METEOR-Berichte

Interactions of trace metals, DOM, and particles in the Amazon estuary and associated plume as key processes for trace metal and DOM fluxes into the Atlantic

A Contribution to the International GEOTRACES Program

Cruise No. M147

April 19 – May 21, 2018
Las Palmas (Gran Canaria) – Belém (Brazil)

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1. Summary

METEOR Cruise M147 (Amazon – GEOTRACES) was set to assess in detail the role of the Amazon River towards the input of trace metals and dissolved organic matter (DOM) into the Atlantic Ocean as well as the isotopic characterization of water masses and mixing processes. The cruise is an official process study for the internationally coordinated GEOTRACES program (www.geotraces.org). The main research topic is to determine the distribution and speciation of trace elements along the salinity gradients in the mixing zone of the Amazon River estuary and its freshwater plume in order to quantify their biogeochemical cycling, the riverine contribution to open the ocean metal budgets, and its interaction with DOM and particulate matter. The trace metal flux to the ocean will likely be enhanced by complexation with DOM, which competes with colloidal coagulation and sedimentation. Within this frame, important factor to be considered are trace metal associations with physically different size fractions of matter (truly dissolved, organic and inorganic colloids, particles) along the salinity gradient between the river and the ocean. Therefore, a variety of filters including ultrafiltration were used to separate the different fractions. The cruise followed the Pará, as well as the Amazon south and north outflow, along the salinity transect to the open Atlantic Ocean. Furthermore, sampling continued northwards of the Amazon plume, along the coast line of Brazil and French Guiana. In total, 74 standard stainless-steel CTD-rosette profiles, 15 trace-metal clean CTD profiles, 10 single GoFlo-bottles, 60 pumps for radium samples, 107 surface samples with the towed fish and 22 multicorer stations were conducted. With this, the river water and seawater endmembers as well as the entire mixing zone within the exclusive economic zones of Brazil and French Guiana between 6°N and 1°S were covered by sampling.

Zusammenfassung

Die METEOR Fahrt M147 (Amazon-GEOTRACES) erfolgte mit dem Ziel, die Biogeochemie von Spurenmetallen und gelöstem organischem Material (DOM), sowie der isotopischen Charakterisierung von Wassermassen und Vermischungsprozessen im Amazonas Mündungsdelta zu untersuchen. Die Fahrt ist eine anerkannte Prozessstudie des internationalen GEOTRACES-Programms (www.geotraces.org). Hauptziel ist die Untersuchung der Verteilung von Spurenmetallen und DOM entlang des Salinitätsgradienten in der Mischungszone des Amazonas-Mündungsgebietes und seiner Süßwasserfahne, um die biogeochemische Prozesse und Interaktionen der Metalle mit DOM und partikulärem Material zu erfassen. Dies trägt zum Verständnis der Rolle des Amazonas für den Eintrag von Spurenmetallen und DOM in den Atlantik bei. Die Interaktionen von Spurenmetallen und DOM können den Eintrag vermutlich durch Komplexbildung verstärken, da sie in Konkurrenz zu kolloidaler Koagulation und Sedimentation stehen. Ein weiterer zu untersuchender Faktor in diesem Zusammenhang ist die Assoziation der Metalle mit physikalisch verschiedenen Größenklassen von Material (echt gelöst, organische und anorganische Kolloide, Partikel) entlang des Mischungsgradienten zwischen Fluss und Ozean. Deshalb wurden verschieden Filtergrößen einschließlich Ultrafiltration verwendet, um die Größenfraktionen aufzutrennen. Die Fahrt folgte dem Paráausstrom, sowie dem Süd- und Nordausstrom des Amazonas in den offenen Atlantik entlang der steigenden Salinität. Darüber hinaus erfolgte die Beprobung des Amazonas-Plumes nach Norden, entlang der Brasilanischen und Französisch-Guayanischen Küste. Insgesamt wurden 74

Standard CTD Profile, 15 spurenmetallreine CTD Profile, 10 einzelne GoFlo-Flaschen, 60 Pumpen für Radiumisotopenproben, 107 Oberflächenwasserproben mit dem Fish und 22 Multicorer Stationen gefahren. Hiermit wurden die Fluss- und Meerwasserendglieder, sowie die gesamte Mischungszone innerhalb der ausschließlichen Wirtschaftszonen von Brasilien und Französisch-Guyana zwischen 6°N und 1°S beprobt.

2. Participants

Name	Task	Institution
1. Koschinsky, Andrea, Prof. Dr.	Chief Scientist	JUB
2. Frank, Martin, Prof. Dr.	(Co-)Chief scientist, sampling for radiogenic isotopes	GEOMAR
3. Dittmar, Thorsten, Prof. Dr.	DOM sampling and experiments	Univ. Oldenburg
4. Scholten, Jan, Dr.	Ra isotopes, in situ pump	Univ. Kiel
5. Gledhill, Martha, Dr.	Trace metal clean sampling, Fe ligands, dissolved and particulate trace metals	GEOMAR
6. Hathorne, Ed C., Dr.	Sampling for radiogenic isotopes and rare earth elements	GEOMAR
7. Border, Evan	CTD	Univ. Heidelberg
8. Spiegel, Timo	CTD, MUC	GEOMAR
9. Vosteen, Paul	MUC (sediment sampling)	GEOMAR
10. Mutzberg, André	Nutrient analysis onboard	GEOMAR
11. Leist, Lisa	Nutrient analysis onboard	GEOMAR
12. Bretschneider, Lisa	Oxygen measurements, sampling for radiogenic isotopes	GEOMAR
13. Lodeiro, Pablo, Dr.	Trace metal clean sampling	GEOMAR
14. Seidel, Michael, Dr.	DOM sampling and experiments	Univ. Oldenburg
15. Knoke, Melina	DOM sampling and experiments	Univ. Oldenburg
16. Heinrich, Luise	Ultrafiltration, MUC (sediment and pore water sampling)	JUB
17. Paul, Sophie	Ultrafiltration, MUC (sediment and pore water sampling)	JUB
18. Zitoun, Rebecca	Trace metal clean sampling	JUB/Univ. Otago
19. Fronzek, Julia	MUC (sediment and pore water sampling)	JUB/Univ. Bremen
20. Münch, Jessica	MUC (sediment and pore water sampling)	JUB/Univ. Bremen
21. de Rezende, Carlos, Prof. Dr.	DOM and Hg	UENF

22. Cherene Bras de Oliveira, Braulio	DOM and Hg	UENF
23. Marques da Silva, Jomar, Dr.	DOM and Hg	UENF
24. Walter, Juline Marta, Dr.	Microbiology	SAGE-COPPE
25. Soares Nóbrega, Maria	Microbiology	SAGE-COPPE
26. de Carvalho, Leandro , Prof. Dr.	Onboard analyses of trace metals	UFSM
27. Schneider, Alexandre, Prof. Dr.	Onboard analyses of trace metals	UFRGS
28. Maguire, Clive	Logistics support, public outreach	JUB (contractor)
29. Rohleder, Christian	Meterology	DWD
30. Freire Peireira, Almir	Brazilian Observer	Brazilian Navy

JUB	Jacobs University Bremen
GEOMAR	Helmholtz Centre for Ocean Research Kiel
Univ. Oldenburg	Institute for Chemistry and Biology of the Marine Environment (ICBM), University of Oldenburg
Univ. Kiel	Institute of Geosciences, Christian Albrechts, University of Kiel
Univ. Heidelberg	Institute of Environmental Physics, University of Heidelberg
Univ. Bremen	University of Bremen
Univ. Otago	University of Otago
UENF	Laboratório de Ciências Ambientais, Centro de Biociências e Biotecnologia; Universidade Estadual de Norte Fluminense
SAGE-COPPE	Laboratório de Sistemas Avançados de Gestão da Produção (SAGE), Instituto Alberto Luiz Coimbra de Pós-Graduação e Pesquisa de Engenharia (COPPE), Universidade Federal do Rio de Janeiro (UFRJ)
UFSM	Instituto de Química, Universidade Federal de Santa Maria
UFRGS	Instituto de Química, Universidade Federal do Rio Grande do Sul
DWD	Deutscher Wetterdienst

3. Research Program

METEOR Cruise M147 (Amazon - GEOTRACES) is an accepted GEOTRACES process study. The aim of the GEOTRACES program is to record the distribution of trace elements and their isotopes in the ocean and to understand the processes that control this distribution. Internationally established sampling protocols are applied, which guarantee the full comparability of data acquired during different cruises carried out by different nations. The core of the research program of M147 was detailed sampling of the water column for trace metals, their isotopes, and dissolved organic matter (DOM) along the salinity gradient of the Amazon estuary and its associated freshwater plume in the Atlantic during the high discharge season from the end of April until late May 2018. The Pará outflow as well as the mangrove-dominated area southeast of the main estuary were sampled to complete the picture of freshwater entering the Atlantic in this greater Amazon area. The focus lies on trace metal and DOM biogeochemistry and the isotopic characterization of water masses and mixing processes. The scientific goal of the cruise was to study interactions between trace metals and DOM as well as particulate matter and the flux of trace metals and DOM from the Amazon into the Atlantic. This will enhance our understanding of the riverine contribution to open ocean budgets of trace metals and DOM in the Atlantic. An important aspect of this flux is also the speciation of the trace metals (including redox speciation and organic complexation by metal-binding DOM), as interaction with DOM and particulate matter depend on it. The complexation of trace metals with DOM will likely enhance the trace metal export to the ocean but also competes with removal via colloidal coagulation and sedimentation during the mixing process of fresh water and salt water. Within this frame, an important factor to be considered are trace metal associations with physically different size fractions of matter (truly dissolved, organic and inorganic colloids, particles) along the salinity gradient between river and ocean. Therefore, a variety of filters including ultrafiltration were used to separate the different fractions.

To enable measurements of the very low trace metal concentrations in seawater without sampling artefacts a trace metal clean CTD (TM-CTD) was used. For surface water samples, a Fish was towed at low speed, which also allows trace metal clean sampling and the water was directly pumped in the clean laboratory. TM-CTD and Fish samples are filtered and distributed into aliquots for various trace metal analyses in the home labs in the trace metal clean container. Some trace metals were already analyzed on board using voltammetry. At some stations, ultrafiltration was conducted in addition to the filtration in the trace metal clean container to get samples from the truly dissolved phase. Samples for oxygen, nutrients (e.g. nitrate, phosphate, silicate), oxygen and nitrogen isotopes and DOM were taken from the conventional stainless steel CTD and in case of oxygen also from the TM-CTD in order to be able to calibrate the sensors. Concentrations of oxygen (via Winkler titration) and nutrients (photometric methods) were immediately analyzed on board. Additionally, incubation and mixing experiments to assess the degradation of organic matter were carried out on board. Pumps to take samples for particles and isotope analyses were run in parallel to the TM-CTD for large volume samples.

For the analyses of sediment and its pore water, which will give insights into the removal processes in the mixing zone because it acts as a sink and possibly additional source of trace metals and DOM, a multicorer (MUC) was deployed. Pore water was extracted by means of centrifuge and filtration for trace metal including rare earth elements and yttrium and nutrient analyses.

The trace metals that will be analyzed as part of this cruise are micronutrients (Fe, Mn, Cu, Ni, Co, Zn, Mo, V), particle reactive elements (Ti, Zr, Hf, Nb, W), rare earth elements and yttrium (REY), and Hg as a potential tracer for anthropogenic metal input. Our objectives include the characterization of net Ba, Nd and Hf isotopic fluxes from the Amazon into the Atlantic Ocean from dissolved and suspended sediment sources, the assessment of the source of trace metals and water masses, the tracing of the mixing processes, and the advection and mixing of the plume via the combination of radiogenic Nd and Ra isotopes.

Essentially all the trace metal parameters can only be measured in the home laboratories on land, which is the reason why the major focus of cruise M147 was contamination-free sampling of sea water and particulate samples. The sample analysis will therefore be conducted following the return of the samples to the laboratories. Most of the work during the cruise hence focused on filtration, preservation, and preconcentration on columns.

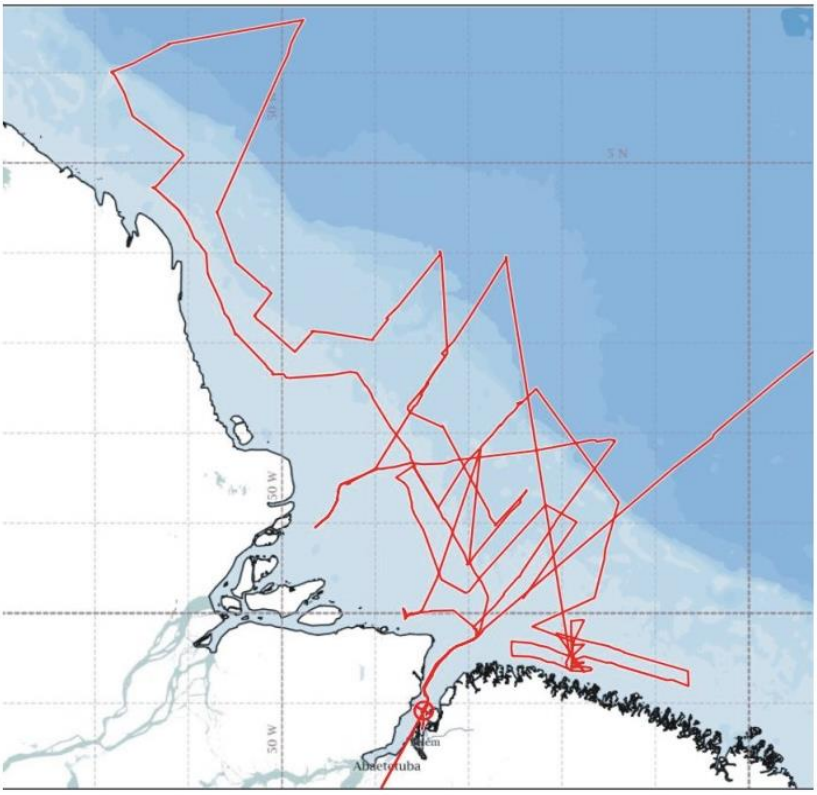

Fig. 3.1 Cruise track of RV METEOR cruise M147, along which water and sediment stations and continuous monitoring of salinity and CO2 were carried out.

4. Narrative of the Cruise

(A. Koschinsky; JUB)

Cruise M147 started in Las Palmas, Canary Islands. Initially a group of 12 scientists from GEOMAR, Kiel, Jacobs University Bremen and the University of Oldenburg and an observer from Brazil arrived in Las Palmas between the 16th and 18th of April, 2018. All containers from Germany had already arrived and thus the installation of the trace metal clean CTD-rosette equipped with 24 x 12 liter GO-FLO water samplers and the mobile winch with an 8 km plastic coated conducting cable of GEOMAR could start immediately. These devices were essential for contamination-free sampling of seawater. The clean lab container of GEOMAR served as clean laboratory space. On 19th April at 9:00 a.m. RV METEOR left Las Palmas. The scientists set up the laboratories testing devices and the methods while they travelled to Belém for 10 days. Glove boxes were set up in some of the laboratories to guarantee clean laboratory handling of contamination-prone trace elements and their isotopic compositions. The equipment for sediment sampling and pore water extraction was established and additionally, the ultrafiltration devices were assembled and tested.

On the way to the south, the towed surface fish was used for the first time to pump water into the clean-room container to carry out an experiment with dissolved organic matter (DOM), for which the organic matter was extracted, concentrated, and preserved for subsequent work. In addition to the use of the towed surface fish, the trace-metal clean rosette sampler with CTD was deployed to recover 400 liters of seawater from a depth of 500 m for an experiment with DOM. Another 400 liters were taken from a depth of 1000 m as a reference sample for the international GEOTRACES program. The water was filtered and aliquots were filled into bottles that measure

0.5 liters in the clean laboratory of GEOMAR.

The second group of scientists from Jacobs University Bremen, GEOMAR, the University of Kiel, ICBM at the University of Oldenburg, and all the Brazilian project partners from four different institutions and locations arrived in Belém on the 28th of April. The group boarded the RV METEOR early in the afternoon on April 29th through a transfer made with a boat from Mosqueiro Station. The ship made its way back through the shipping canal of the Rio Pará around 5 p.m. and three hours later we started sampling the surface water of the river as one of the endmembers of the estuarine mixing zone using the towed fish. The newly arrived scientists set up their lab equipment and integrated themselves into the thematic working groups that were formed during the transit, which allowed a very fast and efficient start to the full sampling program. The next morning, four standard CTD-rosette stations, three trace-metal CTD-rosette stations, and two multicorer stations were deployed in the outflow zone of the Rio Pará and along a section towards the northeast as soon as we left the shipping canal. A surface pump was deployed at most stations to attain large volumes of water, which were pumped across manganese fibers to adsorb the dissolved radium that is applied as a tracer for the last contact of the respective waters with the coastal or shelf area. The first section was completed on May 1st which included sampling the seawater endmember with the CTD rosette samplers and the multicorer in a water depth >2000 m. All stations were successful and delivered an impressive number of samples to the different laboratories, challenging the different groups with a large diversity of material and with an extremely high particle load of the water samples from the river endmember and the proximal river plume. Methods were partly to be adapted in order to deal with the specific properties of the samples. In addition, there were short transit times between the stations, strong tidal effects, a shallow water depth of only 10-20 m over the large distance along the estuary and the shelf that required specific navigation and sampling strategies. The station work was often affected by extremely strong rain showers, as we were in a region where it was the end of the rainy season during the time of high discharge of water from the Amazon River. However, as everyone from the scientific team and the ship's crew contributed their best to find solutions for all the situations, the sampling schemes could be kept as planned and only the station sequences had to be adapted to the extended periods of time which were needed for processing the samples between the stations. While most samples were processed for storage and for later analysis via sensitive and highly sophisticated methods in home laboratories, some data were already produced onboard which helped to refine the sampling strategies. These include dissolved nutrient analyses (nitrate, phosphate, silicate), dissolved oxygen, and radium isotopes which were plotted against the salinity gradients along the sections. In addition, some trace metal concentrations and species were already analyzed with voltammetry methods in one of the ship labs. Furthermore, river water - seawater mixing experiments and photodegradation experiments with DOM were carried out onboard.

The ship then steamed towards Canal do Norte, the northern outflow channel of the Amazon river, to occupy a salinity section perpendicular to the coastline and parallel to the Rio Pará salinity section. We started CTD-rosette and multicorer sampling at the wide sandbank which during low tide is partly shallower than 10 m and separates the estuary from the extended shelf area. At high tide, the ship then crossed the sandbank into the Canal do Norte and steamed a few hours upstream to meet the river endmember at a salinity below 0.1. Nevertheless, all measured values remained slightly above this value. We sampled the river water and sediment at the southwestern-most point of the planned section and then steamed back in order to cross the sandbank again at the next high tide. From there, we slowly continued towards the northeast and stopped to sample with the CTD-rosette and the fish as soon as our chosen salinities of 1 – 2 – 3 – 4 – 6 – 9 – 14 - 20 - 27 had been reached at water depths between 15 and 100 m. The northernmost point again represented the seawater salinity endmember of 35 at a water depth of about 2000 m, where a multicorer was also taken.

From the end point of this section, we had a longer transit of about 28 hours to the mangrove belt which was southeast of the Pará river mouth slightly south to the equator. This gave the scientists an opportunity to catch up with the processing of the remaining samples and also to get some sleep. In the morning of the 5th of May, a longer salinity section including a CTD and pump sampling campaign started along the coastline, as close to the coast as the shallow water depth and some obstacles allowed us to go. While to the east of 47°W, we had to keep a distance of about 20 nm to the shoreline, nevertheless we were able to go as close as 10 m around the contour line on the western side towards the Rio Pará. A second section was performed at a distance of 10 nm from the nearshore section. Throughout the whole sampling campaign, the salinity of the water was significantly reduced (down to 15 PSU) and the water had a greenish color from high amounts of algae which was a clear indication of the enormous outflow of relatively fresh groundwater and the strongly enhanced biological productivity in this area. Similar to the mangroves in other parts of the world, this mangrove belt plays a very important role in the carbon budget and it is a major contributor of DOM to the ocean. The radium isotope measurements confirmed the far-reaching impact of these waters, while further to the west the northward directed surface currents merge them with the dominant freshwater plumes of the Rio Pará and the Amazon.

