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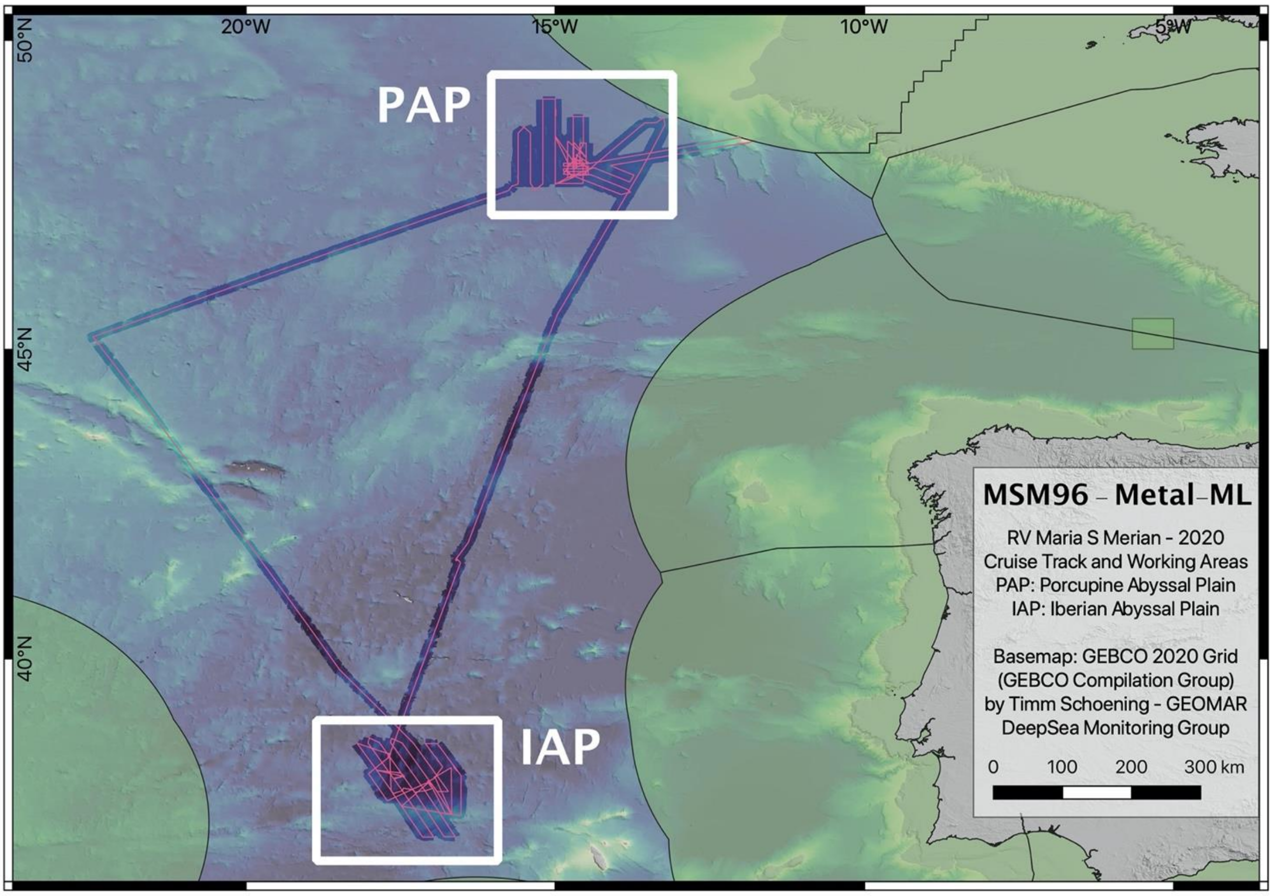
Short Cruise Report
RV MARIA S. MERIAN – MSM96 (GPF 20-3_088)

Emden – Emden (Germany)
10.10.2020 – 10.11.2020
Chief Scientist: Timm Schoening
Captain: Ralf Schmidt



Objectives

The goal of cruise MSM96 was to assess small- and large-scale geochemical and seafloor substrate heterogeneity across the NE Atlantic deep-sea basin. Specifically, we employed a hierarchical surveying strategy at three spatial scales: local, regional, and basin to look into trace metal and Rare Earth Element and Yttrium (REY) concentrations. At each of two survey sites, we deployed sampling gear covering three data resolution scales: centimeter (TV-MUC), meter (OFOS), and kilometer scale (MBES). Our research objective is to quantify the impact of topography on the geochemistry within and between regions and to establish the link – across resolution scales – between geochemistry, imagery and bathymetry. This link shall facilitate spatial extrapolation of seafloor geochemistry and substrate characteristics to kilometer-scale.

