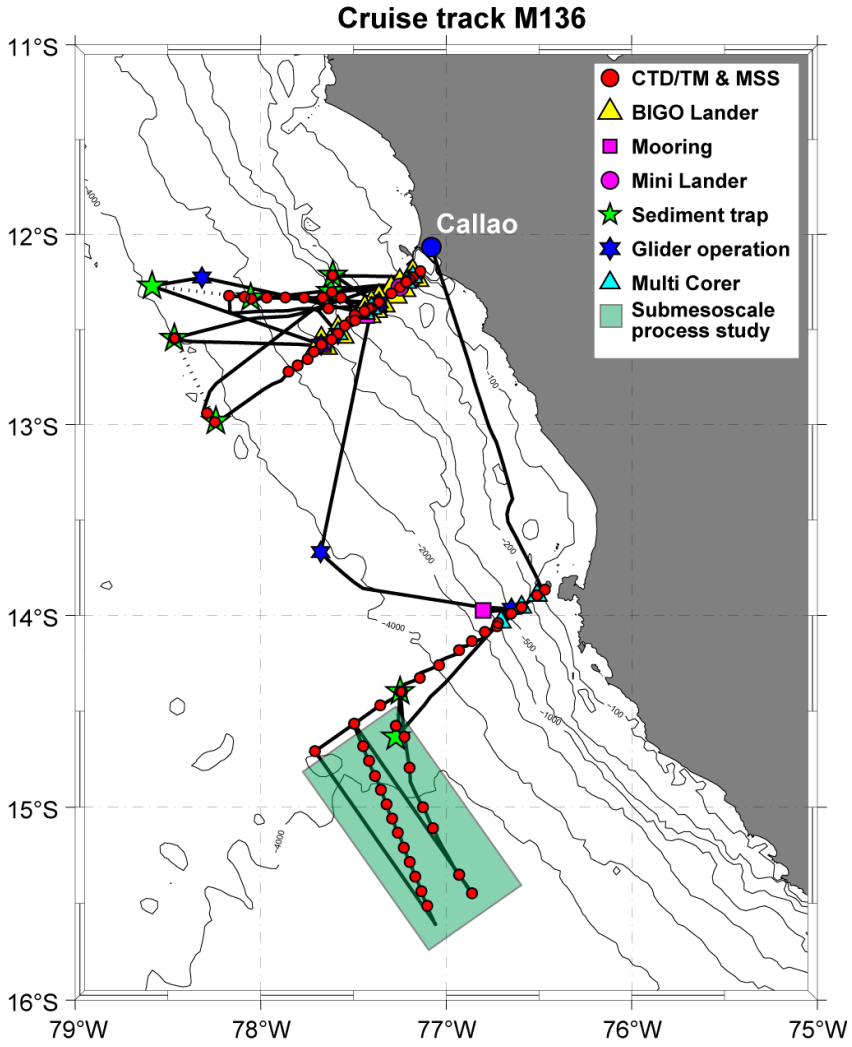
Dr. Marcus Dengler
GEOMAR Helmholtz-Zentrum für Ozeanforschung
Dienstgebäude Westufer
Düsternbrooker Weg 20
D - 24105 Kiel

Tel.: 0431-600 4107
Fax: 0431-600 4102
e-mail: mdengler@geomar.de

Short Cruise Report
R/V METEOR M136
Callao, Peru – Callao, Peru
11th April – 3rd May 2017
Chief Scientist: Dr. Marcus Dengler
Captain: Jan F. Schubert



Figs. 1: Bathymetric map with cruise track of R/V METEOR cruise M136 (black solid line) including locations of CTD stations, Biogeochemical Observatory (BIGO) Lander, mooring and Mini Lander deployments, sediment trap deployments and recoveries, glider operations and Multicorer stations. The region of the submesoscale process study is contoured in light green.

Objectives

The research cruise M136 of R/V METEOR to the Peruvian oxygen minimum zone was carried out within the framework of the DFG Collaborative Research Centre (SFB) 754 „Climate-Biogeochemical Interactions in the Tropical Ocean“. In the oxygen minimum zone off Peru, oxygen deficient waters extend vertically from the near-surface to depths below 400 m. Biogeochemical processes within these anoxic waters account for a large fraction of the global loss of nutrients and play a critical role in the oceanic nutrient inventory. The overarching goal of the cruise was to investigate benthic and pelagic cycling of nutrients, oxygen, and trace metals by measuring benthic and pelagic nutrient, oxygen, and trace metal fluxes and cycling processes as well as determining organic matter export in the oxygen minimum zone during austral fall.

A major aim of the cruise was quantifying the effect of benthic nutrient release on the nutrient inventories in the water column and its feedback on primary productivity at the near surface. Benthic nutrient fluxes were determined with Biogeochemical Observatory (BIGO) landers equipped with benthic chambers. To improve quantitative understanding of nutrient loss, a major objective was to determine pelagic cycling of nutrients, oxygen, and trace metals by budgeting physical fluxes of these solutes including turbulent fluxes, lateral-diffusive and advective fluxes in the water column and combining those with the BIGO measurements. To achieve this objective, moorings measuring velocity and hydrography as well as Gliders were deployed and shipboard sampling of velocity, turbulence and hydrography was carried out along with solute concentration measurements. Furthermore, biogeochemical measurement techniques were used to quantify different microbial nutrient cycling processes from water samples directly. A particular focus of the pelagic biogeochemical programme was to investigate how particle load and oxygen transport within particles from the euphotic zone regulate the nutrient cycling. On several stations, sinking particles about to enter the anoxic water column were collected using a large water bottle (Snow Catcher).

Nutrient loss is fuelled by the export flux of organic matter, which is still largely unknown. A major cruise objective was thus to investigate effects of anoxia on particle remineralisation rates, elemental stoichiometry, and on patterns of organic geochemical tracer changes during the degradation process. This objective was approached by collecting particulate organic matter using drifting sediment traps and by Thorium isotope measurements in the water column using large volume pumps. In addition, a major objective was to quantify the role of oxygen and dissolved organic matter transport by submesoscale subduction processes, and improving understanding of organic matter availability to heterotrophic bacteria in oxygen minimum zones. A 3-day process study was carried out in upwelling filaments to investigate the interplay of biogeochemical processes in frontal zones that included high-resolution hydrography sampling. Finally, a major objective of the cruise was to determine iron fluxes, and the mechanisms of iron stabilization, removal and recycling, with an emphasis on the effects of spatial and temporal variations in redox conditions in the water column.

The measurement program was carried out as planned and we are happy to report that all objectives of the cruise were accomplished.