On May 7th around noon, we left the area and steamed north, while continuing the salinity records and surface water sampling with the towed fish. About 24 hours later we started the salinity section from the ocean endmember towards the Canal do Sul, the southern outflow channel of the Amazon at 2°20'N 47°28'W. We sampled the seawater endmember at a station which was about 1030 m deep with both CTD-rosette systems, the pumps, and the multicorer and then followed the salinity gradient towards the river endmember in southwesterly direction. However, after the first few stations, the constraints of the tidal cycles forced us to interrupt the sampling along the selected salinity, but we had to steam south to the sandbank to be able to still cross it at high tide. We were not able to go further up the river because of the very shallow and the incompletely mapped bathymetry in the Canal do Sul but since the salinity was already as low as 0.03 PSU directly behind the sandbank, we sampled the river endmember with CTD-rosette and pump at two different positions and also took sediment cores. With the incoming high tide, we covered the salinity points of 1,2, and 4 before crossing the sandbank again in the evening of May 9, from where we had to return to Belém due to a medical emergency.

We then returned to the sampling track of the salinity section of the southern Amazon outflow, which we had left two days earlier. On the way there, in the evening of May 10, we included a 20 m deep station at 48°W in the middle between the Pará and the southern Amazon channel outflows, which marked the first point of our next sampling section along the plume during its northwesterly advection with the surface currents. We took water and sediment samples and then met the salinity section of the Amazon-south profile again in early morning of 11th of May. Salinity points 21, 16, 12, 9 and 6 PSU were covered with regular CTD-rosette and pumps. Sampling of sediment proved to be difficult at a water depth range between 40 to 50 m. The sediment was very coarse-grained and difficult to penetrate and also the porewater sampling was not possible. The sediment closer to the river outflow, however, mainly consisted of liquefied mud without any layered structure because it is apparently continuously resuspended by the tidal currents. Thus, sampling of the pore water and discrete solid layers was only possible to a very limited extent.

After the last salinity point of 6 which was covered in the afternoon of 11th of May, we started to move further southeast to meet the long SE-NW section following the advection of the plume along the shore on the 20 m depth contour line, which brought us north into the EEZ of French Guiana after one and a half days. Intense fishing activities with nets and fishing lines floating along large parts of the section required special attention by the crew on the bridge and the sampling points partly had to be slightly relocated. We sampled the surface water with regular CTD-rosette, fish and pump about every 35 nm at 13 different locations in order to investigate the biogeochemical processes prevailing in the plume. Also, at three of these locations the surface sediment was recovered with the multicorer, providing a good sample recovery with structured sediments that could be sampled in depth intervals.

Since we had to stay out of the 50 nm mile zone of the EEZ of French Guiana, we moved further away from the coast towards the northeast on 13th of May as soon as we had reached the border between Brazil and French Guiana. Since in this region we were north of the intertropical convergence zone ITCZ, we had stable dry weather conditions. While the freshwater plume flows northward in a rather small strip along the coast up to about 5°N, from here it widens notably and reaches further into the Atlantic. We investigated the extension of the Amazon River plume into the Atlantic by a first station at about 5°N 51’W and then moved further to the northeast up to 6°29’N 50°35’W using stainless steel and trace-metal clean CTD-rosette sampler systems as well as one multicorer station. On our northeastern-most station at 6°35’N 51°12’W we had transparent blue water for the first time, with a salinity of more than 35, which was a clear indication that we had left the freshwater plume behind us and that we had the pure seawater endmember of the Atlantic under the keel for the first time in two weeks. Due to a problem with the frame of the trace-metal clean CTD system we had to stop its use at some point during this transect and from then on could only use individual GoFlo-bottles from the rosette sampler on a Kevlar rope. This also affected our intercalibration station of the GEOTRACES program, close to a point were earlier the different water masses were sampled and analysed within the framework of the GEOTRACES program. Our renewed sampling allows a comparison of the data at different times and from the different institutions.

On the 15th of May we started our plume transect back from northwest to southeast, moving about 30 nautical miles east of the previous transect And following a line parallel to the SE-NW transect approximately on the 40-50 m depth contour line. The water column was sampled at all stations and one more surface sediment station using the multicorer was carried out. The sampling program was structured similarly to the previous one and was only interrupted to cover missing stations and salinity points of the Amazon outflow transects along the NW-directed salinity gradient into the Atlantic. Among others, we included one deep station at about 1000 m depth to complete a mixing transect from the northern Amazon outflow channel into the Atlantic. The significant impact of the tidal currents on the exact position and distribution of the mixing zones and salinity points required a repeated adaptation of the station plans to the local conditions. Again, the occasionally very intense fishing activities with boats and nets impacted our straight-line profiles. The last days were used to close further gaps in the sampling grid and to finish all profiles. After the last water column sample had been taken with a GoFlo bottle, we used the remaining time for salinity and CO_2 recordings parallel to the coastline along the 10 m depth contour line between the Amazon river and the Rio Pará, another section along the Rio Pará mixing transect, and then back to the shipping canal of the Rio Pará from where we approached the port of Belém. Data recording was finished on May 20 in the early morning.

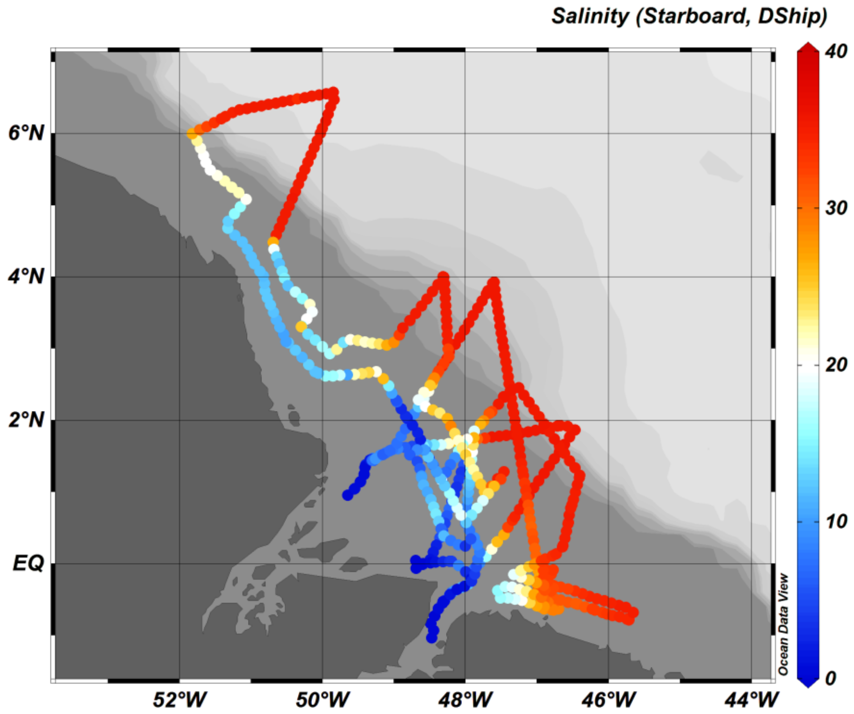

Fig. 4.1 Salinity gradients in the surface water based on DSHIP data recorded during M147, plotted with Ocean Data Viewer (Martha Gledhill).

At the end of the journey, we had covered all river and seawater endmembers and the whole mixing zone between the EEZ of French Guiana at 6°N and 1°S in the mangrove groundwater discharge area southeast of the Rio Pará, according to the original plan. The total profile and sampling track of cruise M147 shown on the cover page includes 74 standard CTD-rosette samplers, 15 trace-metal clean rosettes, 10 single GoFlo-bottles, 60 pumps for radium samples, 107 surface samples with the towed fish and 22 multicorer stations. Salinity data and CO_2 readings in the surface water were carried out continuously during the whole time. Based on the salinity data, we now already have a good overview of the spread of the freshwater outflow and its impact on biological and biogeochemical processes within the region, which can be assessed based on the nutrient data (nitrate, phosphate, silicate) produced onboard. The first evaluation of the radium isotope data gives hints about the influence of the ground water discharges of the mangrove belt on the composition of the water masses and the temporal frame of the water mass movement to the northwest.

5. Preliminary Results

5.1 Trace Metal Clean CTD (TM-CTD)

(M. Gledhill, P. Lodeiro, R. Zitoun)

Seawater samples were collected with a towed Fish, TM-CTD equipped with 24 contaminant-free OTE bottles and a contaminant free OTE sampler suspended from a Kevlar wire. Water from the sea surface was pumped into the trace metal laboratory container using a Teflon diaphragm pump and a braided PVC tube. The Fish was positioned in about 2 to 3 m water depth. Samples were filtered in-line through a 0.8/0.2 μm cartridge filter (AcroPak1000™) into acid washed low-density polyethylene (LDPE) bottles. Surface seawater samples were collected for dissolved trace metals, total dissolvable trace metals, soluble trace metals, iron speciation and nutrient analysis from a total of 105 Fish samples.

The TM-CTD water sampling rosette was deployed at 14 stations with depths > 40 m. After recovery, the OTE bottles were immediately carried to the trace metal clean sampling container. At 7 stations with water column depths between 10 and 40 m and a GEOTRACES crossover station, a contaminant free OTE bottle was deployed using a Kevlar wire. Samples were collected as soon as possible after recovery of the OTE bottles. Samples were collected for dissolved trace metals (<0.2 μm, 170 samples, GEOMAR, JUB, UFRGS and UFSM), particulate trace metals (55 samples >0.2 μm, GEOMAR), unfiltered total dissolvable trace metals (102 samples, GEOMAR, UFRGS and UFSM), particulate and dissolved iron isotopes (37 samples, M. Staubwasser, University of Cologne), iron speciation (63 samples, <0.2 μm GEOMAR), copper speciation (<0.2 μm, JUB) and nutrients. The soluble trace metal fraction (GEOMAR, 129 samples) was obtained by further filtration through 0.02 μm Anapore filters (Millipore).

5.2 Dissolved, Particulate, and Total Dissolvable Trace Metals

(M. Gledhill, P. Lodeiro, R. Zitoun)

Trace elements are essential micronutrients in the ocean and provide information on material sources and water mass provenance. Large rivers such as the Amazon can be a significant source of trace elements to coastal areas. Nevertheless, processes within the estuarine mixing zone can extensively modify riverine fluxes. Such processes include primary productivity and interactions with lithogenic particles. In this study we aim to identify processes influencing the transportation of trace elements through the Amazon estuary and calculate the flux of iron, copper, nickel, zinc, lead, cadmium, manganese and cobalt from the River Amazon to the shelf edge.

Samples for dissolved, particulate and total dissolvable metals were acidified to pH<2 by ultra-pure grade hydrochloric acid (HCl, UpA Romil). Samples were stored in the dark and shipped to the home laboratories for further analysis. Samples for iron speciation and particulate metals were frozen at -20°C prior to shipment to GEOMAR for analysis. At GEOMAR, the trace metal content of soluble, dissolved, total dissolvable and particulate seawater samples will be analyzed by inline pre-concentration and isotope dilution inductively coupled plasma mass spectrometry (ID-ICP-MS, Element XR, Thermo) (Rapp et al., 2017).

5.3 Biogenic Iron Compounds

(M. Gledhill)

Iron is an essential nutrient for marine life. Large rivers such as the Amazon are known to be a significant source of iron to coastal areas. Nevertheless, iron concentrations on shelf environments can rapidly decrease to extremely low concentrations as a result of particle adsorption and primary productivity (Birchill et al., 2017). At low concentrations of iron, marine microbes reduce the cellular content of essential iron containing proteins. Approximately 20% of these proteins contain heme b as a cofactor (Bellworthy et al., 2017). In addition, some bacteria produce specific iron binding compounds called siderophores in order to enhance iron acquisition and to effectively compete with other microbes for this scarce resource (Mawji et al., 2008). In this study we will investigate the occurrence of heme b and siderophores in order to assess how the microbial community adapts to the changing iron gradient in the Amazon plume.

Analysis of heme b in particulate material: A total of 85 seawater samples were collected from the trace metal clean underway sampling system (Tow Fish) and from the METEOR and trace metal clean (TM) CTDs when on station. Between 0.1 and 2 L were filtered onto glass fibre filters (25mm). Filters for pigment analysis and particulate organic carbon/nitrogen (POC/N) were also collected on the same samples for comparative purposes. Filters were frozen at -70°C for later analysis. Heme b will be analysed by high performance liquid chromatography with detection by mass spectrometry (Gledhill, 2014).

Analysis of siderophores in dissolved and particulate material: Seawater (2 L) was collected from the trace metal clean tow fish or from the METEOR and TM CTDs and filtered through 0.2 µm polyvinyldifluoride filters (Sterivac). Filters were frozen at -80 °C for later analysis of particulate siderophores after extraction into ethanol. Dissolved siderophores were concentrated onto polystyrene divinyl benzene polymeric resin (ISOLUTE ENV+ solid phase extraction cartridge) and frozen at -20 °C. Siderophores abundance and diversity will be assessed by high performance liquid chromatography (HPLC) – electrospray ionization – mass spectrometry (ESI-MS)(Mawji et al., 2008).

5.4 High Field Strength Elements, Humic Substances and Copper Binding Ligands

(S. Paul, L. Heinrich, R. Zitoun, J. Fronzek, J. Münch)

Trace metals play an important role for the biogeochemical cycles in the world's oceans, but their distribution, sources and sinks along a salinity gradient are not yet well understood. During the M147 cruise, 25 filtered (0.2 µm) depth water samples between 10 and 2000 m were taken at 8 stations using the TM-CTD or messenger triggered GoFlo bottles in order to investigate the distribution and controlling factors of trace metals, ligands and humic substances along a salinity gradient. We collected 13 samples at 4 superstations for dissolved trace metals (dTM) (e.g., Ti, W, Nb, Hf, Zr, V, and Mo), copper ligands, humic substances, and bulk samples (500 mL) for redox speciation analysis of Cr, V, and Mo. All samples were filtered (0.2µm) in the trace metal clean container using 0.8/0.2 µm cartridge filters (AcroPak1000^{TM}). Subsequently, the samples underwent another filtration step, except for redox species samples, using 0.1 M suprapure hydrochloric acid (HCl) cleaned 0.015 µm membrane filters (Whatman, nuclepore Track-Etch Membrane) to differentiate between size pools. A reduced program was performed at four "normal" TM-CTD stations, obtaining samples only for dTM (n=12), redox speciation (n=12), copper ligands and humic substances (n=4) without 0.015 µm filtration. Additionally, a total of 106 filtered (0.8/0.2 µm cartridge filters (AcroPak1000^{TM})) surface water samples (2-3 m water depth) were collected along the cruise track with a trace metal clean Fish. The Fish collection included the full program for 21 stations and a reduced program for 85 stations. In total, 106 dTM, 39 Mo, V, and Cr redox species, 25 copper ligands, and 24 humic substances samples were taken with the Fish. Samples were collected in acid cleaned low density polyethylene bottles (LDPE) and taken under trace metal clean conditions in a trace metal clean sampling container. Aliquots of dTM (n=23), humics and copper-ligand (n=24) samples at selected Fish stations were additionally filtered through 0.1 M suprapure HCl cleaned 0.015 µm membrane filters (Whatman, nuclepore Track-Etch Membrane) to remove the colloidal fraction. This process will allow the evaluation of the importance of different size fractions regarding the distribution of trace elements in the ocean, since some of the investigated elements are highly particle reactive, and it will help to characterise prevailing ligands and humic substances in the water column. Samples for copper complexing ligands and humics were immediately transferred to a -20 °C freezer and shipped frozen to the Jacobs University Bremen and the University of Brest, respectively. Copper ligands will be determined by adsorptive cathodic stripping voltammetry (AdCSV) at Jacobs University Bremen, while humics will be analysed at the University of Brest. Dissolved trace metal samples (100 mL) were acidified using 200 µL ultrapure HCl (34%, Roth) and 10 µL hydrofluoric acid (HF) (48%, Roth). Trace metal samples were then stored in the dark at 4°C until shipment to Jacobs University Bremen, which occurred under ambient temperature conditions. Trace metal samples will be analysed using ICP-MS at Jacobs University Bremen. Bulk samples for redox speciation of Cr, V, and Mo (bottles filled without headspace in the trace metal clean container) were separated into individual 100 mL acid cleaned sample bottles under a nitrogen atmosphere within an acid cleaned glove box on board. Redox speciation samples were immediately frozen (-20 °C) and kept frozen until analysis with at Jacobs University Bremen.

5.5 Ultrafiltration for DOM and Trace Metal Analyses

(S. Paul, L. Heinrich, R. Zitoun, J. Fronzek, J. Münch)

The distribution of trace metals, DOM, and copper ligands among different size pools in the river-seawater mixing zone is not yet well understood. Therefore, we took 2 L and 5 L water samples at four selected stations (three at the Amazon North transect and one at the mangrove area) from the trace metal clean Fish during cruise M147 to perform 1kDa and 10kDa ultrafiltration with a Merck Millipore Cross Flow system. This procedure will help to determine the distribution of trace metals, metal-DOM complexes and copper ligands in the truly dissolved, colloidal and particulate fractions. After each sample, 30 mM ultrapure HCl (34%, Roth) was circulated for 10 minutes to remove any remaining colloids from the system. Permeate, retentate and 30mM HCl samples were taken for trace metal analyses (e.g., Ti, W, Nb, Hf, Zr, V, and Mo) at Jacobs University Bremen and for DOM, Fe and Cu analyses at the University of Oldenburg. Additionally, only permeate samples were aliquoted for voltammetric analyses on board and frozen at -20°C for copper ligand analyses at Jacobs University Bremen. Permeate and Retentate samples for on-board voltammetric analyses, DOM, Fe, and Cu were acidified with 100 µL ultrapure HCl (34%, Roth), while trace metal samples were acidified with 200 µL per 100 mL ultrapure HCl (34%, Roth) and 10 µL per 100 mL ultrapure hydrofluoric acid (HF) (48%, Roth).

Trace metal samples were stored dark at 4°C until container shipping, which took place without refrigeration.

5.6 Onboard Speciation Analysis of Trace Metals by Stripping Voltammetry

(A. Schneider, L. Carvalho)

During the cruise M147, samples from the Fish and the TM-CTD were directly taken to the clean container, where unfiltered and filtered (0.2 μm) aliquots were prepared. In addition, ultrafiltered (1 kDa and 10 kDa) samples were prepared and analyzed onboard. The on-board direct determinations of trace metals were carried out by stripping voltammetric methods in filtered and ultrafiltered samples to quantify the electrochemically active form of the analytes, which naturally exist as labile complexes or hydrated ions. In this approach, the following elements were determined: copper, nickel, cobalt, uranium, vanadium, titanium, molybdenum and zirconium. The voltammetric methods used for each analyte were the following:
Cu: Anodic Stripping Voltammetry in Acetate buffer (pH 4.6)
Ni: Adsorptive Stripping Voltammetry with Dimethylglioxime as complexing agent (pH 9.5)
Co: Adsorptive Stripping Voltammetry with Dimethylglioxime as complexing agent (pH 9.5)
U: Adsorptive Stripping Voltammetry with Chloranilic acid as complexing agent (pH 2.3)
V: Adsorptive Stripping Voltammetry with Cupferron as complexing agent (pH 4.6)
Zr: Adsorptive Stripping Voltammetry with Cupferron/Oxalic acid/1,3-Diphenylguanidine as complexing agents (pH 4.8)
Mo: Adsorptive Stripping Voltammetry with Mandelic acid as complexing agent (pH 2.0)
Ti: Adsorptive Stripping Voltammetry with Mandelic acid as complexing agent (pH 3.3)

The active forms of Ni, Mo and V could be measured in all the samples collected on-board. Comparing with expected results in sea and river waters, it seems that the most part of the analysed elements are present as labile complexes with the dissolved organic matter. The results will be compared with the concentrations of total dissolved elements after UV digestion of the filtered and unfiltered samples. The complete speciation work will be carried out in the laboratories of UFRGS and UFSM (Brazil) within the next 4 months. The speciation analysis will involve the determination of total dissolved (filtered aliquot), total (unfiltered aliquot) and active dissolved trace metals, as well as the truly dissolved (ultrafiltered aliquots) species of the analytes in the samples. The difference between the total (unfiltered) and the total dissolved (filtered) will be also important to verify the particulate species of the elements. The main goal of the experiments by stripping voltammetry is the study of the chemical mass balance of the elements and its species along the salinity gradients in the Amazon plume.

