Sufficiency of existing measures for marine litter in the Baltic Sea

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Sufficiency of existing measures for marine litter in the Baltic Sea

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Summary of main results

The SOM analysis for marine litter assesses the reductions in the input of top 15 beach litter items, considering the effect of existing measures and change in the extent of human activities during 2016–2030. In addition, it provides estimates of the effectiveness of measures types in reducing the direct input of microplastics. Other types of marine litter have not been included in the current analysis.

The results suggest large reductions in the input of the top 15 litter items if existing measures are fully implemented. The top 15 litter items comprise on average 74% of all items collected from surveyed beaches around the Baltic Sea, and thus reductions in the input of all beach litter would also be high.

No-special fee system for waste reception, educational programs, promoting public awareness as well as improved beach waste management and clean-up for public beach events appear to be among the most effective measure types to reduce the input of the top 15 litter items.

Four activities contribute to the input of these 15 top litter items to the beach: fish and shellfish harvesting, tourism and leisure activities, shipping, and riverine inputs covering other land-based activities (e.g. urban uses, wastewaters, solid waste). Tourism and leisure activities is the category responsible for the main input of many of the litter items.

The design of the marine litter SOM approach has somewhat outpaced the design of the general SOM approach. Issues relating to the complex interplay between sub-pressures, sub-areas, and Baltic wide estimates of effectiveness have not been fully explored in other topics. This additional complexity applied for the marine litter assessment has produced more detailed results than for the other topics, but it has also increased the resources needed for the analysis considerably and can influence comparability and integration across topics. The overall certainty of the assessment for marine litter can generally be characterized as moderate to high. The number of expert responses is moderate, and experts from eight coastal countries have contributed to some part of the assessment. However, novelty of the topic design results in additional uncertainty.

Introduction

Report background

The sufficiency of measures (SOM) analysis assesses improvements in environmental state and reduction of pressures that can be achieved with existing measures in the Baltic Sea region, and whether these are sufficient to achieve good environmental status (GES). The analysis involves estimating the state of the marine environment in 2030, based on a starting point of 2016 (i.e. the latest HELCOM status assessment), and given measures in existing policies, their implementation status, and the projected development of human activities over time. The evaluation can be carried out compared to relevant and agreed HELCOM threshold values for GES, where available.

The main aim of the SOM analysis is to support the update of the HELCOM Baltic Sea Action Plan (BSAP) by identifying potential gaps in achieving environmental objectives with existing measures for the Baltic Sea. In addition, the analysis can indicate both thematically and spatially where new measures are likely needed.

The same overall approach has been applied across all topics included in the SOM analysis to ensure comparability and coherence of the results, while considering topic-specific aspects and making necessary adjustments. The main components of the analysis include assessing the contribution of activities to pressures, the effect of existing measures on pressures, the effect of development of human activities on pressures, and the effect of changes in pressure on environmental state. The SOM approach, model and data collection are described in detail in the methodology report.

The methodology for the SOM analysis is designed to accommodate the broad array of topics relevant in the HELCOM region and to enable a region-level analysis. It balances between state-of-the-art knowledge, availability of data, and advice taken onboard from various HELCOM meetings and bodies.

The data used in the SOM analysis have been collected using expert elicitation and by reviewing existing literature, model outputs and other data sources. Data availability varies substantially across topics and data components, which is reflected in the presentation of the methods and results in this report.

The SOM analysis presents the first attempt to quantify the effects of existing measures and policies on the environment and achieving policy objectives for various environmental topics in HELCOM and the Baltic Sea area. It is aimed at assessing the overall sufficiency of existing measures at the Baltic Sea level. The results are based mainly on expert elicitation, and thus they should be utilized appropriately. Due to the pioneering nature of the approach and variable data quality and availability in the SOM analysis, the findings do not provide conclusive answers on the need for new measures, but indicate likely gaps, and should thus also be reviewed in relation to the results of other assessments.

This topic report describes the analyses carried out and the results for the SOM analysis on marine litter, providing detailed topic-specific information. First, it presents background information and describes the data and methods for addressing the topic in the SOM assessment, including relevant assumptions and challenges. Second, it presents and

discusses the findings for each result component. Third, it provides discussion on the impacts of alternative assumptions and data, evaluates the quality and confidence of the analysis, and provides implications and future perspectives. The annexes contain detailed information on the data components, topic structure and expert surveys for the analysis, as well as supplementary results.

Similar topic reports have been prepared for all nine topics covered in the SOM analysis. In addition, the results are summarized in the main report and the full methodology is described in the methodology report.

Topic background[1]

Marine litter is a clearly visible problem along the Baltic Sea coastline. It also appears under the surface and in many different size classes. The smallest, microliter, is invisible to the human eye, but enters the marine food web when animals ingest it. Larger marine litter deteriorates habitat quality and can cause direct harm to animals when they swallow it or become entangled. Around 70 % of the marine litter in the Baltic Sea is plastic. Plastic materials are of special concern due to their risks to the environment and slow degradation. The regional goal agreed in HELCOM is to reduce the amount of marine litter significantly by 2025 and prevent harm from litter in the coastal and marine environment.

Besides having clear effects on the environment, marine litter also has a strong socioeconomic dimension. Marine litter may affect human activities and health, reduce the value of tourism and recreation, or result in direct costs for removal. It can also damage fishing gear, contaminate catches or be a risk to navigational safety.

Marine life is impacted both directly and indirectly. Litter may cause harm to animals when they ingest it, by clogging or injuring their digestive tract, or by causing contamination. Another main impact occurs when animals are entangled and strangled in lost fishing equipment or packaging material. Additionally, marine litter affects the quality of habitats by effects on physical structure or local biogeochemistry and is a possible vector for the transfer of non-indigenous species, leading to effects on biodiversity. The risk associated with microlitter for marine animals is under extensive study (Werner *et al*. 2016). Artificial, polymer materials, more commonly known as plastics, are of special concern due to their persistence, a factor further prolonged below the photic zone, and because they have been identified as a potential pathway for harmful chemicals to enter the marine environment and food webs.

Globally, it is estimated that 275 million metric tons of plastic waste were generated in 2010 (calculated for 192 coastal countries), of which between 4.8 and 12.7 million metric tons entered the ocean, and that the world annual plastic production is still increasing (Jambeck *et al*. 2015). Most plastics are used in packaging or in the building industry and are discarded within a year of their production.

[1] Paraphrased or quoted from HELCOM (2018): State of the Baltic Sea – Second HELCOM holistic assessment 2011-2016. Baltic Sea Environment Proceedings 155.

Description of marine litter in the SOM assessment

Marine litter is a complex topic in the SOM analysis, with legislation and regulation frequently targeted toward specific litter items. Estimating the impact of a measure targeted toward a single beach litter item on total litter input was not considered feasible. This led to a hybrid approach that balances between the importance of individual beach litter items while maintaining a single cohesive litter pressure input, *Input of top litter items to the beach*.

This pressure input reflects the structure of the HELCOM pre-core indicator "Beach litter" and MSFD criteria D10C1[2] (Figure 1). No HELCOM GES threshold value has currently been established for the input of litter, and therefore the topic is assessed using the relative improvement from present conditions. Recently, at the EU level, a threshold value for macro litter on coastlines of 20 litter items/100 meter of coastline was adopted through a written procedure (concluded on 18 September 2020), one item of 'beach litter' being defined as any discarded item over 2.5 centimetres in length (which covers small items like cigarette filters, up to larger items like netting, ropes or industrial packaging) found on the beach. It is important to note that the SOM analysis only addresses the top 15 litter items which comprise 74% of all items collected from surveyed beaches. Thus, a 100% reduction of the pressure input would not necessarily lead to the eventual elimination of all litter surveyed on beaches and any change in the remaining 36% of beach litter is not tracked by this assessment. Change in this pressure input in the SOM analysis is based on effectiveness of measures assessment targeted at the 15 top litter items on Baltic beaches (HELCOM 2018). These effectiveness estimates are then used to assess the reduction in the total input of top beach litter items based on data from the HELCOM SPICE project (methodology report).

In addition to the primary analysis focusing on the input of top beach litter items as a pressure input, two marine litter pressures are included in the SOM analysis: *Bycatch in ghost nets* and *Effects of marine litter (excluding bycatch in ghost nets)* (Figure 1). These pressures aim at reflecting the impact of marine litter rather than the quantity of litter added to the environment. They do not directly correspond to a HELCOM indicator or MSFD criteria, but instead more holistically assess marine litter effects in the Baltic Sea. Moreover, abandoned, lost and otherwise discarded fishing gear (ALDFG) are an issue of concern both regionally and at EU level, thus this is very valuable information in relation to further actions addressing this source of litter. While the MSFD criteria D10C4[3] might be used as a metric to generate species-specific litter pressure assessments, a complete assessment of the pressure using concrete criteria is beyond the scope of this current assessment. Bycatch in ghost nets has been separated from the main litter pressure due to its very specific source and effect on the environment. These two pressures related to marine litter could be selected when identifying the most significant pressures linked to any of the state components included in the SOM analysis. In the SOM analysis, no link has been made

[2] Marine Strategy Framework Directive criteria D10C1 – Primary: The composition, amount and spatial distribution of litter on the coastline, in the surface layer of the water column, and on the seabed, are at levels that do not cause harm to the coastal and marine environment. Member States shall establish threshold values for these levels through cooperation at Union level, taking into account regional or subregional specificities

[3] Marine Strategy Framework Directive criteria D10C4 – Secondary: The number of individuals of each species which are adversely affected due to litter, such as by entanglement, other types of injury or mortality, or health effects. Member States shall establish threshold values for the adverse effects of litter, through regional or subregional cooperation.

between the litter pressure input, *input of top litter items to the beach,* and either of the impact-related litter pressures (Figure 1). If either of the marine litter pressures has been identified as significant to one of the state components in the SOM analysis, these results are reported in the documents for other SOM topics.

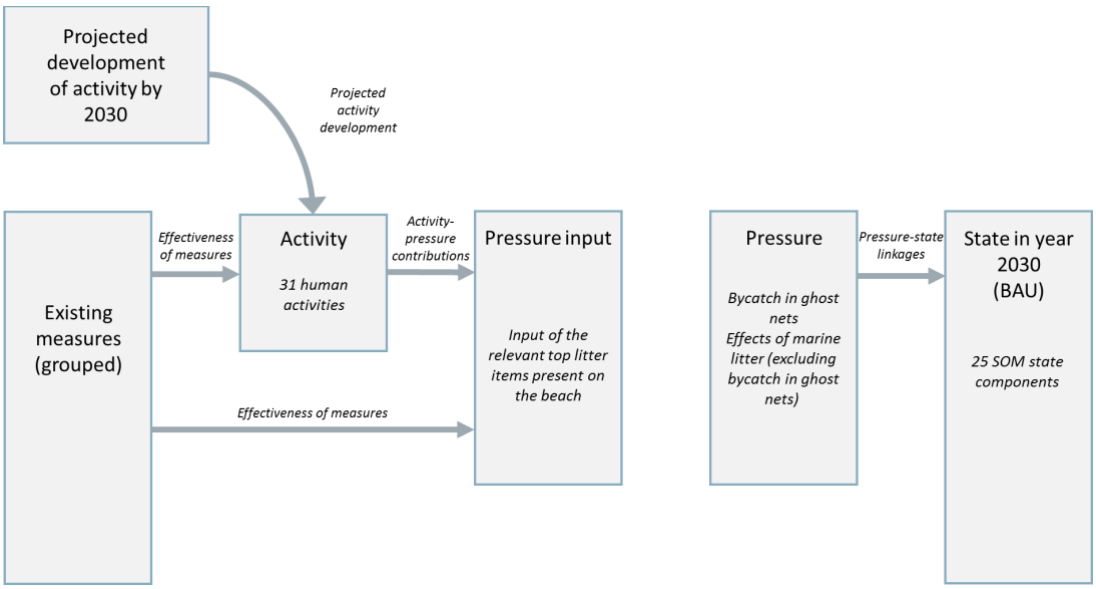

Figure 1. Schematic of the SOM analysis for marine litter. The impacts of the litter pressure input (*Input of the relevant top litter items present on the beach*) on the litter pressures (*Bycatch in ghost nets; Effects of marine litter (excluding bycatch in ghost nets)*) have not been estimated within the SOM analysis.

Supplementary activities

Though not directly included in the SOM analysis, an effect of measures survey was also implemented for the direct input of microplastics, where direct input of microplastics is defined as litter that enters the environment as a microplastic. This result is included in this report as supporting information, but microplastics are not assessed further in the SOM context.

The main HELCOM instrument addressing sources of marine litter in the Baltic Sea is the HELCOM Regional Action Plan on Marine Litter (RAP ML), adopted in 2015 (HELCOM 2015), and currently under a revision process to be concluded during 2021. The plan has already led to significant progress on marine litter, including the development of a knowledge base and various HELCOM commitments to address marine litter in the Baltic Sea. As a first step, a thorough evaluation of the implementation of each of the regional and voluntary national actions has been initiated. The revision of the RAP ML is being conducted simultaneously and in connection with the update of the BSAP, and should represent an important supplementary documents in the updated BSAP. New measures may also be added to the updated RAP ML in view of the newly acquired knowledge, availability of novel technologies and latest regulations that enter into force, such as measures targeted towards discarded fishing gear and single use plastic items.

Methods and data

The section below includes an overview of any topic-specific methodologies. A full description of the general approach, methods and data collection for the SOM analysis is available in this document. Note that the detailed results are presented for the most likely development of human activities and using the expert data on effectiveness of measures.

Activity-pressure input contributions

The contributions of activities to the *input of top litter items to the beach* was determined using surveys that were distributed to national topic experts via the HELCOM Expert Network on Marine Litter (EN Marine Litter). Responses from individual experts were accepted, but because national responses were preferred, all responses were weighted nationally to standardize the data set. Respondents were asked to assess the contribution of the activities *transport – shipping*, *tourism and leisure activities (boating, beach use, water sports, etc.)*, *fish and shellfish harvesting (all gears, professional, recreations)*, and *riverine inputs* to the input of the top 10 most frequent items contributing to beach litter for each of the three HELCOM beach types (urban, peri-urban and rural; HELCOM, 2017). When combined, these three separate top ten litter lists results in a list of the top 15 litter types across all beach types which has been used in this assessment. Assessments were done on a five point scale, where 0 indicated insignificant contribution (<5% of the total load), 1 low contribution (5-20% of the total load), 2 moderate contribution (20-40% of the total load), 3 high contribution (40-60% of the total load), and 4 very high contribution (>60% of the total load). The minimum, maximum and mean values of these contribution ranges were averaged across the three beach types and then used to calculate the activity-pressure contributions presented in this report and used in the SOM model.

Effectiveness of measures

Measure types (Annex 3) and structural relationships between the measure types and activities and pressure inputs (Annex 7) were designed by the SOM Litter Topic Team in collaboration with HELCOM ACTION WP6. The measure types were informed by the existing measures list (Annex 4) but were also designed to acknowledge the full breadth of potential measures.

