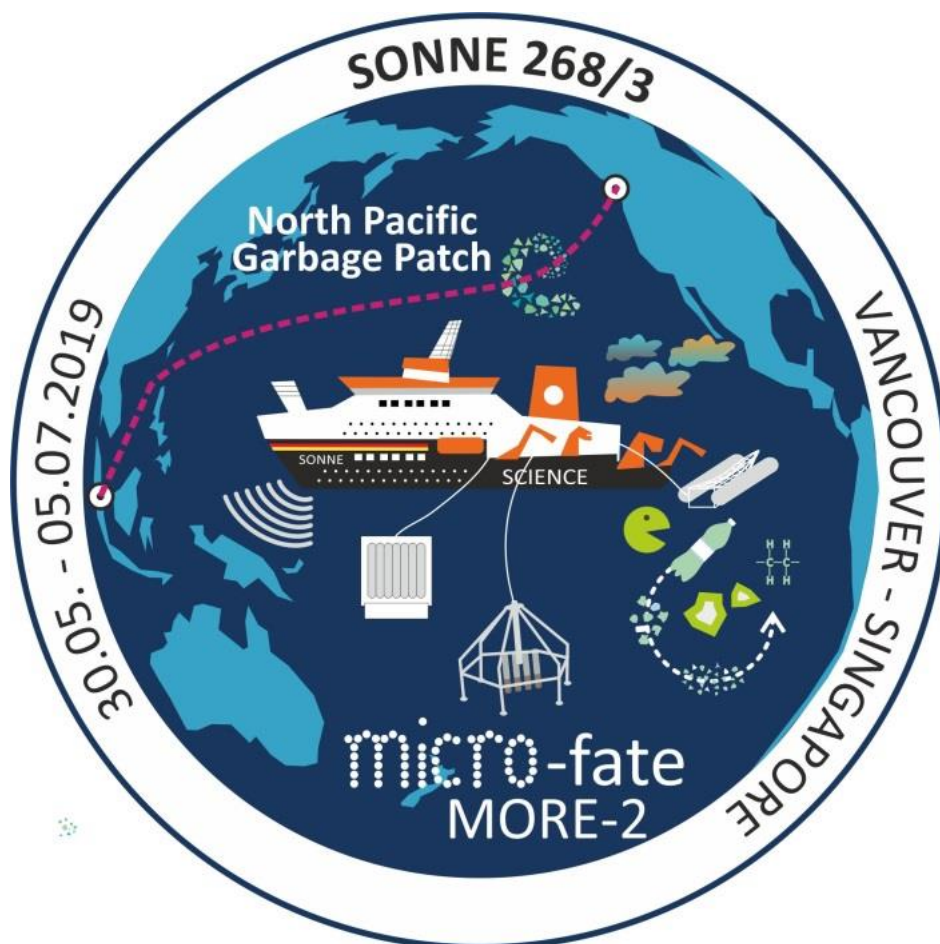


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Short Cruise Report
RV SONNE SO268/3
MICRO-FATE / MORE-2
Vancouver, Canada – Singapore
30.05.2019 – 05.07.2019
Chief Scientist: Stefan Kinne
Captain: Oliver Meyer



Objectives

The SO 268-3 cruise covered goals of two different projects: MICRO-FATE and MORE-2.

The MICRO-FATE project investigated the occurrence, fate and possible effects of plastic in the so-called "Great Pacific Garbage Patch" and along gradients to less polluted areas. The transit from Vancouver to Singapore was an ideal route to investigate this topic. According to ocean current modeling, the center of the garbage patch was expected to be in the region between 30 and 35°N and 135 and 145°W with increased concentrations also westward near 30°N. MICRO-FATE involved 5000m plus depth probing and near surface probing at 8 day-long stations across the northern Pacific. The first station at 39°N and 135°W was chosen as a low plastic load reference site, three stations were in the garbage patch region (at 33°N 144°W, at 30°N 141°W and at 30°N 152°W), three stations were westward of the garbage patch (at 29°N 162°W, at 29°N 175°W - with a permit near the Midway Atoll, at 29°N 171°E) and the final station was sampled in the Japanese EEZ at 22°N 127°E. The depth probing involved (1) vertical profiling with the on-board CTD with water filtering to collect particles larger than 0.45 μm , 10 μm and 35 μm size via attached McLane *in situ* pumps, (2) multi-hour image surveys with the on-board OFOS camera and (3) sampling of 20 sediment cores with a MUC. The near-surface probing involved the sampling of particles in (1) a Neuston catamaran with a 335 μm mesh size net, (2) a cascade filtration unit to collect particles of different sizes (larger than 0.45 μm , 10 μm , 50 μm , 100 μm , 200 μm and 500 μm), (3) a marine snow catcher, (4) a plankton net, (5) a scoop and occasionally (6) a coarse "SONNE" net specifically built by the crew for sampling of large items. Continuous sampling involved (1) enrichment of dissolved organic pollutants in a solid-phase extraction unit, (2) a visual observation-based ocean litter survey and (3) a plastic aging experiment with exposure of plastic items to seawater with or without exposure to solar irradiation.

