Task 2.1.2 Development of baselines of marine litter - Litter on the seafloor in the HELCOM area- analyses of data from BITS trawling hauls 2012-2016

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Contents

Summary

This report contains an analysis of amounts of marine litter recorded in trawl hauls under the BITS (Baltic international trawl surveys) monitoring programme, during the years 2012-2016.

- Data from 1599 hauls were used. The data set contained samples from 9 sub regions: The Bornholm Basin, The Arkona Basin, The Eastern Gotland Basin, The Great Belt, The Kiel Bay, The Western Gotland Basin, The Bay of Mecklenburg, The Gdansk Basin, and the Northern Baltic Proper (listed in decreasing order of sampling frequency).
- Sampling frequency has increased over the years, from 257 reported hauls in 2012 to 433 hauls in 2016.
- 42 % of the hauls contained no items.
- The average total number of items overall years was 58.9± 20.9 items per km^2 (Average ± 95 confidence interval). The average total weight of items overall years was 85.3±65.2 kg per km^2 (Average ± 95% confidence interval).
- There is no statistically significant trend of decreasing number of items per unit area. However, this trend should be interpreted with caution, as the geographical scope of trawl hauls has changed during the period with the addition of hauls from the Gdansk Basin and the Northern Baltic Proper in 2015-2016. There is no statistically significant trend in the weight of items.
- The average number of items differed significantly among sub-basins, with the Western Gotland Basin having significantly higher numbers than other basins.
- For weights, the tows from the Northern Baltic proper were significantly higher than hauls from all other sub-regions. However, this analysis is based on the contents of only 9 hauls, and must therefore be interpreted with caution. There were no statistically significant differences among other sub-regions.
- The different sub regions showed different trends. Arkona basin and Eastern Gotland basin show signs of a decreasing trend, but these trends are not statistically significant. Kiel Bay has a statistically significant increasing trend. Other areas show no clear tendencies of trends.
- Items made from natural materials is most common both in terms of number of items (44.6%) and in terms of weight (56.6%). Plastic is the second most common material category (30.6% of number of items, 15.7% of the weight).
- The composition of litter differed significantly among sub-regions. While items made from natural materials dominated in most regions, plastic items dominated in hauls from the Northern Baltic proper and the Gdansk basin, and metal items dominated in the Kiel bay.
- If items made from natural materials are excluded from the analysis, a somewhat different pattern emerges, with a weak but statistically significant increase with time in the number of items found on the seafloor.

Scope of this report

This report is produced as a part of the EU project “Implementation and development of key components for the assessment of Status, Pressures and Impacts, and Social and Economic evaluation in the Baltic Sea marine region” (SPICE). The report contains an analysis of amounts of marine litter recorded in trawl hauls under the BITS (Baltic international trawl surveys) monitoring programme, during the years 2012-2016. This version of the report describes the results of the analyses made during late October 2017.

Data sources

The analyses in this report are based on data collected in the BITS (Baltic international trawl surveys) programme during the years 2012-2016. This programme is designed for the estimation of fish stocks, but also records the number and/or weight of litter items, as specified in standardised protocols common for the BITS and the IBTS (International benthic trawl surveys) programmes. Data on marine litter in the format of "Litter exchange data" was downloaded from the ICES DATRAS database on May 17, 2017.

GIS layers on HELCOM sub regions (GIS layer "HELCOM Sub basins") and on sediment types (GIS layer "Seabed sediment polygon (BALANCE)") were downloaded from the HELCOM Data and Map service in September 2016.

Data handling

Data from the DATRAS database recorded using the protocols C-TS-REV and RECO-LT was included in the analyses for this report. These protocols differ mainly in the definitions used to separate items into categories (See ICES DATRAS website for further details about these protocols). In the DATRAS dataset for BITS, data points recoded under the protocol RECO-LT mainly consist of "0" (zero) or missing data ("-9"). A limited number of RECO-LT data points also contain data on items found. For the purpose of this report, the RECO-LT data marked as either "0" or "-9" was included as hauls that did not contain litter. The BITS data set also includes some hauls taken in the OSPAR region; for this report however, only data from the HELCOM region was included.

Two types of trawls distinguished by size are used in the BITS programme: TVL (full name TV3 930 meshes) and TVS (full name TV3 520 meshes), see Table 1. For this analysis, data collected by both trawl types have been used, but using different data on trawls width (see below). If the two trawls have different catchability profiles, it is not suitable to mix the data, but for this report it has been assumed that there are no differences between the trawls except the area swept.

Table 1: type of trawl used for collecting litter data

Country	Gear used
DK	TVS+TVL
ES	TVS
DE	TVS
LV	TVL
LT	TVS
PL	TVL
SE	TVL

The DATRAS litter exchange data is reported as number and/or weight of litter in a single haul. Hauls can be of different duration, so data was standardised to number and weight per area (km^2) trawled. The area is calculated by multiplying the length of the haul by the width of the haul. The length of the hauls is either given directly (commonly in meter) or can be calculated from the duration of the haul (in minutes) multiplied by the speed of the vessel. The width of the haul is more complicated to assess. In the BITS dataset, several different measures of the width of a haul are given, commonly the distance between the trawl doors (door spread). For litter data however, the distance between trawl wings (wingspread) is probably the most relevant measure of width, but this is less commonly reported. For an image explaining the difference between these two distances, see Appendix 1. The information on trawl width is handled differently among countries: some countries report on both measures for each individual haul, some countries report only on door width for individual hauls, some countries report the same standard width for all hauls, and some countries give no information on the width of the haul. For future analyses, it would be highly desirable if wingspread was reported for each individual haul. For the purpose of this report, Swedish data on the ratio Door spread/wingspread have been used to calculate wingspread for TVL for Swedish and Danish hauls (set to 30.7 m) and Polish data to set the wingspread for Polish and Latvian TVL hauls (27 m), and Estonian data to calculate wingspread for TVS (set to 16 m).

Based on the criteria described above, there were 1599 hauls during the period 2012-2016 with recorded litter data. Figure 1 shows the geographical distribution of trawl hauls. Of these, all 1599 hauls included data on litter weight, while 1253 included data on litter numbers. The difference consists of hauls where weight was recorded but not the number of items.

