

NORWEGIAN RETAILERS' ENVIRONMENT FUND, MICROPLASTICS

# Microplastic in sediments and fauna. Offshore and inshore.

HANDELENS MILJØFOND



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**Objective:**

This study presents microplastic analysis of sediments and sediment-dwelling fauna collected from selected offshore and inshore locations in Norway.

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## 1 ACKNOWLEDGEMENT

This study presents microplastic analysis of sediments and sediment-dwelling fauna collected from selected offshore and inshore locations in Norway. The sampling area covers large geographical areas on the Norwegian Continental Shelf (NCS) and four fjord areas along the southern coast of Norway. The samples have been collected as an extra task during the regional offshore sediment monitoring on the NCS on behalf of the Oil & Gas industry or as extra samples from various fjord campaigns that have been retained in storage. This study had therefore not been initiated without the good will from Oil & Gas operators, especially Statoil/Equinor, which allowed use of some additional time during field work to take these samples. Samples from Nordgulen have been collected in conjunction with environmental monitoring on behalf of Elkem Bremanger.

The Norwegian Retailers` Environment Fund (Handelens Miljøfond) saw this as a good opportunity to acquire knowledge of microplastic abundances from the NCS and in fjord systems and therefore funded the project.

The Norwegian Geotechnical Institute (NGI) has put in own efforts and internal funding on the development of the analytical protocols and execution of the analysis and reporting. A special thanks to Prof. Hans Peter Arp, Mari Engvig Løseth, Maren Valestrand Tjønneland, Desirée Maloney, Heidi Knutsen, Bianca Petzold and Arne Petersen for the cooperation and all the work they have put in.

Høvik 31<sup>st</sup> of January 2022

Øyvind Fjukmoen – project manager DNV

## 2 EXECUTIVE SUMMARY

Samples of sediment and sediment-dwelling organisms were obtained from the Norwegian Continental Shelf and fjords in Southern Norway. These are referred to as offshore areas and inshore areas, respectively.

The sediments samples in inshore areas had significantly higher concentrations of microplastics/kg dw. (mean  $\pm$  SD: 6 132  $\pm$  5 537) than the offshore sediments (mean  $\pm$  SD: 1 298  $\pm$  788). This is most likely due to closer proximity to anthropogenic influences and sources of plastic emissions, as well as the presence of accumulation areas of marine debris closer to the coastline.

The inshore polychaeta samples trended towards higher concentrations of microplastic items/g w.w. (mean  $\pm$  SD: 1 773  $\pm$  2 598), than the offshore polychaeta (mean  $\pm$  SD: 485  $\pm$  607), though due to the large statistical variations in individual biota samples, this cannot be considered statistically significant

The most frequently detected plastic polymers were polyolefins (PE, PP), chlorinated-polyethers (PVC, chlorinated PE), PS and rubber in both sediments and polychaeta samples, however there was also large variation in polymer composition between corresponding sediment and polychaeta samples.

The environmental impact of microplastics on benthic ecosystems are unknown and in need of further investigation. The anticipated concentrations of microplastics are expected to increase in the foreseeable future, potentially leading to threshold concentrations, so it is of relevance to repeat this monitoring exercise to account for this.

In general the study in this survey were comparable with that of a previous survey also looking at microplastic and sediment concentrations in this region, though some of the polychaete concentrations were higher in this study, but nevertheless the biota-to-sediment enrichment factors (11 to 4 864 g<sub>d.w.</sub>/ g<sub>w.w.</sub>) were on the low range of the previous study (100 to 11 000 11 to 4 864 g<sub>d.w.</sub>/ g<sub>w.w.</sub>).

### 3 INTRODUCTION

Since before the 1950s, the production of mass-produced plastics has increased exponentially. According to Plastics Europe the world production of plastic increased from 299 million tonnes in 2013 to 368 million tonnes in 2019 (Plastics Europe, 2014; 2020), and the production rates are forecasted to continue to increase in the future. Even though the amounts of post-consumer plastics sent to recycling or incineration has increased notably during the last decade, still around 25 % of the registered post-consumer are being landfilled (European Parliament, 2021; Plastics Europe, 2020), and there is also a considerable amount that is not subjected to proper waste management and may ultimately end up in the environment. Landfilling of plastic has also been proposed to contribute as a significant source of microplastic to the aquatic environment, and ultimately the oceans (Silva et al., 2021; Su et al., 2019). The weathering and loss of plastic items used in aquaculture, shipping and oil and gas production, such as ropes, pipes, bags or equipment, are also contributing as a source of plastics to the marine environment. In Norway, the major sources of plastic litter detected on beaches originate from packaging and consumer products, such as plastic bags and drinking bottles, and materials from the aquaculture industry, such as fishing nets and ropes (Falk-Andersson et al., 2019).

In recent years, knowledge and an acknowledgement that plastic pollution in the marine environment is a global challenge, has grown. Plastic is found in all parts of the world's oceans such as the littoral zone, water surface, water column in general, at the seafloor, frozen in sea ice and in biota. Negative effects of plastic have been documented through findings in dead marine mammals and sea birds ([https://litterbase.awi.de/interaction\\_graph](https://litterbase.awi.de/interaction_graph)). During the last decade, concern has been raised regarding smaller plastic pieces, referred to as microplastics; which may pose a threat to sensitive marine ecosystems. Microplastics are generally defined as plastic items smaller than 5 mm. These can originate from weathering of larger plastic items due to the influence of e.g. UV-light, mechanic abrasion, waves and temperature fluctuations (so-called secondary microplastics), or from direct emissions of plastics that were manufactured smaller than 5 mm (so-called primary or virgin microplastics). A variety of studies suggest that the seafloor is the ultimate sink for microplastics (Bergmann et al., 2017; Goldberg 1997; Woodall et al., 2014). However, there have been some surveys of microplastics on the sea floor, few studies have investigated the impacts of microplastics on benthic ecosystems (Galloway et al., 2017).

In 2018, DNV and NGI performed analyses of 35 sediments samples on behalf of the Norwegian Environment Agency (Miljødirektoratet) to investigate concentrations of microplastics in sediments from the Norwegian Continental Shelf (Miljødirektoratet, 2018a; 2018b). The sediment samples were collected in 2017 from a large geographical area covering the seabed of the central North Sea, northern North Sea and the Barents Sea, where several samples were collected in areas with high shipping, fishing, and oil and gas activity. The majority of the detected particles were unknown, however microplastics were found in sediments from northern North Sea ( $9 \pm 15$  mg/ kg d.w.), central North Sea ( $5 \pm 10$  mg/kg d.w.) and the Barents Sea ( $6 \pm 5$  mg/kg d.w.). Sediments from central North Sea was dominated by polyacrylamide and phenoxy resins, while sediments from the northern North Sea was dominated by chlorinated polyethylene (and PVC), and the Barents Sea sediments displayed various polymers (Miljødirektoratet, 2018a; 2018b). In another study by DNV and NGI on behalf of the Norwegian Environment Agency, microplastic concentrations in tube forming polychaeta collected from sediments sampled in the same regions on the Norwegian Continental Shelf were investigated (Miljødirektoratet, 2018c), and further published in a study by Knutsen et al., (2020) where microplastic data from sediment and respective polychaeta samples were combined to examine potential correlations between the two.

The present report adds on to the data published by Knutsen et al (2020), by investigating microplastics in polychaeta samples which correspond to previously analysed sediment samples collected by DNV in the Norwegian Sea, North Sea and Barents Sea in 2017. In order to provide more information on microplastic abundance in sediments in areas with higher anthropogenic pressure than the North Sea and Barents Sea, the present report have also analysed polychaeta and sediments from inshore areas. The microplastic analyses were performed by the Norwegian Geotechnical Institute (NGI). Samples were obtained and prepared by DNV.

## 4 PLASTIC IN GENERAL

Plastic is a general term used for materials produced industrially for decades and which have contributed to an increased quality of life for people throughout the world. Plastic is a mixture of synthetic polymers and stabilizing chemicals which can be divided into different categories such as thermoplastic and thermosets. Thermoplastic has been foreshortened to plastic in everyday speech (UNEP 2016) and comprise a material that during the manufacturing process can be molded by adding heat at specific temperature. The main difference between what is called thermoplastic and thermoset is that thermoplastic can be reshaped during re-heating while thermoset cannot.

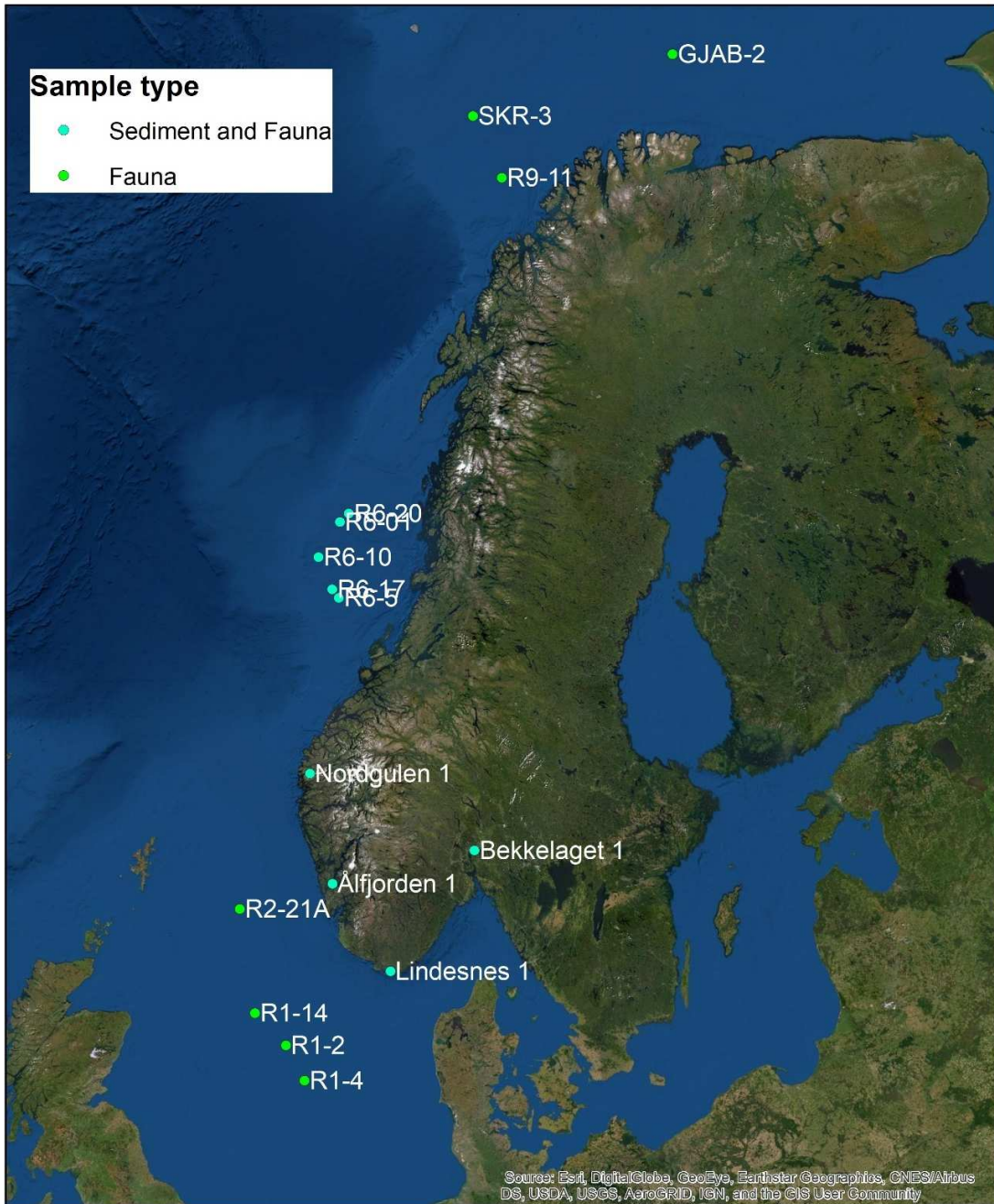
There exist many different plastic types with different properties such as polyvinyl plastic (PVC), polyurethane (PUR), polystyrene (PS), polypropylene (PP), polyethylene (PE), bio-based plastic, biodegradable plastic and more. The areas of application are diverse and vary from packaging of food and other consumer products, plastic bags, drinking cups, in plates and laminates, in foundations of road constructions, in clothes, cosmetics and hygiene articles, in surgical implants, prosthesis and more.

## 5 MATERIAL AND METHODS

### 5.1 Sampling locations

Sample material has been obtained from a wide geographical area in Norwegian waters. Offshore samples were collected during regional environmental sediment monitoring cruises on the Norwegian Continental Shelf on behalf of the Oil & Gas industry that was carried out in the Norwegian Sea (Region 6) in 2018 (sediment samples and fauna) in the North Sea (Region I and II) in 2020 (fauna samples) and in the Barents Sea (Region IX) in 2017 (fauna samples). A detailed overview of the sampling locations is presented in Figure 5-1 .

Offshore sediments analysed in the present report have been collected in remote areas relatively close to oil platforms, which is a likely local source of microplastics in the region other than fishing, aquaculture and shipping. The inshore sediments are most likely more affected by anthropogenic sources of microplastics such as emissions from waste-water treatment plants (WTP), various industry, urban waste, landfills, aquaculture and boat traffic. Relevant sample specific information is presented for sediment samples in Table 5-1 and for polychaeta samples in Table 5-2.



**Figure 5-1 Overview of offshore and inshore sampling locations for samples analysed in this project. Samples from Nordgulen, Alfjorden, Lindesnes and Bekkelaget represents Inshore locations.**



### 5.1.1 Ålfjorden, Vestland and Rogaland

Ålfjorden is a fjord in both Vestland and Rogaland county, located in southwestern Norway. Potential coastal and offshore sources of microplastic in the fjord is aquaculture, industry related to construction of oil platforms, collection and recycling of plastic from aquaculture, fisheries and agriculture. One sediment and one polychaeta sample was collected in Ålfjorden in 2021.

### 5.1.2 Lindesnes, Agder

Lindesnes is the most southern point of Norway, located in Agder county. The coastal area of Lindesnes constitutes the inshore part of the Norwegian sea. Areas around Lindesnes for being home to various shipping and textile industries, which can all be potential sources of microplastics to sediments in this area. One sediment sample and one polychaeta was collected in the fjord outside Lindesnes in 2021.

### 5.1.3 Nordgulfjorden, Vestland

Nordgulfjord is a part of the fjord Gulen in Vestland county. The areas surrounding the fjord are mainly mountains and agriculture, with some aquaculture and a metal smelter. One sediment sample was collected in Nordgulfjorden in 2014 and one polychaeta sample was collected from sediments sampled in 2020.

### 5.1.4 Bekkelaget, Oslo

Bekkelaget is an area located at the inner basin of the Oslo fjord and the northern parts of Bunnefjorden. The area is one of Oslo's main container ports, and also is an active site for the shipping, cement- and asphalt industry. It is also the site of the main wastewater treatment plant for Oslo residents. One sediment and one polychaeta sample was collected from Bekkelaget in 2021.

### 5.1.5 Norwegian Sea

The sampled stations in the Norwegian Sea are located in a deep area with water depth of 300-400 m. The sediments collected in this area are mainly fine sand and were sampled at regional stations. Regional stations represent the natural state in the region nearby, as they are considered not influenced by Oil & Gas activities, and as such can be considered as reference stations. For the present report, five sediment and five polychaeta samples collected from 5 stations within Region 6 in 2017 were analysed. The previous report from Miljødirektoratet (2018a; 2018b), and Knutsen et al., (2020) have also analysed sediments collected at Region 6 in 2017.