Narrative

One day before the departure from Callao port, a reception was held on R/V METEOR. It was nicely arranged by the German Embassy in Lima, Peru. About 80 guests joined the reception from different departments of the Peruvian government, colleagues from Peruvian research institutions, and employees of the German Embassy including vice Ambassador Schmidt. We were particularly happy about the visit of vice Minister for Production Hector

Soldi and the President of the Peruvian marine research institution IMARPE Admiral Javier Gaviola. The reception was a great success and was complemented upon by our guests.

R/V Meteor left Callao port at noon local time on April 11th and headed south to complete a transect perpendicular to the coastline at 14°S (Fig. 1). Weather and sea conditions were excellent during the first 10 days when significant seas of 1-2 m and southeasterly trade winds between 3 Bft. and 5 Bft. were experienced. Measurements along the 14°S transect started in the early morning of April 12th and included conductivity-temperature-depth-oxygen (CTD/O2) profiles and water sampling using Niskin bottles that was analyzed for nutrients and various other biogeochemical parameters. A metal-free CTD/O_2 system having its own winch was used to collect water samples for trace metals concentration analysis in the water column. Usually, one trace metal CTD/O_2 (TM-CTD/O_2) profile was collected each day. Additionally, ship-board microstructure measurements, upper-ocean velocity measurements using R/V METEORs' Ocean Surveyors, sediment sampling with a Multicorer, particle sampling with a Snow Catcher and Thorium sampling using large volume in situ pumps were performed. In the evening of April 12th, a mooring with an acoustic Doppler current profiler attached was successfully deployed at 1000 m depth about 5 nm to the north of the transect. Subsequently, the 14°S transect was continued. R/V METEOR arrived at the 5000 m isobath in the morning of April 14th, where a drifting sediment trap was deployed.

For the next 3 days, a submesoscale process study (SMPS) was performed to the south of the transect investigating the physical-biogeochemical interaction at fronts and filaments. Satellite sea surface temperature data and real-time data from gliders deployed during the previous cruse in the 14°S region indicated that temperature and salinity fronts were located further offshore than we had anticipated during cruise planning. The sampling region for the SMPS was thus relocated to the region between 14.5°S, 77.8°W and 15.5°S, 76.6°W. Sampling included underway CTD profiles using the Rapid Cast system, shipboard velocity measurements and CTD/O_2 profiles including water sampling that was analyzed nutrients, dissolved organic matter, primary productivity, nutrient cycling processes via incubations and trace metals. In total, two CTD/O_2 transects and 4 underway CTD transects were competed. In the morning of April 17th, the drifting sediment trap deployed three days earlier was recovered about 10 nm to the south of the deployment position. The SMPS was terminated at 15:30 UTC on April 17th. After taking a last Multicorer at 800 m depth on the continental slope, the 14°S transect was completed.

While heading towards the main transect at 12°S, two gliders were recovered. The position of the first glider (IFM12) was reached in the late afternoon following the Multicorer station. The second glider (IFM09) had reported difficulties during ascent in the morning of April 17th. Since then, it had remained at the sea surface. R/V Meteor arrived at the glider's position at 23:00 local time and despite darkness, the recovery went very well. It turned out that water had leaked into the nose cone of the microstructure probe attached to the glider. The fast recovery of the package prevented further damage or loss of the instruments.

The main working area at 12°S was reached at 13:00 UTC on April 18th. The working schedule along the 12°S transect was predominately constrained by eight 40-hour long deployments of the Biogeochemical Observatory (BIGO) landers, four 3 to 6-day deployments of drifting sediment traps, four mooring deployments, glider operations, and sediment sampling using the multi corer that all needed to be conducted during day time. During night time, the measurement program focused on CTD/O_2 and TM-CTD/O_2 profiling including water sampling, additional water sampling using a bottom water sampling device, particle sampling using a Snow Catcher, intensive microstructure profiling and trace element sampling using large volume in situ pumps.

The coordinated benthic and pelagic sampling concentrated on different water depths along the transect. The stations were chosen based on oxygen and nutrient distributions and on expected benthic providences. On the shelf, benthic - pelagic sampling stations were

selected at 75 m, 128 m, 143 m, and 200 m water depth, while along the continental slope stations at 240 m, 300 m, 750 m and 1000 m were sampled. Sampling at these sites included BIGO lander deployments, CTD/O_2 profiling and water sampling that were analyzed for oxygen, nutrients, nutrient cycling rates, primary productivity and trace metal concentrations. Additionally, in situ pump deployments were carried out to determine export rates, a bottom water sampler was used at some of these stations to determine near-bottom nutrient gradients and particles were collected with the Snow Catcher. Microstructure profiling combined with CTD/O_2 and nutrient sampling was frequently repeated at these sites to allow for determining diapycnal nutrient fluxes. Sediment samples using the Multicorer were taken to investigate trace metal cycling in the sediments. Furthermore, moorings with attached acoustic Doppler current profiler and a McLane Moored Profiler were deployed and distributed along the continental slope to allow for determining the role of nutrient advection by the boundary currents. Finally, the pelagic measurement program was supported by autonomous glider measurements with additional turbulence and nitrate sensors that sampled a 12°S transect 5 nm to the north of the main transect to avoid collision with the research vessel. Altogether, 6 glider operations were performed in the region of 12°S. The coordinated benthic –pelagic sampling program started with the deployment of a BIGO lander at the 240 m in the late afternoon on April 18th and was terminated after taking sediment samples with a Multicorer in the morning of May 2nd. All deployments/recoveries and station measurements within the coordinated sampling were carried out successfully.

Drifting sediment trap deployments along the 12°S transect started in the afternoon of April 20th with a deployment in a water depth of 500 m. Two days later, a second trap was deployed at the outermost position of the transect at 5000 m water depth before the 500 m trap was successfully recovered in the morning of April 24th. The analyzed upper ocean velocity data from R/V METEOR's ocean surveyors and also the surface drift of the 500 m trap had indicated an unexpected but persistent onshore flow during the first week of sampling along the 12°S transect. The onshore flow originated from the presence of an anticyclonic subsurface mesoscale eddy having its center about 30 nm to the north of the 12°S transect. The eddy had just recently been formed, presumably by an instability process of the Peruvian Undercurrent. To investigate the characteristics of the eddy, a physical-biogeochemical station in the center of the eddy center was carried out in the afternoon of April 26th. This station included the deployment of the fourth sediment trap at about 2000 m water depth and in situ pump measurements. Eddy sampling was concluded after a zonal CTD/O_2 transect across the inshore flack of the eddy along a 12°20'S that included nutrient concentration measurements during the night of April 26th. The 5000 m trap was recovered after 7 days 30 nm to the north of deployment position in the evening of April 29th. The sediment trap released in the eddy center drifted to west and was recovered 40 nm away from its release position on April 30th.