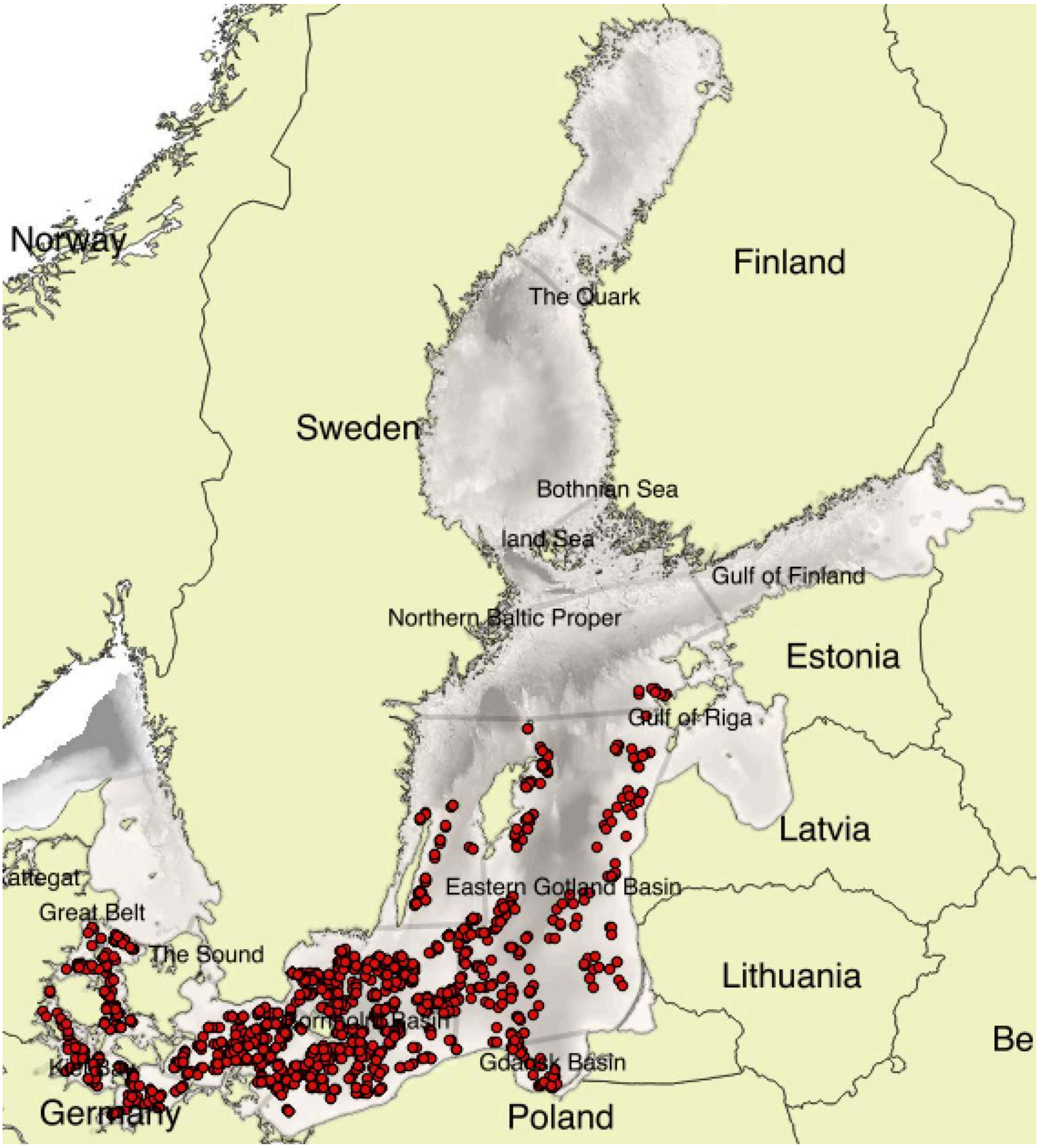


Figure 1: Trawl haul stations used for the analysis of this report. The map shows hauls taken during the period 2012-2016.

The number of hauls per year with data on litter has increased with time (Table 2), from 257 hauls in 2012 to 433 in 2016.

Table 2: The number of hauls meeting the criteria for inclusion in the analyses in this report.

Year	Number of hauls
2012	257
2013	309
2014	265
2015	335
2016	433

Statistical analyses

Data were visually checked for heterogeneity of variances and non-normality using residual plots and Levene's test of equality of error variances. As data commonly had a relationship between residuals and mean, data was Ln(x+1)-transformed for statistical analyses. Overall differences among quarters or regions were assessed with One-way Anova. Differences among individual groups were assessed with Games-Howell post-hoc tests. Temporal trends were assessed by linear regression: If the variances remained heterogeneous or the data distribution remained strongly non-normal after LN-transformation, differences among means were analysed with Kruskal-Wallis test, and temporal trends were analysed with Kendall Rank correlation analysis. All statistical analyses were done using the software IBM SPSS Statistics v 24 or V25.

GIS analyses

Position data of hauls were combined with GIS layers on HELCOM sub regions and on BALANCE sediment data to assign sub region and sediment characteristics for each haul. Analyses were done using the software QGIS 2.18.

Number and weight of litter items in all sub regions combined

The average total number of items overall years was 58.9± 20.9 items per km^2 (Average ± 95 confidence interval). The average total weight of items overall years was 85.3±65.2 kg per km^2 (Average ± 95% confidence interval). The coefficient of variation (CV) for the number of items was 659%, while the coefficient of variation for weights was 1558%, indicating that the variable weight differs more among hauls than the variable numbers.

Trawl hauls in the BITS programme are taken twice each year, during Quarter 1 and Quarter 4. The average number of items found in hauls was 100.5 ±16.1 during Quarter 1 and 79.9 ±11.8 during Quarter 4 (average ± 95% confidence limit), but this difference is marginally non-significant (One-way ANOVA $F_{1,743}$=3.66, P=0.053). In contrast, the average weight was higher during Quarter 4 (35.4±24.6 kg/km^2) than in Quarter 1 (19.8±5.7 kg/km^2), but this difference is non-significant (One-way ANOVA $F_{1,969}$=0.17, P=0.895). For the rest of this report, data from both quarters is therefore pooled for analyses.

Proportion of items in different material categories in all sub regions combined

The proportion of different materials is given in table 3 below. Items made from natural materials is most common both in terms of number of items (44.6%) and in terms of weight (56.6%). Plastic is the second most common material category (30.6% of number of items, 15.7% of the weight). A list of what types of objects are identified in different material categories in the CTS-REV protocol is included in Appendix 2. The large amount of natural products (wood, paper, natural fibers and other natural materials) makes the interpretation of trends and amounts more complicated. Therefore, at the end of this report a section on some results from analyses with litter items made from natural materials excluded (i.e., excluding material category E, See Appendix 2) is included.

Table 3: The proportion of items in different material categories for all sub-regions combined.

Material	Proportion (%) by number of items	Proportion (%) by weight
Plastic	30.6	15.7
Metal	7.5	11.2
Rubber	2.7	2.6
Glass and ceramics	8.6	6.1
Natural	44.6	56.6
Miscellaneous	6.1	7.8

Temporal trends of litter items in all sub regions combined

The temporal development of the number of items per km^2 is shown in Figure 2 below. There is no statistically significant trend of decreasing number of items (based on either correlation or linear regression). However, this absence of a trend should be interpreted with caution, as the geographical scope of trawl hauls has changed during the period (see section on sub regional analyses below), with the addition of hauls from the Gdansk Basin and the Northern Baltic Proper in 2015-2016. As the geographical scope of the monitoring program can be expected to improve or at least stabilize in the future, temporal trends over the entire region will be easier to interpret.

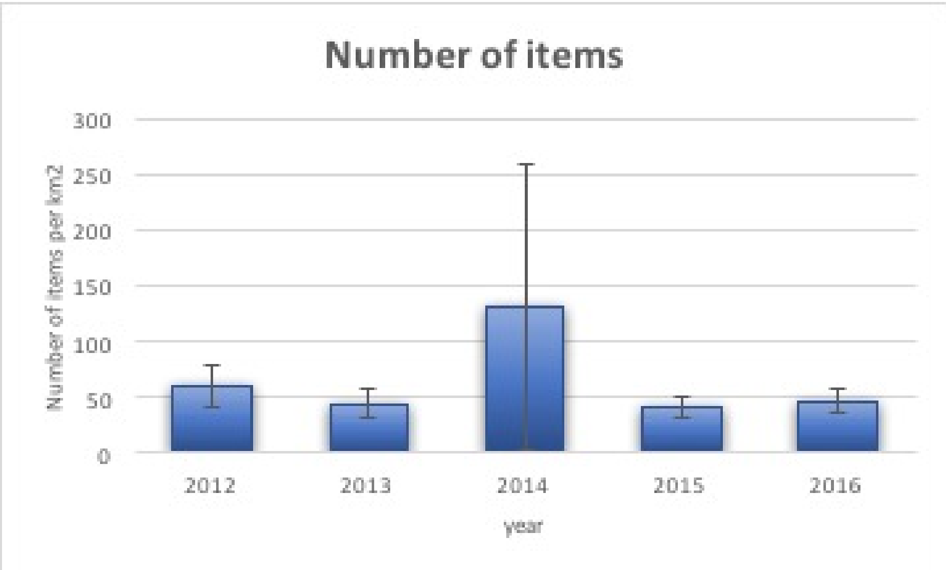


Figure 2: The average number per km^2 of items (±95% confidence interval) found in trawl hauls.

