SOUTHAMPTON OCEANOGRAPHY CENTRE

CRUISE REPORT No. 53

RRS *DISCOVERY* CRUISES D277/D278

RAPID mooring cruise report
February – March 2004

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2005

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DOCUMENT DATA SHEET

AUTHOR	*PUBLICATION DATE*
RAYNER, D, & CUNNINGHAM, S A et al	2005

TITLE

RRS *Discovery* Cruises D277/D278, RAPID mooring cruise report, February – March 2004.

REFERENCE

Southampton Oceanography Centre Cruise Report, No. 53, 103pp.

ABSTRACT

This report describes the mooring operations conducted during RRS *Discovery* Cruises D277 and D278. These cruises were conducted between 26 February 2004 and 30 March 2004, as part of the Natural Environment Research Council (NERC) funded RAPID Programme to monitor the Atlantic Meridional Overturning Circulation at 26.5ºN.

Cruise D277 was from Tenerife to the Bahamas with participants from the Southampton Oceanography Centre (SOC), with cruise D278 a barter cruise also involving participants from the Rosenstiel School of Marine and Atmospheric Science (RSMAS), University of Miami.

An array of moorings were 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 refined and refurbished during subsequent years.

The deployed mooring array consisted of 19 moorings from the SOC, with 3 from the RSMAS. 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 D277 2004, cruise D278 2004, CTD, current meter, Discovery, Meridional Overturning Circulation, MOC, mooring array, Moorings, North Atlantic, RAPID, RAPIDMOC, THC, thermohaline circulation

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Scientific and Ship's Personnel

Table 1a: Details of Personnel on Cruise D277

Scientific and Technical	
Stuart Cunningham	Principal Scientist (Southampton Oceanography Centre)
Darren Rayner	Scientist (Southampton Oceanography Centre)
Pedro Vélez Belchi	Scientist (Instituto Español de Oceanografía)
Stephen Whittle	Tech (Southampton Oceanography Centre)
Ian Waddington	Tech (Southampton Oceanography Centre)
John Wynar	Tech (Southampton Oceanography Centre)
Robert McLachlan	Tech (Southampton Oceanography Centre)
Elizabeth Rourke	Tech (Southampton Oceanography Centre)
Christian Crowe	Tech (Southampton Oceanography Centre)
Peter Keen	Tech (Southampton Oceanography Centre)
10 persons	
RSU Personnel	
Roger Chamberlain	Master
Derek Noden	Chief Officer
John Mitchell	2nd Officer
Annalaara K-Willis	3rd Officer
Sam Moss	Chief Engineer
Martin Holt	1st Engineer
Antony Healy	2nd Engineer
Gary Slater	3rd Engineer
Dean Hurren	ETO
Greg Lewis	CPO (Deck)
Stephen Smith	Deck Technician
Andy MacLean	PO (Deck)
Stephen Day	SG1A
Robert Dickinson	SG1A
Robert Spencer	SG1A
William McLennan	SG1A
Donald MacDiarmid	MM1A
Keith Curtis	SCM
Paul Lucas	Chef
Walter Link	Assistant Chef
John Giddings	Steward
Michael Minnock	Deck Technician
22 persons	

Table 1b: Details of Personnel on Cruise D278

Scientific and Technical	
Stuart Cunningham	Principal Scientist (Southampton Oceanography Centre)
Darren Rayner	Scientist (Southampton Oceanography Centre)
Harry Bryden	Scientist (Southampton Oceanography Centre)
Marc Lucas	Scientist (Southampton Oceanography Centre)
Jochem Marotzke	Scientist (Max-Planck Institute)
Johanna Baehr	Scientist (Max-Planck Institute)
Clotilde Dubois	Scientist (Max-Planck Institute)
Fiona McLay	Scientist (Max-Planck Institute)
Bill Johns	Scientist (University of Miami)
Lisa Beal	Scientist (University of Miami)
Deb Shoosmith	Scientist (University of Miami)
Mark Graham	Technical (University of Miami)
Robert Jones	Technical (University of Miami)
Ian Waddington	Technical (Southampton Oceanography Centre)
John Wynar	Technical (Southampton Oceanography Centre)
Robert McLachlan	Technical (Southampton Oceanography Centre)
Christian Crowe	Technical (Southampton Oceanography Centre)
Jeffrey Benson	Technical (Southampton Oceanography Centre)
Jeffrey Bicknell	Technical (Southampton Oceanography Centre)
Chris Hunter	Technical (Southampton Oceanography Centre)
20 persons	

RSU Personnel	
Roger Chamberlain	Master
Richard Warner	Chief Officer
Phil Oldfield	2nd Officer
Darcy White	3rd Officer
Sam Moss	Chief Engineer
Stephen Bell	2nd Engineer
John Harnett	3rd Engineer
Chris Uttley	3rd Engineer
Dennis Jakobaufderstroht	ETO
Greg Lewis	CPO (Deck)
Martin Harrison	Deck Technician
Andy MacLean	PO (Deck)
Mark Moore	SG1A
Robert Dickinson	SG1A
Robert Spencer	SG1A
William McLennan	SG1A
Donald MacDiarmid	MM1A
Keith Curtis	SCM
Stephen Nagle	Chef
John Giddings	Assistant Chef
Alastair Harkness	Steward
Michael Trevaskis	Ext. CPOD
Gerry Cooper	Extra SG1A
23 persons	

Itinerary

D277
Depart Santa Cruz de Tenerife, Tenerife, 26th February 2004 – Arrive Freeport, Grand Bahama, 16th March 2004.

D278
Depart Freeport, Grand Bahama, 19th March 2004 – Arrive Freeport, Grand Bahama, 30th March 2004.

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 from theory. 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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Cruise Narrative and Daily Log

2nd Feb to 11th Feb
Various staff involved in mobilising for the moorings cruises (D277, D278) and for hydrography cruise (D279).

12th to 24th Feb
UKORS winch trials cruise (D276) and passage from Glasgow (King George V dock) to Tenerife (Santa Cruz de Tenerife). Ian Waddington and four others embarked Glasgow to prepare moorings and instrumentation on passage. Arrives Santa Cruz de Tenerife 0845 on 24th Feb.

D277
24th and 25th Feb (055 & 056 day of year)
Continue mobilisation of mooring equipment, instruments and underway instrumentation.
G12 power supply failed during night of 25th. Spares ordered during the Glasgow mobilisation not delivered to ship. Familiarisation briefing.

26th (057)
1030 muster stations
1200 sailed. Heading for 3000m depth to NE of Tenerife for acoustic release tests
1200 Instruments logging: ADCP (150, 75), all nav, surfmet, non-toxic, autoflux and PES fish deployed.

ADCP150 user end programme for clock corrections does not work.

1430 on station in water depth 3307m for acoustic release trials (releases for EBADCP and EBH5 to EBH1). Using CTD winch. 1715 completed cast, u/way to EB ADCP (ETA 0500). First useful scientific deployment from this new winch. See winch section in D279 hydrography cruise report for analysis of winch data. PES fish unserviceable (u/s). No spares aboard and resorted to the hull transducer.

27th (058)
EB ADCP (*Discovery station number 15253*) on station 0604, water depth (w/d) 452m uncorrected (u/c). 27° 54'N, 13° 23.79'W. Mooring lifted in one piece using aft port crane. Release time 062722 at 27° 54' 1.66''N, 13° 23' 36.5''W (27.90046N, -13.39349W). Bestnav positions throughout. Slight winds from NE and slight seas.

EBH5 (*15254*) on station 0724, 0.5nm downwind of position, w/d 1011m u/c. Still assembling mooring, so circle round back to position. Begin deployment 0741, 27° 51.15'N, 13° 31.77'W w/d 1025m u/c, streaming mooring at speed over ground (sog) 0.5kn. Heading course made good (cmg) 30°M, w/d slowly increasing. 0750 turn upslope on ~060°M, increase sog to 1.5kn. 0801 mooring all out with anchor suspended and towing to correct w/d. Release time 080937 27° 51' 24.12''N, 13° 31' 14.5''W (27.85670N, -13.52071W).

