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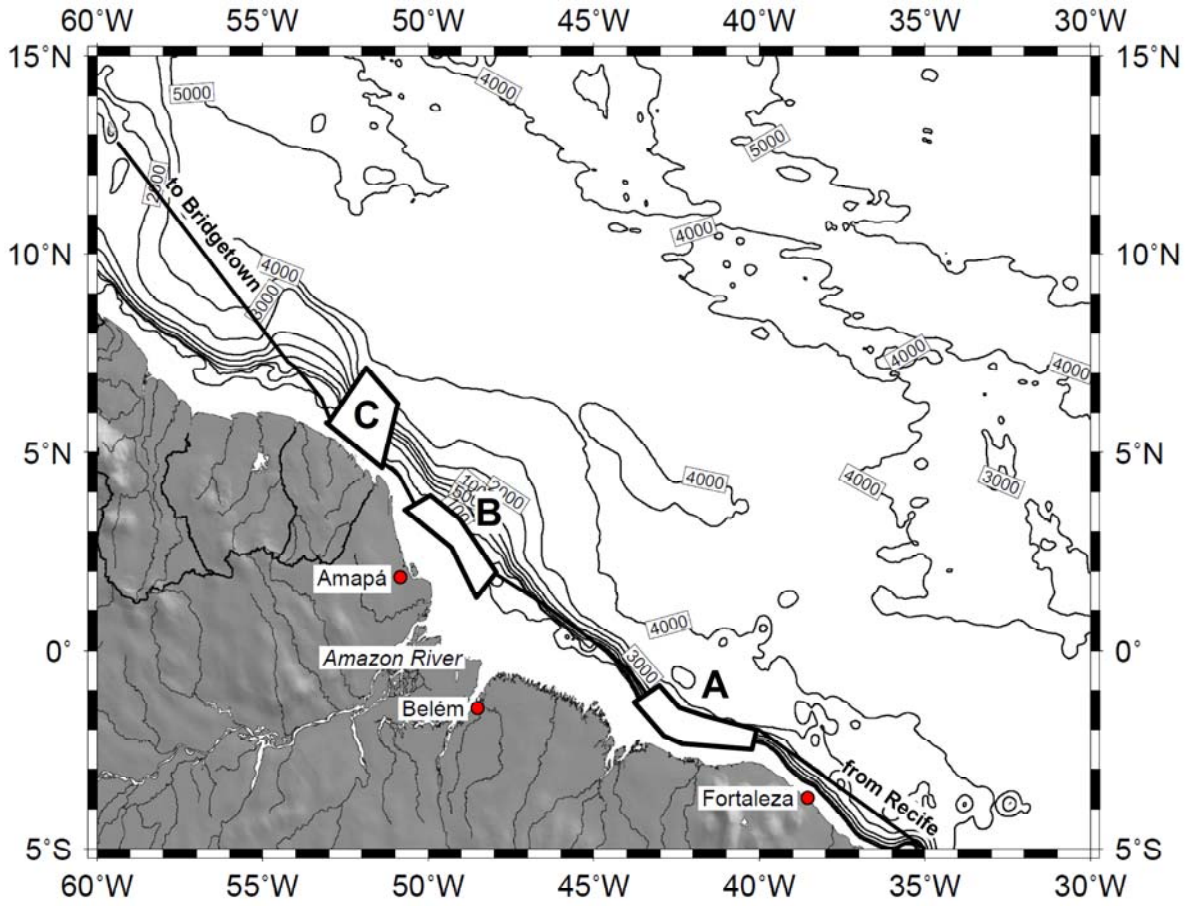
Short Cruise Report
MARIA S. MERIAN-CRUISE MSM20/3

Recife - Bridgetown
19.02.2012 - 11.03.2012
Chief Scientist: Dr. Stefan Mulitza
Captain: Karl-Friedhelm von Staa



Objectives

The Amazon rainforest plays a vital role for global climate through its influence on the water cycle and the atmospheric circulation. The primary goal of expedition MSM20/3 was to explore the Holocene and Pleistocene climate history of the Amazon River basin in relation to changes in ocean circulation on millennial to decadal time scales as well as the Holocene development and architecture of the Amazon submarine delta.