The MORE-2 project collected atmospheric properties of aerosols, clouds and trace-gases, because reference data coverage over oceans is sparse – especially over the Pacific. The data will serve as (1) calibration data for satellite remote sensing retrievals and (2) as evaluation data for (global) modeling, and data associations should assist in constraining simulations of atmospheric processes. In addition, 21 ARGO floats were deployed to maintain the monitoring capabilities of the upper ocean (i.e., temperature, salinity) and underway hydroacoustic data were prepared for the Seabed 2030 project.

During the SO268-3 research cruise, in total 31 stations were assigned and their locations are indicated in the official station map of Figure 1. Most of the assigned stations mark only a slowing down of the vessel for the deployment of an ARGO float. The locations of the 8 profiling stations are listed in Table 1 and are highlighted in Figure 2.

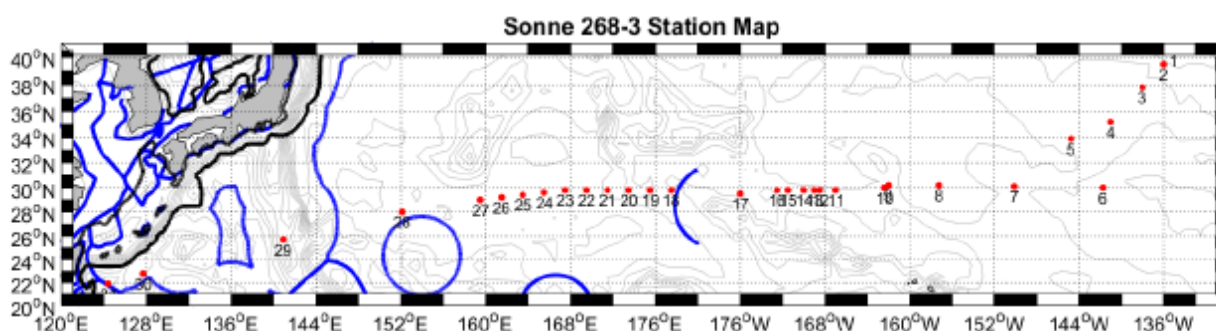


Figure 1 Official station map of the R/V SONNE research cruise SO268-3.

Table 1 the deep oceans profiling stations during SO268-3.

	#	date	time (UTC)	lat N	lon E	z (m)	
1	3	6/2/2019	03:40-20:38	39.4734	224.0450	5129	CTD, OFOS, MUC
2	5	6/4/2019	15:40-11:50	33.9194	215.2169	5260	CTD, OFOS, MUC
3	6	6/6/2019	10:36-07:37	30.0412	218.2360	5069	CTD, OFOS, MUC
4	7	6/9/2019	00:30-22:41	30.0858	208.0724	5238	CTD, OFOS, MUC
5	10	6/11/2019	17:42-17:08	29.9896	196.3954	5670	CTD, OFOS, MUC
6	17	6/14/2019	22:50-19:39	29.8324	187.5002	5298	CTD, OFOS, MUC
7	21	6/17/2019	20:38-16:25	29.8317	171.4991	5240	CTD, OFOS, MUC
8	30	6/26/2019	15:38-12:01	22.7466	127.7269	5360	CTD, OFOS, MUC
9	31	6/28/2019	01:57-07:29	21.9526	124.4131	5152	CTD only



Figure 2 R/V SONNE 268-3 track chart displaying the location of the 9 profile stations (green) and the deployment locations of the 21 ARGO floats (yellow, Scripps Oceanic Institute, La Jolla, CA).

Narrative

The SO268-3 cruise covered the MICRO-FATE and the MORE-2 projects. Under the MICRO-FATE project distributions of oceanic litter across the Pacific were surveyed with a focus on the full range from large pieces (such as barrels) down to micrometer sizes. Central activities were eight stations with three locations near the projected core of the North Pacific Garbage Patch. At each station, the sampling program lasted almost one day due to the great depth. The plastic litter sampled covered material collected at the surface (with nets and filters of various mesh size), the vertical distribution from different depths (snow catcher, plankton net, *in situ* pumps) and material from the seabed (sediment (MUC), visual surveys (OFOS)). These samples were complemented by near-continuous observations of floating litter, plastic aging experiments, water filtering and initial characterization of the biofilm growing on the surface of plastic debris. Under the MORE-2 project atmospheric reference data for satellite remote sensing and modeling data were sampled underway, and recorded ocean floor data were analyzed. Furthermore, for deployments of the 21 US ARGO floats the speed of the vessel was temporarily reduced.