For marine litter, the effectiveness of measures survey structure comprised 28 unique measure types covering four activities. The same measure type may be listed under multiple activities and pressure inputs. Altogether this resulted in 39 assessments of measure type effectiveness. The exact list of measure types, and their grouping by activities and pressure inputs is shown in Annex 7. The effectiveness of measures survey itself is included as Annex 8.

Projected reductions in pressure inputs

The calculations on the projected reductions in the input of litter are based on the activity-pressure contributions, effectiveness of measure types, links between existing measures and measure types, links between measure types and litter items and projected development of activities. The activity-pressure data are at the level of 6 sub-areas (Figure 2) and the effectiveness of measures data at the Baltic Sea level. The total pressure reductions are presented at the sub-area level. Pressure reductions can be positive (pressure is reduced), negative (pressure is increased) or zero (no change in pressure), depending on the combined effect of existing measures and changes in the extent of human activities.

The projected reductions account for the joint impacts across the measure types, as well as the spatial area where the pressure inputs can be reduced to avoid overestimating the pressure input reductions. Pressure input reductions can in principle be positive, negative or zero, depending on the combined effect of existing measures and changes in the extent of human activities. When the reduction in pressure inputs from existing measures is larger than the increase from changes in human activities, pressure inputs are reduced.

Topic specific model structure, assumptions and challenges

The SOM analysis for marine litter is one of the most heavily adapted of all the SOM topics. This was done to accommodate the requests by topic experts to utilize an item-based approach, while simultaneously keeping the number of individual pressures low. In addition to the altered activity-pressure survey described above, the measure type structures and effectiveness of measure types survey were also modified.

For the evaluation of effectiveness of measures, each measure type is linked to the litter items reduced by that measure type. Experts were then asked to assess measure effectiveness as the average across all the litter items affected by that measure type. These measure types and effectiveness values were then applied to each applicable litter type. The weighted average of the resulting reductions, based on the proportion of each litter type to the total top litter items, generated an estimate of total reduction across all litter types. One complication to this approach is the presence of the litter item category “Plastic and polystyrene pieces”, which includes otherwise unidentified pieces which may or may not belong to another top litter category if properly identified. To overcome this, two further adjustments were made. Firstly, experts were asked to assess the effectiveness separately for measure types that impact the input of all top litter items and those that impact a subset of those items. Secondly, when assessing effectiveness for those measure types that impact a subset of top litter items, “Plastic and polystyrene pieces” was not included because it was considered not feasible to directly assess litter sources. Instead, effectiveness of measure types for “Plastic and polystyrene pieces” was calculated by determining the proportion of all plastic litter items recovered during beach surveys that are impacted by the measure type and applying the measure type effectiveness only to that portion. This calculation assumes that all plastic litter proportionally contributes to the litter category “Plastic and polystyrene pieces”. Reflection on these modifications can be found in the section Lessons learned.

Overview of data

The SOM analysis for litter evaluates the pressure reductions achievable by 2030 on the input of beach litter items, considering the effects of existing measures and the future development of human activities.

Table 1 shows the origin and spatial resolution for the data components in the SOM analysis for marine litter. Activity-pressure input contributions, pressure-state links and time lags are based on expert data. Information on existing measures comes from literature reviews and Contracting Parties, and development of human activities is based on existing literature, data and projections.

Estimates of the effectiveness of measures were collected both via expert surveys and a literature review . The aim of the literature review was to compile information from scientific articles and reports providing estimates on the effects of measures in reducing pressure inputs that could be used in the SOM analysis, either by including the estimates in the SOM model or by providing comparison points. The literature review was conducted by topic, with the information collected into structured excel files (see the methodology document, Annex 5 and Annex 6 for more information). For marine litter, 34 effectiveness estimates from 9 studies were compiled. Out of these, 12 estimates from 6 studies could be included in the model. Detailed results are presented using only the expert-based data, and the implications of using the literature data for the effectiveness of measures are reviewed in the discussion section. Scenarios for the development of human activities were based on existing information and projections for the Baltic Sea region, and pressure-state links were evaluated with expert elicitation.

The spatial resolution (level of detail) differs across the data components of the SOM analysis. All areas are based on the 17 HELCOM scale 2 sub-basins and the assessment areas range in size from the whole Baltic Sea to individual sub-basins. The activity-pressure contributions for marine litter are assessed across aggregations of sub-basins, forming six sub-areas of the Baltic Sea (Figure 2), while the effectiveness of measure types in reducing pressures and the effect of development of human activities are assessed at the scale of the entire Baltic Sea.

Table 1. Data for litter (more information on data collection is available in the methodology document).

Data component	Origin of data	Spatial resolution
Activity-pressure contributions	Expert evaluation	6 sub-areas (Figure 2)
Existing measures	Literature review, Contracting Parties	17 sub-basins
Effectiveness of measures	Expert evaluation	Whole Baltic Sea
Development of human activities	Literature review, existing data and projections	Whole Baltic Sea
Pressure-state links	NA	NA

NA = not applicable

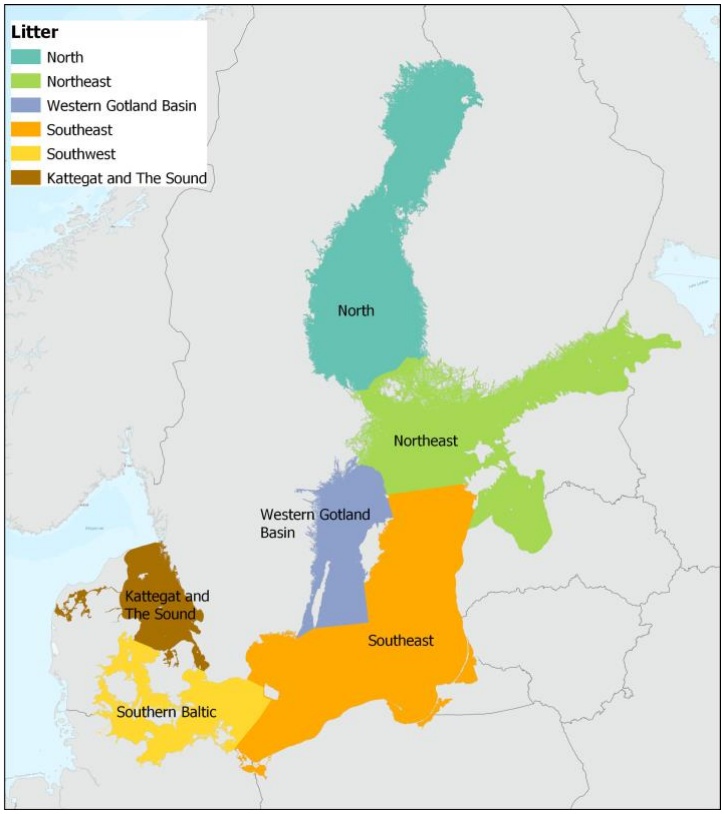

Figure 2. Spatial division of the Baltic Sea used for determining contributions of human activities to the input of marine litter. The six sub-areas are: Kattegat and the Sound; Southern (Great Belt, Kiel Bay, Bay of Mecklenburg, Arkona Basin); Southeast (Bornholm Basin, Gdansk Basin, Eastern Gotland Basin); Western Gotland Basin; Northeast (Gulf of Riga, Northern Baltic Proper, Gulf of Finland, Åland Sea); and North (Bothnian Sea, The Quark, Bothnian Bay).

Development of human activities

In addition to existing measures, changes in the extent of human activities may affect pressure inputs over time. Four scenarios for future changes in human activities were developed: 1) no change, 2) low change, 3) moderate (most likely) change, and 4) high change. These alternative scenarios aim to capture uncertainties and variation in the future development of human activities. The results of the SOM analysis were estimated for each of the four scenarios to assess how the alternative assumptions on the development of human activities affects the findings. Detailed results are presented for the most likely development scenario, and implications of using the other scenarios on the results are reviewed in the discussion section.

The scenarios specify a percent change in each activity during 2016–2030 based on existing information and projections from the Baltic Sea region (for details and references see the methodology report). Change scenarios were made only for predominant activities in the Baltic Sea region, including agriculture, forestry, waste waters, (commercial) fish and shellfish harvesting, aquaculture, renewable energy production, tourism and leisure activities, transport shipping and transport infrastructure. Other activities are assumed to stay unchanged. This means that only 9 of the 31 standard SOM activities have change

scenarios in the SOM analysis. This results in varying influence of these scenarios on the results across topics, pressures and state components, depending on the significance of the activities to the pressure inputs relevant to the topic.

For marine litter, coverage of activities that contribute to pressure inputs in the change scenarios is relatively high, as three out of four activities (fish and shellfish harvesting, tourism and leisure activities and transport – shipping) all have development scenarios. Although the scenarios cover also waste waters, specific scenarios were not made for the activity riverine inputs covering other land-based activities (e.g. urban uses, wastewaters, solid waste), and thus this activity is assumed to stay constant until 2030. For most sub-areas and litter items, fish and shellfish harvesting, tourism and leisure activities and shipping make up around 70-95% of the contribution. The share is lower only for plastic and polystyrene pieces in Kattegat and the Sound and Southwest, and for plastic bags, bottles and containers and industrial packaging in the Kattegat and the Sound. Thus, activities contributing to the input of litter are rather well covered in the development scenarios. In the most likely scenario, fish and shellfish harvesting is assumed to stay constant until 2030, and tourism and leisure activities and shipping are expected to increase by 30% and 20%, respectively. More information on the development scenarios and source materials is given in section 9 of the methodology report.

The current situation with COVID-19 and its possible implications on the development of human activities is not reflected in the scenarios, as there is no information on the long-term effects it may have on the economy or activities. The current situation poses a challenge for choosing the most likely scenarios for the development of human activities, which has been done based on currently available information.

Results and interpretation

Background

The SOM results are presented in the format of percent shares or probabilities. The main finding of the analysis is the probability to achieve GES or specific state improvements/pressure input reductions, taking into consideration the effects of existing measures and changes in the activities on pressure inputs. The contribution of activities to pressure inputs, the effect of measures on pressure inputs, and the significance of pressures to state components are presented as percent values (e.g. how many percent would the measure reduce the pressure input). Results are presented mainly in tables, which show the most likely (expected) values and standard deviations. Standard deviation is a way of showing the variation in the values. When it is high, values are spread over a wider range, and when it is low, values are closer to the most likely value. Figures and graphs presenting distributions are included in the annexes. They show the same results as the tables but allow an alternative visualisation of the results.

For the data that are based on expert surveys, the confidence rating gives the most common answer to experts' assessment of the confidence in their own survey responses on a low-moderate-high scale. More detailed information on how each result has been calculated is presented in a separate document.

This document presents the detailed results based on the expert-based data (survey responses). Literature data on the effectiveness of measures has been collected and included in an alternative model estimation. The impacts of using the literature data are evaluated in the discussion section. In the detailed results, the projected development of human activities is based on the most likely future development until 2030 (for details, see the methodology document), and the impacts of alternative scenarios on human activities are examined in the discussion section.

Format of presentation

The format the results are reported in differs (not presented, qualitative/semi-quantitative, quantitative) depending on the type of result and the number of participating experts. Further, for all results utilizing other SOM results as input data, reporting is done at the most conservative standard used in the input data. In practice this means that if one input data point is reported as 'insufficient data', all results using that data point will also be reported as 'insufficient data'; similarly for qualitative/semi-quantitative data points. However, note that this standard is only applied in the case of data points actively used to calculate another result. For example, many measure types are hypothetical or otherwise not implemented in the Baltic Sea and therefore do not factor into results on projected pressure input reductions from existing measures. Insufficient data for such measure types does not affect reporting other results that rely on data for effectiveness of measure types. However, all the data components for marine litter meet the thresholds for fully quantitative presentation.

For results concerning required pressure reductions and significance of pressures to state components, results with 2 or fewer respondents are not reported; results with 3 to 4

respondents will be either not reported, or qualitatively/semi-quantitatively reported based on feedback from the SOM topic teams or other HELCOM expert body; results with 5 or more respondents are reported quantitatively. This standard allows flexibility for reporting on assessments that are of spatially limited areas and therefore have fewer experts available to survey, while also being somewhat conservative in reporting fully quantitative results.

For expert-based effectiveness of measures results, measure types with 5 or more respondents are reported quantitatively and those with 4 or fewer respondents are listed as having insufficient data.

For expert-based activity-pressure input results, expert responses where primarily sought through the HELCOM expert networks in the form of national responses. Individual expert responses were accepted but were consolidated into average responses by country to conform to the format of other responses. Thus, the maximum number of responses is 9. This maximum is rarely reached due to responses typically only applying to areas adjacent to the specific country. Acknowledging this, activity-pressure input relationships are reported if there are expert responses from 3 or more countries or if the number of countries providing expert responses is greater than 1/2 the number of countries bordering any given sub-area (see Table 2 below; responses from experts based in any HELCOM country will be counted toward the reporting threshold, i.e. the reporting assessment is not limited to responses from bordering countries).

Table 2. Required number of countries providing expert responses to the activity-pressure input survey to meet the minimum data threshold for reporting.

Bordering countries	Required number of countries providing expert responses to meet minimum data threshold	Example areas
1	1	Western Gotland Basin
2	2	Bothnian Sea, Gulf of Riga
3	2	Gulf of Finland
4+	3	Eastern Gotland Basin, Baltic Sea

Coverage of pressures in the SOM analysis

In general, the SOM analysis has only been able to account for a portion of all pressures that affect the state components, and the effect of several significant pressures have not been included due to not being able to quantify the link between the pressure inputs, pressures and state components in the analysis. This means that the effect of reductions in these excluded pressures on the state components is not included in the total pressure reductions, and the projected total pressure reductions and probability to achieve GES may be underestimated for some of the topics in the SOM analysis. This underestimation does not apply to the results for litter, as the assessments concludes at the level of input of beach litter items. However, as the SOM analysis has not been able to include a quantitative link between the input of beach litter and effects of litter, this has an impact on the results for other topics and state components in the SOM analysis that are considered to be affected

by marine litter. Thus, the total pressure reductions and state improvements for state components affected by marine litter are potentially underestimated, as the effects of reducing the input of litter are not fully accounted for.

What are the reductions in pressure inputs from existing measures?

There is no agreed HELCOM GES threshold value or a core indicator for marine litter, only a pre-core indicator on beach litter currently lacking threshold values (under final development). As no HELCOM GES threshold value for beach litter was adopted during the making of the SOM analysis, a full analysis of the sufficiency of measures has not been possible. However, a threshold value has since been developed at the EU level and could be applied in future analyses. Thus, the focus of the SOM analysis has been to evaluate the changes in the input of beach litter items during the period 2016-2030, considering the effects of existing measures and changes in the extent of relevant human activities.