EBH4 (*15255*) on station 0950, turned to ~030°M slightly upslope direction, w/d 1521m u/c. 0958 w/d 1525m u/c, 1009 w/d 1520m u/c, 1011 turn to ~090°M upslope at sog 2kn. Release time 102629, 27° 49’ 55.92’’N, 13° 47’ 18.7’’ (27.83220, -13.78855W).

EBH3 (*15256*) on station 1258, turned into wind, w/d 2000m u/c. Mooring streamed overboard (o/b), buoyancy first. Start deployment at 1259. Release time 131159, 27° 37’ 20.57’’N, 14° 12’ 19.58’’W (27.62238, -14.20544).

EBH2 (*15257*) on station 1600 turned into wind w/d 2512m u/c. Mooring streamed o/b buoyancy first. Start deployment at 1601, Release time 161526 (top buoy submerged 1621), 27° 29’ 16.94’’N, 14° 41’ 4.49’’W (27.48804N, -14.68458W).

EBH1 (*15258*) on station 2012 turned into wind w/d 3010m u/c. Irregular steep hillock just shallower than this position. Mooring streamed o/b buoyancy first. Start deployment at 2017, Release time 203222 (top buoy submerged 2034 – sunk far quicker than other EBH moorings), 27° 16’ 33.56’’N, 15° 24’ 59.7’’W (27.27599N, -15.41659W)

EBH5&4 identical moorings. 500m long using braided synthetic rope. Billings float top buoyancy (light and flag), distributed syntactics, 1 railway wheel anchor with acoustic release and BPR frame, 5x SBE37MP CTDs at 100m intervals. EBH3 has glass spheres as top buoyancy. EBH2 as EBH3 construction with the following instruments: SBE37MP, Idronaut, S4, S4, RBR.

28th (059)

Sea and winds slight. Arrived close to EB3 position at 1215. Usually the mooring wires are wound onto the mooring winch straight from their delivery drums, with tension being generated by a wooden friction device. However, the long moorings used here means that the drums are too heavy to be braked by such a system. The EB3 wire having been wound onto the mooring winch was judged to be under insufficient tension for a safe deployment. If the tension on the mooring winch is insufficient there is a danger that the wire will run unimpeded through the double barrel capston winch. Therefore, the EB3 mooring wire (3000m, jacketed wire) was used to lower dual release pairs for EB2 and EB3 to 3000m. Release tests satisfactory. However, during deployment the mooring wire was nicked three times through the plastic jacket. This was because having been loaded onto the spooling winch under low tension it did not spool cleanly. Therefore, repairs involving setting plastic were required which took some time. Wire finally recovered at 0730. Heading slowly to mooring position. Begin preparing mooring at 0800.

EB3 (*15259*) 1010 moving to position 4nm NE of nominal position. 1030 turn and steam at sog 2kn to the SW along depth contour ~3498m u/c. Start deployment at 1037, lowering satellite buoy using the crane followed by the 250m subsurface tether/conductor with syntactic floats. Dolphins playing round the buoy. On lifting main buoyancy o/b at 1037 the electrical connector between the conducting swivel at the bottom of the buoy and the buoy was pulled out. The connectors are too flimsy. Remedial work undertaken adding extra support to the connector using cable ties. All other conducting swivels will be altered accordingly. Commenced deployment at 1108, main buoyancy o/b at 1110. Mooring deployment slow as clamps required fitting to the instruments and clamping the instruments to the moorings was time consuming, particularly for Sontek/SBE pairs to ensure that all cabling was tidy. Release time 144948, 26° 59' 46.1''N, 16 13' 50.1W (26.99614N, -16.23060W). Mooring deployment time ~4 hrs 10 mins.

Subsurface buoyancy, tether/conductor, syntactic floats and satellite buoy visible on surface being towed by the anchor. Ship manoeuvred along side and tracked the satellite buoy through the water. Progressively the mooring was sunk and towing ended at 1516, 26° 59' 49.81''N, 16° 13' 14.2''W (26.99717N, -16.22061W) with 11 of the tether/conductor syntactic floats and satellite buoy remaining on the surface. The separation between the anchor release position and the surface position of the satellite buoy is 0.54 nm (1.00 km). The mooring release was also tracked to the seabed on the PES waterfall display.

Jon Campbell at SOC monitored returns from the satellite buoy. Received emails from the buoy at 1102, 1302 and 1502, and a dial-up message at 1130. This is all normal. From the contents of the messages it would appear that the inductive instruments were gradually added to the cable during the afternoon. The last two emails from the buoy, at 17:02 and 19:02, show no data received from the inductive instruments, whereas the email at 15:02 showed 11 SBE37 IMP readings and 11 Sontek readings in the previous 2 hours. The mooring anchor was released at 1449 and reached the seabed at 1516. The satellite buoy continues to email engineering data. Given the problems (described above) with the flimsy connection between the mooring wire and swivel and then from the swivel to the sub-surface buoy the most likely conclusion is that this connection failed during deployment.

The swivel to subsurface buoy fittings do not conform to the design prepared by Ian Waddington. Unfortunately, the swivels were delivered at the last moment before shipping when it was too late to change them. The current design uses shackles to join the swivel to the buoy allowing too much movement between them. This exposes the electrical conductor from the top of the swivel to the buoy to mechanical wear. The details of this can be seen clearly in Photograph 6.

1530 proceed slowly to site of EB2, whilst mooring is prepared. More attention is being paid to winding the mooring wire onto the mooring winch under tension. Instruments programmed and ready for deployment.

EB2 (*15260*) on station 1850, start deployment at 1858 w/d 3510m u/c, heading 340T. MMP stops not tight on wire. Wire is 3/16" and stops probably for 1/4". Spare stops usually used for glass spheres placed above and below the stops to secure. MMP lifted against top stop and swung out using crane. Lowered gently into water and streamed aft. Wire streamed with sog 1.5kn. Release time 211644 26° 53' 29.94''N. –16° 14' 2.11''W (26.89165N, -16.23392W). Mooring tracked to bottom using the pinger. Top light and ARGOS beacon disappeared simultaneously. One pinger's phase for pinging was found to be slightly wrong so that the mooring was apparently moving away from the ship at a steady rate. After switching from one pinger to the other it was seen that the mooring was safely on the sea-bed.

29th (060)

Leap year day and 1st Sunday in Lent. Seas and winds slight-moderate. Steaming at sog 12-13kn towards EB1. ETA tomorrow morning. Instrument and mooring preparation in progress and routine data processing beginning. SBE26 instruments do not accept leap day start dates.

1st March (061)

Clocks retarded by one hour 0200 to 0100. Wind and seas moderate from the ENE.

EB1 (*15261*) turn onto station at 0805 w/d 4979m u/c, start deployment at 0827. Mooring streaming aft sog 1.5kn. Release time 095512 (deployment time ~1hr 30mins), 24° 31' 26.15''N, -23° 26' 55.5''W (24.52393N, -23.44877W).

Recovered PES fish at end of deployment.

1400 on station for mooring release tests to 5000m. At 2000m wire out cast terminate and hauled in at 70 m/min. Release data sheets not packed so codes need to be transcribed from release pressure cases.

The following is specified as a winch trial. Veer package to achieve speed of 60m/min. Stop for 5mins on down and upcast at 1000 2000 3000 4000 5000 m wire out. At 5000 m haul at 30m/min to 4950. Veer to 5000m. Haul at 60m/min.

Release tests took considerable time due to poor acoustic conditions: ranges to the pingers were inconsistent and pinger positions were not visible on the waterfall display – this principally due to the lack of a PES fish!

2nd (062)

Winds light, 1m swell. Underway to MAR. Making sog ~13kn. ETA 2300 on Thursday 4th. Data processing and training. Mooring team making final preparations for MAR moorings. At present time we have four work days in hand to complete the moorings.

3rd (063)

Winds and swell moderate. On passage to MAR moorings. SOG 12.5kn. Data processing, training and mooring preparation throughout the day.

4th (064)

Clocks retarded 0200 to 0100, now ship's time is GMT-2. Winds freshened overnight and swell picked up to 1.5m. SOG 12.5kn on passage to MAR4 and MAR3. ETA 2300. Constant temperature laboratory air conditioning switched on at 1000 and set to 19°C (salinometers to be set to 21°C). Modifications to mechanical connections between buoy and swivel complete so that deployment of satellite buoy on WB4 is possible. PES fish has been stripped and is undergoing maintenance and repair.

