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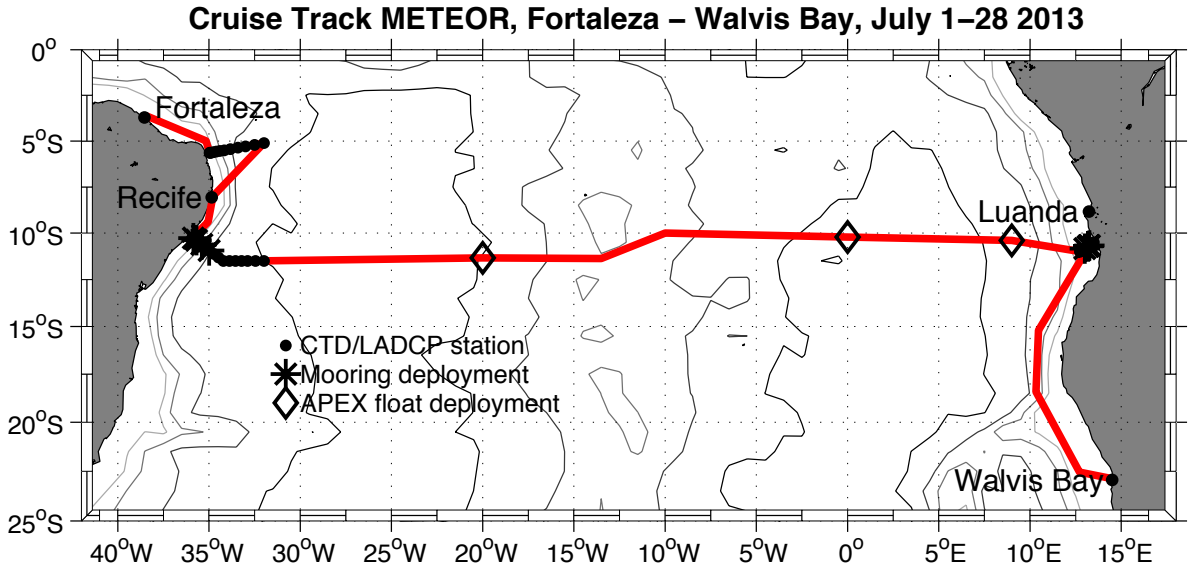
Short Cruise Report
R/V METEOR M98 Fortaleza – Walvis Bay
1st July – 28th July 2013
Chief Scientist: Prof. Dr. Peter Brandt
Captain: Michael Schneider



Ship track of R/V METEOR cruise M98 with locations of CTD/LADCP stations, mooring deployments, and APEX float deployments.

Objectives

Cruise M98 to the southern tropical Atlantic joins important field work of the BMBF projects RACE and SACUS. Both projects have the overarching goal to gain a better understanding of the role of the tropical Atlantic in relation to climate variability and change in the Atlantic region. According to the special issues within the subprojects, this cruise has two major regional focuses: Within the framework of RACE the aim of this cruise is to investigate the variability of the western boundary current system offshore of South America. A special focus will be placed on the transport variability of the North Brazil Undercurrent (NBUC) – as part of the Atlantic meridional overturning circulation (AMOC) – on timescales from intraseasonal to decadal. The project SACUS is concerned with the influence of the equatorial Atlantic on the coastal upwelling region off Southwest Africa. This cruise aims at investigating these teleconnections from the equatorial region towards the upwelling system and their attributed time scales via wave propagation and water mass advection. A significant portion of this cruise consists of the deployment of two mooring arrays at about 11°S at the shelf and continental slope off the Brazilian coast and off the Angolan coast. Additionally, the boundary current systems will be surveyed with high-resolution, hydrographic sections (CTD/LADCP, microstructure) at 5°S and 11°S off Brazil and at 11°S off Angola. The research program of M98 is complimented by continuous measurements of near-surface concentrations of CO_2, N_2O, DMS, and acetone, air-sea gas exchange measurements via turbulent gas fluctuation measurements in the atmosphere, sea surface temperature and salinity as well as measurements of upper ocean temperature and salinity with the underway CTD (UCTD) system. The measurements for gas exchange are part of the Helmholtz Junior Research Group of Christa Marandino.

