Flanders
is agriculture and fisheries

ILVO Mededeling 275
July 2021

DISTRIBUTION AND SOURCES OF MACROLITTER ON THE SEAFLOOR OF BELGIAN FISHERIES AREAS

ILVO
Flanders Research Institute for
Agriculture, Fisheries and Food

www.ilvo.vlaanderen.be

Distribution and sources of macrolitter on the seafloor of Belgian fisheries areas

ILVO MEDEDELING 275

July 2021

ISSN 1784-3197

Wettelijk Depot: D/2021/10.970/275

Bavo De Witte

Katrien Verlé

Lisa Devriese

Loes Vandecasteele

Els Torreele

Kris Hostens

Distribution and sources of macrolitter on the seafloor of Belgian fisheries areas

Content

1 INTRODUCTION

Marine litter has been recognised as a global environmental concern. Vast quantities of plastic litter enter the ocean (Jambeck et al., 2015; Galgani et al., 2021). Marine litter may cause negative effects to the marine ecosystem as animals may swallow litter or get entangled, which can lead to injuries and even death of individual organisms. Litter may scour or smother the seafloor, which may impact fragile benthic habitats, reduce photosynthesis and prevent the movement of animals, gases and nutrients. Marine litter may also act as a vector for invasive species, transporting non-indigenous organisms into new areas where they can outcompete or prey upon native organisms. (OSPAR, 2017b). Within the Marine Strategy Framework Directive (MSFD), a primary aim is that composition, amount and spatial distribution of litter on the coastline, in the surface layer of the water column and on the seafloor are at levels that do not cause harm to the coastal and marine environment(2008/56/EG; 2017/848/EU). Monitoring of seabed litter is therefore essential.

Multiple techniques are available to assess seabed litter, each with specific advantages and disadvantages. Remotely operated vehicles equipped with cameras can be applied to record seabed litter, divers may collect or film litter along predefined transects or litter can be collected with fish trawls. Macrolitter monitoring by trawling has the advantage of covering a large area. It is typically included in fisheries survey cruises, which offers the advantage that monitoring is cost efficient. However, as cruises are not dedicated to litter collection, sampling locations are selected based on importance for fish stock assessments rather than for litter assessment. Moreover, trawling is prohibited at rocky areas and canyons. A trawl does not collect all litter items on the seafloor. The catchability is linked to the net size but also to the type of fishing net, limiting comparability between areas were different fishing techniques are applied (ICES, 2021).

At the Belgian fisheries areas, marine litter sampled by trawling is already recorded since 2011, following international OSPAR and MSFD guidelines (OSPAR, 2017a; JRC, 2013). The ILVO environmental monitoring surveys at the Belgian Part of the North Sea (BPNS) and the Belgian Fisheries surveys offer a vast dataset on seafloor macrolitter which can even be enlarged with data of the United Kingdom, Germany and the Netherlands to complete the view on litter distribution at the North Sea, English Channel, Irish Sea and Celtic Sea. Within the Marine Plastics project, the aim was to compile available seafloor litter data gathered within monitoring campaigns and to assess the distribution of litter items, considering not only total litter, but also specific litter categories such as plastic, metal or rubber, or even sub-categories. Links between spatial distribution of litter items and human activities such as fisheries, dredge disposal, sand extraction and offshore wind farms (OWF) were investigated.

2 METHODS

2.1 MARINE LITTER DATA SOURCE

For the assessment of seafloor litter at Belgian fisheries areas, two independent data sets were used: seafloor litter data collected (1) within the ILVO environmental monitoring campaigns and (2) within the international beam trawl survey (BTS). The ILVO environmental monitoring campaigns cover the BPNS. Seafloor litter is collected within the net, using an 8 m beam trawl with a cod end mesh size of 20 mm (stretched). The length of a fish track is about 1 nautical mile. The BTS covers the North Sea, English Channel, Celtic Sea and Irish Sea. Beam trawl lengths can vary from 4 to 8m. Nets have a cod end mesh size of 40 mm (stretched).
Data is collected according to OSPAR (2017a) and MSFD (JRC, 2013) guidelines. Seafloor litter data from environmental monitoring campaigns was collected between March 2013 and March 2019. A total of 467 hauls were included in the original dataset (Fig. 1). One haul lost its catch and was excluded. Another 5 hauls had partially missing data when it

came to quantifying the number of litter items. These were excluded when analysing the number of litter items per area, leading to 461 observations including 29 tracks with no litter (6%).
BTS marine litter data was retrieved on the 22nd of January 2021 from the DATRAS Beam Trawl Survey (BTS) database publicly available on the website of the International Council for the Exploration of the Sea, ICES (https://datras.ices.dk/Data_products/Download/Download_Data_public.aspx). It is based on litter data submissions and haul information from Belgium, Germany, the Netherlands and Great Britain. Data between 2011 and 2019 was included (Fig. 1).

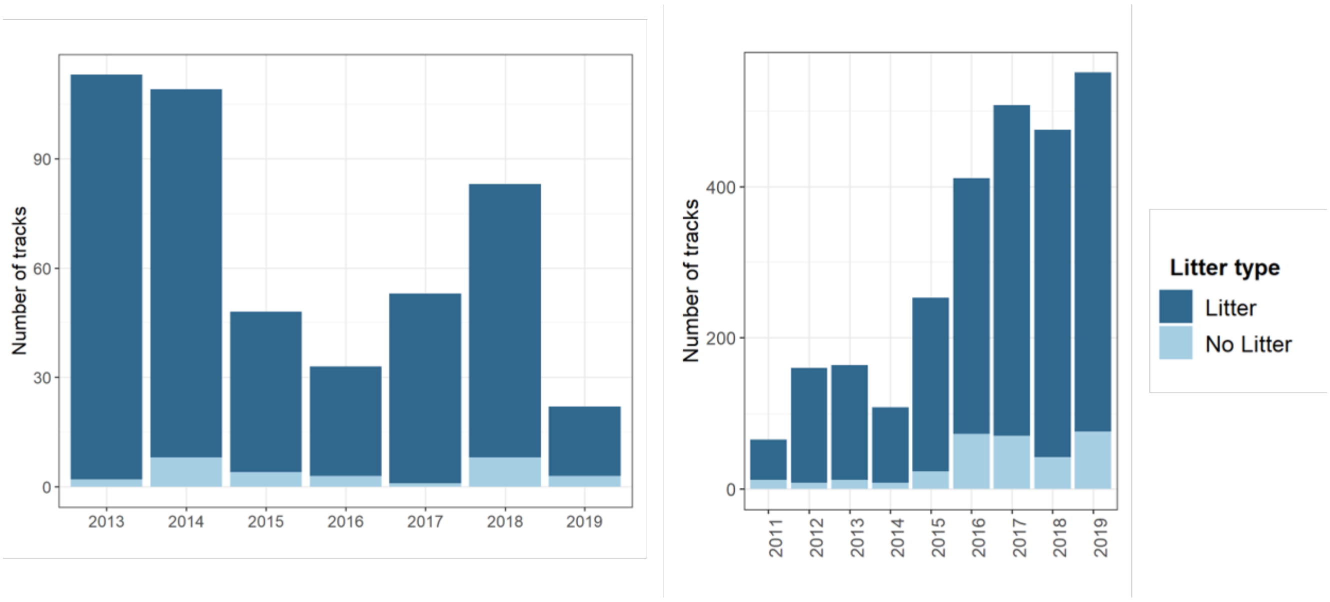

Fig. 1 Total number of hauls with and without litter observations per year for (A) Environmental monitoring (N=461) and (B) BTS (N= 2695).

The number of items per haul were standardized by dividing by the swept surface area for each haul (length of the haul times the length of the beam). If no length was available, the distance between the shoot and haul coordinates of the track was calculated as follows:

Calculated Distance = Earth radius*acos(cos(as_radians(90- ShootLat)) *cos(as_radians(90-HaulLat)) + sin(as_radians(90- ShootLat)) * sin(as_radians(90-HaulLat)) * cos(as_radians(ShootLong-HaulLong))) *1000

2.2 BTS DATA CLEANING

For the BTS survey data, on a total of 2800 hauls, 60 were labelled as invalid (HaulVal) in the original database. All invalid hauls were excluded. We understood that in the BTS database "LT-TOT" under the variable "PARAM" (LTREF = RECO-LT) denotes that no litter items were found in the haul (number of litter items ("LT_Items") equals 0). For 4 hauls, both "LT-TOT" and specific litter items were found in the dataset. In this case, the record with "LT-TOT" was assumed to be a mistake and removed, while the haul was kept in the database.

In 41 hauls "LT-TOT" was mentioned while the number of litter items was missing (-9), making these hauls inconclusive. These hauls were all excluded in both analyses. As it is possible that mixing of the notation of zero hauls occurred (recording "-9" instead of "0"), this decision may have led to an underestimation of the amount of zero hauls. However, inclusion would lead to overestimation. One of the hauls labelled "-9" was labelled invalid and therefore already excluded from the analyses in the first step. As a result, another 40 hauls were excluded in this step.

Furthermore, 2 more hauls with at least one missing value (-9) for the number of items of any type of litter were excluded when considering the number of litter items, as these could not be used to calculate totals. We assumed that in this case no litter data were recorded, or data got lost.

When comparing lengths in the database with calculated distances using the formula above, 24 hauls had large deviations (at least 1.2 times larger or 0.8 times smaller). These tracks all belonged to the Netherlands' data. In these few cases, it was decided to use the calculated distances instead of the lengths in the database.

Finally, 3 outliers with more than 100 items per haul were removed for the analysis of the litter items. This led to 2695 observations when considering the number of litter items, including 324 tracks with no litter (12%). To simplify matters the same observations were included in the presence/absence analysis.

Fig. 2 shows the amount of tracks per country over the years. No tracks without litter were reported by Germany. This might indicate that hauls without litter were not reported or indicated as "-9" in data recording. The number of tracks without litter was lower in 2019 for the Netherlands compared to other years.

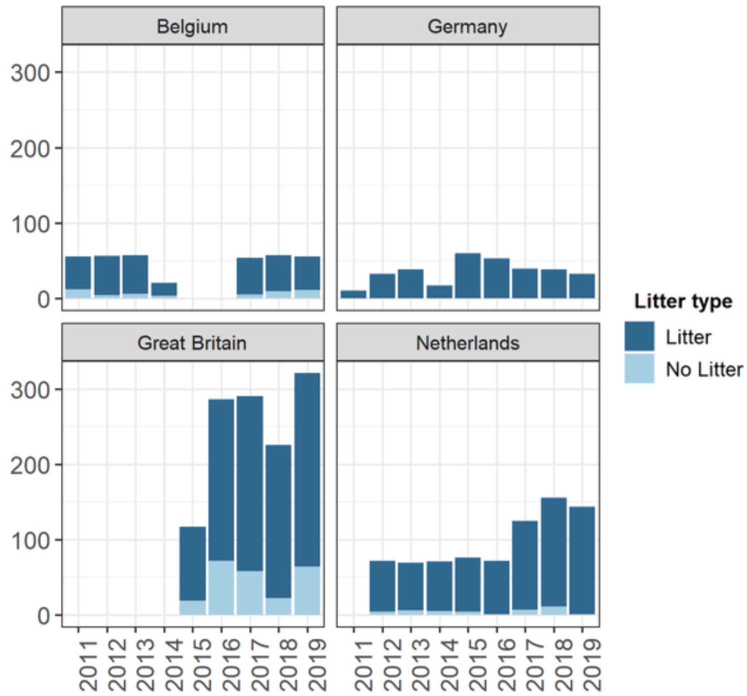

Fig. 2 Number of BTS hauls (with and without litter observations) per country and per year (N = 2695).

