Monitoring of Seafloor Litter on the Dutch Continental Shelf

International Bottom Trawl Survey 2022, Dutch Beam Trawl Survey 2021

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Summary

The Marine Strategy Framework Directive (MSFD) requires EU Member States to develop programmes of measures that aim to achieve or maintain Good Environmental Status (GES) in European seas. In order to be able to evaluate the quality status of marine waters on a regular basis and the effects of the measures taken, monitoring programs for MSFD descriptors and indicators have been established by the Member States. The Dutch monitoring program for Marine Litter (Descriptor 10) includes the collection of data on the presence, abundance and distribution of macro litter on the seafloor. According to the Dutch program, the data on seafloor litter must be collected during statutory task fish surveys using a standardised Grand Ouverture Verticale (GOV) fishing net as part of the International Bottom Trawl Survey (IBTS), which is carried out yearly in the North Sea.

Anthropogenic pollution of our oceans, including marine litter, threatens wildlife, hinders human activities and reduces the recreational value of our coasts. Marine litter affects all groups of marine wildlife through effects such as entanglement and ingestion. Various initiatives to reduce litter in the (marine) environment have recently been started or are currently under discussion. Despite management measures to decrease the input of litter and to remove litter from the environment, litter is still found in monitoring of the seafloor.

This report presents the seafloor litter composition, abundance and spatial distribution based upon catches of the regular fish surveys, the IBTS and the Dutch Beam Trawl Survey (BTS). Only the catches on the Dutch Continental Shelf (DCS) are used for data analysis. To assess the status of seafloor litter on the DCS, the Dutch data are supplemented with those from international partners surveying the DCS within the IBTS.

The seafloor litter catches on the DCS consisted mainly of plastic items: 93% (IBTS) and 88% (BTS) of the litter items found were made of plastic. Monofilaments, plastic sheets and various types of (plastic) ropes/lines were the most commonly caught litter types. A mean density of 88 litter items per km^2 over the years 2020-2022 was calculated for the IBTS on the DCS, whereby for the BTS a mean density of 198 litter items per km^2 over the last two years (2020-2021) was calculated on the DCS. It should be noted that the net used during the IBTS (GOV) and BTS (beam trawl) is not designed to catch litter. For the GOV, the catchability of many benthic species is assumed to be less than 5% compared to a beam trawl, therefore the chance of catching a litter item when it is present in the trawl path is likely to be even smaller than 5%. The fact that these items are caught despite the suggested low catchability thus indicates that it is plausible that there are many more litter items in the trawl path and that current values are a large underestimation of the actual amount of litter present. On top of that, due to the selectivity of the fishing gears used in the surveys, only a selection of the types of litter items present retain in the net. This is reflected by the fact that hardly any (small) single-use plastics, such as cutleries, straws and stirrers, were caught. However, by including the BTS survey a slightly better picture of the litter types present on the seafloor is provided since two times more items were collected and a wider range of litter items was caught. Therefore, the BTS data will be included in this report the coming years. Yet, the abundance and density estimations of seafloor litter presented in this report have to be considered a minimum estimation of the total amount of a selection of litter types present on the DCS, rather than its actual status.

1 Introduction

The Marine Strategy Framework Directive (MSFD) requires EU Member States to develop programmes of measures that aim to achieve or maintain Good Environmental Status (GES) in European seas. In order to be able to evaluate the quality status of marine waters on a regular basis and the effects of the measures taken, monitoring programs for MSFD descriptors and indicators have been established by the Member States. The Dutch monitoring program for Marine Litter (Descriptor 10) includes the collection of data on the presence, abundance and distribution of macro litter on the seafloor.

The oceans are of substantial socio-economic importance, providing employment, food and recreation for much of the world's population (Costanza 1999). Yet anthropogenic pollution abounds in our oceans, with marine litter threatening wildlife, hindering human activities and reducing the recreational value of our coasts (Fleet et al. 2009). Sources of marine litter can be sea- or land-based, although it is widely assumed that the latter contributes the overwhelming majority of the litter to the marine environment (Jambeck et al. 2015). Land-based sources and pathways of marine litter include sewage and river outlets, landfills and recreational activities along the coast (Viega et al. 2016). Via a complex web of ocean pathways land-based litter from the source country can end up in waters of another country far apart from each other (Chassignet et al. 2021). Shipping, fisheries, offshore installations and illegal dumping all constitute some of the sources of sea-based marine litter (Viega et al. 2016).

Plastics represent the majority of marine litter (Galgani et al. 2015). According to Meijer et al. (2021) between 0.8 to 2.7 million metric tonnes of post-consumer plastics enter the oceans solely by rivers every year. This has an impact on all groups of marine wildlife through effects such as entanglement and ingestion (Kühn et al. 2015, 2020). Entanglement may limit movement and inflict injury, thus reducing an animal's ability to avoid predators, acquire food or increase the potential for drowning. Ingestion of marine debris (both intentional and accidental) may cause a suppressed appetite or blockage of the gastrointestinal tract leading to malnutrition or harmful toxicological effects which in some cases may be lethal (Kühn et al. 2015; Rochman 2015; Thompson 2015). Additionally, there is increasing evidence that plastic can enter and accumulate in predators (including humans) by indirect (accidental) ingestion via trophic transfer from contaminated prey (Nelms et al. 2018; Hasegawa & Nakaoka 2021). Litter in the oceans can also have negative (sometimes lethal) effects on marine flora through smothering and crushing, resulting in reduced exposure to sunlight and the development of anoxic conditions on the seafloor (Kühn et al. 2015). At last, marine litter can act as suitable substrate for macrozoobenthic fauna whereby via displacement (wind, currents e.g.) it can introduce and spread some non-indigenous species (Mancini et al. 2021; Mantelatto et al. 2020).

Various initiatives to reduce litter in the environment have been started or are currently under discussion. The taxation of single-use plastic carrier bags introduced in 2016 is a good example which led to a significant reduction on an European level of single-use carrier bags in litter. The most recent European legislation (2019) is a ban on all single-use plastics. Nationally, on the first of July 2021 a deposit regulation for small plastic bottles (0.5 L) was put in force by the Dutch government, and since July 3rd 2021 single use plastics like cutleries, plates, straws, stirrers and cotton bud sticks are banned. Disposable plastic cups and meal containers for "on-the-go" and "take-away" consumption will be charged from July 2023 on and by 2024 the use of these disposable plastics will not be allowed on site anymore (restaurant, festival or office). The awareness of plastic pollution is also globally growing. Recently, the United Nations Environmental Assembly (UNEA) decided during an environmental summit in Nairobi (Kenya) in 2022 that within two years there will be a global binding treaty to reduce plastic pollution. During the summit the UNEA member states unanimously chose the most ambitious options and because of that this upcoming treaty is seen as (one of) the most important “green deal” since the 2015 Paris climate agreement.

The measures described above can help towards achieving GES for Marine Litter that is dictated by the European Marine Strategy Framework Directive (MSFD 2008/56/EC) to its EU member states. Top-down EU policies (e.g. MSFD) are seen as the most influential pieces of legislation (Frantzi et al. 2021). In addition, the MSFD requires to monitor the amount of litter in the marine environment and, where possible, monitor potential effects of the measures taken to reduce the amount of litter. The requirements for monitoring are divided in a number of categories: monitoring litter deposited onto the beach (Boonstra & Hougee, 2021), in the water column and biota, and deposited on the seafloor. The beach litter monitoring conducted in the North Sea indicates that a large part of the North Sea litter washes ashore on beaches near the Skagerrak. This is also modelled by Chassignet et al. (2021) whereby a large part of plastic waste of the Netherlands is displaced to Germany, Denmark and Norway by currents. Monitoring of litter washed ashore results in the indicator on “Beach litter” (OSPAR commission 2010; Schulz et al. 2017; Schulz et al. 2019) while the monitoring in biota results in the indicator on “Plastic particles in fulmar stomachs” (Van Franeker et al. 2017, 2021). In addition to these two indicators, there is a “Seabed litter” indicator describing the litter deposited on the seafloor (OSPAR commission 2017). Approximately 70% of marine litter reaches the seafloor where it can accumulate (Pham et al. 2014). Once deposited on the seafloor, marine litter degradation leads to the formation of microplastics. These microplastics degrade very slowly, since degradation occurs primarily through temperature-dependent solar UV-radiation, and therefore accumulate on the seafloor (Andrady 2015).

This report describes the methods used and presents and discusses the data collected in 2021 for the Dutch part of the monitoring of litter deposited on the seafloor as commissioned by Rijkswaterstaat (RWS). The OSPAR commission proposed to collect seafloor litter by using the catches of the International Bottom Trawl Survey (IBTS). This is an internationally coordinated survey covering the Greater North Sea to get recruitment indices of the fish community, focussing on cod, haddock, Norway pout, saithe, whiting, mackerel, herring and sprat. Despite the fact that the sampling gear is not optimal for sampling litter, the IBTS provides a good platform for internationally collected litter data. Data collection on board follows the CEMP Guidelines of Litter on the Seafloor (OSPAR, n.d.) and the most recent Working Group on Marine Litter (WGML) guidelines which are included in the IBTS survey manual (ICES 2020) as well as in the Dutch survey manual (van Damme et al. 2020). All international partners of the IBTS should follow these guidelines for seafloor litter collection, enabling the combination of the Dutch seafloor litter data from fishing hauls with those from the other partners on the Dutch continental Shelf (DCS). To get a better insight in the composition and amount of marine litter on the DCS, data collection of the Dutch Beam Trawl Survey (BTS) is following the same guidelines (protocol). This report provides insight in and summarises the seafloor litter composition, abundance and spatial distribution on the DCS.

The current focus on the DCS is a result of the way the MSFD is organised. Each European member state is only responsible for their part of the continental shelf and is obliged to report on their own part. Although excluded from this report, Dutch litter data collected by Wageningen Marine Research (WMR) in 2022 but outside the DCS are reported to the ICES DATRAS database, and are used for the OSPAR North Sea wide seafloor litter assessments.

Aims

Since 2013, IBTS data on seafloor litter have been collected by WMR, provided to RWS and stored in the ICES DATRAS database. Including the data collected in 2022, data for a total time span of ten years is available. RWS requested WMR to report on the current status of seafloor litter on the DCS, including litter data of international IBTS partners on the DCS and the Dutch BTS data. The core of this report presents the seafloor litter data collected during the (Dutch) IBTS in quarter 1 (Q1) of 2022. Additionally, the data collected during the latest BTS in quarter 3 (Q3) of 2021 are reported. The objectives of this report are to:

- Provide insight into the composition and abundance of seafloor litter on the Dutch continental shelf.
- Assess the spatial distribution of seafloor litter on the Dutch continental shelf.
- Compare the findings of the IBTS and the BTS to provide a more detailed insight of the state of seafloor litter on the Dutch continental shelf.