Narrative

Several events aimed at enhancing the scientific cooperation between different research groups from Brazil and Germany were planned around R/V METEOR cruise M98. As early as 28 June, a joint meeting between Labomar, the Marine Research Institute of the Federal University of Ceará, Fortaleza (UFC), and GEOMAR took place to initiate collaboration between the institutes. During the meeting, a scientific symposium on the subject "Ocean research on biochemical-physical interactions in the tropical Atlantic," in May 2014 was agreed upon which could serve as a highlight towards the conclusion of the German-Brazilian Year (2013/2014). In addition, on 29 June, about 50 invited guests from science, politics and government attended a reception on R/V METEOR. There were many stimulating discussions on the role of science in society, but also related to specific research projects with our various Brazilian partners. Once again, R/V METEOR was open for visiting students, and many expressions of admiration were seen and heard throughout regarding the great opportunities that R/V METEOR has to offer various research groups on board.

The working groups on board this cruise again reflect the strong international focus of our research programs. In addition to colleagues from the Universities of Natal and Recife in Brazil, we welcomed three scientists from Angola on board. They come from the Fisheries Institute INIP of Angola and are partners in SACUS. This collaboration is further

strengthened by the EU FP7 project PREFACE "Enhancing Prediction of Tropical Atlantic Climate and its impacts", which will officially begin in November 2013. This project brings together scientists from 17 European and 10 African institutions. Overall we were very relieved that after many problems upon arrival, with a general strike in Portugal, delayed flights and no luggage, as well as the late berthing after the on-time arrival of R/V METEOR in Fortaleza, everyone and most equipment was sufficiently on time to leave the harbor as scheduled on July 1, 2013 at 9:00.

On July 2 at 13:30, one day after departure from Fortaleza, we commenced the research program with measurements using the CTD/LADCP system along 5°S. Such measurements have been carried out several times during the period 1990 to 2004. With the new measurements, we wanted to demonstrate possible changes in the water mass characteristics of the North Brazil Current due to an increased influx from the Indian Ocean into the South Atlantic. After completion of measurements at 5°S with 13 surface-to-bottom CTD/LADCP stations on July 4, 2013 at 16:50, R/V METEOR headed southwest towards Recife where we stopped offshore briefly to obtain spare parts for the UCTD that were not delivered in time to Fortaleza. After transit to the next working area, the CTD/LADCP station and mooring work along 11°S commenced on July 5, 2013. Along this section 4 current meter moorings, one bottom pressure sensor and one PIES (inverted echo sounder with pressure sensor) were deployed. The mooring work went very smoothly without any problems: MicroCAT instruments were calibrated at the CTD prior to deployment. In between and following the mooring work, a total of 21 surface to bottom CTD/LADCP station were carried out. Water samples were taken only for calibration of salinity and oxygen sensors of the CTD system. The CTD section was finished on July 10, 2013, and the UCTD section commenced with hourly measurements along the 11-day transit from Brazil to Angola. During this transit, three APEX floats were deployed additionally.

One important aspect of this cruise crossing the South Atlantic at about 11°S were the measurements with the chemistry underway systems. These systems have been working non-stop, providing information on the air-sea concentration gradients of climate-relevant trace gases, namely CO_2, N_2O, DMS, and acetone. In addition, during the first two weeks of the cruise, the TRASE-EC team was working to assemble and test the eddy covariance (EC) DMS, acetone, and CO_2 air-sea gas exchange systems to be ready for this transit. The goal of this work is to directly and simultaneously measure the air-sea flux of the aforementioned gases in conjunction with their air-sea concentration gradients in order to derive the gas transfer coefficient (k). In general, the signals were rather weak during the Atlantic crossing, but were strongly enhanced in the eastern tropical South Atlantic, particularly close to the coastal upwelling regions.