We studied three distinct topography types: a) valleys, b) plains and c) hills. For our purposes, we define valleys and hills as features -/+ 100 m of flat seafloor (plain), respectively, within the regional sampling sites. The location of the three topography types was objectively chosen based on an automated terrain classification algorithm.

The hierarchical surveying strategy is designed to:

- assess the heterogeneity within one topography type at local scale (100 m),
- assess heterogeneity within one topography type as well as between topography types at regional scale (20 km),
- assess heterogeneity within one topography type between regions across the NE Atlantic at basin scale (1000 km),
- assess heterogeneity between topography types across the NE Atlantic at basin scale (1000 km),

Our hypotheses are, that:

- seafloor substrate and habitats as well as geochemistry of plains is less variable on each spatial scale than in valleys and hills,
- shale-normalized REY patterns are less variable across topography types and scales than REY concentrations,
- varying image-derived seafloor features of substrates and habitats can be linked with point-based geochemistry measurements to extrapolate those to larger areas,
- automated and well-documented data acquisition and processing workflows from sea to public archives speed up data analysis and FAIR data publication.

All sampled sites consist of sedimentary seafloor and represent seafloor features common in the Abyss. By studying heterogeneity in the local and regional scales, we focused on topographic heterogeneity because spatial heterogeneity with respect to particle and organic matter flux from the sea surface can be expected to be minimal.

As a basis, sediment samples were taken for on-shore lab analyses of the major elements that also indicate general sediment composition: Al+K+Ti (terrestrial input, clays), Ca (carbonates), P (phosphates), Fe (Fe oxyhydroxides, Fe-rich clays), and Mn (Mn oxides). For the assessment of redox conditions, TOC, nitrate, as well as dissolved Mn and Fe will be quantified. Physical sediment properties, i.e. porosity, will also be measured after the cruise. This basic data helps to assess REY controls in the solid phase and pore water. All geochemical parameters together will be used to assess local- to basin-scale heterogeneity and how it is linked to topography.

Our aim – to link geochemistry and seafloor substrates to topography – is a first step of systematically assessing seafloor heterogeneity. In the future, this should be extended to also incorporate, e.g., oceanography, minerology, microbiology, and eventually link all these parameters across scales.

Narrative

Following a three-night quarantine stay in Leer, cruise MSM96 started from Emden on October 10th, 2020 with two other research vessels in sight: SONNE and METEOR. Shortly after leaving port, we took the first water sample in preparation of later experiments. It followed the transit towards the open Atlantic, outside of national waters where we began our almost continuous hydroacoustic mapping program which included water current data of the upper ca. 500m, seafloor bathymetry (water depth) and the sub-bottom profiling system to look into the upper layers of the seafloor. The route of the vessel was placed mainly in areas where no previous high-resolution mapping data existed to contribute to the Seabed 2030 initiative.

We surveyed two study areas in international waters: the northern “Porcupine Abyssal Plain” (PAP, ca. 14°W, 48°N) and the southern “Iberian Abyssal Plain” (IAP, ca. 17°W, 38°N). Both areas were mapped extensively during MSM96 by the multibeam. The goal was to better understand the terrain of the areas. We had chosen the working areas as the satellite-derived topography data showed some of the hill, valley and plain features that we were looking for. The maps we acquired by the multibeam show more detail and confirmed that we had chosen appropriate spots for the following sampling.

We classified the depth maps automatically which provided us with deterministic and distinct areas for our planned sampling scheme. On top of the echo-sounding work for the maps, we collected water samples with the hydrocast and images of the seafloor with the towed OFOS camera frame. With a rapid succession of Multicorer deployments we managed to physically sample our three target topographies – hills, plains and valleys – extensively in both areas, giving us confidence, that we surveyed the natural variability at a local to regional scale (100m – 20km). In total, we collected twelve multicores, both in the PAP and IAP area, completing sets of four samples per each of the three topography types (hill, plain, valley). Two samples of each topography were taken in close vicinity to serve as the local replicates to assess variability at 100m scale.