The voyage began in Vancouver, Canada on May 30, 2019. The ship left its north-side quay in the morning at 5 a.m.. The pilot stayed until Victoria, BC, and the ship then headed in SW direction as soon as the open Pacific was reached towards the garbage patch area (30-35°N 140-145°W).

Once the ocean depths exceeded 5000 m (similar to depths in the garbage patch area) near 39.5° N 135°W on June 1, the “background” profile station #1 was selected to establish a largely litter-free ocean reference. Further proceeding towards the garbage patch area, the frequency of floating litter and plastic increased, as observed in the litter survey. Profile station #2 was picked near the Northern rim of the garbage patch region at 34°N 145.5°W on June 4. Profile station #3 at 30°N 141.5°W on June 6 was at the Southern rim of the garbage patch region. In efforts to capture the longitudinal distribution of floating debris the voyage continued then in a westward direction near 30°N, with profile station #4 at 152°W on June 8 and profile station #5 at 162°W on June 11 (after passing a cold front with considerable rain near 155°W).

Although the floating litter frequency had decreased since the core garbage patch region, there were still occasional patches with very high litter levels, probably related to the dominating mesoscale currents in the Pacific near 30°N. A particular effort was made to catch a large plastic barrel, which was not just filled with seawater but also contained many small fishes, with one of them already too big to escape through the openings; the fish was rescued by opening the barrel with a saw. Several ARGO floats were deployed before the Papahānaumokuākea Marine National Monument (PMNM) zone in the Northwestern Hawaiian Archipelago was entered. Profile station #6 at 175°W on June 15 (as the data of June 14 was skipped in anticipation of the dateline crossing) supported the collection of large litter pieces during the scheduled routine testing of the fast rescue boat. Still, at this stop near the Midway Islands it was easy to collect floating plastic litter with the scoop next to the ship from the main deck.

The dateline was crossed in the night to June 17 and from now on marine birds had started to compete for the best positions on the front mast and pollute the area below. After the PMNM region the remaining ARGO floats were released every two degrees in longitude with the profile stop #7 on June 17 near 172°E in between. When halting for technical reasons for a couple of hours near 165°E, two passing bigger ships lured some of the birds away. By June 21 all ARGO floats had been deployed. The EEZ of Japan was entered on June 23, now with warmer temperatures, higher humidity, deep convection, occasional precipitation and hardly any blue skies. After passing a frontal zone with heavy precipitation on June 25, the last profile station # 8 was reached on June 26 near 23°N 127°E. Another CTD-only station on June 28 near 22°N 124°E ended the station work. The rest of the way was a (relative rough) transit through a windy South China Sea, and Singapore was reached late on July 4.

Data-access

HYDRO-acoustic data are archived at BSH and HCU-Hamburg (harald.sternberg@hcu-hamburg.de).

OFOS ocean floor images will be uploaded to the PANGAEA data base (melanie.bergmann@awi.de)

MICROTOPS will be available at http://aeronet.gsfc.nasa.gov/new_web/maritime_aerosol_network.html

CEILOMETER will be available at ftp://ftp-projects.zmaw.de/aerocom/ships/ceilometer_SO

CLOUD-CAMERA will be available at MPI-M by request (stefan.kinne@mpimet.mpg.de)

MAX-DOAS will be available at KNMI and MPI-C by request (ping.wang@knmi.nl, steffen.doerner@mpic.de)

PANDORA will be available at FU-B by request (thomas.ruhtz@fu-berlin.de)

BRUKER EM27/SUN Fourier Transform Spectrometer data by request (andre.butz@iup.uni-heidelberg.de)

If interested in any atmospheric data sampled during the SO268-3 cruise it is also recommended to contact stefan.kinne@mpimet.mpg.de - to be informed on updates and to avoid data misinterpretations.

If you are interested in the sampled oceanic plastic debris and the analyses of the polymers, their surface properties, associated biofilms and sorbed environmental pollutants during the SO268-3 cruise, please contact annika.jahnke@ufz.de.