After arriving in Angolan waters on July 21, 2013, the station work started with a CTD station at the continental slope aimed at calibrating salinity and oxygen sensors for the upcoming mooring deployments. R/V METEOR then sailed along the section on the shelf from 11°S, 12°45'E to 10°30'S, 13°30'E at 7kn to measure the bathymetry using the echo sounder EM122, as well as currents using both shipboard ADCPs. The detailed topography survey allowed us the determine the final mooring positions along this section. In the shallow waters on the shelf, starting at about 40m water depth, microstructure and CTD measurements were

performed during the night to reach the first mooring position at the shelf break (200m water depth).

On July 22, 2013, the first of the two bottom shields with an 150 kHz ADCP was deployed without problems. At the same position, following the mooring deployment, the glider ifm02 with a microstructure probe attached was deployed using the zodiac of R/V METEOR. The glider was programmed to profile along a 4 nm-section following the 200 m isobath, measuring the turbulent mixing at the shelf break for about two days. Weak winds and waves allowed for a very smooth deployment. After deploying a bottom pressure sensor at about 300m water depth, the deployment of the second bottom shield with a 75 kHz Longranger ADCP started after lunch of the same day at a water depth of 500 m. The procedure to deploy the bottom shield was again to lower the shield with the ship's wire close to the bottom and then release it with a standard mooring release. The depth of this release as well as the release in the bottom shield can be ranged by acoustic signals transferred via a hydrophone from a board unit. Unfortunately, the shield release opened and due to its buoyancy - the shield plus instrumentation rose to the surface. We recovered the shield and prepared it for another deployment. The following night was used to continue the CTD and microstructure section from the night before. We noted that the microstructure board unit did not receive data from the probe, indicating a potential problem with the cable – a problem we had also experienced during previous cruises. An inspection of the microstructure cable showed indeed a long cut in the cable mantle for unknown reasons. The cable had to be substantially shortened to continue with microstructure measurements during the next day. On July 23, the second bottom shield was deployed without problems. It was released a few meters above the bottom and was easily tracked after dropping to the sea floor. On the same day the last two moorings, one at the shelf at 450 m depth with temperature, salinity and oxygen sensors and another one at about 1230 m depth with another 75 kHz Longranger ADCP, were deployed. The CTD section was completed with station separation of about 3.5 nm. During the night about 11 h of microstructure measurements on the shelf were carried out at about 1.5 kn ship speed. These measurements were aimed at understanding the strong sea surface cooling observed near the coast under very low wind conditions that likely is triggered by the breaking of tidally induced internal waves generated at the continental slope and propagating onshore. After recovery of glider ifm02 the scientific program at the 11°S section was completed and the ship headed toward Walvis Bay with a continuation of underway measurements. The last station of M98 was the glider deployment off Walvis Bay on July 27, 2013. The glider is aimed at surveying upwelling filaments which are the subject of cruise M99 with chief scientist Detlef Quadfasel on board. The glider will be recovered at the end of M99.

The ship arrived at the port of Walvis Bay, Namibia on July 28 at 8:00.

Acknowledgements

We greatly appreciate the cooperative working atmosphere as well as the professionalism and seamanship of crew, officers and Captain of R/V METEOR, which made this work a success. Financial support came from the German Federal Ministry of Education and Research (BMBF) as part of the Joint Project RACE (03F0443B) and SACUS (03F0462A).

