

Timothy G. Ferdelman
Max Planck Institute for Marine Microbiology
Celsiusstr. 1
D-28359 Bremen, Germany

Tel.: +49(0)2028-632
Fax: +49(0)2028-690
email: tferdelm@mpi-bremen.de

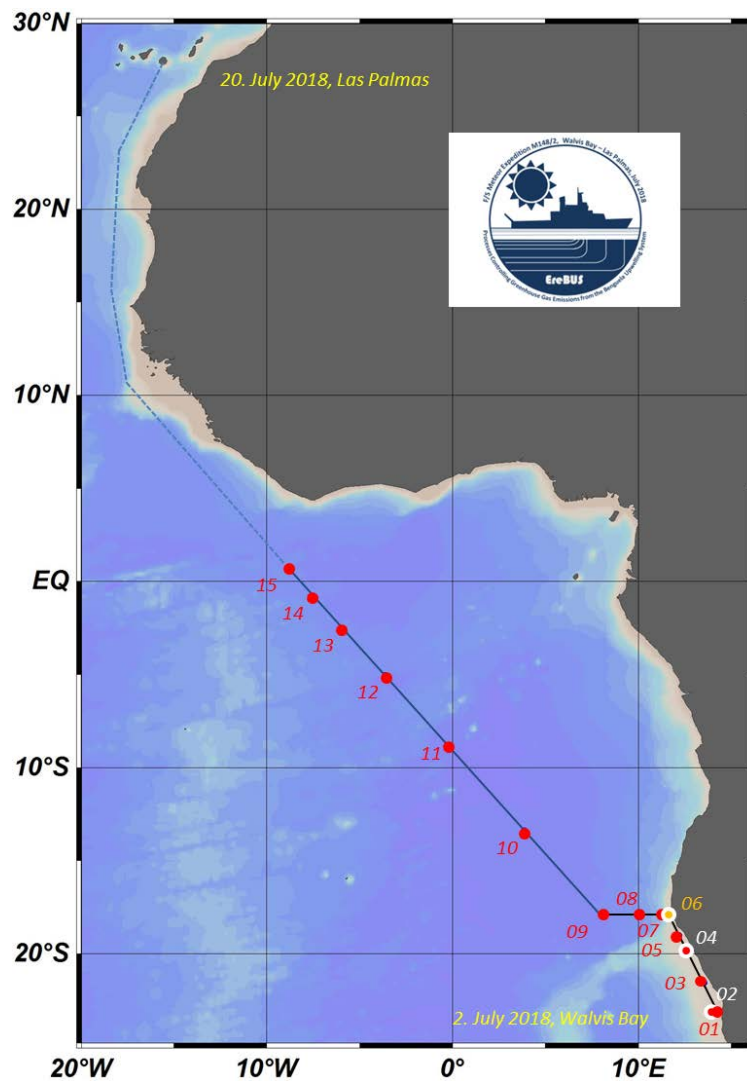
Short Cruise Report R/V Meteor M148/2

Walvis Bay, Namibia – Las Palmas, Spain

2 July 2018 – 20 July 2018

Chief Scientist: Timothy Ferdelman

Captain: Detlef Korte



Objectives

The Meteor Expedition M148/2 "EreBUS" aimed to investigate the microbial processes producing and consuming the trace green-house gases (TGG) methane and nitrous oxide in the Benguela Upwelling System (BUS) and physical and geochemical controls regulating these processes.

During the transit from Walvis Bay to Las Palmas, the goal was to sample the water column and surface sediments on the Namibian shelf and across the continental margin at the 18°S Kunene Upwelling Cell, and continue sampling the upper 500 m of the water column on a transect through the Angola Gyre to the Equator.

The principle aim was to identify microbial communities contributing to TGG turnover at key water and surface sediment depths, and explore the metabolic capacities of these microorganisms with state-of-art cultivation and genomic techniques. The contribution of symbiotic microorganisms living with small eukaryotes and contributing to these processes was also a focus of the expedition. Hydrographic and optical properties were gathered in support of the experiments. We also took samples to measure primary productivity and nitrogen fixation as well as determine the dissolved organic matter and trace metal availability and fluxes that may regulate key enzymatic processes controlling trace greenhouse gas emissions.