5.7 CTD

(E. Border)

During the course of the M147 cruise, a primary focus was using CTD casts to observe and sample from the freshwater plume emerging from the mouth of the Amazon river. Towards the end, two separate CTD systems were utilized: the RV METEOR conventional stainless steel CTD as well as a specialized TM-CTD system brought from GEOMAR designed to minimize the contamination of ambient water with metals from the CTD/cable and allow the best possible conditions for analysing trace metal samples along the water column. Both systems were equipped with 24-bottle sampling rosettes. A specialized winch and plastic-coated cable (also from GEOMAR) were used to operate the TM-CTD, which only allowed for the CTD to be deployed from the rear of the ship. This proved to be a complicated factor when using the TM-CTD, as the rolling of the ship made the deployment and the retrieval of the CTD difficult. On two occasions the frame of the CTD was damaged because it collided with the ship's hull.

In total, 91 CTD stations were carried out, 15 with the TM-CTD and 76 with the METEOR CTD. During the Transit from Las Palmas to Belém only the TM-CTD was used, however, once in the Amazon region each TM station was preceded by a METEOR CTD at the sample location. This allowed for better targeted sampling with the TM- CTD of features such as the Chlorophyll Maximum, due to the METEOR CTD being equipped with a fluorescence sensor. There was a large variability in the types of stations which were carried out, ranging from <20m depth stations directly in the Amazon to more typical oceanic stations thousands of meters deep. At very fresh stations (<8 PSU) the CTD pumps could not be turned on, meaning that a comprehensive profile was not possible. At other stations, particularly along the salinity gradient transects, the METEOR CTD was only briefly submerged at the surface in an effort to avoid vertical mixing and allow sampling of just the upper freshwater layer at the chosen salinity. A typical CTD station involved casting a full profile of the water column and sampling either only at the surface (to get Amazon plume water) or both at depth (tropical ocean water) and the surface.

Aside from pressure, temperature, salinity, and oxygen content sensors, both CTD systems were slightly different in their setups. The METEOR CTD was equipped to measure fluorescence and PAR, while the TM-CTD had a second oxygen sensor and a transmissometer for measuring turbidity.

Samples for salinometry were taken to calibrate the salinity sensors of both CTDs. Those samples were measured by salinometry on the following cruise M148 under the guidance of Markus Dengler (GEOMAR).

5.8 Nutrients

(L. Leist, A. Mutzberg)

The objective was the determination of the concentrations of the macronutrients phosphate, silicate, nitrate and nitrite in the estuarine plume and the entire sample area. Macronutrients strongly influence the level of primary productivity in the Amazon plume area and set the biogeochemical context for the behaviour of other chemical constituents. The development of phytoplankton blooms is especially dependent on the available nutrients.

Nutrients were analysed with a SEAL QuAAtro, continuous flow auto analyser. CTD and Fish samples were filtered for water samples with high turbidity, otherwise the samples were measured unfiltered. Measurements were made simultaneously on four channels to determine concentrations of phosphate, silicate, nitrate and nitrite. All measurements were calibrated with an eight-point-calibration-curve. Artificial seawater (ASW) was used as wash-water between the samples. Before and after each run we checked our standards with reference material for nutrients in seawater (CRM Lot. CG and CRM Lot. BW) following recommendations by SCOR working group 147. Nutrient samples were taken directly from the CTD Niskin bottles or the Towfish in pre-cleaned PP bottles and stored at 4°C and measured within 24 h. Pore water samples were taken by the JUB group in pre-cleaned PP bottles and immediately stored at 4°C and measured within 24 h. During the cruise we measured 769 samples: overall 440 samples from the METEOR CTD and the TM-CTD, 107 Fish samples and 180 pore water samples. As a reference 42 CRM samples were measured.

The nutrients are important parameters allowing other parameters to be related to primary production and remineralization. With the nutrients data it was possible to get a first idea of the distribution and advection of the Amazon plume (Fig. 5.8.1).

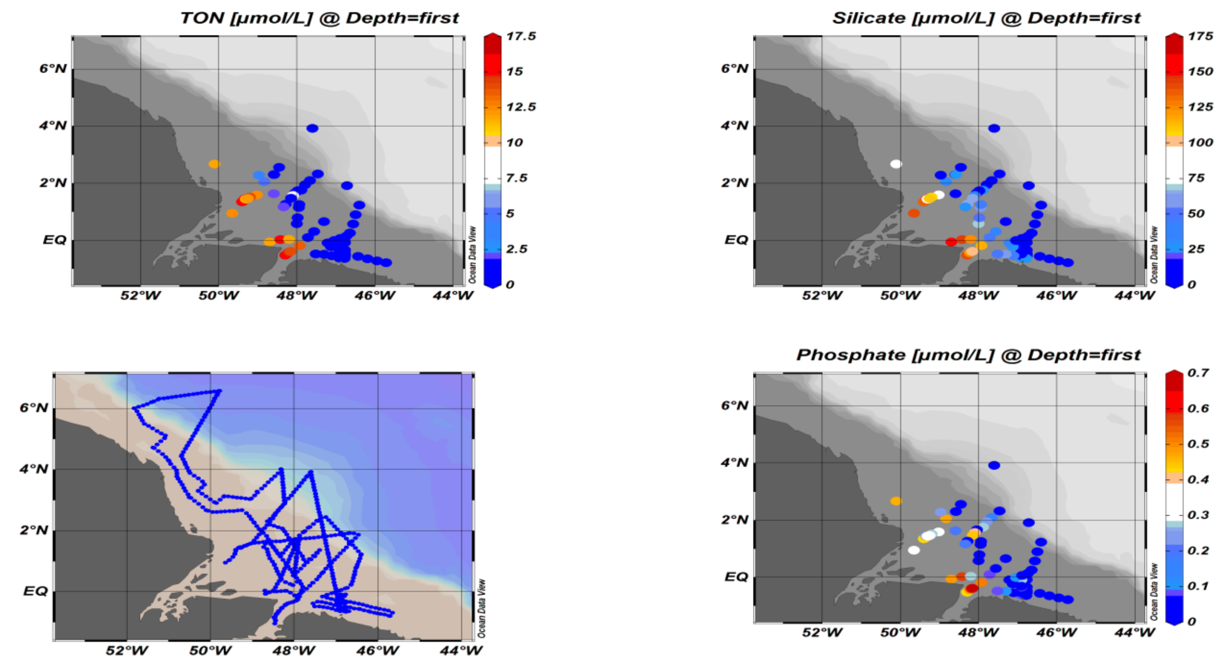

Fig. 5.8.1 Concentrations of total oxidised nitrogen (TON), silicate and phosphate observed in surface waters (2 m depth) between 30.04.2018 and 16.05.2018.

5.9 DOM Sampling, Incubation and Photodegradation Experiments

(T. Dittmar, M. Seidel, M. Knoke)

Surface water samples were collected with Niskin bottles at all >100 stations where the conventional (stainless steel) CTD was employed. In addition, near-bottom samples were collected at the deeper stations where the TM-CTD was employed. In Rio Pará, the CTD could not be employed because of logistical reasons. Here, surface samples were collected with the continuously towed Fish.

All water samples were filtered through a membrane of 0.1 µm pore size. DOM of 2 L of each sample was solid-phase extracted for detailed molecular, elemental and carbon isotopic analysis at the home laboratory at the University of Oldenburg. Aliquots of all samples were prepared for dissolved organic carbon, organic nitrogen and optical analyses.

Experiments performed onboard: The main processes, such as estuarine mixing, microbial degradation and photodegradation, were simulated onboard. Amazon River water (filtered and unfiltered) was mixed with Atlantic water in 11 steps regarding salinity, following the sampling procedure in the estuary and on the shelf. River water was also incubated with the natural microbial community in the dark, and sterile photodegradation incubations were performed by exposing the samples to natural sunlight in quartz vessels over two weeks. All experimental samples were processed as the samples taken from the CTD. In addition, samples for metal ligand titration and trace element analysis were taken. Overall, about 150 discrete water samples were taken. In addition, aliquots of sediment samples, taken with the MUC, and aliquots of the retentates and permeates of ultrafiltered water samples were prepared for the chemical analysis at home. Fluorescence of terrigenous DOM was measured onboard in all samples. CO2 concentration in the water was continuously monitored in the ship's seawater line. Samples will be shipped to Oldenburg, where we will perform all molecular, isotopic and elemental analyses. All data will be interpreted in close collaboration with the complementary research activities by the various partners in Brazil and Germany.

5.10 Biogeochemistry and Microbiology

(C. de Rezende, J. Marques da Silva Jr., B. Cherene Bras de Oliveira, J. M. Walter, M. Soares Nóbrega)

The major biogeochemical processes are related to the organic matter and Hg in the gradient continent-ocean continuum from the estuaries to the breaking of the continental shelf. Molecular markers such as benzene polycarboxylic acids (BPCAs) and lignin phenolic derivatives were used to characterize the transport, degradation, and early diagenesis of organic matter along the continent-ocean interface. Efforts were made to improve the understanding of the influence of climate change on the biogeochemistry of organic matter and Hg compared to other regions. The taxonomic and metabolic profiles of the bacterial and virus communities across the -ocean transect, including the mixing zones, were unravelled.

The main microbial metabolisms occurring in the plume were characterised and connected to the involved taxa. An investigation was done on the influence from the virus diversity and the abundant metal (e.g., iron) concentration. Meanwhile, the grain size will be measured with a particle analyser (Shimadzu SALD-310), conducting measurements for water, sediments and suspended particulate matter. Total organic carbon and nitrogen (TOC and TN, respectively) and, δ13C and δ15N isotope will be determined using elemental analyser Flash 2000 (Organic Elemental Analyser – Thermo Scientific) coupled to a mass spectrometer Delta V Advantage (Isotope Ratio Mass Spectrometer, IRMS- Conflo IV interface – Thermo Scientific) after removal of inorganic carbon. The Total Hg (THg) will be analysed by cold-vapor atomic fluorescence spectrometry (CVAFS) using the Tekran 2600 based on EPA Method 1631. Aluminium and Ti (Total concentration), Fe and Mn (Total and Reactive concentration) will be determined by ICP OES (Varian 720 ES) after chemical preparation. Lignin-derived phenols will be measured using alkaline CuO oxidation in a microwave digestion system and its quantification by gas chromatography-mass spectrometry (GC-MS-QP2010Plus- Shimadzu). Black carbon (BC) quantification will be conducted by gas chromatography-mass spectrometry (GC-MS-FID QP2010 ULTRA) after a proper chemical preparation.

Activities on board

1. Salinity and conductivity determination on board of all CTD samples and 13 Fish samples
2. Filtering water samples for particulate and dissolved Hg (120 samples)
3. Ultrafiltration F1: Ø > 0.1µm; F2: 10 kDa < Ø < 0.1µm; F3: 1 kDa <Ø<10 kDa; F4 UDOM: Ø < 1 kDa (Ultra Dissolved Organic Matter) –5 samples
4. SPL preparation after filtration –120 samples

5. Sediments for our group were sampled by Paul Vosteen and Timo Spiegel. We will stay in contact after expedition M147 and exchange our results. –19 cores with several depths.
6. Metagenomics: flow through microbial biomass contained in ten-litre seawater were concentrated onto 0.22 µm Sterivex filters (Merck Millipore), using a peristaltic system. Filters are used in triplicate for each water sample. Filters were stored in liquid nitrogen until further analyses. Total samples: 41
7. Metatranscriptomics: flow through microbial biomass contained in the seawater were concentrated onto 0.22 µm Sterivex filters (Merck Millipore) for 30 minutes using a peristaltic system. Filters are used in quadruplicate for each water sample. Filters were sodden with RNAlaterTM-Ice (Invitrogen), for RNA stabilization, and they were stored in liquid nitrogen until further analyses. Total samples: 41
8. Viromics: for virus purification and concentration we used a tangential flow filtration (TFF), which include a peristaltic system (Cole-Parmer) and a membrane filter (Amersham Biosciences). Total samples: 15

5.11 Carbonate Chemistry

(M. Gledhill, J. Scholten)

The plume of the Amazon estuary has been identified as a significant sink for CO_2, with concomitant effects on seawater pH and the chemical speciation of anions and cations. The high organic matter content within the plume also potentially influences alkalinity and thus characterization of the carbonate system. Of particular interest for the aims of this work is the impact of the changes in pH on metal speciation and the solubility of metals in the plume waters. In order to accurately determine pH and investigate the distribution of the dissolved inorganic carbon species in the Amazon, samples were collected for dissolved inorganic carbon, total alkalinity (DIC/TA) and organic alkalinity.

63 Samples for DIC/TA (GEOMAR) and organic alkalinity (Severino Ibánhez, Trinity College, Dublin, Ireland) were collected from surface waters (3-4 m depth) using the METEOR CTD rosette. Depth profiles were also collected from the TM-CTD. Water for DIC/TA was sampled as soon as possible after the CTD was secured on deck, taking care to minimize gas exchange during sampling. Samples were preserved to prevent bacterial growth and shipped back to GEOMAR for analysis. Samples for organic alkalinity were collected, filtered (0.2 µm) and frozen for analysis in the laboratory in Ireland.

5.12 Nitrogen and Oxygen Isotopes

(S. Paul, L. Heinrich, R. Zitoun, J. Fronzek, J. Münch)

In order to determine N- and O-isotopes along the salinity gradient from the Amazon river endmember to the Atlantic Ocean seawater endmember and with depth in the water column, 44 50 mL water samples were collected from the stainless steel CTD rosette at selected stations. Samples were filtered through 0.45 µm cellulose acetate syringe filters (Sartorius) and immediately frozen at -20°C. Analyses will be performed at the Institute for Baltic Sea Research in Warnemünde (IOW).

5.13 Radiogenic Isotopes (Nd, Hf), Rare Earth Elements (REEs), Ba and Si Isotopes

(M. Frank, L. Bretschneider, E. Hathorne)

Radiogenic Nd and Hf isotopes are a set of tracers that provide information about erosional input into seawater and in the ocean serve as proxy tracers for water mass mixing. The isotopic signatures in continental rocks vary as a function of type and age of the rocks, which release these signatures during weathering and mainly transfer them to seawater via dissolved and particulate riverine inputs, but also via exchange with shelf sediments and submarine groundwater discharge (e.g. Frank, 2002). The dissolved Rare Earth Elements (REEs) have been shown to experience significant transformations in estuaries such as the one of the Amazon (cf. Rousseau et al., 2015) in that very efficient removal via coagulation with Fe oxyhydroxides in the low salinity range between 0 and 3 has been observed. At mid to high salinities, in contrast, release of REEs from suspended particles occurs and increases their concentrations and modifies the isotopic compositions of the Amazon inputs into seawater. For Hf and its radiogenic isotope composition there is, however, to date no information on its estuarine behavior and transformations. The combined investigations of dissolved and particulate Nd and Hf concentrations and isotopic compositions, as well as REE distributions are one of the main goals of this cruise. The expected results will allow a more reliable application of these isotope tracers for modern seawater studies as well as reconstructions of past seawater based on extractions from marine sediments.

During cruise M147, the main goal was the determination of the metals and isotopic compositions along the complete salinity gradient from freshwater to seawater in order to investigate which factors control their transformation in the estuary and which signatures ultimately arrive in the open tropical western Atlantic Ocean. The Nd and Hf isotope data will be combined with the Ra isotope measurements of the surface waters performed by Jan Scholten, which will provide detailed information about the dissolved metal fluxes from land (see section 5.15). An additional focus will be surface water samples from two sections perpendicular to the mangrove coast to the east of the Amazon estuary, where it is known that large scale submarine groundwater discharge occurs. While it is known that this discharge is important for REEs, its impact on the Hf and Ba isotope compositions of seawater are unknown and will be subject of our investigations. An additional goal was to monitor the geochemical changes of the plume surface waters with increasing distance from the Amazon mouth along their northeastward pathway. In addition, the water column below the plume and near the sediment was sampled to investigate interactions with the particles.

For the combined radiogenic Nd and Hf isotope measurements a total of 85 large volume samples were taken covering the entire study area. Given that it is not known to what extent Hf is removed in the estuary via coagulation and particle scavenging, 20-40l of seawater from two to four Niskin bottles of the stainless steel standard rosette were collected per sample in 20l cubitainers or 20l carboys and were filtered through 0.45µm Nucleopore filters within a few hours after collection (filtered particles were also collected). The samples were acidified to prevent adsorption to the walls of the bottles and will also serve for analyses of stable Ba and Si isotopes, which allow investigation of the particulate process in the plume waters during transition from the river to the open ocean. In the home laboratory at GEOMAR the metals will be concentrated by iron hydroxide coprecipitation and after ion-chromatographic cleaning the isotopic compositions will be measured via Multi-Collector-ICPMS.

5.14 Uranium Isotopes

(E. Border)

Samples were taken at every METEOR CTD station as well as selected TM-CTD stations for the measurement of uranium concentrations and 234U/238U activity ratio. The aim was to better understand the effects of Amazon uranium input into the ocean, with particular emphasis on seeing how this input would affect the oceanic isotopic composition. Also of interest is the process by which uranium is removed from the ocean, which is thought to happen strictly through scavenging in estuarine environments. Through sampling along the salinity gradient.

Samples were filtered using a 0.45 µm Acropak filter and collected in 250 ml HDPE bottles. These samples were acidified with 400µl 32% HCl to prevent biological processes altering the pH leading to the uranium becoming insoluble. Further large samples were taken from selected stations along the salinity gradient in 1.5 l water bottles which were not acidified. In total 168 250 ml and 9 1.5 l samples were taken. These will be processed and analyzed at the Institute of Environmental Physics in Heidelberg, Germany.

5.15 Radium Isotopes

(J. Scholten)

The four radium isotopes (223Ra t1/2 = 11.3 days; 224Ra t1/2228Ra t1/2 = 5.7 years; 226Ra t1/2 = 1600 y) have shown to be very helpful for the determination of continent-derived elemental fluxes. They are produced in the sediments by radioactive decay of thorium. In contrast to thorium, radium is mobile in the marine environment. Once released from the sediments via diffusion, desorption from suspended sediments and/or submarine groundwater discharge only mixing and decay influence the radium distribution in the water column (Ku and Luo, 2008). From the distribution of radium in surface waters mixing time scales of water masses can be determined and combined with elemental data but also fluxes of elements (Su et al., 2013). As the four radium isotopes have very different half-lives water mass transport acting on different time scales (days to years) can be investigated. For instance, the application of radium isotopes helped to better quantify the shelf-derived trace element inputs to ocean basins (Charette et al., 2016). Previous investigations at the Amazon shelf indicate that the radium isotope distribution depends on the salinity. The radium water column inventory is controlled by the sediment supply, water mixing and the seawater residence time (Moore et al., 1995). Based on radium apparent ages a rapid release of dissolved Rare Earth Elements from the Amazon plume was observed (Rousseau et al., 2015).

The main goal during M147 was the determination of the radium isotope distribution along the salinity gradient from freshwater to seawater. This spatial distribution allows us to investigate the processes controlling the radium release and dispersion along the flow path of the Amazon plume. Furthermore, the influence of submarine groundwater discharge occurring south of the Amazon estuary was investigated. In cooperation with the other groups of M147 the radium data will help to better estimate elemental fluxes from the Amazon river.

For radium determinations at 62 stations between 16l and 236 l of seawater was pumped from ~ 2m water depth into 100l barrels. Seawater salinity was measured using a hand-held conductivity probe. To preconcentrate radium the water was filtered with a flow rate of ~ 1 l per hour over MnO2-impregnated acrylic fibres. The isotopes 224Ra and 223Ra were subsequently measured on-board using a radium coincidence counting system (RaDeCC) following the methods outlined in Moore (2008). Measurements of 228Ra and 226Ra concentrations will be conducted in the home laboratory using gamma spectrometry.

5.16 MUC (Solid Phase)

(P. Vosteen, T. Spiegel)

The Amazon estuary is one of the biggest river systems in the world and features a very high sediment flux from the Brazilian rainforest into the open ocean. Due to its dynamic environment, the sediments in the river mouth system vary on a small scale. At the same time the bathymetry plays a key role in distributing the sediment while underwater and wind induced currents transport the sediments along shelf, as well as from on- to offshore. In order to understand the processes of the interchange between the sediments and the water column as well as the diverging composition of the sediments itself it is needed to collect samples from the dry sediment, pore water and bottom water from different locations all over the amazon estuary and shelf. Therefore, we sampled 21 different locations with the MUC.