Participants M98

1	Brandt, Peter, Prof. Dr.	Chief Scientist	GEOMAR
2	Arevalo Martinez, Damian	Underway N_2O, CO, CO_2	GEOMAR
3	Bonou, Frédéric Kpèdonou	CTD, UCTD	UFPE
4	de Araújo Magalhães, Phellipe	Brazilian observer	CHM
5	Dengler, Marcus, Dr.	Microstructure, vmADCP	GEOMAR
6	Didwischus, Sven-Helge	CTD, UCTD, moorings	GEOMAR
7	Hounsou-Gbo, Gbèkpo Aubains	CTD, UCTD	UFPE
8	Lüdke, Jan	CTD, UCTD	GEOMAR
9	Kisjeloff, Boris	CTD, optodes, MicroCATs	GEOMAR
10	Krahmann, Gerd, Dr.	LADCP, CTD processing, glider	GEOMAR
11	Macuéria, Marisa Francisca de Novato	CTD, UCTD	INIP
12	Marandino, Christa, Prof. Dr.	Atmospheric flux DMS, CO_2	GEOMAR
13	Müller, Mario	CTD, UCTD, moored ADCPs	GEOMAR
14	Niehus, Gerd	Moorings, CTD, releaser	GEOMAR
15	Ostrovski, Marek	CTD, vmADCP	IMR
16	Papenburg, Uwe	Moorings, current meters	GEOMAR
17	Pereira da Silva, Mario, Dr	CTD, UCTD	UFRN
18	Raeke, Andreas	Meteorology	DWD
19	Rühs, Siren	Salinometer, CTD, UCTD	GEOMAR
20	Schweizer, Ellen	Winkler oxygen, DMS, CO_2	GEOMAR
21	Steinhoff, Tobias, Dr.	Underway CO_2, CO, N_2O	GEOMAR
22	Tchipalanga, Pedro Cláver Mota	Angolan observer, CTD, UCTD	INIP
23	Vasco, Enoque Canganjo	CTD, UCTD	INIP
24	Vogel, Bendix	Salinometer, CTD, UCTD	GEOMAR
25	Zavarsky, Alex	Atmospheric flux DMS, CO_2	GEOMAR

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CHM	Encarregado da Seção de Elementos (CHM-311), phellipe@chm.mar.mil.br
DWD	Deutscher Wetterdienst, Seeschifffahrtsberatung, Bernhard-Nocht-Straße 76, 20359 Hamburg, Germany, http://www.dwd.de
IMR	The Institute of Marine Research IMR, Bergen, Norway
INIP	Instituto Nacional de Investigação Pesqueira Republica de Angola
UFPE	Lab. Oceanografia Física Estuarina e Costeira – LOFEC, Depart. Oceanografia da Universidade Federal de Pernambuco – UFPE, Av. Arquitetura, s/n, 50740-550 - Cidade Universitária Recife-PE Brasil, http://www.ufpe.br/docean/index.php
UFRN	Departamento de Geofísica / CCET, Universidade Federal do Rio Grande do Norte – UFRN, Lagoa Nova, Natal - RN, Brazil. CEP 59078-970, http://www.ccet.ufrn.br/

Tab. 1.1: Station list of R/V METEOR cruise M98.