Specifically the retrieved samples shall allow to

- relate changes in the composition of sediments deposited over the Anthropocene to changes in Amazon deforestation and discharge
- assess the relative magnitude of historical changes in Amazon outflow and sedimentation against the background climate variability over the Holocene
- reconstruct the decadal-scale variability of Amazon outflow and surface water hydrography over the last ~3000 years
- understand the architecture and Holocene development of the Amazon submarine delta/mudbelt in relation to the precipitation history of the Amazon basin
- analyse the internal clinoform build-up in time and space in high resolution with special emphasis on the foreset and bottomset beds where most of the accretion occur
- image the surface structures (i.e., terraces, sand waves) on the Amazon shelf as well as possible mudflows/suspension flows
- reconstruct millennial-scale variations in the position of the Brazilian rainbelt during the last ~50,000 years in relation to changes in ocean circulation
- reconstruct millennial-scale variations in surface water hydrography during the last ~50,000 years in relation to changes in the Atlantic meridional overturning circulation
- complement existing core profiles to reconstruct changes in vertical water mass stratification in the western equatorial Atlantic.

These goals required to sample sediments and the water column on the continental slope and shelf off northern Brazil (working areas A and B) and French Guiana (working area C) with gravity corer, multicorer, rosette/CTD, in-situ and shipboard pump systems. Since information on sediment structures were sparse in the working areas an intense site survey with PARASOUND and EM120/1002 was done prior to geological sampling. Furthermore high-resolution multichannel seismic system was used in working area B in order to understand the Holocene architecture and development of the Amazon submarine delta. All investigations have been carried out in the framework of the research areas “Ocean and Climate” and “Sediment Dynamics” of the DFG Research Center and Cluster of Excellence MARUM in close collaboration with the University of São Paulo.

Narrative

The scientific crew of Expedition MSM20/3 included four colleagues from the University of Sao Paulo, one colleague from Fluminense Federal University, Rio de Janeiro, and one

colleague from the Federal University of Rio de Janeiro. Furthermore, the cruise was accompanied by an observer of the Brazilian Navy. The permission to work in Brazilian territory included approvals by the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA), the Brazilian National Security Council (NSC), the Brazilian NAVY, and the Ministry of Science, Technology and Innovation. The final permission to work in Brazilian territory was granted by the Brazilian Ministry of External Relations on February 16, 2012. Planned working areas within Brazilian territory had to be reported to the observer within a radius of +/- 25 miles about 24 hours in advance. Work was only allowed outside a distance of 24 miles of the coast. The permission to work off French Guiana was issued on February 17, 2012 by the French Ministry for Foreign Affairs.

MARIA S. MERIAN departed from Recife, Brazil to the third leg of its 20th expedition in the morning of Sunday, February 19 at about 8:30. After a transit of about 2 days, MARIA S. MERIAN arrived in working area A in the morning of February 21 (Figure 1). Since site survey data from Area A were not available, we started immediately with a PARASOUND/EM120 survey along the continental slope at about 2°S. After the first profile we successfully tested CTD/Rosette as well as the in-situ pump on station GeoB16201 and continued the site survey until the early morning of February 22. Echo sounder data showed that the slope is characterized by gullies and canyons. Below about 1500 m water depth the slope was less steep and PARASOUND showed well stratified sediments. Gravity corer and multicorer were successfully deployed on stations GeoB16202 (2248 m), GeoB16203 (1590 m) and GeoB16204 (1211 m). During a subsequent 11h survey with PARASOUND/EM120 at the northern limit of working area A, we identified two additional sites in 1956 m (GeoB16205) and about 1367 m (GeoB16206) water depth where sediments were successfully sampled with gravity and multicorer. Our preliminary biostratigraphy indicates sedimentation rates of 15-20 cm/kyr for cores in working area A, ideal to investigate millennial climate changes as suggested in the proposal. Since all goals in working area A were reached as scheduled we departed to working area B in the morning of February 24. During transit, data acquisition was stopped completely.

