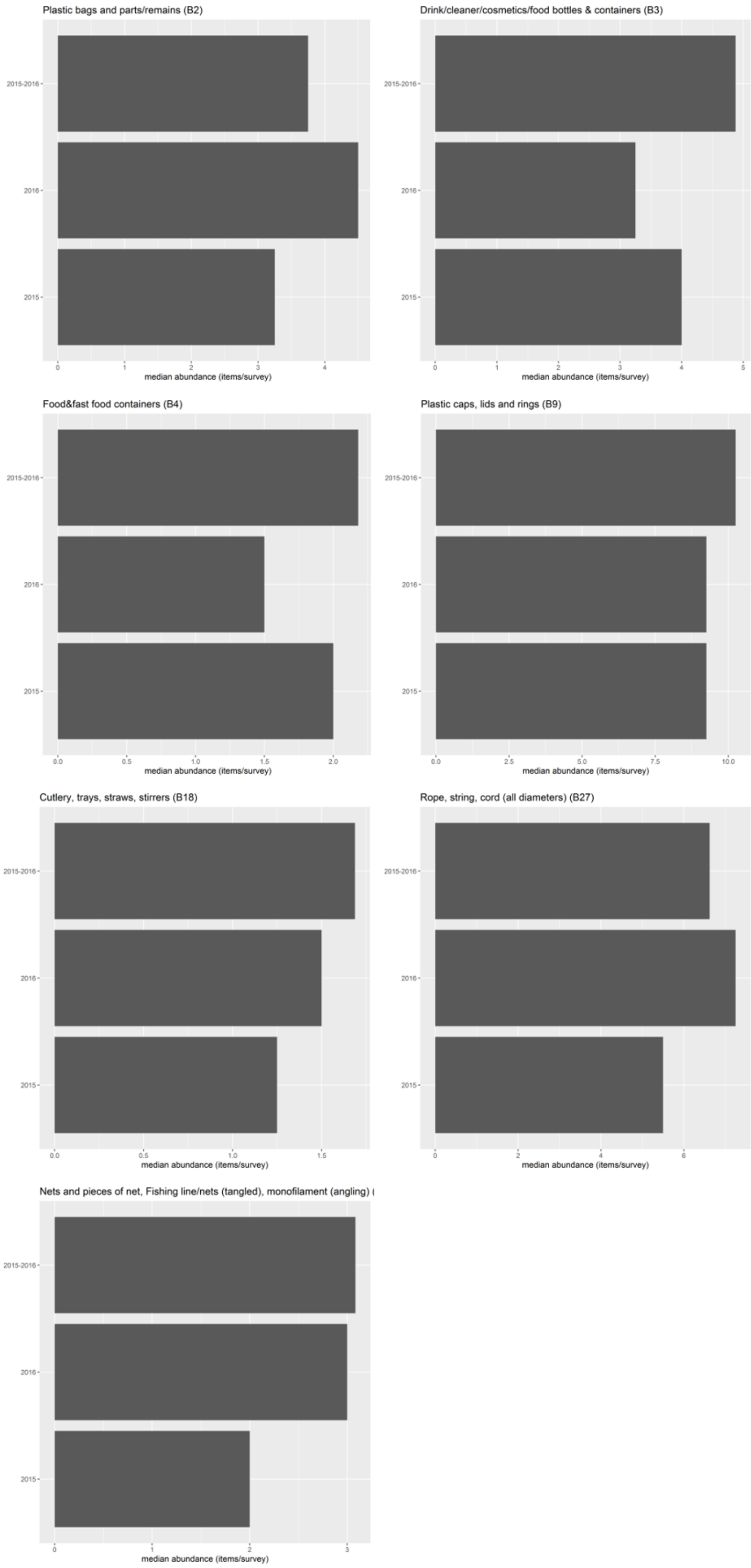

Figure 41: EU level single categories (Italy only included for plastic bags)

9 Conclusions

9.1 Beach Litter Baselines

This first-time analysis of a harmonised EU beach litter dataset allows numerous conclusions. These apply to the process and methodology for monitoring and baseline setting, the outcome from the scenario analysis based on the selection of parameters, i.e. the agreed baseline and the policy implications of the baselines. These implications include the selection and prioritisation of measures, the setting of thresholds and the evaluation of the success of implemented measures.

- Data availability 2012-2016 allows the consideration of all EU regions, though with different coverage. All subregions, except for the Eastern Mediterranean Sea, can be evaluated.
- Litter aggregate groups can be analysed across Europe.
- Litter category analyses are possible from single beaches at different data aggregation levels (depending on the comparability of litter categories between surveys)

The beach litter data analysis provides input for different issues that are currently being developed. Here the main issues are being compiled for consideration in the discussion processes.

9.2 Monitoring guidance

The in-depth analysis of this complete dataset has highlighted numerous issues in relation to monitoring of beach litter, a non-exhaustive list being presented here:

- The need to harmonise beach survey length in order to enable comparable sampling detail and effort.
- The need to use an agreed list of well-described litter categories for monitoring (i.e. to implement the currently developed Joint List of Litter Categories). The litter category list should be detailed enough to allow the use of data for policy purposes, i.e. it should enable information on single litter categories.
- The potential of monitoring tools (as the EEA MarineLitterWatch) for the facilitated acquisition of harmonised data.
- Beach litter data are an indicator for local littering as well as beached litter from the sea. It might be useful to investigate (as e.g. done in Italy) the origin of the beach litter in more detailed studies. This does not necessarily need to be part of routine monitoring but could also be done in large-scale collaborative projects.
- As plastic fragments provide little information for the management of litter, additional studies on the polymer composition, e.g. by adding in-situ analysis of litter material during surveys, might provide information of value for the development of measures.
- There is much interest in estimating absolute amounts of litter in different environmental compartments. The introduction of a litter size parameter, e.g. through reporting size classes, might be useful to better quantify litter fragments (2.5-50 cm), as weight is not recorded during surveys.
- The monitoring of meso litter requires specific monitoring, this should be implemented in order to understand litter degradation on beaches.
- While cigarette filters/butts appear to be very abundant in some areas, monitoring is not yet comparable. There should be harmonisation regarding the litter category (filters versus paper/tobacco butts), size category (macro or meso) and survey length (10 or 100 m) scope of monitoring. Cigarette butts are an important contributor to beach litter and should be quantified.
- Training and capacity building for litter monitoring is essential to provide quality data.

These considerations are proposed for use in the updating of ML monitoring guidance.

9.3 Threshold setting

- Results from the beach litter baseline study show that amounts of litter on many beaches are unacceptably high and this is the basis of the public interest and the political pressure to reduce ML, which are highlighted to ongoing policy action in the Circular Economy context.
- The correct quantitative assessment of litter and the setting of threshold values that provide the motivation for drastic reductions are important and closely related measures for ML reduction. The beach litter baseline scenario study confirms that a percentual reduction, even if ambitious, may not be enough to achieve the ultimate goal of decently clean beaches and significant reduction of litter input into the seas.
- Calculation methods for beach litter baselines should be closely related to the setting of thresholds. Unless there are no significant reasons for deviation, baselines, trends and thresholds should follow the same basic monitoring and data treatment.

