Methods for monitoring of pellets and mesoplastic fragments on Dutch beaches

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Method version information

VersionNr	Date	Information
1	2021	The Dutch starting method, applied for the first time. Sampling was performed using 5 quadrants of 1 m^2 at the springtide line, 1-2 days after springtide. Morphology classes were not yet discriminated. In 2021 we used location Texel.
2	Spring 2022	The method was updated by increasing the sampling area to 10 quadrants of 1 m^2; 5 quadrants at the springtide line and 5 quadrants at the second tideline closer to the sea. The EU method (Galgani et al., 2023) was used for identifying five morphology groups. The location Texel was changed to Terschelling in 2022, because this is a standard beach macrolitter monitoring location.
3	July 2022	The EU sampling method, including 5 transects of 1 m width from the low waterline to the dune front, was fully implemented. For Neeltje Jans and Bergen 2 out of 4 surveys in 2022 were carried out according to the EU method; for Terschelling and Monster this applies for 3 out of 4 surveys. The number of pellets and mesoplastics found approx. doubled compared to method version 2.

Abbreviations

NPEL, number of pellets; NMES, number of mesoplastic fragments; WPEL, total weight of pellets; WMES, total weight of mesoplastic fragments; NMES_Fil, number of mesoplastic Filaments; NMES_Film, … Films; NMES_Frag, … Fragments; NMES_Foa, … Foams; NMES_Sty, … Styrofoams.

1. Monitoring Strategy

1.1 Locations

Four Dutch beaches were chosen to apply the monitoring method. The OSPAR beach selection criteria were used (2022). In addition, the proximity to sources (harbour or estuary outlet) was used as an additional beach selection criterion (Galgani et al., 2023). This led to the selection of the locations Neeltje Jans (close to the outlet of the Westerschelde estuary and indicated as pellet hotspot) and Monster (close to the outlet of the Nieuwe Waterweg and to the port of Rotterdam). Terschelling and Bergen, both national monitoring locations for beach litter, were also selected. These two beaches are standard monitoring locations for beach macro litter. The selected locations are shown in Figure 2 and specified in Table 1.

Figure 2: monitoring locations for pellets and mesoplastic fragments in 2022.

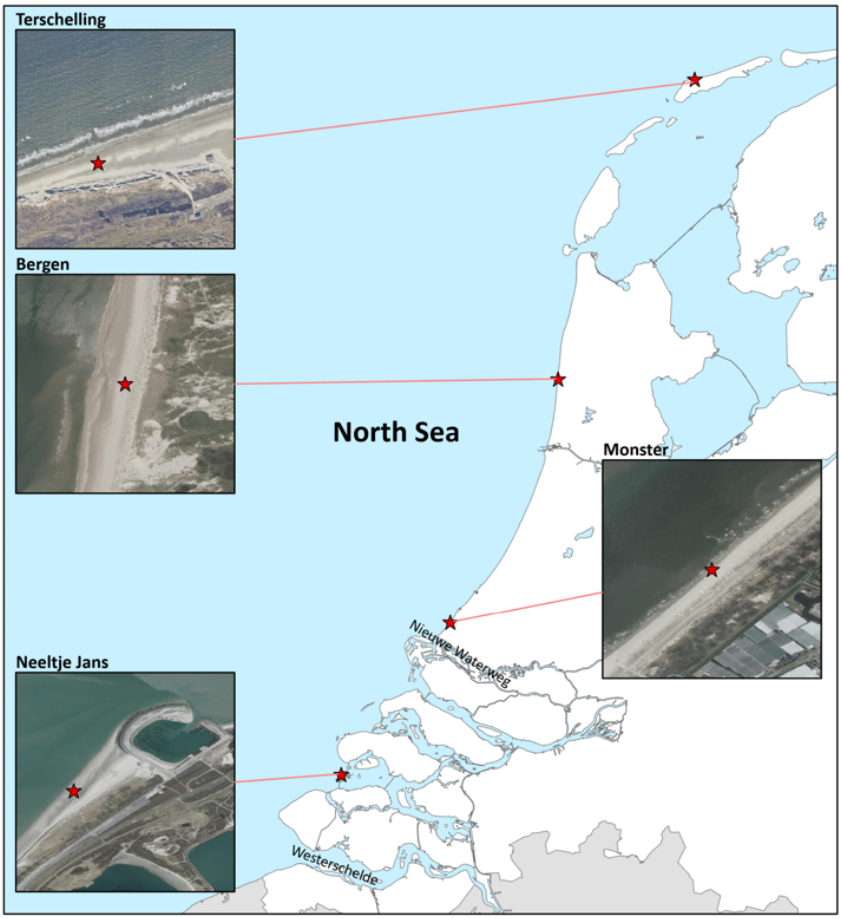


Table 1: detailed description of monitoring locations

Location	Latitude	Longitude	Motivation
Terschelling (TSL) Beach pole: 8.200	53.400992	5.236688	Location on the Northern Dutch Wadden islands, same coastline as national beach litter monitoring location
Bergen (BGN) Beach pole: 35.250	52.642145	4.624206	National beach litter monitoring location
Monster (MSR) Beach pole: 112,5	52.022186	4.152487	Near the outlet of the Nieuwe Waterweg, connected to Rotterdam harbour
Neeltje Jans (NJS) Dune corner	51.635109	3.692583	Near the outlet of the Westerschelde estuary with harbours and industry