2.3 Spatial visualization

The observations were pooled per spatial area, taking the midpoint of the track to allocate an observation to a grid cell. For environmental monitoring survey data at the BPNS, grid cells were 0.05 x 0.05 degrees, whereas grid cells of 0.5x0.5 degrees were applied for the BTS data. The number of hauls per grid cell are mapped in Fig. 3. Fig. 4 visualizes the haul locations of each data providing country.

The data were analyzed using two different approaches. For BTS and environmental monitoring data, all available detailed information was used to calculate the number of litter items per swept surface area and per litter type. For the BTS data, a second approach was also applied, calculating the risk of finding at least one item per haul using a dichotomous outcome on the presence or absence of litter in a haul.

Pooling the observations allocated to the same grid cell, the average number of litter items per 10,000m^2 per grid cell was calculated and plotted on maps to be used as visual output of the analysis. For the presence/absence analysis, per grid cell, the number of hauls reporting litter was divided by the number of hauls observed, calculating the risk of finding litter in a haul. These risks were plotted on maps.

For environmental monitoring survey, 66 grid cells were covered. For the BTS survey, 256 grid cells were covered in the analysis of the number of litter items and in the presence/absence analysis. It was decided not to interpolate observations.

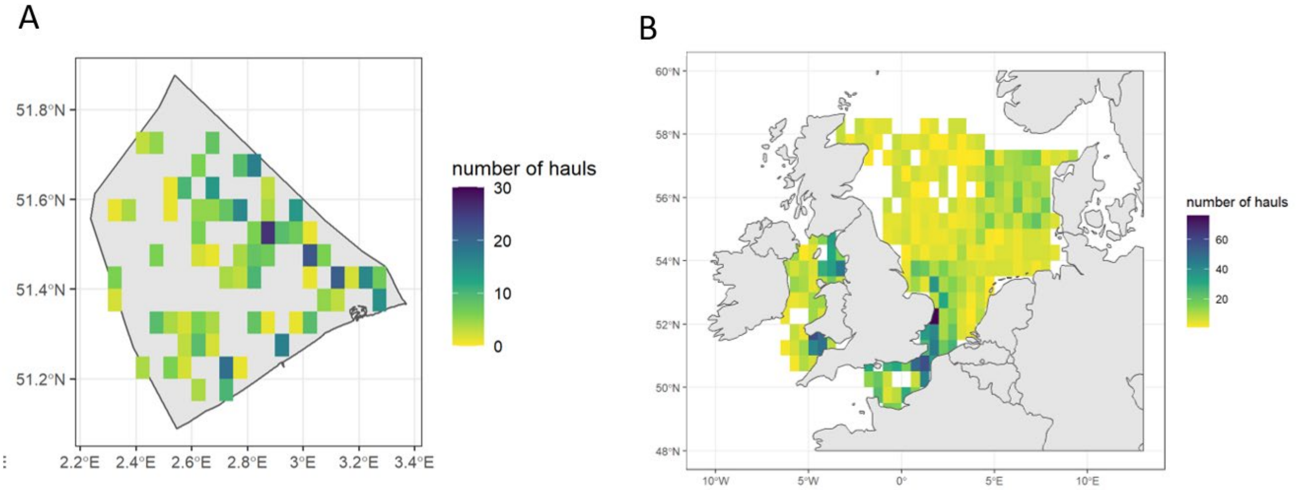

Fig. 3 Spatial overview of the number of hauls per grid of all years combined for (A) Environmental monitoring (N=461) and (B) BTS (N=2695).

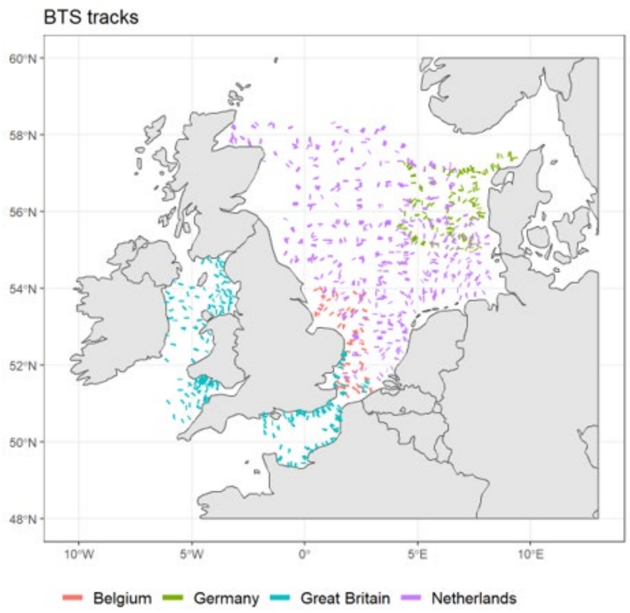

Fig. 4 Spatial overview of the BTS hauls (observations) per country of all years combined (N=2695)

2.4 Litter categories and subcategories

Different litter categories and subcategories were explored, following the classification as described by OSPAR (2017a) and MSFD (JRC, 2013). Types include plastic (A), metals (B), rubber (C), glass and ceramics (D), natural Products (E) and miscellaneous objects (F). Within these different types of litter, 33 subtypes were identified within the environmental monitoring dataset and 40 subtypes were identified within the BTS dataset. A closer look was taken at the frequent occurrences. A complete list of subcategories can be found in annex 1.

A5, A6, A8, B3 and C3 were pooled to look at material coming from fishing activities. This is an indicative classification, as not all monofilaments (A5, A6) will results from fisheries activities. On the other hand, part of the synthetic ropes (A7) will also originate from fisheries activities.

2.5 Sediment type categorization

The midpoints of the fish tracks were linked to sediment information using the EMODnet-Geology substrate map on a scale of 1:250.000 (version October 2016) (Van Lancker, 2019). This data includes 5, 7 or 16 classes of the Folk classification. This classification makes distinctions based on the percentages of mud (< 63 m), sand (63 m – 2 mm) and gravel (fraction above 2mm).

Based on the Folk classification with 5 classes, 4 different types of substrate material were encountered (1. Mud to muddy Sand; 2. Sand; 3. Coarse substrate; 4. Mixed sediment). Since only 1 track location belonged to the fourth class, mixed sediment, this class was not included. The fifth class, bedrock and boulders, was not encountered. The North Sea in general is predominantly sandy and sand-rich areas are commonly close to a sediment source (e.g. a large river or a coastline marked by easily erodible sandstone) (Kaskela et al. 2019).

2.6 Fisheries activity data

Data on Bottom Fishing Intensity was retrieved from OSPAR special request to ICES (ICES 2018). Data for several years were pooled (2011-2017) and mapped (Fig. 5-6), including all mobile bottom contacting gears (beam trawlers, dredge, demersal seine, otter trawl). ICES (2016) defines the swept area as the cumulative area contacted by a fishing gear within a grid cell over one year. The swept area ratio (SAR, also defined as fishing intensity) is the swept area divided by the surface area of the grid cell times 100. Two types of SAR are defined: surface (<2 cm penetration depth of the gear components) and subsurface (≥2 cm penetration depth of the gear components).

These fisheries data were allocated to a grid with cells of 0.05 x 0.05 degrees. As this is the size of the grid cells applied for mapping litter data of the environmental monitoring campaigns but smaller than used for the BTS survey litter data, the average number of litter items per 10,000m^2 retrieved from the BTS surveys was also allocated to a 0.05 x 0.05 degrees grid cell. This made it possible to merge the fisheries and litter data and explore correlations between litter items and fishing hours, surface SAR and subsurface SAR. In total 962 grid cells were covered by both data sets (out of 1027 grid cells covered by BTS litter data).

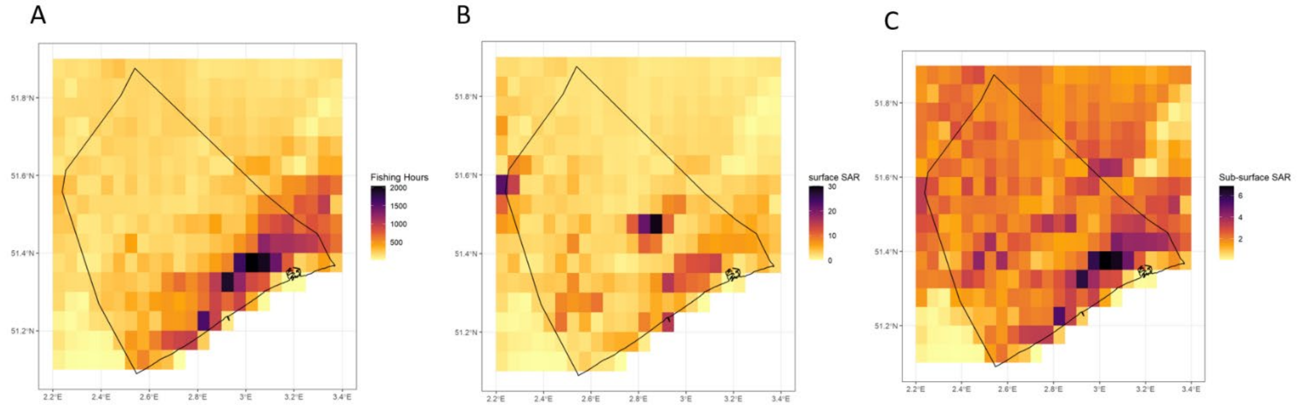

Fig 5. Spatial overview per grid cell of (a) the number of fishing hours, (b) the surface swept area ratio (SAR) and (c) subsurface SAR for the BPNS, data 2011-2017 retrieved from the OSPAR special request to ICES (ICES 2018).

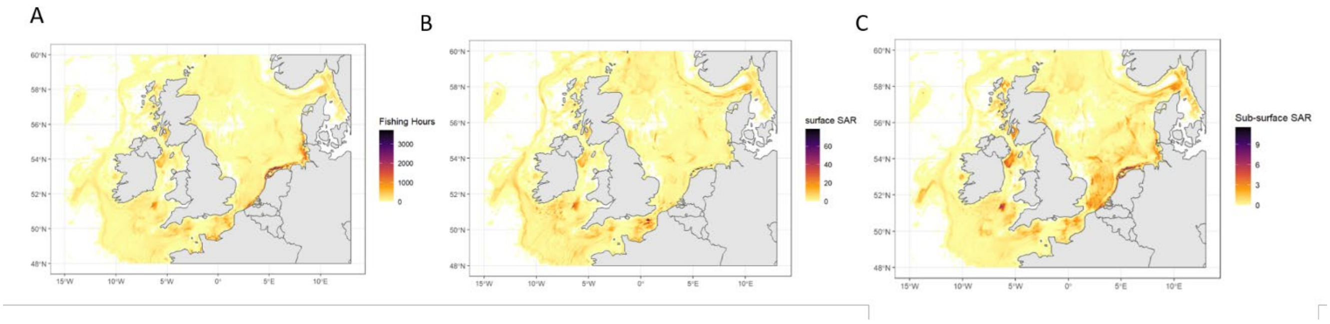

Fig 6. Spatial overview per grid cell of (a) the number of fishing hours, (b) the surface swept area ratio (SAR) and (c) subsurface SAR for the North-east Atlantic, data 2011-2017 retrieved from the OSPAR special request to ICES (ICES 2018).