After a short transit into working area B (Figure 2), we started immediately with seismic profiling in the southern compartment in the foreset area of the Amazon Submarine Delta. Generally, the swell in the shallow waters in working area B was higher than expected which sometimes hampered the quality of the seismic data, especially when high gas content limited penetration. PARASOUND, however, provided generally excellent data quality.

Surface salinities during the seismic survey decreased from ~36 psu to values as low as ~15 psu in the vicinity of the Amazon River plume, which suggests a considerable admixture of freshwater. The seismic survey was used to obtain suspension and water samples via the shipboard pumping system for stable isotope and trace element investigations. Furthermore, water samples from the water column were obtained with the shipboard rosette/CTD system at various stations in the Amazon Delta between the seismic surveys.

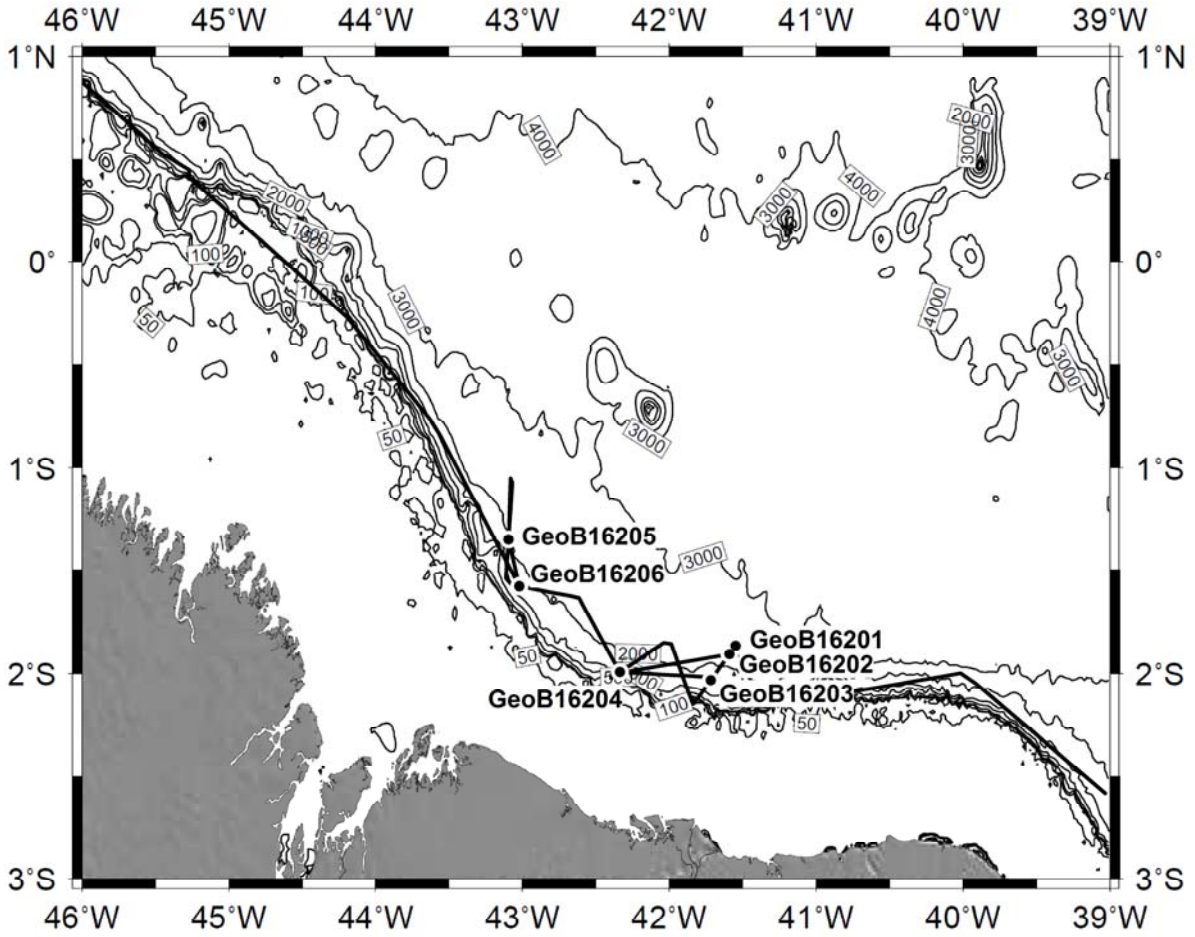


Fig. 1: Cruise track and stations in working area A. Bathymetry from Smith and Sandwell (1997).