Station No. MSM Ship/Science		**Latitude**	**Longitude**	**Time**	**Work**
1362	CTD_1	5°39.0'S	34°57.6'W	2.7. 13:30-13:50	**CTD/LADCP** station (250m), stopped at 80m
1363	CTD_2	5°39.0'S	34°57.6'W	2.7. 16:20-16:40	**CTD/LADCP** station (280m)
1364	CTD_3	5°38.3'S	34°56.0'W	2.7. 17:10-17:40	**CTD/LADCP** station (740m)
1365	CTD_4	5°38.0'S	34°54.0'W	2.7. 18:20-19:40	**CTD/LADCP** station (1680m)
1366	CTD_5	5°36.6'S	34°46.0'W	2.7. 21:00-23:00	**CTD/LADCP** station (2830m)
1367	CTD_6	5°34.8'S	34°36.0'W	3.7. 00:10-3:00	**CTD/LADCP** station (3400m)
1368	CTD_7	5°32.7'S	34°24.0'W	3.7. 4:20-7:10	**CTD/LADCP** station (3760m)
1369	CTD_8	5°30.2'S	34°10.0'W	3.7. 08:50-11:20	**CTD/LADCP** station (4110m)
1370	CTD_9	5°26.6'S	33°50.0'W	3.7. 13:20-16:30	**CTD/LADCP** station (4350 m)
1371	CTD_10	5°21.7'S	33°25.0'W	3.7. 19:00-22:20	**CTD/LADCP** station (4500 m)
1372	CTD_11	5°17.7'S	33°00.0'W	4.7. 01:00-04:20	**CTD/LADCP** station (4580 m)
1373	CTD_12	5°12.3'S	32°30.0'W	4.7. 07:30-10:10	**CTD/LADCP** station (4620 m)
1374	CTD_13	5°07.0'S	32°00.0'W	4.7. 13:20-16:50	**CTD/LADCP** station (4640 m)
1375	EM710 KPO1095	10°12.5'S 10°13.7'S	35°52.0'W 35°52.5'W	6.7. 5:30-7:30	**Topography sections along 300m, 500m and 900m depth** (at 7kn)
1376	KPO1109 PIES_1	10°14.15'S	35°51.9'W	6.7. 8:50-9:00	**Deployment of PIES** (500m)
		10°14.2'S	35°54.2'W	6.7. 9:30	**Start ADCP section** (70m)
1377	CTD_14	10°14.6'S	35°53.6'W	6.7. 9:50-10:10	**CTD/LADCP** station (220 m)
1378	CTD_15	10°15.3'S	35°52.6'W	6.7. 10:40-11:10	**CTD/LADCP** station (520 m)
1379	CTD_16	10°16.0'S	35°51.7'W	6.7. 12:10-12:50	**CTD/LADCP** station (900 m)
1380	KPO1095	10°16.0'S	35°51.7'W	6.7. 12:50-15:10	**Drifttest, Mooring deployment** (900 m)
1381	KPO1108 BPR_1	10°13.7'S	35°52.5'W	6.7. 15:40-16:10	**Deployment of Bottom Pressure Sensor** (300m)
1382	CTD_17	10°19.5'S	35°46.1'W	6.7. 17:20-19:00	**CTD/LADCP** station (1760 m)
1383/ 1384	CTD_18	10°22.8'S	35°40.8'W	6.7. 19:50-21:20	**CTD/LADCP** station (2320 m), releaser test

