OSPAR Beach Litter Monitoring in the Netherlands

Update 2021

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About
The North Sea Foundation is an independent non-governmental organization that provides knowledge necessary for an integrated sustainable protection, exploitation and spatial use of the North Sea and its coastal zones.

Contents

Summary

Marine litter, in particular the accumulation of plastic litter in the marine environment causing socio-economic and ecological harm, has been identified as a major global environmental problem. Due to ingestion and entanglement it is most likely harmful for many marine species. Qualitative and quantitative information about marine litter in the Dutch North Sea and coastline is required for setting up Dutch, litter reduction measures for OSPAR and MSFD, and to assess the effectiveness of these programmes of measures.

In the year 2000, The Netherlands was one of the first countries to start with the monitoring of beach litter. This report provides an annual update of Dutch beach litter monitoring data and an overview of the Dutch beach litter data analysis results for the periods 2019-2021 (state analysis) and 2016-2021 (trend analysis), respectively. The statistical analysis was conducted according the revised OSPAR CEMP guidelines and using the litteR software.

The median total count for macrolitter for the period 2019-2021 is 118 counts/100m beach. Trend analysis of the Dutch beach litter monitoring data (2016-2021) shows a significantly decreasing trend of -27 litter counts/100m, which shows that the Dutch beaches are getting cleaner in the period 2016-2021. On the beach level, all beaches show decreasing total count slopes, with the beaches Bergen and Noordwijk showing significant decreasing trends.

The median weight of litter per 100m beach for the period 2019-2021 is 2.5 kg litter/100m beach, and shows a decreasing trend of -0.9 kg litter/100m per year in the period 2016-2021.

Material analysis shows that plastic remains the most found litter material (91%) with a median of 105 counts/100m in the period 2019-2021. The trend analysis results shows significantly decreasing trends for plastic/polystyrene (-23 counts/100m per year), rubber (-1.5 count/100m per year) and metal. For the other materials (wood, glass, cloth, paper and pottery) no significant trends were found.

The SUP litter group has a median of 22 counts/100m beach (19%, for the period 2019-2021) and shows a significantly decreasing trend of -7 counts/100m per year (period 2016-2021). The FISH litter group which mainly contains of fishing related items has a median of 58 counts/100m (49%, period 2019-2021) with a significantly decreasing trend of -11 counts/100m per year (period 2016-2021). The OTHER litter types have a median value of 38 (32%, period 2019-2021) and show a significantly decreasing trend of -6 counts/100m per year (period 2016-2021).

Although the total abundance of beach litter shows a significantly decreasing trend on Dutch beaches, the adopted beach litter threshold value (TV) of median 20 counts/100m beach is still far from being reached. The most recent forecast indicates that the TV could be reached in 2038-2039 (90% confidence interval: 2034-2045). It is therefore important that current policies and measures are continued and strengthened in order to reach the TV in the future and minimize the environmental impacts of marine litter.

List of abbreviations

BLM Beach Litter Monitoring
CEMP Coordinated Environmental Monitoring Programme
CSV Comma-separated values
D10 MSFD Descriptor 10, marine litter
FISH Fishing related litter types
GES Good Environmental Status
ICGML OSPAR Intersessional Correspondence Group on Marine Litter
JRC Joint Research Centre
MSFD European Marine Strategy Framework Directive (MSFD)
MSC Mediterranean Shipping Company
NL Netherlands
NSF North Sea Foundation
OSPAR the organization in which 15 Governments & the European Union cooperate to protect the marine environment of the North-East Atlantic.
RAP OSPAR Regional Action Plan for Marine Litter
RWS Rijkswaterstaat – Department of Waterworks and Public Works
SEA Sea related litter types
SUP Single Use Plastics
TV Threshold value
WAXPOL Other pollutants category

1. Introduction

1.1 General introduction

Marine litter and in particular the accumulation of plastic litter in the marine environment, has been identified as a major global problem alongside other key environmental issues of our time (Sutherland et al., 2010; G7 Leader´s declaration 2015). Due to ingestion and entanglement it particularly harms marine life, at least 817 marine species are affected by marine litter (Kühn & Franeker, 2020). Millions of animals that live in the oceans are harmed, mutilated, and killed by marine litter each year (Butterworth et al., 2012).

It is estimated that more than 150 million metric tonnes of plastic have accumulated in the world's oceans and each year 12 million metric tonnes are added (Jambeck et al. 2016). Currently, plastic production continues to increase. In 2017 the production grew from 335 to 348 million tonnes of plastic materials (Statista, 2019).

Marine litter is defined as: "*any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment. Marine litter consists of items that have been made or used by people and deliberately discarded into the sea or rivers or on beaches; brought indirectly to the sea with rivers, sewage, storm water or winds; accidentally lost, including material lost at sea in bad weather (fishing gear, cargo); or deliberately left by people on beaches and shores*" (United Nations, 2019).

Marine litter travels long distances with ocean currents and is found all over the globe in marine environments, even in very remote areas (Werner et al. 2016). Research shows that large quantities of floating plastics from Europe and US end up in the Arctic Ocean and in the pristine Arctic ecosystem (Cózar et al. 2017).

Apart from the ecological impacts there are socioeconomic impacts such as costs for cleaning activities and reduced attractiveness for recreational activities. It was calculated that the potential costs across the EU for coastal and beach cleaning was estimated at almost €630 million per year (OSPAR, 2016). Furthermore, lost, and discarded fishing nets can cause propeller issues and can consequently lead to shipping delays, lost fishing time and safety hazards for both the fishing boat and other vessels nearby when the ship becomes rudderless.

The accumulation and dissemination of marine litter not only pose threats to the health of the world's oceans, but potentially also to human health, as the effects of plastic ingestion are being investigated.

1.2 Sources of marine litter

The European Commission has categorised the following main land and sea based sources. Land-based litter comes from landfills and littering of beaches and coastal areas (recreation), rivers and floodwaters, industrial emissions, discharge from storm water drains and untreated municipal sewerage. The main sea-based sources are fishing and aquaculture, illegal or accidental dumping at sea from ships (e.g. transport, tourism) and offshore mining and extraction (EU, 2019).

The European Commission estimates that 60,000 up till 300,000 tonnes of ship-generated garbage (excluding oily- and sewage waste) end up in European sea waters every year (EC, 2019). A study conducted to estimate the contribution of shipping waste in the Mediterranean sea, shows an contribution of 20,000 tons of plastic marine debris per year (Liubartseva et al. 2018). Overall, the European Maritime Safety Agency states that shipping account for 20 percent of global discharge in the sea (EMSA, 2019).

There are a number of important characteristics of the North Sea that should be taken in consideration when determining sources of marine litter related to economic activities at sea. The North Sea is one of the most important fishing grounds in the world and has some of the busiest shipping lanes in the world. Rotterdam is the largest port in Europe.

The North Sea is home to an active fishing fleet. For European seas, it was estimated by a recent study that the loss of plastic waste from fishing and aquaculture lies between 9,888 – 32,770 tonnes per year (EC, 2018). Specific fishing gear used by the Dutch and Belgium fleet to protect nets from wearing down is dolly rope. In the Netherlands, 100-200 tons of dolly rope is used annually (Tauw,

2018). It is estimated that the loss rate at sea is around 50%, which accounts for 50-100 tons of dolly rope (Bekaerd et al., 2015; Tauw, 2018). During fishing operations or maintenance work, threads or bundles of dolly rope threads end up in the sea. The result is that this plastic material is commonly found on the beaches in Northern Europe. Apart from impacting wildlife, dolly rope floating at sea is also a safety hazard for the maritime sector.

New research shows that rivers are a source and discharge route for litter to the sea (van Emmerik et al., 2022). The presence of plastics in rivers has meanwhile been observed in the water column and water surface, on banks and in the sediment, but also in plants and animals (Emmerik & Schwarz, 2019).

1.3   European Marine Strategy Framework Directive (MSFD)

Within the European Marine Strategy Framework Directive (MSFD) marine litter is one of the descriptors (DG10) to assess the 'Good Environmental Status' of the marine environment. At EU level, the MSFD is the dedicated binding legal instrument for assessing, monitoring, setting targets and reaching good environmental status with regard to marine litter. The Directive obliges Member States to monitor marine litter.

The MSFD goal for DG10 for marine litter is defined as follows: <u>Properties and quantities of marine litter do not cause harm to the coastal and marine environment by 2020.</u>

The revised European Commission Decision 2017/848 requires EU Member States to establish threshold values (TVs) for criteria of Descriptor 10 on marine litter. TVs which are now mandatory through the new provisions, are intended to contribute to Member States determination of a set of characteristics for GES and enable their assessment of the extent to which GES is being achieved. The threshold value for marine litter has been set by the European Commission at a median of 20 litter counts per 100 meter of beach. This excludes meso-plastic fragment 0.5-2.5cm and waxes.

1.4   OSPAR

In the year 2000, a standardized protocol for the 'OSPAR Pilot Project on Monitoring Marine Litter' was developed aiming to monitor the amounts and sources of marine litter in the North East Atlantic region. The protocols for 100-metres and 1-km surveys were developed, tested and used during fieldwork from 2000 onwards. The initial pilot project was executed for a period of six years (2000-2006) by nine countries: The Netherlands, Belgium, Germany, United Kingdom, Sweden, Denmark, France, Spain and Portugal. In 2007, after the pilot ended, it was decided to transfer the pilot in a regular OSPAR monitoring programme.

Thereafter the OSPAR's Coordinated Environmental Monitoring Programme (CEMP) guidelines were developed to deliver comparable data from across the OSPAR Maritime Area, which can be used in assessments to address the specific questions raised in OSPAR's Joint Assessment and Monitoring Programme, (JAMP).

The monitoring guidelines in the CEMP are based on the OSPAR (2010) monitoring guidance. The OSPAR guideline has been designed to generate data on marine litter according to a standardized methodology. A uniform way of monitoring allows for regional interpretation of the litter situation in the OSPAR area and comparisons between countries and regions. The guideline has been designed in such a way that all OSPAR countries can participate, bearing in mind adequate quality assurance of the data generated.

The OSPAR beach litter assessment has been developed since 2013 (Schulz et al., 2017; Schulz et al., 2019), and has recently been updated with a statistically correct regional assessment method which has been implemented in the litteR software (Walvoort and Van Loon, 2021). In addition, OSPAR has developed a new asymptotic model to estimate more accurately when the beach litter threshold value could be reached (Walvoort et al., 2021; Van Loon et al., 2020).

In 2016, it was decided by Rijkswaterstaat to stop the 1-km surveys in Netherlands due to influence of factors such as increased beach cleaning effort by authorities, non-governmental organisations and public in which the larger litter items are most easily removed.