2.7 Data from other human activities at sea

The fish tracks taken within the environmental monitoring campaigns are part of long-term monitoring on the effects of anthropogenic activities at sea such as dumping dredged material, OWF and sand extraction. As such, tracks made during these campaigns took place on reference sites (“reference”), near the occurrence of the activity (“nearby”/”low activity”) and in the area where the activity took place (impact). The number of litter items per 10,000m^2 was compared taking into account the exploitation locations. An overview of all tracks is provided in annex 2. For a more detailed geographical visualization, the midpoints of the tracks were plot (Fig. 7). Geographical information on the marine spatial plan (MSP) for the Belgian part of the North Sea was retrieved in March and October 2020 from http://www.marineatlas.be/en/data. This data was used to visualize areas designated to the activities studied. Fig. 8 gives an overview on the location of the 5 dredge disposal sites of the BPNS: LNP, BR&WOO, BR&WZE, BR&WS1 and BR&WS2.

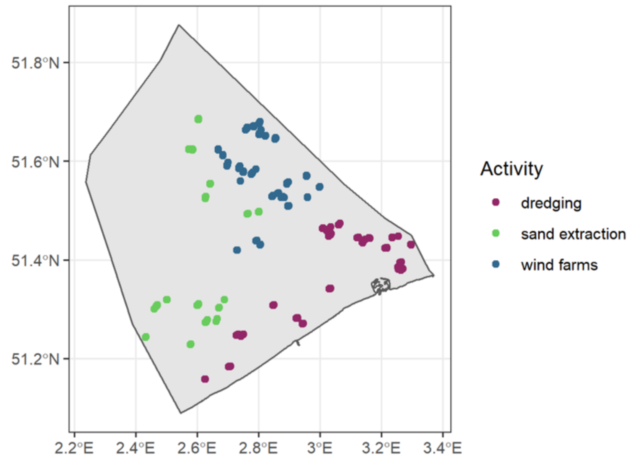

Fig 7. Spatial overview of the midpoints of a haul according to the anthropogenic activities monitored between 2013 and 2019 (including where the activity itself occurs, near the occurrence of the activity and reference sites). (N=458) Note: some reference sites were used as a reference for several activities and may therefore be included more than once.

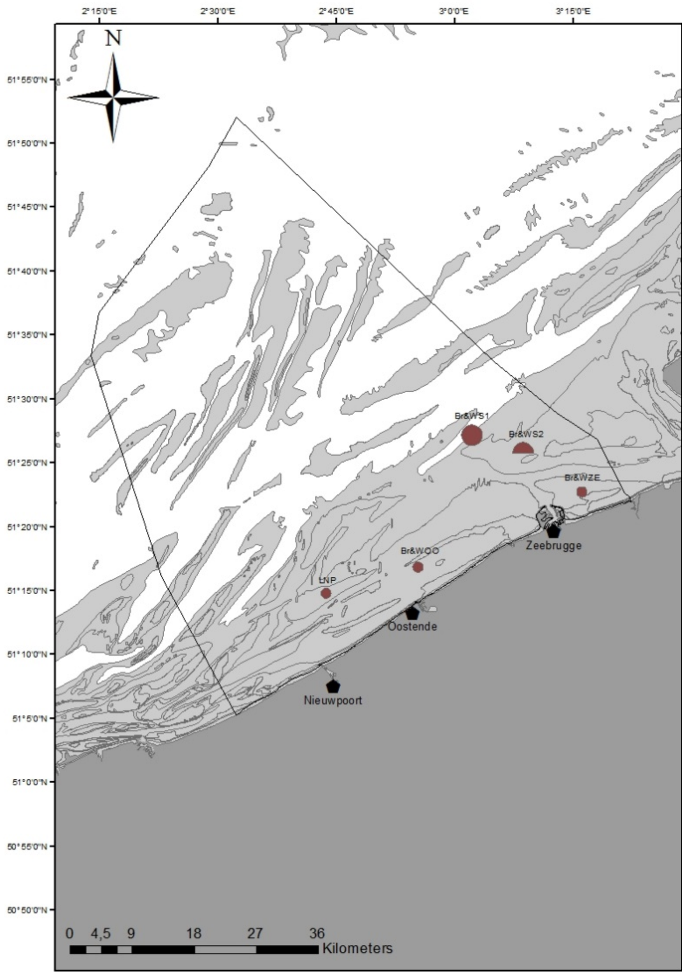

Fig 8. Spatial overview of the dredge disposal sites of the BPNS.

3 Results and Discussion

3.1 Marine litter at the BPNS

3.1.1 Temporal and spatial variation in total litter items

Within environmental monitoring campaigns at the BPNS, marine litter is monitored in a consistent way, applying a uniform way of litter categorization, since 2013. Fig. 9 shows the litter distribution, combining all years litter data. Fig. 10 shows the trend of litter items per ha, differentiating between the early march sampling campaign ("spring survey") and September-October sampling campaign ("fall survey").

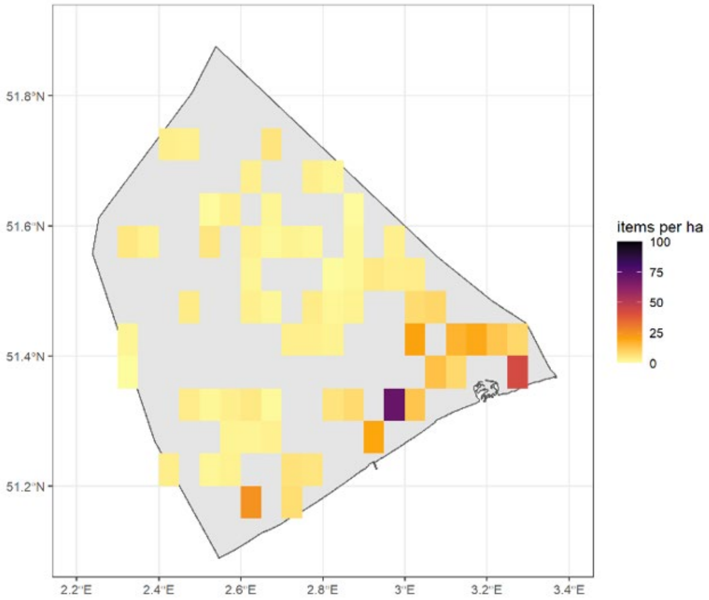

Fig 9. Average number of litter items per grid cell at the BPNS, pooled data of 2013 to 2019 (n=456).

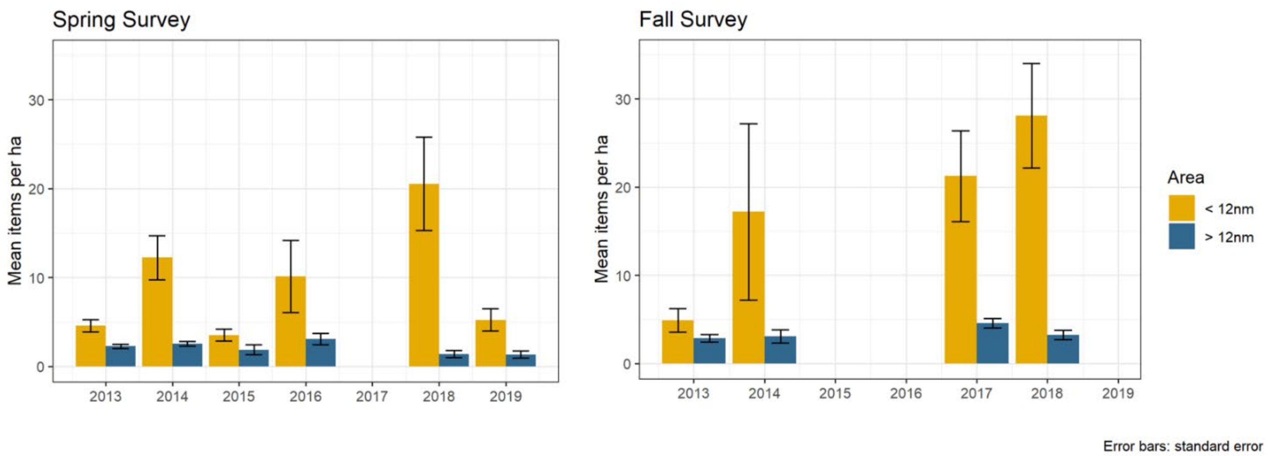

Fig 10. Average number of litter items within and beyond 12 nm of the Belgian coast, per year between 2013 and 2019 for spring survey and fall survey.

Largest number of litter items can be found at the coastal zone (Fig.9-10), with on average 12.7 ± 1.7 litter items per ha caught in the net of fish tracks taken within the 12 nautical miles (nm) zone compared to 2.8 ± 0.2 items per ha outside the 12 nm zone. This indicates an impact from land-based sources of marine litter or from marine activities within the 12 nm. However, current patterns and sedimentation may also play a role in the accumulation of litter. At the eastern part of the BPNS (Fig. 9), the coastal area is a known sedimentation area (Fettweis et al., 2009). Sedimentation will increase when water velocities are low, resulting in fine sediments close to the coast. This will also affect litter settling at coastal environment, with higher amounts of litter in mud to muddy sand regios (Fig. 11).

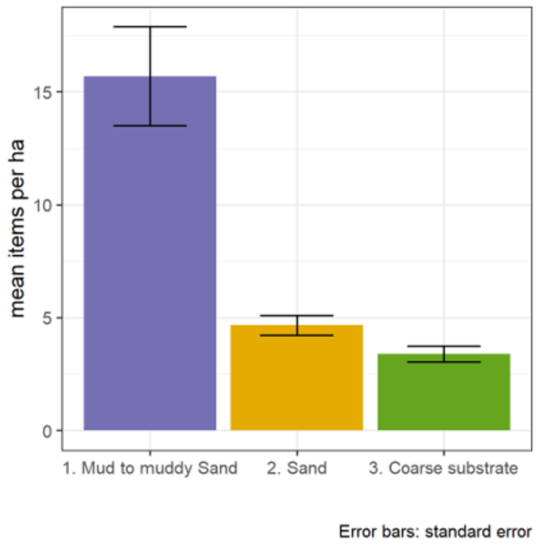

Fig 11. Average number of litter according to sediment type per substrate material based on the Folk pooled data, 2013-2019 (N=456). Error bars show the standard error of the average.