2 Methods

2.1 International Bottom Trawl Survey

2.1.1 Dutch IBTS Q1 2022

The International Bottom Trawl Survey quarter 1 (IBTS Q1) is carried out annually in January and February, and is performed by France, Scotland, Germany, Sweden, Norway, Denmark and the Netherlands (ICES 2020). The survey design divides the North Sea into grids (ICES rectangles) of 0.30° latitude and 1° longitude, which are distributed amongst the participating countries. Each rectangle needs to be sampled twice over the course of the IBTS but the allocation of rectangles among countries results in the majority of rectangles being sampled once by two different countries. For many years the distribution of areas covered by each country remained unchanged. However, in 2017, France had to reduce its surveying effort and was no longer able to cover all its allocated rectangles which resulted in a redistribution of rectangles among the participating countries. This change also affected the area covered by the Netherlands: it became more compact, no longer reaching as far north to Aberdeen nor as far south as the British Channel and the southern English coast. The planned area for 2022 (Figure 2.1) remained unchanged since the 2019 survey (van Hal 2019).

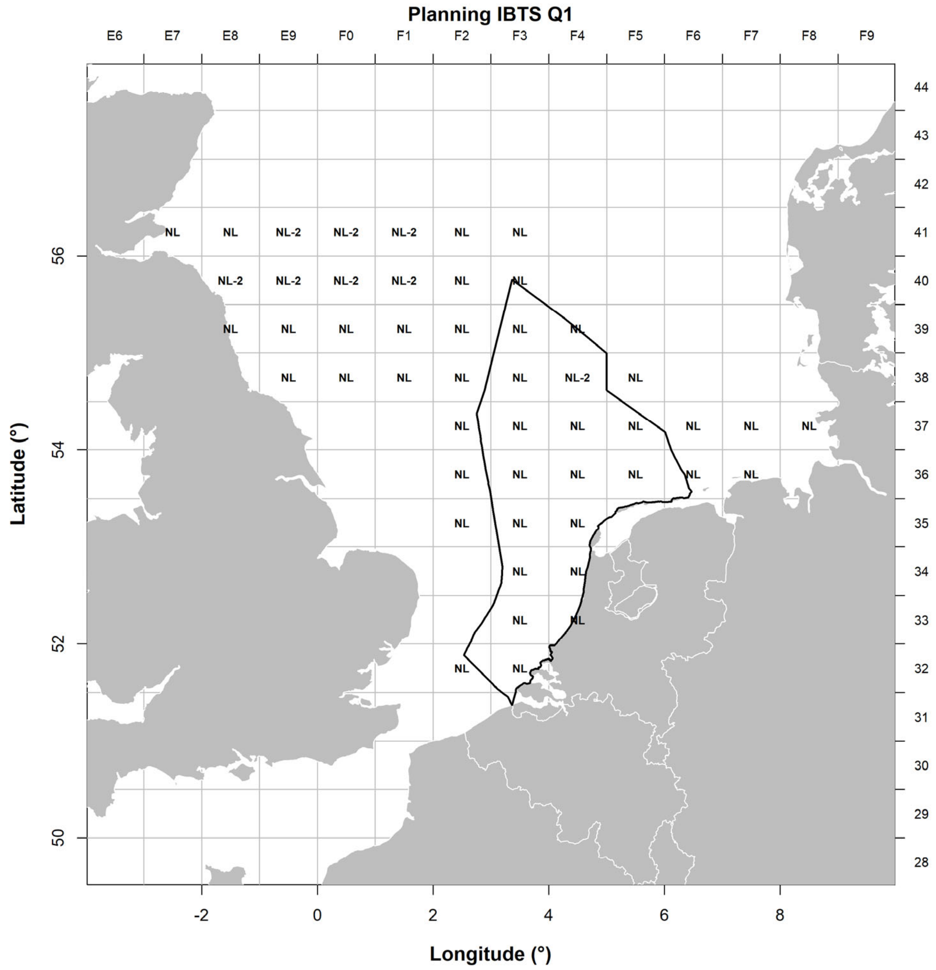

Figure 2.1. Planned ICES rectangles for the Dutch GOV hauls during the 2022 IBTS Q1. Rectangles marked “NL” are those that should be covered once by the Netherlands and once by another participating country. Rectangles marked “NL-2” are those that should be covered twice by the Netherlands. Empty rectangles are covered by other participating countries. Thick black line indicate the outline of the DCS.

The sampling gear used for the IBTS is the Grand Ouverture Verticale (GOV), a (semi-pelagic) bottom trawl. The mesh size of the net is 100 mm and 10 mm in the cod-end. The headline of the net lies about 5 m above the seafloor, which is particularly convenient for sampling pelagic fish species and species that dwell just above the bottom. However, as the ground rope of the GOV only touches the bottom, flatfish, benthic organisms and seafloor litter may well go underneath it, and the proportion that escapes the net can be substantial. For example, the proportion of small flatfish (<25 cm) going underneath the ground rope is assumed to be 50% (Piet et al. 2009). Due to the weak ground contact of the GOV, small flatfish, other small bottom dwelling species and epibenthos are caught by the GOV in a rather random manner (<5% compared to a beam trawl, e.g. each item has less than 5% chance to be retained in the net), and are thus not representative of what is actually present on the seafloor (ICES 2003). This is also likely to apply to the majority of other types of seafloor litter.

Table 2.1. Classification of marine litter items (ICES 2020). The table presents six categories of litter (A-F) and their respective subcategory (red), as well as size categories (A-F) used in the categorisation of seafloor litter items caught during the IBTS (green).

Litter overview			
A: Plastic	**B: Metals**	**Related size category**	
A1. Bottle	**B1.** Cans (food)	**A:** < 5*5 cm = 25 cm^2	
A2. Sheet	**B2.** Cans (beverage)	**B:** < 10*10 cm = 100 cm^2	
A3. Bag	**B3.** Fishing related	**C:** < 20*20 cm = 400 cm^2	
A4. Caps/Lids	**B4.** Drums	**D:** < 50*50 cm = 2500 cm^2	
A5. Monofilament	**B5.** Appliances	**E:** < 100*100 cm = 10000 cm^2 = 1 m^2	
A6. Entangled filaments	**B6.** Car parts	**F:** > 100*100 cm = 10000 cm^2 = 1 m^2	
A7. Synthetic rope	**B7.** Cables		
A8. Fishing net	**B8.** Other		
A9. Cable ties			
A10. Strapping band			
A11. Crates and containers			
A12. Diapers			
A13. Sanitary towel/tampon			
A14. Other			
C: Rubber	**D: Glass/Ceramics**	**E: Natural products**	**F: Miscellaneous**
C1. Boots	**D1.** Jar	**E1.** Wood (processed)	**F1.** Clothing/Rags
C2. Balloons	**D2.** Bottle	**E2.** Rope	**F2.** Shoes
C3. Bobbins (fishing)	**D3.** Piece	**E3.** Paper/Cardboard	**F3.** Other
C4. Tyre	**D4.** Other	**E4.** Pallets	
C5. Glove		**E5.** Other	
C6. Other			

The horizontal opening of the net is determined by the pressure on the two doors (otter boards), one on each side of the net. The horizontal opening of the net varies with depth. The width between the doors (door spread) is therefore measured continuously during each haul. The doors are connected to the net by a 10 m back strop and a 50 m sweep. This sweep moves over the seafloor creating a dust cloud, herding fish towards the actual net opening. The actual net opening (wing spread) varies with depth as well. The wing spread is considered most relevant for seafloor litter as it is not expected that seafloor litter is herded towards the net by the dust cloud created by the sweeps. The standard haul duration is 30 minutes, with a fishing speed of approximately 4 knots (7.4 km/h). Trawling is only carried out during daylight hours.

The Netherlands uses the research vessel Tridens II (Tridens) for the IBTS each year. In 2015 and 2016, due to a refit of the Tridens, the English research vessel CEFAS Endeavour was hired. Since the refit of the Tridens, the Dutch GOV-net and otter boards, as well as a new SIMRAD net-geometry system attached to the doors have been used for the IBTS.

2.1.2 Sampling Litter

The IBTS manual states that litter has to be collected in every haul (ICES 2020). On the Tridens the complete net is hoisted on board however a (part) of the ground rope is left hanging over the side and thus cannot be checked for the presence of litter. The net is inspected and cleaned as much as possible after each haul by an assigned person. Since the ground rope is hanging over the side of the vessel, it is only inspected and cleaned once on board in case of maintenance or reparations. Litter items in the net and in the catch are collected after each haul. Each litter item is then classified (Table 2.1), weighed, its size is estimated, photographed (can be used to check the data in case of odd recordings), and in case of linear objects the length is measured. In case similar items are found in a single haul, these are recorded as a single category, weighed together and the number of individual items is registered. When organisms are attached to litter items, the different kind of species are recorded as well. Moreover, a more detailed description of the litter items is given for each haul. The latter in combination with the photos taken facilitate a post-survey quality check of the data.

2.1.3 Area surveyed

Seafloor litter is presented as number of items per km^2. To be able to calculate items per km^2, knowledge on the surveyed area (total swept area) is required. The swept area of the GOV is variable, and depends on the depth and the amount of fishing line used. For fish calculations, two swept areas are calculated: one based on door spread and the other on wingspread. The door spread is the area between the doors (otter boards) of the gear, which is relevant for fish that are herded together into the net. The wingspread is the area between the wings, which is considered to be the actual net opening. We assume that marine litter is not herded into the net by the doors and cables, and thus wingspread is considered the relevant measure for seafloor litter.

The SIMRAD net geometry system records the door spread only. Therefore, wingspread needs to be calculated based on this data. In some cases door spread is not recorded properly, and in these cases depth and line length are used to estimate door spread instead. The formulas are based on (1) recorded door spread during the Dutch IBTS on the research vessel Tridens in previous years, and (2) the information gathered during the two years the Dutch IBTS was executed using the CEFAS Endeavour using the English wingspread sensors.

The equation for door spread in case door spread is not recorded properly is fitted to data recordings as follows:

(1) Door spread = 14.2 * LOG(Depth) + 16.72 * LOG(Warp length) + 18.49

Where Depth is the depth in meters and Warp length the length (m) of fishing line used. Once the door spread is known, wingspread (m) can be derived via the following equation:

(2) Wingspread = Door spread * 0.18870 + 5.87280

To calculate the number of litter items per km^2, the number of items per haul needs to be divided by the swept area as follows:

(3) Number of litter items per km^2 = Litter items / (Wingspread (km) * Distance trawled (km))

The above described data processing was done for the most recent (2022) Dutch litter data to obtain the number of litter items per km^2. Litter data from other IBTS partners from 2013 onwards were processed in the same way. However, the fitted constants in their formulas might slightly differ from the above mentioned values (ICES, n.d.).