1.4.1 Other litter monitoring projects

There are several other litter monitoring projects in The Netherlands which are 1) the Clean River project, initiated by the North Sea Foundation, Institute for Nature Education and Plastic Soup Foundation which includes large monitoring program on river banks (currently on more than 500 locations along the Meuse and the Rhine (Schone Rivieren, 2021); 2) a pilot monitoring in de Wadden Sea on unhabituated sand flats executed by Bureau Waardenburg on assignment of Rijkswaterstaat North Netherlands (RWS, 2019); 3) beach litter monitoring based on the OSPAR methodology on the island of Bonaire, Caribbean Netherlands executed by Clean Coast Bonaire, supported by World Wide Fund for Nature – Netherlands (Caporusso and Hougee, 2019).

In 2018, the central Dutch government launched a microplastics policy programme in which the problems of macro- and microplastics in the rivers will be mapped out by developing a monitoring strategy and monitoring methodology. A roadmap has been developed and monitoring programs are currently developed for litter on riverbanks, in the water column and on the water surface. A final monitoring program of river litter is expected to be ready in 2023.

1.5 Overview of policies and measures to reduce marine litter

The last years, policies have been developed and implemented to address marine litter. In the following paragraphs relevant legislation and measures taken are described in short.

1.5.1 OSPAR Regional Action Plan

OSPAR's marine litter objective is "to substantially reduce marine litter in the OSPAR Maritime Area to levels where properties and quantities do not cause harm to the marine environment". The North-East Atlantic Environment Strategy (2010 – 2020) commits to "develop appropriate programmes and measures to reduce amounts of litter in the marine environment and to stop litter entering the marine environment, both from sea-based and land-based sources".

To fulfil this objective the OSPAR Contracting Parties agreed on a Regional Action Plan (RAP) for Marine Litter for the period 2014-2021. In June 2022, the second RAP for Marine Litter was launched at the United Nations Ocean conference in Lisbon for the period 2022-2030. The RAP ML2 is the main instrument to deliver one the four strategic objectives of the North-East Atlantic Environment Strategy (NEAES) 2030. This NEAES strategic objective is "prevent inputs of and significantly reduce marine litter, including microplastics, in the marine environment to reach levels that do not cause adverse effects to the marine and coastal environment with the ultimate aim of eliminating inputs of litter". It contains three thematic actions A) Actions to reduce land-based sources of marine litter; B) Actions to reduce sea-based sources of marine litter; C) Cross cutting actions. All 25 actions are lead by specific contracting parties and observing parties. Progress on actions is overseen and assessed by the Intersessional Correspondence Group on Marine Litter (ICG-ML).

1.5.2 Objectives and measures in the Netherlands

The Dutch government has set a target for 2020 to reduce the amount of litter on the coast (beach litter) and the impact in marine organisms (plastic particles in stomachs of Northern Fulmars). The Dutch MSFD goals set for 2020 are (a) the amount of visible litter on the coast has decreased and (b) there is a decreasing trend in the amount of litter in marine organisms.

In reducing litter, the Netherlands focuses on prevention by means of an integrated source approach, communication and awareness campaigns, and closing product chains (through e.g. Green Deals, product requirements- and waste management policies). The Netherlands is also supporting the cleaning of beaches and the Fishing for Litter and DollyropeFree project.

In 2022 the Dutch government has developed the North Sea Programme 2022-2027, including the update of programme of measures of the Marine Strategy Part 3 which is an integral part of the National Water Programme (NWP) 2022-2027. To strengthen to the marine ecosystem, additional measures to achieve and retain good environmental status have been included to combat pollution which are: "Reduce litter at sea by additional measures to tackle the major sources of pollution, namely beaches (action: knowledge exchange, support collaborative projects), river basin districts (action: increase awareness of the litter problem among site and water managers along rivers), shipping (action: improved prewash procedure to prevent persistent floating substances in the environment), fishing (action: phasing out of conventional dolly rope), and plastic products (action: implement OSPAR recommendation to tackle pre-production pellets in the environment).

1.5.3 European Single Use Plastic (SUP) and fishing gear Directive

In 2018 the European SUP Directive was proposed by the European Commission and approved by the European Parliament in March 2019 (European Parliament, 2019). This year, it was officially implemented on July 1st 2020 in The Netherlands. The directive contains measures to address marine litter originating from the 10 single-use plastic products most often found on European beaches, as well as abandoned fishing gear and oxo-degradable plastics. Single Use Plastics are defined as: *"products that are made wholly or partly of plastic and are typically intended to be used just once or for a short period of time before they are thrown away"*. Fishing gear is defined as: *"any item or piece of equipment that is used in fishing and aquaculture to target and capture or rear marine biological resources, or that floats on the surface of the sea and is deployed with the objective of attracting and capturing or rearing such marine biological resources"*.

The following measures are included in the Directive: a) Measures to reduce consumption of food containers and beverage cups made of plastic, and specific marking and labelling of certain products; b) extended Producer Responsibility schemes covering the cost to clean-up litter, applied to products such as tobacco filters and fishing gear; c) 90% separate collection target for plastic bottles by 2029 (77% by 2025) and the introduction of design requirements to connect caps to bottles, as well as a target to incorporate 25% of recycled plastic in PET bottles as from 2025 and 30% in all plastic bottles as from 2030; d) the following single-use plastics are banned by July 3rd 2021: straws, cotton buds, drink stirrers, cutlery and plates, beverage cups and food and beverage containers made from expanded polystyrene, and the so-called oxo-degradable plastics.

The extended producer responsibility (EPR) schemes for various single use plastics and fishing gear will be implemented in the coming years. A detailed time line of the implementation of the EPR can be found here.

1.5.4 Resolution United Nations Environment Assembly

In March 2022, at the United Nations Environmental Assembly a resolution to combat the worldwide pollution of plastic has been adopted. This resolution establishes an Intergovernmental Negotiating Committee (INC), with the ambition of completing a draft global legally binding agreement by the end of 2024. The goal is "to present a legally binding instrument, which would reflect diverse alternatives to address the full lifecycle of plastics, the design of reusable and recyclable products and materials, and the need for enhanced international collaboration to facilitate access to technology, capacity building and scientific and technical cooperation".

1.6   Aims of the report

Quantitative and qualitative information about marine litter entering our seas and oceans is required for the development and evaluation of Dutch and regional measures to reduce marine litter. Therefore, the aims of this report are (a) to provide an annual update of the Dutch beach litter monitoring data of 2021; (b) to calculate and present state analysis results (for 2019-2021) and trend analysis results (for 2016-2021) using the Dutch beach litter data. This year report is prepared according the specifications for data analysis specified in the currently revised CEMP guidelines (2022) and with some additional specifications such as the weighing of marine litter from Rijkswaterstaat and NSF, respectively.

2. Methods

2.1 Selection of reference beaches

The following criteria have been identified for selecting reference beaches. The beaches should be a) composed of sand or gravel and exposed to the open sea; b) accessible to surveyors all year round; c) accessible for ease of marine litter removal; d) have a length of 100 metres) free of 'buildings' all year round; f) not subject to any other litter collection activities.

Four reference beaches have been selected in the Netherlands (see figure 1). All the Dutch reference beaches are composed of sand, are accessible all year round, are easily accessible for marine litter removal, have a length of 100 metres, are free of buildings all year round and comply with the OSPAR criteria a, b, c, d, e.

Additional information in regards to physical and geographical characteristics e.g. proximity of shipping lanes, river mouths, waste water outlets of each beach are available in the OSPAR beach litter databases and updated when changes occur.

Figure 1 The Dutch reference beaches

The compliance of criteria (f), 'no collection of any other litter activities', does not apply to all the beaches. The reference beach Bergen is cleaned on a weekly basis all year round. Volunteers and/ or local authorities incidentally clean the other beaches.

Therefore, contact with local beach authorities is important. Before a monitoring on a reference beach is executed, the local beach coordinator is contacted to check for any local activities that can influence the monitoring session, e.g. a local clean-up, an accident with cargo, a recent storm, etc. In the period 2015-2020 all local beach coordinator and/or municipalities have been contacted on a regular basis. As a guideline, no local beach cleaning should have occurred within the two weeks before a planned beach monitoring date. If this has occurred, it is attempted to postpone the monitoring to about two weeks after the cleaning date. However, in cases of extreme weather events, unexpected changes in employee schedules, or for any reason poor communication with local beach coordinators, the monitoring may occur within two weeks after a cleaning activity. In addition, not all organised cleaning activities are announced publicly or are known by the municipalities (see results and discussion). This accounts especially for individuals who clean up when visiting the beach.

2.2 Monitoring method

Each reference beach is a fixed section of beach covering the whole area between the water line to the back of the beach i.e. start of the dunes. Within the OSPAR area, the standard survey unit is 100 meters long from the water's edge to the back of the beach. Litter types are classified according to the 'CEMP Guidelines for marine monitoring and assessment of beach litter' using the adjusted OSPAR scoring lists (OSPAR Commission, 2020).

The monitoring session starts at the back of the beach on the landside. All visible macro- and mesolitter (>0.5 cm) on the beach surface is counted and registered on the OSPAR beach litter monitoring form. A small strip of about 2-3 meters is monitored; walking distance between the two surveyors is about 2-3 meters. Two surveyors walk parallel with the beach towards the end of the 100 meter monitoring area and draw a line in the sand during monitoring of the litter types. After reaching the 100-meter border of the monitoring area, the surveyors make a turn and proceed with the next strip. All litter is collected in garbage bags. The drawn line is now the border of the monitoring strip. This method is repeated until the sea line is reached (see figure 2).
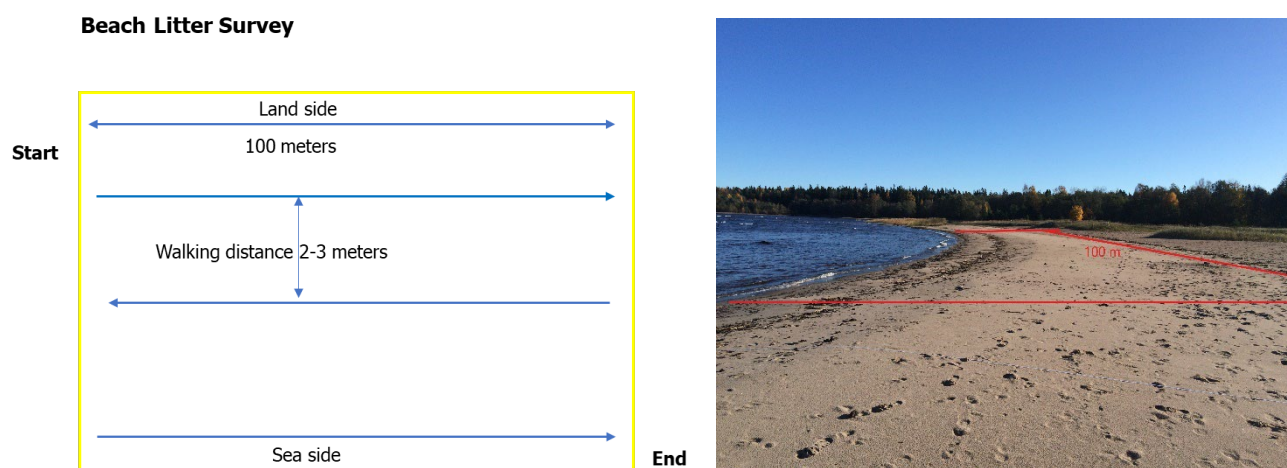
Figure 2 Walking pattern used for the beach litter monitoring and survey area.