Analysing temporal trends in litter contamination is not straightforward (Fig. 10), as average number of litter items strongly vary between years. In 2013, 2015 or 2019, yearly averages within the 12 nm zone were at maximum 5.3 ± 1.3 litter items/ha, while much higher yearly averages were noted for 2014, 2016, 2017 and 2018, with a maximum of 24.6 ± 4.0 litter items/ha within the 12 nm zone in 2018. Litter item counts in the net are highly variable (Maes et al., 2018; Kamman et al., 2018) and are affected not only by the amount of litter at a location, but also by other factors such as the type of net or the size of the fishery catch (Kamman et al., 2018). Moreover, numbers present annual averages over all fish tracks, but the selection of fish tracks will slightly vary between campaigns with a higher amount of tracks within fall campaigns (53 ± 5) compared to spring campaigns (41 ± 15), which impacts the effect of a single track to the average litter load.

3.1.2 Spatial variations in specific litter items

Of all litter items caught in the net within the environmental monitoring survey, 88% were plastic. The relative share of non-plastics is however different at coastal areas (<12nm) compared to offshore areas. At the BPNS, 13% of litter items in the net are non-plastics within the 12 nm zone compared to 8% outside this zone (Fig. 12). The dominance of plastic in total marine litter contamination is coherent with other literature. Within the International Bottow Trawl Surveys (IBTS), recorded percentages of plastic items vary from 58% for the Celtic Sea, up to 68% for the Greater North Sea and 98% for the Eastern Bay of Biscay (Ospar, 2017b). On a larger scale, plastic is estimated to account for 80% of global marine litter items (UNEP, 2016).

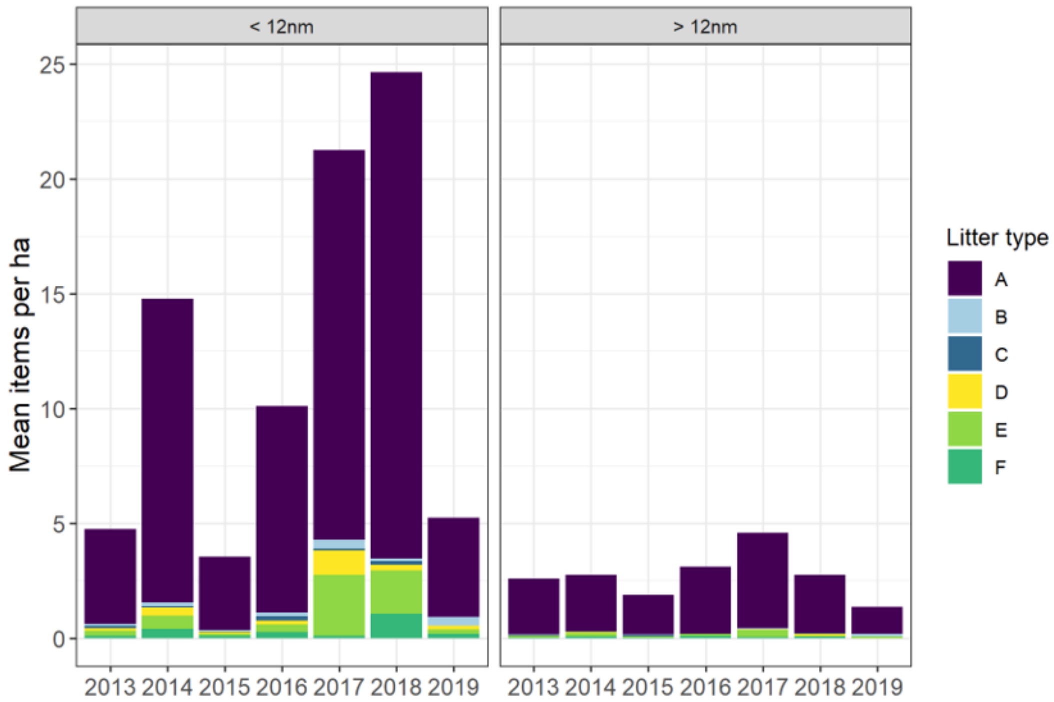

Fig 12. Average number of litter items per ha per year for the different litter material types, within and beyond 12nm of the BPNS, 2013-2019.

Within the litter category, sheets and filament fishing line (monofilament or entangled) are the dominating categories within as well as beyond the 12 nm zone (Table 1). This is in accordance with the work of Kamman et al. (2018) who found the same categories dominating within the IBTS of the North Sea. The relative contribution of these items is, however, not equally spread over the BPNS: the relative share of sheets, "crates and containers" and "caps and lids" is much higher in the coastal zone compared to the offshore area. In contrast, monofilaments have a high relative share at the offshore area. The source of the different items is a factor that impacts the spatial distribution as items from the categories sheets, "crates and containers" and "caps and lid" will mainly have a land-based origin whereas monofilaments are strongly linked to fisheries activities, e.g. by the use of dolly rope on nets. The physical characteristics of the litter item will also impact spatial distribution as shape, size and density will determine if an item rapidly sinks to the seafloor or is distributed over longer distances. As monofilaments from dolly rope are low density polyethylene plastics (Bekaert et al., 2015), they can be transported over longer distances along with the current.

Table 1. Overview of plastic litter items within and beyond the 12 nm zone. % is expressed as items of this category relative to the total amount of plastic litter items within this zone.

Litter category	Within 12nm zone		Beyond 12 nm zone	
	Number of items	% of plastic items	Number of items	% of plastic items
A1. Bottle	73	2.3	2	0.2
A2. Sheet	1525	47.9	267	28.7
A3. Bag	43	1.4	7	0.8
A4. Caps/lids	61	1.9	4	0.4
A5. Fishing line (monofilament)	718	22.5	450	48.3
A6. Fishing line (entangled)	405	12.7	70	7.5
A7. Synthetic rope	97	3.0	83	8.9

A8. Fishing net	16	0.5	7	0.8
A9. Cable ties	2	0.1	1	0.1
A10. Strapping band	8	0.3	3	0.3
A11. Crates and containers	69	2.2	3	0.3
A12. Diapers	0	0	0	0
A13. Sanitary towel/tampon	1	0	0	0
A14. Other	167	5.2	34	3.7
Total	3185	100	931	100

When non-plastic litter items are considered, natural products such as processed wood are recorded most, followed by items belonging to the groups miscellaneous and glass/ceramics. Categories metal and rubber each account for less than 10% of all non-plastic litter items (Table 2). No clear spatial difference can be found in relative abundance between the categories (Table 2).

Table 2. Overview of non-plastic litter items within and beyond the 12 nm zone. % is expressed as items of this category relative to the total amount of non-plastic litter items within this zone.

Litter category	Within 12nm zone		Beyond 12 nm zone	
	Number of items	% of plastic items	Number of items	% of plastic items
B. Metal	46	9.5	8	9.5
C. Rubber	27	5.6	8	9.5
D. Glass/ceramics	83	17.1	11	13.1
E. Natural products	238	49.0	39	46.4
F. Miscellaneous	92	18.9	18	21.4
Total	486	100	84	100

3.1.3 Litter contamination in relation to fisheries activities

The distribution of total litter items as well as fishing related litter items was studied for the BPNS. Fishing related litter items consisted of A5 and A6 (filaments), A8 (fishing net), B3 (fishery related metal) and C3 (rubber bobbins). Although the total amount of fisheries related items was higher within the coastal area (Fig. 13), the relative share of these items was lower, being 31% in the coastal area compared to 52% beyond the 12 nm zone.

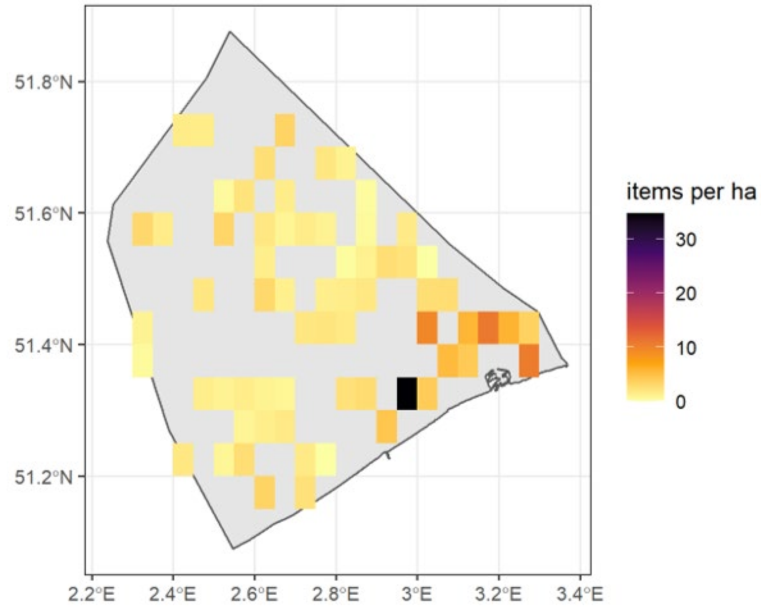

Fig 13. Average number of litter items from fishing material per ha per grid cell, pooled data 2013-2019.

Fishing activity, both expressed as number of fishing hours and intensity (swept area ratio, SAR), appeared correlated with both, the number of total litter items as well as the fishing material litter items (n=66). Results are not completely convincing as the correlation between the number of litter items and surface SAR was not statistically significant (correlation coefficient of 0.15 for total litter and 0.2 for fishing related litter). The correlation between number of fishing litter items and fishing hours (0.48) and number of fishing litter items and subsurface SAR (0.35) were statistically significant. However, the area with the highest fishing effort and intensity is also close to the coast (Fig. 5) which makes it difficult to assess the net effect of fisheries activities in relation to other sources and effects, such as land-based sources or sedimentation effects.

3.1.4 Litter contamination in relation to other activities at sea

The effect of sand extraction, OWF and dredging on total litter contamination at the BPNS was assessed, comparing impacted locations with reference locations and nearby or lowly impacted locations (annex 2). Sand extraction and OWF did not affect the total litter contamination. At the sand extraction areas of the BPNS, an average of 2.4 ± 2.0 litter items/ha was found in the net compared to 2.7 ± 2.5 litter items/ha at the reference zone. Within OWF, 2.6 ± 2.5 litter items/ha were detected compared to 2.2 ± 2.0 litter items/ha at the reference area (Fig. 14).

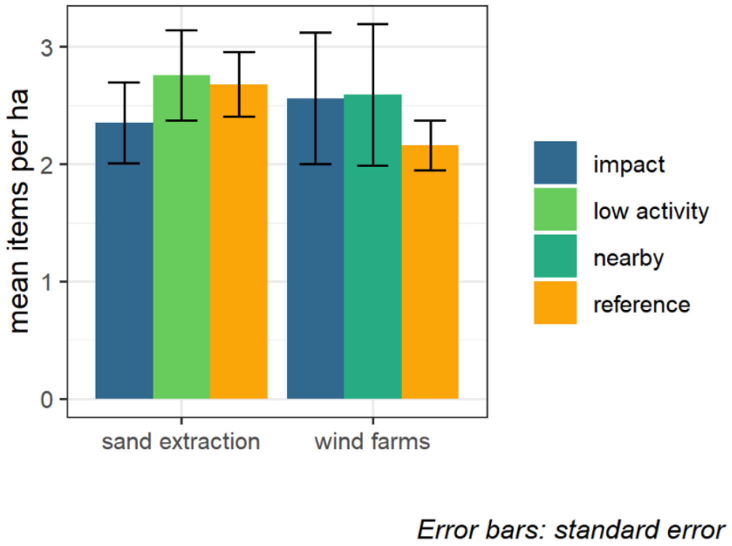

Fig 14. Average number of litter items per ha per year at sand extraction and OWF areas and corresponding reference areas (2013-2019).