2.1.4 Data analysis

The data analysis is done in two parts: (1) the Dutch IBTS 2022 Q1, and (2) the status of seafloor litter on the DCS (international data). The litter data of the Dutch IBTS 2022 Q1 is shown as the spatial distribution of litter items per km^2 (Figure 3.1). To focus on the Dutch continental shelf, further analyses were done with DCS data, including the data of the international IBTS partners on the DCS. Litter data of the international IBTS partners performed on the DCS was downloaded from ICES DATRAS database from 2013 onwards (Annex 1). However, not all available data could be used for the litter DCS data analysis due to inconsistencies in the counting of items. For some years, only the presence of seafloor litter and litter items was recorded. While the Netherlands started to count litter items from 2013 onwards (except A5 "Monofilaments", from 2014 onwards), most countries started to count single litter items a couple of years later. For example, France only started to count A2 "Sheets" in 2015 and Germany in 2018. An overview of the seafloor litter data used for this analysis is shown in Table 2.2 and the quality control for the available data on the DCS can be found in Annex 2.

Table 2.2. International seafloor litter data on the DCS. The table shows the seafloor litter data (number of hauls) per country per year on the DCS of which count data is available.

Country	Institute	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Denmark*	DTU-AQUA									3	4
France	IFREMER			19	19	13	17	17	13	14	12
Germany**	vTI							3			
The Netherlands	WMR	17	13	12	12	19	18	17	17	16	19

**Denmark only started to count marine seafloor litter in 2021.*

***Germany only executed three hauls on the DCS in 2019 as they swapped area with Denmark that year.*

To level out strong year-to-year variances, the DCS litter data of the three most recent years (2020-2022) are presented as figures showing the composition of the seafloor litter by categories A-F and the Top-10 most commonly caught litter types. To calculate the percentage per litter category or litter type, mean values per km^2 were taken based on all individual hauls executed on the DCS for the period 2020 – 2022. Spatial distribution of number of litter items per km^2 per ICES rectangle was shown by taking the mean value of total litter count per ICES rectangle. Densities per ICES rectangle were only based on hauls executed on the DCS, even if an ICES rectangle partly overlapped the DCS. To define hauls that were executed on the DCS, the outline of the DCS as shown in Figure 2.1 was used.

2.2 Beam Trawl Survey

In addition to the IBTS data, the BTS (Q3) is included in the marine seafloor litter report to expand the dataset and to get better insights in the amount of marine litter on the DCS since 2021. The BTS is carried out annually from July until September. The survey design is similar to the IBTS, except that this survey is only performed by the Dutch and that not all ICES rectangles need to be sampled twice a year (Figure 2.2). Instead, in the south-eastern North Sea and in the German Bight a minimum of two and a maximum of four hauls has to be performed per rectangle. The research vessel Tridens is also used for the BTS each year, where a beam trawl of 8 m with a 40 mm cod-end mesh size is used. This gear has better bottom contact and is therefore assumed to have higher catches of seafloor litter than the GOV used in the IBTS (Van der Sluis & van Hal 2017). Despite the better bottom contact of the beam trawl there might be on the other hand a higher escapement of small litter items since the cod-end mesh size of the beam trawl is larger compared to the GOV (12 mm). Like for the GOV, only a selection of the types of litter items present retain in the net. Litter items are recorded following the same methodology to that of the IBTS. Seafloor litter caught with the beam trawl is also presented as number of items per km^2, the net width of the beam trawl is fixed and the surveyed area is therefore calculated by making use of the following equation:

(1) Number of litter items per km^2 = Litter items / (Beam trawl width (km) * Distance trawled (km))

Data analysis for the DCS is performed in a similar way as described for the IBTS (section 2.1.4), except that it is exclusively based on Dutch hauls since it is only performed by the Dutch. In addition, only the data of 2020 and 2021 was used since the recording of marine litter during the BTS started to be done consistently in 2020.

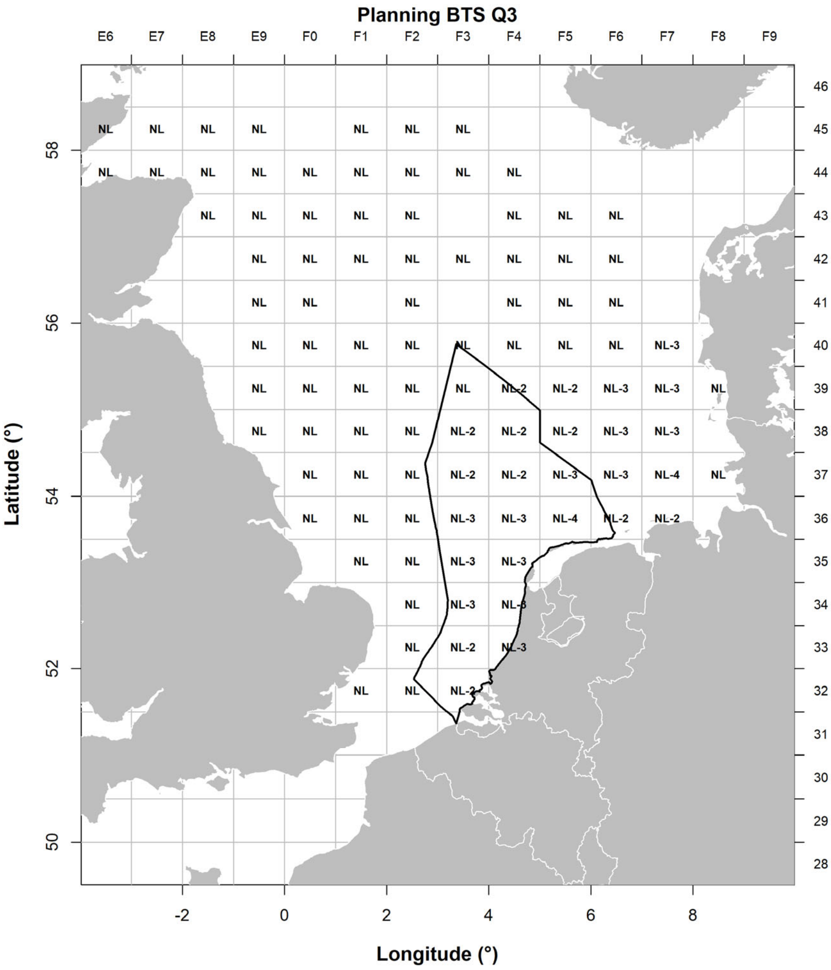

Figure 2.2. Planned ICES rectangles for the Dutch bottom trawl hauls during the 2021 BTS Q3. Rectangles marked "NL" are those that should be covered once, rectangles marked "NL-2" should be covered twice, etc. Empty rectangles are those that are not covered at all. The thick black line indicates the outline of the DCS.

3 Results

3.1 International Bottom Trawl Survey

3.1.1 Dutch IBTS Q1 2022

The Dutch IBTS 2022 Q1 performed 53 valid hauls, of which 19 were conducted on the Dutch continental shelf. Almost all hauls lasted the standard 30 minutes. The planned survey area for 2022 remained unchanged from the surveyed area of previous years. However, less hauls were executed than planned due to extremely bad weather conditions during the survey. In the second week of the survey, the survey area was first impacted by storm Corrie (31 Jan) and in the last two weeks consecutively by the storms Dudley (16 Feb), Eunice (18 Feb) and Franklin (20 Feb). In addition to that, the southernmost hauls in ICES rectangle 32F2 were taken over by France. In general, however, most of the planned hauls could be sampled by the Dutch. All the available GOV-data are presented in the file: RWS_dataformat_GOV_data_NCP_2013-2022.xls.

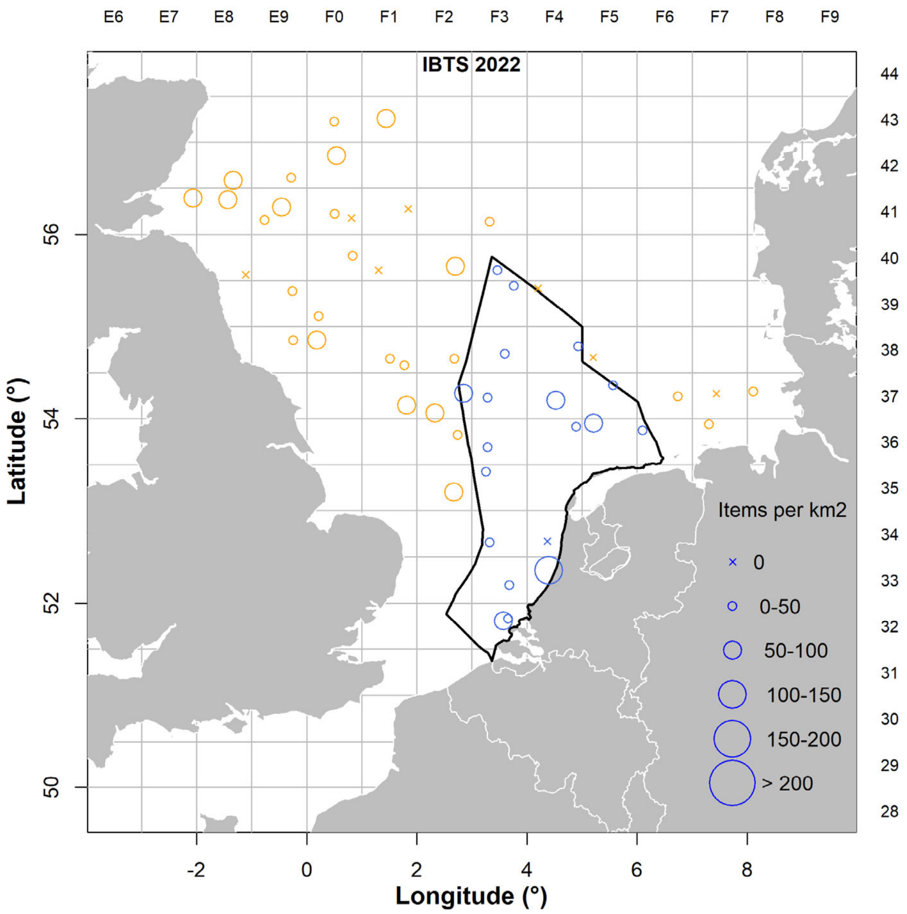

Figure 3.1. Executed Dutch GOV hauls and total items per km² during the 2022 IBTS. GOV-hauls executed on the DCS (blue) and GOV-hauls executed by the Netherlands (WMR) outside the DCS (orange). The size of the circles indicates the number of items caught per km².