5th (065)

Steaming due west to MAR. Bathymetry is extremely rugged. Steamed past nominal mooring position and found likely spots for MAR3 and MAR4.

MAR3 (*15262*) 0110 turned to heading 090°T, speed through water 0.5kn. Too close to mooring site. Steamed on to –41° 10'W, turn to 270°T. Deployment started 0210. Pickup float and top buoyancy o/b at 0217. 0219 deployment halted as a longline buoy drifted past. No evidence of nets so deployment continued at 0223. Deployment downwind was hopeless as SOG was 1.5 to 2.5kn to keep mooring streaming.

However, mooring paid out just as we came to the mark. Release time 033500 (1hr 25mins), 24° 29’ 59.2’’N, 41° 15’ 7.2’’W (24.49978N, -41.21527W).

MAR4 (*15263*) Heading south-west for start of MAR4 deployment to be run into wind 3nm from site. Main buoyancy o/b 0500. Deployment slow as the mooring wire develops loose turns on the spooling winch with a risk of jamming and snapping. One section damaged at ~1500m wire out and repaired with tape. On lifting the duel release and BPR unit the RSU quick release hook failed dropping the unit onto the deck. The releases took the brunt of the impact. The bosun was glad of his protective shoes. These were tested before deploying but the effect on the BPR is unknown. On lifting the anchor it swung to port and the bosun was almost squashed, being hemmed in by spare anchors. Release time 080615, 24° 30’ 6.95’’N, 41° 18’ 4.25’’W (24.50193N, -41.30118W), deployment time 3hrs 6mins. Tracked pinger to seabed. Argos signal and light vanished at 0840, anchor on bottom at 0853 (descent time 47m, slant range 4870m).

6th (066)

Mooring and instrument preparation. Great attention was paid to winding the MAR1 wire onto the winch. Each shackle was wrapped and then layers were covered in duck canvas and taped in place. This was to prevent the problems of loose turns causing problems on the deployment by snagging shackles or by locking under other loose turns.

7th (067)

MAR1 (*15264*) 0106 slowed to 6kn approaching nominal site for echo sounding survey. Continued on for 30mins, turned on reciprocal course. Moved 3nm to SW of identified position. Main buoyancy o/b 0257. Mooring paid out well with instruments being attached rapidly. However, a strong tail current forced us past the mark at 0442 before the mooring was fully streamed and the bathymetry shallowed, with poor returns from the echo sounder. Mooring towed round in a large circle with the main buoyancy light visible at a constant heading of 60W. Finally, a satisfactory position close to the identified mark and with strong bottom returns from the echo sounder. Release time 062731 (3hrs 36min), 24° 29’ 29.11’’N, 50° 15’ 37.51’’W (24.49142N, -50.26042). Release pinger monitored to bottom. Argos transmissions ended and main buoyancy light disappeared at 0652.

MAR2 (*15265*). A lengthy steam west along 24.5N eventually identified a suitable site. The wind being easterly we turned into wind at 0942 to begin deployment. Main buoyancy o/b 0947. Mooring streamed swiftly. Release time 104945 (1hr 2mins), 24° 28’ 33.74’’N, 50° 34’ 13.26’’W (24.47604N, 50.57035W).

Underway for next waypoint nominal position 24° 30N, 55° 56’W (1998 CTD station 71).

8th (068)

Arrived on station at 1100. There were four goals: 1. deploy the CTD to test the CTD and obtain data to set up the CTD processing path (for D279); 2. trial the CTD winch to depths in excess of 6000m; 3. to test the western boundary array acoustic releases at depth and; 4. enable the new winch drivers to gain operational experience. Three stations to depths greater than 5000m were successfully completed. The acoustic release trials showed one release not functioning: the release codes for this instrument are different from the other releases. A further trial of this release will be required. The table below is a brief summary of the three stations.

Table 2: Winch/CTD/Acoustic release trials on day 068. Data reported in D279 Cruise Report

Stat. num	Discovery number	Nom. Lat (deg min)	Nom. Lon (deg min)	Start (Doy hhmm)	Stop (Doy hhmm)	Wire out (m)	Water depth corr (m)	CTD depth (m)	CTD Pmax (dbar)	N bot
1	15266	24° 29.5’	56° 56’	068 1210	068 1735	6200	6460	6209		5
2	15267	24° 28’	56° 2’	068 1824	068 2248	5051	6431	5025	5102	6
3	15268	24° 26’	56°1.5’	068 2312	069 0314	6420	6443	6420	6559	6

Salinometers in CT lab filled and switched on. Temperature baths set to 24°C as CT laboratory around 22°C.

9th (069)

Under way to next way point 26° 30’N, 71° 44’W but travelling along path of 1998 section for a bathymetry survey along the D279 cruise track. WB4 mooring preparation: wire winding, instrument setup, satellite buoy preparation. Data processing continues.

10th (070)

During the past few days a deep low pressure centred on 38°N, 68°W has generated strong winds and swell from the north west. Passage speed reduced by 1 to 1.5kn. ADCP data quality poor. OS75 swiched to narrow band mode. Also found that we did not have the correct direct command in the configuration file of the ADCP150 so that slave mode has probably not been operating correctly.

11th (071)

Continuing west at latitude 24.5°N. Underway logging and data processing continuing. 1555 altered course (a/c) to 320°T. Heading directly into increasing swell. ADCP data extremely poor.

12th (072)

0100. Clocks retarded one hour, ship’s time is GMT-5. 0654 a/c to 270°T at latitude 26.5°N. Rolling heavily due to beam swell. 1420 CTD/acoustic release test (CTD 4, Discovery station *15269*, maximum depth 5000m). Deployed PES fish 1515. John Wynar has now completely rewired the PES from the internal harness back to the junction box. High quality data now being received. GPS differential receiver G12 not receiving differential corrections – noticed at 1500. Manual gave no clues to rectifying problem. Email sent to help desk.

13th (073)

WB4 (*15270*). 1011 found depth 4750m u/c (4788m corr) at 26.5°N 75° 58’’ 20’W. Taking up position 4nm SW of mark. 1102 at position to begin deployment. A last minute tighten of the satellite buoy ring bolts found one seized. Bolt sheared off and new bolt inserted. Begin deployment at 1139. 1140 satellite buoy o/b, paying out tether directly from storage crate. 1048 main buoy o/b, paying out. Seven men to fit

SBE/Sontek pairs in timely manner. Mooring 4409m, buoy to be 50m subsurface (=4459m), w/d 4788m so add 329m to bottom of mooring. Added as 2x150m ropes with an S4 (additional to plan) between the sections. Release time 151910, 26° 29' 57.84''N, 75° 58' 36.16''W (26.49940°N, 75.97671°W). Deployment time 3hrs 40mins. Track acoustic release to bottom. Steamed along track to inspect surface satellite buoy. An extensive search, in conditions of good visibility, did not locate the buoy. The last reported position of the buoy occurred at 1530, 11 mins after anchor release. Suspected that buoy became flooded during release. As the weight and drag of a flooded buoy would be a significant danger to the main mooring we decided to recover the mooring for deployment during D278. The table below describes the recovery.