Permanent reference points (marked by beach poles) are used to ensure that the same site will be monitored for all surveys. The Dutch Beach Litter reference beaches are:

Table 1 Metadata of the 4 Dutch OSPAR Beach Litter reference beaches.

Beach code	Beach name	Access point	Number Beach Pole (start of 100 survey)	Direction
NL1	Bergen	Egmond aan Zee	35.250	South
NL2	Noordwijk	Langevelderslag	72.250	South
NL3	Oostkapelle / Veere	Oranjezon	10.300	North
NL4	Terschelling	Oosterend Badweg	18.200	West

2.2.1 Monitoring of macro- and mesolitter litter

The current 100m-survey form contains 126 litter types that are categorised into plastic, rubber, paper, metal, wood, glass, cloth, pottery, sanitary and medical waste (marked by item-codes). This includes identifiable litter types and associated pieces of these items, unknown items and unknown litter fragments. Unknown litter or litter types that are not on the survey form are noted in the appropriate "other item box". A short description of the "other" item will be included on the survey form. If possible, digital photos should be taken of unknown litter types for them to be identified later. The presence of pellets on the survey site is registered with yes/no.

Mesoplastics fragments

All beach litter items >5mm are surveyed. However, meso-plastic fragments (0.5-2.5 cm) are not included in the total count calculation. The CEMP guidelines prescribe they are monitored less comparably within the OSPAR area due to their small size and the occurrence of very high numbers on some beaches. A separate monitoring method is currently under development. Due to the fact that the beach litter monitoring in the Netherlands is conducted by the same organisation and professional surveyors team for many years now, the quality of the monitoring data for meso-plastic fragments can be considered to be useful. In this report, these fragments are descriptively analysed at the country level for a 3-year period.

Presence of waxes

During each monitoring, the presence of paraffin is registered under OSPAR code 108 size 0-1 cm, 109 size 1-10 cm and 110 size >10 cm. The frequency of how many pieces or lumps of paraffine are found is estimated per meter of strandline. Waxes are monitored along the flood line with the assumption based on experience that all waxes are gather there. The total number per size category within three squares of 1 by 1 meter along the flood line is registered. If the waxes are found along the entire flood line then for three squares of 1 meter by meter all lump waxes are counted for each size category and divided by three and recorded on the OSPAR form.

In the last years, the monitoring method for the presence of paraffin waxes has proved to be limited. Starting from 2023, a new monitoring method will be applied. This will include 1) collection and counting of all paraffin wax pieces and other pollutants on the survey site and 2) separate weighing of paraffin and other pollutants. This method will give more precise information of the presence of paraffin on the survey site and its mass. During the pilot monitoring of pellets and meso-plastic fragments (see section 2.5) on Dutch beaches also data on meso-wax fragments were collected and reported. In the future, this information could be combined with data collected by the beach litter monitoring program.

Total weight

Since 2016, supplementary research has been conducted by weighing the marine litter gathered after each survey. From 2017 on, during all surveys marine litter weighted and recorded. All litter types were collected in a plastic bag after the sand was manually removed by shaking off the sand as much as possible. The bag was weighed with a digital balance (see Appendix IV for the overview). The aim is to get a better insight in the weight of marine litter washing ashore.

2.3   Frequency and period

The reference beaches are surveyed four times, approximately equidistant, within a year. However, circumstances may lead to inaccessible situations for surveyors: such as stormy wind, and hazards such as rain, snow, or ice, and unexpected events such as container loss may result in a postponed or cancelled beach survey. The survey periods are as follows: 1) winter: mid-December – mid-January; 2) spring: April; 3) summer: mid-June – mid-July; and 4) autumn: mid-September – mid-October.

The reporting period for this report is 2016-2021. During this period, 95 surveys were performed by the BLM survey team of the NSF. Due to intense cleaning activities after the container losses of the vessel MSC Zoë early January 2019, the monitoring on Terschelling in quarter 1 of 2019 was not conducted.

2.4   Monitoring program for pellets and mesoplastic fragments

In 2021 a pilot was conducted for the monitoring of pellets and meso-plastic fragments on Dutch beaches (Wenneker, 2022). Monitoring was conducted on four locations and four times in a year. One location is also conducted at Bergen. The three other locations were selected based on additional beach selection criterion which was the proximity to sources (harbour or estuary outlet) which are Neeltje Jans (close to the outlet of the Westerschelde estuary and known as pellet hotspot) and Monster (close to the Nieuwe Waterweg and the Port of Rotterdam). For these locations one fixed stretch of beach of 100 meter is selected and 5 sampling units (squares) of 1m2 and the sand top layer of 1-2 cm are sampled at the springtide line, at a fixed distance of 25 m: 0, 25, 50, 75, 100 meters.

Based on the results of the conducted pilot, RWS has decided to continue this monitoring in the coming years and will contribute to a harmonised European and OSPAR methodology for the monitoring of pellets and meso-plastic fragments.

At the same time, the OSPAR category small plastic fragments [117] which are the meso-plastic fragments (0-2.5 cm) and the test items [1171] and [1172] and the presence of pellets will be continued to be monitored. When more than 500 pellets are found at a survey site, this will be stated in this report. Detailed information in regards to the abundance of mesoplastics and pellets is provided in future monitoring report of pellets and meso-plastic fragments.

2.5   Data Management

The beach litter monitoring data are entered in the OSPAR database within three working days after the monitoring took place, to have a good visual memory of the results and circumstances. The monitoring forms are scanned, digitally stored and are present within RWS. RWS CIV also stores the beach litter

data in the RWS DONAR database. The monitoring data were exported from OSPAR database for data analysis and reporting (see 2.5).

2.5.1   Unknown litter types

Photographs of unknown litter types are stored in a photo database at the NSF, sent to ICGML Basecamp for judgment of other marine litter experts and are displayed in the annual report.

2.5.2   Survey dates and special circumstances

Survey dates and relevant special circumstances, such as extreme weather conditions, nearby sand supplementation or any other activities that may influence the monitoring, are listed on the field forms and published in the annual report.

2.5.3   Data clean-up

After downloading the survey results from the OSPAR database, the OSPAR beach litter data files are cleaned by removing the wax types (types 108-110) and other pollutants (type 111), presence of pellets from the datafile and comments columns and prepared for analysis with LitteR software. This removal is also automatically performed via the litteR type file, because these types are excluded (not selected) in the Total Count and the other groups.

2.6   Data analyses

In the table 2, the overview of analyses performed for this report are presented. These analyses are performed at the country level (four beaches aggregated), and partly on the beach level. Table 2 gives the overview of the analysis groups, type of analysis, periods and on which level the analyses are performed. For data analysis the litteR software was used (available at: https://cran.r-project.org/web/packages/litteR/index.html). This package has been developed for OSPAR beach litter data analysis and uses robust statistics. These robust statistics are very suitable to analyse the skewed distributions of beach litter data (Schulz et al., 2017).

2.6.1 Outlier analysis

For data quality control purposes, the outlier analysis is performed with LitteR. This analysis detects outliers in the surveys selected for the data analysis. In statistics, an outlier is a data point that differs significantly from other observations. The outliers are presented in box- and whisker plots. These surveys are checked by the lead surveyor to ensure the registration of the surveys is correct and whether there were special circumstances that could explain the outlier. These explanations are included in the report.

2.6.2 State analysis

In the annual report, beach litter monitoring results of the 3- year descriptive statistics are performed which includes the total count (TC) of all litter items, all material groups, the SUP, FISH and OTHER groups, and the top 10 types. The descriptive statistics that are included in Results & Discussion chapter are further explained in the sections below.

2.6.3 Trend analysis

Trend analyses are performed on the total count (TC) of all litter items, all material groups, the SUP, FISH and OTHER groups, and the top 10 types. The trend period used is 6 years, in order to show relatively recent trends. Trends are analysed by non-parametric Theil-Sen analysis, and p-values are calculated using the Mann Kendall analysis. The descriptive statistics that are included in Results & Discussion chapter are further explained in the sections below.

2.6.4 Descriptive statistics

The following descriptive statistics are included in the report:

Median total litter count

The median total litter count is calculated for 3 years (OSPAR period) and 6 years (MSFD period), respectively. The medians are first calculated at the beach level using the indicated periods, and then aggregated to the country level using the median beach value (blocking method, see CEMP guidelines (OSPAR, 2022). The litter type mesoplastic fragments 0.5-2.5 cm [117] is excluded from the total count calculation and is analysed separately.

Material analysis

A material analysis is performed for a 3 and 6-year period of the total abundances of litter groups which have been assigned to any of the following categories: Plastic/polystyrene, Rubber, Paper/cardboard, Wood, Glass, Cloth/textile, Metal and Ceramic/pottery.

The litter composition percentages are calculated based on the calculated medians of each material type.

Functional group analysis

A specific litter group analysis is performed for a 3-year period using the combined total counts for following material group types:

- Single Use Plastics (SUP)
- Fishing related items (FISH)
- All other items (OTHER)

The categorisation of the OSPAR litter types per specific litter group is compared with The Joint List of Litter Categories for Macrolitter Monitoring that was prepared by the MSFD Technical Group on Marine Litter (MSFD TG ML) for European Commission. One OTHER item was therefore moved to the FISH group. The updated list is included in Appendix V.

Top 10 litter types

The top 10 most found litter types is calculated for a 3-year period. A top-20 list of most found litter types on individual beaches is constructed. These top-20 litter types per beach are then aggregated at the country level and the top 10 list with the highest aggregated median values are selected. The top 10 most found items is now included in the litteR package.

Mesoplastics fragments

In this report, the fragments are descriptively analysed at the country level for a 3-year period.

Total weight

The weights per survey are reported and the average and median weight for the five year period 2016-2021 and the three year period 2019-2021 is calculated and included in the report.

Threshold value

The threshold value is calculated based on the period 2019-2021, meso-plastic fragments 0.5-2.5cm. and waxes/other pollutants [117] are excluded. The median value is calculated of these 47 surveys to calculate the median assessment value. This value is compared to the threshold value of the median of 20 litter counts per 100 meter coastline.