Table 3 shows the projected reduction in the input of beach litter in 2016-2030, taking into consideration effects of existing measures in reducing the input of marine litter by assessment area and changes in the extent of human activities. Estimates are presented by sub-area for both the top 15 most common beach litter items and for all beach litter items, based on the share of the 15 top litter items of all beach litter. The results are based on the assumption that the measures would not reduce the input of litter items other than the top 15 items, as it has not been possible to estimate the effects of the measures on other than the top 15 beach litter items due to the limited scope of the analysis. This is likely incorrect and means that the estimate for the reduction in all beach litter might be an underestimation.

Large reductions in the *input of top 15 litter items to the beach* are projected across all sub-areas. In some areas, the pressure reductions are close to 100% for the 15 top litter items addressed. The high projected reductions are a result of several EU directives and regulations adopted in recent years. These measures are often expected to have strong effects as they are to be implemented in eight of the nine Baltic Sea countries.

The top 15 litter items comprise on average 74% of all items collected from surveyed beaches around the Baltic Sea. Based on the share of top 15 litter items of all beach litter, reductions in the input of all beach litter are around 50-80%, depending on the area.

Thus, the analysis indicates that existing measures have the capacity to reduce the input of beach litter substantially, provided that they are fully implemented.

The total reductions in the *input of top litter items to the beach* are aggregated based on the share of 15 most common litter items listed in Table 4 (the word in brackets refer to the material the litter item is made of).

The projected pressure reductions are influenced by both existing measures and changes in the extent of human activities until 2030. In the most likely scenario, tourism and leisure activities, and shipping are expected to increase by 30% and 20%, respectively, and fish and shellfish harvesting is assumed to stay constant. In this case, the effect of existing measures is larger than the effects of changes in human activities.

Also note that reductions from "Plastic and polystyrene pieces" were calculated by determining the proportion of all plastic litter items recovered during beach surveys that are impacted by the measure type and applying the measure type effectiveness only to that portion. This calculation assumes that all plastic litter proportionally contributes to the litter category "Plastic and polystyrene pieces". Full methodology can be found in the section Methods and data.

The certainty of the projected reduction in the input of beach litter is evaluated to be high. However, as the standard deviations and certainty values are calculated by combining the projected reductions in the input of various litter items, they do not correspond to the certainty of the underlying data and may not be the best indicator of the accuracy of the results.

Further details on the effectiveness of different measure types and activity-pressure input contributions can be found in Tables 6 and 7.

Table 3. Projected total reductions (%) in the input of beach litter from existing measures in the Baltic Sea during 2016-2030. The table depicts the most likely/expected values of total pressure reductions and gives standard deviations in parenthesis.

Pressure input **Sub-area**	**Reduction in the input of top 15 litter items to the beach (%)**	**Percent of top litter items of all beach litter (%) ***	**Calculated reduction in the input of all beach litter (%)**
Kattegat and the Sound	100 (1) ●●●	70	70 (1) ●●●
Southern	99 (1) ●●●	65	64 (1) ●●●
Southeast	76 (2) ●●●	75	57 (2) ●●●
Western Gotland Basin	95 (2) ●●●	80	76 (2) ●●●
Northeast	77 (2) ●●●	81	63 (2) ●●●
North	87 (2) ●●●	74	64 (1) ●●●

*Excludes paraffin litter types from the total beach litter count, due to the extreme regional variation found. This variation is likely due to extreme counts of paraffin after a major spill in the Baltic Sea.
Colour scale for the pressure reductions in percent (based on the expected value):
<0%, 0-10%, 10-20%, 20-40%, 40-60%, 60-100%
Categories for the certainty of the pressure input reductions (based on the relative size of the standard deviation to the expected value): low: ○○●, moderate: ○●●, high: ●●●
Data used: expert estimates of activity-pressure input contributions, expert estimates of effectiveness of measure types, information on existing measures, information and projections of development of human activities.

Table 4. List of the 15 most common beach litter items

ID	Litter item (material)	Share of each of the top 15 litter items to the total of the top 15 top litter items in the Baltic Sea (%)
1	Plastic and polystyrene pieces 0-50 cm (PLASTIC)	26
2	Food related items, such as containers, lolly sticks, wrappers, packets (PLASTIC)	6
3	Drinking related items such as cups, caps, lids, six-pack rings (PLASTIC)	9
4	Plastic bags of different size and colour (PLASTIC)	4
5	Bottles and containers (PLASTIC)	2
6	String and ropes of different size (PLASTIC)	3
7	Cigarette butts and remains	21
8	Glass and ceramic fragments of different sizes and other glass items (GLASS)	4
9	Industrial packaging, such as sheeting and strapping bands (PLASTIC)	2
10	Processed wood and pieces of processed wood of different sizes (WOOD)	9
11	Drinking related items such as bottle caps, lids, pull tabs (METAL)	4
12	Single-use cutlery and straws (PLASTIC)	4
13	Paper and cardboard items and pieces of different size (PAPER)	3
14	Drinking related cans (METAL)	2
15	Foil wrappers and pieces of metal (METAL)	2

How effective are measure types in reducing pressure inputs?

This section presents the effectiveness of measure types in reducing the *input of top litter items to the beach* and *direct input of microplastics* from specific activities. The estimates are presented per activity, i.e. they portray the percent reduction in the pressure input from the activity in question, and not in the total input across all activities. Information on the reductions over all activities contributing to the pressure input is given in the section on the impacts of measure types. Data on the effectiveness of measure types originate from expert surveys and are at the Baltic Sea scale. This assumes that the measure types are equally effective throughout the Baltic Sea region.

In the following, percent effectiveness is presented per pressure, activity and measure type, and pooled across expert responses. The effectiveness estimates can be compared across measure types to assess, on average, how effective they are in relation to each other in reducing the pressure from the specific activities, or across activities to assess which measure type could be the most effective for each activity.

Table 5.1 shows the effectiveness of measure types that reduce *the input of top litter items to the beach* from four different activities. The effectiveness estimates present the effectiveness to reduce the total input of the 15 top beach litter items, and not by item. In this case, each measure type can only reduce the input of beach litter from one activity. The effectiveness of the measure types ranges from low to rather high, a factor in part due to some strong activity-specific measure effectiveness relationships. *No-special fee system for waste reception*, *educational programs*, *promoting public awareness* and *improved beach*

waste management and clean-up for public beach events appear to be among the most effective measure types. The certainty of the effectiveness estimates is low or moderate, and experts' confidence in the estimates is moderate.

Table 5.2 presents the effectiveness of measure types in reducing the input of top litter items to the beach for measure types affecting a subset of top beach litter items. Only measure types affecting specific litter items from a particular activity are included in this table. Most of the measure types appear to be moderately effective in reducing the input the specific litter items they apply to. Due to the varying list of affected litter items for each measure type, direct comparison of values in this table, either to each other, or values in Table 5.1, is not appropriate unless the list of affected litter items is identical.

Table 5.3 shows the effectiveness of measure types to reduce the *direct input of microplastics* from riverine inputs covering other land-based activities. Direct input of microplastics (referred to as primary microplastics) is defined as litter that enters the environment as a microplastic. The effectiveness of the measures types is moderate or rather high. *Improved stormwater collection systems* and *improved wastewater treatment* seem to be the two most effective measure types. The certainty of the effectiveness estimates is low or moderate, and the confidence is moderate. The effectiveness of measure types targeting the *direct input of microplastics* was assessed in the expert surveys but was not used further in the SOM analysis to assess the projected reductions in the input of litter (see previous section). This is due to the fact that, unlike beach litter, there is currently no coordination of microlitter monitoring in the Baltic Sea and no solid indicator basis.

Annex 10 presents the distributions of the effectiveness of measure types in reducing the input of litter for additional information. Estimates of the effectiveness of measure types to reduce the input of top beach litter items are used to assess the effects of existing measures and calculate the reductions from existing measures by 2030.

Table 5.1 Effectiveness of measure types (%) in reducing the *input of top litter items to the beach* for measure types affecting all litter items. The effectiveness of a measure type is the percent reduction in the input of all 15 top beach litter items resulting from a specific activity. The table depicts the most likely/expected effectiveness, and standard deviation is given in parenthesis. Only measure types affecting all 15 litter items from a particular activity are included in this table. Comparison of values within this table is possible. However, direct comparison with the values in Table 5.2 is not appropriate due to the varying list of affected litter items for each measure type.

Measure type ID	Activity Measure type	Affected litter items	Fish and shellfish harvesting	Tourism and leisure activities	Transport – shipping	Riverine inputs covering other land-based activities	Has corresponding existing measures in the SOM analysis (Yes/No)
171	More stringent controlling and reporting of ships' delivery of waste in ports	All 15 litter items	Not assessed	Not assessed	35 (19) ○●●	Not assessed	Yes
172	Implementation of ISO standard for port waste reception facilities	All 15 litter items	Not assessed	Not assessed	27 (15) ○●●	Not assessed	Yes
173	Full implementation of the no-special fee system for waste reception in all Baltic Sea ports	All 15 litter items	Not assessed	Not assessed	46 (24) ○●●	Not assessed	Yes
174	Implementing ecolabel schemes and/or incentive systems for environmentally friendly shipping	All 15 litter items	Not assessed	Not assessed	25 (15) ○●●	Not assessed	Yes
175	Including marine litter issues in educational programs and materials for professional sea use sectors	All 15 litter items	Not assessed	Not assessed	42 (21) ○●●	Not assessed	Yes
176	No-special fee system for waste reception in ports from fishing vessels, including for the litter caught in fishing nets	All 15 litter items	45 (24) ○●●	Not assessed	Not assessed	Not assessed	Yes
177	Information and education to fishermen about management and environmental impacts of fishing gear containing plastics and best practice in waste management within fishing sector	All 15 litter items	42 (25) ○●●	Not assessed	Not assessed	Not assessed	Yes
179	Promotion of garbage collection for pleasure crafts by marinas (e.g. through ecolabeling, such as Blue Flag)	All 15 litter items	Not assessed	30 (13) ○●●	Not assessed	Not assessed	Yes
180	Public awareness raising measures on marine litter impacts and prevention, promotion of sustainable consumption and production and appropriate waste management of single-use plastic products	All 15 litter items	Not assessed	44 (20) ○●●	Not assessed	36 (24) ○○●	Yes
181	Including marine litter issues in educational programs and materials for recreational sea use sectors (e.g. for diving and sailing schools)	All 15 litter items	Not assessed	33 (19) ○●●	Not assessed	Not assessed	Yes

Measure type ID	Activity Measure type	Affected litter items	Fish and shellfish harvesting	Tourism and leisure activities	Transport – shipping	Riverine inputs covering other land-based activities	Has corresponding existing measures in the SOM analysis (Yes/No)
182	Reducing the amount of plastic litter through improving municipal regulatory provisions concerning organisation of beach waste management, requirements for waste management and clean-up for public beach events and leases on beaches	All 15 litter items	Not assessed	48 (21) ○●●	Not assessed	Not assessed	Yes
192	Regional (Baltic Sea) guidelines on best practice for improving wastewater systems and stormwater management	All 15 litter items	Not assessed	Not assessed	Not assessed	28 (20) ○○●	Yes
193	Improving stormwater collection systems to prevent emissions of litter into the environment	All 15 litter items	Not assessed	Not assessed	Not assessed	36 (27) ○○●	Yes
194	Including marine litter in national and municipal waste management plans and implementing provisions of these plans in coastal municipalities to prevent litter entering the aquatic environment	All 15 litter items	Not assessed	Not assessed	Not assessed	33 (29) ○○●	Yes
	Confidence		Moderate	Moderate	Moderate	Moderate	
	Number of experts		10-13	9-13	8-12	11-14	

Colour scale for the effectiveness of a measure type in percent (based on the expected value): 0-10%, 10-20%, 20-40%, 40-60%, 60-100%

Categories for the certainty of the effectiveness estimate (based on the relative size of the standard deviation to the expected value): low: ○○●, moderate: ○●●, high: ●●●

Data used: expert estimates of effectiveness of measure types

Full activity names:

- Fish and shellfish harvesting (all gears; professional, recreational)
- Tourism and leisure activities (boating, beach use, water sports, etc.)
- Transport – shipping (incl. anchoring, mooring)
- Riverine inputs covering other land-based activities (e.g. urban uses, wastewaters, solid waste)

Table 5.2 Effectiveness of measure types (%) in reducing the *input of top litter items to the beach* for measure types affecting a subset of top litter items. The effectiveness of a measure type is the percent reduction in the input of a subset of the 15 top beach litter items resulting from a specific activity. The table depicts the most likely/expected effectiveness, and standard deviation is given in parenthesis. Only measure types affecting specific litter items from a particular activity are included in this table. Due to the varying list of affected litter items for each measure type, direct comparison of values in this table either to each other or values in other tables is not appropriate, unless the list of affected litter items is identical.

