Study on plastic in stomachs of northern fulmars and other seabirds in relation to the containers lost from MSC Zoe in early January 2019

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Contents

Summary **4**

1 Introduction **5**

2 Materials and Methods **6**

3 Results **7**

3.1 Details of plastics and microbeads 8

4 Discussion **10**

5 Conclusions and recommendations **12**

6 Acknowledgements **13**

7 Quality Assurance **14**

References **15**

Justification **16**

Annex 1 Details fulmars 2019 **17**

Annex 2 Details of pellets **18**

Summary

Stomach contents of dead birds beached along the Dutch Wadden Sea and North Sea coast during 2019 were investigated for the potential presence of plastics lost from containers in the MSC Zoe incident, 1 to 2 January 2019. The focus was on the detection of industrial polyethylene (PE) pellets and Polystyrene (PS) microbeads as were spilled during the incident. For northern fulmars reference material from earlier years was available.
Looking at the presence of PE pellets and PS beads in 2019 in comparison to earlier years there was no direct effect of the container incident. For some species no adequate reference data were available, however, no plastics similar to those lost during the incident were found.

1 Introduction

One of the potentially negative effects of the container loss by MSC Zoe is the uptake of plastic items by marine organisms such as seabirds. Huge quantities of user plastics, packaging material and polystyrene items were the most obvious items found at sea or on the beaches. Also an unknown but substantial quantity of industrial pellets (high density polyethylene (PE)) packed in bags of 25 kg fell overboard, as well as an estimated 11 tonnes of smaller polystyrene microbeads (hereafter simply 'microbeads'), intended for the production of expanded polystyrene. The PS microbeads had a diameter of 0.7 mm. More detailed information on the material properties such as size distribution and potential additives are described by Foekema et al. (2021; in Dutch). This short report focuses on the potential uptake of plastics by seabirds.

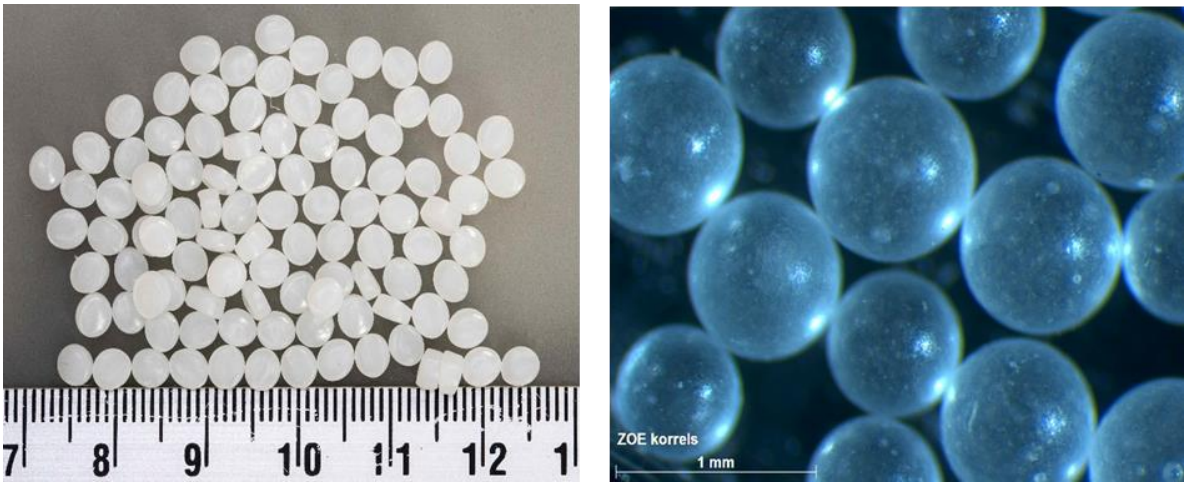

Photo 1 *Industrial HDPE pellets and EPS microbeads (heavily enlarged) originating from the container ship MSC ZOE.*