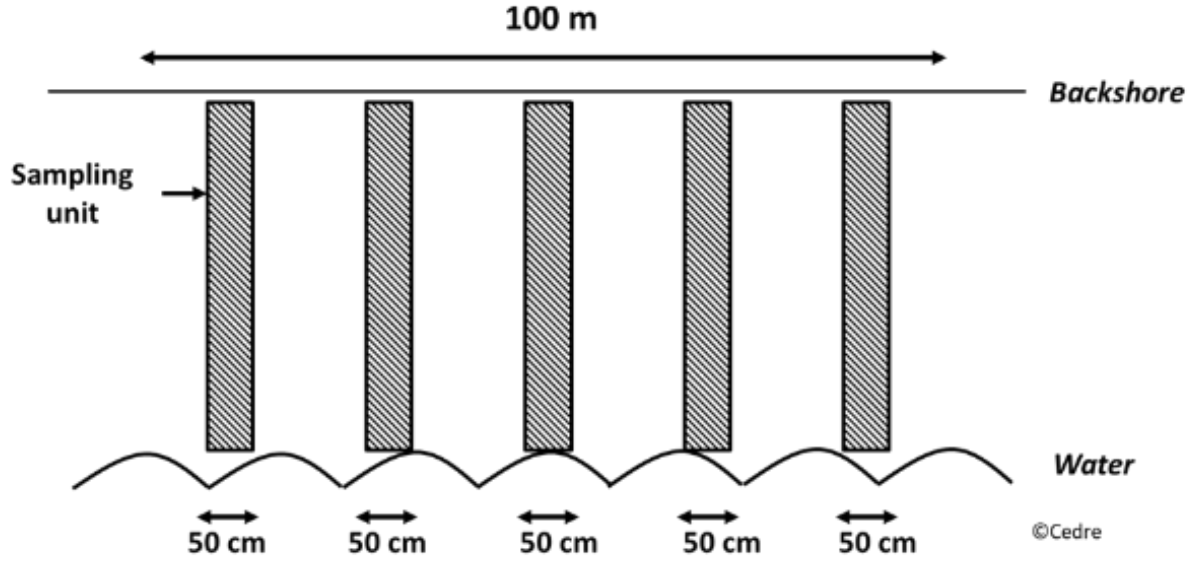
3. Sampling dates

The monitoring is performed every year, four times per year, conform the beach litter monitoring guidelines (OSPAR, 2022). The surveys dates are available in the data set.

4. Monitoring method

The monitoring method is based on the EU TGML protocol (Galgani et al., 2023). It focusses on the smaller plastic particles, namely pellets (1-5 mm; large microplastics) and mesoplastic fragments (5-25 mm) which cannot be identified according to the OSPAR beach litter categories . The major monitoring parameters are the number of pellets (NPEL), the total weight of pellets (WPEL), the number of mesoplastic fragments (NMES) and the total weight of the mesoplastic fragments (WMES). In addition, for mesoplastic fragments five morphology classes are distinguished: fragments, filaments, films, foam and styrofoam. Within a standard beach length of 100 m, 5 transects (from the low water line to the dunes) with a width of 100 cm are sampled in detail (Figure 1). Where the target plastics are observed the top layer (1 cm) of the beach sand is sampled with a shovel, sieved with a sieving bag and sieve of 1 mm, and the plastics are counted and weighed. The results for these five transects are combined and extrapolated to 100 m beach length. Because the number and weight data relate very well (see paragraph 6.3), only number data are reported to limit the size of the report. However, the weight data are available in the dataset for further analysis and reporting. For a full description of the sampling and analytical procedures see Galgani et al. (2023).

Figure 1: sampling method for pellets and mesoplastic fragments. Note that in the Dutch monitoring method a transect width of 100 cm is used instead of 50 cm. This is allowed for less polluted beaches to improve the detection limits (Galgani et al., 2023).