Sediment samples were taken on three stations (GeoB16212-16214) across a depth transect from the topset to the bottomset area of the Amazon Submarine Delta. The multicorer deployments were successful at all stations on this transect. The retrieved sediments show a clear trend to finer grain sizes towards the bottom set area. One 6 m long gravity core barrel was bent during an attempt to core the very sandy topset area on station GeoB16209-4. On this station, a failure of the small boom crane, presumably due to strong current-related pressure on the core retrieval frame (Kernabsatzgestell), caused a temporary failure of gravity coring until the boom crane was fixed. Gravity coring resumed on station GeoB16211 in the foreset area of the Amazon Delta where we retrieved a 368 cm long core with faintly laminated sediments. During retrieval of gravity core GeoB16211-3 the boom crane broke again. The time needed to fix the crane was used to map a sediment-filled channel in front of the Amazon Submarine Delta (already described on Meteor-Cruise M34/4 in 1996) in order to find appropriate stations for sediment sampling. Generally, the reflectors in the channel indicate well stratified sediments. Also, it was possible to trace specific reflectors throughout the entire channel. The comparison with the sediment reflectors mapped on M34/4 showed that a significant amount of sediment accumulated in the channel since 1996. After the boom crane was fixed again we sampled Core GeoB16212-3 in the channel in 75 m water depth. During retrieval of gravity core GeoB16212-3 the cable jumped out of the pulley wheel of the

large boom crane and damaged the wheel. Since the operation of the crane was critical for further sediment sampling and because sediment sampling in the southern compartment seemed difficult, it was decided to leave the southern compartment of the delta and to continue with a seismic connection line to the northern compartment in order to gain time to repair the wheel. The seismic data obtained on the connection line show that most seismic reflectors can be traced from the southern compartment to the northern compartment. Hence the concept of two compartments, designed in the 1980's, probably has to be revised.