Selected pictures of the cruise SO268/3

(many pictures by Roman Kroke)

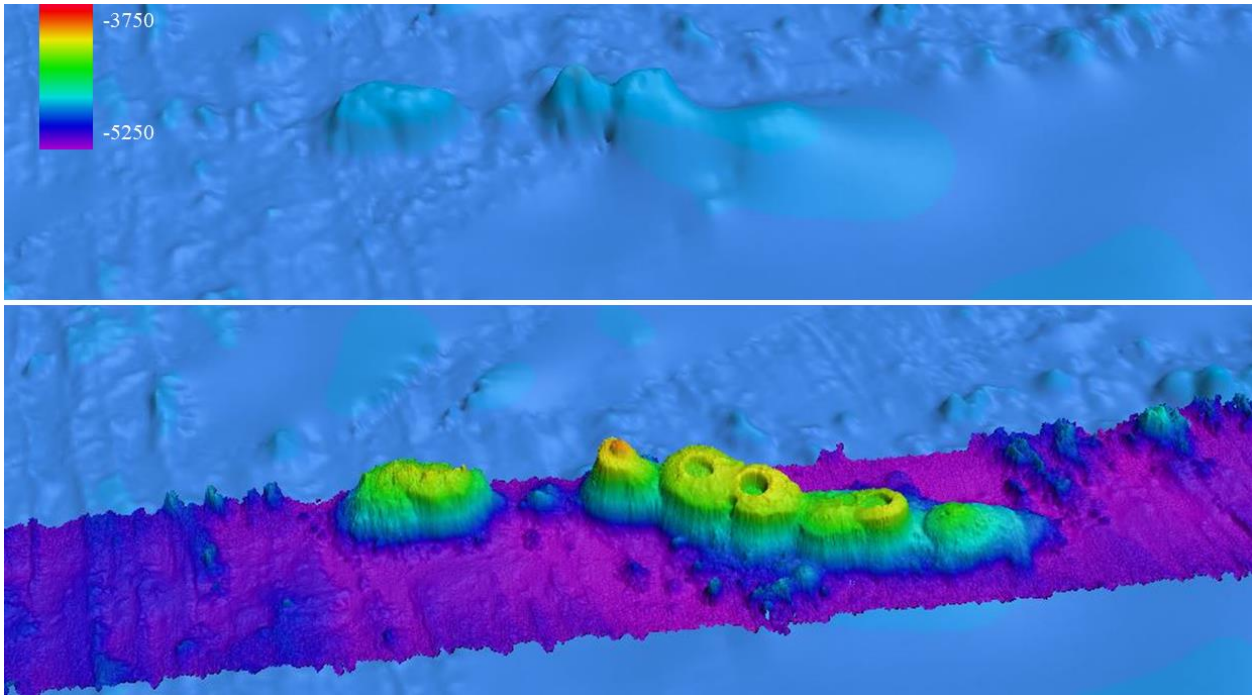


Figure 3 EM122 unnamed seamount chain mapped on June 7, 2019 at 30.123°N -144.039°W.

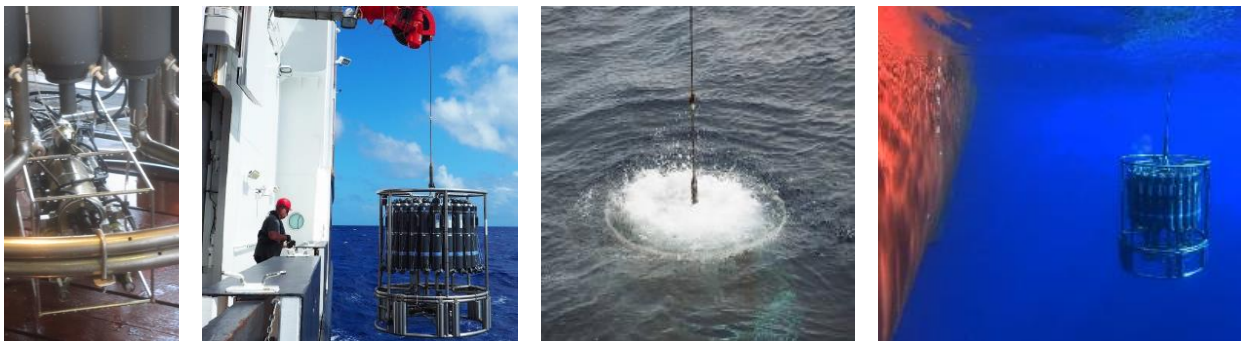


Figure 4 Images of the CTD, before (left), during (center) and after (right) its lowering in the water.

