National Oceanography Centre, Southampton

Cruise Report No. 5

RRS *Charles Darwin* Cruise CD177

12 – 29 NOV 2005

RAPID mooring cruise report

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2006

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ABSTRACT

This report describes mooring operations and underway measurements conducted during RRS *Charles Darwin* Cruise CD177. Cruise CD177 was conducted between 12 November 2005 and 29 November 2005. The first part of the cruise consisted of a transit from Falmouth, UK to Santa Cruz de Tenerife, Tenerife with mooring preparation conducted on this leg. Further scientific staff joined in Santa Cruz de Tenerife for the second leg that started on the 19 November. The cruise finished in Tenerife on the 29 November.

This cruise was completed as part of the United Kingdom Natural Environment Research Council (NERC) funded RAPID Programme to monitor the Atlantic Meridional Overturning Circulation at 26.5ºN. The primary purposes of this cruise were to service the two key moorings (EB1 and EB2) on the eastern boundary of the 26.5ºN mooring array and to deploy two Pressure Inverted Echosounders (PIES). The array was first deployed in 2004 during RRS *Discovery* cruises D277 and D278 (Southampton Oceanography Centre Cruise Report No. 53) in order to set up a pre-operational prototype system to continuously observe the Atlantic Meridional Overturning Circulation (MOC). It was subsequently serviced on RRS *Charles Darwin* cruise CD170 and RV *Knorr* cruise KN182-2 (both covered in National Oceanography Centre Southampton Cruise Report No. 2). The array will be further refined and refurbished during subsequent years.

This cruise was planned in response to mooring losses suffered in the first year of the 26.5ºN array deployment. The two key eastern boundary moorings were subjected to damage through suspected fishing activity causing the loss of data above 1200m at the eastern boundary. To reduce the risk of data loss we plan to service the two key moorings on a six-monthly cycle.

Instruments deployed on the array consists of a variety of current meters, bottom pressure recorders and CTD loggers which, combined with time series measurements of the Florida Channel Current and wind stress estimates, will be used to determine the strength and structure of the MOC at 26.5ºN. (http://www.noc.soton.ac.uk/rapidmoc)

KEYWORDS

Atlantic Ocean, bottom pressure recorder, BPR, cruise CD177 2005, CTD, current meter, *Charles Darwin*, meridional overturning circulation, MOC, mooring array, moorings, North Atlantic, RAPID, RAPIDMOC, thermohaline circulation THC, McLane Moored Profiler, MMP, Pressure Inverted Echousounder, PIES, IES

ISSUING ORGANISATION

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Scientific and Technical	
Stuart Cunningham	Principal Scientist (National Oceanography Centre, Southampton)
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Darren Rayner	Scientist (National Oceanography Centre, Southampton)
Jeff Bicknell	Technician (National Oceanography Centre, Southampton)
Christian Crowe	Technician (National Oceanography Centre, Southampton)
Jeremy Evans	Technician (National Oceanography Centre, Southampton)
Colin Hutton	Technician (National Oceanography Centre, Southampton)
Robert McLachlan	Technician (National Oceanography Centre, Southampton)
Stephen Whittle*	Technician (National Oceanography Centre, Southampton)
Rory Bingham	Scientist (Proudman Oceanographic Laboratory)
Philip Staley	Scientist (National Oceanography Centre, Southampton)
Enrique Vidal Vijande	Scientist (National Oceanography Centre, Southampton)
12 persons	
RSU Personnel	
Peter Sargeant	Master
Peter Reynolds	Chief Officer
Malcolm Graves	2nd Officer
John Holmes	3rd Officer
John Holt	Chief Engineer
James Bills	2nd Engineer
David Ardern	3rd Engineer
Glynn Collard	3rd Engineer
Robert Masters	Electro-technical Officer
Michael Minnock	Chief Petty Officer (Science)
Michael Drayton	Chief Petty Officer (Deck)
Mark Squibb	Petty Officer (Deck)
Stewart Barrett	Seaman 1A
David Buffery	Seaman 1A
Perry Dollery	Seaman 1A
Michael Coles	Seaman 1A
Peter Searle	Motorman 1A
Keith Curtis	Ship's Catering Manager
John Giddings	Chef
Neil Rodda	Assistant Chef
Peter Robinson	Steward
21 persons	

Table 1.1: Details of personnel on cruise CD177 (* only completed the transit leg from Falmouth to Tenerife)

2. Itinerary

CD177
Depart Falmouth, UK, 12th November 2005 – Arrive Santa Cruz de Tenerife, Tenerife, 18th November 2005. Depart Santa Cruz de Tenerife, Tenerife, 19th November 2005 – Arrive Santa Cruz de Tenerife, Tenerife 21st Novmber 2005. Depart Santa Cruz de Tenerife, Tenerife 22nd November 2005 – Arrive Santa Cruz de Tenerife, Tenerife, 29th November 2005.

3. Acknowledgements

The Captain, Officers and crew were particularly helpful during the cruise and mindful of alternative options that minimised time lost through port calls for ship repairs.

The NOC moorings team were efficient and coped well despite being a person down following the unscheduled port call in Tenerife (and an incident with a wall that was higher than first thought!).

4. Introduction

S. Cunningham

The goal of this cruise was to recover and redeploy some RAPID-MOC moorings near the Eastern Boundary as part of our six-month turnaround programme. Specific cruise objectives were to:

1. Recover moorings EB1 (24 microcats) and EB2 (MMP profiling from 50m to 2500m with microcats and current meters below), two principal tall eastern boundary moorings, sited on a Topex crossover point near 24N, 24W.
2. Redeploy EB1 (24 inductive microcats plus the telemetry system) and EB2 (MMP mooring).
3. Deploy EBADCP to replace the instrument deployed in April but trawled after 10 days and recovered by the RV *Poseidon.*
4. Deploy two University of Rhode Island Pressure Inverted Echo Sounders. One in 1000 m and one in 5000 m next to the BPR lander at mooring EB1.
5. CTD stations for pre and post deployment calibrations of mooring instrumentation.
6. Search for and if possible recover MMP mooring EB2 deployed in April 2004 and located 150 km north of the deployment position, south of Gomera in October 2004.

The scientific and technical party consisted of six scientists and six technicians. However, only five technicians sailed after Steve Whittle broke his leg returning to the ship during the port call on 21st November.

RRS *Charles Darwin* finally sailed from Falmouth, delayed by one week due to technical problems with the ship (she had to be dry-docked to repair a hole in the hull). The scientific party flew to Tenerife and joined ship on the evening of Friday 18th November. Sailing was further delayed by the non-functioning bow thruster. Over the weekend, we sailed for Moroccan waters, deploying EBADCP and EBP2 (PIES instrument in 1000m), as both these operations did not require the use of the bow thruster. We returned to Tenerife to effect repairs and finally sailed again on Monday morning. Good weather and extremely hard work ensured the completion of objectives 1 to 5.

5. Bridge Timetable of Events

Date	Time (GMT)	Lat (N)	Lon (W)	Event
12/11/05 – 18/11/05				Transit from Falmouth to Tenerife
19/11/05	18:22	28º26.9	16º10.6	Set sail from Tenerife.
	18:27	28º26.8	16º10.6	Vessel stopped for PES deployment
				PES fish outboard. Resume passage on course 105ºT
20/11/05	08:48	27º55.9	13º23.1	Hove to at EBADCP. Assessing drift
	09:07	27º55.8	13º22.7	Commence deployment
	09:12	27º55.79	13º22.77	EBADCP Released. Hove to listening to ADCP descent
	09:18	27º52.3	13º30.4	ADCP on bottom. Transit to PIES site
	10:21	27º51.86	13º31.19	Hove to for drift check
	10:35	27º51.78	13º31.37	Repositioning for correct depth
	11:04	27º51.88	13º31.20	PIES deployed
	11:13	27º52.19	13º30.72	Transducer over side
	11:25			Transducer in board. Proceed to drift position
	11:48			Transducer outboard
	12:00			Vessel drifting NE at approx 1 kt over PIES site
	12:30			Vessel approx 0.5 NE of PIES position. Science
	12:52			completed. Transducer inboard
				Set course for Tenerife
	16:15			Emergency Drill
21/11/05	06:00			Arrive Tenerife
22/11/05	11:36	28º23.17	16º16.19	Set sail from Tenerife
	12:19			Vessel hove to. PES fish deployed. Stay in shallow water around Tenerife to calibrate ADCP. Heading to EB1/EB2 mooring site.
23/11/05				Continue transit to EB1/EB2 site
24/11/05	13:31	23º48.95	24º05.53	Vessel hove to approx 4 cables NNE of EB1 position.
	13:37			Fire releases. Buoy visible on surface.
	14:07	23º48.6	24º05.7	Grappled.
	14:14			Top buoy inboard
	14:20			Commence recovery of 1st string of Microcats
	15:18	23º48.0	24º05.6	1000m buoyancy at transom
	15:21			Buoyancy inboard. Commence recovery of 2nd string
	15:55	23º47.8	24º05.7	2000m buoyancy inboard
	16:42	23º47.6	24º05.6	Microcat 3931 inboard
	17:18	23º47.4	24º05.2	All inboard
	18:05	23º47.5	24º05.8	Vessel hove to for CTD
	18:08	23º47.5	24º05.8	CTD outboard
	19:38	23º47.4	24º05.7	Cease veer at 5000m
	19:58	23º47.3	24º05.7	Commence recovery
	22:40	23º47.4	24º05.4	CTD inboard
	23:39	23º47.4	24º05.6	CTD outboard

25/11/05	00:35	23º47.38	24º05.78	3000m wire out. Commence hauling
	02:51	23º47.35	24º05.93	CTD on deck
	02:53	23º47.33	24º05.96	CTD secured. Proceeding to PIES position
	03:04	23º47.65	24º06.25	Set course 342º T towards PIES position
	03:32	23º48.65	24º06.80	Commence drift check at EBP1 station.
	04:06	23º48.50	24º06.47	PIES lander deployed. Transducer outboard
	05:03	23º48.9	24º06.5	Monitored drift. Lander on bottom. Transducer inboard. Repositioning
	05:22	23º48.3	24º06.5	Vessel repositioned up stream of PIES lander. Transducer outboard
	07:22	23º49.4	24º06.8	Transducer inboard
	07:26	23º49.4	24º06.8	Repositioning
	07:48	23º47.5	24º05.6	Commence swath run. Course 355ºT at 8kts
	08:23	23º51.9	24º06.0	Complete swath survey.
	08:53	23º52.5	24º06.4	Hove to on station for start of EB1 deployment
	09:06	23º52.5	24º06.4	Telemetry buoy overboard
	09:10	23º52.4	24º06.4	Steel buoyancy overboard
	09:29	23º52.2	24º06.3	4th Microcat fitted. Straightening streaming
	10:48	23º51.1	24º06.2	2000m mark on mooring
	11:32	23º50.7	24º06.2	Syntactic buoyancy outboard
	12:23	23º49.82	24º05.99	Final Microcat attached
	12:34	23º49.63	24º05.98	Reduced ½ knot at mooring team's request
	12:52	23º49.50	24º05.99	Glass spheres in water. Anchor released
	12:58	23º49.80	24º06.18	Vessel on reciprocal track to observe buoyancy sinking
	13:17	23º50.91	24º06.18	Vessel reversed course around telemetry buoy
	13:23	23º50.51	24º06.09	Telemetry buoy under surface
	13:45	23º50.74	24º05.89	Set course towards EB2 recover site
	14:37	23º55.90	24º02.93	Vessel hove to on station. Releasing mooring
	14:39	23º55.91	24º02.96	Buoy sighted ahead
	15:09	23º56.01	24º03.03	Next set of flotation on surface
	15:19	23º55.95	24º02.94	Next set of flotation on surface
	15:40	23º55.9	24º02.8	Grappled and clear of transom
	15:56			Argos, buoy, RCM11 and SBE37 inboard
	16:48	23º55.7	24º02.5	Bunching of wire at approx 1500m
	17:10			Hauling at slow speed
	17:30			MMP recovered to deck
	17:45	23º55.5	24º02.1	12 pack of buoyancy at stern
	17:52			SBE37 and MMP stop recovered
	18:24	23º55.4	24º01.9	SBE 3921 inboard
	18:33	23º55.4	24º01.8	SBE 3921 inboard and 6 pack glass and 4 pack
	18:57	23º55.3	24º01.7	All inboard. PES fish redeployed
	19:59	23º55.9	24º02.7	Hove to for CTD
	20:00	23º55.9	24º02.6	CTD outboard. Commence veering
	21:04	23º55.9	24º02.8	Cease veering at 3000m.
	21:07	23º55.8	24º02.8	Commence hauling
	23:18	23º55.8	24º02.8	CTD inboard
26/11/05	00:11	23º56.05	24º02.52	CTD in water
	01:05	23º56.00	24º02.44	CTD at 3000m and hauling
	03:16	23º26.07	24º02.32	CTD inboard
	04:06	23º56.0	24º02.3	CTD outboard
	05:07	23º56.0	24º02.1	CTD veered to 3000m. Commence hauling
	07:25	23º55.5	24º01.6	CTD inboard. Vessel stopped to check drift.
	07:54	23º55.6	24º01.7	Vessel proceeding to start position for swath survey
	08:14	23º54.9	24º02.0	Commence swath survey course 300ºT
	08:48	23º58.7	24º04.1	Cease survey. Hove to.
	09:15	23º58.4	24º04.2	On track for EB2 deployment
	09:52	23º58.4	24º04.2	Commence streaming mooring
	09:54			Argos and 2 instruments in water
	10:22	23º57.9	24º03.9	Attaching MMP
	10:37	23º57.5	24º03.7	MMP released
	11:50	23º55.9	24º03.1	Bottom stopper and SBE attached (2500m)
	11:59	23º55.7	24º03.2	Increased 0.25kt. Spheres and RCM11 deployed.
	12:37	23º54.9	24º03.1	Reduced to 1.1kt over ground.
	12:46	23º54.7	24º03.2	8 x glass deployed.
	13:56	23º53.39	24º03.32	Streaming final buoyancy
	13:57	23º53.38	24º03.32	Mooring anchor released
	14:01	23º53.39	24º03.45	Completed turn to starboard
	14:16	23º55.08	24º03.34	Vessel steering around north end of mooring
	14:26	23º54.12	24º03.18	Mooring submerged