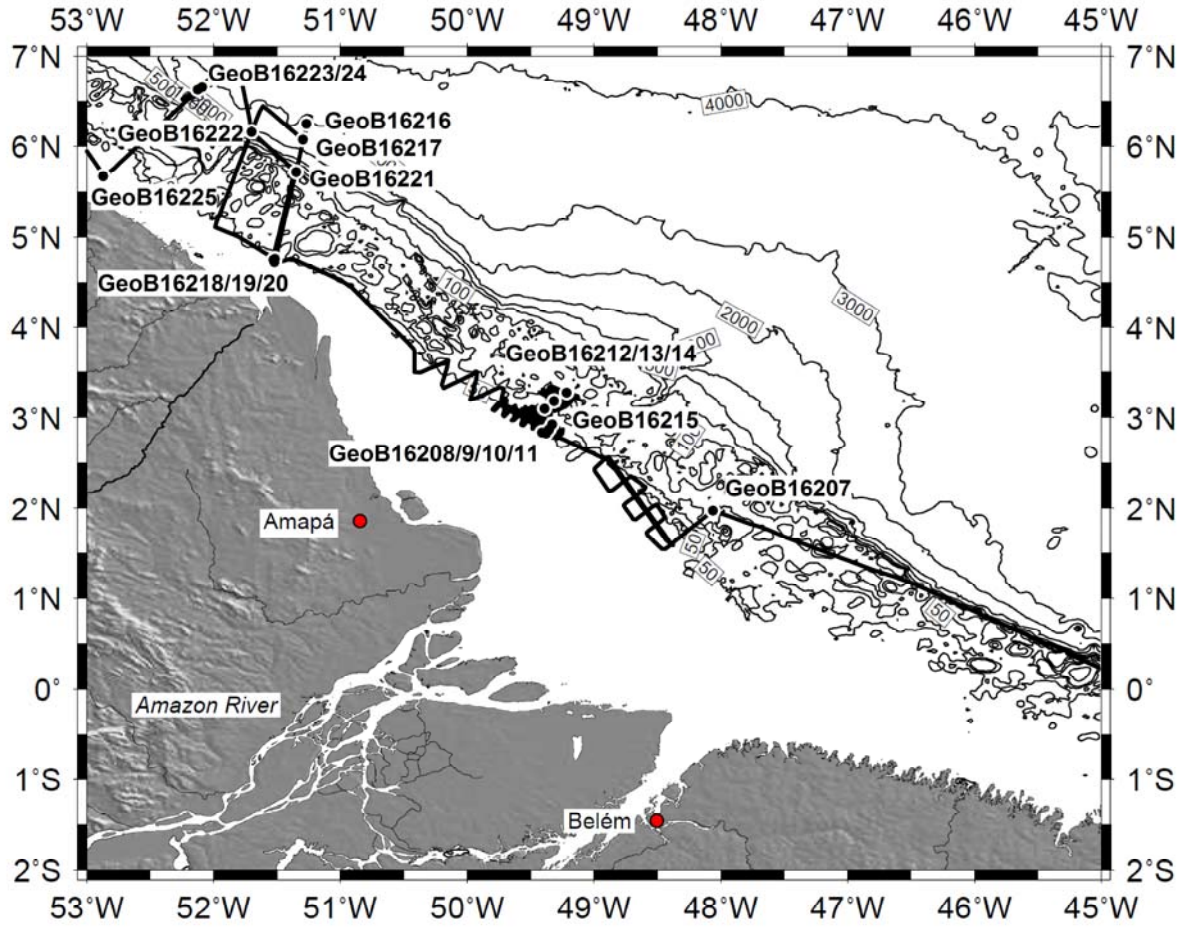


Fig. 2: Cruise track and stations in working areas B and C. Bathymetry from Smith and Sandwell (1997).

In the morning of March 3 we started with the seismic survey in the northern compartment of the Amazon Delta. Due to low gas content the hydroacoustic imagery shows more details than in the southern compartment. Generally the northern survey showed thicker sediment coverage than the southern part of the delta. Also the vertical stratification is more complex than in the southern part. On March 4, the seismic survey in the Amazon Delta was successfully finished and we continued with a PARASOUND/EM120/1002 survey in the adjacent Area C off French Guiana (Figure 2). The data show that the Amazon mudbelt on the shelf off French Guiana is indeed a continuation of the Amazon Delta rather than a separated feature. Furthermore, reef structures previously described by Parra and Pujos (1998,

Continental Shelf Research 18 1613-1629) were clearly visible in the bathymetric data obtained with EM1002.

The selection of the survey lines on the continental slope was based on the sediment classification maps of Loncke et al. (2009, Marine and Petroleum Geology 26, 711–723). Our PARASOUND data are in excellent agreement with the maps by Loncke et al. (2009) and showed well stratified sediments below ~2400 m water depth. After the pulley wheel was fixed on March 5 we were able to take two gravity cores (GeoB16216-3, GeoB16217-1) on the continental slope at 2833 m and 2440 m water depth. Both cores show a relatively condensed Holocene and a largely expanded glacial section.

On March 6 sediment sampling was continued on the continental shelf off French Guiana in the area of the Amazon mudelt. Based on previous work of Parra and Pujos (1998) a thick sediment deposit was identified at ~4°45°N/51°31W. Three gravity cores were taken on a profile across the mudbelt in 31, 38 and 41 m water depth. Due to high waves and a strong roll the multicorer smashed against the ship's side and bent the central mounting of the multicorer. Subsequently no multicorers were deployed on stations GeoB16219 - GeoB16222. The gravity cores reached length of 5.41 to 6.34 m and consist of fine grained and partly laminated sediments with coarser sediments at the base. A comparison with the stratigraphy in Parra and Pujos (1998) suggests that the cores document at least the last 2000 years with increasing sedimentation rates towards shallower water depths.

In the morning of March 7 we deployed a grab sampler on top of one of the larger reef structures at the outer shelf off French Guiana with the purpose to get hints on the origin. In one of the grab samples from 95 m water depth (GeoB16221-2), a heavily bio-eroded coral was indeed identified.