In the first part of 2022, two sampling squares of 1 m^2, covering two tidelines, per transect were sampled. Monitoring was performed 1-2 days after springtide to obtain focussing of pellets and mesoplastic fragments in the tidelines/accumulation zones. Mesoplastic fragment morphologies were registered. From July 2023 onwards, the sampling was fully performed according to the EU guidance (Galgani et al., 2023) using five transects. Transects with a length of 1 m instead of 50 cm were used because for 2 of the 16 surveys (13%) the sum of the pellets or mesoplastic fragments was lower than 5. In that case, the EU guidance recommends to use a transect width of 1 m.

In line with the Dutch beach macrolitter monitoring, sampling was postponed for two weeks in case of a storm at or a few days before the sampling date, because a storm can change the beach morphology and can obscure the high tideline.

Because the number of pellets and mesoplastic fragments on Dutch beaches is relatively low and pellets are the primary interest, we started with the quality control of five pellets per survey instead of 10 as specified by Galgani et al. (2023).
The samples are stored in glass jars (see photo on front page) in a sample archive for possible additional analysis in the future.

5. Data format and storage

We follow the data format as specified in Galgani et al. (2023, paragraph 6.5).
Note that we store and analyse these data in Wide format, which can be analyzed easily in Excel.
It has been proposed by the OSPAR beach litter lead to ICGML to store the validated pellet and mesoplastic fragment data in the OSPAR beach litter database. This proposal is currently under consideration.

6. Data analyses

There is little description of the data analysis in the EU guidelines (Galgani et al., 2023). Therefore, this is specified in detail below.

6.1 Data format and analysis tool

A wide format is used, similar to the OSPAR beach litter wide format (see example in Annex 1).
Because this format is simple and user friendly, all data quality control and data analysis steps are performed manually in Excel.

6.2 Data quality control

The data quality is performed (QC) using the following checks:

- The correct number of survey records (16 per year) should be present in the data file.
- No double records per location-survey_date should be present in the data file
- No empty fields should be present in the data records
- The correct summation of the mesoplastic morphology group data to the mesoplastic groups NMES and WMES should be checked.
- Perform **outlier analysis** by judging in the data table for each monitoring parameter if unexpectedly large values occur. If this is the case, check this value with the original sample in the sample archive.
- Perform **FTIR analyses** of pellets to verify the plastic material.

6.3 Comparison of number and weight data

We investigated the relations between number and weight data and results are presented.
We found an excellent relation between NPEL and WPEL (Figure 3) and a good relation between NMES and WMES (Figure 4), respectively. As expected, the relation for mesoplastic fragments is less good compared to pellets due to the larger variety of morphologies and polymers.
Because of these overall very good relationships found, we limit the presentation of results to number-based results. This limits the amount of results and consequently provides a clearer overview.

*Figure 3: Relation between the number of pellets and weight per survey. The model formula is: WPEL = 0.0269*NPEL (R^2 0.998).*

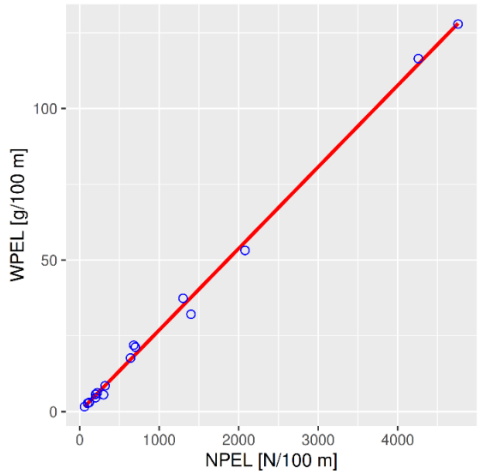
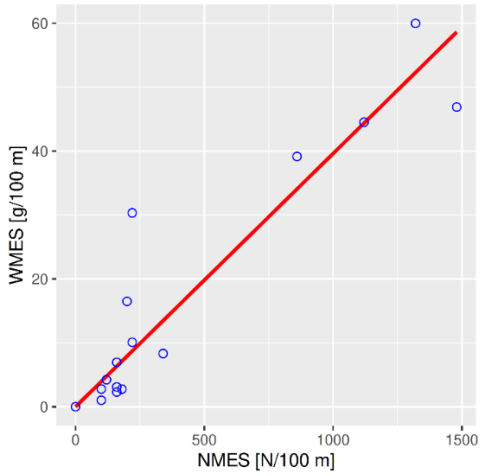


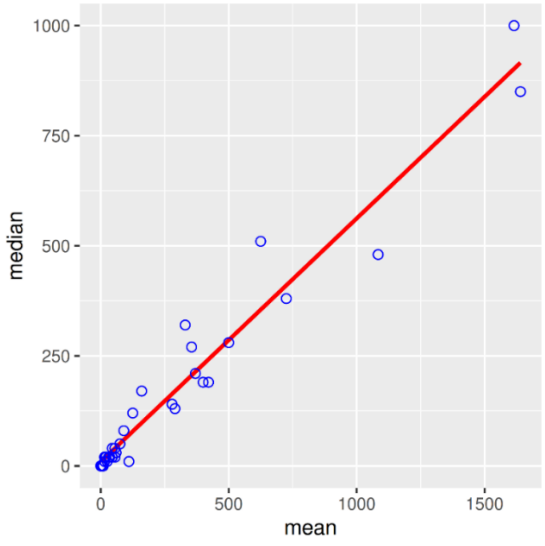
*Figure 4: Relation between the number of mesoplastic fragments and weight per survey. Model formula: WMES = 0.0396*NMES (R^2 0.9212).*