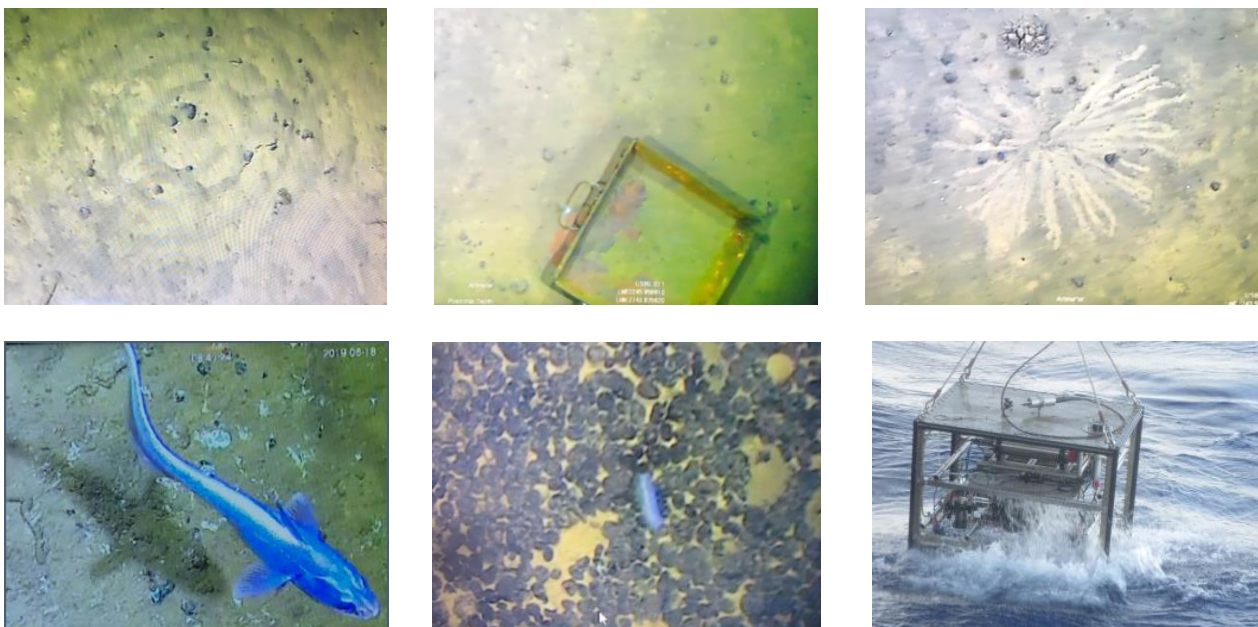


Figure 5 OFOS camera (lower right) images at the ocean floor depth at more than 5000m with a 'maze' (top left), a drawer (top center), a 'volcano' (top right) and a (ca 40cm long) fish (bottom left).

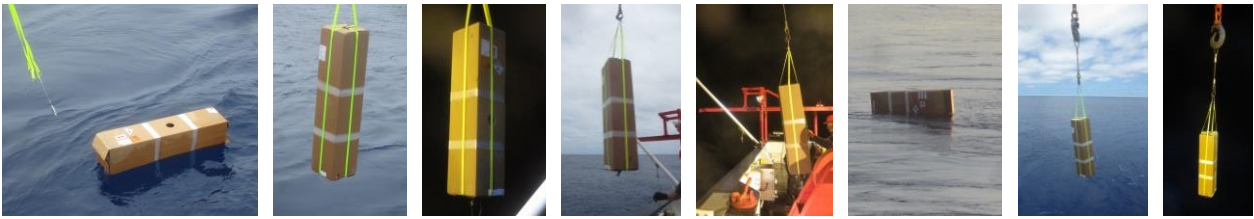


Figure 6 Scripps type ARGO float deployments in the Pacific during the SO268-3 research cruise.



Figure 7 Solar spectrometers operated during SO 268-3: an handheld sunphotometer (upper left), 3 MAX-DOAS type instruments (top center and right) and a fourier-transform spectrometer (bottom)