A species well-known to regularly ingest plastics is the northern fulmar (*Fulmarus glacialis*). This species has been studied for plastic ingestion since the 1980's and the quantity of plastics ingested is being used as a monitoring tool by OSPAR (Oslo-Paris Convention of the Protection of the North East Atlantic) and within the European Union Marine Strategy Framework Directive (EU MSFD). Reports are published annually, covering the Dutch monitoring of plastics in fulmars (e.g. Van Franeker & Kühn 2020a) and in other countries (Van Franeker et al. 2011; OSPAR 2017, 2019). In 2019, after the container incident, the volunteer network that collects dead fulmars on Dutch beaches was encouraged to collect additional corpses of fulmars.
In addition to fulmars, the volunteer network was asked to also collect dead beached kittiwakes (*Rissa tridactyla*) and scoters (*Melanitta spp*) as well as eiders (*Somateria mollisima*). For these birds only incidental records of plastic ingestion were available (Ens et al. 2002; Van Franeker 1983). Recently comprehensive studies were conducted on the stomach contents of 120 common guillemots (*Uria aalge*), that beached shortly after the Zoe incident in 2019 (Leopold et al. 2019; in Dutch). In the current report, details on a small sample size of Auks (*Alca torda*) is added.

The aim of this study is to report potentially unusual quantities or types of plastics in seabirds that may be related to the Zoe incidence and that may deviate from the 'normal' plastic loads encountered in these species. Fulmars and kittiwakes can be considered as representatives for plastic on the water surface, while sea ducks (feeding on bivalves) can be seen as indicators of plastics on the sea floor (or plastics ingested by bivalves). Auks and guillemots forage in the water column and may therefore have encountered plastics in this specific ocean compartment, ingested directly or via fish prey.

2 Materials and Methods

For this study, the following numbers of birds were collected in 2019: 47 northern fulmars (of which 44 had an intact stomach), 14 common scoters (*Melanitta nigra*), one velvet scoter (*M. fusca*), 12 auks and four kittiwakes. Although eiders were searched for as well, no intact corpses were found in 2019. Most of the birds were collected in the Dutch coastal zone around the Wadden Sea. Dissections were conducted according to the fulmar protocol (Van Franeker 2004; OSPAR 2015).
The content of the stomach and the guts were studied for the occurrence of plastics but also other anthropogenic litter. The stomachs were opened and rinsed with tap water. The standard procedure requires rinsing over a 1 mm mesh-sized sieve, which would be sufficient to detect the PE pellets lost by the MSC Zoe, which have an average diameter of 4.1 mm and a height of 2.3 mm. Due to the potential presence of the smaller PS microbeads (~0.7 mm diameter), a second sieve with a mesh width of 0.3 mm was added. Gut section (from stomach to cloaca) were exposed to 5 M potassium hydroxide (KOH) for a few days, which dissolves organic material (e.g. gut wall, soft tissue of food remains) but leaves plastics intact (Kühn et al. 2017).
All remaining stomach content items were studied under a microscope for the abundance of plastics and other anthropogenic litter. These items were categorized according to Van Franeker et al. (2011). Plastics are separated into two main categories, industrial pellets and user plastics. In this case, microbeads are included in the industrial category. User plastics are further split into sheets, threads, foams, hard fragments and 'other' plastic types. Anthropogenic litter that is not made of plastic includes paper, aluminium foil, processed wood, paint and kitchen waste. A last category describes industrial waste such as coal, slags and paraffine. Per (sub)category the items were counted and weighed (to 0.0001 g).
The encountered plastic pellets were subjected to infrared (FTIR) analysis to determine their polymer type. The analysis was performed with a 'Shimadzu IRSpirit' spectroscope. The absorbance of laser light is measured and the resulting spectrum is compared with an intern library. For each item, 45 scans were made within a spectrum of 600 and 4000 nm.

In summary, the stomach content and separately the gut content were sieved over:

- A 1 mm sieve, as it is the standard in the OSPAR/MSFD plastic monitoring scheme. This sieve is sufficient to filter the PE pellets lost by the MSC Zoe.
- A 0.3 mm sieve to also catch the much smaller PS microbeads in stomachs or guts.

Therefore each birds consists of four samples, the stomach (1.0 and 0.3 mm sieves) and the gut (1.0 and 0.3 mm sieves). Using two different sieve sizes was necessary to comply with the standard OSPAR/MSFD plastic monitoring scheme.