Table 3: Summary of deployment and recovery of initial WB4

Time GMT	Description
1139	Start deployment
1519	Anchor release
1530	Last transmission from satellite buoy
1550	Descent rate of mooring slows (satellite buoy submerging and adding buoyancy?).
155742	Descent rate increases (satellite buoy implosion)
155849	Anchor on bottom.
1945	Start interrogating acoustic release for range, status and release
1959	Subsurface buoy at surface
2033	Pellet floats for subsurface buoy to satellite buoy umbilical along side and grapneled. Tether recovered and satellite buoy lifted by tether inboard. Satellite buoy imploded (design depth maximum 20m).
2130	Subsurface buoyancy inboard (i/b) and first SeaBird recovered. Main mooring wire secured and being drawn inboard to the double barrel capstan and reeling winch.
2135	50m down from subsurface the first Sontek/SeaBird instrument pair formed a bight that was drawn in into the propeller as the ship was moved ahead on the main propeller rather than the bow thrusters! The cable parted leaving the top 50m inboard. Fortunately, no one was caught by the wire coming inboard. At this point it was not definitely known whether the instruments were lost.
2140 to 2200	Tracked line of mooring distributed glass spheres (in bright yellow plastic hats) trying to find the eight pack at the bottom end of the mooring immediately above the releases and BPR. Not on surface so decision to pick mooring up in the middle and recover as a double bight.
2200 to 2225	Ship made a rapid turn east then west to put a float (not identified at which point in the mooring this was) along the starboard side. Unfortunately, attempts to grapnel this failed. Sunset now and light disappearing fast.
2225 to 2230	Fast turn to WNW in a clockwise direction then crossed mooring line to the south to manoeuvre along side mooring.
2240	Turn was too fast and not complete at line of mooring which was crossed at an angle of 30° with the mooring hitting the ship abeam the starboard A Frame then running aft and disappearing under the starboard side at about the winch cab. Fortunately the mooring and floats caught in the rudder post, did not break and were not drawn into the propeller.
2240 to 2310	After an anxious 30mins of manoeuvring the mooring broke free from the rudder post and before they disappeared aft (in the near dark) they were grapneled at the last second.
2300 to 0127	Mooring recovered as a double bight approximately 1000m from the top of the wire. Capstan and spooling winch used. Instruments removed from wire, rinsed in fresh water and taken to the lab for immediate data download.

Draft summary of problem

1. Immediate analysis of the pressure records show that: 1. the bottom depth was exactly as planned within a few meters; 2. the top of the mooring descended below 350m after anchor release before recovering to 200m. The satellite buoy is rated to 20m and has a 250m umbilical/tether. Clearly it was dragged to at least one hundred meters below the surface. The mooring was designed to have the main subsurface buoyancy at 50m. A close inspection of the PES paper record reveals that the mooring descended at a steady rate. Two minutes before the anchor reached bottom the descent rate slowed (satellite buoy submerging adding buoyancy?). Then 67s before the anchor reached bottom the mooring descent rate increased (satellite buoy implosion?) – these effects are very subtle on the PES record and were not spotted at the time.
2. Initial suspect was the water depth. However, it was clear that the bottom pressure measured by the S4 corresponded closely to the PES measured depths.
3. Suspicion then fell on the length of the main mooring wire. This was a single plastic jacketed inductive wire constructed by WHOI. They precisely measured its length to be 4500m. At SOC the wire was measured twice end for end on our less accurate measuring wheel. This gave two estimates of length within 37m of the stated wire length. The wire was then sent out of SOC to a company who made the electrical terminations. For some time we strongly suspected that 200m had been lost from the mooring during this process.
4. During deployment of the mooring a strong surface current of two knots was experienced. The ocean surveyor data are being analysed to feed into the mooring dynamic programme. It is now suspected that strong currents caused the mooring to drag under. It was designed for maximum speed of 50 to 70 cm/s in the upper water column.
5. We recovered nearly all instruments and have spare wires/buoys/argos/anchors etc to build a mooring for deployment during D278.

14th (074)

From 0130 we steamed along 26.5°N inshore of WBADCP position to obtain a bathymetric survey for D278. We then turned to sail round to the north of Grand Bahama to the Florida Straits. We began a CTD section (planned 9 stations) across the FC along the regular cable calibration section. Station positions kindly provided by Molly Baringer. ADCPs in bottom track mode.

15th (075)

CTD section continuing. Last station not completed due to CTD failure – problem not yet diagnosed but wasn't the termination. Section terminated at 1105. Eight CTDs completed, station numbers 5 to 12 (Discovery numbers 15270 to 15278). NB Station 6 was done twice due to CTD problems and given a new Discovery number but not station number. Turned on reciprocal bearing across the FC for a 5kn sog ADCP survey. This survey by the skill of the navigating officer and Captain sampled shallow waters (50 to 100m) at either end of the line in fast currents and close to steeply shoaling reefs. Section ended at 2300.

Data from this section are reported in Southampton Oceanography Centre Cruise Report No 54 (Cunningham et al. 2005.)

16th (076)

Made passage speed south though the Florida Straits to reach a point on the south side of New Providence Channel at 0600. Another 5kn transect to the NE across the Channel to measure eastward flow joining the FC. Transect finished at 1200, less than five miles from Freeport, Grand Bahama. Pilot due on board at 1400. Tied up alongside at 1500.

D278

18th (079)

Mobilisation continues. Miami containers, crane and forklift arrived at 1300 (0800 local). Scientific party moved aboard. Safety and familiarisation briefing 1930. Data logging continued to same data streams. Cruise id on Level B remains as 277. Data gap 04 076 17:51:00 to 04 078 15:43:50.

19th (080)

Ship's time GMT-5. Emergency muster stations 1530. Slipped moorings at 1700. Heading east through New Providence Channel.

20th (081)

Watches started at 0100. Watchkeeping instructions and log started.

WB ADCP (*Discovery station number 15280*). From the bathymetry obtained on D277 across the nominal WBADCP position no suitable position was found. We conducted a survey east along 26° 30'N and then northward at 76° 52.84'W to 26° 32'N. A suitable site was found, w/d 393m u/c (400m corr). Mooring lifted in one piece using aft port crane. Release time 081525 at 26° 32' 20.65''N, 76° 52' 51.74''W (26.53907N, 76.88104W). Bestnav positions throughout.

Steam 90°T along 26° 30'N at 5knots for a bathymetric survey along line. At 76° 38.6'W increase to full speed toward BJE. After the survey it was discovered that poor echo sounding data were recorded using the hull echo sounder as it had not been switched back to fish when leaving Freeport. A number of new joiners and first timers feeling particularly seasick.

21st (081)

BJE (*15281*). Start deploy 1717. Anchor released at 2327 at 26° 29.67N, 71° 58.28W. Deployment method: 1. bathymetric survey around site, 1.5hrs; 2. check ship drift at intended anchor release point; 3. move 7nm from position to deploy into the wind. Box survey for ranges to release completed at 0110.

22nd (082)

On completing BJE two lowerings of Sontek current meters to 2500m then CTD15282 at the site of BJE (0200 to 1328). CTD 15283 at 73° 21.1'W.

23rd (083)

WB4 (*15285*). MMP mooring. Surveyed east to west across mooring position, then from the NE to the SW and confirmed location satisfactory. Turn on station SW of site at 1800. Top buoy deployed using release hook, top stop fitted before anything o/b, main buoy o/b 1824. Profiler fitted to wire at 1858 with about 1000m wire out to develop sufficient o/b tension to support the weight of the profiler. Profiler held close to the crane block, lifted 3m above deck, then released down wire using a guide rope through the crane block. 2012 preparing to fit bottom stop, 1.5nm from site at 1.4kn sog. 2026 paid out 300m of rope at bottom of mooring and preparing to add releases and BPR. 2036 8 cables to site, anchor secured and towing to site. Release anchor 2111 at 26° 29' 56.98''N, 76° 2' 29''W (26.49916°N, 76.04139°W). Mooring descent tracked, initially descent rate decrease at 2141, argos transmissions ceased at 2144, at bottom 2155. Descent rate 106m/min. We then surveyed round the site using the release pinger to give closest athwart ship point of approach whilst steaming a known bearing.

24th (084)

Sontek current meter lowering to 2000m completed at 0245. CTD 15286 at WB4.

BJB (*15287*). Set course 240°T for mooring start position ready to commence streaming mooring wire at 1200. Anchor release at 1722 26° 29.95'N, 76° 29.67'W.

2148 set course 270°T for bathymetric survey of mooring sites WB1 and WB2 on small shelves at the edge and foot of the continental slope respectively. Each survey consisted of five N/S lines 2 cables (0.2nm) apart at 5knots. The echosounder has a 15° beam. Therefore, for WB1 w/d is 1411m corr so the footprint is 369m (0.2nm) and for WB2 w/d 3855m corr the footprint is 1009m. (0.55nm). Surveys were successful and identified potential deployment sites.

25th (085)

30 knot winds and large swell from 060°T. Pressure rising during the morning.