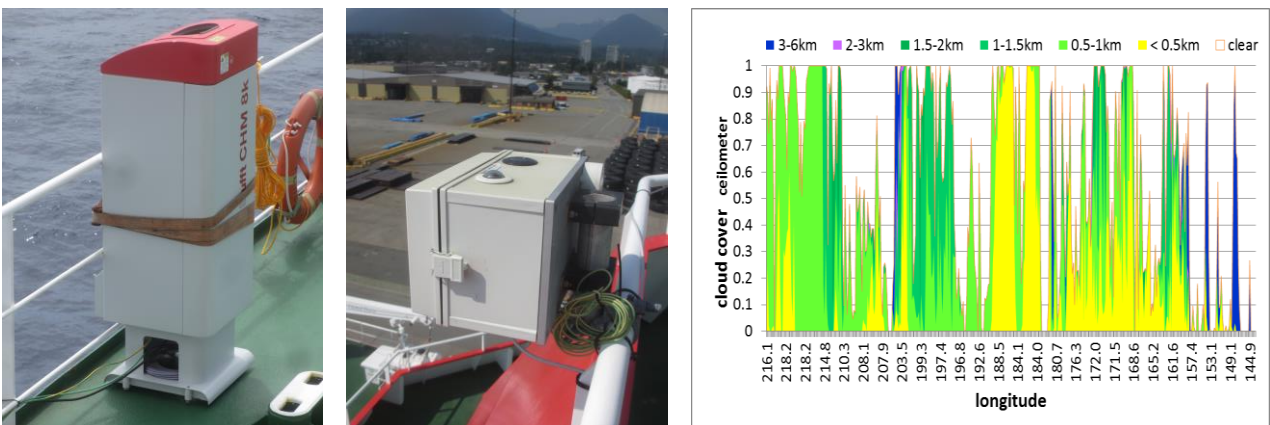


Figure 8 ceilometer (left) and camera (center) for capturing cloud cover and cloud-base as function of longitude (right)



Figure 9 CAT trawling next to the SONNE (left) and a collected Garbage Patch sample (right).

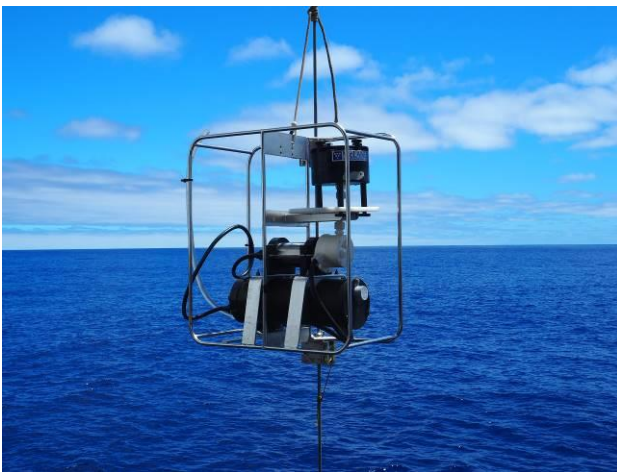


Figure 10 McLane in situ pumps during deployment and sample collection after taking them on board after successful sampling.



Figure 11 Operation of CAS on board of RV SONNE and sample collection.

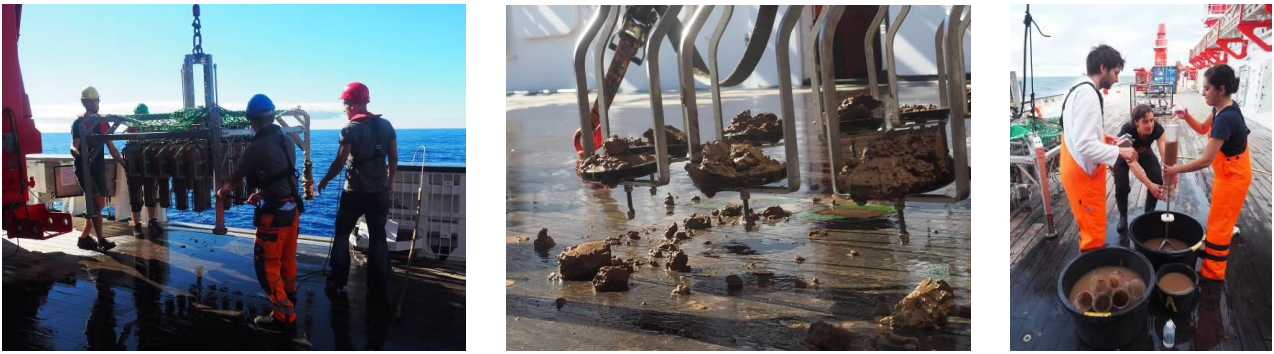


Figure 12 Operation of the MUC and sampling of the sediment on board of RV SONNE



Figure 13 Water was submitted to the LV-SPE either from the ship's seawater supply or from the CTD/Rosette (left) to process deep sea samples. The pollutants from 50-100 L of seawater were enriched on a sorptive phase



Figure 14 Nighttime deployment of the MSC (left) and search for "marine snow" (right)



Figure 15 The “SONNE net” (left) specifically built by the crew to capture large marine litter (center) was also used to capture a barrel (right), with many small fishes inside.



Figure 16 Large, still identifiable plastic debris is collected to investigate pollutants and their mixture effects, in field-weathered plastic as opposed to the pristine material.

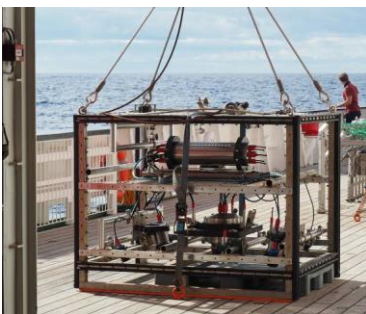


Figure 17 The OFOS system on the working deck (top) and evaluation of the pictures (bottom).