In the afternoon of March 7 we continued the sampling on the continental slope in the northern part of working area C. Three gravity cores were taken in 1749 m (GeoB16222-1), 2252 m (GeoB16223-2) and 2510 m (GeoB16224-1) water depth. After provisional repair, the multicorer was deployed again on stations GeoB16223 and GeoB16224.

The last station of MSM20/3 (GeoB16225) was carried out on the shelf at the northern rim of working area C. Here we successfully deployed the multicorer and the Rosette/CTD. After work was finished on this station in the early morning of March 9, we started the transit to Bridgetown, Barbados, where the expedition ended in the morning of March 11.

Participants

Name	Discipline	Institution
Mulitza, Stefan	Marine Geology / Chief Scientist	MARUM
Chiessi, Cristiano Mazur	Marine Geology	USP
Cruz, Anna Paula Soares	Marine Geology	UFF
Frederichs, Thomas Willibald	Geophysics	MARUM
Gomes, Jairo Geraldo	Observer	Bras. Navy
Gurgel, Marcio Henrique da Costa	Oceanography	USP
Haberkern, Julia	Geophysics	MARUM
Huang, Enqing	Marine Geology	MARUM
Jovane, Luigi	Geophysics	USP
Kuhnert, Henning	Marine Geology	MARUM
Pittauerová, Daniela	Environmental Physics	IUP
Reiners, Sally-Jane	Micropaleontology	MARUM
Roud, Sophie Charlotte	Geophysics	MARUM
Schefuß, Enno	Organic Geochemistry	MARUM
Schewe, Felix	Marine Geology	MARUM
Schwenk, Tilmann Alexander	Marine Geophysics	MARUM
Sicoli Seoane, Jose Carlos	Marine Geophysics	UFRJ
Sousa, Silvia Helena Mello e	Micropaleontology	USP
Wangner, David Johannes	Marine Geology	MARUM
Wiers, Steffen	Marine Geophysics	MARUM

IUP	Institute of Environmental Physics, University of Bremen
MARUM	Center for Marine Environmental Sciences, University of Bremen
UFF	Fluminense Federal University
UFRJ	Federal University of Rio de Janeiro
USP	University of São Paulo