Narrative

On Friday June 29, 2018 the first group of 13 scientific members of the M148/2 EreBUS transit expedition arrived in Walvis Bay to begin unloading containers and setting up laboratories on the *R/V Meteor*. Walvis Bay port activities continued through the weekend and also included a Reception sponsored by the German embassy in Namibia for local Namibian dignitaries and press. On Sunday morning July 1, the rest of the science party (11 members) joined the ship. After a slight delay waiting for a box of scientific supplies, the *R/V Meteor* left port shortly after 11 AM on July 2, 2018 and the M148/2 EreBUS Expedition was underway. Heading to our first stations at 23°S we were immediately confronted with high winds of 17 to 20 m s⁻¹ and 5 meter wave heights. It proved to be a challenging start for the first main sampling station, but after several hours we were able to meet most of our sampling goals. Only the sediment multi-corer deployment was dropped due to inclement wind and wave conditions. We also had initial problems with the special plastic coated sampling line brought for trace metal sampling and deployed on winch W4, but were able to effectively switch to the metal-free Aramide cable on winch W1. Thereafter, we commenced an extremely busy sampling campaign running northwards along the Namibian shelf, finally reaching our northernmost shelf station on Wednesday, July the 4th. Deploying a so-called pump-CTD we obtained high depth resolution profiles of the important greenhouse gases N₂O and methane as well as other chemical constituents. Here, in addition to our standard sampling program, we recovered, serviced and re-deployed a seafloor-moored ADCP unit from the Institute of Baltic Research Warnemünde (IOW) used in making continuous current measurements through the water column.

Along the continental shelf transect in the Benguela upwelling region, hydrographic and geochemical profiling with the CTD showed a well-mixed upper water column with increased chlorophyll concentrations indicative of the high productivity of the Namibian shelf. The bottom layer was mostly hypoxic with oxygen concentrations of about 20 to 40 μM. No anoxic bottom water was detected during the cruise. Surface oxygen concentrations ranged between 130 and 200 μM which is well below the saturation level and could be explained by the upwelling of low oxygen water from the subsurface layer. Dissolved hydrogen sulfide, which frequently occurs in micromolar concentrations in these shelf waters, was not detected in the water column, and was restricted to sediment pore waters. The oxygen conditions on the northern Namibian shelf were highly correlated with the distribution of central water masses. Lower oxygen concentrations were proportional with a greater the fraction of South Atlantic Central Water (SACW).

A set of four stations was performed perpendicular to the coast in the Kunene upwelling cell at 18°S, and we completed this transect by noon on the 6th of July. Despite very coarse station resolution, general vertical patterns of the upwelling cell were resolved and the coastal station was within the zone of active upwelling. The surface temperature and salinity increased towards the open ocean to about 18°C and 36 g kg⁻¹, respectively. In contrast to the inner shelf the offshore region depicted a well-developed thermocline and halocline at the bottom of the surface mixed layer near 70m depth.

During our transit from the shelf zone off Namibia into the open waters sampling began for the much more oligotrophic waters of the Eastern South and Equatorial Atlantic. Special Teflon-coated Go-Flo bottles deployed on the Aramid line (W1) were used to obtain clean water samples for the analysis of dissolved and particulate trace elements, particularly iron

(Fe). The fixation of dinitrogen (N_2) gas, the largest external source of biologically available nitrogen (N) to the ocean, can also be limited by the availability of Fe. Experiments using stable isotopes were carried out on-board to determine both the rate of primary production and N_2 fixation. The offshore transects also saw the first deployments of the Multi-Plankton Sampler to 500 meters to examine the composition of the zooplankton community in the Benguela Upwelling and Angola Gyre, and further into the Equatorial Atlantic region.