The spatial distribution of litter caught during the Dutch IBTS 2022 is presented in Figure 3.1. Note that not all hauls were performed as planned, e.g. ICES rectangles 32F2 was taken over by France in 2022 and in 35F4 and 38F4 not all hauls were executed. The small crosses represents hauls without litter items in the catch, empty hauls. There was one empty haul (0 items/km²) located in front of the Dutch coast (34F4), four in British waters and two in German waters. The haul with the highest amount of items per km^2 was located on the DCS in the coastal zone (33F4), with 113 litter items per km^2.

3.1.2 Seafloor litter on the Dutch Continental Shelf

The analyses in this section is performed using all available and usable seafloor litter data for the Dutch continental shelf for the three most recent years, 2020-2022. A total of 99 hauls were conducted on the Dutch continental shelf for these three years during the IBTS by Denmark, France and the Netherlands, covering a swept area of 5.9 km^2. The general composition of seafloor litter and the Top-10 litter types were calculated by mean values. Since the dataset contains a large amount of zero values, the median might give a biased (zero) outcome. Therefore, mean values are used.

3.1.2.1 Material composition on the Dutch Continental Shelf

Plastic was the most dominant category of seafloor litter on the DCS in the IBTS, accounting for 93% of the caught litter items (Figure 3.2). "Natural products" and metals were the second and third most dominant litter categories, responsible for 4% and 2% of all litter items caught, respectively. Rubber, glass and miscellaneous were each representing less than 1% of the litter items.

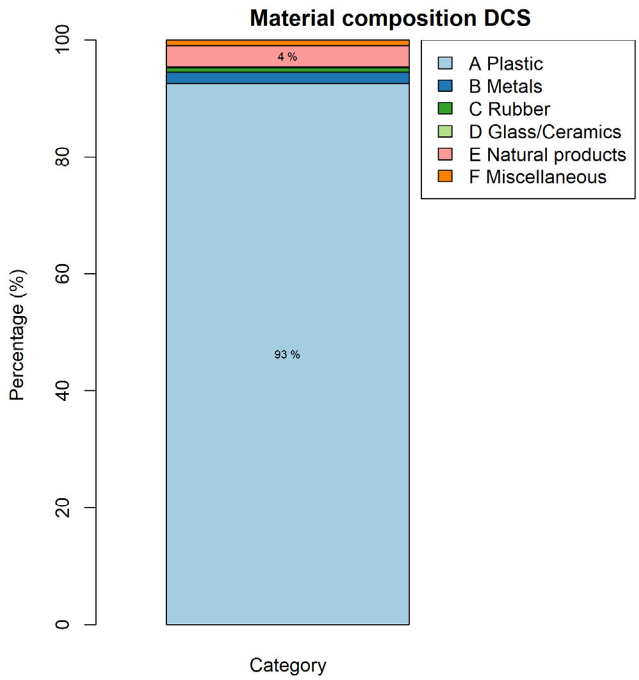

Figure 3.2. Material composition of the seafloor litter in the catches of the IBTS on the DCS for 2020-2022. The percentages are based on mean values per km^2 per litter category. No percentage is presented for the litter categories B – Metals (2%), C - Rubber (0.7%), D - Glass/Ceramics (0.1%) and F – Miscellaneous (0.9%).

3.1.2.2 Top-10 litter types

Based on the mean values per litter type, a Top-10 of most dominant litter types caught in the IBTS on the DCS was compiled (Figure 3.3). The Top-10 are dominated by plastic litter types and these 10 litter types account for 94% of the total litter items caught. Only three litter types were made of natural materials, respectively "Wood" (E1), "Rope" (E2) and "Clothing/Rags" (F1). The most dominant litter type was "Sheet" (A2), representing 30% of the litter items caught. Followed by "Monofilament" (A5), "Synthetic rope" (A7) and "Bag" (A3), accounting for 29%, 15% and 8% of the litter items caught. The other litter types in the Top-10 list were each responsible for 5% or less of the litter items caught on the DCS (Figure 3.3).

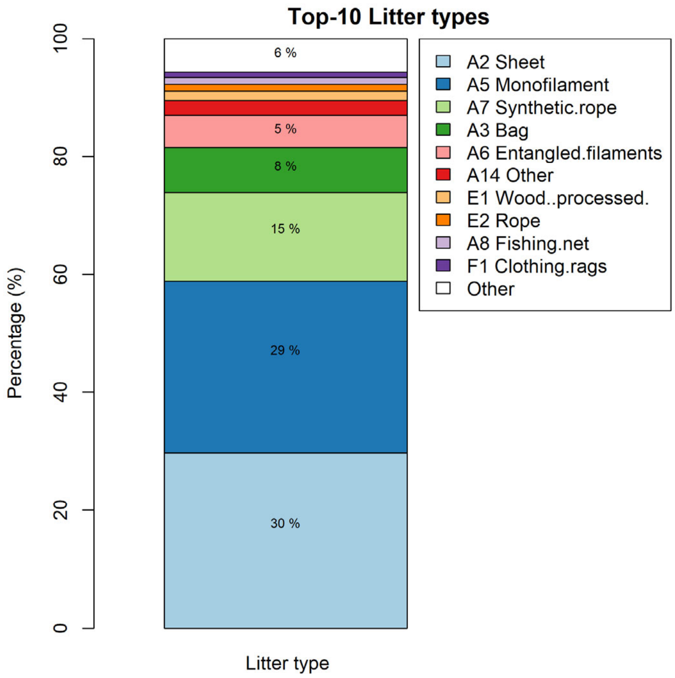

Figure 3.3. Top-10 list of seafloor litter items in the catches of the IBTS on the DCS for 2020-2022. The percentages are based on mean values per km^2 per litter type. The Top-10 litter types for which no percentages are indicated are: A14 – Other (2.5%), E1 – Wood (1.4%), E2 – Rope (1.1%), A8 – Fishing net (1.0%), F1 – Clothing/rags (0.8%).

3.1.2.3 Abundance and distribution of seafloor litter

Litter was found in 91% of the IBTS hauls on the Dutch continental shelf in the period between 2020 and 2022 (Table 3.2). The maximum recorded amount was 481 litter items per km^2 (total count), this number was dominated by "Monofilaments" (A5) and recorded by France. The ratio of the mean and median values in Table 3.1 do not indicate that these high international (French) values influence the overall mean result significantly.

Table 3.1. IBTS summary table presenting seafloor litter abundance on the DCS in the period 2020-2022. The minimum (Min), median, mean, 90th percentile (p90th), maximum (Max), percentage of total count and the percentage of hauls with at least one item present are shown for total count, the different litter categories and the Top-10 litter types.

Items per km^2	Min	Median	Mean	p90th	Max	% of Total Count	% of hauls with >0 item present
Total count	0	68	88	191	481		91
Litter categories							
A - Plastic	0	60	82	180	481	93	86
B - Metals	0	0	2	0	36	2	8
C - Rubber	0	0	1	0	18	<1	4
D - Glass	0	0	0	0	12	<1	1
E - Natural	0	0	3	2	113	4	10
F - Miscellaneous	0	0	1	0	24	<1	4
Top - 10 Litter types							
A2. Sheet	0	16	26	73	373	30	62
A3. Bag	0	0	7	19	86	8	23
A5. Monofilament	0	0	26	69	313	29	45
A6. Entangled filaments	0	0	5	17	123	5	21
A7. Synthetic rope	0	0	13	36	202	15	35
A8. Fishing net	0	0	1	0	30	1	5
A14. Other	0	0	2	16	21	3	13
E1. Wood (processed)	0	0	1	0	85	2	4
E2. Rope	0	0	1	0	32	1	5
F1. Clothing/Rags	0	0	1	0	24	1	4

Despite the WGML guidelines, the best way to count the number of individual monofilaments or sheets correctly and in a consistent way is still under discussion. The guideline states that if items are entangled but recognisable as separate items, they should be counted as separate items. Annex 3 shows some examples of entangled monofilaments and synthetic rope. Where the Netherlands counted all of these examples as "Entangled items" (A6), some international partners might have separated some of these items and counted them as multiple litter items ("Monofilaments" (A5) and/or "Synthetic rope" (A7)).

The spatial distribution on the Dutch continental shelf based on the IBTS is presented as litter items per km^2 per ICES rectangle, with light colours (green) representing low number of items and dark (purple) colours representing high numbers of litter items. The amount of litter items per ICES rectangle is shown as the mean number of litter items per km^2 over the last three years (2020-2022). Highest densities were recorded in the 35F4 rectangle close to the coast. However, the spatial distribution of litter seems more or less random, no clear pattern or litter hotspot can be distinguished (Figure 3.4). Likewise, no clear pattern is identifiable when comparing the total count of litter items on the DCS over time (2013 – 2022), where the recordings fluctuated strongly from year to year (Figure 3.5).