These considerations have been considered in the discussions on beach litter threshold setting through the TG ML Threshold discussion document and Beach Litter Threshold proposal document (Van Loon et al. 2020).

9.4 Policy implications

The analysis of beach litter baselines across Europe has been driven through the MSFD implementation process. Monitoring provisions of the MSFD are closely related to the development of measures, the EU Plastics Strategy, Port Reception Policy, Waste Management Policy, the neighbourhood policy and others. The baseline study has therefore implications for different EU policy aspects that should be mentioned here:

- The ranking of the most abundant litter items, the Top Litter Item ranking, which has been the basis for the development of EU legislation, can be reviewed over time, updating priority needs.
- There is need for further continuation of data acquisition and compilation efforts in order to allow for trend analysis aiming at the evaluation of measures' effectiveness. EU MS have therefore agreed to provide 2017/2018 data through an ongoing process of litter data ingestion and analysis.
- Litter abundance is very high in many areas, including extreme hotspots. This requires urgent action, investigation and measures.
- As ML is a cross-boundary issue, beach litter can be transported to or from non-EU countries. It is therefore important to extend harmonised monitoring across different policy frameworks, in close collaboration with the RSCs. Also, the inclusion of the Arctic. Oceanographic modelling can provide an important tool in that context.
- Beaches are just one component of the marine environment. In terms of litter sinks on the seafloor, including the deep sea, beaches may well be regarded as "the tip of the iceberg". Therefore, quantitative assessments of other MSFD litter criteria should be further developed and implemented (floating/seafloor litter, micro-litter, litter impact criteria).
- The availability of quantitative information on single, well defined, litter categories enables the tackling of litter sources by specific measures.
- The reduction of macro litter, besides the direct avoidance of harm to wildlife and socioeconomic activities, is also important in order to reduce micro-litter, including microplastics, resulting from degradation.

9.5 Outlook

The EU Marine Litter Baseline exercise shows the possibility to derive quantitative evidence on marine pollution issues across Europe in a collaborative way. It indicates the urgent need for action and provides the possibility to analyse environmental pressures at different spatial scales, thus enabling the prioritisation of efforts and the evaluation of a successful implementation of measures.
While here applied in the context of the European MSFD, such an approach appears useful also beyond Europe, in collaboration with the neighbouring countries and policy frameworks, as well as on a global level.

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List of abbreviations and definitions

EU	European Union
EMODNET	European Marine Observation and Data Network
FISH	Fishery related litter types
GES	Good Environmental Status
HELCOM	Helsinki Convention for the Protection of the Baltic Sea
JRC	Joint Research Centre
ML	Marine Litter
MS	Member States
MSCG	Marine Strategy Coordination Group
MSFD	Marine Strategy Framework Directive
NGO	Non-Governmental Organization
TG ML	MSFD Technical Group on Marine Litter
OSPAR	Oslo Paris Convention for the Protection of the North Atlantic and North Sea
QA/QC	Quality Assurance/Quality Control
RSC	Regional Sea Convention
SUP	Single Use Plastic
TA	Total Abundance
UNEP	United Nations Environmental Program

Annexes

Annex 1. Mapping of litter categories

Aggregated codes for beach litter data analysis, derived from combination of different litter category lists. Attribution to litter category groups has been made for Total Abundance **TA**, Single Use Plastic **SUP**, Fishery related litter types **FISH** and plastic bags **BAG**. Due to a non-compatibility of lists, Italian categories could not be mapped consistently and are presented separately.

Code	Aggregated_name	TA	SUP	FISH	BAG	Combined category codes
B1	4/6-pack yokes, six-pack rings	X	X	-	-	1+G1+PL05
B2	Plastic bags and parts/remains	X	X	-	X	2+3+112+G2+G3+G4+G5+PL07
B3	Drink/cleaner/cosmetics/food bottles & containers	X	X	-	-	4+5+7+12+G6+G7+G8+G9+G11+G12+G13+PL02
B4	Food & fast food containers	X	X	-	-	6+G10+PL06
B5	Engine oil bottles & containers, Buckets, Jerry cans	X	-	-	-	8+9+10+38+G14+G15+G16+G65+PL03
B6	Injection gun containers	X	-	-	-	11+G17
B7	Crates, trays, containers/baskets	X	-	-	-	13+G18+PL13
B8	Car parts	X	-	-	-	14+G19
B9	Plastic caps, lids and rings	X	X	-	-	15+G20+G21+G22+G23+G24+PL01
B10	Tobacco pouches / cigarette box packaging	X	-	-	-	G25
B11	Cigarette lighters	X	-	-	-	16+G26+PL10
B12	Cigarettes, butts and filters	X	X	-	-	64+G27+PL11
B13	Pens and pen lids	X	-	-	-	17+G28

Code	Aggregated_name	TA	SUP	FISH	BAG	Combined category codes
B14	Combs/hairbrushes/sunglasses	X	-	-	-	18+G29
B15	Crisps packets, sweets wrappers, lolly sticks	X	X	-	-	19+G30+G31
B16	Toys and party poppers	X	-	-	-	20+G32+PL08
B17	Cups and cup lids	X	X	-	-	21+FP02+G33
B18	Cutlery, trays, straws, stirrers	X	X	-	-	22+G34+G35+PL04
B19	Fertiliser/animal feed bags	X	-	-	-	23+G36
B20	Mesh vegetable bags	X	-	-	-	24+G37+PL15
B21	Gloves (washing up)	X	-	-	-	25+G39+G40+PL09
B22	Gloves (industrial/professional, rubber)	X	-	-	-	113+G41+RB03
B23	Fish boxes (plastic & expanded polystyrene), octopus & crab/lobster pots/tops, light sticks	X	-	X	-	26+27+34+36+71+95+119+G42+G44+G57+G58+G60+G163+G164+G207+PL17+WD02
B24	Tags (fishing and industry)	X	-	X	-	114+G43
B25	Mussel nets, Oyster nets, Oyster trays, Tahitians	X	-	X	-	28+29+G45+G46
B26	Plastic sheeting from mussel culture (Tahitians)	X	-	X	-	30+G47
B27	Rope, string, cord (all diameters)	X	-	X	-	31+32+200+201+G48+G49+G50+PL19
B28	Nets and pieces of net, Fishing line/nets (tangled), monofilament (angling)	X	-	X	-	33+35+115+116+CL04+FP04+G51+G52+G53+G54+G55+G56+G59+G142+PL18+PL20
B29	Other fishing related	X	-	X	-	G61

