12. OCCURRENCE OF MICROPLASTICS IN THE SOUTHERN OCEAN

Patricia Burkhardt-Holm[1]; Clara Leistenschneider[1,2], Gunnar Gerdts[2] (not on board)

[1]CH.UNIBAS
[2]DE.AWI

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Objectives

Our aim is to study the occurrence, concentration, distribution, composition and, eventually, the possible sources and sinks of microplastics (MP) in the Antarctic marine ecosystem. We aim to achieve the following results by:

(1) Sampling and analyzing surface- and sub-surface water of the Southern Ocean.
(2) Characterizing the MP in the Southern Ocean with respect to particle size, morphology, polymer types and color to ascertain origins and possible (former) uses.
(3) Assessing the characteristics, concentration and distribution of MP in the relatively pristine Weddell Sea (WS) to compare it (in future cruises and in collaboration with other partners) to the more anthropogenically-impacted Scotia Sea (SS) and Western Antarctic Peninsula (WAP).
(4) Analyzing MP in scats of Weddell Seals to assess the amount of MP in an exemplary marine mammal predator and to gain insight on the importance of MP in the Antarctic food web.
(5) Sampling and analyzing potential sinking MP throughout the water column (at 100m, 200m, 300m depth) by means of drift trap samples.
(6) Investigating the occurrence of MP in sediments, a potential sink for MP pollution.

Work at sea

Surface water was sampled for MP (10µm – 500µm) with an immersion pump (HOMA, CH432; n = 17). To sample surface water out of the reach of vessel-induced contamination we made use of the rubber boat to deploy a small Manta Trawl (Hydro-Bios, Microplastic net, 43827; mesh size: 300µm) for 20 minutes at a distance of 600m and 500m to the RV, respectively (n = 2). Sub-surface water was sampled by filtering pumped seawater from beneath the vessel at approximately 11.2 m depth (n = 18).

In addition to water samples, seal scats were collected for MP analyses by the SEAROSE and the Sea Ice team (see Chapter 4, and Chapter 6, respectively, n= 23). Sediment samples collected with the Multi Grab were provided to us by the Benthic Fauna group and drifting sediment trap gels were taken in cooperation with the Particle Flux group (see Chapter 10 and Chapter 7, respectively).

Samples which were taken for MP >300µm (Manta trawl and Drifting Trap) were screened visually for MP on board using a stereo microscope (Olympus SZ61) equipped with a camera (Olympus SC50). Particles were imaged and the longest diameter of each particle was measured (CellSense, Version 2.1). Suspicious particles will be analyzed using Attenuated

Total Reflection (ATR) Fourier Transform Infrared Spectrometry (FT-IR) to confirm that particles are synthetic polymers and to evaluate the polymer composition. Samples that will be analyzed for small MP (10µm – 500µm) were stored frozen at -20°C and will be analyzed at the laboratories of AWI Helgoland in cooperation with Gunnar Gerdts (AWI) applying Focal Plane Array (FPA) based FT-IR subsequently to a purification treatment.

Surface water sampled by in situ immersion pump

17 surface water samples were collected by means of the immersion pump on PS124 (Figure 12.1, Table 12.1). Except for one sampling event, where only 273.9 liters were pumped due to unknown reasons, all sampling events were completed successfully and the 1000l stainless steel tank (Inox Behälter GmbH, PC1000A4) was completely filled with sea water. The mobile immersion pump and the 1000l tank were connected via a 15 m PTFE hose. All three components were rinsed with seawater from the respective station prior to filling the tank with the final sample.

For rinsing and sampling the immersion pump with the attached PTFE-hose was deployed by the on-board crane. The crane was extended to its maximum and the steel rope of the crane was released long enough to submerge the pump (approx. 30 - 80 cm below the water surface depending on the sea state). During sampling the immersion pump was approximately 5 m away from the side of the hull at starboard side. Sampling was performed when the vessel was standing. The rinsing process took approximately 15 min., while sampling and filling the tank took approximately 2 min.