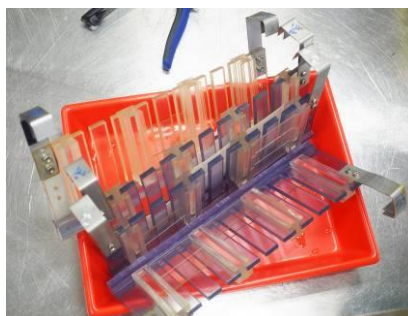


Figure 18 Installation of the mesocosms and the exposed plastic.

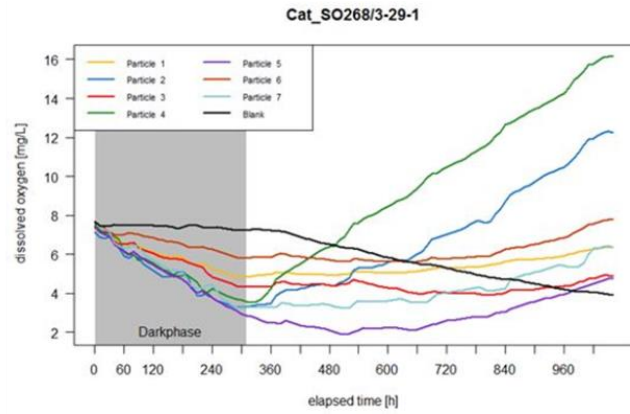


Figure 19 Gas-sealed Oxygen chambers (left) and oxygen profile after incubation of plastic-colonizing biofilms for 10 h in light/dark phases (right).



Figure 20 Sampling of biofilm on board of RV SONNE.



Figure 21 Processing of the biofilm-coated plastic debris on board of RV SONNE

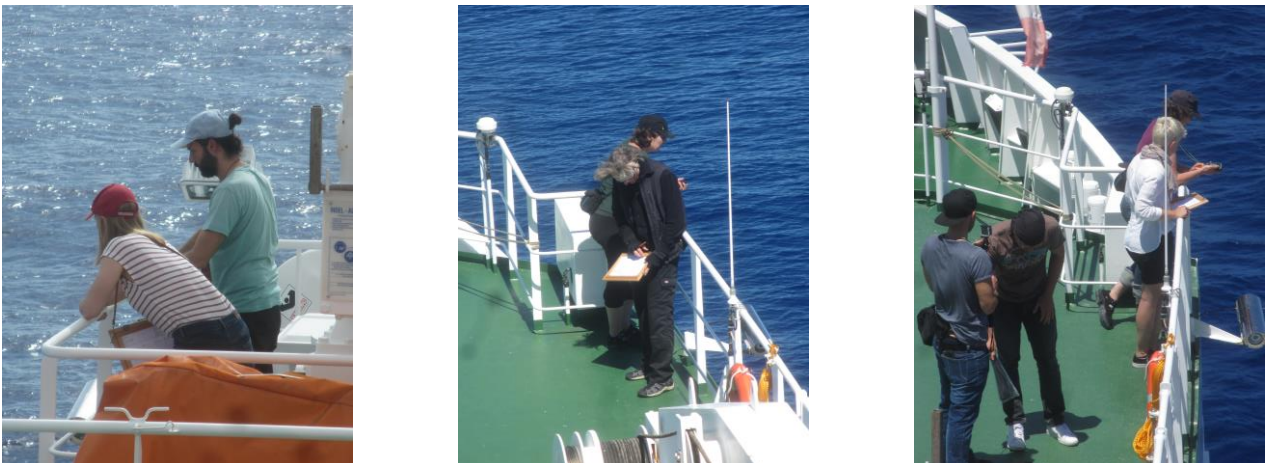


Figure 22 Pairs of volunteers counting the debris and plastic floating near the ocean surface.

Acknowledgements

The scientific staff of RV SONNE Cruise SO268/3 gratefully acknowledges the friendly and enjoyable atmosphere and the helpful assistance of Captain Meyer and his crew. Also the support of the Leitstelle Deutsche Forschungsschiffe (German Research Fleet Coordination Centre) at the University of Hamburg was highly appreciated. The expedition was funded by DFG and BMBF (MICRO-FATE project, project no. 03G0268TA). cruise projects.