	14:38	23º53.26	24º03.00	Commenced triangulation at 8kts
	14:43	23º52.91	24º03.37	A/C 331ºT. Vessel at southern point of triangle
	14:59	23º54.58	24º04.09	A/C 095ºT. Vessel at NW point of triangle
	15:15	23º54.23	24º02.30	Vessel at NE point of triangle. A/C 215ºT. Survey completed
	15:23	23º53.38	24º02.93	Set course 225ºT towards EB1 telemetry buoy
	15:51	23º50.18	24º05.87	Vessel approx 0.5' N of EB1 sat buoy
	16:08	23º48.5	24º06.00	Commence triangulation. Vessel at south point of triangle. A/C 332ºT
	16:22	23º50.2	24º06.9	A/C to 90ºT
	16:36	23º50.1	24º04.8	Triangulation complete. A/C to 057ºT to lost mooring.
27/11/05				Transit to lost EB2 position
28/11/05	10:30	27º48.4	17º18.1	Releases fired. Vessel hove to N of position
	12:14	27º47.74	17º17.81	Hove to. Slant ranges increasing
	12:28	27º47.53	17º17.66	Vessel commencing triangulation
	12:32	27º47.18	17º17.54	A/C 200ºT. Vessel approx 0.5' SE of datum
	12:38	27º46.79	17º17.83	A/C 300ºT. Vessel approx 1.0' south of position
	12:44	27º47.50	17º18.33	1430m slant range
	12:50	27º48.28	17º18.78	Vessel approx 1.0' NW of datum
	12:52	27º48.39	17º18.62	A/C 095ºT
	13:08	27º48.20	17º16.81	Vessel approx1.0' NE datum. A/C 244ºT
	13:20	27º47.70	17º17.87	Vessel passed through datum
	13:25	27º47.49	17º18.34	Vessel passed through min slant range to position
	13:30	27º47.37	17º18.48	Vessel hove to.
	13:58	27º47.47	17º18.25	Vessel crabbing East towards Min-Slant range positions
	14:04	27º47.49	17º18.09	Ranges increasing
	14:11	27º47.48	17º18.22	1,426m min slant range
	14:14	27º47.49	17º18.32	Slant ranges increasing
	14:21	27º47.42	17º18.52	Vessel crabbing Eastward to reduce ranges
	14:43	27º47.50	17º17.97	Vessel crabbing westward
	14:56	27º47.53	17º18.22	Vessel slow steaming to the southward
	16:04	27º45.90	17º15.12	Vessel securing main deck deadlights and vents
	16:14	27º45.74	17º14.94	Main deck deadlights and FWD vents secured. Set course 297ºT
	16:33	27º46.8	17º17.3	Commence triangulation. A/C to 270ºT
	16:47	27º46.8	17º18.9	A/C to 000ºT
	16:57	27º48.2	17º18.9	A/C to 090ºT
	17:12	27º48.2	17º17.3	Triangulation complete. Vessel continuing on 090ºT to Tenerife.
29/11/05				Arrive Tenerife

6. Data Logging and Email.

The standard RVS ABC suite was used on this cruise. Few problems were encountered with the data logging. On 25/11/05 the gps_ash Level A was replaced. Email links were made at least twice a day to NOC with no major problems. Additional links were made on request.

7. Single Beam Bathymetry

P. Staley

Bathymetry data were acquired using a Simrad EA500 hydrographic echosounder and a Precision Echosounding transducer (PES) mounted in a 'Fish'. A hull mounted echosounder was used in the transit leg from Falmouth to Santa Cruz de Tenerife whilst the PES fish was used during the rest of the cruise and mooring operations. The EA500 gave continuous uncorrected depth measurements and a visual display of bathymetry used for mooring operations, with the data streamed and logged. The echosounder was switched off when communicating with the deployed Pressure Inverted Echosounders (PIES).

The PES fish was brought back on deck when entering Santa Cruz de Tenerife port. It was also brought in from 15:15 and redeployed at 19:05 on day 329 (25/11/05) in order to recover the EB2 mooring from the port side. Missing data from the EA500 in the transit leg where attributed to rough seas and high ship speeds.

Echosounder raw data (*ea500d1*) was streamed to level-A and -B monitors where they were regularly checked. The RVS program *prodep* corrected the raw dataset twice daily for variations in the speed of sound using Carter tables. The RVS format raw data containing time, uncorrected depth, corrected depth and Carter area were read into PSTAR through the *Simexec0* program which uses '*datapup*' and '*pcopya*' to create the file sim177ii.cal. These data were manually edited in *plxyed* to remove errors, spikes and anomalous data values. *Simexec1* runs '*pintrp*' to interpolate any missing data in the sim177ii.cal file. The program then calls '*pmerg*' to merge the bathymetry dataset with the navigational dataset abnv1771. This outputs the file sim177ii.nav containing time, latitude, longitude, uncorrected depth, corrected depth, Carter area and speed made good. Sim177ii.nav contains data in intervals of 6-10 seconds depending upon the echosounder ping return time. *Simexec1*'s final operation is to average the sim177ii.nav file into 5 minute intervals using '*pavrge*'.

The daily output files created were:

Sim177ii -	Uncorrected depth, from the echosounder using a constant sound speed of 1500 m/s.
Sim177ii.cal -	Data corrected with prodep and manual plot editing.
Sim177ii.nav -	Data merged with the navigational file abnv.1771.
Sim177ii.5min -	Data averaged into 5 minute intervals.

8. Navigation and Shipboard Acoustic Doppler Current Profiler

R. Bingham

Processing of the Navigation and Acoustic Doppler Current Profiler (ADCP) data involved four separate data streams: The best navigation stream "abnv"; the ashtech data stream; the gyro stream; and the ADCP data stream itself. This section provides a brief summary of each of these stages in the order in which they were processed.

8.1 Navigation

There are four GPS systems on RSS *Charles Darwin*. These are ranked for the quality of positional fix they give, with the preferred system being the differential GPS system Trimble 4000. The RVS data stream abnv provides the best available estimate of the position. Usually this will be from the Trimble 4000 receiver, but if at any time a fix from this system is unavailable then next highest ranked available system is used.

Processing of the abnv data stream involved executing the UNIX script *navexec0*. This updated the PSTAR best navigation file abnv1771. As described below, this file was used to determine absolute water velocities from the ADCP relative velocities.

8.1.1 Ship's Gyrocompass

The gyrocompass provides a continuous measurement of the ship's heading. The output from the gyrocompass is logged as the RVS data stream "gyro". This was processed daily by executing the UNIX script *gyroexec0* which captured the RVS data stream for a specific interval and created a PSTAR file with the name format gyr177nn.

8.1.2 3DGPS – Ashtech

The Ashtech GPS system uses four receiving antennae, mounted atop the bridge, to determine the ships attitude (heading, pitch, and roll) by comparing the phase difference between the four incoming signals. Although more accurate than the gyrocompass the Ashtech GPS system only provides heading at discrete intervals. For this reason the ADCP system uses the gyrocompass to resolve the east-west and north-south components of the relative velocities, with the Ashtech system used to provide a heading correction (ash heading - gyro heading) in the post-processing of the ADCP data. This is described below.

Processing of the Ashtech attitude measurements was performed in a number of stages: Firstly the UNIX script *ashexec0* was used to convert the RVS data stream "ashtech" to a PSTAR file with the naming convention ash177*nn*. Following this the *ashexec1* script was executed. This script takes, as its inputs, the output from *ashexec0* and *gyroexec0* and merges them into a single file that includes the heading difference (ash heading - gyro heading). The *ashexec2* script was then used to edit out data cycles not satisfying certain requirements, and wave noise was reduced by averaging the data into 2 minute bins. The two output files were named ash177*nn*.edit and ash177*nn*.ave respectively.

The program *plxyed* was then used to manually edit any data cycles that showed a spike in the averaged heading differences. In most cases this was not necessary. Finally *papend* was used to append the .ave file to a master file ash177a1, and also to the master file ash177i1.int. It is this final file that is incorporated into the ADCP data stream. Unless there are data gaps this final step is superfluous since the use of *plxyed* to edit the .ave file means that additional interpolation of data gaps where data has been edited is not required. In case of data gaps *pintrp* can be used to fill these by linear interpolation.

8.2 ADCP

Having processed the three data streams as described above, the ADCP data stream was processed. Firstly, the script *adpexec0* was used to capture for a specific time interval the RVS ADCP data stream adcp and split it into two components: the PSTAR files adp177*nn* contains gridded profile (depth dependent) data while the bot177*nn* files contain depth independent data, such as bottom track velocities and spot headings. Apart for a few times when in bottom tracking mode (see below) the ADCP was set to record data for 40 bins each 8m thick.

Because the ADCP clock tends to drift relative to the ship's master clock regular observations (generally every 12 hours) of this offset were made. This drift is to a close approximation linear and was found to be of the order of 2 seconds per hour. On several occasions during the cruise the ADCP logging PC crashed due to the PC overheating. The processing of the ADCP data was performed in batches corresponding to the continuous operation of the logging PC.

The script *adpexec1* applies the clock corrections to the adp and bot files created in the previous step and generates the corrected files adp177*nn*.corr and bot177*nn*.corr. To make this process easier *adpexec1* was modified to provide the user with the option of supplying a list of corrections as an ASCII file rather than entering each correction individually at the terminal when the script is run. The script also creates a file – clock*nn* – that can be used to check the linearity of the drift. Any departure from linearity can usually be ascribed to human error.

The next script to be executed was *adpexec2*. This takes the .corr files and applies the heading correction (ashtech heading – gyro heading) created by the *ashexec2* script, so that the horizontal velocities are referenced to the more accurate Ashtech headings rather than the ship's gyrocompass heading. This corrected data was output as .true files.

The ADCP derived water velocities are biased due to how the instrument is installed in the ships hull, and therefore the velocities must be calibrated to remove this bias. This step is performed with the script *adpexec3* that takes as its input the .true files, applies a calibration and then outputs the calibrated files with a .cal extension. Calibration values from an earlier cruise will not necessarily apply to a later cruise because when the instrument is removed from the ship for servicing, as it was before this cruise, it will not be reinstalled in precisely the same position.

The two calibration constants required by *adpexec3* are the time mean values of

$$A = \frac{s_g}{s_a}, \quad \text{and} \quad \phi = \phi_g - \phi_a ,$$

where s_g and s_a are the speeds of the ship deduced from GPS and from the ADCP, and ϕ_g and ϕ_a are the ship's directions deduced from GPS and from the ADCP.

The best way to calibrate the ADCP is to compare the ship's velocity as determined by GPS with the ship's speed relative to the ocean bottom, as determined from ADCP bottom tracking data. However, as discussed in more detail below, such data were not available. Therefore a less satisfactory approach was used that assumes that over a long enough time interval the currents (absolute water velocities) will integrate to zero, which of course may not be the case. Under this assumption the relative water velocity - the sum of the ship's velocity relative to the bottom plus the velocity of actual currents - are used to determine s_a and s_g. A script *calexec0* was developed for this purpose. This script takes as input the master best navigation data file and the ADCP data file adp177nn and uses *pcmcal* to calculate $s_{a,g}$ and $\phi_{a,g}$ for each data stream. From these, timeseries of A and ϕ are computed and output with filename cal177nn, and the temporal means of A and ϕ are output as the file cal177nn.params. These values are unlikely to be the best choice for A and ϕ so the actual timeseries should be inspected and a time interval over which A and ϕ are relatively constant be used to determine the calibration values. For the calibration constants used on CD177, where A=1.018 and ϕ=4.640, these were calculated over the interval t_1=27547744 s to t_2=27583743 s.