### 5.1.6 North Sea

The sampled regional stations in the North Sea are located in a shallow area with a water depth of around 70 m. Three polychaeta samples collected from three stations within Region 1, and one polychaeta sample collected from sediments in Region 2 was also analysed for microplastic content. The previous report from Miljødirektoratet (2018a; 2018b), and Knutsen et al., (2020) have analysed sediments from Region 1 sampled in 2017, of which information on microplastic content will be used for comparison with polychaeta samples from the same regions analysed in the present report.

### 5.1.7 Barents Sea

The samples taken in the Barents Sea were sampled in relation to baseline investigations covering relatively large areas in the northern area of the Norwegian Continental Shelf. The water depth in the region is variable, from 240 m to above 500 m. The varying water depth results in different sediment characteristics such as sand and gravel to finer material as clay and silt. Sediments sampled from stations in the Barents Sea where previously analysed by Miljødirektoratet (2018a;2018b) and Knutsen et al., (2020), while the present report have analysed three polychaeta samples from the same region.

**Table 5-1. Sediment sample information for samples relevant to this report**

Sampling station	Year of sampling	Category, sampling location	Depth (m)	Distance (m)	Sediment characteristic MD $\Phi$ (mm)	TOC (%)	Sediment analysed for MP
Reg-01-01	2017	Offshore, North Sea	73	-	Fine sand, 2.83 (0.141)	0.30	Knutsen et al., 2020
Reg-01-02	2017	Offshore, North Sea	68	-	Fine sand, 2.79 (0.145)	0.31	Knutsen et al., 2020
Reg-01-04	2017	Offshore, North Sea	71	-	Fine sand, 2.75 (0.14)	0.32	Knutsen et al., 2020
Reg-01-14	2017	Offshore, North Sea	80	-	Fine sand, 2.74 (0.150)	0.24	Knutsen et al., 2020
Reg-06	2017	Offshore, North Sea	72	-	Fine sand, 2.87	0.33	Knutsen et al., 2020
Reg-06 - 01	2018	Offshore, Norwegian Sea	395	-	Silt and clay, 5.97	0.9	<i>This report</i>
Reg-06 - 05	2018	Offshore, Norwegian Sea	275	-	Silt and clay, 5.46	0.63	<i>This report</i>
Reg-06 - 10	2018	Offshore, Norwegian Sea	398	-	Silt and clay, 4.81	0.58	<i>This report</i>
Reg-06 - 17	2018	Offshore, Norwegian Sea	295	-	Silt and clay, 5.52	0.68	<i>This report</i>
Reg-06 - 20	2018	Offshore, Norwegian Sea	334	-	Silt and clay, 5.86	0.79	<i>This report</i>
STT-2	2017	Offshore, Barents Sea	251	250	Silt and clay, 5.31 (0.025)	1.93	Knutsen et al., 2020
KF2-6	2017	Offshore, Barents Sea	242	900	Silt and clay, 4.05 (0.060)	1.76	Knutsen et al., 2020
SC3-4	2017	Offshore, Barents Sea	461	100	Silt and clay, 5.57 (0.021)	1.56	Knutsen et al., 2020
KRT-14	2017	Offshore, Barents Sea	440	-	Silt and clay, 5.70 (0.018)	1.34	Knutsen et al., 2020
GRS-2	2017	Offshore, Barents Sea	508	250	Silt and clay, 5.93 (0.016)	2.09	Knutsen et al., 2020
Ålfjorden 1	2018	Inshore	194	-	Sand	7.4	<i>This report</i>
Nordgulen 1	2020	Inshore	101	-	-	-	<i>This report</i>
Lindesnes 1	2021	Inshore	103	-	Silt and clay	28	<i>This report</i>
Bekkelaget 1	2021	Inshore	34	-	Silt and clay	-	<i>This report</i>

MD $\Phi$  = Median grain diameter (mm)

1) Distance from oil & gas installation

**Table 5-2 Polychaeta sample information for samples relevant for this report**

Sampling station	Year of sampling	Sampling location, field	Sample size (n)	Sample weight (g w.w.)	Species	Polychaeta analysed for MP content
Reg-01-02	2020	Offshore, North Sea	17	0.1371	<i>Galathowenia oculata</i>	<i>This report</i>
Reg-01-04	2020	Offshore, North Sea	17	0.1516	<i>Galathowenia oculata</i>	<i>This report</i>
Reg-01-14	2020	Offshore, North Sea	17	0.1540	<i>Galathowenia oculata</i>	<i>This report</i>
Reg-02-21A	2020	Offshore, North Sea	17	0.0626	<i>Galathowenia oculata</i>	<i>This report</i>
Reg-06-01	2018	Offshore, Norwegian Sea	~8	0.3323	Tube dwellers*	<i>This report</i>
Reg-06-05	2018	Offshore, Norwegian Sea	~17	0.2629	Tube dwellers*	<i>This report</i>
Reg-06-10	2018	Offshore, Norwegian Sea	~15	0.5824	Tube dwellers*	<i>This report</i>
Reg-06-17	2018	Offshore, Norwegian Sea	12	0.3150	Tube dwellers*	<i>This report</i>
Reg-06-20	2018	Offshore, Norwegian Sea	~7	0.0466	Tube dwellers*	<i>This report</i>
GJAB-2	2017	Offshore, Barents Sea	17	0.2552	<i>Galathowenia oculata</i>	<i>This report</i>
SKR-03	2017	Offshore, Barents Sea	15	0.2359	<i>Galathowenia fragialis</i>	<i>This report</i>
Reg-9-11	2017	Offshore, Barents Sea	17	0.1937	<i>Galathowenia fragialis</i>	<i>This report</i>
Ålfjorden 1	2018	Inshore	16	0.1702	<i>Galathowenia fragialis</i>	<i>This report</i>
Nordgulen 1	2020	Inshore	5	0.0174	<i>Galathowenia oculata</i>	<i>This report</i>
Lindesnes 1	2021	Inshore	15	0.2598	<i>Galathowenia oculata</i>	<i>This report</i>
Bekkelaget 1	2017	Inshore	9	0.0427	<i>Galathowenia oculata</i>	<i>This report</i>
* Several species, including <i>Paradiopathra quadricuspis</i> , <i>Euclymene lindrothi</i> , <i>Clymenura</i> , <i>Galathowenia fragilis</i> , <i>Terrebellides stroemii</i>						

## 5.2 Sample collection and description

### 5.2.1 Offshore sediments

Sediment samples were collected using a van Veen grab from 0 – 1 cm with a surface area of 0,1 m<sup>2</sup>. In total 5 samples were collected in Region 6 in the Norwegian Sea during June 2018. The samples consisted of fine sediments and clay with a soft brownish top layer. The sediments and kept in glass jars with a metal screw cap with no other sealant, and were stored at ambient temperatures before microplastic analyses at NGIs Environmental Lab. The gasket and inside of the metal screw caps had a plastic coating which was investigated using macro FT-IR at NGI. The gasket had a match of 78.1 % for PVC, while the inside of the lid had an 80.6 % match for polyethylene terephthalate (PET). Due to the potential contamination from the lid, results regarding PVC and PET need to be interpreted with caution.

## 5.2.2 Inshore sediments

Sediment samples from Ålfjorden, Lindesnes and Bekkelaget were collected from 0 – 2 cm using a van Veen grab with a surface of 0.1 m<sup>2</sup>, while sediments from Nordgulen were collected from 0 – 2 cm using a sediment core sampler (PVC tubes). The sediment samples consisted mostly of fine dark grey to dark brown sediments. The sample from Nordgulfjorden was dark brown and contained a lot of fine organic material. The sample from Bekkelaget also contained a lot of organic material as well as coal, some visible red paint flakes and white fibers.

The inshore sediment samples collected at Nordgulfjorden, Lindesnes and Bekkelaget were kept in Rilsan (nylon) bags, while the sample from Ålfjorden was kept in a low-density PE bag. All samples were kept at ambient temperature during field sampling. After arrival at DNV Biolab and delivery at NGI the samples were kept frozen -20 °C until microplastic analyses. The bag materials were investigated and confirmed using macro FT-IR at NGI's Environmental Lab. The zip-lock bag had a 99.1 % match for PE, while the Rilsan bag had a 97.9 % match for nylon (polyundecanoamide). Due to the potential contamination from the sample bags and sampling methods, results regarding nylon, PE and nylon need to be interpreted with caution in the respective samples. The frozen sediment samples were gently thawed at 4 °C for one day and further at room temperature before microplastic analyses.

## 5.2.3 Polychaeta samples

The species selected for the present study were all tube dwelling polychaeta, which collect material from the sediments and seabed to compose tubes to protect their soft bodies, to serve as lairs for catching passing prey, to provide clean oxygenated water in sandy or muddy substrates, or to allow worms to live attached to rocks, shells and seaweed. Most sampled polychaeta belonged to the *Oweniidae* family, where the main species were *Galatowenia oculata* and *Galatowenia fragilis*. These polychaeta are thin, cylindrical, segmented worms that live in their flexible tubes and are burrowed in the sediment, with just their anterior ends protruding from the sediment surface. The tubes can be composed of various sand grains or shell fragments glued together in an overlapping manner (Oug et al., 2011, as shown in Figure 5-2 below). The present report has focused on analyses of microplastics in the worm and the tube combined, as both are ingested by their prey. *Galatowenia oculata* and other *Oweniidae* are important organisms within the lower trophic levels of the marine food web, and studies have reported their presence in stomach-contents of Haddock, different species of flatfish and small Atlantic hookear sculpins (Schückel et al., 2010; Yeung and Yang, 2014; Källgren et al., 2014). As such, concentrations of microplastics in the *Oweniidae* family are relevant for more than the benthic fauna itself, as they can be potential vectors for trophic transfer of microplastics.

The family *Oweniidae* are registered at moderate sediment depths and in continental slopes (Fauchald, 1977). Information about the *Galatowenia oculata* (previously called *Myriochele oculata*) is scarce, but it has a wide distribution in the northern hemisphere, according to World Register of Marine Species (Read and Fauchald, 2022). *Oweniidae* feeds on sediments around itself and can filter water (Rouse and Pleijel, 2001).

The polychaeta were retrieved from the sediments by pooling 5 separate 0.15 m<sup>2</sup> van Veen grab samples to obtain 5 L of sediment and sieving the samples at 1 mm. The bottom fauna was then transferred to glass jars and conserved with a solution of formaldehyde and hexamine (Carlo Erba Erbapharm, France). After sorting and further classification at DNV GL's accredited Biology lab, polychaetes were preserved on dram glass with plastic lids on 70% ethanol (Antibac AS, Norway) and shipped to NGI's lab for microplastic analysis, where they were stored at 4 °C until analysis. The lids were investigated by macro FT-IR and had a match of 99.2% for high density PE. During microscopy of the preserved samples prior to analyses visible particles and colourful fibers (blue, white, red) were seen in the ethanol surrounding the polychaeta samples. As these particles and fibers were difficult to remove from the vial before or the steel mesh after filtration of the sample onto the steel mesh, all samples were visually investigated using 30 x magnification by polarized and normal light to record visible fibers and particles (Figure 5-2).

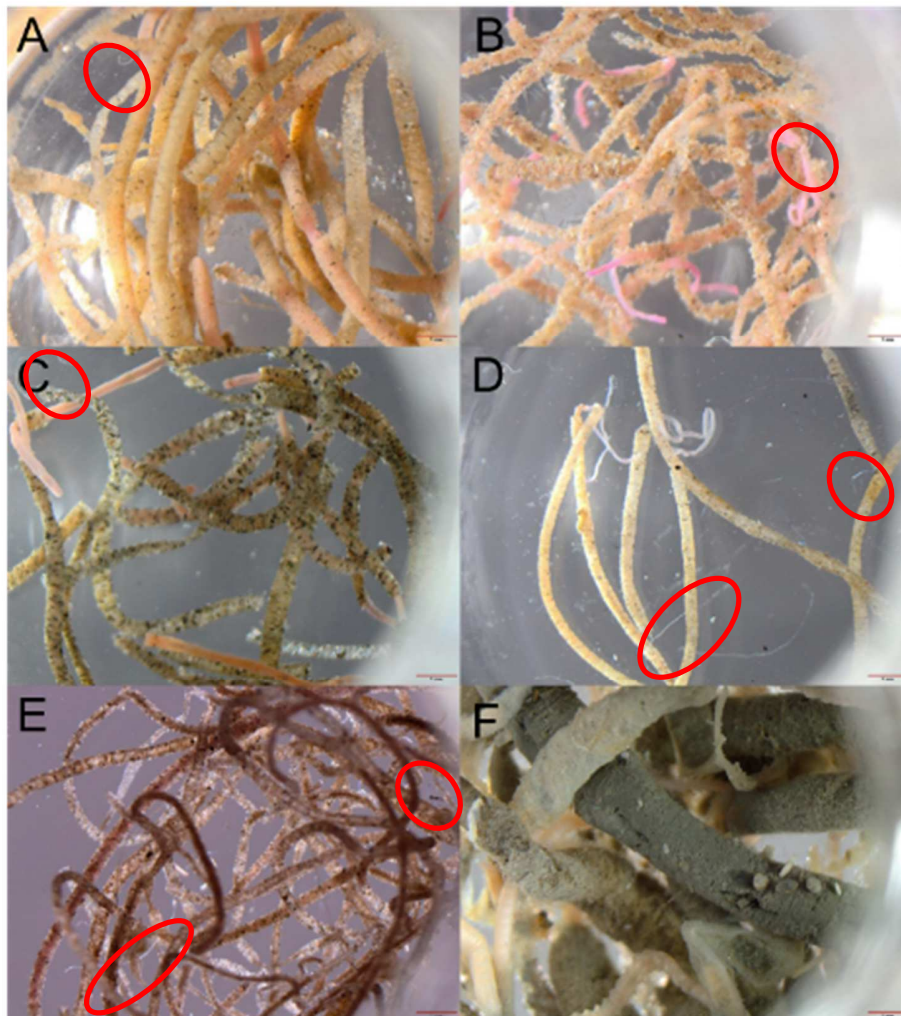


Figure 5-2 A) Barents Sea – GJAB-2, B) Barents Sea – R9-11, C) Inshore – Bekkelaget, D) Inshore – Nordgulfjorden, E) Inshore – Lindesnes, F) Norwegian Sea – R6-10. Red circles are surrounding fibres floating in the preservation fluid.

## 5.3 Sample preparation and density separation

### 5.3.1 Sediment – microplastic separation

The 9 sediment samples and 16 polychaeta samples were received at NGI after delivery by DNV AS 2021-05-05 and were processed and analysed for microplastics (45 µm – 5 mm) at NGI's Environmental laboratory between September and December 2021 by Mari Engvig Løseth (NGI), Maren Valestrand Tjønneland (NGI), Desiree Maloney (NGI) and BSc student Bianca Petzold (Hochschule Fresenius University of Applied Sciences).

### 5.3.2 Chemicals and spiking material

All chemicals used for the analytical method and spiking materials are listed in Table 5-3 and Table 5-3.