The northern “Porcupine Abyssal Plain” area consists of mainly plain seafloor with slopes less than one degree at a mean depth of ca. 4800 meters. The area is additionally covered by North-South facing ridges, rising up to 600 meters above the plains. One wider seamount feature in the area even rises to 1000 meters above the plain. In this area, the multicorer sampling and porewater analysis revealed suboxic conditions. More geochemical data on Total Organic Carbon content, Dissolved Organic Carbon concentration, Nutrients, Porosity, Trace Metals, especially Rare-Earth-Elements and Neodymium Isotopic composition, – all in the solid phase and pore water – will be measured in the home lab on shore after the cruise.

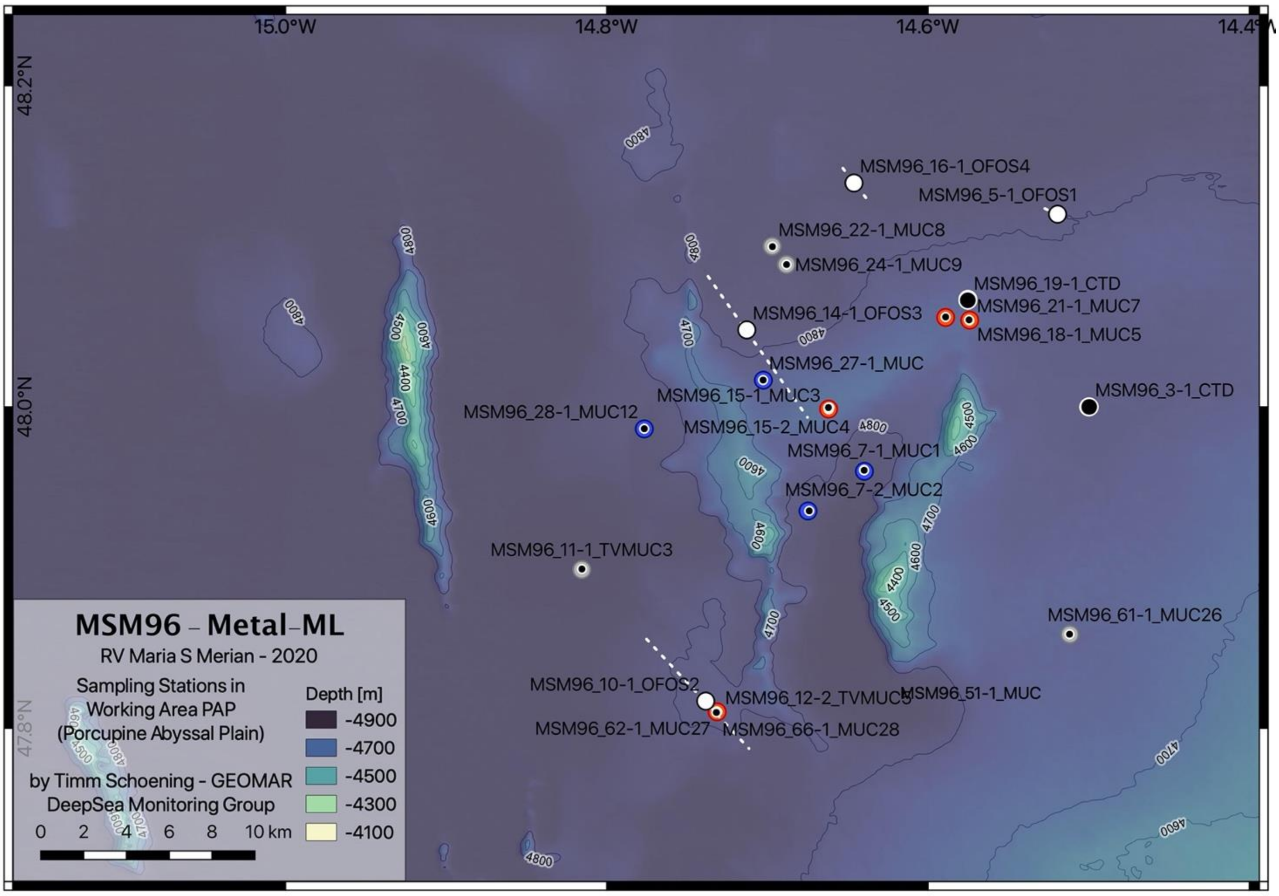
The southern “Iberian Abyssal Plain” area is located right North of the “Gloria Fracture Zone” separating the European and African plates. The hydro-acoustic map of this area shows narrow and steep valleys in the North-West section, also mainly in a North-South direction as in PAP. Towards the West, wider and up to 6000m deep plains exist and the fracture zone itself lies to the South which is rising up to 2500m above the plains we sampled. The geochemical analyses on board revealed oxic to suboxic conditions in the area and the same set of analyses as for the PAP area will follow later.