3 Results

Find data of the 44 fulmars with suitable stomachs and details of the plastic contents in stomachs and guts, are included as Annex I to this report. The results in the annex are those for the sum samples of stomach and gut, from both the 1 mm and 0.3 mm sieve sizes.
Industrial pellets were found in 20 of 44 fulmars, almost always in the stomach, but in two birds also in the gut. Two microbeads were found in the gut of one fulmar. As usual, the total quantity of plastic in these birds was mainly determined by user plastics (further detailed in Table 2).

Table 1 Details for plastics found in the gastrointestinal system of several seabird species in 2019. *For the fulmar, reference values for plastics > 1 mm in stomachs (st) are available from 2014-2018. The 2019 survey covered the entire contents of stomach plus intestines (st+i) for plastic particles > 0.3 mm. For proper comparison with the 2014-2018 period, the 2019 fulmar data are also given for analysis of only stomach contents for particle size > 1 mm. Indicated are the number of birds surveyed (n), the percentage of birds in which the plastic category occurs (%FO) and average number (avg n) for separately pellets, microbeads, and all plastics combined (=including user plastics). To the latter category, the average plastic total stomach weight (avg g; in grams) was also added.*

	n birds	**Industrial pellets**		**microbeads**		**All plastics**		
		%FO	**avg n**	**% FO**	**avg n**	**% FO**	**avg n**	**avg g**
Reference fulmars 2014-2018 (st >1 mm)	*116*	44.8%	1.53	2.6%	0.05	93.1%	23.5	0.26
Reference fulmars 2019 (st >1 mm)	*44*	40.9%	0.77	0%	0	95.5%	11.4	0.09
Fulmars 2019 (st+i >0.3 mm)	*44*	45.4%	0.84	2.3%	0.05	95.5%	17.4	0.10
Kittiwake 2019 (st+i >0.3 mm)	*4*	0%	0	0%	0	75.0%	1.3	0.05
Sea-ducks 2019 (st+i >0.3 mm)	*15*	0%	0	0%	0	0%	0	0
Guillemot 2019 (st+i >0.3 mm)	*120*	0.8%	0.01	0.8%	0.01	27.5%	0.5	0.004
Auk 2019 (st+i >0.3 mm)	*12*	0%	0	0%	0	0%	0	0

A direct comparison to previous years is difficult because the standard monitoring only covers stomach contents washed out over a 1 mm sieve. Therefore, Table 1 shows not only the monitoring data from the previous 5 year period 2014-2018, but also the directly comparable values for plastics in stomachs in 2019. It can be seen that adding the stomach plastics and small plastics found on 0.3 mm sieve sizes does produce an increase in the total number of pieces of mainly user plastics, but not substantially for pellets or microbeads. The total weight of plastic from stomach plastic plus gut samples, 1.0 and 0.3 mm combined, was about 10% higher than if only stomach and particles larger than 1 mm had been considered as in standard monitoring. Table 2 provides more details on the different categories of plastic in fulmar stomachs. The comparison covers the 5-year period 2014-2018 and the year 2019, for plastics found in stomachs at sieve size 1.0 mm.
In three of the four stomachs of kittiwakes, a total of 6 pieces of user plastic were found, all on the 1 mm sieve. No pellets or microbeads were found.
No plastic litter at all was found in the stomachs or intestines of the 15 sea ducks (14 black and one velvet scoter).
Plastics were found in 33 of 120 guillemots (27.5%). In the vast majority of cases, these were threadlike pieces, but one pellet, and one microbead were also found.
No plastics were found in the stomachs and intestines of 12 Razorbills from early 2019.

Table 2 *Detailed comparison of further categorised quantities of plastic in fulmar stomachs (>1 mm) prior and after the ZOE incident (5-year period 2014-2018 compared with 2019). Column names are described in the caption to Table 1.*

	2014-2018 (*n*=116)				**2019 (*n*=44)**		
	%FO	**avg n**	**avg g**		**%FO**	**avg n**	**avg g**
industrial pellets	44.8%	1.5	0.032		40.9%	0.8	0.018
microbeads	2.6%	0.1	0.000		0.0%	0.0	0.000
sheets	48.3%	3.6	0.030		52.3%	1.2	0.005
threads	31.9%	1.1	0.007		45.5%	1.8	0.006
foam	43.1%	2.6	0.019		27.3%	1.7	0.007
fragments	86.2%	14.5	0.111		81.8%	5.5	0.044
other plastic	11.2%	0.3	0.058		22.7%	0.5	0.013
ALL PLASTICS	**93.1%**	**23.5**	**0.257**		**95.5%**	**11.4**	**0.093**