Measure type ID	Activity Measure type	Affected litter items	Fish and shellfish harvesting	Tourism and leisure activities	Transport – shipping	Riverine inputs covering other land-based activities	Has corresponding existing measures in the SOM analysis (Yes/No)
178	Improvement in the marking of fishing gear and reporting on lost fishing gear	String and ropes of different size (PLASTIC)	21 (19) ○○●	Not assessed	Not assessed	Not assessed	Yes
183	National measures for "significant reduction" in consumption of single-use plastic food containers and beverage cups (following relevant EU Directives)	Food related items, such as containers, lolly sticks, wrappers, packets (PLASTIC); Drinking related items such as cups, caps, lids, six-pack rings (PLASTIC)	Not assessed	44 (22) ○●●	Not assessed	33 (25) ○○●	Yes
184	Prohibition for placing on market certain single-use plastic products (cotton bud sticks, cutlery, plates, straws, beverage stirrers, balloons sticks)	Single-use cutlery and straws (PLASTIC)	Not assessed	56 (32) ○●●	Not assessed	38 (32) ○○●	Yes
185	Requiring that plastic caps and lids remain attached to single use plastic beverage containers during the product's intended use	Drinking related items such as cups, caps, lids, six-pack rings (PLASTIC)	Not assessed	45 (29) ○○●	Not assessed	33 (27) ○○●	Yes
186	Establishing extended producer responsibility schemes for all packaging and plastic products which create the most frequently found litter items in the marine environment	Food related items, such as containers, lolly sticks, wrappers, packets (PLASTIC); Drinking related items such as cups, caps, lids, six-pack rings (PLASTIC); Plastic bags of different size and colour (PLASTIC); Bottles and containers (PLASTIC); String and ropes of different size (PLASTIC); Cigarette butts and remains; Glass and ceramic fragments of different sizes and other glass items (GLASS); Industrial packaging, such as sheeting and strapping bands (PLASTIC)	Not assessed	48 (28) ○●●	Not assessed	37 (29) ○○●	Yes
187	Labelling biodegradable and compostable plastic bags	Plastic bags of different size and colour (PLASTIC)	Not assessed	18 (17) ○○●	Not assessed	13 (16) ○○●	Yes
188	EU mandated reduction in consumption of lightweight plastic bags by implementing administrative and/or economic measures	Plastic bags of different size and colour (PLASTIC)	Not assessed	52 (31) ○●●	Not assessed	36 (30) ○○●	Yes

189	EU mandated increase in the share of reusable packaging on the market and of systems to reuse packaging in an environmentally sound manner	Food related items, such as containers, lolly sticks, wrappers, packets (PLASTIC); Drinking related items such as cups, caps, lids, six-pack rings (PLASTIC); Bottles and containers (PLASTIC); Industrial packaging, such as sheeting and strapping bands (PLASTIC)	Not assessed	49 (24) ○●●	Not assessed	37 (25) ○○●	Yes
190	Establishing systems to provide for return and/or collection of used packaging and packaging waste from consumers, including achieving 90% level of separate collection for beverage bottles	Food related items, such as containers, lolly sticks, wrappers, packets (PLASTIC); Drinking related items such as cups, caps, lids, six-pack rings (PLASTIC); Bottles and containers (PLASTIC); Glass and ceramic fragments of different sizes and other glass items (GLASS);	Not assessed	48 (22) ○●●	Not assessed	37 (20) ○●●	Yes
191	Modification of products and substitution of materials creating high risk litter for the marine environment	Food related items, such as containers, lolly sticks, wrappers, packets (PLASTIC); Drinking related items such as cups, caps, lids, six-pack rings (PLASTIC); Plastic bags of different size and colour (PLASTIC); Bottles and containers (PLASTIC); String and ropes of different size (PLASTIC); Industrial packaging, such as sheeting and strapping bands (PLASTIC); Single-use cutlery and straws (PLASTIC)	Not assessed	48 (29) ○○●	Not assessed	43 (31) ○○●	Yes
	Confidence		Moderate	Moderate	Moderate	Moderate	
	Number of experts		10-13	9-13	8-12	11-14	

Colour scale for the effectiveness of a measure type in percent (based on the expected value): 0-10%, 10-20%, 20-40%, 40-60%, 60-100%
Categories for the certainty of the effectiveness estimate (based on the relative size of the standard deviation to the expected value): low: ○○●, moderate: ○●●, high: ●●●
Data used: expert estimates of effectiveness of measure types
Full activity names:

- Fish and shellfish harvesting (all gears; professional, recreational)
- Tourism and leisure activities (boating, beach use, water sports, etc.)
- Transport – shipping (incl. anchoring, mooring)
- Riverine inputs covering other land-based activities (e.g. urban uses, wastewaters, solid waste)

Table 5.3 Effectiveness of measure types (%) in reducing the *direct input of microplastics*. Direct input of microplastics is defined as litter that enters the environment as a microplastic (primary microplastics). The effectiveness of a measure type is the percent reduction in the pressure resulting from a specific activity. The table depicts the most likely/expected values of effectiveness, and standard deviation is given in parenthesis.

Measure type ID	Activity Measure type	Riverine inputs covering other land-based activities	Has corresponding existing measures in the SOM analysis (Yes/No)
195	Regulatory measures or voluntary commitments by producers to avoid the use of microplastics in products (e.g. cosmetics, cleaning products).	38 (25) ○○●	Effectiveness values are not used in the SOM assessment and are advisory only
196	Information measures on microplastics in consumer products (e.g. awareness raising, implementing eco certification schemes)	30 (19) ○○●	
197	Regional (Baltic Sea) guidelines on best practice for improving wastewater systems and stormwater management	38 (19) ○●●	
198	Improving stormwater collection systems to prevent emissions of microlitter into the environment	47 (23) ○●●	
199	Improved wastewater treatment to reduce emissions of microplastics	46 (24) ○●●	
	Confidence	Moderate	
	Number of experts	12-13	

Colour scale for the effectiveness of a measure type in percent (based on the expected value): 0-10%, 10-20%, 20-40%, 40-60%, 60-100%
Categories for the certainty of the effectiveness estimate (based on the relative size of the standard deviation to the expected value): low: ○○●, moderate: ○●●, high: ●●●
Data used: expert estimates of effectiveness of measure types
Full activity names:

- Riverine inputs covering other land-based activities (e.g. urban uses, wastewaters, solid waste)

Which activities contribute to pressure inputs?

Table 6 shows the contribution of activities to the *input of top litter items to the beach*. Expert elicitation has been used to estimate the activity-pressure relationships for the input of beach litter. For the assessment, the Baltic Sea was divided into six sub-areas (Figure 2), and contributions are presented by item.

The number of countries contributing to the assessment per sub-area are presented separately in Table 7. The required amount of responses needed for inclusion into the SOM analyses differed across the six sub-areas, depending on the number of countries with a coastal border in the area. All assessed sub-areas had sufficient responses to be included in the analyses (please see Table 7 below).

Four activities were identified to contribute to the input of the 15 top litter items to the beach: *fish and shellfish harvesting*, *tourism and leisure activities*, *transport – shipping*, and *riverine inputs covering other land-based activities (e.g. urban uses, wastewaters, solid waste)*. The contribution of the activities to the input of beach litter varies in the six areas of the Baltic Sea and depends also on the litter item. Generally, *tourism and leisure activities* are the main contributors for the input of many of the litter items. In almost all areas of the Baltic Sea, these activities contribute the most to the input of the following litter items:

- Food related items, such as containers, lolly sticks, wrappers, packets (PLASTIC)
- Drinking related items such as cups, caps, lids, six-pack rings (PLASTIC)
- Plastic bags of different size and colour (PLASTIC)
- Bottles and containers (PLASTIC)
- Cigarette butts and remains (PLASTIC)
- Glass and ceramic fragments of different sizes and other glass items (GLASS)
- Drinking related items such as bottle caps, lids, pull tabs (METAL)
- Single-use cutlery and straws (PLASTIC)
- Drinking related cans (METAL)
- Foil wrappers and pieces of metal (METAL)

For the input of plastic and polystyrene pieces 0-50 cm (PLASTIC) and paper and cardboard items and pieces of different size (PAPER), *tourism and leisure activities* as well as *riverine inputs covering other land-based activities* contribute the most. *Shipping* has the highest contribution for industrial packaging, such as sheeting and strapping bands (PLASTIC), as well as processed wood and pieces of processed wood of different sizes (WOOD). *Fish and shellfish harvesting*, as well as *tourism and leisure activities* contribute the most to string and ropes of different sizes (PLASTIC).

The values in Table 6 can be adjusted to reflect total beach litter rather than the top 15 items using the “Top 15 litter items as percentage of all beach litter” data available in Annex 12.

The certainty of the activity-pressure input estimates ranges from low to high, depending on the item and sub-area.

Table 6. Activity-pressure contributions (%). The activity-pressure contributions show the percent share the activity contributes to the *input of 15 top litter items to the beach*. Standard deviation is given in parenthesis. The type of litter is given in parentheses.

Activity **Area and litter item**	**Fish and shellfish harvesting**	**Tourism and leisure activities**	**Transport – shipping**	**Riverine inputs covering other land-based activities (e.g. urban uses, wastewaters, solid waste)**
Kattegat & The Sound *Plastic and polystyrene pieces 0-50 cm (PLASTIC)*	11 (2) ●●●	20 (3) ●●●	2 (1) ○●●	67 (3) ●●●
Southwest *Plastic and polystyrene pieces 0-50 cm (PLASTIC)*	11 (2) ●●●	20 (3) ●●●	2 (1) ○●●	67 (3) ●●●
Southeast *Plastic and polystyrene pieces 0-50 cm (PLASTIC)*	23 (21) ○○●	51 (25) ○●●	22 (20) ○○●	4 (4) ○○●
Western Gotland Basin *Plastic and polystyrene pieces 0-50 cm (PLASTIC)*	16 (3) ●●●	38 (4) ●●●	11 (2) ●●●	35 (3) ●●●
Northeast *Plastic and polystyrene pieces 0-50 cm (PLASTIC)*	19 (6) ●●●	46 (9) ●●●	14 (4) ●●●	21 (7) ○●●
North *Plastic and polystyrene pieces 0-50 cm (PLASTIC)*	22 (3) ●●●	32 (3) ●●●	13 (3) ●●●	33 (3) ●●●
Kattegat & The Sound *Food related items, such as containers, lolly sticks, wrappers, packets (PLASTIC)*	2 (1) ○●●	58 (4) ●●●	2 (1) ○●●	37 (4) ●●●
Southwest *Food related items, such as containers, lolly sticks, wrappers, packets (PLASTIC)*	2 (1) ○●●	67 (10) ●●●	7 (5) ○○●	24 (11) ○●●
Southeast *Food related items, such as containers, lolly sticks, wrappers, packets (PLASTIC)*	24 (22) ○○●	57 (25) ○●●	14 (12) ○○●	5 (4) ○○●
Western Gotland Basin *Food related items, such as containers, lolly sticks, wrappers, packets (PLASTIC)*	6 (1) ●●●	64 (3) ●●●	6 (2) ●●●	23 (3) ●●●
Northeast *Food related items, such as containers, lolly sticks, wrappers, packets (PLASTIC)*	3 (1) ○●●	63 (6) ●●●	6 (5) ○○●	28 (5) ●●●
North *Food related items, such as containers, lolly sticks, wrappers, packets (PLASTIC)*	3 (1) ○●●	71 (3) ●●●	3 (2) ○●●	23 (3) ●●●

Activity Area and litter item	Fish and shellfish harvesting	Tourism and leisure activities	Transport – shipping	Riverine inputs covering other land-based activities (e.g. urban uses, wastewaters, solid waste)
Kattegat & The Sound *Drinking related items such as cups, caps, lids, six-pack rings (PLASTIC)*	5 (1) ●●●	56 (3) ●●●	2 (1) ○●●	36 (3) ●●●
Southwest *Drinking related items such as cups, caps, lids, six-pack rings (PLASTIC)*	4 (2) ○●●	66 (10) ●●●	7 (5) ○○●	23 (11) ○●●
Southeast *Drinking related items such as cups, caps, lids, six-pack rings (PLASTIC)*	10 (8) ○○●	66 (17) ●●●	20 (17) ○○●	4 (2) ○●●
Western Gotland Basin *Drinking related items such as cups, caps, lids, six-pack rings (PLASTIC)*	5 (2) ●●●	66 (4) ●●●	8 (2) ●●●	21 (3) ●●●
Northeast *Drinking related items such as cups, caps, lids, six-pack rings (PLASTIC)*	5 (2) ○●●	69 (6) ●●●	5 (3) ○○●	22 (5) ●●●
North *Drinking related items such as cups, caps, lids, six-pack rings (PLASTIC)*	3 (1) ○●●	71 (3) ●●●	3 (1) ○●●	23 (3) ●●●
Kattegat & The Sound *Plastic bags of different size and colour (PLASTIC)*	2 (1) ○●●	50 (3) ●●●	2 (1) ○●●	45 (3) ●●●
Southwest *Plastic bags of different size and colour (PLASTIC)*	3 (1) ○●●	58 (12) ●●●	8 (6) ○○●	31 (14) ○●●
Southeast *Plastic bags of different size and colour (PLASTIC)*	17 (4) ●●●	40 (4) ●●●	40 (4) ●●●	3 (1) ○●●
Western Gotland Basin *Plastic bags of different size and colour (PLASTIC)*	6 (2) ●●●	56 (4) ●●●	11 (2) ●●●	27 (3) ●●●
Northeast *Plastic bags of different size and colour (PLASTIC)*	8 (5) ○○●	60 (5) ●●●	7 (2) ●●●	25 (4) ●●●
North *Plastic bags of different size and colour (PLASTIC)*	3 (1) ○●●	68 (3) ●●●	8 (2) ●●●	22 (3) ●●●
Kattegat & The Sound *Bottles and containers (PLASTIC)*	2 (1) ○●●	36 (3) ●●●	2 (1) ○●●	59 (3) ●●●
Southwest *Bottles and containers (PLASTIC)*	3 (1) ○●●	58 (17) ●●●	7 (6) ○○●	32 (17) ○●●

Activity Area and litter item	Fish and shellfish harvesting	Tourism and leisure activities	Transport – shipping	Riverine inputs covering other land-based activities (e.g. urban uses, wastewaters, solid waste)
Southeast *Bottles and containers (PLASTIC)*	10 (8) ○○●	66 (17) ●●●	20 (17) ○○●	4 (2) ○●●
Western Gotland Basin *Bottles and containers (PLASTIC)*	6 (2) ●●●	57 (3) ●●●	10 (2) ●●●	27 (3) ●●●
Northeast *Bottles and containers (PLASTIC)*	11 (4) ○●●	58 (8) ●●●	12 (4) ○●●	19 (6) ○●●
North *Bottles and containers (PLASTIC)*	7 (2) ●●●	64 (3) ●●●	7 (2) ●●●	21 (3) ●●●
Kattegat & The Sound *String and ropes of different size (PLASTIC)*	40 (3) ●●●	40 (3) ●●●	17 (2) ●●●	2 (1) ○●●
Southwest *String and ropes of different size (PLASTIC)*	52 (10) ●●●	22 (12) ○●●	24 (5) ●●●	2 (1) ○●●
Southeast *String and ropes of different size (PLASTIC)*	82 (3) ●●●	3 (1) ○●●	13 (3) ●●●	3 (1) ○●●
Western Gotland Basin *String and ropes of different size (PLASTIC)*	48 (3) ●●●	29 (3) ●●●	19 (3) ●●●	4 (1) ○●●
Northeast *String and ropes of different size (PLASTIC)*	54 (8) ●●●	15 (7) ○●●	23 (4) ●●●	8 (2) ●●●
North *String and ropes of different size (PLASTIC)*	12 (3) ●●●	75 (3) ●●●	12 (2) ●●●	2 (1) ○●●
Kattegat & The Sound *Cigarette butts and remains*	5 (1) ○○●	71 (3) ●●●	2 (1) ○●●	21 (3) ●●●
Southwest *Cigarette butts and remains*	4 (2) ○○●	68 (5) ●●●	6 (4) ○○●	23 (4) ●●●
Southeast *Cigarette butts and remains*	3 (1) ○○●	91 (2) ●●●	3 (1) ○●●	3 (1) ○●●
Western Gotland Basin *Cigarette butts and remains*	4 (1) ○●●	74 (3) ●●●	5 (1) ●●●	17 (3) ●●●
Northeast *Cigarette butts and remains*	4 (2) ○●●	76 (5) ●●●	6 (4) ○○●	14 (3) ●●●
North *Cigarette butts and remains*	2 (1) ○●●	75 (3) ●●●	7 (2) ●●●	15 (2) ●●●
Kattegat & The Sound *Glass and ceramic fragments of different sizes and other glass items (GLASS)*	3 (1) ●●●	65 (4) ○○●	16 (3) ●●●	16 (3) ●●●