**Table 5-3. List of chemicals.**

Chemicals	Molecular formula	Manufacturer/ Distributor	Purity (%)
Zinc Chloride	ZnCl <sub>2</sub>	VWR International	97
Calcium Chloride	CaCl <sub>2</sub>	VWR International	90-98
Hydrogen peroxide	30 % H <sub>2</sub> O <sub>2</sub>	VWR International	Analytical grade
Urea	CO(NH <sub>2</sub> ) <sub>2</sub>	Sigma Aldrich	≥ 98
Thiourea	CH <sub>4</sub> N <sub>2</sub> S	Merck K GaA	≥ 98
Sodium hydroxide	NaOH	Merck K GaA	99 – 100
Sodium dodecyl sulphate	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>11</sub> OSO <sub>3</sub> Na	Sigma Aldrich	≥ 99 (Chromatography)

**Table 5-4. List of microplastics used for spiked blanks.**

Shape	Polymer type	Manufacturer / Distributer	Properties	
			Density (g/cm <sup>3</sup> )	Diameter (µm)
<b>Powder</b>	Polyester (PET)	Goodfellow Cambridge Ltd. (UK) - catalogue nr. ES306030	1.40	45-300 µm
<b>Fiber</b>	Polyethylene (LDPE)	Goodfellow Cambridge Ltd. (UK) catalogue nr. ET315710	0.92	38 µm consisting of 90 fibers Length: ~1 cm
<b>Granulate</b>	Polyester (PET)	Goodfellow Cambridge Ltd. (UK) catalogue nr. ES306312	1.40	3000-5000 µm

### 5.3.3 Sediment sample preparation

The 9 sediment samples were prepared for microplastic analyses according to Knutsen et al. (2020), with minor modifications. Due to prolonged storage, the offshore sediment samples had settled with pore water on top of the sediments. The water phase was thoroughly mixed into the sediment samples to a muddy consistency. The inshore samples contained more water and were also mixed to a light muddy consistency. To determine the dry matter content (DM%) as shown in Formula 1, homogenously mixed subsamples of approximately 20 g of sediment were transferred to pre-weighed aluminium trays, weighed to determine the wet weight, dried at 60 °C for two days, and then weighed again to determine the dry weight. A temperature of 60 °C was used instead of 110 °C which is normally used to calculate DM, to prevent potential melting or surface changes to the microplastic in the sample. The average (±sd) dry matter content of the sediment samples were 46% (± 6%).

$$DM\% = \frac{\text{Dry weight (g)}}{\text{Wet weight (g)}} * 100\%$$

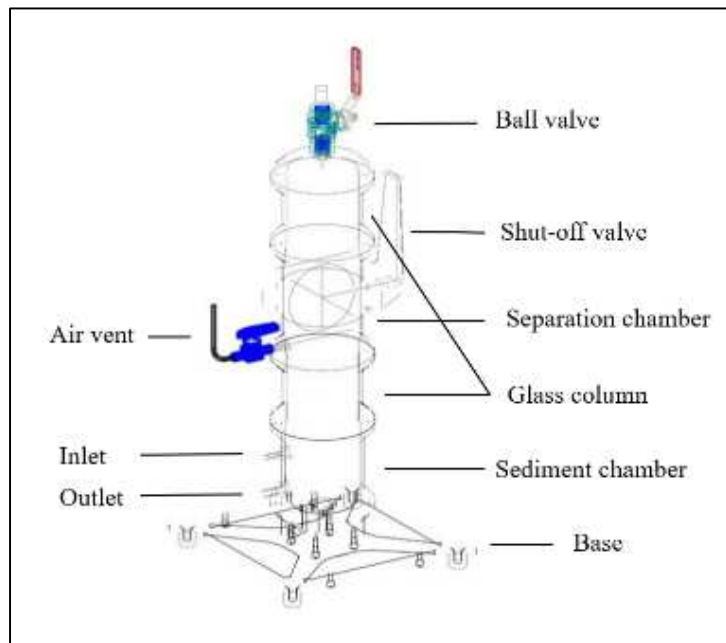
*Formula 1*

For microplastic quantification, approximately 150 g of homogenized wet sediment was gently mixed with zinc-chloride solution until no clumps were visible and the homogenized salt-sediment slurry had a smooth consistency.

### 5.3.4 Sediment density separation by Bauta Microplastic-Sediment Separator

The density separation was performed using an in-house designed density separator referred to as the Bauta Microplastic-Sediment Separator version 2 (BMSS v. 2, Figure 5-3). The design of the BMSS v. 2 is an improved version of the BMSS used in Knutsen et al., (2020) which is NGI's original design, inspired by the Munich Plastic-Sediment Separator (MPSS) presented by Imhof et al., (2012). The BMSS was thoroughly cleaned, flushed with distilled water and methanol, and inspected before each use, to ensure minimal particle contamination. The BMSS 2.0 was designed without the constriction of the glass column in the previous BMSS to prevent particles sticking to the walls of the separator. The setup of the BMSS 2.0 consists of a stainless-steel base and sedimentation chamber with a glass column and separation chamber on top. The separation chamber

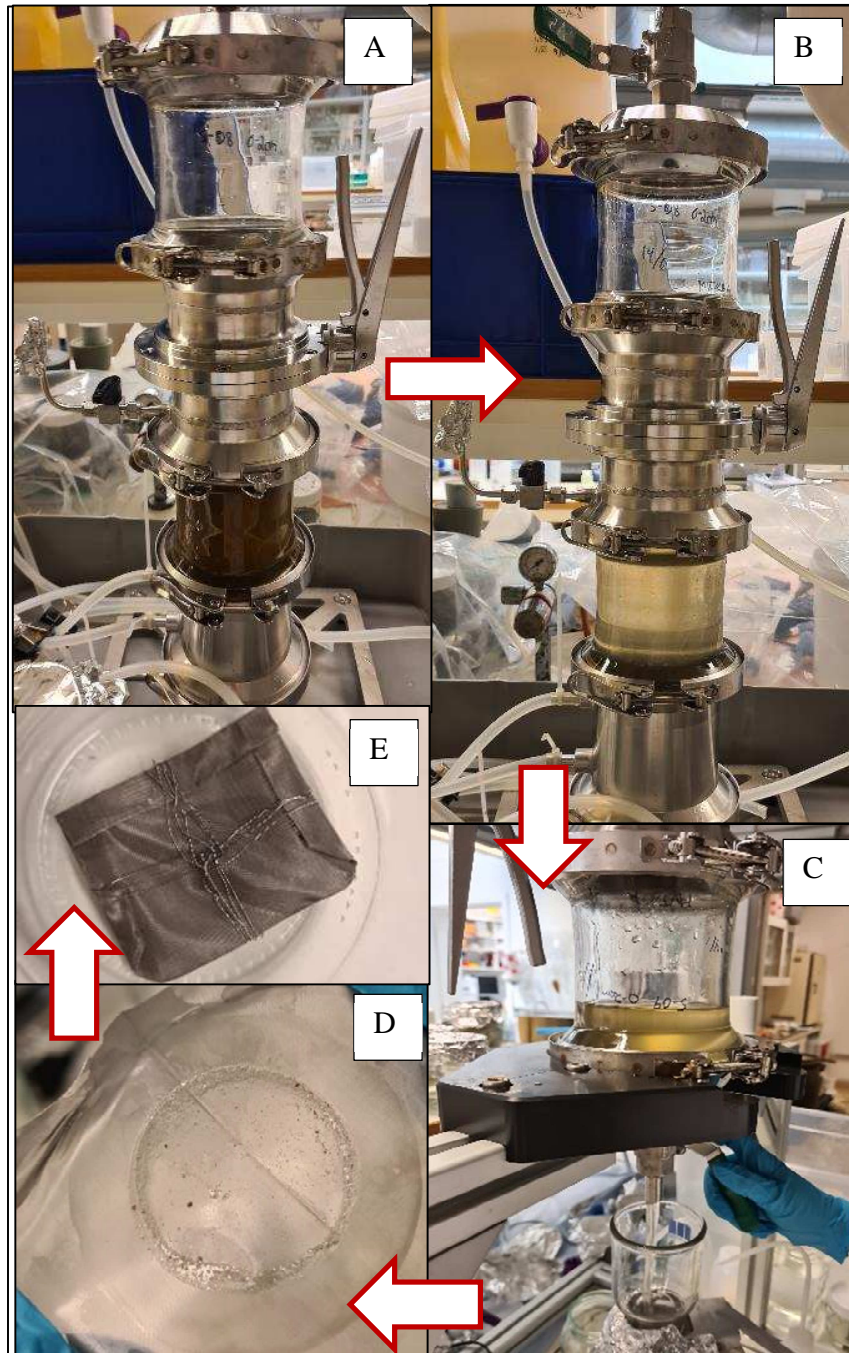
is made up of a stainless-steel part with a shut-off valve and air vent, another glass column and a stainless-steel funnel with a ½" ball valve on top. This unit makes it possible to separate the top-layer of the solution, which after density separation includes non-colloidal particles with a density less than the separation fluid used (i.e. microplastics, organic material and debris with  $\rho < 1.52 \text{ g/cm}^3$ ), whereas all denser particles are collected in the sediment chamber.



**Figure 5-3 NGI's Bauta Microplastic-Sediment Separator 2.0. (Schematic adapted from Philip Hayes).**

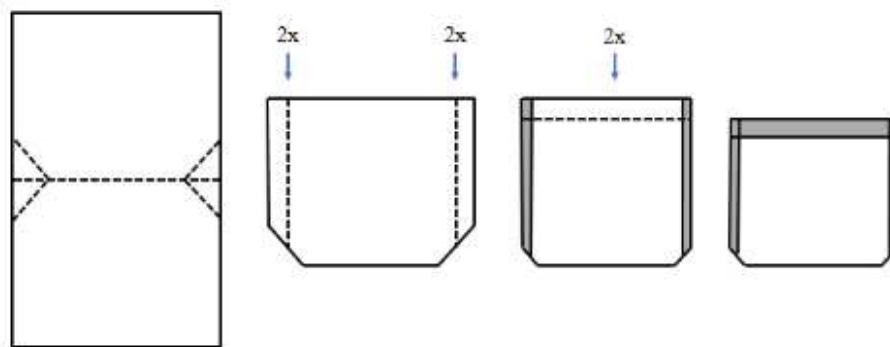
The BMSS v. 2 was filled with filtered high-density zinc-chloride solution ( $\rho \geq 1.52 \text{ g/cm}^3$ ) about halfway in the bottom glass column, and the sediment slurry was introduced gradually with a spatula from the top. After adding the whole sample, the spatula was used to gently stir and homogenize the solution in the BMSS v.2 prior to attaching the separation chamber and raising the level of the zinc-chloride solution to just above the shut-off valve. The top funnel was covered with aluminium foil to prevent airborne contamination. The sample was left at least over-night for density separation until the zinc-chloride solution was visibly clear (Figure 5-4 A to B). Thus, floating material ( $\rho \leq 1.52 \text{ g/cm}^3$ ) was collected in the separation chamber. After closing the shut-off valve and closing the separation chamber, the fluid level was lowered to the glass column by opening the upper air-vent. After this, the separation chamber was dismantled and fastened in an inverted position for vacuum-filtration (Figure 5-4 C to D) onto a 45  $\mu\text{m}$  stainless steel mesh filter (#300 Mesh - 0.043 mm Aperture - 0.04 mm Wire Diameter - SS316 Grade - Woven Wire, purchased from the Mesh Company, Warrington UK). Particles that stuck to the constriction of the glass column were rinsed off onto the filter using zinc-chloride solution until no particles attached to the glass walls were visible. The separation chamber was then remounted, the level of zinc-chloride solution was raised, and the filtration process was repeated two more times. After the last filtration, the filter and the filtration funnel were flushing with MilliQ water several times collect any remaining particles stuck to the Bauta walls. MilliQ-water was introduced via squeezable, laboratory wash bottles that are made of plastic (PE) and were tested to ensure little Microplastic particles; use of glass bottles would be a safer option with regards to potential contamination of the sample.

The concentrated filtrate was enclosed by folding the 45  $\mu\text{m}$  steel mesh filter into an envelope (Figure 5-4 E and Figure 5-5) and secured with a pre-weighed steel wire (Alloy Wire Co. Ltd). Finally, the samples were dried at 60 °C overnight, and weighed before treatment by chemical oxidation of organic matter.



**Figure 5-4** A) sediment sample and zinc chloride solution ( $\rho \geq 1.52 \text{ g/cm}^3$ ) for separation; B) after density separation overnight; C) vacuum filtration of sample onto 45  $\mu\text{m}$  steel mesh; D) close-up of filtered microplastic sample (before chemical digestion of organic matter); E) steel mesh containing sample wrapped into a "tea-bag" like shape.





**Figure 5-5 Folding technique used to secure the concentrated filtrate on inside the steel mesh.**

### 5.3.5 Polychaeta density separation

The polychaeta samples were prepared for microplastic analyses according to Knutsen et al. (2020), with some modifications. In brief, on average 14 polychaeta (min-max: 5 to 17) from 16 sampling locations were transferred to a pre-weighed 45  $\mu\text{m}$  steel mesh filters by using a glass funnel and a vacuum-filtration setup. The polychaeta was transferred by pouring the sample stored in ethanol into the filtration funnel and rinsing the sample vial and the funnel generously with MiliQ-water. The vacuum was applied gently to remove most of the liquid from the filter and the filtration funnel was covered with aluminium foil to reduce potential airborne contamination of the sample. Then, the sample was enclosed by folding the 45  $\mu\text{m}$  steel mesh filter into an envelope and securing it with pre-weighed steel wire. Further, the wet weight of the sample was recorded (mean  $\pm$  sd: 0.20  $\pm$  0.14 g), before drying overnight at 60  $^{\circ}\text{C}$ . The next day, the dry weight of the samples were recorded (mean  $\pm$  sd: 0.05  $\pm$  0.04 g), and the samples were treated with 1 M HCl with stirring for 1 hour in room temperature to remove shells and other calcified material from the tubes of the polychaeta. It was noted that this addition of 1 M HCl also partly dissolves the steel mesh folder. The average weight loss of this steel mesh was (mean  $\pm$  sd: 0.08  $\pm$  0.01 g), Finally, the samples were dried at 60  $^{\circ}\text{C}$  overnight, and weighed before treatment by chemical digestion as described in 5.3.6, see chapter below. The chemical digestion, with step 1 and 2, was repeated until no more mass loss could be recorded.

Following chemical digestion, the steel-mesh envelope was opened, and the extracts added to separation funnel containing zinc-chloride solution ( $\rho > 1.52 \text{ g/cm}^3$ ) and left for 30 min to 4 hours for density separation. Thus, particles with a density less than 1.52  $\text{g/cm}^3$ , such as plastics and other low-density materials that are resilient to the digestion method, like bitumen, charcoal and some forms of natural organic matter will float, while other materials like minerals will sink and be discarded from the separation funnel. The floating material was collected and concentrated on a pre-weighed steel mesh filter (pore size of 45  $\mu\text{m}$ ) by vacuum-filtration and flushed with MiliQ-water, which was then folded to a second envelope and secured with a steel mesh wire. The second envelope with the density separated sample was then submerged in 50 $^{\circ}\text{C}$  SDS-solution for 30 min and then 50 $^{\circ}\text{C}$  MiliQ-water with stirring for up to 8 hours to dissolve potential  $\text{ZnCl}_2$  crystals on the filter, before being filtered onto a pre-weighed 20 mm filter (pore size of 45  $\mu\text{m}$ ). When transferring to the 20 mm filter, the steel mesh envelope was submerged in MiliQ-water and sonicated twice for 30 min, to ensure as many particles as possible were retrieved and not stuck to the steel mesh envelope.

