National Oceanography Centre, Southampton

Cruise Report No. 2

RRS *Charles Darwin* Cruise CD170
and RV *Knorr* Cruise KN182-2

RAPID mooring cruise report April – May 2005

Principal Scientist
S A Cunningham

Editor
D Rayner

2006

National Oceanography Centre, Southampton
University of Southampton, Waterfront Campus
European Way
Southampton
Hants SO14 3ZH
UK

Tel: +44 (0)23 8059 6436
Fax: +44 (0)23 8059 6204
Email: scu@noc.soton.ac.uk

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AUTHOR

CUNNINGHAM, S A & RAYNER, D et al

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ABSTRACT

This report describes the mooring operations conducted during RRS *Charles Darwin* Cruise CD170 and RV *Knorr* Cruise KN182-2. Cruise CD170 was conducted between 2 April 2005 and 27 April 2005, and Cruise KN182-2 was conducted between 2 May 2005 and 26 May 2005.

These cruises were completed as part of the United Kingdom Natural Environment Research Council (NERC) funded RAPID Programme and the United States of America National Science Federation (NSF) funded MOCHA Programme to monitor the Atlantic Meridional Overturning Circulation at 26.5ºN. The primary purpose of these cruises was to service the 26.5ºN mooring array deployed in 2004 during RRS *Discovery* cruises D277 and D278 (cruise report number 53).

Cruise CD170 was from Tenerife to Bermuda, and covered the Eastern Boundary and Mid-Atlantic Ridge moorings deployed on D277. On arrival in Bermuda equipment and personnel were transferred to the RV *Knorr,* with Cruise KN182-2 covering the Western Boundary moorings deployed on Cruise D278. These cruises are the first annual refurbishment an array of moorings deployed across the Atlantic in order to set up a pre-operational prototype system to continuously observe the Atlantic Meridional Overturning Circulation (MOC). This array will be further refined and refurbished during subsequent years.

The mooring array deployed in 2004 consisted of 19 moorings from the National Oceanography Centre, Southampton (NOC – formerly the Southampton Oceanography Centre), with 3 from the Rosenstiel School of Marine and Atmospheric Science (RSMAS), University of Miami. The replacement array deployed in 2005 consisted of 24 NOC moorings, and 5 RSMAS moorings. Moorings are focused at the Eastern and Western boundaries, along with a grouping at the Mid Atlantic Ridge.

The 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.

KEYWORDS

Atlantic Ocean, bottom pressure recorder, BPR, cruise CD170 2005, cruise KN182-2 2005, CTD, current meter, *Charles Darwin*, *Knorr*, Meridional Overturning Circulation, MOC, mooring array, Moorings, North Atlantic, RAPID, RAPIDMOC, THC, thermohaline circulation

ISSUING ORGANISATION **National Oceanography Centre, Southampton**
University of Southampton, Waterfront Campus
European Way
Southampton SO14 3ZH UK

Copies of this report are available from: **National Oceanographic Library, NOCS** *PRICE*:
Tel: +44(0)23 80596116 Email: nol@noc.soton.ac.uk

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1. Scientific and Ship's Personnel

Scientific and Technical	
Stuart Cunningham	Principal Scientist (National Oceanography Centre, Southampton)
Darren Rayner	Scientist (National Oceanography Centre, Southampton)
Torsten Kanzow	Scientist (National Oceanography Centre, Southampton)
Jochem Marotzke	Scientist (Max-Planck Institute)
Ian Waddington	Tech (National Oceanography Centre, Southampton)
Stephen Whittle	Tech (National Oceanography Centre, Southampton)
Robert McLachlan	Tech (National Oceanography Centre, Southampton)
Christian Crowe	Tech (National Oceanography Centre, Southampton)
Peter Keen	Tech (National Oceanography Centre, Southampton)
Robert Lloyd	Tech (National Oceanography Centre, Southampton)
Colin Hutton	Tech (National Oceanography Centre, Southampton)
Mark Hebden	Scientist (British Oceanographic Data Centre)
Owen Gaffney	Cameraman/Scientist (Natural Environment Research Council, Swindon)
13 persons	
RSU Personnel	
P. Gould	Master
P. Newton	Chief Officer
P. Reynolds	2nd Officer
K. Hailes	3rd Officer
J. Holt	Chief Engineer
A Greenhorn	2nd Engineer
G. Slater	2nd Engineer
G. Collard	3rd Engineer
D. Hurren	ETO
M Harrison	CPO (Science)
G. Pook	CPO (Deck)
P. Allison	PO (Deck)
S. Cook	S1A
G. Crabb	S1A
M. Moore	S1A
A. Pearce	S1A
C. Moore	ERPO
C. Perry	SCM
P. Lynch	Chef
W. Link	Ass. Chef
A. Harkness	Steward
21 persons	

Table 1.1: Details of personnel on cruise CD170

Scientific and Technical	
Bill Johns	Principal Scientist (University of Miami)
Lisa Beal	Scientist (University of Miami)
Chris Meinen	Scientist (NOAA)
Jonathan Molina	Scientist (University of Miami)
Tania Casal	Scientist (University of Miami)
Humberto Guarin	Tech (NOAA)
Carlos Fonseca	Tech (NOAA)
Benjamin Kates	Tech (NOAA)
Mark Graham	Tech (University of Miami)
Robert Jones	Tech (University of Miami)
Stuart Cunningham	Scientist (National Oceanography Centre, Southampton)
Darren Rayner	Scientist (National Oceanography Centre, Southampton)
Ian Waddington	Tech (National Oceanography Centre, Southampton)
Stephen Whittle	Tech (National Oceanography Centre, Southampton)
Christian Crowe	Tech (National Oceanography Centre, Southampton)
David Childs	Tech (National Oceanography Centre, Southampton)
Aazani Mujahid	Scientist (National Oceanography Centre, Southampton)
Julie Collins	Scientist (British Oceanographic Data Centre)
18 persons	

RV Knorr Personnel	
A.D. Colburn	Master
Dee Emrich	Chief Officer
Adam Seamans	2nd Officer
Derek Bergeron	3rd Officer
Steve Walsh	Chief Engineer
Mike Merrill	1st Assistant Engineer
Wayne Sylvia	2nd Assistant Engineer
Pete Marczak	3rd Assistant Engineer
Thidiane Kanoute	Electrician
Russ Adams	Oiler
Andy Gillen	Oiler
Tom Keller	Oiler
Jeff Perkins	ComET
Pete Liarikos	Bosun
Eddie Graham	AB
Bill Dunn	AB
Kevin Butler	AB
Lorna Allison	OS
Jennifer Hickey	OS
Murph	Chief Steward
Karen	Chef
Tony	Steward
22 persons	

Table 1.2: Details of personnel on cruise KN182-2

2. Itinerary

CD170

Depart Santa Cruz de Tenerife, Tenerife, 2nd April 2005 – Arrive St George's, Bermuda, 27th March 2005.

KN182-2

Depart St George's, Bermuda, 2nd May – Arrive Miami, USA, 26th May 2005.

3. Acknowledgements

The Officers and crew of both the *RRS Charles Darwin* and the *RV Knorr* provided great assistance throughout the cruises. The NOC moorings team were professional throughout and cooperated well with the RSMAS mooring team on the second cruise. This cooperation led to smooth deployments and recoveries. The UKORS operations group worked hard during mobilisation of CD170 to ensure that the *Charles Darwin* ship could sail as early as possible on what was a tight cruise schedule.

4. Introduction

J. Marotzke, S. Cunningham and H. Bryden

Monitoring the Atlantic Meridional Overturning Circulation at 26.5°N
Background: Objective 1 of the RAPID programme is "to establish a pre-operational prototype system to continuously observe the strength and structure of the Atlantic meridional overturning circulation (MOC)". The MOC is commonly defined as the zonally integrated meridional flow, as a function of latitude and depth. While parts of the MOC are wind-driven, the basin-scale Atlantic MOC is largely buoyancy-forced. Hence, observing the Atlantic MOC is the fundamental observational requirement of a programme aiming to assess the role of the Atlantic thermohaline circulation (THC) in rapid climate change.

Rationale for observing the MOC at 26.5ºN: While much of RAPID is focussed on the high latitudes, it is ultimately the ocean heat transport around 25º-35ºN that is most relevant for climate. Much of the heat transported northward in the Atlantic is given off to the atmosphere over the Gulf Stream extension (e.g., Isemer et al., 1989), from where it is transported north-eastward toward Europe by the atmosphere. Two characteristics of ocean heat transport mechanisms are crucial: First, the ocean heat transport is mainly accomplished by the MOC (Hall and Bryden, 1982; Ganachaud and Wunsch, 2000). Second, fluctuations in heat transport (and, by implication, transports of other quantities such as freshwater and carbon) are expected to be dominated by fluctuations in the transporting velocity field, and only to a lesser extent by variability in heat (or property) content. For example, Jayne and Marotzke (2001) showed that in a global high-resolution model, heat transport variability equatorward of 40º arose almost exclusively because of velocity fluctuations advecting the mean temperature field. These two characteristics justify this programme's emphasis on the MOC. As one consequence, the basic monitoring of the MOC should occur near the heat transport maximum. 26.5ºN has the triple advantage of being close to the heat transport maximum in the Atlantic, of being the latitude of four modern hydrographic occupations, and of offering a long time series of boundary current observations not existing anywhere else (Baringer and Larsen, 2001; see below for the significance of this fact).

Basic observational strategy: Our proposed strategy relies on a combination of moored arrays (temperature, salinity, currents, and pressure), hydrographic lines, satellite observations (sea level, winds), the opportunistic use of float data, cable measurements (Florida Strait transport), and modelling to synthesise the observations. The starting point lies in applying geostrophy: Geostrophic mass transport between any two points depends only on the pressure difference between these points; to estimate the MOC thus would require the continuous observation of density at eastern and western boundaries, plus the establishment of a reference level. This idea has been implemented in various ways, though not in a systematic attempt to observe the MOC continuously. Whitworth (1983) monitored Drake Passage transport; Lynch-Stieglitz et al. (1999) estimated Florida Strait transport during the Last Glacial Maximum; Lynch-Stieglitz (2001) used marginal density information to infer both modern and past integrated circulations; McPhaden and Zhang (2002) found a slowdown of the shallow low-latitude Pacific MOC by using boundary XBT profiles; Curry and McCartney (2001) estimated changes in subpolar gyre strength. Marotzke et al. (1999) tested endpoint monitoring ideas in their GCM, with some success, while Kanzow (2000) performed array design studies for moorings dedicated to monitoring integrated transports in the western North Atlantic. In part based on Kanzow's findings, Send and co-workers from IfM Kiel deployed moorings at 16ºN to observe the deep integrated flow west of the Mid-Atlantic Ridge, as a pilot study to an observing system for the entire MOC (U. Send, 2000, pers. comm.).

The 26.5ºN section has the fundamental advantage that the western boundary current (flow through Florida Strait) can be measured relatively straightforwardly by cable (existing long-term programme by the US, e.g., Larsen, 1992; Baringer and Larsen, 2001) and regular calibration cruises. This makes the monitoring of the entire MOC equivalent to the task of monitoring the depth profile at which the flow through the Florida Straits returns southward. Currently, its contribution to the MOC returns southward at depths between 1000m and 4000m (e.g., Roemmich and Wunsch, 1985); dramatic shoaling of this return path would be equivalent to a collapse of the MOC (note that there is expected always to be wind-driven flow through the Florida Strait, as shown by the existence of the Kuroshio in the Pacific despite the absence of a deep sinking MOC cell in the North Pacific).

Instrumentation: We proposed to monitor continuously full-depth density profiles at and near the eastern and western boundaries (Figures 2 to 6). In total, we proposed to deploy 8 full-depth moorings, three of which would be equipped with a McLane Moored Profiler (MMP) taking roughly one CTD profile every other day. The use of profilers has the big advantage over individual, fixed-location CTD sensors that only a single instrument needs to be calibrated. Several moorings would be required near each boundary, for obtaining boundary current measurements through thermal wind, improving the signal-to-noise ratio, and as failsafe measures. We proposed to use one conventional full-depth mooring at each end with fixed-depth CTDs. Based on Kanzow (2000), we concluded that 14 CTDs obtain sufficiently dense sampling in the vertical; the investment needed for these instruments equals that of the MMP. All moorings would be equipped not only with CTDs but also with bottom pressure sensors, and some with current meters. This gives added information for estimating the depth-independent part of the MOC that is not in thermal wind balance but is rather dominated by high-frequency barotropic dynamics (e.g., Jayne and Marotzke, 2001; Böning et al., 2001). To test the boundary array, two transoceanic sections would be required to obtain MOC estimates toward the beginning and the end of the deployment period, using an independent approach. The SOC James Rennell Division performed a 26.5ºN hydrography cruise (Cunningham, 2005) as part of its Core Programme in 2004; we expect a second cruise to take place in 2008, toward the end of the RAPID programme.

The presence of the Mid-Atlantic Ridge (MAR) complicates the endpoint monitoring of the MOC, because a pressure drop may exist across the ridge. Below the ridge crest, the sub-basins to the east and west therefore have to be monitored separately. We proposed to use an MMP mooring on one side of the MAR and a conventional fixed depth CTD mooring on the other. There are also back-up fixed-depth CTD moorings that only reach to the ridge crest. The tall MMP and CTD moorings will tell us how the shallow Gulf Stream return flow is divided between eastern and western basins.

In addition to the full-depth sampling, we proposed to instrument the sloping shelfbreak topography, from the deep water to shallow depths, with CTDs, bottom pressure recorders (BPR), and current meters (CM), to obtain continuous observations at fixed depths. This would provide an alternative vertical sampling strategy, and also help solve the bottom triangle problem (e.g., Whitworth and Peterson, 1985). It would be the continuous analogue to the sampling strategy employed by Lynch-Stieglitz et al. (1999) who used density information inferred from foraminiferal oxygen isotope data.

In summary, our design is based on the strategy that even the complete loss of any one mooring would not jeopardise the project as a whole.

Antenna design tests in numerical models: We have "deployed" the above-described array in two high-resolution ("eddy-permitting") numerical models, OCCAM (Webb, 1996; 1/4º resolution) and FLAME (e.g., Beismann and Redler, 2002; 1/3º resolution). Our reconstructions of the MOC are based on a superposition of Ekman and thermal wind contributions (similar to the approach of Lee and Marotzke, 1998). Knowing the wind stress allows the determination of the Ekman transport. We assume that the Ekman transport is compensated by a spatially constant return flow across the section, so that there is no net meridional mass transport related to the zonal wind stress. The thermal wind balance allows us to calculate the vertical shear of the meridional velocity component between adjacent vertical density profiles, across the section. Integrating the shear from bottom to top yields a meridional velocity field. As for the Ekman transport a spatially (but not temporally) constant correction is applied to the velocity field in order to ensure zero net meridional mass transport. We assume that the vertical profile of mass transport across Florida Strait is known, (according to what cable measurements and profiling sections could provide in the real Atlantic).

We demonstrated (Hirschi et al., 2003, and Baehr et al., 2004) that our reconstruction does an excellent job in recovering the vertical structure and time history of the maximum MOC, at 26ºN. The FLAME analysis shows a slight bias of around 2 Sv, but the variability is very well reproduced. Both thermal wind and Ekman contributions are required to reconstruct the total MOC.

We tested the sensitivity of our method to uncertainties in the Florida Strait transport, by adding noise (standard deviations of 1, 2, 5 Sv) to the Florida Strait transport simulated in OCCAM. The resulting uncertainty in the MOC reconstruction was of order one half of the assumed Florida Strait transport measurement error.

We have also performed systematic tests leaving out parts of the array. Leaving out either the MAR moorings or covering the eastern boundary less densely only has a small effect on our reconstruction. However, we advise caution in taking the models literally on this point. At this resolution, the eddy kinetic energy is still considerably underestimated (e.g., Stammer et al., 1996), and we suspect that the models underestimate the vigour and variability of eastern boundary currents. We therefore rely on the strategy of sampling the eastern boundary to the extent we think is sufficient, with the possibility of reduction in future years.

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5. Bridge Timetable of Events

5.1 CD170

Date	Time (GMT)	Lat (N)	Lon (W)	Event
2nd April				Set Sail from Santa Cruz de Tenerife.
	1818	28°27.1’	15°34.3’	Hove to on station
	1830			CTD cast and acoustic release. PES fully deployed
	1940	28°27.8’	15°34.5’	CTD at 3000m
	2006			Start hauling CTD
	2122	28°28.3’	15°34.6’	CTD inboard
	2126			Proceed to next station – set course 120°
3rd April	0411	27°54.0’	14°30.5’	A/C 90°
	0700	27°53.8’	13°57.4’	A/C 114° towards station EBH4
	0815	27°49.7’	13°47.4’	Hove to at 2 cables downwind of mooring
	0820			Transducer outboard
	0824			Mooring released
	0850	27°50.0’	13°47.5’	Grappled
	0855			Commence mooring recovery
	0922	27°50.3’	13°47.5’	Mooring fully recovered. Proceed to EBH5
	1114	27°51.3’	13°31.4’	Hove to at EBH5
	1122			Mooring Released
	1128			Mooring at surface
	1154	27°51.5’	13°31.6’	Grappled, commence recovery
	1220	27°51.7’	13°31.9’	All inboard
	1225			All secure, set course 073° to EBADCP
	1324	27°53.8’	13°23.7’	Hove to at EBADCP
	1424	27°54.1’	13°23.7’	Mooring not found. Set course 072° at 5 knots for survey
	1458	27°54.8’	13°21.0’	Survey complete. Repositioning to new H5 deployment site.
	1546	27°53.4’	13°22.6’	Commence deployment of new EBH5
	1613	27°53.8’	13°22.5’	Mooring stoppered, towing to deployment site
	1634	27°54.5’	13°21.9’	Mooring released and clear.
	1639			Mooring lost anchor, preparing to recover
	1655	27°54.5’	13°22.0’	EBH5 grappled
	1722	27°54.5’	13°22.1’	All inboard. Proceeding to deployment position
	1750	27°53.7’	13°22.5’	Commence deploy EBH5, 2nd attempt
	1811	27°53.8’	13°22.4’	Mooring stoppered, towing to deployment site
	1836	27°54.5’	13°21.9’	Mooring released. Heaving to.
	1850	27°54.5’	13°21.9’	Proceeding to new EBADCP deployment site
	1925	27°53.9’	13°23.6’	Hove to deploying EBADCP
	1951	27°53.97’	13°23.60’	Anchor released
	2006	27°53.9’	13°23.6’	Proceed to new EBH4 position
	2047	27°51.8’	13°28.3’	Commence deployment of mooring
	2109	27°52.21’	13°28.20’	Anchor released
	2120	27°52.3’	13°28.1’	All secure. Proceeding to EBH3 New
4th April	0028	27°50.6’	13°43.1’	At new EBH3. Slow steaming in vicinity waiting for daylight
	0527	27°48.8’	13°44.4’	Commence deployment of EBH3
	0553	27°49.1’	13°44.3’	EBH3 released. Heaving to.
	0556	27°49.1’	13°44.3’	Proceeding to old EBH3 (244° T).
	0846	27°37.2’	14°12.4’	Hove to, 2 cables downwind of mooring position
	0850	27°37.2’	14°12.4’	Mooring released
	0921	27°37.3’	14°12.2’	Mooring sighted and grappled. Commence recovery
	0950	27°37.5’	14°11.8’	Mooring recovery complete. Repositioning
	1020	27°36.5’	14°13.0’	Commence deployment of mooring new EBH2
	1035	27°36.59’	14°12.85’	Anchor released.
	1040	27°36.6’	14°12.9’	Set course 253°T for old EBH2
	1314	27°29.1’	14°41.3’	Hove to, 2 cables downwind for recovery
	1320	27°29.2’	14°41.3’	Mooring release from seabed
	1346	27°29.2’	14°41.2’	Mooring at surface
	1359	27°29.3’	14°41.2’	Grappled, commence recovery
	1429	27°29.7’	14°41.1’	Mooring all inboard, secure. Set course 252°T
	1829	27°16.4’	15°25.2’	Hove to. H1 released from seabed

	1859	27°16.4’	15°25.2’	Mooring on surface
	1915	27°16.3’	15°25.1’	Grappled, commence recovery
	1945	27°16.5’	15°25.0’	Mooring fully recovered. Repositioning
	1958	27°16.1’	15°25.3’	In position ½ ‘ downwind of mooring position EBH1
	2020	27°16.2’	15°25.3’	Commence mooring deployment
	2034	27°16.3’	15°25.24’	Anchor released.
	2100	27°16.7’	15°24.9’	Set course 241°T towards CTD position.
5th April	0245	26°55.0’	16°09.0’	Hove to for CTD
	0318	26°55.0’	16°09.11’	CTD outboard
	0722	26°54.9’	16°09.1’	CTD Inboard. Proceed to EB3
	0815	26°59.7’	16°13.9’	Hove to at EB3 position
	0830	26°59.7’	16°13.8’	EB3 mooring interrogated. All ok. Proceed to EB2
	0940	26°50.3’	16°13.9’	In position at EB2
	1006	26°50.3’	16°13.6’	Mooring released. Commence search
	1045	26°50.6’	16°13.1’	Hove to. Attempting to find mooring.
	1100	26°50.4’	16°13.’	Carrying out acoustic search for mooring
	1121	26°50.0’	16°14.9’	Search complete. Proceeding to EB3
	1230	26°59.7’	16°14.0’	Hove to at EB3
	1239	26°59.8’	16°14.0’	Released
	1350	26°59.8’	16°13.8’	Surfaced
	1422	26°59.8’	16°13.8’	Grappled
	1600	27°01.2’	16°12.1’	All inboard
	1647	26°59.8’	16°13.9’	Hove to for CTD station
	1905	26°59.9’	16°13.6’	CTD outboard
	2020	27°00.3’	16°13.4’	CTD at 3480m. Commence haul
	2216	27°00.6’	16°13.0’	CTD inboard. Proceed to next station (180°T)
6th April	0240	26°49.6’	16°13.9’	Hove to in vicinity of EB2
	0324	26°50.5’	16°13.6’	Commence boxing in of EB2
	0530			Proceeding to dragging start point
	0605	26°48.7’	16°17.0’	Hove to preparing to deploy dragging gear
	0623	26°48.7’	16°16.9’	Commence deploying dragging gear
	0817	26°49.6’	16°15.7’	Gear on bottom
	0902	26°50.2’	16°14.9’	6016m out
	0956	26°51.0’	16°13.9’	6516m out
	1011	26°51.2’	16°13.6’	7016m out. Commence turn 140°T
	1039	26°50.9’	16°13.1’	7516m out. Turn complete
	1105	26°50.4’	16°12.7’	Commence slow turn to starboard
	1220	26°50.6’	16°14.2’	Turn complete
	1230	26°50.7’	16°13.8’	Hove to, commence hauling
	1250	26°50.9’	16°13.8’	Mooring on surface
	1450	26°49.7’	16°14.3’	Commence recovery of grappling gear
	1543	26°49.6’	16°14.9’	All dragging gear inboard
	1612	26°50.6’	16°15.1’	Mooring grappled. Commence recovery
	1810	26°52.5’	16°16.5’	Most of mooring inboard. Searching for lost bottom section.
	1920	26°51.4’	16°12.9’	Search abandoned. Proceed to EBH1
7th April	0026	27°16.2’	15°25.6’	Hove to at EBL2 site
	0055	27°16.46’	15°25.14’	Commence deployment of lander
	0104	27°16.57’	15°25.02’	Lander deployed
	0116	27°16.6’	15°25.0’	All secure. Proceed to EB3
	0600	26°59.6’	16°13.6’	Hove to at EBH0
	0608	26°59.6’	16°13.6’	Commence deployment of EBH0
	0612	26°59.6’	16°13.7’	Mooring fully deployed. Set course to new EBHi
	0730	26°55.8’	16°26.5’	Now heading towards EB1 at science request. Intention to stop in vicinity of 25°30’N, 21°W to deploy mooring.
8th April	0100	25°49.6’	19°39.9’	Clocks retarded one hour. Ship time now equals GMT.
	1105	24°56.9’	21°16.4’	In position at EBHi. Commence deployment
	1142	24°57.40’	21°15.60’	Anchor released. Proceed to EB1
	2338	24°31.6’	23°24.8’	Hove to for CTD
9th April	0034	24°31.8’	23°24.7’	CTD outboard
	0233	24°31.5’	23°24.7’	CTD at 4950m. Commence hauling
	0454	24°31.4’	23°24.6’	CTD inboard. Proceeding to EB1
	0526	24°31.4’	23°26.8’	Hove to at EB1
	0714	24°31.1	23°26.9’	EB1 released from seabed
	0745	24°31.2’	23°27.6’	Mooring on surface
	0805	24°31.1’	23°27.8’	Proceed towards mooring
	0822	24°31.3’	23°27.2’	Commence recovery of mooring
	0934	24°31.9’	23°26.6’	Mooring fully recovered

	0942	24°31.8’	23°26.5’	All secure. Proceed to next station
	1354	24°08.3’	23°57.2’	Alter course down Topex track
	1630	23°45.3’	24°07.7’	Hove to at new EB1 assessing current
	1700	23°45.3’	24°07.7’	Proceeding to deployment start position
	1747	23°48.0’	24°10.6’	At start position
	1820	23°48.2’	24°09.9’	Commence deployment. Speed = 1kt through water
	1944	23°48.7’	24°98.5’	Increase speed to 1.8kts through water (1kt OG)
	2121	23°49.5’	24°06.4’	Towing mooring into position
	2148	23°49.69’	24°05.72’	Anchor released
	2235			Top buoy light observed. Proceeding to investigate
	2300	23°49.42’	24°06.05’	Standing off buoy till daylight
10th April	0836	23°48.6’	24°05.7’	Grappled. Commence recovery
	0854	23°48.63’	24°05.66’	Mooring redeployed after changing sphere
	0910	23°48.6’	24°05.1’	Repositioned ½ mile away from deployment
	0944	23°48.6’	24°06.3’	Hove to
	1005	23°48.6’	24°06.3’	Commence deployment of EBL1 mooring
	1008	23°48.62’	24°06.31	Lander deployed
	1018	23°48.62’	24°06.31’	Proceed to EB2 deployment site
	1130	23°57.1’	24°06.6’	3.5 miles downwind of mooring position. Drift check.
	1206	23°57.0’	24°06.2’	Repositioning to start point
	1218	23°57.2’	24°06.5	Hove to for deployment
	1228	23°57.2’	24°06.4’	Commence deployment of mooring. Top sphere o/b
	1254	23°57.0’	24°05.7’	MMP o/b
	1508	23°55.79’	24°02.57’	Anchor o/b. Mooring deployed
	1548	23°56.4’	24°03.1’	All secure. Set course 272°T to MAR3
11th April				In transit
12th April	1430	24°12.5’	32°48.4’	Speed reduced to 8kts for Swath trial
	1620	24°13.0’	33°04.7’	End of Swath trial. Resume full speed.
13th April	0200			Clocks retarded 1 hour to read GMT-1. In transit
14th April	1030	24°29.9’	41°13.0’	Hove to 2 cables downwind of mooring MAR3
	1130	24°29.8’	41°12.7’	Grappled. Commence recovery
	1301	24°29.5’	41°12.2’	Mooring fully recovered
	1308	24°29.4’	41°12.1’	Set course to MAR4
	1354	24°30.1’	41°18.4’	Hove to at MAR4
	1358	24°30.1’	41°18.1’	Mooring released
	1415	24°30.0’	41°18.5’	Grappled
	1422	24°30.0’	41°18.4’	Top buoy inboard
	1637	24°30.0’	41°14.6’	Mooring all inboard. Remaining hove to for CTD
	1814	24°30.7’	41°13.6’	CTD outboard
	2245	24°31.0’	41°13.1’	CTD inboard
15th April	0012	24°31.2’	41°12.8’	CTD outboard. Commence veer to 3444m
	0132	24°31.0’	41°12.6’	CTD veered to 3444m. Commence hauling
	0319	24°31.0’	41°12.4’	CTD inboard
	0335	24°30.9’	41°12.2’	All secure. Set course 260°T to start of Swath survey
	0445	24°29.1’	41°23.3’	Commence swath survey. Course 157°T at 8kts
	0847	24°00.4’	41°10.1’	Change course 093°T
	1005	24°00.0’	41°00.1’	Change course 180°T
	1052	23°54.0’	41°00.0’	Change course 270°T
	1219	23°54.0’	41°12.0’	Change course 180°T
	1309	23°48.1’	41°11.9’	Change course 090°T
	1501	23°48.0’	41°00.0’	Survey complete. Proceeding to next station.
	1600	23°52.1’	41°05.8’	Hove to assessing suitability of site
	1615	23°52.1’	41°05.7’	Repositioning to MAR3 deployment position
	1655	23°55.6’	41°08.3’	Hove to 2 cables downwind of deployment position
	1708	23°55.6’	41°08.2’	Commence deployment of MAR3
	1912	23°55.96’	41°06.21’	Anchor released
	2020	23°55.9’	41°06.1’	Mooring reported to be on seabed.
16th April	0551	23°52.6’	40°59.9’	Commence run towards MAR4 for survey purposes
	0654	23°52.1’	41°05.8’	Passing through proposed MAR4 position
	0754	23°51.6’	41°10.6	Hove to. Preparing to deploy MAR4
	0910	23°51.7’	41°10.3’	Commence deployment of mooring
	1323	23°52.12’	41°05.40’	Mooring deployed. Returning along track to look for top buoy
	1355	23°51.8’	41°06.7’	Mooring sighted sinking below surface
	1530	23°52.1’	41°05.5’	Hove to for deployment of MARL2 lander
	1551	23°52.1’	41°05.6’	Commence deployment
	1557	23°52.10’	41°05.55’	Lander deployed

	1604	23°52.1’	41°05.5’	All secure. Repositioning to CTD position
	1648	23°56.0’	41°05.7’	Hove to for CTD
	1720	23°55.9’	41°05.5’	CTD outboard
	2145	23°56.1’	41°05.7’	CTD inboard
	2150	23°56.2’	41°05.7’	All secure. Proceeding to Swath Start position.
17th April	0812	24°29.8’	39°59.7’	Change course 270°T. Speed 8kts. Swath Survey
18th April	0300			Clocks retarded 1 hour to read GMT-2. Swath Survey on transit to MAR1
19th April				Swath Survey on transit to MAR1
20th April	0839	24°30.1’	50°15.6’	End of swath survey. Hove to near MAR1
	0915	24°30.1’	50°15.6’	Attempting to communicate with MAR1
	0937	24°29.5’	50°15.6’	Top mark on surface. Waiting for rest to surface
	1004	24°30.0’	50°16.0’	Proceed to recover mooring
	1014	24°26.7’	50°15.9’	Commence recovery
	1240	24°28.2’	50°16.2’	Mooring fully recovered
	1250	24°28.0’	50°16.5’	Proceed to MAR2
	1430	24°28.9’	50°34.3’	Hove to for recovery of mooring
	1444	24°28.9’	50°34.3’	Mooring released
	1502	24°28.8’	50°34.4’	On surface
	1522	24°28.3’	50°34.6’	Grappled. Commence recovery
	1636	24°27.0’	50°34.6’	All inboard. Set course 087°T
	1910	24°27.9’	50°11.2’	Hove to. CTD outboard
	2045	24°28.0’	50°10.9’	CTD stopped at 4430m wire out
	2104	24°28.0’	50°10.9’	Commence hauling
	2324	24°27.7’	50°10.4’	CTD inboard. Proceed to swath start position
21st April	0104	24°28.9’	49°53.5’	Change course 158°T. Reduce speed to 8kts
	0502	24°00.0’	49°40.2’	Change course 090°T
	0614	23°59.7’	49°30.1’	Change course 180°T
	0657	23°54.0’	49°30.0’	Change course 270°T
	0822	23°54.0’	49°42.0’	Change course 180°T
	0911	23°48.0’	49°42.0’	Change course 090°T
	1040	23°47.9’	49°30.0’	Change course 180°T
	1125	23°42.2’	49°30.0’	Change course 270°T
	1255	23°41.9’	49°41.9’	Unsuitable position for mooring. Continue survey at best speed.
	1351	23°42.6’	49°32.6’	Change course 338°T
	1642	24°10.0’	49°44.5’	Hove to for CTD
	1700	24°10.0’	49°44.4’	CTD outboard. Commence veering
	2017	24°10.0’	49°42.8’	CTD inboard and secure
	2030	24°10.0’	49°42.8’	Commence survey towards MAR1 at 8kts
	2109	24°12.5’	49°47.4’	Complete survey run
	2124	24°11.2’	49°46.7’	Commence survey toward MAR2
22nd April	0800	24°12.3’	49°47.6’	Hove to 3 miles downwind of new MAR2 position
	0851	24°12.2’	49°47.4’	Commence deployment of MAR2
	1050	24°10.20’	49°45.01’	Anchor released
	1110	24°10.1’	49°44.9’	Proceed to MAR1 site
	1205	24°14.0’	49°48.8’	Hove to 4 miles downwind. Preparing for deployment
	1221	24°14.0’	49°48.8’	Commence deployment of mooring MAR1
	1519	24°11.33’	49°45.22’	Anchor released
	1608	24°11.3’	49°45.1’	Mooring on seabed. Repositioning for lander deployment
	1630	24°11.7’	49°45.6’	Mooring sighted unexpectedly on surface. Hove to
	1648	24°11.6’	49°45.5’	Approaching top buoy to try to shorten wire
	1700	24°11.4’	49°45.3’	Grappled. Commence hauling
	1906	24°11.4’	49°45.3’	Mooring stoppered off. Reterminating
	1940	24°11.3’	49°45.2’	Termination complete. Resume deployment
	2055	24°11.3’	49°45.2’	Termination at top buoy parts. Attempting to release.
	2113			Mooring on surface
	2120	24°11.3’	49°45.1’	Grappled. Commence recovery
23rd April	0045	24°10.5’	49°43.4’	All inboard
	0055	24°10.4’	49°43.2’	Proceed to swath start position
	0452	24°45.9’	50°01.1’	Speed reduced to 8kts
	0538	24°51.4’	50°03.8’	Commence swath survey. 337°T at 8kts
	1255	25°44.5’	50°27.9’	Proceed to survey possible site. Change course 150°T
	1332	25°40.0	50°25.0’	Change course 310°T to survey site at 8kts
	1346	25°40.3’	50°26.2’	Not suitable. Change course 140°T to survey next possible site

	1416	25°37.0’	50°24.7’	Commence swath run over possible mooring site
	1454	25°41.1’	50°27.8’	Hove to 4 miles downwind of position
	1510	25°41.0’	50°27.7’	Commence deployment of mooring
	1827	25°37.53’	50°25.09’	Anchor released
	1920	25°37.7’	50°24.9’	Commence deployment of MARL1 lander
	1922	25°37.7’	50°24.9’	Anchor released
	1936	25°37.7’	20°24.9’	PES Fish inboard. Set course 299°T full speed. End of science.

5.2 KN182-2

Date	Time (GMT)	Lat (N)	Lon (W)	Event
2nd May	1030	32°22.8’	64°38.5	Depart Bermuda
	1320	32°12	64°54	Fire and Emergency Drill
	1340	32°12	64°54	Abandon Ship Drill
	1452	32°09.51	64°51.47	1st Drifter Deployed
	2232	31°05.0	66°06.1	2nd Drifter Deployed
3rd May	0400			Retard ship’s clocks by 1 hour to GMT-4
	0650	29°57.0	67°35.5	3rd Drifter deployed
	1459	28°50.0	69°01.2	4th Drifter deployed
	1818			Hove to for test CTD
	1834			Start test CTD cast
	1859			CTD on deck
	1912			Underway
	2030			Hove to for 2nd CTD test cast
	2048	28°14.11	69°47.3	Start CTD test cast
	2327			CTD onboard. Set course for CTD Station 1
4th May	0323	27°43.0	70°26.53	5th Drifter deployed
	1114	26°36.20	71°50.88	6th Drifter deployed
	1200	26°29.97	71°59.43	Hove to on Station 1
	1212			Commence CTD 1
	1355	26°30.13	71°59.9	Max wire out 5312m
	1612			CTD on deck
	1618			Underway
	1622	26°30.10	72°00.02	7th Drifter deployed
	1824	26°30.24	72°22.30	Hove to at 2nd CTD station
	1832			Commence CTD
	2220			CTD on deck
	2224			Underway to Station 3
5th May	0012			Hove to for 3rd CTD station
	0020			Commence CTD
	0156	26°29.98	72°46.02	Max wire out 5157m
	0412			CTD on deck
	0418			Underway to station 4
	0521	26°30.1	73°00.01	8th Drifter deployed
	0600			Hove to at station 4
	0622			Commence CTD
	0805	26°29.98	73°08.01	Max wire out 5072m
	1012			CTD on deck
	1018			Underway
	1200			Hove to at station 5
	1210			Commence CTD 5
	1345	26°30.01	13°29.96	Max wire out 4986m
	1545			CTD on deck
	1548			Underway to station 6
	1730			Hove to at station 6
	1740			Commence CTD
	1916	26°29.89	73°57.22	Max wire out.
	2100			CTD on deck
	2149	26°29.56	74°00.0	9th Drifter deployed
	2254			Hove to at station 7
	2304			Commence CTD 7

6th May	0030	26°29.98	74°14.00	Max wire out.
	0212			CTD on deck. Underway to station 8
	0336			Hove to station 8.
	0520	26°29.95	74°32.10	Max wire out 4506m
	0710			CTD on deck
	0718			Underway to station 9
	0836			Hove to on station 9
	0851			Commence CTD9
	1014	26°29.85	74°48.03	Max wire out
	1154			CTD on deck
	1200			Underway to station 10
	1256	26°29.95	74°59.61	10th Drifter deployed
	1324			Hove to on station 10
	1330			Commence CTD 10
	1500	26°29.77	75°05.26	Max wire out 4649m
	1626			CTD on deck
	1630			Underway
	1748			CTD 11 deployed
	2042			CTD on deck
	2048			Underway to station 12
	2148			Hove to on station 12
	2200			Commence CTD 12
	2330	26°30.13	75°30.89	Max wire out
7th May	0056			CTD on deck
	0100			Underway to station 13
	0200			Hove to on station 13
	0206			Commence CTD cast 13
	0335	26°30.34	75°42.68	Max wire out 4726m
	0459			CTD on deck
	0500			Underway to station 14
	0600			Hove to on station 14
	0610			Commence CTD
	0744	26°29.33	75°52.86	Max wire out 4474m
	0910			CTD on deck
	0912			Underway to station 15
	0955	26°30.10	76°00.57	11th drifter deployed
	1006			Hove to CTD 15 deployed
	1144	26°30.44	76°02.45	Max wire out 4855m
	1311			CTD on deck
	1312			Underway
	1400			Hove to
	1415			Commence CTD cast 16. Recover CTD. Fouled tag line.
	1420			CTD in water
	1550	26°30.17	76°10.86	Max wire out.
	1721			CTD 16 aboard
	1730			Underway
	1806			Hove to
	1829			CTD 17 deployed
	2138			CTD 17 aboard
	2142			Underway to station 18
	2230			Hove to
	2246			Commence CTD cast 18
8th May	0015	26°30.60	76°28.91	Max wire out.
	0145			CTD on deck
	0148			Underway
	0230			Hove to
	0255			Commence CTD cast 19
	0430	26°30.89	76°30.89	Max wire out 4930m
	0557			CTD on deck
	0600			Underway to station 20 at 6 kts
	0703			Commence CTD 20
	0833	26°30.5	76°39.42	Max wire out 4622m
	0958			CTD on deck
	1000			Underway
	1048			Hove to
	1056			CTD 21 deployed
	1209	26°30.85	76°45.61	Max wire out 3862m
	1320			CTD on deck
	1324			Underway for station 22 at 8 kts

	1400			Hove to
	1416			Commence cast
	1444	26°31.12	76°49.97	Max wire out 1092m
	1515			CTD on deck
	1518			Underway to station 23
	1542			Hove to
	1656			Bahamian Customs Officials aboard
	1803			Customs boat away
	1818			Underway for WB2 site
	2000			Hove to
	2048			Start Microcat 1 (calibration cast)
	2207	26°31.79	76°43.02	Max wire out
	2330			CTD on deck
9th May	0045			Commence cast
	0155	26°32.74	76°44.35	Max wire out
	0354			CTD/Microcats on deck
	1050			Surface float secure on deck
	1200			Mooring on deck. Underway to Mooring "A" site
	1312			Mooring on surface
	1336			Along side
	1348			Surface float aboard/secure
	1425			On deck
	1436			Underway to WBH2
	1730			Mooring confirmed release. 1 hr 10 mins to surface.
	1845			Commence mooring recovery
	1917			End recovery
	1924			Underway to WBH1
	2012			Hove to
	2015			Hydrophone over side
	2116			Floats at surface
	2132			Float grappled
	2212			On deck
	2315			Commence ADCP test cast
10th May	0048			On deck
	0200			Commence dip 3
	0300	26°31.52	76°43.07	Max wire out 3004m
	0430			Test cast on deck
	0800			Adjust positioning for mooring deployment
	1112			Commence Autotrack survey
	1130			In position for start of mooring deployment
	1241			Commence WBADCP mooring deployment
	1249			WBADCP released (600m depth)
	1300	26°32.50	76°52.13	Mooring on the bottom
	1400			Set up 1.25Nm SE of drop wpt for mooring A
	1409			Float in water
	1528			Anchor deployed
	1536	26°30.50	76°50.50	A/S listening to Mooring transducer
	1605			Hove to to listen to mooring
	1828			Commence WB1 deployment
	2033			WB1 anchor away
	2118	26°29.85	76°48.90	Launch IES A
	2230	26°30.67	76°50.39	Commence dip cast 4
	2300			Max wire out
	2325			On deck
	2330	26°31.41	76°50.49	Underway to station 18
11th May	0130			Hove to
	0135			Commence dip cast
	0230	26°30.36	76°28.90	Max wire out
	0406			Dip cast 4 on deck. Hove to awaiting science
	1015			Float surface
	1400			X-Band secure
	1448			X-Band on. Underway to WB2
	1548			Hove to
	1650			Top float on deck
	1851			Release on deck. End recovery
	1912			Underway to B
	2036			Hove to at B
	2110			Commence CTD cast dip 6
	2210	26°30.17	76°30.35	Max wire out

12th May	0000			On deck. Underway to Station IES B
	0030			Hove to at IES B. Transducer in water
	0240			Transducer aboard
	0300			Reposition
	0315			Transducer in water
	1510			CTD dip 7 in water
	1609	26°30.51	76°28.49	Max wire out.
	1806			CTD on deck
	1906			CTD dip 8 in water
	2006	26°32.97	76°30.77	Max wire out
	2200			CTD on deck
	2230			Underway. Repositioning for IES B telemetry
	2312			All stop. Transducer in water
13th May	0150			Transducer out of water
	0215			CTD dip 9 in water
	0315	26°33.75	76°31.10	Max wire out
	0454			CTD on deck
	0500			Underway to IES B station
	0600			On station. Transducer over side
	0830			Transducer on deck. Hove to at B awaiting science
	1120			Commence mooring B
	1530	26°29.44	76°29.89	B anchor away
	1647	26°29.44	76°29.90	Lander away
	1800			Underway for WB2 deployment
	1930			Hove to at WB2 to analyze current
14th May	0015	26°30.62	76°44.63	Anchor away (WB2)
	0030			Transducer in water. Reposition for WBL2
	0130			WBL2 away
	0135			Transducer in water
	0140			Transducer on deck
	0148			Underway for station B
	0300			Hove to
	0309			Transducer in water
	0340			Transducer on deck
	0442			Underway to IES-C
	0706			Hove to at IES-C station
	0709			Commence dip 10
	0845	26°31.70	76°02.66	Max wire out 4902m
	1016			CTD on deck
	1024			Repositioning for WB4 recovery
	1048			Hove to
	1212			Transducer over side
	1230			Transducer aboard
	1321			Floats on surface
	1335			Floats along side
	1336			Crane hooked up
	1340			Top float on deck
	1645			Finish recovery
	1748			Hove to at start position for WB4 deployment
	1917			Commence mooring deployment. Top float away.
	2218	26°30.21	76°02.66	Anchor away.
	2230			Transducer in water
	2310			Transducer on deck
	2318			Underway to station IES-D
15th May	0118			Hove to. Transducer in water
	0230			Transducer out. Reposition.
	0242			Transducer in.
	0600			Transducer on deck
	0618			Underway to IES-E
	1900			Hove to to test current meter
	1844			Current meter on deck
	2155	26°32.26	72°58.22	Max wire out 2984m
	2327			On deck
	2330			Underway to IES-E

16th May	0400			Hove to on station. Transducer over side
	0830			Transducer on deck. Underway to station E
	0930			Hove to at station E
	1000			Transducer in water
	1030			Top floats on surface
	1058			Top float hooked
	1106			Top float secure on deck. Commence mooring recovery
	1455			Releases on deck
	1600			Standing by for science to ready instruments for dip cast.
17th May	0400			Hove to on station. Commence Dip 13/CTD 36
	0512	26°30.36	71°58.62	Max wire out 3008m
	0657			CTD on deck. Waiting on science
	1237			Start mooring E. Top float launched.
	1540			Mid depth 51" float in.
	1832	26°29.96	71°58.28	Anchor away
	1938	26°29.95	71°58.27	Lander deployed.
	2100			Transponder aboard. Underway.
18th May	0600			Hove to on station 37
	0612			Commence CTD 37
	0756	26°30.65	70°00.22	Max wire out 5519m
	0943			CTD on deck
	0951	26°30.03	69°59.89	Drifter deployed
	1000			Underway
	1230			Hove to on station 38
	1238			Commence CTD 38
	1445	26°29.94	70°30.00	Max wire out 5500m
	1613			CTD 38 on deck
	1618			Underway for station 39
	1848			Hove to on station 39
	1859			CTD deployed
	2043	26°30.63	70°59.45	Max wire out
	2230			CTD on surface
	2236			CTD on deck. Underway to station 40
	2240	26°30.81	71°00.00	13th drifter deployed
19th May	0100			Hove to
	0107			Commence CTD
	0245	26°30.32	71°30.07	Max wire out.
	0433			CTD on deck
	0736			Underway
	0736			Hove to on station 41
	0739			Commence CTD 41
	0940	26°30.78	71°59.89	Max wire out.
	1131			CTD on deck
	1200			Underway
	1400			Hove to
	1404			Commence CTD 42
	1540	26°30.56	72°23.47	Max wire out.
	1727			CTD aboard
	1736			Underway for station 43
	1924			Hove to.
	1937			CTD deployed
	2118	26°30.86	72°46.14	Max wire out
	2254			CTD on deck
	2300			Underway
20th May	0010	26°30.20	73°00.00	14th drifter deployed
	0048			Hove to
	0055			Commence CTD cast
	0230	26°30.20	73°08.03	Max wire out.
	0410			CTD on deck
	0412			Underway
	0606			Hove to on station 45
	0612			Commence CTD 45
	0745	26°30.07	73°30.04	Max wire out 4985m
	0921			CTD on deck
	0924			Underway
	1112			Hove to
	1120			CTD 46 deployed
	1250	26°30.36	73°52.21	Max wire out 4758m
	1422			CTD on deck

	1424			Underway
	1458	26°30.31	74°00.00	15th drifter deployed
	1606			Hove to on station 47
	1611			CTD 47 deployed
	1738	26°29.73	74°14.01	Max wire out
	1858			CTD aboard
	1906			Underway
	2048			Hove to
	2054			CTD 48 deployed
	2216	26°29.69	74°30.44	Max wire out 4507m
	2355			CTD on deck
21st May	0000			Underway for station 49
	0130			Hove to. CTD deployed
	0255	26°30.03	74°47.68	Max wire out.
	0425			CTD on deck
	0430			Underway
	0542	26°30.03	75°00.00	Drifter deployed
	0606			Hove to on station 50
	0610			Commence CTD 50
	0742	26°30.00	75°05.00	Max wire out 4630m
	0907			CTD on deck
	0912			Underway
	1018			Hove to
	1023			CTD 51 deployed
	1152	26°29.99	75°17.93	Max wire out 4659m
	1319			CTD on deck
	1324			Underway
	1424			Hove to
	1435			Commence CTD cast 52
	1603	26°29.69	75°30.50	Max wire out
	1743			CTD aboard
	1754			Underway
	1848			Hove to
	1905			CTD 53 deployed
	2030	26°30.07	75°43.47	Max wire out
	2200			CTD on deck. Underway
	2248			Hove to
	2314			Commence CTD cast 54
22nd May	0040	26°30.02	75°52.68	Max wire out 4758m
	0215			CTD on deck
	0218			Underway
	0300			Hove to for Lander deployment
	0308	26°30.01	76°02.78	WBL2 deployed
	0315			Transducer in water
	0330			Transducer out. Reposition 3000m North.
	0612			Hove to station 55
	0618			Commence CTD 55
	0750	26°30.68	76°04.87	Max wire out 4840m
	0916			CTD on deck
	0918			Underway
	1000			Hove to standing by for science due to battery problems
	1049			CTD 56 deployed
	1218	26°30.88	76°11.09	Max wire out
	1316			CTD on deck
	1348			Underway
	1448			Hove to
	1459			Commence CTD cast
	1643	26°30.58	76°19.81	Max wire out
	1800			CTD 57 aboard
	1806			Underway for station 58
	1900			Hove to
	1923			CTD 58 deployed
	2030	26°30.50	76°28.93	Max wire out
	2228			CTD on deck
	2230			Underway to station 59
	2330			Hove to
	2340			Commence CTD cast

23rd May	0110	26°30.45	76°34.29	Max wire out
	0240			CTD on deck
	0242			Underway
	0342			Hove to
	0350			Commence CTD cast
	0514	26°30.63	76°40.08	Max wire out 4494m
	0642			Underway for station 61
	0730			Hove to station 61
	0735			Commence CTD
	0858	26°30.56	76°45.41	Max wire out 3919m
	1012			CTD 61 aboard. Reposition to check WB2 surface float.
	1100			Underway for station 62
	1200			Hove to on station 62. Commence CTD 62
	1224	26°31.08	76°50.16	Max wire out
	1300			CTD on deck. Underway to station 63
	1318			Hove to station 63
	1324			Commence CTD 63
	1345	26°31.68	76°53.16	Max wire out
	1400			CTD on deck. Underway to Station A1
	1530			At A1. Change course for A2
	1930			Change course for revised A4
	2230			Arrive A4. Change course for CTD 64
24th May	0300			Hove to
	0305			Commence CTD 64
	0324	26°04.04	78°50.99	Max wire out
	0338			CTD on deck
	0342			Underway for station 65
	0418			Hove to at station 65
	0440	26°09.87	78°48.89	Max wire out 450m
	0454			CTD on deck
	0500			Underway
	0530			Hove to on station 66
	0533			Commence CTD 66
	0550	26°14.96	78°45.93	Max wire out 506m
	0609			CTD on deck
	0612			Underway for station 67
	0648			Hove to on station 67. Commence CTD
	0708	26°19.92	78°43.14	Max wire out 674m
	0730			CTD on deck
	0812			Hove to station 68
	0817			Commence CTD 68
	0837	26°25.80	78°40.34	Max wire out 750m
	0900			CTD on deck. Underway for station 69
	1300			Hove to on station 69
	1312			Commence CTD 69
	1325	27°00.05	79°12.07	Max wire out 466m
	1345			CTD on deck
	1348			Underway for station 70
	1418			Hove to
	1425			Commence CTD cast 70
	1344	27°00.16	76°16.92	Max wire out.
	1505			CTD on deck
	1530			ABORT CTD CAST TO RECOVER WB4
	2350			Alter course for updated projected position
25th May	0656			Drifting mooring sighted
	0748	27°22.44	75°53.15	Top part of mooring aboard
	0800			Underway for WB4 deployment site
	1242			Hove to talking to WB4 releases. Transducer over side
	1300			WB4 released
	1500			On surface
	1506			All stop
	1512			Commence recovery
	1740			Finish recovery
	1852			Commence deployment of WB4
	2135	26°29.99	76°02.99	Anchor away
	2218			Repositioning 500m. Transducer in water
	2230			Mooring OPS complete. Transducer aboard. Underway for "Hole in the Wall".