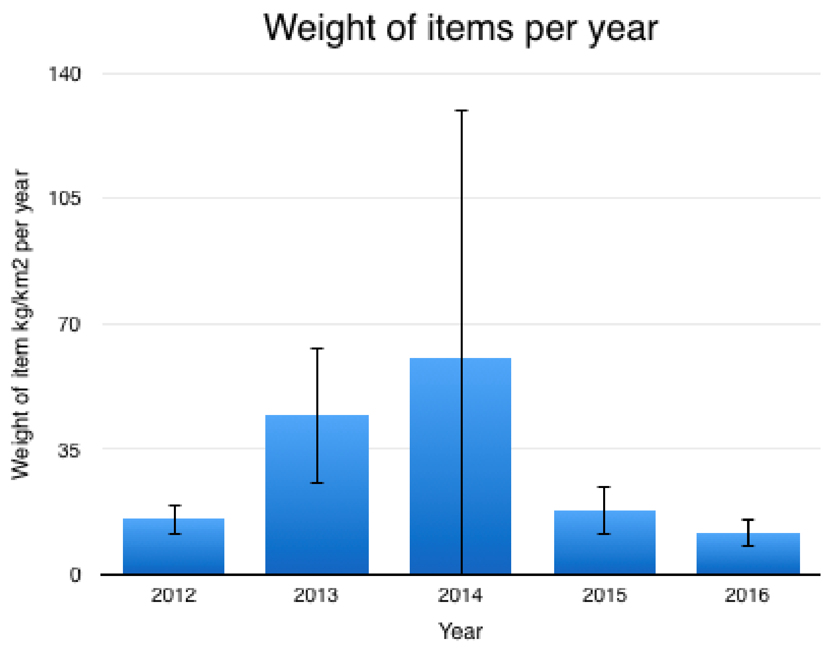


Figure 3: The average weight (kg/ per km^2) of items (±95% confidence interval) found in trawl hauls.

The temporal development of the average weight of items per years does not show a statistically significant decreasing trend. As shown in Figure 3 the average weight increases until 2014 with a decrease after that. Note however the great variability in the 2014 data.

HELCOM sub regions: Number of items all years combined

The number of hauls differed among sub regions (Table 4), with the highest number of hauls in the Bornholm basin, and the lowest number of hauls in the Northern Baltic Proper.

Table 4: Number of hauls in the different sub-basins. Note that many hauls contained data for both number and weight, therefore numbers add up to more than 1599 hauls.

Sub-region	Number of hauls with weight data	Number of hauls with number of items data	Number of hauls with no litter	Percentage hauls with no litter
Arkona basin	315	314	157	50%
Bay of Mecklenburg	58	57	23	40%
Bornholm Basin	648	479	223	34%
Eastern Gotland basin	295	247	93	32%
Gdansk basin	29	29	8	28%
Great belt	125	0	114	91%
Kiel Bay	61	59	36	59%
Northern Baltic proper	9	9	2	22%
Western Gotland basin	59	59	5	8%
Total	1599	1253	661	42%

In total, 42 % of the hauls did not contain any litter items, but this proportion differed significantly among sub-basins: while 91 % of the hauls from the Great Belt did not contain litter, only 8 % of the hauls from the Western Gotland basin were empty.

The average number of items differed significantly among sub-basins (One-way ANOVA $F_{7,737}$=11.1, P<0.001), with the Western Gotland Basin significantly higher than other basins (Games-Howell post-hoc test).

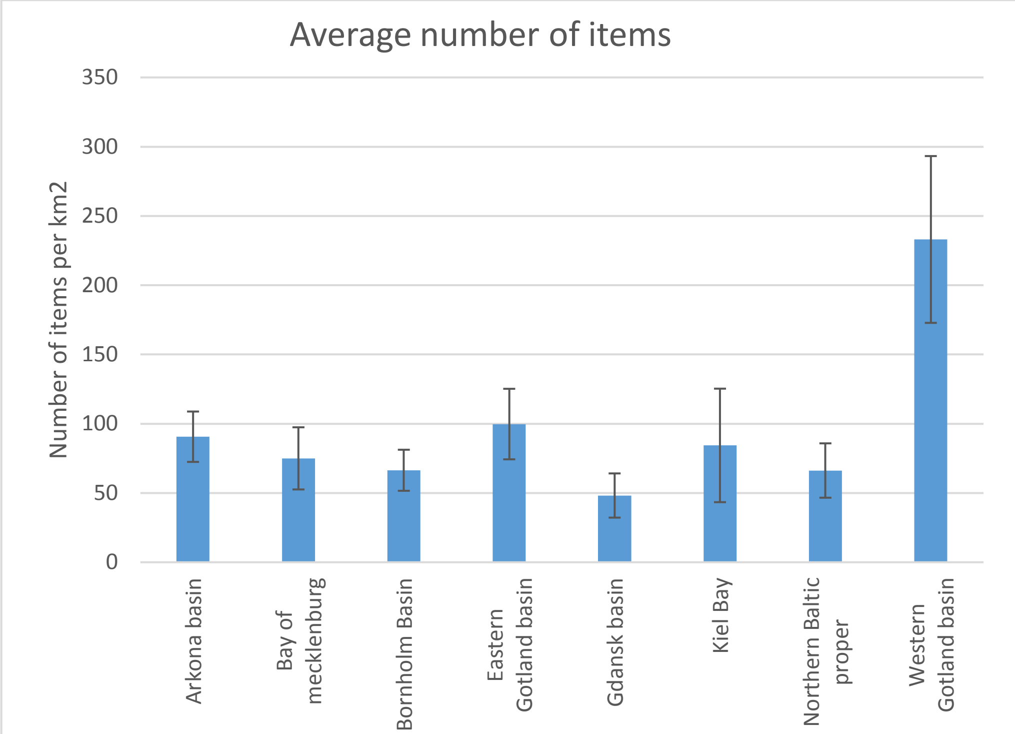


Figure 4: The average number of items per km^2 (±95% confidence interval) found in trawl hauls in different sub-regions.

Weight of items all years combined

The average weight in hauls from The Northern Baltic Proper was significantly higher that hauls from all other sub-regions (Figure 5). In fact, this weight was so high (5195 kg/km^2) that it is possible that there has been a mistake in the data entry, or else data have been misinterpreted. This data point therefore needs to be checked before any major conclusions are drawn from this material. In addition, this value is based on 9 hauls and must therefore be interpreted with caution. Despite the large difference among other sub-regions (note the high value in the Eastern Gotland basin) the variation among hauls was so great that there were no statistically significant differences among other sub-regions.

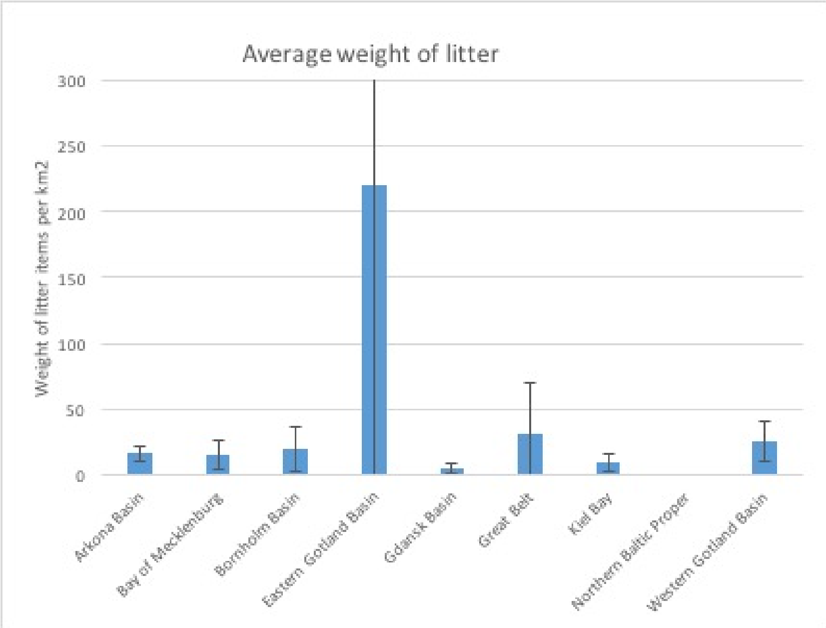


Figure 5: The average weight of items kg per km^2 (±95% confidence interval) found in trawl hauls in different sub-regions. The average weight for The Northern Baltic proper was 5195 kg /km^2, off the scale for the graph.

HELCOM Sub regions: Proportion of items in different material categories

The composition of litter differed significantly among sub-regions (Table 5). While items made from natural materials dominated in most regions, plastic items dominated in hauls from the Northern Baltic proper and the Gdansk basin, and metal items dominated in the Kiel bay.