On the last transect crossing the Angola Gyre we switched to a program of placing hydrographic stations at approximately 36 hour intervals, either in the early morning or evening hours, so as to avoid photo-inhibition of nitrogen-fixing communities during sampling. Offshore, the chlorophyll- maximum moved into the subsurface and below the mixed layer zone. In the Angola Gyre the sub-surface chlorophyll maximum (SCM) was detected at about 60m depth with estimated chlorophyll-a concentration of about 1.3 mg m^{-3} . The chlorophyll-a concentration decreased with depth continuously to 0.1 mg m^{-3} at 135 m depth. Near the equator the SCM was found at 25m depth with chlorophyll-a concentration of about 1.8 mg m^{-3} . A secondary SCM was observed at 25m depth with chlorophyll-a concentration of about 0.25 mg m^{-3} . The mixed layer depth in the Angola Gyre (Station M148-211, $08^\circ 49'S$) was about 60m. Below the mixed layer temperature, salinity and oxygen concentration dropped rapidly according the expected central water properties. Dissolved oxygen concentration exhibited a high degree of vertical variability in the upper 500 m. The minimum oxygen concentration of about $30\mu\text{M}$ was reached at 450 m depth in the Angola Gyre. Below 500 m depth the oxygen concentration increased again slowly.

The last hydrographic station activities on the Meteor M148-2 EreBUS transit expedition took place just north of the Equator (Station M148-215; $00^\circ 40' N$; $8^\circ 45' W$) and were completed on Thursday July 12, 2018 at approximately 10:30 local board time. Underway sampling and data collection continued for another couple of hours until short before the R/V Meteor reached the EEZ of Liberia. Experimentation and analysis of samples onboard continued during the transit. Transit progress was good through the Intertropical Convergence Zone, but significantly impeded by high wind, swell and current upon reaching the eastern North Atlantic trades on Monday July 16. On Friday morning July 20th the R/V Meteor reached Las Palmas in the Canary Islands, thus concluding the M148/2 expedition.

Acknowledgements

The chief scientist and scientific party would sincerely like to thank Captain Detlef Korte and the crew of the Meteor for their professionalism, enduring patience and cheerfulness. Ulrike Tietjen's organizational magic back home on shore also deserves a word of thanks. We gratefully acknowledge the Meteor Leitstelle, the German National Science Foundation (DFG), and the Federal Ministry for Education and Research (BMBF) for the organization and financing of Meteor Expedition M148/2. We also thank the Max Planck Society for substantial contributions to the execution of this research project.



Teilnehmerliste/Scientific Party

Name / Name	Task	Institut/Institute
1. Timothy Ferdelman	Fahrtleiter / Chiefscientist	MPI
2. Jana Milucka	TGG Biogeochemistry	MPI
3. Hannah Marchant	TGG Biogeochemistry	MPI
4. Gaute Lavik	TGG Biogeochemistry	MPI
5. Sina Schorn	TGG Biogeochemistry	MPI
6. David Benito Merino	TGG Biogeochemistry	MPI
7. Jon Graf	TGG Biogeochemistry	MPI
8. Sten Littmann	Deck Coordination	MPI
9. Tomas Wilkop	Deck Coordination	MPI
10. Wiebke Mohr	Nitrogen Fixation	MPI
11. Gabriele Klockgether	Analytical Chemistry	MPI
12. Kirsten Imhoff	Analytical Chemistry	MPI
13. Miriam Philippi	Nitrogen Fixation	MPI
14. William Orsi	Eukaryote Microbiology	LMU
15. Philipp Böning	Trace Elements	ICBM
16. Martina Schulz	Trace Elements	ICBM
17. Gonzalo Gómez	Dissolved Organic Matter	ICBM
18. Yanik Oertel	Dissolved Organic Matter	ICBM
19. Shungudzemwoyo Garaba	Ocean Optics	ICBM
20. Claudia Thoelen	Ocean Optics	ICBM
21. Volker Mohrholz	Physical Oceanography	IOW
22. Sebastian Beier	Physical Oceanography	IOW
23. Michael Siccha	Micropaleontology	MARUM
24. Martin Stelzner	Bordwetterwarte	DWD