6. CD170 Data Logging.

R. Lloyd

The standard RVS ABC suite was used on this cruise. Raw data streams were:

Log_chf	Chernikeef EM log
Gyronmea	Ships gyro compass (formatted as an NMEA message)
Gps_g12	Combined GPS and Glonas position data
Gps_ash	Trimble/Ashtec GPS attitude sensor
Gps_4000	Trimble Surveyor 4000 – primary navigation aid
Surfmet	Meteorological and surface data logger
Winch	Winch data logger
Ea500d1	Simrad EA500 depth data
Adcp	Acoustic Doppler current profiler

Derived data streams were:

Bestnav	Ten second 'best' navigation data
Prodep	Simrad EA500 depth data corrected by Carters Area
Pro_wind	Absolute wind speed and direction

Few problems were encountered with the data logging. On day 104 (14/04/05) between 07:25 and 10:04 the log_chf Level A was replaced; Navigation data was patched into bestnav from gps_4000.

A replacement SUN workstation was provided for this cruise providing two 300Gb external discs. These were made available to the scientific workstation 'sohydro6'. There remains work to do the fully integrate this system with the ship's network. Backups of the primary disc '/data32' were made daily on LTO2 tapes.

7. CD170 Email.

R. Lloyd

Email links were made at least twice a day to SOC with no major problems. At busy times when contact was needed with equipment manufacturers in the USA extra links were made on request.

8. CD170 Single Beam Bathymetry

M. Hebden

Single beam bathymetry was collected throughout the cruise using the ship's fitted Simrad EA500 hydrographic precision echosounder and "fish". The fish was deployed just after sailing from Tenerife and used in preference to the hull mounted transducer throughout the cruise.

Raw bathymetric data files from the Simrad EA500 hydrographic echosounder were read by the program *simexec0* to produce prodep-corrected .cal files. These data were subsequently plotted using *plxyed* and any obvious data spikes removed manually.

During the periods when swath bathymetric surveys were being conducted, there was a substantial increase in the level of noise within the data profiles. Data that were severely affected in this way were edited out altogether. This accounts for the period of absent data between days 101 at 07:03:32 and 104 at 23:59:59.

The de-spiked bathymetric data and corresponding bestnav data were subsequently merged using program *simexec1* and averaged into five-minute periods. This procedure was repeated at several intervals throughout the cruise.

9. CD170 Swath Bathymetry.

R. Lloyd

The Simrad EM12 swath bathymetry system was run for one test and 4 scientific surveys. A sound velocity profile was entered for the first three and the last two surveys. Using the manual edit option the SV data was entered with particular care being taken to adjust the depth/SV pairs to include inflexion points. Good coverage was obtained with no major weather problems. Swath widths of three times depth were easily obtained. The surveys were named:-

Test
MAR34
24N
MAR12
MAR12N

During these surveys a realtime display using the Merlin package was run in the computer room. Hourly plots were made on the HP750 to enable a mosaic of the data for quick ‘first look’ purposes. The ‘colour mapping’ fixed scale option made these plots easier to interpret.

Data from these areas were processed using the Simrad Neptune software using only the default editing rules. The occasional isolated bad data point can be seen on the processed XYZ plots but in general these were adequate for mooring location purposes.

10. CD170 Navigation

J. Marotzke

There are four GPS receivers on RRS *Discovery*: the Trimble 4000 (gps_4000), which is a differential GPS; the Glonas (gps_glos), which uses a combination of Russian and American satellite networks; the Ashtech (gps_ash); and the GPS G12 (gps_g12). Data from all instruments were logged to the RVS Level A system before being transferred to RVS Level C system. Also, the ship’s gyrocompass readings were logged (gyro). In the absence of a dedicated ADCP measurement programme, navigation was in use mainly during mooring location targeting, and no systematic analysis is presented here.

A standard PSTAR best navigation file was updated regularly from data stream bestnav, using the script runnavexec, archiving from cruise start until Julian Day 104, 23:59:59, logged in files *001*; and runnavexec2 thereafter, files *002*. The preferred input for bestnav is the Trimble 4000, as it has been found on previous cruises to give higher positional accuracy. If there were gaps in the Trimble 4000 data, the bestnav process used other inputs as necessary in the order Glonass, Ashtech, G12, gyro.

From positions logged in port at the start of the cruise, the maximum error in both lat and lon of the gps_4000 was found to be around +/- 5m, which appears large for differential gps. The gps_4000 coverage was extremely good during CD170, with only a few brief time-gaps. Surprisingly, gaps were found in the bestnav datastream, which goes counter to the entire concept of having a well-defined continuous best navigation result. The cause is an outdated design of the data stream processing, which shuts down entirely if the last in order of priorities, dead reckoning, fails. The problem has been patched and the data gaps filled (see earlier section on data logging).

For easy and efficient visualisation of the cruise track, especially in relation to mooring location, altimeter tracks and data points, the two pstar files from gps_4000 were converted to matlab files positions_jday104 and positions_jday115, respectively, which can be read and plotted with pos.m.

11. CD170 CTD Operations

P. Keen

11.1 Introduction

A total of nine CTD casts were conducted on cruise CD170 (see table 11.1). CTD casts were taken in combination with a variety of instruments recovered from the moorings as a pre and post deployment calibration procedure. Twelve bottles were removed from the rosette to accommodate these instruments, while still providing an adequate number of bottle samples for salinity calibrations. On casts of appropriate depth, Ixsea acoustic releases were shackled to the outside of the CTD frame to test their release mechanisms at their planned deployment depths.

After the attachment of all instruments requiring calibration and the normal CTD frame set up, the Sea Bird logging software was initiated and data recording begun while the instrument package was still on deck. Subsequently the package was lifted from deck, lowered over the side of the ship and taken to a depth of 10 meters to purge pumps of air and allow the logging instrumentation to stabilise. After three minutes, the package was raised to the surface and thereafter began a downcast to a depth calculated to be approximately 50 meters off seabed. Distance from the CTD to the seabed was observed using a 10 kHz pinger, monitored with the Simrad EA500 echo sounding system. If acoustic conditions allowed, the CTD was taken to within 20 metres of the seabed, otherwise the downcast was terminated at the previously defined depth based on echo sounder measurements and Carter Table corrections.

The three minute bottle stops was repeated at intervals throughout the up cast. At the end of the cast the conductivity and temperature sensors on the main instrument package were flushed with a dilute solution of Triton X and twice with MilliQ water and capped while still full of the MilliQ water.

11.2 Configuration

The serial numbers and calibration coefficients of CTD instruments deployed on this cruise are as follows:

1) Frequency channel 0, Temperature
Serial number : 4489
Calibrated on : 12/29/04
G : 4.36985005e-003
H : 6.45644119e-004
I : 2.27228210e-005
J : 1.99064966e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

2) Frequency channel 1, Conductivity
Serial number : 3052
Calibrated on : 12/30/04
G : -1.01167697e+001
H : 1.41046907e+000
I : 1.40888638e-004
J : 6.06099170e-005
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

3) Frequency channel 2, Pressure, Digiquartz with TC
Serial number : 94756
Calibrated on : 05 Jan 2005
C1 : -4.722750e+004
C2 : 1.465524e-001
C3 : 1.449080e-002
D1 : 3.863800e-002
D2 : 0.000000e+000
T1 : 3.011286e+001
T2 : -2.710648e-004
T3 : 4.095660e-006
T4 : 2.377730e-009
T5 : 0.000000e+000
Slope : 1.00000000
Offset : 0.00000
AD590M : 1.282874e-002
AD590B : -9.075593e+000

4) Frequency channel 3, Temperature, 2
Serial number : 4490
Calibrated on : 12/28/04
G : 4.40572536e-003
H : 6.48538846e-004
I : 2.30142379e-005
J : 2.02318152e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

5) Frequency channel 4, Conductivity, 2
Serial number : 3054
Calibrated on : 12/22/04
G : -9.90666069e+000
H : 1.36319852e+000
I : -2.43252028e-004
J : 8.05596827e-005
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

Station Number	Year	Month	Day	Time	lat	lon	pmin (dbar)	pmax (dbar)	depth at pmax (m)	corrected depth (m)	cordepth-depth at pmax (m)	Near mooring
1	2005	4	2	19:55:52	28° 27.86’	-15° 34.48’	3	3057	3014.6	3540.9	526.3	Release test
2	2005	4	5	04:43:08	26° 54.96’	-16° 08.93’	3	3535	3482.7	3578.8	96.1	EB2R/3
3	2005	4	5	20:16:22	27° 00.23’	-16° 13.42’	1	3545	3492.4	3508.6	16.2	EB3
4	2005	4	9	02:16:47	24° 31.52’	-23° 24.68’	3	5063	4971.8	5000.8	29	EB1
5	2005	4	14	19:57:36	24° 30.95’	-41° 13.63’	3	4887	4800.9	5560	759.1	MAR3/4
6	2005	4	15	01:28:36	24° 31.05’	-41° 12.59’	1	3509	3457.8	5253.5	1795.7	MAR3/4
7	2005	4	16	19:09:18	23° 56.08’	-41° 05.61’	3	5065	4973.9	5021.1	47.2	MAR3/4
8	2005	4	20	20:45:43	24° 28.02’	-50° 10.96’	1	4525	4448.9	4470.7	21.8	MAR1/2
9	2005	4	21	18:10:51	24° 09.93’	-49° 43.74’	3	3461	3411	5199.1	1788.1	MAR2

Table 11.1: CTD summary information.

12. CD170 CTD Data Processing and Calibration

S. Cunningham and J. Marotzke

CTD data processing followed procedures outlined in more detail in [*Bryden*, 2003] and [*Cunningham*, 2005].

12.1 SeaBird Processing Routines

SeaBird routines (software version 5.30a) converted raw engineering data to physical units, outputting an ascii file of 24Hz CTD data, and a file with a single scan, with the time at which each bottle was fired.

1. DatCNV; 2. WildEdit; 3. CellTM; 4.Trans

12.2 CTD Processing

Processing of CTD profiles beyond the .cnv files and assimilation of bottle sample data are performed by PSTAR fortran programmes run from the following cshell execs. *ctd0*, read 24Hz ascii SeaBird .cnv file into PSTAR (.24hz); *ctd1*, despike and average 24Hz file to 1Hz (.1hz) and further average to 10s (.10s); *ctd2*, create 1Hz file with bad records at start and end of cast removed (.ctu) , and create 2db (.2db) file; *ctd3* plot 1hz file; *fir0*, read SeaBird .ros file into PSTAR, merge on CTD data from 10s file, and read winch data; *sam0*, create a blank PSTAR sample file and paste in CTD firing file. *Get_ctd_pos.exec*, extracts positions from the bestnav file based on the times at start, bottom and end of the .ctu file; *add_depth.exec* merges depths from the 5min averaged echosounder file into the CTD positions files; *add_positions.exec*, adds the nadir position to the PSTAR header files.

12.3 Calibration Introduction

CTD conductivities are calibrated by comparing them to bottle conductivities, derived from salinity samples obtained during the CTD upcast (see below for details). The CTD upcast is calibrated and applied to the downcast: the downcast and upcast must be free from hysteresis effects for this to be a valid procedure.

Bottle sample data are entered in an excel file as text (tab delimited) files, transferred to the UNIX system through ftp and read into a PSTAR file by *sal.exec.* These values are pasted into the individual station sample files *passal*. Bottle conductivity is calculated from bottle salinity and (CTD – bottle) comparisons using *botcond.exec*, which writes a matlab data file *sam_append_cal.mat*. This .mat file is read by *ctd_cal.m* to determine CTD calibration parameters.

12.4 Method

CTD conductivities are corrected to match bottle conductivities using the ratio $K=\langle C_{bot}/C_{CTD}\rangle$ where C_{bot} is the measured bottle conductivity, C_{CTD} the upcast CTD conductivities and < > denotes the station mean. Bottles were removed from the calibration; that had a difference greater than 0.1mS/m from the CTD; or whose conductivity was more than 2 standard deviations from the station average difference (see table 12.1 and figure 12.1).

K=1.0001 was applied to all stations. A final 2nd order polynomial fit of bottle-CTD conductivity residuals was used to correct a small pressure dependence in the final residuals: cond_corr=-3.0928E-7*press+1.0708e-11*P^2 (figure 12.2). The routine *ctd_calibrate.exec* applied these calibrations to the 1hz files, and then the routines from *ctd2* onward created the calibrated CTD and sample files.

.Mean μ	Standard deviation σ	Total number of bottle samples used to compute mean. N	Total number of bottle samples. N_tot	Percent rejected	Limits	Notes
0.0000	0.001	108	120	10	±0.1, ±2σ	Final data set
0.0000	0.0007	48	48	0	P > 2500db, ±2σ	Final data set

Table 12.1: Bottle-CTD conductivity residuals in mS/cm. N_tot is the total number of bottle samples and N the number used to compute the mean.

12.5 References

Bryden, H.L., RRS Charles Darwin Cruise 139, 01 MAR - 15 APR 2002, Trans-Indian Hydrographic Section across 32°S, pp. 122, Southampton Oceanography Centre, Southampton, 2003.

Cunningham, S.A., RRS Discovery Cruise 279, 04 APR - 10 MAY 2004: A transatlantic hydrographic section at 24.5°N, pp. 150, Southampton Oceanography Centre, Southampton, 2005.

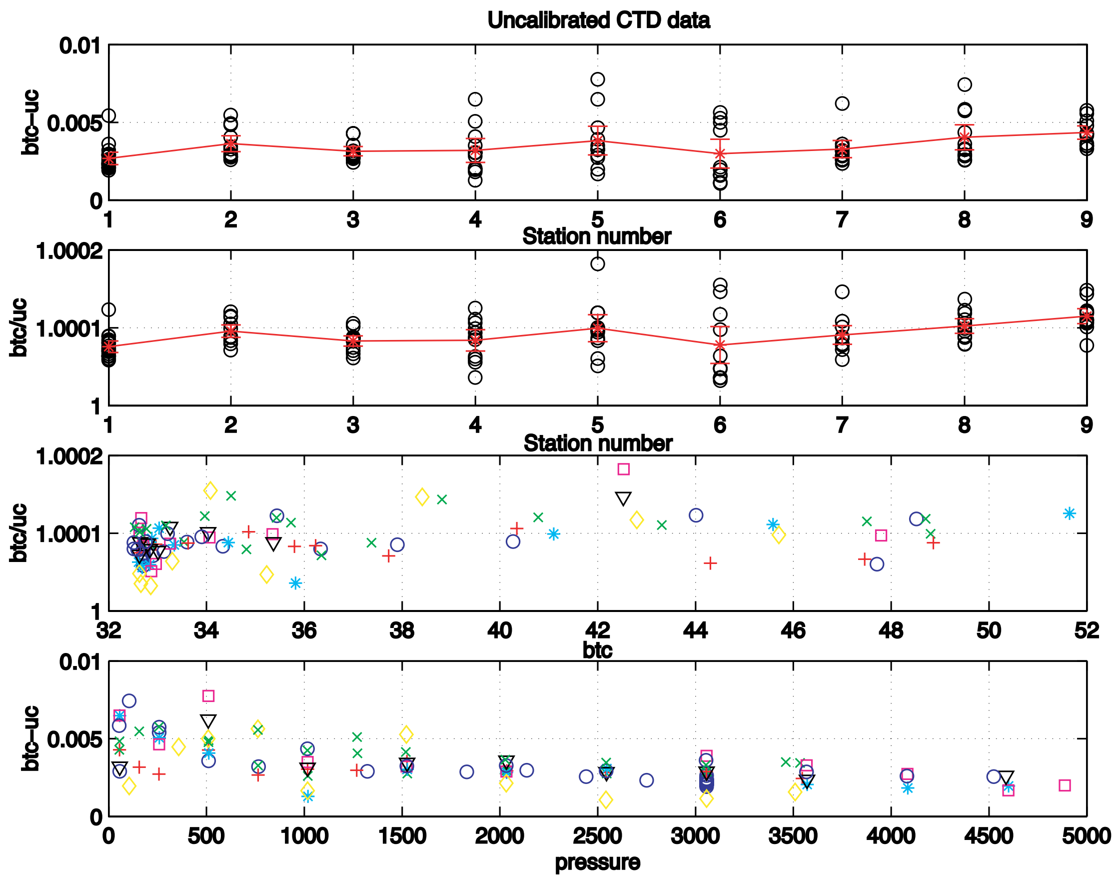


Figure 12.1: Uncalibrated CTD data: i. (btc-uc) v station number, ii. B(btc/uc) v pressure, iii. (btc/uc) v btc and, iv (btc-uc) v pressure. Where btc is bottle conductivity and uc is CTD upcast conductivity.

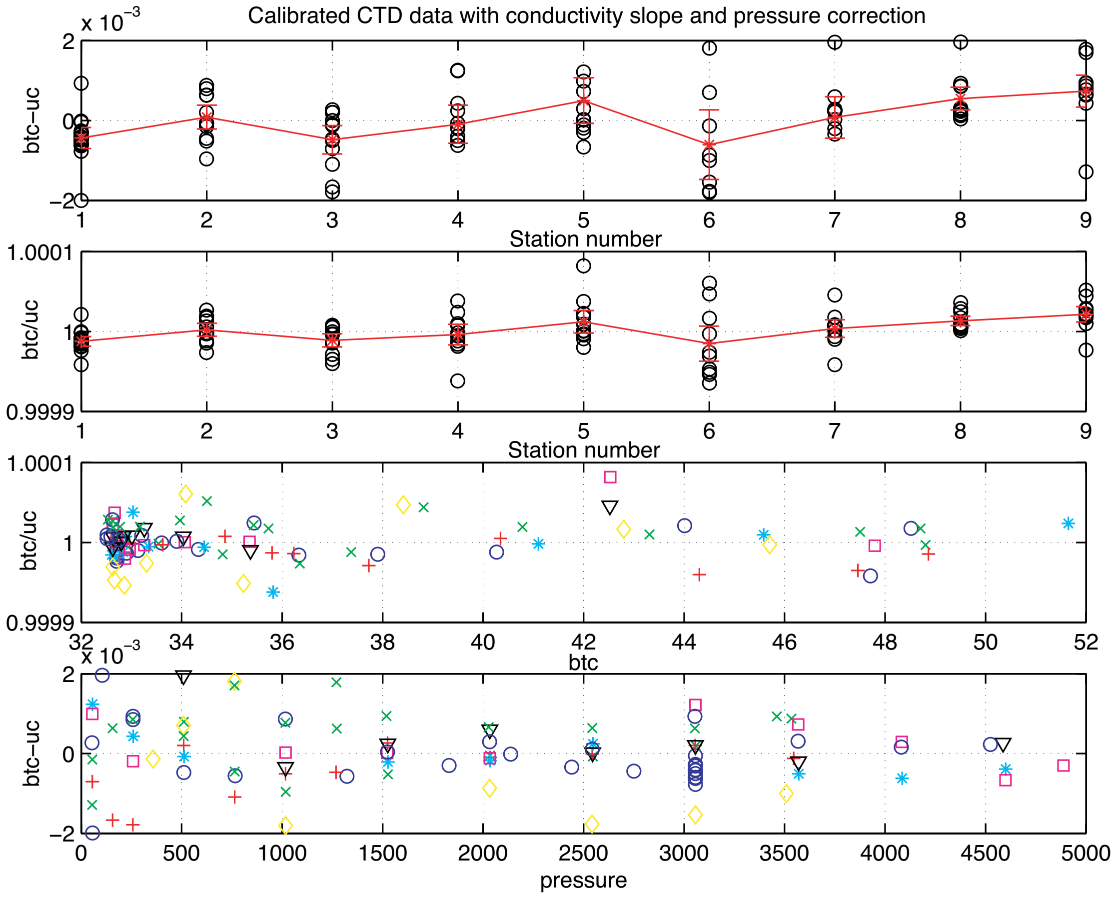


Figure 12.2: Calibrated CTD data: i. (btc-uc) v station number, ii. B(btc/uc) v pressure, iii. (btc/uc) v btc and, iv (btc-uc) v pressure. Where btc is bottle conductivity and uc is CTD upcast conductivity.

13. CD170 Surface Temperature and Salinity

S. Cunningham and M. Hebden

Surface temperature and salinity were measured continuously during the cruise. A high precision FSI temperature sensor measured water temperature at the bow of the ship, approximately five meters below the surface. Surface conductivities and temperatures for calculating salinity were measured in this same water after passing through a debubbling system. Sampling frequency was once per second. To calibrate surface conductivities, samples were drawn once every four hours whilst underway or during periods of steaming between mooring operations.

The following cshell routines running PSTAR programmes were used to process the data.
1. *surexec0*: read continuously measured sea surface and met. measurements from RVS file format to PSTAR format. File out: sur170nnn (sequential) and sur17001 (master file that is appended to each time *surexec0* is run).
2. *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 0 to calculate salinities from conductivities; merge in positions from bestnav file. File out: sur17002 (master file of edited calibrated data).

3. *sur.exec*: read salinity sample data from excel file to PSTAR
4. *surexec2*:. Convert times to time in seconds past start of year from the sample times recorded as jday, hrs, mins, sec. File in: sur170nnn.txt, File out: sur170nnn.bot. File in: sur170nnn.bot, File out: sur170.samples.

To calibrate the continuous salinity data in sur17001 these data were merged with bottle sample data using the time variable. The discrete bottle samples with matching salinities are used to compute a salinity difference that was filtered and added to the surface salinities. File: sur170.master, File: sur170.samples. The final calibrated sea surface temperature and salinity are shown in figure: 13.1.

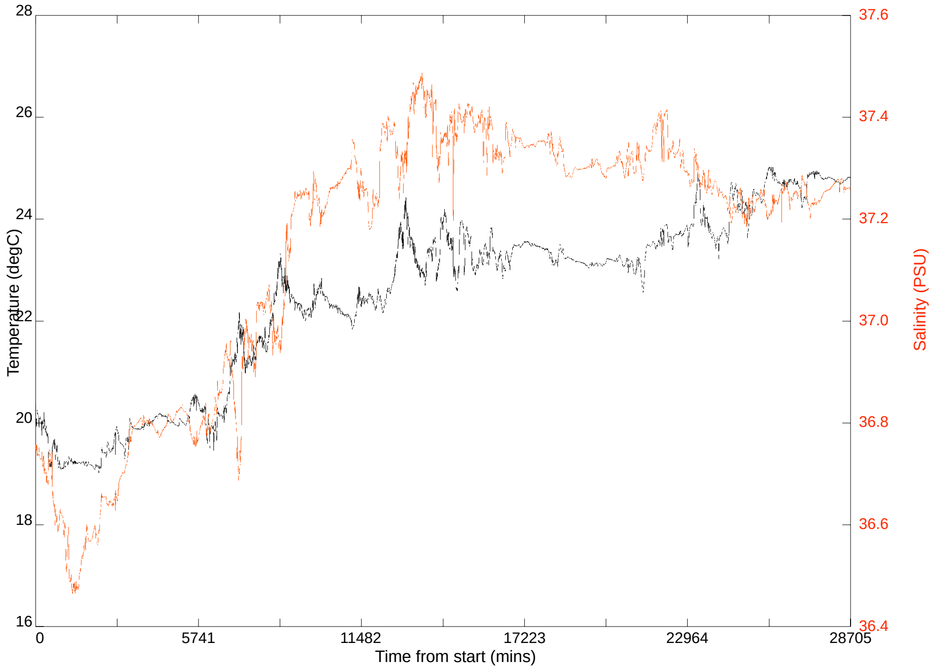


Figure 13.1: Calibrated sea surface temperature and salinity records

14. CD170 Water Sample Salinity Analysis

M. Hebden

14.1 Laboratory set up

One Guildline 8400A salinometer (s/n 56.747) was set up in the constant temperature (CT) laboratory on RRS Charles Darwin, for the analysis of CTD and thermosalinograph (TSG) discrete samples. The temperature in the laboratory was set to 16°C, with the salinometer operating at 18°C. Minor repairs had to be carried out to the peristaltic pump prior to the first analysis, after which no significant problems were encountered.

14.2 Sampling and analysis

Water samples were collected from each Niskin bottle in numbered 200ml glass sample bottles. A disposable plastic stopper was inserted into the dried neck of the bottle before being capped with a screw top lid. Bottles were then placed in wire crates and left in the CT laboratory for a minimum of twelve hours prior to analysis. In addition, samples were also drawn from the ship's non-toxic supply for the purpose of TSG calibration. These were collected approximately every four hours, avoiding times when the ship was on station.

Salinity analysis followed the standard procedure. Crates of samples were analysed back-to-back with a standard seawater sample run between each crate and at the start and end of each session. All samples and standards were homogenised by inverting the bottles several times before being drawn into the salinometer. Standards were flushed through five times before any readings were taken; this was reduced to three times for the sample analyses. Successive readings were taken until a stable conductivity ratio was obtained, or an average could be calculated. These ratios were ultimately typed into an Excel spreadsheet, which converted conductivity ratios to salinities, taking account of variations from the standard readings. Figure 14.1 shows the corrections applied to the conductivity ratio measured by the Guildline salinometer for each CTD station. Corrections were calculated from the expected and actual readings of standard seawater.

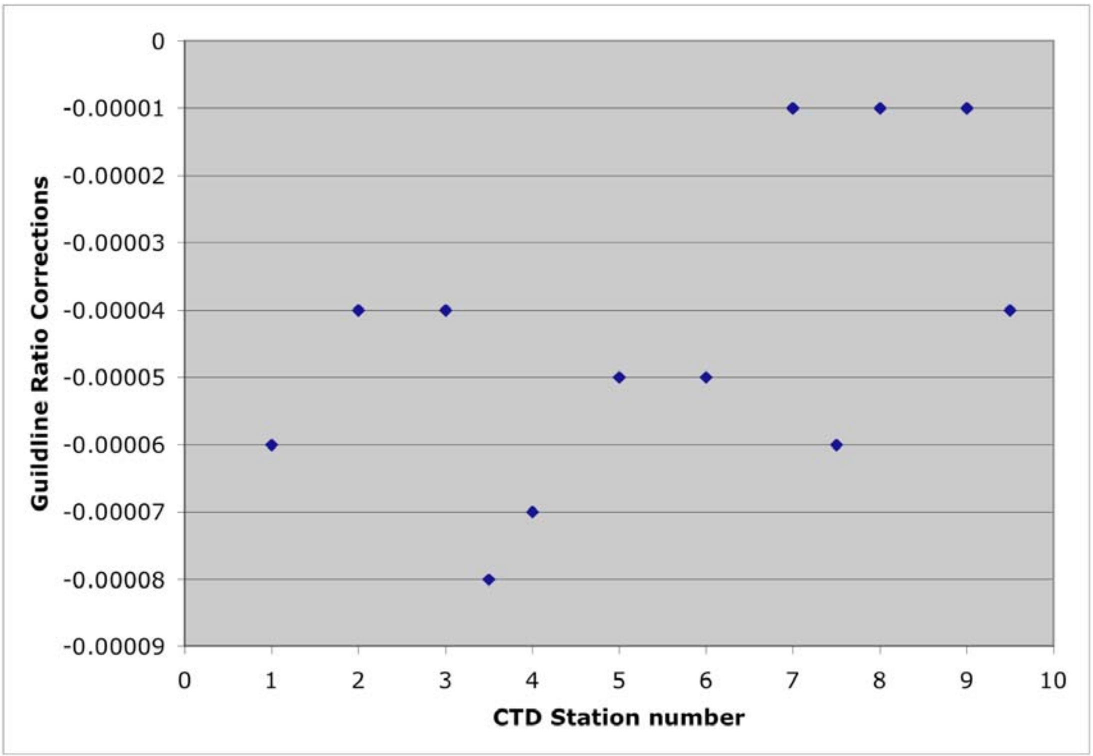


Figure 14.1: Standard seawater correction to the Guildline ratios for SSW batch P144. CTD stations 3.5, 7.5 and 9.5 refer to the underway sample crates 1, 2 and 3 respectively, which were analysed between CTD station crates.

15. CD170 Filming Operations

O. Gaffney

Owen Gaffney from NERC's communications group filmed the mobilisation, mooring retrieval and mooring deployments of the Rapid Climate Change cruise. 12

hours of footage was shot on a Sony PD170 camera (DVCAM) and edited into a short DVD using Adobe Premier. The DVD has been shown at a Science festival in Hamburg (dubbed into German) and at the Meteorological conference, Exeter, September 2005. Paul Hardaker, chief scientific advisor, Met Office, has expressed an interest in using the footage for a forthcoming Sunday Times DVD on climate change he is preparing. The British Council have offered Bangladeshi broadcasters the footage for a forthcoming event on climate change in Dhaka and the film is due to be shown in the House of Commons at a reception on climate change, 10 November 2005.

16. Mooring Array Design Changes for 2005-2006

S. Cunningham

16.1 Introduction

The RAPID-MOC array is a pre-operational prototype. As such, the array design is evolving, driven by practical demands – such as a response to mooring losses to deep-sea fishing, and scientifically – as each set of retrieved data suggests improvements to the measurement array to improve our estimates of the Atlantic meridional overturning circulation.

16.2 Changes in the Eastern-Boundary Mooring Array in Response to Mooring Losses Due to Deep-Sea Fishing

During the year 2004-2005 three moorings in the Eastern Boundary were lost through fishing activity: EBADCP, EB2, and the top part of EB3.

The EBADCP mooring was a total loss and was not recovered. As the releases could not be located we suspect the mooring has been relocated by trawling. Fishing activity is suspected, but no definite proof is available. Another ADCP was deployed in Spring 2005 and survived only a few days. This instrument was recovered and inspection suggests that the mooring was dragged before breaking beneath the release. Deploying again in Autumn 2005 the mooring has a weak link below the release to the anchor. This is to ensure that fishing will break the mooring allowing the instrument to surface and be recovered.

Mooring EB2, deployed in February 2004 surfaced in early October 2004 some 100km north east of its deployment position. Again, no definitive evidence of fishing has been obtained but the displacement distance to much shallower water suggested trawling.

On recovering the EB3 mooring we found that the mooring had been cut at 1000m, with clear damage on the wire indicating damage from a fishing cable.

To combat losses to the principal tall boundary moorings we have moved them much further offshore, adding two more near bottom moorings crawling up the continental slope.

16.3 Pressure Inverted Echo Sounders (PIES)

PIES measure bottom pressure, and travel time to the surface and back to the seabed instrument. The travel time measurement can often be interpreted as a measure of the density structure. Being a seabed instrument the PIES should be less prone to fishing activity. However, to interpret the travel time estimates as vertical density, comparisons between density and travel time are required. We will obtain this by deploying one PIES at the EB1 mooring site offshore so we can test the method. A second PIES will be deployed in 1000m depth, giving estimates of the variability in the thermocline density structure very close to the eastern boundary.

16.4 Bottom Pressure Measurements

Based on recent analysis of bottom pressure records (Johns *et al*, 2005; and Kanzow *et al*, 2006) annual deployments and recoveries of BPRs does not allow estimation of bottom pressure fluctuations on longer than annual timescales, because of problems with pressure sensor drift and the difficulty of levelling bottom pressure measurements from separate deployments. To combat this we are focussing our BPR measurements at specific sites, two sites at the western and eastern boundaries and one site on each side of the mid-Atlantic ridge. At each site BPRs have been deployed for a two year duration. At the start of year two a second BPR will be deployed at each site, giving BPR records that overlap by one year. This should help eliminate the problem of drift and levelling the pressure records between separate deployments, ensuring we obtain effectively continuous levelled bottom pressure records across the Atlantic.

16.5 Vertical Resolution of CTD Measurements on Moorings

In the papers and thesis (Kanzow, 2004; Johns *et al*, 2005; and Kanzow *et al*, 2006), the importance of increased vertical resolution relative to our present resolution, and making measurements at matching depths on moorings either side of the Atlantic is emphasised. Both improved vertical resolution and matching depths helps reduce biases in the estimates of horizontal gradients. We have adopted the following standard levels: 50m, 100m, 175m, 250m, 325m, 400m, 500m, 600m, 700m, 800m, 900m, 1000m, 1100m, 1200m, 1400m, 1600m, 1800m, 2000m, 2500m, 3000m, 3500m, 4000m, 4500m, and 5000m.

16.6 Limiting use of McLane Moored Profilers

In the first and second years of the RAPID-MOC array we have had limited success with MMPs, recovering only 1078km out of 4086km of vertical CTD profiles (the 2 MMPs from MAR4 and EB2 that are currently deployed are not included in this calculation). This has been due to the total loss of two instruments through fishing (the original EB2 in 2004, and WB4 in 2005); the implosion of vehicle buoyancy on mooring MAR4; and the failure of the CTD pressure sensor and drive train on mooring WB4. Consequently, we conclude that in fishing regions the MMP mooring type is extremely vulnerable. Any wire break is likely to lead to total loss: in contrast vertically distributed instruments on a mooring with backup buoyancy are likely to be partially recoverable, as illustrated by the recovery of EB3 in 2005 despite loss of the top 1000m of mooring. Also, if there is a failure of the CTD then data loss is total. Our remaining two MMPs will be used only in the eastern boundary in the offshore region where fishing is less likely to be a problem. The moorings on the MAR and western boundary have been replaced by vertically distributed CTDs.

16.7 Changes to Mooring Locations

The principal moorings across the array and where BPR measurements will be made, WB2, MAR1, MAR2, EB1 and EB2 have been relocated slightly so that they lie beneath cross over points of the TOPEX satellite.

16.8 References

Johns, W. E., T. Kanzow, and R. Zantopp, 2005: Estimating ocean transports with dynamic height moorings: An application in the Atlantic Deep Western Boundary Current. *Deep Sea Research*.
Kanzow, T., 2004: Monitoring the integrated deep meridional flow in the tropical North Atlantic, Mathematics and Natural Sciences, University of Kiel, IFM-GEOMAR, 140.
Kanzow, T., U. Send, W. Zenk, A. Chave, and M. Rhein, 2006: Monitoring the deep integrated meridional flow in the tropical North Atlantic: Long-term performance of a geostrophic array. *Deep Sea Research*, **accepted**.

17. Mooring Operations

I. Waddington

17.1 CD170 Deck Layout

The deck was set out with the DBC winch system on the centreline of the ship, arranged to align with the mooring table. Removable chains fitted to each side of the table permitted large buoys and anchors to be swung outboard near deck level. Glass buoys were stored in cages on the starboard side aft deck and starboard side deck (See photographs C.1 and C.2 in Appendix C). Steel buoys were stored on upper deck alongside a soft top mooring storage container. All anchors for EB moorings were stored on the aft deck with wires. MAR anchors and spare Parafil were stored on the upper deck in the soft top storage container. The mooring workshop container was used for the preparation of acoustic releases and storage of MMPs and ADCP. Main lab used for instrument servicing and preparation. (see photograph C.3 in Appendix C). The wet lab was used as the morgue for flooded and badly damaged instruments that were awaiting attention.

The Double Barrel Capstan winch (DBC) and reelers were all hydraulic machinery driven from the ships supply. (see photograph C.4 in Appendix C). The extended reeler was completed in Tenerife with UKORS technicians building scrolling gear before sailing. The DBC and orange reeler had all major refitting completed before this cruise. The diverter sheave was an old unit which was built up onto a base, again fabricated onboard in Tenerife by UKORS technicians. The machinery ran well throughout the cruise and a list of improvements was drawn up for future modifications, to enable better placement and operation. This is to be undertaken on return to UKORS.

On the last 2 mooring operations of the cruise the extended reeler motor started making “dramatic knocking” noises symptomatic of nearing failure. This motor is to be replaced on return to UKORS.

17.2 CD170 Recovery Operations

After firing the acoustic releases all recovery operations commenced with using a grappling line on the starboard side midships. The recovery line was hauled aft and then inboard using the DBC. Mooring recovery was then conducted over the stern using the new mooring table, ships cranes and DBC system.

The addition of a drive shaft to the extended reeler, which permitted wooden drums to be used for recovery, enabled a fast turn-around of moorings. Drums could be filled with mooring line and then lifted off to allow deployment or further recovery operations without off winding line. Hauling speed averaged at 60 metres a minute.

Moorings recovered with no top buoy or recovery line were grappled and then hooked by a lifting hook on an aluminium pole. The hook has a lifting capacity of 1 tonne which is adequate for all the RAPID moorings. Moorings that had significant problems with tangled lines were hauled onboard with as many as seven lines being wound simultaneously around the capstan. To prevent tangling whilst passing round the capstan the line was taped together at intervals.

17.3 CD170 Deployment operations

All deployments took the form of buoy first, anchor last with the anchor being free fall. The EBH series of moorings using all glass or syntactic floats were deployed by hand with the line being flaked down into fish baskets. This voyage the aft rails were left up on occasion to try over rail deploys however the deployment of the heavier glass packages was awkward and necessitated lifting the tripod assembly with heavy ballast high over the rails by crane, this worked fine in the calm weather throughout these deployments but would have been hazardous in any rougher weather. Large buoys and anchors were lifted outboard mainly with the rails down.

Deployment of the longer moorings was achieved using the DBC, mooring table and ships crane. This being the first cruise UKORS has used its own table the methods were developed throughout the cruise and modifications and additions list made for future use. The table worked well and is a valuable addition to the operation (see photographs C.6 and C.7 in Appendix C). A new procedure document is required to incorporate the moorings table techniques.

Anchor release was effected using the SeaCatch release hook which was a size larger than the version first used in August 2004 (see photograph C.8 in Appendix C). This hook is intrinsically safe and easy to operate. On only one occasion did a pre-release occur which was probably due to incorrect closure. The hook can be released by hand for all the anchors, (up to 1.3 tonnes each). This hook will now be the main moorings tool for this type of operation with the BOSS Tow hook being taken out of service.

17.4 Day to Day Mooring Operations

For mooring diagrams of moorings recovered on CD170 and KN182-2 see Rayner & Cunningham *et al* 2005. For mooring diagrams of moorings deployed on CD170 and KN182-2 refer to figures A.8 – A.33 in Appendix A.

A summary of the mooring recovery dates can be found in table 19.1. For precise timings see the Bridge Timetable of Events in section 5.

17.4.1 CD170

2nd April 2005:-
Acoustic release wire test

3rd April 2004:-

EBH4	Mooring recovery	27 49.8N	13 47.5W

EBH4was the most fouled of the EBH series of moorings but only occurring on the upper surfaces of buoys and tripod. Recovery line also heavily fouled. (See Photographs C.9 and C.10 in Appendix C).

EBH5	Mooring recovery	27 51.2N	13 31.5W
ADCPE	**NO CONTACT**	27 53.8N	13 23.7W

Numerous transmissions at various ranges – Set up for single element PES fish.

EBH5 Mooring deployment
Anchor dropped when interrogating during freefall

2nd Anchor away		27 54.5N	13 21.9W
ADCPE	Mooring deployment	27 53.97N	13 23.6W

This mooring later resurfaced and activated an Argos SMM alert approximately 11 days after deployment (at which time the *RRS Charles Darwin* had sailed to the Mid Atlantic Ridge). Tracking was conducted by staff at NOC and a recovery accomplished through help from the *RV Poseidon*, which was passing the area. The cause of the premature surfacing has not been determined at this time.

EBH4	Mooring deployment	27 52.21N	13 28.2W

4th April 2005:-

EBH3	Mooring deployment	27 49.1N	13 44.3W
EBH3	Mooring recovery	27 37.2N	14 12.6W

There was fouling present on EBH3, reaching down to 800m depth on the mooring line. (See Photograph C.11 in Appendix #).

EBH2	Mooring recovery	27 29.3N	14 41.2W
EBH2	Mooring deployment	27 36.59N	14 12.85W

Photograph C.12 in Appendix C shows the deployment of a glass package on EBH2.

EBH1	Mooring recovery	27 16.4N	15 25.2W
EBH1	Mooring deployment	27 16.3N	15 25.24W

5th April 2005:-
Acoustic release wire test

EB3 position check with acoustics on route to EB2		26 59.7N	16 13.9W
EB2R	Mooring recovery attempt		

EB2R was a replacement mooring deployed in December 2004 to replace EB2, of which the majority was lost through fishing activity. (see the short EB2R report in Appendix D)

Both acoustic releases were fired but the mooring failed to surface. Diagnostics on the releases indicated correct operation, and that the releases were upright and approximately 100m above the seabed, but this offset was later thought to be caused by an incorrect speed of sound calibration in the release deck unit. A surface search was conducted due to the 100m offset reading but nothing was found. It was decided to leave this mooring and recover EB3 so that the dragging gear could be made ready for the following morning.

EB3 Mooring recovery 26 59.8N 16 14.0W

The former telemetry buoy mooring was in an unknown state.

After release a rise was observed on ranging the releases. Both releases were fired as the mooring seemed reluctant to lift off the bottom at first. This was later attributed to the loss of the top part of the mooring and a resulting reduction in buoyancy causing a slower ascent rate.