The 5 dredge disposal sites at the BPNS are all located within the 12 nm zone (Fig.7). As a result, higher amount of average litter items are detected in the net (21.6 ± 38.6 items/ha) compared to sand extraction and OWF areas which are mainly located at the offshore area. Between the 5 dredge disposal sites, large differences can be seen with a highest average of 61.4 ± 79.2 litter items/ha at the impact zone of dredge disposal site Br&WZE and a lowest average value of 6.8 ± 3.3 litter items/ha at LNP (Table 3). Again, it is impossible to link differences univocally to 1 factor, as not only the dredge disposal intensity differs between the sites but also the sedimentation rate is different. At LNP, dredge disposal intensity was 0.08 ton dry matter (DM).m^{-2}.$year^{-1}$ from 2007 until 2017 while a much higher value of 1.84 ton DM.m^{-2}.$year^{-1}$ was recorded at Br&WZE (Lauwaert et al., 2019). However, this is not a prove that dredge disposal impact the marine litter input as LNP is also located on a sandy area at the western part of the BPNS, while dredge disposal site Br&WZE is located at a sedimentation area at the eastern part of the BPNS, classified as "mud to muddy sand". At individual dredge disposal sites, no clear difference can be found between impact, nearby and reference areas (Table 3) on the disposal sites LNP, BR&WOO, Br&WS1 and Br&WS2. At Br&WZE, however, 61.4 ± 79.2 litter items/ha were caught in the net at the impact area, compared to 15.0 ± 14.6 and 11.5 ± 14.1 litter items/ha at nearby and reference zones, respectively. As the nearby zone is also a sedimentation zone, this data suggests a significant input of litter from the dredging activities at Br&WZE. Br&WZE is a dredge disposal site, mainly receiving dredge disposal from the harbour of Zeebrugge. It is also the site with highest dredge disposal intensity (Lauwaert et al., 2019). A more detailed source investigation at this local litter hotspot is therefore recommended.

Table 3. Average total litter contamination at different dredge disposal site of the BPNS, pooled data, 2013-2019 (N=191).

Location	Type	Number of items	Number of tracks	Average number of items/ha	Minimum number of items/ha	Maximum number of items/ha
	Impact	90	9	6.8 ± 3.3	1.5	13.0
LNP	Nearby	79	10	5.4 ± 3.1	2.0	10.2
	Reference	252	14	12.4 ± 15.1	0	59.9
	Impact	330	10	22.2 ± 24.6	5.2	76.1
Br&WOO	Nearby	177	7	16.5 ± 15.8	4.1	50.2
	Reference	250	17	10.0 ± 16.2	0.6	70.7
Br&WS1	Impact	253	17	9.8 ± 13.5	1.4	52.3

	Nearby	111	9	8.4 ± 4.3	2.7	15.7
	Reference	252	14	12.4 ± 15.1	0	59.9
Br&WS2	Impact	316	11	19.0 ± 21.2	1.3	68.2
	Nearby	270	12	15.2 ± 20.3	1.6	68.8
	Reference	379	23	11.5 ± 14.1	0.6	58.3
Br&WZE	Impact	625	9	61.4 ± 79.2	3.9	252.9
	Nearby	131	6	15.0 ± 14.6	4.2	43.6
	Reference	379	23	11.5 ± 14.1	0.6	58.3

3.2 MARINE LITTER AT THE NORTH SEA, ENGLISH CHANNEL CELTIC SEA AND IRISH SEA

3.2.1 Temporal and spatial variation in total litter items

Amount of litter items caught in the net within the BTS (2011-2019) are shown within Fig. 15. Fig. 16 gives a view on the probability to find litter in the net. For 2695 BTS fish tracks, on average 2.2 ± 2.8 items per ha were caught with a median value of 1.4 items. This number is much lower than the amount of litter items caught in the net within the environmental monitoring campaigns at the BPNS, for which 12.7 ± 1.7 litter items per ha were found in the coastal zone and 2.8 ± 0.2 items per ha outside the 12 nm zone. This can be related to the fact that mainly tracks from outside the 12 nm are taken within the BTS, but also the mesh size of the net is different, which can lead to a lower catchability. Mesh size at the cod end is 40 mm for BTS campaigns compared to 20 mm for environmental monitoring.

The map on litter distribution at the North sea, Celtic Sea, Irish Sea and English channel (Fig.15) does not reveal clear spatial trends, although somewhat higher litter amounts can be noted at the Dutch coast. These observations are in contrast to the results of the OSPAR intermediate assessment (OSPAR, 2017b), based on the IBTS data, were a north-south gradient was detected at the North Sea, which could be linked to difference in anthropogenic inputs, rivers, prevailing winds and/or currents (OSPAR, 2017b). The presence/absence analysis on BTS tracks, showing the probability of having litter items in the net (Fig. 16) shows an opposite gradient as observed by the IBTS: based on BTS data, there is a higher probability to have litter in the net at the Northern Part of the North Sea compared to the Southern Part and the English channel. However, it should be noted that no zero litter catches were recorded from the German BTS tracks (Fig. 15). This is possibly related to misreporting in the ICES database, biasing the presence/absence analysis. The ICES working group on marine litter states that it is difficult to perform temporal and spatial trend analyses based on litter items caught in the net during fisheries surveys due to the low number of items, the high variability and the fact that seafloor litter monitoring is mostly a secondary objective at fisheries surveys (ICES, 2021). Differences in registration and reporting between countries may occur, impacting the accuracy of the results (ICES, 2021).

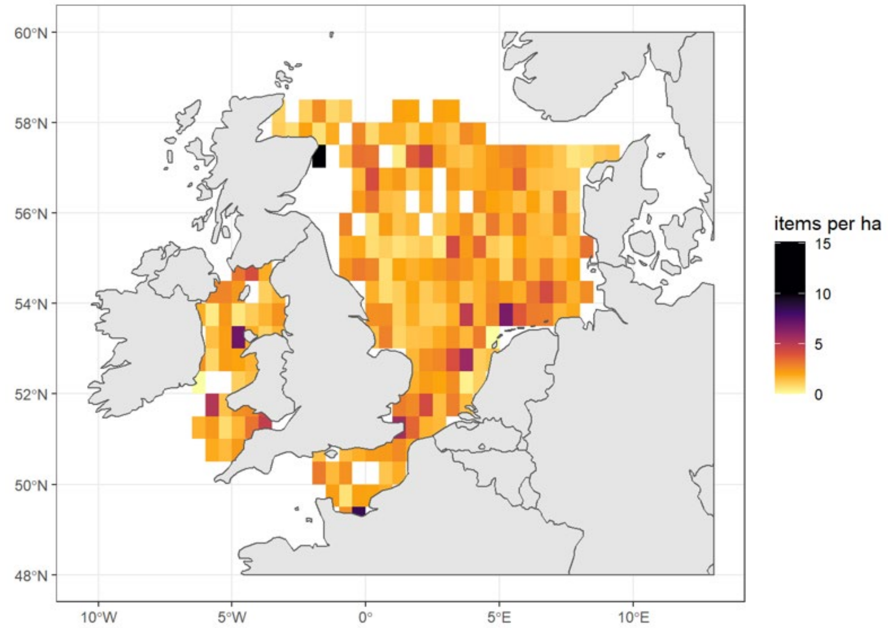

Fig 15. Average number of litter items per grid cell for the BTS, pooled data of 2011 to 2019 (n=2695)

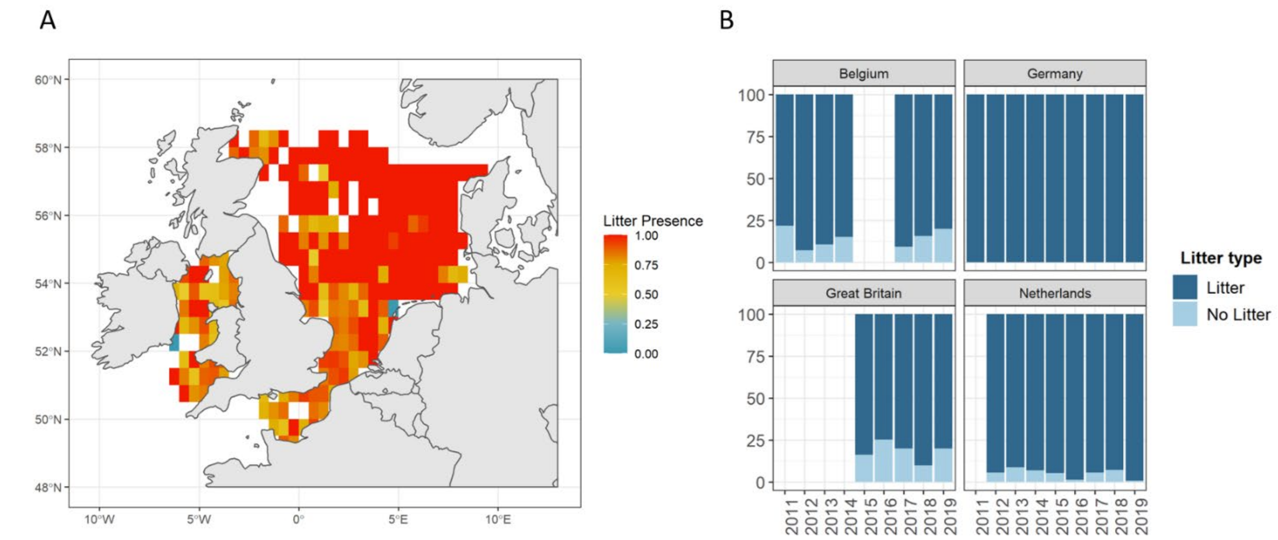

Fig 16. (A) Probability of finding litter in a haul per grid cell (based on presence or absence data) and (b) percentage of hauls with and without litter observations per country and per year (BTS, 2011-2019, n=2695)

3.2.2 Litter item categorisation

Of all recorded litter items within the BTS (2011-2019), 77% of the items are plastic, followed by miscellaneous (6%), rubber (6%) and natural products (6%) (Fig. 17). Within the litter category, dominant items are plastics sheets (A2, 25% of all plastic items), monofilament fishing line (A5, 22%), synthetic rope (A7, 11%), fishing line entangled (A6, 6%) and fishing net (A8, 2%). These results are in line with the results of the environmental monitoring survey at the BPNS and international studies on the North Sea based on IBTS data (OSPAR, 2017b; Kamman et al., 2018). The dominance of plastic is also reported at global scale (UNEP, 2016).