The work program was completed at 21:30 UTC on May 2nd. The cruise was terminated as scheduled in Callao port at 14:00 UTC on May 3rd.

Acknowledgements

We are grateful to Capitan Schubert and his crew for the excellent collaboration. The crew of FS METEOR greatly contributed to the success of the cruise. The ship time of R/V METEOR was provided by the German Science Foundation (DFG) within the core program METEOR/MERIAN. Financial support was provided by the German Science Foundation (DFG) as part of the SFB754 "Climate Biogeochemistry Interactions in the Tropical Ocean".

M136 Participants

No.	Name	Function	Institution
1	Dengler, Marcus Dr.	Chief scientist, MSS, Moorings	GEOMAR
2	Sommer, Stefan, Dr.	BIGO Lander, Multicorer, N Geochemistry	GEOMAR
3	Achterberg, Eric, Prof. Dr.	Trace-Metal CTD, Fe dynamics, Thorium	GEOMAR
4	Lavik, Gaute, Dr.	Particles, Incubations, N_2-fix, anamox/denitri.	MPI-Bremen
5	Krahmann, Gerd, Dr.	Glider, CTD, Salinometer	GEOMAR
6	Dale, Andy, Dr.	Multicorer, Geochemistry	GEOMAR
7	Vosteen, Paul (Student)	CTD watch, Geochemistry	GEOMAR
8	Thomsen, Sören, Dr.	CTD watch, MSS, Glider, Rapid Cast	GEOMAR
9	Lüdke, Jan, (PhD Student)	CTD watch, MSS, ADCP	GEOMAR
10	Papenburg, Uwe (Technician)	Moorings, CTD, MSS	GEOMAR
11	Beck, Antje (Technician)	BIGO Lander, oxygen	GEOMAR
12	Türk, Matthias (Technician)	BIGO Lander, Electronics	GEOMAR
13	Petersen, Asmus (Technician)	BIGO Lander, Mechanics	GEOMAR
14	Clemens, David (PhD Student)	BIGO Lander, N Geochemistry	GEOMAR
15	Scholz, Florian, Dr.	Multicorer, Fe Geochemistry	GEOMAR
16	Plass, Anna (PhD Student)	Multicorer, Fe Geochemistry	GEOMAR
17	Surberg, Regina (Technician)	Geochemistry, nutrients	GEOMAR
18	Schüßler, Gabriele (Technician)	Geochemistry, ammonium	GEOMAR
19	Hopwood, Mark, Dr.	Trace Metal CTD, Fe dynamics	GEOMAR
20	Xie, Ruifang, Dr.	Thorium, in situ pumps	GEOMAR
21	Klüver, Tanja (Technician)	Dissolved organic matter, Lipids	GEOMAR
22	Massmig, Marie (PhD Student)	Dissolved organic matter, Lipids	GEOMAR
23	Le Moigne, Frederic Dr.	Sediment traps	GEOMAR
24	Cisternas-Novoa, Carolina Dr.	Sediment traps	GEOMAR
25	Roa, Jon (Technician)	Sediment traps	GEOMAR
26	Bristow, Laura, Dr.	Incubations, N_2-fix, anamox/denitri.	MPI-Bremen
27	Karthäuser, Clarissa (PhD Student)	Particles, incubations	MPI-Bremen
28	Spiegel, Timo (Student).	CTD watch, Fe Geochemistry	GEOMAR
29	Rentsch, Harald	Bordwetterwarte	DWD
30	Raeke, Andreas (Technician)	Bordwetterwarte	DWD

GEOMAR GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel, Düsternbrooker Weg 20, 24105 Kiel, Germany, http://www.geomar.de

DWD Deutscher Wetterdienst, Seeschifffahrtsberatung, Bernhard-Nocht-Straße 76, 20359 Hamburg, Germany, http://www.dwd.de

MPI Bremen Max-Planck Institute for Marine Microbiology, Celsiusstrasse 1, 28359 Bremen, Germany, http://www.mpi-bremen.de