To ensure that all particles had been transferred to the separation funnel from the first steel mesh envelope, the filter envelope was thereafter cleaned in an ultrasonic bath A) submerged in zinc-chloride solution twice at 30 min and transferred to the separation funnel for density separation, or B) submerged in MiliQ-water twice at 30 min and thereafter filtered onto a separate pre-weighed 20 mm filter (pore size of 45  $\mu\text{m}$ ). The pre-weighed 20 mm filters were dried overnight, and the mass of the samples were recorded prior to  $\mu\text{FT-IR}$  analysis of polymer composition as described in section 5.3.7 below.

### 5.3.6 Chemical digestion

A two-step chemical digestion process was performed for removal of organic material. Chemical digestion was performed using a two-step dissolution oxidation method as described by Knutsen et al. (2020) and Olsen et al. (2020). In brief, the first step involves dissolution of organic polymers, such as chitin and cellulosic materials, by soaking the sample in a mixture of 8% NaOH, 6.5% thiourea and 8% urea in water in a ratio of 40 ml per 0.1 g dry weight sample and keeping it at  $-20\text{ }^{\circ}\text{C}$  for 45 min, with intermittent stirring, to cool down the reaction (Jin et al., 2007; Olsen et al., 2020; Zhang et al., 2013). During this step, some of the organic material dissolves and is rinsed through the "tea bag" filter or is otherwise partially dissolved to facilitate oxidation in the second step.

In the second step, oxidation is performed using 30%  $\text{H}_2\text{O}_2$  and 1.0% NaOH, by first adding  $\text{H}_2\text{O}_2$  at ratios of 30 mL per 0.1 g dry weight sample aliquots of 0.75 mL 10M NaOH per 0.1g of sample (Olsen et al., 2020). Initial tests with this digestion method indicated that it can successfully remove organic solids like paper and cotton ( $98 \pm 4\%$  sample digestion) yet is relatively harmless to the plastics tested (4% maximum sample digestion for PET fibres) (Olsen et al., 2020). The chemical digestion was performed at least once and repeated, up to seven times for sediment samples and fifteen times for biota sample, depending on a visual assessment of organic material remaining and weight reduction from the previous step. The chemical digestion was repeated until no more mass loss could be recorded. Therefore, there could have been some loss of thinner PET materials and fibres. The weight of the remaining sample includes all particles with a density  $\leq 1.52\text{ g/cm}^3$ , a size  $\geq 45\text{ }\mu\text{m}$ , and with resilience to the chemical digestion process. In addition to microplastics, this can include other materials such as soot, char, undigested organic matter and porous glass/carbonates. Therefore, further analysis with Fourier-Transform Infrared spectroscopy (FT-IR microscopy) was performed to quantify particles and determine the material composition.

### 5.3.7 FT-IR analysis

Fourier Transform Infrared Spectroscopy (FT-IR) was performed to determine the material composition and to quantify the particles in the density separated and oxidized samples. First, the processed samples were transferred from the "tea bag" steel mesh filters and onto pre-cut, spherical steel mesh filters (pore size of  $43\text{ }\mu\text{m}$ , diameter of 20 mm) with a filtration area of 13 mm. This was done by opening the "tea bag" filters into Milli-Q water followed by sonication and vacuum filtration. Once transferred to the 20 mm filters, the samples were imaged using visual microscopy (Olympus SZX16 stereo microscope) to provide information about the colours and shapes of the particles and to give an overview of the distribution of particles prior to FT-IR analysis.

The micro FT-IR system applied was Perkin Elmer Spotlight 200i FT-IR microscope, equipped with a Frontier FTIR spectrometer. The system consists of a microscope, spectrometer, PC, stage controller and joystick (Figure 5-6).



**Figure 5-6 Spotlight 200i – microscope and Frontier IT System**

Prior to analysis, the Spotlight 200i was set up, and the microscope was focussed as described in the Spotlight 200 User's Guide. The scan parameters were set to the following settings: resolution: 4 cm<sup>-1</sup>, wave number range: 4000-600 cm<sup>-1</sup>, 4 number of accumulations.

For samples with larger particles (approximately > 2 mm based on visual determination), large enough to be picked up by tweezers, their length was measured using Vernier callipers, and thereafter individual particle analyses using the Frontier ATR assembly was conducted. The ATR crystal was cleaned with methanol between each analysis to reduce the chance of cross-contamination between samples. For particles too small to be picked up, the analysis was performed using the FTIR microscope in transmittance mode.

In transmittance mode, the infrared radiation penetrates the particle before arriving at the detector, giving an infrared spectrum of the entire volume of the particle. This mode works best with thin or translucent particles. Using the ATR technique allows for the analysis of materials that are too opaque for transmission measurements and too strongly absorbing for good reflectance measurements. The FT-IR microscope only scans the inner 10 mm of the total 20 mm filter, and thereby excludes some of particles on the edge of the filter (though these were a minority).

The obtained IR spectrums were compared with libraries of polymer spectra available through Perkin-Elmer, namely "Polymer", "ATR-Spectra", "Transmission-Spectra" and "Fluka", plus some in house NGI libraries using plastic reference materials. Particle identification is done through the dedicated software Spectrum™ version 10.7.2. by Perkin-Elmer, which compares the obtained spectrum with those in the spectrum libraries. These libraries include a wide variety of plastic polymers, organic substances, salts and minerals, many of which are highly unlikely to be a major component of marine samples. The "Polymer" library also included typical polymer blends (e.g. polyethylene and polypropylene blends). Particles with a quality index ≥ 0.7 (i.e. 70 % match with FT-IR library) were accepted, unless there was a reason to exclude them, such as low peak height, or bad resolution. Particle spectra with a quality index <0. were rejected and are denoted "unknown" in this report. The identified items were categorized into the groups according to particle categories listed in Table 5-5 and plastic polymer categories listed Table 5-6.

In this study, a minimum of 200 particles and at least 45 % of each 20 mm filter were scanned per sediment sample, and at least 25 % (mean: 50 %) of each 20 mm filter were scanned per polychaeta sample.

Several investigated particles, especially from sediment collected at Bekkelaget, got a match for Resinall CP-25, which may be categorized as a rubber material or stearate. However, the spectra for Resinall CP-25 also strongly resemble PE spectra and it cannot be ruled out that some of the particles with Resinall CP-25 could potentially be PE. Due to the difficulties in classifying these particles, all particles with matches for Resinall CP-25 were excluded from this report in order to avoid potential overestimation of microplastic particles.

**Table 5-5 Particle categories used in this report.**

Particle Category	Description
<b>Unknown</b>	Particles identified by FT-IR with a quality index < 0.7
<b>Mineral</b>	Particles with no organic chemical bond visible in the IR spectrum (such as inorganic salts, glass, etc.)
<b>Coatings-adhesives*</b>	Particles containing oxy-resins, such as ethoxy resin, epoxy resin, phenoxy resin, or bisphenol-a containing particles.
<b>Petro-Pyro</b>	Typical petroleum substances, such as hydrocarbon resins, petroleum products, etc.
<b>Plastic*</b>	Commercial synthetic polymers, or a weathered derivative thereof, such as oxygenated polymers; semi-synthetics derived from biopolymers like cellulose, such as rayon, viscose etc are not included
<b>Rubber*</b>	Particles identified as rubbers, polymers used as rubbers (e.g. SBR, silicon rubber), or resins containing rubber compounding products
<b>Organic</b>	Particles identified as organic macromolecules like cellulose, rayon, chitin, proteins, or in general particles containing organic carbon molecular bonds, that do not fit into any of the above categories

\*Microplastics as defined in this report also includes coatings, oxy-resin adhesives, plastic polymers and rubber materials.

Plastic polymers were further subdivided into the plastic types in Table 5-6 below. In case of blends, the main polymers in the composition was selected. It is noted that many spectra are quite similar. These include PE-chlorinated being similar to PVC, PE-chlorosulfonated, PP-chlorinated making them difficult to distinguish. Further, weathered or biofilm coated polyolefins (e.g. PE and PP) could give spectra resampling PE-oxidized or PE-chlorinated.

**Table 5-6 Plastic polymer categories used in this report.**

Plastic polymer category	Description
PE	Polyethylene (E.g. LDPE, HDPE, LLDPE, etc.)
PE-chlorinated	Chlorinated polyethylene
PE-chlorosulfonated	Chlorosulfonated polyethylene
PE-oxidized	Oxidized polyethylene
PE:PP	Blends of polyethylene:polypropylene
PP	Polypropylene
PET	Polyester, polyethylene terephthalates
PS	Polystyrene
PTFE	Polytetrafluoroethylenes
PP-chlorinated	Chlorinated polypropylenes
PAM	Polyacrylamide
PMMA	Polymethylmethacrylate and other polyacrylates
PU	Polyurethane foam
PVF	Polyvinyl fluoride
PVC	Polyvinyl chloride
Melamine	Melamine (all resin blends)
Nylon	Nylon and polyamide
Other	Synthetic polymers not belonging to the above list

## 5.4 Quality control

The samples were quantified by weight and visually through light microscopy, as described in chapter **Error! Reference source not found.** In both cases, precautions were taken to account for laboratory contamination through the use of blanks and keeping the sample closed to the laboratory atmosphere as much as possible. To reduce airborne contamination, several contamination prevention strategies were performed, which included:

- ✓ Only garments and lab coats consisting of cotton or other natural fibres were used in the laboratory
- ✓ All glass ware and equipment were thorough rinsed with MilliQ water and visually inspected before use.
- ✓ All steel mesh filters were visually inspected by microscopy before use. If particles were observed, filters were ultrasonic cleaned with SDS and MiliQ water prior to use. After cleaning the filters were controlled by microscopy.
- ✓ The samples were covered and sealed as much as possible during analyses to prevent airborne contamination. Samples were never covered with plastic.
- ✓ Analyses of several method and spiked blanks following all the steps of the analyses, as described below. Weights were recorded for both types of blanks. In addition, methods blanks were examined under a microscope and by  $\mu$ FT-IR.
- ✓ Spiked sediment recovery blanks were performed for all different sediment types. Several spiked polychaeta blanks were performed.

### 5.4.1 Method blanks

The method blank sample protocol included the exact same steps as the sediment and polychaeta samples, except they were done without using any sample material. Blanks were then controlled by weight and microscopy and analysed by  $\mu$ FT-IR. To evaluate polymer composition resulting from the preparation and analytical procedure and correct for this.

The weight of materials in the blanks ( $m_{blank}$ ) was calculated as:

$$m_{blank} = m_{total\ blank} - m_{filter} - m_{wire} \quad \text{Formula 1}$$

Where  $m_{total\ blank}$  is the total weight of the dried steel-mesh filter containing the "blank" sample and steel wire after digestion and drying over-night at 60 °C,  $m_{filter}$  is the pre-weighed filter weight and  $m_{wire}$  is the pre-weighed wire weight.

#### 5.4.1.1 Sediment

A total of five method blanks were prepared during the analyses and extraction of microplastic from sediment samples. Three method blanks were prepared the first week and two method blanks were prepared during the second week of density separation of sediments.

The mean and standard deviation (SD) of particles detected in the five method blanks are listed in Table 5-7. On average 93 unknown particles, 103 organic particles and 36 MP particles were detected in the blanks. The unknown particles were typically particles with noisy spectra where the matches were below 70% in the FT-IR spectrum library. The organic particles were usually fibres (cotton) or wood (chipboard) which most likely originate from lab coats and the production of 20 mm steel mesh filters. The most abundant plastic polymers in the blanks were PE, PP and PET. The limit of detection was set to mean + SD for each category. The average weight of the sediment method blanks prior to FT-IR analyses was – 0.0009 g, this "weight loss" is most likely due to the sensitivity of the analytical balance which is 0.001 g and is not caused by the chemical oxidation as HCl was not used for the sediment samples. Thus, the recorded mass of the sediment samples after chemical oxidation was not corrected for this potential mass loss of blanks.

#### 5.4.1.2 Polychaeta

Method blanks for the polychaeta samples included both washed ( $n = 3$ ), unwashed filters ( $n = 3$ ) and a washed filter exposed to the preservation solution surrounding the polychaeta ( $n = 1$ ), which were ultimately averaged together. The reason for having washed and unwashed filter blanks, is that filter washing was introduced for the polychaeta after some black, PE-oxidized particles (91% match with FT-IR) were spotted on the unwashed filters in the filter container. The preservation fluid blank was to get information on the visible fibres in the preservation fluid solution. The washing method involved ultrasonic cleaning in SDS solution, followed by MilliQ water rinsing. One method blank was density separated at least every second week during density separation of polychaeta samples.

The mean and standard deviation (SD) of particles detected in the seven method blanks are listed in Table 5-7. On average 401 unknown particles, 241 organic particles and 117 MP particles were detected in the blanks. The unknown particles were typically particles with noisy spectra where the matches were below 70% in the FT-IR spectrum library. The organic particles were usually fibres (cotton) or wood (chipboard) which most likely are from lab coats and the production of 20 mm steel mesh filters. The most abundant plastic polymers detected in the blanks were PE, PP, melamine and PE-oxidized. The limit of detection was set to mean + SD for each category. The final mass of each polychaeta sample after chemical oxidation and density separation was corrected with the average weight of the method blanks (prior to FT-IR analyses) of 0.0039 g, to correct for the presence of some  $ZnCl_2$  crystals still present on the filters after repeated rinsing with hot MilliQ-water.

**Table 5-7 Mean ± standard deviation (SD) of particles detected in the polychaeta method blanks (n = 7) and sediment method blanks (n = within each defined FT-IR category of microplastics\*.**

Particle		Number of MP particles in sediment blanks (mean ± SD)	Number of MP particles in polychaeta blanks (mean ±SD)
<b>Plastic polymer</b>	PE	14 ± 16	74 ± 65
	PP	7.9 ± 5.7	14 ± 15
	PET	6 ± 1.4	5.3 ± 2.8
	PS	0.4 ± 0.9	0.9 ± 1.1
	PE-chlorinated	n.d.	0.3 ± 0.8
	PMMA	n.d.	1.4 ± 2.2
	PU	0.8 ± 1.8	0.3 ± 0.8
	PE-oxidized	1.8 ± 2.5	6.7 ± 6.9
	PE:PP	n.d.	0.7 ± 1.3
	PVC	0.2 ± 0.4	n.d.
	Melamine	1.5 ± 1.7	8.6 ± 10
	Nylon	1.6 ± 1.7	2.3 ± 2.1
	EVA	n.d.	0.3 ± 0.8
	Additive	0.4 ± 0.9	1 ± 1.3
	Plastic (Other)	1.6 ± 2.6	0.6 ± 1.5
<b>Total</b>	<b>36 ± 27</b>	<b>117 ± 85</b>	
<b>Rubber</b>	SBR	n.d.	0.3 ± 0.8
	Silicon	0.4 ± 0.9	n.d.
<b>Coatings-adhesives</b>	Coatings-adhesives (other)	n.d.	0.3 ± 0.8
	Phenoxy Resin	1.2 ± 2.7	n.d.
<b>Unknown</b>		<b>93 ± 37</b>	<b>401 ± 535</b>
<b>Mineral</b>		<b>0.2 ± 0.4</b>	<b>25 ± 59</b>
<b>Organic</b>		<b>103 ± 105</b>	<b>241 ± 102</b>
<b>Petro-pyro</b>		<b>0.4 ± 0.9</b>	<b>1 ± 1</b>

n.d.: not detected

\* Microplastics are herein defined as total plastic, paint and rubber particles

## 5.4.2 Spiked recovery blanks

The precision of the analytical method was tested by adding a known amount of microplastics (granulates, fibres and micropowders, shown in Figure 5-7 and Table 5-4) to sediment where organic matter and microplastics have already been removed by the BMSS separation step. For polychaeta, this was done by spiking empty steel mesh filter. After spiking the sediment sample or empty filter, the spiked blank samples were then processed following the standard protocol for microplastics separation as described above. These spiked blanks were processed as normal samples and used to adjust recovery concentrations based on weight, though not based on FT-IR data.