At each, station one to six sediment cores were brought into the cool lab to be sampled. The temperature of the cool lab was mostly at 12°C but was cooled down to 4°C for the deeper stations. One core at every station was sampled to take sediments for measurements of physical properties (density, water content, porosity etc.), as well as measurements for different element distributions and concentrations (e.g. phosphorus or iron content). The cores were mainly sampled in intervals of 1 cm up to a sediment depth of 6 cm and in intervals of 2 cm for the rest of the core. In some special cases these intervals were modified due to specific characteristics of single sediment cores. At several stations the surface sediments from a second core were sampled for later measurements of alkenones. All samples were stored at 4°C during the whole cruise. The samples for physical properties and alkenone measurements were later stored at -20°C and stayed on board until being shipped to Germany at -80°C on dry ice. The other sediment samples remained at room temperature in containers and were transported to Germany without further cooling.

5.17 MUC (Solid Phase and Pore Water)

(S. Paul, L. Heinrich, R. Zitoun, J. Fronzek, J. Münch)

In order to understand the interplay of water column and benthic processes in the Amazon estuary, pore water and sediment samples from the MUC were taken during M147 to investigate removal of particles and colloids from the water column to the sediment in the mixing zone of the Amazon plume.

First, bottom water was sampled with a 0.1 M suprapure hydrochloric acid (HCl) and deionized water (DI) pre-cleaned syringe and filtered through a 0.1 M suprapure HCl and DI pre-cleaned 0.2 μm PC syringe filter (Whatman, nuclepore Track-Etch Membrane; MUCs 11-67) or a 0.2 μm cellulose acetate (CA) syringe Filter (Whatman; MUCs 73-117).

Pore water for Fe and Mn, nutrients, as well as trace elements such as Cu, Co, V, Mo and U was sampled in a glove bag filled with nitrogen in the cold room of RV METEOR at 4-12°C, depending on the water depth and temperature of the sampling station. Samples for rare earth elements and yttrium (REY) and particle reactive high field strength elements (e.g., Ti, W, Nb, Hf, Zr) were sampled from a second MUC core at the same station in the cold room without a glove bag. In the upper 2 cm, 1 cm intervals of sediment were sampled and below, roughly 2 cm intervals were sampled, depending on core length and the sediment layers in each core. Sediment was transferred into acid and DI pre-cleaned 50 mL centrifuge tubes and centrifuged at 4-12°C at

3500rpm for 40 minutes. Afterwards, samples taken in a glove bag were filtered through 0.1 M suprapure HCl pre-cleaned 0.2 µm syringe filters (Whatman, nuclepore Track-Etch Membrane MUCs 11-67) or a 0.2 µm CA syringe Filter (Whatman; MUCs 73-117) in a glove bag, while samples taken outside the glove bag were also filtered outside a glove bag. Nutrient samples were kept cold until analysis on board. REY as well as Fe and Mn samples were acidified with 1 µL ultrapure HCl (34%, Roth) per 1 mL sample. Samples for trace metals such as Cu, Co, V, Mo and U were acidified using 2 µL ultrapure HCl (34%, Roth) per 1 mL sample. Samples for trace metals (e.g., Ti, W, Nb, Hf, Zr) were acidified with 2 µL ultrapure HCl (34%, Roth) per 1 mL sample and 0.1 µL ultrapure HF (˜48%, Roth) per 1 mL sample. All trace metal samples were stored in the dark at 4°C until container shipping, which was done without refrigeration. Centrifuged sediment was kept for solid phase analyses (bulk acid digestion followed by major and trace element measurements at JUB) as well.

5.18 Public Outreach

(C. Maguire, A. Koschinsky)

Fig. 5.18.1 Image of Amazon GEOTRACES M147 blog.

A simple Wordpress website and blog was set up for the project, using a cloud-based site package from Hostgator (*hostgator.com*) and with the domain name *amazongeotraces-m147.com*. Because of the English-Portuguese bi-lingual needs of the site, additional premium software Elementor (*elementor.com*) and WPML (*wpml.org*) - a theme package and multilingual plugin respectively - were added to the basic package, and these worked well. Standard plugins were added to provide cost-free solutions for antispam, contacts, captcha, malware, firewall and backup.

Site design was streamlined to provide 28 static bilingual pages, while bilingual blog posts were added once per day, to provide a total of 55 bilingual posts during the cruise period. The subjects covered different functional areas, and posts were prepared to a standard format that included a headline image and smaller illustrations. The posts covered scientific background information about cruise M147, technical information, introduced the different scientific and ship's crew members and gave insights into the daily work onboard, including station work, sampling and lab work. As part of the package, a Spot satellite tracker (*findmespot.com*) was set up on board, with data from the tracker available from a separate page on the website and set to record a map point at intervals of 60 minutes.

Although bandwidth on the ship was restricted, the IT staff of the RV Meteor were very supportive, and there were no issues with maintaining or updating the website or uploading photos or text for individual blog entries. A total of 3,932 page views were recorded during the period of the cruise. With respect to the satellite tracker, this worked reasonably well as a near-realtime tracker, with the exception of some downtime relating to satellite detection and battery reliability.

The short cruise timescale meant that investment in time and bandwidth to set up and maintain social media links, was not considered appropriate. Press releases in English and Portuguese were prepared and sent to various publications.

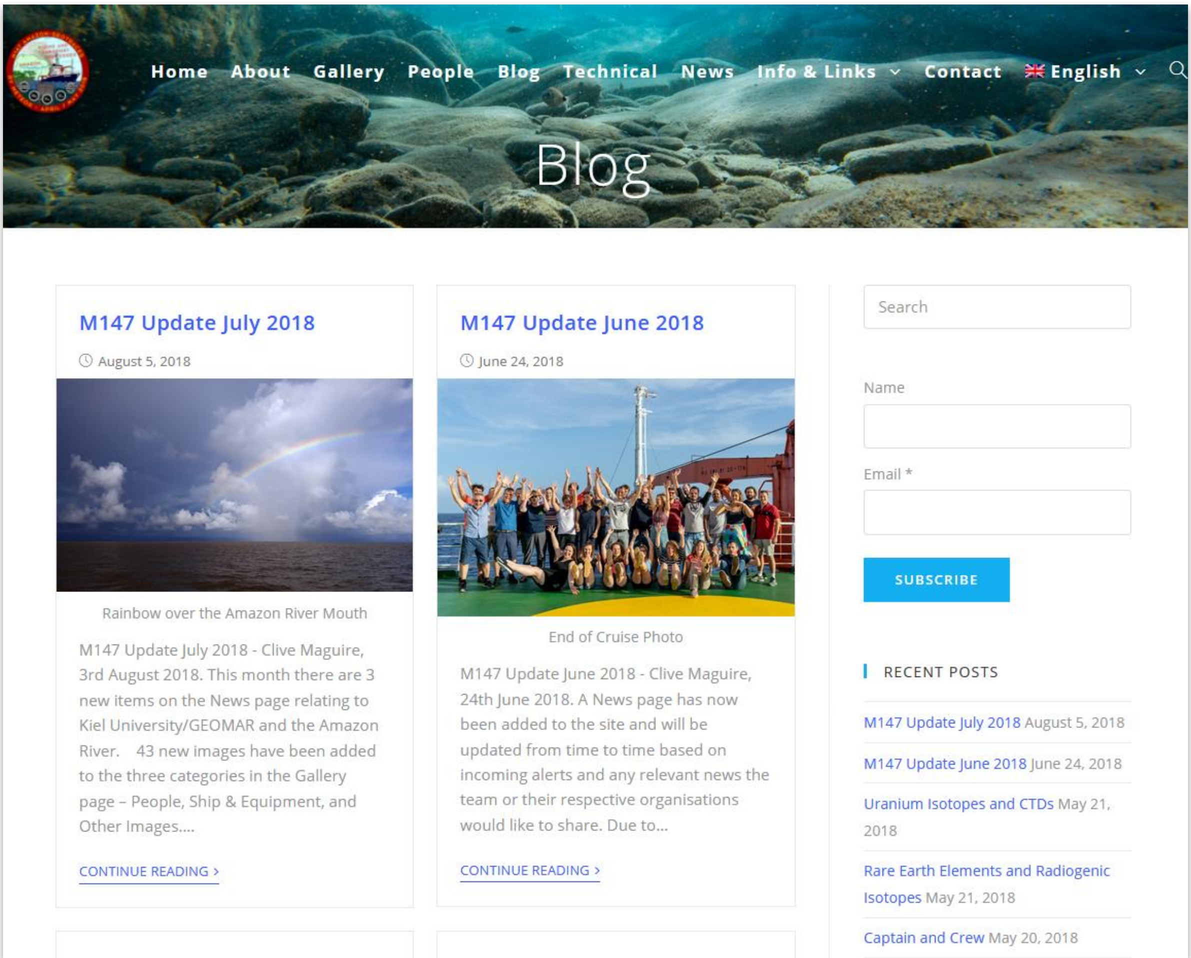

Fig. 5.18.2 Amazon GEOTRACES M147 website and blog: www.amazongeotraces-m147.com.

In addition to our own blog site, our cruise M147 was presented to the public in German language by a logbook published by the BMBF-funded online portal planeterde *http://www.planeterde.de/*. The logbook publications were prepared in advance with a report on the goals and introduction of the research institutions involved in cruise M147 (https://www.planeterde.de/logbuecher/fs-meteor-amazonas/mit-der-meteor-dem-ausstrom-des-amazonas-folgend). During the cruise, several times a week text and pictures of work and life onboard were prepared by the chief scientist and the cruise team members and sent to the editorial staff of planeterde.de. After a short lectorate, the contributions were published on the planeterde starting page, on Facebook and Twitter and were later stored in the logbook archive. Altogether, 10 logbook entries were published from cruise M147 (https://www.planeterde.de/logbuecher/fs-meteor-amazonas; see screenshots below).

planeterde Welt der Geowissenschaften

„Die ganze Welt der Geowissenschaften"

Startseite | News | Wissen | Logbücher | Geozahlen | Projekte | mehr...

19. Apr. 2018 Schriftgröße Drucken

Mit der Meteor dem Ausstrom des Amazonas folgend

Satellitenbild der Amazonasmündung.

Bild: CC0

Im April 2018 bricht das Forschungsschiff Meteor unter Leitung von Prof. Dr. Andrea Koschinsky von der Jacobs University Bremen zu einer Expedition in das Amazonas-Mündungsgebiet und die assoziierte Zone des Frischwassereintrags in den Atlantik auf. Ziel der Reise ist die Untersuchung des Eintrags von gelösten Metallen und organischen Substanzen vom Amazonas in den Atlantik.

Suchen ...

GEFÖRDERT VOM

Bundesministerium für Bildung und Forschung

FONA Forschung für Nachhaltige Entwicklungen BMBF

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UNESCO

planeterde-Geokarte

#10: Das Ende naht

Gemischte Gefühle begleiten die Crewmitglieder der Expedition M147, als sie den Hafen von Belém erreichen. Das Forschungsschiff Meteor ist vom schwimmenden Labor zum Zuhause und die Besatzung zur Familie auf Zeit geworden. Für Fahrtleiterin Andrea Koschinsky ...

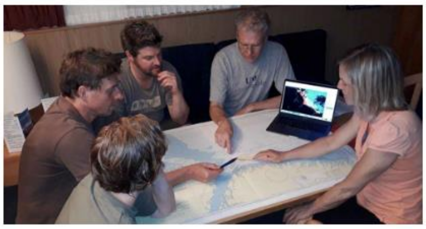
weiterlesen...

#9: Ein großes Dankeschön

Die Expedition M147 ist fast abgeschlossen und die Meteor wieder auf dem Weg zurück in den Hafen von Belém. Für Fahrtleiterin Andrea Koschinsky und die Besatzung neigt sich eine einmalige Zeit dem Ende zu – Anlass, einmal Danke zu sagen. Nachdem ein großer ...

weiterlesen...

#8: Dynamische Stationsplanung



Auf einer Forschungsexpedition fallen so allerlei Organisationsaufgaben an: Nicht nur die Tagesabläufe für alle Crewmitglieder, die Arbeitszeiten in Laboren und an Deck und die Stationsroute wollen geplant sein, auch die Kommunikation an Bord und mit dem Land ...

weiterlesen...

#7: Mit Schal und Mütze am Äquator

Dauerregen. Wärme. Feuchte. Eiseskälte?! Trotz der äquatorialen Breitengrade, in denen sich die FS Meteor an der Amazonasmündung bewegt: die Temperaturen sind es nicht immer. Denn eine exakte Untersuchung der Sedimentproben benötigt neben diversen anderen ...

weiterlesen...

#6: Eine besondere Herausforderung

Die Ausfahrt M147 ist in vollem Gange und tags wie nachts ist die Besatzung im Einsatz. Eines der Kernziele der Expedition stellt Fahrtleiterin Andrea Koschinsky und Ihre Kolleginnen und Kollegen sowie auch die wissenschaftlichen Gerätschaften an Bord dabei ...

weiterlesen...

#5: Die Farben des Wassers

Braun, blau, grün – Der Amazonas zeigt sich den Expeditionsteilnehmerinnen und -teilnehmern nicht nur als der wasserreichste, sondern auch der farbenreichste Fluss der Erde. Genauso bunt wie die Töne des Flusses stellt sich auch die Arbeit an Bord des FS ...

weiterlesen...

#4: Die ersten Beprobungen

Die Meteor ist aus dem Hafen von Belém ausgelaufen und schon laufen die ersten Forschungsarbeiten an. Fahrtleiterin Andrea Koschinsky und die Crew haben nicht nur mit dem starken Regen, sondern auch mit der ungewohnten Materie des Amazonas zu ...

weiterlesen...

#3: Ankunft in Belém und auf der Meteor

Der Transit der Meteor von Las Palmas nach Belém ist beendet – und die Expedition M147 beginnt! Die deutschen Forscherinnen und Forscher werden herzlich willkommen geheißen – von den brasilianishen Partnern, viel Regen und dem beeindruckenden Amazonas. Ab ...

weiterlesen...

#2: Fish Time

Die Meteor hält weiterhin Kurs auf die brasilianische Küste am Amazonas-Mündungsgebiet. Die Forschenden an Bord sind fasziniert vom Leben an Bord und mittlerweile kann dank ruhiger See auch das erste Gerät zum Einsatz kommen – "der Fisch". Petri Heil, Meteor! ...

weiterlesen...

#1: Den Wind im Rücken

Das Ziel der Ausfahrt M147, die Amazonasmündung vor der brasilianischen Küste, liegt noch in weiter Ferne, doch die Arbeit an Bord des Forschungsschiffes Meteor hat bereits vor dem Auslaufen aus dem Hafen von Las Palmas begonnen. Der zehntägige Transit nach ...

weiterlesen...

6. Ship's Meteorological Station

(C. Rohleder; Translation Michael Knobelsdorf – Deutscher Wetterdienst WV13)

Before the actual research work began, RV METEOR had to complete a transit across the Atlantic. The ship left the port of Las Palmas on the Canary Islands on the morning of 19.04.2018. At departure, the cruising area laid between a low above Western Sahara and an extensive high near 34N 45W in a northerly airstream. The following day a trough of low pressure (979 hPa) over the North Atlantic shifted over the Canaries. Travelling along the south-eastern flank of the largely stationary subtropical high, winds in the range of 5-6 Bft were measured on RV METEOR in the first days, at times up to 7 Bft. A northerly swell and wind-sea rose up to 3.5 m. Under a pronounced inversion there were often flat cumulus clouds, which at times joined together in layers. On the fourth day of transit only isolated rainfall occurred. As the journey to the southwest continued, RV METEOR moved further and further away from the core of the subtropical high and the trade winds soon blew with a constant 5 Bft from north-eastern directions. The swell and the wind-sea only reached heights of up to 2m.

Fig. 6.1 CB cap with rainbow in the canal Sul of the Amazon Delta (Photo: Christian Rohleder).

On Friday, the 27th of April, RV METEOR crossed the fifth northern latitude on its southwestern course and approached the Intertropical zone of convergence (ITC). At that time, the ITC extended approximately along the equator across the Atlantic. First strong showers, accompanied by gusts up to 7 Bft, reached RV METEOR in the course of the day. The last two days of the transit were also marked by some heavy showers. Daily rainfall of more than 20 l/sqm was uncommon. The first thunderstorm could be observed in the afternoon of the 29th. Meanwhile RV METEOR had reached its anchorage on the roadstead off Belém in the Rio Pará, southeast of the Amazon delta. Here the main group of scientists embarked and the actual research work began.

In the late afternoon RV METEOR left the anchorage in front of Belém and travelled the night along the Rio Pará to the estuary, where the first station was completed. In the course of the following week, work concentrated in the immediate area of the Amazon delta and thus in the direct sphere of influence of the ITC. These days were marked by frequent showers with high rainfall. On the 02th of May, e.g, 54.6 l/sqm of precipitation were measured between 9 a.m. and 3 p.m.. Thunderstorms occurred only occasionally and were mostly observed as sheet lightning on the horizon. Apart from a few squalls, the wind was weak to moderate, mostly from eastern directions.

On the 05^{th} the focus of the work moved for a few days to the area of the mangrove belt east of the Rio Pará estuary. RV METEOR was located slightly to the south of the core zone of the ITC. The showers in this area decreased significantly, nevertheless, there was daily rainfall reported. On the evening of 06^{th} single funnel clouds were spotted.

From the 09^{th} work concentrated on the Canal Sul, the southern end of the Amazon into the Atlantic. With the high tide in the morning, RV METEOR crossed a sandbank and spent the whole day in exploring the fresh water of the Amazon. Due to shallow water and weak winds, the swell and wind- sea hardly played a role. However, as on most days of this trip, precipitation was frequent and intense.

On the 12^{th} RV METEOR started a transect on the 20-metre-deep line along the Brazilian coast to the border of French Guiana. The ship moved away from the ITC area and, as expected, showers became less frequent. This stage ended with a station on the 14^{th} for reference measurements for the international GEOTRACES program at 06.5°N/49.8°W. On this day the sounding from 18 UTC showed a clear trade wind inversion with the associated relatively dry air above 1600m altitude. According to these conditions, the clouds were mainly flat cumuli clouds, there was no precipitation. The northeast wind blew with 5-6 Bft much stronger than in the core zone of the ITC and also the significant wave height by 2.5 m was higher than usual from the previous days.

After completion of the reference measurement, RV METEOR headed south again and thus approached the ITC again. The sounding data from the next day showed the typical relatively humid air up to high altitudes. After reaching about 5°N showers could be observed again. The last days of this journey RV METEOR explored again in the estuary area of the Amazon and the usual weather with regular showers continued.

In total the ship's rain gauge registered rainfall of 425 l/sqm on this voyage. The work at the individual stations was not hindered, however the influence due to the high rainwater entry was discussed at the first evaluations of the measurements, which were primarily considering the distribution of Amazon water into the Atlantic.

In the morning of the 20^{th} RV METEOR reached the anchorage closed to Belém in Rio Pará.

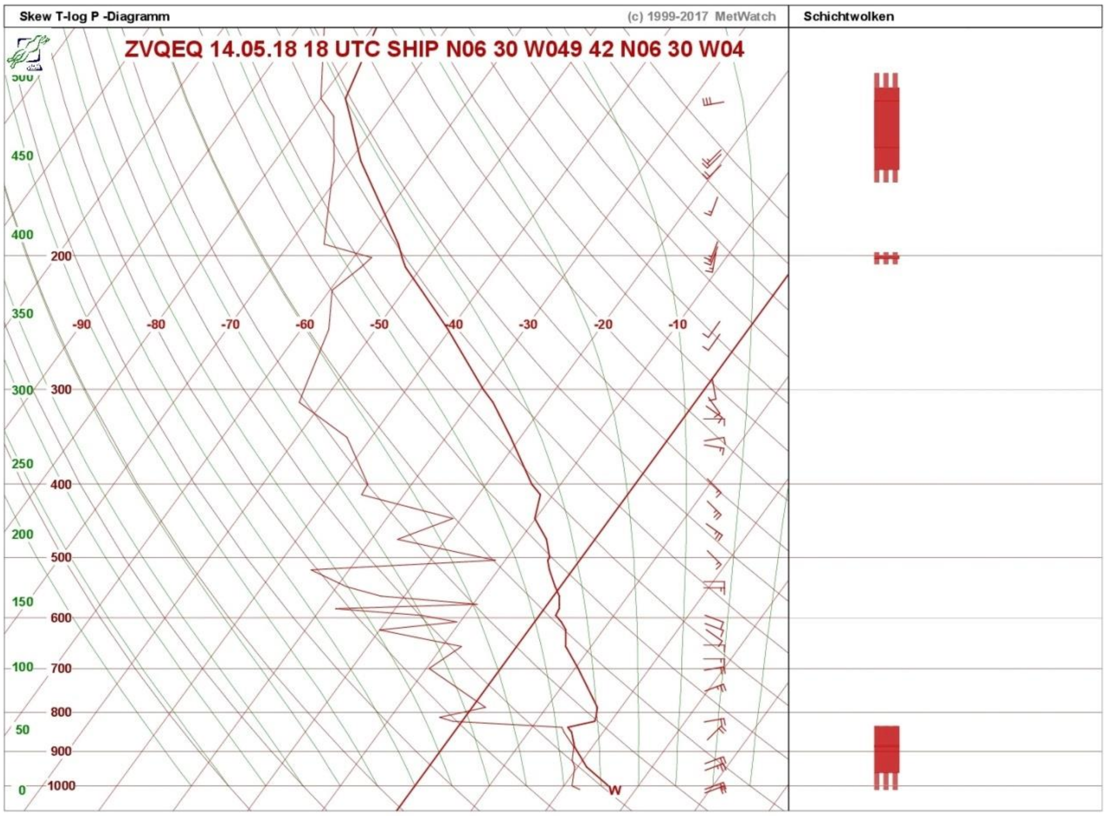


Fig. 6.2 Evaluation of the sounding from the 14.05.2018 far north of the ITC.