M136 station list

Station No.		Date	Gear	Time	Latitude	Longitude	Water Depth	Remarks/Recovery
METEOR (M136-)	GEOMAR	2017		[UTC]	[°S]	[°W]	[m]	
335-1	RC 1	12.04.	Rapid Cast	00:33	12° 43.36'	076° 51.83'	134.3	
336-1	CTD 1	12.04.	CTD/RO	13:07	13° 51.90'	076° 28.10'	88.4	CTD Station (80 m, bottom)
337-1	MSS 1	12.04.	MSS	13:44	13° 51.92'	076° 28.10'	87.3	
338-1	MUC 1	12.04.	TV-MUC	15:20	13° 53.69'	076° 30.65'	165.6	Multicorer 160 m
339-1	CTD 2	12.04.	CTD/RO	16:01	13° 53.64'	076° 30.61'	166.0	CTD Station (160 m, bottom)
340-1	MSS 2	12.04.	MSS	17:15	13° 53.81'	076° 30.64'	163.7	
341-1	CTD 3	12.04.	CTD/RO	18:23	13° 53.70'	076° 30.62'	164.2	CTD Station (160 m, bottom)
342-1	MUC 2	12.04.	TV-MUC	20:15	13° 57.36'	076° 35.63'	307.4	Multicorer 300 m
343-1	KPO1183	12.04.	Mooring	23:37	13° 58.414’	076° 47.942’	990.0	Mooring deployment
343-2	RC 2	13.04.	Rapid Cast	00:00	13° 58.43'	076° 47.52'	956.8	
344-1	CTD 4	13.04.	CTD/RO	01:21	13° 57.39'	076° 35.64'	305.5	CTD Station (300 m, bottom)
345-1	MSS 3	13.04.	MSS	02:14	13° 57.40'	076° 35.61'	306.4	
346-1	CTD 5	13.04.	CTD	04:15	13° 59.37'	076° 39.00'	505.6	CTD Station (500 m, bottom)
347-1	MSS 4	13.04.	MSS	05:09	13° 59.38'	076° 39.00'	505.1	
348-1	CTD 6	13.04.	CTD/RO	06:45	14° 02.36'	076° 43.24'	1051.0	CTD Station (1050 m,
349-1	MSS 5	13.04.	MSS	07:56	14° 02.38'	076° 43.25'	1056.3	
350-1	CTD 7	13.04.	CTD/RO	08:56	14° 03.41'	076° 43.58'	1173.2	CTD Station (200 m)
351-1	CTD 8	13.04.	CTD/RO	10:09	14° 05.15'	076° 47.47'	1903.5	CTD Station (1950 m,
352-1	MSS 6	13.04.	MSS	11:56	14° 05.99'	076° 47.97'	1990.5	
353-1	CTD 9	13.04.	CTD/RO	13:37	14° 08.02'	076° 51.67'	2073.9	CTD Station (2000 m)
354-1	CTD-TM 49	13.04.	CTD-TM	15:19	14° 08.02'	076° 51.67'	2312.7	
355-1	MSS 7	13.04.	MSS	17:10	14° 08.49'	076° 51.10'	2355.6	
356-1	ISP 1	13.04.	In-Situ pumps	18:14	14° 08.06'	076° 51.77'	2315.0	Pumps at 30 m, 100 m, 400 m depth
357-1	MSS 8	13.04.	MSS	21:23	14° 09.79'	076° 56.32'	2984.8	
358-1	CTD 10	13.04.	CTD/RO	22:25	14° 10.90'	076° 55.86'	3019.9	CTD Station (2000 m)
359-1	MSS 9	14.04.	MSS	00:37	14° 14.13'	077° 01.99'	3824.3	
360-1	CTD 11	14.04.	CTD	02:10	14° 15.56'	077° 02.29'	3903.1	CTD Station (2000 m)
361-1	MSS 10	14.04.	MSS	05:06	14° 18.11'	077° 08.29'	4802.0	
362-1	CTD 12	14.04.	CTD/RO	06:06	14° 19.57'	077° 08.56'	4799.2	CTD Station (2000 m)
363-1	RC 3	14.04.	Rapid Cast	07:28	14° 19.58'	077° 08.56'	4795.3	
364-1	MSS 11	14.04.	MSS	08:17	14° 22.17'	077° 14.77'	5148.2	
365-1	SC 1	14.04.	Snow Catcher	11:02	14° 23.83'	077° 14.85'	5103.5	Snow catcher closed at 100 m depth
366-1	CTD-TM 50	14.04.	CTD-TM	11:53	14° 23.83'	077° 14.86'	4994.4	
367-1	Trap 1	14.04.	Sediment trap	16:07	14° 23.85'	077° 14.83'	5127.7	Deployment of drifting sediment trap
368-1	CTD 13	14.04.	CTD/RO	17:00	14° 23.93'	077° 14.33'	5150.9	CTD Station (2000 m)
369-1	RC 4	14.04.	Rapid Cast	18:23	14° 23.94'	077° 14.35'	5147.3	
370-1	CTD 14	14.04.	CTD/RO	19:17	14° 28.13'	077° 21.31'	4685.2	CTD Station (2000 m)
371-1	SC 2	14.04.	Snow Catcher	22:52	14° 33.90'	077° 29.76'	4422.7	Snow catcher closed at 130 m depth
372-1	CTD 15	14.04.	CTD/RO	23:23	14° 33.90'	077° 29.77'	4426.2	CTD Station (2000 m)
373-1	MSS 12	15.04.	MSS	00:54	14° 33.97'	077° 29.73'	4424.7	
374-1	CTD 16	15.04.	CTD/RO	02:16	14° 33.90'	077° 29.79'	4421.6	CTD Station (400 m)
375-1	CTD 17	15.04.	CTD/RO	04:43	14° 42.47'	077° 42.43'	4196.4	CTD Station (2000 m)
376-1	RC 5	15.04.	Rapid Cast	06:10	14° 42.61'	077° 42.40'	4192.2	
377-1	CTD-TM 51	15.04.	CTD-TM	13:27	15° 36.42'	077° 03.46'	2881.0	
378-1	CTD 18	15.04.	CTD/RO	15:12	15° 30.72'	077° 06.14'	2926.2	CTD Station (200 m)
379-1	CTD 19	15.04.	CTD/RO	16:18	15° 26.15'	077° 08.04'	2972.8	CTD Station (200 m)