WBH2 (*15288*). Mooring 500m long with five SBE37 CTDs, deployed in nominal w/d 4821m (corr). On station 1300, recovery float o/b 1447, complete mooring o/b at 1455, towing 0.3 cables to mark. Release time 151330 at 26° 30.02'N, 76° 35.95'W (26.50032°N, 76.59922°W).

WBH1 (*15289*). Mooring 500m long with five SBE37 CTDs, deployed in nominal w/d 4358m (corr). Deployment started at 1629. Anchor release 1658 26° 30.02'N, 76° 41.9'W (26.50026°N, -76.69838°W).

On completion of WBH1 the swell was large and breaking so deployment of WB2 was postponed for better weather. Commenced CTD winch lowering tests with a chain clump. Test complete and satisfactory by 1500. CTD station to test LADCPs conducted to 1000m. On completion of station hove to to replace the broadband (from the new build unit) to the WHOI unit. 2345 proceeding in heavy swell to mooring position BJB to complete a CTD station. CTD suspended due to increasing swell and winds, speed 35 to 45 kn. Large breaking swells. Weather continued to deteriorate and CTD operations were suspended for the night from 0500.

26th (086)

WB2 (*15291*). A weather inspection at 1200 showed the swell sufficiently abated to begin mooring deployment. On station at 1300. Mooring requires top 100m built and instrumented on deck so we can stream the top of the mooring quickly in the heavy swell (buoy, SBE, 50m, SBE/Sontek). 1420 begin streaming mooring, range 4nm to anchor release position. 1547 at ~1200m wire out, several loose turns developed. Wire stopped off and loose turns removed from reeling winch then relaid.
Anchor release 181907, 26° 32.32’W, 76° 44.22’W (26.51386°N, -76.73708°W). Anchor tracked to bottom. Descent slowed at 1843, bottom at 1851. Descent rate 93m/min. Triangulate release position by steaming a square of 2nmile legs using the closest point of approach to the pinger. A new programme triang.m was written to process these data.

BJA (*15292*). Heave too on mooring site to check bathymetry and ships drift. 2213 started streaming mooring. Anchor release 2315 26° 30.52’N, 76° 50.16’W. Whilst switching off the release pinger the transducer wire caught in prop. Eventually freed 45mins later but tranducer was lost.

27th (087)

Steamed to position close to WBADCP to begin CTD survey along the line of moorings. Station 15293 completed in water depth 36m – much shallower than anticipated from the 1998 cruise report which reported depths greater than 700m in this position. Completed three further CTD stations, then turned to the last mooring.

WB1 (*15297*). 1930 turned on station, began streaming mooring at 1944. A tow of 1.6nmiles at 2.1kn brought us directly over the site identified in the bathymetric survey. Anchor release 212930 at 26° 30.16’N, -76° 48.83’W (26.50266°N, 76.81375°W). Releases tracked down but a pinger drift problem and weak bottom returns prevented a positive identification of the landing time. This is possibly due to the complicated bathymetry at this site. A triangular survey around the mooring to fix the pinger position also gave poor results.

28th (088)

CTDs continue eastward along the mooring line. Finally the weather is hot, sunny and calm after a week of continual strong winds and heavy swell.

29th(090)

Continue CTDs in a westward direction. Last CTD 15304 at 1742. Set course 233°T for Freeport.

30th(091)

Pilot aboard at 1400, berthed by 1500.

Bridge Timetable of Events

D277

Date	Time (UT)	Event
24/02/04	0926	Arrived Santa Cruz de Tenerife End of Cruise 277P 1500-1700 Bunkers taken
25/02/04	1500	Familiarisation of Newly joined Non-RSU Personnel
26/02/04	1030	Emergency and Lifeboat Muster
	1200	Pilot embarked
	1213	Vessel cleared berth
	1225	Pilot disembarked
	1230	Full away. Course 109T
	1246	PES Fish cast outboard 28 28.5N 016 12.0W
	1436	Hove to - testing acoustic releases on CTD cage 28 22.1N 015 51.2W
	1605	CTD and releases veered to 3000m – Hauling 28 22.5N 015 51.0W
	1715	CTD cage and releases inboard
	1724	Resumed 109T at full speed 28 23.0N 015 51.1W
27/02/04	0000	Position 27 57.7N 014 29.7W
	0218	Main Motor failure – stopped 27 56.1N 014 00.2W
	0300	Resumed Passage - Full speed 27 55.7N 014 00.5W
	0628	**Station 15253 - Mooring EB ADCP deployed 27 54.03N 013 25.59W**
	0812	**Station 15254 - Mooring EB H5 deployed 27 51.40N 013 31.24W**
	1027	**Station 15255 - Mooring EB H4 deployed 27 49.93N 013 47.31W**
	1312	**Station 15256 - Mooring EB H3 deployed 27 37.30N 014 12.40W**
	1620	**Station 15257 - Mooring EB H2 deployed 27 29.30N 014 41.07W**
	2034	**Station 15258 - Mooring EB H1 deployed 27 16.56N 015 24.98W**
28/02/04	0052	Hove to - testing acoustic releases on CTD cage 27 01.5N 016 10.6W
	0726	CTD cage and releases inboard – re-locating 27 04.4N 016 06.4W
	1038	Commenced deploying mooring EB 3 27 04.33N 016 07.70W
	1450	**Station 15259 - Mooring EB 3 deployed 26 59.78N 016 13.85W**
	1900	Commenced deploying mooring EB 2 26 50.05N 016 13.80W
	2117	**Station 15260 - Mooring EB 2 deployed 26 53.52N 016 13.99W**
	2236	Set course 249 T Full Away 26 53.6N 016 13.6W
29/02/04	0000	Position 26 48.7N 016 29.6W
	1200	Position 25 57.9N 019 03.7W
01/03/04	0000	Position 25 05.8N 021 43.1W
	0812	Hove to on Station EB1 24 30.6N 023 30.1W
	0827	Commenced deploying mooring EB 1
	0954	**Station 15261 - Mooring EB 1 deployed 24 31.44N 023 26.92W**
	1005	PES Fish inboard. Set Course 270 T – Full away
	1400	Hove to - testing acoustic releases on CTD cage 24 32.0N 024 20.0W
	1452	Recovering Releases due to an administrative mishap
	1528	Releases and CTD frame cast outboard 24 32.3N 024 19.7W
	1721	Stopped at 5000 metres
	1821	commenced hauling 24 32.6N 024 19.0W
	2020	CTD and releases inboard
	2024	Set Course 270 T – full away 24 32.7N 024 18.5W
02/03/04	0000	Position 24 32.0N 025 06.5W