After the tank was filled, it was transported to the working alley with a pallet wagon, where the seawater was filtered. By means of a pneumatic pump (Almatec, E15TTT-F4) water was led and filtered through a 500µm cartridge filter (Wolftechnik, 01WTGD05) to remove bigger particles, followed by a stainless-steel pressure filter holder (Pieper Filter GmbH, H293SSI) with a 10µm stainless-steel filter (diameter: 293mm; Körner, 1076420) to collect particles between 10µm and 500 µm in size. The tank and the filter holders were connected in series via ½" PTFE-hoses. Before the 10µm filter was inserted, 100 L of the sampled seawater were pumped through the filtration setup to rinse the system and to avoid cross contamination.

The 10µm filters with the suspended solids were folded, wrapped in Milli-Q rinsed aluminum foil and stored in Milli-Q rinsed aluminum boxes at -20°C.

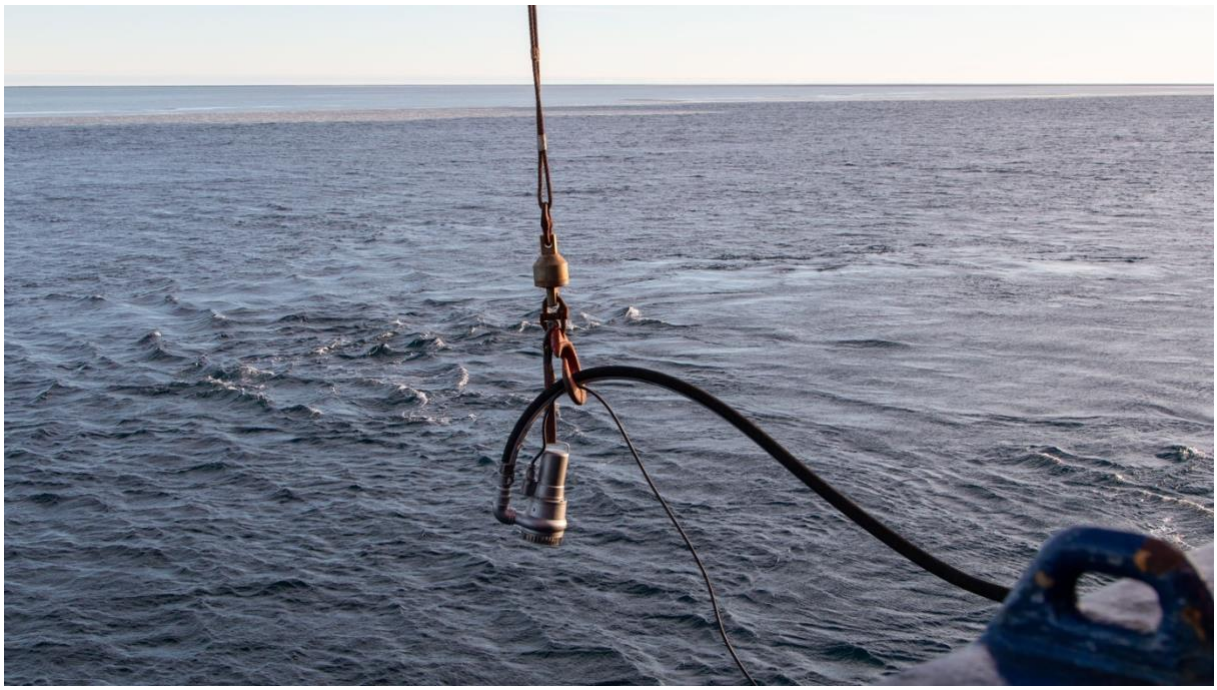

Fig. 12.1. Immersion pump in action to sample surface water.