The planned science program was often challenged by technical failures or weather conditions. This means that we had to adjust the work plans frequently to exchange equipment that could not currently be deployed. Especially the OFOS work was challenged by technical failures yet the limited image data of both areas seems to show varying frequencies of fauna with generally the same groups appearing but with apparent differences between deployment sites. Due to the small size of the image dataset, statistically robust image analyses will anyhow not be possible calling for future expeditions to the area.

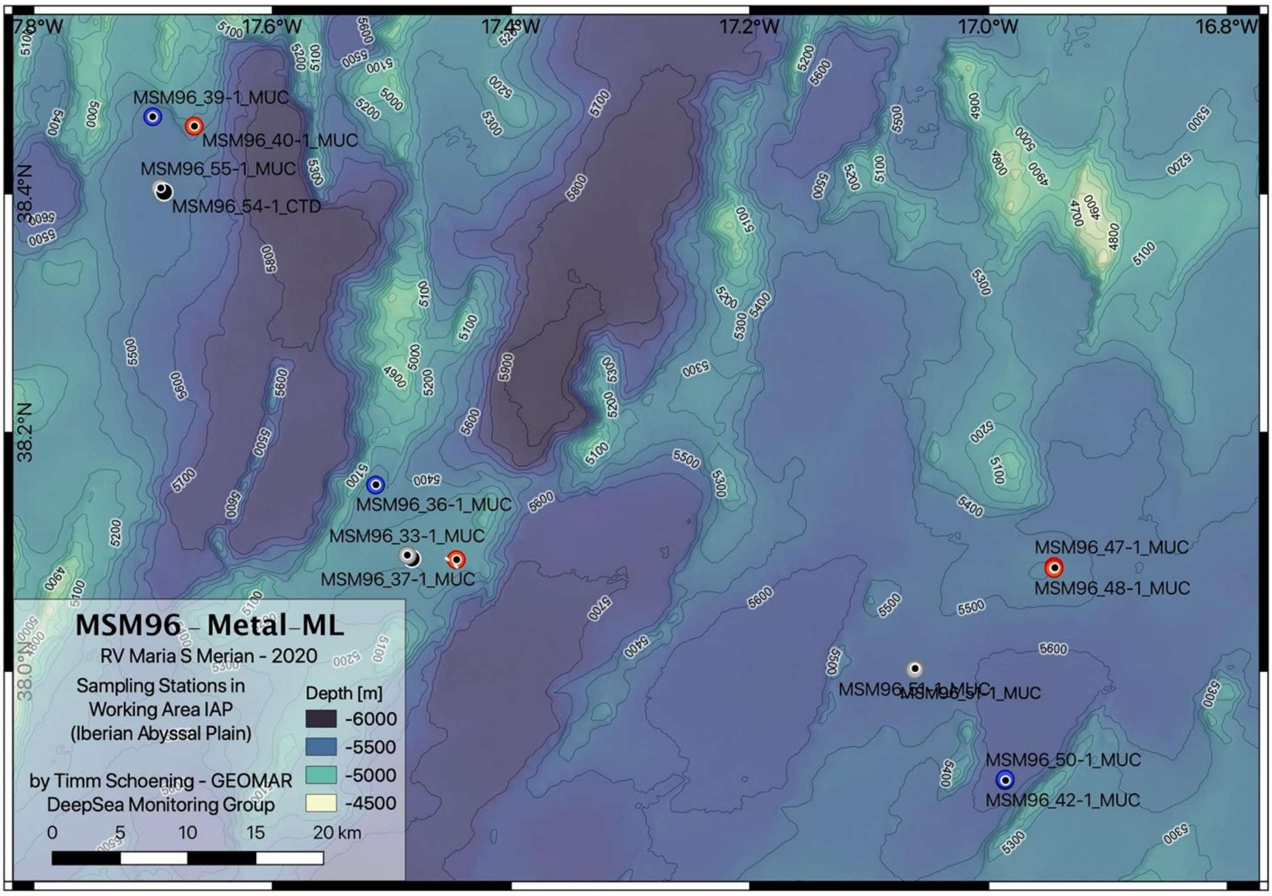
Sampling and surveying during the fifth week of cruise MSM96 was dominated by the coordination and execution of the recovery of the PAP ODAS buoy. Following a general enquiry by British colleagues from National Oceanography Centre (NOC) some days earlier to recover this scientific equipment, it had become clear that we could create an opportunity to finish work in the southern IAP working area, then transit back north to pick up the torn-off buoy as well as complete the previously interrupted work in the northern PAP area. On the way north towards the buoy, we added one multicorer sample in between the southern IAP and northern PAP area. The coordination of the buoy rescue mission was an excellent example of European diplomatic and research teamwork and the recovery successfully ended on November 5.