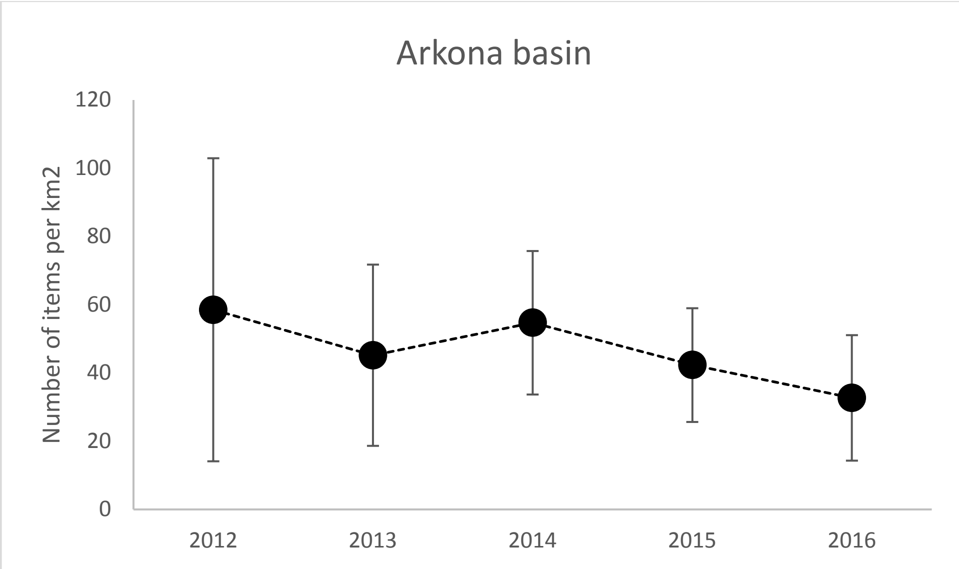
Table 5: Proportion (%) of material categories in hauls in different sub regions (summed overall years). No data on the number of items in different categories was available from hauls in the Great belt sub region.

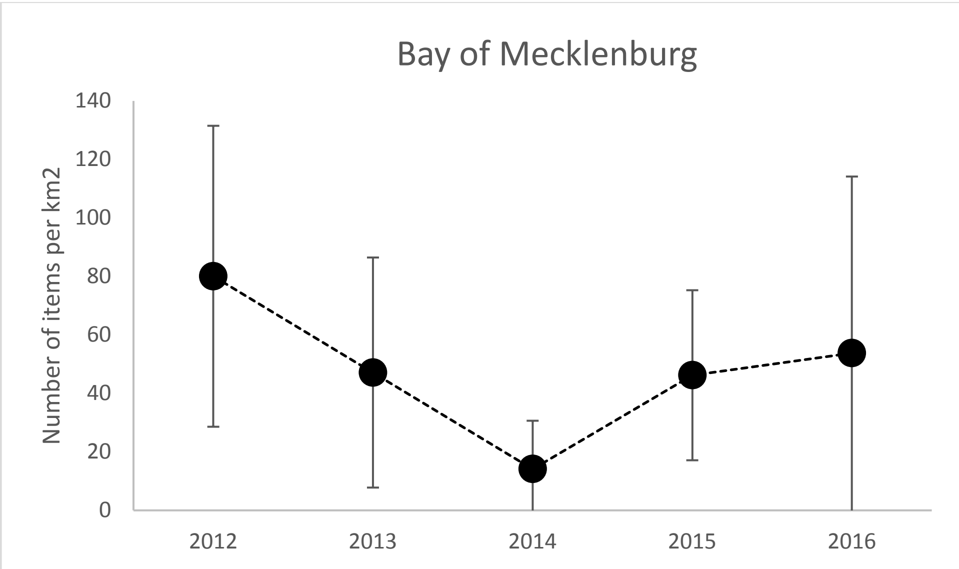
	Kiel Bay		Great Belt		Bay of Mecklenburg		Arkona Basin		Bornholm Basin		Gdansk Basin		Western Gotland Basin		Eastern Gotland Basin		Northern Baltic Proper	
Material category	**Wt**	**n**	**Wt**	**n**	**Wt**	**n**	**Wt**	**n**	**Wt**	**n**	**Wt**	**n**	**Wt**	**n**	**Wt**	**n**	**Wt**	**n**
Plastic	5	24	51	-	5	17	29	25	6	34	43	72	11	13	24	43	53	85
Metal	47	31	0	-	2	4	12	13	6	5	1	8	7	3	24	7	0	0
Rubber	3	4	0	-	0	2	2	3	1	3	1	3	11	1	6	3	0	0
Glass and ceramics	18	17	0	-	19	29	15	21	2	5	0	0	13	3	2	2	0	0
Natural	11	13	49	-	33	36	34	33	79	48	48	5	45	77	38	35	0	0
Miscellaneous	17	10	0	-	41	11	8	5	6	4	8	12	12	3	6	10	47	15

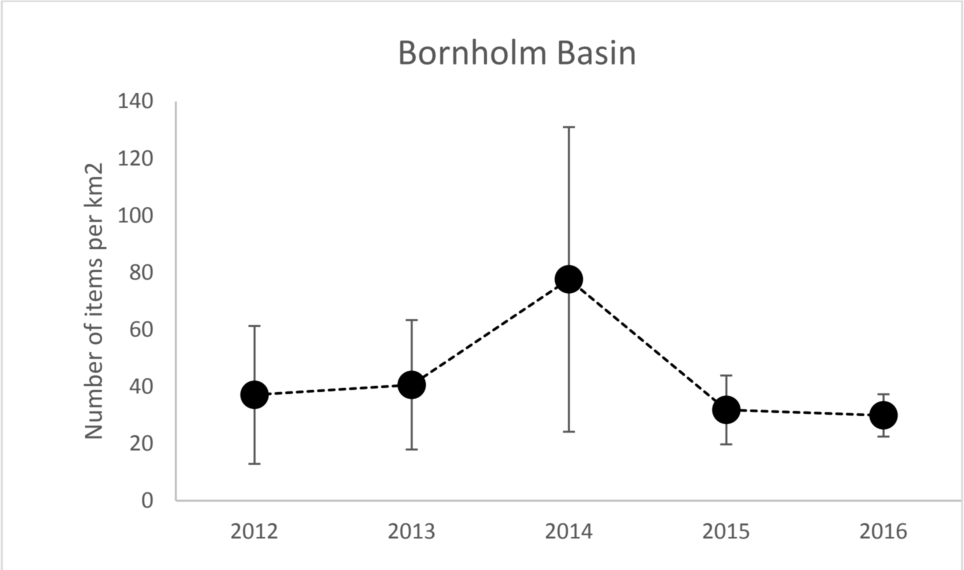
The material categories as given here are taken from the IBTS/BITS protocol for marine litter.