Surface water sampled by Manta Trawl

Two trawls were performed from a rubber boat during PS124 with a target sampling duration of 20 min (Figure 12.2 and Table 12.2). Even though the first sample was still taken successfully, it was aborted after 16 minutes due to ice accumulation in the mesh. The Manta Trawl (MT; aperture: 30 cm x 15 cm) was equipped with a mechanical flowmeter and a 300 µm mesh with a removable cod end. The MT was deployed from a pole that was attached to the rubber boat making it possible to deploy the trawl from the starboard side, approximately 1.5 m away from the rubber boat, to avoid contamination due to turbulence generated by the boat. Prior to sampling the trawl was pulled through the water without the attached cod end sampler for 1 minute to remove possibly adhered particles from the mesh. After rinsing, the cod end was attached to the mesh and the sample was collected. The tows resulted in a filtered volume of 71 m^3 and 75 m^3, respectively. The samples were screened for putative MP immediately after sampling in the onboard laboratory. To do so, the content of the cod end was rinsed into a glass beaker by means of Milli-Q water. For visual screening samples were transferred portion wise to a Bogorov counting chamber and inspected under a stereo microscope (Olympus SZ61) equipped with a camera (Olympus SC50). Putative MP particles were sorted, imaged and measured (CellSense, Version 2.1). Afterwards the particles were transferred to glass petri dishes and dried at 40°C. ATR-FTIR measurements to evaluate the chemical composition of these putative MP will be conducted in the laboratories at AWI in Helgoland.

Fig. 12.2 Manta Trawl pulled by the rubber boat.

Sub-surface water sampled by on-board sea water pump

A Klaus Union Sealex Centrifugal Pump (Bochum, Germany) delivered seawater from approx. 11.2 m depth to the laboratory via stainless steel pipes (first described by Lusher et al., 2014). The water was filtered twice a day for approximately one hour onto a geological sieve with 20 µm stainless steel meshes, protected by a dimension-tailored solid wooden construction (Figure 12.3 and Table 12.3). One sample was taken by a Teflon membrane pump in cooperation with the biochemical cycling group (chapter 8) from a depth of 25m (Table 12.3). Samples were transferred to pre-rinsed glass jars by means of a PTFE squirt bottle and Milli-Q water and were stored at -20°C.

Fig. 12.3 Installation of the geological sieve with protection by a wooden box to sample sub-surface water by the Klaus pump on board.

Seal scats sampled

In total 22 Weddell Seal scats and one scat of a Crabeater Seal were collected (Figure 12.4 and Table 12.4). Samples were collected by the SEAROSE and Sea Ice team during their work on ice and on an extra flight for seal scats sampling.

Samples were taken with a stainless-steel spoon that was cleaned with snow prior to sampling and between sampling different scats. The samples were transferred to Milli-Q rinsed glass jars and stored at -20°C. In our home laboratory the scat samples will be prepared for MP analyses according to Bravo Rebolledo et al. (2013) and machine washed in gauze bags (mesh size: 300µm) with enzymatic detergent prior to visual sorting and ATR-FTIR measurements.

Fig. 12.4 Sampling of seal scats.

Sediments sampled by multi grab

The Benthic Fauna group provided us a box core from 14 sampling events with the Multi Grab (Table 12.5). From these sediment cores the upper 6- 12 cm were transferred to aluminum boxes and stored frozen at -20°C (Figure 12.5). Sediment samples will be analyzed in our home laboratories according to Abel et al (2021). Previous to FPA based µ-FT-IR organic residues will be removed by an oxidation treatment (Fenton's reagent) while remaining inorganic material will be removed by density-separation (modified from Abel et al. 2021 with sodium bromide, density: 1.4 - 1.6 g/cm^3).

Fig. 12.5 Box core form the multi grab, sampling of the upper sediment layer.

Drifting sediment sampled by sediment traps

Drifting sediment traps were deployed by the Particle Flux group at 6 stations (Table 12.6). At each depth of the drifting sediment trap (100, 200 and 300 m) a viscous gel was deployed in the collection cylinders. These gels were, and will further be screened for sinking MP.

After recovery the collection cylinders were set for approximately 4 hours before the gels were removed. The gels were screened for putative MP under the stereo microscope (Olympus SZ61) equipped with a camera (Olympus SC50). Putative MP particles were imaged, measured and the position of the particles in the gel was mapped. After imaging of the gels at AWI Bremerhaven by the Particle Flux group, we will recover putative MP from the gels and conduct FT-IR measurements to evaluate the chemical composition.