Institute

DWD

Deutscher Wetterdienst
Seeschiffahrtsberatung
Bernhard-Nocht-Straße 76
20359 Hamburg / Germany
Internet: www.dwd.de

ICBM

Institut für Chemie und Biologie des Meeres
Carl von Ossietzky Universität Oldenburg
Car-von-Ossietzky-Str. 9-11
D-26129 Oldenburg/Germany
www.icbm.de
email: icbm@uni-oldenburg.de

LMU

Ludwig-Maximilians Universität München
Fakultät Geowissenschaften, Geobiologie & Paleontologie
Richard-Wagner Str. 10
80333 München/ Germany
www.palaeontologie.geowissenschaften.uni-muenchen.de
email: w.orsi@lrz.uni-muenchen.de

MARUM

Zentrum für Marine Umweltwissenschaften
Universität Bremen
Leobener Str. 8
28359 Bremen/Germany
<https://www.marum.de>
info@marum.de

MPI

Max-Planck-Institut für Marine Mikrobiologie
Celsiusstr.1,
D-28359 Bremen/Germany
www.mpi-bremen.de
email: contact@mpi-bremen.de

Stationsliste/ Station List

Station -	Event	Date Time	Device	Latitude	Longitude	Water Depth (m)	Rope Length (m)
M148/201-	1	02.07.2018 12:48	CTD	22° 59.920' S	014° 13.242' E	114	103
M148/202-	1	02.07.2018 14:19	CTD	22° 59.645' S	014° 03.067' E	140.3	126
M148/202-	2	02.07.2018 14:41	SD	22° 59.646' S	014° 03.067' E	140.9	3
M148/202-	3	02.07.2018 16:07	ACS	22° 59.645' S	014° 03.065' E	138.8	100
M148/202-	4	02.07.2018 17:10	Pump	22° 59.643' S	014° 03.063' E	140.2	120
M148/202-	5	02.07.2018 17:51	CTD	22° 59.645' S	014° 03.064' E	140.5	124
M148/202-	6	02.07.2018 19:27	GOFLO	22° 59.645' S	014° 03.066' E	139.3	106
M148/202-	7	02.07.2018 19:55	CTD	22° 59.644' S	014° 03.067' E	138.6	122
M148/203-	1	03.07.2018 08:36	CTD	21° 32.778' S	013° 31.126' E	114.9	107
M148/203-	2	03.07.2018 09:00	SD	21° 32.777' S	013° 31.125' E	114.2	0
M148/203-	3	03.07.2018 09:35	ACS	21° 32.778' S	013° 31.126' E	114.7	0
M148/203-	4	03.07.2018 10:02	ACS	21° 32.779' S	013° 31.125' E	114.4	100
M148/203-	5	03.07.2018 10:30	GOFLO	21° 32.778' S	013° 31.125' E	114.5	100
M148/204-	1	03.07.2018 19:58	CTD	19° 50.954' S	012° 39.977' E	123.5	109
M148/204-	2	03.07.2018 20:38	ACS	19° 50.955' S	012° 39.974' E	123.1	100
M148/204-	3	03.07.2018 21:05	GOFLO	19° 50.954' S	012° 39.974' E	123.1	104
M148/204-	4	03.07.2018 22:27	Pump	19° 50.954' S	012° 39.976' E	122.6	105
M148/204-	5	04.07.2018 01:01	CTD	19° 50.955' S	012° 39.974' E	123.1	109
M148/204-	6	04.07.2018 02:07	MUC	19° 50.954' S	012° 39.976' E	122.6	109
M148/204-	7	04.07.2018 02:30	MUC	19° 50.953' S	012° 39.974' E	123.5	115
M148/204-	8	04.07.2018 03:06	MUC	19° 50.954' S	012° 39.975' E	122.8	116
M148/205-	1	04.07.2018 08:20	CTD	18° 59.996' S	012° 09.869' E	130.1	119
M148/205-	2	04.07.2018 08:13	SD	18° 59.996' S	012° 09.871' E	130.2	10
M148/205-	3	04.07.2018 08:58	ACS	18° 59.998' S	012° 09.871' E	130	100
M148/205-	4	04.07.2018 09:25	GOFLO	18° 59.996' S	012° 09.869' E	129.8	110
M148/206-	1	04.07.2018 15:21	CTD	17° 59.998' S	011° 39.257' E	134.7	123
M148/206-	2	04.07.2018 15:12	SD	18° 00.000' S	011° 39.260' E	134.7	10
M148/206-	3	04.07.2018 15:55	ACS	18° 00.000' S	011° 39.258' E	134.8	98
M148/206-	4	04.07.2018 16:17	GOFLO	17° 59.999' S	011° 39.257' E	135.2	120
M148/206-	5	04.07.2018 16:51	MUC	17° 59.999' S	011° 39.258' E	135	130
M148/206-	6	04.07.2018 17:36	MUC	18° 00.000' S	011° 39.259' E	136.5	130