The *calexec0* script also served as a useful way of quickly validating the ADCP velocities against the GPS velocities. By this means a 180 degrees reset of the ship's gyrocompass while in port in Tenerife was quickly detected. Apparently when reset the gyrocompass may be completely out of phase with its previous setting. This then causes, for a given heading, the ADCP velocities to differ from their prior values by a factor of -1. It was found that for the first part of the cruise the gyrocompass was out of phase with its setting on the previous cruise CD170. This meant that a -1 multiplication of velocities introduced to *adpexec0* during CD170 was unnecessary; while after the reset in Tenerife it was necessary to reintroduce this factor. The gyrocompass was not reset for the remainder of the cruise.

The final step in processing the ADCP data was to run *adpexec4*. This script removed the ship's velocity components, as determined by the best navigation, from the calibrated ADCP velocity components to obtain the actual current velocity components in each bin.

8.2.1 Bottom tracking

Because most the ship's time was spent in deep water very little bottom track data were obtained. To try to remedy this it was decided upon leaving Tenerife on the 22nd November to initially follow the coast approximately along the 500 m isobath on route to the EB1/EB2 mooring sites. Prior to leaving port the ADCP was reset in bottom tracking mode. In port the depth was determined to be 15 m. However, once the depth exceeded approximately 225 m the ADCP could not detect the bottom. We experimented with the number of bins, trying first 80 and then 100, and changed the ratio of water to bottom pings from 4:1 to 1:1. Yet, apart for a brief period when travelling over a seamount, no more bottom track data were obtained.

Inspection of the echo intensity for each beam and the spectral amplitude from the ADCP raw data stream revealed that beam four was significantly weaker than the other beams. Since the ADCP can only return bottom velocities if the all of the four beams exceed a certain quality threshold – 25% percent good returns averaged over all bins over the sample interval – the weak beam 4 is a possible explanation of the lack of bottom tracking data. Once into deeper water the ADCP was reset to water tracking mode with 40 bins of 8 m thickness.

Upon inspection it was found that the short interval of bottom tracking velocities was of insufficient quality to determine calibration constants.

9. CTD Operations

S. Cunningham

9.1 CTD Instrument Configuration and Sensor Serial Numbers

The Sea-Bird CTD configuration for the stainless steel frame was as follows:

- SBE 9 *plus* Underwater unit s/n 09P-37898-0782
- Frequency 0—SBE 3P Temperature Sensor s/n 03P-4151 (primary)
- Frequency 1—SBE 4C Conductivity Sensor s/n 04C-3054 (primary)
- Frequency 2—Digiquartz Temperature Compensated Pressure Sensor s/n 94756
- Frequency 3—SBE 3P Temperature Sensor s/n 03P-4105 (secondary)
- Frequency 4—SBE 4C Conductivity Sensor s/n 04C-2580 (secondary)
- SBE 5T Submersible Pump s/n 05T-2793
- SBE 5T Submersible Pump s/n 05T-3609
- SBE 32 Carousel 24 Position Pylon s/n 32-19817-0243
- SBE 11 *plus* Deck Unit s/n 11P-24680-0587

The auxiliary A/D output channels were configured as below:

- V1 --- SBE 43 Oxygen s/n 43B-0709
- V2 --- Benthos Altimeter s/n 874
- V3 --- Chelsea MKIII Aquatracka Fluorometer s/n 88-2050-095 (088095)
- V4 --- PML/RVS PAR DWIRR s/n 10 not used
- V5 --- PML/RVS PAR UWIRR s/n 11 not used
- V7 --- Chelsea MKII Alphatracka 10cm path Transmissometer s/n 161050

9.2 CTD and Salinity Sample Processing Paths

9.2.1 Sample Path

The purpose of the sample path is to convert text files containing bottle salinities into PSTAR files that can then be manipulated for the purposes of calibrating the CTD. Raw salinity sample data were saved in Excel format tab delimited text files, and after checking the spreadsheets against the log sheets **ftp**'d to sohydro6. It was found that UNIX text editors could not read the .txt files due to an octal 15 incompatibility. The files were converted to octal 12 text format by tr '\015' '\012' < filein >! fileout in the routine >**macunixascii.exec**.

>sal.exec was then used to convert the .txt files into binary PSTAR format, File in: sal177*nnn*.txt, File out: sal177*nnn* .

9.2.2 CTD Path

The purpose of the CTD path was to generate from the raw ctd data files 10 s time averaged ctd data that could be compared to the rosette bottle data, and hence derive a calibration for the CTD conductivity measurements.

CTD data were logged to PC using Sea-Bird software (Seasave Win32 V 5.35). Raw CTD data files were first processed using Sea-Bird software (SEASOFT v5.30a) applying the following modules: DatCnv, AlignCTD, WildEdit, CellTM and Trans. See Cunningham, S. A., 2005 for complete details of the equations and parameters applied in these modules. An ASCII file was transferred from the PC to sohydro6 for processing and calibration using PSTAR.

9.3 CTD Processing

The following cshell scripts applied various PSTAR programmes for processing CTD data.

>**ctd0** was used to read the 24hz ASCII Sea-Bird file and output to PSTAR. A header time was constructed from the time within the Sea-Bird .cnv file. File in: CD177*nnn*.cnv, File out: ctd177*nnn*.24hz.

>**ctd1** was used to process the 24hz data to 1hz (median despike, average on time to 1hz, interpolate pressure to remove any absent data). It was also used to average 1hz files to 10s for matching to bottle samples. File in: ctd177*nnn*.24hz, Files out: ctd177*nnn*.1hz & ctd177*nnn*.10s.

>**ctd2** was used to generate .2db and .ctu files. This routine requires records of the datacycles at start downcast, maximum pressure and end upcast from the 1hz file. File in: ctd177*nnn*.1hz, File out: ctd177*nnn*.2db & ctd177*nnn*.ctu.

Salinity sample and CTD data were merged using the following.

>**fir0** was used to read the Sea-Bird rosette firing file into PSTAR and merge 10s average CTD files to produce a file with the 10s averaged upcast CTD variables at the time of the bottle firing. Winch data were also read in using **datapup** from RVS file “winch”. File in: CD177*nnn*.ros & ctd177*nnn*.10s, File out: fir177*nnn* & wini177*nnn*.

>**sam0** is a routine that was used to create a blank sample file for station *nnn* from the master sample file (sam.masterCD177) created at the beginning of the cruise with all required variables set to absent. File in: sam.master & fir177*nnn*, File out: sam177*nnn*.

>**passal** pastes salinity from the sal files into the sam files. File in: sal177*nnn*, File out: sam177*nnn*.

>**botcond** was used to: i. Calculate the salinity sample conductivity using the CTD pressure and temperatures at the bottle stops using PSTAR programme *peos83*, File out: sam177*nnn*.cal. ii. Create an appended file of sample data from all casts. File out: sam.appended.cal.

>pload loads the appended sample file sam.appended.cal into MATLAB. Calibrations were then derived using MATLAB.

9.4 CTD Calibration

J. Watson and S. Cunningham

>**ctd_cal.m** was the *MATLAB* script used to generate statistical and functional calibration information. Variables involved are: botcond (bottle conductivity), botcond/cond (bottle divided by CTD upcast conductivity), btc – uc (bottle – CTD upcast conductivity).

Prior to calibration of the CTD conductivities, plots of the deep θ/S revealed a significant offset between bottle and CTD salinities. The primary conductivity sensor was around 0.02 fresh in salinity and the secondary conductivity around 0.015 fresh on constant θ surfaces relative to the bottle salinities. Also on our two deepest stations 001 and 002 there was a significant hysteresis between down and up casts with the upcast being around 0.001 saltier than the down cast. The remaining stations are not deeper than 3000 dbar and no hysteresis is evident.

At the end of the cruise the CTD conductivity and temperature sensors were returned to SeaBird for post-cruise calibrations. These calibrations confirmed the general size of the offset since the last calibration (which is much larger than the expected for these sensors), but did not identify any problem with the conductivity sensors. The explanation forwarded by the UKORS CTD group is biofouling of the sensors. At present they are implementing a new cleaning routine procedure using a mild bleach solution as now recommended by SeaBird.

The usual correction applied to CTD conductivity is a slope correction to account for sensor drift (usually lower values with time). This is often calculated as the station mean ratio of bottle to CTD conductivity:

$$K = \langle C_{bot}/C_{CTD} \rangle$$

where C_{bot} is the bottle conductivity obtained from the measured bottle salinity and CTD pressure and temperature at the bottle depth and C_{CTD} is the upcast CTD conductivity average over 10 s at the time of the bottle closure.

However because of the unexpectedly large shift of CTD conductivity relative to the bottles we calibrated CTD conductivities by first obtaining coefficients a and b in the following fit to all stations,

$$C_{bot} - C_{CTD} = a + b \times C_{bot}$$

so that the corrected CTD conductivities are obtained by,

$$C_{CTD\_corrected} = (a/1-b) + C_{CTD} \times (1/1-b)$$

Bottle minus CTD conductivity differences greater than ±0.1 mS/cm were rejected from the calibration dataset, as were bottles with a K greater than 1.001. For the remaining data, the mean (μ) and standard deviation (σ) are recomputed and differences greater than $\mu \pm 2\sigma$ are rejected.

A final station-by-station offset to conductivity was obtained by fitting a 2nd order polynomial to the station average of the resulting residuals,

$$C_{bot} - C_{CTD} = 0.00259 - 0.001432 \times C_{bot} + 0.000157 \times C_{bot}^2$$

giving the following conductivity offsets (Table 9.1) that were added to each station.

The final calibrated bottle-CTD conductivity residuals are shown in Figure 9.1. Over the full water column for 62/72 points conductivity residuals are 0.000028 ± 0.0014 mS/cm. For bottles deeper than 2500 dbar the residuals are 0.0000 ± 0.0012 mS/cm.

Station	Conductivity offset
	mS/cm
1	0.0006
2	-0.0009-
3	-0.0006
4	0.0010
5	0.0003
6	-0.0004

Table 9.1: Conductivity offsets applied to each station

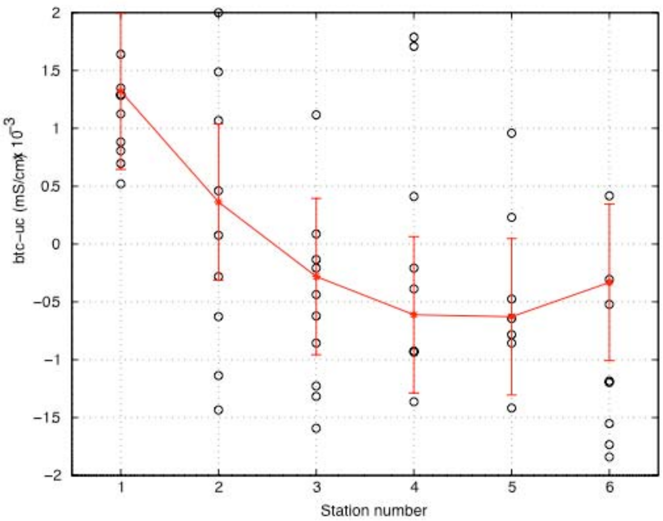


Figure 9.1 Conductivity differences against station number for calibrated data

>ctd_calibrate was used to apply K to the 1hz files. File in: ctd177*nnn*.1hz, File out: ctd177*nnn*.1hz & ctd177*nnn*.10s. From these calibrated datasets the rest of the file types (.2db, .ctu, .24hz, fir177*nnn*, sam177*nnn*) were generated by the method described above in the CTD path.

>position.exec was then used to create a file with positions at the three times from the ctd177001.1hz file corresponding to the start down, maximum pressure and end up cast data positions. The user is also given the option of adding the position at the bottom of the downcast (nadir position) to the .1hz, .10s, fir, and sam files. File in: ctd177*nnn*.1hz & abnv177 (master gps navigation file), File out: *nnn*.position.

>position_CD177.exec was used to add the maximum downcast (nadir) position to 1hz, 10s, fir, 24hz, and sam files.