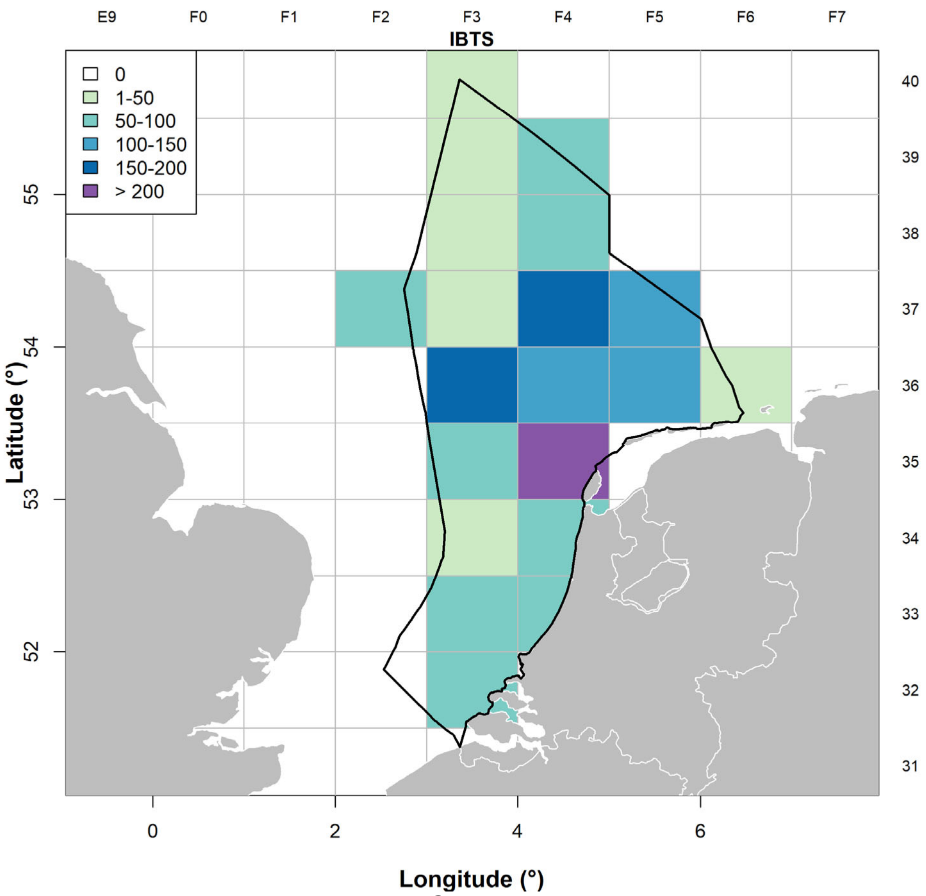

Figure 3.4. Density of litter items per km^2 per ICES rectangle in the IBTS on the DCS. The different colours represent the numbers (total count) of litter items per km^2, this number is calculated as the mean value per ICES rectangle for 2020-2022.

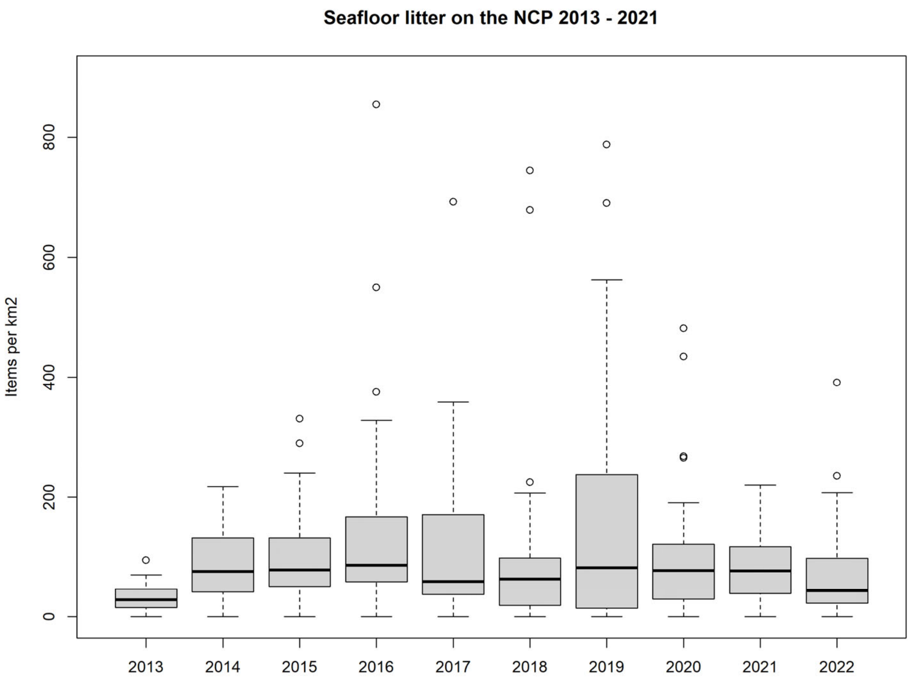

Figure 3.5. Boxplot of the seafloor litter items per km² for all IBTS hauls conducted on the DCS each year (2013 – 2022). The data selection as shown in Table 2.2 was used. For 2013 and 2014, the input data is exclusively based on Dutch count data. From 2015 onwards French data is included and from 2019 on data from Germany and Denmark is also included.

3.2 Beam Trawl Survey

3.2.1 BTS Q3 2021

The Dutch BTS 2021 Q3 performed 142 valid hauls, of which 38 were conducted on the Dutch continental shelf. As presented in Figure 2.2, the planned area and amount of hauls per ICES rectangle for 2021 remained generally unchanged compared to those of previous years (Volwater & van Hal 2021). The executed hauls and spatial distribution of litter caught during the Dutch BTS 2021 are presented in Figure 3.6. There were only four empty hauls (0 items/km^2), two located on the DCS and two west of the DCS. The hauls with the highest amount of items per km^2 (± 1840 items/km^2) were located in ICES rectangle 37F8 (German EEZ) and 43E8 (UK EEZ), both close to the coast and an estuary. The highest amount of litter items recorded on the DCS in the Dutch BTS Q3 2021 was 1013 items per km^2 and was found near the coast North of Terschelling (36F5).

3.2.2 Seafloor litter on the Dutch Continental Shelf

The analysis in this section is done with all available and usable seafloor litter data on the Dutch continental shelf for the most recent years, 2020 and 2021. In total, 85 hauls were conducted on the Dutch continental shelf for these two years, combined accounting for a swept area of 2.7 km^2. The general composition of seafloor litter and the Top-10 litter types were calculated by mean values. Since the dataset contains a large amount of zero values, the median might give a biased (zero) outcome. Therefore, mean values are used.

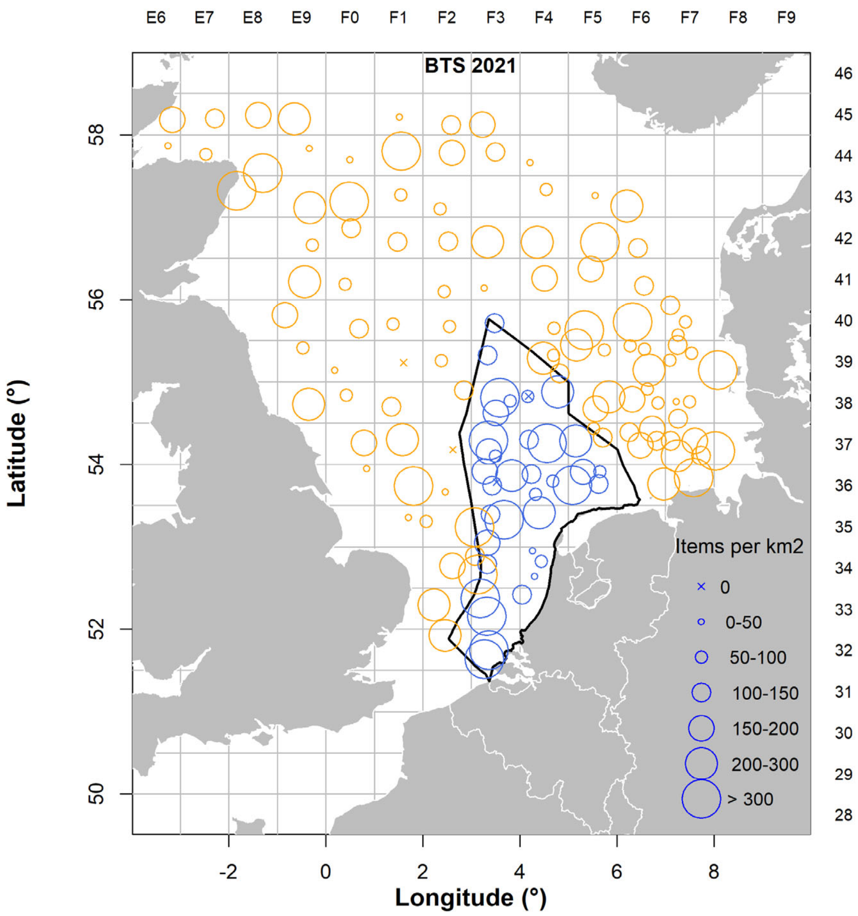

Figure 3.6. Executed beam trawl hauls and total items per km² during the 2021 BTS. BTS hauls executed on the DCS (blue) and outside the DCS (orange) are presented. The size of the circles indicates the number of items caught per km². The small crosses represents hauls without litter items in the catch, empty hauls.

3.2.2.1 Material composition on the Dutch Continental Shelf

Plastic was the most dominant category of seafloor litter on the DCS in the BTS, accounting for 88% of all litter items (Figure 3.7). "Natural products" (E) was the second most dominant category, responsible for 5% of all litter items caught. "Metals" (B) and "Rubber" (C) represented 3% and 2% of the litter items, respectively, while "Glass" (D) and "Miscellaneous" (F) were representing both around 1% of the total litter items.

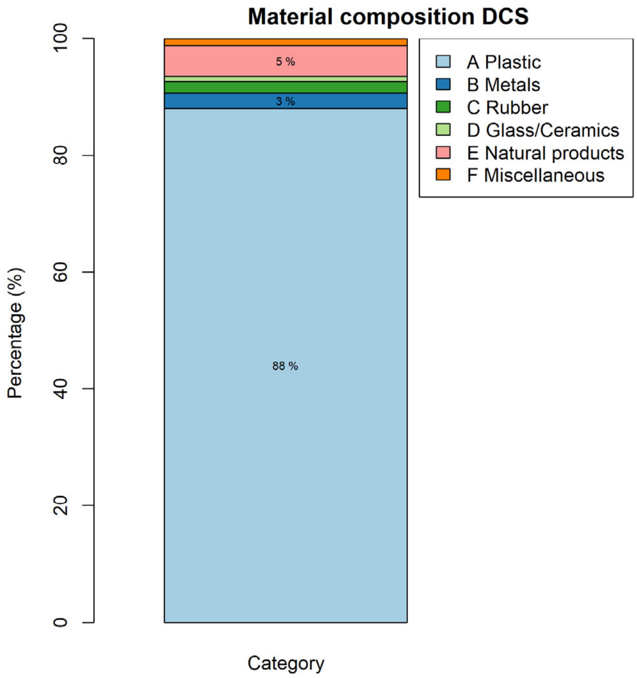

Figure 3.7. Material composition of the seafloor litter in the catches of the BTS on the DCS in 2020 and 2021. The percentages are based on mean values per km^2 per litter category. The litter categories for which no percentages are indicated are: C - Rubber (2%), D - Glass/Ceramics (1%) and F – Miscellaneous (1%).

3.2.2.2 Top-10 litter items

Based on the mean values per litter type, a Top-10 of most dominant litter types caught in the BTS on the DCS was compiled (Figure 3.8). The Top-10 is dominated by plastic litter types. Meanwhile, only three litter types were made of natural material, metal or rubber, namely "Wood (processed)" (E1), "Cans (beverage)" (B2) and "Glove" (C5). The most dominant litter type was "Monofilament" (A5), accounting for 35% of the litter items caught. This is followed by "Sheet" (A2), "Others" (A14) and "Synthetic rope" (A7), accounting for 23%, 8% and 7% of the litter items caught, respectively. The remaining Top-10 litter types were each responsible for less than 7% of the total litter items caught on the DCS.