The first buoyancy observed to surface was a glass package and not the expected steel sphere. The ship stood by the buoyancy to observe what else came to surface, further glass packages were observed and slant ranges from the deck unit were constant as the release buoyancy reached the surface.

The first glass package was grappled on the second pass as there was no line on the surface to hook. The package was attached using a hook on a pole to connect to the chain between glass spheres. Hauling commenced with tangled wires coming onboard (see Photographs C.13 and C.14 in Appendix C). Many loose bights were hauled around the DBC onto a wooden recovery drum, and despite many lines being hauled together (up to 7 at one time) all lines passed around the capstan without any problems.

When the mooring was inboard the wire was searched through to the top end; a clean cut was identified with wire scrapes along the mooring wire. This was thought to be caused by a fine wire passing up the mooring, and severing the mooring line beneath the Microcat at 1000m (see figure A.7). The end was cut off and saved for evidence and future reference.

The mooring buoyancy was checked and broken down to cages. All clamp on glass spheres were in position and they caused no marking of the mooring wire other than minor clamp marks. All mooring hardware that was recovered was in good condition.

A calibration CTD was conducted after mooring operations were completed.

6th April 2005

EB2 Dragline recovery

An acoustic box survey around the mooring was conducted to accurately determine the anchor position (see figure 17.1). With a good acoustic boxing and a run over the best new position a start position was determined. The dragline was deployed as shown in figure 17.1. Details of the dragline used are shown in figure 17.2.

When the dragline was laid out around the mooring site, the wire was hauled and the mooring surfaced on the starboard quarter as expected from the acoustic positioning survey. Whilst recovering the remaining dragging gear, the mooring buoyancy was kept on the starboard side and then grappled when the dragging gear was stowed.

When the mooring was recovered it was found that the lowest Microcat, back up buoyancy and acoustic releases were missing. At the time it was thought the glass spheres had been seen on the surface during recovery. Acoustic ranging commenced and with various courses it was soon found that the mooring was still upright and firmly anchored on the seabed; the mooring wire had been severed by the dragline just above the Microcat. The position was re-fixed and then we left the area.

It is suspected that the failure of the mooring to release may have been caused by a faulty doubler kit or by the mooring line being caught around the release assembly. From the signal on the echosounder it appeared that the dragline did lift the anchor during hauling, and it is surprising that this did not dislodge the release mechanism. As a precaution all doubler kits were abandoned and the releases have now been placed in tandem, one above the other. No problems were found with any other doubler release assemblies throughout the rest of the recoveries, with all releasing correctly.

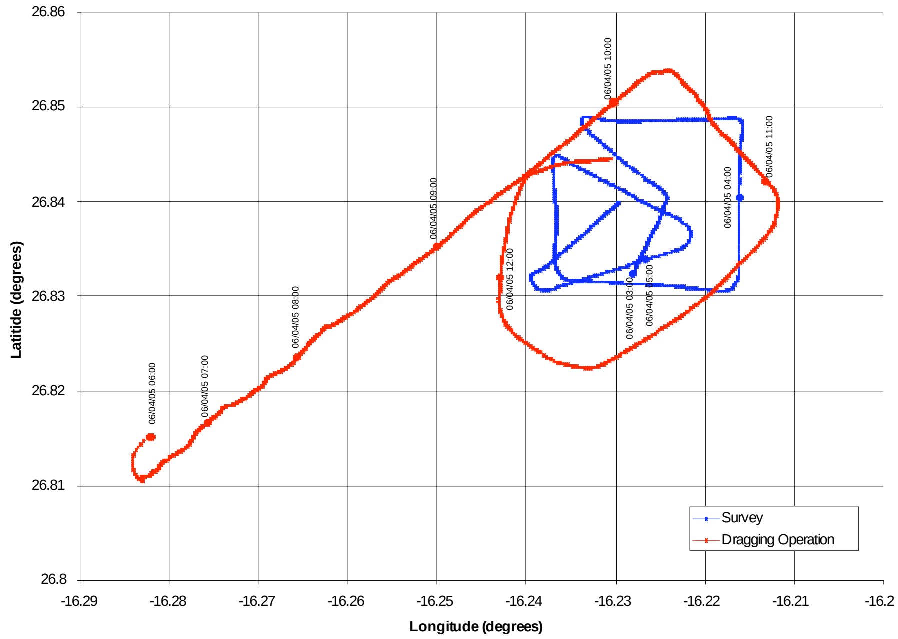


Figure 17.1: Ship's track for acoustic survey (blue) and dragging operations (red) at EB2.

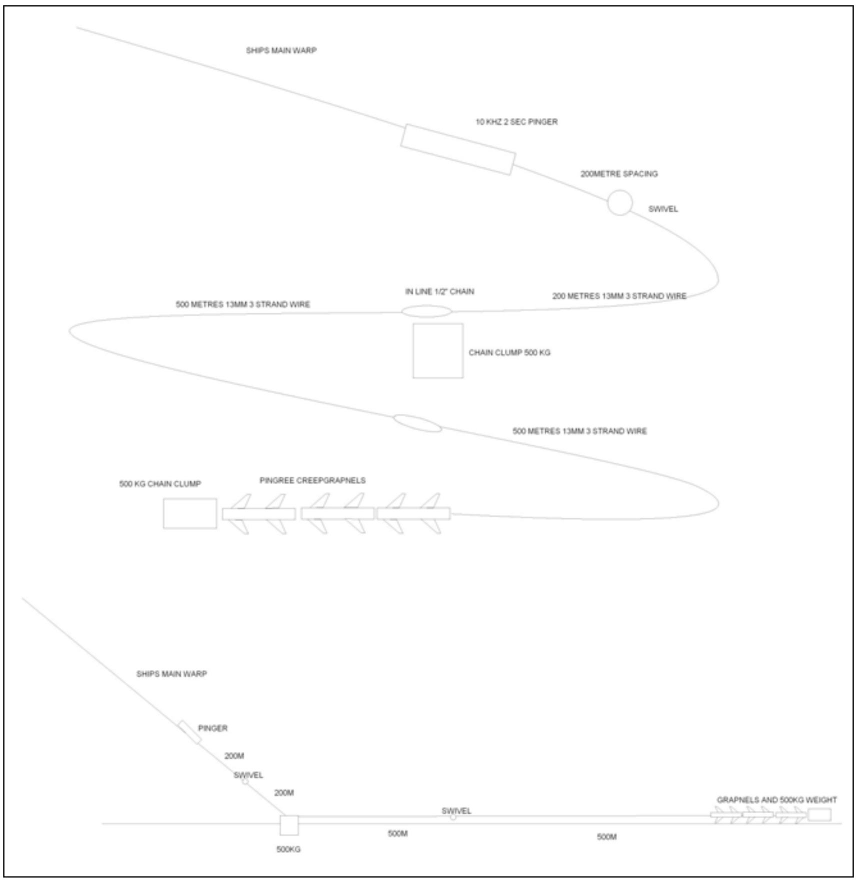


Figure 17.2: Configuration of dragline used for recovery of EB2_R

7th April 2005

EBL2	Mooring deployment	27 16.57N	15 25.02W
EBH0	Mooring Deployment	26 59.6N	16 13.7W

8th April 2005

EBHi	Mooring Deployment	24 57.40N	21 15.60W
Calibration CTD			

9th April 2005

EB1	Mooring recovery	24 31.1N	23 26.9W
Topex Poseidon Track Swath Survey			
EB1	Mooring deployment	23 49.69N	24 05.72W

On observing the descent of the anchor using acoustics, all looked fine: However when checking that the Argos signal had ceased being received by the deck unit on the bridge, a signal was detected which indicated the buoy on the surface. On looking aft from the bridge the mooring buoy could be observed as a single flash from the Bowtech light.

In order to check correct recognition the ship was brought alongside and using the searchlight the buoy was identified as being EB1 awash and just afloat. This could have been caused by two things; either the mooring was over length or the anchoring was too light meaning the mooring would be afloat.

Ranges were made on acoustics and the minimum range was shallower than the echo sounding, indicating a floater. Checks were made on mooring statics calculations and it was discovered that the anchor weight was in air what the water weight was calculated for. Thus the mooring was adrift. Checks were made to determine mooring drift by steaming up close during the night. The ship maintained close contact throughout the night but at dawn with a low sun, temporary loss occurred. However using the acoustics and ARGOS the ship soon came up into contact again.

Overnight a plan was made to exchange the top 48 inch buoy for a 41 inch sphere, which when tested on dynamics still gave adequate performance and meant the mooring did not have to be fully recovered. Just exchanging top buoys would sink the mooring and anchor hold down would be adequate. A 41 inch ORE was prepared with ARGOS ready-rigged with underbuoy chain and recovery line.

10th April 2005

The great EB1 buoy swap 23 48.63N 24 06.31W

The ship was brought alongside the buoy and grappled. When hauling astern it was unfortunate that the recovery line caught under the Argos and light assembly, and as load came on to the line the assembly was wrenched into the air and sank away.

The 48 buoy was hauled into the A frame and stopped off using a vertical chain rigged by the bosun; under the live loading of mooring and anchor this was the only hazardous part of the operation. When the buoy/mooring was stopped off the 48 inch sphere was removed, the 41 inch sphere quickly attached and then lifted outboard and lowered on the winch rope to check that the mooring would sink. The buoy was lowered some metres below the surface and load during payout was considerable, indicating the buoy would sink and that the anchor was well off seabed at this point.

The lowering rope was then cutaway with the buoy close into the side of the vessel and the buoy observed to sink rapidly away. Checks were made on the acoustics using the TT801 deck unit and a discrepancy of 100m determined when the descent had stopped. Ranging was then checked on the TT300 deck unit and correct ranges established. A sigh of relief was breathed all round. On checking the TT801 strange event it was found that the turn-around time set at 300msec caused this. When this was reset to 20 msec the ranging was correct.

EB2 Mooring Deployment 23 55.79N 24 02.57W

The mooring top buoy was reduced from 50 to 48 and glass adjusted.
Mooring watched down on acoustics - buoy sinks.

11th April 2005

Quiet day R & R

12th April 2005

Preparation of mooring parts for MAR3 and 4 and MARL2

13th April 2005

Winding on completed – buoys assembled

14th April

MAR 3 Mooring Recovery 24 29.9N 14 12.7W

MAR4 Mooring Recovery

As soon as the top buoy was inboard and secure, and the winch had started hauling the ship's speed was increased to 2 kts to stream the mooring to try and prevent tangling of the profiler in its wire as the lower glass rose. This was achieved OK and hauling went well. As the quantity of wire built up the winch struggled to pull the loaded wire and slippage occurred on the capstan drums. The reeler was low on torque for this volume of wire so back tension pressure was increased and hauling continued.

As the MMP was seen hauling towards the ship the sting was seen out of the water with one sting point broken. On hauling closer it could be seen that the MMP was missing most of its outer covers and a substantial part of its structure. Sensors were hanging from the remains on their connector cables. All was safely hauled onboard and photographs of the remains taken. A thorough examination was made of the shattered MMP and all parts which could be dismantled were taken apart. (see photographs C.15, C.16 and C.17 in Appendix C).

CTD

15th April

Swath survey – for MAR3 and MAR4 deployment sites

MAR3 Mooring Deployment

16th April

Continued Swath towards MAR4 site

MAR4 Mooring Deployment

MARL2 Mooring Deployment

17th April

Swath survey – 8 knots towards MAR1 site

Mooring preparation
Make up glass and moorings for MAR 1 and 2

18th April
Swath
Major sorting of mooring gear into Knorr required parts and parts required for UK, all glass onboard made up.
Update paperwork.
Prep deck for MAR1 and MAR2 sites.

19th April
Swath

20th April
End of Swath

MAR1	Mooring recovery	24 29.5 N 50 15.6W

Heavy fouling was found on the Microcat at 50m depth (see photograph C.18 in Appendix C), but this fouling was only evident to a depth of 100m on the mooring line.

MAR2	Mooring recovery	24 28.8N 50 34.4W

CTD

21st April
Swath and PES survey of potential mooring sites. No suitable site found.
CTD
Continue swath survey
22nd April

MAR 2	Mooring deployment	24 10.2N 49 45.01W
MAR1	Mooring deployment and recovery	24 11.33N 49 45.22W

The deployment operation for MAR1 went smoothly, however the surface buoy was see on the surface after the anchor had been confirmed on the bottom. At first it was thought that the same had happened as with EB1, but checks on the calculations confirmed that the anchoring was sufficient. Wire lengths were correct and the problem was attributed to the anchor landing on a small elevation on the rough seabed which caused the mooring to be in less water than intended. From the echosounder trace a slight side echo could be seen and this was what was assumed the anchor hit.

A plan was formulated to try to shorten the mooring. The highest point at which this could be achieved was at 2000m depth, beneath the first section of Parafil. The buoy was recovered and the mooring carefully hauled inboard with the anchor still attached. The Parafil section was disconnected, shortened, terminated and reattached. The mooring was then lowered back into the water and all was going well until the final stages, where the termination beneath the steel buoyancy parted and the mooring was left anchored with no top float.

As the light was starting to fade, the acoustic releases were fired immediately to allow us to recover the mooring. Due to time constraints on the cruise, there was not the opportunity to stay on site and prepare the mooring and redeploy it. Instead the ship made progress to Bermuda so that the mooring could be made ready without losing much time. Whilst steaming, a swath survey was conducted to find a suitable alternative mooring site.

23rd April
Swath survey for new MAR1 site.
MAR1 Mooring deployment 25 37.53N 50 25.09W
The mooring design was changed slightly to allow us the option to shorten it more easily if required next time. (Thankfully this option was not needed)
MARL 1 Mooring deployment 25 37.7N 50 24W
Photograph C.19 shows the deployment of the bottom pressure recorder lander at the MARL1 site.
After the final mooring deployment of CD170, the PES fish was recovered inboard and the ship headed to Bermuda.

17.4.2 KN182-2

4th – 7th May
Acoustic release servicing and mooring preparation.
Releases:-
RT661 #370 - Stripped down hook assembly - retaining screws to hook plates badly corroded at heads - probably copper slip action - new screws made from hex screws. Check lithium battery packs - 22.0v and 9.1v. Lab test OK.
AR861 #315 - Disassemble - batteries 9.0v ea. stack - replaced 9.73v ea. stack. Replace motor drive PP3 - 9.74v. All tested OK but poor air coupling when using TT801 deck unit- OK with TT300 deck unit.
AR861 #326 - Remove lever and bottom latch. Change battery packs 9.01v replace to 9.69v. Replace motor drive PP3 - 9.69v. Lab test OK
AR861 #359 – Manufactured September '04. Lab test OK.
AR861 #364 - Manufactured September '04. Lab test OK.
AR861 #251 - Manufactured November '03. New batteries - April 05 - CD170. No build sheet in box.
Argos Beacons -
48 inch yellow/red sphere – Fitted Novatech serial number 71716. id 42749.
48 inch yellow sphere – Fitted Novatech. id 46243 and Novatech light.
Novatech VHF Beacons
Fitted VHF beacons to both red and yellow billings floats for use with WBL1 and WBL2.

8th May
Acoustic release wire test.
AR861s:- Serial numbers **359, 326, 315**
RT661 serial number **370.**
The releases were wire tested, but with difficulty due to ship noise. Each release was sent the release codes 4 times and all except serial number 315 had released correctly when recovered. AR861 serial number 315 requires a repeat test. All releases were switched to off mode ready for deployment.
Spooled WB1 and "A" mooring wires. Assembled WB1 hardware.

9th May
WB1 Mooring recovery
A Mooring recovery
Unspool both moorings.

Lab test releases from WB1 without opening.
AR861 # 244 – Full function test - OK
RT661 # 162 – Full function test - OK
Switched to off mode ready for redeploy
Each of the above releases were fitted for single release operation.

WBH2 Mooring recovery

This mooring was rising slower than expected at 50 to 55 metres/min. On recovery it was found that the Billings marker float was missing, with only the shattered lower stub present. The sharp edges had deposits on them indicating failure early in the year's deployment, possibly during the actual deployment stage. The shattered stub was thought to have been caused by the implosion of the glass.

WBH1 Mooring recovery

This mooring rose at approximately 79 metres/min.
When on the surface all buoyancy was close together and the lines could be seen leading vertically downwards from the packs of glass. There were two slight tangles that were easily resolved. All mooring equipment was in good condition.

10th May

ADCP W Mooring deployment

The mooring was deployed in two stages with the anchor dropped from the release hook over the stern. As the WBADCP mooring had been subject to severe corrosion on the previous deployment, causing it to surface prematurely, all materials were increased in size and then roped through to provide back up support should the major in line components fail.

Poor welding and fitting of the ADCP buoy meant that considerable modifications were necessary to fit the ADCP into the buoy. No mechanical fixings could be used, so the ADCP was let into the buoy by chiselling the buoyancy away at to let the fixtures into the buoy. Rope collars were wound around the ADCP to act as buffers within the buoy body, and ropes were taken around the transducers and secured through the buoy to the lower shackle of the buoy framing. A bypass line was produced around the buoy into both top and bottom frames and into chain below. This rope extended to the top of the swivel, and a similar rope then extended from beneath the swivel to the top cage of the release. A rope was also placed from the release link to and through the anchor.

A Mooring deployment

WB1 Mooring deployment

WB1 was deployed buoy first anchor last, towing onto position. The mooring was deployed with no mishaps.

11th May

B Mooring recovery

WB2 Mooring recovery

WB2 was located quickly and accurately giving good ranges from the first interrogation. The release operated at first transmission, with the release being effected using only the AR861 unit (serial number 245). The mooring recovered easily with no tangles.

The Microcat with serial number 3241 was recovered with a bent cell guard, missing connector shroud and chipped end plate. These were possibly caused as the mooring rose to the surface. On inspection of the RT661 unit with serial number 184,

the vertical release hook plate screws were found to be heavily corroded, caused by copperslip being used in the threads.
Unspool both moorings.

12th May
Spool B onto winch 1
Spool WB4 on winch 2
Spool WB2 on winch 2 over WB4.

13th May
B Mooring deployment
WB2 Mooring deployment
WB2 was prepared during the deployment of Mooring B. The box containing the telemetry buoy having been lifted down from the 01 deck before deployment of Mooring B commenced. On completion of mooring B deployment the telemetry buoy could be moved aft and into a centreline position. The umbilical cable could then be coiled down and connected to the top 49 inch syntactic swivel. This buoy assembly was then put together with the electrical cable through it and inductive swivel at each end. The buoy swivel was then connected to the inductive mooring wire on the winch.

Deployment commenced by lifting over the telemetry buoy using the aft crane and release hook. Deployment of the telemetry tether cable was by hand at 0.5kts overground. The tether was deployed all the way back to the 49 inch syntactic which was lifted over by crane using a jury rigged through buoy lift line (there were no lift points designed into this assembly). Deployment went well and the buoy streamed away astern. Ship's speed was increased to improve streaming and tension in the mooring.

Sontek and SBE37 SMP pairings with SBE37 IMPs were secured at pre marked positions on the mooring wire. During this attachment phase it became clear that a mistake was made on attaching the instruments and one position was missed (later worked out to be 100m depth). Much clearer marking is required in future to be colour coded and marked on the deployment diagram. The mooring diagram was changed to adjust the positioning of the instruments caused by missing the 1200m marker.

Stopping off this wire proved quite difficult and in order to hold the wire securely, a plastic clamp arrangement had to be buffered with a length of extra wire inserted. This stopper needs to be addressed before recovery and the next deployment.

When deployment reached the end of the inductive section polyester was used as the adjusting lengths, this having been recovered from the previous WB2 mooring. The anchor was deployed by lifting over directly on the crane using the release hook directly from the crane.

On descent of the anchor attempts were made to range on the AR861 but no realistic ranges could be obtained. The ship then adjusted its attitude and stopped its propellers. As the ship drifted ranges were obtained, with the mooring being tracked all the way to the seabed. As darkness had fallen it was decided not to box in the mooring as the surface telemetry buoy might be run down.
WBL1 Mooring deployment
After deployment of WB2, WBL1 was assembled from scratch on the aft deck. Lugs on the framing were ground off and new extended lugs made. The BPRs were fitted and the acoustic release tensioned to the anchor using ships crane. The lander was then deployed using the push over technique for the buoyancy, and a lift and release

for the tripod. The descent was observed acoustically to 1000 metres, at which point the ship proceeded to the next location.

14th May

WB4 Mooring recovery

The ship was positioned approx 1 mile from the mooring and attempts made to obtain acoustic contact. No contact could be established, and this was thought to be due to poor acoustic conditions. The ship was moved closer to the mooring and still no contact. It was then decided to release the mooring blind whilst also monitoring the GONIO unit for an ARGOS signal. Almost simultaneous to the first full transmission sequence the buoy was sighted and the GONIO detected a transmission. The buoy surfaced some 300 metres away on the starboard quarter.

WB4 Mooring deployment

WB4_02 was prepared on deck after finishing recovery of WB4_01. Deployment commenced buoy first. The MMP was deployed using the same technique as previous MMP deployments with a slip line through the crane hook. This line proved somewhat short and the MMP was released closer to the ship than previously, but tension was good and the MMP rolled gently down the mooring wire. The remainder of the mooring was deployed conventionally and smoothly. Observations of descent were made acoustically.

15th May

Unspool WB4 mooring

Spool E on winch 2

16th May

E Mooring recovery

17th May

E Mooring deployment

E-Lander Mooring deployment

18th -21st May

Steaming on CTD line. Packing and sorting docs. Loading and sorting workshop container. Sorting all shackles/swivels etc. Sort cages for stacking.

Prepare WBL2.

Acoustic releases overhaul.

RT661 serial no. 215. Remove lithium batteries. Transducer disconnected. New B2S hook required.

RT661 serial no. 184. Remove lithium batteries. Transducer disconnected. New B2S hook required. Remove drive motor. Remove and check through drive shaft. Reassemble after inspection.

AR861 serial no. 326. Checked. Has new batteries. Needs wire test before use.

AR861 serial no. 246. Replaced dropper hook shaft as previously doubled. Inspect and check all acoustic functions. Batteries removed.

SMM 258 - Flooded - leave in container.

SMM 254 – OK. Airfreight to UK in RT661 box 184. All lithium batteries removed

22nd May

WBL2 Mooring deployment

23rd May

Checked position of WB2 telemetry buoy.
It was noted that the buoy was leaning over more than intended, thought to be caused by the attachment point of the tether being at the equator of the buoy.

24th May

WB4 reported adrift.

Messages were relayed from NOC to say that the WB4 deployed on the 14th May mooring had surfaced and was drifting. Immediate tracking was set in place to determine the set and drift of the mooring, and shortly thereafter the Knorr turned to steam at full speed for a rescue operation. Continued monitoring was made onboard and from NOC. The GONIO ARGOS radio direction finder system was set up on the bridge top and aligned to the ships heading with ARGOS id 46243. Notification was given to Maureen Edwards at NOC that this beacon was being used as a set beacon to prevent further alerts being issued.

A possible replacement mooring scenario was discussed and a mooring design using all fixed instruments devised, with a further possibility of using the MMP on an extended mooring if recovered.

Parafil winding, cutting and measuring was then carried out and completed just as a tropical storm broke over the ship and further winding was stopped. Instrument preparation was conducted during this period using previously recovered instruments.

25th May

WB4 Mooring recovery

On approaching the best established position in the early hours a navigation light was seen and shortly afterwards the GONIO gave confirmation of signal and direction of the ARGOS beacon (42745). The steel buoy was seen to be riding high out of the water and swinging violently indicating little mooring equipment beneath. The buoy with RCM11 current meter beneath was recovered by crane, and a trailing length of mooring wire hauled onboard by hand. The end of this wire showed what appeared to be a severe overload failure. Approximately 100m of wire was recovered, but no upper profiler stop was seen although it should have been on the wire at 25 metres from the current meter. Damage was seen to the wire where the stop should have been.

The ship proceeded at full speed to the mooring site of WB4 to search for the bottom of the mooring. On arrival at the WB4 mooring site transmissions were made to acoustic release 244 and ranges obtained. Initial slant range was 4375 metres. The acoustic release was fired and the decreasing range determined. Rise rate was monitored throughout using the TT801 deck unit. As the rise continued the rate was seen to decrease from 60m/min to around 20m/min as the mooring neared surface. When the range reached 950 metres it didn't seem to change further and it was felt the mooring could be on the surface. The ship then moved 500 metres north and the range was checked, indicating an increase in to 1092 metres. The ship then moved South West and the range was seen to close to 467 metres. Moving a further distance South West and as the first transponder range of 182 metres was determined the lower glass sphere package was sighted as it to rose to the surface on the starboard side.

The Knorr came alongside the package of spheres on the surface and the chain joining the buoys was hooked after some difficulty; there is little chain visible when these packages are at the surface. The float package was lifted astern by the crane and the complete package with acoustic releases recovered. The mooring was then recovered as normal, although inverted. Each instrument had links for stopping off at each end as is normal UKORS practice.

From the upper four sphere package the profiler wire was leading near vertical giving some cause for optimism that the MMP might still be on the wire, potentially held by a wire knot as the mooring collapsed. During hauling several knots were seen in the wire becoming more severe as hauling continued. At times some 5 or 6 wires were being hauled aboard and wuzzles became larger.

Eventually the load on the profiler wire decreased so much that the final "bitter end" was hand hauled aboard. From this it might be possible to surmise that whatever severed the MMP wire did so when the profiler was at the top of the wire and as the wire fell down the MMP slipped off. The broken wire from the top of the MMP wire was recovered and this matched damage on the wire from the top buoy recovered earlier that day. Also it could be seen that the profiler wire broken end had mud embedded in it indicating that it had indeed fallen to the sea floor.

WB4 Mooring deployment

On completion of the rescue of WB4 (UKORS mooring number 2005/30), a replacement mooring was completed ready for deployment. This mooring used instruments recovered from 2005/30 and additional instruments recovered on CD170, prepared in a short time for this re-deployment.

The mooring comprised spare wires and Parafil wound from the 2700m emergency stock drum on the evening of the 24th May. A steel top sphere could not be used due to the minimum float depth being 1000m, so a glass buoyancy pack had to be used instead. Wire winding was completed just prior to deployment and also just as the modified buoyancy was completed.

The mooring deployment went very well and only a short tow was required as the ship had increased speed during deployment to close on the release position in better time. Anchor release was from the aft crane using the SeaCatch hook.

Observations of release descent were made and seen with good reception until just before the anchor was on the seabed when replies became difficult to determine from spurious noise. The ship was moved some 500 metres from drop site to see if masking was occurring from the glass immediately above the acoustic releases. A good range was determined at 4672 metres although noise level and reception was still poor. It was decided to then depart the area.

18. Anchor Triangulation Process

D. Rayner

During the first year's deployment cruises, D277 and D278, triangulation of the anchor position was achieved using the Waterfall system to determine the point of closest approach to a pinging acoustic release (see report in Appendix F). For cruises CD170 and KN182-2 the Waterfall system was not used, with the acoustic releases transponder being wired into the echosounder fish onboard CD170, and the dunker used on KN182-2.

To determine accurate anchor position, ranges to the release were collected from 3 different locations around the suspected anchor site using the deck unit. The position can then be calculated by drawing intersecting loci. The routine *bottom.m* was written on board to make this drawing operation faster. An example plot generated by this routine can be seen in figure 18.1.

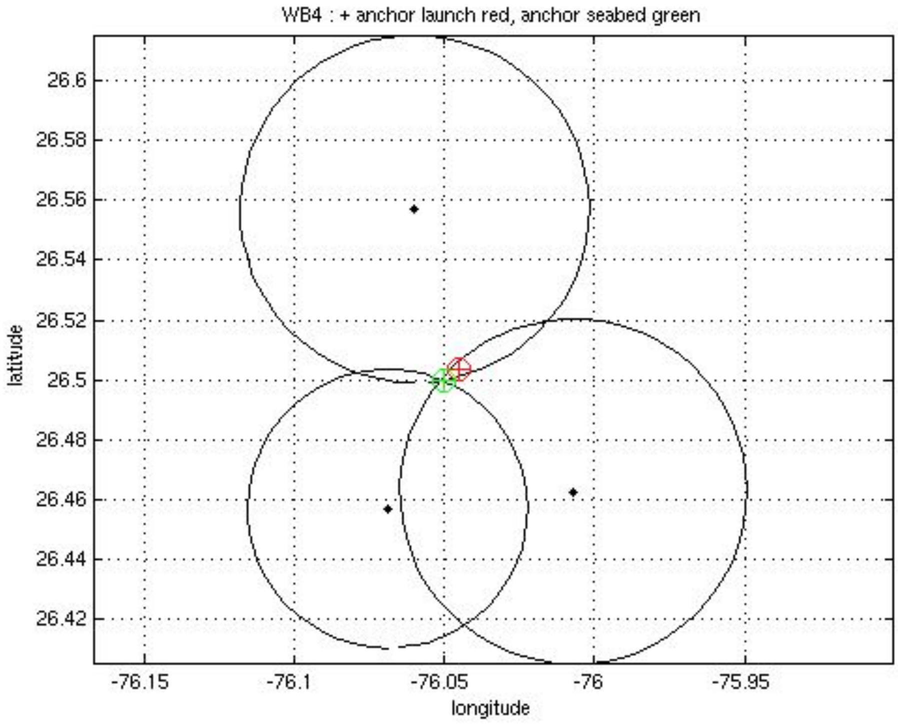


Figure 18.1: Example plot of triangulation of anchor seabed position. Range recorded at each point with interception of loci giving anchor position.

19. Mooring Dates, Locations and Depths

Mooring	UKORS Mooring Number	Deployment Date	Recovery Date	Comment
EBADCP	2004/01	27/02/2004	N/A	Lost
EBH5	2004/02	27/02/2004	03/04/2005	
EBH4	2004/03	27/02/2004	03/04/2005	
EBH3	2004/04	27/02/2004	04/04/2005	
EBH2	2004/05	27/02/2004	04/04/2005	
EBH1	2004/06	27/02/2004	04/04/2005	
EB3	2004/07	28/02/2004	05/04/2005	Top section lost
EB2	2004/08	28/02/2004	27/09/2004	Only top instrument recovered. Surfaced 18/09/2004
EB2_02	2004/42	11/12/2004	06/04/2005	Dragline recovery. Lost bottom instrument and releases
EB1	2004/09	01/03/2004	09/04/2005	
MAR3	2004/10	05/03/2004	14/04/2005	
MAR4	2004/11	05/03/2004	14/04/2005	MMP Imploded
MAR1	2004/12	07/03/2004	20/04/2005	
MAR2	2004/13	07/03/2004	20/04/2005	
WB4	2004/16	23/03/2004	14/05/2005	
WBH2	2004/17	25/03/2004	09/05/2005	
WBH1	2004/18	25/03/2004	09/05/2005	
WB2	2004/19	26/03/2004	11/05/2005	
WB1	2004/20	27/03/2004	09/05/2005	
WBADCP	2004/15	20/03/2004	20/10/2004	Surfaced 19/10/2004

Table 19.1: Summary details of recovery dates for year 1 moorings

Mooring	UKORS Mooring Number	Lat (°N) A/L	Lon (°W) A/L	Lat (°N) A/L	Lon (°W) A/L	Corrected Water Depth at A/L (m)	Lat (°N) A/B	Lon (°W) A/B	Corrected Water Depth at A/B (m)	Deployment Date	Deployment Time (GMT)	Deployment Duration (hhmm)	Post deployment survey	comment	Argos Platform i.d.
EBH5	2005/07	27.9085	13.3660	27° 54.51'	13° 21.96'	260				03/04/2005	183605	0047	n		42748
EBADCP	2005/08	27.8993	13.3935	27° 55.96'	13° 23.61'	433				03/04/2005	195050	0020	n	trawled 14/4 recovered 26/4	21442
EBH4	2005/09	27.8701	13.4700	27° 52.21'	13° 28.20'	817				03/04/2005	210800	0022	n		
EBH3	2005/10	27.8177	13.7391	27° 49.06'	13° 44.35'	1413				04/04/2005	055322	0019	n		
EBH2	2005/11	27.6098	14.2143	27° 36.59'	14° 12.86'	2021				04/04/2005	103446	0016	n		
EBL2	2005/13	27.2758	15.4172	27° 16.55'	15° 25.03'	3024				07/04/2005	010400	0015	n		
EBH1	2005/12	27.2714	15.4209	27° 16.29'	15° 25.26'	3014				04/04/2005	203400	0014	n		
EBH0	2005/14	26.9936	16.2289	26° 59.62'	16° 13.73'	3511				07/04/2005	061200	0015	n		
EBHi	2005/15	24.9565	21.2599	24° 57.39'	21° 16.6'	4499				08/04/2005	114250	0039	n		
EB2	2005/18	23.9298	24.0432	23° 55.79'	24° 2.59'	5092				10/04/2005	150820	0300	n		46242
EB1	2005/16	23.8099	24.0955	23° 48.60'	24° 05.73'	5092	23° 48.64'	24° 05.70'	5098	10/04/2005	084500	0330	y	Topex, 48" buoy release position	13346
EBL1	2005/17	23.8105	24.1056	23° 48.63'	24° 06.33'	5100				10/04/2005	100800	0020	n		
MAR4	2005/20	23.8687	41.0901	23° 52.12'	41° 5.4'	5052				16/04/2005	142300	0415	y	Topex, MMP	
MARL2	2005/21	23.8684	41.0929	23° 52.1'	41° 5.57'	5041				16/04/2005	155600	0030	y		
MAR3	2005/19	23.9326	41.1040	23° 55.95'	41° 6.24'	5082				15/04/2005	191223	0200	y	2500m	
MAR2	2005/22	24.1703	49.7498	24° 10.22'	49° 44.99'	5213				22/04/2005	104950	0150	y	2500m	
MARL1	2005/25	25.6288	50.4159	25° 37.73'	50° 24.96'	4870				23/04/2005	192200	0030	n		
MAR1	2005/24	25.6259	50.4186	25° 37.55'	50° 25.12'	4870				23/04/2005	182710	0300	y	full depth	
BJL2 (BJE)		26.4993	71.9713	26° 29.96'	71° 58.28'	5302				17/05/2005	193200	0600	y		
BJE		26.4993	71.9713	26° 29.96'	71° 58.28'	5302	26° 30.10'	71° 58.28'	5298	17/05/2005	183200	0030	n		
WBL2 (WB4)	2005/31	26.5002	76.0953	26° 30.01	76° 02.86'	4794				22/05/2005	030945	0030	n		
WB4		26.5035	76.0450	26° 30.21'	76° 2.7'	4794	26° 30.0'	76° 3.0'	4794	14/05/2005	221900	0300	n	top buoy on surface 1846 23/5, mooring released 1300	42745
WB4 (2)	2005/32	26.5000	76.0500	26° 30'	76° 3'	4793				25/05/2005	213515	0230	n		
BJL1 (BJB)		26.4908	76.4983	26° 29.45'	76° 29.9'	4840				13/05/2005	164700		n		
BJB		26.4908	76.4983	26° 29.45'	76° 29.9'	4840	26° 29.73'	76° 29.98'	4840	13/05/2005	153200		y		
WBL1 (WB2)	2005/29	26.5070	76.7433	26° 30.42'	76° 44.6'	3880				14/05/2005	012931	0030	n		
WB2	2005/28	26.5103	76.7438	26° 30.62'	76° 44.63'	3893				14/05/2005	001500	0330	n		
WB1	2005/27	26.4973	76.8150	26° 29.84'	76° 48.90'	1405				10/05/2005	203305	0215	y		42749
BJA		26.5087	76.8418	26 30.52'	76° 50.51'	1015	26° 30.55'	76° 50.52'	1015	10/05/2005	152600		y		
WBADCP	2005/26	26.5250	76.8689	26° 31.50'	76° 52.13'	609				10/05/2005	124924	0010	n		11033

Table 19.2: Mooring locations, deployment dates and Argos beacon details for year 2 moorings. (A/L = Anchor launch position. A/B = Anchor position on bottom.)

20. Instruments

D. Rayner

20.1 Summary of Instruments Recovered and Deployed

Instrument type	Manufacturer and Model	Total Number Recovered	Total Deployed in 2004	Total Lost in 2004
CTD	Seabird SBE37 SMP Microcat	69 (of which, 1 flooded)	73 (5 on EB2R)	4
	Seabird SBE37 IMP Microcat	11	15	4 (+1 lost on D277)
	RBR XR420	2 (of which, 1 flooded)	2	0
	Idronaut Ocean Seven 304	2 (of which, 1 flooded)	2	0
Single Point Current Meter	Interocean S4AD	15	16 (1 on EB2R)	1
	Sontek Argonaut MD	9	12	3 (+1 lost on D277)
	Aanderaa RCM11	10 (+1 recovered from surfaced EB2)	11 (3 on EB2R)	0
Bottom Pressure Recorder (BPR)	Seabird SBE26	14	15	1
	Ixsea OT660C	2	2	0
Current Profiler	RD Instruments 150kHz BB ADCP	0 (+1 recovered from surfaced WBADCP)	2	1
Current/CTD Profiler	McLane Moored Profiler	2 (1 imploded and 1 drive mechanism broken)	3	1

Table 20.1: Summary of instruments recovered (UK Moorings)

Appendix E gives more detailed information on which instruments were recovered from each mooring along with information on the length of record obtained.

Instrument type	Manufacturer and Model	Total Number Deployed on CD170 and KN182-2 (2005)
CTD	Seabird SBE37 SMP Microcat	86 (+ 3 deployed and recovered on WB4)
	Seabird SBE37 IMP Microcat	14 (+1 deployed and recovered on WB4)
	RBR XR420	1
Single Point Current Meter	Interocean S4AD	11 (+1 deployed and recovered on WB4)
	Sontek Argonaut MD	7
	Aanderaa RCM11	12 (+3 deployed and recovered on WB4)
Bottom Pressure Recorder (BPR)	Seabird SBE26	10
	Seabird SBE53	2
Current Profiler	RD Instruments 150kHz BB ADCP	1 (later recovered by *RV Poseidon*)
	RD Instruments 75kHz Longranger ADCP	1
Current/CTD Profiler	McLane Moored Profiler	3 (1 lost on WB4)

Table 20.2: Summary of instruments deployed (UK Moorings)

A complete summary of the setup details can be found in Appendix B, detailing each instrument per mooring.

20.2 Instrument problems.

There were a number of problems experienced with instrumentation from the moorings, both with those that were recovered and those to be deployed. A summary of each problem is given in the following text along with any solutions found.

Seabird SBE37 Microcats

After recovering the first six of the eastern boundary moorings it became apparent that there was a high proportion of Seabird Microcats on which the pressure sensor failed at some point during the deployment. This displays itself as large spikes and noise before eventually flat-lining and reading a steady value of zero. Following contact with Seabird it was discovered that this was caused by a faulty batch of pressure sensors, which may affect every Microcat we had deployed on the array in 2004. Seabird estimated that of instruments affected by this problem, 50% would fail within 5 years. It therefore became important to return the potentially affected instruments to Seabird and have new pressure sensors installed. Unfortunately there were not enough instruments available to facilitate this plan and a number of instruments had to be turned around at sea and reused. This will mean that when we return in Spring 2006 there are likely to be more Microcats on which the pressure sensor has failed.

A number of Microcats from the National Marine Equipment Pool, that were not using pressure sensors from the affected batch, were sent out to the *RV Knorr* so that we did not need to reuse suspect instruments in the west. These will be replaced by the instruments that have been returned to Seabird for repair under warranty.

Two Microcats were flooded on the cruises. The first was recovered from the MAR3 mooring (SMP serial number 3275), but had the end cap unattached to the pressure casing. The holding screws for the end cap had been sheared off, and from inspection of the electronics it seemed that they had been exposed to sea water for a significant time as there was evidence of corrosion.

The second Microcat to flood (IMP serial number 3281) was recovered from the WB2 mooring. This was fine when recovered and the data downloaded correctly. It was then re-setup and lowered on a CTD cast for calibration purposes. In between recovery and lowering on the CTD frame, the instrument was not opened, but when recovered from the CTD frame it was found to be flooded. The CTD was lowered to a depth greater than when it was on WB2, but was still less than its maximum rated depth. This instrument has also been returned to Seabird for repair.

Some Microcat battery packs that were supposed to be new were found to be depleted. This may have been caused by them being drained during testing at NOC prior to deployment, so in the future it is recommended to use test battery packs and keep these distinct from deployment packs.

There were also some problems experienced when downloading the inductive Microcats. At times the download would stop before it reached the end of the file when downloading all data as one file. One solution could have been to download data in separate blocks, but this would require someone to keep starting them downloading for up to 6 hours per instrument.

At first it was thought to be caused by low batteries but this was discounted by changing for new batteries and trying again. Seabird were unable to recreate the problem, but suggested that it might be a data transfer issue and recommended using USB-Serial converters instead of integrated serial ports. This was not of any help though as we had been using the USB-serial adaptors already.

A second problem with download from these instruments was experienced on the Knorr, where it was found that some data records had been skipped on the download. These records were later recovered, except for 240 records from the Microcat with serial number 3281, which was flooded on the CTD calibration as mentioned above. In the future more checks will need to be conducted on the data immediately after download to match the number of expected records with the number of downloaded records.

Idronaut Ocean Seven 304 CTD

Two Idronauts were deployed on the 2004-2005 array, one on EBH1 and the other on EBH2. The instrument with serial number 113033 was flooded at some point during year’s deployment, but the cause is not yet known. This instrument has been returned to Idronaut for inspection and repair.

RBR XR-420 CTD

As with the Idronauts, two RBR CTDs were deployed on each of EBH1 and EBH2, and again one of these (serial number 9657) was flooded on recovery. At first this was thought to have been caused by corrosion of the pressure sensor as there was a hole where the membrane should have been, but this has since been discounted by the manufacturer, although the actual cause is still not known.

InterOcean S4As

Huge difficulties were experienced when downloading the S4s. Due to the incorrect setups being used when deployed in 2004, the 32MB memories of many of the instruments were full. The first instruments recovered were downloaded as the InterOcean .S4B binary files, however when using the manufacturer supplied software it was realised that these could not easily be converted to ascii format due to their size. The software would run out of memory and crash unless it was loaded and converted in approximately 10 subsets of the main file.

This was not ideal so the instruments were downloaded into ascii format. When using the supplied “Z-Modem” download software the download would not start at a baud rate higher than 9600. The software indicated that this would take 22 hours to download all the data at this speed, which although would be possible, it ties up a computer for a significant period of time and is not feasible for turning around instruments from the WB1 mooring, which has 4 S4s on it.

Contact was made with InterOcean to find a solution. It was pointed out that to correctly change the instrument baud rate to 57600 you need to send the command u57600/p and press return and then press y at the resulting prompt but not pressing return. The software baud rate should then be changed to 57600 and return pressed then.

This was tried and the baud rate successfully changed to 57600. However, the download would not start correctly for all instruments as the software would not connect to the instrument properly. One instrument was eventually downloaded using the data retrieval part of the software, and another started through the terminal window of the Software using the RD1 data retrieval command and a text capture.

There were problems with this method though, as the method would only work at 19200 baud rate instead of the higher 57600. The download process would also be broken after about 3 hours, but not consistently.

Further contact was made with InterOcean who determined that it was only a problem with the new version of the Windows software that had been supplied before the cruise (v4.01) and was a fault with downloading large data files. It was recommended to use version 3.04 that the instruments shipped with, or if we didn't have that, to use a new dos version that was emailed to the ship.

When trying the new Dos software, one of the first instruments was downloaded into an ascii file at 57600 baud without any problems, however the second instrument would not connect to the software and a message was displayed saying that the instrument was in a constant state of reset.

An email from InterOcean on the 26th April (just before we docked in Bermuda) said that they had made progress on finding a reason for the problems encountered and attributed it to an issue with the computer serial port. Instead of using the built in serial port or some USB-Serial adaptors it was recommended to use a Cables Unlimited USB-2920 USB – Serial converter which InterOcean had tested with their instruments. One was sent out to Bermuda and this arrived at the Knorr in time for the KN182-2 cruise.

A number of tests were conducted with different PC laptops and serial ports or USB-Serial adaptors when transiting on the Knorr. It was found that the Cables Unlimited adaptor worked flawlessly when downloading .S4B files through the Windows software, but it could not be made to work to download the ascii .S4A files.

The new version of the DOS software (Application software v2.74) that was sent to the Charles Darwin was tested on Windows XP machines (although InterOcean initially recommended using a machine running Windows 98). This was found to download ascii format files correctly at 57600 baud when combining with the Cables Unlimited USB-Serial adaptor.

In summary, there are two causes of the problems with downloading data from the S4s: firstly, underpowered serial ports and certain USB-serial adaptors may not transfer information between the software and the instrument correctly; and secondly the Windows software itself can be problematic.

It is recommend for future downloads to first download the .S4B file using the Windows based software, and then use the DOS based software to download the ascii .S4A file which can be read into Matlab using a routine written on CD170 and KN182-2. This routine is not yet finished but can be used to check the data recovered.

Separate to the download problems with the S4s, one was found to have a bad conductivity record (serial number 35612567); one a bad pressure sensor that did not affect the deployment data, but was found on a CTD calibration dip (serial number 35612573); one was found to have an apparent crack in the pressure case (serial number 35612572); and one had the temperature sensor broken when lowering to the deck from the recovered mooring (serial number 35612564). These have all been returned to InterOcean for investigation and repair.

Sontek Argonaut MDs

A number of the Sonteks recovered from the array deployed in 2004 were found to have depleted batteries. This caused data collection to cease prior to the end of the deployment. It is thought that this may have been caused by a combination slightly used batteries from tests at NOC, and the unknown power consumption caused by communications with the telemetry buoy. In order to conserve battery life, the Sonteks deployed in 2005 had the sampling interval increased from 20 to 30 minutes.

A significant clock drift of up to 10 minutes was experienced on the Sonteks. This is within the manufacturer's specifications, but may need to be considered when developing the interrogation timing of the telemetry system.

One of the new Sonteks delivered direct to the Knorr (serial number D322) would not recognise the Microcat CTD attached. On contact with Sontek, it was discovered that there is a command that is not documented in the manuals to enable the CTD. It is "ctdinstalled set yes" and should be entered from the command line without quote marks.