>adddepth.exec was used to add the corrected echo sounding depth to the position files. File in: five minute averaged corrected depth (sim177k1.ed5min) & position.*nnn*, File out: position.*nnn*.

statnum	year	mm	dd	hhmmss	lat	lat	lon	lon	pmin	pmax	cordepth
					deg	min	deg	min	dbar	dbar	m
1	2005	11	18	093718	28	54.67	-15	55.79	1	2025	3623.5
2	2005	11	24	194909	23	47.40	-24	5.67	3	5121	5084.5
3	2005	11	25	003125	23	47.36	-24	5.77	1	3041	5084.3
4	2005	11	25	210405	23	55.88	-24	2.85	1	3043	5091.4
5	2005	11	26	010503	23	56.01	-24	2.45	1	3043	5091.1
6	2005	11	26	050116	23	56.03	-24	2.1	1	3039	5089.9

Table 9.2: Summary of CTD station times and positions.

9.5 References

Cunningham, S. A., 2005: RRS Discovery Cruise 279, 04 APR - 10 MAY 2004: A transatlantic hydrographic section at 24.5°N. Cruise Report No. 54, 150 pp.

10. Surface Temperature and Salinity

E. Vidal Vijande

Temperature and salinity data measured by the onboard thermosalinograph was logged continually to the dedicated PC. On a daily basis it was converted from raw RVS format to PSTAR format. Sensor calibrations were applied and the data merged with positions from the bestnav file.

This was done using two main execs:

surexec0 : Convert the raw data to PSTAR format

surexec1 : Edit data within sensible ranges, edit for spikes and interpolate
Apply sensor calibrations
Change variable names and units
Create sea surface pressure value of zero to convert conductivity to salinity
Merge in positions from bestnav file.

Erroneous data spikes and all data collected during the time spent in port was edited out of the PSTAR files using the editing program *plxyed*.

To calibrate salinity measurements from the underway data recorded by the thermosalinograph, bottle salinities were collected from the uncontaminated water supply at four hour intervals during daytime hours only (genearlly between 08:00 and 20:00). Time of sample collection was accurate to 30 seconds.
Sampling was interrupted during slow ship speed periods (mooring recovery /deployment and CTD casts).

11. Water Sample Salinity Analysis

E. Vidal Vijande and P. Staley

11.1 Equipment

All salinity sample analysis was performed on the AUTOSAL Guildline 8400B Salinometer in the Constant Temperature (CT) laboratory. The water bath temperature was set to 21°C and the laboratory temperature oscillated between 17.5 and 19°C.

11.2 Sample Collection and Analysis

Water samples were collected from both the uncontaminated water supply (TSG) and CTD casts. All samples were taken in 200 ml glass sample bottles, rinsed three times and sealed with disposable plastic stoppers and screw on caps after drying the cap and neck. Samples were stored in the CT lab for a minimum of 24 hours prior to analysis to allow equilibration to the laboratory temperature, except for the samples from the uncontaminated water supply which were placed in the CT lab six hours prior to analysis (all but the last bottle had been in the air conditioned wet lab for at least 24 hours).

Six CTD casts were executed, one test cast with 24 bottles being fired and five casts for Microcat calibration purposes where only 12 bottles were fired each time.

Analysis followed the standard procedure. A sample of IAPSO Standard Sea Water was run every 12 samples for salinometer calibration. Three Standard Seawater batches were used: P145 from cast one (test) up to cast six, except the last calibration of cast five where P146 was used. The TSG sample calibration used P146 for the first calibration and P144 for the end calibration. The RS value was adjusted at the beginning of the cruise and was left fixed for the remainder of the cruise. Philip Staley and Enrique Vidal carried out all analysis.

The Raw conductivities from the salinometer were converted to salinities using an Excel spreadsheet, accounting for calibration of the salinometer itself.

12. Mooring Operations

R. McLachlan

12.1 Day to Day Mooring Operations

12th November.
Drove down from Southampton and arrived at ship at 1600.
Sailed from Falmouth at 1700.

13th November.
Unpacked instrumentation from container.

Set up lab and put new batteries in seabirds.
Serviced and put new batteries in the following releases; 243, 439, 326, 263 and 370.

14th November.
Finished off preparing seabirds.
Installed batteries in MMP, fitted Seabird and successfully communicated with the instrument.
Produced working mooring diagrams.

15th November.
Unpacked and started up telemetry buoy, light on buoy flashed on indicating that it was working. Sent an email to Jon Campbell to let him know. Received a message from Jon that the buoy was talking away merrily.
Unpacked all the telemetry wires and connected them together with swivels and bridles, carried out an electrical test, all was working well.
Wound EB1 telemetry mooring on to reeler.

16th November.
Wound EB2 on to reeler. Put mooring table in to position, changed aft rails for chains.

17th November.
Assembled EBADCP. Started to paint double barrel winch.

18th November.
Serviced mooring table rollers. Continued painting double barrel winch.
Docked at Tenerife at 1630.

19th November.
Set up broadband ADCP for deployment.
Set up PIES and assembled in frames with anchor attached.
Sailed at 1700 heading for EBADCP/EBP2 sites as we didn't need the bow thruster for the deployment, ETA. 0900.

20th November.
Deployed EBADCP at 0900 using both aft cranes in synchronisation.
Steamed to PIES site, deployed EBP2 at 1100 with one lift straight over using aft STBD crane with release hook.
Heading back in to Tenerife to collect bow thruster parts.

21st November.
Docked at Tenerife at 0900.

22nd November.
Sailed at 1100.
Changed over reeler drums ready for recovery operations.
Made up recovery lines for reelers.

23rd November.
Made up all the glass.
Test fitted SBE clamps on to CTD frame, minor adjustments made.

Prepared deck for recovery operations.

24th November.
Recovered EB1.
Wire tested releases, all fired fine apart from s/n 440. This unit needs to go back to Ixsea for repair.
Prepared EB1 ready for deployment.

25th November.
Deployed EB1 telemetry, all SBEs, apart from last two confirmed working by Jon Campbell.
Recovered EB2 (MMP mooring) – major wire tangles.

26th November.
Messages from Jon Campbell show that the top microcat on EB1 is at 16m depth when should have been at 50m.
Deployed EB2 (MMP mooring). 65m has been taken out of the mooring length as we believe we have a 1-2% error on the counting wheel. Chased subsurface buoyancy to watch down, submergence confirmed by the Gonio and Argos beacon. Triangulated releases.

27th November.
Started packing gear away, prepared deck for EB2 lost mooring recovery.

28th November.
Interrogated lost EB2 releases. The mooring was released, however, due to the weight of wire, the buoyancy never reached the surface. Insufficient back up buoyancy to lift the remains of the mooring. We then boxed in the releases in preparation for dragging operations.
Due to deteriorating weather conditions (the worst Tenerife has seen for 50 years), it was decided to abandon the emergency recovery of the mooring.

29th November.
Docked.

12.2 Acoustic Releases

The acoustic releases used throughout the array are IXSEA AR861 and IXSEA RT661 units. The acoustic releases used on this cruise were originally going to be deployed using a new doubling system with stainless oval links in the release jaw, and a galvanised chain joining the two links. This chain would pass through a large round galvanised link that is attached to the anchor. Firing either release would drop one end of the chain, which would be pulled through the large round link allowing the mooring to surface. If for any reason it snagged then the second release could be fired too. Each shackle would be shielded from the stainless link in the release jaws through use of a welded plate of stainless and a bush. A similar system is being used by IFREMER.

Prior to deployment however, concerns were raised about the quality of the stainless and the welding. To this end we reverted back to the in series system used on CD170.

13. Anchor Triangulation Process

D. Rayner

On the service cruises CD170 and KN182-2 (National Oceanography Centre Cruise Report, No 2) a routine was written to triangulate the most likely anchor position from three slant ranges around the suspected site. This routine was modified on CD177 to allow multiple slant ranges and position fixes.

Slant ranges were determined using the release deck unit patched into the PES fish transducer. These ranges and the position were entered into a text file and the Matlab routine *Anchor.m* then calculates actual ranges to the anchor site using the measured water depth. Loci are then plotted, with the intersect being the most likely anchor seabed position.

The height of the releases above the seabed and the depth of the transducer need to be entered, along with the uncorrected water depth.

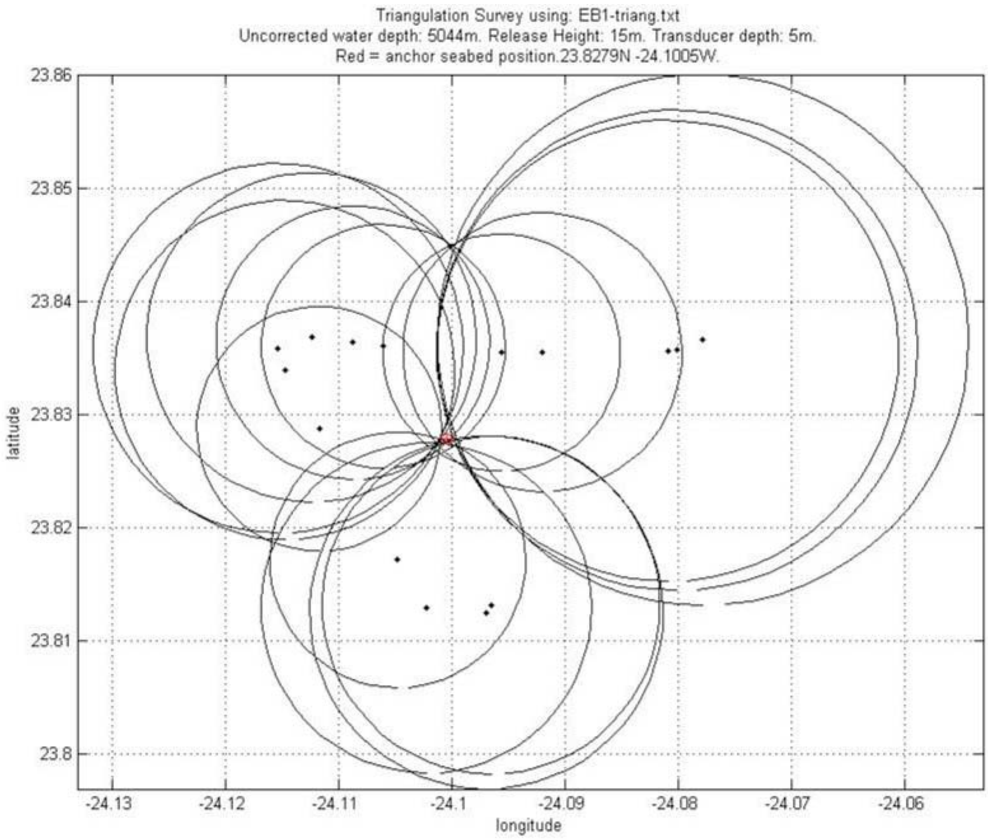


Figure 13.1: Example plot of triangulation of anchor seabed position. Range recorded at each point with interception of loci giving anchor position.

14. Mooring Dates, Locations and Depths

Mooring	UKORS Mooring Number	Deployment Date	Deployment Time	Recovery Date	Comment
EB1	2005/16	10/04/2005	08:45	24/11/2005	Mooring recovered intact
EB2	2005/18	10/04/2005	15:08	25/11/2005	MMP damaged on recovery and battery depleted early. Microcat 3917 battery depleted early.
EB2	2004/08	28/02/2004	21:17	N/A	Mooring lost in 2004. Attempted recovery 28/11/2005 but not enough buoyancy to bring releases to surface
EBADCP	2005/63	20/11/2005	09:12	N/A	Redeployment of ADCP recovered by Poseidon in Spring 2005
EBP2	2005/65	20/11/2005	11:04	N/A	
EBP1	2005/64	25/11/2005	04:06	N/A	
EB1	2005/61	25/11/2005	12:52	N/A	Telemetry system deployed
EB2	2005/62	26/11/2005	13:57	N/A	

Table 14.1: Summary details of recovery and deployment dates

Mooring	UKORS Mooring Number	Lat (ºN) A/L	Lon (ºW) A/L	Corrected Water Depth (m)	Lat (ºN) A/B	Lon (ºW) A/B	Argos ID
EBADCP	2005/63	27º55.79	13º22.76	416			21442
EBP2	2005/65	27º51.86	13º31.16	1010			
EBP1	2005/64	23º48.52	24º06.50	5094			
EB1	2005/61	23º49.52	24º06.00	5093	23º49.67	24º06.03	42749
EB2	2005/62	23º53.4	24º03.32	5086	23º53.49	24º03.39	42745

Table 14.2: Mooring locations, deployment dates and Argos beacon details. (A/L = Anchor launch position. A/B = Anchor position on bottom determined from triangulation.)

15. Instruments

D. Rayner

15.1 Summary of Instruments Recovered and Deployed

In total 28 SeaBird Microcat SMP CTDs, two Aanderaa RCM11 current meters and one McLane Moored Profiler (MMP) were recovered. Replacing these were 24 Inductive Microcats, four standard Microcats, two Aanderaa RCM11s and one MMP. In addition to these instruments two Pressure Inverted Echosounders, supplied by the University of Rhode Island, and one RD Instruments Broadband ADCP were deployed. Details of the setup parameters used for the deployed instruments can be found in Appendix B, detailing each instrument by mooring.