3.1 Details of plastics and microbeads

Details of all 36 industrial pellets found in stomachs (34) or guts (2) of fulmars are included in annex II. According to the FTIR polymer analysis, these were mostly pellets made of polyethylene (PE). In many cases, based on FTIR analyses, these pellets from the birds were indistinguishable from pellets collected in 25 kg bags from the ZOE incident. When an 'average ZOE spectrogram' was added to the standard comparison library, 17 out of 36 (47%) pellets from fulmar stomachs were found to be indistinguishable from these (marked * in Annex II). But by comparison, in an earlier sample of 30 pellets from the stomach and gut of a fulmar from the year 2010, as many as 24 (80%) were found to be indistinguishable from the spectrogram of the later ZOE pellets. Based on appearance, i.e. the combination of shape and color, none of the fulmar pellets from 2019 seemed to compare well with the ZOE HDPE pellets, but that is a subjective judgement. An example of the appearance of pellets is shown in Photo 2. For similar pictures of plastics from stomachs of all individual fulmars, see the illustrations in Van Franeker & Kühn, 2020b. Additional physical or chemical determinations to compare pellets from the stomachs of fulmars with those from the ZOE containers were not possible in this study.

Photo 2 *Plastics from fulmar NET-2019-047 (stomach contents > 1mm). In addition to an unusually high number of industrial pellets for this year, various plastic sheets, threads and harder fragments are visible. None of these pellets appear to originate from the ZOE containers in terms of shape and colour combination. See also Annex II and Van Franeker & Kühn (2020b).*

The only microbeads found were in the gut contents of fulmar NET-2019-032 (Photo 3). These objects were too small and brittle to safely subject to the pressure required for FTIR analysis, but color appearance and crystalline structure of these microbeads in no way resemble the EPS granules lost by MSC ZOE.

In the 120 guillemots studied (Leopold et al. 2019), one bird had a pellet, and one bird had a single microbead. The pellet was brown-black in color and consisted of polypropylene (PP). The single microbead was white, had a diameter of about 5 mm and was not polystyrene, but consisted mainly of carboxylmethyl cellulose.
In stomachs or intestines of kittiwakes and sea ducks no pellets and no microbeads were found.

Photo 3 *The only two microbeads found in the surveyed fulmars from 2019 from gut contents of fulmar NET-2019-032 on a 0.3 mm sieve; see also Van Franeker & Kühn (2020b).*

4 Discussion

For a reference to the 'normal' quantity of plastics in fulmar stomachs, it is best to look at the 5-year periods used in the monitoring approach. Numbers for individual years may fluctuate due to different conditions or limited sample sizes. The dataset for ZOE year 2019, with the number of 44 stomach contents examined, can be considered reliable. This follows from the pilot study for fulmar monitoring (Van Franeker & Meijboom 2002) in which previous annual series showed that a number of around 40 birds provides, in principle, a reliable estimate for the quantity of plastics in fulmar stomachs in the surveyed area and period.
However, when considering the data, it must be taken into account that in 2019, due to the small 'ZOE microbeads', both stomachs and intestines were washed out over both a 1 mm and a 0.3 mm sieve, while standard fulmar monitoring (OSPAR 2015) is limited to stomach contents sieved over a 1 mm mesh. Therefore, Table 1 gives the 2019 data according to both the special ZOE protocol and the standard OSPAR protocol. In terms of plastic weight, adding the gut and small plastics results in an increase of about 10%.
However, the methodological details seem of little importance, as both values (ZOE or OSPAR protocol) for 2019 are significantly below the quantity of plastics found on average across the 116 stomachs of fulmars in the previous 2014-2018 period (Table 1). This applies to all categories of plastic (Table 2), including subcategories such as sheet and foam material released in large quantities from lost container-loads. A decrease in quantity of plastic in stomachs of fulmars found in the Netherlands is a trend known from annual monitoring (Van Franeker & Kühn 2019, 2020a). The ZOE incident had no noticeable impact on this.