Code	Aggregated_name	TA	SUP	FISH	BAG	Combined category codes
B30	Buoys & floats for fishing nets	X	-	X	-	37+FP03+G62+G63+G64+PL14
B31	Strapping bands	X	-	-	-	39+G66+PL21
B32	Sheets, industrial packaging, plastic sheeting	X	-	-	-	40+G38+G67+PL16
B33	Fibre glass/fragments	X	-	-	-	41+G68+PL22
B34	Hard hats/Helmets	X	-	-	-	42+G69
B35	Shotgun cartridges	X	-	-	-	43+G70
B36	Clothing, shoes and sandals, hats & towels	X	-	-	-	44+54+57+CL01+G71+G135+G136+G137+G138
B37	Traffic cones	X	-	-	-	G72
B38	Foam sponge/packaging/insulation/polyurethane	X	-	-	-	45+FP01+G73+G74
B41	Plastic/polystyrene pieces 2.5 cm > < 50cm	X	-	-	-	46+G76
B42	Plastic/polystyrene pieces > 50 cm	X	-	-	-	47+G77
B49	CD, CD-box	X	-	-	-	G84
B50	Salt packaging	X	-	-	-	G85
B51	Fin trees (from fins for scuba diving)	X	-	-	-	G86
B52	Masking tape	X	-	-	-	G87
B53	Telephone (incl. parts)	X	-	-	-	G88
B54	Plastic construction waste	X	-	-	-	G89

Code	Aggregated_name	TA	SUP	FISH	BAG	Combined category codes
B55	Plastic flowerpots	X	-	-	-	G90
B56	Biomass holder from sewage treatment plants	X	-	-	-	G91
B57	Bait containers/packaging	X	-	X	-	G92
B58	Cable ties	X	-	-	-	G93
B59	Tablecloth	X	-	-	-	G94
B60	Sanitary (nappies, cotton buds, tampon applicators, toothbrushes)	X	X	-	-	98+99+100+101+G95+G96+G97+G98+G144+OT02
B61	Syringes/needles	X	-	-	-	104+G99+PL12
B62	Medical/Pharmaceuticals containers/tubes	X	-	-	-	103+G100
B63	Dog faeces bag	X	-	-	-	121+G101
B64	Flip-flops	X	-	-	-	G102+RB02
B65	Other plastic/polystyrene items (identifiable)	X	-	-	-	48+G103+G124+PL24
B66	Balls, balloons, balloon sticks	X	X	-	-	49+G125+G126+RB01
B67	Rubber boots	X	-	-	-	50+G127
B68	Wheels, tyres and belts	X	-	-	-	52+G128+G130+RB04
B69	Inner-tubes and rubber sheet	X	-	-	-	G129+RB05
B71	Rubber bands (small, for kitchen/household/post use)	X	-	-	-	G131+RB06
B72	Bobbins (fishing)	X	-	-	-	G132

Code	Aggregated_name	TA	SUP	FISH	BAG	Combined category codes
B73	Condoms (incl. packaging)	X	-	-	-	97+G133+RB07
B74	Other rubber pieces	X	-	-	-	53+G134+RB08
B75	Backpacks & bags	X	-	-	-	CL02+G139
B76	Sails & canvas, Sacking (hessian)	X	-	-	-	56+CL03+G140+G143
B77	Carpet & Furnishing	X	-	-	-	55+CL05+G141
B79	Other textiles (incl. rags)	X	-	-	-	59+210+CL06+G145
B80	Paper bags	X	-	-	-	60+G147
B81	Paper and Cardboard pieces	X	-	-	-	61+G146+G148+G156+G157+PC02
B82	Cups, food trays, food wrappers, cigarette packs, drink containers, Tetrapack	X	-	-	-	62+63+65+118+204+G149+G150+G151+G152+ G153+PC03
B83	Newspapers & magazines	X	-	-	-	66+G154+PC01
B84	Tubes for fireworks	X	-	-	-	G155+PC04
B86	Other paper items	X	-	-	-	67+G158+PC05
B87	Corks	X	-	-	-	68+G159+WD01
B88	Pallets, Crates and Processed timber	X	-	-	-	69+70+G160+G161+G162+WD04
B91	Ice-cream sticks, chip forks, chopsticks, toothpicks	X	-	-	-	72+G165+WD03
B92	Paint brushes	X	-	-	-	73+G166
B93	Matches & fireworks	X	-	-	-	G167+WD05

Code	Aggregated_name	TA	SUP	FISH	BAG	Combined category codes
B94	Wood boards	X	-	-	-	G168
B95	Beams/Dunnage	X	-	-	-	G169
B96	Wood (processed)	X	-	-	-	G170
B97	Other wood (all length)	X	-	-	-	74+75+G171+G172+G173+WD06
B98	Aerosol/Spray cans industry	X	-	-	-	76+G174
B99	Cans (beverage)	X	-	-	-	78+G175+ME03
B100	Cans (food and other) < 4 L	X	-	-	-	82+G176+G188+ME04
B101	Foil wrappers, aluminium foil	X	-	-	-	81+G177+ME06
B102	Bottle caps, lids & pull tabs	X	-	-	-	77+G178+ME02
B103	Disposable BBQ's	X	-	-	-	120+G179+ME11
B104	Other metal pieces (all lengths)	X	-	-	-	79+83+89+90+G180+G186+G196+G197+G198 +G199+ME10
B105	Tableware (plates, cups & cutlery)	X	-	-	-	G181+G203+GC03+ME01
B106	Fishing related (weights, sinkers, lures, hooks, traps & pots) including remains	X	-	-	-	80+87+G182+G183+G184+ME07
B108	Household batteries	X	-	-	-	G195+OT04
B111	Bottles (glass) incl. pieces	X	-	-	-	91+G200+GC02
B113	Light bulbs and fluorescent light tubes	X	-	-	-	92+G202+G205+GC04+GC05

Code	Aggregated_name	TA	SUP	FISH	BAG	Combined category codes
B115	Construction material (brick, cement, pipes)	X	-	-	-	94+G204+GC01
B117	Glass buoys	X	-	-	-	G206+GC06
B119	Glass or ceramic fragments > 2.5 cm	X	-	-	-	96+G208+G209+GC07
B121	Other glass items	X	-	-	-	93+G210+GC08
B122	Other medical items (swabs, bandaging, adhesive plaster etc.)	X	-	-	-	105+G211+OT05
B123	Slack/Coal	X	-	-	-	G212
B127	other: various rubbish (worked wood, metal parts)	X	-	-	-	G216
B129	Gas bottles, oil drums & buckets (> 4 L), paint tins, barrels	X	-	-	-	84+86+205+206+G187+G189+G190+G192+ME 05
B130	Wire, wire mesh, barbed wire	X	-	-	-	88+G191+ME09
B131	Car parts/batteries	X	-	-	-	G193+OT03
B132	Cables	X	-	-	-	G194
B133	Other sanitary items	X	-	-	-	102
IT1	Envelopes, shoppers, garbage bags / small plastic bags, e.g., freezer bags / central part tear-off roll of plastic bags	X	X	-	X	
IT2	Bottles and containers of cosmetic products (sunscreens)/bottles and containers of detergents and detergents	X	-	-	-	