15.2 Instrument Problems

There were problems experienced with the inductive Microcats when downloading data from the CTD calibration casts. The Seabird software tries to download the data in blocks of 200 records using the *dd1,200* style command where 1 refers to the 1st record to download and 200 the last. The software receives the data reply from the instrument and saves it to an ascii file without displaying it to the screen. At times however, data could be seen written to the screen instead of the ascii file. This meant that the saved file was incomplete and as the capture setting has to be disabled for download this data could not be recovered without re-downloading the instrument. This was seen to occur as the *dd1,200* style command incremented to the next record block.

To retrieve the data, it was necessary to download the data in blocks of 200 records using the *dd1,200* style command from the command line and capture the screen text to file, rather than using the software's download routines. This is a user-intensive method as the user has to manually enter the command every 200 scans, with the total download taking several hours per instrument.

The same problem was experienced on the 2005 Spring service cruise upon the *RV Knorr.* The reason for this fallout of data download has never been found and it has not been able to be recreated in the lab at NOC. Seabird have been contacted but they too cannot recreate the problem. We plan to write a routine that will enable automatic download of the IMPs through the screen capture method, thus bypassing the problem without actually solving it. Further studies will be made on the forthcoming Spring service cruises

The recovered MMP was found to have depleted its batteries after approximately six months. This was one month before recovery, but the deployment parameters used were determined using a total profiling limit of 1,000,000 metres and should have permitted the MMP to run for the full year.

Since the cruise we have been informed by the manufacturer that a revised estimate of total profiling distance of 800,000 metres should be used for future deployments.

16. Instrument Calibration Using CTD Casts

D. Rayner

As with the Spring 2005 service cruises, calibration of the instruments measuring conductivity and temperature was conducted using the ship's CTD system. Once recovered instruments had been downloaded they were set to the fastest possible sampling rate, attached to the CTD frame and lowered to depth as per a normal CTD cast. Bottle stops on the upcast were extended to 5 minutes (2 minutes longer than previously used) to provide time for the instruments to stabilise relative to the more accurate ship's CTD.

Twelve sample bottles were removed from the CTD frame to allow the instruments to be attached using bespoke brackets. Details of instruments deployed on calibration casts are given in Appendix E.

17. Attempted Recovery of EB2

D. Rayner

The mooring deployed at EB2 in 2004 from cruise D277 was not found on the 1st service cruise CD170 in Spring of 2005. The top buoy was recovered by *RRS Discovery*, during a transit cruise, about 150 km from the original deployment position. No acoustic release deck unit was on board at the time of recovery so it was not possible to attempt interrogation of the EB2 releases.

It was thought that the buoy was free drifting to have travelled so far from the deployment position but the opportunity was taken on CD177 to pass over the location of the top buoy recovery and sound for the releases. The releases were found, with a diagnostic implying the releases were upright. It is suspected that the anchor was underweight and the mooring bounced away from the deployment position when subjected to stronger tidal currents. The location was marked for an attempt at recovery during the transit back to Tenerife from the new EB2 position.

On return to the site the releases were fired and a confirmed release received. The initial ascent rate was calculated to be approximately 60 m/min but this was seen to decrease as the amount of wire lifted by the buoyancy increased. A quick calculation of the backup buoyancy indicated that there was insufficient to lift the mooring to the surface.

Approximately two hours after firing the releases the ascent rate was negligible. A triangulation survey was conducted using the procedure described in section 14, and the position determined. It was estimated that the releases had reached approximately 1300 m below the surface (see figure 17.1 for the triangulation survey).

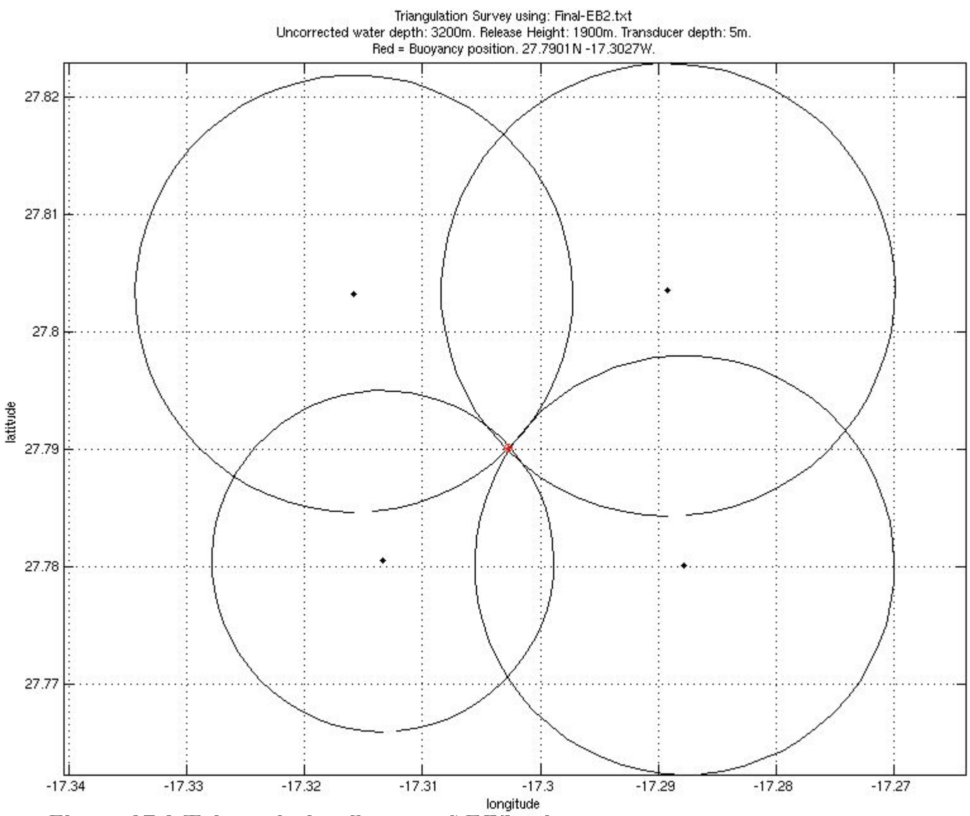


Figure 17.1 Triangulation Survey of EB2 releases

It is thought that the loss of the top buoy caused the mooring to collapse to the seabed as the only remaining buoyancy was immediately above the releases. This pack of ten glass spheres would provide approximately 240kg of lift, but the total water weight of wire, releases and instruments thought to be still attached is approximately 335 kg. This implies that there is approximately 95kg of weight holding the mooring in place.

The option of dragging for the mooring was discussed, but with deteriorating weather the decision was taken to abandon the site and if possible attempt recovery on a subsequent cruise.

18. PIES Deployments

T. Kanzow and D. Rayner

Following deployment of the two PIES their descent rate was monitored and the telemetry option tested: the ship then repositioned and the transducer was lowered over the side. The PIES were supplied with the Matlab routine PPDTb.m to conduct telemetry and this was tested on PC laptops using a stand alone version of Matlab so that connection to the network was not required. After a number of measurement cycles have passed, burst telemetry can be used to verify the correct operation of the PIES.

18.1 Burst telemetry at EBP2

Serial Number: 131
Codes: XPND 70
TELEM 66
BEACON 74
RELEASE 3
CLEAR 76
Position: 27 51.86'N 13 31.15'W
Date: 20/11/05 11:03:15 (GMT)
Water Depth: 1020 m
Descent Rate: could not be measured, PIES had already reached sea floor when transducer was deployed
Communication: Good communication after switching off the echosounder, range of 1020 m.
Telemetry: PPDTb.m Matlab routine supplied by Randy Watts from URI was not stable; it crashed if pulses were not received properly. Software was modified by Torsten Kanzow and Darren Rayner to be more robust. Current version: PPDTb_v3.m

18.2 Burst telemetry at EBP1

Serial Number: 136
Codes: XPND 69
TELEM 65
BEACON 73

RELEASE 8
CLEAR 76
Position: 23 48.50'N 24 06.47'W
Date: 25/11/05 04:06:40 (GMT)
Water Depth: 5090m (corrected)
Descent Rate: ~ 90 meters / minute
Burst telemetry survey conducted between 05:27 and 07:17.
Programme used: PPDTb_v3.m
Settings: Gain 6 for all 8 channels
Connection: USB to serial converter
Recommendations: use gain 6 for all channels, but gain 8 for CH02. Reason for bad reception could either be related to CH02 on DS 7000 or to signal strength of PIES on that frequency (12.5 kHz). Could be checked by receiving 12.5 kHz signal on other channel to see if problems prevail.

Appendix A: Extra Figures

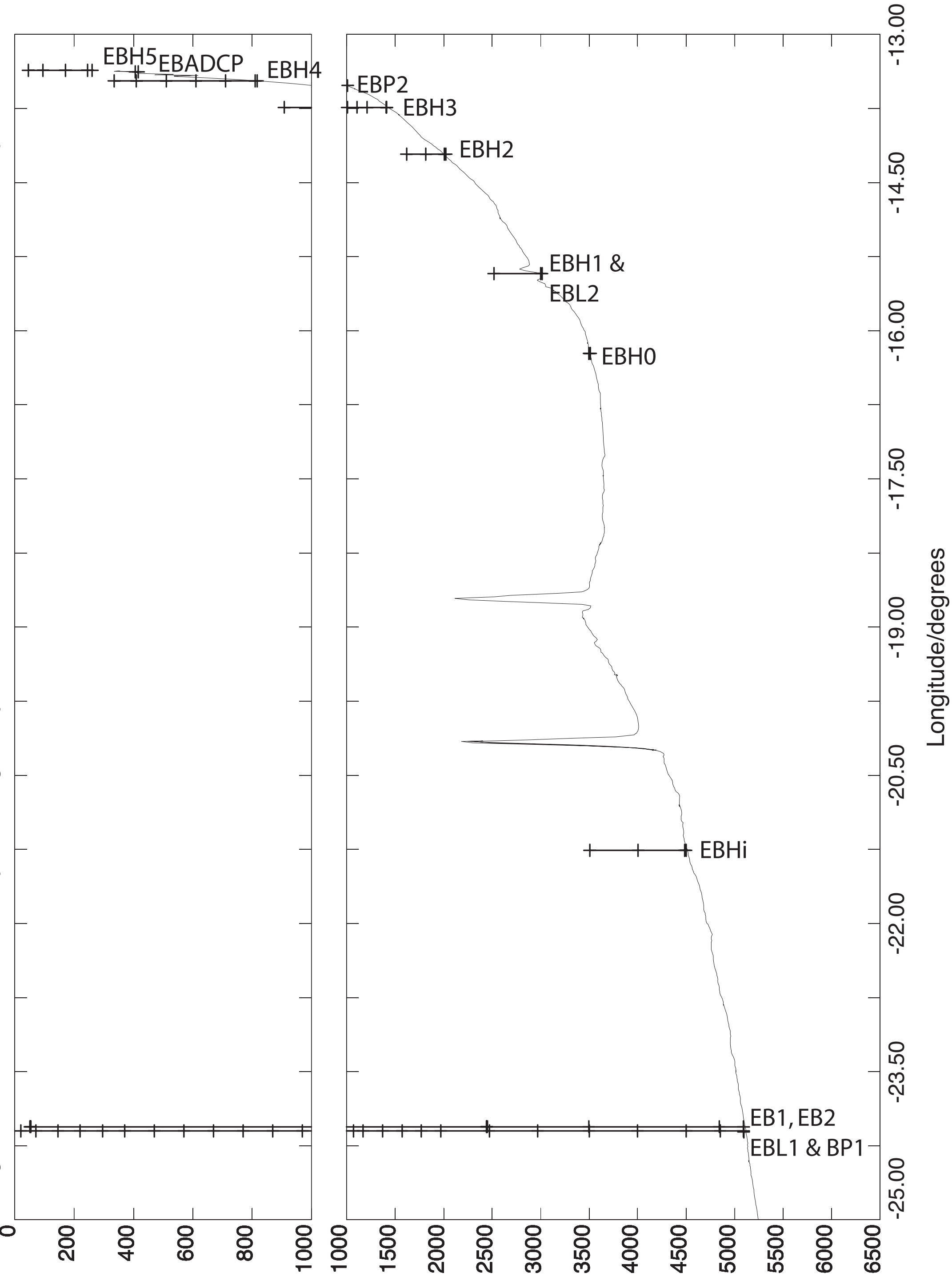


Figure A.1: Eastern Boundary Mooring Array After November 2005 - crosses show instrument positions