Station -	Event	Date Time	Device	Latitude	Longitude	Water Depth (m)	Rope Length (m)
M148/207-	1	04.07.2018 19:55	CTD	17° 59.970' S	011° 21.238' E	612.8	606
M148/207-	2	04.07.2018 20:34	ACS	17° 59.970' S	011° 21.238' E	613.8	97
M148/207-	3	04.07.2018 20:58	GOFLO	17° 59.970' S	011° 21.238' E	612.7	130
M148/207-	4	04.07.2018 21:48	MSN	17° 59.970' S	011° 21.238' E	612.6	510
M148/207-	5	04.07.2018 22:35	MSN	17° 59.970' S	011° 21.238' E	612.4	515
M148/206-	7	05.07.2018 03:48	CTD	17° 59.866' S	011° 39.336' E	133.7	125
M148/206-	8	05.07.2018 05:40	MOOR	17° 59.946' S	011° 39.272' E	956.3	0
M148/206-	9	05.07.2018 07:39	Pump	17° 59.998' S	011° 39.235' E	135.1	119
M148/206-	10	05.07.2018 08:16	SD	17° 59.998' S	011° 39.236' E	135	116
M148/206-	11	05.07.2018 10:46	MOOR	18° 00.007' S	011° 39.005' E	132.8	121
M148/208-	1	05.07.2018 19:19	CTD	17° 59.996' S	010° 00.013' E	4100.1	606
M148/208-	2	05.07.2018 19:58	ACS	17° 59.997' S	010° 00.013' E	4100.3	100
M148/208-	3	05.07.2018 20:34	GOFLO	17° 59.997' S	010° 00.012' E	4100.5	400
M148/208-	4	05.07.2018 21:46	MSN	17° 59.996' S	010° 00.011' E	4100.8	515
M148/208-	5	05.07.2018 22:31	MSN	17° 59.997' S	010° 00.013' E	4101.2	509
M148/209-	1	06.07.2018 08:05	CTD	17° 59.998' S	008° 07.026' E	5020.8	607
M148/209-	2	06.07.2018 08:51	ACS	17° 59.999' S	008° 07.026' E	5022.4	100
M148/209-	3	06.07.2018 09:29	GOFLO	17° 59.997' S	008° 07.026' E	5015	440
M148/209-	4	06.07.2018 10:21	MSN	18° 00.000' S	008° 07.026' E	5022.9	515
M148/209-	5	06.07.2018 11:05	MSN	17° 59.999' S	008° 07.026' E	5023.6	512
M148/209-	6	06.07.2018 11:30	SD	17° 59.999' S	008° 07.025' E	5020.2	0
M148/210-	1	07.07.2018 17:21	CTD	13° 22.799' S	003° 51.407' E	5554.8	604
M148/210-	2	07.07.2018 17:13	SD	13° 22.798' S	003° 51.404' E	5581.6	120
M148/210-	3	07.07.2018 18:04	ACS	13° 22.797' S	003° 51.406' E	5552	98
M148/210-	4	07.07.2018 18:37	MSN	13° 22.798' S	003° 51.405' E	5524.3	514
M148/210-	5	07.07.2018 19:19	MSN	13° 22.798' S	003° 51.406' E	5567	514
M148/210-	6	07.07.2018 20:14	GOFLO	13° 22.906' S	003° 51.405' E	5547.5	440
M148/210-	7	07.07.2018 20:53	CTD	13° 22.906' S	003° 51.405' E	5572.8	202