Cruise MSM96 returned to Emden on November 10th 2020. Overall, we completed 25 multicorer stations, 23 hydroacoustic mapping stations, 6 hydrocast stations for water samples and/or CTD profiles and 3 GoFlo stations for water samples. Only five OFOS stations provided data of which only two were completed as planned yet were also challenged by weather conditions.

Aside from the geochemical and mapping work, cruise MSM96 was also a testbed for data management initiatives by the DAM (Deutsche Allianz Meeresforschung) project “Underway data” and The Helmholtz data management activity “MareHub”. Data was acquired, processed and/or published already during the cruise according to FAIR workflows developed by these projects. Data curation and publication will continue on shore and all digital data will be freely available on Pangaea soon.



Sample locations in the northern “Porcupine Abyssal Plain” (PAP) area.



Sample locations in the southern “Iberian Abyssal Plain” (IAP) area.

Acknowledgements
We thank the crew of R/V MARIA S. MERIAN for their outstanding support, flexibility and optimistic work attitude. The science team is eager to work with you and R/V MARIA S.MERIAN again! We thank the German Research Foundation (DFG and GPF) for supporting this cruise and providing us with the opportunity to conduct our research on R/V MARIA S. MERIAN.

Participant list

1.	Timm Schoening	Fahrtleiter / *Chief Scientist*	GEOMAR
2.	Sophie Paul	Co-Chief Scientist / PI Geochemistry	JUB
3.	Nico Fröhberg	Geochemistry	JUB
4.	Lukas Klose	Geochemistry	JUB
5.	Palash Kumawat	Geochemistry	JUB
6.	Melanie Schnohr	Geochemistry	GEOMAR
7.	Doris Maicher	Geochemistry / IGSN	GEOMAR
8.	Thorsten Schott	MUC / OFOS Technician	GEOMAR
9.	Iason Zois-Gazis	Hydroacoustics	GEOMAR
10.	Jochen Mohrmann	Hydroacoustics	GEOMAR
11.	Karl Heger	OFOS / Data	GEOMAR
12.	Mbani Benson	OFOS	GEOMAR
13.	Lilian Böhringer	OFOS	AWI

Institutes:

GEOMAR:	GEOMAR Helmholtz Center for Ocean Research Kiel
JUB:	Jacobs University Bremen
AWI:	Alfred Wegener Institute Helmholtz Center for Polar and Ocean Research, Bremerhaven

Data publications and samples:
All data of cruise MSM96 will be published openly and FAIR for public use in the context of the data management projects DAM “Underway data” and the Helmholtz “MareHub”. As of January 2021, data is being quality-controlled and subsequently uploaded to OSIS and Pangaea.

You can find the data here:
1) PANGAEA: https://pangaea.de/?q=msm96
2) OSIS: https://portal.geomar.de/metadata/leg/show/357154

All samples (water and sediment) were assigned persistent identifiers (IGSN – International GeoSample Number) for future reference. These IGSNs are given in the device operations table below.

Device Operations (Station list)