1385	CTD_19	10°27.4'S	35°34.9'W	6.7. 22:30-0:30	**CTD/LADCP** station (2880 m)
1386	CTD_20	10°32.0'S	35°29.3'W	7.7. 1:30-3:50	**CTD/LADCP** station (3210 m)
1387	CTD_21	10°36.5'S	35°23.6'W	7.7. 5:20-7:40	**CTD/LADCP** station (3520 m)
1388	KPO1097	10°36.5'S	35°23.6'W	7.7. 7:40-11:50	**Drifttest, Mooring deployment** (3520 m)
1389	KPO1096	10°22.8'S	35°40.8'W	7.7. 14:20-17:10	**Drifttest, Mooring deployment** (2320 m)
1390	CTD_22	10°41.4'S	35°17.6'W	7.7. 20:30-23:20	**CTD/LADCP** station (3680 m)
1391	CTD_23	10°46.4'S	35°11.6'W	8.7. 00:20-2:50	**CTD/LADCP** station (3880 m)
1392	CTD_24	10°51.4'S	35°05.6'W	8.7. 3:50-6:20	**CTD/LADCP** station (3970 m)
1393	CTD_25	10°56.4'S	34°59.6'W	8.7. 7:10-10:10	**CTD/LADCP** station (4110 m)
1394	KPO1098	10°56.4'S	34°59.6'W	8.7. 10:10-15:40	**Drifttest, Mooring deployment** (ca. 4110 m)
1395	CTD_26	11°07.6'S	34°43.9'W	8.7. 17:50-20:30	**CTD/LADCP** station (4250 m)
1396	CTD_27	11°18.8'S	34°28.2'W	8.7. 22:40-1:30	**CTD/LADCP** station (4630 m)
1397	CTD_28	11°30.0'S	34°13.0'W	9.7. 3:40-6:40	**CTD/LADCP** station (4580 m)
1398	CTD_29	11°30.0'S	33°53.0'W	9.7. 8:50-11:50	**CTD/LADCP** station (4620 m)
1399	CTD_30	11°30.0'S	33°33.0'W	9.7. 13:50-17:30	**CTD/LADCP** station (4960 m)
1400	UCTD				**UCTD** test with dummy
1401	CTD_31	11°30.0'S	33°13.0'W	9.7. 19:40-22:30	**CTD/LADCP** station (4280 m)
1402	CTD_32	11°30.0'S	32°53.0'W	10.7. 0:50-3:20	**CTD/LADCP** station (3540 m)
1403 - 1404	UCTD1 - 2			10.7. 4:15	**Underway-CTD** (every 1h)
1405	CTD_33	11°30.0'S	32°27.0'W	10.7. 6:40-9:50	**CTD/LADCP** station (4780 m)
1406 - 1407	UCTD3 - 4				**Underway-CTD** (every 1h)
1408	CTD_34	11°30.0'S	32°00.0'W	10.7. 13:00-15:50	**CTD/LADCP** station (ca. 4400 m)
1409 - 1477	UCTD5 - 74				**Underway-CTD** (every 1h)
1478	APEX_1	11°20.0'S	20°00.0'W	13.7. 8:08	**APEX float deployment**
1479 - 1597	UCTD75 - 193				**Underway-CTD** (every 1h)
1598	APEX_2	10°13.1'S	0°00.2'W	18.7. 15:43	**APEX float deployment**

1599 - 1646	UCTD194 - 251				**Underway-CTD** (every 1h)
1647	APEX_3	10°24.1'S	9°00.0'E	20.7. 17:00	**APEX float deployment**
1648 - 1666	UCTD194 - 212				**Underway-CTD** (every 1h)
1667	CTD_35	11°00'S	12°45'E	21.7. 12:40-14:00	**CTD/LADCP** station (ca. 1200 m)
1668	MSS_1	11°00'S	12°45'E	21.7. 14:20-15:00	**Microstructure** (at 1.5 kn)
1669	EM122	11°00.0'S 10°30.0'S	12°45.0'E 13°30.0'E	21.7. 15:20-23:10	**Section with EM122 and shipboard ADCP** (at 7kn)
1670	CTD_36	10°30'S	13°30'E	21.7. 23:10-23:20	**CTD/LADCP** station (ca. 40 m)
1671	MSS_2	10°30'S	13°30'E	21.7. 23:50-1:20	**Microstructure** (at 1.5 kn)
1672	CTD_37	10°31.4'S	13°27.9'E	22.7. 1:30-1:40	**CTD/LADCP** station (50m)
1673	MSS_3	10°31.7'S	13°27.5'E	22.7. 2:00-3:20	**Microstructure** (at 1.5 kn)
1674	CTD_38	10°32.9'S	13°25.7'E	22.7. 3:30-3:40	**CTD/LADCP** station (75m)
1675	MSS_4	10°33'S	13°25.5'E	22.7. 3:50-5:10	**Microstructure** (at 1.5 kn)
1676	CTD_39	10°34.2'S	13°23.7'E	22.7. 5:20-5:40	**CTD/LADCP** station (90m)
1677	MSS_5	10°34.4'S	13°23.7'E	22.7. 5:40-6:00	**Microstructure** (at 1.5 kn)
1678	CTD_40	10°39.72'S	13°15.43'E	22.7. 7:00-7:40	**CTD/LADCP** station (200m)
1679	KPO1104	10°39.72'S	13°15.43'E	22.7. 8:30-9:30	**Bottom shield deployment** (200m)
1680	ifm02	10°39.72'S	13°15.43'E	22.7. 9:30-10:30	**Glider deployment**
1681	KPO1110	10°40.44'S	13°14.43'E	22.7. 11:00-11:30	**Deployment of Bottom Pressure Sensor** (300m)
1682	KPO1106	10°42.57'S	13°11.13'E	22.7. 12:30-14:40	**Bottom shield deployment** (500m), released and recovered
1683	MSS_6	10°34.4'S	13°23.4'E	22.7. 16:20-17:20	**Microstructure** (at 1.5 kn)
1684	CTD_41	10°35.2'S	13°22.2'E	22.7. 17:20-17:40	**CTD/LADCP** station (100m)
1685	MSS_7	10°35.2'S	13°22.2'E	22.7. 17:40-19:20	**Microstructure** (at 1.5 kn)
1686	CTD_42	10°36.6'S	13°20.2'E	22.7. 19:20-19:40	**CTD/LADCP** station (110m)
1687	MSS_8	10°36.6'S	13°20.1'E	22.7. 19:40-21:10	**Microstructure** (at 1.5 kn)
1688	CTD_43	10°37.9'S	13°18.2'E	22.7. 21:20-21:40	**CTD/LADCP** station (120m)