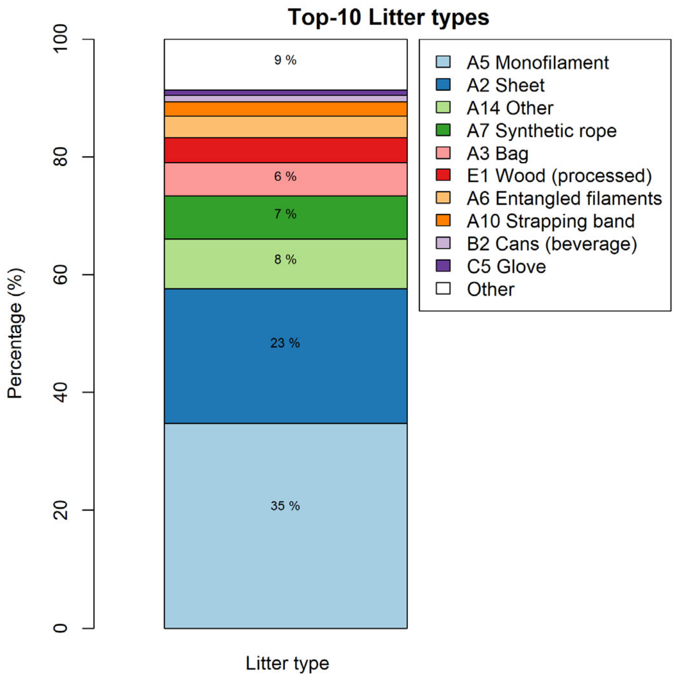

Figure 3.8. Top-10 list of seafloor litter items in the catches of the BTS on the DCS in 2020 and 2021. The percentages are based on mean values per km^2 per litter type. The Top-10 litter types for which no percentages are indicated are: E1 – Wood (4.3%), A6 – Entangled filaments (3.7%), A10 – Strapping band (2.4%), B2 – Cans (2.0%) and C5 – Glove (1.8%).

3.2.2.3 Abundance and distribution of seafloor litter

Litter was found in 93% of the BTS hauls on the Dutch continental shelf in 2020 and 2021 (Table 3.2). The maximum amount recorded was 1013 litter items per km^2 (total count) and was dominated by "Monofilaments" (A5). Since the number of hauls per ICES rectangle in the BTS is not equally distributed (Figure 3.6), the weighted mean for total count, each litter category and the Top-10 litter items is calculated to correct for this.

Table 3.2. BTS summary table of the abundance of seafloor litter on the DCS in the years 2020 and 2021. The minimum (Min), median, weighted mean per ICES rectangle, mean, 90th percentile, maximum (Max), percentage of total count and the percentage of hauls with at least one item present are shown for total count, the different litter categories and the Top-10 litter types.

Items per km^2	Min	Median	Weighted mean	Mean	90th percentile	Max	% of Total Count	% of hauls with >0 item(s) present
Total count	0	153	189	198	370	1013		93
Litter categories								
A - Plastic	0	135	167	174	306	1013	88	92
B - Metals	0	0	5	5	30	53	3	15
C - Rubber	0	0	4	4	28	53	2	12
D - Glass	0	0	2	2	0	55	1	5
E - Natural	0	0	9	10	33	161	5	22
F - Miscellaneous	0	0	3	2	0	80	1	6
Top-10 Litter types								
A2. Sheet	0	31	44	45	112	369	23	60
A3. Bag	0	0	11	11	33	96	6	27
A5. Monofilament	0	34	64	69	167	675	35	67
A6. Entangled filaments	0	0	6	7	32	74	4	18
A7. Synthetic rope	0	0	17	14	46	101	7	33
A10. Strapping band	0	0	4	5	30	86	2	12
A14. Other	0	0	16	17	34	222	8	31
B2. Cans (beverage)	0	0	2	2	0	53	1	6
C5. Glove	0	0	1	2	0	34	1	6
E1. Wood (processed)	0	0	8	8	32	161	4	18

The spatial distribution on the Dutch continental shelf based on the BTS is shown as litter items per km^2 per ICES rectangle, with the same colour legend as in Figure 3.4. The amount of litter items per ICES rectangle is shown as the mean number of litter items per km^2 for 2020 and 2021. No clear pattern or litter hotspot can be identified, but the spatial distribution tends to show higher densities of marine litter closest to the coast (Figure 3.9). Highest densities were recorded in the 33F3 and 35F4 ICES rectangles with densities of 411 and 332 items per km^2, respectively.

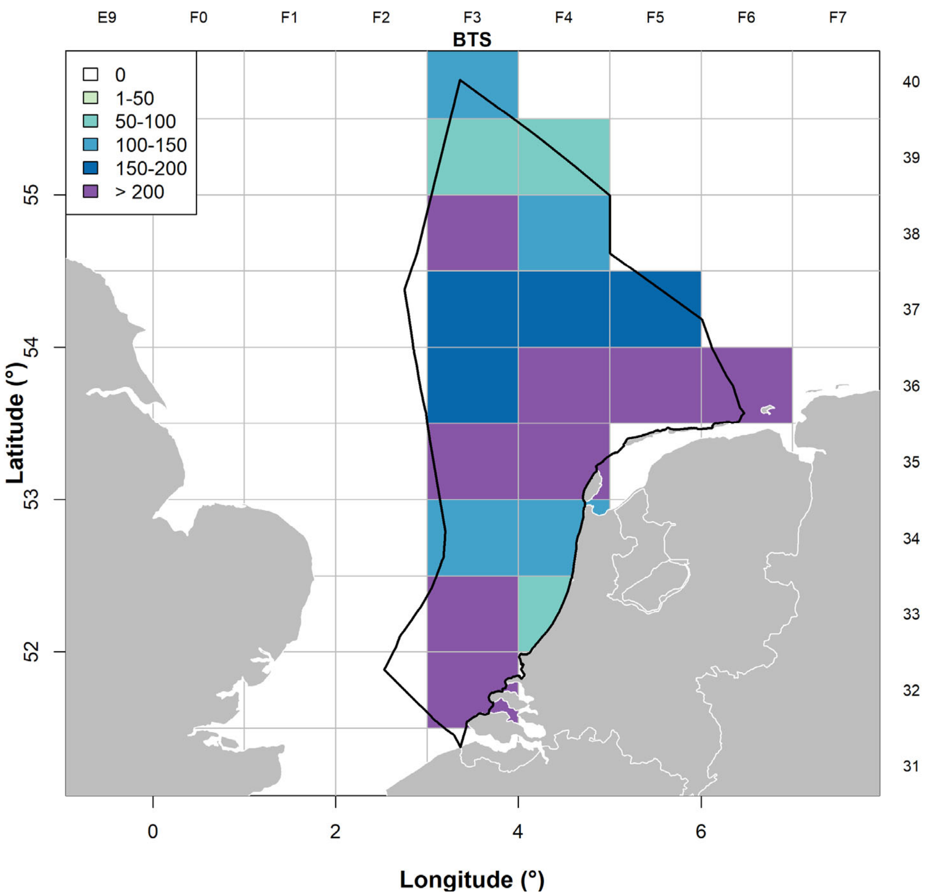

Figure 3.9. Density of litter items per km² per ICES rectangle in the BTS on the DCS. The different colours represent the numbers (total count) of litter items per km². This number is calculated as the mean value per ICES rectangle for 2020 and 2021.

3.3 Comparison IBTS and BTS

The composition of the litter caught on the DCS is generally comparable between the two surveys. While plastic accounts for 93% of the litter caught in the IBTS, it accounts for 88% in the BTS. Litter categories such as natural products, rubber and metals (that might be partly buried in the top layer of the seafloor) were caught more often in the BTS. The beam trawl used in this survey scrapes the top layer of the seafloor and therefore also catches items that are (partly) buried in this top layer. The Top-10 litter types caught in both surveys is also comparable, although the relative abundances of litter types can differ. "Monofilament" (A5) and "Sheet" (A2) represent about 70% of the litter items caught for both surveys. Items in categories such as "Bag" (A3), "Wood" (E1) and "Others" (A14) were more commonly caught in the BTS. The amount of litter caught per km² is clearly larger in the BTS than in the IBTS. Furthermore, in 93% of the BTS hauls litter was caught on the DCS, while in 91% of the IBTS catches litter was found. The presence-absence of litter items per litter category shows noticeable differences between the BTS and the IBTS (Table 3.1; Table 3.2), indicating that the BTS has a higher chance of catching a litter item, despite a BTS haul covering a smaller area of seafloor compared to IBTS.

4 Discussion and Conclusions

The composition of seafloor litter on the Dutch continental shelf as presented in this report is in line with those of previous years. The seafloor litter catches on the DCS consisted mainly of plastic items, 83% (BTS) and 93% (IBTS) of the litter items found were made of plastic, respectively. Monofilaments, plastic sheets and various types of (plastic) ropes/lines were the most commonly caught litter types. Single-use plastics like cups, plates, drink bottles, caps/lids and cigarette butts, which are commonly found on beaches (Boonstra et al. 2016; Scotti et al. 2021), were rarely or not caught by the IBTS and BTS. This could indicate a difference in the spatial distribution of litter items, but for some of these items it is most likely a result of the monitoring method. Cigarette butts, for instance, cannot be retained by the mesh size of the cod-end and are therefore not represented in the catches, but can be found on the beach. The very low amount of single-use plastics shows, however, that management measures banning the use of these cannot be evaluated using the data retrieved from the fish surveys.