Table 2 Overview of analyses performed in this annual report

Analysis group	Analysis performed	Information need	Period	Spatial level
Overview of analyses performed				
State analysis	Outlier analysis	OSPAR, MSFD	2016-2021	Beach
	Total count (median)	OSPAR, MSFD	2019-2021 2016-2021	NL, beach
	Total weight (median)	NL	2019-2021	NL
	Material groups (medians, median-based percentages)*	OSPAR (all) MSFD (plastic)	2019-2021 2016-2021	NL
	SUP, FISH and OTHER groups	OSPAR/MSFD	2019-2021	NL
	Top 10 (median-based)	OSPAR	2019-2021	NL
	Mesoplastics (0.5-2.5cm)	NL	2019-2021	NL
	Threshold value assessment	MSFD	2019-2021	NL
Trend analysis	Total count trend	OSPAR, MSFD	2016-2021	NL, beach
	Total weight trend	NL	2016-2021	NL
	Material group trends	OSPAR, MSFD	2016-2021	NL
	SUP-trend	OSPAR, MSFD	2016-2021	NL
`	FISH trend	MSFD	2016-2021	NL
	Top-10 trends	OSPAR	2016-2021	NL
	Mesoplastics (0.5-2.5cm)	NL	2016-2021	NL

3. Results & Discussion

This chapter includes the beach litter monitoring results of the 3- year descriptive statistics and 6-year trend analysis. Both analyses included the aggregated total count on country level and beach level, material analysis on country and beach level, specific litter group analysis on country and beach level, top 10 most found litter types on country level and top 5 trend plots, trend plots on country and beach level on total count, materials and specific litter groups on country. In addition, 3- year descriptive statistics and 6-year trend analysis plots are presented.

The results of the country and local beach level of the 6- year trend analysis will be elaborated on in more detail.

Exports from the OSPAR database containing all litter data have been added in Appendix I. The scanned field forms are included in Appendix II. The LitteR files and reports are provided in Appendix III and the survey dates and weights overview are included in Appendix IV.

3.1 Outlier analysis

The outlier analysis was performed for the 6- year period 2016-2021. The boxplot of the outlier analysis is presented in figure 3 and table 3 includes the overview of specific outlier per location. All outliers were checked before further analysis.

All survey registrations were checked and no errors were detected. The variability between the locations are considered to be consistent by the lead surveyors. Veere is the location where more often fewer litter types are found. This is also is the case for Noordwijk, this location seems to have high variabilities. Bergen and Noordwijk are the two locations where after a periods of Westerly winds, more often large amounts of litter are found.

The outlier for Bergen in 2020 in April could be explained by heavy winds that hit our coast in February. According to the KNMI there was one heavy storm (Ciara) in 2020 in February with windspeed 10 Beaufort (24.5 m/s) (KNMI, 2021). Heavy winds hit our coast in later in February and August.

Both outliers of Veere in 2017 and 2020 show that variability of the number of items found. There were no specific weather situations that could have a specific influence.

Figure 3 Outlier boxplot 2016-2021 per location. Outliers are given as dots.
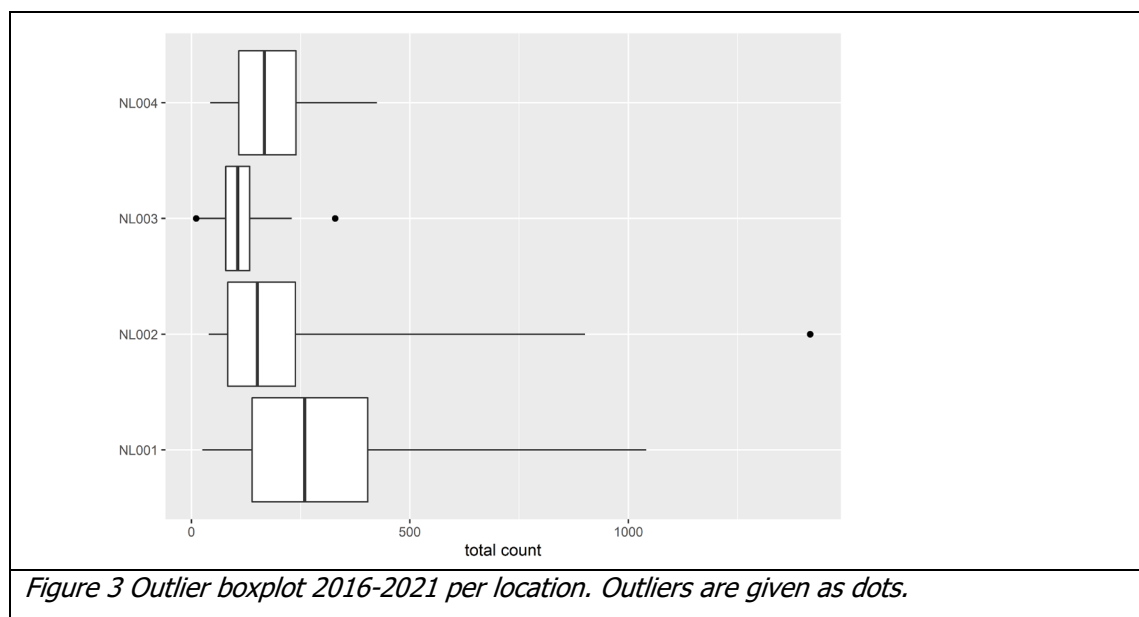
Table 3 Overview of outlier in the period 2016-2021.

6- year outlier analysis		
Location	**date**	**total count**
Noordwijk	08-01-2018	1416
Veere	19-04-2020	11
Veere	27-04-2017	329

3.1.1 Other special circumstances

In 2021 the world wide COVID-19 pandemic was ongoing. In the general discussion section, developments that could have been an influence on the beach litter monitoring results are explained in more detail.

There was a large flood event in July 2021 in the South of Holland in the province of Limburg where the riverbanks Meuse overflood. After the floods, large amounts of water from the rivers flown towards the North Sea. The assumption is that litter from these floods was carried in these flows. Though, the survey results did not seem to show a significant influence and no specific items that could have been related to the floods were found.

In 2021, an new outbreak of the avian (bird) flu started and is still ongoing today in The Netherlands. It was also found in wild birds in 2021. Although it can be coincidental, it was notable that in the last survey period of 2021, more dead birds were found at the survey sites.

3.2 State analysis (2019-2021)

This section includes the three year analysis of the aggregated total count on regional and local beach level, material analysis on regional and local beach level, specific litter group analysis on regional and local beach level, the top 10 most found litter types on regional level and trend plots on regional and local beach level on total count, materials and specific litter groups.

3.2.1 Overview results and trend plots

The results of the descriptive analysis are included in table 4.

Table 4 Overview state analysis results for the period 2019-2021.
Note that material and SUP/FISH/OTHER percentages are reported using this recent period.
The trends for all the groups and types in this table are presented in Table 5.

Total count on country level			
Region	group code	n	median
Netherlands	TC	47	118

Total count at beach level			
Location	group code	n	median
Bergen (NL001)	TC	12	158
Noordwijk (NL002)	TC	12	111
Veere (NL003)	TC	12	105
Terschelling (NL004)	TC	11	126

Material trends at country level				
Region	group code	n	median	%
Netherlands	PLASTIC	47	105	91%
Netherlands	RUBBER	47	3	3%
Netherlands	WOOD	47	3	3%
Netherlands	GLASS	47	2	2%
Netherlands	PAPER	47	1	1%
Netherlands	METAL	47	1	1%
Netherlands	CLOTH	47	0	0%
Netherlands	POTTERY	47	0	0%

Functional group trends at country level				
Region	group code	n	median	%
Netherlands	SUP	47	22	19%
Netherlands	FISH	47	58	49%
Netherlands	OTHER	47	38	32%

Top 10 trends country level			
Region	type name	n	median
Netherlands	plastic: string [32]	47	42.0
Netherlands	plastic: caps [15]	47	11.8
Netherlands	plastic: fishing_net_small [115]	47	7.8
Netherlands	plastic: plastic_large [46]	47	5.2
Netherlands	wood: other_small [74]	47	4.2
Netherlands	plastic: crisp [19]	47	3.2
Netherlands	plastic: small_bags [3]	47	2.5
Netherlands	plastic: foam_sponge [45]	47	2.2
Netherlands	plastic: industrial [40]	47	2.0
Netherlands	plastic: tangled [33]	47	2.0

Total weight on country level in kilograms			
Region	group code	n	median
Netherlands	Total weight	47	2.5

3.3 Trend analysis

This section includes the 6-year trend analysis (2016-2021) of the aggregated total count on country and local beach level, material analysis on country and local beach level, specific litter group analysis on country and local beach level, top-10 most found litter types on country level and trend plots on country and local beach level on total count, materials and specific litter groups on country level and top 5 most found litter types.

3.3.1 Overview results and trend plots

The results of trend analysis for 2016-2021 are included in table 5. In figures 8, 9, 10, and 11. Trend analysis plots are presented for total count and the specific litter groups for PLASTIC, SUP and FISH. The trend plots for the top 5 litter types are presented in figures 12, 13, 14, 15 and 16.

In each plot, the black dots are the observations, the thin gray line segments connect the dots and guide the eye, and the red line is the Theil-Sen slope.

Table 5 Trend analysis results for the period 2016-2021
(significant p values of trends are printed in bold)

Total count at country level					
Region	group code		n	median	slope	p value
Netherlands	TC		95	159	-27.3	**0.000**

Total count at beach level					
Location	group code		n	median	slope	p value
Bergen (NL001)	TC		24	259	-72.1	**0.008**
Noordwijk (NL002)	TC		24	151	-29.0	**0.044**
Veere (NL003)	TC		24	106	-5.2	0.137
Terschelling (NL004)	TC		23	167	-25.6	0.051

Material trends at country level					
Region	group code		n	median	slope	p value
Netherlands	PLASTIC		95	141	-23.3	**0.000**
Netherlands	RUBBER		95	4	-1.5	**0.000**
Netherlands	WOOD		95	3	0.2	0.070
Netherlands	GLASS		95	2	-0.2	0.184
Netherlands	METAL		95	1	0	**0.026**
Netherlands	CLOTH		95	1	0	0.126
Netherlands	PAPER		95	1	0	0.129
Netherlands	POTTERY		95	0	0	0.165

Functional group trends at country level					
Region	group code		n	median	slope	p value
Netherlands	SUP		95	32	-7.1	**0.000**
Netherlands	FISH		95	74	-10.8	**0.000**
Netherlands	OTHER		95	47	-5.9	**0.001**

Top 10 trends country level					
Region	type name		n	median	slope	p value
Netherlands	plastic: string [32]		95	52.5	-8.3	**0.000**
Netherlands	plastic: plastic fragments_large [46]		95	12.0	-1.5	**0.000**
Netherlands	plastic: crisp [19]		95	7.0	-1.4	**0.000**
Netherlands	plastic: fishing_net_small [115]		95	6.5	-1.4	**0.000**
Netherlands	plastic: caps [15]		95	5.5	-1.4	**0.000**
Netherlands	plastic: foam_sponge [45]		95	5.0	-1.3	**0.000**
Netherlands	plastic: industrial [40]		95	4.0	-1.1	**0.000**
Netherlands	rubber: balloons [49]		95	3.5	0.8	**0.028**
Netherlands	plastic: tangled [33]		95	3.2	-0.4	0.213
Netherlands	plastic: small_bags [3]		95	2.5	-0.2	0.076