Code	Aggregated_name	TA	SUP	FISH	BAG	Combined category codes
IT3	Bottles and containers of engine oil	X	-	-	-	
IT4	Parts of cars and motorcycles	X	-	-	-	
IT5	Lighters	X	-	-	-	
IT6	Pens and/or pen lids	X	-	-	-	
IT7	Straws and stirrers (bars) / plastic cutlery / plates / plastic cups and crisp lids / bags, plastic sweets / rings of bottle caps / caps and lids / food containers (e.g. hamburgers) / beverage bottles and containers / packaging for cans of 4/6 rings / lolly sticks	X	X	-	-	
IT8	Gloves (industrial/professional rubber gloves) / household gloves	X	-	-	-	
IT9	Fenders / floats / buoys	X	-	-	-	
IT10	Plastic ties for gardening / nurseries / bands and plastic packaging bands	X	-	-	-	
IT11	Shoes / sandals / glasses / sunglasses / combs / hairbrushes	X	-	-	-	
IT12	Synthetic sponge / helmets / hardhat / glass fibres / industrial packaging, plastic sheeting / mesh bags for vegetables (e.g. potatoes, oranges) / fertilizer bags / animal feed	X	-	-	-	
IT13	CD / CD casing / luminous phosphorescent tubes (tubes with liquid) / toys or parts of them	X	-	-	-	

Code	Aggregated_name	TA	SUP	FISH	BAG	Combined category codes
IT14	Plastic jars / buckets / crates and baskets / jerrycans (plastic containers with handles)	X	-	-	-	
IT15	Boxes and boxes for fish in polystyrene	X	-	X	-	
IT16	Plastic containers for lures / fishing lines and fishing line in nylon (fishing) / plastic boxes and boxes for fish / nets and network pieces / ropes and tops	X	-	X	-	
IT17	Baskets for the cultivation of oysters / nets or bags for mussels or oysters (socks) / plastic plates used in aquaculture or fishing / lobster pots	X	-	X	-	
IT18	Other polystyrene objects	X	-	-	-	
IT19	Other plastic objects	X	-	-	-	
IT20	Inflatable balloons, including valves, ribbons, lanyards / balloons	X	X	-	-	
IT21	Rubber boots and overshoes	X	-	-	-	
IT22	Tires / inner tubes	X	-	-	-	
IT23	Rubber bands (domestic / postal use)	X	-	-	-	
IT24	Other pieces of rubber	X	-	-	-	
IT25	Upholstery / carpet / jute bags / canvas bags	X	-	-	-	
IT26	Backpacks and bags / shoes and sandals / clothing (clothing / hats / towel)	X	-	-	-	
IT27	Other textile products	X	-	-	-	

Code	Aggregated_name	TA	SUP	FISH	BAG	Combined category codes
IT28	Envelopes / paper bags	X	-	-	-	
IT29	Cartons / newspapers and magazines / fragments of paper	X	-	-	-	
IT30	Tetrapack containers / paper cups / cups, food trays	X	-	-	-	
IT31	Packets of cigarettes or parts	X	-	-	-	
IT32	Cigarette butts and filters	-	-	-	-	
IT33	Other paper articles	X	-	-	-	
IT34	Corks	X	-	-	-	
IT35	Boxes	X	-	-	-	
IT36	Ice-cream sticks	X	-	-	-	
IT37	Other worked / processed wood / pallets / manufactured goods	X	-	-	-	
IT38	Spray cans	X	-	-	-	
IT39	Bottle caps / lids / beverage cans / jars or food cans / Aluminium trays and paper (aluminium foil)	X	-	-	-	
IT40	Electrical appliances / appliances / car battery / motorcycle / truck / cables	X	-	-	-	
IT41	Leads / fishing weights / hooks	X	-	X	-	
IT42	Scrap / industrial waste	X	-	-	-	

Code	Aggregated_name	TA	SUP	FISH	BAG	Combined category codes
IT43	Drums, cylinders, barrels, drums, oil cans	X	-	-	-	
IT44	Paint bin, cans or tins	X	-	-	-	
IT45	Wire, wire mesh, barbed wire	X	-	-	-	
IT46	Household batteries	X	-	-	-	
IT47	Other pieces of metal	X	-	-	-	
IT48	Bottles / plates and cups / jars	X	-	-	-	
IT49	Fluorescent tubes light bulbs	X	-	-	-	
IT50	Construction material (debris, bricks)	X	-	-	-	
IT51	Other glass / ceramic items	X	-	-	-	
IT52	Condoms	X	-	-	-	
IT53	Cotton bud sticks	X	X	-	-	
IT54	Sanitary napkins slip / linings / support strips / diapers / tampons and tampon applicators	X	-	-	-	
IT55	Other sanitary items	X	-	-	-	
IT56	Medicinal containers / tubes / blisters	X	-	-	-	
IT57	Syringes / needles	X	-	-	-	
IT58	Other medical articles (tampons, bandages, etc.)	X	-	-	-	
IT59	Dog excrement in bag	X	X	-	-	

Annex 2 Spatial weighting methodology

It has been decided not to apply spatial weighting for this analysis of EU beach litter data to derive baselines, also the methodology has not been considered for such use. The annex here should only be regarded as input to potential future discussions on coastline-related issues.

Deriving the length of a coastline is not trivial, as it depends on the observation scale, due to the fractal dimension. Coastlines of fragmented coasts are much longer than straight coasts. Source of shapefile data: ECOSTAT.