Activity Area and litter item	Fish and shellfish harvesting	Tourism and leisure activities	Transport – shipping	Riverine inputs covering other land-based activities (e.g. urban uses, wastewaters, solid waste)
Southwest *Glass and ceramic fragments of different sizes and other glass items (GLASS)*	3 (1) ●●●	65 (4) ○○●	16 (3) ●●●	16 (3) ●●●
Southeast *Glass and ceramic fragments of different sizes and other glass items (GLASS)*	13 (13) ●●●	58 (24) ○○●	24 (21) ○○●	5 (4) ○○●
Western Gotland Basin *Glass and ceramic fragments of different sizes and other glass items (GLASS)*	5 (2) ●●●	75 (3) ○●●	13 (3) ●●●	8 (2) ●●●
Northeast *Glass and ceramic fragments of different sizes and other glass items (GLASS)*	3 (1) ●●●	83 (6) ○●●	8 (6) ○○●	6 (3) ○●●
North *Glass and ceramic fragments of different sizes and other glass items (GLASS)*	3 (1) ●●●	91 (2) ○●●	3 (1) ○●●	3 (1) ○●●
Kattegat & The Sound *Industrial packaging, such as sheeting and strapping bands (PLASTIC)*	2 (1) ○●●	2 (1) ○●●	47 (3) ○○●	48 (3) ●●●
Southwest *Industrial packaging, such as sheeting and strapping bands (PLASTIC)*	3 (1) ○●●	3 (1) ○●●	61 (14) ●●●	33 (15) ○●●
Southeast *Industrial packaging, such as sheeting and strapping bands (PLASTIC)*	3 (1) ○●●	3 (1) ○●●	68 (3) ○●●	26 (3) ●●●
Western Gotland Basin *Industrial packaging, such as sheeting and strapping bands (PLASTIC)*	3 (1) ○●●	3 (1) ○●●	68 (3) ○●●	26 (3) ●●●
Northeast *Industrial packaging, such as sheeting and strapping bands (PLASTIC)*	3 (1) ○●●	3 (1) ○●●	91 (2) ○●●	3 (1) ○●●
North *Industrial packaging, such as sheeting and strapping bands (PLASTIC)*	3 (1) ○●●	3 (1) ○●●	91 (2) ○●●	3 (1) ○●●
Kattegat & The Sound *Processed wood and pieces of processed wood of different sizes (WOOD)*	29 (3) ●●●	12 (2) ●●●	29 (3) ●●●	29 (3) ○○●

Activity Area and litter item	Fish and shellfish harvesting	Tourism and leisure activities	Transport – shipping	Riverine inputs covering other land-based activities (e.g. urban uses, wastewaters, solid waste)
Southwest *Processed wood and pieces of processed wood of different sizes (WOOD)*	18 (15) ○○●	16 (5) ○●●	39 (9) ●●●	27 (10) ○●●
Southeast *Processed wood and pieces of processed wood of different sizes (WOOD)*	33 (3) ●●●	3 (1) ○●●	32 (3) ●●●	32 (3) ○○●
Western Gotland Basin *Processed wood and pieces of processed wood of different sizes (WOOD)*	20 (3) ●●●	9 (2) ●●●	49 (4) ●●●	22 (3) ○●●
Northeast *Processed wood and pieces of processed wood of different sizes (WOOD)*	14 (6) ○●●	7 (5) ○○●	62 (15) ●●●	17 (15) ○○●
North *Processed wood and pieces of processed wood of different sizes (WOOD)*	13 (3) ●●●	3 (1) ○●●	82 (3) ●●●	3 (1) ○○●
Kattegat & The Sound *Drinking related items such as bottle caps, lids, pull tabs (METAL)*	2 (1) ○●●	75 (3) ●●●	2 (1) ○●●	20 (3) ●●●
Southwest *Drinking related items such as bottle caps, lids, pull tabs (METAL)*	2 (1) ○●●	75 (3) ●●●	2 (1) ○●●	20 (3) ●●●
Southeast *Drinking related items such as bottle caps, lids, pull tabs (METAL)*	3 (1) ○●●	91 (2) ●●●	3 (1) ○●●	3 (1) ○●●
Western Gotland Basin *Drinking related items such as bottle caps, lids, pull tabs (METAL)*	2 (1) ○●●	73 (3) ●●●	4 (1) ○●●	20 (3) ●●●
Northeast *Drinking related items such as bottle caps, lids, pull tabs (METAL)*	3 (1) ○●●	75 (12) ●●●	8 (5) ○○●	15 (12) ○○●
North *Drinking related items such as bottle caps, lids, pull tabs (METAL)*	2 (1) ○●●	59 (3) ●●●	2 (1) ○●●	37 (3) ●●●
Kattegat & The Sound *Single-use cutlery and straws (PLASTIC)*	2 (1) ○●●	75 (3) ●●●	2 (1) ○●●	20 (3) ●●●

Activity Area and litter item	Fish and shellfish harvesting	Tourism and leisure activities	Transport – shipping	Riverine inputs covering other land-based activities (e.g. urban uses, wastewaters, solid waste)
Southwest *Single-use cutlery and straws (PLASTIC)*	2 (1) o●●	76 (3) ●●●	2 (1) o●●	20 (3) oo●
Southeast *Single-use cutlery and straws (PLASTIC)*	3 (1) o●●	92 (2) ●●●	3 (1) o●●	3 (1) o●●
Western Gotland Basin *Single-use cutlery and straws (PLASTIC)*	2 (1) o●●	72 (3) ●●●	4 (1) o●●	21 (3) o●●
Northeast *Single-use cutlery and straws (PLASTIC)*	2 (1) o●●	70 (8) ●●●	7 (5) oo●	20 (8) o●●
North *Single-use cutlery and straws (PLASTIC)*	2 (1) o●●	59 (3) ●●●	2 (1) o●●	37 (3) oo●
Kattegat & The Sound *Paper and cardboard items and pieces of different size (PAPER)*	2 (1) o●●	47 (3) ●●●	2 (1) o●●	47 (3) ●●●
Southwest *Paper and cardboard items and pieces of different size (PAPER)*	2 (1) o●●	48 (3) ●●●	2 (1) o●●	47 (3) ●●●
Southeast *Paper and cardboard items and pieces of different size (PAPER)*	3 (1) o●●	91 (2) ●●●	3 (1) o●●	3 (1) o●●
Western Gotland Basin *Paper and cardboard items and pieces of different size (PAPER)*	4 (1) ●●●	54 (3) ●●●	6 (1) o●●	36 (3) ●●●
Northeast *Paper and cardboard items and pieces of different size (PAPER)*	8 (6) oo●	54 (12) ●●●	8 (6) oo●	30 (14) o●●
North *Paper and cardboard items and pieces of different size (PAPER)*	2 (1) o●●	44 (3) ●●●	11 (2) ●●●	43 (3) ●●●
Kattegat & The Sound *Drinking related cans (METAL)*	2 (1) o●●	70 (3) ●●●	2 (1) o●●	26 (3) ●●●
Southwest *Drinking related cans (METAL)*	2 (1) o●●	70 (3) ●●●	2 (1) o●●	26 (3) ●●●
Southeast *Drinking related cans (METAL)*	9 (8) oo●	62 (21) o●●	25 (22) oo●	3 (2) oo●
Western Gotland Basin *Drinking related cans (METAL)*	4 (1) o●●	63 (3) ●●●	10 (1) ●●●	23 (3) o●●
Northeast *Drinking related cans (METAL)*	3 (1) o●●	59 (3) ●●●	3 (1) o●●	35 (3) ●●●
North *Drinking related cans (METAL)*	2 (1) o●●	59 (3) ●●●	2 (1) o●●	37 (3) ●●●
Kattegat & The Sound *Foil wrappers and pieces of metal (METAL)*	2 (1) o●●	91 (2) ●●●	3 (1) o●●	3 (1) o●●

Activity Area and litter item	Fish and shellfish harvesting	Tourism and leisure activities	Transport – shipping	Riverine inputs covering other land-based activities (e.g. urban uses, wastewaters, solid waste)
Southwest *Foil wrappers and pieces of metal (METAL)*	3 (1) ○●●	92 (2) ●●●	3 (1) ○●●	3 (1) ○●●
Southeast *Foil wrappers and pieces of metal (METAL)*	6 (2) ●●●	88 (2) ●●●	3 (1) ○●●	3 (1) ○●●
Western Gotland Basin *Foil wrappers and pieces of metal (METAL)*	6 (2) ●●●	88 (2) ●●●	3 (1) ○●●	3 (1) ○●●
Northeast *Foil wrappers and pieces of metal (METAL)*	13 (3) ●●●	82 (3) ●●●	3 (1) ○●●	3 (1) ○●●
North *Foil wrappers and pieces of metal (METAL)*	6 (2) ●●●	88 (2) ●●●	3 (1) ○●●	3 (1) ○●●

Colour scale for the activity-pressure contribution in percent (based on the expected value):

0-10%, 10-20%, 20-40%, 40-60%, 60-100%

Categories for the certainty of the activity-pressure contribution (based on the relative size of the standard deviation to the expected value): low: ○○●, moderate: ○●●, high: ●●●

Data used: expert estimates of activity-pressure input contributions

Table 7. Number of countries contributing to the activity-pressure survey for top litter items to the beach per assessed sub-area (see Figure 2 for sub-area divisions).

Assessed sub-areas	Number of responding countries	Fulfilled required minimum number of responses for analyses
Kattegat& The Sound	2	yes
Southwest	3	yes
Southeast	3	yes
Western Gotland Basin	1	yes
Northeast	3	yes
North	2	yes

What are the impacts of measure types?

The impacts of measure types show the impact of measure types on reducing the input of beach litter to the Baltic Sea. They include the effectiveness of measure types and the contribution of activities to this input. Thus, the impact shows how much the measure type reduces the pressure input across all activities contributing to the pressure input and gives indications on which measures could be the most relevant in addressing the input of the 15 top beach litter items. The estimates are presented by litter item, and thus give the percent reduction in the input of that specific item in the sub-area in question (see Annex 11). Note that this presentation format differs from the presentation of the effectiveness of measure type estimates, which are presented as the percent reduction in the input of all top litter items. The basin-specific share of the item of the total input of 15 top beach litter items is provided in Annex 12.

Detailed information about the impacts of measure types is available in Annex 11.

One of the most impactful measures addressing different litter types is the prohibition of placing certain single-use plastic products on market to address the problem of single-use cutlery and straws in Southeast Baltic Sea assessment area. For the North of the Baltic Sea, establishing systems to provide for return and/or collection of used packaging and packaging waste from consumers is considered very effective in terms of addressing glass and ceramic fragments of different sizes and other glass items. In the Kattegat and Sound, reducing the amount of plastic litter through improving municipal regulatory provisions, prohibition of placing certain single use plastic products on the market, and awareness raising measures are considered most effective. In the North of the Baltic Sea establishing systems to provide for return and/or collection of used packaging and packaging waste, reducing the amount of plastic litter through improving municipal regulatory provisions and the establishment of extended producer responsibility schemes are expected to be effective.

In the Northeast of the Baltic Sea the full implementation of the no-special fee system in ports, establishing systems to provide for return and /or collection of used packaging and improving municipal regulatory provisions are among three most effective measures.

In the Southeast of the Baltic Sea the prohibition for placing on market certain single-use plastic products, modification of products and substitution of materials as well as recusing the amount of plastic litter through improvising municipal regulatory provisions are the most effective ones.

In the Southern Baltic Sea region, the most effective measures are considered to be reducing the amount of plastic litter through municipal regulatory provisions, prohibition of placing on market certain single-use plastic products on the market and public awareness raisin measures.

In the Western Gotland Basin measures such as reducing the amount of plastic litter through improving municipal regulatory provisions, prohibition for placing certain single-use plastic products on the market and public awareness raising are expected to be most effective ones.

Main litter items that could benefit from implementation of most effective measures would be single-use cutlery and straws, glass and ceramic fragments, cigarette butts and remains, drinking related items made of metal such as bottle caps, lids or pull tabs and foil wrappers and pieces of metal.

The prioritisation of effective measures in different regions of the Baltic Sea varies a greatly. This might be because of the fact that items of concern are different across the region and furthermore since the level of implementation of already existing measures differs widely.

What are the impacts of existing measures?

This section presents information about existing measures affecting activities and pressures for input of top beach litter items. In the SOM analysis, existing measures are those measures in current policy frameworks (e.g. BSAP, EU MSFD, EU WFD, EU Biodiversity Strategy 2020) that affect pressures and environmental state within the time frame of the analysis (2016–2030). This includes measures that have been implemented, are partially implemented or are planned to be implemented by 2030. Measures which have already been fully implemented and have fully affected pressures and environmental state by 2016 have been excluded, as no further improvement of status is expected during in 2016–2030. Information about existing measures was compiled through a literature review and supplemented by Contracting Parties.

The impact is the percent reduction in a specific pressure from implementing the measure in the relevant spatial area. It has been calculated based on the effectiveness of the measure, proxied by the effectiveness of the measure type it corresponds to, and the contribution of activities to the pressure in question. Similar to the impact of a measure type, the impact of an existing measure indicates how much the measure reduces the pressure across all activities contributing to the pressure.

The impacts of existing measures for reducing the input of top litter items to the beach are presented in Annex 13. They are presented both at the Baltic Sea scale and for the area affected by the existing measure. In addition, information on the share of the Baltic Sea area affected by the existing measure is included. Both the effectiveness of the measure and the spatial area affected are relevant for the impact at the Baltic Sea scale. Some existing measures may have high impact in the affected area, but their impact at the Baltic Sea scale is low because they only affect a small localised area, while some measures may have a relatively low impact in the affected area but affect a large share of the Baltic Sea.

There are altogether around 50 existing measures affecting the input of top beach litter items. The application area of many measures covers over 90% of the Baltic Sea. At the Baltic Sea scale, the most impactful measures include several public awareness and education raising measures, as well as EU packaging waste Directive Article 7 (used packaging return, collection and recovery systems) and EU single-use plastics Directive Article 8 (extended producer responsibility). Existing measures having the largest impacts in the area affected include public awareness measures as well as information and clean-up campaigns.

Background of respondents

For the litter effectiveness of measures survey 11 survey responses, inclusive of 14 contributing experts, were received. Two of the answers were group responses, with two and three contributing experts. For the activity-pressure survey, six responses were received, each from a different contracting party. The number of experts contributing to the litter surveys is shown in Table 8.

Table 8. Number of experts contributing to the litter surveys

Survey	DE	DK	EE	FI	LT	LV	PL	RU	SE	Total
Effectiveness of measures	2	3	2	1	1	1	1	-	3	14
Activity-pressure contributions	1	1	1	1	-	-	1	-	1	6

More detailed information about the background of experts participating in the effectiveness of measures survey is available (Table 9). Experts stated most often litter or marine science as their respective field, but also ecology/earth science and nature protection were mentioned. Almost half of the experts had 5-10 years of experience in their field, while about 20% had over 20 years or 0-2 years of experience, and the rest between 3-5 years or 10-20 years of experience. Experts represented research institutions, NGOs, government institutes, state agencies or ministries.