380-1	CTD 20	15.04.	CTD/RO	17:23	15° 21.64'	077° 10.00'	3062.1	CTD Station (600 m)
381-1	CTD 21	15.04.	CTD/RO	18:46	15° 17.05'	077° 11.83'	3228.2	CTD Station (200 m)
382-1	CTD 22	15.04.	CTD/RO	19:45	15° 12.63'	077° 13.71'	3402.4	CTD Station (200 m)
383-1	CTD 23	15.04.	CTD/RO	20:48	15° 07.95'	077° 15.64'	3447.4	CTD Station (200 m)
384-1	CTD 24	15.04.	CTD/RO	21:50	15° 03.53'	077° 17.50'	3778.7	CTD Station (200 m)
385-1	CTD 25	15.04.	CTD/RO	22:55	14° 59.05'	077° 19.29'	3830.8	CTD Station (200 m)
386-1	CTD 26	15.04.	CTD/RO	23:59	14° 54.56'	077° 21.15'	3835.2	CTD Station (200 m)
387-1	CTD 27	16.04.	CTD/RO	00:58	14° 50.22'	077° 23.01'	4085.1	CTD Station (200 m)
388-1	CTD 28	16.04.	CTD/RO	02:01	14° 45.47'	077° 24.94'	4186.7	CTD Station (200 m)
389-1	CTD 29	16.04.	CTD/RO	03:04	14° 40.89'	077° 26.87'	4306.9	CTD Station (200 m)
390-1	CTD 30	16.04.	CTD/RO	04:18	14° 33.87'	077° 29.73'	4424.2	CTD Station (200 m)
391-1	RC 6	16.04.	Rapid Cast	04:58	14° 34.20'	077° 29.54'	4418.8	
392-1	CTD 31	16.04.	CTD/RO	12:09	15° 26.80'	076° 51.64'	2973.8	CTD Station (400 m)
393-1	CTD 32	16.04.	CTD/RO	13:35	15° 21.00'	076° 55.82'	3199.7	CTD Station (400 m)
394-1	CTD-TM 52	16.04.	CTD-TM	14:30	15° 21.00'	076° 55.81'	3201.5	
395-1	CTD 33	16.04.	CTD/RO	15:23	15° 21.05'	076° 55.85'	3199.5	CTD Station (400 m)
396-1	CTD 34	16.04.	CTD/RO	17:46	15° 06.50'	077° 04.29'	3532.6	CTD Station (1000 m)
397-1	CTD 35	16.04.	CTD/RO	19:34	15° 00.01'	077° 07.50'	3763.5	CTD Station (400 m)
398-1	CTD 36	16.04.	CTD/RO	21:35	14° 47.65'	077° 11.87'	4210.3	CTD Station (400 m)
399-1	CTD 37	16.04.	CTD/RO	23:09	14° 37.96'	077° 13.52'	4495.5	CTD Station (400 m)
400-1	CTD 38	17.04.	CTD/RO	01:12	14° 23.80'	077° 14.91'	5128.3	CTD Station (400 m)
401-1	ISP 2	17.04.	In-Situ pumps	03:37	14° 34.55'	077° 16.24'	4454.5	Pumps at 30 m, 100 m, 200 m, 400 m, 590 m depth
402-1	CTD 39	17.04.	CTD/RO	06:29	14° 34.55'	077° 16.24'	4456.7	CTD Station (600 m)
403-1	CTD-TM 53	17.04.	CTD-TM	07:20	14° 34.55'	077° 16.24'	4592.8	
404-1	CTD 40	17.04.	CTD/RO	08:00	14° 34.58'	077° 16.30'	4571.6	CTD Station (400 m)
405-1	SC 3	17.04.	Snow Catcher	10:11	14° 34.70'	077° 16.30'	4569.2	Snow catcher closed at 140 m depth
406-1	Trap 1	17.04.	Sediment trap	13:00	14° 37.99'	077° 16.03'	4506.6	Recovery drifiting sediment trap
407-1	RC 7	17.04.	Rapid Cast	18:16	14° 19.18'	076° 58.54'	4001.9	
408-1	MUC 3	17.04.	TV-MUC	21:05	14° 02.01'	076° 42.30'	864.5	Multicorer 800 m, failed
409-1	MUC 4	17.04.	TV-MUC	21:52	14° 02.02'	076° 42.30'	864.3	Multicorer 800 m
410-1	GLI 1	17.04.	GLIDER	23:17	13° 58.19'	076° 38.99'	480.5	Recovery Glider IFM12
411-1	GLI2	18.04.	GLIDER	05:53	13° 40.01'	077° 40.56'	4457.2	Recovery Glider IFM09
412-1	MUC 5	18.04.	TV-MUC	13:48	12° 23.30'	077° 24.18'	242.0	Multicorer 240 m
413-1	CTD-TM 54	18.04.	CTD-TM	14:20	12° 23.30'	077° 24.18'	242.4	
414-1	KPO1181	18.04.	Mooring	17:00	12° 21.91'	077° 21.82'	199.2	Mooring deployment failed due to lost anchor weight
415-1	BIGO	18.04.	BIGO	20:27	12° 23.31'	077° 24.17'	242.8	BIGO deployment
416-1	KPO1181	18.04.	Mooring	21:30	12° 22.38'	077° 20.90'	197.1	Recovery after failed deployment
	CTD 41	19.04.	CTD/RO	03:05	12° 24.90'	077° 26.26'	301.3	CTD Station (300 m, bottom)
418-1	MSS 13	19.04.	MSS	03:53	12° 24.97'	077° 26.26'	303.2	
419-1	MSS 14	19.04.	MSS	05:39	12° 22.54'	077° 25.17'	245.1	
420-1	CTD 42	19.04.	CTD/RO	06:23	12° 23.32'	077° 25.05'	255.4	CTD Station (250 m, bottom)
421-1	MSS 15	19.04.	MSS	07:05	12° 22.55'	077° 24.21'	228.0	
422-1	CTD 43	19.04.	CTD/RO	07:52	12° 23.31'	077° 24.18'	242.1	CTD Station (240 m, bottom)
423-1	CTD 44	19.04.	CTD/RO	09:12	12° 23.31'	077° 24.18'	241.5	CTD Station (240 m, bottom)
424-1	SC 4	19.04.	Snow Catcher	11:08	12° 23.30'	077° 23.98'	239.0	Snow catcher closed at 120 m depth
425-1	KPO1181	19.04.	Mooring	12:38	12° 22.288’	077° 21.779’	203.0	Mooring deployment
426-1	MUC 6	19.04.	TV-MUC	13:59	12° 16.68'	077° 14.95'	127.4	Multicorer 126 m
427-1	CTD-TM 55	19.04.	CTD-TM	16:29	12° 23.31'	077° 24.09'	242.2	
428-1	CTD 45	19.04.	CTD/RO	16:45	12° 23.31'	077° 24.09'	240.7	CTD Station (240 m, bottom)