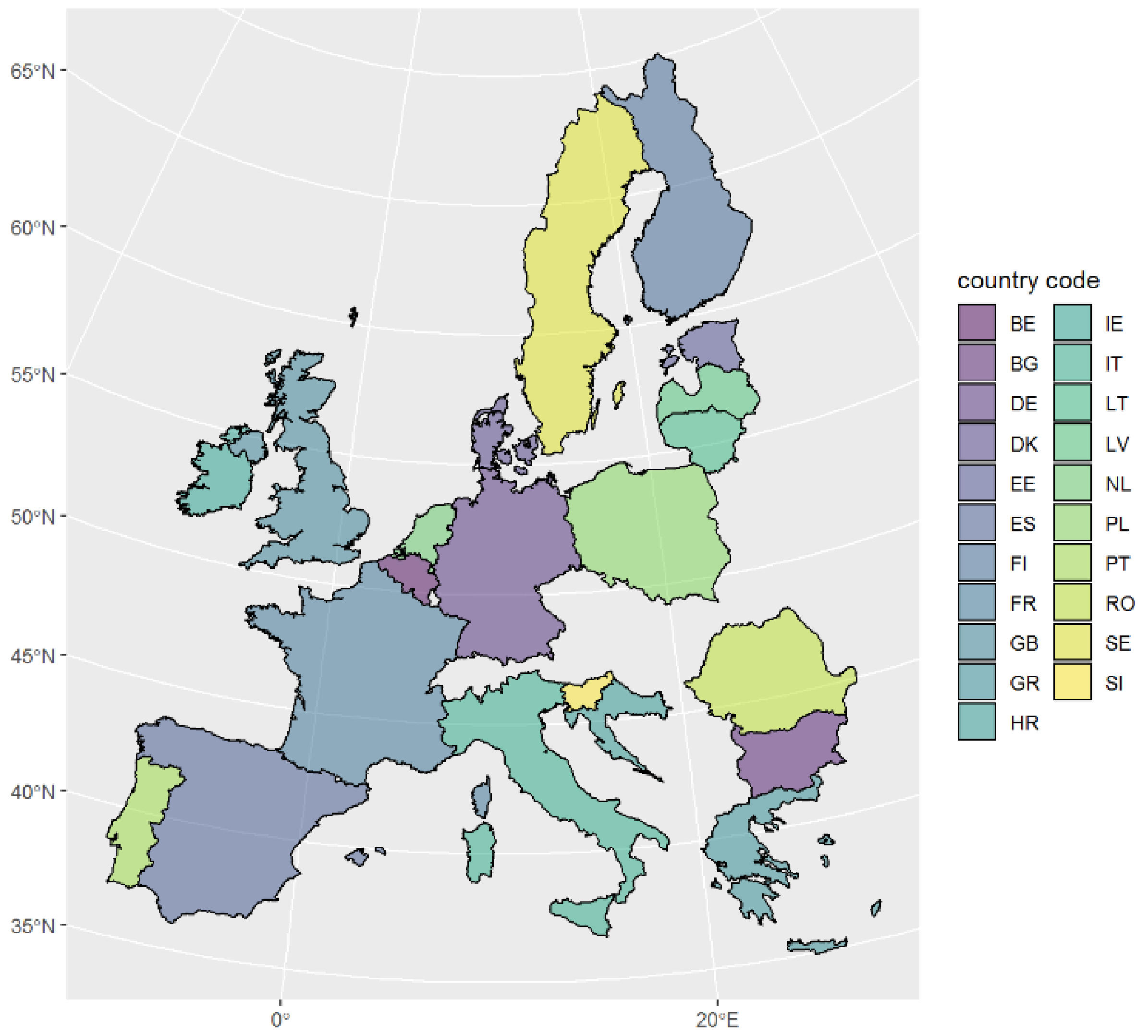

Figure 42: Country boundaries polygons

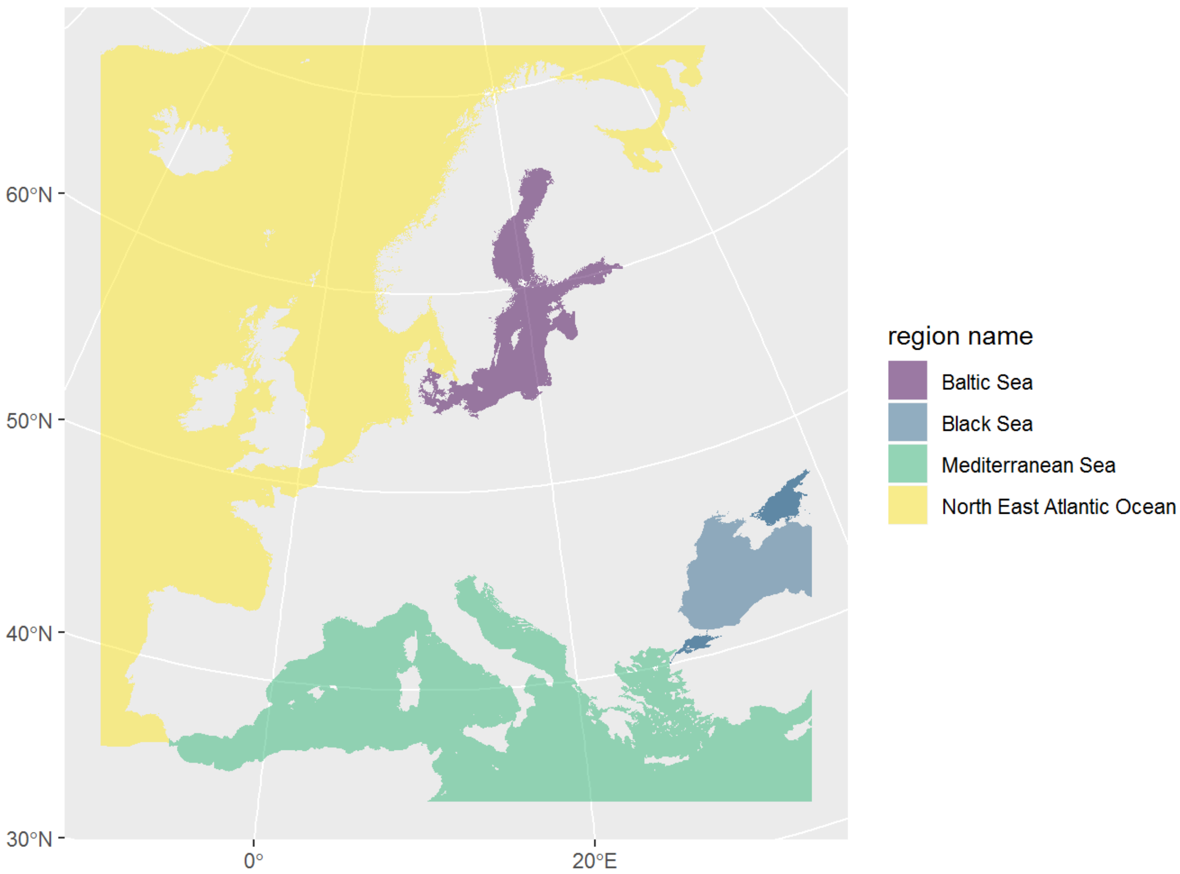

Figure 43: Marine regions

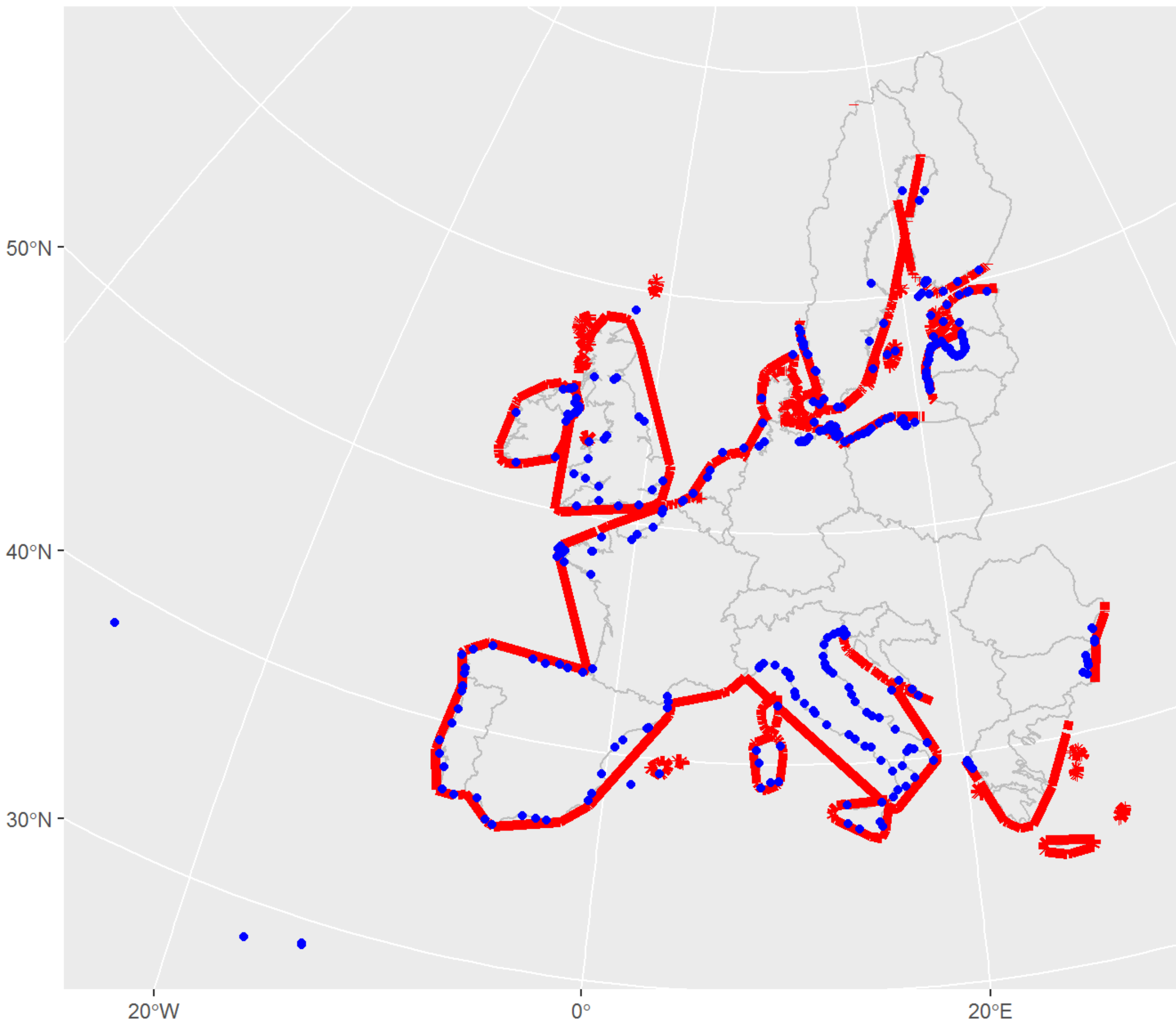

Figure 44: Convex hulls of coastlines on map with beach locations

Generalized coastlines have been extracted by computing the spatial intersection of each convex hull with the sea/ocean.

Table 16: Coastline hull length of countries

Country	Region	Coast length	Region weight	EU weight
BE	North East Atlantic Ocean	92	0.010	0.004
BG	Black Sea	202	0.524	0.009
DE	Baltic Sea	404	0.075	0.017
DE	North East Atlantic Ocean	224	0.024	0.010
DK	Baltic Sea	670	0.125	0.029
DK	North East Atlantic Ocean	828	0.090	0.036
EE	Baltic Sea	814	0.152	0.035

Country	Region	Coast length	Region weight	EU weight
ES	Mediterranean Sea	1522	0.187	0.066
ES	North East Atlantic Ocean	989	0.108	0.043
FI	Baltic Sea	812	0.151	0.035
FR	Mediterranean Sea	810	0.099	0.035
FR	North East Atlantic Ocean	1199	0.131	0.052
GB	North East Atlantic Ocean	3314	0.361	0.144
GR	Mediterranean Sea	2137	0.262	0.093
HR	Mediterranean Sea	580	0.071	0.025
IE	North East Atlantic Ocean	1042	0.114	0.045
IT	Mediterranean Sea	3084	0.378	0.134
LT	Baltic Sea	83	0.015	0.004
LV	Baltic Sea	336	0.063	0.015
NL	North East Atlantic Ocean	426	0.046	0.018
PL	Baltic Sea	404	0.075	0.018
PT	North East Atlantic Ocean	690	0.075	0.030
RO	Black Sea	184	0.476	0.008
SE	Baltic Sea	1839	0.343	0.080
SE	North East Atlantic Ocean	372	0.041	0.016
SI	Mediterranean Sea	28	0.003	0.001