Table 9. Years of experience in the field for the litter effectiveness of measures survey.

	Effectiveness of measures survey	
Years	**Number of experts**	**Share of experts**
0-2 years	3	21 %
3-5 years	1	7 %
5-10 years	6	43 %
10-20 years	1	7 %
over 20 years	3	21 %

Discussion

Impact of alternative scenarios for development of human activities

The detailed results are presented for the most likely development scenario for the extent of human activities in 2016–2030. In addition, three other development scenarios were estimated: no change, low change and high change scenarios. These scenarios cover 9 out of the 31 activities in the SOM analysis. The extent of other activities is assumed to remain constant in all scenarios.

As activities contribute to pressure inputs, their assumed change over time affects the pressure input reductions and probability to achieve GES or state improvements. The impact depends on to what extent the activities contributing to the specific pressure input are covered in the change scenarios. For marine litter, the coverage of activities that contribute to pressure inputs in the change scenarios is rather high, commonly70-95%.

In the most likely scenario, fish and shellfish harvesting is assumed to stay constant until 2030, and tourism and leisure activities and shipping are expected to increase by 30% and 20%, respectively. The impact of the assumption on the development scenario is limited for litter, as differences in the projected reductions in the input of top beach litter items are minor across the scenarios (0-6%). This is likely due to the high cumulative effect of existing measures, which will also affect the increased activities and, in that way, counteract the changes in the extent of activities.

Impact of using literature data on effectiveness of measures

In addition to survey data from experts, literature data on the effectiveness of measures has been compiled. The literature data points have been used in a similar way as the expert survey responses, and when it has been available, it has been used to replace the expert estimates of the effectiveness of the measure type. However, literature estimates are not available for all measure types. Thus, it is not possible to implement the model estimation and provide the results relying entirely on the literature data on effectiveness of measure types. Thus, the model including the literature estimates is a combination of literature and expert data on effectiveness of measure types. The origin of other data components is not affected.

For marine litter, 12 estimates from 6 studies could be included in the SOM model. The projected reductions in the input of top beach litter items are not significantly affected by the inclusion of literature data, as only a few estimates could be included in the SOM model. The difference in the projected pressure reductions ranges from 0 to 4%, being lower for the estimates that include the literature data.

Evaluation of quality and confidence

The SOM analysis for marine litter has evaluated the pressure reductions in the input of beach litter, as without GES threshold values a proper sufficiency of measures analysis has

not been possible. All results have been presented in a quantitative format, as the data have been deemed to suffice for that. However, the analysis has not included a link between the input and effects of litter. Thus, the SOM assessment has not been able to provide results on how the effects of litter might change, and SOM results for the other topics which may be affected by marine litter do not take into account the reduction in the input of beach litter estimated in this report. In addition, the analysis for litter included only beach litter, with focus on the 15 top litter items found on beaches. An estimate of the expected reduction in total beach litter has also been calculated based on the share of top 15 litter items of all beach litter, but it is a rough estimate since it assumes no reductions in the input of other items from existing measures. Effectiveness of measures in reducing the direct input of microplastics were provided, but these were not included further in the analysis and the results do not include pressure reductions in microlitter. Other types of marine litter are outside the scope of the current analysis.

The overall certainty of the assessment for litter could generally be characterized as moderate. The number of expert responses to the effectiveness of measures survey is relatively high, and experts from eight coastal countries have contributed to the assessment. The most common confidence level experts reported for their own evaluations of the effectiveness of measures is moderate. For the activity-pressure contributions, estimates from six countries were received. For the individual results, the average certainty ranges were from low to high for the activity-pressure contributions, and from low to moderate for the effectiveness of measures types. The projected reductions in the input of litter are estimated to have high certainty, but as they are calculated by combining the projected reductions in the input of various litter items, the standard deviations may not be the best indicator of the accuracy of the results. Probability distributions provided in the annexes should be consulted whenever possible.

Two sources of uncertainty specific to litter are i) the exceptionally large number of measures which increases the risk of overcounting overlapping measures and ii) the high frequency of EU directives calling for measures that do not yet have concrete national implementations. To mitigate the risk of overlaps between measures of various policies (e.g. EU directives and HELCOM policy frameworks, and national PoMs in some cases), great care was taken to group similar measures into distinct measure types. Additionally, the conservative methodology applied, where only one instance of any given measure type could be implemented in a given area, further reduces the risk of overcounting. Nevertheless, the very large number of new measures may create additional risk of this effect and therefore could be introducing additional uncertainty into the results. Concerning the estimation of the effectiveness of EU directives currently lacking national implementations, expert evaluation of effectiveness is necessarily based on the language of the directive and perhaps early discussions of national actions. This will increase the uncertainty of the measure effectiveness estimates but this should be captured in the expert responses (i.e. more unknows lead to wider ranges of estimated effectiveness). The methodology should be robust to this potential issue, but this could be one reason for large variation in the effectiveness assessments from the survey.

There were some technical challenges that affected the survey implementation. Firstly, there was a problem in the survey software for the effectiveness of measure types survey that resulted in losing some responses. The original responses became often unusable, as it was not possible to identify which items had been intentionally omitted and which were lost

data. This issue was addressed by sending follow-up invitations for experts to review and, when needed, complement their original saved response. Not all experts participated in the review and those responses that were not confirmed to be correct/complete were deleted from the final sample, thus the final numbers presented above represent only those with completed and reviewed responses. Secondly, the simultaneous assessment of effectiveness of a measure type and certainty of that effectiveness proved in some cases difficult, as it required placing non-quantitative pointers in a coordinate system to generate quantitative estimates. The pointers were translated into effectiveness and certainty values between 0 and 100. Some experts would have preferred that the quantitative estimates would have been visible and could have been transparently influenced.

When interpreting the results, the assumptions and generalizations that were made when collecting the input data and defining and using the data on activity-pressure input contributions, measure type effectiveness and pressure-state linkages need to be taken into account. The input data are based mainly on expert elicitations rather than existing models and data and reflect substantial uncertainty. For example, no distinction has been made between different types of beaches (rural, peri-urban and urban) which can influence the interpretation of the results. For more information on the SOM methodology, data collection and assumptions, see this document.

Reflection on measure types

The unique design of the measure types for marine litter – where measure types impact all or a subset of the top litter items and effectiveness is the average of the impacted items – appears to have functioned relatively well. Additionally, the SOM Litter Topic Team did excellent work in the thorough coverage of the topic by the measure types. However, the complexity and novelty of the topic in general makes a deeper analysis of the measure types (i.e. grouped measures as applied in the assessment of other topics) difficult. More would be learned on reflection following the development of another topic to a similar level of detail as marine litter.

Measure types should be further elaborated in terms of identifying more exactly which specific actions contribute to the implementation of measures. This would enable more accurate assessments of the effects proposed measures.

Lessons learned

The complex design of the marine litter topic pushed the boundaries of the SOM analysis and has helped to outline the limits of topic-specific modifications possible with the given resources. In essence, marine litter has been run as 15 different sub-pressures that combine into the single pressure *input of top litter items to the beach* assessed over six areas, resulting in a total of 90 tracked sub-pressure/area combinations. Significant effort is saved through the combined design of the measure types, though the maximum number of pressure-area combinations in any of the other topics is 34, with the average number of combinations between 10 and 20. Besides the larger effort, the design of marine litter has somewhat outpaced the design of the general SOM approach applied to other topics, as issues relating

to the complex interplay between sub-pressures, sub-areas, and Baltic wide estimates of effectiveness have not otherwise been fully explored. While the challenges caused by this analysis have clear benefits to future work, our analysis of the topic is hampered by the novel complexity and project resource constraints.

While it is clear that the item-specific approach is more appropriate from a management perspective when assessing marine litter, the analysis only managed to assess 74% of macro marine litter monitored on beaches. However, marine litter is more complex than just macro litter or beach litter alone. From the perspective of the integrated SOM model, this ratio of topic coverage (i.e. not all aspects relevant for litter as a whole are addressed) to workload is highly unbalanced. Ideally the topic would cover all of beach litter, seafloor litter and micro litter, using no more resources than was required to reach the partial coverage of beach litter achieved here. A major aspect of any future work will be improving the coverage and accuracy of the existing topic analyses. It may be that the workload required by this iteration of marine litter is common for highly tailored topic assessments, but at present the recommendation is to scale back future analyses of marine litter. This could be achieved without sacrificing the item-specific approach by e.g. reducing the number of litter items, areas, or beach types that are included in the assessment.

One aspect outside the project's control that may aid in future SOM litter assessments would be a more integrated assessment of beach litter at the regional level. Currently, differences in what kind of beaches are surveyed, how many beaches are surveyed, and unclear quantities of each beach type hinder the kind of topic synthesis that would simplify a sufficiency of measures assessment. While the monitoring program does provide the required knowledge for proposing targeted measures and is aligned with regulatory instruments at international, regional and European levels, further standardization of the beach litter monitoring program or data set within the region could alleviate some of the issues identified.

In order to improve similar assessments in the future, more accurate data on all aspects would be needed. This would mean that clear connections should be established between activities, pressures, pathways and impacts of marine litter. This exercise will take time but will be crucial when improving the quality of data on effects of different measures and addressing the most emerging problems of marine litter. While the data on beach litter was used in this assessment there are still vast areas of the sea that are directly or indirectly affected by litter. We can find litter on the sea, in the water column, on the bottom of the sea. Monitoring and data collection for those matrices is yet to be developed and implemented.

Use of results, implications and future perspectives

The results provide rich material for analysing the effectiveness of various measures for achieving reductions in the input of beach litter and, in the future, also potential HELCOM targets for marine litter. Even if the calculated expected reductions are rough estimates, the detailed results on effectiveness and impacts of measures are also useful.

The assessment collects the best available information and knowledge in the region and provides detailed results for analysing activity-pressure-item-measure linkages for future policy making. These detailed results are informative for the EU MSFD Programmes of

Measures purposes and also for existing policies where the (national) measures/regulations are still under development. They can potentially indicate what could be the effect of these policies and specific measures for reducing marine litter.

Despite not being of a conclusive nature, the results of the SOM analysis could be used to assist in the revision process of the Regional Action Plan on Marine Litter, in particular in those actions aimed at addressing specific litter items.

The main limitation is the lack of time to analyse more profoundly the results, including drawing more detailed conclusion on policy gaps in terms of activities/ items/ types of measures.

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SOM report series

HELCOM ACTION 2021a. Sufficiency of existing measures to achieve good status in the Baltic Sea. Available at: http://www.helcom.fi/SOM/MainSOMReport

HELCOM ACTION 2021b. Methodology for the sufficiency of measures analysis. Available at: http://www.helcom.fi/SOM/MethodologyReport

HELCOM ACTION 2021c. A practical guide to interpreting the SOM results. Available at: http://www.helcom.fi/SOM/PracticalGuide

HELCOM ACTION 2021d. Sufficiency of existing measures for benthic habitats in the Baltic Sea. Available at: http://www.helcom.fi/SOM/BenthicHabitatsReport

HELCOM ACTION 2021e. Sufficiency of existing measures for coastal fish in the Baltic Sea. Available at: http://www.helcom.fi/SOM/CoastalFishReport

HELCOM ACTION 2021f. Sufficiency of existing measures for commercial fish in the Baltic Sea. Available at: http://www.helcom.fi/SOM/CommercialFishReport

HELCOM ACTION 2021g. Sufficiency of existing measures for hazardous substances in the Baltic Sea. Available at: http://www.helcom.fi/SOM/HazardousSubstancesReport

HELCOM ACTION 2021h. Sufficiency of existing measures for input of nutrients in the Baltic Sea. Available at: http://www.helcom.fi/SOM/NutrientsReport

HELCOM ACTION 2021i. Sufficiency of existing measures for marine litter in the Baltic Sea. Available at: http://www.helcom.fi/SOM/MarineLitterReport

HELCOM ACTION 2021j. Sufficiency of existing measures for marine mammals in the Baltic Sea. Available at: http://www.helcom.fi/SOM/MarineMammalsReport

HELCOM ACTION 2021k. Sufficiency of existing measures for migratory fish in the Baltic Sea. Available at: http://www.helcom.fi/SOM/MigratoryFishReport

HELCOM ACTION 2021l. Sufficiency of existing measures for non-indigenous species in the Baltic Sea. Available at: http://www.helcom.fi/SOM/NISReport

HELCOM ACTION 2021m. Sufficiency of existing measures for underwater noise in the Baltic Sea. Available at: http://www.helcom.fi/SOM/UnderwaterNoiseReport

HELCOM ACTION 2021n. Sufficiency of existing measures for waterbirds in the Baltic Sea. Available at: http://www.helcom.fi/SOM/WaterbirdsReport

HELCOM ACTION 2021o. Sufficiency and cost-effectiveness of potential new measures to achieve good status in the Baltic Sea. Available at: http://www.helcom.fi/SOM/CostEffectivenessReport

Model code is available at: https://github.com/LiisaSaikkonen/ACTION_SOM

Annexes

Annexes 1–9 contain the expert surveys as well as information on the measure types and the literature review. They are available on the SOM Platform workspace.

Annexes 10–13 contain graphs and tables that provide additional information and perspectives on the results.

Annex 1 Activity-pressure input survey template

Excel used as a template for receiving data for the activity-pressure input survey.

Annex 2 Modified activity list (if modified)

Excel containing the modified activity list.

Annex 3 Measure types list

PDF containing the measure types used in the assessment of the effectiveness of measures for *Marine litter*. Document includes examples of existing measures that if implemented would be included in the corresponding measure type.

Annex 4 Linking existing measures to measure types

Excel containing the identified existing measures and their relationship to the measure types used in the SOM analysis.

Annex 5 Literature review search terms

Excel containing the search terms used during the literature review on effectiveness of measures for *Marine litter*.

Annex 6 Literature review summary

Excel document containing the effectiveness of measures data retrieved from the literature review.

Annex 7 Topic structure

Excel containing the relationships between measure types, activities, pressure inputs, and sub-basins.

Annex 8 Effectiveness of measures survey

PDF of the Effectiveness of measures survey for *Marine litter*.

Annex 9 Pressure-state survey

The SOM analysis for *Marine litter* does not include an analysis to state, so no pressure-state survey is available.

Annex 10 Supplementary results for effectiveness of measures

Table A1. Distribution of the effectiveness of measure types in reducing the *input of top litter items to the beach* for measure types affecting all litter items. The effectiveness of a measure type is the percent reduction in a pressure resulting from a specific activity. The graphs present the probability distribution of effectiveness, based on expert responses or literature estimates. The dashed line represents the expected value. Figures showing only a dashed line and no apparent probability distribution are point estimates without variation.