429-1	ISP 3	19.04.	In-Situ pumps	17:50	12° 23.31'	077° 24.09'	240.7	Pumps at 30 m, 80 m, 100 m, 200 m depth
430-1	BIGO	19.04.	BIGO	20:59	12° 24.89'	077° 26.29'	302.8	BIGO deployment
431-1	Trap 2	20.04.	Sediment trap	00:20	12° 17.99'	077° 37.31'	471.6	Deployment drifting sediment trap
432-1	CTD 46	20.04.	CTD/RO	00:57	12° 18.24'	077° 36.96'	473.3	CTD Station (470 m, bottom)
433-1	RC 8	20.04.	Rapid Cast	01:57	12° 18.18'	077° 35.70'	503.6	
434-1	MSS 16	20.04.	MSS	04:02	12° 15.81'	077° 15.14'	128.9	
435-1	CTD 47	20.04.	CTD/RO	05:03	12° 16.71'	077° 14.95'	130.0	CTD Station (125m, bottom)
436-1	MSS 17	20.04.	MSS	06:25	12° 20.55'	077° 21.74'	186.4	
437-1	CTD 48	20.04.	CTD/RO	07:36	12° 21.41'	077° 21.85'	195.5	CTD Station (190 m, bottom)
438-1	MSS 18	20.04.	MSS	08:24	12° 22.55'	077° 23.54'	223.9	
439-1	CTD 49	20.04.	CTD/RO	10:04	12° 23.28'	077° 24.13'	243.2	CTD Station (240 m, bottom)
440-1	BIGO	20.04.	BIGO	13:26	12° 23.13'	077° 24.20'	241.8	BIGO recovery
441-1	BWS 1	20.04.	BWS	15:15	12° 23.31'	077° 24.18'	242.8	
442-1	GLI 3	20.04.	GLIDER	17:40	12° 31.38'	077° 34.98'	750.4	Deployment Glider IFM12
443-1	CTD-TM 56	20.04.	CTD-TM	18:30	12° 31.37'	077° 34.98'	749.7	
444-1	MUC 7	20.04.	TV-MUC	19:46	12° 31.37'	077° 35.00'	751.9	Multicorer 750 m
445-1	CTD 50	20.04.	CTD/RO	20:24	12° 31.37'	077° 35.00'	751.9	CTD Station (750 m, bottom)
446-1	CTD 51	20.04.	CTD/RO	22:06	12° 31.37'	077° 35.00'	750.0	CTD Station (200 m)
447-1	MSS 19	20.04.	MSS	23:20	12° 26.50'	077° 30.76'	417.4	
447-1	MSS 20	21.04.	MSS	00:24	12° 27.58'	077° 31.00'	478.1	
448-1	CTD 52	21.04.	CTD/RO	02:26	12° 27.57'	077° 31.02'	444.0	CTD Station (440 m, bottom)
449-1	MSS 21	21.04.	MSS	03:35	12° 25.32'	077° 29.53'	358.5	
450-1	CTD 53	21.04.	CTD/RO	05:06	12° 27.17'	077° 29.55'	405.7	CTD Station (400 m)
451-1	MSS 22	21.04.	MSS	06:23	12° 22.97'	077° 25.56'	258.5	
452-1	CTD 54	21.04.	CTD/RO	08:39	12° 24.90'	077° 26.28'	302.5	CTD Station (300 m, bottom)
453-1	SC 5	21.04.	Snow catcher	09:36	12° 24.90'	077° 26.28'	302.0	Snow catcher closed at 130 m depth
454-1	KPO1180	21.04.	Mooring	14:20	12° 25.652’	077° 25.658’	301.0	Mooring deployment
455-1	BIGO	21.04.	BIGO	15:23	12° 24.77'	077° 26.44'	304.2	BIGO recovery
456-1	CTD 55	21.04.	CTD/RO	15:52	12° 24.82'	077° 26.55'	306.2	CTD Station (300 m, bottom),
457-1	CTD-TM 57	21.04.	CTD-TM	17:41	12° 27.18'	077° 29.50'	438.3	
458-1	CTD 56	21.04.	CTD/RO	18:27	12° 27.14'	077° 29.63'	406.7	CTD Station (350 m, bottom)
459-1	ISP 4	21.04.	In-Situ pumps	19:11	12° 27.14'	077° 29.63'	407.6	Pumps in 30 m, 80 m, 150 m, 300 m depth
460-1	BIGO	21.04.	BIGO	22:55	12° 31.35'	077° 34.99'	748.2	BIGO deployment
461-1	CTD 57	21.04.	CTD/RO	23:31	12° 31.35'	077° 34.99'	746.8	CTD Station (740 m, bottom)
462-1	MSS 23	22.04.	MSS	01:03	12° 31.39'	077° 35.04'	753.9	
463-1	CTD 58	22.04.	CTD/RO	04:06	12° 43.32'	077° 51.01'	2092.8	CTD Station (2000 m)
464-1	MSS 24	22.04.	MSS	06:14	12° 43.36'	077° 51.01'	2150.7	
465-1	CTD-TM 58	22.04.	CTD-TM	10:30	12° 59.12'	078° 13.81'	5259.2	
466-1	Trap 3	22.04.	Sediment trap	15:12	12° 58.94'	078° 14.45'	5296.3	Deployment drifting sediment trap
467-1	CTD 59	22.04.	CTD/RO	15:40	12° 59.25'	078° 14.82'	5401.0	CTD Station (800 m)
468-1	CTD 60	22.04.	CTD/RO	17:27	12° 56.40'	078° 17.36'	5821.9	CTD Station (5820 m,
469-1	BIGO	23.04.	BIGO	14:35	12° 31.14'	077° 35.23'	753.9	BIGO recovery
470-1	GLI 4	23.04.	GLIDER	19:00	12° 21.51'	077° 21.71'	194.2	Deployment Glider IFM07
471-1	BIGO	23.04.	BIGO	21:01	12° 21.51'	077° 21.71'	194.4	BIGO deployment
472-1	CTD 61	23.04.	CTD/RO	23:10	12° 13.02'	077° 36.59'	463.9	CTD Station (455m, bottom)
473-1	Trap 2	24.04.	Sediment trap	00:10	12° 12.92'	077° 36.70'	401.8	Recovery drifting sediment trap
474-1	CTD-TM 59	24.04.	CTD-TM	01:44	12° 12.90'	077° 36.74'	404.3	
475-1	CTD 62	24.04.	CTD/RO	02:39	12° 12.96'	077° 36.92'	482.8	CTD Station (460 m)