The weight of materials in the spiked blanks ( $m_{spiked\ blank}$ ) was calculated similarly as the method blanks (Formula 2):

$$m_{spiked\ blank} = m_{total\ spiked\ blank} - m_{filter} - m_{wire} \quad \text{Formula 2}$$

Where  $m_{total\ spiked\ blank}$  is the total weight of the dried filter containing the spiked "blank" sample. The spiked sample recovery was calculated as shown in Formula 4 where  $m_{spiking\ material}$  is the original amount of microplastics spiked into the sample.

$$f_{recovery}(\%) = \frac{m_{recovery\ blank} - (m_{filter} + m_{wire})}{m_{spiking\ material}} \quad \text{Formula 3}$$

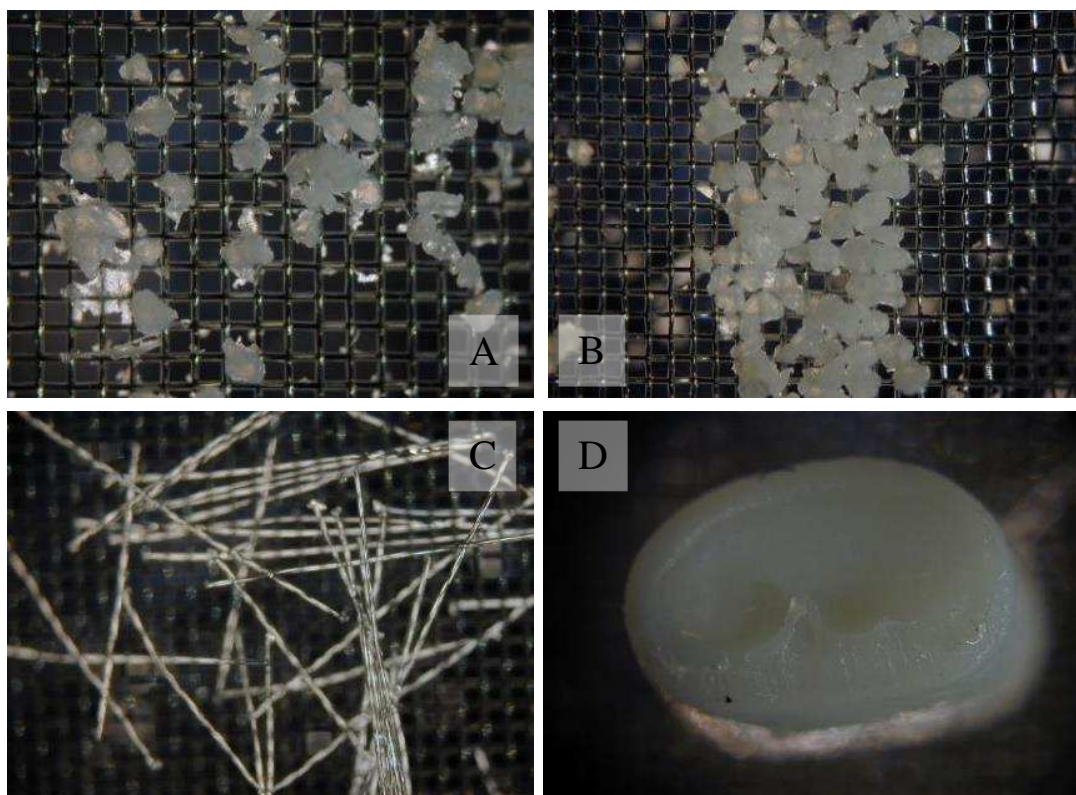


Figure 5-7. Photos of spiking material (x10 magnification). A and B: PET powder; C: PE fibre; D: PET pellet.

#### 5.4.2.1 Sediment

A total of four spiked sediment blanks were analysed, which consisted of two samples spiked with PET powder and two samples spiked with PE fibers, as well as PET granulates in both the powder and fiber blank. The mean ( $\pm$  sd) recovery from the PET powder was 74 % ( $\pm$  11 %) and 92 % ( $\pm$  4 %) for PE fibers. The combined recovery of 83 % was used for correction of the microplastic quantified in the sediment samples.

#### 5.4.2.2 Polychaeta

A total of 8 spiked blanks were analysed, which consisted of 4 blanks with PET powder ( $> 45\mu\text{m}$ ) and 4 blanks with PE fibers ( $\sim 1\text{ cm}$  length,  $\varnothing 38\mu\text{M}$ ). The two different transferring methods were quality assured by performing half of the SB using method

A and the other half using method B. The spiked blanks were rinsed with 50°C MiliQ water four times to remove ZnCl<sub>2</sub> crystals from the sample. Still, after four rinses the recovery of the PE fiber blanks were over 100%. Presence of ZnCl<sub>2</sub> crystals were confirmed by visual inspection of the opened fiber blanks under a stereomicroscope. It is possible that the high number of fibers enclosed in the steel mesh may have clogged the steel mesh filter pores, hampering the washing with MiliQ-water to remove ZnCl<sub>2</sub> crystals.

The average recovery of PET powder was 86 % (± 3 %) for method A and 77 % (± 4 %) for method B, while the average recovery of PE fibers were 101% (± 1 %) for method A and 109 % (± 3 %) for method B. As the recovery of PE fibers were higher due to presence of ZnCl<sub>2</sub> crystals, the recovery was set to 100 % for the calculation of the average recovery of microplastic. Thus, the average of both microplastic particles and fibers, from both method A and B, of 91 % was used for recovery correction of the microplastic quantified in the polychaeta samples.

### 5.4.3 Calculation of microplastic concentrations

The number of plastic particles within each polymer category detected by FT-IR (as listed in Table 5-6 for each sample ( $n_{p,sample}$ ) was corrected according to the average number of particles plus the standard deviation (SD) detected in the method blanks ( $n_{p,method\ blank}$ , Formula 4). The particle concentrations were also corrected for the recovery factor ( $f_{recovery}$ ) for either sediment or polychaeta spiked blanks.

$$n_{plastic} = (n_{p,sample} - n_{p,method\ blank} - SD_{p,method\ blank}) / f_{recovery} \quad \text{Formula 4}$$

Weight results ( $m_{plastic}$ ) were also corrected according to the recovery correction factor ( $f_{recovery}$ ) obtained from the spiked blanks (Formula 5), which were based on mass.

$$m_{plastic} = (m_{p,sample} - m_{p,method\ blank}) / f_{recovery} \quad \text{Formula 5}$$

Based on the weight of the processed samples after density separation and chemical digestion (mg potential MP) and the percentage of identified microplastics in the samples ( $n_{plastic}$ ), microplastic concentrations ( $c_{MP}$ ) was calculated based on mass (Formula 6)

$$c_{MP} \left( \frac{mg\ MP}{kg\ d.w.} \right) = \frac{(m_{plastic}\ mg\ potential\ MP \times n_{plastic})}{m_{sediment}\ kg\ d.w.} \quad \text{Formula 6}$$

And estimated on weight basis (Formula 7). The mass per MP item was estimated to be  $6.283 \times 10^{-07}$  mg (NGU, 2021).

$$c_{MP} \left( \frac{mg\ MP}{kg\ d.w.} \right) = \frac{m_{plastic}\ mg\ potential\ MP}{m_{sediment}\ kg\ d.w.} = \left( \frac{n_{plastic} \times estimated\ mean\ particle\ mass}{m_{sediment}\ kg\ d.w.} \right) \quad \text{Formula 7}$$

Microplastic concentrations were also calculated as number of microplastic particles (blank-corrected) per kg sediment (Formula 8):

$$c_{MP} \left( \frac{items\ MP}{kg\ d.w.} \right) = \frac{n_{plastic}}{m_{sediment}\ kg\ d.w.} \quad \text{Formula 8}$$

The presence of non-plastic particles (organic, mineral, petro-pyro and unknown particles) in the sediment samples were also corrected by subtracting the average number plus SD detected in the method blanks. The number of organic particles in the sample after chemical digestion will vary depending on the number of treatments performed and how successful it has been at removing organic matter, as has been described in Olsen et al. (2020). In all samples, the digestion removed enough particles to be below the analytical detection limit of the weighing balances used. Thus, the success of the digestion cannot be quantified; however, this is generally interpreted as implying that the sample is free of enough organic particles to avoid



interferences in FT-IR analysis. There is also concern that too many repeated digestion procedures could destroy some of the plastics, like PET (Olsen et al., 2020).

#### 5.4.4 Calculation of Biota-Sediment Particle Enrichment Factor

To estimate the potential enrichment of microplastic in polychaeta relative to their surrounding sediments a Biota-Sediment Particle Enrichment Factor was calculated according to Knutsen et al. (2020) shown in Formula 9. The BSPEF was first introduced in Miljødirektoratet (2018c) as biota-sediment accumulation factor (BSAF), however the term BSPEF was introduced to avoid misinterpretation as the formula is calculating particle enrichment and not accumulation of single organic compounds at steady state (Knutsen et al., 2020).

$$BSPEF \left( \frac{g \text{ w.w.}}{g \text{ d.w.}} \right) = MP \text{ items in polychaeta (g w.w.)} / MP \text{ items in sediment (g d.w.)} \quad \text{Formula 9}$$

### 5.5 Statistical analysis

Statistical analyses were conducted using R v. 4.0.2 (R Development Core Team, 2019). Variation among and between group means (offshore vs. inshore) for microplastic concentrations was investigated using variance analyses (ANOVA). The correlation between microplastic concentration in sediments and polychaeta samples were investigated by Spearman's Rank correlation test. The independence of samples, homogeneity of variance and normality of residuals was controlled (Zar, 1999). Log transformation was therefore used to transform non-normalized data prior to analyses. The significance level was set to  $\alpha = 0.05$ .

## 6 RESULTS AND DISCUSSION

### 6.1 Microplastic concentrations in sediments

The concentrations of microplastic identified in the sediment samples are shown in Table 6-1. The highest concentrations of microplastics were detected in the sediment sample from Bekkelaget in the Oslofjord, with 14 091 MP items/kg d.w., followed by the other inshore sediments collected in Ålfjorden with 4 999 items/kg d.w. and Lindesnes with 4 146 MP items/kg d.w. The sediments from Region 6 in the Norwegian Sea had the lowest concentrations of microplastic detected in this report, with a mean concentration of 3 446 items/kg d.w. Thus, the sampled inshore had statistically significant higher concentrations of microplastic compared to the offshore sediment samples in Region 6. The composition of particles classified by FT-IR analyses is listed in Table 6-2 (in appendix A ) and visualized in Figure 6-1.

**Table 6-1 Concentrations of microplastic identified in sediment samples by FT-IR (match score > 0.7 with the FT-IR library)**

Sample / Location	mg MP/kg dry sediment* based on weight (Formula 5)	mg MP/kg dry sediment** extrapolated from particle numbers (Formula 6)	MP items/kg dry sediment
Bekkelaget 1	30.1	8.9	14 091
Lindesnes 1	n.d.	2.6	4 146
Nordgulen 1	n.d.	0.8	1 294
Ålfjorden 1	n.d.	3.1	4 999
R6-01	n.d.	0.4	599
R6-05	n.d.	0.4	665
R6-10	0.2	0.7	1 114
R6-17	n.d.	1.0	1 596
R6-20	n.d.	1.6	2 513
<b>Inshore Mean ± SD (min-max)</b>	(n.d. - 30.1)	3.9 ± 3.5 (0.8 - 8.9)	6 132 ± 5 537 (1 294 – 14 091)
<b>Offshore / Norwegian Sea Mean ± SD (min-max)</b>	n.d. (n.d. - 0.2)	0.8 ± 0.5 (0.4 - 1.6)	1 298 ± 788 (599 – 2 513)
<b>All areas (Mean ± SD (min-max))</b>	10.1 ± 17.3 (0 - 30.1)	2.2 ± 2.7 (0.4 - 8.9)	3 446 ± 4 278 (599 – 14 091)

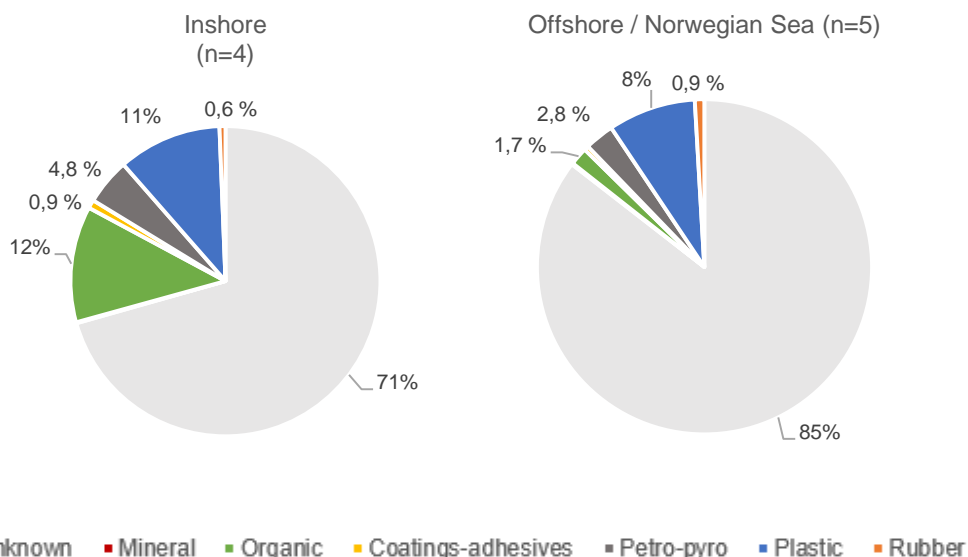
n.d.: weight of sample material was below the limit of detection for the analytical balance (<0,001 g); \*based on measured weight of sample material; \*\*estimated % of MPs based on numbers of MP and estimated density and size

On average, only 11 % of the isolated particles from the sediment samples were identified as plastic and the most frequently identified plastic polymers in the sediments were PE, PP and PE-chlorinated. The majority of the particles were identified as unknown due to match score with the FT-IR library below 0.7. The inshore samples contained more organic material than the offshore samples after chemical oxidation, which could be due to hard to digest marine or terrestrial organic matter either from the native biota or from WTP. The sample from Bekkelaget also contained several particles classified as petro-pyro

(hydrocarbon resin and paraffin) which by visual microscopy appeared similar to coal particles. There was several coal-based gas-work sites earlier at Bekkelaget, which were mostly closed in the 1960s (Arp et al., 2011). The particle composition identified in offshore and inshore sediments are shown in Figure 6-1. With regards to potential contamination of plastic from storage or collection, no significant trends could be observed for PVC, nylon, PET or PE in the respective samples.