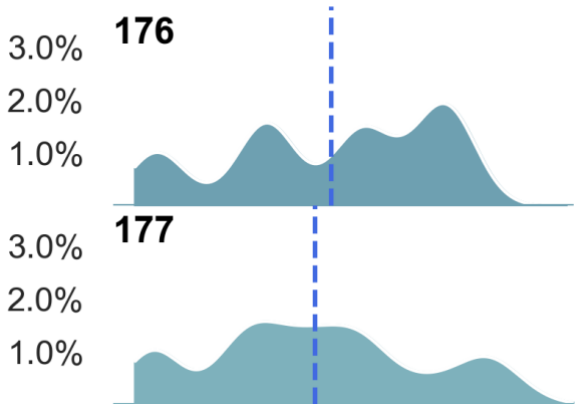
Pressure input: Input of top litter items to the beach

Activity: Fish and shellfish harvesting (all gears; professional, recreational)

Measure type: 176: No-special fee system for waste reception in ports from fishing vessels, including for the litter caught in fishing nets

177: Information and education to fishermen about management and environmental impacts of fishing gear containing plastics and best practice in waste management within fishing sector

Expert assessment: 10-13 experts, confidence = moderate



Pressure input: Input of top litter items to the beach

Activity: Tourism and leisure activities (boating, beach use, water sports, etc.)

Measure type: 182: Reducing the amount of plastic litter through improving municipal regulatory provisions concerning organisation of beach waste management, requirements for waste management and clean-up for public beach events and leases on beaches (all litter items)

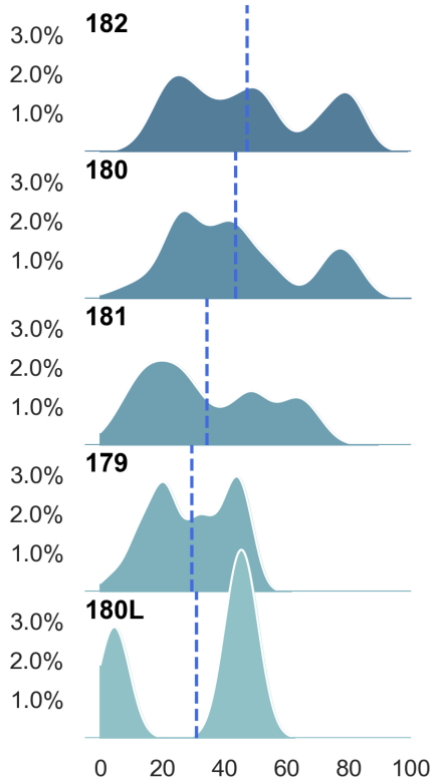
180: Public awareness raising measures on marine litter impacts and prevention, promotion of sustainable consumption and production and appropriate waste management of single-use plastic products (all litter items)

181: Including marine litter issues in educational programs and materials for recreational sea use sectors (e.g. for diving and sailing schools) (all litter items)

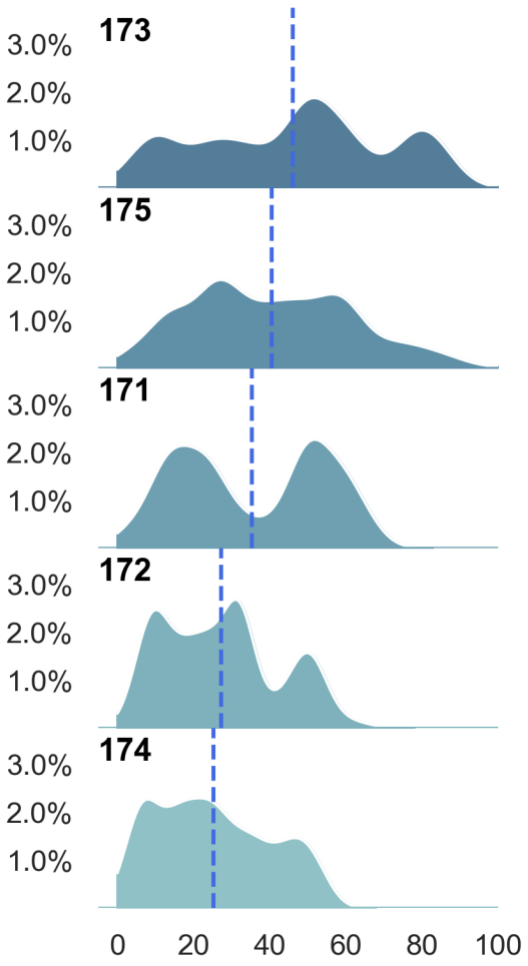
179: Promotion of garbage collection for pleasure crafts by marinas (e.g. through ecolabeling, such as Blue Flag) (all litter items)

180L: Public awareness raising measures on marine litter impacts and prevention, promotion of sustainable consumption and production and appropriate waste management of single-use plastic products (all litter items) (literature based)

Expert assessment: 9-13 experts, confidence = moderate



Pressure input:	Input of top litter items to the beach
Activity:	Transport – shipping (incl. anchoring, mooring)
Measure type:	173: Full implementation of the no-special fee system for waste reception in all Baltic Sea ports (all litter items)
	175: Including marine litter issues in educational programs and materials for professional sea use sectors (all litter items)
	171: More stringent controlling and reporting of ships' delivery of waste in ports (all litter items)
	172: Implementation of ISO standard for port waste reception facilities (all litter items)
	174: Implementing ecolabel schemes and/or incentive systems for environmentally friendly shipping (all litter items)
Expert assessment:	8-12 experts, confidence = moderate



Pressure input: Input of top litter items to the beach

Activity: Riverine inputs covering other land-based activities

Measure type: 193: Improving stormwater collection systems to prevent emissions of litter into the environment (all litter items)

194: Including marine litter in national and municipal waste management plans and implementing provisions of these plans in coastal municipalities to prevent litter entering the aquatic environment (all litter items)

192: Regional (Baltic Sea) guidelines on best practice for improving wastewater systems and stormwater management (all litter items)

180: Public awareness raising measures on marine litter impacts and prevention, promotion of sustainable consumption and production and appropriate waste management of single-use plastic products (all litter items) (figure missing)

180L: Public awareness raising measures on marine litter impacts and prevention, promotion of sustainable consumption and production and appropriate waste management of single-use plastic products (all litter items)

Expert assessment: 11-14 experts, confidence = moderate

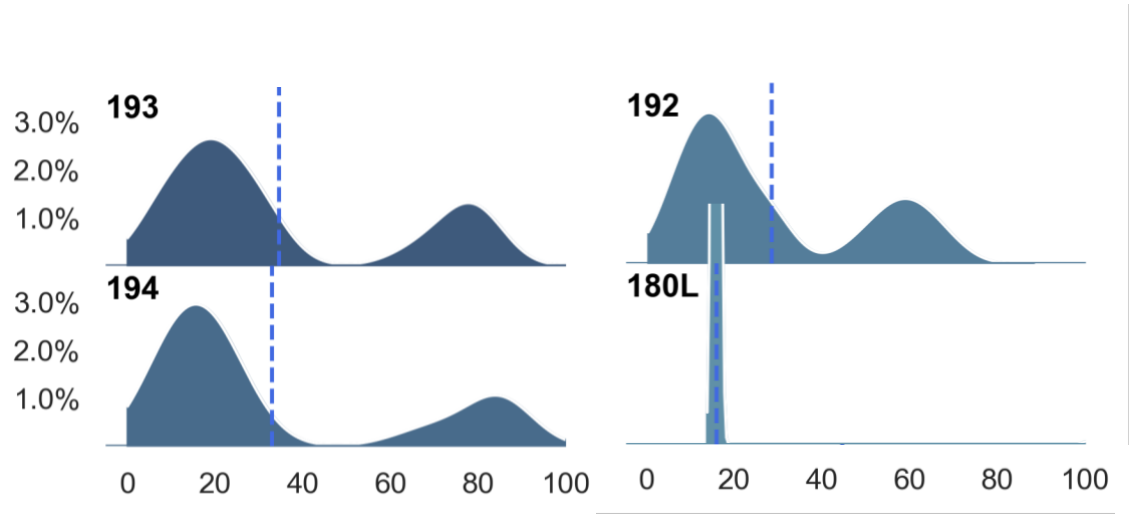


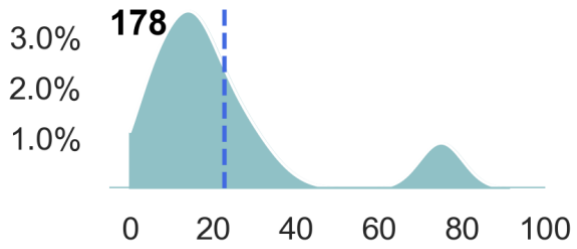
Table A2. Distribution of the effectiveness of measure types in reducing the *input of top litter items to the beach* for measure types affecting a subset of top litter items. The effectiveness of a measure type is the percent reduction in a pressure resulting from a specific activity. The graphs present the probability distribution of effectiveness, based on expert responses or literature estimates. The dashed line represents the expected value. Figures showing only a dashed line and no apparent probability distribution are point estimates without variation.

Pressure input: String and ropes of different size (PLASTIC))

Activity: Fish and shellfish harvesting (all gears; professional, recreational)

Measure type: 178: Improvement in the marking of fishing gear and reporting on lost fishing gear

Expert assessment: 10-13 experts, confidence = moderate

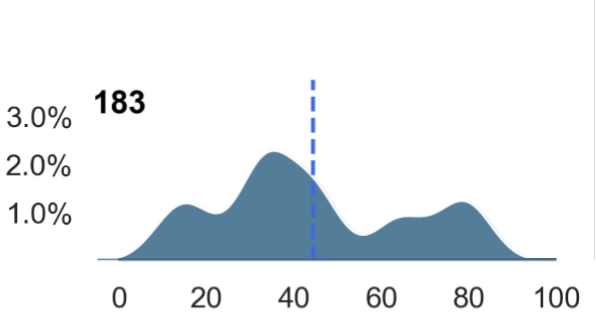


Pressure input: Food related items, such as containers, lolly sticks, wrappers, packets (PLASTIC); Drinking related items such as cups, caps, lids, six-pack rings (PLASTIC)

Activity: Tourism and leisure activities (boating, beach use, water sports, etc.)

Measure type: 183: National measures for "significant reduction" in consumption of single-use plastic food containers and beverage cups (following relevant EU Directives)

Expert assessment: 9-13 experts, confidence = moderate

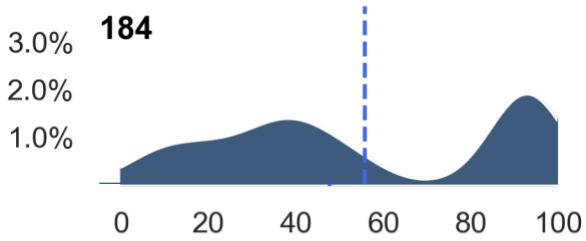


Pressure input: Single-use cutlery and straws (PLASTIC)

Activity: Tourism and leisure activities (boating, beach use, water sports, etc.)

Measure type: 184: Prohibition for placing on market certain single-use plastic products (cotton bud sticks, cutlery, plates, straws, beverage stirrers, balloons sticks)

Expert assessment: 9-13 experts, confidence = moderate

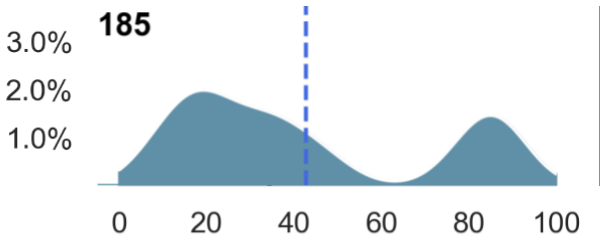


Pressure input: Drinking related items such as cups, caps, lids, six-pack rings (PLASTIC)

Activity: Tourism and leisure activities (boating, beach use, water sports, etc.)

Measure type: 185: Requiring that plastic caps and lids remain attached to single use plastic beverage containers during the product's intended use

Expert assessment: 9-13 experts, confidence = moderate

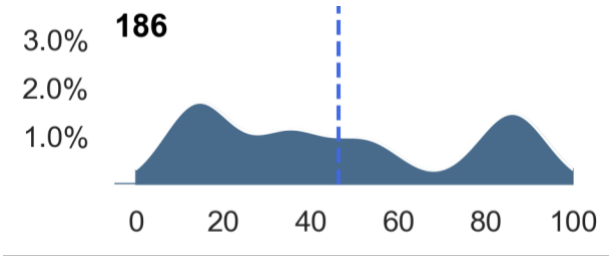


Pressure input: Food related items, such as containers, lolly sticks, wrappers, packets (PLASTIC); Drinking related items such as cups, caps, lids, six-pack rings (PLASTIC); Plastic bags of different size and colour (PLASTIC); Bottles and containers (PLASTIC); String and ropes of different size (PLASTIC); Cigarette butts and remains; Glass and ceramic fragments of different sizes and other glass items (GLASS); Industrial packaging, such as sheeting and strapping bands (PLASTIC)

Activity: Tourism and leisure activities (boating, beach use, water sports, etc.)

Measure type: 186: Establishing extended producer responsibility schemes for all packaging and plastic products which create the most frequently found litter items in the marine environment

Expert assessment: 9-13 experts, confidence = moderate



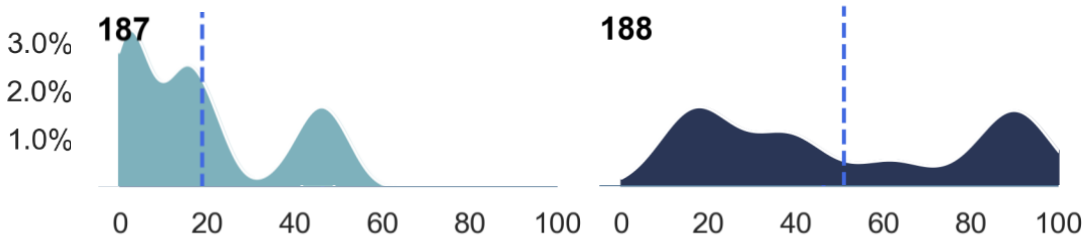
Pressure input: Plastic bags of different size and colour (PLASTIC)

Activity: Tourism and leisure activities (boating, beach use, water sports, etc.)

Measure type: 187: Labelling biodegradable and compostable plastic bags

188: Reduction in consumption of lightweight plastic bags by implementing administrative and/or economic measures

Expert assessment: 9-13 experts, confidence = moderate

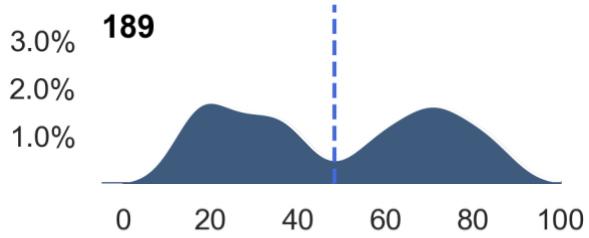


Pressure input: Food related items, such as containers, lolly sticks, wrappers, packets (PLASTIC); Drinking related items such as cups, caps, lids, six-pack rings (PLASTIC); Bottles and containers (PLASTIC); Industrial packaging, such as sheeting and strapping bands (PLASTIC)

Activity: Tourism and leisure activities (boating, beach use, water sports, etc.)