Total weight on country level in kilograms					
Region	group code	n	median	slope	p value
Netherlands	Total weight	89	3.1	-0.9	**0.000**

Netherlands TC

NB: 2 largest counts are missing because only the lower 50% of the plot is given

Netherlands PLASTIC

NB: 2 largest counts are missing because only the lower 50% of the plot is given
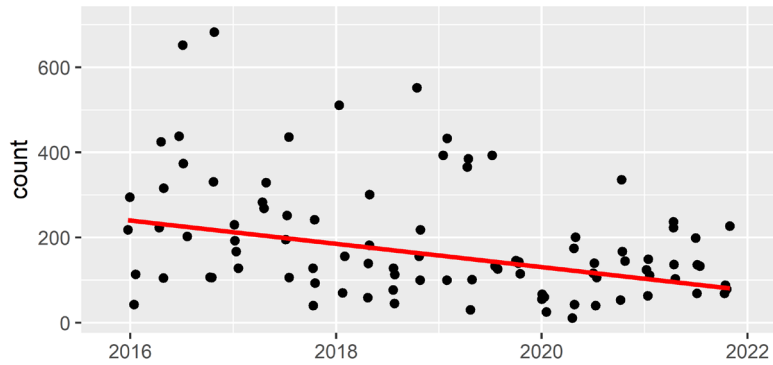
Figure 8 Trend plot 2016-2021: six year plot total count aggregated for all Dutch beaches with significantly decreasing trend (slope -27.3). Exclusively small plastic [117]

Figure 9 Trend plot 2016-2021: six year plot litter group "Plastics" aggregated results for all Dutch beaches with significantly decreasing trend (slope – 23.3). Exclusively small plastic [117]

Netherlands SUP

NB: 1 largest counts are missing because only the lower 50% of the plot is given

Netherlands FISH

NB: 5 largest counts are missing because only the lower 50% of the plot is given

Figure 10 Trend plot 2016-2021: six year plot specific SUP litter group aggregated results for all Dutch beaches with significantly decreasing trend (slope – 7.1).
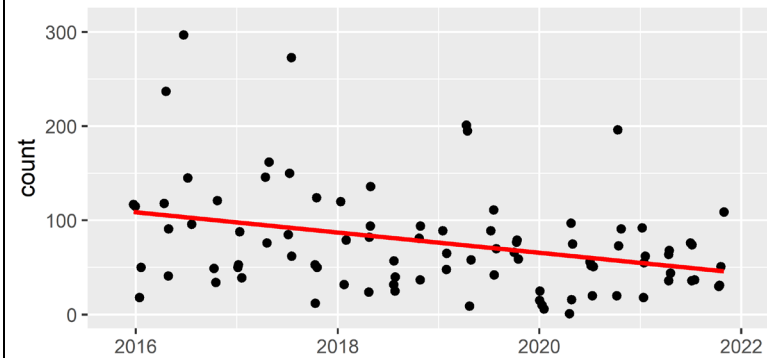
Figure 11 Trend plot 2016-2021: six year plot specific FISH litter group aggregated results for all Dutch beaches with significantly decreasing trend (slope – 10.8).

Netherlands plastic: string [32]

NB: 6 largest counts are missing because only the lower 50% of the plot is given

Netherlands plastic: plastic_large [46]

NB: 2 largest counts are missing because only the lower 50% of the plot is given

Figure 12 Trend plot *plastic: string [32]* 2016-2021: six year plot litter aggregated results for all Dutch beaches with significantly decreasing trend (slope – 8.3).
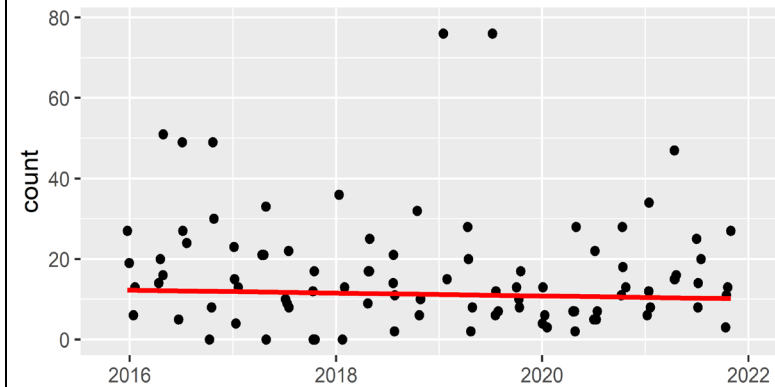
Figure 13 Trend plot Plastic/polystyrene pieces 2.5 cm >< 50 cm [46] 2016-2021: six year plot litter aggregated results for all Dutch beaches with significantly decreasing trend (slope – 1.5).

Netherlands plastic: crisp [19]

NB: 2 largest counts are missing because only the lower 50% of the plot is given

Netherlands plastic: fishing_net_small [115]

NB: 3 largest counts are missing because only the lower 50% of the plot is given
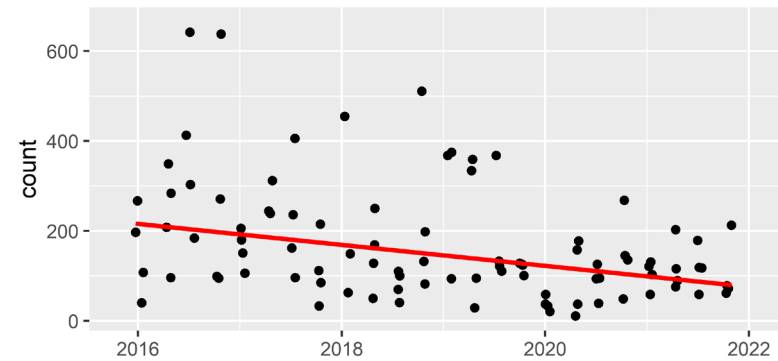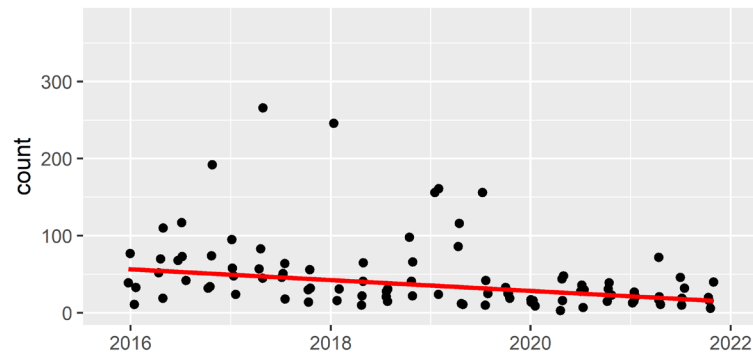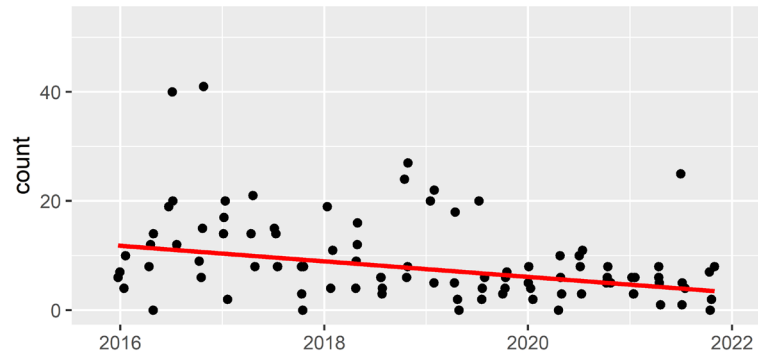
Figure 14 Trend plot Plastic crisp/sweet packets and lolly sticks [19] 2016-2021: six year plot litter aggregated results for all Dutch beaches with significantly decreasing trend (slope – 1.4).
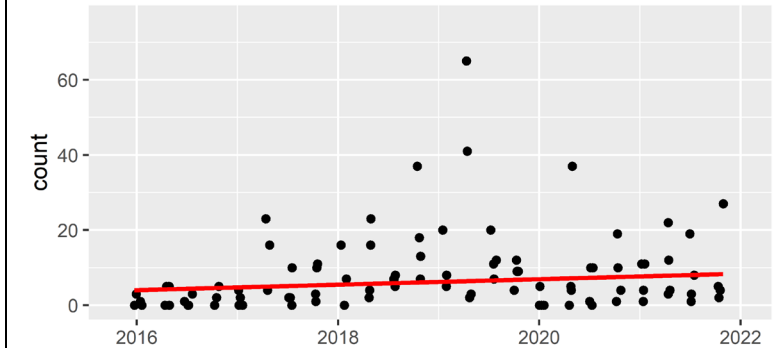
Figure 15 Trend plot plastic fishing net small [115] 2016-2021: six year plot litter aggregated results for all Dutch beaches with significantly decreasing trend (slope – 1.4).

Netherlands plastic: caps [15]

NB: 2 largest counts are missing because only the lower 50% of the plot is given

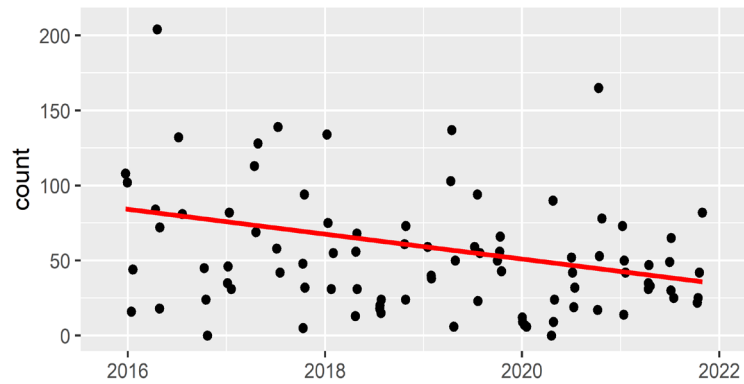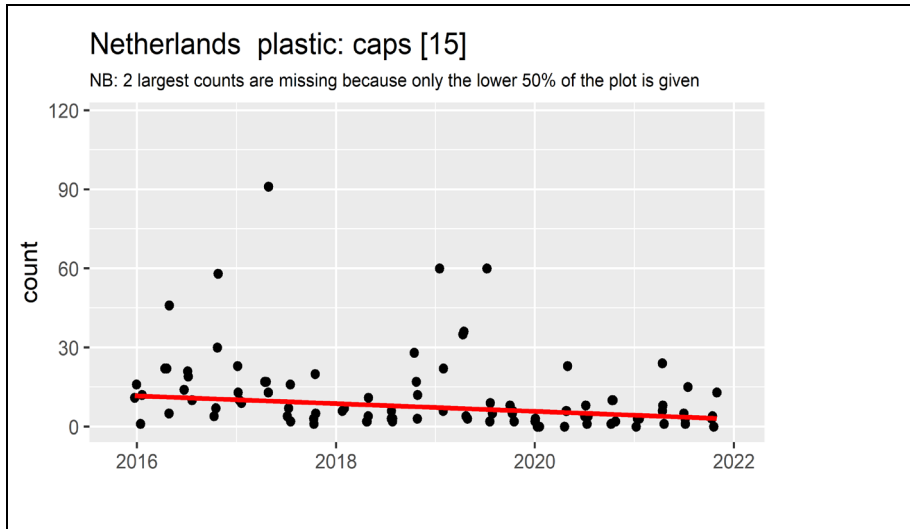*Figure 16 Trend plot plastic: caps & lids [15] 2016-2021: six year plot litter aggregated results for all Dutch beaches with significantly decreasing trend (slope – 1.4).*

Netherlands plastic: plastic_small [117]

NB: 1 largest counts are missing because only the lower 50% of the plot is given

Figure 17 Indicative 6- year trend plot 2016-2021 small plastic fragments [117] six year plot litter aggregated results for all Dutch beaches with no significantly decreasing trend (slope – 2.12).