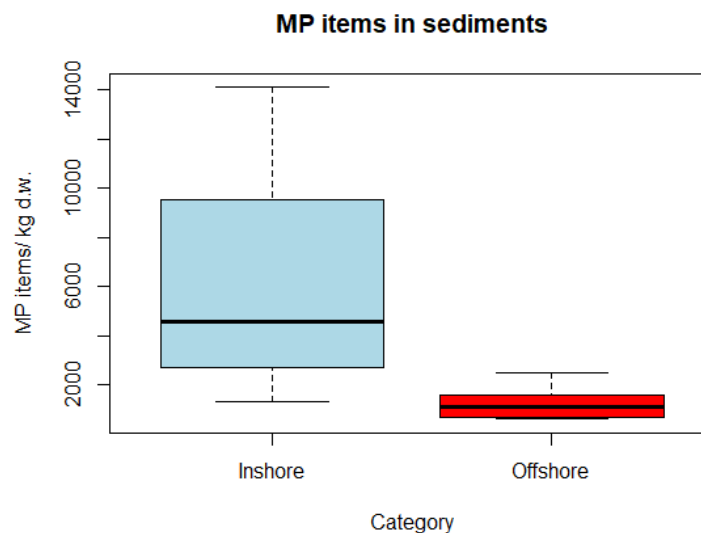
**Table 6-2 Percent composition of particles in sediment samples, as classified by FT-IR (match score of < 0.7 with the FT-IR library)**

Sample / Location	Unknown	Mineral	Undigested Organics	Coatings-adhesives	Petro-pyro	Plastic	Rubber	Most frequent microplastics	
Bekkelaget 1	56%	0.1 %	9.5 %	0.9 %	11.0 %	20%	2%	PE, PP, PS	
Lindesnes 1	80%	0.2 %	6.7 %	0.1 %	1.9 %	11%	0%	PE, PE:PP, Plastic (other)	
Nordgulen 1	64%	0.2 %	28.1 %	2.1 %	3.3 %	2%	0%	Epoxy Resin, Phenoxy Resin, PE-chlorinated	
Ålfjorden 1	82%	0.0 %	4.2 %	0.4 %	3.1 %	10%	0%	PE, Plastic (other), PE:PP	
R6-01	Norwegian Sea	83%	0.0 %	0.0 %	0.0 %	15%	2%	PE:PP, PE-chlorinated, PS	
R6-05		88%	0.2 %	0.0 %	0.3 %	6.2 %	5%	1%	PE-chlorinated, PET, PE:PP
R6-10		93%	0.4 %	0.3 %	1.1 %	1.9 %	3%	1%	PE, Organotin, PE-chlorinated
R6-17		85%	0.7 %	2.6 %	0.2 %	0.1 %	11%	0%	PE, PE-chlorinated, PE:PP
R6-20		79%	0.0 %	1.3 %	0.3 %	1.1 %	18%	0%	PE-chlorinated, PE, PS



**Figure 6-1 Pie-charts of particle composition from inshore and offshore sediment samples after workup**

When comparing microplastic items/kg d.w. sediments collected inshore and offshore (Figure 6-2), the inshore sediments contained a significantly higher concentration than the offshore sediments (F-value = 6.75,  $p$ -value = 0.04). This is most likely due to the higher degree of anthropogenic influence and potential sources of microplastic emissions to sediment in the inshore areas.



**Figure 6-2 Boxplot of microplastic items/kg d.w. sediment sampled inshore and offshore**

Differences in sampling and analytical methodologies make comparisons between microplastic studies difficult, such as the density on the density-solution used and the size range of microplastics quantified; however, some magnitude-scale comparisons can be performed with caution, if these differences are considered. In Table 7-6, information from previously reported microplastic abundances in top sediments from previous studies in adjacent areas have been listed in top sediments. The study by Knutsen et al., (2020) is the only study which may be directly compared with the results in this report as the same analytical method and laboratory facilities were used. The sediment samples analysed from the Norwegian Sea in this report display concentrations of MP items/kg d.w. comparable with those found in Knutsen et al. (2020). The Norwegian Sea sediments are also within the range of MP previously detected in deep-sea sediments at the HAUSGARTEN Observatory (Bergmann et al., 2017). However, it should be kept in mind that the HAUSGARTEN study was able to quantify microplastics less than 10  $\mu\text{m}$  and found the majority of particles to be less than 25  $\mu\text{m}$  (which is below the 45  $\mu\text{m}$  cut-off of this study). The most abundant polymers identified in the sediments from the Norwegian Sea in this report correspond with those frequently identified by Knutsen et al (2020) in sediments from Central North Sea, which were PE-chlorinated, rubber, PET and PAM, as well as those identified in the deep-sea sediments analysed by Bergmann et al. (2017) which were PE-chlorinated, PE, polyamide, PP and nitrile rubber.

A report by NGU (2018) from a pilot study of remote regions in the Norwegian Continental area, including the Barents Sea, though with one coastal location near Ålesund, discovered between 200 – 400 plastic items/kg sediment in three of the investigated areas (near Ålesund and outwards), and 1 – 200 items/kg in other areas. This is much lower than the number reported here for the offshore sediments which may be due to both differences in the methodology used and sampling in more remote locations.

The concentrations of microplastics in sediments in this report are also much higher than those previously found in Arctic sediments, which are subjected to much lower anthropogenic influence than the sediments analysed in this report (Collard et al., 2021; NGU 2019; Ramasamy et al., 2021). However, the most frequently detected plastic polymer in the Arctic sediments was also polyolefins, such as PE and PP, PET and PS (Collard et al., 2021; NGU 2019; Ramasamy et al., 2021).

The concentrations of microplastics detected in the inshore sediments of the present report were much higher than those previously detected in inshore sediments from the Oslo fjord (Bronzo et al., 2021; Olsen et al., 2020). Similar to the present report Olsen et al. (2020) have also analysed top sediments (0 – 10 cm) from Bekkelaget in the Oslo fjord, but detected a total of 270 MP items/kg sediment, where PP (57%), rubber (29) and PE (14%) were the most identified polymers. This is much lower than the concentrations detected in the present report, which could be due to the sampling location of the present sample, which was a marina, while Olsen et al. sampled further from land. Olsen et al. (2020) also analysed other sediments from the Oslo fjord (0 – 5 cm) and detected 240 – 1500 MP items/kg, where the most abundant polymers detected were PVC, PE and PE-oxidized. These results are more comparable to the inshore samples in the present report. Bronzo et al. (2021) have also analysed sediments from the more outer regions of the Oslo fjord, and found higher concentrations of microplastic particles detected in sediments close to WTP emission outlet. The most abundant polymer was polyesters (PET), PP and acrylate and polymethylmethacrylates (A + PMMA) (Bronzo, et al., 2021).

The relatively high microplastic concentrations found in inshore and offshore sediments confirm the widespread occurrence of microplastics in the marine environment. According to a review paper of microplastics in the marine environment (Hidalgo-Ruz et al., 2012), values for abundances ranged from 0.21 to more than 77 000 items per m<sup>2</sup> in sediment, which is several orders of magnitude higher than in the sea surface, which ranged from 0.00008 to 5 items per m<sup>2</sup>. This shows that a substantial amount of microplastics can be found in sediments, as also is indicated by this study. Sediments are proposed as the final destination of microplastics and other pollutants in the environment. This is due to natural processes such as biofouling, the buoyancy and density changes, which eventually can lead to deposition of microplastics in sediments (Arp et al., 2021).

**Table 7-6. Literature assessment on abundance of microplastics in top sediments. The concentrations are expressed as mg or items per kg dry sediment.**

Location	Location specification	Particle size	Measured concentration range	Methodological conditions	Reference
Arctic	Deep sea, HAUSGARTEN Observatory	10 µm – 5mm	42 - 6 595 items/kg d.w. Mean ± SE: 356 ± 675 items/kg	Separation fluid: $\rho = 1.7\text{-}1.8$ g/cm <sup>3</sup> , pore size of filter: 20 µm, chemical digestion: Fenton's reagent (FeSO <sub>4</sub> and H <sub>2</sub> O <sub>2</sub> ), identification: FT-IR	Bergmann et al. (2017)
Norway	Oslofjord sediment	45 µm – 5 mm plus fibres	3.3 – 20 mg/kg 240 – 1 500 items/kg	Separation fluid: $\rho = 1.55$ g/cm <sup>3</sup> , pore size of filter: 45 µm, chemical digestion: 30% H <sub>2</sub> O <sub>2</sub> , identification: FT-IR	Olsen et al. (2020)
Norway	Oslofjord sediment	35 µm – 8.75 mm plus fibres	60 – 1 120 items/kg d.w.	Separation fluid: $\rho = 1.8$ g/cm <sup>3</sup> , pore size of filter: 1.6 µm, identification: visual microscopy and FT-IR	Bronzo et al., 2021
Norway	Svalbard. Inner Kongsfjorden and inner Rijpfjorden	45 µm – 5 mm plus fibers	< 16 mg/ kg d.w. n.d. – 520 items/kg d.w.	Separation fluid: $\rho = 1.52$ g/cm <sup>3</sup> , pore size of filter: 45 µm, chemical digestion: 30% H <sub>2</sub> O <sub>2</sub> , identification: FT-IR	NGU (2019)
Norway	Svalbard, Kongsfjorden	55 – 381 µm	4 – 24 items/kg d.w.	Separation fluid: $\rho = 1.2$ g/cm <sup>3</sup> , pore size of filter: 1.6 µm, chemical digestion: 30% H <sub>2</sub> O <sub>2</sub> , identification: FT-IR	Ramasamy et al., (2021)
Norway	Svalbard, Kongsfjorden	140 µm – 6.3 mm	Mean ± SD.: 1.7 ± 0.4 items/kg d.w.	Separation fluid: $\rho = 1.2$ g/cm <sup>3</sup> , pore size of filter: 5 µm, chemical digestion: 30% H <sub>2</sub> O <sub>2</sub> , identification: visual microscopy and Raman spectroscopy	Collard et al. (2021)
Norway	Reference areas on the Norwegian coastal shelf	0 – 450 µm	23 – 391 items/kg d.w.	Separation fluid: $\rho = 1.6$ g/cm <sup>3</sup> , pore size of filter: 1.6 µm, chemical digestion: 30% H <sub>2</sub> O <sub>2</sub> , identification: visual microscopy and Raman spectroscopy.	NGU (2018)
Norway	Norwegian Continental Shelf	45 µm – 5 mm plus fibres	< 0.66 – ≤ 46 mg/kg d.w. n.d. – ≤ 3 400 items/kg d.w.	Separation fluid: $\rho = 1.52$ g/cm <sup>3</sup> , pore size of filter: 45 µm, chemical digestion: 30% H <sub>2</sub> O <sub>2</sub> , identification: FT-IR	Knutsen et al. (2020)
Norway	Reference areas on the Norwegian coastal shelf	43 µm – 5 mm plus fibres	< n.d. – 2.2 mg/kg 51 – 2 187 items/kg d.w.	Separation fluid: $\rho = 1.52$ g/cm <sup>3</sup> , pore size of filter: 43 µm, chemical digestion: 30% H <sub>2</sub> O <sub>2</sub> , identification: FT-IR	NGU (2021)
Norway	Inshore	45 µm – 5 mm plus fibres	1 294 – 14 091 items/kg d.w.	Separation fluid: $\rho = 1.52$ g/cm <sup>3</sup> , pore size of filter: 45 µm, chemical digestion: 30% H <sub>2</sub> O <sub>2</sub> , identification: FT-IR	<i>This report</i>
Norway	Reference areas in Norwegian Sea	45 µm – 5 mm plus fibres	599 – 2 513 items/kg d.w.	Separation fluid: $\rho = 1.52$ g/cm <sup>3</sup> , pore size of filter: 45 µm, chemical digestion: 30% H <sub>2</sub> O <sub>2</sub> , identification: FT-IR	<i>This report</i>

## 6.2 Microplastic concentrations in polychaeta

The concentrations of microplastic identified in polychaeta samples are listed in Table 6-3. The polychaeta sample collected at Bekkelaget, Oslo in 2021 contained the highest concentrations of MP particles analysed in this report, with 5 670 MP items/g w.w. (26.9 MP items/individual). The second highest concentration was 1 799 items/g w.w. (6 MP items/individual) detected in the polychaeta sample R1-04-B collected in Region 1 in the North Sea. Interestingly, the third highest concentration was 1 574 items/g w.w. (23.6 MP items/individual) detected in sample GJAB-02 collected in the Barents Sea. The lowest concentration was 12 MP items/g w.w. (0.19 MP items/individual) detected in sample R6-05 collected in Region 6 in the Norwegian Sea. Except for the three highest concentrations detected, the majority of the microplastic concentrations were comparable with those found by Knutsen et al. (2020) which ranged from 11 – 880 items/g<sub>ww</sub>.

**Table 6-3 Concentrations of microplastic identified in polychaeta samples by FT-IR (match score > 0.7 with the FT-IR library)**

Sample / Location		MP mg/g w.w.	MP items/individual	MP Items/ g w.w.
Bekkelaget 1		n.d.	26.9	5 670
Nordgulen 1		8.46	1.54	441
Lindesnes 1		0.40	8.35	482
Ålfjorden 1		0.34	5.31	500
R1-02	North Sea	n.d.	5.47	678
R1-04		n.d.	16.0	1 799
R1-14		0.29	4.84	535
R2-21A		n.d.	1.55*	420
R6-01	Norwegian Sea	0.01	3.15*	76
R6-05		n.d.	0.19*	12
R6-10		1.68	0.48*	12
R6-17		n.d.	1.01*	38
R6-20		n.d.	1.04*	156
GJAB-02	Barents Sea	7.17	23.6	1 574
R9-11		0.43	5.09	447
SKR-03		n.d.	1.10	70
North Sea	Mean ± SD (min-max)	0.29 (-)	7 ± 6 (1.6 -16)	858 ± 636 (420 – 1799)
Norwegian Sea	Mean ± SD (min-max)	0.8 ± 1 (0.01 – 1.68)	1 ± 1 (0.19 - 3.15)	59 ± 60 (12 - 156)
Barents Sea	Mean ± SD (min-max)	4 ± 5 (0 - 7)	10 ± 12 (1.1 - 24)	697 ± 783 (70 - 1574)
Inshore	Mean ± SD (min-max)	3 ± 5 (0.3 - 8)	11 ± 11 (1.5 - 27)	1773 ± 2598 (441 - 5670)
Offshore	Mean ± SD (min-max)	2 ± 3 (0 - 7)	5.3 ± 7 (0.2 - 24)	485 ± 607 (12 - 1799)
All areas	Mean ± SD (min-max)	3 ± 3.1 (0 - 8)	6.6 ± 8 (0.2 - 27)	807 ± 1397 (12 - 5670)

n.d.: weight of sample material was below the limit of detection for the analytical balance (<0,001 g); \* Polychaeta worms in samples were fragmented and thus sample size was estimated based on visual interpretation.