When WB2 was recovered it was discovered that there had been a mistake on the mooring diagram from D277/D278. The S4 with serial number 35612572 had been deployed immediately above a Sontek at 1245m. This had been forgotten when the mooring diagram was updated after deployment, but was meant to facilitate a comparison between the acoustic Sontek and electromagnetic S4 current meter readings. However when analysis of the Sontek record was conducted on board, it was realised that there was a very high noise signal. This unit has since been diagnosed defective by the manufacturer with most of the current data being unusable. It is therefore not possible to make a meaningful comparison with the S4 current meter.

Aanderaa RCM11s

The current meters supplied by Aanderaa for the 2004 deployment were fitted with 3000m depth rated "3619" conductivity cells. A set of replacement "3919" conductivity cells rated to 6000m were supplied by Aanderaa to be swapped for the shallow rated cells. These cells have the advantage of having a fully user selectable conductivity range rather than the simple 4 options available previously. Conductivity ranges were selected according to expected values derived from CTD profiles collected on Discovery cruise D279. These ranges are set in the conductivity cell itself using the supplied software, and then the cells are connected to the RCM11 chassis.

It was realised that after the 2004 deployment, a number of RCM11s that were deployed in warmer near surface waters had the temperature ranges set to "low". This caused the signal to peak at an upper limit and so some data were lost. Care was taken over the ranges selected for the 2005 deployment.

After recovery of the trawled WB4 mooring, the RCM11s were downloaded and reset to be redeployed. A quick check of the data from instrument serial number 305 showed that the pressure sensor was suspect. This was therefore not deployed on the replacement WB4 mooring and after analysis of the data by Aanderra, the pressure sensor was replaced under warranty.

RDI 75kHz Longranger ADCP

The pre-deployment tests were run on the ADCP for WBADCP when the ADCP was installed in its syntactic buoyancy. It repeatedly failed the "H/W Operation" test, but we were informed by RDI that this is a hardware test that would test the compass. As the buoyancy was laid on its side, the compass would not work correctly. When the buoy was lifted with the crane, the ADCP passed the H/W test every time.

There were communication problems when setting up the ADCP for deployment. This was found to be caused by an older version of the software being used to talk to the instrument. The setup software would get as far as sending the commands to the instrument, the first ping would be heard, and then the software would crash. As no more pings were heard from the ADCP when expected it was thought that the crash had interrupted the logging of the ADCP. When using a Dell laptop running Windows 2000, with WinSC version 1.29. There were no problems communicating and the instrument started correctly.

McLane Moored Profilers

The success rate with MMPs thus far has been disappointing. One is suspected lost after the EB2_01 mooring surfaced near Gomera, Canary Islands; the profiler deployed on MAR4_01 imploded after 24 profiles; the drive mechanism failed on the profiler from WB2_01 after about 125 profiles; and the new profiler deployed on WB4_02 from cruise KN182-2 was lost when the mooring surfaced prematurely.

It is thought that the implosion of the MAR4 MMP was caused by cycling the glass buoyancy through large pressure gradients. This will hopefully not be an issue for the two remaining MMPs on the 2005-2006 array as the depth that they are each profiling has been reduced from approximately 5000 to 2500m, concentrated in the upper ocean.

If a mooring subject to trawling activity has the mooring wire broken in between the upper and lower MMP stops then the MMP is particularly vulnerable as there is then nothing to prevent the profiler slipping off the wire. This was what happened with the profiler from WB4_02 and it's suspected that this too occurred with the EB2_01 mooring although there bottom part of the mooring has not been found. There is currently no solution to this problem as the profiler needs a clear wire to travel along.

The profiler on which the drive mechanism failed has been returned to McLane for investigation and repair, along with the imploded MMP.

21. Instrument Calibration Using CTD Casts

D. Rayner

To provide start and end point calibrations of instruments, measuring conductivity and temperature, recovered from the 2004-2005 array and redeployed on the 2005-2006 array the ship's CTD system was used. 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 3 minutes to provide time for the instruments to stabilise relative to the more accurate ship's CTD.

On both cruises 12 sample bottles were removed from the CTD frame to allow the instruments to be attached. On CD170 brackets were fitted that firmly held the Microcats (see Photograph C.20 in Appendix C), but for S4s and RCM11s instruments the brackets were removed and the instruments were lashed securely instead (Photograph C.21 in Appendix C). Sontek current meters were tested for their pressure by clamping to the frame in place of the pinger, which was not needed.

On KN182-2 a series of ratchet straps were fitted to the frame for clamping the Microcats (Photograph C.22 in Appendix C), but as for CD170 the S4s had to be securely lashed (Photograph C.23 in Appendix C). RCM11s were clamped in place of the removed water bottles using hose clips.

Details of instruments deployed on calibration casts are shown in Appendix G.

22. Sampling Strategy for EB2 MMP

J. Marotzke

22.1 Investigation

The CD170 EB2 MMP was set to sample one pair of profiles every 2 days and 5 hours, which, incidentally, is close to what was suggested in the original proposal (2 days). This number was simply the expected total distance covered, according to battery capacity, divided by expected deployment time. A reviewer criticised that this would alias tidal movement, so prior to CD170 burst sampling strategies had been contemplated, but not yet investigated quantitatively.

The availability of recovered microcat timeseries from the eastern boundary made it possible to test different sampling strategies *in situ*. There was no spare capacity before the cruise to test sophisticated strategies (John Toole, pers. comm.); moreover, it was determined that T/S was significantly more important than the MMP velocity measurements, so the emphasis had to be on a good representation of the low-frequency (period 10 days and longer) T/S, rather than a good sampling of tidal velocities.

Mooring	EBH4_1_200403	EBH1_1_200406
SerialNumber	3212	3234
WaterDepth	1510	3012
InstrDepth	1060	2562
Start_Date	2004/02/25	2004/02/27
Start_Time	18:00	17:00
End_Date	2005/04/03	2005/04/04
End_Time	08:30	19:00
Latitude	27 49.930 N	27 16.560 N
Longitude	013 47.320 W	016 25.000 W

Table 22.1: Summary information of data for instruments used to check MMP sampling

For EB2, we have turning depths of 2500 and 52 metres. Hence, we assume for s/n 3234 that we have data at the lower turning point (case a). For s/n 3212, we assume that we're 3/5 up the profile (case b). The travel time for a single profile is 3h39min, approximated by 3h45min. The time between two profile pairs is set to 8 hours in the case of two pairs immediately following each other.

The following strategies were tested:
Strategy 1: Two pairs of up and down profiles, 4 days and 11 hours apart:
Strategy 2: Four pairs of up and down profiles, 8 days and 22 hours apart:
The simplest strategy with paired profiles, one pair of up and down profiles, 2 days and 5 hours apart and the same total number of profiles, was approximated by a regular distribution of profiles.

The comparison was done with time series that were filtered with a 10-day Butterworth filter (figures 22.1 and 22.2). Visual inspection of subsampled microcats showed no qualitative difference between the regular scheme and burst sampling Strategy 1 (2 pairs, 4 days 11 hours apart) in case a (2500 metres), with perhaps slightly inferior performance of the Strategy 2 (4 pairs, 8 days 22 hours apart). Case b

(1000 metres), however, which is much less dominated by the tidal signal in its variability, showed a clear advantage of regular sampling, and a clearly lower performance of the extreme burst sampling Strategy 2. Table 1confirms this picture. Detailed visual inspection of the sampling quality during bursts showed that the tidal signal was still poorly sampled; a considerably higher number of successive profiles would be necessary to improve on this. We were thus unable to see an advantage in a burst sampling strategy.

	Strategy 1	Strategy 2	Regular
Case a (2500m)	0.938	0.845	0.935
Case b (1000m)	0.892	0.803	0.984

Table 22.2: Correlations of the filtered subsampled time series with the original filtered time series used to determine MMP sampling. Strategy 1 (2 pairs, 4 days 11 hours apart), Strategy 2 (4 pairs, 8 days 22 hours apart), and regular sampling with the same total number of profiles.

22.2 Conclusions

This analysis provided us with a rational strategy for defining MMP sampling on EB2. On MAR4, we employed almost exactly the “regular” strategy analysed here, taking one profile every 24 hours. But the analysis is clearly limited through the small number of cases studied. Extension would be straightforward and might be a suitable student project. There is no shortage of time series to choose from.

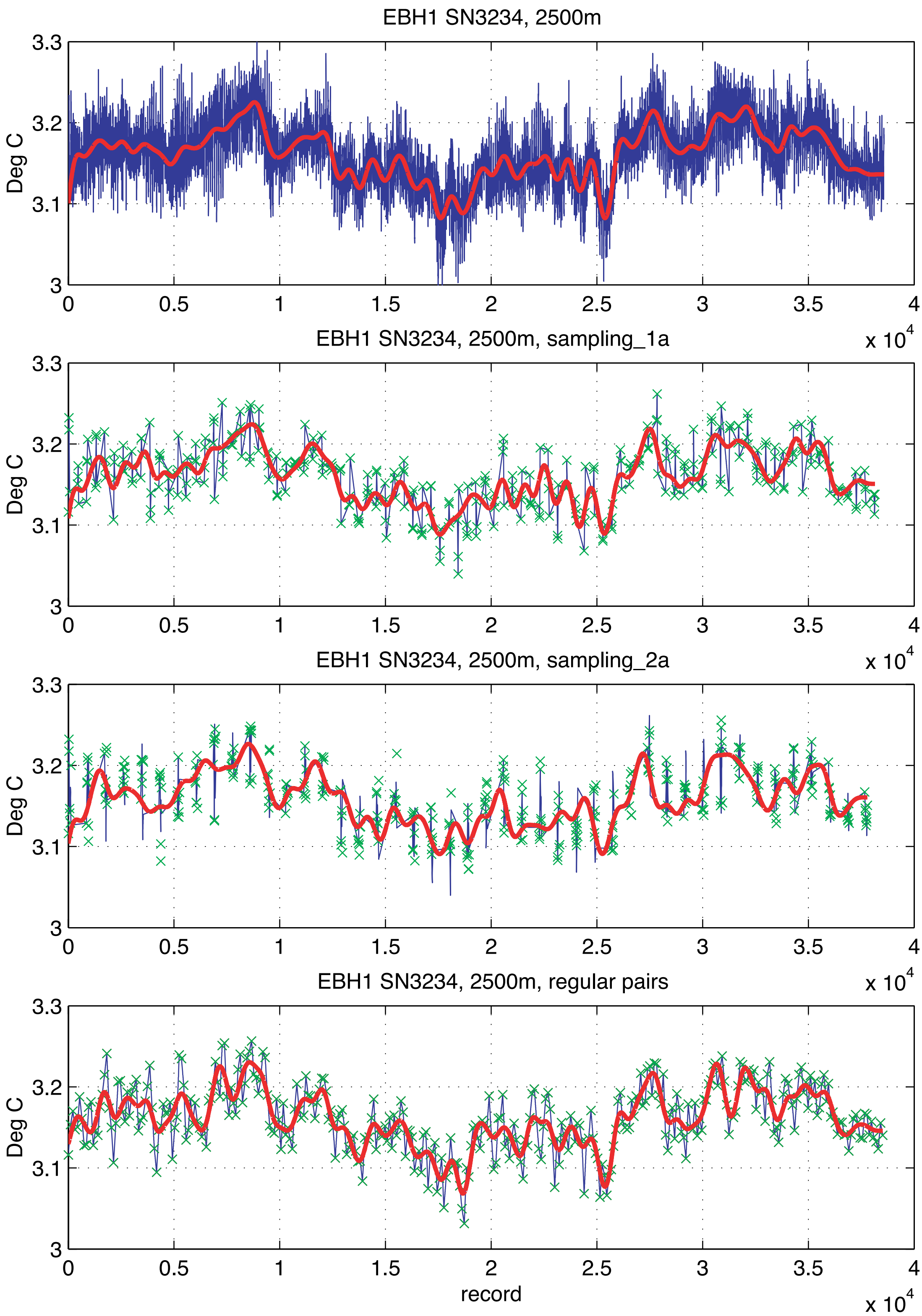


Figure 22.1: top: Temperature time series from microcat 3234 on EBH1 full resolution (blue) and 10-day filtered (red); 2nd from top: same for subsampling Strategy 1, green crosses mark sampling points; 3rd from top: same for subsampling Strategy 2; bottom: same for regular sampling.

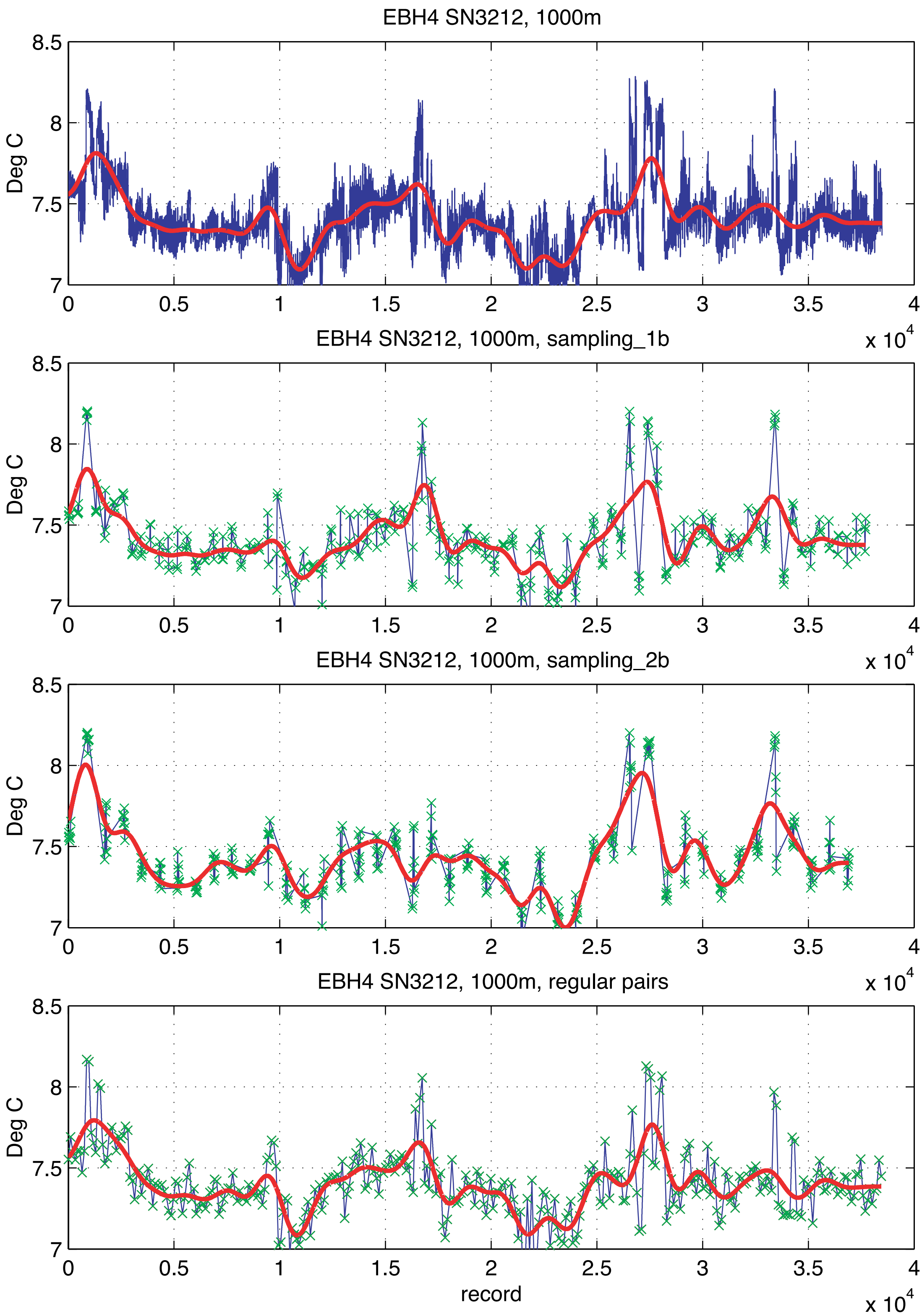


Figure 22.2: top: Temperature time series from microcat 3212 on EBH4 full resolution (blue) and 10-day filtered (red); 2nd from top: same for subsampling Strategy 1, green crosses mark sampling points; 3rd from top: same for subsampling Strategy 2; bottom: same for regular sampling.

Appendix A: Extra Figures

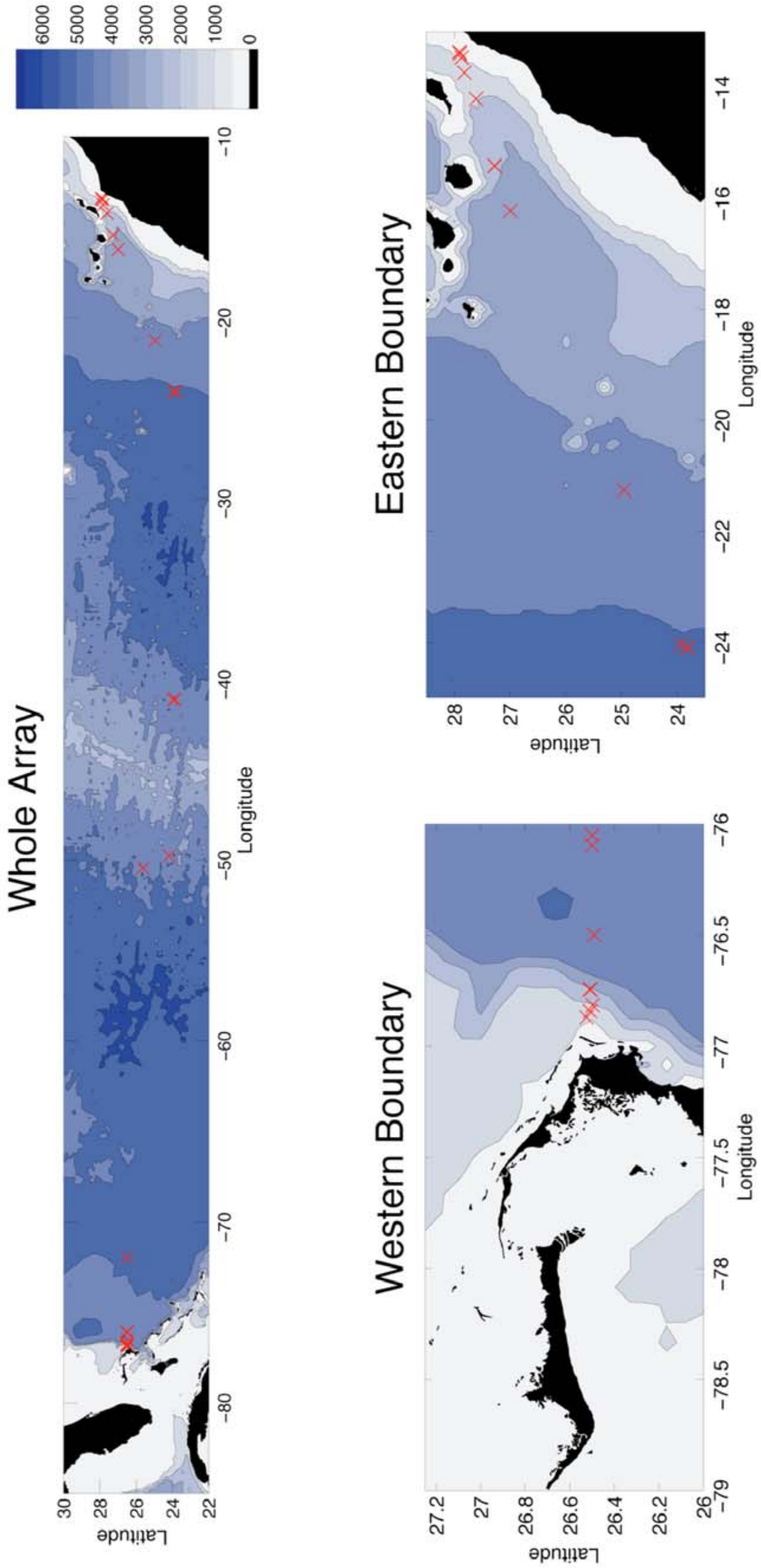


Figure A.1: Mooring Locations

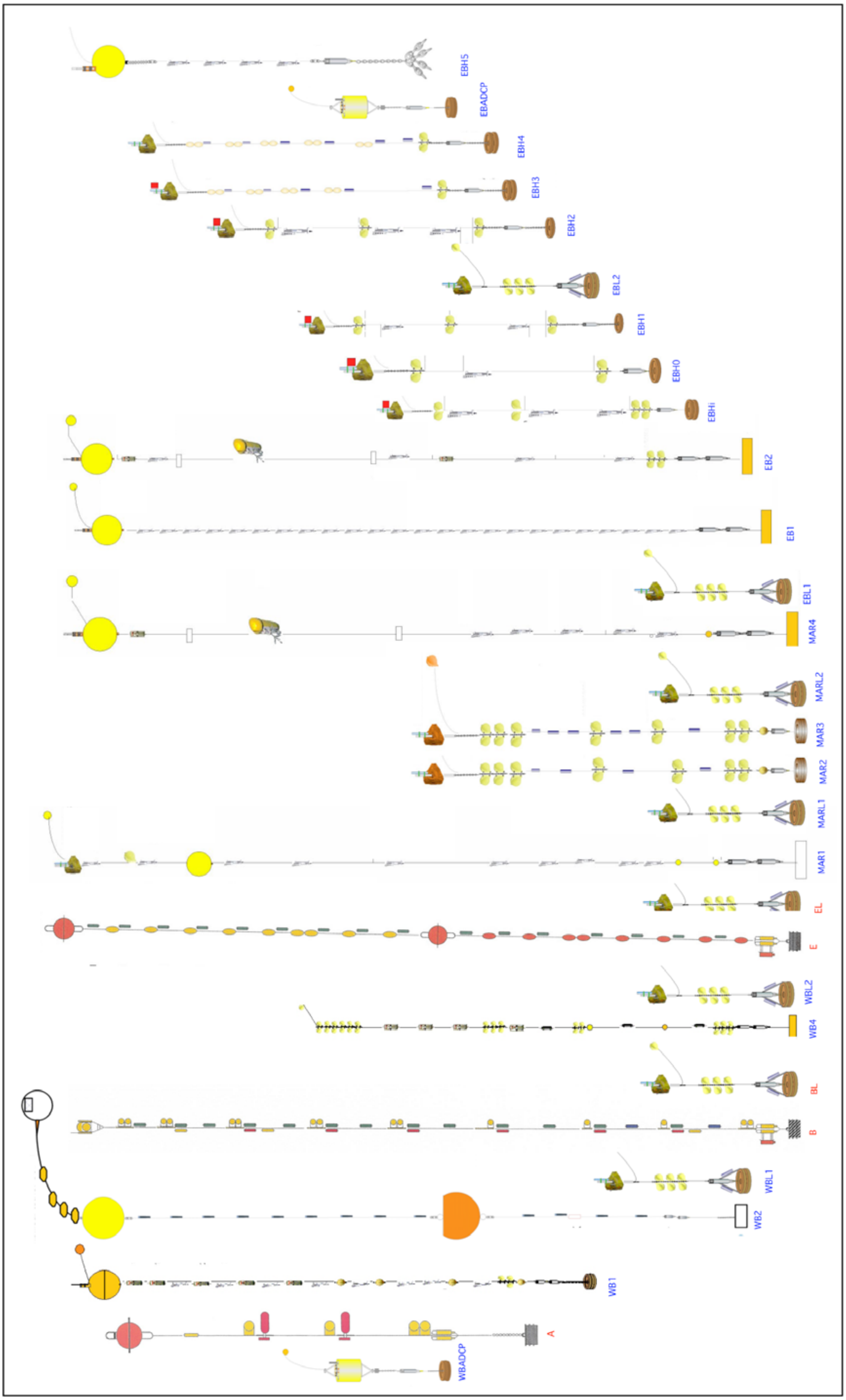


Figure A.2: Mooring Array Schematic

Figure A.3: Whole Mooring Array as Deployed 2005

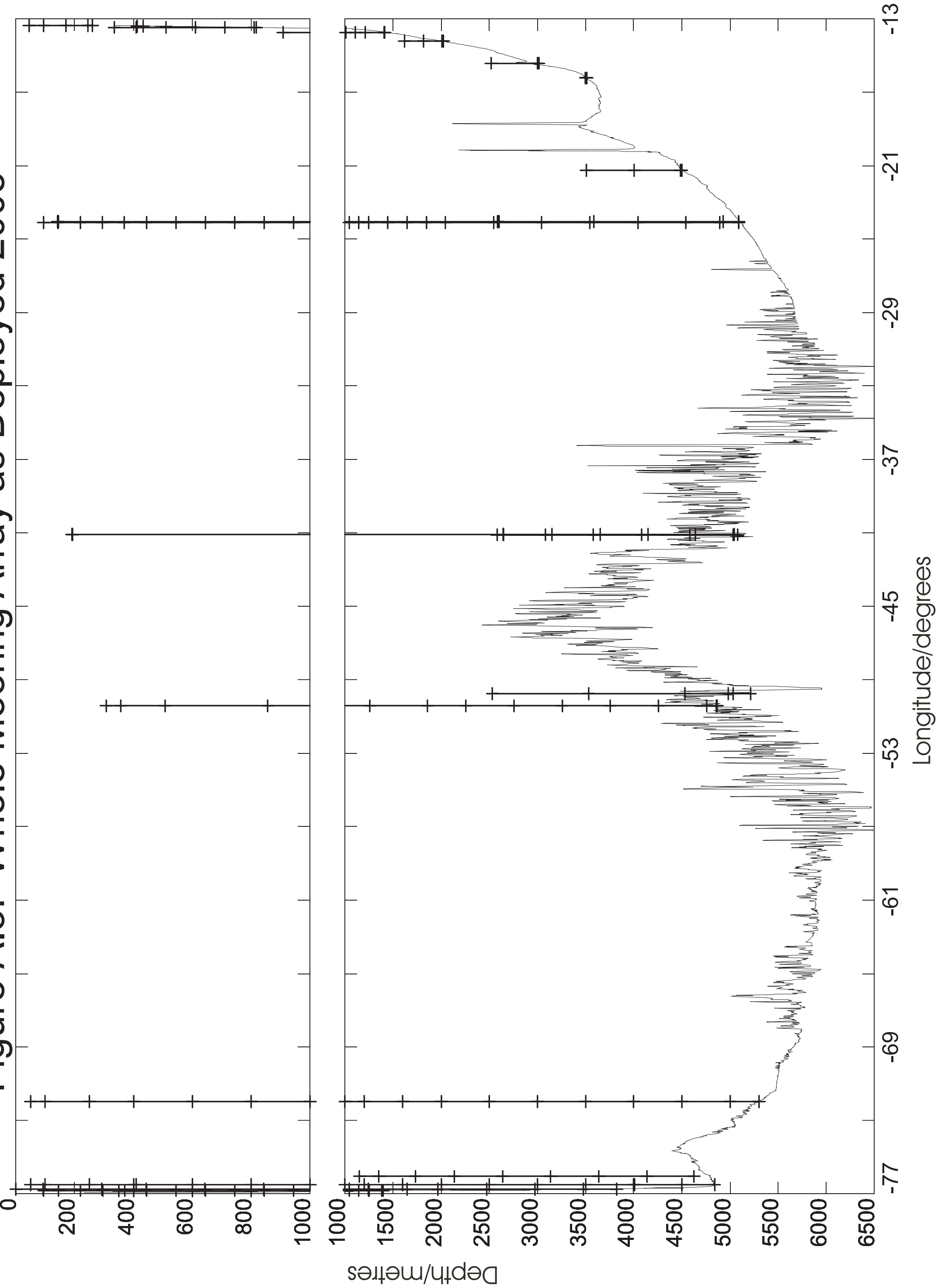
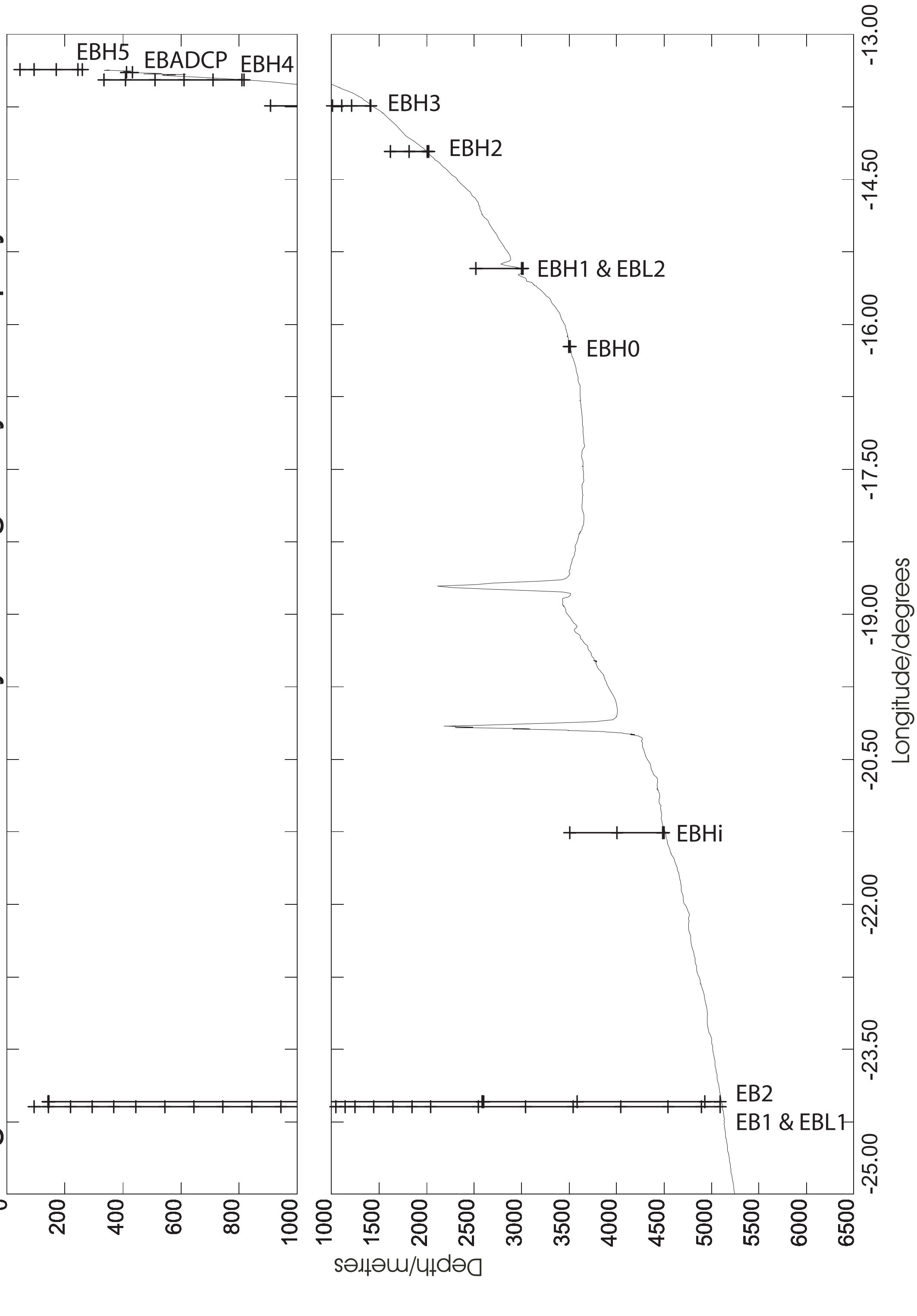


Figure A.4: Eastern Boundary Mooring Array as Deployed 2005



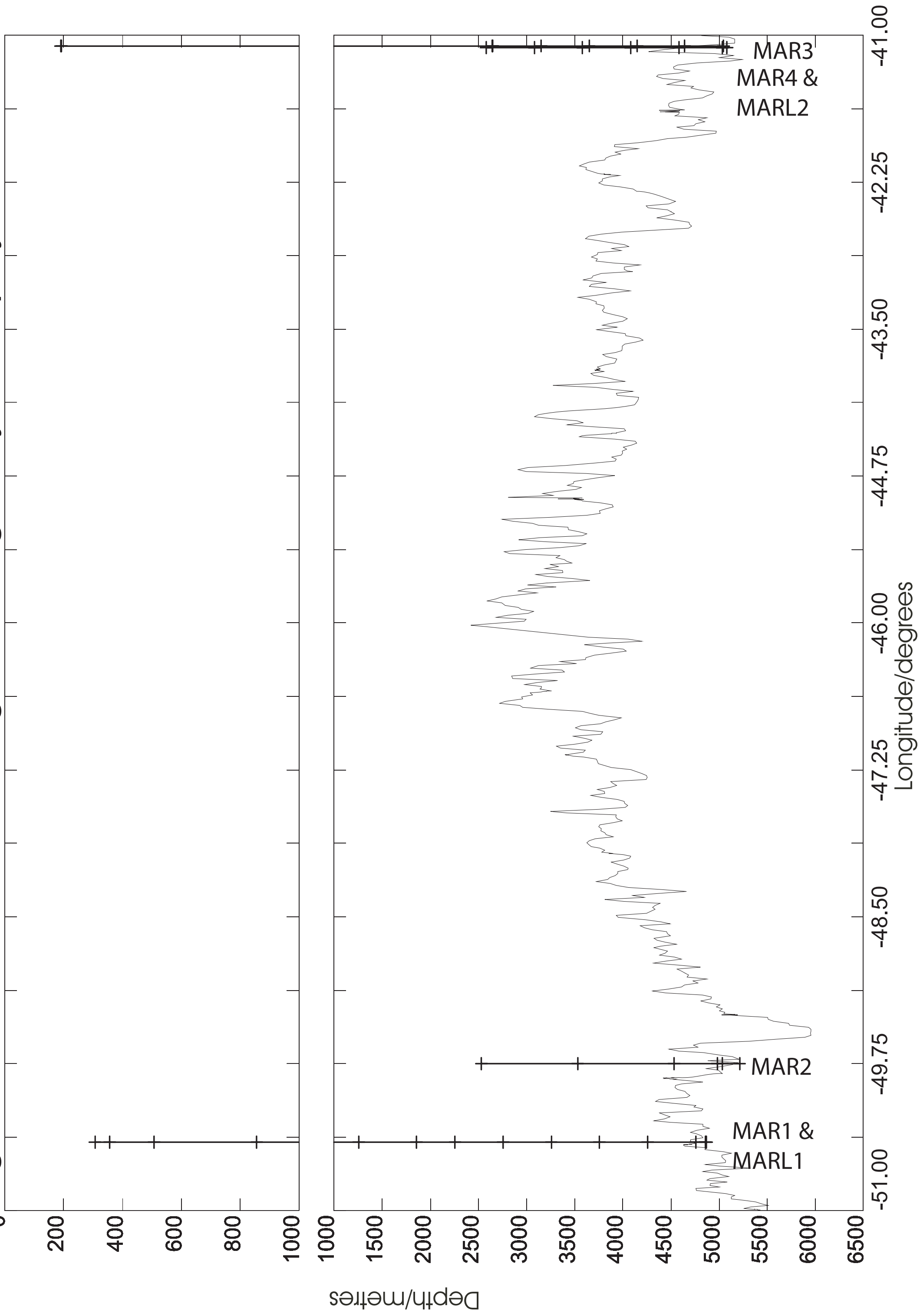


Figure A.5: Mid Atlantic Ridge Mooring Array as Deployed 2005

Figure A.6: Western Boundary Mooring Array as Deployed 2005

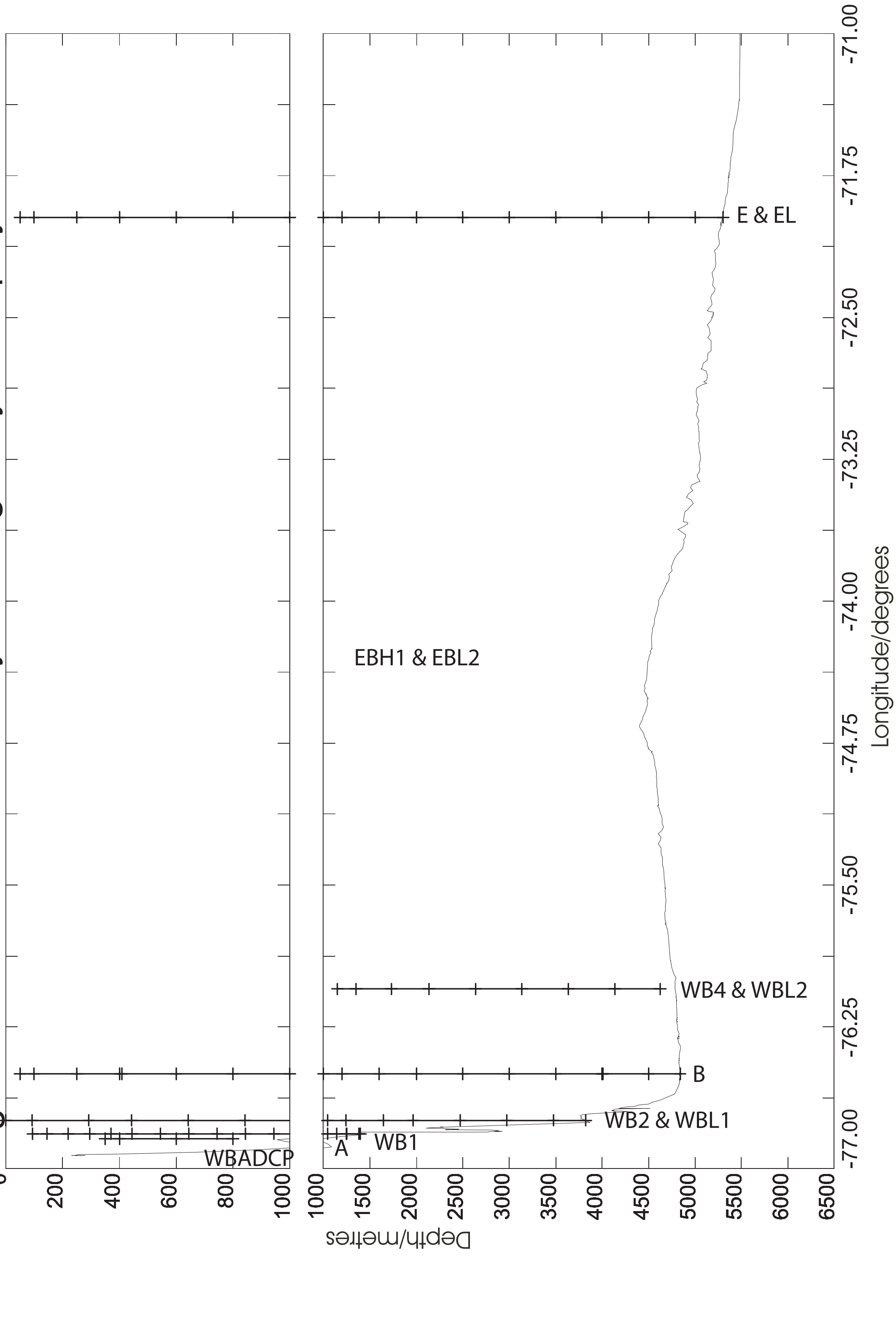


Figure A.7: Mooring Diagram of EB3 as Recovered 2005; highlighting where the mooring was cut and the section lost.