NL TOTAL WEIGHT

Figure 18 Trend analysis 2016-2021: six- year trend analysis plot total weight aggregated results for all Dutch beaches with significantly decreasing trend (slope – 0.9).
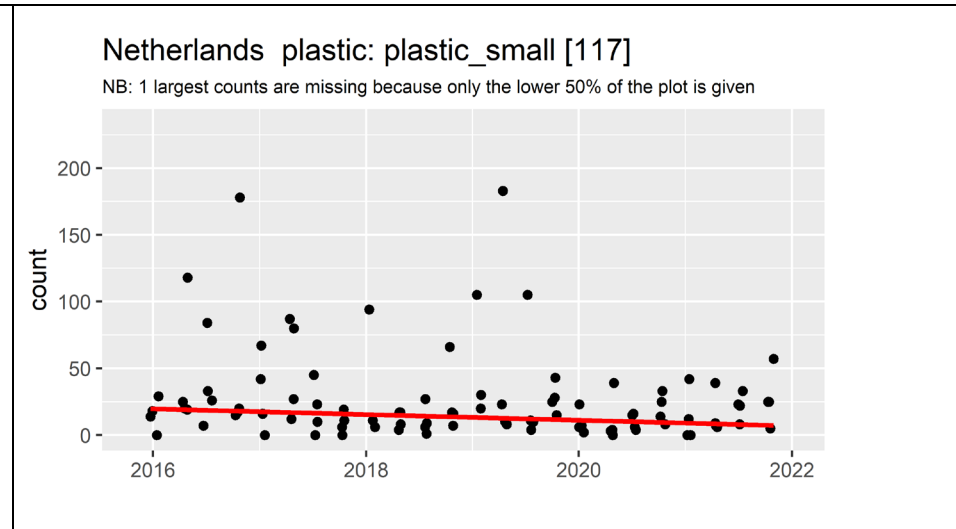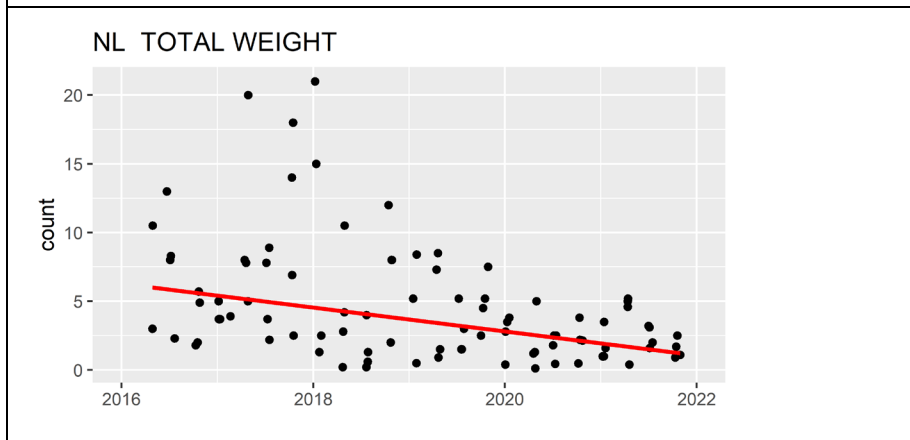
3.3.2 Total count

The aggregated country total count for the period 2016-2021 shows a significant decreasing trend of -27 counts/100m per year. The median total count for the period 2016-2021 is 159 counts/100m. On individual beach level, all four beaches show decreasing slopes with the highest decreasing slope of -72 counts/100m per year at the beach of Bergen.

3.3.2 Material group analysis

The litter types are categorized in following material categories: plastic/polystyrene [406], rubber [407], wood [410], paper/cardboard [409], glass [412], ceramic/pottery [413], metal [411] and cloth/textile [408].

In the period 2016-2021, plastic is the most found type of material (92%) followed by rubber (3%), wood (2%) and glass (1%). The other materials are metal, paper, cloth and pottery. Plastic/polystyrene has a median value of 141 counts per 100 meter beach. The trend analysis results shows significantly decreasing trends for plastic/polystyrene (-23 counts/year), rubber (-2 count/year) and glass (-0.2 count/year). The other materials show no decreasing or increasing slopes.

3.3.3 Functional group analysis

The litter types are categorized in the specific litter group types: SUP, FISH and OTHER. All specific litter groups show decreasing slopes with significant decreasing trends. The SUP litter group has a median value of 32 counts per 100 meter beach and shows a significantly decreasing trend of -7 litter counts/100m per year. The FISH litter group has a median value of 74 counts per 100 meter beach with a significantly decreasing trend of -11 litter counts/100m per year.

3.3.4 Top 10 litter types

The Dutch top 10 most found litter types for the period 2016-2021 shows that plastic string [32] is the most found litter type, this litter type mainly consists of plastic dolly rope (see section 3.6). Plastic string has a median of 53 litter counts per 100 meter of beach with a decreasing trend slope of -8 counts/100m per year. Plastic/polystyrene pieces 2.5 cm >< 50 cm [46] ranks as the number two most found litter type with a median of 12 counts per 100 meter beach and decreasing trend slope of -1.5 counts/100m per year. Plastic crisp/sweet packets and lolly sticks ranks is third most found litter type with a median value of 7 counts per 100 meter beach and decreasing slope of -1.4 counts/100 m per year. The other litter types in top 10 all show significantly decreasing trends, expect from balloon [49] which has a very slight increasing slope of +0.7.

The trend plots for the top 5 most found litter type are included in figure 12, 13, 14, 15 and 16.

Figure 19 Oil solvent found during survey in Noordwijk, 2021

Figure 20 Litter found during winter survey Noordwijk, 2021

Figure 21 Plastic cup found on beach of Terschelling, 2021

Figure 22 Bottle with Asian lable found on beach of Noordwijk, 2021

Figure 23 Very old beer can found at survey on beach of Noordwijk, 2021

Figure 24 Labour election sticker from United Kingdom found on beach of Noordwijk, 2021

Figure 25 Fishnet cutting found on beach of Noordwijk, 2021

Figure 26 Lead surveyor at survey site Bergen, 2021

3.4   Mesoplastics fragments

The category meso-plastic fragments 0.5-2.5cm [117] has been analyzed separately. The indicative 6-year trend analysis shows a non-significant decreasing trend slope (-2.1 counts/100m per year – p value 0.018). The median count for this period is 15 counts per 100 meter beach and account for 8% of the litter recorded in the period 2016-2021. The trend plot is shown in figure 24.

3.5   Test items

In 2018, the registration of so-called "test items" has started. The purpose of the registration of these items was to gain more information about the composition of OSPAR types. For example, the category string and cord [32] includes both string and cord and dolly ropes. To get a better insight in this category and the distinction between these litter types, two test items were added to register both string_cord [321] and dolly_rope [322]. In total 20 test items were added in the OSPAR Beach Litter database. Currently, these items have not yet been officially been added to the OSPAR beach litter protocol and are therefore been analyzed separately.

In the period 2019-2021 only one piece of plastic fish box was found. No cardboard sanitary buds were found.

In table 7 the percentages based on total items found per test category that fall under one OSPAR litter type category are included. It shows that for the litter type category string and cord [32] mostly consist of dolly rope (77%). Also it snows the percentages of EPS materials (food packaging, cups, fragments) found are much lower than plastic polystyrene materials found. 20% of food packaging, 4% of cups, 13% of plastic fragments 0.5-2.5cm, 18% of plastic fragments 2.5- 50cm and 0% of plastic fragments larger than 50cm consist of EPS materials. For the category tangled [33] it shows that 66% of this category consists of tangled nets/cord/rope and string without dolly rope or mixed with dolly rope. The other 34% consists of only tangled cords and ropes.

3.6   Threshold value

The threshold value (TV) is calculated based on 3-year analysis period (2019-2021) and is based on 47 surveys, small plastic fragments 0.5-2.5cm [117] and waxes/other pollutants are excluded. The median total count for this period is 118 litter counts per 100 meter beach.

The threshold value of a median value of 20 counts per 100 coastline is not yet met. Based on new asymptotic trend model of Walvoort et al. (2021) and the Dutch beach litter data from 2011-2019, the TV on Dutch beaches could be reached around 2038/2039 with 90% confidence interval: 2034-2045 (Van Loon, 2022).

3.7   Waxes

Since the beginning of the beach litter monitoring (2002), the presence of pollutants, such as paraffin, has been separately recorded on the OSPAR Marine Litter Monitoring Survey Form. This included three waxes size categories. Paraffin waxes were recorded per size category which are 0-1 cm [108], 1-10 cm [109] and >10cm [110] and the frequency of paraffin per 100m (estimated number per meter of strandline) is recorded.

In the last years, the monitoring method for the presence of paraffin waxes has proved to be limited. Starting from 2023, a new monitoring method will be applied. This will include 1) collection and counting of all paraffin wax pieces and other pollutants on the survey site and 2) separate weighing of paraffin and other pollutants. This method will give more precise information of the presence of paraffin on the survey site and its mass.

3.8 Pellets

In 2021, there were no locations where more than 500 pellets were found at a survey site. In a pilot study of RWS that was conducted in 2021, a method has been tested to quantify the number pellets present on Dutch beaches. The monitoring includes four locations, one of them being the survey site being. On each of the four beaches one fixed stretch of beach of 100 meter is selected. For each 100 meters the top layer (1-2) of 5 sampling units (squares) of 1m2 are sampled at the springtide line, at a fixed distance of 25 m: 0, 25, 50, 75, 100 meters.

The results of this pilot show an estimated (extrapolated) median value of 215 pellets per 100 m on the Dutch beach high springtide line (Wenneker et all., 2022). This estimated value is based on a measured median 11 pellets per 5 m beach length (5 sampling units of 1 m2). Pellets were found at 87% of conducted 16 conducted surveys. This percentage is higher than the median presence at the beach litter monitoring in the period 2019-2021 which was 66% and shows that this additional monitoring gives a better and comprehensive assessment of the presence of pellets on the Dutch coastline.