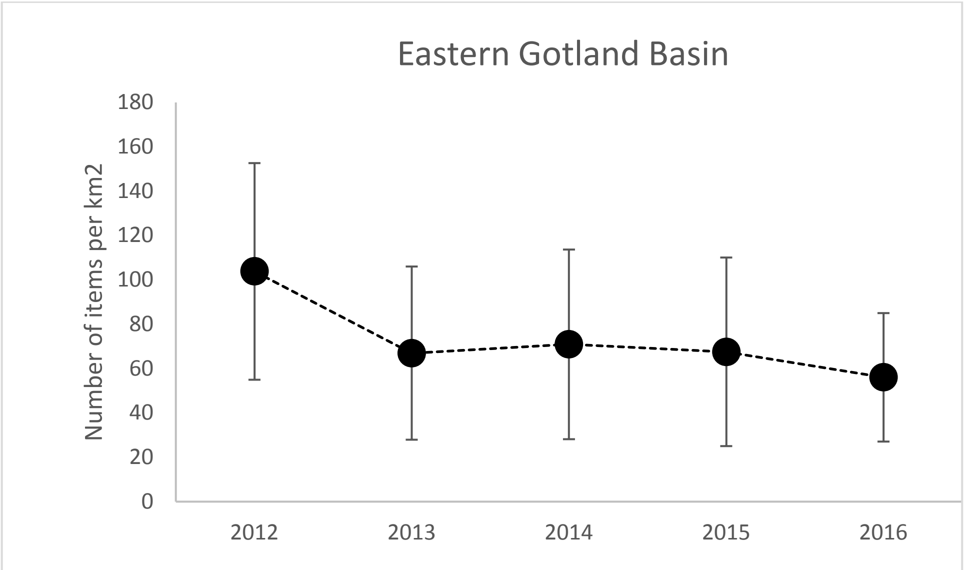
HELCOM sub regions: temporal trends

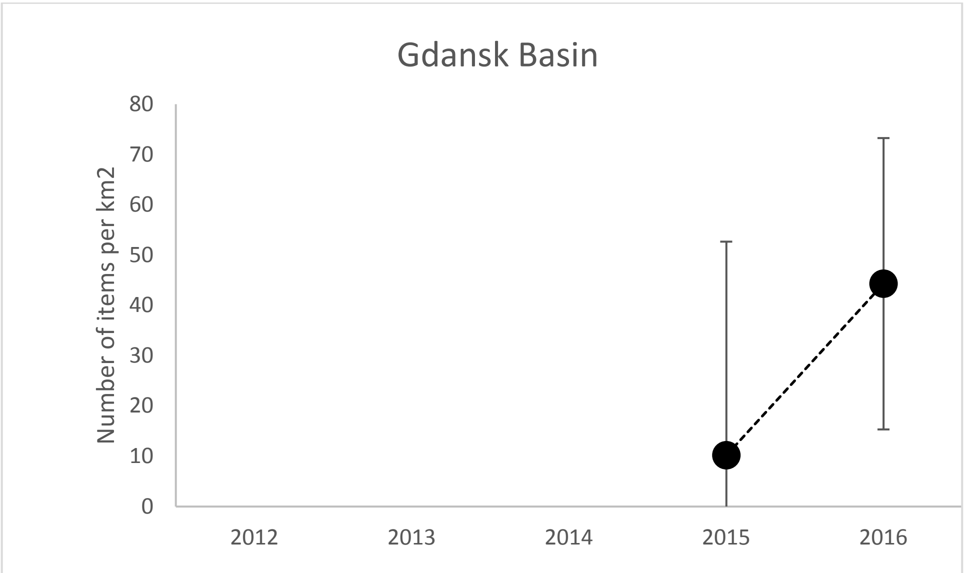
The different sub regions showed different trends in the average number of litter items (Fig 6), indicating that an overall trend summed for the entire Baltic is not necessarily reflected on a sub-regional scale. The Arkona basin and the Eastern Gotland basin show signs of a decreasing trend, but these trends are not statistically significant. The Kiel Bay has a statistically significant increasing trend. Other areas show no clear tendencies of trends.

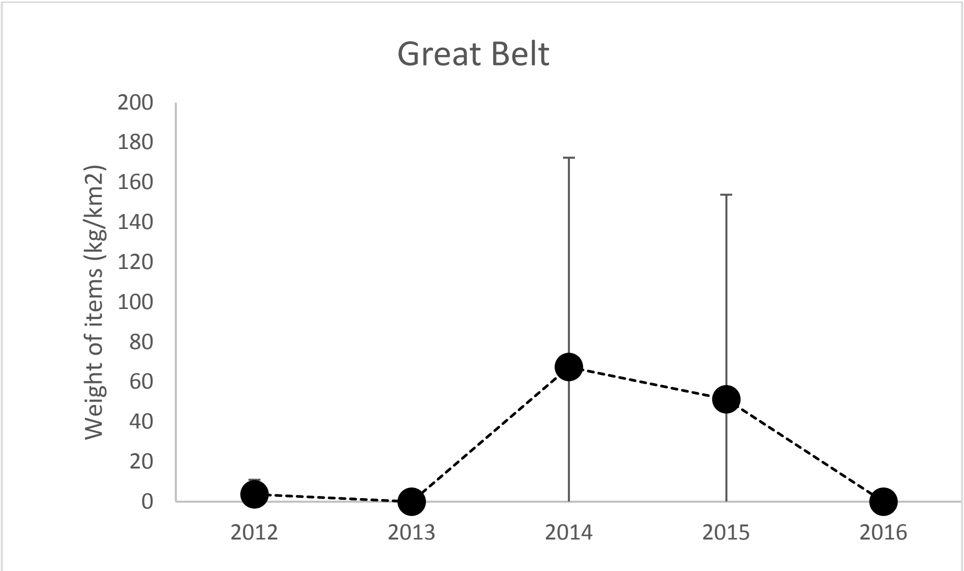


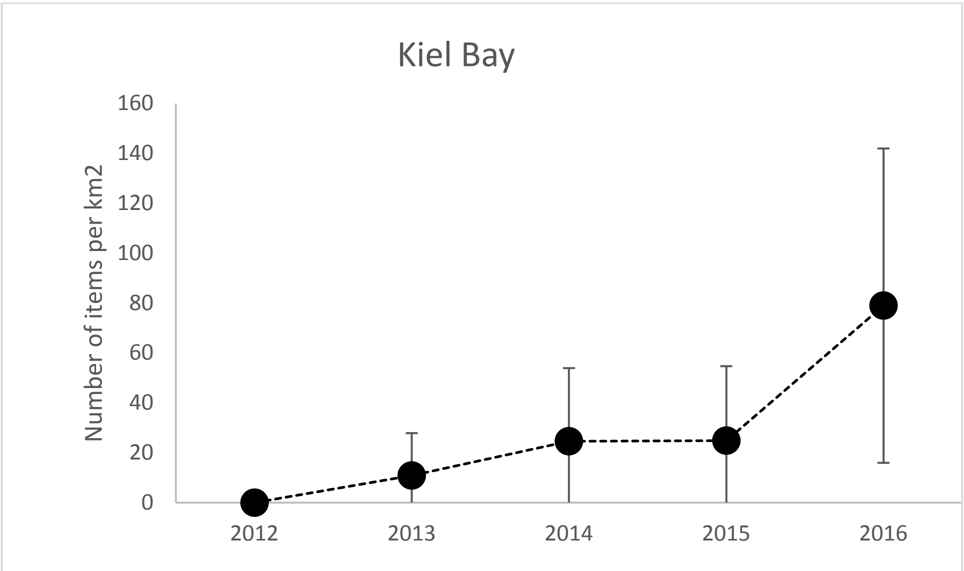


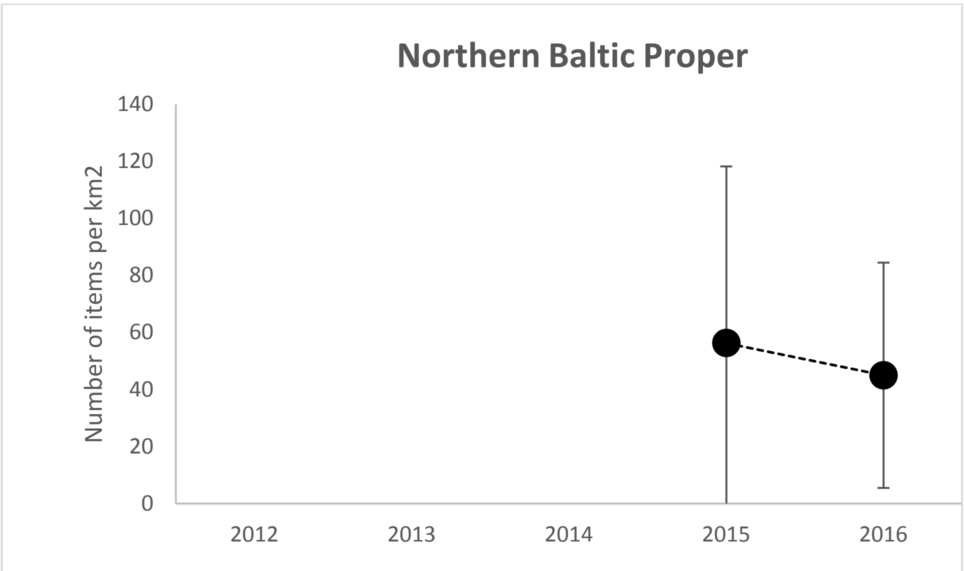

Bornholm Basin
Number of items per km2
0
20
40
60
80
100
120
140
2012
2013
2014
2015
2016


Eastern Gotland Basin
Number of items per km2
0
20
40
60
80
100
120
140
160
180
2012
2013
2014
2015
2016


Gdansk Basin
Number of items per km2
0
10
20
30
40
50
60
70
80
2012
2013
2014
2015
2016


Great Belt
Weight of items (kg/km2)
200
180
160
140
120
100
80
60
40
20
0
2012
2013
2014
2015
2016


Kiel Bay
Number of items per km2
160
140
120
100
80
60
40
20
0
2012
2013
2014
2015
2016


Northern Baltic Proper
Number of items per km2
140
120
100
80
60
40
20
0
2012
2013
2014
2015
2016