	1200	Position 24 31.7N 027 50.1W
03/03/04	0000	Position 24 32.1N 030 33.2W
	1200	Position 24 30.7N 033 16.1W
04/03/04	0000	Position 24 30.4N 035 53.3W
	1200	Position 24 30.1N 038 34.8W
	1642	PES Fish deployed 24 30.5N 039 38.1W
	1800	PES Fish recovered 24 30.5N 039 53.3W
	2148	In vicinity of site MAR 3 – finding right depth 24 29.8N 040 44.4W
05/03/04	0200	Commenced deploying mooring MAR 3 24 30.1N 041 09.8W
	0335	**Station 15262 - Mooring MAR 3 deployed 24 30.00N 041 12.90W**
	0500	Commenced deploying mooring MAR 4 24 27.6N 041 2201W
	0806	**Station 15263 - Mooring MAR 4 deployed 24 30.12N 041 18.07W**
	1200	Position 24 30.0N 041 56.8W
06/03/04	0000	Position 24 29.9N 044 38.6W
	1200	Position 24 29.9N 047 15.2W
07/03/04	0000	Position 24 29.7N 050 01.8W
	0200	Manoeuvring onto MAR 1 site 24 30.0N 050 16.0W
	0254	Commenced deploying mooring MAR 1 24 27.2N 050 17.4W
	0627	**Station 15264 - Mooring MAR 1 deployed 24 29.50N 050 15.60W**
	0750	Re-locating for site MAR 2
	0946	Commenced deploying mooring MAR 2 24 26.9N 050 36.0W
	1049	**Station 15265 - Mooring MAR 2 deployed 24 28.58N 050 34.20W**
	1054	Set course 270 T – Full away
	1200	Position 24 28.7N 050 47.1W
08/03/04	0000	Position 24 30.2N 053 25.2W
	1100	Hove to on CTD Station **15266** 24 29.9N 055 56.1W
	1205	CTD cast outboard
	1517	CTD veered to 6200 metres – hauling 24 28.8N 055 55.6W
	1735	CTD inboard
	1824	Acoustic Releases & CTD Station **15267** 24 28.0N 056 02.0W
	1959	CTD veered to 5050 metres – hauling 24 27.0N 056 02.1W
	2248	CTD and releases inboard.
	2310	Hove to on CTD Station **15268** 24 25.9N 056 01.4W
09/03/04	0125	CTD veered to 6419 metres – hauling 24 25.4N 056 01.4W
	0318	CTD inboard. – Proceeding full away Course 270 T
	1200	Position 24 30.0N 057 54.5W
10/03/04	0000	Position 24 30.1N 060 30.4W
	1200	Position 24 30.6N 063 13.8W
11/03/04	0000	Position 24 30.1N 065 46.0W
	1200	Position 24 30.1N 068 13.4W
	1555	Altered course to 320 T 24 30.1N 069 07.8W
12/03/04	0000	Position 24 34.7N 070 08.5W
	0654	Altered course to 270 T 26 30.0N 071 00.0W
	1400	Hove to on CTD Station **15269** 26 30.4N 072 37.6W
	1420	CTD and releases cast outboard.
	1625	CTD veered to 5000 metres - hauling 26 31.6N 072 38.4W
	1817	CTD inboard – remaining hove to for stowing equipment.
	2000	All secure – Resumed passage 270 T 26 35.4N 072 42.6W
13/03/04	0000	Position 26 30.8N 073 41.0W
	1030	Commenced deploying mooring WB 4 26 28.5N 076 02.2W
	1520	**Station 15270 - Mooring WB 4 deployed 26 29.98N 075 58.65W**
	1610-1848	searching for surface buoy – no success – release mooring.
	1959	Mooring grappled - 26 29.5N 076 00.9W
	2040-0125	Mooring WB 4 being hauled in and recovered

14/03/04	0125	Mooring WB4 recovered 26 29.5N 076 06.0W
	0140	All secure aft – resumed passage 270 T. 26 29.1N 076 06.8W
	0513	Altered course to 060 26 30.0N 076 56.5W (Elbow Cay)
	0546	Altered course to 310 26 34.0N 076 53.3W (Hope Town Lt.)
	0925	Altered course to 293 27 02.0N 077 29.0W
	1200	Position 27 12.1N 077 56.8W
	1520	Altered course to 270 27 25.8N 078 38.4W
	1758	Altered course to 186 27 25.9N 079 12.0W
	1936	Altered course to 156 27 05.0N 079 14.5W
	2016-2100	**Station 15271 – CTD 122 cast outboard 27 00.1N 079 12.1W**
	2141-2222	**Station 15272 – CTD 123 cast FAILED 27 00.1N 079 17.1W**
	2307-55	**Station 15273 – CTD 124 cast outboard 27 00.1N 079 17.1W**
15/03/04	0036-0142	**Station 15274 – CTD 125 cast outboard 27 00.0N 079 23.1W**
	0236-0352	**Station 15275 – CTD 126 cast outboard 27 00.0N 079 29.6W**
	0454-0552	**Station 15276 – CTD 127 cast outboard 27 00.0N 079 37.2W**
	0640-58	CTD outboard – Failed
	0722-0810	**Station 15277 – CTD 128 cast outboard 27 00.0N 079 41.1W**
	0858-0941	**Station 15278 – CTD 129 cast outboard 27 00.0N 079 46.6W**
	1033-1105	**Station 15279 – CTD 130 cast outboard 27 00.0N 079 51.8W**
	1143	Hove to on CTD station 131 – **abandoned** due to electrical failure.
	1236	Moving westward onto 100 metre line 27 00.0N 079 55.0W
	1307	Altered course to 090 26 59.6N 080 00.0W Commencing ADCP Profiling run.
	2207	End of ADCP Profiling run – altered course to 270 T 26 59.77N 079 10.04W
	2229	Altered course to 163 T 26 59.44N 079 11.86W
16/03/04	0554	Altered course to 024 T 26 02.5N 078 52.5W Commencing ADCP Profiling run
	1156	End of ADCP Profiling run – altered course to 204 T 26 29.52N 078 37.94W
	1218	PES Fish inboard 26 27.95N 078 38.69W **END OF SCIENCE**
	1242	End of passage
	1427	Pilot on board
	1518	First line ashore
	1536	All fast alongside FREEPORT, Bahamas

D278

Date	Time (UT)	Event
16/03/04	1518	Arrived Freeport End of Cruise 277
18/03/04	2000	Familiarisation of Newly joined Non-RSU Personnel
19/03/04	1530	Emergency and Lifeboat Muster
	1705	Pilot embarked
	1718	Vessel cleared berth
	1734	Pilot disembarked
	1742	Full away. Course 117T
	1803	PES Fish cast outboard 26 27.7N 078 45.6W
20/03/04	0000	Position 25 59.1N 077 42.1W
	0252	Altered course to 047 T 25 45.7N 077 10.7W
	0320	Altered course to 018 T 25 48.9N 077 06.9W
	0700	Commencing bathymetric survey 26 30.0N 076 55.7W
	0815	**Station 15280 - Mooring WB ADCP deployed 26 32.34N 076 52.85W**
	0821-47	ADCP survey
	0847	Altered course to 090 T @ 5 knots 26 30.0N 076 52.9W
	1122	Increased to full speed 26 30.0N 076 38.6W
21/03/04	0012	Position 26 29.8N 074 33.0W

	1200	Position 26 30.0N 072 28.7W
	1430	Commencing bathymetric survey 26 30.0N 072 00.9W
	1719	Commence deploying Mooring BJE 26 33.5N 072 05.6W
	2327	**Station 15281 - Mooring BJE deployed 26 29.67N 071 58.28W**
22/03/04	0038-0110	Box surveying mooring site
		0200-0405 Lowering 2 current meters to 2500m 26 32.0N 071 59.4W
		0652-0843 Lowering 2 current meters to 2500m 26 32.6N 071 58.2W
	0930-1328	**Station 15282–CTD cast outboard to 5285m 26 30.4N 071 58.1W**
	1328	Set Course 270 T 26 29.7N 071 57.5W
	1953-2350	**Station 15283–CTD cast outboard to 5021m 26 30.1N 073 21.0W**
	2350	Set Course 270 T 26 30.7N 073 21.6W
23/03/04	0607-0942	**Station 15284–CTD cast outboard to 4454m 26 29.6N 074 42.3W**
	1822	Commence deploying Mooring WB4 26 27.4N 076 05.4W
	2110	**Station 15285 - Mooring WB4 deployed 26 29.95N 076 02.47W**
	2206-0030	Box surveying mooring site
24/03/04	0030-0200	Current meters lowered to 2000 metres 26 29.4N 076 02.9W
	0245-0640	**Station 15286–CTD cast outboard to 4775m 26 30.0N 076 03.7W**
	1030	Hove to on mooring site 26 30.0N 076 30.0W
	1046-1135	Box surveying mooring site
	1247	Commence deploying Mooring BJB 26 24.9N 076 36.3W
	1722	**Station 15287 - Mooring BJB deployed 26 29.95N 076 29.67W**
	1825-1946	Transducer outboard – monitoring mooring
	1948	CTD winch compensator problem – survey work proposed.
	2148	Set course 270 T for survey site 26 30.6N 076 31.9W
	2300	Commenced survey of area WB2 26 30.0N 076 44.5W
25/03/04	0115	Completed survey of area WB2 26 29.2N 076 45.4W
	0140	Commenced survey of area WB1 26 30.8N 076 48.0W
	0355	Completed survey of area WB1 26 29.1N 076 49.4W
	0500	Vessel Hove to in vicinity of WB2 26 29.6N 076 41.7W
	1300	Set course for site WBH2 100 T.
	1443	Commence deploying Mooring WBH2 26 29.6N 076 36.7W
	1515	**Station 15288 - Mooring WBH2 deployed 26 30.03N 076 35.92W**
	1630	Commence deploying Mooring WBH1 26 29.7N 076 42.7W
	1658	**Station 15289 - Mooring WBH1 deployed 26 30.00N 076 41.80W**
	1742-1836	CTD Winch tests underway 26 30.4N 076 39.1W
	1918-2012	**Station 15290–CTD cast outboard 26 31.3N 076 39.4W**
26/03/04	0024	Hove to – To wind & sea – weather to violent 26 30.0N 076 37.6W
	1042	Weather ameliorated sufficiently – heading for WB2 Mooring site
	1300	Hove to for mooring deployment 26 29.1N 076 50.7W
	1420	Commence deploying Mooring WB2 26 29.9N 076 48.9W
	1819	**Station 15291 - Mooring WB2 deployed 26 30.82N 076 44.21W**
	1910-2026	Box Survey of WB2 mooring.
	2127	Hove to for mooring deployment 26 30.4N 076 50.1W
	2213	Commence deploying Mooring BJA 26 28.8N 076 51.6W
	2315	**Station 15292 - Mooring BJA deployed 26 30.52N 076 50.46W**
27/03/04	0100-0335	Transducer survey of mooring BJA
	0335	Set course for CTD station 121 26 31.4N 076 50.5W
	0415-25	**Station 15293–CTD 121 cast out to 36m 26 32.0N 076 53.6W**
	0542-0723	**Station 15294–CTD 120 cast out to 1452m 26 31.5N 076 49.0W**
	0917-1138	**Station 15295–CTD 119 cast out to 2660m 26 30.9N 076 47.1W**
	1406-1655	**Station 15296–CTD 118 cast out to 3601m 26 30.9N 076 45.4W**
	1945	Commence deploying Mooring WB1 26 27.8N 076 51.6W
	2130	**Station 15297 - Mooring WB1 deployed 26 30.17N 076 48.80W**
	2218-0001	Triangular Survey of WB1 mooring
28/03/04	0300-0604	**Station 15298–CTD 117 cast out to 4552m 26 30.2N 076 39.9W**