Table 3. *Annual occurrence of plastics in stomachs of fulmars found in the Netherlands. To complement Tables 1 and 2 that focus on average values from the 2014-2018 period. Separate annual averages are sometimes not reliable due to limited sample size or exceptional events. It is beyond doubt that in the year 2019 the ZOE incident did not have a noticeable impact on the quantity of plastic ingested by fulmars in our coastal area.*

Netherlands		**Total plastics**				
YEAR	***sample n***	**%FO**	**average number n ± se**		**average mass g ± se**	
2014	*12*	100%	21.4	± 3.9	0.36	± 0.14
2015	*23*	96%	12.1	± 3.2	0.26	± 0.15
2016	*31*	87%	31.7	± 12.9	0.29	± 0.10
2017	*38*	92%	26.8	± 14.1	0.24	± 0.07
2018	*12*	100%	15.8	± 7.8	0.12	± 0.06
2019	*44*	95%	11.1	± 2.2	0.09	± 0.01

Although certainty cannot be offered, the pellets ingested by fulmars appear to be predominantly, or not at all, related to the milky white HDPE pellets lost from the containers. The few microbeads found are not related to the ZOE accident.
For the other species investigated, no reliable references can be found for the 'normal' quantity of ingested plastics'. Available references are mostly from completely different areas or time periods. Kühn and Van Franeker (2020) report in their review that for kittiwakes the pooled data from 9 publications indicate that among 574 birds studied, 46 had plastic in their stomachs (8%). An old study of the Dutch coast (Van Franeker 1983) found among 32 kittiwakes 37.5% with plastic in the stomach. The sample of four kittiwakes from 2019 is far too small for comparison: the pieces of plastic found cannot be attributed to ZOE material.

The absence of plastics in the stomachs of common and velvet scoters seems to be confirmed in the literature: Kühn and Van Franeker (2020) found 5 studies in which no plastics were found in a total of 58 ducks of the genus *Melanitta* examined. Unpublished data by Mardik Leopold on dietary studies between 1993-2018, report stomach analyses of 111 common scoters from the Dutch Wadden Sea

area and 32 from the German Wadden Sea area without any plastic in the stomach. In 14 common scoters from elsewhere along the Dutch coast, one bird had a piece of 'rope' (material unknown) in its stomach. A single great common scoter from the Wadden area from 2009 had no plastic in its stomach.
For guillemots, Leopold et al. (2019) reported that comparison with guillemot data from the literature is difficult, partly due to the use of different survey methods. Kühn and Van Franeker (2020) found a total of 9 studies, in which plastics were found in 45 individuals among 814 examined (6%). Old Dutch research reported among 210 guillemots 2.9% plastic in the stomach (Van Franeker, 1983). So with plastics in 27.5% of guillemots washed ashore in 2019 shortly after the ZOE incident, the situation is clearly different now. However, the material found was in most cases old fragments of nets or ropes, and not plastics related to the ZOE.

As for auks, Kühn & Van Franeker (2020) cite four literature sources that together found one instance of plastic in 108 stomachs examined (1%). As for the Netherlands in the early 1980s, Van Franeker (1983) found two cases of plastic in the stomach in 82 auks (2.4%).

5 Conclusions and recommendations

The conclusion from this sub-study is that the MSC ZOE accident did not, among the investigated species of seabirds, result in any perceptible increase in quantity or types of ingested plastics. A relevant factor, of course, is that there is a substantial permanent plastic pollution at sea, which does show a decrease over time. The year 2019 fits the decreasing trend. It may play a role that with sustained strong north winds after the incident a lot of plastic, especially styrofoam and other packaging material but also heavier pieces were quickly blown to the coast, a fate that was also observed for smaller material such as HDPE pellets (Van der Heide 2019). Material that did not disappear in this way partially sank to the bottom or drifted with the residual current towards the German Bight or further north. The conclusion that no increase in the amount of ingested plastic or other effect was observed in seabirds washed ashore in the Netherlands is no evidence that effects did not occur elsewhere. Whether noticeable effects among seabirds did occur at a greater distance from the disaster site is not known at this time.