Quality control and contamination protection measures on board

Quality control and contamination protection is a crucial aspect and we tackled this issue very seriously, applying all possible precautionary measures. Cotton clothes and cotton laboratory coats were worn during all procedures in the laboratory and on the deck, whenever possible. When due to weather conditions synthetic clothes had to be worn, precautionary measures (such as keeping distance to the samples and the devices) and taking reference samples of the clothes and synthetic equipment (such as ropes etc.) were taken. All instruments and material (such as sampling jars, spoons, tweezers, aluminum foil and any other utensils) were rinsed with Milli-Q water before use on board, or, when off board, at least cleaned with uncontaminated snow (see scat samples). In the onboard laboratory, all work (e.g. visual screening) was performed under a cotton mosquito net (Bosshart et al. 2020). Additional specific measures were applied according to the following:

The Manta Trawl aperture was sealed with a cotton cloth for transport to the rubber boat and only removed just before releasing the Manta Trawl to the water. As long as stored in the lab, the Manta Trawl was protected by a cotton cover.

Sediment samples: To avoid airborne contamination of the box cores from the sediment samples, the box cores were immediately covered by aluminum foil, as soon as they were on board, and transported to the laboratory for further analysis.

Drift sediment sampling: To avoid contamination of the gels prior to sampling, the gels were poured under a cotton mosquito net, visually screened for MP and microfibers under the stereo microscope after pouring and potential contamination was removed with forceps before sealing and storing the gels till the deployment. Before the deployment, the gels were transferred to weighted dishes under the cotton mosquito net and screened a last time to check that the gels were free of MP.

Use of blanks: During visual screening of the samples retrieved by the manta trawl, and after recovery of the gels off the sediment traps, glass petri dishes with Milli-Q water were placed next to the stereo microscope during visual screening and screened afterwards to test for airborne contamination during the screening processes.

To test for contamination during the deployment and recovery of the drift trap sediment samples on the working deck three blank samples were taken by preparing a gel in a collection cylinder in the same way as the gels deployed with the drift trap. The blanks were opened simultaneously to the collecting cylinders on the drift trap and covered again when the cylinders were submerged with seawater. The same blank was opened when the cylinders were recovered from the sea and sealed simultaneously to the cylinders on the drift trap.

Preliminary (expected) results

Surface water sampled by in situ *immersion pump*

On average (± SD) 873.9 ± 21.4 l of seawater were filtered per successful sample and a total of 13382.2 l were filtered. We expect microplastic particles in the size range 10µm – 500µm.

S*urface* water *sampled by Manta Trawl*

By visual inspection, we found some putative microplastic particles, namely 4 microplastic particles, one of those obviously ship paint, and 4 microfibres in the first manta trawl sample. In the second manta trawl sample, we recovered 2 putative microplastic particles and 3 microfibres (Fig 12.6). Photographs were taken for ease of retrieval in the home laboratory. A thorough ATR-FTIR analysis in the home laboratory has to be conducted for further analysis.

In the gels of the drift sediment trap samples, we visually identified putative microplastic particles (Fig. 12.7), some of those presumably ship paint particles.

We expect to find microplastic particles in the other samples, such as sub-surface water samples, seal scats and sediments samples. All particles and microfibers under suspect will be analysed in the home laboratory, as described above.

Fig. 12.6 Putative blue ship paint and MP fiber and fragment recovered from Manta Trawl samples.