Acknowledgements

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Station List MSM20/3

Station GeoB	Station MSM	Date 2012	Time (UTC)	Device	Latitude (°)	Longitude (°)	WD (m)	Remarks/Recovery
Continental Slope Northeast Brazil (Working Area A)								
16201-1	052-1	21.2.	17:10	ROS/CTD	1° 51.99' S	41° 33.00' W	2495	2200-2000-1900-1800-1500-1200-900-700-500-400-300-200-170-150-120-100-70-50-30-10-5-5-5 m, 13C,18O, Ba/Ca, bottle 10 leaky
16201-2	052-2	21.2.	18:53	ISP	1° 52.00' S	41° 33.00' W	2514	105-115 m
16202-1	053-1	22.2.	14:14	MUC	1° 54.50' S	41° 35.50' W	2247	7/8, 4/4, 19-24 cm
16202-2	053-2	22.2.	15:41	SL9	1° 54.50' S	41° 35.50' W	2248	Geology, 773 cm
16203-1	054-1	22.2	18:07	SL9	2° 02.11' S	41° 43.11' W	1591	Geology, 858 cm, ~10 sediment lost from top
16203-2	054-2	22.2.	19:18	MUC	2° 02.11' S	41° 43.11' W	1590	8/8, 4/4, 30-35 cm
16204-1	055-1	22.2.	23:50	MUC	1° 59.75' S	42° 20.31' W	1212	8/8, 4/4, 32-35 cm
16204-2	055-2	23.2.	00:50	SL9	1° 59.75' S	42° 20.31' W	1211	Geology, 277 cm
16205-1	056-1	23.2.	15:20	ROS/CTD	1° 21.12' S	43° 05.80' W	1949	1900-1800-1500-1000-700-500-300-200-150-130-110-100-80-50-30-10-5-5-5-5-5-5-5, 13C, 18O, Ba/Ca
16205-2	056-2	23.2.	16:32	ISP	1° 21.12' S	43° 05.80' W	1953	105-115 m
16205-3	056-3	23.2.	20:40	MUC	1° 21.11' S	43° 05.80' W	1957	8/8, 4/4, 24-27 cm
16205-4	056-4	23.2.	23:32	SL9	1° 21.11' S	43° 05.80' W	1955	Geology, 620 cm
16206-1	057-1	24.2.	02:00	SL9	1° 34.75' S	43° 01.42' W	1367	Geology, 812 cm
16206-1	057-2	24.2.	03:02	MUC	1° 34.75' S	43° 01.42' W	1367	8/8, 4/4, 30 cm
Amazon Submarine Delta (Working Area B)								
16207-1	060-1	25.2.	11:22	ROS/CTD	1° 59.04' N	48° 03.77' W	54	5-5-5-5-5-5-5-5-20-20-20-20-20-20-20-38-38-38-38-38-38, 13C, 18O, Ba/Ca, Ra
16208-1	062-1	28.2.	14:03	ROS/CTD	2° 50.63' N	49° 24.43' W	24	6-6-6-6-6-6-6-10-10-10-10-10-10-10-10-18-18-18-18-18-18-18-18-18, 13C, 18O, Ba/Ca, Ra
16209-1	063-1	28.2.	14:47	ROS/CTD	2° 49.90' N	49° 22.52' W	24	5-5-5-5-5-5-5-5-10-10-10-10-10-10-10-10-16-16-16-16-16-16-16-16, 13C, 18O, Ba/Ca, Ra, bottles 17 and 24 malfunctioned
16209-2	063-2	28.2.	15:07	MUC	2° 50.01' N	49° 22.46' W	24	2/8, 1/4, 11 cm, samples labeled with 16209-3
16209-3	063-3	28.2.	15:28	MUC	2° 50.01' N	49° 22.46' W	24	2/8, 2/4, 11 cm
16209-4	063-4	28.2.	15:49	SL6	2° 50.01' N	49° 22.46' W	24	No recovery, barrel bent
16210-1	064-1	28.2.	16:30	ROS/CTD	2° 51.82' N	49° 21.55' W	38	7-7-7-7-7-7-7-23-23-23-23-23-23-23-23-33-33-33-33-33-33-33-33, 13C, 18O, Ba/Ca, Ra
16210-2	064-2	28.2.	16:47	MUC	2° 52.00' N	49° 21.58' W	40	7/8, 4/4, 21-24 cm
16211-1	065-1	28.2.	23:06	ROS/CTD	2° 52.76' N	49° 21.06' W	56	4-4-4-4-4-4-4-10-10-10-10-10-10-10-10-47-47-47-47-47-47-47-47-47, 13C, 18O, Ba/Ca, Ra
16211-2	065-2	28.2.	23:28	MUC	2° 52.92' N	49° 21.26' W	57	8/8, 4/4, 29-31 cm
16211-3	065-3	28.2.	23:57	SL6	2° 52.69' N	49° 20.98' W	56	Geology, 368 cm
16212-1	067-1	29.2.	21:59	ROS/CTD	3° 06.35' N	49° 23.44' W	75	9-9-9-9-9-9-9-9-13-13-13-13-13-13-13-72-72-72-72-72-72-72-72, 13C, 18O, Ba/Ca, Ra

Station List MSM20/3 (cont.)