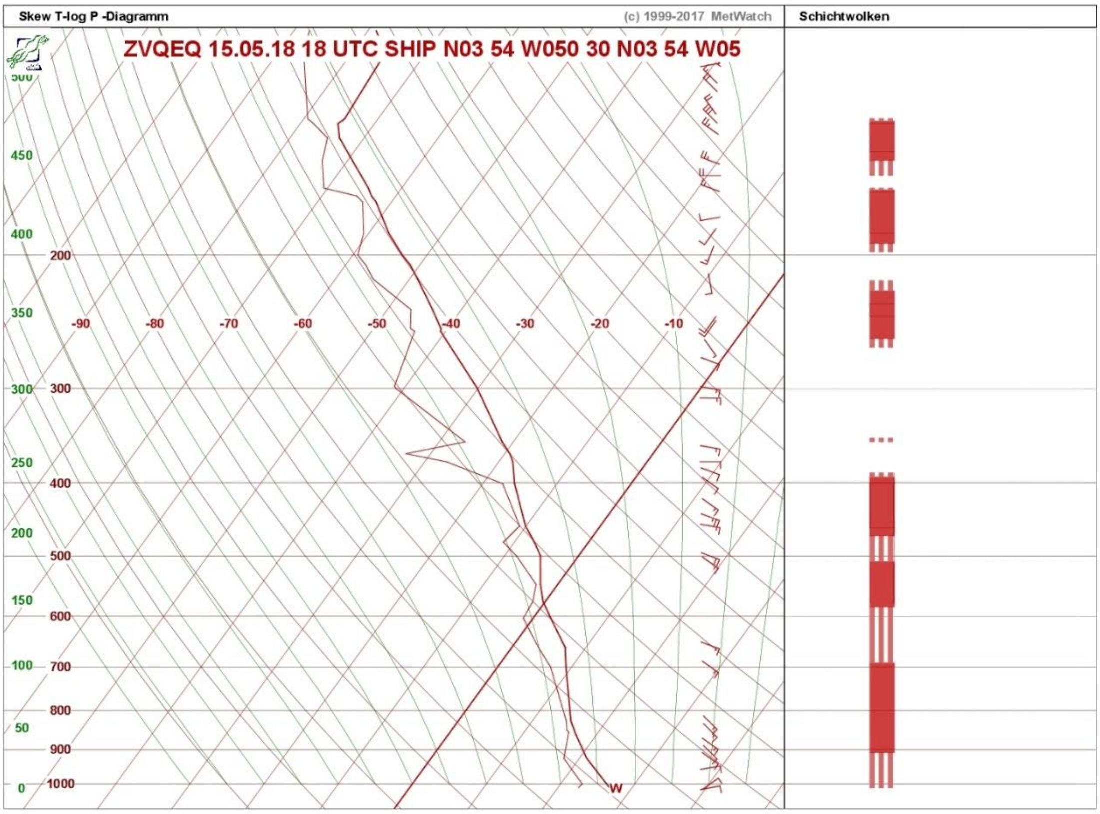


Fig. 6.3 Evaluation of the sounding from the 15.05.2018 at the edge of the ITC.

7. Station List M147

Station No. METEOR	Date / Time UTC	Device	Action	Latitude	Longitude
M147_1-1	04/23/18 11:30	USW	in the water	16° 25,977' N	028° 47,427' W
M147_1-1	04/25/18 09:06	USW	on deck	10° 07,155' N	036° 04,983' W
M147_2-1	04/25/18 09:22	CTD/TM	in the water	10° 07,161' N	036° 04,984' W
M147_2-1	04/25/18 09:40	CTD/TM	max depth/on ground	10° 07,186' N	036° 05,001' W
M147_2-1	04/25/18 09:54	CTD/TM	on deck	10° 07,199' N	036° 05,019' W
M147_3-1	04/25/18 15:08	CTD/TM	in the water	09° 29,982' N	036° 47,524' W
M147_3-1	04/25/18 15:28	CTD/TM	max depth/on ground	09° 30,083' N	036° 47,452' W
M147_3-1	04/25/18 15:41	CTD/TM	on deck	09° 30,125' N	036° 47,409' W
M147_4-1	04/26/18 10:07	CTD/TM	in the water	07° 18,995' N	039° 17,836' W
M147_4-1	04/26/18 10:35	CTD/TM	max depth/on ground	07° 19,123' N	039° 17,843' W
M147_4-1	04/26/18 11:00	CTD/TM	on deck	07° 19,278' N	039° 17,782' W
M147_5-1	04/26/18 16:02	CTD/TM	in the water	06° 42,423' N	040° 00,110' W
M147_5-1	04/26/18 16:28	CTD/TM	max depth/on ground	06° 42,475' N	040° 00,081' W
M147_5-1	04/26/18 16:52	CTD/TM	on deck	06° 42,501' N	040° 00,073' W
M147_6-1	04/27/18 11:30	CTD/TM	in the water	04° 09,510' N	042° 54,756' W
M147_6-1	04/27/18 11:45	CTD/TM	max depth/on ground	04° 09,548' N	042° 54,659' W
M147_6-1	04/27/18 11:58	CTD/TM	on deck	04° 09,588' N	042° 54,574' W
M147_7-1	04/29/18 21:50	USW	in the water	00° 55,060' S	048° 27,189' W
M147_7-1	04/30/18 19:57	USW	on deck	00° 31,348' N	047° 23,580' W
M147_7-1	04/30/18 19:57	USW	in the water	00° 31,357' N	047° 23,578' W
M147_7-1	05/01/18 16:25	USW	on deck	01° 55,048' N	046° 39,097' W
M147_7-1	05/01/18 16:28	USW	in the water	01° 55,091' N	046° 39,271' W
M147_8-1	04/30/18 08:06	CTD	in the water	00° 10,462' S	047° 55,394' W
M147_8-1	04/30/18 08:10	CTD	max depth/on ground	00° 10,459' S	047° 55,403' W
M147_8-1	04/30/18 08:17	CTD	on deck	00° 10,456' S	047° 55,426' W
M147_9-1	04/30/18 08:44	CTD/TM	in the water	00° 10,495' S	047° 55,507' W
M147_9-1	04/30/18 08:54	CTD/TM	max depth/on ground	00° 10,534' S	047° 55,685' W
M147_9-1	04/30/18 09:00	CTD/TM	on deck	00° 10,567' S	047° 55,832' W
M147_10-1	04/30/18 09:32	CTD	Information	00° 10,552' S	047° 55,720' W
M147_10-1	04/30/18 09:36	CTD	max depth/on ground	00° 10,576' S	047° 55,812' W
M147_10-1	04/30/18 09:42	CTD	on deck	00° 10,629' S	047° 55,930' W
M147_11-1	04/30/18 10:12	MUC	in the water	00° 10,208' S	047° 57,134' W
M147_11-1	04/30/18 10:15	MUC	max depth/on ground	00° 10,222' S	047° 57,176' W
M147_11-1	04/30/18 10:19	MUC	on deck	00° 10,236' S	047° 57,225' W
M147_12-1	04/30/18 15:06	Pump	in the water	00° 12,075' N	047° 37,791' W
M147_12-1	04/30/18 15:29	Pump	on deck	00° 13,066' N	047° 37,774' W
M147_13-1	04/30/18 17:59	CTD	in the water	00° 24,046' N	047° 28,350' W
M147_13-1	04/30/18 18:03	CTD	max depth/on ground	00° 24,032' N	047° 28,356' W
M147_13-1	04/30/18 18:09	CTD	on deck	00° 24,016' N	047° 28,341' W

M147_13-2	04/30/18 18:02	Pump	in the water	00° 24,035' N	047° 28,357' W
M147_13-2	04/30/18 18:32	Pump	on deck	00° 24,049' N	047° 28,012' W
M147_14-1	04/30/18 18:16	CTD/TM	in the water	00° 24,050' N	047° 28,265' W
M147_14-1	04/30/18 18:20	CTD/TM	max depth/on ground	00° 24,043' N	047° 28,161' W
M147_14-1	04/30/18 18:25	CTD/TM	on deck	00° 24,041' N	047° 28,078' W
M147_15-1	05/01/18 01:01	CTD	in the water	01° 01,508' N	047° 04,029' W
M147_15-1	05/01/18 01:05	CTD	max depth/on ground	01° 01,513' N	047° 04,037' W
M147_15-1	05/01/18 01:09	CTD	on deck	01° 01,517' N	047° 04,043' W
M147_15-2	05/01/18 01:01	Pump	in the water	01° 01,508' N	047° 04,030' W
M147_15-2	05/01/18 01:47	Pump	on deck	01° 01,572' N	047° 04,004' W
M147_16-1	05/01/18 01:21	CTD/TM	in the water	01° 01,553' N	047° 04,072' W
M147_16-1	05/01/18 01:28	CTD/TM	max depth/on ground	01° 01,605' N	047° 04,122' W
M147_16-1	05/01/18 01:34	CTD/TM	on deck	01° 01,644' N	047° 04,167' W
M147_17-1	05/01/18 01:57	MUC	in the water	01° 01,605' N	047° 04,007' W
M147_17-1	05/01/18 02:01	MUC	max depth/on ground	01° 01,612' N	047° 03,999' W
M147_17-1	05/01/18 02:05	MUC	on deck	01° 01,638' N	047° 04,001' W
M147_17-1	05/01/18 02:27	MUC	in the water	01° 01,536' N	047° 03,997' W
M147_17-1	05/01/18 02:30	MUC	max depth/on ground	01° 01,542' N	047° 04,011' W
M147_17-1	05/01/18 02:33	MUC	on deck	01° 01,546' N	047° 04,018' W
M147_18-1	05/01/18 09:34	CTD	in the water	01° 54,512' N	046° 26,375' W
M147_18-1	05/01/18 10:17	CTD	max depth/on ground	01° 54,878' N	046° 26,760' W
M147_18-1	05/01/18 10:59	CTD	on deck	01° 55,243' N	046° 27,079' W
M147_18-2	05/01/18 09:38	Pump	in the water	01° 54,566' N	046° 26,502' W
M147_18-2	05/01/18 10:35	Pump	on deck	01° 54,996' N	046° 26,854' W
M147_19-1	05/01/18 11:49	CTD	in the water	01° 54,549' N	046° 26,382' W
M147_19-1	05/01/18 12:10	CTD	max depth/on ground	01° 54,850' N	046° 26,763' W
M147_19-1	05/01/18 12:33	CTD	on deck	01° 55,067' N	046° 27,008' W
M147_20-1	05/01/18 13:15	CTD	in the water	01° 55,449' N	046° 28,824' W
M147_20-1	05/01/18 13:18	CTD	max depth/on ground	01° 55,465' N	046° 28,909' W
M147_20-1	05/01/18 13:23	CTD	on deck	01° 55,524' N	046° 29,045' W
M147_21-1	05/01/18 14:32	MUC	in the water	01° 54,435' N	046° 38,312' W
M147_21-1	05/01/18 15:14	MUC	max depth/on ground	01° 54,581' N	046° 38,424' W
M147_21-1	05/01/18 15:57	MUC	on deck	01° 54,581' N	046° 38,422' W
M147_22-1	05/02/18 08:51	CTD	in the water	01° 35,670' N	049° 00,160' W
M147_22-1	05/02/18 08:53	CTD	max depth/on ground	01° 35,658' N	049° 00,173' W
M147_22-1	05/02/18 08:57	CTD	on deck	01° 35,654' N	049° 00,193' W
M147_22-2	05/02/18 08:53	Pump	in the water	01° 35,659' N	049° 00,171' W
M147_22-2	05/02/18 09:09	Pump	on deck	01° 35,654' N	049° 00,198' W
M147_23-1	05/02/18 09:16	MUC	in the water	01° 35,652' N	049° 00,194' W
M147_23-1	05/02/18 09:18	MUC	max depth/on ground	01° 35,653' N	049° 00,195' W
M147_23-1	05/02/18 09:22	MUC	on deck	01° 35,652' N	049° 00,195' W
M147_24-1	05/02/18 17:13	MUC	in the water	00° 57,108' N	049° 38,864' W

M147_24-1	05/02/18 17:15	MUC	max depth/on ground	00° 57,108' N	049° 38,864' W
M147_24-1	05/02/18 17:20	MUC	on deck	00° 57,108' N	049° 38,864' W
M147_24-1	05/02/18 17:36	MUC	in the water	00° 57,107' N	049° 38,864' W
M147_24-1	05/02/18 17:37	MUC	max depth/on ground	00° 57,108' N	049° 38,864' W
M147_24-1	05/02/18 17:42	MUC	on deck	00° 57,108' N	049° 38,865' W
M147_25-1	05/02/18 17:58	CTD	in the water	00° 57,107' N	049° 38,864' W
M147_25-1	05/02/18 17:59	CTD	max depth/on ground	00° 57,107' N	049° 38,864' W
M147_25-1	05/02/18 18:19	CTD	on deck	00° 57,102' N	049° 38,852' W
M147_25-2	05/02/18 17:59	Pump	in the water	00° 57,107' N	049° 38,864' W
M147_25-2	05/02/18 18:24	Pump	on deck	00° 57,101' N	049° 38,851' W
M147_26-1	05/02/18 21:49	CTD	in the water	01° 26,721' N	049° 19,989' W
M147_26-1	05/02/18 21:49	CTD	max depth/on ground	01° 26,721' N	049° 19,989' W
M147_26-1	05/02/18 21:53	CTD	on deck	01° 26,708' N	049° 19,991' W
M147_27-1	05/02/18 22:18	CTD	in the water	01° 27,080' N	049° 19,006' W
M147_27-1	05/02/18 22:19	CTD	max depth/on ground	01° 27,076' N	049° 19,018' W
M147_27-1	05/02/18 22:20	CTD	on deck	01° 27,063' N	049° 19,049' W
M147_28-1	05/02/18 23:03	CTD	in the water	01° 26,269' N	049° 16,785' W
M147_28-1	05/02/18 23:04	CTD	max depth/on ground	01° 26,267' N	049° 16,821' W
M147_28-1	05/02/18 23:07	CTD	on deck	01° 26,263' N	049° 16,889' W
M147_28-2	05/02/18 23:04	Pump	in the water	01° 26,266' N	049° 16,830' W
M147_28-2	05/02/18 23:26	Pump	on deck	01° 26,343' N	049° 17,129' W
M147_29-1	05/02/18 23:35	CTD	in the water	01° 26,391' N	049° 17,101' W
M147_29-1	05/02/18 23:37	CTD	max depth/on ground	01° 26,370' N	049° 17,152' W
M147_29-1	05/02/18 23:40	CTD	on deck	01° 26,351' N	049° 17,281' W
M147_29-2	05/02/18 23:36	Pump	in the water	01° 26,375' N	049° 17,133' W
M147_29-2	05/03/18 00:03	Pump	on deck	01° 26,226' N	049° 17,761' W
M147_30-1	05/03/18 00:15	CTD	in the water	01° 26,295' N	049° 17,770' W
M147_30-1	05/03/18 00:16	CTD	max depth/on ground	01° 26,293' N	049° 17,787' W
M147_30-1	05/03/18 00:20	CTD	on deck	01° 26,239' N	049° 17,967' W
M147_30-2	05/03/18 00:17	Pump	in the water	01° 26,281' N	049° 17,834' W
M147_30-2	05/03/18 00:39	Pump	on deck	01° 25,871' N	049° 18,818' W
M147_31-1	05/03/18 01:28	CTD	in the water	01° 27,834' N	049° 15,274' W
M147_31-1	05/03/18 01:29	CTD	max depth/on ground	01° 27,805' N	049° 15,304' W
M147_31-1	05/03/18 01:34	CTD	on deck	01° 27,693' N	049° 15,425' W
M147_31-2	05/03/18 01:28	Pump	in the water	01° 27,829' N	049° 15,279' W
M147_31-2	05/03/18 01:40	Pump	on deck	01° 27,504' N	049° 15,582' W
M147_32-1	05/03/18 07:44	CTD	in the water	02° 18,100' N	048° 35,141' W
M147_32-1	05/03/18 07:44	CTD	max depth/on ground	02° 18,102' N	048° 35,143' W
M147_32-1	05/03/18 07:48	CTD	on deck	02° 18,116' N	048° 35,159' W
M147_32-2	05/03/18 07:44	Pump	in the water	02° 18,100' N	048° 35,142' W
M147_32-2	05/03/18 08:13	Pump	on deck	02° 18,159' N	048° 35,228' W
M147_33-1	05/03/18 09:31	CTD	in the water	02° 25,537' N	048° 30,248' W

M147_33-1	05/03/18 09:31	CTD	max depth/on ground	02° 25,540' N	048° 30,259' W
M147_33-1	05/03/18 09:35	CTD	on deck	02° 25,553' N	048° 30,330' W
M147_33-2	05/03/18 09:39	Pump	in the water	02° 25,573' N	048° 30,425' W
M147_33-2	05/03/18 10:02	Pump	on deck	02° 25,702' N	048° 30,960' W
M147_34-1	05/03/18 11:13	CTD	in the water	02° 32,953' N	048° 26,304' W
M147_34-1	05/03/18 11:15	CTD	max depth/on ground	02° 32,951' N	048° 26,371' W
M147_34-1	05/03/18 11:20	CTD	on deck	02° 32,938' N	048° 26,523' W
M147_34-2	05/03/18 11:22	Pump	in the water	02° 32,946' N	048° 26,604' W
M147_34-2	05/03/18 11:49	Pump	on deck	02° 32,888' N	048° 27,376' W
M147_35-1	05/03/18 14:35	CTD	in the water	02° 51,246' N	048° 15,518' W
M147_35-1	05/03/18 14:44	CTD	max depth/on ground	02° 51,448' N	048° 15,729' W
M147_35-1	05/03/18 14:52	CTD	on deck	02° 51,631' N	048° 15,825' W
M147_36-1	05/03/18 15:03	CTD/TM	in the water	02° 51,777' N	048° 16,310' W
M147_36-1	05/03/18 15:10	CTD/TM	max depth/on ground	02° 51,953' N	048° 16,451' W
M147_36-1	05/03/18 15:17	CTD/TM	on deck	02° 52,128' N	048° 16,579' W
M147_36-2	05/03/18 15:21	Pump	in the water	02° 52,228' N	048° 16,667' W
M147_36-2	05/03/18 15:48	Pump	on deck	02° 52,729' N	048° 17,605' W
M147_37-1	05/03/18 15:55	MUC	Information	02° 52,836' N	048° 17,666' W
M147_37-1	05/03/18 15:59	MUC	max depth/on ground	02° 52,849' N	048° 17,665' W
M147_37-1	05/03/18 16:05	MUC	on deck	02° 52,855' N	048° 17,667' W
M147_38-1	05/04/18 01:19	CTD	in the water	03° 55,537' N	047° 36,554' W
M147_38-1	05/04/18 01:34	CTD	max depth/on ground	03° 55,683' N	047° 36,623' W
M147_38-1	05/04/18 01:51	CTD	on deck	03° 55,938' N	047° 36,536' W
M147_39-1	05/04/18 02:00	CTD/TM	in the water	03° 55,982' N	047° 36,600' W
M147_39-1	05/04/18 02:47	CTD/TM	max depth/on ground	03° 56,526' N	047° 36,588' W
M147_39-1	05/04/18 03:32	CTD/TM	on deck	03° 57,153' N	047° 36,104' W
M147_40-1	05/04/18 03:47	CTD	in the water	03° 57,166' N	047° 36,101' W
M147_40-1	05/04/18 04:25	CTD	max depth/on ground	03° 57,315' N	047° 36,189' W
M147_40-1	05/04/18 05:00	CTD	on deck	03° 57,501' N	047° 36,297' W
M147_41-1	05/04/18 05:24	MUC	in the water	03° 56,935' N	047° 36,313' W
M147_41-1	05/04/18 05:58	MUC	max depth/on ground	03° 56,933' N	047° 36,313' W
M147_41-1	05/04/18 06:33	MUC	on deck	03° 56,937' N	047° 36,311' W
M147_42-1	05/05/18 10:50	CTD	in the water	00° 38,009' S	046° 54,030' W
M147_42-1	05/05/18 10:51	CTD	max depth/on ground	00° 38,011' S	046° 54,033' W
M147_42-1	05/05/18 10:54	CTD	on deck	00° 38,003' S	046° 54,044' W
M147_42-2	05/05/18 10:56	Pump	in the water	00° 37,998' S	046° 54,060' W
M147_42-2	05/05/18 11:08	Pump	on deck	00° 38,082' S	046° 54,212' W
M147_43-1	05/05/18 13:24	CTD	in the water	00° 35,722' S	046° 46,164' W
M147_43-1	05/05/18 13:24	CTD	max depth/on ground	00° 35,720' S	046° 46,171' W
M147_43-1	05/05/18 13:28	CTD	on deck	00° 35,700' S	046° 46,234' W
M147_43-2	05/05/18 13:30	Pump	in the water	00° 35,699' S	046° 46,292' W
M147_43-2	05/05/18 13:40	Pump	on deck	00° 35,685' S	046° 46,558' W