3.9   Total weight

The state analysis results of monitoring of total weight in period 2019-2021 is included in table 4. The median total weight for the period 2019-2021 is 2.5 kg per 100 meter beach.

Based on trend analysis conducted with data collected in past six years during 89 surveys, the median weight of marine litter per 100 meter beach is 3.1 kg and shows a decreasing trend of -0.9 kg/year (see table 5). A separate analysis was conducted to find out if there is a corelation between total litter count and total weight. The regression analysis of the year median count and the median year total weight shows a p value of 0.003. Figure 27 shows a strong corelation (R^2 = 0.9059).
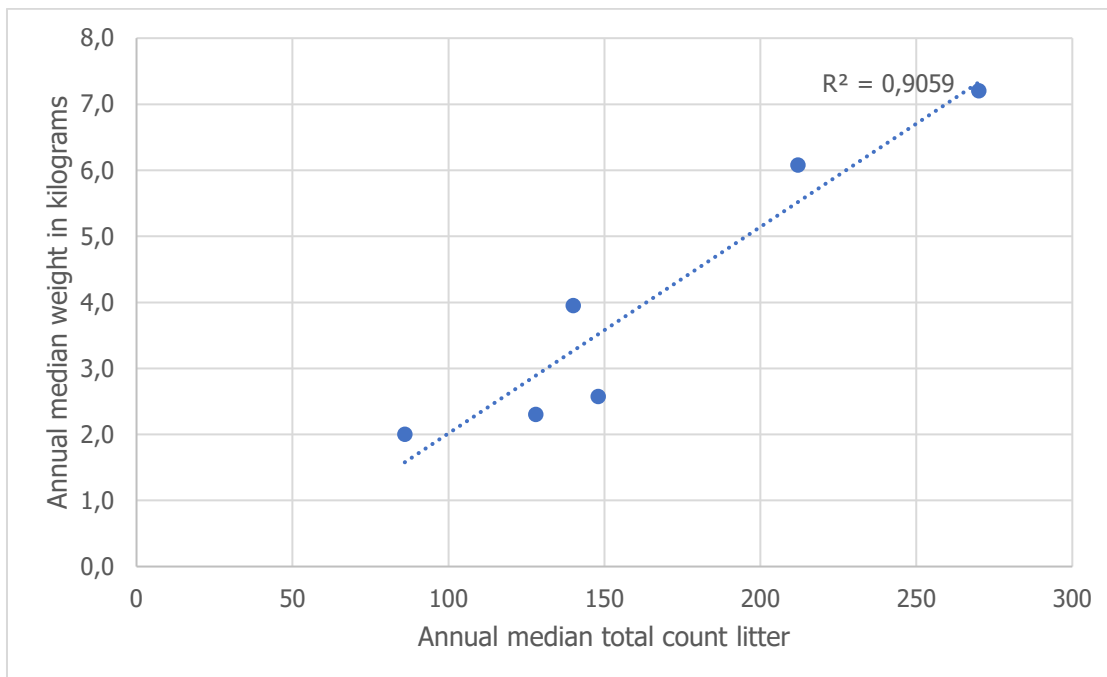
Figure 27 Correlation of total litter count and total weight in period 2016-2021

Table 7 Division of test items in specific categories % per OSPAR category in period 2019-2021

OSPAR category and test items that fall under this category	% division based on total found items of OSPAR litter type category
Plastic: Food [6]	
Plastic: Food_plastic [610]	80%
Plastic: Food_eps [620]	20%
Plastic: Cups [21]	
Plastic: Cups_plastic [211]	96%
Plastic: Cups_eps [212]	4%
Plastic: Plastic_small [117]	
Plastic: Plastic_s [1171]	87%
Plastic: Eps_s [1172]	13%
Plastic: Plastic_large [46]	
Plastic: Plastic_m [461]	82%
Plastic: Eps_m [462]	18%
Plastic: Plastic_vlarge [47]	
Plastic: Plastic_l [471]	100%
Plastic: Eps_l [472]	0%
Plastic: String [32]	
Plastic: String_cord [321]	23%
Plastic: Dolly_rope [322]	77%
Plastic: Tangled [33]	
Plastic: Tangled_nets/cord/rope and string without dolly rope or mixed with dolly rope [331]	66%
Plastic: Tangled_dolly_rope [332]	34%

4. Discussion

The beach litter monitoring aims to gain insight into the quantities and types of litter that wash up on the Dutch North Sea beaches. This provides insight into the presence of (floating) litter in the sea and the degree of pollution in the North Sea.

The good news is that decreasing significant trend continues for the period 2016-2021. In the last years plastic pollution received increased public attention. The downward trend is the combined result of increased public and political awareness, successful public campaigns and projects by various NGO's, implementation and execution of international, European, national laws and policies. However, the beach litter threshold value is not yet reached. A new asymptotic model, applied to Dutch beach litter data, shows that the beach litter TV could be reached around 2038/2039 if the current decreasing trend is maintained. This requires at least that the current measures are maintained, and additional beach litter reduction measures are probably needed (Walvoort et al., 2021).

In 2020 the worldwide COVID pandemic started and was ongoing in 2021. Also in 2021 various national lockdown periods in order to limit contact between people were implemented. This meant that i.e. that the government advised to work from home and not travel abroad, and imposed various restrictions for open hours of shops and restaurants. It remains difficult to estimate the effect of the pandemic on the possible reduced input of litter into the seas worldwide. At the same time, new types of litter were found on streets, roads and beaches etc. due to the increased widespread use of personal protective gear such as (often single-use plastic) masks, gloves, wet wipes and bottles of sanitizers). Due to improper discharge or poor behaviour this type of litter ended up in the environment. Though single use masks have not found in large quantities at beaches, this is more the case in urban areas.

The COVID pandemic also had another effect. After lockdown periods, beach visits became even more popular. During the summer periods, some beach roads were closed off due to large amount of people wanted to visit the beach. Also in 2021 more Dutch people spend their summer holidays in The Netherlands with coastal destinations being popular (CBS, 2021). Another effect is that a growing number of environmental organisations report an increase of individuals who are cleaning up their local environment increased national wide. To illustrate this a record number of volunteers participated in the yearly Boskalis Beach Cleanup Tour.

Like in the previous years, there is a concern in the entire OSPAR region that these cleaning efforts have an influence on the monitoring results. The quantification of cleaning activities and to evaluate its effect on trends remains challenging. In addition, fishermen part of the Fishing For Litter scheme continued to collect debris that gets stuck in their nets during normal fishing activities. The debris is stored in big bags onboard and delivered in ports for processing. In 2021, another record amount of 756 tons of debris was collected which still included lost container goods of the MSC Zoe (KIMO, 2022). It is likely that operational fishing waste is also collected in these bags. Currently, about 140 fishing boats participate in Fishing for Litter. Coastal municipalities participate in "Clean Beach Elections" that are organised since 2003. In the year 2021, fewer items were registered on recreational beaches but no clear trend is visible yet. Cigarette buts remain by far, the most found litter on recreational beaches. Still, no exact information is available on litter amounts and types collected by municipalities and coastal cleaning initiatives on an annual basis.

The long term trend of the fulmar litter monitoring shows a decreasing trend of litter found in the stomachs of Northern Fulmars based on year report with 2021 data (Kühn et al. 2022). Combined with the results of the six year beach litter monitoring trend analysis, this is evidence that the abundance of litter in the Dutch part of the North Sea is decreasing. The six year trend analysis of the total weights confirms this. At the same time the TV for beach litter of 20 litter counts per 100 meter of beach and the TV for plastic particles in the stomachs of fulmars which gives an indication of the presence of floating plastics at sea are not yet in sightIn addition, the latest fulmar report states that the 10- year decreasing trend shows a disruption (Kühn et al. 2022).

Furthermore, the results of the pilot monitoring of pellets and mesoplastic fragments (Wenneker et al., 2022) in combination with the recorded presence of pellets give new insights in the abundance of

pellets in the top sand layer. For the meso-plastic fragments, an estimated median value of 285 meso-plastic fragments per 100 m beach was found. In comparison with the median of 15 mesoplastics fragments per 100 m beach during the beach litter monitoring, shows that the actual abundance on the Dutch coast is much higher. Therefore these monitoring results should be considered indicative. Together with the estimated median value is 215 pellets per 100m beach, there is a clear indication that the presence of pellets and mesoplastics on our coast is significant and needs attention.

5. Conclusions

The 6-year trend analysis (period 2016-2021) of beach litter monitoring data shows a significant decreasing trend of -27 counts/100m per year and shows that the Dutch beaches are getting cleaner in the past six years. The total count median for this period is 159 (excluding small mesoplastic fragments and waxes). The median weight of marine litter per 100 meter beach is 3.1 kilogram and shows a significant decreasing trend. The beach litter threshold value of 20 counts per 100m could be reached in 2038/2039.

The functional litter groups SUP and FISH show significantly decreasing trends. The SUP litter group has a median of 32 counts per 100 meter beach and shows a significantly decreasing trend of -7 counts/100m per year. The FISH litter group which mainly contains of fishing related items has a median of 74 counts/100m with a significantly decreasing trend of -11 counts/100m year.

Plastic remains the most found material (91%) with a median of 105 counts/100m in the period 2019-2021. The trend analysis results shows significantly decreasing trends for plastic/polystyrene (-23 counts/100m per year), rubber (-1.5 count/100m per year) and glass (-0.2 count/100m per year). For wood a slight increasing slope is visible (+0.2). The other materials show no decreasing or increasing slopes.

On beach level, all beaches show decreasing trend slopes with Bergen and Noordwijk showing significant trends.

The top 10 for the period 2019-2021 mainly consists of plastic: string [32], plastic: caps [15], plastic: fishing net small [115], plastic: fragments 2.5<>50cm [46], wood: pieces < 50 cm [74], plastic: crisp [19], plastic: small bags [3], plastic: foam sponge [45], plastic: industrial [40] en plastic: tangled [33].

The top 10 trend analysis show mostly small but decreasing trends slopes for most top-10 types. Only rubber balloons [49] which shows a small increasing slope (+0.7). String and cord show a relatively large decreasing trend of -8 counts/100m per year.

An analysis was conducted on the registration of the OSPAR test items. The most important results are that litter type string and cord [32] mostly consists of dolly rope (77%) and that the category tangled [33] mostly consists of tangled nets/cord/rope and string mixed with dolly rope (66%). Also the analysis showed that the percentages of EPS materials (food packaging, cups, fragments) found are much lower than plastic polystyrene materials found.

Although the total abundance of beach litter shows a significantly decreasing trend on Dutch beaches, the EU beach litter threshold value (TV) of median 20 counts/100m beach is still far from being reached. Although new policies and measures are in place, continued measures are needed to maintain a decreasing trend of marine litter and to reduce the impact of litter in the marine environment. Especially the measure reduce plastic dolly rope (out-phasing of dolly rope in 2027) is an important measure.