476-1	ISP 5	24.04.	In-Situ pumps	03:36	12° 12.96'	077° 36.92'	481.9	Pumps at 40 m, 100 m, 200 m, 290 m depth
477-1	SC 6	24.04.	Snow catcher	05:52	12° 12.96'	077° 36.92'	480.8	Snow catcher from 70 m depth
478-1	RC 9	24.04.	Rapid Cast	06:11	12° 13.09'	077° 37.03'	507.5	
479-1	MSS 25	24.04.	MSS	08:57	12° 12.84'	077° 10.25'	67.7	
480-1	CTD 63	24.04.	CTD/RO	10:00	12° 13.54'	077° 10.79'	75.5	CTD Station (70 m, bottom)
481-1	MSS 26	24.04.	MSS	11:02	12° 13.82'	077° 12.14'	88.8	
482-1	CTD 64	24.04.	CTD/RO	11:57	12° 15.14'	077° 12.88'	103.9	CTD Station (100 m, bottom)
483-1	MUC 8	24.04.	TV-MUC	12:55	12° 13.52'	077° 10.79'	75.5	Multicorer 74 m
484-1	SML	24.04.	SML	14:30	12° 13.520'	077° 10.790'	75.0	Deployment satellite mini
485-1	POZ	24.04.	POZ	16:35	12° 16.690'	077°14.992'	127.0	Deployment POZ lander
486-1	CTD 65	24.04.	CTD/RO	16:55	12° 16.77'	077° 15.04'	128.3	CTD Station (125 m, bottom)
487-1	CTD-TM 60	24.04.	CTD-TM	19:24	12° 16.77'	077° 15.04'	128.2	
488-1	BIGO	24.04.	BIGO	21:05	12° 16.79'	077° 15.01'	128.1	BIGO deployment
489-1	MSS 27	24.04.	MSS	21:24	12° 16.83'	077° 15.02'	127.9	
490-1	MSS 28	24.04.	MSS	23:22	12° 20.59'	077° 21.35'	181.4	
491-1	CTD 66	25.04.	CTD/RO	00:31	12° 21.52'	077° 21.73'	193.7	CTD Station (190 m, bottom)
492-1	CTD 67	25.04.	CTD/RO	03:04	12° 23.42'	077° 38.09'	575.5	CTD Station (200 m)
493-1	RC 10	25.04.	Rapid Cast	03:33	12° 23.52'	077° 39.05'	636.0	
494-1	CTD 68	25.04.	CTD/RO	07:00	12° 19.39'	078° 10.28'	2539.4	CTD Station (400 m)
495-1	CTD 69	25.04.	CTD/RO	08:11	12° 19.77'	078° 05.25'	2066.5	CTD Station (700 m)
496-1	RC 11	25.04.	Rapid Cast	08:47	12° 19.97'	078° 05.56'	2060.0	
497-1	BIGO	25.04.	BIGO	13:42	12° 21.43'	077° 21.72'	194.1	BIGO recovery
498-1	BWS	25.04.	BWS	15:08	12° 16.69'	077° 14.99'	129.0	Deployment failed
499-1	CTD-TM 61	25.04.	CTD-TM	15:42	12° 16.69'	077° 14.99'	127.1	
500-1	BWS	25.04.	BWS	16:35	12° 16.69'	077° 15.02'	127.1	Deployment failed
501-1	BWS	25.04.	BWS	17:28	12° 16.68'	077° 15.02'	127.8	Deployment failed
502-1	GLI 5	25.04.	GLIDER	19:26	12° 22.53'	077° 22.63'	212.1	Deployment Glider IFM09
503-1	BIGO	25.04.	BIGO	22:11	12° 18.70'	077° 17.79'	143.7	BIGO deployment
504-1	BWS 2	25.04.	BWS	22:56	12° 18.65'	077° 17.78'	143.2	
505-1	CTD 70	25.04.	CTD/RO	23:26	12° 18.65'	077° 17.78'	143.1	CTD Station (140 m, bottom)
506-1	MSS 29	26.04.	MSS	00:23	12° 18.67'	077° 17.79'	143.2	
507-1	MSS 30	26.04.	MSS	03:35	12° 26.05'	077° 29.09'	374.1	
508-1	CTD 71	26.04.	CTD/RO	04:39	12° 27.19'	077° 29.51'	404.9	CTD Station (400 m, bottom)
509-1	MSS 31	26.04.	MSS	05:56	12° 23.88'	077° 26.04'	280.3	
510-1	CTD 72	26.04.	CTD/RO	06:57	12° 24.23'	077° 26.43'	296.0	CTD Station (295 m, bottom)
511-1	MSS 32	26.04.	MSS	08:16	12° 22.96'	077° 23.86'	231.6	
512-1	CTD 73	26.04.	CTD/RO	09:18	12° 23.32'	077° 24.25'	243.4	CTD Station (240 m, bottom)
513-1	BIGO	26.04.	BIGO	13:21	12° 16.78'	077° 15.01'	125.3	BIGO recovery
514-1	RC 12	26.04.	Rapid Cast	14:41	12° 16.33'	077° 24.30'	219.9	
515-1	Trap 4	26.04.	Sediment trap	20:49	12° 19.96'	078° 03.18'	1971.1	Deployment drifting sediment trap
516-1	CTD 74	26.04.	CTD/RO	21:10	12° 20.29'	078° 03.07'	1969.8	CTD Station (730 m)
517-1	CTD-TM 62	26.04.	CTD-TM	22:06	12° 20.29'	078° 03.07'	1971.0	
518-1	MSS 33	27.04.	MSS	00:08	12° 20.38'	078° 03.32'	1988.5	
519-1	ISP 6	27.04.	In-Situ pumps	01:21	12° 21.16'	078° 03.39'	2020.6	Pumps at 30 m, 100 m, 200 m, 590 m depth
520-1	CTD 75	27.04.	CTD/RO	04:42	12° 19.98'	077° 58.01'	1716.9	CTD Station (700 m)
521-1	CTD 76	27.04.	CTD/RO	06:05	12° 19.97'	077° 52.00'	1577.1	CTD Station (700 m)
522-1	CTD 77	27.04.	CTD/RO	07:24	12° 20.01'	077° 45.99'	1389.4	CTD Station (700 m)
523-1	CTD 78	27.04.	CTD/RO	08:44	12° 19.99'	077° 39.97'	1054.1	CTD Station (700 m)
524-1	CTD 79	27.04.	CTD/RO	10:03	12° 19.99'	077° 34.00'	381.8	CTD Station (380 m, bottom)
525-1	CTD 80	27.04.	CTD/RO	11:40	12° 23.33'	077° 24.17'	243.6	CTD Station (240 m, bottom)
526-1	BIGO	27.04.	BIGO	13:25	12° 18.59'	077° 17.74'	144.0	BIGO recovery