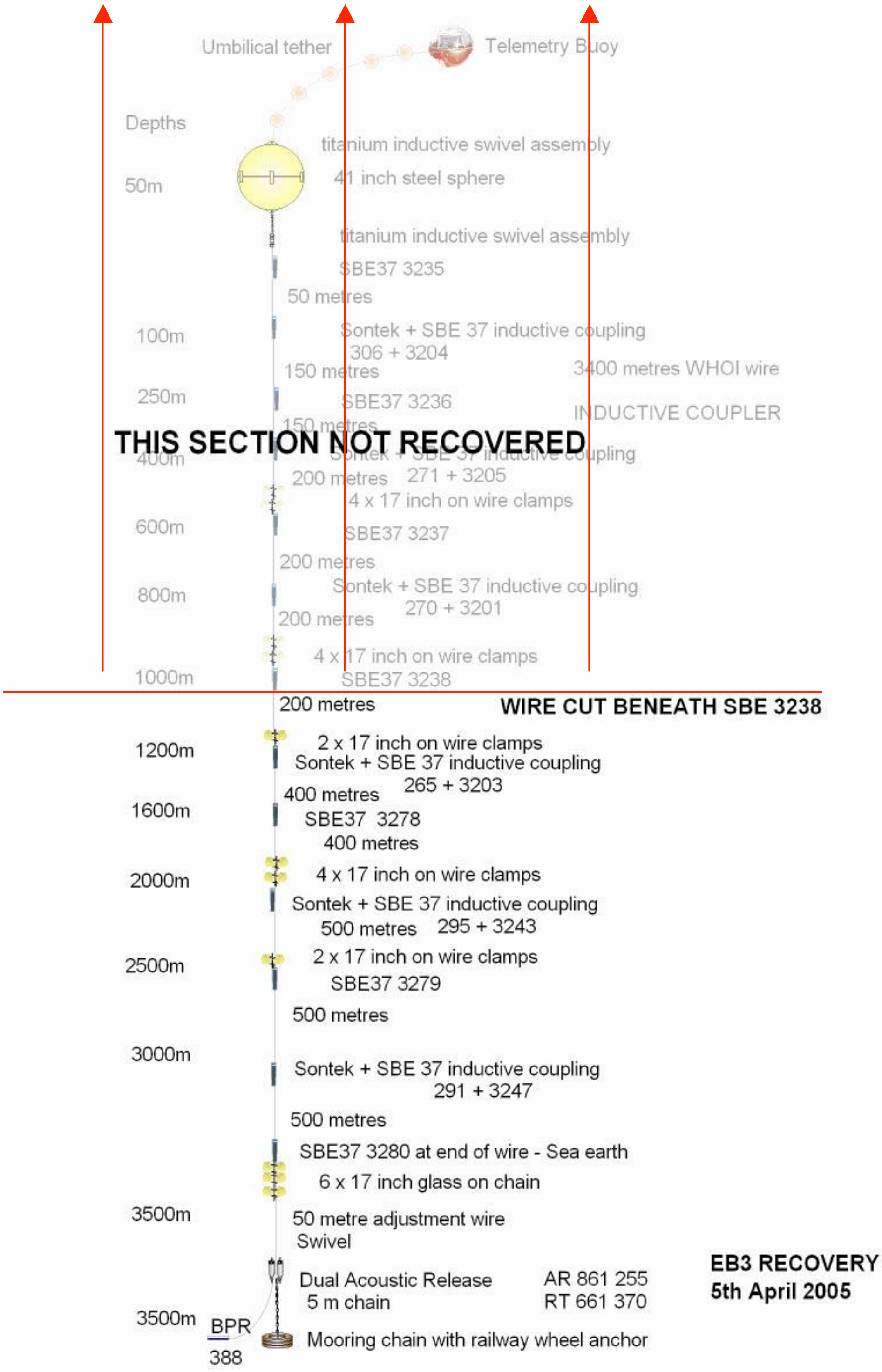


Figure A.8 Mooring Diagram of EBADCP as Deployed 2005

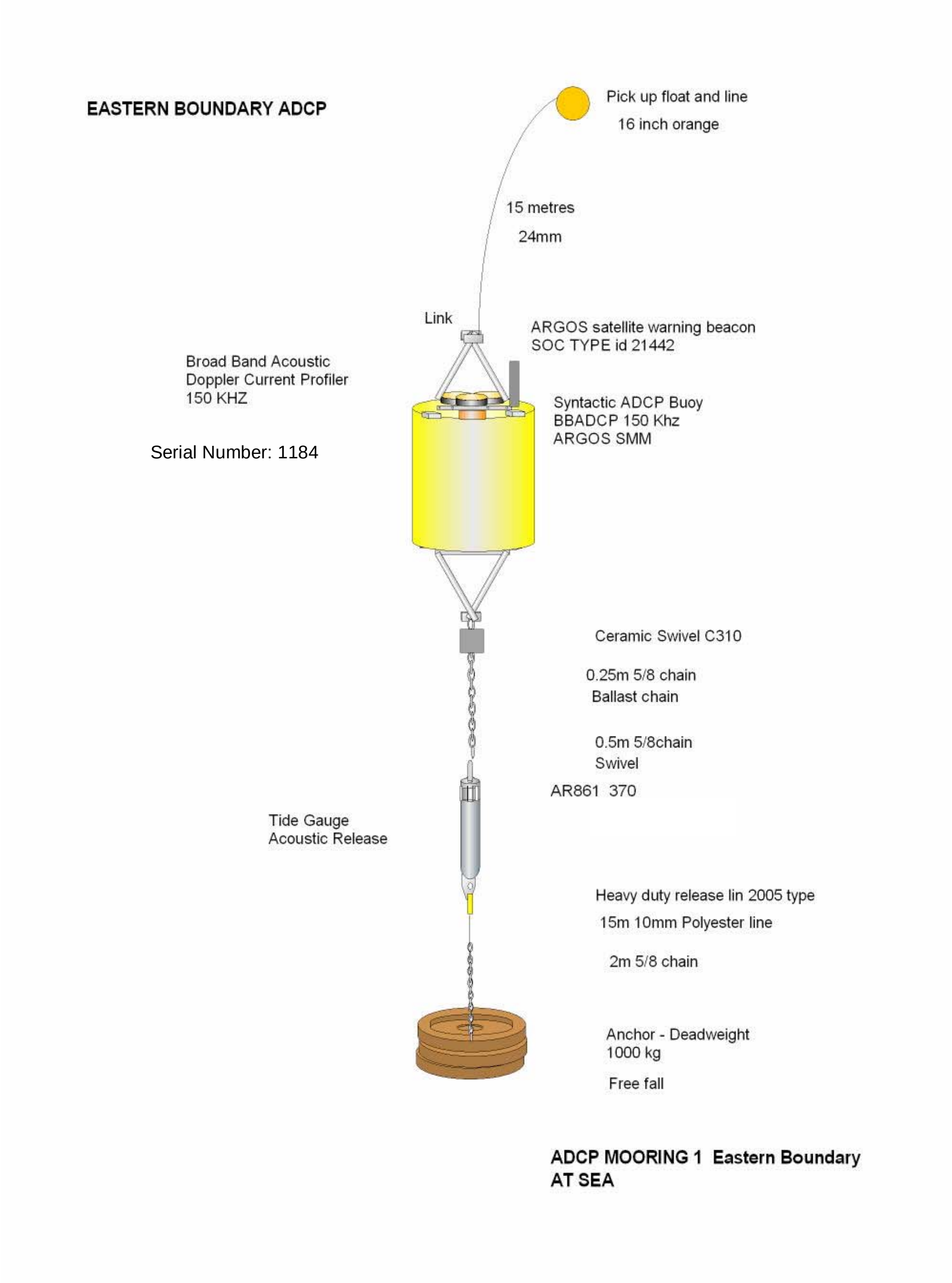


Figure A.9: Mooring Diagram of EBH5 as Deployed 2005

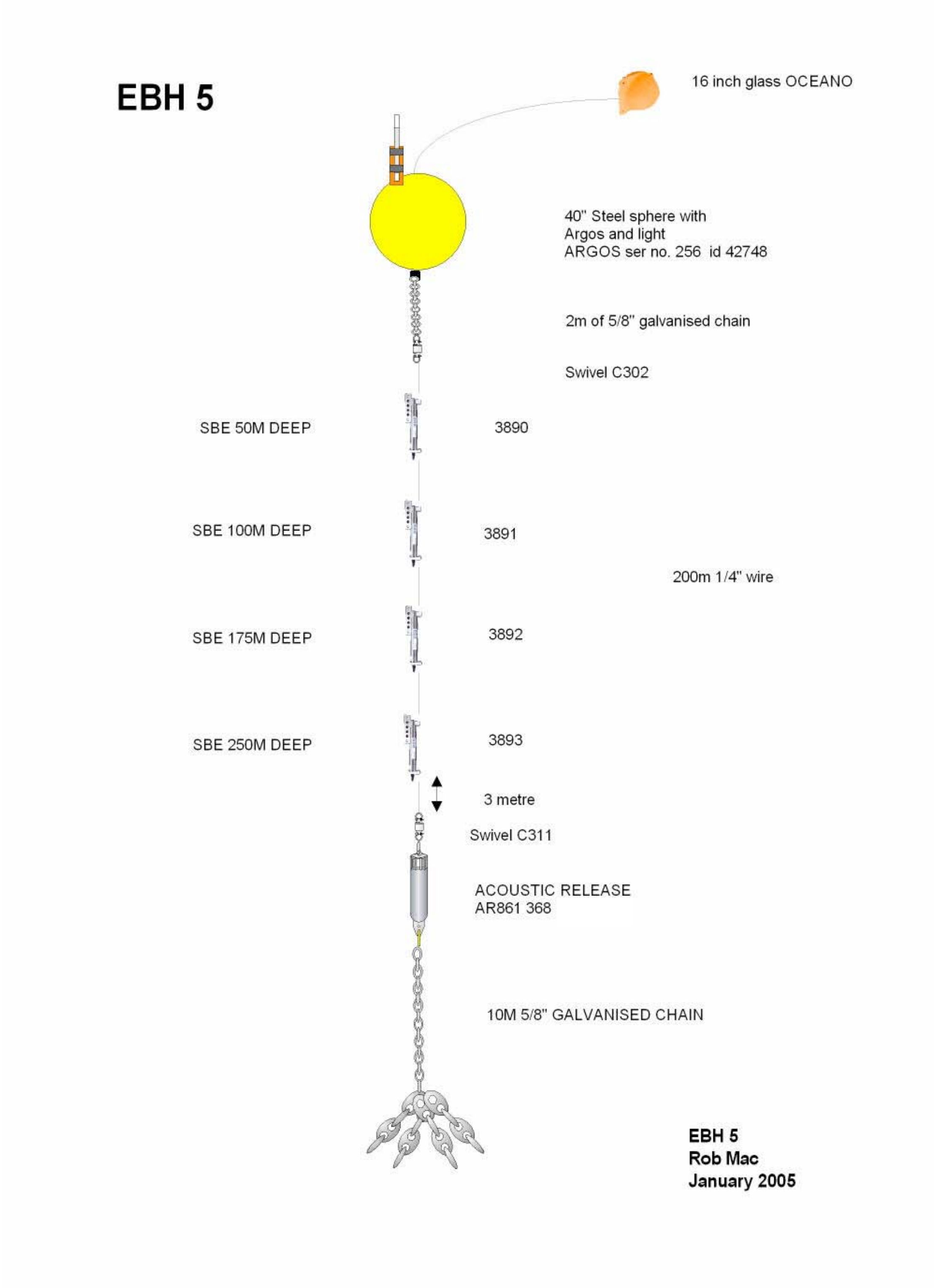


Figure A.10: Mooring Diagram of EBH4 as Deployed 2005

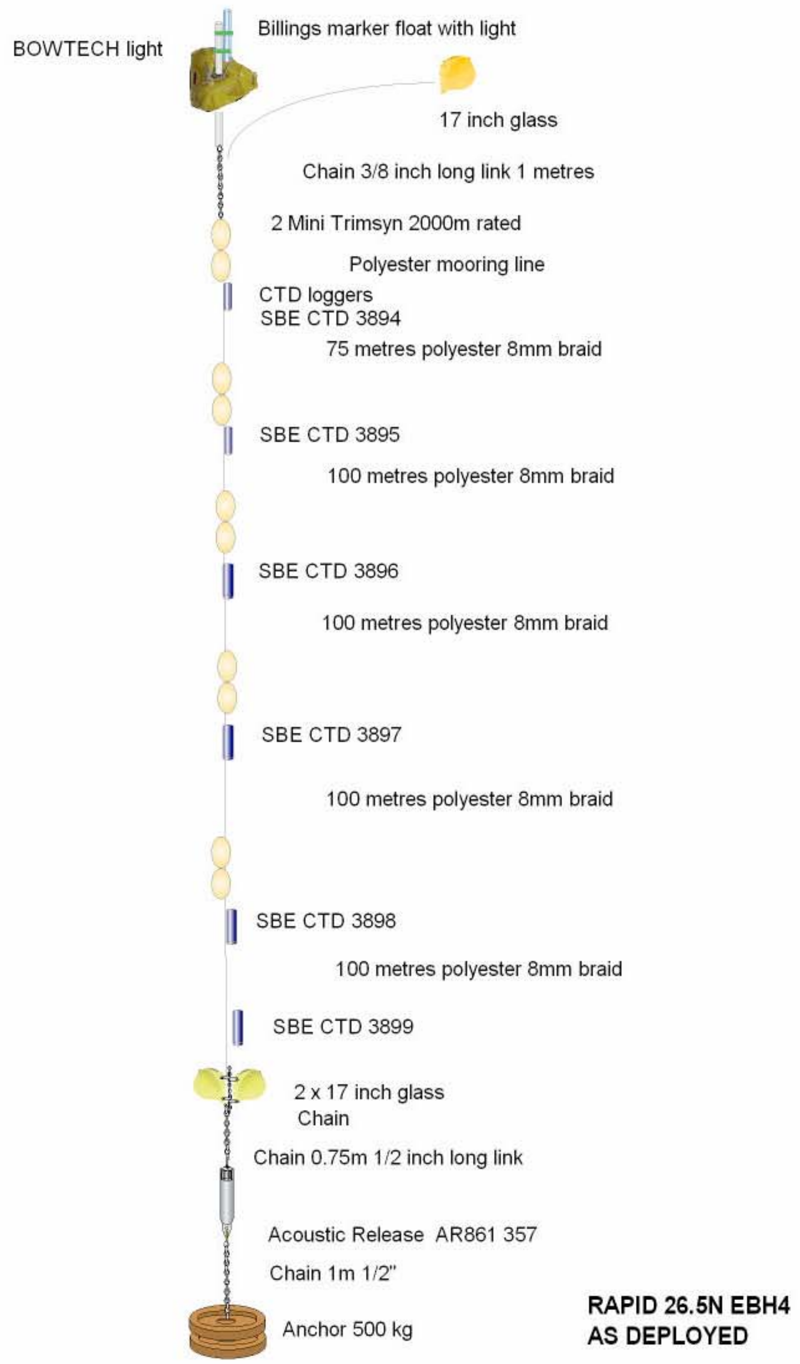


Figure A.11: Mooring Diagram of EBH3 as Deployed 2005

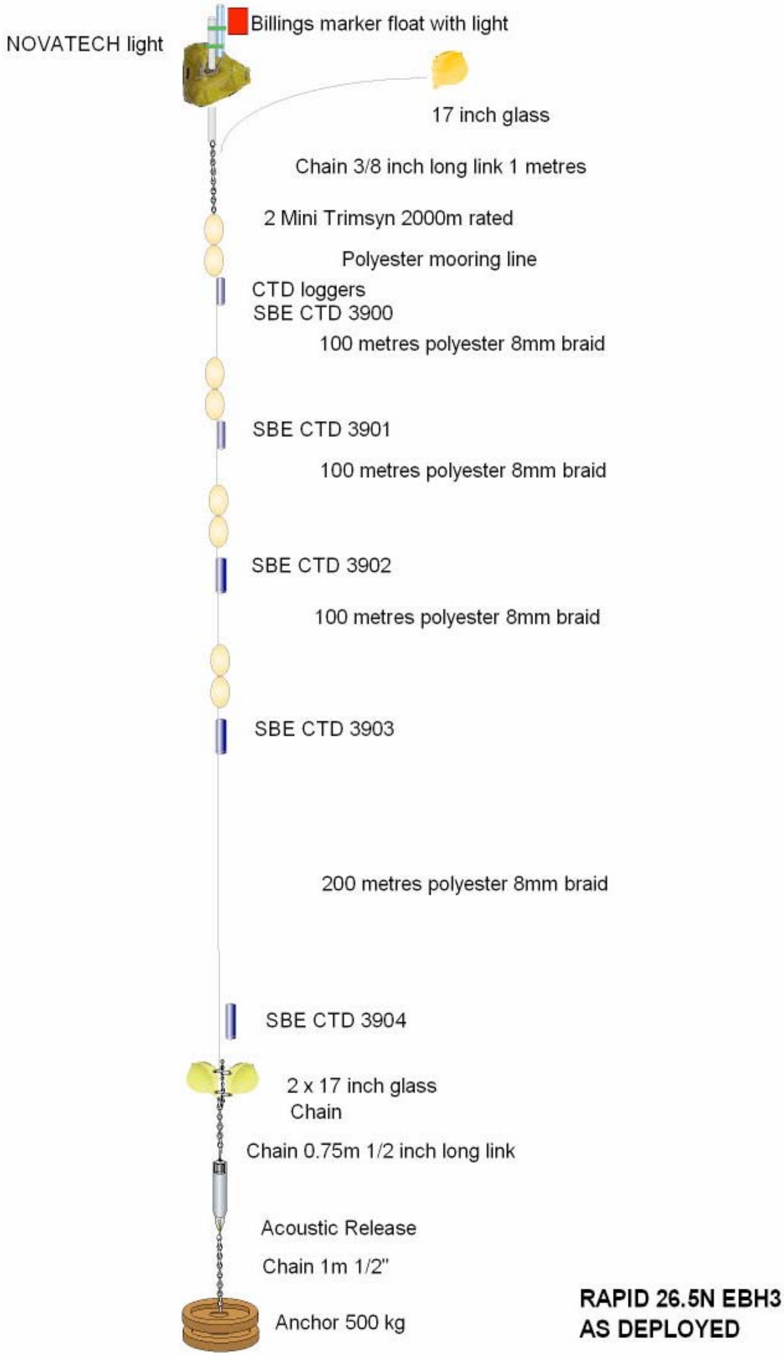


Figure A.12: Mooring Diagram of EBH2 as Deployed 2005

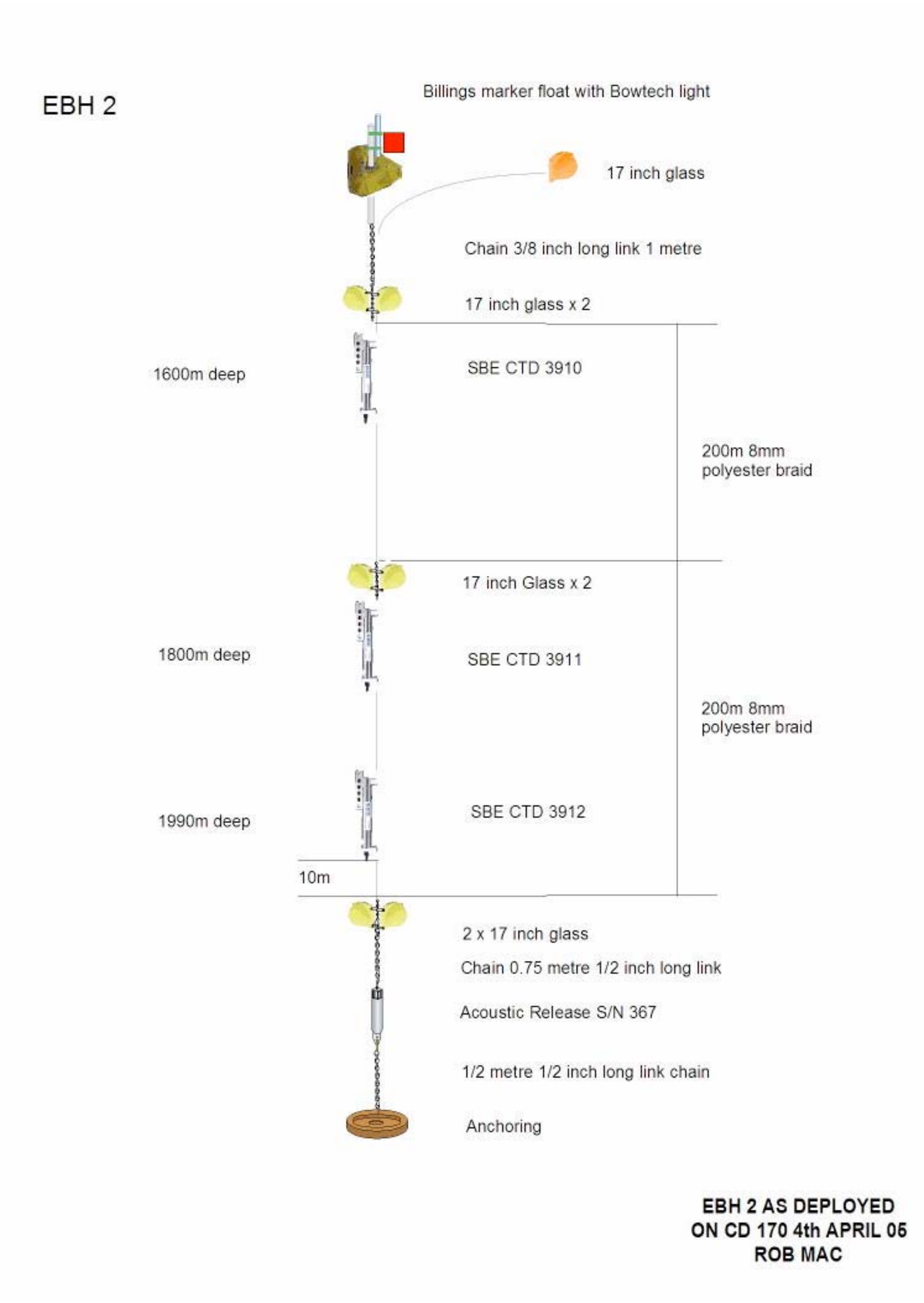


Figure A.13: Mooring Diagram of EBH1 as Deployed 2005

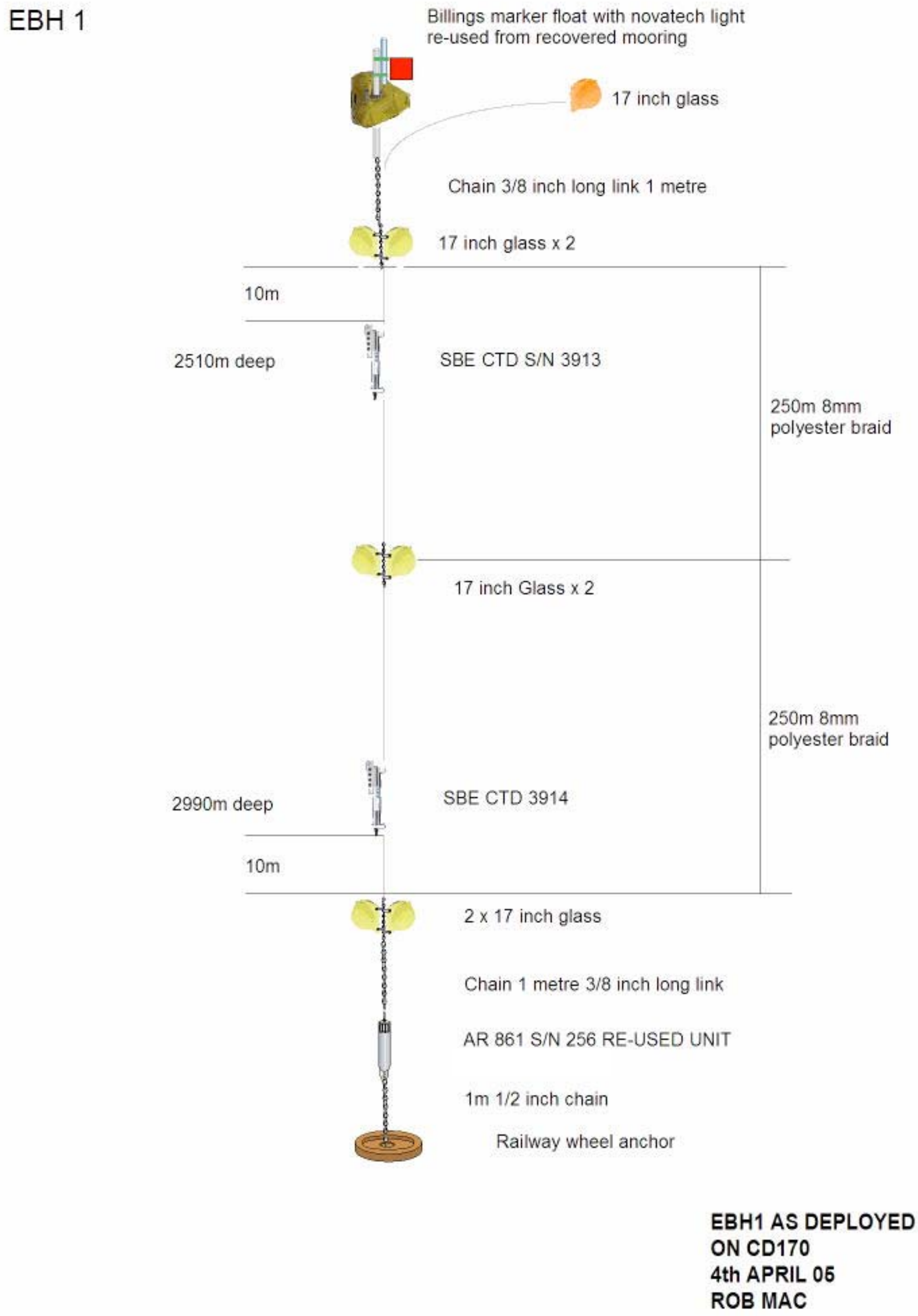


Figure A.14: Mooring Diagram of EBH0 as Deployed 2005

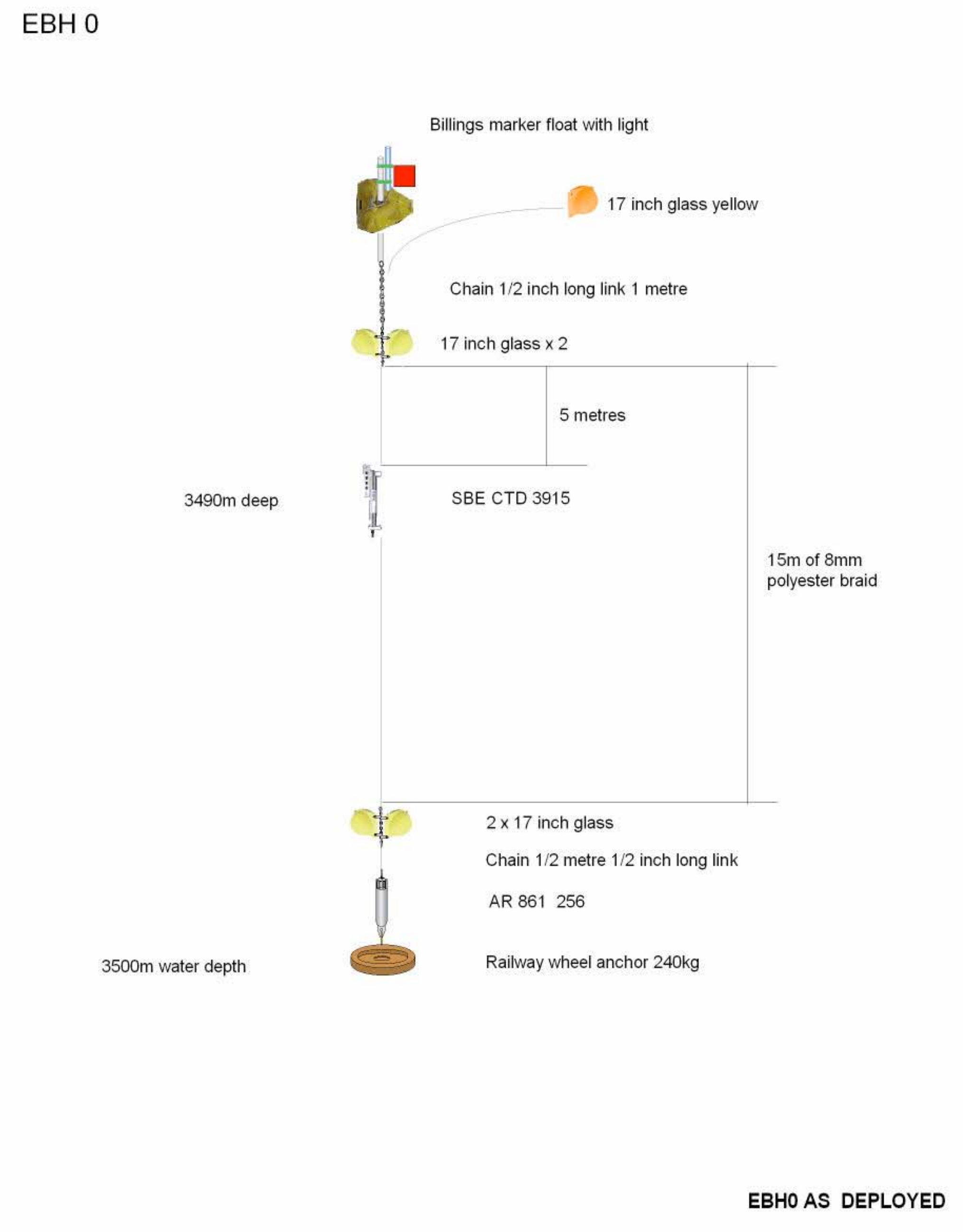


Figure A.15: Mooring Diagram of EBL2 as Deployed 2005

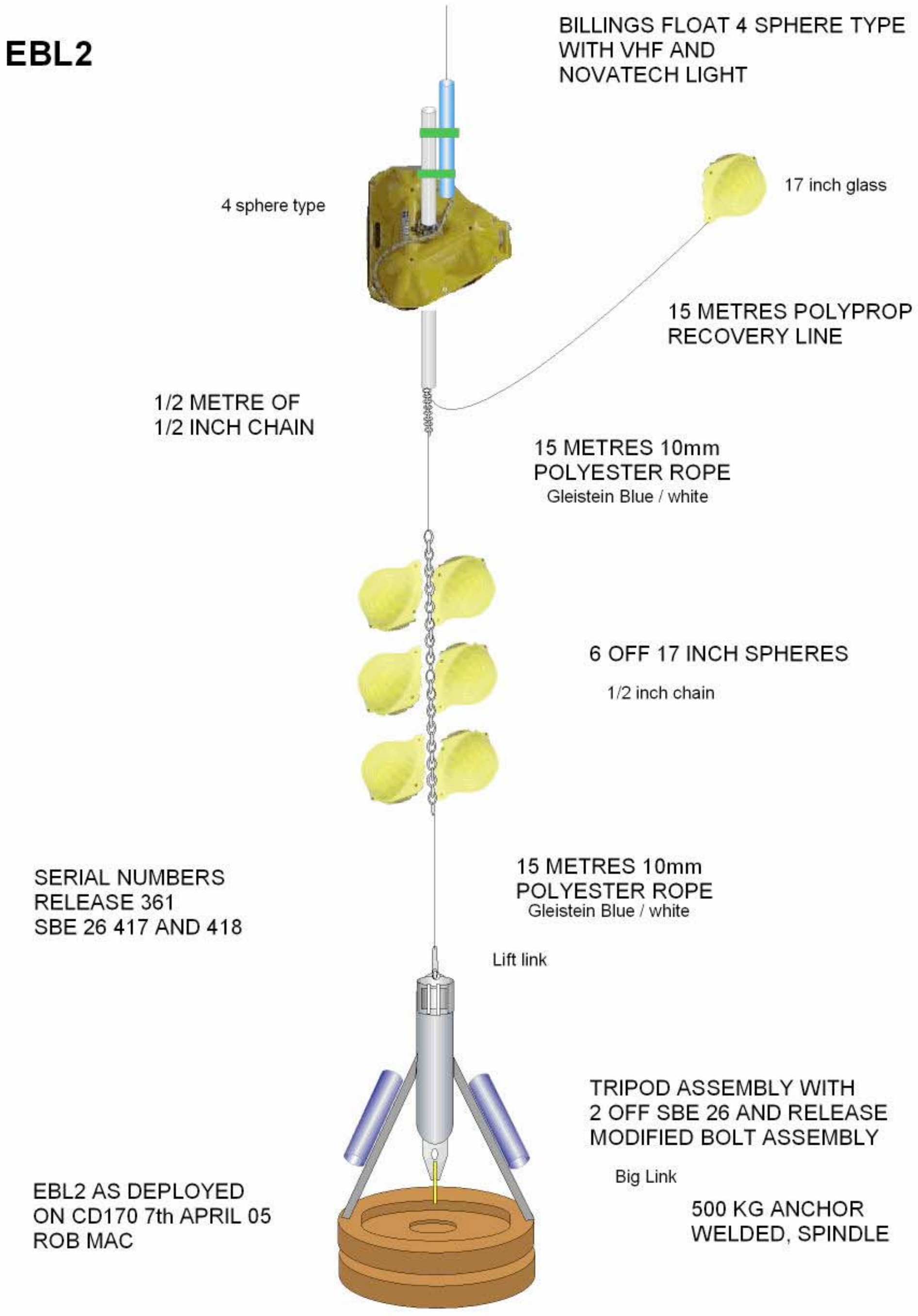


Figure A.16: Mooring Diagram of EBHi as Deployed 2005

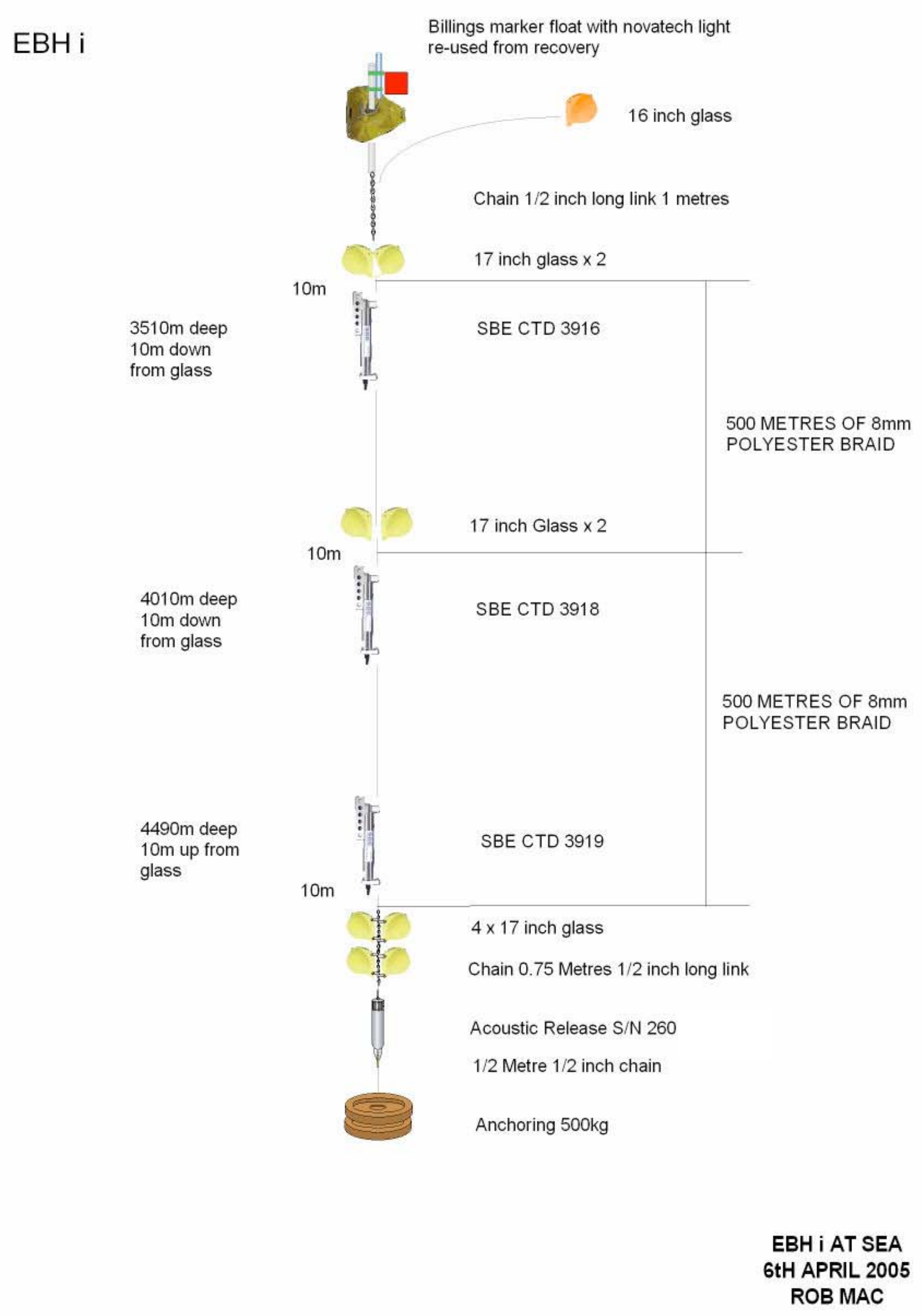


Figure A.17: Mooring Diagram of EB2 as Deployed 2005

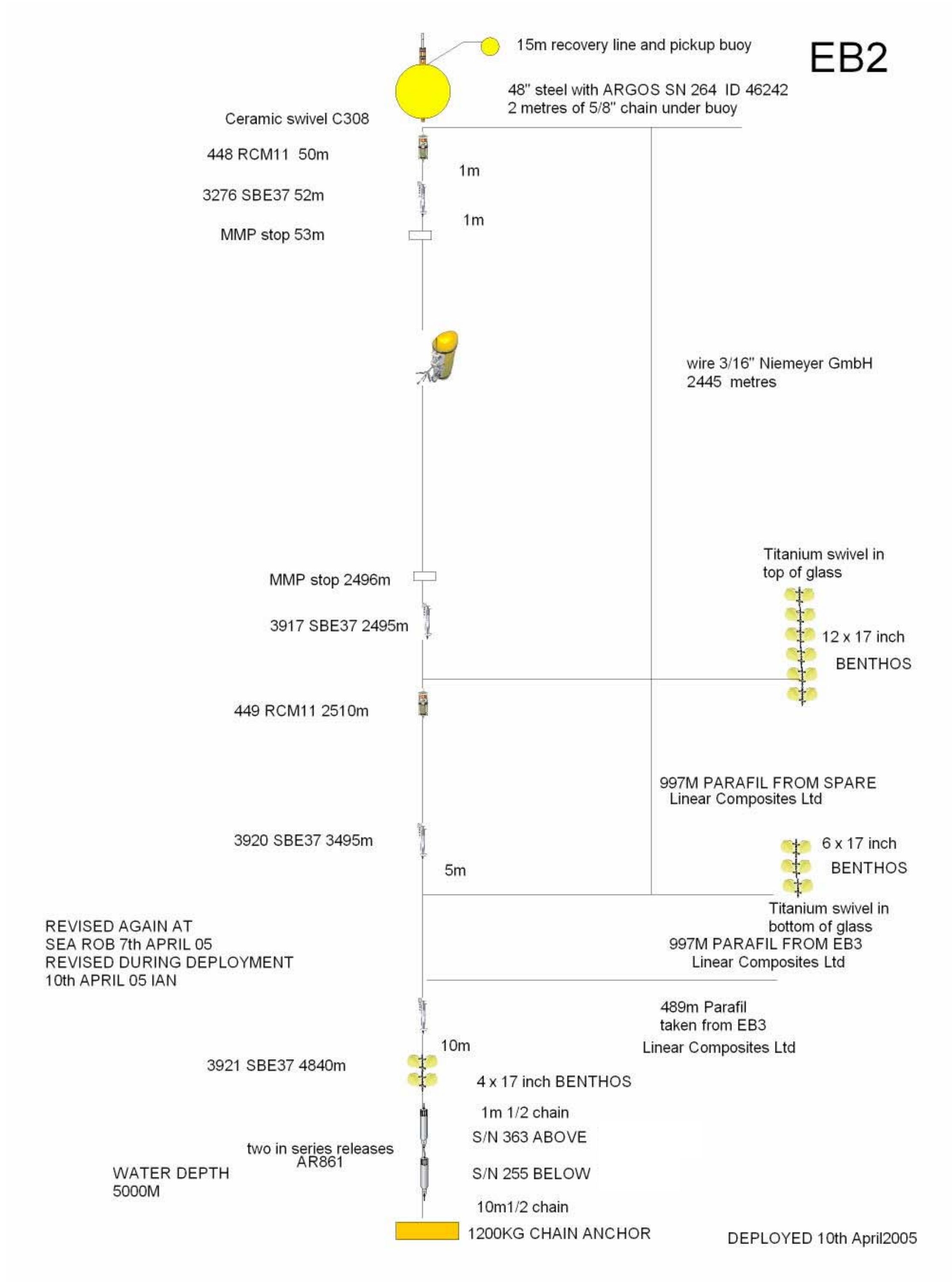


Figure A.18: Mooring Diagram of EB1 as Deployed 2005

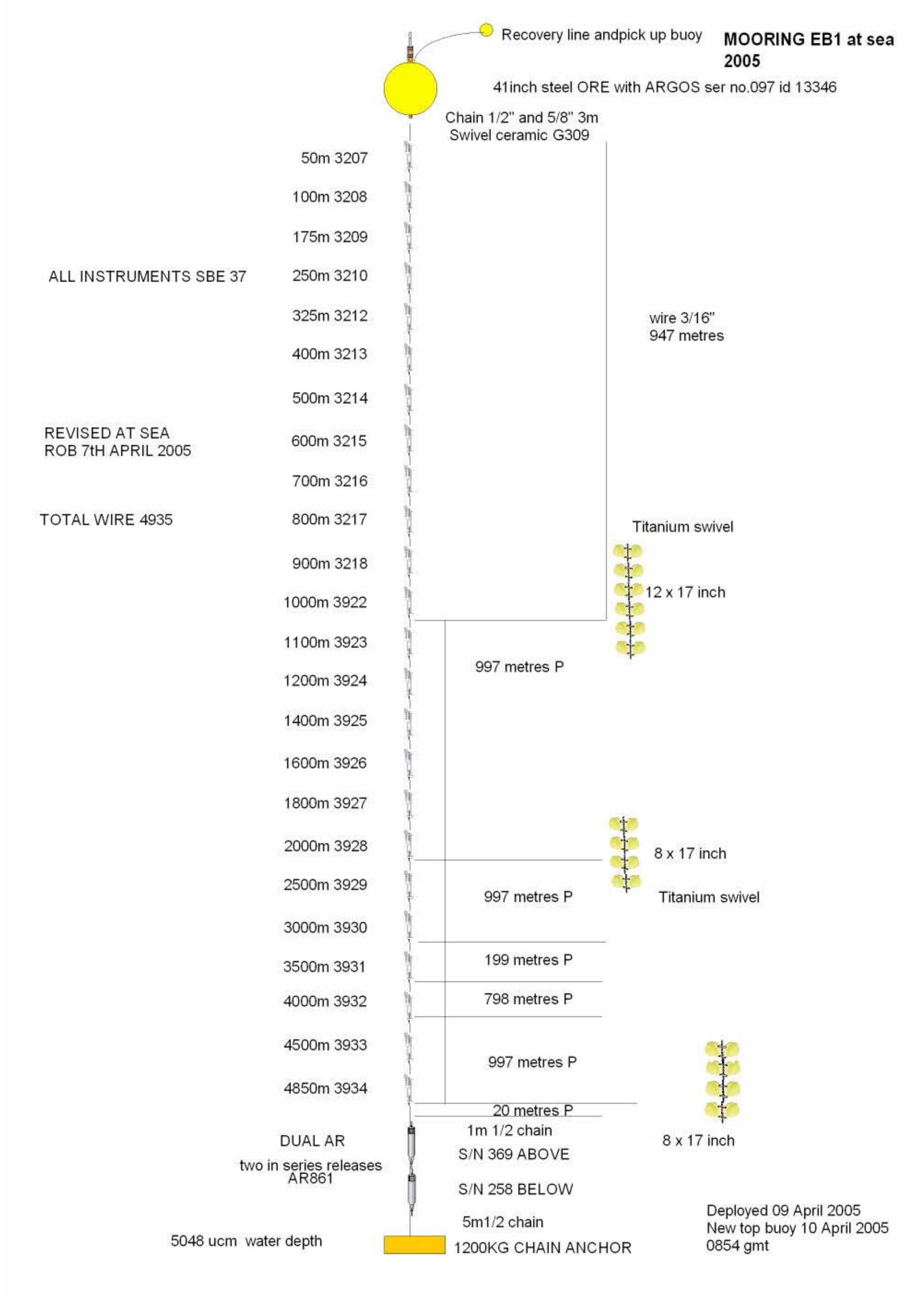


Figure A.19: Mooring Diagram of EBL1 as Deployed 2005

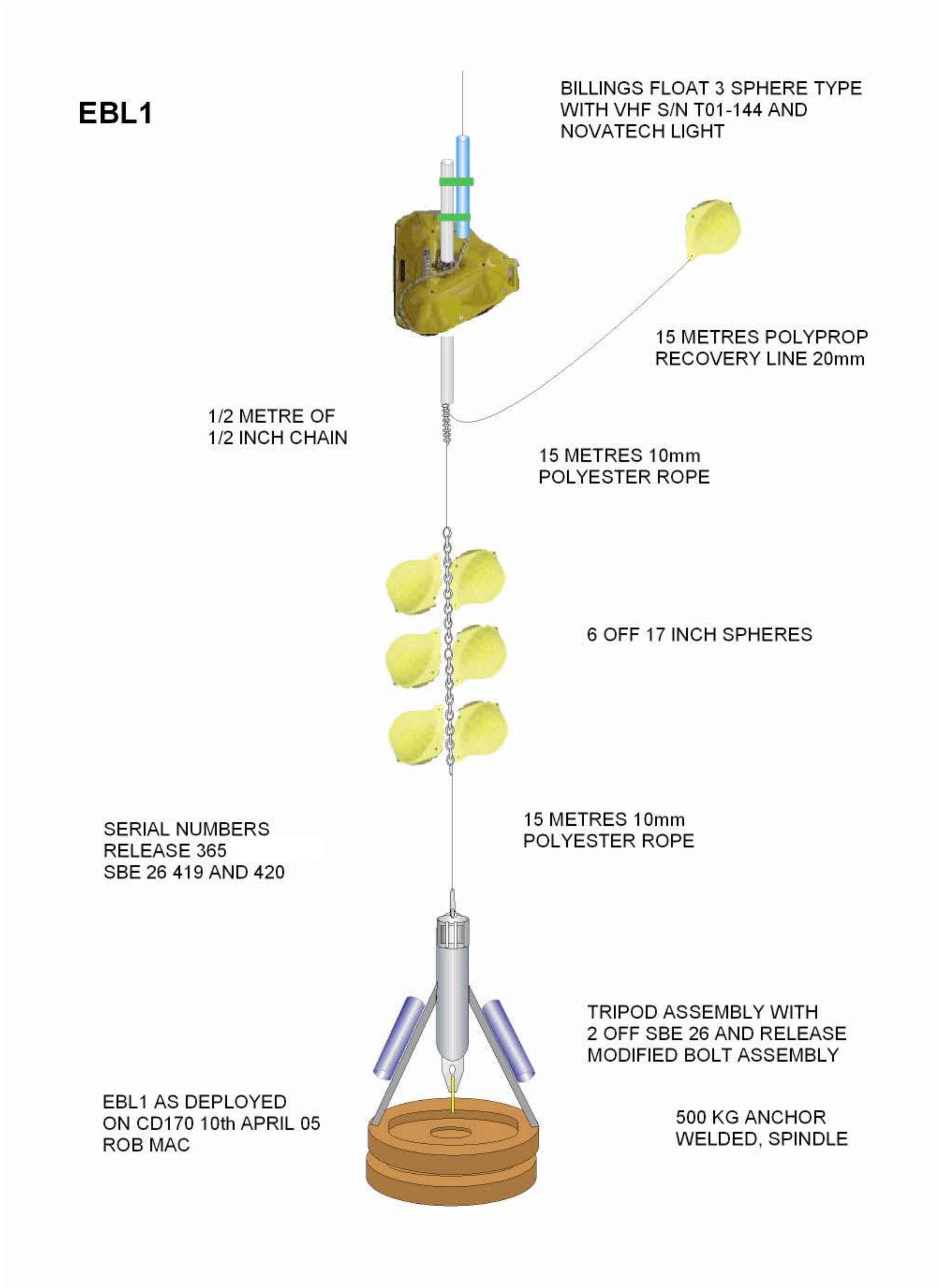


Figure A.20: Mooring Diagram of MAR3 as Deployed 2005

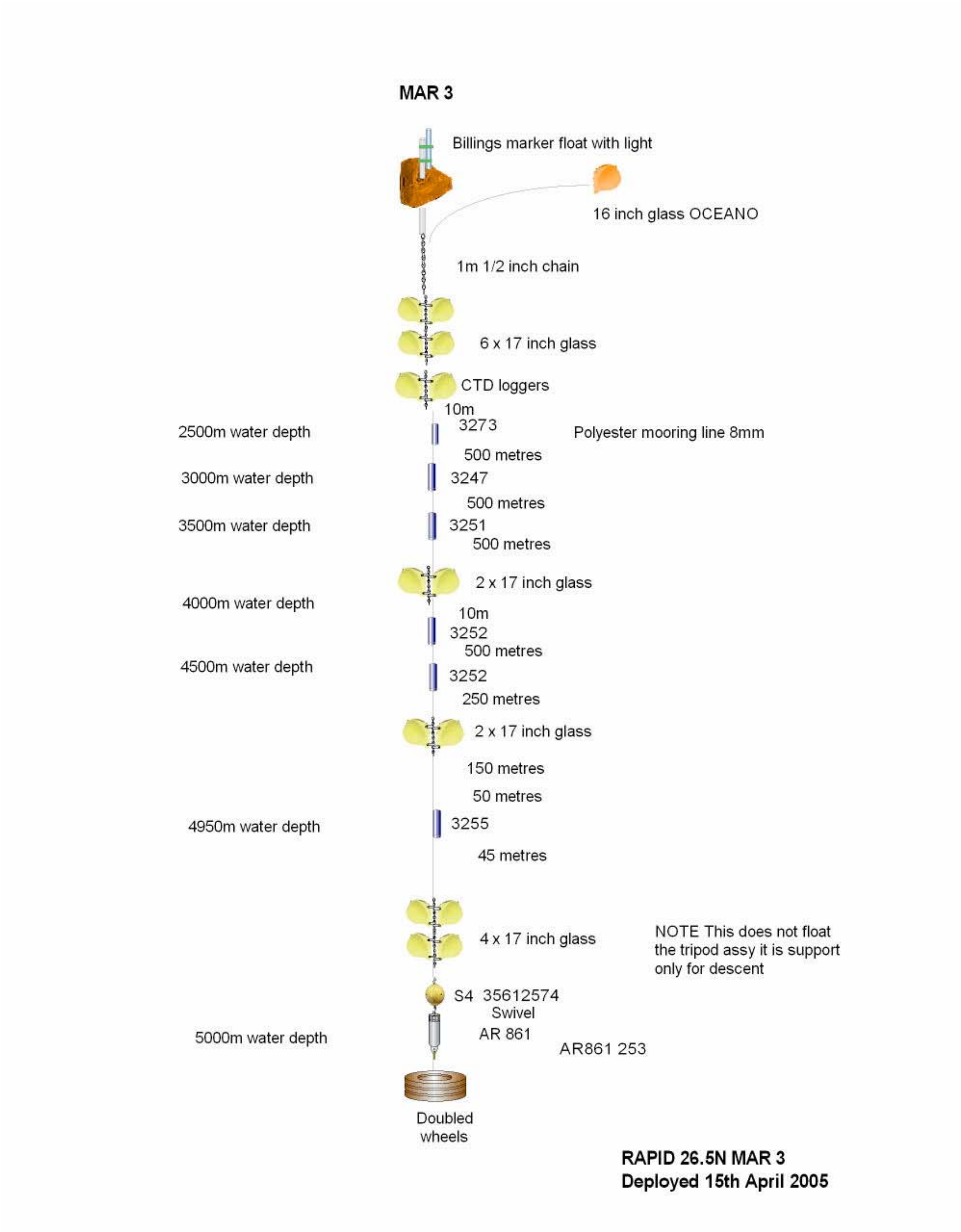