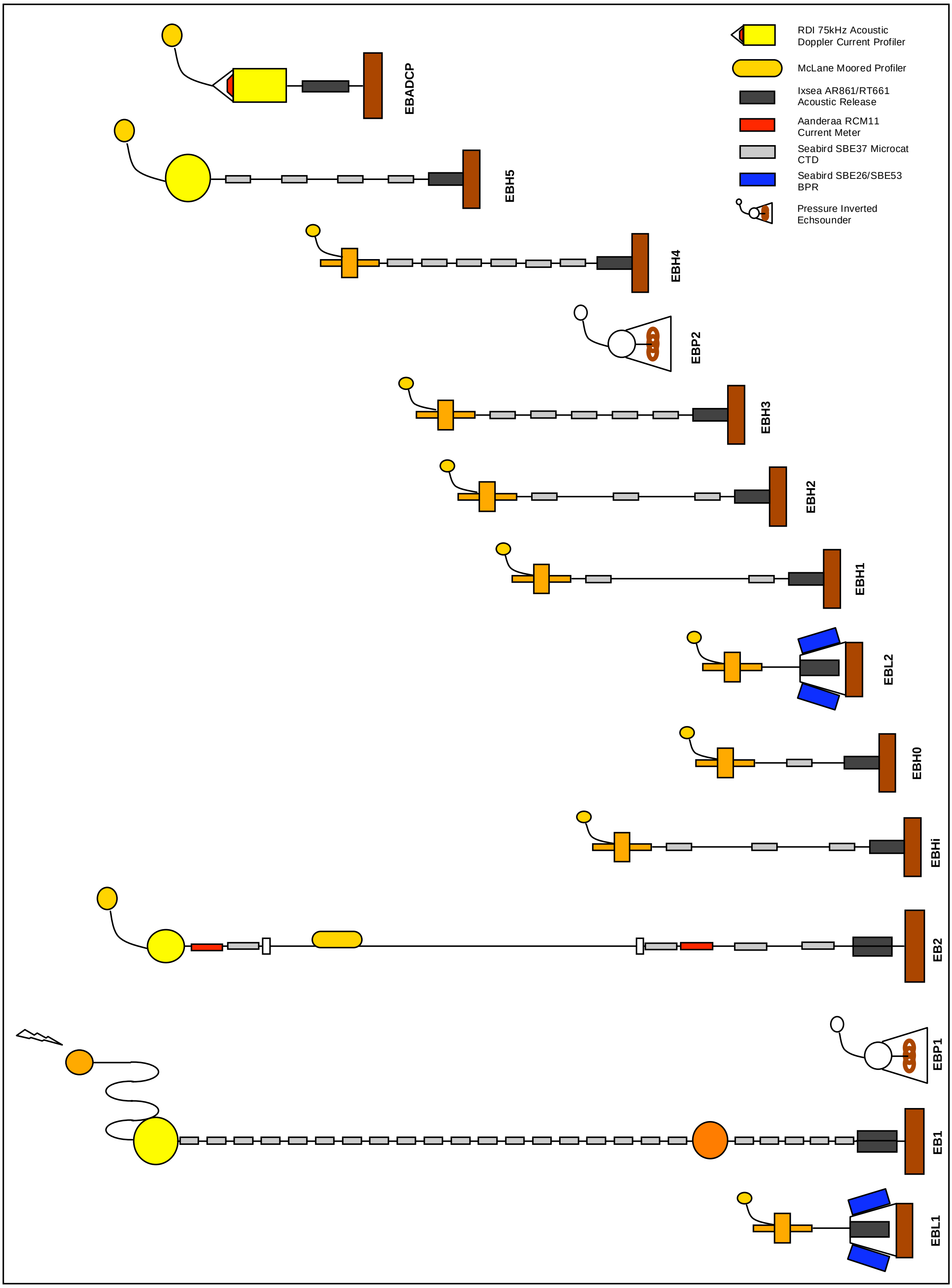


Figure A.2: Schematic of Eastern Boundary Mooring Array After November 2005.