M147_44-1	05/05/18 14:41	CTD	in the water	00° 35,873' S	046° 54,151' W
M147_44-1	05/05/18 14:43	CTD	max depth/on ground	00° 35,857' S	046° 54,179' W
M147_44-1	05/05/18 14:44	CTD	at surface	00° 35,842' S	046° 54,205' W
M147_44-1	05/05/18 14:46	CTD	max depth/on ground	00° 35,829' S	046° 54,237' W
M147_44-1	05/05/18 14:49	CTD	on deck	00° 35,799' S	046° 54,298' W
M147_44-2	05/05/18 14:51	Pump	in the water	00° 35,774' S	046° 54,343' W
M147_44-2	05/05/18 14:59	Pump	on deck	00° 35,704' S	046° 54,499' W
M147_45-1	05/05/18 16:09	CTD	in the water	00° 32,720' S	046° 46,145' W
M147_45-1	05/05/18 16:13	CTD	max depth/on ground	00° 32,664' S	046° 46,158' W
M147_45-1	05/05/18 16:17	CTD	on deck	00° 32,631' S	046° 46,189' W
M147_45-2	05/05/18 16:20	Pump	in the water	00° 32,613' S	046° 46,219' W
M147_45-2	05/05/18 16:28	Pump	on deck	00° 32,573' S	046° 46,336' W
M147_46-1	05/05/18 17:37	CTD	Information	00° 32,682' S	046° 54,003' W
M147_46-1	05/05/18 17:41	CTD	max depth/on ground	00° 32,661' S	046° 53,999' W
M147_46-1	05/05/18 17:44	CTD	on deck	00° 32,647' S	046° 53,997' W
M147_46-2	05/05/18 17:46	Pump	in the water	00° 32,640' S	046° 53,994' W
M147_47-1	05/05/18 19:02	CTD	in the water	00° 28,770' S	046° 46,105' W
M147_47-1	05/05/18 19:06	CTD	max depth/on ground	00° 28,794' S	046° 46,087' W
M147_47-1	05/05/18 19:10	CTD	on deck	00° 28,807' S	046° 46,093' W
M147_47-2	05/05/18 19:12	Pump	in the water	00° 28,811' S	046° 46,095' W
M147_47-2	05/05/18 19:20	Pump	on deck	00° 28,857' S	046° 46,139' W
M147_48-1	05/05/18 20:00	USW	station start	00° 30,224' S	046° 40,918' W
M147_49-1	05/06/18 14:59	CTD	in the water	00° 38,744' S	046° 46,181' W
M147_49-1	05/06/18 15:03	CTD	max depth/on ground	00° 38,716' S	046° 46,256' W
M147_49-1	05/06/18 15:06	CTD	on deck	00° 38,697' S	046° 46,304' W
M147_49-2	05/06/18 15:11	Pump	in the water	00° 38,676' S	046° 46,347' W
M147_49-2	05/06/18 15:18	Pump	on deck	00° 38,641' S	046° 46,405' W
M147_50-1	05/06/18 15:31	MUC	in the water	00° 38,645' S	046° 46,436' W
M147_50-1	05/06/18 15:32	MUC	max depth/on ground	00° 38,644' S	046° 46,438' W
M147_50-1	05/06/18 15:36	MUC	on deck	00° 38,641' S	046° 46,436' W
M147_51-1	05/06/18 17:00	CTD	in the water	00° 28,962' S	046° 54,033' W
M147_51-1	05/06/18 17:04	CTD	max depth/on ground	00° 28,956' S	046° 54,032' W
M147_51-1	05/06/18 17:09	CTD	on deck	00° 28,958' S	046° 54,056' W
M147_51-2	05/06/18 17:10	Pump	in the water	00° 28,959' S	046° 54,064' W
M147_51-2	05/06/18 17:20	Pump	on deck	00° 28,959' S	046° 54,159' W
M147_52-1	05/06/18 18:42	CTD	in the water	00° 20,777' S	046° 46,108' W
M147_52-1	05/06/18 18:47	CTD	max depth/on ground	00° 20,782' S	046° 46,111' W
M147_52-1	05/06/18 18:50	CTD	on deck	00° 20,785' S	046° 46,119' W
M147_52-2	05/06/18 18:52	Pump	in the water	00° 20,786' S	046° 46,123' W
M147_52-2	05/06/18 19:05	Pump	on deck	00° 20,785' S	046° 46,160' W
M147_53-1	05/06/18 20:06	CTD	in the water	00° 21,023' S	046° 54,004' W
M147_53-1	05/06/18 20:10	CTD	max depth/on ground	00° 21,037' S	046° 54,027' W

M147_53-1	05/06/18 20:19	CTD	on deck	00° 21,048' S	046° 54,059' W
M147_53-2	05/06/18 20:22	Pump	in the water	00° 21,058' S	046° 54,066' W
M147_53-2	05/06/18 20:34	Pump	on deck	00° 21,130' S	046° 54,090' W
M147_54-1	05/06/18 22:34	CTD	in the water	00° 04,784' S	046° 46,159' W
M147_54-1	05/06/18 22:39	CTD	max depth/on ground	00° 04,829' S	046° 46,217' W
M147_54-1	05/06/18 22:44	CTD	on deck	00° 04,897' S	046° 46,317' W
M147_54-2	05/06/18 22:47	Pump	in the water	00° 04,951' S	046° 46,395' W
M147_54-2	05/06/18 23:01	Pump	on deck	00° 05,164' S	046° 46,440' W
M147_55-1	05/07/18 00:02	CTD	in the water	00° 05,001' S	046° 54,055' W
M147_55-1	05/07/18 00:06	CTD	max depth/on ground	00° 05,014' S	046° 54,111' W
M147_55-1	05/07/18 00:12	CTD	on deck	00° 05,061' S	046° 54,223' W
M147_55-2	05/07/18 00:13	Pump	in the water	00° 05,074' S	046° 54,256' W
M147_55-2	05/07/18 00:27	Pump	on deck	00° 05,206' S	046° 54,551' W
M147_56-1	05/07/18 03:30	UWS	station start	00° 37,538' S	046° 54,016' W
M147_56-1	05/07/18 12:14	UWS	station end	00° 28,351' S	046° 53,923' W
M147_56-2	05/07/18 07:53	Pump	in the water	00° 18,971' S	047° 32,976' W
M147_56-2	05/07/18 08:07	Pump	on deck	00° 18,890' S	047° 32,889' W
M147_57-1	05/07/18 12:14	USW	station start	00° 28,293' S	046° 53,895' W
M147_57-1	05/09/18 11:31	USW	on deck	00° 03,287' N	048° 42,447' W
M147_57-1	05/09/18 22:15	USW	in the water	00° 01,054' N	048° 24,976' W
M147_57-1	05/10/18 00:38	USW	on deck	00° 01,770' N	048° 11,280' W
M147_57-1	05/11/18 00:14	USW	in the water	00° 34,067' N	047° 59,838' W
M147_57-1	05/13/18 13:14	USW	on deck	05° 30,798' N	051° 36,018' W
M147_57-1	05/13/18 14:04	USW	in the water	05° 36,632' N	051° 38,059' W
M147_57-1	05/19/18 07:00	USW	on deck	00° 14,448' N	048° 00,583' W
M147_58-1	05/08/18 11:56	CTD	in the water	02° 19,184' N	047° 27,388' W
M147_58-1	05/08/18 12:18	CTD	max depth/on ground	02° 19,446' N	047° 28,277' W
M147_58-1	05/08/18 12:45	CTD	on deck	02° 19,753' N	047° 29,024' W
M147_59-1	05/08/18 13:26	CTD/TM	in the water	02° 20,611' N	047° 25,748' W
M147_59-1	05/08/18 13:50	CTD/TM	max depth/on ground	02° 20,469' N	047° 26,022' W
M147_59-1	05/08/18 14:14	CTD/TM	on deck	02° 20,111' N	047° 26,757' W
M147_59-2	05/08/18 14:16	Pump	in the water	02° 20,096' N	047° 26,843' W
M147_59-2	05/08/18 14:43	Pump	on deck	02° 19,992' N	047° 28,066' W
M147_60-1	05/08/18 15:02	MUC	in the water	02° 20,174' N	047° 27,472' W
M147_60-1	05/08/18 15:22	MUC	max depth/on ground	02° 20,224' N	047° 27,493' W
M147_60-1	05/08/18 15:42	MUC	on deck	02° 20,224' N	047° 27,492' W
M147_60-1	05/08/18 15:58	MUC	in the water	02° 20,225' N	047° 27,491' W
M147_60-1	05/08/18 16:17	MUC	max depth/on ground	02° 20,223' N	047° 27,493' W
M147_60-1	05/08/18 16:38	MUC	on deck	02° 20,231' N	047° 27,492' W
M147_61-1	05/08/18 18:58	CTD	in the water	02° 05,073' N	047° 39,683' W
M147_61-1	05/08/18 19:03	CTD	max depth/on ground	02° 05,124' N	047° 39,746' W
M147_61-1	05/08/18 19:10	CTD	on deck	02° 05,172' N	047° 39,857' W

M147_62-1	05/08/18 19:14	CTD/TM	in the water	02° 05,214' N	047° 39,924' W
M147_62-1	05/08/18 19:19	CTD/TM	max depth/on ground	02° 05,309' N	047° 39,934' W
M147_62-1	05/08/18 19:26	CTD/TM	on deck	02° 05,423' N	047° 39,999' W
M147_62-2	05/08/18 19:31	Pump	in the water	02° 05,463' N	047° 40,050' W
M147_62-2	05/08/18 19:44	Pump	on deck	02° 05,464' N	047° 40,075' W
M147_63-1	05/08/18 19:49	MUC	in the water	02° 05,463' N	047° 40,075' W
M147_63-1	05/08/18 19:53	MUC	max depth/on ground	02° 05,466' N	047° 40,075' W
M147_63-1	05/08/18 19:58	MUC	on deck	02° 05,474' N	047° 40,075' W
M147_63-1	05/08/18 20:15	MUC	in the water	02° 05,473' N	047° 40,075' W
M147_63-1	05/08/18 20:19	MUC	max depth/on ground	02° 05,476' N	047° 40,075' W
M147_63-1	05/08/18 20:24	MUC	on deck	02° 05,484' N	047° 40,075' W
M147_64-1	05/08/18 21:47	CTD	in the water	01° 56,464' N	047° 47,247' W
M147_64-1	05/08/18 21:52	CTD	max depth/on ground	01° 56,566' N	047° 47,294' W
M147_64-1	05/08/18 21:58	CTD	on deck	01° 56,676' N	047° 47,348' W
M147_64-2	05/08/18 22:01	Pump	in the water	01° 56,686' N	047° 47,357' W
M147_64-2	05/08/18 22:16	Pump	on deck	01° 56,798' N	047° 47,407' W
M147_65-1	05/09/18 11:03	MUC	in the water	00° 03,240' N	048° 42,492' W
M147_65-1	05/09/18 11:05	MUC	max depth/on ground	00° 03,241' N	048° 42,489' W
M147_65-1	05/09/18 11:08	MUC	on deck	00° 03,243' N	048° 42,485' W
M147_66-1	05/09/18 11:16	CTD	in the water	00° 03,258' N	048° 42,479' W
M147_66-1	05/09/18 11:23	CTD	on deck	00° 03,271' N	048° 42,464' W
M147_66-2	05/09/18 11:27	Pump	in the water	00° 03,276' N	048° 42,443' W
M147_66-2	05/09/18 11:40	Pump	on deck	00° 03,292' N	048° 42,417' W
M147_67-1	05/09/18 11:46	MUC	in the water	00° 03,289' N	048° 42,375' W
M147_67-1	05/09/18 11:50	MUC	max depth/on ground	00° 03,288' N	048° 42,367' W
M147_67-1	05/09/18 11:56	MUC	on deck	00° 03,289' N	048° 42,355' W
M147_68-1	05/09/18 12:49	CTD	in the water	00° 03,945' S	048° 41,421' W
M147_68-1	05/09/18 12:50	CTD	max depth/on ground	00° 03,947' S	048° 41,417' W
M147_68-1	05/09/18 12:53	CTD	on deck	00° 03,951' S	048° 41,392' W
M147_68-2	05/09/18 12:55	Pump	in the water	00° 03,954' S	048° 41,376' W
M147_68-2	05/09/18 13:07	Pump	on deck	00° 03,976' S	048° 41,231' W
M147_69-1	05/09/18 21:54	CTD	in the water	00° 01,069' N	048° 25,126' W
M147_69-1	05/09/18 21:55	CTD	max depth/on ground	00° 01,069' N	048° 25,124' W
M147_69-1	05/09/18 21:57	CTD	on deck	00° 01,072' N	048° 25,099' W
M147_69-2	05/09/18 22:00	Pump	in the water	00° 01,073' N	048° 25,071' W
M147_69-2	05/09/18 22:13	Pump	on deck	00° 01,052' N	048° 24,988' W
M147_70-1	05/09/18 22:32	CTD	in the water	00° 01,203' N	048° 25,023' W
M147_70-1	05/09/18 22:32	CTD	max depth/on ground	00° 01,204' N	048° 25,021' W
M147_70-1	05/09/18 23:15	CTD	on deck	00° 01,404' N	048° 21,192' W
M147_71-1	05/10/18 00:00	CTD	in the water	00° 01,930' N	048° 13,226' W
M147_71-1	05/10/18 00:21	CTD	on deck	00° 01,717' N	048° 11,606' W
M147_71-1	05/10/18 00:37	CTD	Information	00° 01,766' N	048° 11,293' W

M147_71-2	05/10/18 00:23	Pump	in the water	00° 01,717' N	048° 11,552' W
M147_71-2	05/10/18 00:28	Pump	on deck	00° 01,718' N	048° 11,468' W
M147_72-1	05/10/18 23:11	CTD	in the water	00° 33,935' N	047° 59,795' W
M147_72-1	05/10/18 23:22	CTD	max depth/on ground	00° 34,044' N	047° 59,900' W
M147_72-1	05/10/18 23:26	CTD	on deck	00° 34,064' N	047° 59,893' W
M147_72-1	05/10/18 23:41	CTD	Information	00° 34,172' N	047° 59,641' W
M147_72-2	05/10/18 23:31	Pump	in the water	00° 34,077' N	047° 59,847' W
M147_72-2	05/10/18 23:32	Pump	on deck	00° 34,082' N	047° 59,827' W
M147_72-2	05/10/18 23:41	Pump	Information	00° 34,170' N	047° 59,646' W
M147_73-1	05/10/18 23:48	MUC	in the water	00° 34,199' N	047° 59,477' W
M147_73-1	05/11/18 00:04	MUC	max depth/on ground	00° 34,055' N	047° 59,860' W
M147_73-1	05/11/18 00:07	MUC	on deck	00° 34,066' N	047° 59,858' W
M147_74-1	05/11/18 09:04	CTD	in the water	01° 44,141' N	047° 58,333' W
M147_74-1	05/11/18 09:08	CTD	max depth/on ground	01° 44,184' N	047° 58,366' W
M147_74-1	05/11/18 09:13	CTD	on deck	01° 44,232' N	047° 58,394' W
M147_74-2	05/11/18 09:15	Pump	in the water	01° 44,247' N	047° 58,397' W
M147_74-2	05/11/18 09:24	Pump	on deck	01° 44,358' N	047° 58,390' W
M147_75-1	05/11/18 10:36	CTD	in the water	01° 39,038' N	048° 02,419' W
M147_75-1	05/11/18 10:40	CTD	max depth/on ground	01° 39,079' N	048° 02,404' W
M147_75-1	05/11/18 10:47	CTD	on deck	01° 39,150' N	048° 02,352' W
M147_75-2	05/11/18 10:48	Pump	in the water	01° 39,155' N	048° 02,346' W
M147_75-2	05/11/18 10:56	Pump	on deck	01° 39,227' N	048° 02,286' W
M147_76-1	05/11/18 10:57	CTD/TM	in the water	01° 39,214' N	048° 02,279' W
M147_76-1	05/11/18 11:02	CTD/TM	on deck	01° 39,263' N	048° 02,276' W
M147_76-1	05/11/18 11:12	CTD/TM	Information	01° 39,358' N	048° 02,245' W
M147_77-1	05/11/18 11:13	MUC	Information	01° 39,364' N	048° 02,242' W
M147_77-1	05/11/18 11:20	MUC	max depth/on ground	01° 39,419' N	048° 02,230' W
M147_77-1	05/11/18 11:23	MUC	on deck	01° 39,446' N	048° 02,222' W
M147_77-1	05/11/18 11:26	MUC	Information	01° 39,444' N	048° 02,211' W
M147_78-1	05/11/18 12:22	CTD	in the water	01° 34,989' N	048° 05,031' W
M147_78-1	05/11/18 12:43	CTD	max depth/on ground	01° 33,962' N	048° 05,685' W
M147_78-1	05/11/18 12:50	CTD	on deck	01° 34,043' N	048° 05,654' W
M147_78-1	05/11/18 13:08	CTD	Information	01° 34,182' N	048° 05,604' W
M147_78-2	05/11/18 12:54	Pump	in the water	01° 34,080' N	048° 05,640' W
M147_78-2	05/11/18 13:08	Pump	on deck	01° 34,181' N	048° 05,605' W
M147_79-1	05/11/18 14:05	CTD	in the water	01° 28,754' N	048° 08,914' W
M147_79-1	05/11/18 14:12	CTD	max depth/on ground	01° 28,769' N	048° 08,913' W
M147_79-1	05/11/18 14:15	CTD	on deck	01° 28,773' N	048° 08,907' W
M147_79-1	05/11/18 14:29	CTD	Information	01° 28,759' N	048° 08,892' W
M147_79-2	05/11/18 14:16	Pump	in the water	01° 28,774' N	048° 08,905' W
M147_79-2	05/11/18 14:25	Pump	on deck	01° 28,772' N	048° 08,892' W
M147_79-2	05/11/18 14:29	Pump	Information	01° 28,759' N	048° 08,892' W