Figure A.21: Mooring Diagram of MARL2 as Deployed 2005

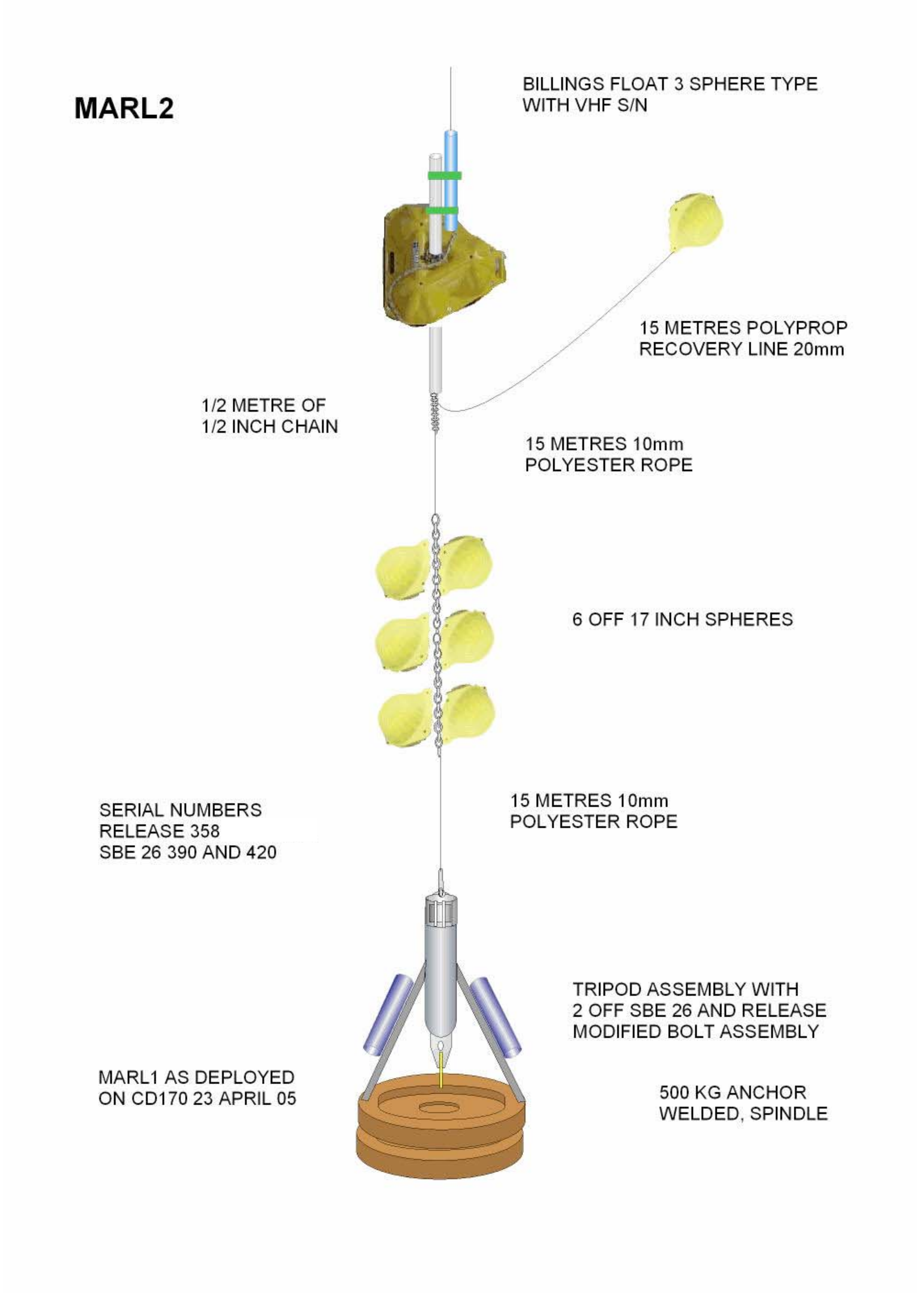


Figure A.22: Mooring Diagram of MAR4 as Deployed 2005

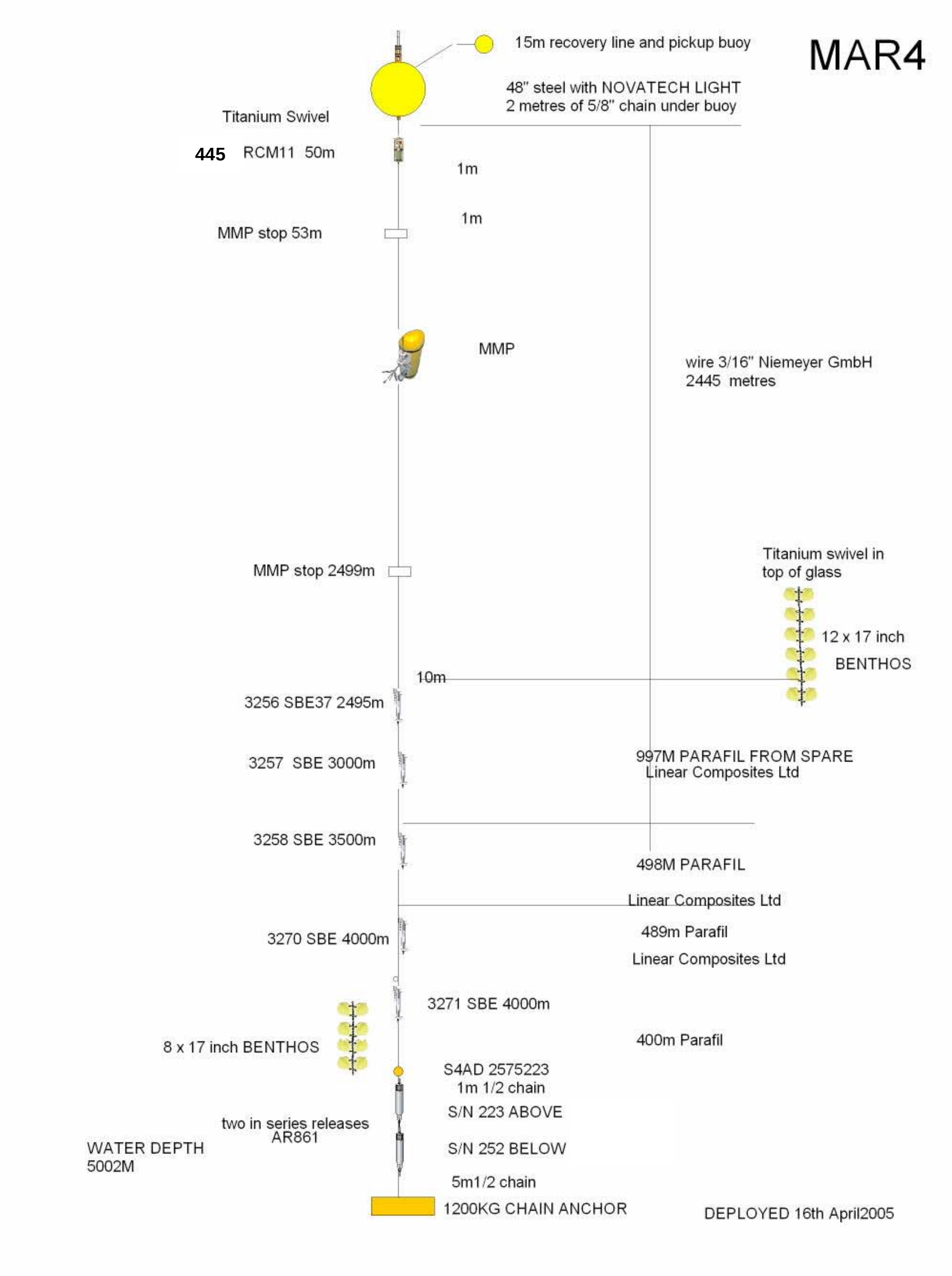


Figure A.23: Mooring Diagram of MAR2 as Deployed 2005

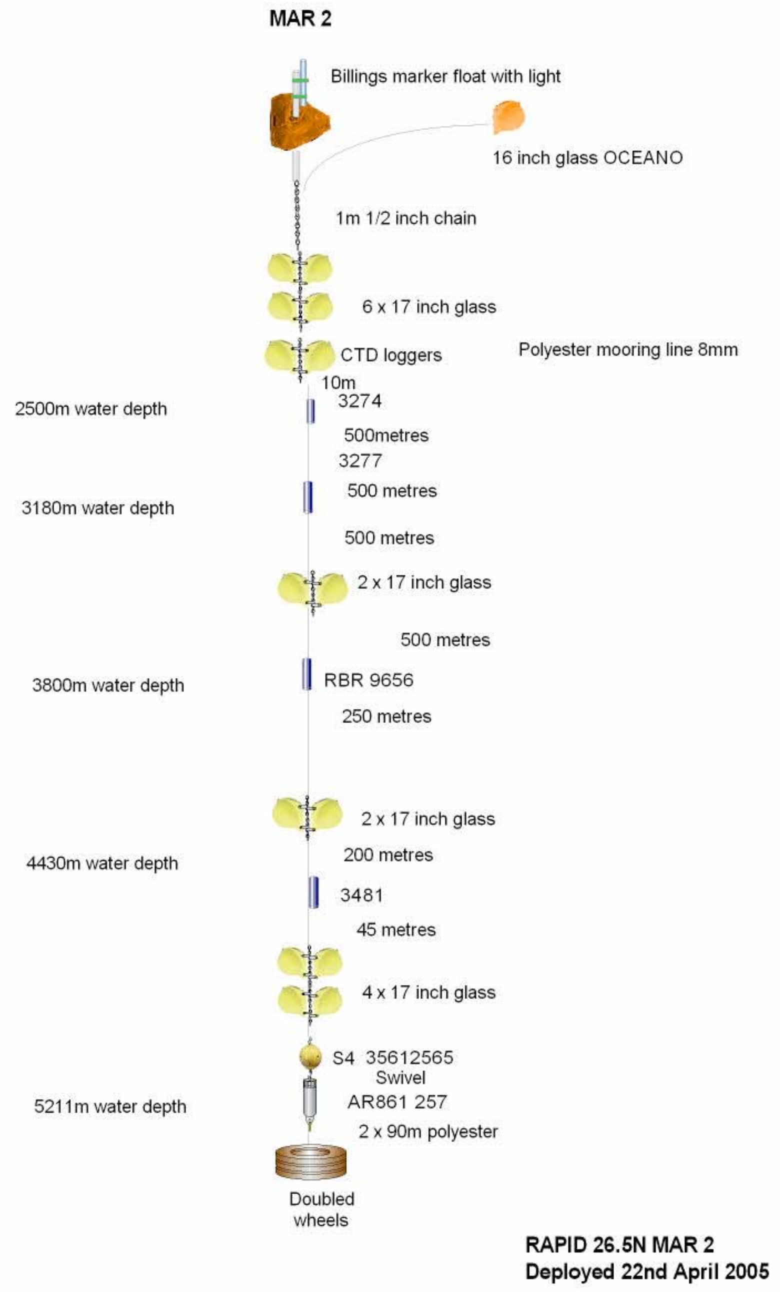


Figure A.24: Mooring Diagram of MAR1 as First Deployed and Subsequently Recovered 2005

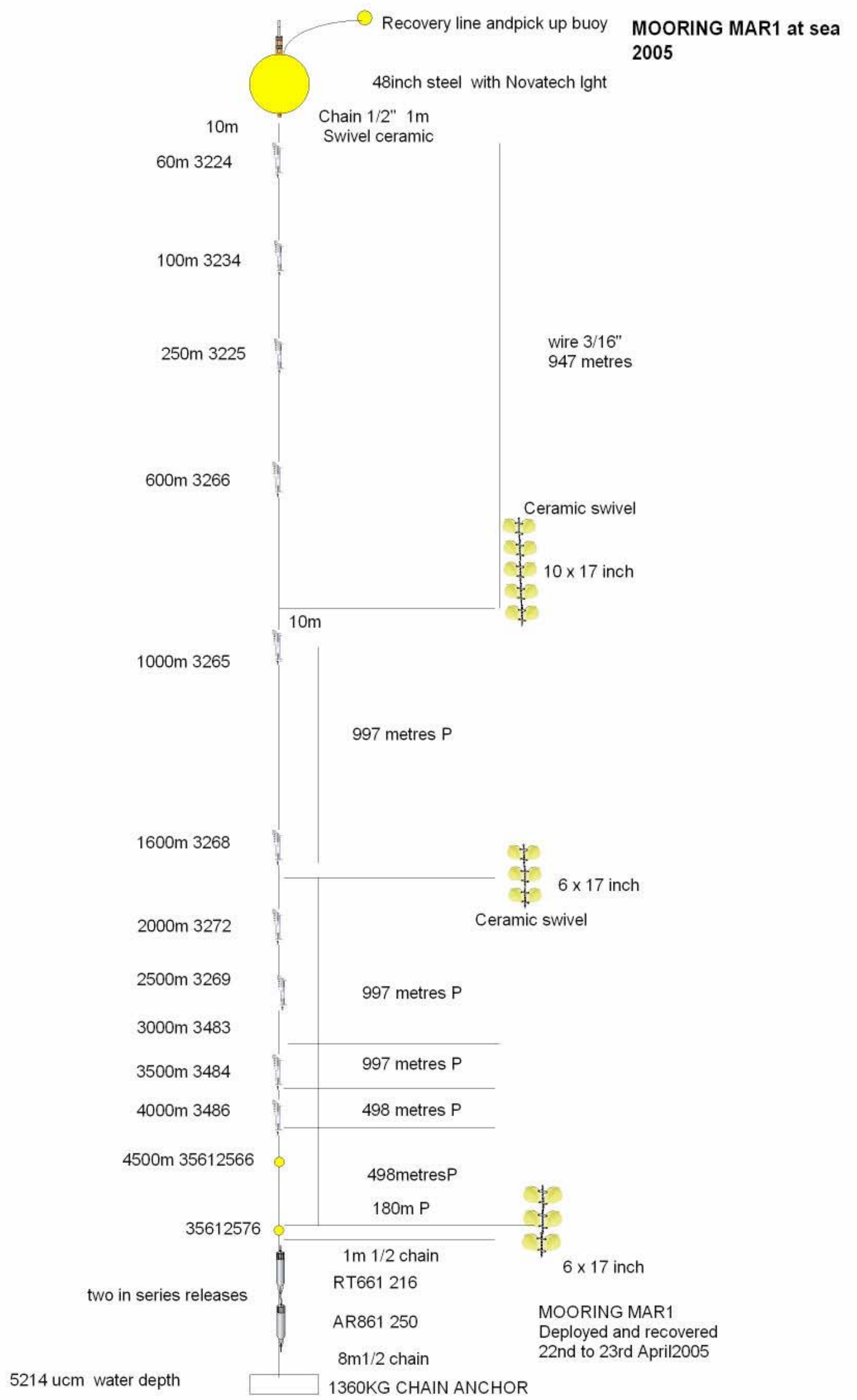


Figure A.25: Mooring Diagram of MAR1 as Secondly Deployed 2005

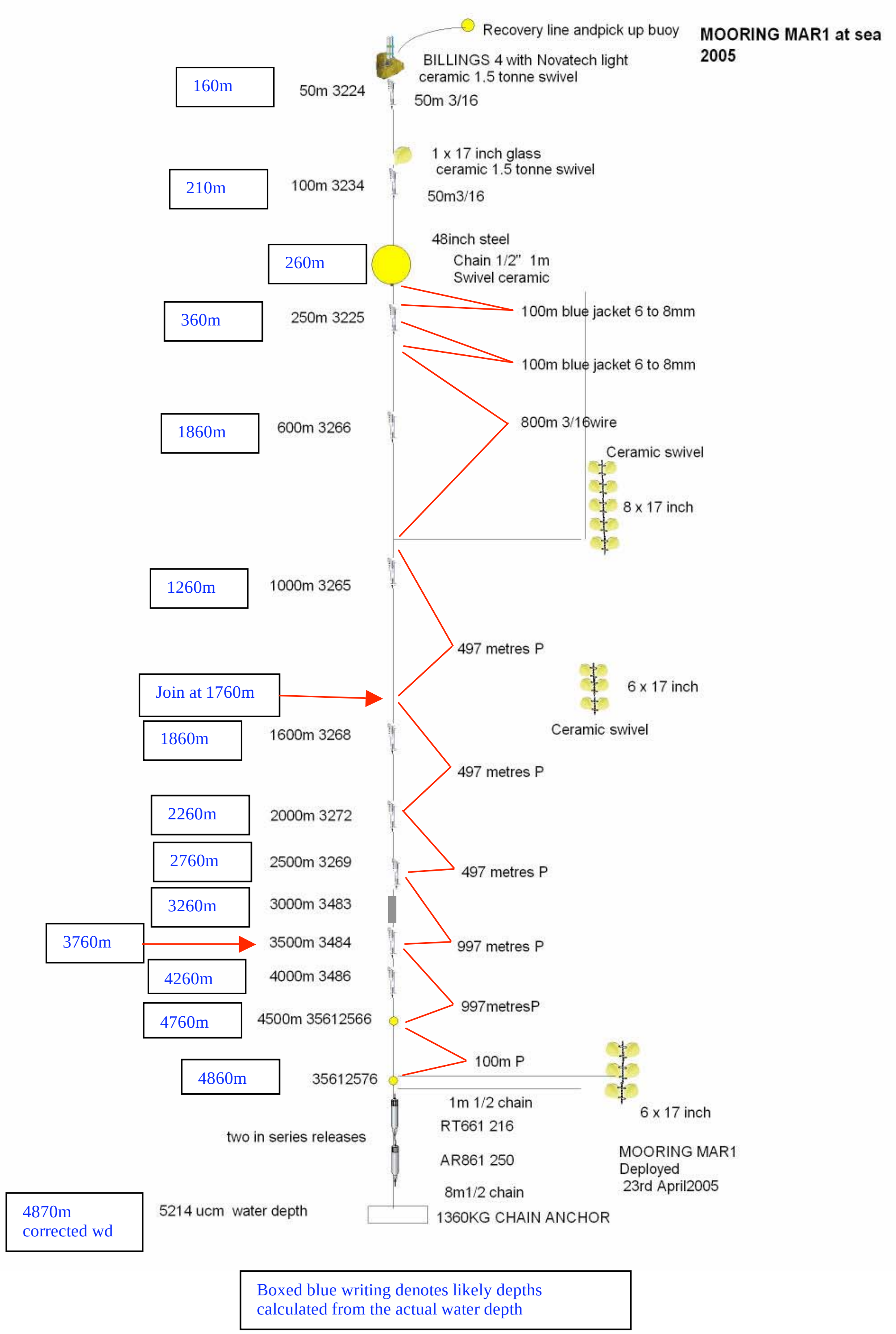


Figure A.26: Mooring Diagram of MARL1 as Deployed 2005

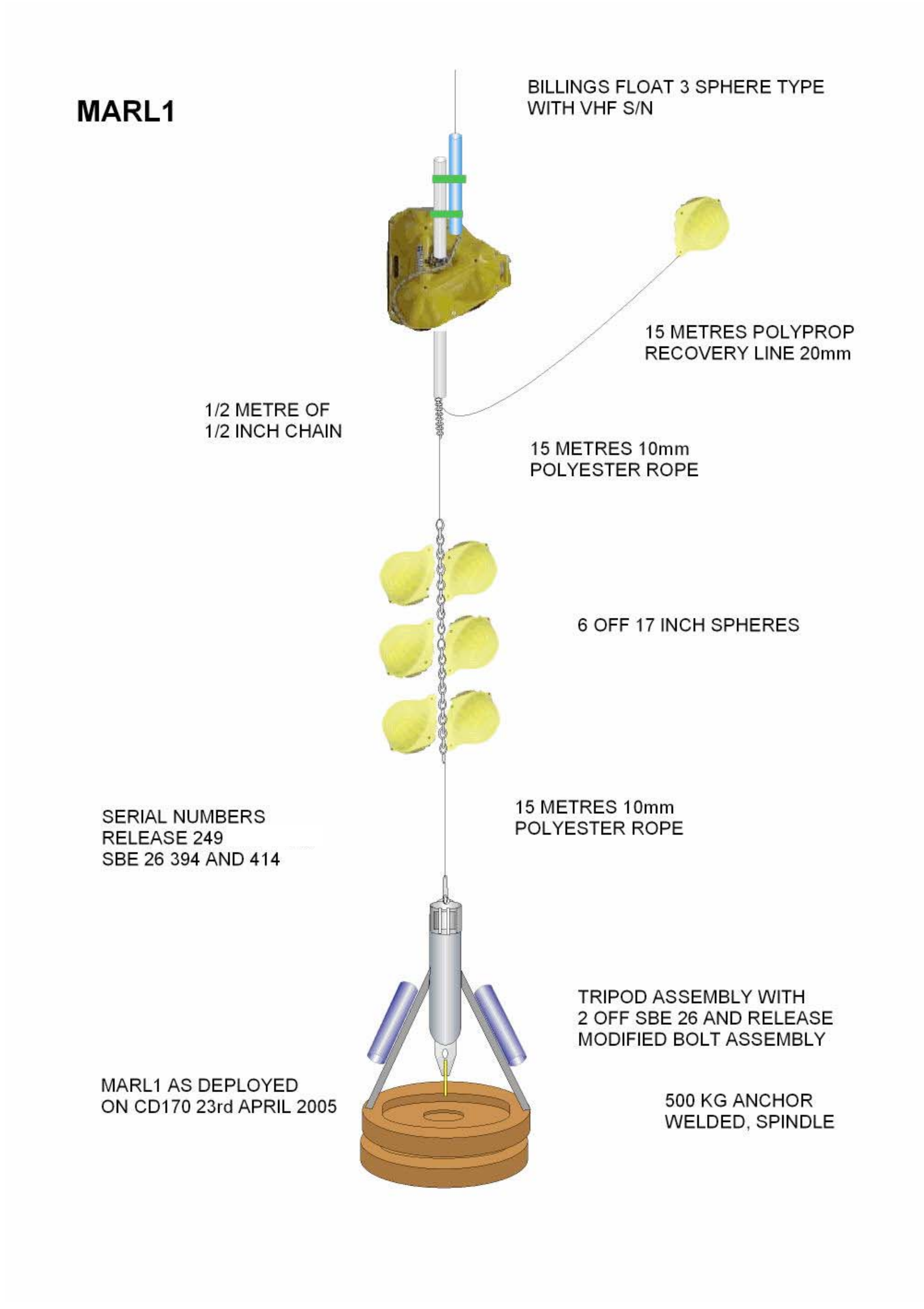


Figure A.27: Mooring Diagram of WB4 as First Deployed and Recovered 2005

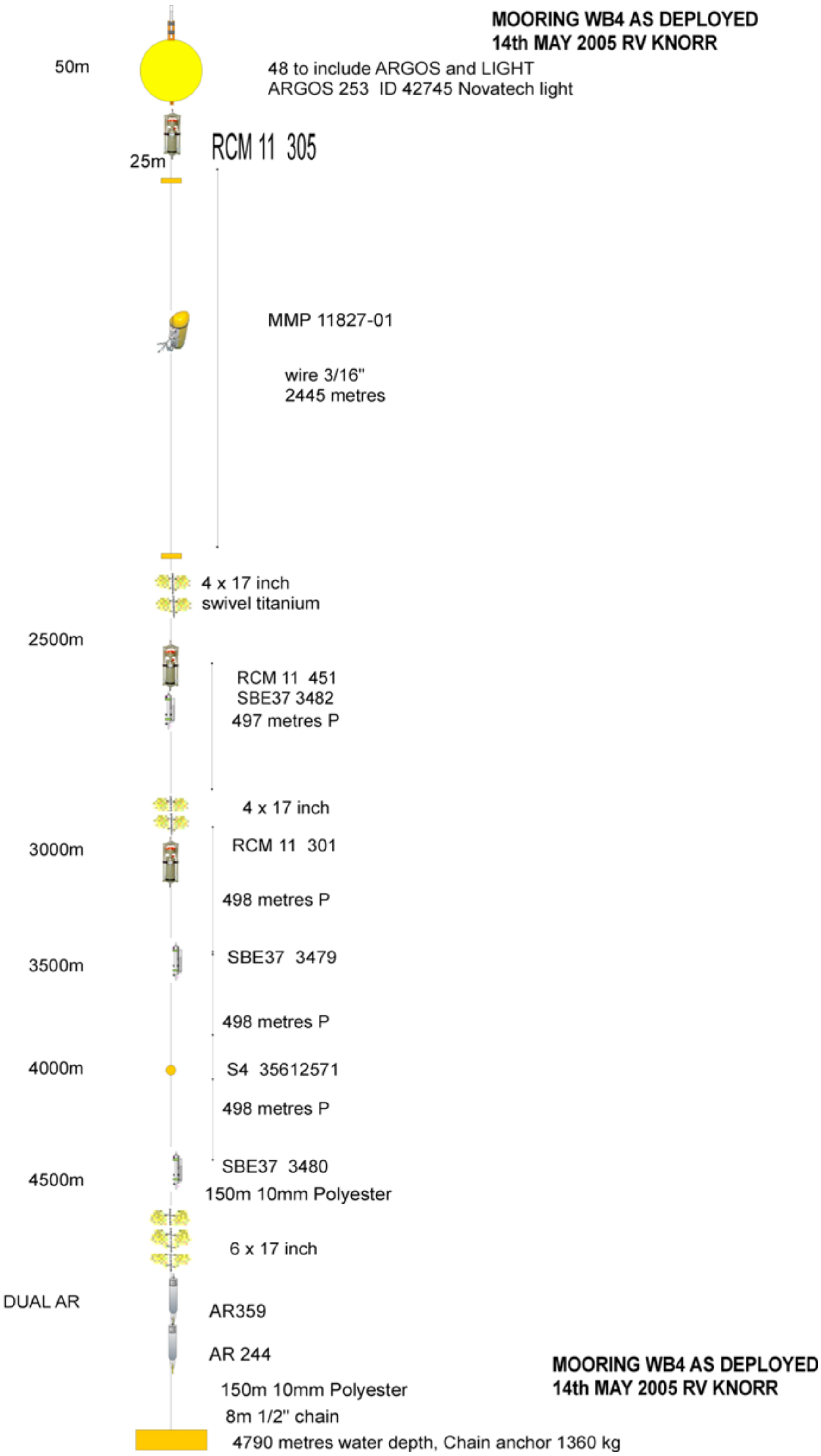


Figure A.28: Mooring Diagram of WB4 as Secondly Deployed 2005

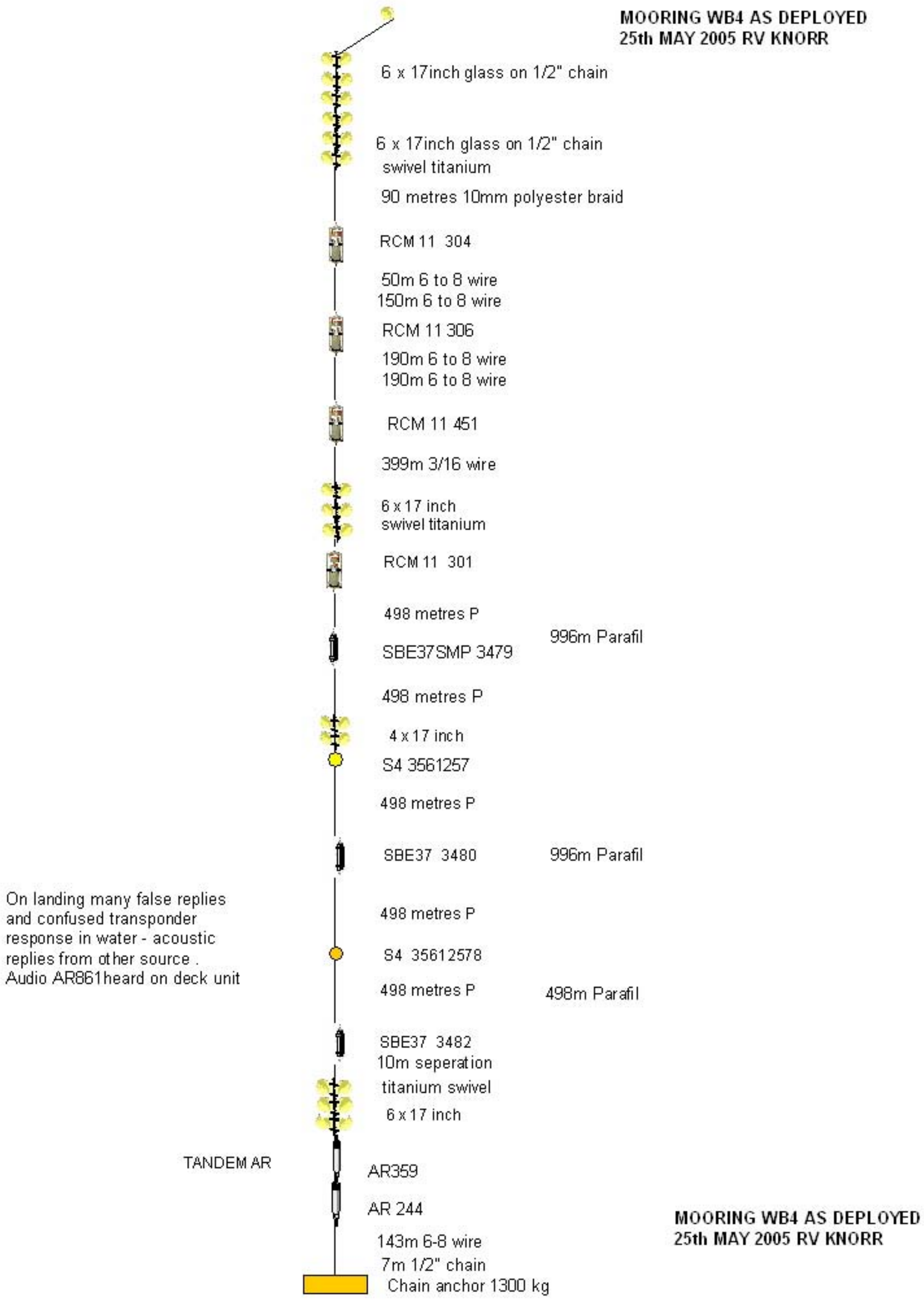


Figure A.29: Mooring Diagram of WBL2 as Deployed 2005

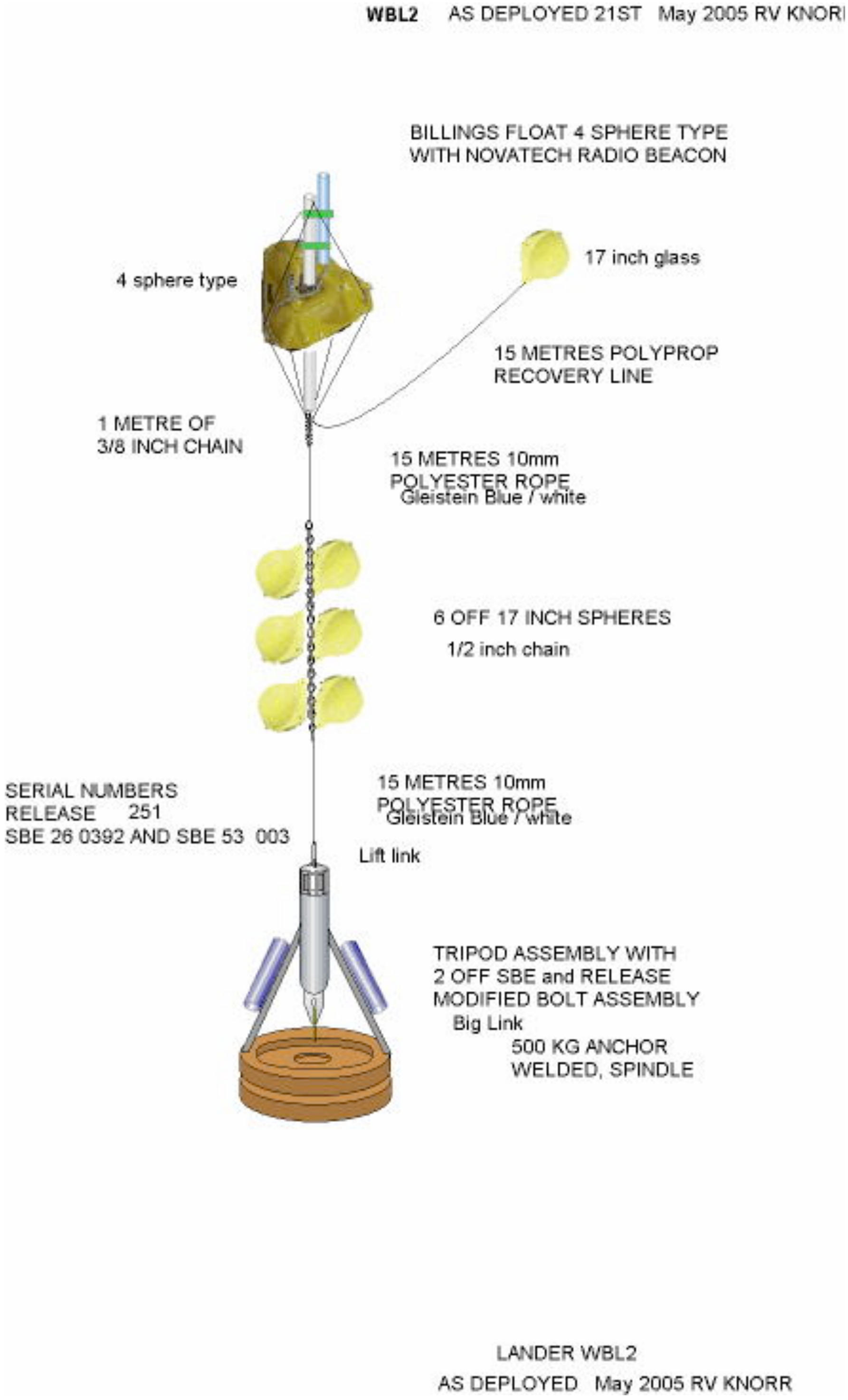


Figure A.30: Mooring Diagram of WB2 as Deployed 2005

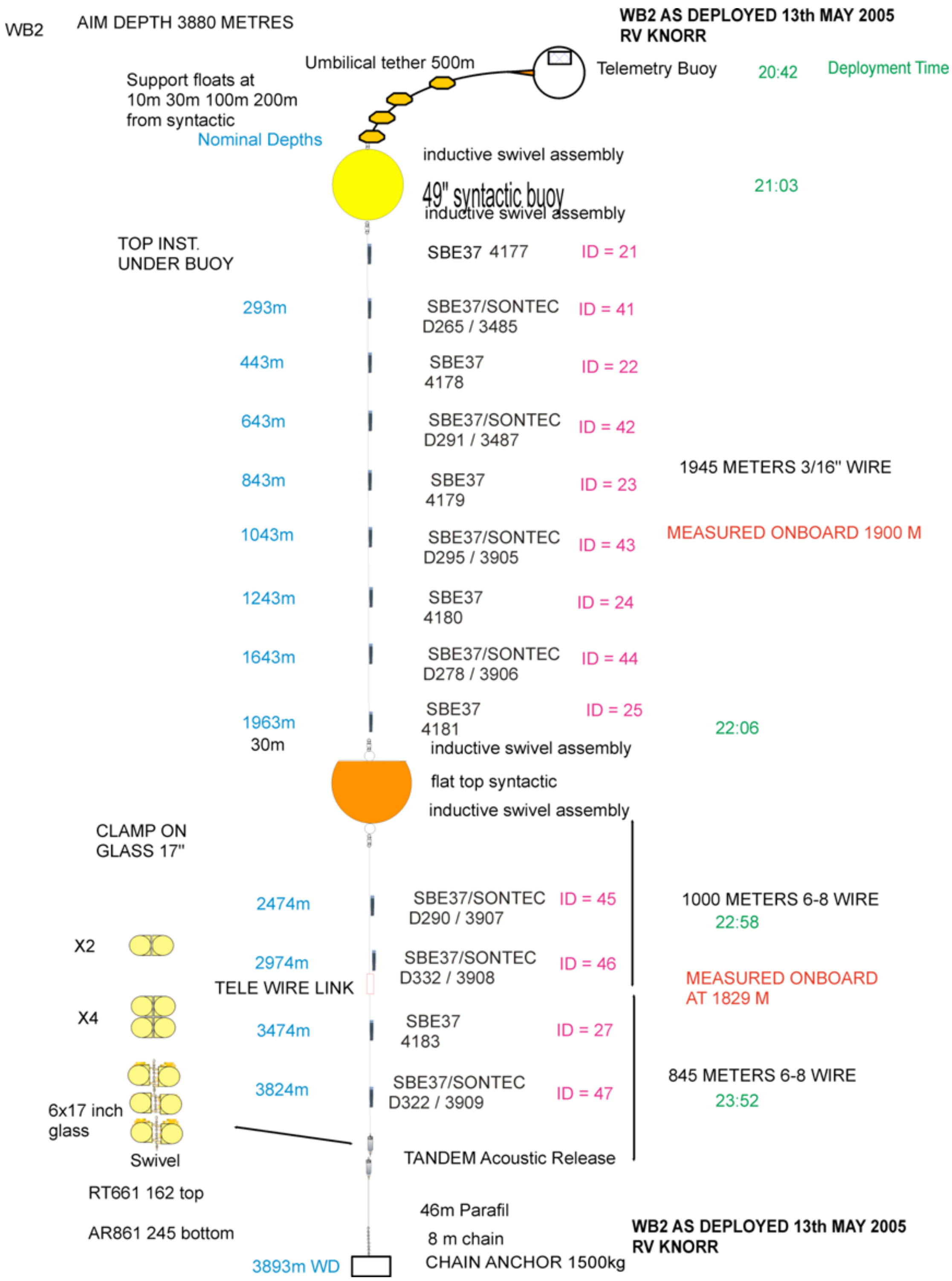


Figure A.31: Mooring Diagram of WBL1 as Deployed 2005

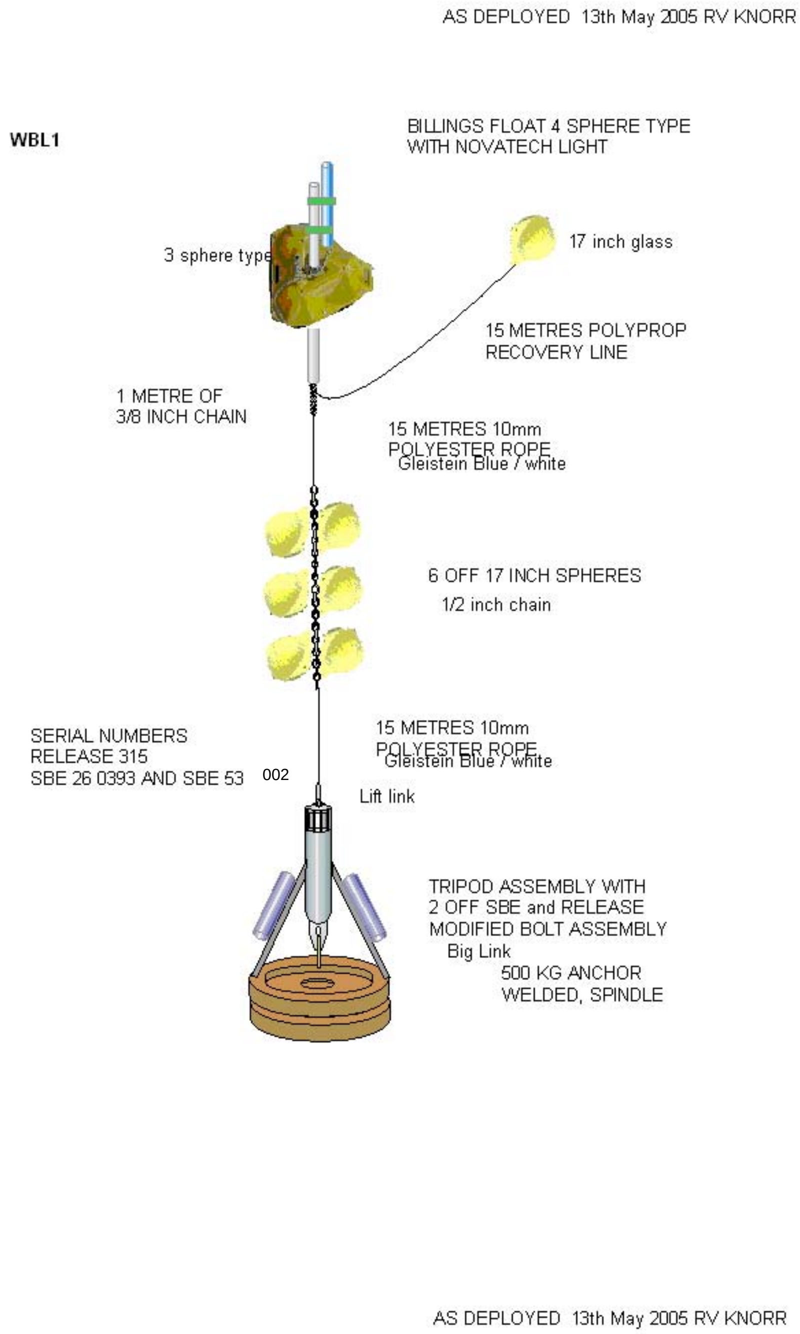


Figure A.32: Mooring Diagram of WB1 as Deployed 2005

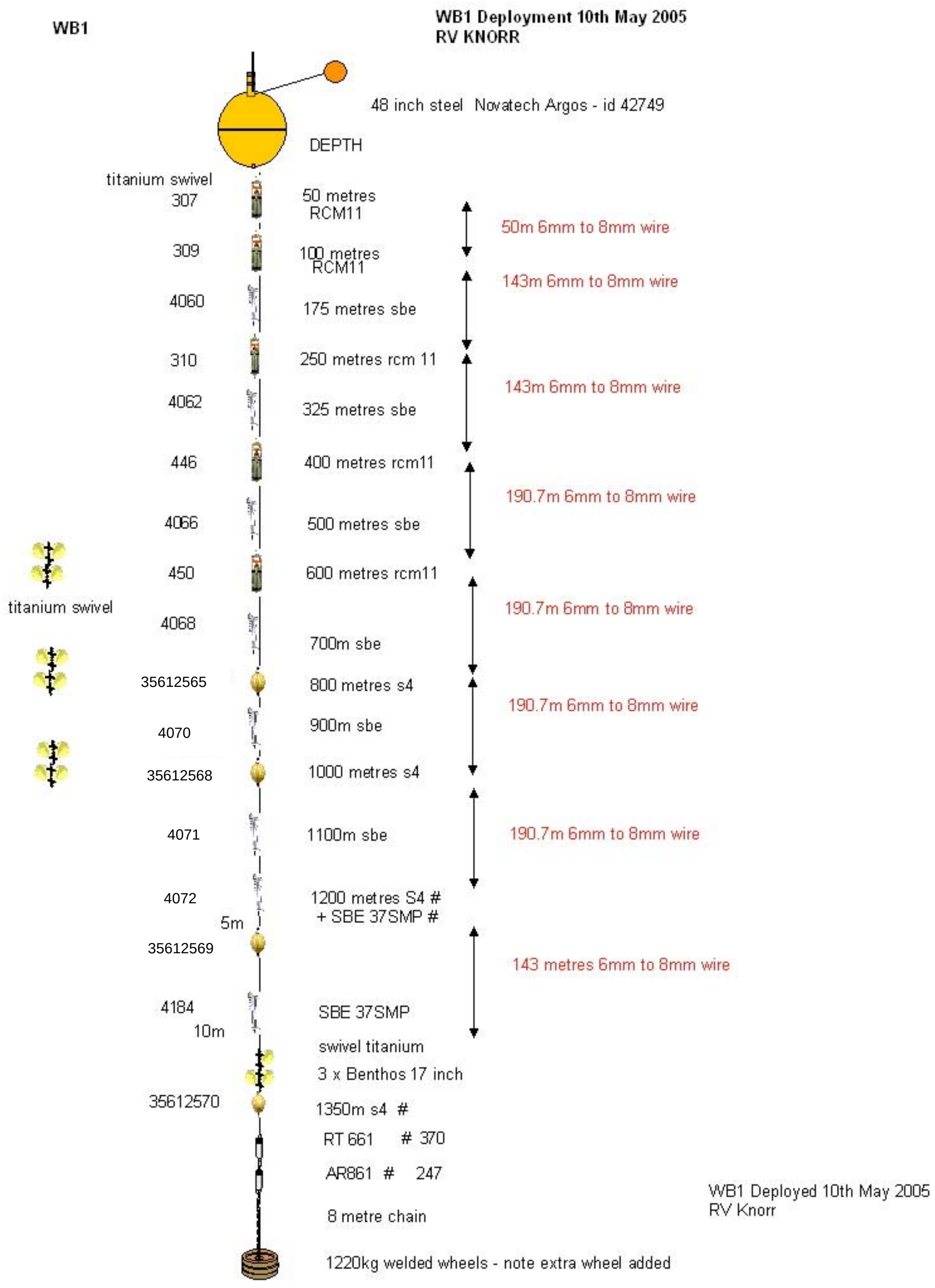
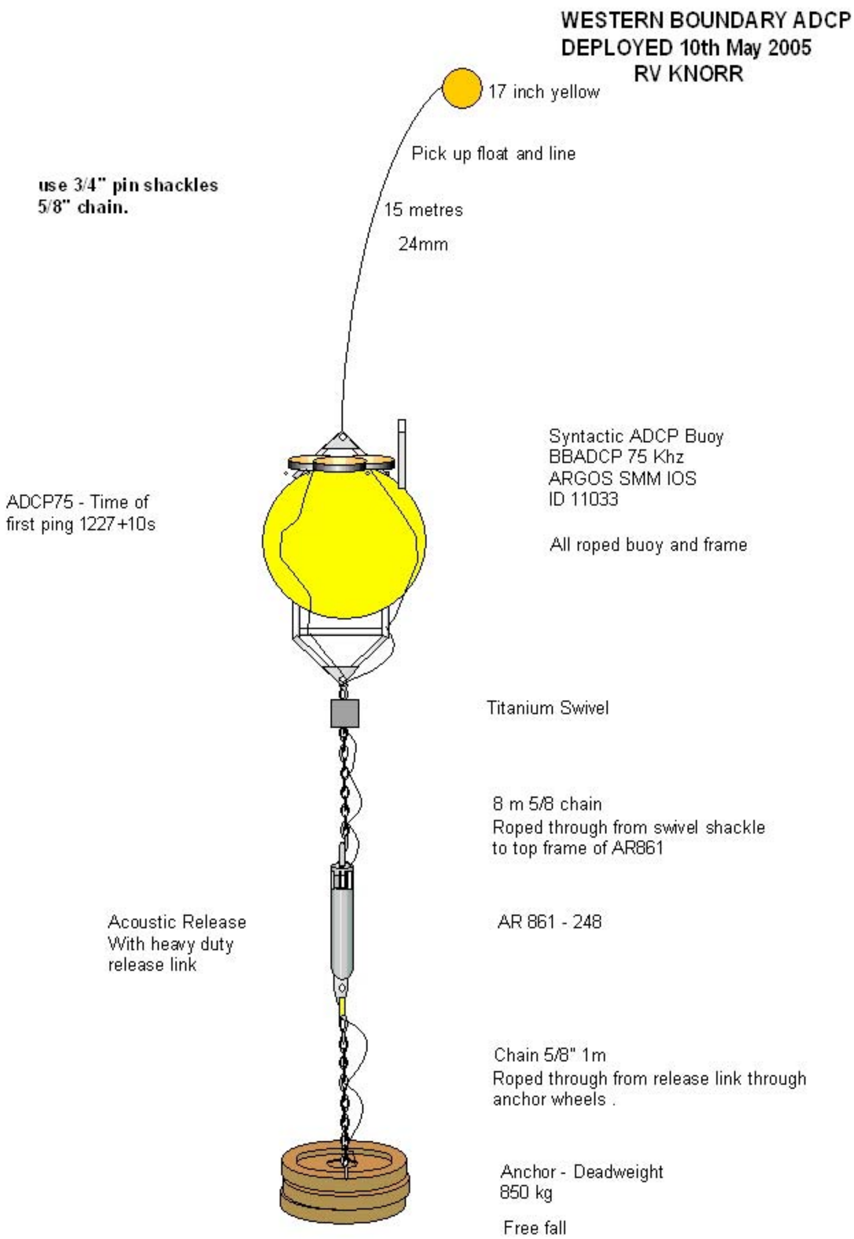