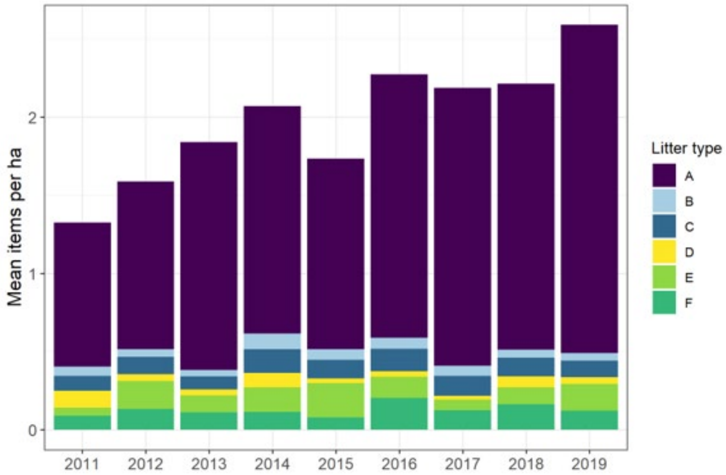

Fig 17. Average number of litter items per ha per year for the different litter material types, BTS, 2011-2019.

The distribution pattern of litter items is category dependent. At the North-West site of the BTS area, near Scotland, an increased occurrence of non-plastic items is recorded, with higher amounts of litter items per ha for metal, rubber, glass/ceramic, natural products and miscellaneous products (Fig. 18). The category plastic reveals less pronounced spatial differences, although larger concentrations of plastic items can be found near the Netherlands. A more detailed look to the different plastic categories learns that especially ropes and filaments (A5, A6, A7) can be found in higher amounts near the Dutch coast (Fig. 19) whereas bottles, crates and containers (A1, A11) and sheets (A2) show a more evenly distribution.

As fisheries activities are considered a major source of filaments, the link between fishing activity and total litter items and between fishing activity and fishing related litter items was investigated. The distribution of fishing related materials (Fig. 20) closely follows the distribution of ropes (Fig. 19c) as both grouped categories are dominated by monofilament fishing line and entangled fishing line. No clear relationship was found between the amount of litter items at the BTS area and fishing intensity. Correlation coefficients between total litter items or fishing related litter items on one hand and fishing hours, SAR and surface SAR on the other hand, were below 0.1. Although fisheries is recognized as an important source of marine litter (Garcia-Alegre et al., 2020), the lack of correlation between fishing effort and marine litter occurrence was also found by other authors (Buhl-Mortensen & Buhl-Mortensen (2018); Garcia-Alegre et al. (2020)). Different reasons may explain this lack of correlation. First issue is the lack of power. With an average value 2.2 ± 2.8 litter items per ha, numbers are low with a high variability, hampering the detection of correlations. Second, the spread of litter items is not only related to its sources, but also to hydrodynamic and geomorphological characteristics (Koutsodendris et al., 2008), which will lead to accumulation zones which can be further away from the source. E.g. deep sea canyons are known to have a higher density of marine litter, including derelict fishing gear (Cau et al., 2017; Pham et al., 2014). Third, fisheries activities themselves reduce litter density at the seafloor, due to delocalization during fishing operations (Lopez-Lopez et al., 2017).

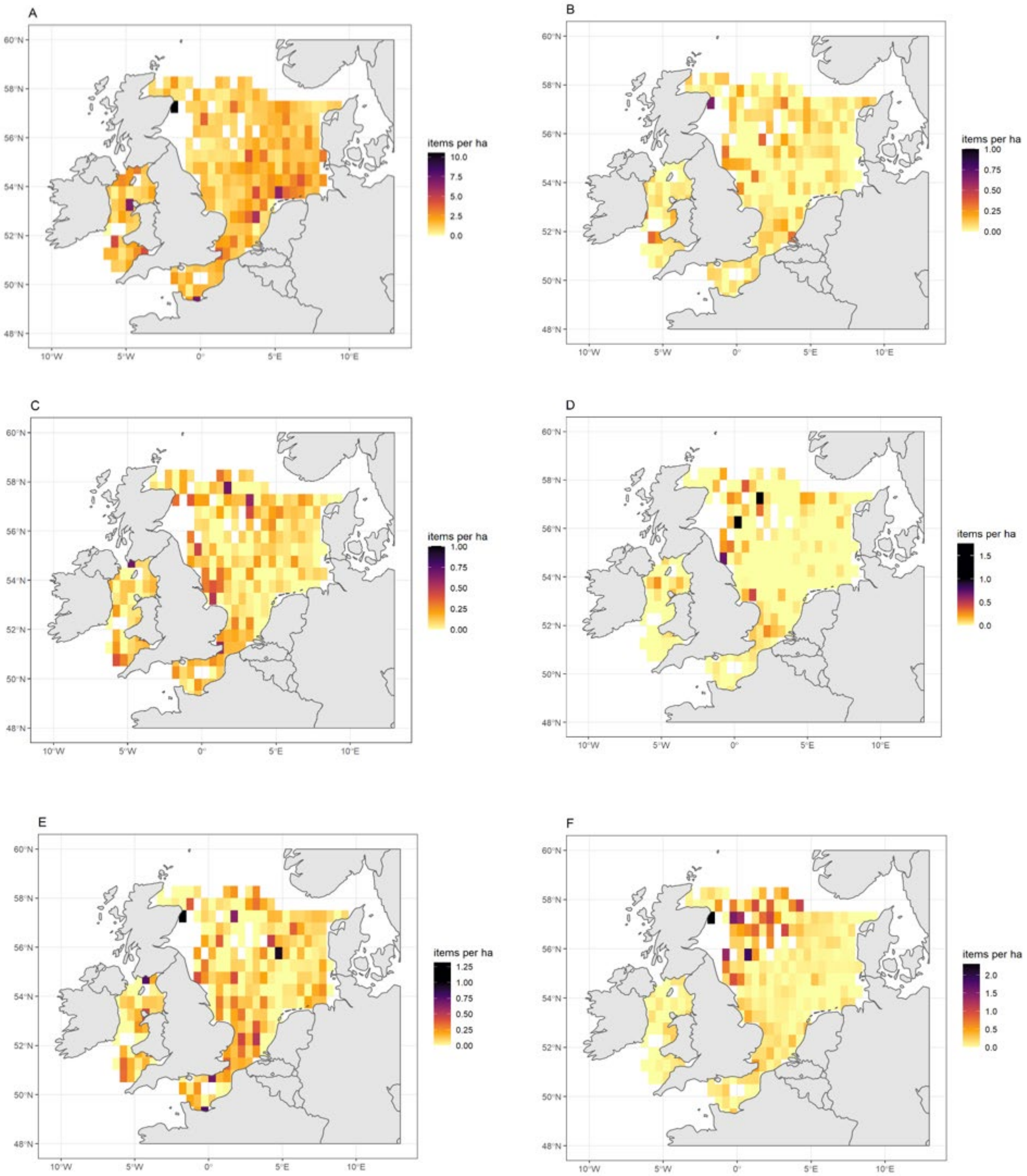

Fig 18. Average number of litter items per ha per grid cell for the different categories (BTS, pooled data, 2011-2019). (A) plastic (B) metal (C) rubber (D) glass/ceramic (E) natural products and (F) miscellaneous

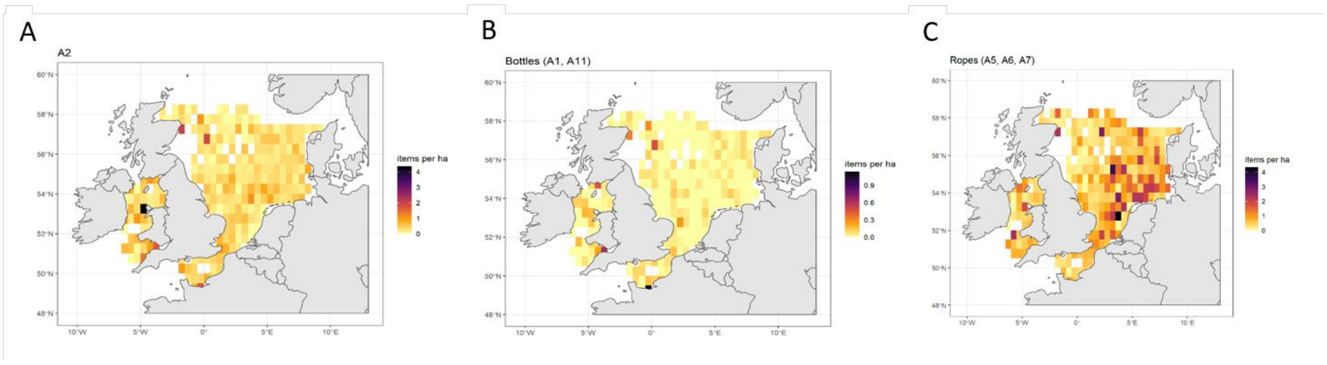

Fig 19. Average number of litter items per ha per grid cell for the different categories (BTS, pooled data, 2011-2019). (A) plastic sheets (B) bottles, crates and containers and (C) fishing line monofilaments, fishing line entangled and ropes.

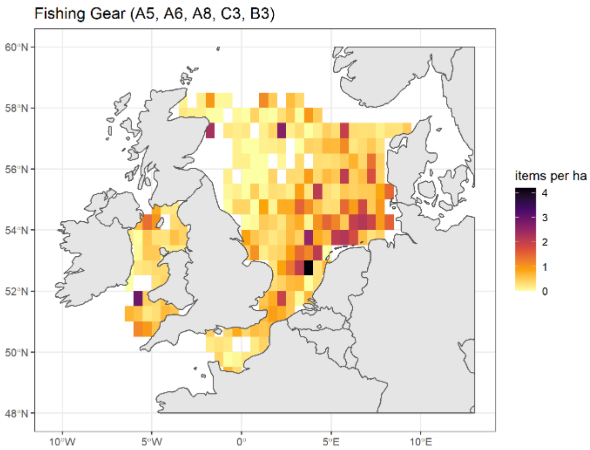

Fig 20. Average number of litter items from fishing material per ha per grid cell, pooled data 2011-2019.

4 CONCLUSIONS

Marine litter at the seafloor of the BPNS and Belgian fisheries areas is assessed, based on trawling data from environmental monitoring campaigns (2013-2019) and the international BTS (2011-2019). The environmental monitoring surveys offer an unique dataset as the regional density of fish tracks at the BPNS is high, with many tracks at a coastal environment sampled with a net with small mesh size. This leads to a relatively high number of litter items in the net, on average 12.7 ± 17 litter items per ha within the 12 nm zone. The amount of litter items caught within BTS fish tracks is much lower, on average on average 2.2 ± 2.8 items per ha, but the dataset offers the advantage of covering a large area, including North Sea, English channel, Celtic Sea and Irish Sea.

Litter at the seafloor of the BPNS and the BTS area mainly consists of plastic, but spatial differences occur in the distribution pattern of specific litter items. Heavier litter items with land-based sources such as bottles or crates and containers are especially found in the coastal area of the BPNS, whereas for example low density filament fishing line is more equally distributed over de BPNS. At the BTS area, filament fishing line has highest densities in front of the Dutch coast. Different factors may impact distribution patterns, as not only the location of the source plays a role, but also hydrodynamic and geomorphological characteristics will impact litter distribution. As a consequence, correlations between litter distribution and human activities are difficult to make. No increased amount of litter items was noted at sand extraction and OWF areas. Clear links between fisheries activities and fisheries related litter items could also not be made. Nevertheless, fisheries are an important source of marine litter with up to 52% of all litter items collected in the offshore area of the BPNS that can be linked to fisheries activities.