The observed dominance of plastic items in the survey catches is comparable to most studies on seafloor litter (Alvito et al. 2018; Carcia-Alegre et al. 2020; Kammann et al. 2018; Spedicato et al. 2019; Meyerjürgens et al. 2022). Many studies reported that most of the litter items found on the seafloor originated from the fishing industry, dominated by fishing lines (e.g. Buhl-Mortensen & Buhl-Mortensen 2017; Consoli et al. 2018; Gutow et al. 2018; Pham et al. 2014). It is impossible to discriminate monofilament used by the fishing industry from those used in other sectors. However, it is very likely that many if not most of the monofilaments and synthetic ropes caught in the IBTS and BTS originate from the fishing industry, predominantly being "fish fluff" or "dolly ropes". Experiments are currently carried out to replace the "fish fluff" with other materials. For instance, an experiment with yak leather as an alternative for "fish fluff" was carried out in the BTS of 2020.
The overall composition of litter on the seafloor is comparable between studies. However, comparing seafloor litter studies in terms of litter presence and density is not straightforward due to the use of different gears and the differences in sampled substrates (Canals et al. 2021). The 91% (IBTS) and 93% (BTS) of hauls on the DCS containing litter are amongst the higher values reported. In other studies, the percentage of hauls including litter items ranges from approx. 8% in the Flemish Pass (Carcia-Alegre et al. 2020) up to 90% in the northern Mediterranean (Spedicato et al. 2019). Studies from areas comparable to the DCS report proportions of 53% in the North and Baltic Seas (Kammann et al. 2018; Zablotski et al. 2019), 63% in the waters surrounding the UK (Maes et al. 2018) and approx. 80% in the German Bight (Meyerjürgens et al. 2022). Furthermore, large differences in litter densities are reported, ranging from a mean number of 1.4 items per km^2 in the Flemish Pass (Carcia-Alegre et al. 2020) up to 1835 items per km^2 in the North and Irish Seas (Maes et al. 2018). The study of Kammann et al. (2018) also used a GOV and identified a litter density of 16.8 litter items per km^2 in the German part of the North Sea. Meanwhile, the use of a bottom trawl net with a mesh size of 5 mm revealed litter densities ranging from 0 to 17,800 items per km^2 (Meyerjürgens et al. 2022).

The decision on how to categorise a litter item has been an issue since the start of the monitoring in 2013. A guideline has been provided by the ICES (ICES 2020) and was refined by the WGML in recent years, solving a number of the classification issues. An ongoing issue is method to count items in case of entanglement. The guideline states: "If an item is made up of two or more objects that have become entangled, and all items are recognisable, all items should be accounted for separately.". In Annex 3, examples of this issue are given. Fully disentangling "Entangled filaments" might result in a large number of separated monofilaments, which potentially increase the number (density) of litter items in these hauls than has currently been reported. Fully disentangling all litter items would

cause a disproportionately high effort and is not possible in all cases (Photo 3 of Annex 3), and would still lead to arbitrary choices. Usually, monofilaments that are recognisable as separate items are counted as separate items, while heavily entangled items that are not recognisable as separate items are counted as a single item. This same discussion occurs for (degrading) "Synthetic rope" (A7). The question remains whether to record it as a synthetic rope or as multiple monofilaments. This becomes even more of a complex issue since most monofilaments originate from the degradation of synthetic rope. Monofilaments and synthetic rope form the majority of the counts of litter items (44% IBTS, 42% BTS). As a consequence, these items determine if a location is seen as litter hotspot, potentially affecting the summary statistics and possible trend analysis.
In addition to the described issues in determining the correct number of items and the arbitrary decision making process in the counting method, there is a methodological error impacting the counts. Cleaning the net of the GOV (and beam trawl) is not a pleasant job, especially since the person cleaning the net has to be outside on deck during potentially bad weather conditions, particularly during winter months. Monofilament/ropes easily wrap around the fishing net, the ground rope chain and the bobbins. Disentangling each single monofilament from the fishing gear is nearly impossible and is even less likely to be done in bad weather conditions. This results in the accumulation of attached items in the fishing gear. Once accumulated it is only taken out when it becomes a clear entanglement. The entangled items can loosen on rough ground and end up in the cod-end or it can be taken out when parts of the net have to be repaired. Repairing the net has yet another impact and can influence the litter counts. Own (netting) materials (ropes, strapping bands) originating from the vessel used for the (I)BTS can be mixed in with the litter which can have an influence on the results. Based on some photos of the litter items made available by the French surveyors in 2019, own materials clearly impacted the French counts. The actual counts of litter items are thus heavily influenced by methodological aspects rather than by the amount of litter on the seafloor.

The overall data of the two gears used in the surveys indicates a higher catchability of litter items in the beam trawl (BTS) than in the GOV used during the IBTS. Despite that, the beam trawl also catches only a part of the litter present in the trawl path. This is one of the issues in using trawls of fish surveys for monitoring seafloor litter as pointed out by Canals et al. (2021). The data of both gears therefore present an underestimation of the actual amount of litter items present on the seafloor. The underestimation resulting from the IBTS data is larger compared to the underestimation introduced when using BTS data. It is suggested to use a conversion factor to raise the values of the IBTS to the levels of the BTS, to present less underestimated values. However, there are some issues to this approach:

- A straightforward conversion factor cannot be used to raise the hauls without litter (zero haul), despite the fact that it is very likely that there was litter in the trawl path. This is indicated by the higher percentage of BTS hauls containing litter and the fact that a BTS haul covers a smaller area of seafloor than IBTS.
- In the comparison between both surveys, there is a seasonal difference. This might influence the amount of litter accessible (e.g. storms). The season also affects the amount of fish caught, which in turn influences the amount of litter that is retained within the cod-end.
- The two gears cannot always be used to fish on the same sediment and habitat types. It is suggested that this has little impact at the level of the DCS, as here both gears can be used more or less on the same grounds. On the larger spatial scale (North Sea level) of both surveys, however, this could hamper the comparison.
- The higher vertical net opening of the IBTS is likely to result in the retention of higher amounts of floating litter, while simultaneously the larger length of the net and the larger mesh size in the first part of the belly of the net are likely to result in a lower retainment of heavier items. This suggests that a different conversion factor would be required for different litter types caught in the BTS.

The differences in fishing locations between the BTS and the IBTS pose an issue in the comparison of these two gear types. However, the effect of the actual fishing location also influences the comparison of the IBTS catches between years. The actual fishing locations of the IBTS are semi-randomly chosen within a rectangle and therefore differ between years.
Litter items can easily be transported from a low-density site by e.g. bottom currents to a site where seafloor structures retain the litter items and form a litter hotspot (Canals et al. 2021). This retainment of litter items is observed in the catches of the IBTS, where in cases that much organic debris (benthos, shells, seaweed e.d.) is retained in the IBTS net, it is more likely to have higher amounts of litter. Unfortunately, habitat characteristics are not recorded in the IBTS (e.g. by side-scan sonar or multibeam), nor are the amounts of debris in the catches thus analyses on this level are not possible. It is known that these habitat characteristics can vary at a small local scale, and with that likely the amount of litter on the sea floor. This might be the explanation for the empty hauls close to larger catches on the Dutch continental shelf in earlier years.

Usually, a trend analysis of the abundance of seafloor litter would be common practice. The package "litteR" is designed for this kind of analysis (Walvoort & van Loon 2018). However, there are several limitations to this approach that would not add valuable/reliable information to this report and is therefore not presented in this report. The goal of a trend analysis is to get statistical support for a potential trend in the amount of litter on the seafloor, or at least of a consistent part of the litter on the seafloor. It is widely accepted that with the GOV, which is not designed to catch litter, the probability of catching a litter item when it is present in the trawl path is low and varies with litter type and size. The GOV is designed to avoid retainment of larger object (stones) by hopping over these, otherwise the gear gets ripped and the haul becomes invalid. As a result, the bottom contact of the gear is minimal, and earlier analysis indicated that the catchability of the GOV for many benthic species was less than 5% (ICES 2003). Therefore, the probability of catching small items on the seafloor is assumed to be random and low. The fact that most items caught are relatively small indicates that it is likely that there are many more items in the trawl path and that current values are a large underestimation of the actual litter present on the seafloor. This was shown clearly when the GOV was used to fish in the area where the container vessel MSC Zoe lost its cargo in 2019. While beam trawls were catching large amounts of items from the cargo, only three items were caught in the two hauls with the GOV (extended in duration) (van Hal 2019).
This issue is recognized in the second OSPAR intermediate assessment (EIHA 19/07/19-Add.1). Due to the low catchability there is a large chance that the zeros (no litter in a GOV-haul) are actually false zeros (no litter caught, while there were multiple items of litter on the seafloor). As a consequence of these limitations it was decided to not present a trend analysis of the GOV data on the DCS within this report. However, beam trawl data, which is assumed to give a better picture of litter types and counts on the seafloor, can be used in the future for trend analysis.

The definition of Good Environmental Status (GES) for marine litter is that "The composition, amount and spatial distribution of litter on the coastline, in the surface layer of the water column, and on the seabed, are at levels that do not cause harm to the coastal and marine environment." (Commission decision (EU 2017/848 of 17 May 2017). It is not yet defined what these levels are and the current approach is to try to reduce the amount of litter in the environment. From previous studies (Maes et al. 2018; Urban-Malinga et al. 2018) and from the results presented in this report it is evident that, despite the management measures to decrease the input of litter and to remove the litter from the environment, there still is litter on the seafloor. The indicators proposed for the MSFD should be able to detect a reduction in litter related to management measures. A situation with a relatively low amount of (or without) litter in the marine environment has not been realized yet and it is unlikely to be realized within a short timeframe (van Loon et al. 2020). Despite the fact that there still is litter in the marine environment there are some hopeful indications towards a North Sea with less litter. A long term trend analysis of beach litter shows that the amount of litter items on the Dutch beaches is slowly decreasing over a 20 year period, mainly a reduction in plastic bags and balloons has been observed as a consequence of effective policy (Boonstra et al. 2021).

To conclude, a relatively low number of litter items found per haul, a low probability of catching an item when it is present in the trawl path and the spatial differences in fishing location (habitat, seafloor structures) make it difficult to draw conclusions on the absolute amounts of litter on the seafloor of the Dutch continental shelf. Since the catchability issue with the GOV net is hard to solve and difficult to incorporate in the analyses, it might be worthwhile to find or develop other methods for detecting the abundance of litter on the seafloor. Incorporating litter data of the BTS indicates that seafloor litter is more abundant than IBTS data indicate. However, it is assumed that even the BTS beam trawl gives an underestimation of the actual litter present on the seafloor. Therefore, the use of additional methods to collect seafloor litter might give a better understanding of the actual amount and composition of litter on the DCS. A dedicated survey, possibly focused on areas where litter is likely to be gathered by dominant currents and habitat features, could assist in providing information of fixed locations (litter hotspots). However, it remains to be proven that these "hotspots" actually exist, and whether these hotspots shift over time, which seems to be suggested by the second OSPAR intermediate assessment. For now, the here reported abundances of litter on the DCS are likely to be a minimum estimation of the amount of litter items presented on the seafloor and thus the Dutch continental shelf.