6 Acknowledgements

The persons or agencies that provided the birds used for this report are listed in Annex I. We are grateful to them for their help. But in addition to these individuals, there are many more individuals and organisations that have provided assistance in repeatedly searching the coast in 2019, as well as in previous years. Even when no birds are found, such efforts are essential, and for that we are very grateful. Mardik Leopold was the important lead for the guillemot and auk survey in 2019, we are very grateful to him and all the individuals mentioned in the guillemot report.

7 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 C078/20a
Project Number: 4315100134-5

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: Edwin Foekema
Researcher

Signature: 

Date: 12 Februari 2024

Approved: Dr. A.M. Mouissie
Business Manager Projecten

Signature: 

Date: 12 Februari 2024

Annex 1 Details fulmars 2019

Table 4 *Details of fulmars found in the Netherlands in 2019 and the plastics in the gastrointestinal tracts (sieved over 1.0 and 0.3 mm). The results given here therefore differ slightly from the monitoring data in Van Franeker & Kühn (2020a), which are based on stomach contents sieved over 1.0 mm only. Adding gut contents and 0.3 mm sieve size adds ± 10% to the plastic weight.*

JAFCODE	DATE	LOCATION	FINDER	pellets	micro beads	user palstic	n plastics	plastic mass (g)
NET-2019-001	4-Jan-2019	Texel paal 18	Maarten Brugge	0	0	1	1	0.0221
NET-2019-002	7-Jan-2019	Ameland paal 14 tot 17 ; of 4 nr 01	Johan Krol	0	0	2	2	0.0082
NET-2019-003	7-Jan-2019	Ameland paal 14 tot 17 ; of 4 nr 02	Johan Krol	1	0	28	29	0.1122
NET-2019-004	7-Jan-2019	Ameland paal 14 tot 17 ; of 4 nr 03	Johan Krol	1	0	8	9	0.1256
NET-2019-005	7-Jan-2019	Ameland paal 14 tot 17 ; of 4 nr 04	Johan Krol	0	0	21	21	0.0451
NET-2019-006	5-Jan-2019	Ameland not specified of 2 nr 1	SBB Ameland	0	0	0	0	0.0000
NET-2019-007	5-Jan-2019	Ameland not specified of 2 nr 2	SBB Ameland	0	0	4	4	0.0163
NET-2019-008	12-Jan-2019	Vlieland Vliehors	Sander Lagerveld	1	0	3	4	0.0300
NET-2019-009	15-Jan-2019	Schiermonnikoog tussen paal 5 en 6.5; of 3 nr 1	J.A. van Franeker & Yvonne Hermes	0	0	1	1	0.0067
NET-2019-010	16-Jan-2019	Schiermonnikoog tussen paal 5 en 6.5; of 3 nr 2	J.A. van Franeker & Yvonne Hermes	2	0	77	79	0.6106
NET-2019-011	17-Jan-2019	Schiermonnikoog tussen paal 5 en 6.5; of 3 nr 3	J.A. van Franeker & Yvonne Hermes	1	0	13	14	0.1607
NET-2019-013	19-Jan-2019	Groningen Warffum Kwelders Noordpolder	Marjolein Postma	1	0	6	7	0.1323
NET-2019-014	20-Jan-2019	Groningen Pieterburen Linthorst Homan polder binnendijk	Marjolein Postma	3	0	11	14	0.1955