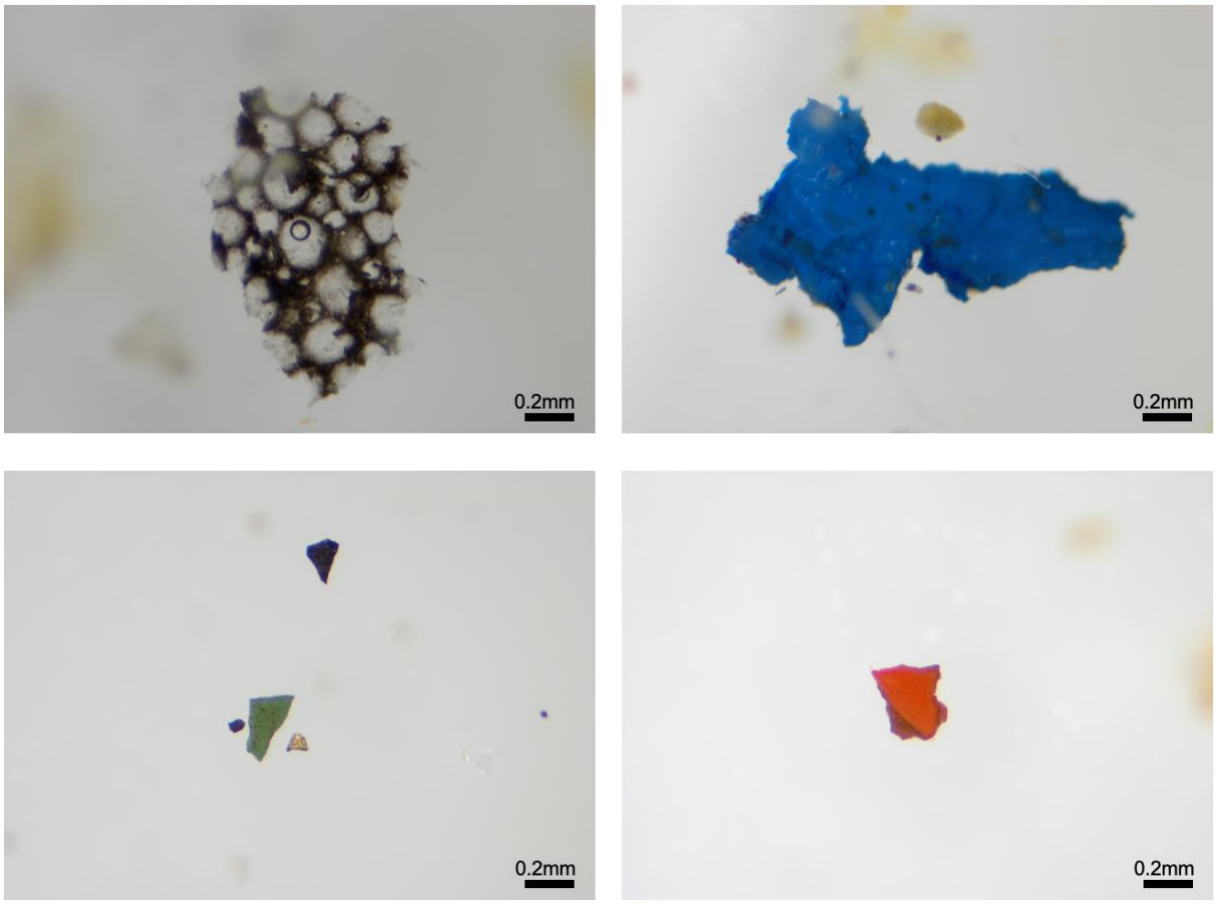

Fig. 12.7 Putative MP foam/fragment and ship paint of blue, green and red/orange color found in the gels of the drifting sediment traps.

Data management

Microplastic samples will either be destroyed by analysis or those not analyzed will be stored at the home laboratory at University of Basel. Environmental data will be archived, published and disseminated according to international standards by the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (www.pangaea.de) within two years after the end of the cruise at the latest. By default the CC-BY license will be applied.

Any other data will be submitted to an appropriate long-term archive that provides unique and stable identifiers for the datasets and allows open online access to the data.

In all publications, based on this cruise, the Grant No. AWI_PS124_10 will be quoted and the following Polarstern article will be cited:

Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung. (2017). Polar Research and Supply Vessel POLARSTERN Operated by the Alfred-Wegener-Institute. Journal of large-scale research facilities, 3, A119. http://dx.doi.org/10.17815/jlsrf-3-163.