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Appendixes

Appendix I OSPAR beach litter data 2016-2021: see Waterinfo-extra.nl

Appendix II Digital copies of OSPAR litter survey forms, year 2021 (present within RWS-CIV, Mervyn Roos)

Appendix III LitteR reports and files 2019-2021 and 2016-2021 (present within RWS-CIV, Mervyn Roos)

Appendix IV Survey dates and total litter weights

#	Survey beach	Year	Weight (kg) per 100m
1	NL003	28-4-2016	3.0
2	NL001	29-4-2016	10.5
3	NL002	22-6-2016	13.0
4	NL001	5-7-2016	8.0
5	NL004	7-7-2016	8.3
6	NL003	22-7-2016	2.3
7	NL002	10-10-2016	1.8
8	NL003	17-10-2016	2.0
9	NL004	22-10-2016	5.7
10	NL001	25-10-2016	4.9
11	NL002	5-1-2017	5.0
12	NL003	6-1-2017	3.7
13	NL004	11-1-2017	3.7
14	NL001	19-2-2017	3.9
15	NL004	14-4-2017	8.0
16	NL002	20-4-2017	7.8
17	NL001	28-4-2017	20
18	NL003	27-4-2017	5.0
19	NL002	6-7-2017	7.8
20	NL004	11-7-2017	3.7
21	NL001	17-7-2017	8.9
22	NL003	18-7-2017	2.2
23	NL001	11-10-2017	14
24	NL003	12-10-2017	6.9
25	NL002	16-10-2017	18
26	NL004	18-10-2017	2.5
27	NL001	12-1-2018	15.0
28	NL001	30-4-2018	10.5
29	NL001	23-7-2018	4.0
30	NL001	15-10-2018	12.0
31	NL002	8-1-2018	21.0
32	NL002	25-4-2018	2.8
33	NL002	28-7-2018	1.3
34	NL002	23-10-2018	2.0
35	NL003	31-1-2018	2.5
36	NL003	23-4-2018	0.2
37	NL003	22-7-2018	0.2
38	NL003	26-10-2018	8.0
39	NL004	24-1-2018	1.3
40	NL004	29-4-2018	4.2
41	NL004	27-7-2018	0.6

42	NL004	27-10-2018	8.0
43	NL001	16-1-2019	5.2
44	NL001	12-4-2019	8.5
45	NL001	9-7-2019	5.2
46	NL001	10-10-2019	4.5
47	NL002	30-1-2019	8.4
48	NL002	15-4-2019	7.3
49	NL002	19-7-2019	1.5
50	NL002	2-10-2019	2.5
51	NL003	29-1-2019	0.5
52	NL003	23-4-2019	0.9
53	NL003	21-7-2019	1.5
54	NL003	17-10-2019	5.2
55	NL004	29-4-2019	1.5
56	NL004	29-7-2019	3.0
57	NL004	29-10-2019	7.5
58	NL003	2-1-2020	0.4
59	NL004	3-1-2020	2.8
60	NL002	10-1-2020	3.5
61	NL001	18-1-2020	3.8
62	NL003	19-4-2020	1.2
63	NL002	24-4-2020	1.3
64	NL004	26-4-2020	0.12
65	NL001	30-4-2020	5.0
66	NL004	2-7-2020	1.8
67	NL001	6-7-2020	2.5
68	NL002	10-7-2020	0.45
69	NL003	14-7-2020	2.5
70	NL002	7-10-2020	0.48
71	NL004	11-10-2020	3.8
72	NL001	13-10-2020	2.2
73	NL003	23-10-2020	2.15
74	NL001	13-1-2021	3.5
75	NL001	13-4-2021	5.0
76	NL001	6-7-2021	1.6
77	NL001	11-10-2021	0.9
78	NL002	12-1-2021	1.0
79	NL002	13-4-2021	4.6
80	NL002	5-7-2021	3.1
81	NL002	14-10-2021	1.7
82	NL003	18-1-2021	1.6
83	NL003	19-4-2021	0.4
84	NL003	16-7-2021	2.0
85	NL003	19-10-2021	2.5
86	NL004	7-1-2021	1.0

87	NL004	14-4-2021	5.2
88	NL004	1-7-2021	3.2
89	NL004	30-10-2021	1.1

Appendix V List of OSPAR litter types and assignment to litter groups

Source: TGML beach litter photo guide.
https://mcc.jrc.ec.europa.eu/main/photocatalogue.py?N=41&O=457&cat=all
Note: Based on the Joint list codes, the category Plastic: Fertiliser [23] is added to the FISH group. The SUP and OTHER group has not changed based on the comparison with the Joint list categorisation.

type_name	included	SUP	FISH	OTHER
Plastic: Yokes [1]	x	x		x
Plastic: Bags [2]	x	x		
Plastic: Small_bags [3]	x	x		x
Plastic: Bag_ends [112]	x	x		x
Plastic: Drinks [4]	x	x		
Plastic: Cleaner [5]	x			x
Plastic: Food [6]	x	x		
Plastic: Toiletries [7]	x			x
Plastic: Oil_small [8]	x			x
Plastic: Oil_large [9]	x			x
Plastic: Jerry_cans [10]	x			x
Plastic: Injection_gun [11]	x			x
Plastic: Other_bottles [12]	x			x
Plastic: Crates [13]	x			x
Plastic: Car_parts [14]	x			x
Plastic: Caps [15]	x	x		
Plastic: Cigarettelighters [16]	x			x
Plastic: Pens [17]	x			x
Plastic: Combs [18]	x			x

Plastic: Crisp [19]	x	x		
Plastic: Toys [20]	x			x
Plastic: Cups [21]	x	x		
Plastic: Cutlery [22]	x	x		
Plastic: Fertiliser [23]	x			x
Plastic: Meshbags [24]	x			x
Plastic: Gloves [25]	x			x
Plastic: Gloves_pro [113]	x			x
Plastic: Lobsterpots [26]	x		x	
Plastic: Fish_tags [114]	x		x	
Plastic: Octopus_pots [27]	x		x	
Plastic: Oyster_nets [28]	x		x	
Plastic: Oyster_trays [29]	x		x	
Plastic: Mussel_sheeting [30]	x		x	
Plastic: Rope [31]	x		x	
Plastic: String [32]	x		x	
Plastic: Fishing_net_small [115]	x		x	
Plastic: Fishing_net_large [116]	x		x	
Plastic: Tangled [33]	x		x	
Plastic: Fishboxes [34]	x		x	
Plastic: Fishing_line [35]	x		x	
Plastic: Light_sticks [36]	x		x	
Plastic: Floats [37]	x		x	
Plastic: Buckets [38]	x			x
Plastic: Strapping [39]	x			x

Plastic: Industrial [40]	x			x
Plastic: Fibre_glass [41]	x			x
Plastic: Hard_hats [42]	x			x
Plastic: Shotgun [43]	x			x
Plastic: Shoes [44]	x			x
Plastic: Foam_sponge [45]	x			x
Plastic: Plastic_small [117]				
Plastic: Plastic_large [46]	x			x
Plastic: Plastic_vlarge [47]	x			x
Plastic: Other [48]	x			x
Rubber: Balloons [49]	x	x		
Rubber: Boots [50]	x			x
Rubber: Tyres [52]	x			x
Rubber: Other [53]	x			x
Cloth: Clothing [54]	x			x
Cloth: Furnishings [55]	x			x
Cloth: Sacking [56]	x			x
Cloth: Shoes [57]	x			x
Cloth: Other [59]	x			x
Paper: Bags [60]	x			x
Paper: Cardboard [61]	x			x
Paper: Purepak [118]	x			x
Paper: Tetrapak [62]	x			x
Paper: Cig_packets [63]	x			x
Paper: Cig_stubs [64]	x	x		

Paper: Cups [65]	x			x
Paper: Newspapers [66]	x			x
Paper: Other [67]	x			x
Wood: Corks [68]	x			x
Wood: Pallets [69]	x			x
Wood: Crates [70]	x			x
Wood: Lobsterpots [71]	x			x
Wood: Fish_boxes [119]	x			x
Wood: Lolly [72]	x			x
Wood: Brushes [73]	x			x
Wood: Other_small [74]	x			x
Wood: Other_large [75]	x			x
Metal: Aerosol [76]	x			x
Metal: Caps [77]	x			x
Metal: Drink [78]	x			x
Metal: Bbqs [120]	x			x
Metal: Electrical [79]	x			x
Metal: Fishing [80]	x			x
Metal: Foil [81]	x			x
Metal: Food [82]	x			x
Metal: Scrap [83]	x			x
Metal: Oil [84]	x			x
Metal: Paint_tins [86]	x			x
Metal: Lobsterpots [87]	x		x	
Metal: Wire [88]	x			x

Metal: Other_small [89]	x			x
Metal: Other_large [90]	x			x
Glass: Bottles [91]	x			x
Glass: Bulbs [92]	x			x
Glass: Other [93]	x			x
Pottery: Construction [94]	x			x
Pottery: Octopus_pots [95]	x		x	
Pottery: Other [96]	x			x
San: Condoms [97]	x			x
San: Buds [98]	x	x		
San: Towels [99]	x	x		
San: Tampons [100]	x	x		
San: Toilet [101]	x			x
San: Other [102]	x			x
Med: Containers [103]	x			x
Med: Syringes [104]	x			x
Med: Other [105]	x			x
Faeces: In_bags [121]	x			x
Pollutants: Wax_small [108]				
Pollutants: Wax_medium [109]				
Pollutants: Wax_large [110]				
Pollutants: Other [111]				
Plastic: Food_plastic [610]				
Plastic: Food_eps [620]				
Plastic: Cups_plastic [211]				

Plastic: Cups_eps [212]				
Plastic: Fishboxes_plastic [341]				
Plastic: Fishboxes_eps [342]				
Plastic: Plastic_s [1171]				
Plastic: Eps_s [1172]				
Plastic: Plastic_m [461]				
Plastic: Eps_m [462]				
Plastic: Plastic_l [471]				
Plastic: Eps_l [472]				
Plastic: String_cord [321]				
Plastic: Dolly_rope [322]				
Plastic: Tangled_string [331]				
Plastic: Tangled_dolly_rope [332]				
San: Buds_plastic [981]				
San: Buds_cardboard [982]				
Plastic: Biofilm [481]				
Glass: Jars [931]				
Survey: Old_rope_small [200]				
Survey: Old_rope_large [201]				
Survey: Old_plastic_pieces [202]				
Survey: Old_gloves [203]				
Survey: Old_cartons [204]				
Survey: Old_oildrums_new [205]				

Survey: Old_oildrums_old [206]				
Survey: Old_human_faeces [207]				
Survey: Old_animal_faeces [208]				
Survey: Old_cloth_rope [210]				