NET-2019-015	28-Jan-2019	Binnenklinge Den Haag via Dierenamb en Asiel de Wulp	Huib den Heijer en Sharon Lexmond	1	0	53	54	0.3180
NET-2019-017	30-Jan-2019	Texel paal 17	Daphna Lavy	0	0	1	1	0.0230
NET-2019-018	31-Jan-2019	Callantsoog Noord-Holland	Job ten Horn en Sanne van den Berg-Blok	1	0	18	19	0.1527
NET-2019-019	31-Jan-2019	Texel paal 7	Job ten Horn and Mardik Leopold	0	0	23	23	0.1022
NET-2019-020	12-Feb-2019	Texel paal 19	Maarten Brugge	2	0	13	15	0.2285
NET-2019-021	14-Jan-2019	Texel paal 15	Ecomare Mariette Smit	1	0	13	14	0.1006
NET-2019-022	15-Jan-2019	Strand Ijmuiden	Jurgen Rotteveel	0	0	1	1	0.0016
NET-2019-023	20-May-2019	Engelsmansplaat	Arjen Dijkstra & Elisa Bravo	0	0	32	32	0.1209
NET-2019-024	31-Mar-2019	Texel paal 17	Job ten Horn en Suse Kühn	0	0	8	8	0.0184
NET-2019-025	29-Mar-2019	Texel paal 11	Sytske Dijksen	1	0	4	5	0.0629
NET-2019-026	9-Mar-2019	Texel paal 16	Maarten Brugge	3	0	34	37	0.1046
NET-2019-027	12-Jan-2019	Eemshaven of 2 nr 1	Arnout de Vries Zeehondencentrum	0	0	18	18	0.2084
NET-2019-028	12-Jan-2019	Eemshaven of 2 nr 2	Arnout de Vries Zeehondencentrum	0	0	3	3	0.0471
NET-2019-029	16-Jan-2019	Zeeland Schouwen Westenschouwen-Haamstede	Maarten Sluijter	0	0	2	2	0.0001
NET-2019-030	26-Mar-2019	Terschelling of 2 nr 1	Jacob de Vries	0	0	0	0	0.0000
NET-2019-031	26-Mar-2019	Terschelling of 2 nr 2	Jacob de Vries	0	0	10	10	0.0641
NET-2019-032	27-May-2019	Texel	Ecomare Jasmijn Hulleman	1	2	157	160	0.2536
NET-2019-033	8-Jul-2019	Texel paal 19	Maarten Brugge	1	0	8	9	0.0267
NET-2019-034	5-May-2019	Scheveningen strand	Vogelasiel de Wulp Sharon Lexmond	1	0	32	33	0.0332
NET-2019-035	10-Nov-2019	Texel paal 9	Hans Verdaat	0	0	31	31	0.0637
NET-2019-036	10-Nov-2019	Texel De Hors Paal 5	Hans Verdaat	0	0	3	3	0.0178
NET-2019-037	14-Aug-2019	Texel Paal 12	Kees Camphuysen	0	0	4	4	0.0569
NET-2019-039	20-May-2019	Ameland paal 9	Johan Krol	0	0	2	2	0.0074
NET-2019-040	20-May-2019	Ameland paal 8	Johan Krol	0	0	4	4	0.1132
NET-2019-041	5-Dec-2019	Texel Hoornderslag	Dick.Schermer; Kees.Camphuysen	0	0	1	1	0.0001
NET-2019-042	8-Dec-2019	Ten zuiden van Egmond strandopgang binnen	Jorg Schagen; Cees Baart	1	0	21	22	0.2796
NET-2019-043	24-May-2019	Ameland Noordzeestrand thv Buren	Arjen Dijkstra & Elisa Bravo	0	0	6	6	0.0296
NET-2019-044	11-May-2019	Vlieland Vliehors	Dirk Bruin Noordwester	2	0	6	8	0.0606
NET-2019-045	14-Jul-2019	Vlieland Vliehors	Dirk Bruin Noordwester	4	0	16	20	0.1840
NET-2019-046	12-May-2019	Schiermonnikoog no detail	Teun Talsma via Pim Lollinga	0	0	2	2	0.0003
NET-2019-047	12-May-2019	Schiermonnikoog no detail	Teun Talsma via Pim Lollinga	8	0	26	34	0.3352
		Fulmars 2019 (n=44)	Frequency of occurrence (%FO)	45.4%	2.3%	95.5%	95.5%	
			Average	**0.84**	**0.05**	**16.5**	**17.4**	**0.1018**