6.4 Comparison of median and mean results

We investigated the relationship between the median and mean values of all reported number parameters combined (NPEL, NMES, NMES_Fil, NMES_Film, NMES_Frag, NMES_Foa, NMES_Sty). There appears to be a very good relation between the mean and median values (Figure 5). Because the monitoring data are not normally distributed, and supported by the very good relationship between the median and mean values, we only report median values in the Summary report.

*Figure 5: Relationship between the median and mean of NPEL, NMES, and 5 mesoplastic morphology groups for four locations (N = 28). The model formula is: Median = 0.57*Mean (R^2 0.959).*



- Median results are presented in tables for NPEL, NMES and the five mesoplastic morphology groups (fragments, filaments, films, foams, styrofoams) per location and for all data combined.
- The variation of the median numbers is not reported because it is more relevant to consider the variation at the national level, which is represented by the median location results.

6.5 Spatial aggregation of results

Spatial aggregation is performed using the blocking method (Van Belle and Hughes, 1984), which is also used for OSPAR and EU beach litter assessments. This method is based on the blocking method of Van Belle and Hughes (1984). Advantages of this method are the statistical correctness; the transparency of the contributions of local median values; its additional robustness against extreme locations and results; and its simplicity.

This method is performed as follows:

- First calculate for each monitoring parameter (e.g. NPEL) the location median value.
  Note that 1-3 years of data are aggregated for a status calculation.
- For a national assessment value, calculate for each monitoring parameter the median value of all Dutch location median values is calculated (**see Annex 1**).
- The variation of the Dutch median values is represented by the underlying location median values.

7. Reporting

- The reporting is divided in two parts: (a) an annual and compact Summary Report designed for easy reading by a broader public and (b) a Methods report, designed for the specialistic reader and with relatively stable content and version information. This methods report partly refers to the EU guidelines (Galgani et al., 2023) for a full description of the monitoring method. Dutch details of the monitoring strategy and additional monitoring methods are described in this Methods report.
- These reports will be published on a website which provides persistent links (URLs).
- The website should provide a good findability of reports in Google searches.

8. References

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Annex 1: example of data analysis sheet in Excel

Note that for each monitoring parameter (a) first the location median is calculated and then (b) for the national level the median of the location medians is calculated (blocking method).

location	date	unit_N	unit_W	NPEL	NMES	NMES_Fil	NMES_Film	NMES_Foa	NMES_Frag	NMES_Sty
BGN	2022-04-20	N/100 m	g/100 m	120	160	40	0	100	20	0
BGN	2022-06-17	N/100 m	g/100 m	2080	1480	200	40	200	620	420
BGN	2022-10-13	N/100 m	g/100 m	640	860	120	40	0	680	20
BGN	2022-12-11	N/100 m	g/100 m	60	0	0	0	0	0	0
BGN median				380	510	80	20	50	320	10
MSR	2022-04-05	N/100 m	g/100 m	700	120	20	20	0	40	40
MSR	2022-07-02	N/100 m	g/100 m	200	220	0	20	20	140	40
MSR	2022-09-28	N/100 m	g/100 m	4260	1320	40	20	100	1020	140
MSR	2022-11-27	N/100 m	g/100 m	1300	340	0	0	60	280	0
MSR median				1000	280	10	20	40	210	40
NTJ	2022-04-19	N/100 m	g/100 m	200	180	0	0	0	80	80
NTJ	2022-06-16	N/100 m	g/100 m	220	100	0	0	0	100	0
NTJ	2022-10-12	N/100 m	g/100 m	320	160	20	0	0	140	0
NTJ	2022-11-26	N/100 m	g/100 m	680	200	0	0	0	180	20
NTJ median				270	170	0	0	0	120	10
TSL	2022-04-03	N/100 m	g/100 m	100	100	20	0	40	40	0
TSL	2022-07-03	N/100 m	g/100 m	300	160	20	20	20	60	40
TSL	2022-09-29	N/100 m	g/100 m	4760	1120	20	0	160	860	100
TSL	2022-12-12	N/100 m	g/100 m	1400	220	0	0	20	200	0
TSL median				850	190	20	0	30	130	20
Netherlands median				**615**	**235**	**15**	**10**	**35**	**170**	**15**