Figure A.33: Mooring Diagram of WBADCP as Deployed 2005



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	02/04/2005
Start Time	10:00:00

EBH5

Seabird SBE37 SMP CTD – serial number **3890**

Sample interval	900 seconds
Start date	03/04/2005
Start time	12:00:00

Seabird SBE37 SMP CTD – serial number **3891**

Sample interval	900 seconds
Start date	03/04/2005
Start time	12:00:00

Seabird SBE37 SMP CTD – serial number **3892**

Sample interval	900 seconds
Start date	03/04/2005
Start time	12:00:00

Seabird SBE37 SMP CTD – serial number **3893**

Sample interval	900 seconds
Start date	03/04/2005

Start time	12:00:00

EBH4

Seabird SBE37 SMP CTD – serial number **3894**

Sample interval	900 seconds
Start date	03/04/2005
Start time	12:00:00

Seabird SBE37 SMP CTD – serial number **3895**

Sample interval	900 seconds
Start date	03/04/2005
Start time	12:00:00

Seabird SBE37 SMP CTD – serial number **3896**

Sample interval	900 seconds
Start date	03/04/2005
Start time	12:00:00

Seabird SBE37 SMP CTD – serial number **3897**

Sample interval	900 seconds
Start date	03/04/2005
Start time	12:00:00

Seabird SBE37 SMP CTD – serial number **3898**

Sample interval	900 seconds
Start date	03/04/2005
Start time	12:00:00

Seabird SBE37 SMP CTD – serial number **3899**

Sample interval	900 seconds
Start date	03/04/2005
Start time	12:00:00

EBH3

Seabird SBE37 SMP CTD – serial number **3900**

Sample interval	900 seconds
Start date	03/04/2005
Start time	12:00:00

Seabird SBE37 SMP CTD – serial number **3901**

Sample interval	900 seconds
Start date	03/04/2005
Start time	12:00:00

Seabird SBE37 SMP CTD – serial number **3902**

Sample interval	900 seconds
Start date	03/04/2005
Start time	12:00:00

Seabird SBE37 SMP CTD – serial number **3903**

Sample interval	900 seconds
Start date	03/04/2005
Start time	12:00:00

Seabird SBE37 SMP CTD – serial number **3904**

Sample interval	900 seconds
Start date	03/04/2005
Start time	12:00:00

EBH2

Seabird SBE37 SMP CTD – serial number **3910**

Sample interval	900 seconds
Start date	03/04/2005
Start time	12:00:00

Seabird SBE37 SMP CTD – serial number **3911**

Sample interval	900 seconds
Start date	03/04/2005
Start time	12:00:00

Seabird SBE37 SMP CTD – serial number **3912**

Sample interval	900 seconds
Start date	03/04/2005
Start time	12:00:00

EBH1

Seabird SBE37 SMP CTD – serial number **3913**

Sample interval	900 seconds
Start date	03/04/2005
Start time	12:00:00

Seabird SBE37 SMP CTD – serial number **3914**

Sample interval	900 seconds
Start date	03/04/2005
Start time	12:00:00

EBH0

Seabird SBE37 SMP CTD – serial number **3915**

Sample interval	900 seconds
Start date	07/04/2005
Start time	04:00:00

EBL2

Seabird SBE26 BPR – serial number **0417**

Tide interval	10 minutes
Wave burst every N tide measurements	9999
Wave samples per burst	68
No. of 0.25 sec periods to integrate waves	33
Instrument started	06/04/2005 10:30:00

Seabird SBE26 BPR – serial number **0418**

Tide interval	10 minutes
Wave burst every N tide measurements	9999
Wave samples per burst	68
No. of 0.25 sec periods to integrate waves	33
Instrument started	06/04/2005 11:40:00

EBHi

Seabird SBE37 SMP CTD – serial number **3916**

Sample interval	900 seconds

Start date	08/04/2005
Start time	03:00:00

Seabird SBE37 SMP CTD – serial number **3918**

Sample interval	900 seconds
Start date	08/04/2005
Start time	03:00:00

Seabird SBE37 SMP CTD – serial number **3919**

Sample interval	900 seconds
Start date	08/04/2005
Start time	03:00:00

<u>EB2</u>

Aanderaa RCM11 – serial number **448**

Pings per ensemble	600
Temperature range	High
Conductivity range	45-55mS (Set in deep rated cell)
Recording interval	30 mins
No of channels	8
Mode	Burst
Instrument started	10/04/2005 00:00:20

Seabird SBE37 SMP CTD – serial number **3276**

Sample interval	900 seconds
Start date	10/04/2005
Start time	11:15:00

McLane Moore Profiler – serial number **11794-01C**

Comprising MMP electronics – serial number **317**
Seabird SBE41 CP – McLane V1.0 – serial number **1008**
FSI ACM – serial number **1766D**

Start date	11/04/2005
Start time	23:00:00
Profile start interval	2 days 5 hours
Reference date	12/04/2005
Reference time	23:00:00
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 **449**

Pings per ensemble	600
Temperature range	Arctic
Conductivity range (rollover on)	32-34mS (Set in deep rated cell)
Recording interval	30 mins
No of channels	8
Mode	Burst
Instrument started	10/04/2005 00:00:20

Seabird SBE37 SMP CTD – serial number **3917**

Sample interval	900 seconds
Start date	10/04/2005
Start time	11:15:00

Seabird SBE37 SMP CTD – serial number **3920**

Sample interval	900 seconds
Start date	10/04/2005
Start time	11:15:00

Seabird SBE37 SMP CTD – serial number **3921**

Sample interval	900 seconds
Start date	10/04/2005
Start time	11:15:00

EB1

Seabird SBE37 SMP CTD – serial number **3207**

Sample interval	900 seconds
Start date	09/04/2005
Start time	15:00:00

Seabird SBE37 SMP CTD – serial number **3208**

Sample interval	900 seconds
Start date	09/04/2005
Start time	15:00:00

Seabird SBE37 SMP CTD – serial number **3209**

Sample interval	900 seconds
Start date	09/04/2005
Start time	15:00:00

Seabird SBE37 SMP CTD – serial number **3210**

Sample interval	900 seconds
Start date	09/04/2005
Start time	15:00:00

Seabird SBE37 SMP CTD – serial number **3212**

Sample interval	900 seconds
Start date	09/04/2005
Start time	15:00:00

Seabird SBE37 SMP CTD – serial number **3213**

Sample interval	900 seconds
Start date	09/04/2005
Start time	15:00:00

Seabird SBE37 SMP CTD – serial number **3214**

Sample interval	900 seconds
Start date	09/04/2005
Start time	15:00:00

Seabird SBE37 SMP CTD – serial number **3215**

Sample interval	900 seconds
Start date	09/04/2005
Start time	15:00:00

Seabird SBE37 SMP CTD – serial number **3216**

Sample interval	900 seconds
Start date	09/04/2005
Start time	15:00:00

Seabird SBE37 SMP CTD – serial number **3217**

Sample interval	900 seconds
Start date	09/04/2005
Start time	15:00:00

Seabird SBE37 SMP CTD – serial number **3218**

Sample interval	900 seconds
Start date	09/04/2005
Start time	15:00:00

Seabird SBE37 SMP CTD – serial number **3922**

Sample interval	900 seconds
Start date	09/04/2005
Start time	15:00:00

Seabird SBE37 SMP CTD – serial number **3923**

Sample interval	900 seconds
Start date	09/04/2005
Start time	15:00:00

Seabird SBE37 SMP CTD – serial number **3924**

Sample interval	900 seconds
Start date	09/04/2005
Start time	15:00:00

Seabird SBE37 SMP CTD – serial number **3925**

Sample interval	900 seconds
Start date	09/04/2005
Start time	15:00:00

Seabird SBE37 SMP CTD – serial number **3926**

Sample interval	900 seconds
Start date	09/04/2005
Start time	15:00:00

Seabird SBE37 SMP CTD – serial number **3927**

Sample interval	900 seconds
Start date	09/04/2005
Start time	15:00:00

Seabird SBE37 SMP CTD – serial number **3928**

Sample interval	900 seconds
Start date	09/04/2005
Start time	15:00:00

Seabird SBE37 SMP CTD – serial number **3929**

Sample interval	900 seconds
Start date	09/04/2005
Start time	15:00:00

Seabird SBE37 SMP CTD – serial number **3930**

Sample interval	900 seconds
Start date	09/04/2005
Start time	15:00:00

Seabird SBE37 SMP CTD – serial number **3931**

Sample interval	900 seconds
Start date	09/04/2005
Start time	15:00:00

Seabird SBE37 SMP CTD – serial number **3932**

Sample interval	900 seconds
Start date	09/04/2005
Start time	15:00:00

Seabird SBE37 SMP CTD – serial number **3933**

Sample interval	900 seconds
Start date	09/04/2005
Start time	15:00:00

Seabird SBE37 SMP CTD – serial number **3934**

Sample interval	900 seconds
Start date	09/04/2005
Start time	15:00:00

EBL2

Seabird SBE26 BPR – serial number **0419**

Tide interval	10 minutes
Wave burst every N tide measurements	9999
Wave samples per burst	68
No. of 0.25 sec periods to integrate waves	33
Instrument started	09/04/2005 21:10:00

Seabird SBE26 BPR – serial number **0420**

Tide interval	10 minutes
Wave burst every N tide measurements	9999
Wave samples per burst	68
No. of 0.25 sec periods to integrate waves	33
Instrument started	09/04/2005 21:20:00

MAR3

Seabird SBE37 SMP CTD – serial number **3203**

Sample interval	900 seconds
Start date	15/04/2005
Start time	16:30:00

Seabird SBE37 SMP CTD – serial number **3247**

Sample interval	900 seconds
Start date	15/04/2005
Start time	16:30:00

Seabird SBE37 SMP CTD – serial number **3251**

Sample interval	900 seconds
Start date	15/04/2005

Start time	16:30:00

Seabird SBE37 SMP CTD – serial number **3252**

Sample interval	900 seconds
Start date	15/04/2005
Start time	16:30:00

Seabird SBE37 SMP CTD – serial number **3254**

Sample interval	900 seconds
Start date	15/04/2005
Start time	16:30:00

Seabird SBE37 SMP CTD – serial number **3255**

Sample interval	900 seconds
Start date	15/04/2005
Start time	16:45:00

Interocean S4AD – serial number **35612574**

Header	MAR3_2005_5200m
On time	1 min
Cycle time	30 mins
Average count	120
Channels at average	Hx, Hy, Cond., Temp., Depth
Special Record Block Count	48
Channels at SRB	Hx, Hy, Cond., Temp., Depth
Start date	15/05/2005
Start time	18:30:00

MARL2

Seabird SBE26 BPR – serial number **0390**

Tide interval	10 minutes
Wave burst every N tide measurements	9999
Wave samples per burst	68
No. of 0.25 sec periods to integrate waves	33
Instrument started	16/04/2005 15:20:00

Seabird SBE26 BPR – serial number **0391**

Tide interval	10 minutes
Wave burst every N tide measurements	9999
Wave samples per burst	68
No. of 0.25 sec periods to integrate waves	33
Instrument started	16/04/2005 15:40:00

MAR4

Aanderaa RCM11 – serial number **445**

Pings per ensemble	600
Temperature range	High
Conductivity range	46-58mS (Set in deep rated cell)
Recording interval	30 mins
No of channels	8
Mode	Burst
Instrument started	16/04/2005 09:30:00

McLane Moore Profiler – serial number **11794-02**

Comprising MMP electronics – serial number **315**

Seabird SBE41 CP – McLane V1.0 – serial number **1009**
FSI ACM – serial number **1775**

Start date	16/04/2005
Start time	23:00:00
Profile start interval	1 day 0 hours
Reference date	17/04/2005
Reference time	23:00:00
Burst interval	Disabled
Paired profiles	Disabled
Shallow pressure limit	52 dbar
Deep pressure limit	2500 dbar
Shallow pressure error	150 dbar
Deep pressure error	100 dbar

Seabird SBE37 SMP CTD – serial number **3256**

Sample interval	900 seconds
Start date	16/04/2005
Start time	09:00:00

Seabird SBE37 SMP CTD – serial number **3257**

Sample interval	900 seconds
Start date	16/04/2005
Start time	09:00:00

Seabird SBE37 SMP CTD – serial number **3258**

Sample interval	900 seconds
Start date	16/04/2005
Start time	09:00:00

Seabird SBE37 SMP CTD – serial number **3270**

Sample interval	900 seconds
Start date	16/04/2005
Start time	09:00:00

Seabird SBE37 SMP CTD – serial number **3271**

Sample interval	900 seconds
Start date	16/04/2005
Start time	09:00:00

Interocean S4AD – serial number **35612575**

Header	MAR4_2005_4700m
On time	1 mins
Cycle time	30 mins
Average count	120
Channels at average	Hx, Hy, Cond., Temp., Depth
Special Record Block Count	48
Channels at SRB	Hx, Hy, Cond., Temp., Depth
Start date	16/04/2005
Start time	10:00:00

MAR2

Seabird SBE37 SMP CTD – serial number **3274**

Sample interval	900 seconds
Start date	22/04/2005

Start time	09:00:00

Seabird SBE37 SMP CTD – serial number **3277**

Sample interval	900 seconds
Start date	22/04/2005
Start time	09:00:00

RBR XR420-CTD – serial number **9656**

Start date	22/04/2005
Start time	09:00:00
End date	22/04/2007
End time	09:00:00
Averaging enabled	NO

Seabird SBE37 SMP CTD – serial number **3481**

Sample interval	900 seconds
Start date	22/04/2005
Start time	09:00:00

Interocean S4AD – serial number **35612577**

Header	MAR2 2005-2006
On time	1 mins
Cycle time	30 mins
Average count	120
Channels at average	Hx, Hy, Cond., Temp., Depth
Special Record Block Count	48
Channels at SRB	Hx, Hy, Cond., Temp., Depth
Start date	22/04/2005
Start time	09:00:00

MAR1

Seabird SBE37 SMP CTD – serial number **3224**

Sample interval	900 seconds
Start date	22/04/2005
Start time	12:00:00

Seabird SBE37 SMP CTD – serial number **3234**

Sample interval	900 seconds
Start date	22/04/2005
Start time	12:00:00

Seabird SBE37 SMP CTD – serial number **3225**

Sample interval	900 seconds
Start date	22/04/2005
Start time	12:00:00

Seabird SBE37 SMP CTD – serial number **3266**

Sample interval	900 seconds
Start date	22/04/2005
Start time	12:00:00

Seabird SBE37 SMP CTD – serial number **3265**

Sample interval	900 seconds
Start date	22/04/2005
Start time	12:00:00

Seabird SBE37 SMP CTD – serial number **3268**

Sample interval	900 seconds
Start date	22/04/2005
Start time	12:00:00

Seabird SBE37 SMP CTD – serial number **3272**

Sample interval	900 seconds
Start date	22/04/2005
Start time	12:00:00

Seabird SBE37 SMP CTD – serial number **3269**

Sample interval	900 seconds
Start date	22/04/2005
Start time	12:00:00

Seabird SBE37 SMP CTD – serial number **3483**

Sample interval	900 seconds
Start date	22/04/2005
Start time	12:00:00

Seabird SBE37 SMP CTD – serial number **3484**

Sample interval	900 seconds
Start date	22/04/2005
Start time	12:00:00

Seabird SBE37 SMP CTD – serial number **3486**

Sample interval	900 seconds
Start date	22/04/2005
Start time	12:00:00

Interocean S4AD – serial number **35612566**

Header	MAR1 2005-2006
On time	1 mins
Cycle time	30 mins
Average count	120
Channels at average	Hx, Hy, Cond., Temp., Depth
Special Record Block Count	48
Channels at SRB	Hx, Hy, Cond., Temp., Depth
Start date	22/04/2005
Start time	12:00:00

Interocean S4AD – serial number **35612576**

Header	MAR1 2005-2006
On time	1 mins
Cycle time	30 mins
Average count	120
Channels at average	Hx, Hy, Cond., Temp., Depth
Special Record Block Count	48
Channels at SRB	Hx, Hy, Cond., Temp., Depth
Start date	22/04/2005
Start time	14:00:00

MARL1

Seabird SBE26 BPR – serial number **0394**

Tide interval	10 minutes
Wave burst every N tide measurements	9999
Wave samples per burst	68
No. of 0.25 sec periods to integrate waves	33
Instrument started	22/04/2005 14:40:00

Seabird SBE26 BPR – serial number **0414**

Tide interval	10 minutes
Wave burst every N tide measurements	9999
Wave samples per burst	68
No. of 0.25 sec periods to integrate waves	33
Instrument started	22/04/2005 14:40:00

WB4 (as first deployed)

Aanderaa RCM11 – serial number **305**

Pings per ensemble	600
Temperature range	High
Conductivity range	0-74mS (Shallow rated cell)
Recording interval	30 mins
No of channels	8
Mode	Burst
Instrument started	14/05/2005 16:07:00

Seabird SBE37 IMP CTD – serial number **4182**

Sample interval	900 seconds
Start date	14/05/2005
Start time	16:30:00

McLane Moore Profiler – serial number **11827-01**

Comprising MMP electronics – serial number **760320**
Seabird SBE41 CP – McLane V1.0 – serial number **1010**
FSI ACM – serial number **1787**

Start date	15/05/2005
Start time	02:00:00
Profile start interval	2 days 0 hours
Reference date	15/05/2005
Reference time	12:00:00
Burst interval	Disabled
Paired profiles	Enabled
Shallow pressure limit	52 dbar
Deep pressure limit	2500 dbar
Shallow pressure error	200 dbar
Deep pressure error	100 dbar

Seabird SBE37 SMP CTD – serial number **3482**

Sample interval	900 seconds
Start date	14/05/2005
Start time	17:00:00

Aanderaa RCM11 – serial number **451**

Pings per ensemble	600
Temperature range	Low
Conductivity range	32-34 (Set in deep rated cell)
Recording interval	30 mins
No of channels	8

Mode	Burst
Instrument started	14/05/2005 18:48:00

Aanderaa RCM11 – serial number **301**

Pings per ensemble	600
Temperature range	Low
Conductivity range	32-34 (Set in deep rated cell)
Recording interval	30 mins
No of channels	8
Mode	Burst
Instrument started	14/05/2005 18:18:00

Seabird SBE37 SMP CTD – serial number **3479**

Sample interval	900 seconds
Start date	14/05/2005
Start time	17:00:00

Interocean S4AD – serial number **35612571**

Header	WB4-2005 deploy
On time	1 mins
Cycle time	30 mins
Average count	120
Channels at average	Hx, Hy, Cond., Temp., Depth
Special Record Block Count	48
Channels at SRB	Hx, Hy, Cond., Temp., Depth
Start date	14/05/2005
Start time	19:00:00

Seabird SBE37 SMP CTD – serial number **3480**

Sample interval	900 seconds
Start date	14/05/2005
Start time	17:00:00

WB4 (as redeployed)

Aanderaa RCM11 – serial number **304**

Pings per ensemble	600
Temperature range	Low
Conductivity range (rollover on)	34-38 (Set in deep rated cell)
Recording interval	30 mins
No of channels	8
Mode	Burst
Instrument started	25/05/2005 13:30:00

Aanderaa RCM11 – serial number **306**

Pings per ensemble	600
Temperature range	Low
Conductivity range (rollover on)	33-37 (Set in deep rated cell)
Recording interval	30 mins
No of channels	8
Mode	Burst
Instrument started	25/05/2005 13:30:00

Aanderaa RCM11 – serial number **451**

Pings per ensemble	600
Temperature range	Low
Conductivity range	32-34 (Set in deep rated cell)
Recording interval	30 mins
No of channels	8
Mode	Burst
Instrument started	25/05/2005 18:00:00

Aanderaa RCM11 – serial number **301**

Pings per ensemble	600
Temperature range	Low
Conductivity range	32-34 (Set in deep rated cell)
Recording interval	30 mins
No of channels	8
Mode	Burst
Instrument started	25/05/2005 18:00:00

Seabird SBE37 SMP CTD – serial number **3482**

Sample interval	900 seconds
Start date	25/05/2005
Start time	17:00:00

Interocean S4AD – serial number **35612578**

Header	WB4-2005 TWO
On time	1 mins
Cycle time	30 mins
Average count	120
Channels at average	Hx, Hy, Cond., Temp., Depth
Special Record Block Count	48
Channels at SRB	Hx, Hy, Cond., Temp., Depth
Start date	25/05/2005
Start time	12:00:00

Seabird SBE37 SMP CTD – serial number **3479**

Sample interval	900 seconds
Start date	25/05/2005
Start time	16:30:00

Interocean S4AD – serial number **35612571**

Header	WB4-2005 deploy
On time	1 mins
Cycle time	30 mins
Average count	120
Channels at average	Hx, Hy, Cond., Temp., Depth
Special Record Block Count	48
Channels at SRB	Hx, Hy, Cond., Temp., Depth
Start date	25/05/2005
Start time	16:30:00

Seabird SBE37 SMP CTD – serial number **3480**

Sample interval	900 seconds
Start date	25/05/2005
Start time	15:45:00

WBL2

Seabird SBE26 BPR – serial number **0392**

Tide interval	15 minutes
Wave burst every N tide measurements	9999
Wave samples per burst	68
No. of 0.25 sec periods to integrate waves	33
Instrument started	20/05/2005 16:45:00

Seabird SBE53 BPR – serial number **0003**

Header	WBL2 Lander Deployment 2005
Tide interval	15 minutes
Tide measurement duration	15 minutes
Frequency of reference measurement (every N tide samples)	96
Start date	20/05/2005
Start time	23:00:00

WB2

Seabird SBE37 IMP CTD – serial number **4177**

ID number	21
Sample interval	900 seconds
Start date	13/05/2005
Start time	08:00:00

Sontek Argonaut MD and Seabird SBE37 SMP pairing – serial numbers **D265** and **3485**

ID	41
Averaging interval	120 seconds
Sampling interval	1800 seconds
Salinity	35.0 ppt
Blanking distance	1.5m
Cell size	1.5m
Deployment name	WB241
Start date	13/05/2005
Start time	10:00:00
Baud rate	600.

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

ID number	22
Sample interval	900 seconds
Start date	13/05/2005
Start time	08:00:00

Sontek Argonaut MD and Seabird SBE37 SMP pairing – serial numbers **D291** and **3487**

ID	42
Averaging interval	120 seconds
Sampling interval	1800 seconds
Salinity	35.0 ppt
Blanking distance	1.5m
Cell size	1.5m
Deployment name	WB242
Start date	13/05/2005
Start time	10:00:00
Baud rate	600.

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

ID number	23
Sample interval	900 seconds
Start date	13/05/2005
Start time	08:00:00

Sontek Argonaut MD and Seabird SBE37 SMP pairing – serial numbers **D295** and **3905**

ID	43
Averaging interval	120 seconds
Sampling interval	1800 seconds
Salinity	35.0 ppt
Blanking distance	1.5m
Cell size	1.5m
Deployment name	WB243
Start date	13/05/2005
Start time	10:00:00
Baud rate	600.

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

ID number	24
Sample interval	900 seconds
Start date	13/05/2005
Start time	08:00:00

Sontek Argonaut MD and Seabird SBE37 SMP pairing – serial numbers **D278** and **3906**

ID	44
Averaging interval	120 seconds
Sampling interval	1800 seconds
Salinity	35.0 ppt
Blanking distance	1.5m
Cell size	1.5m
Deployment name	WB244
Start date	13/05/2005
Start time	10:00:00
Baud rate	600.

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

ID number	25
Sample interval	900 seconds
Start date	13/05/2005
Start time	08:00:00

Sontek Argonaut MD and Seabird SBE37 SMP pairing – serial numbers **D290** and **3907**

ID	45
Averaging interval	120 seconds
Sampling interval	1800 seconds
Salinity	35.0 ppt
Blanking distance	1.5m
Cell size	1.5m
Deployment name	WB245
Start date	13/05/2005
Start time	10:00:00
Baud rate	600.

Sontek Argonaut MD and Seabird SBE37 SMP pairing – serial numbers **D2332** and **3908**

ID	46
Averaging interval	120 seconds
Sampling interval	1800 seconds
Salinity	35.0 ppt
Blanking distance	1.5m
Cell size	1.5m
Deployment name	WB246
Start date	13/05/2005
Start time	10:00:00
Baud rate	600.

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

ID number	27
Sample interval	900 seconds
Start date	13/05/2005
Start time	08:00:00

Sontek Argonaut MD and Seabird SBE37 SMP pairing – serial numbers **D322** and **3909**

ID	47
Averaging interval	120 seconds
Sampling interval	1800 seconds
Salinity	35.0 ppt
Blanking distance	1.5m
Cell size	1.5m
Deployment name	WB247
Start date	13/05/2005
Start time	10:00:00
Baud rate	600.

WBL1

Seabird SBE26 BPR – serial number **0393**

Tide interval	15 minutes
Wave burst every N tide measurements	9999
Wave samples per burst	68
No. of 0.25 sec periods to integrate waves	33
Instrument started	13/05/2005 18:00:00

Seabird SBE53 BPR – serial number **0002**

Header	SBE53 on WBL2 2005 deployment
Tide interval	15 minutes
Tide measurement duration	15 minutes
Frequency of reference measurement (every N tide samples)	96
Start date	13/05/2005
Start time	19:00:00

NB: Header has WBL2 instead of WBL1. This was due to instruments being reallocated after being setup.

WB1

Aanderaa RCM11 – serial number **307**

Pings per ensemble	600
Temperature range	High
Conductivity range	48-58mS (set in deep rated cell)

Recording interval	30 mins
No of channels	8
Mode	Burst
Instrument started	10/05/2005 15:00:00

Aanderaa RCM11 – serial number **309**

Pings per ensemble	600
Temperature range	High
Conductivity range	47-58mS
Recording interval	30 mins
No of channels	8
Mode	Burst
Instrument started	10/05/2005 15:30:00

Seabird SBE37 IMP CTD – serial number **4060**

ID number	01
Sample interval	900 seconds
Start date	10/05/2005
Start time	16:00:00

Aanderaa RCM11 – serial number **310**

Pings per ensemble	600
Temperature range	High
Conductivity range	47-55mS
Recording interval	30 mins
No of channels	8
Mode	Burst
Instrument started	10/5/2005 15:00:00

Seabird SBE37 IMP CTD – serial number **4062**

ID number	22
Sample interval	900 seconds
Start date	10/05/2005
Start time	16:00:00

Aanderaa RCM11 – serial number **446**

Pings per ensemble	600
Temperature range	High
Conductivity range	43-52mS
Recording interval	30 mins
No of channels	8
Mode	Burst
Instrument started	10/05/2005 15:30:00

Seabird SBE37 IMP CTD – serial number **4066**

ID number	07
Sample interval	900 seconds
Start date	10/05/2005
Start time	16:00:00

Aanderaa RCM11 – serial number **450**

Pings per ensemble	600
Temperature range	High
Conductivity range	37-48mS

Recording interval	30 mins
No of channels	8
Mode	Burst
Instrument started	10/05/2005 15:30:00

Seabird SBE37 IMP CTD – serial number **4068**

ID number	09
Sample interval	900 seconds
Start date	10/05/2005
Start time	16:00:00

Interocean S4AD – serial number **35612565**

Header	WB1-2005-2006
On time	1 min
Cycle time	30 mins
Average count	120
Channels at average	Hx, Hy, Cond., Temp., Depth
Special Record Block Count	48
Channels at SRB	Hx, Hy, Cond., Temp., Depth
Start date	10/05/2005
Start time	18:30:00

Seabird SBE37 IMP CTD – serial number **4070**

ID number	11
Sample interval	900 seconds
Start date	10/05/2005
Start time	16:00:00

Interocean S4AD – serial number **35612568**

Header	WB1-2005-2006
On time	1 min
Cycle time	30 mins
Average count	120
Channels at average	Hx, Hy, Cond., Temp., Depth
Special Record Block Count	48
Channels at SRB	Hx, Hy, Cond., Temp., Depth
Start date	10/05/2005
Start time	18:30:00

Seabird SBE37 IMP CTD – serial number **4071**

ID number	12
Sample interval	900 seconds
Start date	10/05/2005
Start time	16:00:00

Interocean S4AD – serial number **35612569**

Header	WB1-2005-2006
On time	1 min
Cycle time	30 mins
Average count	120
Channels at average	Hx, Hy, Cond., Temp., Depth
Special Record Block Count	48
Channels at SRB	Hx, Hy, Cond., Temp., Depth
Start date	10/05/2005

Start time	18:45:00

Seabird SBE37 IMP CTD – serial number **4072**

ID number	13
Sample interval	900 seconds
Start date	10/05/2005
Start time	16:00:00

Interocean S4AD – serial number **35612570**

Header	WB1-2005-2006
On time	1 min
Cycle time	30 mins
Average count	120
Channels at average	Hx, Hy, Cond., Temp., Depth
Special Record Block Count	48
Channels at SRB	Hx, Hy, Cond., Temp., Depth
Start date	10/05/2005
Start time	18:45:00

Seabird SBE37 IMP CTD – serial number **4184**

ID number	24
Sample interval	900 seconds
Start date	10/05/2005
Start time	16:00:00

WBADCP

RD Instruments 75kHz Longranger ADCP – Serial number **5817**

System frequency	150kHz
Beam angle	20 degrees
Water temperature	14 deg C
Planned deployment duration	425 days
Memory size	64 MB
Water salinity	36ppt
Depth of transducer	600m
Ensemble interval	30 minutes
WT Pings per ensemble	10
Depth cell size	16.00m
Number of depth cells	40
Start Date	10/05/2005
Start Time (first ping)	12:27:10 (approx)

Appendix C: Photographs

Photographs C.1 to C.21 from CD170, C.22 and C.23 from KN182-2.

Photograph C.1. Aft deck layout

Photograph C.2. Aft deck layout

Photograph C.3: Main Lab showing instruments in preparation

Photograph C.4: Double Barrel Capstan (DBC) with extended reeler holding a wooden storage drum

Photograph C.5: Raft of glass floats lifted with ship's crane

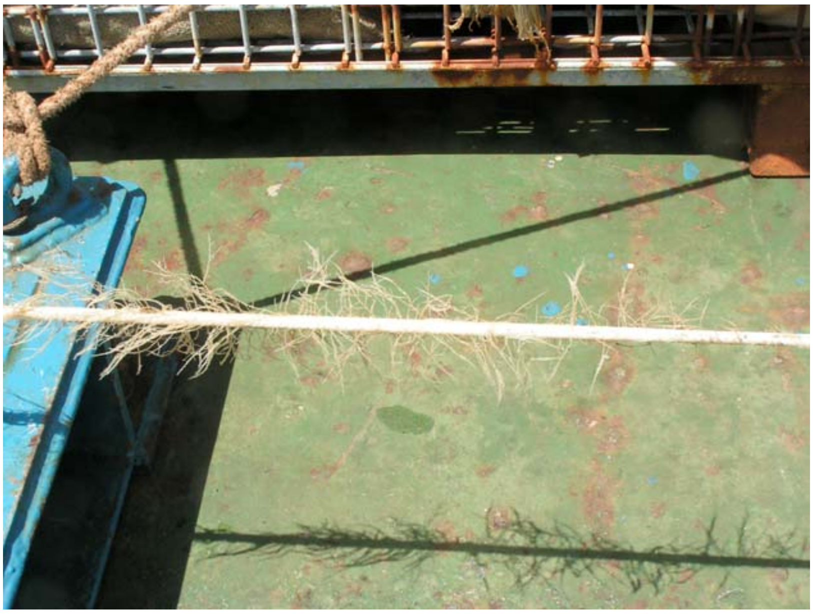
Photograph C.6: Mooring Table – Attaching an SBE37 Microcat

Photograph C.7: Mooring Table with AR861 ready for launch. Mooring wire stoppered off in rollers

Photograph C.8: Seacatch release hook lifting a 1.25 tonne anchor clump

Photograph C.9: Fouling on EBH4 Billings float and recovery line

Photograph C.10: Fouling on EBH4 tripod and BPR



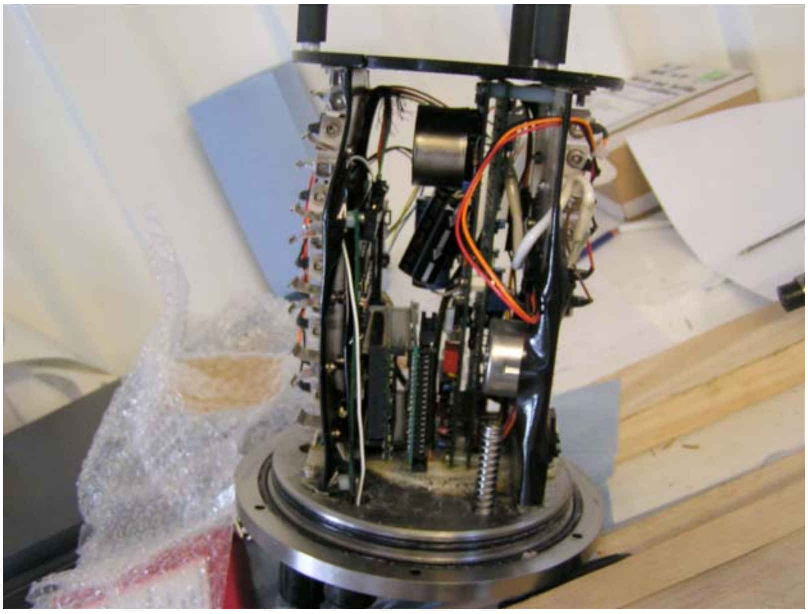
Photograph C.11: Fouling at 800m depth from EBH3 mooring line

Photograph C.12: Hand deployment of a glass buoyancy package, on EBH2, with the rails down

Photograph C.13: Wire wuzzle during EB3 recovery

Photograph C.14: Wire wuzzle during EB3 recovery

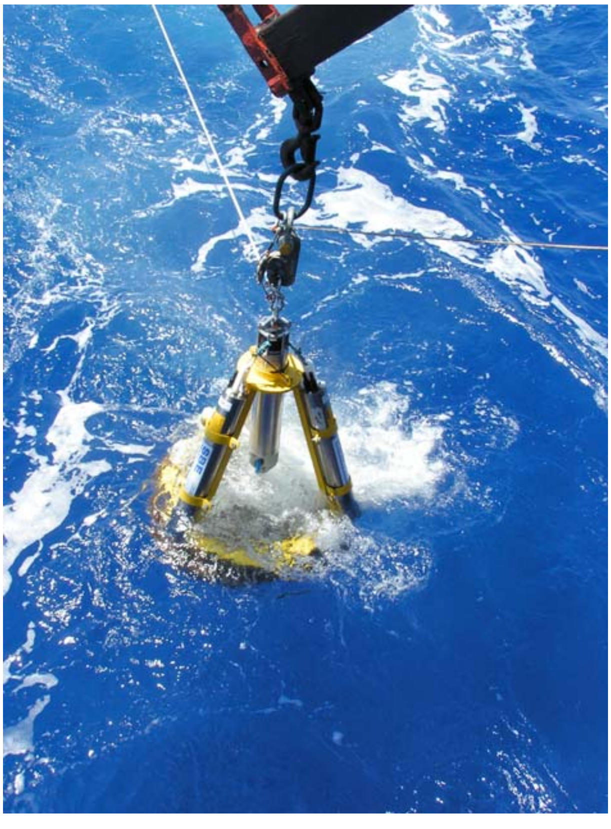
Photograph C.15: Remains of MAR4 MMP chassis



Photograph C.16: MAR4 MMP internal electronics chassis badly distorted, with electronic components broken off boards

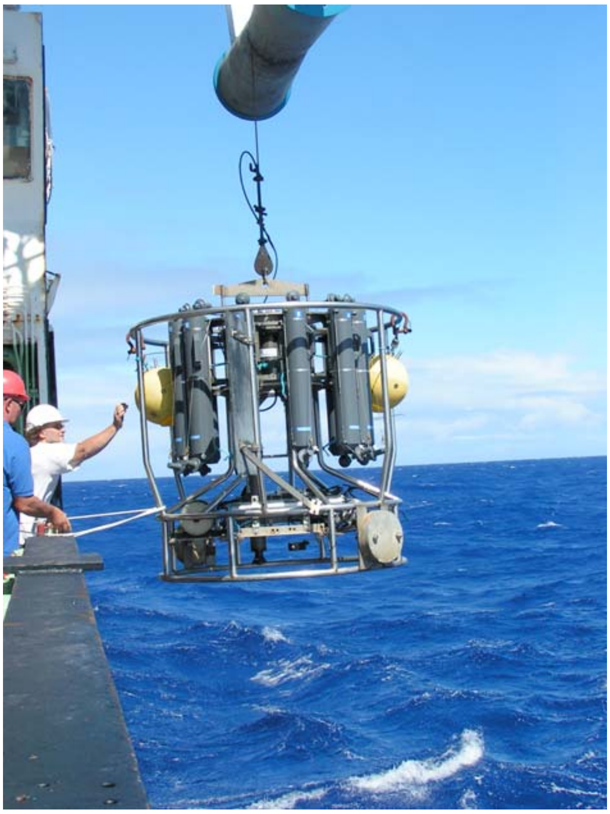
Photograph C.17: MAR4 MMP drive motor internals. – The gearbox was sheared off the motor and all end cap screws were badly bent.

Photograph C.18: Heavy fouling on Microcat at 50m depth on MAR1 mooring



Photograph C.19: Launching MARL1 bottom pressure recorder tripod

Photograph C.20: Microcats attached to CTD frame for calibration on CD170. Fixed using bespoke brackets.



Photograph C.21: S4 current meters attached to CTD frame for calibration on CD170

Photograph C.22: Microcats attached to CTD frame for calibration on KN182-2. Attached using ratchet straps.

Photograph C.23: S4 current meters attached to CTD frame for calibration on KN182-2.

Appendix D: EB2R Reports

Recovery Details and Plans for Redeployment of the Prematurely Surfaced Rapid EB2 Mooring.

D. Rayner

1st October 2004

Details of mooring as deployed:

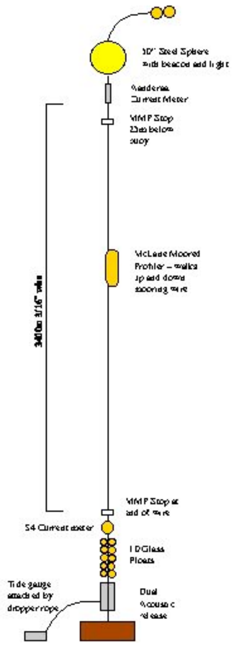


Figure D.1: EB2 mooring design as deployed 28/2/04

The top of the mooring consisted of a steel sphere as subsurface buoyancy with Argos beacon and strobe light attached, with a trailing float to aid recovery. Below the steel sphere a length of chain with a titanium swivel connected to an Aanderra RCM11 current meter. Below the current meter there was a length of 3/16" jacketed wire, 3400m long. This wire had a McLane Moored Profiler attached, with physical stoppers clamped to the wire above the termination at the bottom end and 25m below the top end. Below the wire there was an Interocean S4 current meter with depth adjustment wire and ten glass spheres as backup buoyancy above a swivel and acoustic release pair with a drop off Seabird SBE26 bottom pressure recorder. The anchor was attached by a 5m length of chain. Figure D.1 shows a sketch of the mooring design as deployed 28/2/04.

Brief Chronology of Events:

28/2/04 21:17 GMT	Mooring Deployed – 26.892ºN 16.234ºW
18/9/04 22:35 GMT	First Argos alert received – No position fix
19/9/04 00:26 GMT	First position received – 27.777ºN 17.350ºW
20/9/04 Approx 11:00 GMT	Email to Discovery to see if can assist in recovery (Mooring appears to be staying in roughly the same place)
23/9/04 12:33 GMT	Received position shows increased movement of mooring **(Mooring appears to be staying in roughly same place at new location)**
23/9/04 15:56 GMT	Confirmation that Discovery would attempt recovery after Tenerife
27/9/04 21:45 GMT	Discovery spotted mooring. Buoyancy and RCM11 current meter recovered. 27.792ºN 17.292ºW
27/9/04 22:15 GMT	Cable parted whilst attempting to recover the rest of the mooring.
29/9/04 12:34 GMT	Email from Argos confirming stopping of monitoring of this platform

The first Argos alert received did not have an associated position, but when subsequent fixes came in to SOC via the email alert system it became evident that the mooring had surface approximately 150km from the deployment location (figure D.2). It is not known what caused the mooring to be moved such a distance or what caused it to surface, but first thoughts are that it was trawled, towed sub-surface and then released.

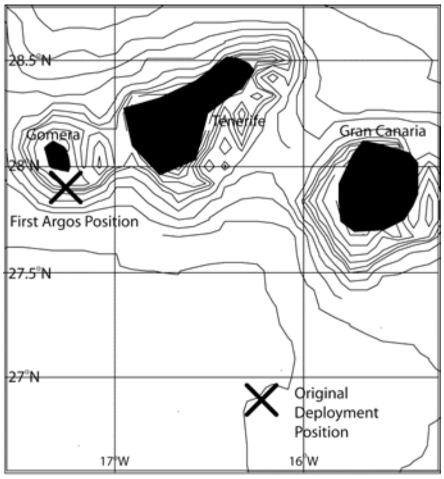


Figure D.2: Surfaced EB2 location map

It was hoped that information would be gained from the wire present beneath the RCM11 current meter, but the wire parted at the termination during attempted recovery so we do not know how much wire was beneath the current meter, or whether the McLane Moored Profiler was still attached to the mooring. Discovery found there to be considerable weight on the mooring line and it is thought that this may be caused by abandoned fishing gear caught on the mooring line.

From the position fixes it appears that the top part of the mooring was being held by something in an area with a fairly small excursion but for whatever reason this anchoring allowed the mooring to be carried North East before it appeared to settle at a new location and again not stray too far from a fixed point (figure D.3).

There was no acoustic release transponder on board Discovery that could have been used to try and interrogate the mooring acoustic releases and see if they were attached to the mooring wire prior to recovery.

Depending on where the original mooring broke apart there are a number of possibilities as to the fate of the MMP.

- If the mooring wire broke between the top termination at the RCM11 and the top MMP stop at 25m then the MMP would be held by the wire and still be present at the original mooring location and may be recoverable.
- If the wire broke at a point between the two MMP stops then there will be nothing to hold the MMP on the wire during recovery unless it is tangled by the wire or something else tangling both the wire and the MMP, and therefore it would not be expected to recover it.
- If the mooring broke at some point between the MMP bottom stop and the S4 then the MMP could be held by the bottom stop during recovery of the top

part of the mooring, but this would now be lost due to the wire parting when Discovery recovered the steel sphere and RCM11.

- If the mooring broke beneath the S4 but above the glass spheres then the S4 would have shared the same fate as the MMP during recovery of the steel sphere.
- If the mooring broke beneath the glass but above the releases then this should have been on the surface with the S4, and the acoustic releases would have been lost. The glass was not seen so it is assumed this is not the case.
- If the mooring broke between the releases and the anchor then the releases should have been on the surface with the glass and S4. Again it is assumed this is not the case as the glass was not seen.

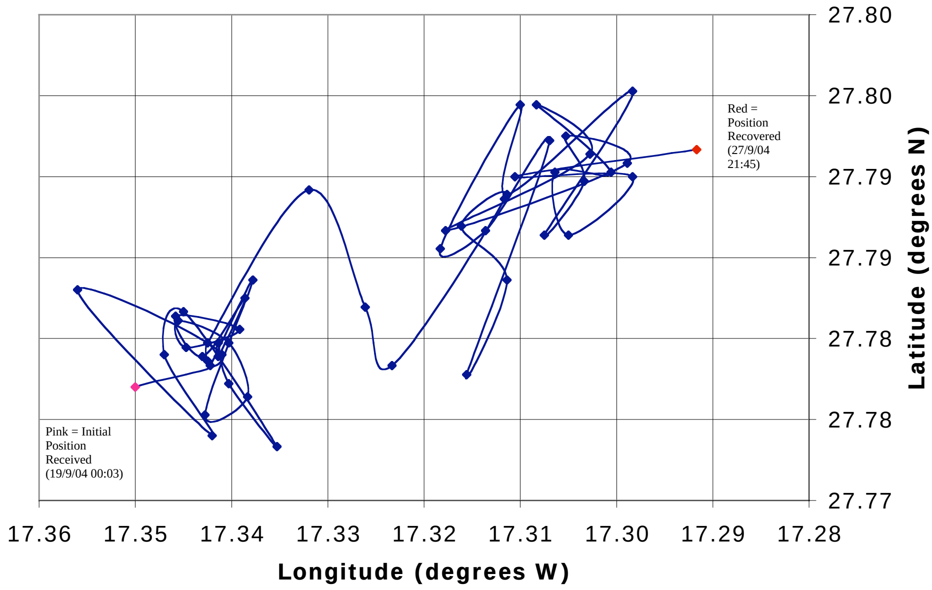


Figure D.3: Positions as Received from Argos Alerts. September 2004

<u>Approximate value of equipment:</u>

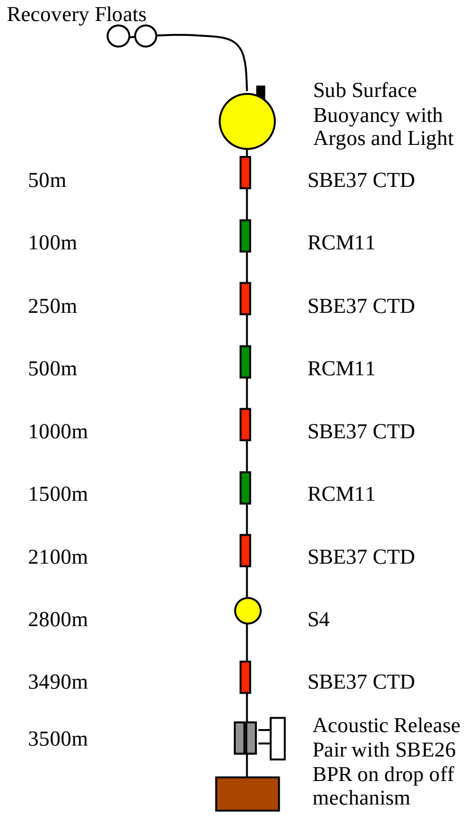
Recovered to date:	
Steel sphere	£2000
Aanderra RCM11	£9300
Argos beacon	£3000
Strobe light	£600
Titanium swivel	£800
Total	**£15700**

Plans:

It is planned to visit the original site using a commercial research vessel and determine whether the acoustic releases are still in position and if so recover them and any instrumentation and mooring hardware attached. There is sufficient backup buoyancy to lift the acoustic releases, bottom pressure recorder, S4 current meter and the full length of mooring wire with MMP, so as long as the releases are upright then the bottom section of the mooring should be recovered.