M147_80-1	05/11/18 16:16	CTD	in the water	01° 15,977' N	048° 16,730' W
M147_80-1	05/11/18 16:19	CTD	max depth/on ground	01° 15,996' N	048° 16,715' W
M147_80-1	05/11/18 16:23	CTD	on deck	01° 16,008' N	048° 16,703' W
M147_80-2	05/11/18 16:27	Pump	in the water	01° 16,013' N	048° 16,708' W
M147_80-2	05/11/18 16:40	Pump	on deck	01° 15,963' N	048° 16,735' W
M147_81-1	05/11/18 17:36	CTD	in the water	01° 09,975' N	048° 20,040' W
M147_81-1	05/11/18 17:40	CTD	max depth/on ground	01° 09,947' N	048° 20,089' W
M147_81-1	05/11/18 17:44	CTD	on deck	01° 09,922' N	048° 20,158' W
M147_81-2	05/11/18 17:46	Pump	in the water	01° 09,917' N	048° 20,166' W
M147_81-2	05/11/18 17:54	Pump	on deck	01° 09,896' N	048° 20,231' W
M147_82-1	05/11/18 18:00	MUC	in the water	01° 09,926' N	048° 20,257' W
M147_82-1	05/11/18 18:02	MUC	max depth/on ground	01° 09,922' N	048° 20,256' W
M147_82-1	05/11/18 18:06	MUC	on deck	01° 09,919' N	048° 20,258' W
M147_82-1	05/11/18 18:35	MUC	in the water	01° 09,986' N	048° 20,037' W
M147_82-1	05/11/18 18:39	MUC	max depth/on ground	01° 09,992' N	048° 20,030' W
M147_82-1	05/11/18 18:41	MUC	on deck	01° 09,988' N	048° 20,034' W
M147_82-1	05/11/18 19:10	MUC	in the water	01° 10,040' N	048° 20,062' W
M147_82-1	05/11/18 19:12	MUC	max depth/on ground	01° 10,042' N	048° 20,062' W
M147_82-1	05/11/18 19:15	MUC	on deck	01° 10,041' N	048° 20,062' W
M147_82-1	05/11/18 19:24	MUC	in the water	01° 10,043' N	048° 20,073' W
M147_82-1	05/11/18 19:26	MUC	max depth/on ground	01° 10,043' N	048° 20,078' W
M147_82-1	05/11/18 19:29	MUC	on deck	01° 10,045' N	048° 20,089' W
M147_83-1	05/11/18 22:56	CTD	Information	01° 38,021' N	048° 35,175' W
M147_83-1	05/11/18 23:00	CTD	max depth/on ground	01° 38,023' N	048° 35,175' W
M147_83-1	05/11/18 23:03	CTD	on deck	01° 38,024' N	048° 35,176' W
M147_83-1	05/11/18 23:13	CTD	Information	01° 38,016' N	048° 35,130' W
M147_83-2	05/11/18 23:05	Pump	in the water	01° 38,025' N	048° 35,175' W
M147_83-2	05/11/18 23:13	Pump	on deck	01° 38,016' N	048° 35,131' W
M147_84-1	05/12/18 02:29	CTD	in the water	02° 03,070' N	048° 49,947' W
M147_84-1	05/12/18 02:33	CTD	max depth/on ground	02° 03,103' N	048° 49,929' W
M147_84-1	05/12/18 02:36	CTD	on deck	02° 03,115' N	048° 49,903' W
M147_84-2	05/12/18 02:40	Pump	in the water	02° 03,111' N	048° 49,906' W
M147_84-2	05/12/18 02:48	Pump	on deck	02° 03,172' N	048° 49,982' W
M147_85-1	05/12/18 03:09	MUC	in the water	02° 03,053' N	048° 49,930' W
M147_85-1	05/12/18 03:13	MUC	max depth/on ground	02° 03,053' N	048° 49,926' W
M147_85-1	05/12/18 03:15	MUC	on deck	02° 03,050' N	048° 49,905' W
M147_86-1	05/12/18 07:37	CTD	in the water	02° 40,035' N	049° 12,091' W
M147_86-1	05/12/18 07:41	CTD	max depth/on ground	02° 40,050' N	049° 12,156' W
M147_86-1	05/12/18 07:47	CTD	on deck	02° 40,065' N	049° 12,263' W
M147_86-2	05/12/18 07:50	Pump	in the water	02° 40,076' N	049° 12,345' W
M147_86-2	05/12/18 07:59	Pump	on deck	02° 40,120' N	049° 12,571' W
M147_87-1	05/12/18 13:22	CTD	in the water	02° 39,049' N	050° 06,536' W

M147_87-1	05/12/18 13:27	CTD	max depth/on ground	02° 39,226' N	050° 06,476' W
M147_87-1	05/12/18 13:27	CTD	on deck	02° 39,233' N	050° 06,473' W
M147_87-2	05/12/18 13:29	Pump	in the water	02° 39,318' N	050° 06,435' W
M147_87-2	05/12/18 13:49	Pump	on deck	02° 40,098' N	050° 06,110' W
M147_88-1	05/12/18 17:04	CTD	Information	03° 06,106' N	050° 29,971' W
M147_88-1	05/12/18 17:08	CTD	max depth/on ground	03° 06,020' N	050° 30,075' W
M147_88-1	05/12/18 17:11	CTD	on deck	03° 05,919' N	050° 30,190' W
M147_88-2	05/12/18 17:11	Pump	in the water	03° 05,916' N	050° 30,193' W
M147_88-2	05/12/18 17:22	Pump	on deck	03° 05,599' N	050° 30,543' W
M147_89-1	05/12/18 17:35	MUC	in the water	03° 05,661' N	050° 30,458' W
M147_89-1	05/12/18 17:39	MUC	max depth/on ground	03° 05,657' N	050° 30,464' W
M147_89-1	05/12/18 17:42	MUC	on deck	03° 05,653' N	050° 30,479' W
M147_90-1	05/12/18 22:06	CTD	in the water	03° 46,037' N	050° 48,019' W
M147_90-1	05/12/18 22:10	CTD	max depth/on ground	03° 46,093' N	050° 48,013' W
M147_90-1	05/12/18 22:15	CTD	on deck	03° 46,159' N	050° 48,000' W
M147_90-2	05/12/18 22:15	Pump	in the water	03° 46,161' N	050° 47,999' W
M147_90-2	05/12/18 22:22	Pump	on deck	03° 46,254' N	050° 47,973' W
M147_91-1	05/13/18 01:19	CTD	in the water	04° 18,025' N	051° 00,137' W
M147_91-1	05/13/18 01:23	CTD	max depth/on ground	04° 18,073' N	051° 00,216' W
M147_91-1	05/13/18 01:26	CTD	on deck	04° 18,107' N	051° 00,284' W
M147_91-2	05/13/18 01:27	Pump	in the water	04° 18,118' N	051° 00,305' W
M147_91-2	05/13/18 01:34	Pump	on deck	04° 18,202' N	051° 00,466' W
M147_92-1	05/13/18 04:25	CTD	in the water	04° 43,205' N	051° 22,502' W
M147_92-1	05/13/18 04:29	CTD	max depth/on ground	04° 43,309' N	051° 22,712' W
M147_92-1	05/13/18 04:35	CTD	on deck	04° 43,405' N	051° 22,983' W
M147_92-2	05/13/18 04:36	Pump	in the water	04° 43,426' N	051° 23,045' W
M147_92-2	05/13/18 04:44	Pump	on deck	04° 43,592' N	051° 23,486' W
M147_93-1	05/13/18 05:10	MUC	in the water	04° 43,133' N	051° 22,503' W
M147_93-1	05/13/18 05:12	MUC	max depth/on ground	04° 43,135' N	051° 22,498' W
M147_93-1	05/13/18 05:17	MUC	on deck	04° 43,138' N	051° 22,496' W
M147_93-1	05/13/18 05:35	MUC	in the water	04° 43,149' N	051° 22,515' W
M147_93-1	05/13/18 05:37	MUC	max depth/on ground	04° 43,150' N	051° 22,514' W
M147_93-1	05/13/18 05:42	MUC	on deck	04° 43,149' N	051° 22,513' W
M147_94-1	05/13/18 09:05	CTD	in the water	05° 04,937' N	051° 03,566' W
M147_94-1	05/13/18 09:13	CTD	max depth/on ground	05° 05,119' N	051° 03,850' W
M147_94-1	05/13/18 09:19	CTD	on deck	05° 05,261' N	051° 04,001' W
M147_95-1	05/13/18 09:30	CTD/TM	in the water	05° 05,750' N	051° 04,242' W
M147_95-1	05/13/18 09:35	CTD/TM	max depth/on ground	05° 05,927' N	051° 04,320' W
M147_95-1	05/13/18 09:43	CTD/TM	on deck	05° 06,195' N	051° 04,426' W
M147_95-2	05/13/18 09:46	Pump	in the water	05° 06,313' N	051° 04,502' W
M147_95-2	05/13/18 09:55	Pump	on deck	05° 06,617' N	051° 04,705' W
M147_96-1	05/13/18 12:56	CTD	in the water	05° 30,219' N	051° 35,124' W

M147_96-1	05/13/18 13:01	CTD	max depth/on ground	05° 30,375' N	051° 35,340' W
M147_96-1	05/13/18 13:06	CTD	on deck	05° 30,523' N	051° 35,609' W
M147_97-1	05/13/18 16:58	CTD	in the water	05° 59,339' N	051° 48,555' W
M147_97-1	05/13/18 17:04	CTD	max depth/on ground	05° 59,488' N	051° 48,775' W
M147_97-1	05/13/18 17:10	CTD	on deck	05° 59,656' N	051° 48,997' W
M147_98-1	05/13/18 17:18	CTD/TM	in the water	05° 59,884' N	051° 49,318' W
M147_98-1	05/13/18 17:31	CTD/TM	on deck	06° 00,185' N	051° 49,687' W
M147_99-1	05/13/18 17:58	MUC	in the water	06° 00,039' N	051° 49,195' W
M147_99-1	05/13/18 18:01	MUC	max depth/on ground	06° 00,047' N	051° 49,210' W
M147_99-1	05/13/18 18:08	MUC	on deck	06° 00,099' N	051° 49,235' W
M147_99-1	05/13/18 18:27	MUC	in the water	06° 00,265' N	051° 49,383' W
M147_99-1	05/13/18 18:30	MUC	max depth/on ground	06° 00,281' N	051° 49,413' W
M147_99-1	05/13/18 18:35	MUC	on deck	06° 00,346' N	051° 49,549' W
M147_99-1	05/13/18 19:22	MUC	in the water	06° 00,182' N	051° 49,203' W
M147_99-1	05/13/18 19:28	MUC	max depth/on ground	06° 00,264' N	051° 49,350' W
M147_99-1	05/13/18 19:36	MUC	on deck	06° 00,381' N	051° 49,457' W
M147_100-1	05/14/18 01:24	CTD	in the water	06° 19,091' N	051° 12,256' W
M147_100-1	05/14/18 01:31	CTD	max depth/on ground	06° 19,100' N	051° 12,473' W
M147_100-1	05/14/18 01:37	CTD	on deck	06° 19,105' N	051° 12,613' W
M147_100-2	05/14/18 01:38	Pump	in the water	06° 19,119' N	051° 12,609' W
M147_100-2	05/14/18 01:57	Pump	on deck	06° 19,101' N	051° 13,354' W
M147_101-1	05/14/18 12:32	CTD	in the water	06° 35,068' N	049° 46,576' W
M147_101-1	05/14/18 13:19	CTD	max depth/on ground	06° 34,998' N	049° 46,644' W
M147_101-1	05/14/18 14:11	CTD	on deck	06° 34,938' N	049° 46,867' W
M147_102-1	05/14/18 15:38	GO-FLO	in the water	06° 34,939' N	049° 46,865' W
M147_102-1	05/14/18 15:58	GO-FLO	max depth/on ground	06° 34,939' N	049° 46,867' W
M147_102-1	05/14/18 16:21	GO-FLO	on deck	06° 34,938' N	049° 46,865' W
M147_103-2	05/15/18 12:23	Pump	in the water	04° 27,157' N	050° 41,900' W
M147_103-2	05/15/18 12:30	Pump	on deck	04° 27,206' N	050° 41,937' W
M147_103-1	05/15/18 12:26	CTD	in the water	04° 27,137' N	050° 41,918' W
M147_103-1	05/15/18 12:28	CTD	max depth/on ground	04° 27,155' N	050° 41,922' W
M147_103-1	05/15/18 12:28	CTD	on deck	04° 27,165' N	050° 41,924' W
M147_104-1	05/15/18 12:47	GO-FLO	in the water	04° 27,286' N	050° 42,012' W
M147_104-1	05/15/18 12:50	GO-FLO	max depth/on ground	04° 27,312' N	050° 42,033' W
M147_104-1	05/15/18 12:55	GO-FLO	on deck	04° 27,407' N	050° 42,075' W
M147_105-1	05/15/18 17:08	CTD	in the water	03° 53,931' N	050° 30,026' W
M147_105-1	05/15/18 17:12	CTD	max depth/on ground	03° 53,956' N	050° 30,082' W
M147_105-1	05/15/18 17:18	CTD	on deck	03° 54,000' N	050° 30,172' W
M147_105-2	05/15/18 17:19	Pump	in the water	03° 54,015' N	050° 30,202' W
M147_105-2	05/15/18 17:27	Pump	on deck	03° 54,083' N	050° 30,350' W
M147_106-1	05/15/18 20:58	CTD	in the water	03° 32,984' N	050° 07,041' W
M147_106-1	05/15/18 21:03	CTD	max depth/on ground	03° 32,993' N	050° 07,095' W

M147_106-1	05/15/18 21:09	CTD	on deck	03° 33,015' N	050° 07,183' W
M147_106-2	05/15/18 21:11	Pump	in the water	03° 33,023' N	050° 07,211' W
M147_106-2	05/15/18 21:19	Pump	on deck	03° 33,074' N	050° 07,347' W
M147_107-1	05/15/18 21:26	GO-FLO	in the water	03° 33,118' N	050° 07,477' W
M147_107-1	05/15/18 21:28	GO-FLO	max depth/on ground	03° 33,125' N	050° 07,512' W
M147_107-1	05/15/18 21:34	GO-FLO	on deck	03° 33,152' N	050° 07,609' W
M147_108-1	05/15/18 21:48	MUC	in the water	03° 33,042' N	050° 07,245' W
M147_108-1	05/15/18 21:52	MUC	max depth/on ground	03° 33,051' N	050° 07,247' W
M147_108-1	05/15/18 21:55	MUC	on deck	03° 33,069' N	050° 07,278' W
M147_109-1	05/16/18 00:00	CTD	in the water	03° 18,144' N	050° 17,857' W
M147_109-1	05/16/18 00:10	CTD	max depth/on ground	03° 18,437' N	050° 17,754' W
M147_109-1	05/16/18 00:11	CTD	on deck	03° 18,472' N	050° 17,742' W
M147_109-2	05/16/18 00:12	Pump	in the water	03° 18,491' N	050° 17,736' W
M147_109-2	05/16/18 00:18	Pump	on deck	03° 18,686' N	050° 17,665' W
M147_110-1	05/16/18 04:39	CTD	in the water	02° 54,066' N	049° 51,925' W
M147_110-1	05/16/18 04:43	CTD	max depth/on ground	02° 54,157' N	049° 51,915' W
M147_110-1	05/16/18 04:47	CTD	on deck	02° 54,223' N	049° 51,926' W
M147_110-2	05/16/18 04:48	Pump	in the water	02° 54,237' N	049° 51,920' W
M147_110-2	05/16/18 04:57	Pump	on deck	02° 54,390' N	049° 51,995' W
M147_111-1	05/16/18 07:23	CTD	in the water	03° 07,984' N	049° 40,094' W
M147_111-1	05/16/18 07:27	CTD	max depth/on ground	03° 07,975' N	049° 40,211' W
M147_111-1	05/16/18 07:31	CTD	on deck	03° 07,959' N	049° 40,370' W
M147_111-2	05/16/18 07:36	Pump	Information	03° 07,943' N	049° 40,559' W
M147_111-2	05/16/18 07:41	Pump	on deck	03° 07,923' N	049° 40,773' W
M147_112-1	05/16/18 07:44	GO-FLO	in the water	03° 07,913' N	049° 40,873' W
M147_112-1	05/16/18 07:47	GO-FLO	max depth/on ground	03° 07,892' N	049° 41,002' W
M147_112-1	05/16/18 07:51	GO-FLO	on deck	03° 07,867' N	049° 41,170' W
M147_113-1	05/16/18 12:28	CTD	in the water	03° 01,870' N	049° 01,853' W
M147_113-1	05/16/18 12:33	CTD	max depth/on ground	03° 01,988' N	049° 01,886' W
M147_113-1	05/16/18 12:39	CTD	on deck	03° 02,100' N	049° 01,916' W
M147_113-2	05/16/18 12:41	Pump	in the water	03° 02,109' N	049° 01,918' W
M147_113-2	05/16/18 12:52	Pump	on deck	03° 02,371' N	049° 01,988' W
M147_114-1	05/16/18 12:56	GO-FLO	in the water	03° 02,325' N	049° 01,968' W
M147_114-1	05/16/18 12:58	GO-FLO	max depth/on ground	03° 02,338' N	049° 01,963' W
M147_114-1	05/16/18 13:03	GO-FLO	on deck	03° 02,457' N	049° 01,987' W
M147_115-1	05/16/18 14:56	CTD	in the water	03° 15,998' N	048° 52,159' W
M147_115-1	05/16/18 15:02	CTD	max depth/on ground	03° 16,070' N	048° 52,305' W
M147_115-1	05/16/18 15:10	CTD	on deck	03° 16,181' N	048° 52,510' W
M147_115-2	05/16/18 15:12	Pump	in the water	03° 16,218' N	048° 52,564' W
M147_115-2	05/16/18 15:32	Pump	on deck	03° 16,436' N	048° 53,237' W
M147_116-1	05/16/18 21:49	CTD	Information	03° 59,966' N	048° 18,045' W
M147_116-1	05/16/18 22:11	CTD	max depth/on ground	04° 00,052' N	048° 18,250' W

M147_116-1	05/16/18 22:34	CTD	on deck	04° 00,211' N	048° 18,518' W
M147_117-1	05/17/18 10:26	MUC	in the water	02° 19,250' N	048° 37,903' W
M147_117-1	05/17/18 10:28	MUC	max depth/on ground	02° 19,249' N	048° 37,903' W
M147_117-1	05/17/18 10:31	MUC	on deck	02° 19,249' N	048° 37,903' W
M147_118-1	05/17/18 14:17	CTD	in the water	02° 04,068' N	048° 16,994' W
M147_118-1	05/17/18 14:22	CTD	max depth/on ground	02° 04,192' N	048° 17,068' W
M147_118-1	05/17/18 14:27	CTD	on deck	02° 04,313' N	048° 17,120' W
M147_118-2	05/17/18 14:29	Pump	in the water	02° 04,358' N	048° 17,113' W
M147_118-2	05/17/18 14:39	Pump	on deck	02° 04,610' N	048° 17,157' W
M147_119-1	05/17/18 14:39	GO-FLO	in the water	02° 04,607' N	048° 17,156' W
M147_119-1	05/17/18 14:41	GO-FLO	max depth/on ground	02° 04,668' N	048° 17,183' W
M147_119-1	05/17/18 14:45	GO-FLO	on deck	02° 04,756' N	048° 17,223' W
M147_120-1	05/17/18 22:23	CTD	in the water	00° 58,977' N	047° 43,013' W
M147_120-1	05/17/18 22:27	CTD	max depth/on ground	00° 58,912' N	047° 43,064' W
M147_120-1	05/17/18 22:32	CTD	on deck	00° 58,824' N	047° 43,126' W
M147_120-2	05/17/18 22:35	Pump	in the water	00° 58,794' N	047° 43,161' W
M147_120-2	05/17/18 22:43	Pump	on deck	00° 58,632' N	047° 43,297' W
M147_121-1	05/17/18 22:44	GO-FLO	in the water	00° 58,606' N	047° 43,312' W
M147_121-1	05/17/18 22:46	GO-FLO	max depth/on ground	00° 58,554' N	047° 43,355' W
M147_121-1	05/17/18 22:49	GO-FLO	on deck	00° 58,473' N	047° 43,413' W
M147_122-1	05/18/18 02:23	CTD	in the water	01° 21,575' N	047° 23,023' W
M147_122-1	05/18/18 02:27	CTD	max depth/on ground	01° 21,631' N	047° 23,051' W
M147_122-1	05/18/18 02:33	CTD	on deck	01° 21,696' N	047° 23,103' W
M147_122-2	05/18/18 02:35	Pump	in the water	01° 21,717' N	047° 23,120' W
M147_122-2	05/18/18 02:53	Pump	on deck	01° 21,932' N	047° 23,299' W
M147_123-1	05/18/18 02:52	GO-FLO	in the water	01° 21,922' N	047° 23,292' W
M147_123-1	05/18/18 02:55	GO-FLO	max depth/on ground	01° 21,961' N	047° 23,322' W
M147_123-1	05/18/18 02:59	GO-FLO	on deck	01° 21,996' N	047° 23,354' W
M147_124-1	05/18/18 12:02	CTD	in the water	00° 32,836' N	048° 00,393' W
M147_124-1	05/18/18 12:05	CTD	max depth/on ground	00° 32,772' N	048° 00,486' W
M147_124-1	05/18/18 12:08	CTD	on deck	00° 32,717' N	048° 00,581' W
M147_125-1	05/18/18 12:21	GO-FLO	in the water	00° 32,481' N	048° 01,028' W
M147_125-1	05/18/18 12:22	GO-FLO	max depth/on ground	00° 32,458' N	048° 01,084' W
M147_125-1	05/18/18 12:26	GO-FLO	on deck	00° 32,400' N	048° 01,209' W
M147_126-1	05/18/18 19:55	CTD	in the water	01° 38,035' N	048° 35,958' W
M147_126-1	05/18/18 19:58	CTD	max depth/on ground	01° 38,087' N	048° 35,872' W
M147_126-1	05/18/18 20:02	CTD	on deck	01° 38,147' N	048° 35,775' W
M147_127-1	05/18/18 20:28	GO-FLO	in the water	01° 38,216' N	048° 35,629' W
M147_127-1	05/18/18 20:30	GO-FLO	max depth/on ground	01° 38,230' N	048° 35,601' W
M147_127-1	05/18/18 20:32	GO-FLO	on deck	01° 38,237' N	048° 35,581' W

Gear acronyms in the Station list and explanations:

USW	Underway Water Sampling
CTD	CTD-SS stainless steel water sampler with Niskin bottles
CTD/TM	Trace metal clean CTD water sampler with GO-FLO bottles
Underway water sampling	Towed Fish surface water sampler
Pump	In-situ pumping system for Ra isotopes
MUC	Multicorer (surface sediment)
GO-FLO	Individual GO-FLO Bottle Water Sampler on Kevlar rope

8. Data and Sample Storage and Availability

A short cruise report was submitted to Leitstelle Deutsche Forschungsschiffe directly after the cruise.