References

Abel SM, Primpke S, Int-Veen, Brandt A, Gerdts G (2021) Systematic identification of microplastics in abyssal and hadal sediments of the Kuril Kamchatka trench. Environmental Pollution, 269, 116095.

Bosshart S, Erni-Cassola G, Burkhardt-Holm P (2020) Independence of microplastic ingestion from environmental load in the round goby (Neogobius melanostomus) from the Rhine river using high quality standards. Environmental Pollution, 267, 115664.

Bravo Rebolledo EL, Van Franeker JA, Jansen OE, Brasseur SMJM (2013) Plastic ingestion by harbour seals (Phoca vitulina) in The Netherlands. Marine Pollution Bulletin, 67, 200-202.

Lusher AL, Burke A, O'Connor, I, Officer, R (2014) Microplastic pollution in the Northeast Atlantic Ocean: validated and opportunistic sampling. Marine Pollution Bulletin 88(1–2), 325–333.

Table 12.1: Samples taken with the *in situ* immersion pump

Sample ID	Station ID	Date and Time	Position	Filtered vol (l)
IP01	PS124_5-8	09.02.21 07:14	70° 25,066' S 030° 01,214' W	821.20
IP02	PS124_7-3	11.02.21 18:51	74° 01,535' S 028° 04,000' W	273.9
IP03	PS124_8-7	12.02.21 14:37	74° 55,231' S 029° 25,393' W	874
IP04	PS124_16-5	14.02.21 18:44	75° 08,543' S 030° 26,653' W	891.7
IP05	PS124_21-4	15.02.21 23:32	74° 52,069' S 030° 39,909' W	882.2
IP06	PS124_26-4	16.02.21 20:05	74° 51,339' S 031° 49,895' W	885.2
IP07	PS124_30-4	17.02.21 20:11	74° 51,112' S 032° 59,498' W	870.9
IP08	PS124_37-3	20.02.21 20:26	74° 34,796' S 036° 23,988' W	854.4
IP09	PS124_45-5	22.02.21 10:14	74° 20,802' S 036° 02,543' W	893.3
IP10	PS124_54-7	25.02.21 10:33	74° 40,112' S 033° 35,769' W	853.3
IP11	PS124_72-4	01.03.21 19:41	75° 57,673' S 031° 32,994' W	862.2
IP12	PS124_76-4	02.03.21 23:29	75° 51,823' S 032° 09,251' W	884.4
IP13	PS124_78-4	03.03.21 21:06	76° 02,404' S 031° 03,864' W	905.7
IP14	PS124_88-3	06.03.21 01:06	77° 06,494' S 036° 34,165' W	896.4
IP15	PS124_100-2	10.03.21 07:15	74° 29,426' S 032° 31,736' W	872.9
IP16	PS124_107-7	12.03.21 06:54	75° 01,582' S 026° 54,327' W	860.5
IP17	PS124_111-4	14.03.21 03:45	75° 16,625' S 024° 57,973' W	838.3

Table 12.2: Samples taken with the Manta-Trawl

Sample ID	Date and Time	Minutes	RV. position	Av.distance RV	Filtered vol (m^3)
MTZ01	18.02.21 11:29	16	74° 41,429' S 032° 41,062' W	~600m	70.956
MTZ02	24.02.21 14:39	20	74° 04,974' S 032° 21,630' W	~500m	75

Table 12.3: Samples taken by pumped seawater (Klaus pump, Teflon pump)