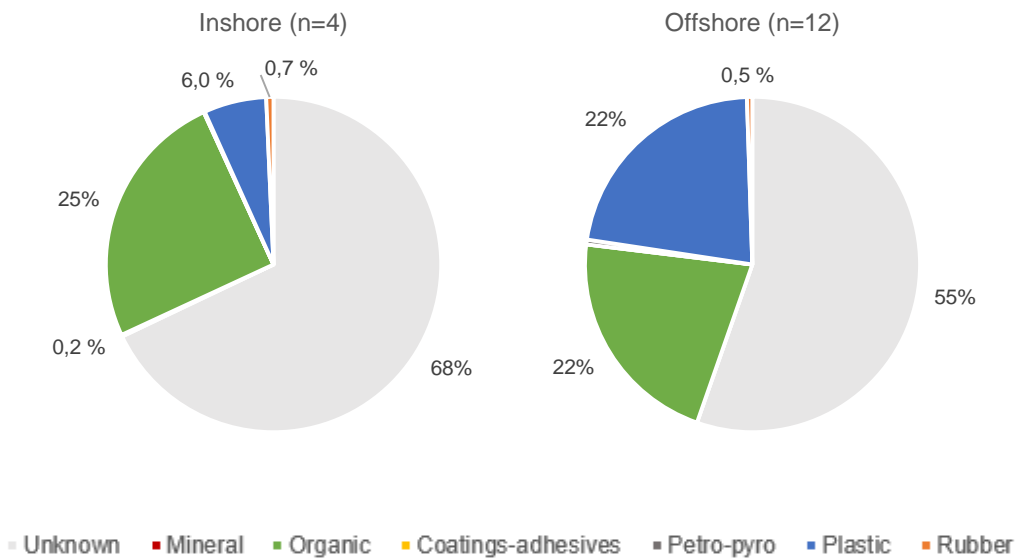
The composition of particles classified by FT-IR analyses is listed in Table 6-4 (in appendix A) and visualized in Figure 6-3. On average, 18.7 % of the particles analysed by FT-IR were confirmed to be microplastic (plastic, coatings-adhesives or rubber). The most frequent plastic polymers detected in the polychaeta samples were PE-chlorinated, PE, nylon and rubber, which is comparable with Knutsen et al. (2020). As all the samples were stored the same way as the polychaeta samples analysed in Knutsen et al., (2020) with PE-lids, the amount of PE and PE-chlorinated should be interpreted with caution. PE was only detected in 5 of the 16 polychaeta samples, while PE-chlorinated was detected in 15 of 16 samples with an average detection frequency of 38 %. The amount of organic material is varying greatly and can reflect both amount of fibre from lab coats or production of 20 mm filters, or the successfulness of the chemical oxidation of the sample.

**Table 6-4 Percent composition of particles in the polychaeta samples, as classified by FT-IR analyses (match score of < 0.7 with the FT-IR library)**

Sample / Location	Unknown	Mineral	Organic	Coatings-adhesives	Petro-pyro	Plastic	Rubber	Most frequent microplastics*	
Bekkelaget 1	83%	0.0 %	7.5 %	0.0 %	0.0 %	10%	0.1 %	PE-chlorinated, PVC, Plastic additive	
Nordgulen 1	0.0 %	0.0 %	92 %	0.0 %	0.0 %	5.6 %	2.2 %	PE-chlorinated, Rubber (other), PE:PP	
Lindesnes 1	92%	0.6 %	0.7 %	0.0 %	0.3 %	6.1 %	0.5 %	PE-chlorinated, Rubber (other), PAM	
Ålfjorden 1	97%	0.0 %	0.0 %	0.0 %	0.0 %	3.0 %	0.0 %	PE, PE-chlorinated, PS	
R1-02	North Sea	69%	0.0 %	18%	0.0 %	0.2 %	13%	0.0 %	PE-chlorinated, Nylon, PS
R1-04		77%	0.0 %	8.5 %	0.0 %	0.0 %	14%	0.5 %	PE, PE-chlorinated, Rubber (other)
R1-14		91%	0.0 %	5.5 %	0.0 %	0.0 %	3.0 %	0.0 %	PE-chlorinated, PE:PP, Plastic (other)
R1-21A		0.0 %	0.0 %	53 %	0.0 %	5.1 %	39 %	3.5 %	Nylon, Melamine, PE-oxidized
R6-01	Norwegian Sea	97%	0.0 %	0.0 %	0.0 %	0.0 %	2.8 %	0.0 %	PE-chlorinated, PET, Plastic (other)
R6-05		99%	0.0 %	0.7 %	0.0 %	0.0 %	0.1 %	0.0 %	PE-chlorinated
R6-10		0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	100%	0.0 %	Nylon, PE-chlorinated, PE:PP
R6-17		0.0 %	0.0 %	90%	0.0 %	0.0 %	8.2 %	1.8 %	PE-chlorinated, Rubber (other), PE:PP
R6-20		0.0 %	0.0 %	83%	0.0 %	0.0 %	17%	0.0 %	Plastic (other), PE, PMMA
GJAB-02	Barents Sea	39%	0.0 %	0.0 %	0.0 %	0.0 %	61%	0%	PE, Plastic (other), PE-oxidized
R9-11		93%	0.0 %	0.2 %	0.0 %	0.0 %	6.6 %	0.0 %	PE, PE-oxidized, PE-chlorinated
SKR-03		99%	0.0 %	0.0 %	0.0 %	0.2 %	0.4 %	0.5 %	Rubber (other), PE-chlorinated

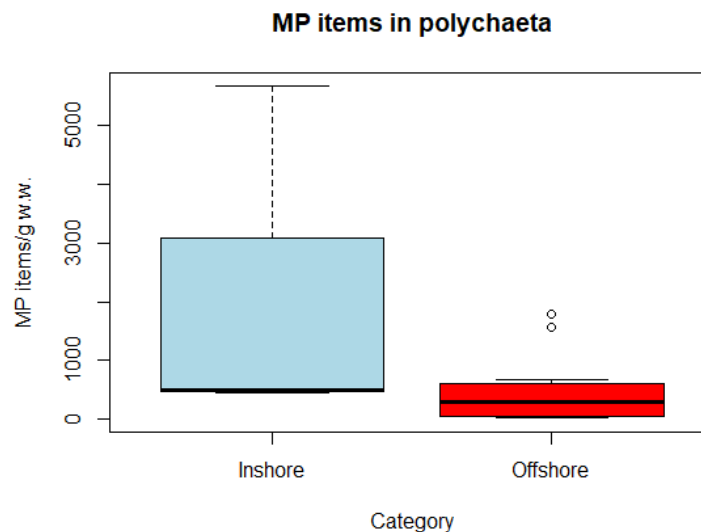
\* PE and PE-chlorinated need to be interpreted with caution due to storage in glass vials with PE lids





**Figure 6-3 Pie-chart of particle composition in polychaeta samples**

Due to the large variation in amount of microplastic particles detected, especially in the inshore polychaeta samples (Figure 6-4), the difference in microplastic items/g w.w. identified in samples from inshore and offshore sediments were not statistically significant (F-value= 2.89,  $p$ -value = 0.11), though inshore polychaeta had generally larger concatenations than offshore polychaeta



**Figure 6-4 Boxplot of microplastic items/g w.w. identified in polychaeta sampled inshore and offshore**

### 6.3 Comparisons between microplastics in sediments and its associated polychaeta

A comparison of microplastic concentrations in sediment and polychaeta samples are shown in Table 6-5, as well as the projected Biota-Sediment Particle Enrichment Factor (BSPEF) to estimate the potential enrichment of microplastic in polychaeta relative to their surrounding sediments (Knutsen et al., 2020). To our knowledge, is the second study applying the BSPEF to compare microplastic concentrations detected in polychaeta and sediment samples. The BSPEF ranged from 11 to 4 864 g<sub>d.w.</sub>/ g<sub>w.w.</sub> which is in the lower range compared to Knutsen et al., (2020) were 100 to 11 000 g<sub>d.w.</sub>/ g<sub>w.w.</sub>.. was detected for polychaeta and sediments also sampled on the Norwegian continental shelf. Knutsen et al., (2020) also analysed polychaeta and sediments sampled at Reg 1-14, both in 2017, and estimated a BSPEF of 208 g<sub>d.w.</sub>/ g<sub>w.w.</sub>. The BSPEF for Reg 1-14 of 4 864 in this report used data from polychaeta sampled in 2020 and sediments from 2017 (Knutsen et al., 2020) and is over 17 times higher than the previous BSPEF, indicating large variations between sampling years for polychaeta, or alternatively simply large variations from the same area. There may also be large variations in settlement of microplastic particles in sediments, thus the present BSPEFs presented in Table 6-5 should be interpreted with caution as the polychaeta and sediments for all samples, except those from Region 6 (R6) and Lindesnes were sampled in different years. When investigating BSPEF calculated for samples collected within the same location and year, the range is from 11 to 127 g<sub>d.w.</sub>/ g<sub>w.w.</sub>.

**Table 6-5 A comparison of the concentrations of microplastics identified in polychaeta and sediments by FT-IR (match score > 0.7 with the FT-IR library), as well as the estimated Biota-Sediment Particle Enrichment Factor (BSPEF).**

Sample	Location	Polychaeta Items/ g w.w.	Sediments Items/ g d.w.	Items BSPEF g d.w./ g w.w.
Bekkelaget 1		5 670	14.09	402
Nordgulen 1		441	1.29	342
Lindesnes 1		482	4.15	116
Ålfjorden 1		500	5.00	100
R1-02	North Sea	678	n.d.	-
R1-04		1 799	n.d.	-
R1-14		535	0.11	4 864
R2-21A		420	n.a.	-
R6-01	Norwegian Sea	76	0.60	127
R6-05		12	0.67	18
R6-10		12	1.114	11
R6-17		38	1.60	24
R6-20		156	2.51	62
GJAB-02	Barents Sea	1 574	n.a.	-
R9-11		447	0.54 <sup>*(SC3-4)</sup>	828
SKR-03		70	0.05 <sup>*(KRT-14)</sup>	1 400

n.d.: not detected; n.a. : not analysed; \* : Data collected from Knutsen et al.(2020), identity of sediment sample is specified if it varies from the polychaeta id.

No significant correlation could be detected between microplastic items in polychaeta and sediments (RS = 0.35, p-value = 0.26). However, it is noted that this data may be reinterpreted in future, due to some of the polychaeta being sampled at locations at considerable distances and time from the sediment samples. In future only data from simultaneously sampled polychaete and sediment may be considered, with a selection of other samples that meet a proximity criterion.

The most abundant plastic polymers identified in the sediment and polychaeta samples are listed in Table 6-6.

**Table 6-6 Comparisons of the most abundant plastics identified in sediment – and polychaeta samples from the same stations. Plastics are herein defined as plastic polymers, coatings-adhesives and rubber.**

Sample / Location		Most frequent microplastics identified in sediment	Most frequent microplastics identified in polychaeta
Bekkelaget 1		PE, PP, PS	PE-chlorinated, PVC, Plastic additive
Nordgulen 1		PE, PE:PP, Plastic (other)	PE-chlorinated, Rubber (other), PE:PP
Lindesnes 1		Epoxy Resin, Phenoxy Resin, PE-chlorinated	PE-chlorinated, Rubber (other), PAM
Ålfjorden 1		PE, Plastic (other), PE:PP	PE, PE-chlorinated, PS
R1-02	North Sea	n.d.*	PE-chlorinated, Nylon, PS
R1-04		n.d.*	PE, PE-chlorinated, Rubber (other)
R1-14		PP, PVC, PE *	PE-chlorinated, PE:PP, Plastic (other)
R2-21A		n.a.	Nylon, Melamine, PE-oxidized
R6-01	Norwegian Sea	PE:PP, PE-chlorinated, PS	PE-chlorinated, PET, Plastic (other)
R6-05		PE-chlorinated, PET, PE:PP	PE-chlorinated
R6-10		PE, Organotin, PE-chlorinated	Nylon, PE-chlorinated, PE:PP
R6-17		PE, PE-chlorinated, PE:PP	PE-chlorinated, Rubber (other), PE:PP
R6-20		PE-chlorinated, PE, PS	Plastic (other), PE, PMMA
GJAB-02	Barents Sea	n.a.	PE, Plastic (other), PE-oxidized
R9-11		Rubber, phenoxy resin, PE:PP, PE-oxidized *(SC3-4)	PE, PE-oxidized, PE-chlorinated
SKR-03		Rubber, organo-tin resin, PP *(KRT-14)	Rubber (other), PE-chlorinated

n.d.: not detected; n.a. : not analysed; \* : Data collected from Knutsen et al.(2020), identity of sediment sample is specified if it varies from the polychaeta id.

For sediments polyolefins such as PE, PP, PE:PP, and PE-chlorinated, some adhesives-coatings and rubber were among the most frequently detected. This was quite similar for the polychaeta samples, where PE-chlorinated, PE and rubber were the most frequently identified polymers. However, by direct comparisons between polychaeta and sediment samples within the same sampling location show differences in plastic polymers detected in the two matrixes, as previously seen in Knutsen et al., (2020). Thus, the high BSPEF values does not indicate enrichment of specific polymer types, but rather net enrichment of microplastic particles. The high BSPEF values detected in the present report, and in Knutsen et al, (2020) indicate substantial

enrichment, which indicate accumulation and potential transport of microplastic particles by polychaeta in sediments. One potential explanation for this could be that PE-chlorinated was found to have similar FT-IR spectra to biofouled PE in previous studies, and further PVC materials could also be reported as PE-chlorinated, which can indicate PE-chlorinated data is difficult to distinguish between PE and PVC.

## 6.4 Uncertainties and evaluation of method

### 6.4.1 Density limitation

Typical densities for sand or other sediments, including carbonate seashells, are approximately 2.6 g/cm<sup>3</sup>, whereas density values for virgin plastic resins range from 0.8 to 1.4 g/cm<sup>3</sup> (Hidalgo-Ruz et al., 2012). Density separation with zinc-chloride solution ( $\rho \sim 1.53$  g/cm<sup>3</sup>) will thus separate the lighter particles from the heavier sediment grains. However, there are some types of plastic with densities higher than this, such as Teflon and mixtures of polymers and glass or polymers and metals. By that means, plastics with a density higher than 1.53 g/cm<sup>3</sup> are not extracted by the method applied in this report, which may have led to an underestimation of the total microplastics concentration present in the samples. However, the density of the zinc-chloride solution in this report ( $\rho \sim 1.53$  g/cm<sup>3</sup>) is higher than the density of saturated sodium chloride solutions used in other sediment surveys (ten of 13 sediment studies applied a concentrated saline solution with a density of 1.2 g/cm<sup>3</sup>, and other solutions applied were a sodium polytungstate solution with a density of 1.4 g/cm<sup>3</sup>) (Hidalgo-Ruz et al., 2012).

### 6.4.2 Particle size limitation

Due to the filter size of 45  $\mu$ m, the results in this report may have been underestimated, as Bergmann et al. (2017) reported that a significant amount of the counted MP particles were smaller than 25  $\mu$ m in their study. Thus, some of the smaller microplastics were not detected by the method used in this report.

### 6.4.3 Digestion limitation

The digestion method used here was optimised to be as destructive as possible to organic matter (including cellulose, chitin, proteins, lipids, etc.), while leaving synthetic polymers intact. In the development of this method, it was systematically tested for this and found to digest recalcitrant organic matter like cellulose at 98  $\pm$  4%, while not causing any weight change to granules and only a minimum weight change to plastic fibres (0-4%), as described in Olsen et al., (2020).

Most of the material separated in the BMSS was  $\ll$  1 mm. Thus, it is likely that the digestion removed most of the organic matter, as it is more difficult and time consuming to completely digest larger organic matter particles than smaller particles. Nevertheless, some organic matter did remain in some of the sediment and polychaeta samples which was confirmed by the FT-IR analyses. Further, other low density carbonaceous materials like coal, charcoal, bitumen, etc. could have also survived and may have poor spectres due to weathering or biofouling, thus being characterized as an unknown particle. Another concern for some of the samples was that rust was observed on the steel filter after digestion, which may have occurred from residual ZnCl<sub>2</sub> reacting with water in the atmosphere. Digestion of plastic materials themselves is to some extent accounted for by the correction using spiked blanks. Thus, overall, these digestion limitations represent a bias that would increase the reported concentrations of microplastics in both sediment and polychaeta samples.