A hotspot marine litter location was identified at dredge disposal site BR&WZE, at the eastern coastal zone of the BPNS. Also at this area, effects of dredge disposal cannot be unambiguously differentiated from the effect of hydrodynamic processes such as sedimentation. However, due to the high amount of litter items, we recommend a detailed investigation on the sources and the processes affecting litter accumulation in this area in order to tackle litter pollution of the marine environment and to efficiently remediate hotspot areas.

5 ACKNOWLEDGEMENTS

We acknowledge the “marine plastics” project, funded by the European Maritime and Fisheries Fund (EMMF). We also want to thank the scientists, sea-going observers, technicians and lab-technicians of the Marine Biology group and the group Aquatic Environment and Quality of ILVO for sampling and litter registration. Fish tracks were taken by the research vessel Belgica (operated by the Belgian Navy under charter of RBINS).

6 REFERENCES

Bekaert , K., Devriese, L., Vandendriessche, S., Vanderperren, E., 2015. Spekvis – op zoek naar duurzame alternatieven voor spekking. ILVO mededeling 192. 54p.

Buhl-Mortensen, P., Buhl-Mortensen, L., 2018. Impacts of bottom trawling and litter on the seabed in Norwegian waters. Frontiers in Marine Science, 5(42), doi.org/10.3389/fmars.2018.00042

Cau, A., Alvito, A., Mocci, D., Canese, S., Pusceddu, A., Rita, C., Angiolillo, M., Follesa, M.C., 2017. Submarine canyons along the upper Sardinian slope (Central Western Mediterranean) as repositories for derelict fishing gears. Marine pollution bulletin, 123(1-2), 357-264. Doi.org/ 10.1016/j.marpolbul.2017.09.010

Fettweis, M., Houziaux, J.-S., Du Four, I., Van Lancker, V., Baeteman, C., Mathys, M., Van den Eynde, D., Francken, F., Wartel, S., 2009. Long-term influence of maritime access works on the distribution of cohesive sediments: analysis of historical and recent data from the Belgian nearshore area (southern North Sea). Geo-Mar. Lett., 29, 321-330.

Galgani, F., Brien, A.S., Weis, J., Ioakeimidis, C., Schuyler, Q., Makarenko, ., Griffiths, H., Bondareff, J., Vethaak, D., Deidun, A., Sobral, P., Topouzelis, K., Vlahos, P., Lana, F., Hassellov, M., Gerigny, O., Arsonina, B., Ambulkar, A., Azzaro, M., Bebianno, M.J., 2021. Are litter, plastic and microplastic quantities increasing in the ocean? Miroplastics and nanoplastics, 1, 2. Doi.org/10.1186/s43591-020-00002-8.

Garcia-Alegre, A., Roman-Marcote, E., Gago, J., González-Nuevo, Sacau, M., Durán Muñoz, P., 2020. Seabed litter distribution in the high seas of the Flemish Pass area (NW Atlantic). Scientia Marine, 84(1), 93-101. Doi.org/10.3989/scimar.04945.27A.

ICES. 2018. Spatial data layers of fishing intensity/ pressure per gear type for surface and subsurface abrasion, for the years 2009 to 2017 in the OSPAR regions II and III (ver. 2, 22 January, 2019): ICES data product release, http://doi.org/10.17895/ices.data.4686

ICES. 2016. OSPAR request for further development of fishing intensity and pressure mapping. In Report of the ICES Advisory Committee, 2016. ICES Advice 2016, Book 1, Section 1.6.6.4. 27 pp.

ICES, 2021. Working Group on Marine Litter (WGML; outputs from 2020 meeting). ICES Scientific Reports. 3:51. 90 pp. https://doi.org/10.17895/ices.pub.8185

Jambeck, J.R., Geyer, R., Wilcox, C., Siegler, T.R., Perryman, M., Andrady, A., Narayan, R., Law, K.L., 2015. Plastics waste inputs from land into the ocean. Science, 347, 6223, 768-771. Doi.org/10.1126/science.1260352.

JRC, 2013. Guidance on monitoring of marine litter in European seas. JRC Scientific and policy reports. MSFD technical subgroup on marine litter, 128p.

Kamman, U., Aust, M.O., Bahl, H., Lang, T., 2018. Marine litter at the seafloor – Abundance and composition in the North Sea and the Baltic Sea. Mar. Pollut. Bull., 127, 774-780. Doi: 10.1016/j.marpolbul.2017.09.051

Kaskela, A.M., Kotilainen, A.T., Alanen, U., Cooper, R., Green, S., Guinan, J. ,Van Hetere, S., Kihlman, S., Van Lancker, V., Stevenson, A., Emodnet Geology partners. Picking Up the Pieces—Harmonising and Collating Seabed Substrate Data for European Maritime Areas. Geosciences, 9, 84; doi:10.3390/geosciences9020084

Koutsodendris, A., Papatheodorou, G., Kougiourouki, O., Gergiadis, M., 2008. Benthic marine litter in four Gulfs in Greece, Eastern Mediterranean; abundance, composition and source identification. Estuarine, Coastal and Shelf Science, 77, 501-512. Doi.org/10.1016/j.ecss.2007.10.011

Lauwaert, B., Fettweis, M., De Witte, B., Van Hoey, G., Timmermans, S., Hermans, L., 2019. Vooruitgangsrapport (juni 2019) over de effecten op het mariene milieu van baggerspeciesstortingen (vergunningsperiode 01/01/2017-31/12/2021). BL/2019/01.

Lopez-Lopez, L., Gonzalez Irusta, J.M., Punzón, A., Serrano, A., 2017. Benthic litter distribution on circalittoral and deep sea bottoms of the southern Bay of Biscay: Analysis of potential drivers. Continental Shelf Research, 144, 112-119. Doi.org/10.1016/j.csr.2017.07.003

OSPAR, 2017a. CEMP guidelines on litter on the seafloor. OSPAR Agreement 2017-006, OSPAR commission, 11p.

OSPAR, 2017b. Composition and spatial distribution of litter on the seafloor. OSPAR intermediate assessment 2017, OSPAR commission, www.ospar.org/assessments.

Pham, C.K., Ramirez-Llodra, E., Alt, C.H.S., Amaro, T., Bergmann, M., Canals, M., Company, J.B., Davies, J., Duineveld, G., Galgani, F., Howell, K.L., Huvenne, V.A.I., Isidro, E., Jones, D.O.B., Lastras, G., Morato, T., Nuno Gomes-Pereira, J.N., Purser A., Stewart, H., Tojeira, I., Tubau, X., Van Rooij, D., Tyler, P.A., 2014. Marine Litter Distribution and Density in European Seas, from the Shelves to Deep Basins. PLoS ONE 9(4): e95839. Doi.org/10.1371/journal.pone.0095839

Maes, T., Barry, J., Leslie, H.A., Vethaak, A.D., Nicolaus, E.E.M., Law, R.J, Lyons, B.P., Martinez, R., Harley, B., Thain, J.E., 2018. Below the surface: Twenty-five years of seafloor litter monitoring in coastal seas of North West Europe (1992–2017). Sci. Total. Environ., 630, 790-798. Doi: 10.1016/j.scitotenv.2018.02.245

UNEP, 2016. Marine plastic debris and microplastics - global lessons and research to inspire action and guide policy change. United Nations Environment Programme (UNEP) Nairobi, 252 pp.

Van Lancker, V. 2019. SediCURVE@SEA: a multiparameter sediment database in support of environmental assessments at sea. In: Van Lancker V. et al., Quantification of Erosion/Sedimantation patterns to Trace the natural versus anthropogenic sediment dynamics (QUEST4D). Final report Phase 1. Science for Sustainable Development. Brussels, Belgian Science Policy, 2009, 63p.

7 Annex 1: Litter categories and subcategories

Type	Description_Type	PARAM	Description_PARAM
A	Plastic	A1	Plastic bottle
A	Plastic	A2	Plastic sheet
A	Plastic	A3	Plastic bag
A	Plastic	A4	Plastic caps/lids
A	Plastic	A5	Plastic fishing line (monofilament)
A	Plastic	A6	Plastic fishing line (entangled)
A	Plastic	A7	Synthetic rope
A	Plastic	A8	Plastic fishing net
A	Plastic	A9	Plastic cable ties
A	Plastic	A10	Plastic strapping band
A	Plastic	A11	Plastic crates and containers
A	Plastic	A12	Plastic diapers
A	Plastic	A13	Sanitary towel/tampon
A	Plastic	A14	Other plastics
B	Metals	B1	Cans (food)
B	Metals	B2	Cans (beverage)
B	Metals	B3	Fishing related metal
B	Metals	B4	Metal drums
B	Metals	B5	Metal appliances
B	Metals	B6	Metal car parts
B	Metals	B7	Metal cables
B	Metals	B8	Other metal
C	Rubber	C1	Boots
C	Rubber	C2	Balloons
C	Rubber	C3	Rubber bobbins (fishing)
C	Rubber	C4	Tyre
C	Rubber	C5	Glove
C	Rubber	C6	Other rubber
D	Glass/Ceramics	D1	Jar
D	Glass/Ceramics	D2	Glass bottle
D	Glass/Ceramics	D3	Glass/ceramic piece
D	Glass/Ceramics	D4	Other glass or ceramic
E	Natural products	E1	Wood (processed)
E	Natural products	E2	Rope
E	Natural products	E3	Paper/cardboard
E	Natural products	E4	Pallets
E	Natural products	E5	Other natural products
F	Miscellaneous	F1	Clothing/rags
F	Miscellaneous	F2	Shoes
F	Miscellaneous	F3	Other

8 ANNEX 2: CATEGORISATION OF ENVIRONMENTAL MONITORING CAMPAIGN FISH TRACKS

Overview of fish track locations within environmental monitoring, indicating the zone (within or beyond the 12 nautical mile zone) and location category. The latter is linked to anthropogenic activity (dredge disposal, sand extraction, offshore wind farms). Ref. = reference, Low act. = low activity.