Sample ID	Date	Time Start	Minuten	filtered vol. (l)	Coord. Start	Coord. Stop
SWP01	05.02.21	09:58	53	242	54° 25,322' S 056° 22,870' W	54° 37,348' S 056° 17,796' W
SWP02	06.02.21	09:59	58	158	63° 38,289' S 048° 24,496' W	63° 46,127' S 048° 05,882' W
SWP03	06.02.21	19:58	61	174	64° 59,905' S 045° 06,297' W	65° 08,402' S 044° 45,087' W
SWP04	07.02.21	08:58	58	96	66° 46,886' S 040° 30,184' W	66° 53,738' S 040° 06,059' W
SWP05	07.02.21	21:46	60	139	68° 33,853' S 035° 34,105' W	68° 42,197' S 035° 10,063' W
SWP06	08.02.21	08:07	59	161	70° 00,759' S 031° 16,141' W	70° 07,494' S 030° 48,257' W
TeflonPump01	08.02.21	22:36	48	223.2	70° 25,157' S 030° 00,276' W	70° 25,115' S 030° 00,156' W
SWP07	10.02.21	08:07	60	168	72° 40,596' S 022° 09,864' W	72° 47,450' S 022° 03,094' W
SWP08	10.02.21	19:02	63	152	73° 31,418' S 023° 18,637' W	73° 32,934' S 023° 55,585' W
SWP09	11.02.21	09:10	60	175	73° 46,802' S 026° 09,981' W	73° 52,039' S 026° 39,313' W
SWP10	11.02.21	20:10	61	177	74° 01,825' S 028° 04,715' W	74° 01,891' S 028° 04,897' W
SWP11	12.02.21	08:20	75	193	74° 54,423' S 029° 24,634' W	74° 54,774' S 029° 24,957' W
SWP12	12.02.21	19:50	80	236	74° 55,213' S 029° 25,395' W	74° 55,218' S 029° 25,456' W
SWP13	13.02.21	08:15	60	176	74° 00,397' S 030° 30,120' W	74° 00,706' S 030° 40,049' W
SWP14	13.02.21	20:08	58	163	74° 15,890' S 030° 18,241' W	74° 15,870' S 030° 18,165' W
SWP15	14.02.21	09:18	67	186	74° 35,144' S 030° 00,157' W	74° 35,799' S 029° 55,067' W
SWP16	14.02.21	20:27	64	190	75° 08,553' S 030° 26,658' W	75° 08,558' S 030° 26,707' W
SWP17	15.02.21	08:26	65	180	74° 54,554' S 029° 25,202' W	74° 55,322' S 029° 30,634' W
SWP18	15.02.21	20:19	29295	133	74° 51,007' S 030° 23,089' W	74° 50,957' S 030° 25,886' W

Table 12.4: Seal scats (1-22: from Weddell seals, taken by the SEAROSE team, 23: from Crabeater Seal, taken by the Sea Ice team)

Sample no	Date	Latitude	Longitude	Comment
1	14.02.21	75°40.030'S	034°25.805'W	Seal 1 (tag no)
2	17.02.21	74°39.35'S	035°53.63'W	Seal 2
3	19.02.21	74°38.75'S	035°50.73'W	Seal 3
4	22.02.21	74°24.00'S	037°02.72'W	Seal 5
5	24.02.21	74° 14'S	033° 22' W	
6	25.02.21	74° 30.6'S	035° 21.0'W	
7	27.02.21	75° 00' S	035° 40' W	
8	27.02.21	75°02.355'S	035°40.611'W	Seal 6
9	04.03.21	75° 17.527'S	031° 09.921'W	
10	04.03.21	75° 17.527'S	031° 09.211'W	Seal 7
11	04.03.21	74° 42.305'S	029° 16.929'W	
12	11.03.21	74° 42.305'S	025° 16.929'W	
13	11.03.21	74°42.305'S	025°16.929'W	Seal 8
14	14.03.21	74° 42.02'S	025° 07.03'W	
15	14.03.21	74° 42.02'S	025° 07.03'W	
16	14.03.21	74° 42.02'S	025° 07.03'W	Two jars
17	18.03.21	70° 34.055 S	008°00.941'W	
18	18.03.21	70° 37.746'S	008° 06.166'W	Two jars (1 & 2)
19	18.03.21	70° 37.746'S	008° 06.166'W	
20	18.03.21	70° 37.746'S	008° 06.166'W	
21	18.03.21	70° 37.746'S	008° 06.166'W	
22	18.03.21	70° 37.746'S	008° 06.166'W	
23	18.02.21	74°59.886'S	023°36.831'W	