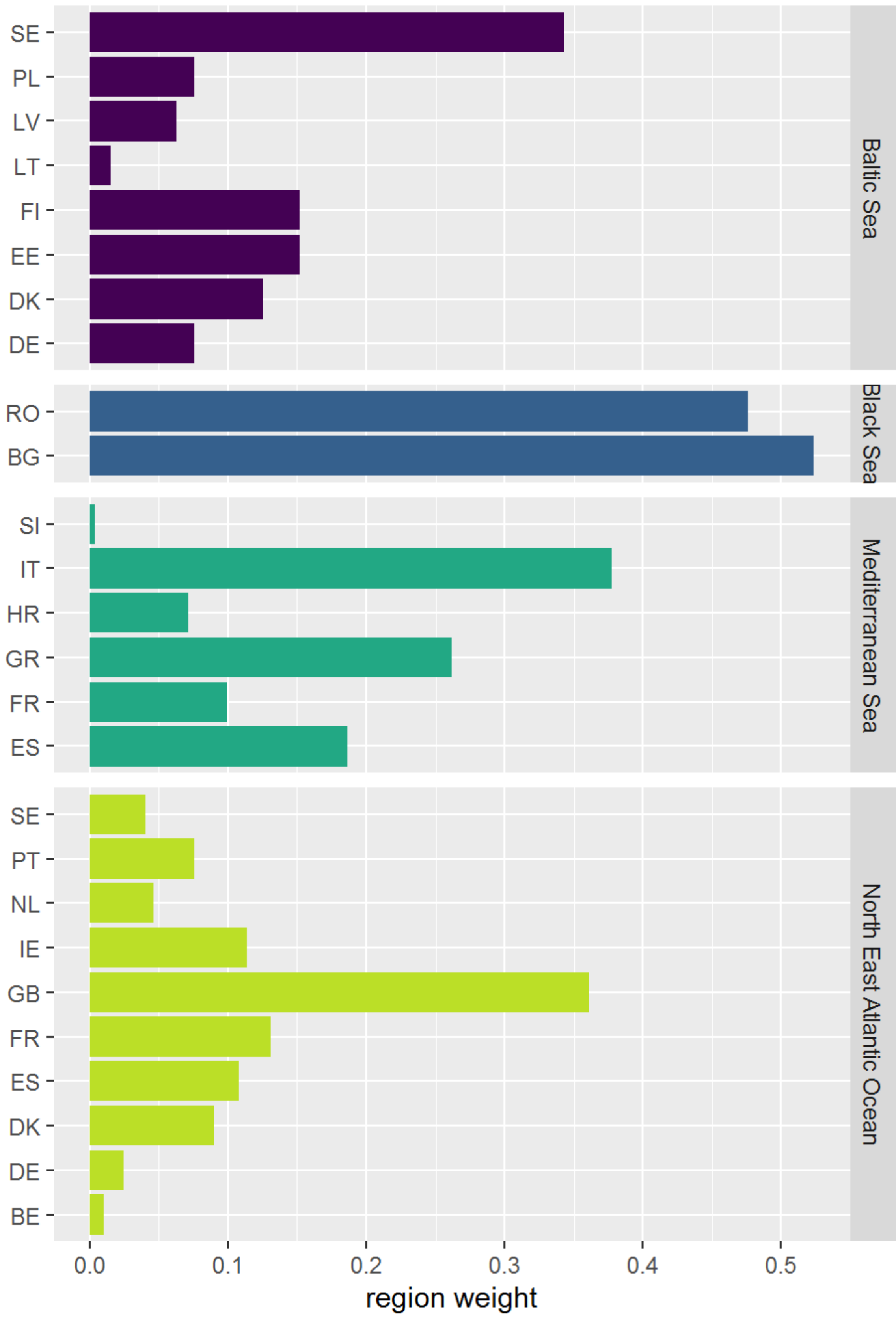

Figure 45: Weight of individual country coastline length based on convex hull calculations

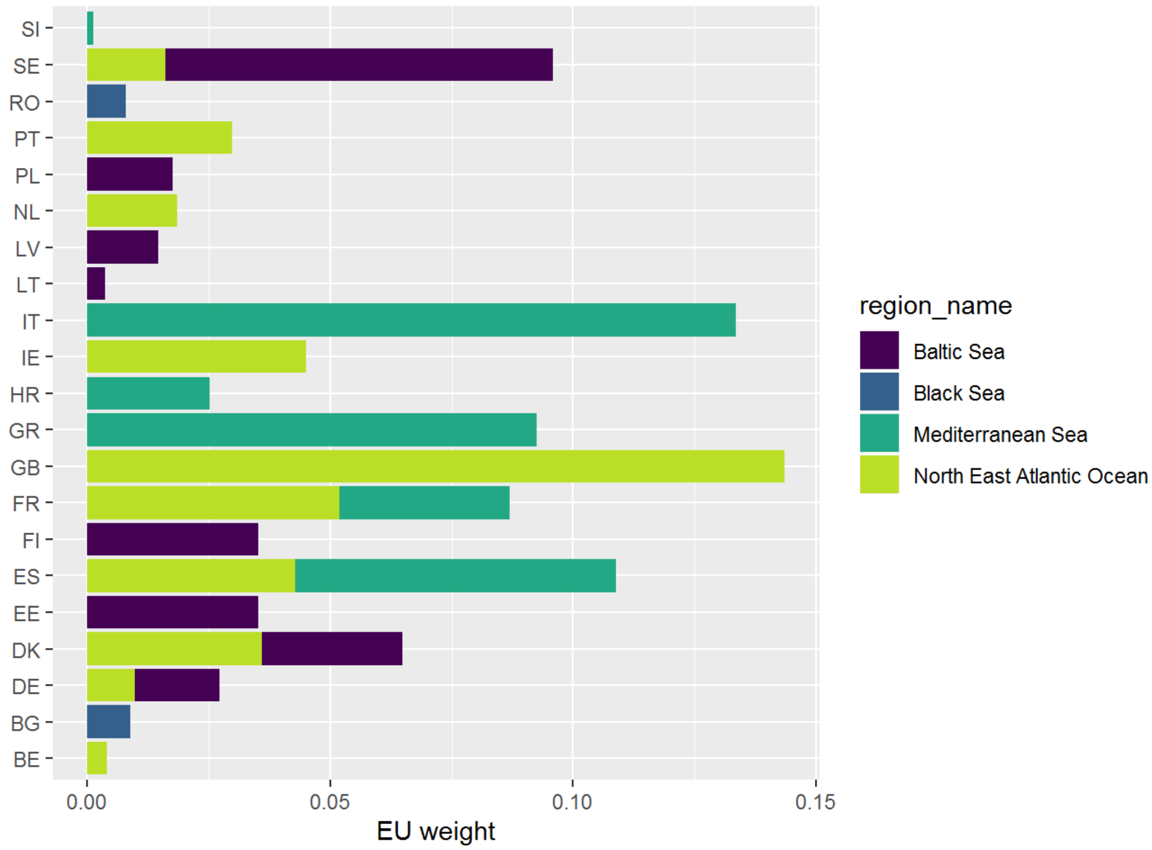

Figure 46: Spatial weights per country for aggregation to the European level. For each country, also the contribution of its regions is given, based on convex hull calculations

This methodology provides the possibility to derive results of beach litter, weighted by the countries' contribution to the regional or European coastline. Its application depends on the policy derived aim of the calculations.