Measure type: 189: Increase in the share of reusable packaging on the market and of systems to reuse packaging in an environmentally sound manner

Expert assessment: 9-13 experts, confidence = moderate

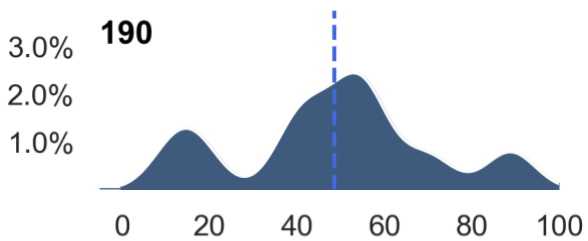


Pressure input: Food related items, such as containers, lolly sticks, wrappers, packets (PLASTIC); Drinking related items such as cups, caps, lids, six-pack rings (PLASTIC); Bottles and containers (PLASTIC); Glass and ceramic fragments of different sizes and other glass items (GLASS)

Activity: Tourism and leisure activities (boating, beach use, water sports, etc.)

Measure type: 190: Establishing systems to provide for return and/or collection of used packaging and packaging waste from consumers, including achieving 90% level of separate collection for beverage bottles

Expert assessment: 9-13 experts, confidence = moderate

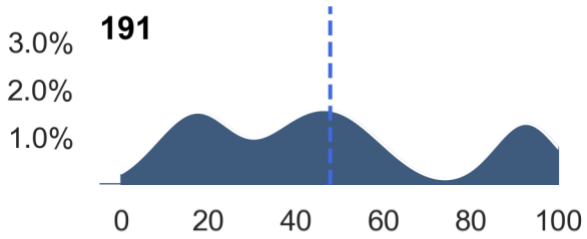


Pressure input: Food related items, such as containers, lolly sticks, wrappers, packets (PLASTIC); Drinking related items such as cups, caps, lids, six-pack rings (PLASTIC); Plastic bags of different size and colour (PLASTIC); Bottles and containers (PLASTIC); String and ropes of different size (PLASTIC); Industrial packaging, such as sheeting and strapping bands (PLASTIC); Single-use cutlery and straws (PLASTIC)

Activity: Tourism and leisure activities (boating, beach use, water sports, etc.)

Measure type: 191: Modification of products and substitution of materials creating high risk litter for the marine environment

Expert assessment: 9-13 experts, confidence = moderate



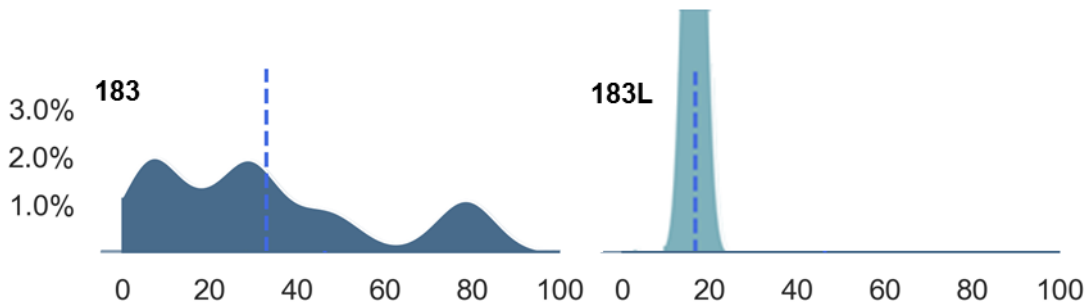
Pressure input: Food related items, such as containers, lolly sticks, wrappers, packets (PLASTIC); Drinking related items such as cups, caps, lids, six-pack rings (PLASTIC)

Activity: Riverine inputs covering other land-based activities

Measure type: 183: National measures for "significant reduction" in consumption of single-use plastic food containers and beverage cups (following relevant EU Directives)

183L: National measures for "significant reduction" in consumption of single-use plastic food containers and beverage cups (following relevant EU Directives) (literature based)

Expert assessment: 11-14 experts, confidence = moderate

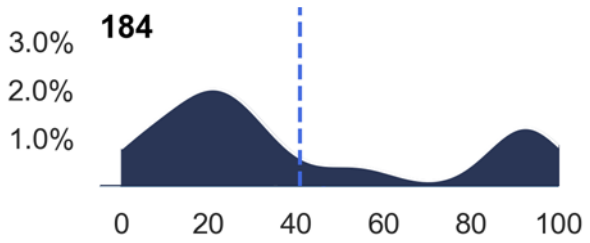


Pressure input: Single-use cutlery and straws (PLASTIC)

Activity: Riverine inputs covering other land-based activities

Measure type: 184: Prohibition for placing on market certain single-use plastic products (cotton bud sticks, cutlery, plates, straws, beverage stirrers, balloons sticks)

Expert assessment: 11-14 experts, confidence = moderate

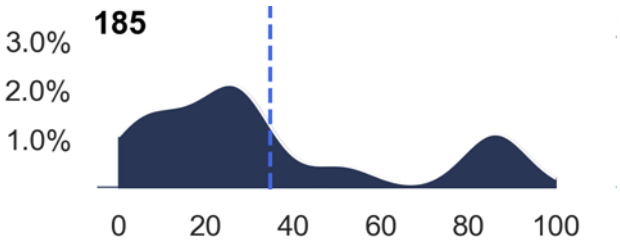


Pressure input: Drinking related items such as cups, caps, lids, six-pack rings (PLASTIC)

Activity: Riverine inputs covering other land-based activities

Measure type: 185: Requiring that plastic caps and lids remain attached to single use plastic beverage containers during the product's intended use

Expert assessment: 11-14 experts, confidence = moderate

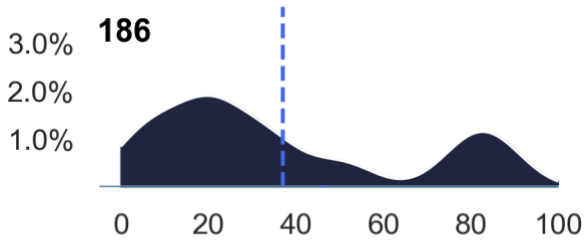


Pressure input: Food related items, such as containers, lolly sticks, wrappers, packets (PLASTIC); Drinking related items such as cups, caps, lids, six-pack rings (PLASTIC); Plastic bags of different size and colour (PLASTIC); Bottles and containers (PLASTIC); String and ropes of different size (PLASTIC); Cigarette butts and remains; Glass and ceramic fragments of different sizes and other glass items (GLASS); Industrial packaging, such as sheeting and strapping bands (PLASTIC)

Activity: Riverine inputs covering other land-based activities

Measure type: 186: Establishing extended producer responsibility schemes for all packaging and plastic products which create the most frequently found litter items in the marine environment

Expert assessment: 11-14 experts, confidence = moderate



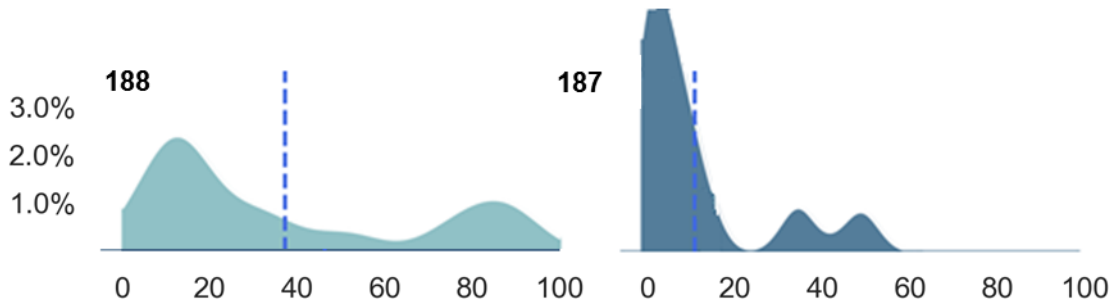
Pressure input: Plastic bags of different size and colour (PLASTIC)

Activity: Riverine inputs covering other land-based activities

Measure type: 188: Reduction in consumption of lightweight plastic bags by implementing administrative and/or economic measures

187: Labelling biodegradable and compostable plastic bags

Expert assessment: 11-14 experts, confidence = moderate

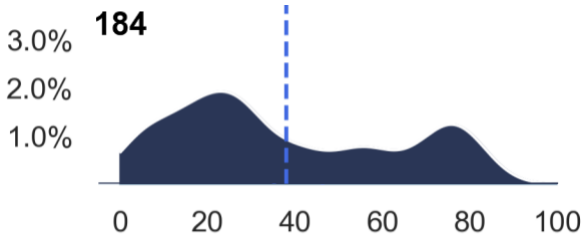


Pressure input: Food related items, such as containers, lolly sticks, wrappers, packets (PLASTIC); Drinking related items such as cups, caps, lids, six-pack rings (PLASTIC); Bottles and containers (PLASTIC); Industrial packaging, such as sheeting and strapping bands (PLASTIC)

Activity: Riverine inputs covering other land-based activities

Measure type: 189: Increase in the share of reusable packaging on the market and of systems to reuse packaging in an environmentally sound manner

Expert assessment: 11-14 experts, confidence = moderate



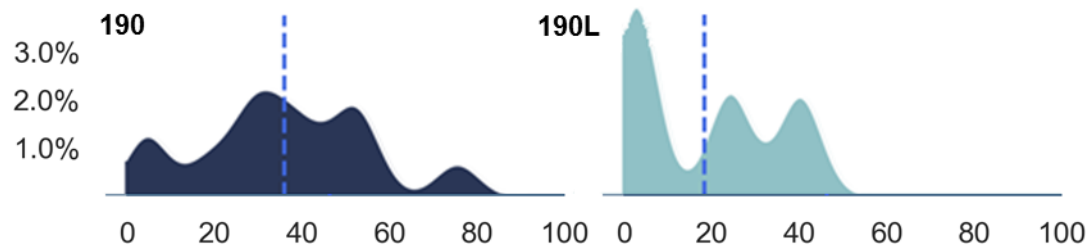
Pressure input: Food related items, such as containers, lolly sticks, wrappers, packets (PLASTIC); Drinking related items such as cups, caps, lids, six-pack rings (PLASTIC); Bottles and containers (PLASTIC); Glass and ceramic fragments of different sizes and other glass items (GLASS)

Activity: Riverine inputs covering other land-based activities

Measure type: 190: Establishing systems to provide for return and/or collection of used packaging and packaging waste from consumers, including achieving 90% level of separate collection for beverage bottles

190L: Establishing systems to provide for return and/or collection of used packaging and packaging waste from consumers, including achieving 90% level of separate collection for beverage bottles (literature based)

Expert assessment: 11-14 experts, confidence = moderate

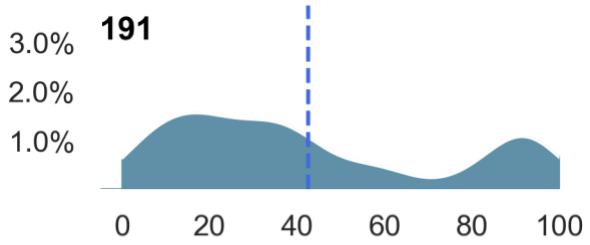


Pressure input: Food related items, such as containers, lolly sticks, wrappers, packets (PLASTIC); Drinking related items such as cups, caps, lids, six-pack rings (PLASTIC); Plastic bags of different size and colour (PLASTIC); Bottles and containers (PLASTIC); String and ropes of different size (PLASTIC); Industrial packaging, such as sheeting and strapping bands (PLASTIC); Single-use cutlery and straws (PLASTIC)

Activity: Riverine inputs covering other land-based activities

Measure type: 191: Modification of products and substitution of materials creating high risk litter for the marine environment

Expert assessment: 11-14 experts, confidence = moderate



Annex 11 Impacts of measure types

Table A3. Impacts of measure types (%) in reducing the input of a specific beach litter item in the sub-area in question. The impact shows how much the measure type reduces the pressure input across all activities contributing to the pressure input.

The impact table is provided as an excel file in the SOM workspace.

Annex 12 Litter items by sub-basin

Table A4. Share of each of the top 15 litter items to the total of the top 15 top litter items to the beach by sub-basin. Top 15 litter items as percentage of all beach litter by sub-basin is also shown. Paraffin litter types are excluded from this calculation due to extreme regional variation.

ID	Litter item	Kattegat & The Sound	South	Western Gotland Basin	Southeast	Northeast	North	Whole Baltic
1	Plastic and polystyrene pieces 0-50 cm (PLASTIC)	49%	28%	25%	16%	38%	29%	26%
2	Food related items, such as containers, lolly sticks, wrappers, packets (PLASTIC)	5%	9%	10%	3%	7%	9%	6%
3	Drinking related items such as cups, caps, lids, six-pack rings (PLASTIC)	4%	14%	6%	8%	7%	6%	9%
4	Plastic bags of different size and colour (PLASTIC)	9%	5%	5%	2%	5%	2%	4%
5	Bottles and containers (PLASTIC)	3%	4%	1%	1%	2%	4%	2%
6	String and ropes of different size (PLASTIC)	9%	5%	2%	3%	3%	4%	3%
7	Cigarette butts and remains	4%	12%	7%	34%	12%	11%	21%
8	Glass and ceramic fragments of different sizes and other glass items (GLASS)	0%	6%	2%	1%	6%	1%	4%
9	Industrial packaging, such as sheeting and strapping bands (PLASTIC)	2%	4%	1%	1%	4%	1%	2%
10	Processed wood and pieces of processed wood of different sizes (WOOD)	7%	3%	3%	17%	4%	4%	9%
11	Drinking related items such as bottle caps, lids, pull tabs (METAL)	1%	2%	10%	5%	3%	2%	4%
12	Single-use cutlery and straws (PLASTIC)	2%	3%	14%	4%	3%	7%	4%
13	Paper and cardboard items and pieces of different size (PAPER)	5%	3%	11%	2%	4%	13%	3%
14	Drinking related cans (METAL)	2%	1%	1%	3%	1%	1%	2%
15	Foil wrappers and pieces of metal (METAL)	1%	2%	4%	1%	3%	5%	2%
	Top 15 litter items as percentage of all beach litter	70%	65%	80%	75%	81%	74%	74%

Annex 13 Impacts of existing measures

Table A5. Impacts of existing measures (%) in reducing the input of top beach litter items. Impact is the percent reduction in the input of 15 top litter items to the beach from implementing the measure. Both means and standard deviations are presented. Note that values less than 0.5 have been rounded to zero.

The impact table is provided as an excel file in the SOM workspace.