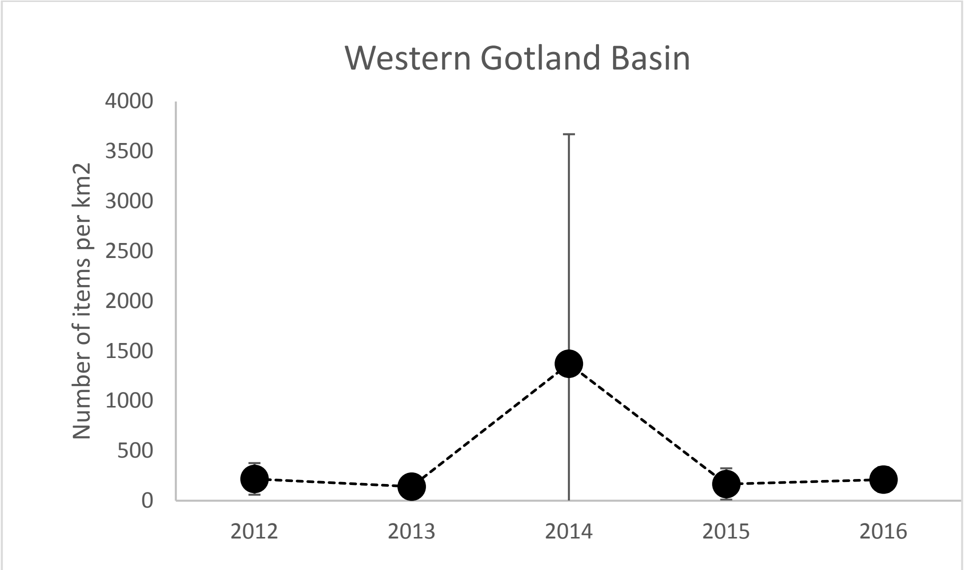


Figure 6: Temporal trends for the number of items (mean± 95% confidence interval) in different sub regions. For Great Belt, the trend is for the weight of items.

Top 15 items

The BITS protocol does not provide an identification of collected items as detailed as most beach litter monitoring protocols. However, the BITS protocol lists 6 main material categories (plastic, metal, rubber, glass/ceramics, natural products, and miscellaneous), divided further into 40 different sub-categories. Based on this, Table 6 below shows the most frequently occurring items recorded in the data set. As can be seen, the category “Other natural products” dominates in terms of number, and is the second most common in terms of weight. This may be problematic, as it is not possible from the DATRAS database to know what these items are. Are they items that are of interest for the assessment of marine litter? If they are excluded from the analyses made above, the results may be quite different.

This analysis is based on the total number of items found in the programme, which means that surveys with many items will contribute more to the list. During the autumn 2017 there is an ongoing discussion within HELCOM-EN Marine Litter about the best methods to calculate top X item lists. While the simple method used here is intuitive and have some merits, it has also been argued that some form of ranking system would be better as it would give equal weight to each survey (which may be important if the data set is temporally and spatially unbalanced). Ranking systems may be problematic for seafloor litter data, as each haul commonly contains only one or a few different item types. To produce a rank list for each survey would be difficult. It may therefore be necessary to test the consequences for pooling data from several surveys at some level also for ranking methods. This has not been explored for seafloor litter data in time for this report to be written.

Number of items			Weight of items		
BITS ID	**% of total**	**Type of item**	**BITS ID**	**% of total**	**Type of item**
E5	54%	Other natural products	E1	33%	Wood (processed)
A3	6.2%	Plastic bag	E5	26%	Other natural products
A2	6.1%	Plastic sheet	F2	22%	Shoes
A14	5.2%	Other plastics	A3	12%	Plastic bag
D2	3.6%	Glass bottle	A14	11%	Other plastics
A7	3.2%	Synthetic rope	D2	10%	Glass bottle
F3	3.1%	Other	F1	3.0%	Clothing/rags
B8	3.0%	Other metal	A	2.1%	Plastic
E1	2.5%	Wood (processed)	B8	2.1%	Other metal
B2	1.5%	Cans (beverage)	F	1.3%	Miscellaneous
D3	1.5%	Glass/ceramic piece	B6	0.6%	Metal car parts
F1	1.3%	Clothing/rags	B	0.5%	Metal car parts
C6	1.3%	Other rubber	D	0.5%	Glass/Ceramics
E3	1.1%	Paper/cardboard	C4	0.4%	Tyres
A1	0.8%	Plastic bottle	B3	0.4%	Fishing related metal

Table 6: The 15 most common types of items (in terms of number and weight) found in trawl hauls for all 9 sub-regions combined.

Number of items on different types of seafloor sediments

The Balance dataset identifies 6 different landscape types relevant for seafloor litter analysis (Figure 7, Table 7). The average number of litter items differs significantly among seafloor types when all data from the Baltic is pooled (Figure 7). The highest density of litter was found on the seafloor type Non-photic mud and clay, while the lowest amounts were found on photic mud and clay. If the spatial pattern of litter occurrence mainly is governed by accumulation processes, the deep accumulation bottoms should have the highest number of litter items. Indeed, according to this analysis the average litter density is highest on Non-photic mud and clay bottoms, typical accumulation bottoms. However, the average densities are also high on e.g. photic hard bottoms, the least likely bottoms to accumulate items. There may be several reasons for this:

a) There pattern of litter occurrence is caused by a combination of different sources and accumulation patterns.
b) The pattern of occurrence depends on the types of items. Some of the items found on the seafloor (e.g. glass, ceramic or metal items) are heavy, and simply sink on the site where they are released, and thus reflect place of origin (sources and pathways). Other items (e.g. wood, plastic, paper) are light and are transported by currents and waves. The geographical pattern of such items should thus rather reflect patterns of accumulation processes. This would be possible to test with the present data set, but falls outside the scope of this report.

c) It may also be that the spatial resolution of sediment data in the Balance dataset does not match the spatial resolution of the trawls hauls. If so, this analysis must be interpreted with caution.

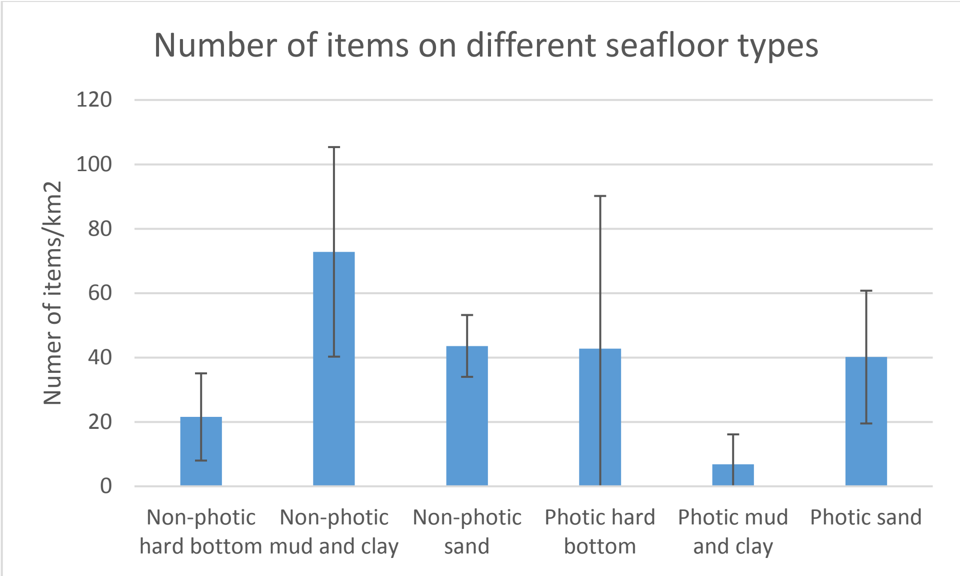


Figure 7: Average number of litter items per km^2 (mean ± 95% confidence interval) found on different types of seafloor sediments.

However, a third possibility is that the overall pattern is composed of different patterns in different parts of the Baltic. Indeed, the pattern varies significantly among sub-basins (Table 8), which suggests that a whole-basin analysis is not necessarily representative for a single sub-basin. For example, the large number of items found on Non-Photic mud and clay in the Western Gotland basin undoubtedly contributes to the overall dominance of items seen in Figure 7. There may appear to be a contradiction between e.g. the high numbers of items found on Photic mud and clay in the Arkona basin, and the low average number seen in Figure 7. However, this is caused by the uneven representation of hauls in different regions and sediment (Table 7).