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U. Bie	University, Bielefeld
U. Hei	University, Heidelberg
U. HH	University, Hamburg
UFZ	Helmholtz Centre for Environmental Research – UFZ, Leipzig
UFZ M	Helmholtz Centre for Environmental Research – UFZ, Magdeburg
IHI	Internationales Hochschulinstitut, Zittau

station list

station - No.	date, time	Device	latitude	longitude	d (m)	remarks
SO268-3/1	2019/06/01 21:30:40	FLOAT in water	40° 30.088' N	134° 59.977' W	4204.8	
SO268-3/2	2019/06/02 03:53:37	CTDin water	39° 28.403' N	135° 57.298' W	5131.6	CAT, OFOS, MUC, ...
SO268-3/3	2019/06/03 07:46:17	FLOATin water	37° 48.054' N	137° 59.947' W	5254.8	
SO268-3/4	2019/06/03 23:32:19	FLOATin water	35° 12.473' N	140° 59.447' W	5213.8	
SO268-3/5	2019/06/04 15:42:39	CTDin water	33° 55.180' N	144° 46.977' W	5212.3	CAT, OFOS, MUC, ...
SO268-3/6	2019/06/06 10:38:21	CTDin water	30° 02.473' N	141° 45.843' W	5029.5	CAT, OFOS, MUC, ...
SO268-3/7	2019/06/09 00:34:10	CTDin water	30° 05.145' N	151° 55.655' W	5178.7	CAT, OFOS, MUC, ...
SO268-3/8	2019/06/10 22:37:25	FLOATin water	30° 12.021' N	157° 59.729' W	5831.9	
SO268-3/9	2019/06/11 14:29:01	FLOATin water	30° 13.006' N	161° 59.431' W	4255.6	
SO268-3/10	2019/06/11 17:44:08	CTDin water	29° 59.375' N	162° 36.275' W	5664.3	
SO268-3/11	2019/06/13 10:53:10	FLOATin water	29° 49.983' N	167° 00.024' W	5451.0	
SO268-3/12	2019/06/13 16:38:27	FLOATin water	29° 49.900' N	168° 30.007' W	5465.1	
SO268-3/13	2019/06/13 18:58:01	NETin water	29° 49.783' N	168° 57.670' W	5350.3	
SO268-3/14	2019/06/13 23:25:35	FLOATin water	29° 50.005' N	169° 59.956' W	5312.8	floating barrel
SO268-3/15	2019/06/14 05:31:38	FLOATin water	29° 49.984' N	171° 29.966' W	5364.5	
SO268-3/16	2019/06/14 09:27:33	FLOATin water	29° 49.946' N	172° 29.986' W	5371.1	
SO268-3/17	2019/06/14 22:58:13	CTDin water	29° 33.429' N	175° 58.232' W	5299.4	boat, CAT, O, M, ...
SO268-3/18	2019/06/16 20:57:42	FLOATin water	29° 50.002' N	177° 29.981' E	5305.9	
SO268-3/19	2019/06/17 04:46:18	FLOATin water	29° 50.014' N	175° 30.032' E	5224.4	
SO268-3/20	2019/06/17 12:39:55	FLOATin water	29° 50.013' N	173° 30.542' E	3955.3	
SO268-3/21	2019/06/17 20:40:34	CTDin water	29° 50.012' N	171° 29.956' E	5255.4	CAT, OFOS, MUC, ...
	2019/06/18 16:33:27	FLOATin water	29° 49.997' N	171° 31.701' E	5233.3	
SO268-3/22	2019/06/19 00:50:05	FLOATin water	29° 49.994' N	169° 30.335' E	5672.9	
SO268-3/23	2019/06/19 08:58:58	FLOATin water	29° 47.977' N	167° 30.047' E	5865.3	
SO268-3/24	2019/06/19 17:28:48	FLOATin water	29° 35.980' N	165° 29.980' E	5958.5	
SO268-3/25	2019/06/20 06:45:52	FLOATin water	29° 23.980' N	163° 29.842' E	5976.8	
SO268-3/26	2019/06/20 14:59:18	FLOATin water	29° 12.008' N	161° 30.174' E	5889.3	
SO268-3/27	2019/06/20 23:04:42	FLOATin water	29° 00.005' N	159° 30.051' E	6134.6	
SO268-3/28	2019/06/22 04:33:53	CAT in water	28° 01.119' N	152° 04.671' E	6026.3	
SO268-3/29	2019/06/24 05:30:29	CAT in water	25° 42.052' N	140° 56.497' E	2100.4	
SO268-3/30	2019/06/26 15:38:47	CTDin water	22° 44.794' N	127° 43.612' E	5360.4	CAT, OFOS, MUC, ...
SO268-3/31	2019/06/28 01:57:54	CTDin water	21° 57.156' N	124° 24.785' E	5200.0	CTD

CAT catamaran nemicat
 OFOS Ocean Floor Observation System
 MUC 20 sample Multi-Corer
 CTD Conductivity-Temperature-Depth ocean profiling probe
 FLOAT ARGO float deployment
 NET fishing net for large litter collection
 boat outside boat for litter collection