	0738-1050	**Station 15299–CTD 116 cast out to 4708m 26 30.7N 076 38.3W**
	1207-1532	**Station 15300–CTD 115 cast out to 4850m 26 30.4N 076 32.0W**
	1932-2304	**Station 15301–CTD 114 cast out to 4840m 26 30.4N 076 26.2W**
29/03/04	0130-0527	**Station 15302–CTD 113 cast out to 4850m 26 29.6N 076 18.6W**
	0749-1108	**Station 15303–CTD 112 cast out to 4848m 26 30.2N 076 13.1W**
	1320-1742	**Station 15304–CTD 111 cast out to 4790m 26 29.6N 076 05.4W**
	1742	Set Course 296 T for Freeport 26 29.4N 076 05.7W
	2322	Altered Course to 296 T 25 47.1N 077 10.1W
30/03/04	1215	PES Fish inboard - END OF SCIENCE 26 24.4N 078 38.5W
	1324	End of passage 26 27.2N 078 44.6W
	1424	Pilot on board
	1500	First line ashore
	1506	All fast alongside FREEPORT, Bahamas

Moorings

Appendix A contains schematic representations of the mooring array, and individual mooring diagrams along with plots of the array over bathymetric data collected during the deployment cruise.

Operational Notes

I. Waddington

Cruise 276 Preparation.

The mooring equipment for the array was shipped out of SOC and arrived at King George V dock Govan – Glasgow Monday 9th February. Throughout 9th to 11th February all the equipment was loaded, fixed down and deck winch system fitted.

The GONIO rdf system was fitted into bridge with cables run to bridge top for the rdf antenna. The system was aligned with one of the new SMM SIS 500 beacons at which point it was discovered that the id returned on the Gonio was not that of the new SIS 500. Contact was made with RS Aqua where an incompatibility between the new SMM500 and the older Gonio deck unit was determined, all the new series SMM500 beacons will deliver an id of 3453.

Some preparation of instruments was commenced with fitting of batteries to SBE37 units.

The ship sailed for the Trials cruise at 1400h 12th February.

Preparation was commenced on assembly of Eastern Boundary dual acoustic release units and individual units lab tested.

Throughout 13th February all the Billings Marker floats were assembled on deck and testing of the SBE37 units for the Eastern boundary was well underway.

From 14th to 16th February modifications were underway to the Eastern Boundary SBE 37 clamps for polyester rope attachment and SBE37 tests of sampling and logging completed. Ixsea BPRs were tested.
Clamps and spacers manufactured to accommodate the Ixsea BPRs to the tripod anchor assemblies.
BPR SBE26 drop off assemblies 6 off put together.

From 16th to 17th February parts were manufactured to protect Idronaut end cap switch and all mooring attachments modified for polyester attachment.
SMM 500 and Novatech beacons were assembled to subsurface masts, modifications being made to reduce the number of Stauff fittings involved.
S4D, Ixsea BPR, RCM 11,SBE26 and RBR CTD units set up for logging tests.
Ixsea BPR set up using Sealog software.

18th February to 19th February, Data checking on all test run instruments.

Mooring layout checks and drawings prepared, static loading checks on all mooring designs carried out to validate anchoring arrangements.
Idronaut CTDs set up for testing

20th February to 21st February,
McLane moored profiler EB2 run tests.
Run test on BBADCP, failed to run.
Termination of telemetry umbilical and modifications.

22nd February to 25th February – In port preparation for deployments. Power up and run winch system.
Tenerife

Cruise 277 Deployments and preparation.

26th February sailed at 1200h
Set up test rig for wire testing acoustic releases for Eastern Boundary array. BBADCP repairs and testing. Set up BBADCP for Eastern deploy. Set up SBE37 loggers for Eastern Boundary. Prepare moorings ADCP and EBH series. Wire test acoustic releases

27th February
Deploy ADCP east. Deploy WBH 5, 4,3, 2, 1. Modify dropper bars for dual releases increase chamfer at spigot end.

28th February
Deploy EB3 and EB2

29th February
Preparation for EB1

1st March
Deploy EB1. Wire test acoustic releases for Mid-Atlantic array. Winding on lines for MAR 3 to wooden drum for deploy. Wind on 4500m for MAR 4. Umbilical preparation splicing for Western array

2nd to 4th March
Mid-Atlantic array preparation. PES repairs

4th March
Echo sounder survey of MAR 3 and 4

5th March
Deploy MAR 3. Deploy MAR 4. Continued prepn. Of telemetry umbilical

6th March
Wind on MAR 1 and prep line for MAR2. Prepare instruments. Echo sounder survey of MAR 1 site

7th March
Deploy MAR 1. Deploy MAR 2.

8th March
Continue work on telemetry umbilical. Preparing hardware for Western Boundary array. Wire test acoustic releases. Preparing instruments.

9th March
Wind on WB4 mark instrument positions. Clean off paint from DBC drums. Preparing instruments

10th to 11th March
Complete modifications to telemetry parts. Chip and paint reeler, new rollers made for reeling gear. Preparing instruments

12th March
Acoustic release wire test, repeats. Power up instruments. Re-stow deck and moving buoyancy

13th March
Deploy WB4. See detailed report on problems. Recover WB4

14th to 15th March
Wind off wrecked wire from WB4. Check wires in hold and redesign a replacement mooring

16th March
Dock Freeport

17th to 18th March
Re-stow and bring up spares for rebuild of WB4 mooring. Load Miami equipment. Wind on Miami mooring in port

Cruise 278 Deployments and preparation.

19th March
Sail Freeport 1200h. Prepare ADCP west mooring

20th March
Deploy ADCP west mooring

21st March
Deploy Miami mooring. Sontek wire tests.

22nd March
Redesign Mooring WB4 – this now profiler mooring moved from WB2 site. Addition of buoyancy and increase in anchor weight. Wind on mooring WB4 revised. Set up 50 inch and anchor with chains etc. Change recovery buoy to 17 inch glass due to max expected knock down possibly deeper than 400m. Check design of WB4 given extreme current profile. Produce new drawing – amend spreadsheet and parts list

23rd March
Check Mooring WB4 for profiler set ups. Re-allocate instruments for WB2 – WBH1 – WBH2. Deploy revised WB4. Revised slip technique for Profiler using guide through block on crane to maintain better height and control. Wind on Miami mooring and adjust glass spheres.