Location	Lat. 1 (North)	Long. 1 (East)	Lat. 2 (North)	Long. 2 (East)	Zone	Activity 1	Sample category	Activity 2	Sample category
115s	51°09.263'	2°36.896'	51°09.747'	2°38.291'	<12nm	Dredge dis.	Ref.	NA	NA
120s	51°10.939'	2°41.568'	51°11.128'	2°43.135'	<12nm	Dredge dis.	Ref.	NA	NA
140biss	51°20.752'	3°02.689'	51°20.287'	3°01.271'	<12nm	Dredge dis.	Ref.	NA	NA
140triss	51°20.128'	3°00.643'	51°19.667'	2°59.193'	<12nm	NA	NA	NA	NA
215s	51°16.123'	2°37.265'	51°16.854'	2°38.356'	<12nm	Sand ext.	Low act.	NA	NA
230s	51°18.126'	2°50.351'	51°18.783'	2°51.556'	<12nm	Dredge dis.	Ref.	NA	NA
315s	51°17.990'	2°27.707'	51°18.803'	2°28.637'	>12nm	Sand ext.	Ref	NA	NA
330s	51°25.599'	2°47.639'	51°26.040'	2°49.079'	>12nm	OWF	Ref	NA	NA
340s	51°29.617'	2°59.425'	51°30.201'	3°00.731'	<12nm	NA	NA	NA	NA
415s	51°23.611'	2°19.676'	51°24.420'	2°20.631'	>12nm	NA	NA	NA	NA
421s	51°29.050'	2°28.208'	51°28.131'	2°27.574'	>12nm	NA	NA	NA	NA
820s	51°34.636'	2°21.181'	51°35.530'	2°21.904'	>12nm	NA	NA	NA	NA
830s	51°42.259'	2°26.496'	51°43.067'	2°27.445'	>12nm	NA	NA	NA	NA
840s	51°44.097'	2°38.672'	51°44.257'	2°40.266'	>12nm	NA	NA	NA	NA
1401s	51°16.666'	2°54.798'	51°17.121'	2°56.222'	<12 nm	Dredge dis.	Impact	NA	NA
1402s	51°16.009'	2°56.001'	51°16.477'	2°57.414'	<12nm	Dredge dis.	Nearby	NA	NA
2251s	51°14.567'	2°43.160'	51°15.101'	2°44.510'	<12 nm	Dredge dis.	Impact	NA	NA
2252s	51°14.494'	2°44.071'	51°15.082'	2°45.362'	<12nm	Dredge dis.	Nearby	NA	NA
7001s	51°22.801'	3°14.957'	51°22.940'	3°16.544'	<12 nm	Dredge dis.	Impact	NA	NA
7002s	51°23.598'	3°14.920'	51°23.757'	3°16.503'	<12nm	Dredge dis.	Nearby	NA	NA
7003s	51°22.672'	3°15.004'	51°22.825'	3°16.587'	<12nm	Dredge dis.	Impact	NA	NA
7101s	51°25.788'	3°07.576'	51°26.413'	3°08.826'	<12nm	Dredge dis.	Impact	NA	NA
7102s	51°26.382'	3°06.591'	51°26.961'	3°07.897'	<12nm	Dredge dis.	Nearby	NA	NA
7103s	51°26.043'	3°7.530'	51°26.043'	3°9.134'	<12nm	Dredge dis.	Impact	NA	NA
7104s	51°26.288'	3°7.526'	51°26.288'	3°9.130'	<12nm	Dredge dis.	Impact	NA	NA
7105s	51°26.979'	3°9.130'	51°26.268'	3°10.258'	<12nm	Dredge dis.	Nearby	NA	NA
7802s	51°27.906'	3°03.130'	51°28.620'	3°04.255'	<12nm	Dredge dis.	Nearby	NA	NA
7803s	51°27.248'	3°00.890'	51°27.950'	3°02.032'	<12nm	Dredge dis.	Impact	NA	NA
7804s	51°26.765'	3°01.568'	51°27.475'	3°02.699'	<12nm	Dredge dis.	Impact	NA	NA
7805s	51°28.218'	3°01.173'	51°27.520'	3°00.023'	<12nm	Dredge dis.	Nearby	NA	NA
B03s	51°25.394'	3°12.255'	51°25.488'	3°13.851'	<12nm	Dredge dis.	Ref.	NA	NA
B04s	51°26.602'	3°13.357'	51°26.834'	3°14.917'	<12nm	Dredge dis.	Ref.	NA	NA
B07s	51°25.897'	3°18.560'	51°25.746'	3°16.975'	<12nm	Dredge dis.	Ref.	NA	NA
BRN01s	51°18.182'	2°35.702'	51°18.902'	2°36.811'	<12nm	Sand ext.	Low act.	NA	NA
BRN02s	51°18.322'	2°34.920'	51°17.621'	2°33.779'	<12nm	NA	NA	NA	NA
BRZRs	51°14.143'	2°31.766'	51°14.906'	2°32.795'	<12nm	NA	NA	NA	NA

GB01s	51°25.382'	2°44.578'	51°24.963'	2°43.122'	>12nm	Sand ext.	Ref.	OWF	Ref.
GB02s	51°26.512'	2°48.254'	51°26.05'	2°46.831'	>12nm	Sand ext.	Ref.	OWF	Ref.
HB6s	51°37.912'	2°35.282'	51°36.922'	2°35.048'	>12nm	Sand ext.	Ref.	NA	NA
HB8s	51°37.992'	2°34.526'	51°36.996'	2°34.394'	>12nm	Sand ext.	Ref.	NA	NA
HB9s	51°40.582'	2°36.227'	51°41.579'	2°36.361'	>12nm	Sand ext.	Ref.	NA	NA
HB10s	51°33.682'	2°38.948'	51°32.787'	2°38.229'	>12nm	Sand ext.	Impact	NA	NA
HB11s	51°31.053'	2°37.481'	51°32.028'	2°37.834'	>12nm	Sand ext.	Impact	NA	NA
KB1s	51°18.569'	2°40.600'	51°17.678'	2°39.862'	<12nm	Sand ext.	Impact	NA	NA
KB2s	51°18.614'	2°41.458'	51°19.605'	2°41.242'	<12nm	Sand ext.	Impact	NA	NA
KBR01s	51°13.322'	2°34.262'	51°14.087'	2°35.290'	<12nm	Sand ext.	Ref.	NA	NA
KBZ01s	51°16.173'	2°39.373'	51°17.036'	2°40.181'	<12nm	Sand ext.	Low act.	NA	NA
LWO11s	51°22.461'	3°07.703'	51°23.313'	3°06.865'	<12nm	Dredge dis.	Ref.	NA	NA
LWO12s	51°22.900'	3°08.900'	51°22.900'	3°08.900'	<12nm	Dredge dis.	Ref.	NA	NA
MIC3s	51°28.816'	2°40.109'	51°30.056'	2°42.527'	>12nm	NA	NA	NA	NA
MIC4s	51°36.558'	2°32.043'	51°38.109'	2°33.703'	>12nm	NA	NA	NA	NA
ODC01s	51°18.721'	2°29.819'	51°19.632'	2°30.481'	>12nm	Sand ext.	Impact	NA	NA
ODR01s	51°14.169'	2°25.561'	51°15.008'	2°26.430'	<12nm	Sand ext.	Ref.	NA	NA
STP01s	51°22.702'	3°03.446'	51°23.321'	3°04.709'	<12nm	Dredge dis.	Ref.	NA	NA
TB1s	51°29.645'	2°47.399'	51°30.048'	2°48.869'	>12nm	Sand ext.	Impact	NA	NA
TB2s	51°29.340'	2°45.360'	51°30.000'	2°46.740'	>12nm	Sand ext.	Impact	NA	NA
Track2	51°32.859'	2°54.316'	51°32.358'	2°55.267'	>12nm	NA	NA	NA	NA
Track3	51°32.878'	2°55.259'	51°32.408'	2°56.268'	>12nm	NA	NA	NA	NA
Track5	51°33.759'	2°58.943'	51°34.388'	2°59.978'	>12nm	NA	NA	NA	NA
Track6	51°33.722'	2°57.948'	51°34.349'	2°58.975'	>12nm	NA	NA	NA	NA
WBB01s	51°34.139'	2°46.197'	51°34.852'	2°47.326'	>12nm	OWF	Ref.	NA	NA
WBB02s	51°34.177'	2°44.642'	51°35.057'	2°45.406'	>12nm	Sand ext.	Ref.	OWF	Ref.
WBB02bs	51°33.937'	2°44.752'	51°33.021'	2°44.105'	>12nm	Sand ext.	Ref.	OWF	Ref.
WBB03s	51°34.743'	2°43.902'	51°35.621'	2°44.674'	>12nm	OWF	Ref.	NA	NA
WBB04s	51°38.380'	2°50.989'	51°39.263'	2°51.746'	>12nm	OWF	Nearby	NA	NA
WBB05s	51°38.646'	2°49.248'	51°39.628'	2°49.554'	>12nm	OWF	Impact	NA	NA
WBB05bs	51°40.020'	2°48.986'	51°40.954'	2°49.559'	>12nm	NA	NA	NA	NA
WBB06as	51°38.887'	2°47.955'	51°39.825'	2°48.515'	>12nm	OWF	Impact	NA	NA
WBB06bs	51°41.133'	2°48.498'	51°40.195'	2°47.939'	>12nm	OWF	Impact	NA	NA
WBB07s	51°39.730'	2°46.824'	51°40.673'	2°47.360'	>12nm	OWF	Impact	NA	NA
WBB08s	51°39.598'	2°45.518'	51°40.512'	2°46.172'	>12nm	OWF	Nearby	NA	NA
WG2s	51°27.170'	2°50.670'	51°27.625'	2°52.099'	>12nm	NA	NA	NA	NA
WOH01s	51°35.076'	2°41.772'	51°36.052'	2°42.121'	>12nm	Sand ext.	Ref.	OWF	Ref.
WOH02s	51°37.225'	2°41.192'	51°36.240'	2°40.916'	>12nm	Sand ext.	Ref.	OWF	Ref.
WOH03s	51°37.922'	2°40.282'	51°36.935'	2°40.028'	>12nm	Sand ext.	Ref.	OWF	Ref.
WT1biss	51°30.754'	2°54.598'	51°30.348'	2°53.130'	>12nm	Sand ext.	Low act.	OWF	Ref.
WT2biss	51°31.815'	2°53.863'	51°31.402'	2°52.396'	>12nm	NA	NA	NA	NA
WT2triss	51°31.883'	2°53.411'	51°31.457'	2°51.957'	>12nm	Sand ext.	Ref.	OWF	Ref.
WT3s	51°31.582'	2°50.098'	51°31.953'	2°51.590'	>12nm	Sand ext.	Ref.	OWF	Ref.

WT3biss	51°32.365'	2°52.616'	51°31.831'	2°51.257'	>12nm	Sand ext.	Ref.	OWF	Ref.
WT7	51°32.462'	2°59.280'	51°33.117'	3°00.497'	>12nm	OWF	Nearby	NA	NA
WT9	51°33.824'	2°56.816'	51°34.479'	2°58.032'	>12nm	OWF	Nearby	NA	NA
WT10	51°33.564'	2°54.241'	51°33.134'	2°52.965'	>12nm	OWF	Nearby	NA	NA
WT11	51°31.864'	2°58.167'	51°31.290'	2°56.909'	>12nm	OWF	Nearby	NA	NA

Contact

Bavo De Witte, Scientific Researcher
Flanders Research Institute for Agriculture, Fisheries and Food
Animal Sciences Unit
Aquatic Environment and Quality
Ankerstraat 1
8400 Oostende - Belgium
T + 32 59 56 98 64
bavo.dewitte@ilvo.vlaanderen.be

ILVO

ILVO

Flanders Research Institute for Agriculture, Fisheries and Food
Burg. Van Gansberghelaan 92
9820 Merelbeke - Belgium

T +32 9 272 25 00
ilvo@ilvo.vlaanderen.be
www.ilvo.vlaanderen.be