Station	Start [UTC]	End [UTC]	Longitude	Latitude	Depth	DOI / IGSN
MSM96_1-1_GoFlo	10.10.20 09:55	10.10.20 10:05	06°25.264‘W	53°37.290‘N	10	
Transit	10.10.20 10:05	13.10.20 00:00	Transit			
MSM96_2-1_EM122	13.10.20 00:00	13.10.20 08:00	Profile			
MSM96_3-1_CTD	13.10.20 08:00	13.10.20 11:30	14°29.900'W	47°59.999'N	4769	KIEL0233GEAU201
MSM96_4-1_EM122	13.10.20 12:30	13.10.20 22:30	Profile			
MSM96_5-1_OFOS	13.10.20 22:30	14.10.20 03:00	Transect			
MSM96_6-1_EM122	14.10.20 04:45	14.10.20 11:00	Profile			
MSM96_7-1_MUC	14.10.20 11:30	14.10.20 14:30	14°38.389’W	47°57.647’N	4821	
MSM96_7-2_MUC	14.10.20 14:30	14.10.20 17:30	14°38.390’W	47°57.640’N	4828	
MSM96_7-3_TVMUC	14.10.20 19:00	14.10.20 22:15	14°38.386’W	47°57.634’N	4813	KIEL0233GEBU201
MSM96_8-1_TVMUC	14.10.20 23:00	15.10.20 02:00	14°40.437’W	47°56.117’N	4814	KIEL0233GECU201
MSM96_9-1_EM122	15.10.20 02:00	15.10.20 07:30	Profile			
MSM96_10-1_OFOS	15.10.20 09:00	15.10.20 22:45	Transect			
MSM96_11-1_TVMUC	15.10.20 23:30	16.10.20 02:30	14°48.927’W	47°53.945’N	4822	KIEL0233GEMU201
MSM96_12-1_TVMUC	16.10.20 04:00	16.10.20 06:30	14°43.885’W	47°48.610’N	3633	
MSM96_12-2_TVMUC	16.10.20 08:00	16.10.20 09:15	14°43.868’W	47°48.611’N	1211	
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MSM96_15-2_MUC	17.10.20 13:00	17.10.20 16:45	14°39.688’W	47°59.980’N	4700	
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MSM96_19-1_CTD	18.10.20 11:00	18.10.20 14:00	14°34.516'W	48°04.365'N	4769	KIEL0233GENU201
MSM96_20-1_MUC	18.10.20 14:30	18.10.20 17:30	14°35.343’W	48°03.359’N	4742	KIEL0233GEPU201
MSM96_21-1_MUC	18.10.20 18:00	18.10.20 21:15	14°34.468’W	48°03.252’N	4742	KIEL0233GEQU201
MSM96_22-1_MUC	18.10.20 22:15	19.10.20 01:30	14°41.810’W	48°05.987’N	4824	KIEL0233GERU201
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MSM96_25-1_MUC	19.10.20 16:15	19.10.20 20:15	14°39.721’W	47°59.976’N	4708	KIEL0233GETU201
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MSM96_28-1_MUC	20.10.20 13:30	20.10.20 16:45	14°46.600’W	47°59.187’N	4832	KIEL0233GEVU201
MSM96_29-1_EM122	20.10.20 18:15	22.10.20 07:00	Profile			
MSM96_30-1_EM122	22.10.20 07:15	25.10.20 01:30	Profile			
MSM96_31-1_EM122	25.10.20 01:30	26.10.20 13:15	Profile			
MSM96_32-1_CTD	26.10.20 14:00	26.10.20 17:45	17°29.219'W	38°05.817'N	5221	KIEL0233GEWU201
MSM96_33-1_MUC	26.10.20 17:45	26.10.20 21:30	17°29.218'W	38°05.832'N	5221	KIEL0233GEXU201
MSM96_34-1_OFOS	26.10.20 22:15	27.10.20 03:00	Transect			
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MSM96_36-1_MUC	27.10.20 12:00	27.10.20 16:00	17°30.827'W	38°09.352'N	5333	KIEL0233GEYU201
MSM96_37-1_MUC	27.10.20 16:50	27.10.20 20:45	17°26.811'W	38°05.639'N	5210	KIEL0233GEZU201
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MSM96_40-1_MUC	28.10.20 08:30	28.10.20 11:30	17°39.921'W	38°27.396N	5339	KIEL0233GE1V201
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MSM96_59-1_MOOR	05.11.20 08:30	05.11.20 09:30	13°16.666'W	48°44.949'N	0	
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MSM96_61-1_MUC	05.11.20 15:30	05.11.20 19:00	14°30.714'W	47°51.511'N	4774	KIEL0233GEBV201
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MSM96_63-1_CTD	05.11.20 23:25	06.11.20 00:45	14°48.879'W	47°48.609'N	4784	
MSM96_64-1_EM122	06.11.20 00:45	06.11.20 10:45	Profile			
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MSM96_67-1_CTD	06.11.20 15:00	06.11.20 18:30	14°43.902'W	47°48.591'N	4785	KIEL0233GEEV201
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MSM96_0-2_TSG	13.10.20 00:00	07.11.20 10:30	Profile			
MSM96_0-3_P70	13.10.20 00:00	07.11.20 10:30	Profile			
MSM96_0-4_ADCP	13.10.20 00:00	07.11.20 10:30	Profile			10.1594/PANGAEA.925936 10.1594/PANGAEA.925938