### 6.4.4 Limitation of FT-IR analyses

There are also limitations regarding to the FT-IR analysis used. In literature, it is common to use a quality index of 0.7 as the limit (Obbard et al., 2014). This limit was also used in this report. However, weathering of the polymers affects their surface and thereby their spectra, which makes comparison with reference spectra more difficult. Therefore, a score limit of 0.7 could lead to an underestimation of plastics, as particles with a lower score in fact could be plastics. At the same time, the cut-off of 0.7 could have resulted in an overestimation of plastics if the limit is not conservative enough, as the uncertainty increases with decreasing score.

Furthermore, there are uncertainties associated with the actual FT-IR apparatus. For instance, to obtain high quality spectra in transmission mode, it is best with samples that are translucent, and they should sit as flat on the window as possible. However, particles from environmental samples, like in this project, are often irregularly shaped and with an uneven surface, or they can be highly opaque and thick, which may reduce the quality of the recorded spectra using ATR. Further, in order to get good transmission signals, the beam path should not be obstructed by the steel mesh threads during analysis. To avoid this, effort was made to only scan a part of the particles that were not overlapping with the steel mesh. However, keeping the steel filters completely flat during sample preparation prior to FT-IR analysis was challenging and may have led to the pore size appearing smaller in bent areas of the filter. When slightly bent, the risk of losing particles during transfer of the filters from the filtration apparatus to the sample holder appeared to be higher as they were more inclined to move around on the filter. It is uncertain to what extent this may have led to an underestimation of the results.

Unknown particles are particles whose FT-IR spectra gave a match score  $< 0.7$  with the library. In addition to the fact that the particles classified as unknown may have been particles missing in the library database, their relatively low scores could be caused by other factors, such as differences between the surface of the reference sample and measurement target and bad transmission signals of opaque particles. E.g. if the surface of the sample is weathered and oxidized, or if it is coated, the spectrum will not match well with the reference. A relatively poorer match is also expected if an analysed microplastics particle consists of a mixture of different polymers and additives, such as many coatings-adhesives and epoxides. Hence, if the samples contained highly weathered microplastics and composite particles, this could lead to an underestimation of the microplastic concentration. It is, however, considered more likely that most of the unknowns consists of other materials such as coal, charcoal and incompletely digested organic material.

Further, some FT-IR matches can be ambiguous due to closely overlapping spectra. As mentioned above, PE-chlorinated FT-IR spectra resemble both bio-filmed coated PE and PVC, making them difficult to distinguish, particularly when the scores are between 0.7-0.9.

#### 6.4.5 Potential sources of contamination of sediment samples

The offshore sediment samples were collected in glass jars with metal screw cap with no other sealant. The gasket and inside of the metal screw caps had a plastic coating which was investigated using macro FT-IR at NGI. The gasket had a match of 78.1 % for PVC, while the coating on inside of the lid had a match of 80.1 % for PET. The inshore sediment samples were collected in low density PE zip-lock bags (Ålfjorden) or Rilsan (nylon) bags. The bag materials were confirmed using macro FT-IR, the zip-lock bag had a 99.1 % match for PE, while the Rilsan bag had a 97.9 % match for nylon (polyundecanoamide). We can therefore not exclude the possibility of potential PVC, PET, PE or nylon contamination of these respective sediment samples when opening and closing of the glass jars or bags.

To prevent microplastic contamination, future sediment samples should be stored in glass jars, preferably pre-rinsed with MiliQ-water, with aluminium foil covering the lid to avoid contact with the gasket. Samples may also be stored in airtight and leak-proof stainless-steel containers.

#### 6.4.6 Potential sources of contamination of the polychaeta samples

The polychaeta samples were not collected with the aim of analysing microplastic content. Thus, no specific consideration was taken to minimize potential sources of microplastic during sorting, handling and storage prior to microplastic analyses at NGI. The polychaeta were first sorted from other in white plastic trays (PVC), then stored in ethanol dram glass with plastic click lid. The glasses were not rinsed with MiliQ-water to remove potential dust particles before adding the samples. The plastic trays had a 79.5 % match for PVC and the click lid had a match of 99.2 % for high density PE.

To prevent microplastic contamination, future polychaeta samples should be sorted in glass or metal trays and stored in ethanol in dram glass with metal or glass lids pre-rinsed with MiliQ-water to remove potential dust particles.

## 7 CONCLUSION

This report provides information regarding microplastic content in sediments and polychaeta from inshore and offshore areas in Norway. The main conclusions are:

- ✓ The sediments samples in inshore areas had significantly higher concentrations of microplastics/kg dw. (mean  $\pm$  SD: 6 132  $\pm$  5 537) than the offshore sediments (mean  $\pm$  SD: 1 298  $\pm$  788). This is most likely due to more anthropogenic influence and sources of plastic emissions. These concentrations are comparable with those reported in the previous study (Knutsen et al, 2020).
- ✓ Although the difference was not statistically significant, the inshore polychaeta samples had somewhat higher concentrations of microplastic items/g w.w. (mean  $\pm$  SD: 1 773  $\pm$  2 598), than the offshore polychaeta (mean  $\pm$  SD: 485  $\pm$  607). The polychaeta concentrations were similar to range previously reported by Knutsen et al. (2020) of 11 – 880 items/g<sub>ww</sub>. with the exception of three samples which were higher in this study.
- ✓ The most frequently detected plastic polymers were PE, PE-chlorinated, PP, PS and rubber in both sediments and polychaeta samples, however there was also large variation between corresponding sediment and polychaeta samples. This may be partly due to the PE-chlorinated spectra resembling both biofouled PE and PVC.
- ✓ The BSPEF ranged from 11 to 4 864 g<sub>d.w.</sub>/ g<sub>w.w.</sub> which is in the lower range compared to Knutsen et al., (2020) were 100 to 11 000 g<sub>d.w.</sub>/ g<sub>w.w.</sub>. was detected for polychaeta and sediments also sampled on the Norwegian continental shelf.

The environmental impact of microplastics on benthic ecosystems are unknown and in need further investigation (Galloway et al. 2017). This is particularly the case because the anticipated concentrations of microplastics are expected to increase in the foreseeable future, potentially reaching levels where they become a planetary boundary threat (Arp et al., 2021; Jahnke et al. 2017).

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## APPENDIX A

### Supplementary information analyses of sediments and fauna

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## APPENDIX A

### Contents

1	RESULTS.....	1
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# 1 RESULTS

## 1.1 Sediment

**Table A1-1 Percent composition of plastic polymers in sediment samples identified by FT-IR (match score > 0.7). n.d. = not detected**

Sample / Location	Category	PE	PP	PE:PP	PE-chlorinated	PE-chloro-sulfonated	PE-oxidized	PET	PVC	PS	
Bekkelaget 1	Inshore	29.0%	21.8%	4.0%	1.5%	0.1%	2.6%	0.6%	1.8%	9.5%	
Lindesnes 1	Inshore	57.5%	4.3%	10.2%	5.1%	n.d.	4.0%	0.3%	n.d.	0.4%	
Nordgulen 1	Inshore	n.d.	9.3%	n.d.	17.0%	n.d.	n.d.	14.6%	n.d.	n.d.	
Ålfjorden 1	Inshore	52.7%	5.6%	5.8%	n.d.	n.d.	4.5%	2.5%	n.d.	3.9%	
R6-01-S	Norwegian Sea	Offshore	n.d.	n.d.	40.7%	23.2%	n.d.	5.0%	n.d.	n.d.	13.7%
R6-05-S		Offshore	n.d.	n.d.	9.5%	38.0%	n.d.	8.8%	10.9%	n.d.	n.d.
R6-10-S		Offshore	25.6%	n.d.	7.6%	17.6%	n.d.	7.2%	n.d.	n.d.	n.d.
R6-17-S		Offshore	46.2%	n.d.	6.0%	41.9%	n.d.	n.d.	n.d.	n.d.	n.d.
R6-20-S		Offshore	19.4%	n.d.	4.1%	53.4%	n.d.	5.3%	n.d.	n.d.	8.7%

**Table A1-2 Continuation of Table A1-1 Percent composition of plastic polymers in sediment samples identified by FT-IR (match score > 0.7). n.d. = not detected**

Sample / Location	Category	PAM	PMMA	PVF	Melamine	Nylon	EVA	Plastic additive	Plastic other	
Bekkelaget 1	Inshore	0.5%	5.0%	0.3%	0.1%	1.7%	0.8%	2.2%	7.4%	
Lindesnes 1	Inshore	1.0%	1.0%	n.d.	0.4%	4.5%	n.d.	n.d.	6.0%	
Nordgulen 1	Inshore	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.2%	9.9%	
Ålfjord 1	Inshore	n.d.	2.0%	n.d.	0.5%	1.0%	0.7%	0.3%	13.4%	
R6-01	Norwegian Sea	Offshore	n.d.	5.8%	n.d.	n.d.	n.d.	n.d.	n.d.	
R6-05		Offshore	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	9.0%	
R6-10		Offshore	n.d.	n.d.	n.d.	n.d.	3.4%	n.d.	0.9%	n.d.
R6-17		Offshore	2.0%	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
R6-20		Offshore	n.d.	1.4%	n.d.	n.d.	1.9%	n.d.	3.2%	n.d.



**Table A1-3 Percent composition of rubber in sediment samples identified by FT-IR (match score > 0.7). n.d. = not detected**

Sample / Location	Category	Rubber.Resinall	Rubber.Plasthall	SBR	Silicon	Rubber other
Bekkelaget 1	Inshore	2.7%	n.d.	n.d.	0.4%	4.0%
Lindesnes 1	Inshore	n.d.	n.d.	1.0%	n.d.	3.1%
Nordgulen 1	Inshore	n.d.	n.d.	n.d.	n.d.	n.d.
Ålfjorden 1	Inshore	0.6%	1.4%	n.d.	n.d.	1.4%
R6-01	Norwegian Sea	Offshore	5.8%	5.8%	n.d.	n.d.
R6-05		Offshore	n.d.	9.5%	n.d.	n.d.
R6-10		Offshore	2.5%	2.5%	n.d.	n.d.
R6-17		Offshore	n.d.	n.d.	n.d.	n.d.
R6-20		Offshore	n.d.	n.d.	1.4%	n.d.
		Offshore				

**Table A1-4 Percent composition of coatings and adhesives in sediment samples identified by FT-IR (match score > 0.7). n.d.= not detected**

Sample / Location	Category	Phenoxy Resin	Epoxy Resin	Epoxy Resin (as cyano-guanidine)	Organotin	Coatings-adhesives (other)
Bekkelaget 1	Inshore	0.3%	1.9%	n.d.	0.3%	1.6%
Lindesnes 1	Inshore	n.d.	n.d.	n.d.	n.d.	1.0%
Nordgulen 1	Inshore	20.7%	27.3%	n.d.	n.d.	n.d.
Ålfjorden 1	Inshore	2.1%	0.8%	n.d.	0.8%	n.d.
R6-01	Norwegian Sea	Offshore	n.d.	n.d.	n.d.	n.d.
R6-05		Offshore	n.d.	n.d.	n.d.	4.8%
R6-10		Offshore	n.d.	n.d.	n.d.	22.7%
R6-17		Offshore	n.d.	n.d.	n.d.	2.0%
R6-20		Offshore	n.d.	n.d.	n.d.	n.d.
		Offshore				



## 1.2 polychaeta

**Table A1-5 Percent composition of plastic polymers in polychaeta samples identified by FT-IR (match score > 0.7). n.d. = not detected**

Sample / Location	Category	PE	PP	PE:PP	PE-chlorinated	PE-chloro-sulfonated	PE-oxidized	PET	PVC	PS	PAM	
Ålfjorden 1	Inshore	93.5%	n.d.	n.d.	3.8%	n.d.	n.d.	n.d.	n.d.	2.68%	n.d.	
Bekkelaget 1	Inshore	n.d.	n.d.	n.d.	93.9%	n.d.	n.d.	n.d.	1.82%	0.03%	n.d.	
Nordgulen 1	Inshore	n.d.	n.d.	0.46%	70.9%	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	
Lindesnes 1	Inshore	n.d.	n.d.	n.d.	86.9%	n.d.	n.d.	n.d.	n.d.	n.d.	3.51%	
<b>R1-02</b>	North Sea	Offshore	n.d.	n.d.	74.4%	n.d.	n.d.	n.d.	n.d.	2.45%	n.d.	
<b>R1-04</b>		Offshore	54.1%	n.d.	0.82%	35.8%	n.d.	n.d.	n.d.	2.45%	n.d.	
<b>R1-14</b>		Offshore	n.d.	n.d.	2.71%	94.7%	n.d.	n.d.	n.d.	n.d.	n.d.	
<b>R1-21A</b>		Offshore	n.d.	n.d.	8.49%	4.0%	n.d.	9.98%	n.d.	n.d.	n.d.	n.d.
<b>R6-01</b>	Norwegian Sea	Offshore	n.d.	n.d.	65.3%	n.d.	n.d.	17.3%	n.d.	0.32%	n.d.	
<b>R6-05</b>		Offshore	n.d.	n.d.	n.d.	10n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	
<b>R6-10</b>		Offshore	n.d.	n.d.	0.49%	45.1%	n.d.	n.d.	n.d.	n.d.	n.d.	
<b>R6-17</b>		Offshore	n.d.	n.d.	0.29%	81.5%	n.d.	n.d.	n.d.	n.d.	n.d.	
<b>R6-20</b>		Offshore	35.2%	n.d.	0.48%	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
<b>R9-11</b>	Barents Sea	Offshore	75.3%	n.d.	n.d.	1.2%	n.d.	23.35%	n.d.	n.d.	0.09%	n.d.
<b>SKR-03</b>		Offshore	n.d.	n.d.	n.d.	46.5%	n.d.	n.d.	n.d.	n.d.	n.d.	
<b>GJAB-02</b>		Offshore	83.8%	n.d.	n.d.	4.1%	n.d.	5.03%	n.d.	n.d.	n.d.	n.d.



**Table A1-7 Percent composition of rubber in polychaeta samples identified by FT-IR (match score > 0.7). n.d. := not detected**

Sample / Location	Category	Rubber.Resinall	Rubber.Plasthall	SBR	Silicon	Rubber.other
Ålfjorden 1	Inshore	n.d.	n.d.	n.d.	n.d.	n.d.
Bekkelaget 1	Inshore	n.d.	n.d.	n.d.	n.d.	0.9%
Nordgulen 1	Inshore	n.d.	n.d.	n.d.	n.d.	28.6%
Lindesnes	Inshore	n.d.	n.d.	n.d.	n.d.	7.0%
R1-02	Central North Sea	Offshore	n.d.	n.d.	n.d.	n.d.
R1-04		Offshore	n.d.	n.d.	n.d.	3.2%
R1-14		Offshore	n.d.	n.d.	n.d.	n.d.
R1-21A		Offshore	n.d.	n.d.	n.d.	8.4%
R6-01	Norwegian Sea	Offshore	n.d.	n.d.	n.d.	n.d.
R6-05		Offshore	n.d.	n.d.	n.d.	n.d.
R6-10		Offshore	n.d.	n.d.	n.d.	n.d.
R6-17		Offshore	n.d.	n.d.	n.d.	18.2%
R6-20		Offshore	n.d.	n.d.	n.d.	n.d.
R9-11	Barents Sea	Offshore	n.d.	n.d.	n.d.	n.d.
SKR-03		Offshore	n.d.	n.d.	n.d.	53.5%
GJAB-02		Offshore	n.d.	n.d.	n.d.	n.d.





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