Station -	Event	Date Time	Device	Latitude	Longitude	Water Depth (m)	Rope Length (m)
M148/211-	1	09.07.2018 03:09	CTD	08° 49.007' S	000° 16.773' W	5679.4	372
M148/211-	2	09.07.2018 03:39	ACS	08° 49.008' S	000° 16.772' W	5686.8	100
M148/211-	3	09.07.2018 04:09	MSN	08° 49.008' S	000° 16.772' W	5682.7	481
M148/211-	4	09.07.2018 04:53	MSN	08° 49.008' S	000° 16.772' W	5675.8	515
M148/211-	5	09.07.2018 05:54	GOFLO	08° 49.064' S	000° 16.806' W	5672.9	432
M148/211-	6	09.07.2018 06:36	CTD	08° 49.063' S	000° 16.806' W	5677.7	605
M148/211-	7	09.07.2018 07:13	SD	08° 49.062' S	000° 16.807' W	5669.4	0
M148/212-	1	10.07.2018 08:38	CTD	05° 01.139' S	003° 40.302' W	4504.5	1516
M148/212-	2	10.07.2018 08:21	SD	05° 01.139' S	003° 40.300' W	4509	503
M148/213-	1	10.07.2018 14:25	CTD	04° 18.728' S	004° 18.519' W	4732.8	1092
M148/213-	2	10.07.2018 14:25	SD	04° 18.728' S	004° 18.520' W	4732.8	1098
M148/213-	3	10.07.2018 15:07	ACS	04° 18.729' S	004° 18.519' W	4732.4	100
M148/213-	4	10.07.2018 15:37	MSN	04° 18.729' S	004° 18.520' W	4731.3	515
M148/213-	5	10.07.2018 16:20	MSN	04° 18.729' S	004° 18.520' W	4731.1	515
M148/213-	6	10.07.2018 17:13	GOFLO	04° 18.782' S	004° 18.530' W	4737.5	440
M148/213-	7	10.07.2018 17:51	CTD	04° 18.782' S	004° 18.529' W	4732.7	265
M148/214-	1	11.07.2018 12:11	CTD	01° 29.515' S	006° 49.103' W	4672.6	143
M148/214-	2	11.07.2018 12:12	SD	01° 29.515' S	006° 49.104' W	4669.2	110
M148/214-	3	11.07.2018 13:29	CTD	01° 29.513' S	006° 49.102' W	4673.8	1049
M148/215-	1	12.07.2018 03:10	CTD	00° 39.978' N	008° 44.135' W	5091.8	186
M148/215-	2	12.07.2018 03:39	ACS	00° 39.928' N	008° 44.226' W	5905.1	140
M148/215-	3	12.07.2018 04:07	MSN	00° 39.882' N	008° 44.304' W	5818.6	515
M148/215-	4	12.07.2018 04:51	MSN	00° 39.834' N	008° 44.447' W	5879.5	513
M148/215-	5	12.07.2018 06:24	GOFLO	00° 39.819' N	008° 44.721' W	5864.6	1040
M148/215-	6	12.07.2018 08:26	CTD	00° 39.888' N	008° 44.839' W	5855	1086
M148/215-	7	12.07.2018 09:20	GOFLO	00° 39.834' N	008° 45.054' W	4793.4	45

Codes
 CTD *CTD - Rosette*
 SD *Secchi Disk*
 ACS *ACS Optical Profiler*
 Pump *Pump-CTD*
 GOFLO *Go Flo Bottles*
 MSN *MultiNet*
 MOOR *Mooring*