Figure A.3: Mooring diagram of EBADCP_3_200563 as deployed on CD177

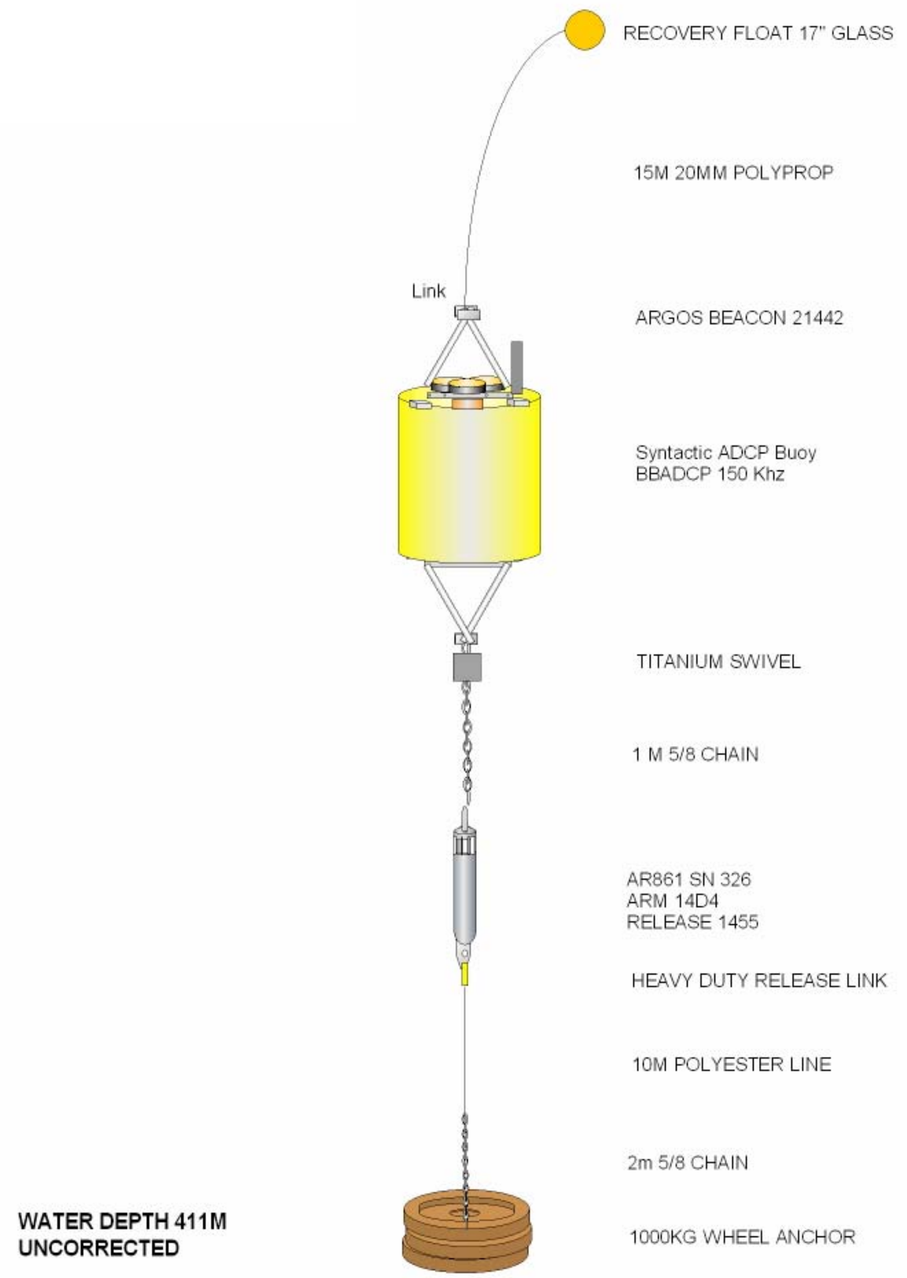


Figure A.4: Mooring diagram of EBP2 as deployed on CD177

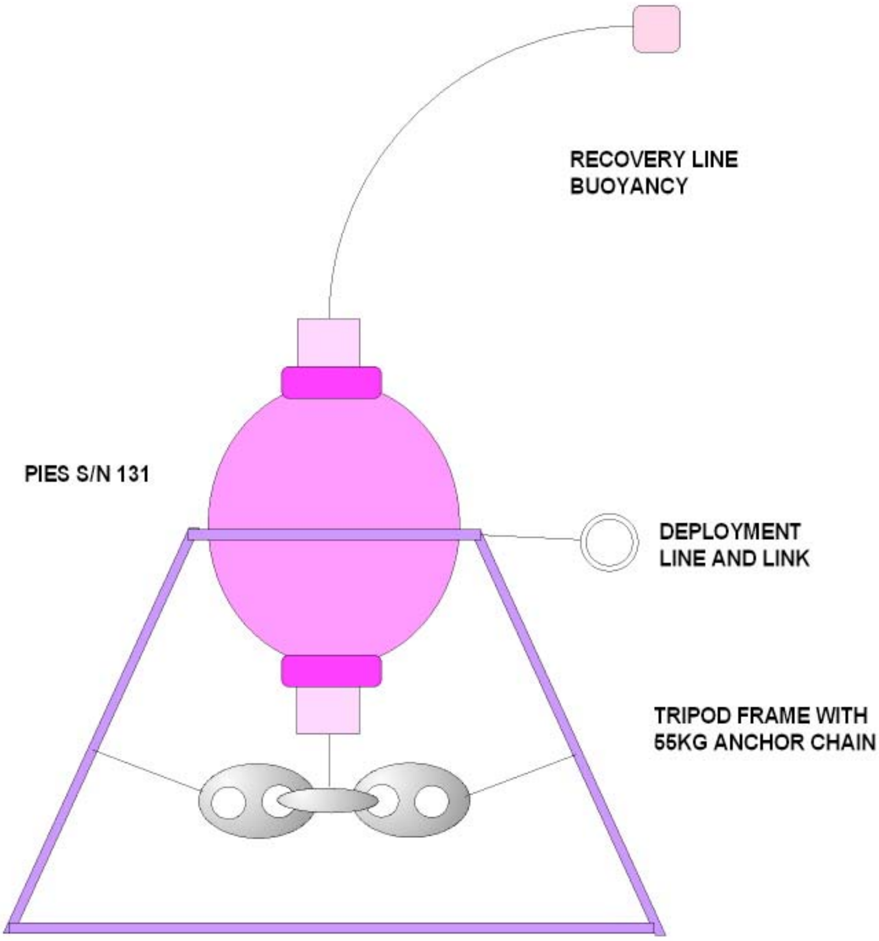


Figure A.5: Mooring diagram of EBP1 as deployed on CD177

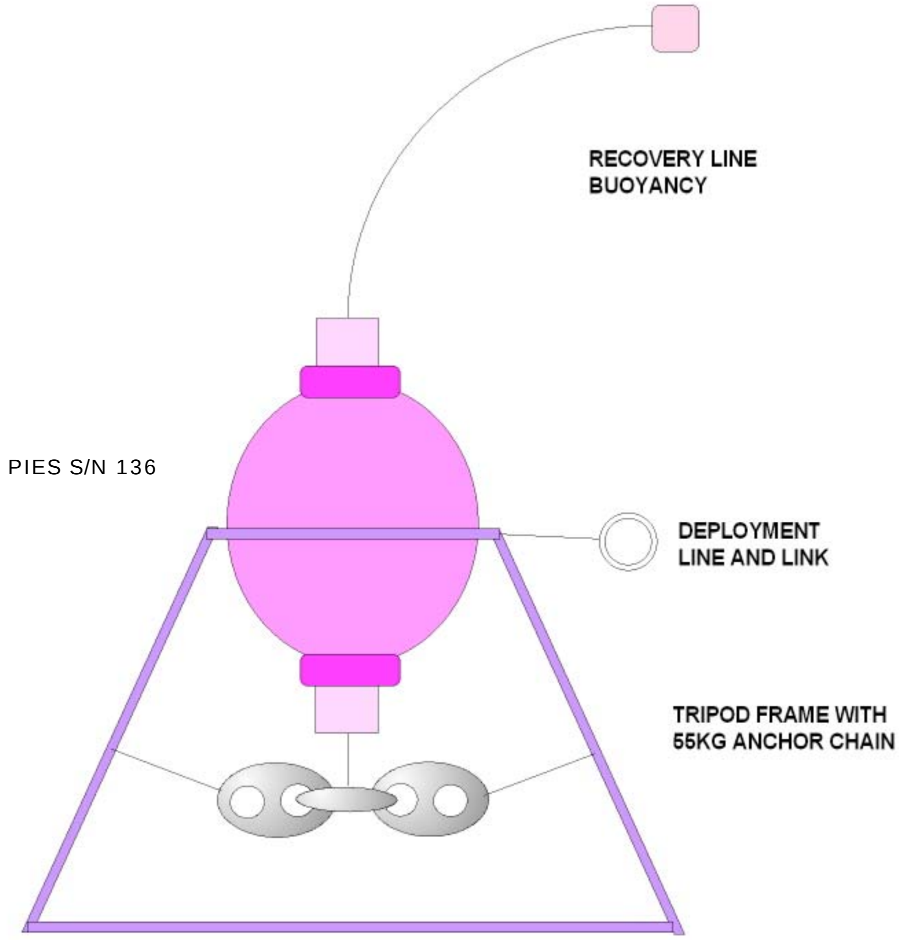
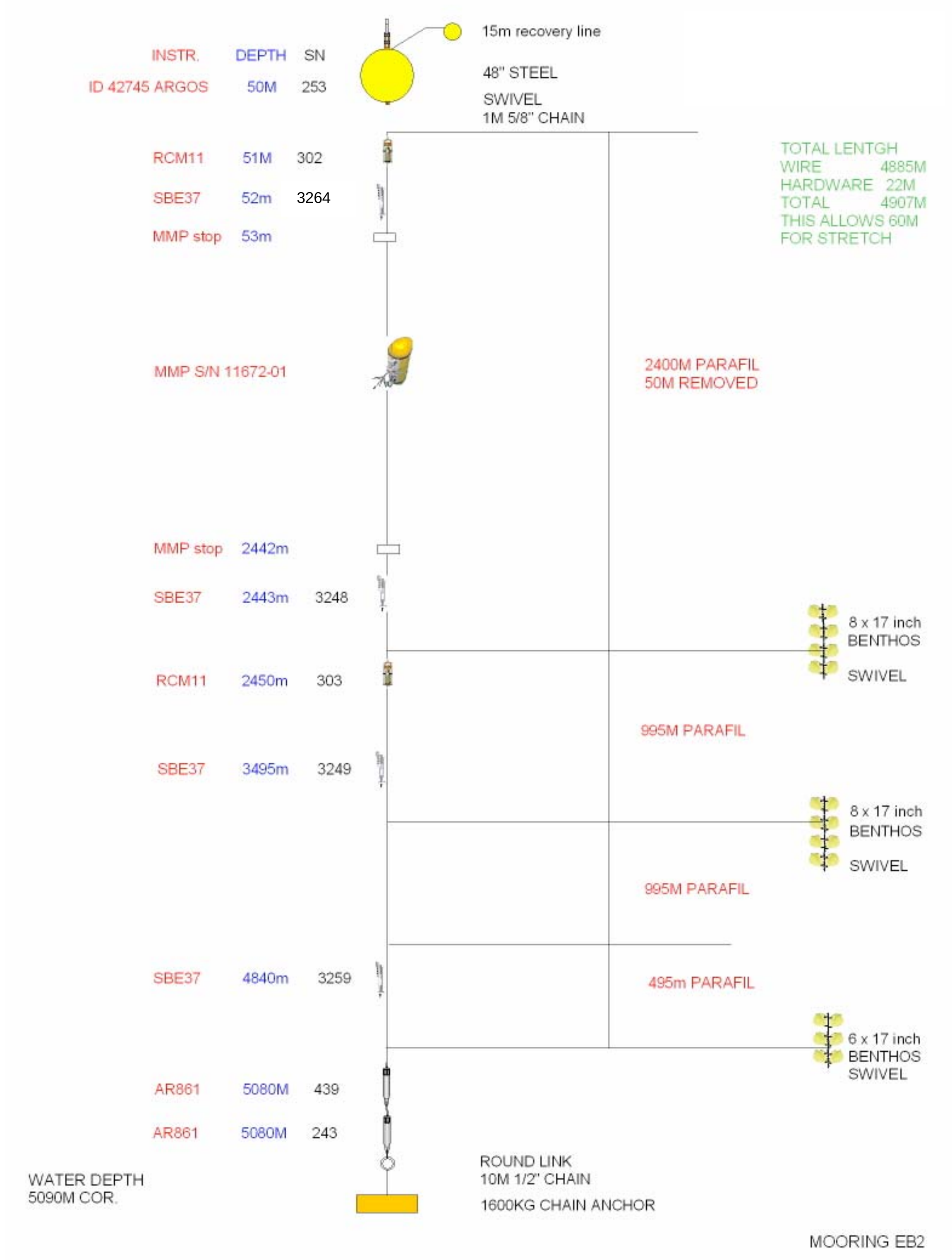


Figure A.6: Mooring diagram of EB1_3_200561 as deployed on CD177

Figure A.7: Mooring diagram of EB2_4_200562 as deployed on CD177



Appendix B: Instrument Setup Details

EBADCP

RD Instruments 150kHz Broadband ADCP – Serial Number **1184**

System frequency	150kHz
Beam angle	20 degrees
System Power	Low
Water temperature	15 deg C
Water salinity	35ppt
Depth of transducer	430m
WT Pings per ensemble	16
Depth cell size	12.00m
Number of depth cells	40
Blank after transmit	4.00m
WT profiling mode	4
WT ambiguity velocity	480cm/s
BT pings per ensemble	0
Time between ping groups	0.00s
Time per ensemble	00:20:00:00
Deployment length	450 days
Velocity collected	YES
Coordinate system	Earth
Correlation collected	YES
Intensity collected	YES
Percent good collected	YES
Status collected	YES
Enable recorder	YES
Enable serial output	NO
Baud rate	38400
Start date	19/11/05
Start time	13:00:00

EBP2

University of Rhode Island PIES – serial number **131**

Mission statement	EBP2 November 2005 deployment from cruise CD177
Travel time measurements	4 pings every 10 minutes
Pressure and temperature	measured every 10 minutes
Telemetry data file	enabled
Estimated water depth	1000m
Acoustic lockout	1.20 seconds
Acoustic output	172dB
Release date/time	Sat Jun 30, 2012. 12:00:00

EB2

Aanderaa RCM11 – serial number **302**

Pings per ensemble	600
Temperature range	High
Conductivity range	45-55mS (rollover on)

Recording interval	30 mins
No of channels	8
Mode	Burst
Instrument started	26/11/05 01:30:00

Seabird SBE37 SMP CTD – serial number **3264**

Sample interval	900 seconds
Start date	26/11/2005
Start time	06:00:00

McLane Moore Profiler – serial number **11672-01**

Comprising
MMP electronics – serial number **5236**
Seabird SBE41 CP – McLane V1.0 – serial number **0705**
FSI ACM – serial number **1683**

Start date	26/11/2005
Start time	18:00:00
Profile start interval	2 days 5 hours
Reference date	27/11/2005
Reference time	18:00:00
Burst interval	Disabled
Paired profiles	Enabled
Shallow pressure limit	52 dbar
Deep pressure limit	2500 dbar
Shallow pressure error	100 dbar
Deep pressure error	100 dbar

Aanderaa RCM11 – serial number **303**

Pings per ensemble	600
Temperature range	Arctic
Conductivity range (rollover on)	32-34mS (rollover on)
Recording interval	30 mins
No of channels	8
Mode	Burst
Instrument started	26/11/05 02:00:30

Seabird SBE37 SMP CTD – serial number **3248**

Sample interval	900 seconds
Start date	26/11/2005
Start time	06:00:00

Seabird SBE37 SMP CTD – serial number **3249**

Sample interval	900 seconds
Start date	26/11/2005
Start time	06:00:00

Seabird SBE37 SMP CTD – serial number **3259**

Sample interval	900 seconds
Start date	26/11/2005
Start time	06:00:00

<u>EB1</u>

Seabird SBE37 IMP CTD – serial number **3242**

ID Number	31
Sample interval	900 seconds
Start date	25/11/2005

Start time	08:00:00

Seabird SBE37 IMP CTD – serial number **3241**

ID Number	32
Sample interval	900 seconds
Start date	25/11/2005
Start time	08:00:00

Seabird SBE37 IMP CTD – serial number **3240**

ID Number	33
Sample interval	900 seconds
Start date	25/11/2005
Start time	08:00:00

Seabird SBE37 IMP CTD – serial number **3239**

ID Number	34
Sample interval	900 seconds
Start date	25/11/2005
Start time	08:00:00

Seabird SBE37 IMP CTD – serial number **3284**

ID Number	35
Sample interval	900 seconds
Start date	25/11/2005
Start time	08:00:00

Seabird SBE37 IMP CTD – serial number **3283**

ID Number	36
Sample interval	900 seconds
Start date	25/11/2005
Start time	08:00:00

Seabird SBE37 IMP CTD – serial number **3282**

ID Number	37
Sample interval	900 seconds
Start date	25/11/2005
Start time	08:30:00

Seabird SBE37 IMP CTD – serial number **3281**

ID Number	38
Sample interval	900 seconds
Start date	25/11/2005
Start time	08:30:00

Seabird SBE37 IMP CTD – serial number **4475**

ID Number	39
Sample interval	900 seconds
Start date	25/11/2005
Start time	08:30:00

Seabird SBE37 IMP CTD – serial number **4474**

ID Number	40
Sample interval	900 seconds
Start date	25/11/2005
Start time	08:30:00

Seabird SBE37 IMP CTD – serial number **4473**

ID Number	41
Sample interval	900 seconds
Start date	25/11/2005
Start time	08:30:00

Seabird SBE37 IMP CTD – serial number **4472**

ID Number	42
Sample interval	900 seconds
Start date	25/11/2005
Start time	08:30:00

Seabird SBE37 IMP CTD – serial number **4471**

ID Number	43
Sample interval	900 seconds
Start date	25/11/2005
Start time	08:30:00

Seabird SBE37 IMP CTD – serial number **4470**

ID Number	44
Sample interval	900 seconds
Start date	25/11/2005
Start time	08:30:00

Seabird SBE37 IMP CTD – serial number **4469**

ID Number	45
Sample interval	900 seconds
Start date	25/11/2005
Start time	08:30:00

Seabird SBE37 IMP CTD – serial number **4468**

ID Number	46
Sample interval	900 seconds
Start date	25/11/2005
Start time	08:30:00

Seabird SBE37 IMP CTD – serial number **4467**

ID Number	47
Sample interval	900 seconds
Start date	25/11/2005
Start time	08:30:00

Seabird SBE37 IMP CTD – serial number **4466**

ID Number	48
Sample interval	900 seconds
Start date	25/11/2005
Start time	08:30:00

Seabird SBE37 IMP CTD – serial number **4465**

ID Number	49
Sample interval	900 seconds
Start date	25/11/2005
Start time	08:45:00

Seabird SBE37 IMP CTD – serial number **4464**

ID Number	50
Sample interval	900 seconds
Start date	25/11/2005
Start time	08:45:00

Seabird SBE37 IMP CTD – serial number **4463**

ID Number	51
Sample interval	900 seconds
Start date	25/11/2005
Start time	08:45:00

Seabird SBE37 IMP CTD – serial number **4462**

ID Number	52
Sample interval	900 seconds
Start date	25/11/2005
Start time	08:45:00

Seabird SBE37 IMP CTD – serial number **4461**

ID Number	53
Sample interval	900 seconds
Start date	25/11/2005
Start time	09:00:00

Seabird SBE37 IMP CTD – serial number **4460**

ID Number	54
Sample interval	900 seconds
Start date	25/11/2005
Start time	09:00:00

Appendix C: Instrument Record Lengths

Mooring	Instrument	Serial Number	Approx. depth (m)	Recovered?	Date of first useable record	Date of Last usable record
EB2	Aanderaa RCM11	448	50	Yes	10/4/05	25/11/05
	Seabird SBE37 SMP CTD	3276	51	Yes	10/4/05	25/11/05
	McLane Moored Profiler	11794-01	55-2490	Yes	10/4/05	20/10/05‡
	Seabird SBE37 SMP CTD	3917	2495	Yes	10/4/05	30/8/05‡
	Aanderaa RCM11	449	2510	Yes	10/4/05	25/11/05
	Seabird SBE37 SMP CTD	3920	3500	Yes	10/4/05	25/11/05
	Seabird SBE37 SMP CTD	3921	4850	Yes	10/4/05	25/11/05
EB1	Seabird SBE37 SMP CTD	3207	50	Yes	10/4/05	20/11/05
	Seabird SBE37 SMP CTD	3208	100	Yes	10/4/05	20/11/05
	Seabird SBE37 SMP CTD	3209	175	Yes	10/4/05	20/11/05
	Seabird SBE37 SMP CTD	3210	250	Yes	10/4/05	20/11/05
	Seabird SBE37 SMP CTD	3212	325	Yes	10/4/05	20/11/05
	Seabird SBE37 SMP CTD	3213	400	Yes	10/4/05	20/11/05
	Seabird SBE37 SMP CTD	3214	500	Yes	10/4/05	20/11/05
	Seabird SBE37 SMP CTD	3215	600	Yes	10/4/05	20/11/05
	Seabird SBE37 SMP CTD	3216	700	Yes	10/4/05	20/11/05
	Seabird SBE37 SMP CTD	3217	800	Yes	10/4/05	20/11/05
	Seabird SBE37 SMP CTD	3218	900	Yes	10/4/05	20/11/05
	Seabird SBE37 SMP CTD	3922	1000	Yes	10/4/05	20/11/05
	Seabird SBE37 SMP CTD	3923	1100	Yes	10/4/05	20/11/05
	Seabird SBE37 SMP CTD	3924	1200	Yes	10/4/05	20/11/05
	Seabird SBE37 SMP CTD	3925	1400	Yes	10/4/05	20/11/05
	Seabird SBE37 SMP CTD	3926	1600	Yes	10/4/05	20/11/05
	Seabird SBE37 SMP CTD	3927	1800	Yes	10/4/05	20/11/05
	Seabird SBE37 SMP CTD	3928	2000	Yes	10/4/05	20/11/05
	Seabird SBE37 SMP CTD	3929	2500	Yes	10/4/05	20/11/05
	Seabird SBE37 SMP CTD	3930	3000	Yes	10/4/05	20/11/05
	Seabird SBE37 SMP CTD	3931	3500	Yes	10/4/05	20/11/05
	Seabird SBE37 SMP CTD	3932	4000	Yes	10/4/05	20/11/05
	Seabird SBE37 SMP CTD	3933	4500	Yes	10/4/05	20/11/05
	Seabird SBE37 SMP CTD	3934	4850	Yes	10/4/05	20/11/05

‡ indicates battery failure

Appendix D: Details of Instruments Lowered on CTD Calibration Casts.