Station GeoB	Station MSM	Date 2012	Time (UTC)	Device	Latitude (°)	Longitude (°)	WD (m)	Remarks/Recovery
16212-2	067-2	29.2.	22:41	MUC	3° 06.22' N	49° 23.29' W	77	8/8, 4/4, 34-60 cm
16212-3	067-3	29.2.	23:58	SL12	3° 06.27' N	49° 23.28' W	75	Geology, 605 cm, cable unreeved when core was lifted from sea floor, complete core barrel with sediment was retrieved at 04:38 (UTC)
16213-1	069-1	1.3.	16:49	ROS/CTD	3° 16.85' N	49° 12.80' W	84	9-9-9-9-9-9-9-37-37-37-37-37-37-37-79-79-79-79-79-79-79-79-79-, 13C, 18O, Ba/Ca
16214-1	070-1	1.3.	18:27	ROS/CTD	3° 11.37' N	49° 18.70' W	93	5-5-5-5-5-5-5-30-30-30-30-30-30-30-76-76-76-76-76-76-76-76-76-, 13C, 18O, Ba/Ca
16215-1	072-1	2.3.	10:52	ROS/CTD	2° 56.02' N	49° 19.64' W	69	4-4-4-4-4-4-4-12-12-12-12-12-12-12-12-61-61-61-61-61-61-61-61-61-, 13C, 18O, Ba/Ca
French Guiana (Working Area C)								
16216-1	075-1	5.3.	17:44	ROS/CTD	6° 14.61' N	51° 15.72' W	2840	5-5-5-5-5-5-5-5-20-40-64-64-64-64-100-200-300-400-500-700-1000-1800-2700, 13C, 18O, Ba/Ca
16216-2	075-2	5.3.	21:03	MUC	6° 14.43' N	51° 15.39' W	2851	8/8, 4/4, 23-27 cm
16216-3	075-3	5.3.	23:05	SL9	6° 14.43' N	51° 15.34' W	2833	Geology, 722 cm, over-penetration
16217-1	076-1	6.3.	02:24	MUC	6° 03.98' N	51° 17.18' W	2433	8/8, 4/4, 24-29 cm
16217-2	076-2	6.3.	04:07	SL9	6° 04.17' N	51° 17.41' W	2440	665 cm, over-penetration
16218-1	078-1	7.3.	00:15	ROS/CTD	4° 45.74' N	51° 30.59' W	40	3-3-3-3-3-3-3-8-8-8-8-8-8-8-8-36-36-36-36-36-36-36-36, 13C, 18O, Ba/Ca. bottle 17 malfunctioned
16218-2	078-2	7.3.	00:34	MUC	4° 45.91' N	51° 30.91' W	40	4/8, 4/4. 1 large tube over-penetrated, 57-60 cm
16218-3	078-3	7.3.	01:03	MUC	4° 46.03' N	51° 31.10' W	44	5/8, 3/4. 1 small tube over-penetrated, MUC damaged, 40-54 cm
16218-4	078-4	7.3.	01:34	SL6	4° 46.17' N	51° 31.33' W	41	Geology, 559 cm
16219-1	079-1	7.3.	02:39	ROS/CTD	4° 44.85' N	51° 30.75' W	37	3-3-3-3-3-3-3-6-6-6-6-6-6-6-6-30-30-30-30-30-30-30-30, 13C, 18O
16219-2	079-2	7.3.	03:11	SL9	4° 45.15' N	51° 31.27' W	38	Geology, 634 cm
16220-1	080-1	7.3.	04:15	SL9	4° 43.41' N	51° 30.82' W	31	Geology, 541 cm
16221-1	082-1	7.3.	12:14	BG	5° 42.85' N	51° 20.53' W	104	no recovery
16221-2	082-2	7.3.	12:28	BG	5° 42.87' N	51° 20.55' W	98	encrusted coral, carbonate sand
16221-3	082-3	7.3.	12:45	BG	5° 42.87' N	51° 20.56' W	98	carbonate sand
16222-1	084-1	7.3.	17:05	SL9	6° 09.31' N	51° 41.60' W	1749	Geology, 608 cm
16223-1	086-1	8.3.	12:39	MUC	6° 37.63' N	52° 06.99' W	2251	8/8, 4/3, 39-41 cm
16223-2	086-2	8.3.	14:07	SL9	6° 37.63' N	52° 06.99' W	2253	Geology, 715 cm
16224-1	087-1	8.3.	16:07	SL9	6° 39.38' N	52° 04.99' W	2510	Geology, 760 cm
16224-2	087-2	8.3.	17:53	MUC	6° 39.46' N	52° 05.03' W	2519	0/8, 2/4, 28 cm
16225-1	088-1	9.3.	02:11	ROS/CTD	5° 39.61' N	52° 51.42' W	35	3-3-3-3-3-3-3-3-3-3-3-3-30-30-30-30-30-30-30-30-30-30-30, 13C, 18O
16225-2	088-2	9.3.	02:28	MUC	5° 40.04' N	52° 51.74' W	34	5/8, 4/4, 20-32 cm