Table 7: The average number items per km^2 found in different types of seafloor sediments in the different regions. Number in parentheses show the number of hauls in that particular sediment/sub-basin combination. Dashes represent combinations where no hauls were taken. The data for the Great Belt is based on weight (kg/km^2)

	Arkona Basin	Bay of Mecklenburg	Bornholm Basin	Eastern Gotland Basin	Gdansk Basin	Great Belt	Kiel Bay	Northern Baltic Proper	Western Gotland Basin
Non-photic hard bottom	4 *(5)*	-	13 *(3)*	30 *(7)*	-	0 *(3)*	0 *(3)*	90 *(1)*	45 *(5)*
Non-photic mud and clay	33 *(182)*	40 *(41)*	44 *(311)*	74 *(190)*	29 *(11)*	98 *(37)*	35 *(47)*	45 (8)	506 (51)
Non-photic sand	57 *(78)*	64 *(8)*	33 *(147)*	41 *(49)*	38 *(18)*	0 *(1)*	62 *(5)*	-	198 *(3)*
Photic hard bottom	-	57 *(7)*	-	67 *(1)*	-	4 *(4)*	-	-	
Photic mud and clay	206 *(2)*	-	13 *(1)*	-	-	5 *(65)*	-	-	
Photic sand	70 *(47)*	0 *(1)*	6 *(17)*	-	-	0 *(15)*	0 *(4)*	-	

An analysis as the one done here could potentially be very valuable for assessing representativity (see below) and for improving the design of a monitoring programme. It may also give important information about accumulation patterns, the occurrence of potential hotspots, and the ability to extrapolate over non-sampled areas. However, the current analysis must be interpreted with caution as the match between haul data and actual sediment characteristics remains uncertain. The collection of sediment data can be expected to advance in the future, but until that data is available, collecting haul specific data (e.g. through the use of video camera attached to the trawl or haul-specific back-scatter echo sound data) would be one way to improve this type of analysis.

Representativity of the current sampling programme

The number of hauls in different sub-basins is shown in Table 8 below. Also shown is the approximate area of each particular sub-basin, as measured from the HELCOM GIS dataset. The total area of the sub-basins included here sums up to approximately 227000 km^2, that is 54% of the total area of the Baltic Sea. From Table 8 can be seen that the representativity of the current monitoring basin is best for the Kiel Bay, followed by the Arkona Basin and the Bornholm Basin (low numbers in column 4, showing how many km^2 each haul would theoretically represent). The lowest representativity is for the Northern Baltic proper, followed by the Western Gotland basin. This uneven representativity is possibly an illustration of one of the drawbacks of the current programme, that the geographical representativity is mainly decided by the needs of the fish stock monitoring programme. That said, the representativity is probably far better than it would have been if it was not possible to combine the two purposes.

Table 8: Representativity of the sampling programme in different sub-basins. The second column shows the area of the sub-basin. The third column shows the number of hauls during the entire analysed period 2012-2016. The fourth column shows the area of the sub-basin divided by the number of hauls, i.e. an indicator of the area that each haul represents. Column number 5 shows the number of hauls reported during 2016, and column number 6 shows the area that each haul 2016 represents. The low number of hauls from the Great belt is probably caused by the timing of reporting rather than a decreased sampling effort.

Sub-basin	Area of sub-basin (km^2)	No of Hauls 2012-2016	Km^2 per haul 2012-2016	No hauls 2016	Km^2 per haul 2016
Arkona Basin	17616	315	56	73	241
Bay of Mecklenburg	4620	58	80	11	420
Bornholm Basin	42219	648	65	168	251
Eastern Gotland Basin	75093	295	255	126	596
Gdansk Basin	5876	29	203	21	280
Great Belt	10760	125	86	1	10760
Kiel Bay	3356	61	55	15	224
Northern Baltic Proper	39674	9	4408	5	7935
Western Gotland Basin	27683	59	469	13	2129

The representativity of sampling in different sediment types is shown in Table 9 below. In this case, the total area of the Baltic covered by the BALANCE data set (calculated from GIS layer to 442000 km^2) was used to assess representability. As can be seen in Table 9, the dominating seafloor type (Non-photic mud and clay) has the second highest representativity, while the lowest representativity is found for photic hard bottoms. Again, some caution should be used in the interpretation of this (see previous section), but it is encouraging that the two largest seafloor types (Non-photic sand and Non-photic mud and clay) also are the most sampled seafloor types.

Table 9: Representatively of the sampling programme in different sediment types. The second column shows the area of the sediment type. The third column shows the number of hauls during the entire analysed period 2012-2016. The fourth column shows the area of the sediment type divided by the number of hauls, i.e. an indicator of the area that each haul represents. Column number 5 shows the number of hauls reported during 2016, and column number 6 shows the area that each haul 2016 represents. The low number of hauls from the Great belt is probably caused by the timing of reporting rather than a decreased sampling effort.

Sediment type	Sediment type area (km^2)	No of Hauls 2012-2016	Km^2 per haul	No hauls 2016	Area /haul 2016
Non-photic hard bottom	41330	28	1476	10	4133
Non-photic mud and clay	238000	1066	223	288	826
Non-photic sand	50600	341	148	121	418
Photic hard bottom	30970	12	2581	3	10323
Photic mud and clay	24430	68	359	1	24430
Photic sand	37300	84	444	10	3730

The most obvious problem of representativity is of course the areas where fish survey trawling does not occur at all presently, i.e. mainly north and east of the current geographical scope of the BITS programme, and in coastal shallow areas (Figure 1). There are several alternative solutions to trawl surveys for monitoring litter on the seafloor, including scuba surveys, ROVs, or video surveys. Indeed, several Baltic countries (e.g. Finland) has done pilot surveys for this particular purpose, or included monitoring for seafloor litter in surveys conducted for the purpose of habitat mapping. The results from such alternative methods are of course difficult to include in a common statistical analysis with trawl survey data, as the methods differ so much in terms of specificity temporal/spatial scope. However, it may be important to start a discussion on the possibility of using similar (compatible) protocols for shallow-water surveys in different HELCOM countries.

Analysis of litter excluding items made from natural materials

As mentioned in the section on materials above, items made from natural materials (e.g. wood, natural fibres and paper) are very common in the Baltic. Almost 45 % by number and 57% by weight of the items found were made from natural materials (see also Table 6). As mentioned previously, this may complicate the interpretation of trends and amounts of litter. In principle, items made from natural materials are included in the definition of marine litter as long as it is a manufactured object, and therefore it is also included in all basic calculations in this report. From a harm perspective, it may share some of the physical characteristics of other materials (e.g. a bird may get entangled also in a rope made from natural fibres, a paper sheet may cover the seafloor), but natural products probably disintegrate faster than e.g. plastics, glass or metal, and furthermore is possibly less likely include chemical pollutants.

As items made from natural materials are so common in the dataset, the pattern of amounts and trends change if they are excluded from the analysis. The average number of items made from non-natural materials found during the period 2012-2016 in all sub-basins combined were 30 ± 3.7 items per km^2, and the average weight was 50.1 ± 33.9 kg/km^2.

When items made from non-natural materials are excluded, there is a weak but statistically significant increase (Kendall rank correlation, $P<0.01$) in the number of items per km^2 (Figure 8), contrary to the non-significant temporal trend when all types of items are included (Figure 2). However, the caution in interpreting this pattern due to the changed geographical scope with time is still valid.

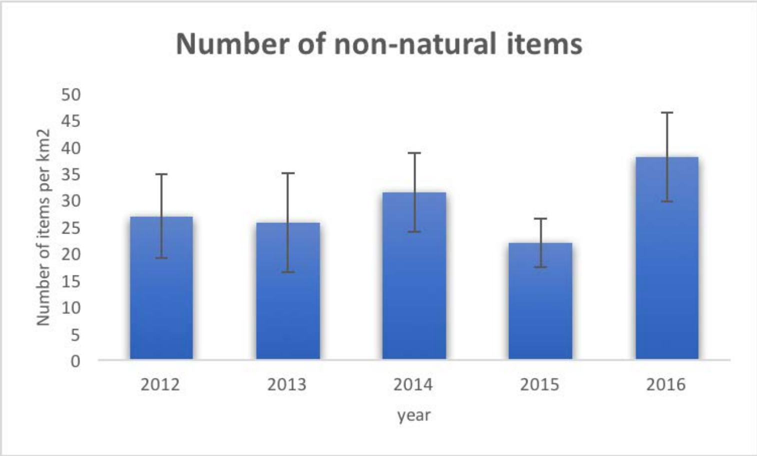


Figure 8: The average number per km² of items (±95% confidence interval) made from non-natural materials found in trawl hauls during different years.