Annex 2 Details of pellets

Table 5. *Details of pellets found in fulmar stomachs and guts in 2019.*

pellet identifier	length (mm)	width (mm)	height (mm)	mass (g)	Polymer by FTIR	Match score		comments
NET-2019-003_I_IND-001	4.2	4	2.1	0.0214	HDPE	95%	*	rough surface milky white pellet
NET-2019-004_M_IND-001	3.4	3.1	4.5	0.0301	PE	96%	*	degraded biobead
NET-2019-008_M_IND-001	2.8	2.4	2.5	0.0164	Paraffin	83%		dark smooth pellet. Not waxy
NET-2019-010_M_IND-001	4.2	4	2	0.0188	PE	92%		light yellow; semi-transparant
NET-2019-010_I_IND-001	3	2.9	0.7	0.0012	Styrene	88%		likely solid foam
NET-2019-011_M_IND-001	4.8	4.5	2.4	0.0257	PE	93%	*	dark smooth pellet
NET-2019-013_M_IND-001	3.4	3.3	4.9	0.0327	PE	94%	*	light yellow
NET-2019-014_M_IND-001	3.6	3.3	3.7	0.0209	PE	92%		degraded white
NET-2019-014_M_IND-002	4.1	3.8	2.3	0.0200	PS	92%		light yellow; brittle
NET-2019-014_M_IND-003	5.1	3.8	4.3	0.0515	Ionomer	89%		black smooth surface; white inside
NET-2019-015_M_IND-001	2.7	2.2	2.2	0.0112	PE	92%		solid yellow; white inside
NET-2019-018_M_IND-001	2.5	2.5	2.2	0.0210	Ionomer	92%	*	solid black; square
NET-2019-020_M_IND-001	4	3.9	2.5	0.0200	PE	95%	*	white transparant
NET-2019-020_M_IND-002	5.1	3.1	3	0.0252	PP	85%		solid grey
NET-2019-021_M_IND-001	3.4	2.9	3.9	0.0273	PP	90%		solid white
NET-2019-025_M_IND-001	4.9	4	4.4	0.0576	PE	94%	*	smooth black
NET-2019-026_M_IND-001	3.9	3.8	1.7	0.0157	PE	97%	*	solid yellow; white inside
NET-2019-026_M_IND-002	2.9	2.7	4.4	0.0217	SBS	91%		transprant brown
NET-2019-026_M_IND-003	3.6	3.6	4	0.0196	SBS	91%		transprant yellow
NET-2019-032_M_IND-001	2.1	1.5	1.4	0.0029	PE oxydized	93%	*	tiny; black outside white inside
NET-2019-033_M_IND-001	2.6	2.6	2.8	0.0117	HDPE	95%	*	transparant yellow; brittle
NET-2019-042_M_IND-001	2.7	2.6	3.7	0.0193	PP	88%		smooth black
NET-2019-044_M_IND-001	4.3	2.9	2.5	0.0193	PP	87%		smooth black
NET-2019-044_M_IND-002	3.5	3.4	3.9	0.0284	Microcrystalline Wax	92%		biobead
NET-2019-045_M_IND-001	4	3.9	2.2	0.0245	PE	95%		degraded white
NET-2019-045_M_IND-002	4.2	3.4	3	0.0269	PE	95%		smooth black
NET-2019-045_M_IND-003	3.9	3.7	4.4	0.0487	EVA	94%		solid yellow; white inside
NET-2019-045_M_IND-004	4.2	4	1.9	0.0177	PE	96%	*	transparant white
NET-2019-047_M_IND-001	3.9	3.9	2.9	0.0200	PE	95%		solid dark brown
NET-2019-047_M_IND-002	3.1	2.9	2.9	0.0151	PE	97%	*	solid dark brown
NET-2019-047_M_IND-003	3.8	3.3	3.4	0.0249	PE	97%	*	smooth black
NET-2019-047_M_IND-004	4.9	4.4	2.3	0.0275	PE	95%	*	brown
NET-2019-047_M_IND-005	5	3.9	3	0.0339	ABS	88%		solid yellow; very hard
NET-2019-047_M_IND-006	3.9	3.3	3.5	0.0245	PE	94%	*	degraded yellow
NET-2019-047_M_IND-007	2.8	2.7	3.2	0.0152	PE	97%	*	smooth black
NET-2019-047_M_IND-008	4.3	3.9	1.8	0.0135	PE	95%	*	smooth black
Average fulmar 2019 (=36)	3.744	3.336	2.958	0.0231				
Average Zoe pellets (n=100)	4.1	4.1	2.26	0.0236				
min	3.8	3.8	1.8	0.0192				
max	4.4	4.4	3	0.0328				

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