1689	MSS_9	10°37.9'S	13°18.2'E	22.7. 21:40-22:50	**Microstructure** (at 1.5 kn)
1690	CTD_44	10°38.8'S	13°16.8'E	22.7. 23:00-23:20	**CTD/LADCP** station (140m)
1691	CTD_45	10°40.6'S	13°14.2'E	23.7. 1:00-1:20	**CTD/LADCP** station (290m)
1692	CTD_46	10°42.1'S	13°11.8'E	23.7. 1:50-2:20	**CTD/LADCP** station (440m)
1693	CTD_47	10°44'S	13°09'E	23.7. 2:50-3:20	**CTD/LADCP** station (700m)
1694	CTD_48	10°46'S	13°06'E	23.7. 4:00-4:40	**CTD/LADCP** station (950m)
1695	CTD_49	10°48'S	13°03'E	23.7. 5:10-6:00	**CTD/LADCP** station (1160m)
1696	KPO1106	10°42.57'S	13°11.13'E	23.7. 7:40-9:00	**Bottom shield deployment** (500m)
1697	KPO1105	10°42.1'S	13°11.85'E	23.7. 10:00-11:00	**Drifttest, mooring deployment** (450 m)
1698	CTD_50	10°50'S	13°00'E	23.7. 12:40-13:10	**CTD/LADCP** station (1230m)
1699	KPO1107	10°50'S	13°00'E	23.7. 13:40-14:50	**Drifttest, mooring deployment** (1230 m)
1700	CTD_51	10°52'S	12°57'E	23.7. 15:20-16:10	**CTD/LADCP** station (1270m)
1701	CTD_52	10°54'S	12°54'E	23.7. 16:40-17:30	**CTD/LADCP** station (1340m)
1702	CTD_53	10°56'S	12°51'E	23.7. 18:00-19:00	**CTD/LADCP** station (1370m)
1703	CTD_54	10°58'S	12°48'E	23.7. 19:30-20:30	**CTD/LADCP** station (1410m)
1704	CTD_55	11°00'S	12°45'E	23.7. 21:10-22:10	**CTD/LADCP** station (1430m)
1705	ADCP	11°00.0'S 10°30.0'S	12°45.0'E 13°30.0'E	23.7. 22:30-3:40	**Section with shipboard ADCP**
1706/ 1707	MSS_10	10°27.9'S 10°37.3'S	13°33.0'E 13°19.0'E	24.7. 3:50-14:50	**Microstructure** (at 1.5 kn)
1708	ifm02	10°39.7'S	13°16.3'E	24.7. 15:40-15:50	**Glider recovery**
1709	Ifm02	22°34.85'S	12°36.92'E	27.7. 15:10-16:00	**Glider deployment**