Table 12.5 Samples taken from the Multi Grab (*= total sediment length 7 cm)

Sample ID	Station ID	Date and Time	Position	Depth (m)	Average cm sampled
MG01	PS124_8-10	12.02.21 20:31	74° 55,211' S 029° 25,240' W	404.6	11.03
MG02	PS124_16-7	14.02.21 21:23	75° 08,559' S 030° 26,664' W	454.7	10.33
MG03	PS124_21-6	16.02.21 02:00	74° 52,079' S 030° 39,767' W	495.5	8.00
MG04	PS124_26-8	17.02.21 05:20	74° 50,880' S 031° 51,050' W	636.1	6.07
MG05	PS124_33-6	19.02.21 07:52	74° 43,377' S 035° 09,574' W	498.3	9.83

Sample ID	Station ID	Date and Time	Position	Depth (m)	Average cm sampled
MG06	PS124_37-4	20.02.21 21:29	74° 35,855' S 036° 25,995' W	411.5	9.00
MG07*	PS124_52-2	22.02.21 11:28	74° 20,434' S 036° 03,692' W	1542	9.47
MG08	PS124_45-7	24.02.21 20:52	74° 15,612' S 032° 20,289' W	928.5	10.00
MG09	PS124_68-6	01.03.21 05:26	76° 03,968' S 030° 16,746' W	467.8	9.77
MG10	PS124_88-4	06.03.21 01:57	77° 06,505' S 036° 33,932' W	1101.8	10.27
MG11	PS124_92-1	07.03.21 11:27	77° 09,961' S 033° 41,647' W	269.2	7.00
MG12	PS124_100-6	10.03.21 14:24	74° 33,548' S 032° 40,005' W	663.6	10.97
MG13	PS124_111-6	14.03.21 05:35	75° 16,649' S 024° 57,935' W	638.9	11.67
MG14	PS124_112-3	14.03.21 22:05	75° 22,331' S 025° 43,625' W	790.6	12.33

Table 12.6 Samples from the sediment drift traps, with blanks

Sample ID	Station ID deployment	Date and Time deployment	Position deployment	Depth (m)
DT01	PS124_8-4	12.02.21 11:45	74° 57,191' S 029° 26,654' W	100
				200
				300
DT02	PS124_26-1	16.02.21 17:29	74° 51,113' S 031° 54,038' W	100
				200
				300
DT03	PS124_54-8	25.02.21 12:01	74° 40,961' S 033° 34,277' W	100
				200
				300
DT04	PS124_71-1	01.03.21 15:59	75° 58,599' S 031° 22,128' W	100
				200
				300
DT04 - BLANK	PS124_71-1	01.03.21 15:59	75° 58,599' S 031° 22,128' W	BLANK - 200
DT05	PS124_79-1	04.03.21 08:58	76° 05,540' S 030° 25,282' W	100
				200
				300

DT05 - BLANK	PS124_79-1	04.03.21 08:58	76° 05,540' S 030° 25,282' W	BLANK - 100
DT06	PS124_90-1	06.03.21 14:29	77° 02,413' S 033° 39,062' W	100
				200
				300
DT06 - BLANK	PS124_90-1	06.03.21 14:29	77° 02,413' S 033° 39,062' W	BLANK - 300

Table 12.7 Putative microplastic particles in gels of the sediment drift trap samples

Sample ID	Depth (m)	Potential MP	Potential ship paint
DT01	100	-	2
	200	-	2
	300	-	-
DT02	100	1	8
	200	-	-
	300	-	9
DT03	100	2	2
	200	-	2
	300	2	5
DT04	100	1	3
	200	-	6
	300	-	3
DT04 - BLANK	200*	5 (2 x clear spherules)	4
DT05	100	-	1
	200	-	13
	300	-	3
DT05 - BLANK	100*	1	18
DT06	100	1	4
	200	-	5
	300	-	8
DT06 - BLANK	300*	-	11