CTD Cast	Max Depth	Instrument details			
		Type	Serial numbers	Comment	Calibration type
1					
2		Microcat	3281		Pre-deployment
		Microcat	3282		Pre-deployment
		Microcat	3283		Pre-deployment
		Microcat	4460		Pre-deployment
		Microcat	4461		Pre-deployment
		Microcat	4462		Pre-deployment
		Microcat	4463		Pre-deployment
		Microcat	4464		Pre-deployment
		Microcat	4465		Pre-deployment
		Microcat	4466		Pre-deployment
		Microcat	4467		Pre-deployment
		Microcat	4468		Pre-deployment
3		Microcat	3239		Pre-deployment
		Microcat	3240		Pre-deployment
		Microcat	3241		Pre-deployment
		Microcat	3242		Pre-deployment
		Microcat	3284		Pre-deployment
		Microcat	4469		Pre-deployment
		Microcat	4470		Pre-deployment
		Microcat	4471		Pre-deployment
		Microcat	4472		Pre-deployment
		Microcat	4473		Pre-deployment
		Microcat	4474		Pre-deployment
		Microcat	4475		Pre-deployment
4		Microcat	3248		Pre-deployment
		Microcat	3249		Pre-deployment
		Microcat	3259		Pre-deployment
		Microcat	3264		Pre-deployment
		Microcat	3276		Post-deployment
		Microcat	3917		Post-deployment
		Microcat	3920		Post-deployment
		Microcat	3921		Post-deployment
		RCM11	302		Pre-deployment
		RCM11	303		Pre-deployment
5		Microcat	3207		Post-deployment
		Microcat	3212		Post-deployment
		Microcat	3214		Post-deployment
		Microcat	3215		Post-deployment
		Microcat	3923		Post-deployment
		Microcat	3925		Post-deployment
		Microcat	3929		Post-deployment
		Microcat	3930		Post-deployment
		Microcat	3931		Post-deployment

		Microcat	3932		Post-deployment
		Microcat	3933		Post-deployment
		Microcat	3934		Post-deployment
		RCM11	448		Post-deployment
		RCM11	449		Post-deployment
6		Microcat	3208		Post-deployment
		Microcat	3209		Post-deployment
		Microcat	3210		Post-deployment
		Microcat	3213		Post-deployment
		Microcat	3216		Post-deployment
		Microcat	3217		Post-deployment
		Microcat	3218		Post-deployment
		Microcat	3922		Post-deployment
		Microcat	3924		Post-deployment
		Microcat	3926		Post-deployment
		Microcat	3927		Post-deployment
		Microcat	3928		Post-deployment

Appendix E: Mooring Deployment and Recovery Log Sheets.

UKORS MOORINGS GROUP

CRUISE CD177 **MRG ID:** EB1

FALMOUTH - UK PJS RECOVERY **UKORS ID**

LATITUDE	23 49 01278N	**DATE**	24/11 328
LONGITUDE	024 05 44071W	**DAY**	Thursday

NOTE ALL TIMES RECORDED IN GMT

COMMENCE TIME	14.06
COMPLETION TIME	17.16

ITEM	SER NO	COMMENT	TIME
RECOVERY BUOY		Cut when grappled	14.06
ARGOS BEACON	097	ID. 13346 algae cover	14.11
41" STEEL SPHERE		Algae cover. Wire rubbing on transom, and swivel	14.11
SBE	3207		14.16
SBE	3208	Lost guard frame and conductivity cell	14.21
SBE	3209	Creature attached to guard	14.30
SBE	3210		14.34
SBE	3212		14.36
SBE	3213		14.38
SBE	3214		14.41
SBE	3215		14.45
SBE	3216	P wire entangled (above the top clamp of the SBE) The Pwire was damaged and taped up.	14.49
SBE	3217	The same taped up section of P wire entangled above this SBE	14.57
SBE	3218	P wire well entangled around 3/16" wire	15.00
SBE	3922	SBE entangled in glass buoy packet, had some scratches	15.16
12 GLASS SPHERES		And swivel	15.20
SBE	3923	Line untangled and free– back to single line.	15.22
SBE	3924	Arrived and recovered after SBE3218. line entangled	15.03
SBE	3925	Recovered after SBE3923. Previously taped up P wire comes up between 3924-3925	15.36
SBE	3926		15.41
SBE	3927		15.47
SBE	3928		15.55
8 GLASS SPHERES		& swivel	15.55
SBE	3929		16.09
SBE	3930	16.21 drums changed	16.19
SBE	3931		16.38
SBE	3932		16.50
SBE	3933		17.01

SBE	3934		17.11
8 GLASS SPHERES			17.16
ACOUSTIC RELEASE	369		17.16
ACOUSTIC RELEASE	258		17.16

MOORING METHOD FREEFALL DEPLOYMENT

Contact with mooring at : time:13.26 depth:5047m
pos: 23 49 02133N, 024 05 30016W
Acoustic release activated at: time: 13.35 depth: 5047m
Pos: 23 49 99431N, 024 05 49294W range: 5017m
Surface visual (Port forward) at: 13.37 depth: 5047m

COMMENTS Pos: 23 49 01278N, 024 05 44071

UKORS MOORINGS GROUP CRUISE CD177

MRG ID: EB2

FALMOUTH - UK E.V.V. RECOVERY **UKORS ID**

LATITUDE	Not recorded on log sheet	**DATE**	25/11/05
LONGITUDE	Not recorded on log sheet	**DAY**	329

NOTE ALL TIMES RECORDED IN GMT

COMMENCE TIME 15:49:00

COMPLETION TIME 18:31:00 (last element on board)

18:55:00 (last of wire on board)

ITEM	SER NO	COMMENT	TIME
RECOVERY BUOY			15:49:00
ARGOS BEACON	264	ID. 46242	15:49:00
48" STEEL SPHERE			15:49:00
RCM 11	448	Ok. just a little algae	15:49:30
SBE	3276	Connector wrenched off on recovery	15:49:30
MMP STOP			15:19:30
MMP		See comments below…	17:21:00
MMP STOP			17:44:30
SBE	3917		17:44:30
12 GLASS SPHERES			17:45:00
RCM 11	449	Entangled with swivel of 6 spheres	17:45:00
SBE	3920	Hitting against swivel of 6 spheres	18:31:30
6 GLASS SPHERES			18:31:30
SBE	3921		18:22:45
4 GLASS SPHERES			18:27:00
ACOUSTIC RELEASE	363		18:27:00
ACOUSTIC RELEASE	255		18:27:00
		Last of wire on deck	18:55:00

MOORING METHOD FREEFALL DEPLOYMENT

COMMENTS

16:41:00 - Huge "fankle" of wire between first MMP stop and MMP. Involving 3/16" wire and parafil. 5 different lines coming up at the same time. Tangle and lines taped and pulled in.

17:21:00 - MMP arrives tangled in wire. During recovery CTD 'antenna' impacts against the ship and is bent. Current meter sting is tangled in wire and support ripped off (all cables fine though). Rest of MMP OK.

Below RCM11 449 huge fankle again.

UKORS MOORINGS GROUP

CRUISE CD177

MRG ID: EB1

FALMOUTH - UK E.V.V. DEPLOYMENT **UKORS ID**

LATITUDE 23°49.67N **DATE** 25/11/05

LONGITUDE 24°06.03W **DAY** 329

NOTE ALL TIMES RECORDED IN GMT

COMMENCE TIME 08:56:30 Position : 23°52.53 N, 24°06.38

COMPLETION TIME 12:53:00

ITEM	SER NO	COMMENT	TIME
TELEMETRY BUOY			08:56:30
ARGOS BEACON	257	ID. 42749	09:09:30
49" STEEL SPHERE		Upper and Lower conducting swivels taped	09:09:30
SBE	3242	ID 31	09:09:30
SBE	3241	ID 32 - Cell guard slightly bent	09:12:45
SBE	3240	ID 33 -	09:24:50
SBE	3239	ID 34 - A few worm/barnacles on cell	09:28:00
SBE	3284	ID 35 -	09:33:20
SBE	3283	ID 36	09:36:45
SBE	3282	ID 37	09:40:45:
SBE	3281	ID 38	09:43:10
SBE	4475	ID 39	09:47:30
SBE	4474	ID 40	09:50:55
SBE	4473	ID 41	09:54:35
4 CLAMP ON SPHERES		Cable stopped at 990m to clamp on spheres	10:14:45
SBE	4472	ID 42	10:16:45
SBE	4471	ID 43	10:20:10
SBE	4470	ID 44	10:23:40
SBE	4469	ID 45	10:29:15
SBE	4468	ID 46	10:35:25
SBE	4467	ID 47	10:41:20
SBE	4466	ID 48	10:52:00
SBE	4465	ID 49	10:58:15
SBE	4464	ID 50 - On diagram appears after Syntacic buoy	11:12:00
SYNTACTIC BUOY		Attached at 3062m depth (12 m deeper than expected)	11:33:50
SBE	4463	ID 51	11:44:10
SBE	4462	ID 52	11:51:00
SBE	4461	ID 53	12:14:20
SBE	4460	ID 54	12:23:60
8 GLASS SPHERES			12:53:00
ACOUSTIC RELEASE	UPPER	Serial no: 370	12:53:00
ACOUSTIC RELEASE	LOWER	Serial no: 263	12:53:00
ANCHOR		Release Position : 23°49.508 N, 24°05.988 W	12:53:00

MOORING METHOD FREEFALL DEPLOYMENT

COMMENTS
24 Small red floats on telemetry buoy cable.
Yellow buoy leaving surface 13:17:25,Pos: 23°50.91N, 24°6.18 W

UKORS MOORINGS GROUP

CRUISE CD177

MRG ID: EB2

FALMOUTH - UK R.J.B. DEPLOYMENT **UKORS ID**

LATITUDE 23°53.49N

LONGITUDE 24°03.39W

DATE 26/11/05

DAY 330

NOTE ALL TIMES RECORDED IN GMT

COMMENCE TIME 09:00:00

COMPLETION TIME 14:35:00

ITEM	SER NO	COMMENT	TIME
RECOVERY BUOY			09:49
ARGOS BEACON	253	ID. 42745	09:52
48" STEEL SPHERE			09:52
RCM 11	302		09:52
SBE	3264		09:52
MMP STOP			09:52
MMP	11672-01	Small crack in housing	10:35
MMP STOP			11:38
SBE	3248		11:58
8 GLASS SPHERES			11:59
RCM 11	303		11:59
SBE	3249	Clamped 985m beneath RCM 303	12:40
8 GLASS SPHERES			12:45
SBE	3259	~5m cable + spheres unmeasured	13:40
6 GLASS SPHERES			13:55
ACOUSTIC RELEASE	Upper	S/N: 243	13:55
ACOUSTIC RELEASE	Lower	S/N: 439	13:55
ANCHOR		Rel.: 23°53.42N, 24°3.2W, 5098m (corr)	13:56

MOORING METHOD FREEFALL DEPLOYMENT

COMMENTS

10:40 : Cable tension too low therefore increased ship speed to 1.5 knots to increase deployment rate (to avoid overshooting the target site).

11:10 : Speed increased for extra tension.

Heading change midway due to possibility of overshooting target site into an uncertain depth area. New heading going towards area where depth was well mapped.

Depth correction for area = +47m

NB: No deployment log sheets were completed for EBADCP, EBP2 or EBP1.