Furthermore, the differences among sub-regions in the number of items made from non-natural materials (Figure 9) were much smaller than when the entire data set is used: the only remaining statistically significant difference was between the eastern Gotland basin and the Bornholm basin.

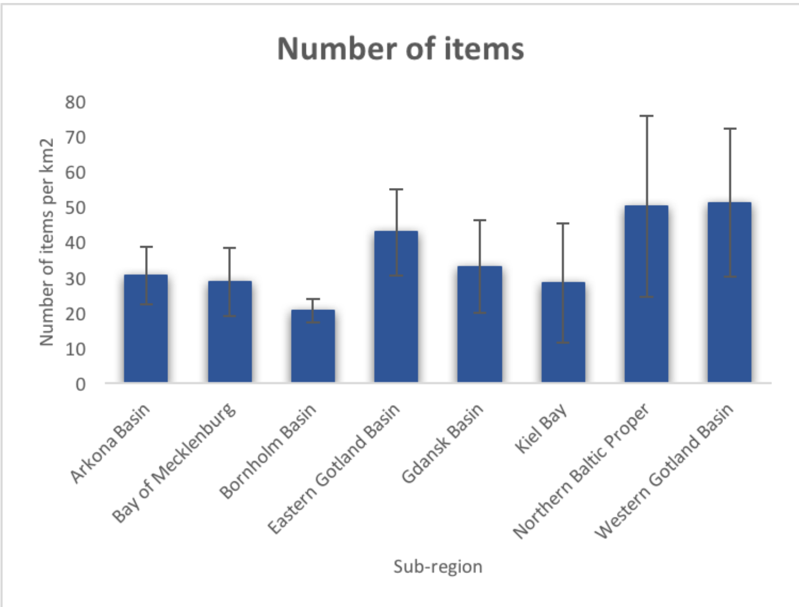


Figure 9: The average number per km² of items (±95% confidence interval) made from non-natural materials found in trawl hauls in different sub-regions.

The distribution of items among different sediment types also differed significantly when non-natural items are excluded (Figure 10), but the patters have a strong resemblance to that found when all items are included (compare with Figure 7), with the major difference that the number of items now are highest in non-photic sands.

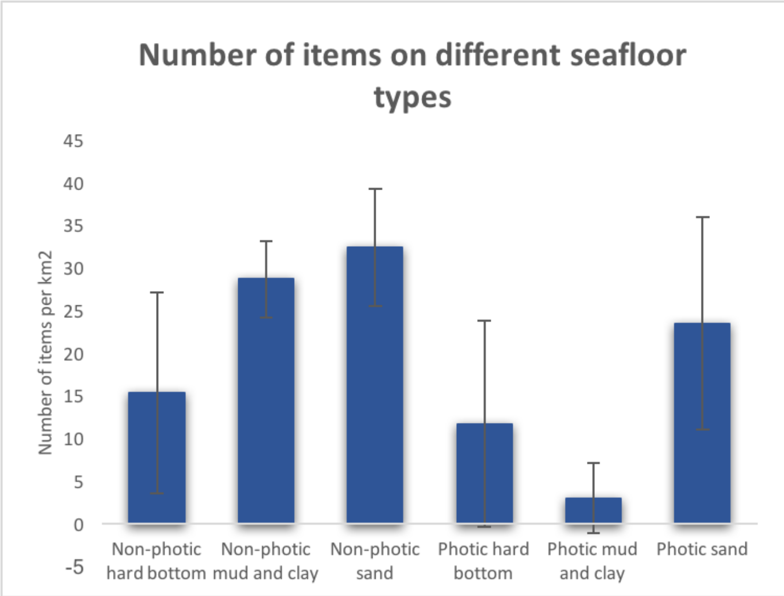


Figure 10: The average number per km^2 of items (±95% confidence interval) made from non-natural materials found in different seafloor sediment types.

In summary, excluding items made from non-natural materials means that there is a weak but statistically significant increasing temporal trend in the average number of items found. It also changes the relative relationship among sub-regions, and increases the relative abundance of items on non-photic sandy sediments. As mentioned above, manufactured items made from natural materials are by definition part of marine litter, so these changes in patterns should not change the conclusions drawn from the entire data set. It is however interesting to discuss from the perspectives of sources and harm.

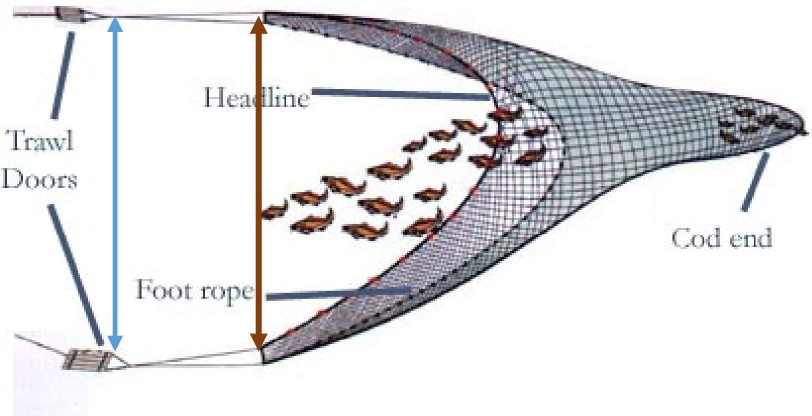
A note on the statistical power of the sampling programme

Ideally this report should also include an analysis if the statistical power of the present monitoring programme, indication both what type of temporal change that the current programme is able to detect (e.g. over a 6 year period), but also how many hauls would be necessary to detect a certain X% change. Technically such an analysis is possible to do, as the current data set allows for calculation of variances etcetera necessary for a statistical power analysis. However such an analysis would be premature: several decisions for the scope of such an analysis have to be made first:

a) Should natural products be included or not?
b) Should the analysis be made on a regional or sub-regional level?
c) What kind of patter is expected for good status – no significant increase, or a significant decrease, or a particular threshold?

Appendix 1: A schematic picture of a trawl

The picture below shows a schematic picture of a trawl, with Door spread (blue arrow) and Wing spread (red arrow) indicated. On the picture, there is little difference in the size of door spread and wing spread, but in the trawls used in the BITS programme (TVL or TVS trawls) the ratio between door spread and wing spread can be up to 3x. For collecting fish, lines connecting the trawl doors to the trawl help to herd fish into the trawl. For that reason, door spread is the more appropriate measurement to calculate areas swept. For marine litter, the selection mechanism of the trawl is not well studied, but it is commonly assumed (including in this report) that the wing spread (≈actual width of the footrope touching the seafloor) is the more appropriate measurement for area calculations.



Source: Wikipedia commons

Appendix 2: List of item categories in the most frequently used ICES/BITS protocol C-TS-REV

ID	Type of item
A	Plastic
A1	Plastic bottle
A10	Plastic strapping band
A11	Plastic crates and containers
A12	Plastic diapers
A13	Sanitary towel/tampon
A14	Other plastics
A2	Plastic sheet
A3	Plastic bag
A4	Plastic caps/lids
A5	Plastic fishing line (monofilament
A6	Plastic fishing line (entangled)
A7	Synthetic rope
A8	Plastic fishing net
A9	Plastic cable ties
B	Metals
B1	Cans (food)
B2	Cans (beverage)
B3	Fishing related metal
B4	Metal drums
B5	Metal appliances
B6	Metal car parts
B7	Metal cables
B8	Other metal
C	Rubber
C1	Boots
C2	Balloons
C3	Rubber bobbins (fishing)

C4	Tyre
C5	Glove
C6	Other rubber
D	Glass/Ceramics
D1	Jar
D2	Glass bottle
D3	Glass/ceramic piece
D4	Other glass or ceramic
E	Natural products
E1	Wood (processed)
E2	Rope
E3	Paper/cardboard
E4	Pallets
E5	Other natural products
F	Miscellaneous
F1	Clothing/rags
F2	Shoes
F3	Other