5 Recommendations

- Reconsidering the goals and purpose of the monitoring of litter. The use of the IBTS as monitoring platform only provides indicative results of a small part of the litter composition. For the evaluation of specific management measures the IBTS data is questionable and it is also unsuitable to produce a good estimation of the litter present on the seafloor. Its best use, other than to raise awareness, would most likely be as an indication of very large changes in the litter part caught by the IBTS, in this case being a large change in the amount of monofilament and synthetic rope in the marine environment.
- Following the progress of alternative methods of collecting seafloor litter data and explore the application of alternative methods on the DCS, for example the use of benthos dredge sampling. The use of additional methods to collect seafloor litter might give a better understanding of the actual amount and distribution of litter items on the Dutch continental shelf.

6 Quality Assurance

Wageningen Marine Research utilises an ISO 9001:2015 certified quality management system. The organisation has been certified since 27 February 2001. The certification was issued by DNV.

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Justification

Report C061/22
Project Number: 4316100081

The scientific quality of this report has been peer reviewed by a colleague scientist and a member of the Management Team of Wageningen Marine Research

Approved: Eleni Melis
Quantitative ecologist

Signature:

Date: 27-10-2022

Approved: Drs. J. Asjes
MT Member Integation

Signature:

Date: 27-10-2022

Annex 1 Litter data in DATRAS

The ICES Database of Trawl Surveys (DATRAS) is the international database in which the results of the North Sea IBTS, but also a large number of other surveys in the North Sea and other ICES regions are stored and made publicly available. The data of the fish surveys is made publicly available as raw data (Exchange format) and in a large variety of data-products depending on the survey (e.g. indices, Age-Length-keys, CPUE (Catch Per Unit Effort) by length or by age, etc.)

Since a couple of years DATRAS also contains the international litter data of the trawl surveys and makes these publicly available. The Dutch data is provided to DATRAS every year after the survey, with a deadline of providing the data prior to the WGML.

DATRAS makes the litter data available as raw data and as a data-product, being the latest OSPAR litter assessment output.

DATRAS can be accessed via: datras.ices.dk
On the right side of the page the download page and the DATRAS documents page can be selected. The latter contains all the relevant documents with, amongst others, the survey manuals and the Litter format. Via the download page all the data and data products can be downloaded.

- First, select the preferred data product. In case of litter the options are:
    - Litter Exchange data (raw data)
    - Litter Assessment output (the OSPAR product).
- Then select the preferred survey, relevant for the North Sea:
    - NS-IBTS
    - BTS (beam trawl survey)
- Select the preferred quarter and year (or all)
- Submit
- Accept the download policies
- A zip-file is downloaded, including a disclaimer, a pdf met metadata and references to the headers and a csv-file with the data.
- The first column of this file is the RecordType: HH (haul information) and LT (litter data). Based upon year, country and StNo the HH and LT can be combined to get all the haul information added to the litter information.

Issues with these downloads should be communicated directly to the ICES data centre. Advice on improvements to the data products should be communicated to the IBTSWG-chair(s) and the ICES data centre.

Annex 2 Quality – Outlier check

2.1 IBTS

Marine litter data from the international IBTS partners was obtained from ICES DATRAS. A data analyses determining the data to be used was done in Volwater & van Hal (2021). It was concluded that Dutch count data was available from 2013 on, French and German count data from 2015 and Danish count data only from 2021 on. Other IBTS partner countries did not conduct hauls on the DCS within the period 2013-2022.

Before conducting the analyses in section 3.1.2, a quality check of the last three years of data on the DCS was done to check whether litter recordings are true outliers. To do so, boxplots were prepared for the three most commonly caught litter types and for the total count to visualise potential outliers. The boxplots show multiple hauls with (very) high litter recordings. All these hauls were double checked for potential inconsistencies whereby for most hauls pictures were available to verify the recordings. There were no inconsistencies and the recordings were all correct. The high recordings were mostly done by France but spread over the three years (2020-2022). This suggest that France deals differently with counting "entangled" filaments. The idea was to level out high recordings and year-to-year variance in the IBTS litter analysis by combining data of the three most recent years, including the international data on the DCS, as requested by RWS. Instead, large variance in number of items per km^2 arose between the French data and other IBTS data due to structural higher recordings by France for especially plastic "Sheets" (A2), "Monofilaments" (A5) and "Synthetic ropes" (A7).

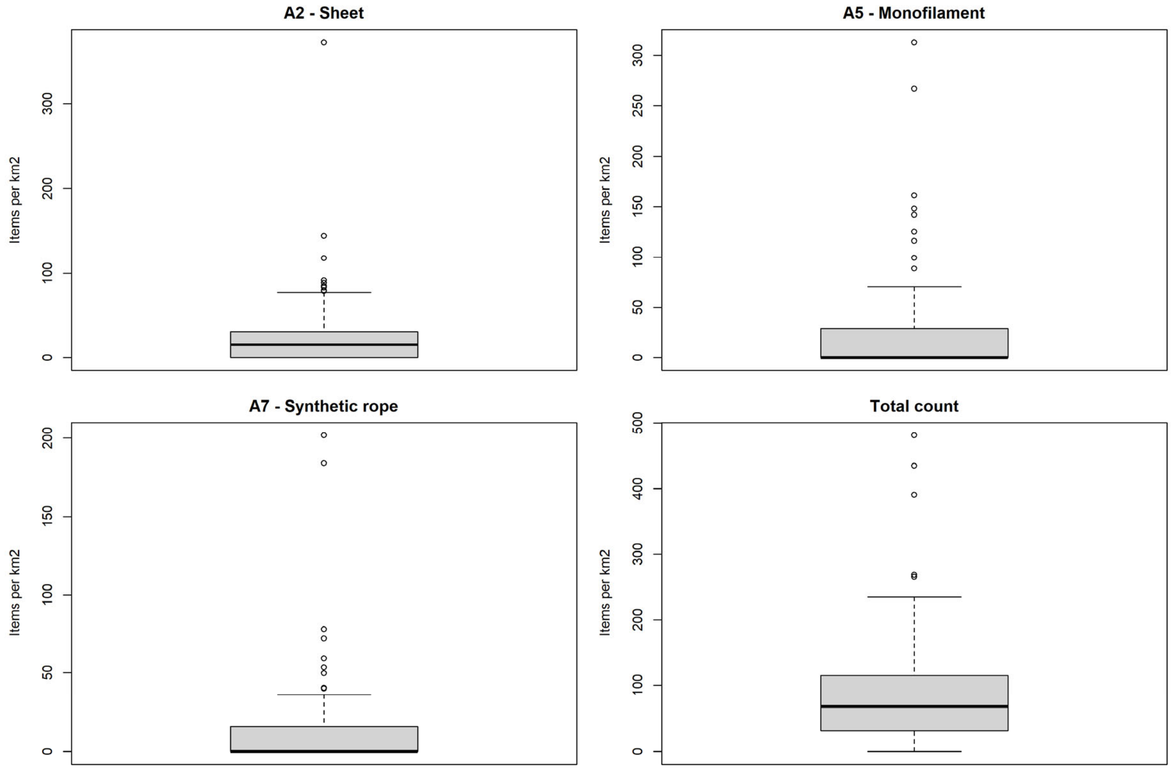

Figure B 1. Boxplots of the mean amount of "Sheet" (A2), "Monofilaments" (A5), "Synthetic rope" (A7) and "Total count" litter items per km^2 of the IBTS on the DCS between 2020 and 2022.

Comparing the high recordings of the IBTS with those of the BTS, it appears that many of those recordings would not even be considered as an outlier. The probability of catching (small) litter items is assumed to be low and random whereby the litter recordings are an underestimation of the actual litter present. The high recordings are rather an actual representation of litter items on the seafloor other than outliers. It was therefore decided that the high recordings were included for further analyses instead of being removed as outliers. Afterwards, the ratio of the mean and median values (Table 3.1) does not indicate that these high recording values strongly influence the overall mean litter items per km^2.

2.2 BTS

The same quality check was done for the BTS data of 2020 and 2021. Since the BTS dataset only consist of Dutch data there is no difference in counting litter items between countries. Still, there are some high recordings within the BTS data. All these hauls were doublechecked for potential errors whereby for most hauls pictures were available to verify the recordings. There were no inconsistencies and the recordings were all correct. Therefore, it was decided that the high recordings were included for further analysis instead of being removed as outliers. Afterwards, the ratio of the mean and median values (Table 3.2) does not indicate that these high recording values influence the overall mean litter items per km^2 strongly.

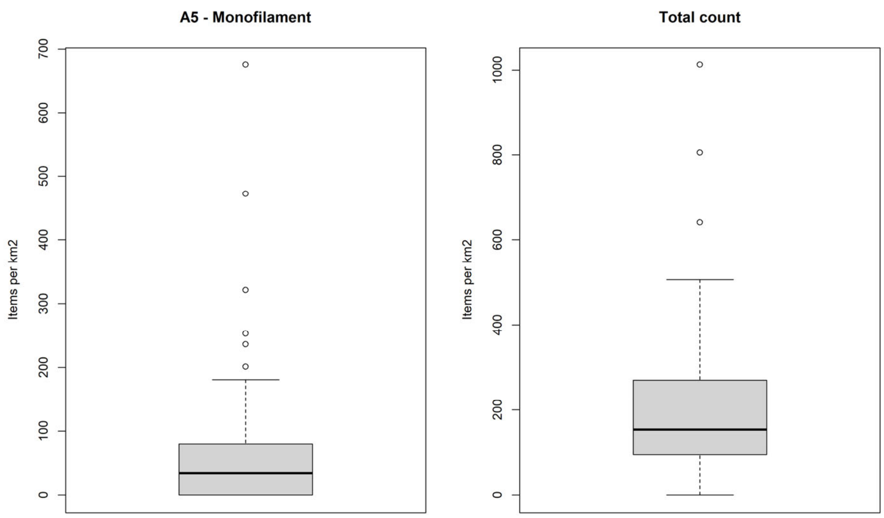

Figure B 2. Boxplots of the mean amount of "Monofilaments" (A5) and total litter items per km^2 of the BTS on the DCS in 2020 and 2021.

Annex 3 Photos entangled filaments

Photo 1. Example of entangled "Monofilaments" (A5) with "Synthetic rope" (A7). The Dutch surveyors counted this item as one single "Entangled filament" (A6). Note: These items on the pictures were all the litter items caught in haul number 3400024 in 2022 during the Dutch IBTS.

Photo 2. Example of entangled "Monofilaments" (A5) with "Synthetic rope" (A7). The Dutch counted this item as one single "Entangled filament" (A6) whereby French surveyors might have detangled this item and counted it as multiple "Monofilaments" (A5) and one "Synthetic rope" (A7). Note: These items on the picture were all the litter items caught in haul number 3400016 in 2022 during the Dutch IBTS.