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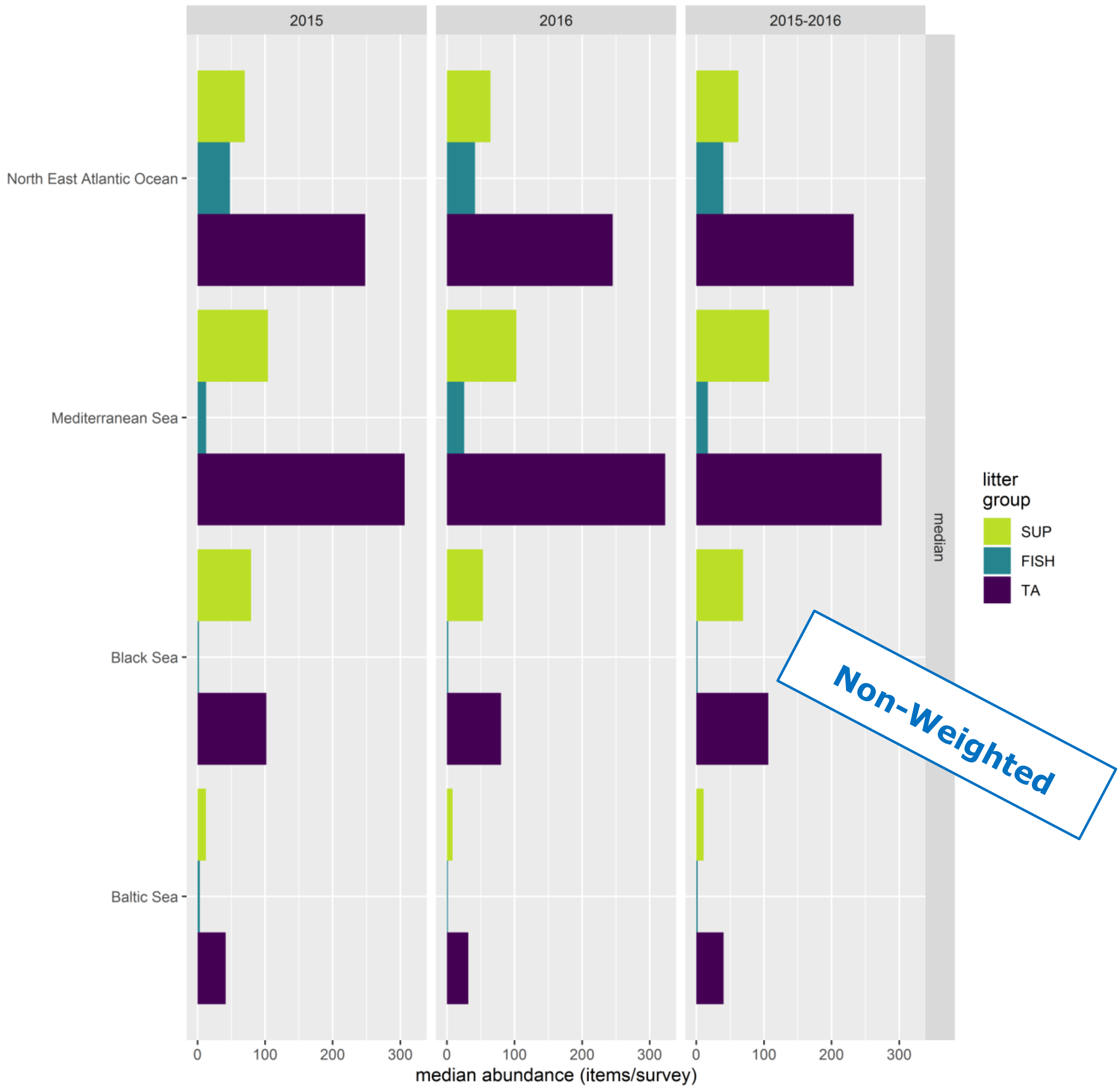
Examples of non-weighted versus weighted results:



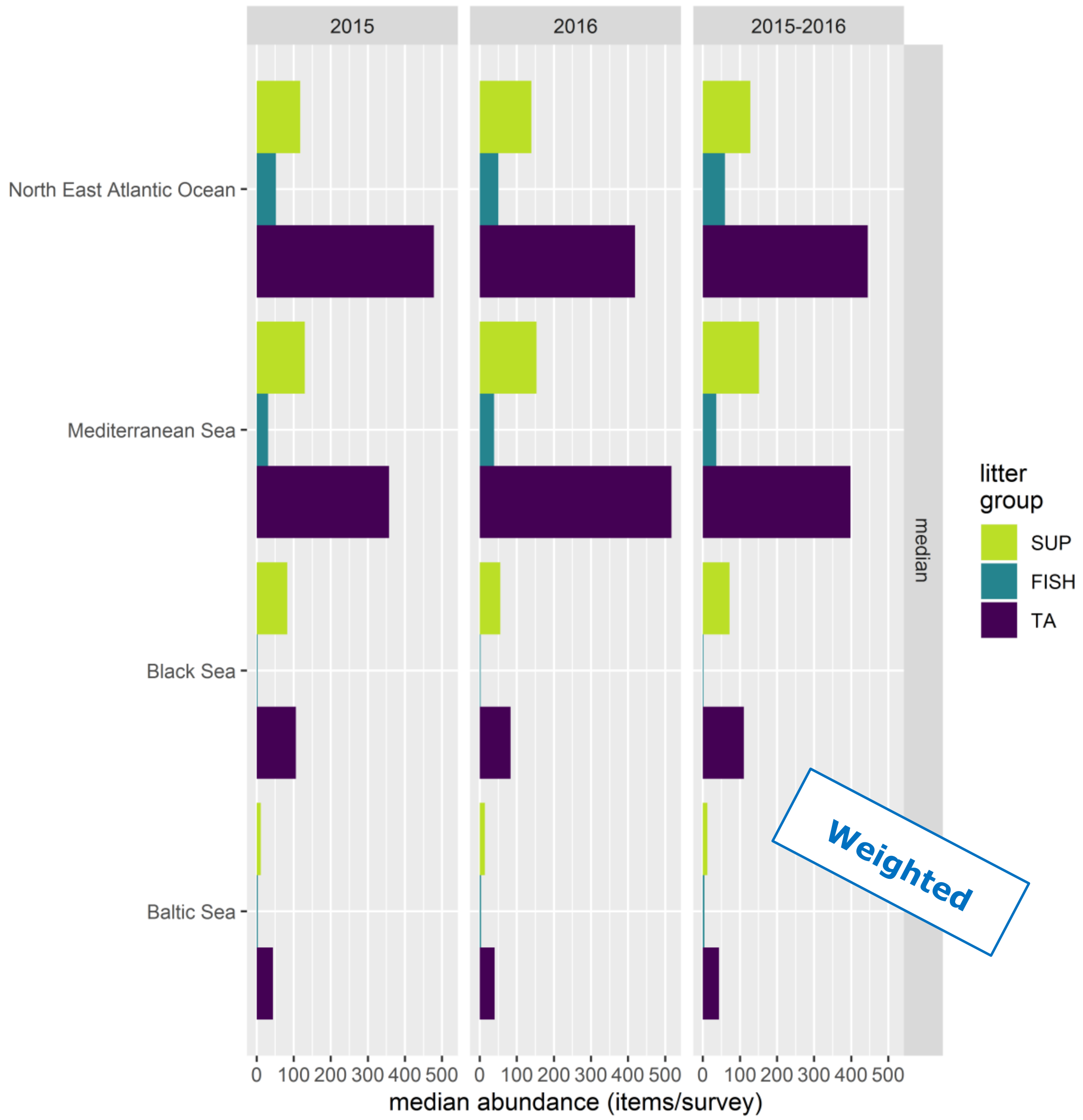


Figure 47: Weighted (below) versus non-weighted graphs of regional litter group abundance

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