The water, particulate, and sediment samples will be stored at the respective institutes where the analyses are carried out (see detailed list below). All samples are available since September 2018.

All data acquired during the cruise will the stored at **OSIS** data base at GEOMAR for preliminary and published data and for the shared used of data by cruise participants and researchers involved in the project. Published data will be stored in the international database **PANGAEA**. Data will also be stored at the GEOTRACES data base at BODC, Liverpool, U.K.

Hydrography – CTD data are held by Jacobs University Bremen (responsible person: A. Koschinsky) and by University of Heidelberg (responsible person: E. Border)
Dissolved, particulate, and total dissolvable trace metals – samples and data are held by GEOMAR, Kiel (responsible person: M. Gledhill)
Biogenic iron compounds – samples and data are held by GEOMAR, Kiel (responsible person: M. Gledhill)
High Field Strength Elements, and Cu-ligands - samples and data are held by Jacobs University Bremen (responsible person: A. Koschinsky)
Humic substances - samples and data are held by University of Brest (responsible person: H. Whitby)
Trace metals for voltammetric analyses - samples and data are held by Universidade Federal de Santa Maria (responsible person: L. de Carvalho) and Universidade Federal do rio Grande do Sul (responsible person: A. Schneider)
DOM - samples and data are held by University of Oldenburg (responsible person: T. Dittmar)
Biogeochemistry and microbiology - samples and data are held by Universidade Estadual do Norte Fluminense (responsible person: C. de Rezende) and SAGE-COPPE (responsible person: F. Thompson)
DIC/TA – samples and data are held by GEOMAR, Kiel (responsible person: M. Gledhill)
Organic alkalinity – samples and data are held by Trinity College, Dublin, Ireland (responsible person: Severino Ibánhez,)
Nitrogen (N) and oxygen (O) isotopes - samples and data are held by Institut für Ostseeforschung Warnemünde (responsible person: M. Voss)
Radiogenic Isotopes (Nd, Hf), Rare Earth Elements (REEs), Ba and Si isotopes – samples and data are held by GEOMAR, Kiel (responsible person: M. Frank)

Uranium Isotopes – samples and data are held by University of Heidelberg (responsible person: E. Border)
Radium Isotopes – samples and data are held by University of Kiel (responsible person: J. Scholten)
Sediment and pore water – samples are held by Jacobs University Bremen (responsible person: A. Koschinsky) and GEOMAR, Kiel (responsible person: F. Scholz)

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Appendix

Appendix I: Fish Sampling Stations.

Exact time and location exemplarily chosen for dissolved trace metal samples.

Towfish sample number	Date	Time	Latitude (°N)	Longitude (°E)
3_F	30/04/2018	00:54:00	-0.50081	-48.2783
4_F	30/04/2018	01:44:00	-0.43171	-48.2185
5_F	30/04/2018	02:17:00	-0.4024	-48.1863
6_F	30/04/2018	02:51:00	-0.37833	-48.1525
7_F	30/04/2018	07:39:00	-0.1854	-47.9237
8_F	30/04/2018	13:52:00	0.113595	-47.699
9_F	30/04/2018	16:48:00	0.321278	-47.5406
10_F	30/04/2018	21:24:00	0.66804	-47.2994
11_F	01/05/2018	17:19:00	1.897347	-46.8154
12_F	02/05/2018	11:21:00	1.575803	-49.0451
13_F	02/05/2018	12:12:00	1.501757	-49.2125
14_F	02/05/2018	13:33:00	1.30162	-49.4061
15_F	02/05/2018	18:39:00	0.951692	-49.6475
16_F	02/05/2018	22:08:00	1.45079	-49.3222
17_F	02/05/2018	22:28:00	1.450948	-49.3185
18_F	02/05/2018	23:20:00	1.4382	-49.2843
19_F	02/05/2018	23:48:00	1.438913	-49.2904
20_F	03/05/2018	00:56:00	1.43793	-49.3026
21_F	03/05/2018	01:37:00	1.460232	-49.2583
22_F	03/05/2018	08:02:00	2.302242	-48.5866
23_F	03/05/2018	08:23:00	2.300378	-48.58
24_F	03/05/2018	11:57:00	2.55413	-48.454
25_F	04/05/2018	07:07:00	3.907738	-47.5976
26_F	05/05/2018	11:19:00	-0.63418	-46.8948
27_F	05/05/2018	13:50:00	-0.59386	-46.7878
28_F	05/05/2018	15:06:00	-0.59382	-46.9049
29_F	05/05/2018	16:37:00	-0.54139	-46.7776
30_F	05/05/2018	18:03:00	-0.53782	-46.8956
31_F	05/05/2018	19:29:00	-0.48175	-46.7621
32_F	05/05/2018	21:29:00	-0.56948	-46.4283
33_F	05/05/2018	22:59:00	-0.64887	-46.186
34_F	06/05/2018	00:31:00	-0.72531	-45.941
35_F	06/05/2018	02:00:00	-0.78714	-45.7124
36_F	06/05/2018	15:46:00	-0.63872	-46.7763
37_F	06/05/2018	17:25:00	-0.48233	-46.9014
38_F	06/05/2018	19:12:00	-0.34853	-46.7729

Towfish sample number	Date	Time	Latitude (°N)	Longitude (°E)
39_F	06/05/2018	20:42:00	-0.34666	-46.8988
40_F	06/05/2018	23:11:00	-0.08479	-46.7742
41_F	07/05/2018	00:37:00	-0.09629	-46.9091
42_F	07/05/2018	04:43:00	-0.54489	-47.1193
43_F	07/05/2018	05:46:00	-0.49275	-47.3157
44_F	07/05/2018	06:50:00	-0.48013	-47.5211
45_F	07/05/2018	13:20:00	-0.30431	-46.9168
46_F	07/05/2018	14:30:00	-0.2263	-47.1274
47_F	07/05/2018	16:23:00	-0.09134	-47.209
48_F	07/05/2018	17:33:00	-0.00779	-47.0318
49_F	07/05/2018	18:35:00	0.065448	-46.8765
50_F	07/05/2018	19:35:00	0.137212	-46.7244
51_F	07/05/2018	20:33:00	0.259577	-46.6359
52_F	07/05/2018	22:33:00	0.579225	-46.5588
53_F	08/05/2018	00:33:00	0.901278	-46.4893
54_F	08/05/2018	02:46:00	1.238487	-46.4036
55_F	08/05/2018	17:16:00	2.274805	-47.4955
56_F	08/05/2018	20:34:00	2.0857	-47.6699
57_F	08/05/2018	22:22:00	1.94253	-47.7929
58_F	09/05/2018	22:29:00	0.01987	-48.4177
59_F	10/05/2018	00:20:00	0.028773	-48.1938
60_F	11/05/2018	00:34:00	0.584143	-47.9983
61_F	11/05/2018	02:02:00	0.800153	-47.9771
62_F	11/05/2018	04:23:00	1.151457	-47.9427
63_F	11/05/2018	05:03:00	1.260043	-47.932
64_F	11/05/2018	08:03:00	1.764597	-47.8826
65_F	11/05/2018	09:34:00	1.731918	-47.9747
66_F	11/05/2018	11:42:00	1.651823	-48.0427
67_F	11/05/2018	13:16:00	1.566142	-48.0968
68_F	11/05/2018	14:40:00	1.471603	-48.1528
69_F	11/05/2018	16:45:00	1.266252	-48.2793
70_F	11/05/2018	19:56:00	1.16936	-48.3338
71_F	11/05/2018	23:22:00	1.634653	-48.5867
72_F	12/05/2018	03:34:00	2.05872	-48.8397
73_F	12/05/2018	05:09:00	2.287563	-48.9746
74_F	12/05/2018	13:59:00	2.67596	-50.106
75_F	12/05/2018	17:54:00	3.098588	-50.5054
76_F	12/05/2018	22:32:00	3.78043	-50.8023
77_F	13/05/2018	01:42:00	4.310383	-51.0113
78_F	13/05/2018	05:53:00	4.722225	-51.3714
79_F	13/05/2018	10:03:00	5.118268	-51.0826

Towfish sample number	**Date**	**Time**	**Latitude (°N)**	**Longitude (°E)**
80_F	13/05/2018	19:49:00	6.015703	-51.8081
81_F	14/05/2018	02:03:00	6.318302	-51.2248
82_F	14/05/2018	16:38:00	6.578918	-49.7811
83_F	14/05/2018	18:32:00	6.429588	-49.858
84_F	14/05/2018	23:40:00	6.028193	-50.0188
85_F	15/05/2018	03:04:00	5.718607	-50.151
86_F	15/05/2018	06:01:00	5.293055	-50.3353
87_F	15/05/2018	09:11:00	4.777363	-50.5585
88_F	15/05/2018	13:21:00	4.440947	-50.6963
89_F	15/05/2018	15:23:00	4.154933	-50.5927
90_F	15/05/2018	17:49:00	3.886597	-50.4919
91_F	15/05/2018	22:31:00	3.491247	-50.1595
92_F	16/05/2018	00:30:00	3.30728	-50.2933
93_F	16/05/2018	05:10:00	2.91225	-49.8605
94_F	16/05/2018	08:10:00	3.12889	-49.6677
95_F	16/05/2018	13:22:00	3.058217	-49.0211
96_F	16/05/2018	15:42:00	3.279368	-48.8837
97_F	16/05/2018	23:54:00	4.011812	-48.3154
99_F	17/05/2018	14:57:00	2.075982	-48.2846
100_F	17/05/2018	23:02:00	0.976758	-47.7216
101_F	18/05/2018	03:09:00	1.368795	-47.3907
102_F	18/05/2018	12:40:00	0.540317	-48.0227
103_F	18/05/2018	20:41:00	1.635667	-48.5961
104_F	18/05/2018	23:03:00	1.390988	-48.6538
105_F	19/05/2018	02:02:00	0.871047	-48.4721
106_F	19/05/2018	04:58:00	0.400158	-48.308
107_F	19/05/2018	06:45:00	0.22882	-48.0299

Appendix II: Table for MUC Pore Water Sampling

Station Device	Area	Latitude	Longitude	Water depth / m	TM JUB	TM seaFAST JUB	nutrients	Fe/Mn	REY	Core length / cm	No. samples
11_MUC_1	Pará, medium salinity	00° 10,222' S	047° 57,176' W	23.8	x	x				44	13
11_MUC_2	Pará, medium salinity	00° 10,222' S	047° 57,176' W	23.8			x	x	x	44	13
21_MUC_1	Pará, seawater endmember	01° 54,581' N	046° 38,424' W	2349.3	x	x	x	x	x		9
24_MUC_1	Amazon northern transect, river endmember	00° 57,108' N	049° 38,864' W	23.5	x		x	x		32	13
24_MUC_2	Amazon northern transect, river endmember	00° 57,108' N	049° 38,864' W	23.5		x			x	32	13
41_MUC_1	Amazon northern transect, seawater endmember	03° 56,933' N	047° 36,313' W	1974.2	x		x	x		18	11
41_MUC_2	Amazon northern transect, seawater endmember	03° 56,933' N	047° 36,313' W	1974.2		x			x	19	11
50_MUC_1	Mangroves Superstation	00° 38,644' S	046° 46,438' W	21.5	x		x	x		29.5	12
50_MUC_2	Mangroves Superstation	00° 38,644' S	046° 46,438' W	21.5		x			x	29.5	12
67_MUC_1	Amazon southern transect, river endmember	00° 03,288' N	048° 42,367' W	15.8	x		x	x		30	13
67_MUC_2	Amazon southern transect, river endmember	00° 03,288' N	048° 42,367' W	15.8		x			x	30	13
73_MUC_1	South-North transect 20m contour, southern endmember	00° 34.055'N	47° 59.860'W	27.9	x		x	x		38	12

Station Device	**Area**	**Latitude**	**Longitude**	**Water depth / m**	**TM JUB**	**TM seaFAST JUB**	**nutrients**	**Fe/Mn**	**REY**	**Core length / cm**	**No. samples**
73_MUC_2	South-North transect 20m contour, southern endmember	00° 34.055'N	47° 59.860'W	27.9		x			x	37	12
77_MUC_bw	Amazon southern transect, medium salinity and depth	01° 39,419' N	048° 02,230' W	53.1	x	x	x	x	x	17	1
82_MUC_1	South-North transect 20m contour	01° 10,043' N	048° 20,078' W	29.7	x		x	x	x	50	13
82_MUC_3	South-North transect 20m contour	01° 10,043' N	048° 20,078' W	29.7		x					5
85_MUC_1	South-North transect 20m contour – Amazon northern transect cross station	02° 03,053' N	048° 49,926' W	24.9	x		x	x		24.5	13
85_MUC_2	South-North transect 20m contour – Amazon northern transect cross station	02° 03,053' N	048° 49,926' W	24.9		x			x	24	13
89_MUC_1	South-North transect 20m contour	03° 05,657' N	050° 30,464' W	21.1	x		x	x		50	13
89_MUC_2	South-North transect 20m contour	03° 05,657' N	050° 30,464' W	21.1		x			x	50	13
93_MUC_1	South-North transect 20m contour endmember	04° 43,150' N	051° 22,514' W	50.6	x		x	x		38	13
93_MUC_2	South-North transect 20m contour endmember	04° 43,150' N	051° 22,514' W	50.6		x			x	39	13
99_MUC_bw	Plume dispersal	06° 00.281' N	51° 49.413' W	91	x	x	x	x	x		1
108_MUC_1	South-North transect 20m contour	03° 33.051' N	50° 07.247' W	73.6	x		x	x		55	12

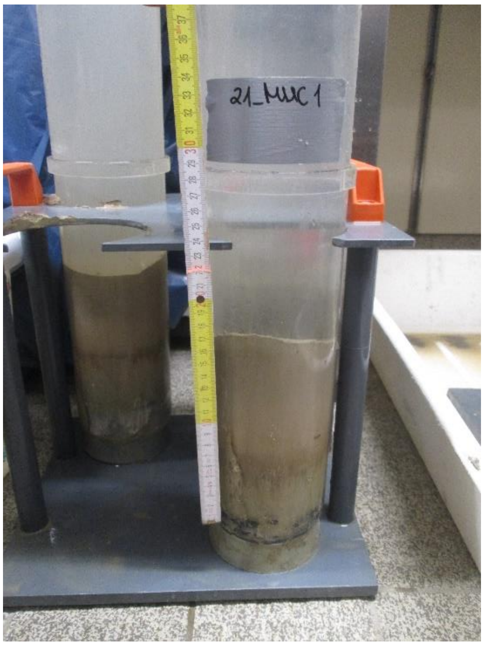
Station Device	**Area**	**Latitude**	**Longitude**	**Water depth / m**	**TM JUB**	**TM seaFAST JUB**	**nutrients**	**Fe/Mn**	**REY**	**Core length / cm**	**No. samples**
108_MUC_2	South-North transect 20m contour	03° 33.051' N	50° 07.247' W	73.6		x			x	55	12
117_MUC	South-North transect 20m contour	02° 19,249' N	048° 37,903' W		x		x	x		34	13
117_MUC	South-North transect 20m contour	02° 19,249' N	048° 37,903' W			x			x	34	13

Appendix III: Pictures of MUC Cores for each Station

M147_11_MUC_1 and 2

M147_11_MUC_3

M147_21_MUC_1



M147_21_MUC_1

M147_23_MUC_1

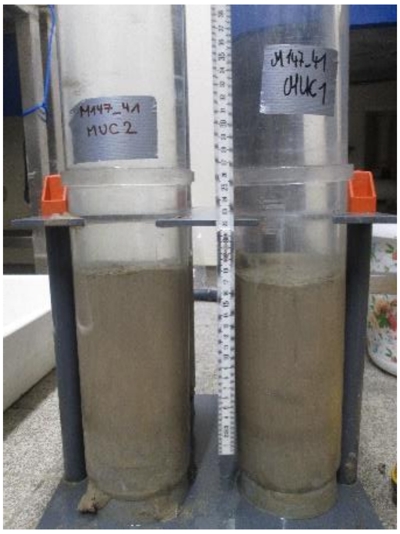
M147_24_MUC_1

M147_24_MUC_2

M147_24_MUC_3

M147_36_MUC_1

M147_41_MUC 1 and 2



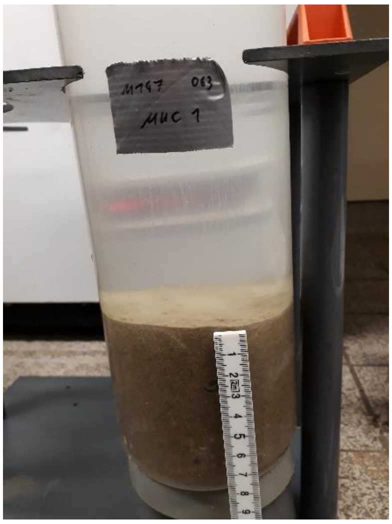
M147_41_MUC_3

M147_50_MUC_1

M147_50_MUC_2

M147_50_MUC_3

M147_63_MUC_1



M147_65_MUC

M147_67_MUC_1

M147_67_MUC_2

M147_67_MUC_3

M147_73_MUC_1

M147_73_MUC_2

M147_77_MUC_1

M147_82_MUC_1

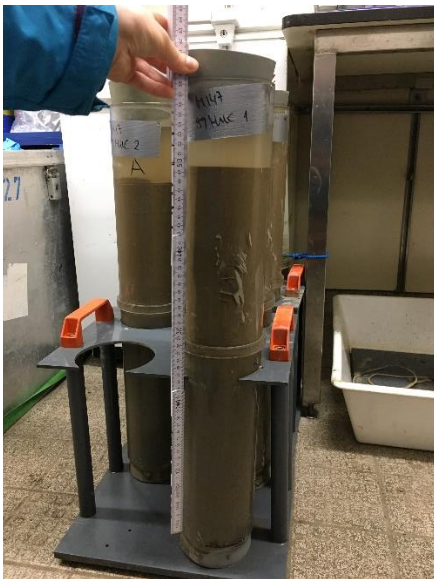
M147_82_MUC_3

M147_85_MUC_1

M147_85_MUC_2

M147_85_MUC_3

M147_89_MUC 1



M147_89_MUC 2

M147_93_MUC 1

M147_93_MUC 2

M147_99_MUC

M147_117_MUC 1

M147_117_MUC 2