We plan to deploy a replacement mooring using spare Rapid instruments and hardware available at SOC, with the intended date being in the week beginning 18th October 2004 subject to the RV *Eva* being available.

The instrument spacing is different to the adjacent EB3 mooring as there are not sufficient instruments available. The bottom pressure recorder is dependent on the original EB2 mooring BPR being recovered and serviced at sea.



(Additional buoyancy not shown)

Figure D.4: Replacement mooring design sketch

There is also concern for mooring EB3. This was the telemetry buoy mooring for the Eastern side that had a connector fail on deployment. Prior to the Discovery returning on cruise D279 the engineering data from the buoy ceased to be transmitted. It was decided to recover this buoy during the hydrography cruise D279, but it could not be found. Concern arises because it is thought that if the telemetry buoy has become flooded it will hang down and may entangle the mooring line and cause increased drag, possibly breaking the mooring.

There is no Argos beacon on this mooring as it was originally planned to have the telemetry buoy in place. We are hoping to recover this mooring, determine the cause of the telemetry buoy failure, service the instruments and redeploy them on a replacement mooring. Provided we recover all the instruments, the replacement mooring will have the same spatial coverage and an Argos beacon attached.

RAPID Mooring EB2 Re-deployment

J Wynar

12th December 2004

Introduction

An opportunity arose to use the FS Poseidon in December (cruise P139) to deploy a mooring (EB2_02_2004/42) in the place of the partially recovered EB2_01_2004/08. This cruise would also be used to investigate the site of the original position of EB2, and to interrogate the releases of the EB3_01_2004/07 mooring. The ship cruise dates were from the 9th to the 17th December. The Principal Scientist was Goetz Ruhland from the University of Bremmen (gruhland@marum.de).

Calibration Cast

The instruments to be deployed on EB2_02_2004/42 were calibrated against the CTD available on the vessel, a SBE911 (Temperature sensor s/n: 4234, Conductivity sensor s/n: 2995), during a calibration cast. The cast profile was down to a depth of 2000m, hold at that depth for 15 minutes, and then return to the surface. The instruments were set logging at their fastest achievable rate.

The instruments included five SBE37SMP's, three RCM11's, and one S4A. The set-ups for each instrument were as shown below:

<u>SBE37SMP</u>
Start Date/Time 10 Dec 2004 17:00:00
Sample Interval = 5 seconds
do not transmit real-time data
do not output salinity with each sample
do not output sound velocity with each sample
store time with each sample
number of samples to average = 4
serial sync mode disabled

<u>RCM11</u>
Pings/ensemble: 600
Temperature range: Low
Conductivity range: 25 – 55 mS/cm
Recording interval: Non-stop
No.channels: 8
Mode: Normal

<u>S4A</u>
Continuous logging enabled
Avg. count: 1
SRB count: 60
Analogue channels: Hx, Hy, Conductivity, Temperature, Depth
Log mode: N/E
Write mode: internal

For the respective data files these will be available in electronic format.

Release Test

Two paralleled AR861 acoustic releases (#356 and #366) were to be deployed on EB2_02_2004/42 and these both had to be tested at their operational depths of approximately 3500m. Both AR861's were attached to the CTD wire and lowered to a wire-out of 3400m where they were interrogated using an 801 deck unit and over-side transducer. The results are given below:

S/N: 356
Release command given; range: 3585m
Diagnostic command given; range: 3300m, response: 4512ms

S/N: 366
Release command given; range: 3383m
Diagnostic command given; range: 3386m, response: 4512ms

Both AR861's gave immediate and consistent replies and on return to the surface both B2S hooks had released. The response of 4512ms in both cases indicated that the releases were vertical.

EB2 site investigation

The vessel positioned itself near the original EB2 deployment site and an acoustic search attempted using an 801 deck unit and transducer. No response was heard from either the AR861 #254 or the RT661 #260 that were originally deployed. Additionally, the Bremen University personnel used their own equipment to listen for any replies across a wide spectrum of frequencies but no response was heard.

It was concluded that either the releases were no longer within acoustic range, or that they were no longer functioning.

EB3 site investigation

On 11/1/:04 at approx. 18:45 the vessel was positioned near to the EB3 mooring site and an interrogation of the acoustic releases attempted. The results are shown below:

AR861 S/N: 255
Diagnostic command given; range: 3545m, response: 4727ms

RT661 S/N: 370
Diagnostic command given; response: 4724ms, 4725ms

Both releases gave immediate and consistent replies in a water depth of 3497m (uncorr, 3513m corrected). From the diagnostic values, it was concluded that the state of the releases is healthy and they are in a vertical position.

EB2-R deployment

The vessel was in position at 14:00 on the 11/12/04 and deployment began at 14:47 in a water depth of 3506m (uncorr.), 3519m (corr.). The method of deployment was over the stern of the ship and buoy first. See approximate timings below:

14:47 steel 40/41 sphere deployed with Argos beacon (ptt: 13346) and flashing light
14:47 SBE37SMP #3481
14:53 RCM11 #307
14:58 SBE37SMP #3483
15;14 RCM11 #309
15:29 SBE37SMP #3484
15:43 RCM11 #310
16:02 SBE37SMP #3486
16:17 S4A #35612574
16:32 SBE37SMP #3488
17:02 releases (AR861 #356 and #366) in water
17:08 anchor weight deployed

The anchor weight was let-go at position 26° 50.19'N, 016° 14.35'W.

The ship then sailed back towards the starting position to witness the time and position of the submergence of the top-most steel sphere. This occurred at 17.38 whereupon an estimate of the actual mooring position was made of 26° 50.41'N, 016°13.54'W.

The set-ups for the instruments as deployed were as shown below:

SBE37SMP
Start Date/Time 11 Dec 2004 14:00:00
Sample Interval = 900 seconds
Samplenumber = 0, free = 190650
do not transmit real-time data
do not output salinity with each sample
do not output sound velocity with each sample
store time with each sample
number of samples to average = 4
serial sync mode disabled
wait time after serial sync sampling = 30 seconds

RCM11
Start time: 20:30 on 10/12/04
Pings/ensemble: 600
Temperature range: Low
Conductivity range: 25 – 55 mS/cm
Recording interval: 30min
No.channels: 8
Mode: Normal

S4A

Start time: 15:00 on 11/12/04
Interval: 30min
On time: 2min
Avg. count: 240
SRB count: 12
Analogue channels: Hx, Hy, Conductivity, Temperature, Depth
Log mode: N/E
Write mode: internal

Appendix E: Instrument Record Lengths

Mooring	Instrument	Serial Number	Approx. depth (m)	Recovered?	Date of first useable record	Date of Last usable record
EBADCP	Aanderaa WLR8 BPR	1622	435	No	n/a	n/a
	RDI Broadband ADCP	1504	432	No	n/a	n/a
EBH5	Ixsea-Oceano BPR	472	1015	Yes	27/02/04	03/04/05
	Seabird SBE37 SMP CTD	3211	965	Yes	27/02/04	03/04/05*
	Seabird SBE37 SMP CTD	3210	915	Yes	27/02/04	03/04/05
	Seabird SBE37 SMP CTD	3209	765	Yes	27/02/04	03/04/05
	Seabird SBE37 SMP CTD	3208	665	Yes	27/02/04	03/04/05
	Seabird SBE37 SMP CTD	3207	565	Yes	27/02/04	03/04/05
EBH4	Ixsea-Oceano BPR	473	1510	Yes	27/02/04	03/04/05
	Seabird SBE37 SMP CTD	3216	1460	Yes	27/02/04	03/04/05
	Seabird SBE37 SMP CTD	3215	1410	Yes	27/02/04	03/04/05
	Seabird SBE37 SMP CTD	3214	1260	Yes	27/02/04	03/04/05
	Seabird SBE37 SMP CTD	3213	1160	Yes	27/02/04	03/04/05
	Seabird SBE37 SMP CTD	3212	1060	Yes	27/02/04	03/04/05
EBH3	Seabird SBE26 BPR	0391	2005	Yes	27/02/04	04/04/05
	Seabird SBE37 SMP CTD	3258	1955	Yes	27/02/04	04/04/05
	Seabird SBE37 SMP CTD	3257	1905	Yes	27/02/04	04/04/05
	Seabird SBE37 SMP CTD	3256	1755	Yes	27/02/04	04/04/05
	Seabird SBE37 SMP CTD	3218	1655	Yes	27/02/04	04/04/05
	Seabird SBE37 SMP CTD	3217	1555	Yes	27/02/04	04/04/05
EBH2	Seabird SBE26 BPR	0389	2510	Yes	27/02/04	03/04/05
	RBR XR420 CTD	9657	2460	Yes. Flooded	n/a	n/a
	Interocean S4	35612577	2410	Yes	27/02/04	28/09/04
	Interocean S4	35612576	2260	Yes	27/02/04	28/09/04
	Idronaut Ocean Seven 304 CTD	1103034	2160	Yes	27/02/04	04/04/05
	Seabird SBE37 SMP CTD	3277	2060	Yes	04/11/04	04/04/05
EBH1	Seabird SBE26 BPR	0390	3012	Yes	27/02/04	04/04/05
	RBR XR420 CTD	9656	2962	Yes	27/02/04	04/04/05
	Interocean S4	35612575	2912	Yes	27/02/04	29/09/04
	Seabird SBE37 SMP CTD	3276	2762	Yes	27/02/04	04/04/05
	Idronaut Ocean Seven 304 CTD	1103033	2662	Yes. Flooded	n/a	n/a
	Seabird SBE37 SMP CTD	3234	2562	Yes	27/02/04	04/04/05
EB3	Seabird SBE26 BPR	0388	3515	Yes	28/02/04	05/04/05
	Seabird SBE37 IMP CTD	3280	3460	Yes	28/02/04	05/04/05*
	Sontek Argonaut MD	D291	2960	Yes	28/02/04	17/02/05
	Seabird SBE37 SMP CTD	3247	2960	Yes	28/02/04	17/02/05
	Seabird SBE37 IMP CTD	3279	2460	Yes	28/02/04	05/04/05*
	Sontek Argonaut MD	D295	1960	Yes	28/02/04	24/10/04
	Seabird SBE37 SMP CTD	3243	1960	Yes	28/02/04	24/10/04*
	Seabird SBE37 IMP CTD	3278	1560	Yes	28/02/04	05/04/05*
	Sontek Argonaut MD	D265	1160	Yes	28/02/04	15/01/05
	Seabird SBE37 SMP CTD	3203	1160	Yes	28/02/04	15/01/05
	Seabird SBE37 IMP CTD	3238	960	No	n/a	n/a
	Sontek Argonaut MD	D270	760	No	n/a	n/a
	Seabird SBE37 SMP CTD	3201	760	No	n/a	n/a
	Seabird SBE37 IMP CTD	3237	560	No	n/a	n/a

	Sontek Argonaut MD	D271	360	No	n/a	n/a
	Seabird SBE37 SMP CTD	3205	360	No	n/a	n/a
	Seabird SBE37 IMP CTD	3236	210	No	n/a	n/a
	Sontek Argonaut MD	D306	60	No	n/a	n/a
	Seabird SBE37 SMP CTD	3204	60	No	n/a	n/a
	Seabird SBE37 IMP CTD	3235	10	No	n/a	n/a
EB2	Seabird SBE26 BPR	0387	3532	No	n/a	n/a
	Interocean S4	35612563	3424	No	n/a	n/a
	McLane Moored Profiler	11672-02	75-3423	No	n/a	n/a
	Aanderaa RCM11	300	50	Yes. Sep '04	28/02/04	18/9/04‡
EB2-R	Seabird SBE37 SMP CTD	3488	3490	No	n/a	n/a
	Interocean S4	35612574	2800	Yes	11/12/04	09/03/05
	Seabird SBE37 SMP CTD	3486	2100	Yes	11/12/04	06/04/05
	Aanderaa RCM11	310	1500	Yes	11/12/04	06/04/05
	Seabird SBE37 SMP CTD	3484	1000	Yes	11/12/04	06/04/05
	Aanderaa RCM11	309	500	Yes	11/12/04	06/04/05
	Seabird SBE37 SMP CTD	3483	250	Yes	11/12/04	06/04/05
	Aanderaa RCM11	307	100	Yes	11/12/04	06/04/05
	Seabird SBE37 SMP CTD	3481	50	Yes	11/12/04	06/04/05
EB1	Seabird SBE26 BPR	0414	5000	Yes	01/03/04	09/04/05
	Seabird SBE37 SMP CTD	3255	4850	Yes	01/03/04	09/04/05
	Seabird SBE37 SMP CTD	3254	4500	Yes	01/03/04	09/04/05
	Seabird SBE37 SMP CTD	3253	4000	Yes	01/03/04	09/04/05*
	Seabird SBE37 SMP CTD	3252	3500	Yes	01/03/04	09/04/05
	Seabird SBE37 SMP CTD	3251	3000	Yes	01/03/04	09/04/05
	Seabird SBE37 SMP CTD	3250	2500	Yes	01/03/04	09/04/05*
MAR3	Seabird SBE26 BPR	0396	5200	Yes	05/03/04	14/04/05
	Interocean S4	35612566	5198	Yes	05/03/04	03/10/04
	Seabird SBE37 SMP CTD	3275	5150	Yes. Flooded	n/a	n/a
	Seabird SBE37 SMP CTD	3274	4700	Yes	05/03/04	14/04/05
	Seabird SBE37 SMP CTD	3273	4200	Yes	05/03/04	14/04/05*
	Seabird SBE37 SMP CTD	3272	3700	Yes	05/03/04	14/04/05
	Seabird SBE37 SMP CTD	3271	3200	Yes	05/03/04	14/04/05
	Seabird SBE37 SMP CTD	3270	2700	Yes	05/03/04	14/04/05
MAR4	Seabird SBE26 BPR	0397	4730	Yes	05/03/04	14/04/05
	Interocean S4	35612567	4652	Yes	05/03/04	03/10/04
	McLane Moored Profiler	11333-01	131-4651	Yes. Imploded	05/03/04	04/05/04
	Aanderaa RCM11	301	106	Yes	05/03/04	14/04/05
MAR1	Seabird SBE26 BPR	0394	4760	Yes	07/03/04	20/04/05
	Interocean S4	35612564	4503	Yes	07/03/04	03/10/04
	Seabird SBE37 SMP CTD	3227	4003	Yes	07/03/04	20/04/05
	Seabird SBE37 SMP CTD	3226	3503	Yes	07/03/04	20/04/05
	Seabird SBE37 SMP CTD	3225	3003	Yes	07/03/04	20/04/05
	Seabird SBE37 SMP CTD	3224	2503	Yes	07/03/04	20/04/05
	Seabird SBE37 SMP CTD	3233	1603	Yes	07/03/04	20/04/05
	Seabird SBE37 SMP CTD	3232	1003	Yes	07/03/04	20/04/05
	Seabird SBE37 SMP CTD	3231	603	Yes	07/03/04	20/04/05
	Seabird SBE37 SMP CTD	3230	253	Yes	07/03/04	20/04/05
	Seabird SBE37 SMP CTD	3229	53	Yes	07/03/04	20/04/05*
MAR2	Seabird SBE26 BPR	0395	5050	Yes	07/03/04	20/04/05
	Interocean S4	35612565	5048	Yes	07/03/04	03/10/04
	Seabird SBE37 SMP CTD	3269	5000	Yes	07/03/04	20/04/05
	Seabird SBE37 SMP CTD	3268	4550	Yes	07/03/04	20/04/05

	Seabird SBE37 SMP CTD	3267	4050	Yes	07/03/04	20/04/05*
	Seabird SBE37 SMP CTD	3266	3550	Yes	07/03/04	20/04/05
	Seabird SBE37 SMP CTD	3265	3050	Yes	07/03/04	20/04/05
	Seabird SBE37 SMP CTD	3228	2550	Yes	07/03/04	20/04/05
WB4	Seabird SBE26 BPR	0392	4790	Yes	24/03/04	14/05/05
	Interocean S4	35612578	4785	Yes	24/03/04	23/10/04
	Seabird SBE37 SMP CTD	3263	4784	Yes	24/03/04	14/05/05
	McLane Moored Profiler	11672-01	79-4454	Yes. Damaged	24/03/04	11/11/04
	Aanderaa RCM11	308	54	Yes	24/03/04	14/05/05
WBH2	Seabird SBE26 BPR	0393	4800	Yes	25/03/04	09/05/05
	Seabird SBE37 SMP CTD	3264	4750	Yes	25/03/04	09/05/05
	Seabird SBE37 SMP CTD	3262	4700	Yes	25/03/04	09/05/05
	Seabird SBE37 SMP CTD	3261	4550	Yes	25/03/04	09/05/05*
	Seabird SBE37 SMP CTD	3260	4450	Yes	25/03/04	09/05/05
	Seabird SBE37 SMP CTD	3259	4350	Yes	25/03/04	09/05/05
WBH1	Seabird SBE26 BPR	0400	4287	Yes	26/03/04	09/05/05
	Seabird SBE37 SMP CTD	3244	4237	Yes	25/03/04	09/05/05*
	Seabird SBE37 SMP CTD	3249	4187	Yes	25/03/04	09/05/05
	Seabird SBE37 SMP CTD	3248	4037	Yes	25/03/04	09/05/05*
	Seabird SBE37 SMP CTD	3246	3937	Yes	25/03/04	09/05/05
	Seabird SBE37 SMP CTD	3245	3837	Yes	25/03/04	09/05/05
WB2	Seabird SBE26 BPR	0398	3898	Yes	29/03/04	11/05/05
	Interocean S4	35612573	3889	Yes	26/03/04	22/10/04
	Seabird SBE37 IMP CTD	3284	3746	Yes	26/03/04	11/05/05
	Seabird SBE37 IMP CTD	3283	3556	Yes	26/03/04	11/05/05
	Sontek Argonaut MD	D298	3055	Yes	26/03/04	14/04/05
	Seabird SBE37 SMP CTD	3223	3055	Yes	26/03/04	11/05/05
	Seabird SBE37 IMP CTD	3282	2554	Yes	26/03/04	11/05/05
	Sontek Argonaut MD	D273	2052	Yes	26/03/04	03/03/05
	Seabird SBE37 SMP CTD	3222	2052	Yes	26/03/04	11/05/05
	Seabird SBE37 IMP CTD	3281	1660	Yes	26/03/04	11/05/05*
	Sontek Argonaut MD	D272	1259	Yes	26/03/04	09/04/05 ◊
	Interocean S4	35612572	1259	Yes	26/03/04	23/10/04
	Seabird SBE37 SMP CTD	3221	1259	Yes	26/03/04	11/05/05
	Seabird SBE37 IMP CTD	3242	1059	Yes	26/03/04	11/05/05
	Sontek Argonaut MD	D303	858	Yes	26/03/04	01/04/05 ◊
	Seabird SBE37 SMP CTD	3220	858	Yes	26/03/04	11/05/05
	Seabird SBE37 IMP CTD	3241	658	Yes	26/03/04	11/05/05
	Sontek Argonaut MD	D274	457	Yes	26/03/04	11/05/05 ◊
	Seabird SBE37 SMP CTD	3206	457	Yes	26/03/04	11/05/05
	Seabird SBE37 IMP CTD	3240	317	Yes	26/03/04	11/05/05
	Sontek Argonaut MD	D301	167	Yes	26/03/04	27/09/04
	Seabird SBE37 SMP CTD	3219	167	Yes	26/03/04	11/05/05
	Seabird SBE37 IMP CTD	3239	117	Yes	26/03/04	11/05/05
WB1	Seabird SBE26 BPR	0399	1382	Yes	28/03/04	09/05/05
	Interocean S4	35612571	1377	Yes	28/03/04	09/05/05
	Interocean S4	35612570	1127	Yes	28/03/04	09/05/05
	Interocean S4	35612569	936	Yes	28/03/04	09/05/05
	Interocean S4	35612568	745	Yes	28/03/04	09/05/05
	Aanderaa RCM11	306	554	Yes	28/03/04	09/05/05
	Aanderaa RCM11	305	411	Yes	28/03/04	09/05/05
	Aanderaa RCM11	304	268	Yes	28/03/04	09/05/05
	Aanderaa RCM11	303	125	Yes	28/03/04	09/05/05

	Aanderaa RCM11	302	75	Yes	28/03/04	09/05/05
WBADCP	Aanderaa WLR8 BPR	1684	395	Yes. Oct '04	20/03/04	19/10/04
	RDI Broadband ADCP	1184	392	Yes. Oct '04	20/03/04	19/10/04

* indicates pressure sensor failure so usable record date will be earlier for pressure and possibly conductivity
‡ Exact useable end date not known as not clear from record when mooring was moved off position
◊ indicates current sensor failure

Appendix F: Triangulation Methodology from 2004 Deployment Cruises D277 and D278.

Triangulation Process

M. Lucas and D. Rayner

Introduction:

The SIMRAD EA500 is a modular frequency hydrographic echo sounder with a high performance and high accuracy receiving system as well as independent parallel processing within each of the frequency channels.

It uses internal software for bottom detection with an emphasis on reliability. This means that it will report an unsuccessful detection rather than an erroneous depth.

The fish was deployed on the portside from the midships winch and the combined monitor screens/control unit was installed at the back of the main lab. A secondary control/display unit was slaved to the first one and positioned at the front of the main lab. An HP paint jet printer continuously recorded on paper the screen output.

It was continuously working throughout D278, recording the bathymetry along the ship's track. More specifically, it was used to locate suitable positions for the moorings as well as to independently control the descent of the CTD when it approached the bottom. Finally, it was used to triangulate the position of a mooring once its anchor had reached the bottom.

Watchkeepers were required to make sure on an hourly basis that the screen display was sensible and that the printer was functioning correctly. They were also required to make sure that the range and bottom detection settings were appropriate. Generally, the whole system functioned well throughout although the bathymetry was in some places so steep that the instrument had trouble tracking it, this even when the ship speed had been reduced to 5 knots.

For the first few CTD casts, the printer was switched off while the ship was on station. This practice was discontinued after the watchkeepers and CTD operators failed to switch it back on again, leading to the loss of the paper trace of important sections. In the worse case, there was no printout for over 16 hours. Fortunately, the electronic logging did not similarly fail.

Normal data acquisition and processing:

The instrument continuously logged its estimation of the bottom depth in a binary file format. This file, prodep was regularly converted to pstar format using a routine called simexec0. simexec0 requires the user to input the start and end time of the data chunk to be converted. It then outputs a pstar file called on the cruise sim278nn.cal which list the time, uncorrected depth and corrected depth as well as the carter table area. The sim278nn file was then run through another pstar routine, plxyed which allows the user to manually remove erroneous data. The main aim of this routine is to facilitate the identification and removal of spikes.

The data is then averaged by running the pstar routine pintrp. Finally, through another pstar routine called simexec1, it is merged with the navigation file, abnv27801 to create two files, one with a 3second interval between each of the data cycles, sim278nn.nav and one with a 5min average, sim278nn.5min. These both list the time, latitude, longitude, depth uncorrected, depth corrected, carter table area, distance, and speed made good.

This continuous bathymetric logging was very useful in that it showed significant differences with the expected bottom topography. This led to a revaluation of the moorings positions and designs.

Mooring site surveying:

Prior to the deployment of moorings WB2 and WB1, bathymetric surveys of the proposed areas of deployment were conducted.

These were accomplished by following a succession of parallel tracks, the distance between each track being equal to the width of the footprint of the beam on the seafloor. The data was then passed through the simexec0 and simexec1 routine and a pstar interpolation routine called pgridh. This routine requires among other things, the time stamp at the start and end of the file, and the radius of the search pattern. The routine ucontr.exec was then used to generate colour bathymetric maps of the data (Figure F1 and Figure F2). This proved particularly useful as the proposed location for both the moorings were in the vicinity of steep slopes, and, in the case of WB1, a steep cliff where the depth drops from 1300 metres to over 3800 metres.

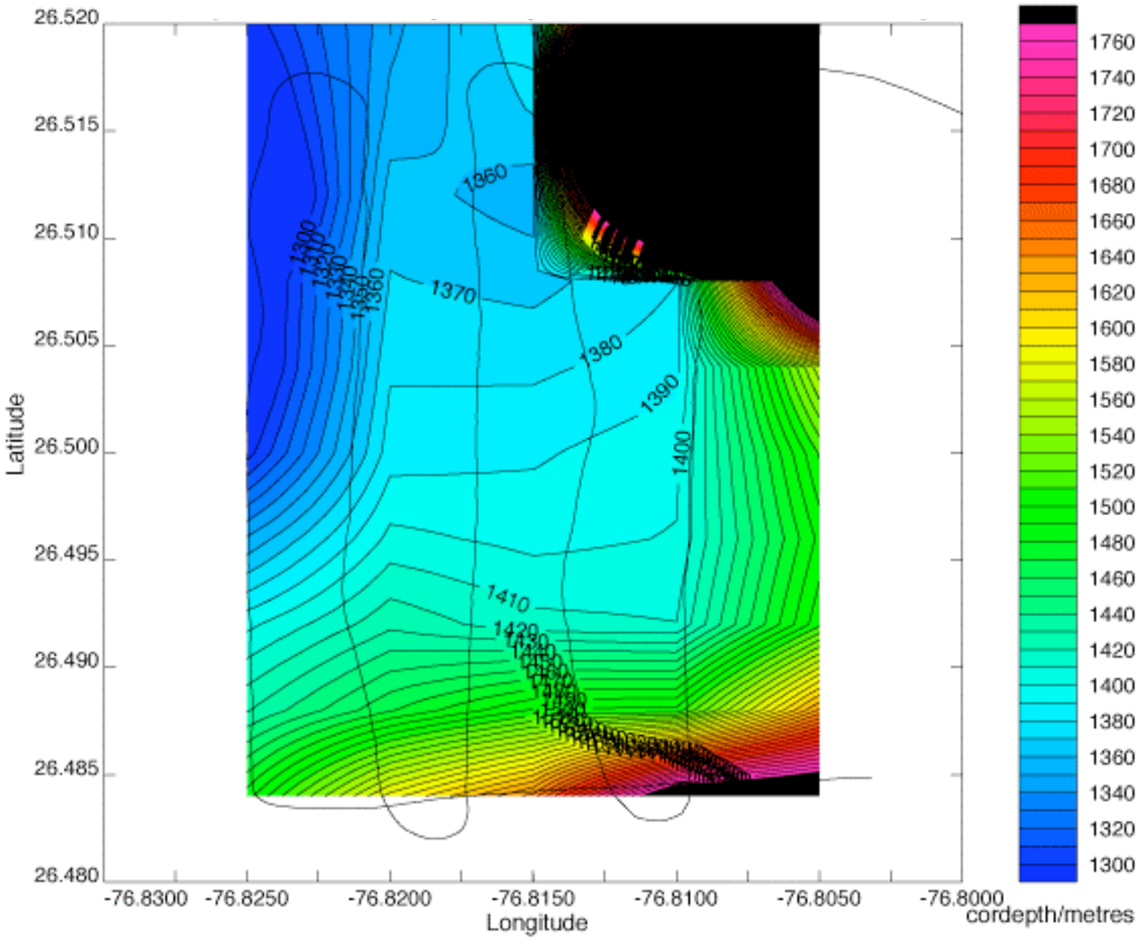


Figure F.1: Interpolated bathymetry from WB1 site survey

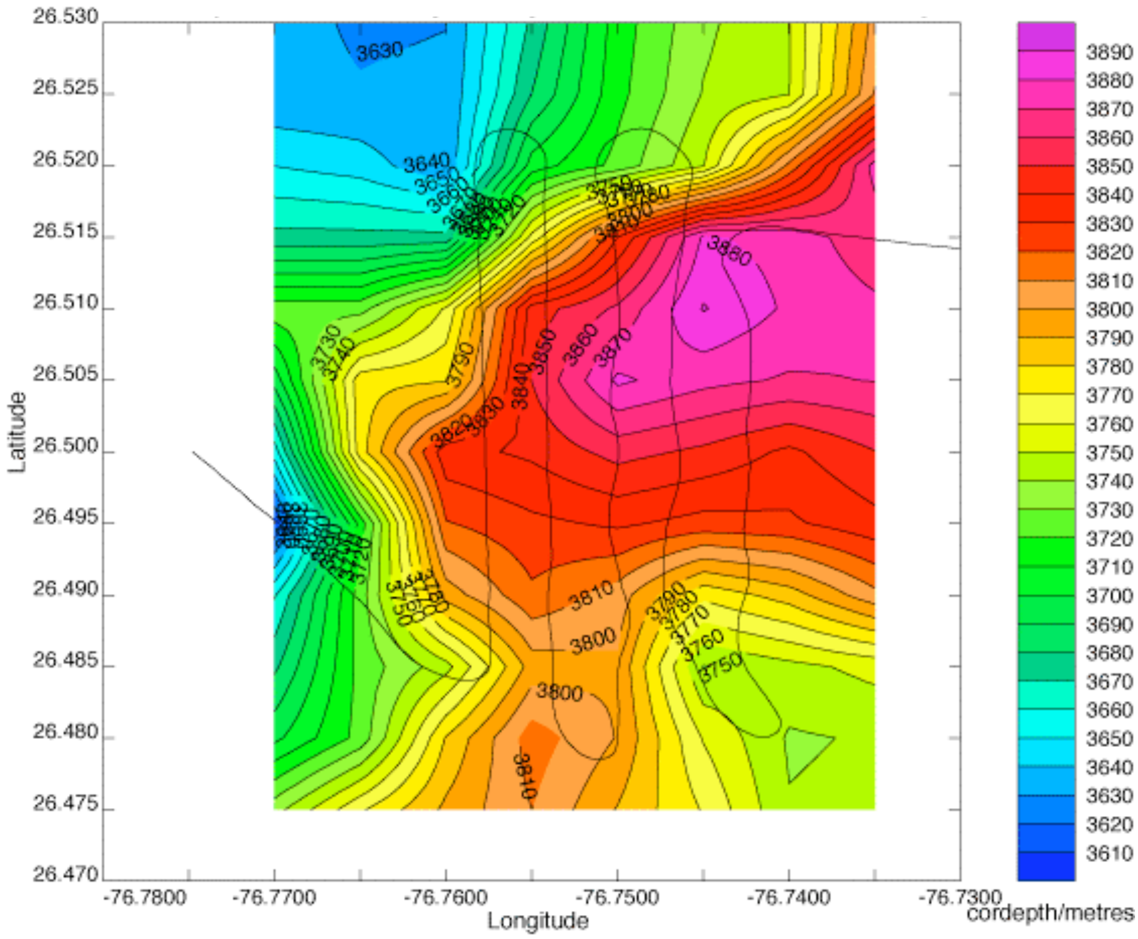


Figure F.2: Interpolated bathymetry from WB2 site survey

Mooring triangulation:

Upon deployment of the mooring, the ship follows a course that takes it round the mooring in a square or triangular track. The anchor regularly emits a ping, the echo of which is picked up by the echosounder. If the pinger is at a steady distance from the echosounder (i.e. the ship is not moving relative to the ground) then the signal received by the echosounder will be displayed as a vertical line through the water column. This echo shows up on both the Simrad echosounder trace and the OED waterfall system that is used to track the acoustic release pingers during deployment. If the ship is moving towards the pinger the trace on the Waterfall system will display a trace with a negative gradient as each successive ping received travels a shorter distance to the echosounder (each successive ping is plotted from the bottom up on the Waterfall display). The Simrad echosounder trace will display a line with a positive gradient as each successive plotted ping appears on the right of the scrolling paper. Similarly when the ship is moving away from the pinger the Waterfall system will display a trace with positive gradient, and the echosounder trace a negative gradient. As the ship passes the anchor position at it's closest point the gradient will change sign and the beam on position of the anchor will manifest itself as an inflexion in the plotted trace. At this point the time and ship's position should be noted.

By plotting the position of the ship when the anchor is determined to be abeam, and perpendicular to the ship's track at this point, it is possible to triangulate an area where the anchor has landed (Figure F3). The precision to which this area can be found is restricted by the accuracy to which the beam on position of the ship is determined from the echosounder/Waterfall trace during each segment, which is often subjective and varies between different users.

Two different track shapes were tried, a square and a triangular one. Because of poor data, it was not clear which of the strategies worked best. A matlab routine, trian.m was written to draw and compute the track and perpendicular line.

The time of each mark must be carefully written down. The abnv file must then be updated and the cycle corresponding to each mark noted as well as the cycle corresponding to the anchor drop.

The pstar routine pmatlb is then used to export the relevant chunk of data from abnv file. The latitude, longitude and heading must be included in the .mat file exported. It is important to note the cycle of the first line of the export, as it will be used by the trian.m routine.

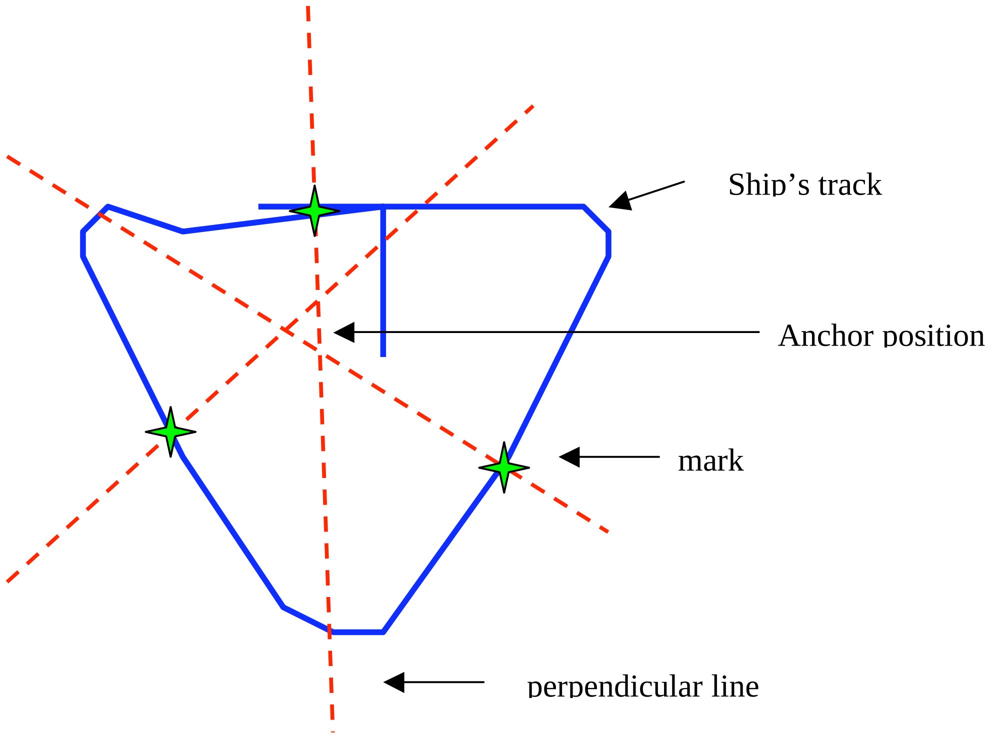


Figure F.3: Example output plot for determining anchor position by triangulation

The trian.m routine allows the user to choose between averaging the heading and choosing a waypoint on the same segment of the track in order to determine the perpendicular. In practise, it was found that the waypoint method yielded the better results, as the heading does not give the track over ground.

The relevant .mat files for the WB1 and WB2 moorings are WB1pos.mat and WB2pos.mat respectively. Inputting this data in the trian.m routine will generate matlab figures showing the location of the mooring as obtained from the navigation data. One figure shows the position in a longitude/latitude domain while the others displays it in a metre/metre plot.

<u>Reference:</u>

SIMRAD, 1991, SIMRAD EA 500 operator manual, Simrad Subsea A/S, Horten Norway.

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

CTD Cast	Cruise	Max Depth	Instrument details			
			Type	Serial numbers	Comment	Calibration type
1	CD170		Releases	n/a	Release test only	n/a
2	CD170	3503m	Microcat	3207		Post and Pre-deployment
			Microcat	3208		Post and Pre-deployment
			Microcat	3209		Post and Pre-deployment
			Microcat	3210		Post and Pre-deployment
			Microcat	3211	Bad P	Post Deployment
			Microcat	3212		Post and Pre-deployment
			Microcat	3213		Post and Pre-deployment
			Microcat	3214		Post and Pre-deployment
			Microcat	3215		Post and Pre-deployment
			Microcat	3216		Post and Pre-deployment
			Microcat	3217		Post and Pre-deployment
			Microcat	3218		Post and Pre-deployment
3	CD170	3505m	Microcat	3915		Pre-deployment
			Microcat	3916		Pre-deployment
			Microcat	3917	Flat battery	Pre-deployment
			Microcat	3918		Pre-deployment
			Microcat	3919		Pre-deployment
			Microcat	3920		Pre-deployment
			Microcat	3921		Pre-deployment
			Microcat	3922		Pre-deployment
			Microcat	3923		Pre-deployment
			Microcat	3924		Pre-deployment
			Microcat	3925		Pre-deployment
			Microcat	3926		Pre-deployment
			Microcat	3927		Pre-deployment
			Microcat	3928		Pre-deployment
			Microcat	3929		Pre-deployment
4	CD170	5000m	Microcat	3243		Post Deployment
			Microcat	3247		Post Deployment
			Microcat	3256		Post Deployment
			Microcat	3257		Post Deployment
			Microcat	3258		Post Deployment
			Microcat	3278	Bad P	Post Deployment
			Microcat	3279	Bad P	Post Deployment
			Microcat	3280	Bad P	Post Deployment
			Microcat	3917	Retry from previous cast	Pre-deployment
			RBR	9656		Post and Pre-deployment
5	CD170	4798m	Microcat	3250	Bad P	Post Deployment
			Microcat	3251		Post and Pre-deployment
			Microcat	3252		Post and Pre-deployment
			Microcat	3253	Bad P	Post Deployment
			Microcat	3254		Post and Pre-deployment
			Microcat	3255		Post and Pre-deployment

			Microcat	3257		Post and Pre-deployment
			Microcat	3277		Post and Pre-deployment
			Microcat	3481		Post and Pre-deployment
			Microcat	3483		Post and Pre-deployment
			Microcat	3484		Post and Pre-deployment
			Microcat	3486		Post and Pre-deployment
6	CD170	5177m	Microcat	3203		Post and Pre-deployment
			Microcat	3211	Bad P	Post Deployment
			Microcat	3234		Post and Pre-deployment
			Microcat	3243	Bad P	Post Deployment
			Microcat	3270		Post and Pre-deployment
			Microcat	3271		Post and Pre-deployment
			Microcat	3272		Post and Pre-deployment
			Microcat	3273	Bad P	Post Deployment
			Microcat	3274		Post and Pre-deployment
			Microcat	3278	Bad P	retry with PCOR changed
			Microcat	3279	Bad P	retry with PCOR changed
			Microcat	3280	Bad P	retry with PCOR changed
			Argonaut	D265		Post and Pre-deployment
7	CD170	5016m	Argonaut	D291		Post and Pre-deployment
			S4	35612566		Post and Pre-deployment
			S4	35612577		Post and Pre-deployment
8	CD170	4513m	Microcat	3265		Post and Pre-deployment
			Microcat	3266		Post and Pre-deployment
			Microcat	3267	Bad P	Post Deployment
			Microcat	3268		Post and Pre-deployment
			Microcat	3269		Post and Pre-deployment
			Argonaut	D295		Post and Pre-deployment
			S4	35612567		
			S4	35612576		Post and Pre-deployment
9	CD170	5151m	Microcat	3224		Post and Pre-deployment
			Microcat	3225		Post and Pre-deployment
			Microcat	3226		Post Deployment
			Microcat	3227		Post Deployment
			Microcat	3228		Post Deployment
			Microcat	3229	Bad P	Post Deployment
			Microcat	3230		Post Deployment
			Microcat	3231		Post Deployment
			Microcat	3232		Post Deployment
			Microcat	3233		Post Deployment
			RCM11	307		Post and Pre-deployment
			RCM11	309		Post and Pre-deployment
			RCM11	310		Post and Pre-deployment
10	KN182-2	4122m	Microcat	3485		Pre-deployment
			Microcat	3487		Pre-deployment
			Microcat	3905		Pre-deployment
			Microcat	3906		Pre-deployment
			Microcat	4060		Pre-deployment
			Microcat	4062		Pre-deployment
			Microcat	4066		Pre-deployment
			Microcat	4068		Pre-deployment

			Microcat	4070		Pre-deployment
			Microcat	4071		Pre-deployment
			Microcat	4072		Pre-deployment
			Microcat	4184		Pre-deployment
11	KN182-2	3548m	RCM11	307		Pre-deployment
			RCM11	309		Pre-deployment
			RCM11	310		Pre-deployment
			RCM11	446		Pre-deployment
			RCM11	450		Pre-deployment
12	KN182-2	4229m	S4	35612565		Post and Pre-deployment
			S4	35612568		Post and Pre-deployment
			S4	35612569		Post and Pre-deployment
			S4	35612570		Post and Pre-deployment
13	KN182-2	4813m	Microcat	3479		Pre-deployment
			Microcat	3482		Pre-deployment
			Microcat	3907		Pre-deployment
			Microcat	3908		Pre-deployment
			Microcat	3909		Pre-deployment
			Microcat	4177		Pre-deployment
			Microcat	4178		Pre-deployment
			Microcat	4179		Pre-deployment
			Microcat	4180		Pre-deployment
			Microcat	4181		Pre-deployment
			Microcat	4182		Pre-deployment
			Microcat	4183		Pre-deployment
14	KN182-2	4805m	Microcat	3859	RSMAS Instrument	Post Deployment
			Microcat	3860	RSMAS Instrument	Post Deployment
			Microcat	3861	RSMAS Instrument	Post Deployment
			Microcat	3862	RSMAS Instrument	Post Deployment
			Microcat	3863	RSMAS Instrument	Post Deployment
			Microcat	3864	RSMAS Instrument	Post Deployment
			Microcat	3865	RSMAS Instrument	Post Deployment
			Microcat	3866	RSMAS Instrument	Post Deployment
			Microcat	3867	RSMAS Instrument	Post Deployment
			Microcat	3868	RSMAS Instrument	Post Deployment
			Microcat	3869	RSMAS Instrument	Post Deployment
			Microcat	3870	RSMAS Instrument	Post Deployment
			Microcat	3871	RSMAS Instrument	Post Deployment
			Microcat	3872	RSMAS Instrument	Post Deployment
15	KN182-2	4805m	Seacat	482	RSMAS Instrument	Post Deployment
			Seacat	483	RSMAS Instrument	Post Deployment
			Seacat	485	RSMAS Instrument	Post Deployment
			Seacat	486	RSMAS Instrument	Post Deployment
			Microcat	3163	RSMAS Instrument	Post Deployment
			Microcat	3164	RSMAS Instrument	Post Deployment
			Microcat	3165	RSMAS Instrument	Post Deployment
			Microcat	3166	RSMAS Instrument	Post Deployment
			Microcat	3167	RSMAS Instrument	Post Deployment
			Microcat	3168	RSMAS Instrument	Post Deployment
16	KN182-2	4815m	Microcat	3244	Bad P	Post Deployment
			Microcat	3245		Post deployment

			Microcat	3246		Post deployment
			Microcat	3248	Bad P	Post deployment
			Microcat	3249		Post deployment
			Microcat	3259		Post deployment
			Microcat	3260		Post deployment
			Microcat	3261	Bad P	Post deployment
			Microcat	3262		Post deployment
			Microcat	3264		Post deployment
			Microcat	3480		Pre-deployment
			RCM11	451		Pre-deployment
17	KN182-2	4821m	Microcat	3240		Post deployment
			Microcat	3241		Post deployment
			Microcat	3242		Post deployment
			Microcat	3219		Post deployment
			Microcat	3206		Post deployment
			Microcat	3220		Post deployment
			Microcat	3221		Post deployment
			Microcat	3222		Post deployment
			Microcat	3223		Post deployment
			Microcat	3284		Post deployment
18	KN182-2	4787m	Microcat	3281	Flooded on cast	Post deployment
			Microcat	3282		Post deployment
			Microcat	3283		Post deployment
			S4	35612571		Pre-deployment
			S4	35612572		Pre-deployment
			S4	35612573		Pre-deployment
19	KN182-2	4982m	Microcat	3239		Post deployment
			Microcat	3263		Post deployment
			RCM11	308		Post deployment
			S4	35612578		Post deployment
20	KN182-2	5247m	Microcat	3147	RSMAS Instrument	Post deployment
			Microcat	3148	RSMAS Instrument	Post deployment
			Microcat	3150	RSMAS Instrument	Post deployment
			Microcat	3152	RSMAS Instrument	Post deployment
			Microcat	3153	RSMAS Instrument	Post deployment
			Microcat	3154	RSMAS Instrument	Post deployment
			Microcat	3155	RSMAS Instrument	Post deployment
			Microcat	3156	RSMAS Instrument	Post deployment
			Microcat	3158	RSMAS Instrument	Post deployment
			Microcat	3159	RSMAS Instrument	Post deployment
			Microcat	3161	RSMAS Instrument	Post deployment
			Microcat	3162	RSMAS Instrument	Post deployment