527-1	SC 7	27.04.	Snow catcher	14:45	12° 23.30'	077° 24.17'	241.8	Snow catcher from 140 m depth
528-1	MSS 34	27.04.	MSS	15:16	12° 23.35'	077° 24.18'	242.7	
529-1	MSS 35	27.04.	MSS	17:54	12° 14.08'	077° 12.68'	94.1	
530-1	CTD 81	27.04.	CTD/RO	18:54	12° 14.67'	077° 12.80'	100.3	CTD Station (90 m, bottom)
531-1	MSS 36	27.04.	MSS	19:42	12° 12.98'	077° 10.67'	69.9	
532-1	CTD 82	27.04.	CTD/RO	20:40	12° 13.50'	077° 10.78'	74.1	CTD Station (70 m, bottom)
533-1	BIGO	27.04.	BIGO	21:17	12° 13.50'	077° 10.78'	73.6	BIGO deployment
534-1	CTD 83	27.04.	CTD/RO	21:55	12° 11.66'	077° 08.37'	41.3	CTD Station (40 m, bottom)
535-1	CTD-TM 63	27.04.	CTD-TM	22:14	12° 11.66'	077° 08.37'	42.0	
536-1	RC 13	27.04.	Rapid Cast	22:35	12° 11.75'	077° 08.44'	44.4	
537-1	MSS 37	27.04.	MSS	23:28	12° 13.19'	077° 11.56'	76.7	
538-1	CTD 84	28.04.	CTD/RO	00:54	12° 14.32'	077° 11.86'	90.6	CTD Station (85 m, bottom)
539-1	MSS 38	28.04.	MSS	02:31	12° 20.26'	077° 21.76'	183.2	
540-1	CTD 85	28.04.	CTD/RO	03:56	12° 21.48'	077° 21.71'	191.9	CTD Station (190 m, bottom)
541-1	MSS 39	28.04.	MSS	05:28	12° 25.19'	077° 29.59'	358.0	
542-1	CTD 86	28.04.	CTD/RO	07:51	12° 25.51'	077° 29.59'	366.9	CTD Station (360 m, bottom)
543-1	MUC 9	28.04.	TV-MUC	13:11	12° 31.35'	077° 35.01'	750.5	Multicorer 750 m
544-1	KPO1182	28.04.	Mooring	17:14	12° 34.732’	077° 39.618’	999.0	Mooring deployment
545-1	BIGO	28.04.	BIGO	18:27	12° 34.88'	077° 40.39'	974.9	BIGO deployment
546-1	RC 14	28.04.	Rapid Cast	18:54	12° 34.95'	077° 40.38'	979.3	
547-1	CTD 87	28.04.	CTD/RO	23:17	12° 32.80'	078° 27.60'	4332.3	CTD Station (600 m)
548-1	Trap 3	29.04.	Sediment trap	00:00	12° 32.78'	078° 27.86'	4357.3	Recovery drifting sediment trap
549-1	CTD 88	29.04.	CTD/RO	01:52	12° 32.84'	078° 28.03'	4358.3	CTD Station (400 m)
550-1	SC 8	29.04.	Snow catcher	02:54	12° 32.84'	078° 28.03	4357.5	Snow catcher closed at 130 m depth
551-1	ISP 7	29.04.	In-Situ pumps	03:25	12° 32.84'	078° 28.03'	4354.8	Pumps at 50 m, 100 m, 200 m, 590 m depth
552-1	RC 15	29.04.	Rapid Cast	05:42	12° 32.85'	078° 27.83'	4374.2	
553-1	BIGO	29.04.	BIGO	14:03	12° 13.59'	077° 10.75'	76.0	BIGO Recovery
554-1	CTD 89	29.04.	CTD/RO	14:53	12° 15.09'	077° 12.89'	105.9	CTD Station (100 m, bottom)
555-1	CTD 90	29.04.	CTD/RO	16:35	12° 21.49'	077° 2.71'	194.7	CTD Station (190 m, bottom)
556-1	CTD-TM 64	29.04.	CTD-TM	17:26	12° 21.47'	077° 21.79'	194.9	
557-1	BWS 3	29.04.	BWS	18:22	12° 21.42'	077° 21.91'	194.4	
558-1	GLI 6	29.04.	GLIDER	21:29	12° 34.79'	077° 40.41'	967.0	Deployment Glider IFM03
559-1	CTD 91	29.04.	CTD/RO	22:11	12° 34.84'	077° 40.39'	973.8	CTD Station (970 m, bottom)
560-1	MSS 40	29.04.	MSS	23:56	12° 34.87'	077° 40.40'	973.3	
561-1	CTD-TM 65	30.04.	CTD-TM	11:18	12° 35.03'	077° 40.46'	985.9	
562-1	BIGO	30.04.	BIGO	13:42	12° 34.58'	077° 40.57'	956.3	BIGO recovery
563-1	Trap 4	30.04.	Sediment trap	19:17	12° 16.27'	078° 35.06'	3456.6	Recovery drifting sediment trap
564-1	RC 16	30.04.	Rapid Cast	21:08	12° 16.10'	078° 35.76'	3396.7	
565-1	GLI 7	30.04.	GLIDER	23:28	12° 13.56'	078° 18.75'	2745.6	Recovery Glider IFM12
566-1	RC 17	01.05.	Rapid Cast	00:03	12° 13.56'	078° 19.33'	2775.1	
567-1	CTD 92	01.05.	CTD/RO	01:12	12° 17.13'	078° 30.02'	3188.7	CTD Station (2000 m)
568-1	SC 9	01.05.	Snow catcher	02:52	12° 17.12'	078° 29.95'	3178.9	Snow catcher closed at 230 m depth
569-1	CTD 93	01.05.	CTD/RO	03:40	12° 17.12'	078° 29.95'	3176.4	CTD Station (400 m)
570-1	ISP 8	01.05.	In-Situ pumps	04:22	12° 17.13'	078° 29.96'	3180.3	Pumps at 50 m, 100 m, 300 m, 490 m depth
571-1	RC 18	01.05.	Rapid Cast	06:32	12° 16.95'	078° 30.49'	3200.2	
572-1	CTD-TM 66	01.05.	CTD-TM	09:40	12° 18.94'	078° 04.45'	1992.4	
573-1	RC 19	01.05.	Rapid Cast	11:22	12° 18.88'	078° 05.06'	2013.8	
574-1	MUC 10	01.05.	TV-MUC	15:39	12° 24.90'	077° 26.29'	302.4	Multicorer 300 m

575-1	MSS 41	01.05.	MSS	17:24	12° 19.17'	077° 20.44'	165.7	
576-1	CTD 94	01.05.	CTD/RO	18:19	12° 20.12'	077° 20.73'	174.1	CTD Station (170 m, bottom)
577-1	MUC 11	01.05.	TV-MUC	20:09	12° 15.16'	077° 12.88'	105.5	Multicorer 100 m
578-1	GLI 8	01.05.	GLIDER	22:15	12° 23.32'	077° 24.21'	241.7	Deployment Glider IFM13
579-1	CTD 95	01.05.	CTD/RO	22:58	12° 23.49'	077° 24.30'	246.1	CTD Station (240 m, bottom)
580-1	MSS 42	02.05.	MSS	00:33	12° 28.90'	077° 32.61'	506.8	
581-1	CTD 96	02.05.	CTD/RO	01:44	12° 29.91'	077° 32.92'	549.9	CTD Station (550 m, bottom)
582-1	MSS 43	02.05.	MSS	02:59	12° 32.16'	077° 37.47'	912.1	
583-1	CTD 97	02.05.	CTD/RO	04:10	12° 33.14'	077° 37.68'	947.1	CTD Station (940 m, bottom)
584-1	MSS 44	02.05.	MSS	06:14	12° 36.83'	077° 43.66'	1100.2	
585-1	CTD 98	02.05.	CTD/RO	07:12	12° 36.97'	077° 43.82'	1112.2	CTD Station (1110 m,
586-1	MSS 45	02.05.	MSS	08:52	12° 40.49'	077° 48.66'	1615.9	
587-1	CTD 99	02.05.	CTD/RO	10:07	12° 41.14'	077° 48.76'	1692.7	CTD Station (1700 m,
588-1	MUC 12	02.05.	TV-MUC	13:02	12° 34.90'	077° 40.34'	979.3	Multicorer 1000 m
589-1	CTD-TM 67	02.05.	CTD-TM	15:24	12° 27.20'	077° 29.55'	406.5	
590-1	OFOS 1	02.05.	OFOS	16:59	12° 26.10'	077° 27.93'	350.7	
591-1	OFOS 2	02.05.	OFOS	18:29	12° 24.90'	077° 26.37'	305.0	
592-1	OFOS 3	02.05.	OFOS	19:55	12° 23.29'	077° 24.18'	241.1	
593-1	OFOS 4	02.05.	OFOS	21:16	12° 21.48'	077° 21.70'	194.7	

List of Abbreviations

BIGO	Biogeochemical observatory lander with 2 benthic chambers
BWS	Bottom water sampler with 6 Niskin bottles within 2 m
CTD/RO	Conductivity-temperature-depth profile with water sampling using 24 Niskin bottles attached to a rosette frame
CTD-TM	Conductivity-temperature-depth profile using a metal-free system for water sampling for trace metal concentration analysis
ISP	Large-volume in situ pumps
MSS	Shipboard microstructure profiling system measuring turbulence
OFOS	Video-guided ocean floor observing system
RC	Rapid cast system for underway CTD measurements
SC	Snow Catcher, large (100 liter) water sampler
Trap	Drifting sediment trap
TV-MUC	Video-guided Multicorer