24th March
Deploy Miami Mooring – Lumpy - all went smoothly. Wind on for WB2. Instruments powered up. Prepare polyesters for WBH

25th March
Deploy WBH2 and WBH1 – hand deploy with anchor on release hook on crane. Prepare buoyancy for WB2 as used on WBH 1 and 2. Redesign WB1 and instrument allocate

26th March
Deploy WB2. Marginal conditions. Navigate mooring in using pinger mode on RT661. Steam box at 2 mile sides. Pinger OFF. Deploy Miami Mooring. Dunker caught on prop shaft freed but dunker txdcer lost

27th March
Wind on WB1. Add 150 kg of chain to anchor – wound into wheels and securely lashed. Deploy WB1 in lumpy conditions.
Measure line tension during tow.

1.9 kts	160 kg peak
2.6 kts	300 kg peak
3 kts	350 kg peak

Deployed – no time on bottom – as pinger not switched on – On deck.
Pinger on RT661 162 has a definite slew and progresses left to right across screen of waterfall. Looking at waterfall display – reverb/echo from glass spheres at 5m delay
Navigate in using triangle of courses. Move back to anchor release and tx OFF – slant range 1380m. TX OFF pinger to AR861 off observed on Waterfall.

28th March
Sort and stow all deck and hangar mooring parts. Deck stowed for transit back to UK. Measure DBC back tension. Secure hangar stowage

29th March
Lab packing. Download pc to pcmia card and Portable dell. Meeting – cruise wash up
Meeting – year plans for Knorr

30th March
Docking Freeport – Bahamas at 0900 h

Mooring Deployment methods

I. Waddington

The mooring design for the array moorings was conducted to provide a minimised drag configuration coupled with high reliability components. As design progressed it became apparent that with these designs the deployment method must be buoy first anchor last freefall, other than the ADCP simple short moorings. To this end methods were prepared well beforehand to utilise the Double Barrel Capstan (DBC) winch system and ships cranes. This as a proven method developed by UKORS on RSU vessels for several years.

As there are distinct mooring types and methods this is discussed by type and mooring numbers indicated.

ADCP moorings
Eastern Boundary and Western Boundary.
There are 2 moorings of this type deployed each in approximately 500 metres of water. The mooring is a conventional short mooring with single floatation containing a 150 kHz ADCP which is moored to the seabed through an acoustic release to a deadweight, railway wheel anchor. This mooring is lifted overside all connected together to the anchor using the aft ships crane. In this configuration the lift height and air weight were adequate for a single lift. The vessel is nominally hove to on the deployment position.

The ADCP buoy is lifted off the deck by crane using a load release hook and raised such that the mooring is lifted vertically to the anchor. In calm weather this operation is quite safe. If there is any movement on the vessel then slip/steady lines are attached at the anchor and the ADCP buoy framing to control the lift.

With the mooring lifted and the anchor just off the deck the crane is slewed overside and lowered such that the anchor enters the water quickly. With the anchor in the water the mooring is then relatively stable. The slip lines at the anchor can then be removed.

Continued lowering of the crane then places the ADCP buoy into the water, at this point. The slip lines on the framing are slipped clear and the recovery line and float can be slipped overboard clear of the ADCP buoy.

When all is ready, position and depth checked the load release hook is triggered and the mooring then freefall to the seabed.

CTD slope moorings
EBH mooring series EBH 1 to 5 and WBH moorings WBH 1 and 2

These moorings are designed to be simple ctd moorings suitable for rapid and simple deployment. No winch is required for this operation although the DBC was ready with a rope attached should it be necessary to haul back the mooring.

All the polyester lines are flaked into fish baskets and connected together with in line buoyancy and clamp on CTD loggers and other in-line instruments attached. The mooring line is connected to the anchor/release/tide gauge tripod which is placed at the stern connected through a load release hook to the crane, this in readiness to swing the anchor outboard and into the water.

The moorings are relatively lightweight and all components can be manhandled by 1 or 2 persons. The ship is positioned some 0.5 kilometres downwind of the proposed site and proceeds at around 0.5 knots towards the mooring site. The recovery float, marker buoy and top buoyancy package are deployed over the stern by hand at this slow speed.

With the buoys in the water the vessels speed is increased to 1 to 1.5 knots and as the buoys stream astern the mooring line, buoys and instruments are all hand deployed over the stern, care being taken to maintain tension in the mooring line to prevent tangling.

The mooring payout is controlled by one person on the stern with assistance in bringing instruments and buoyancy to the stern from other hands. Care is taken throughout that no-one is positioned in a bight of the line being paid overside.

As the line reaches the tripod the tension is allowed to come onto the tripod buoyancy and this then pulls out from the top of the tripod. The tripod assembly with anchor is then lifted overside by crane and lowered into the water. Care is taken to ensure the buoyancy and mooring line do not tangle at the tripod. With the tripod submerged and checks of position and depth having been made, the mooring line leading clear, the load release hook is triggered and the anchor freefall to the seabed.

If towing onto position is required the tow is made with all the mooring deployed, the tripod attached to the crane by release hook and the tripod secured back to strongpoints by slip lines. With the ship on position the slip lines are freed as the crane lifts the tripod overside for deploy.
Towing speed can be up to 3kts.

The mooring is observed visually as it sinks and observations continued until all the mooring is seen to submerge. In the case of these moorings some of which were night deployments the xenon navigation light can be seen throughout the operation.

Future deployments – To enable less sea preparation for future deployments an improvement can be made by flaking the lines down into fish baskets at SOC prior to shipping. This will reduce preparation time at sea and pre-check all the mooring lines.

CTD deepwater moorings
Moorings EB1, MAR 2 and MAR 3

The moorings for deepwater CTD measurements are essentially similar to the simple slope CTD moorings but use much longer mooring line lengths and increased buoyancy. Thus deployment is made through the DBC to control payout and attachment of instruments and buoyancy.

The mooring polyester is all pre-wound onto a single wooden drum with each mooring connection having shackles and links fitted. This is placed behind the DBC drums and is hand controlled during pay out and haul in, for stopping off.

Deployment commences some 1 mile to 1.5 miles downwind of the mooring site and using the DBC and crane the upper floatation, marker and recovery buoys are deployed. The mooring is then streamed astern with the vessel making 1 to 2 knots towards the mooring site.

The anchor tripod is moved into position at the stern during deployment and prepared with floatation and lifting /release link. Secured with slip lines to strongpoints.

Stopping off to insert instruments is by deck chain and BOSS hook into the pre-prepared links in the mooring line.

As the last mooring line is being deployed a tail rope is prepared to allow transfer of the mooring line to the tripod. This can also be used as a control / tow line. The mooring line is then transferred to the tripod and secured, by using the crane and DBC the line tension is transferred to the tripod and the DBC line removed or in the case of a towing situation the DBC line is left in position for the duration of the tow. Both as a towline and as a safety line.

When on position the tripod/anchor is lifted overside on the release hook attached to the crane and with the tripod submerged the release hook is triggered to allow the freefall of the mooring.

As these moorings are comparatively long it is not possible to observe the marker float submerge and as such the preferred method is to observe descent of acoustic release using either transponder mode or pinger observations on the Waterfall display. Transpond method with dunker is not usually very useful due to ship noise and as such the preferred method is with the Waterfall and echo sounder fish or towed fish.

As the echosounder fish was out of commission during the deployment of these moorings, descent monitoring was not carried out.

Future deployments – To enable less sea preparation for future deployments an improvement can be made by pre-winding these moorings to a single drum at SOC prior to shipping. This will reduce preparation time at sea and pre-check all the mooring lines.

Echosounder fish or overside fish must be available to monitor mooring descent.

Moored Profiler Moorings
EB2 MAR4 WB4

The Moored Profiler moorings (MMP mooring) are single wire length moorings with a McLane MMP traversing the length of the wire at preset sampling intervals. Thus the mooring is constructed of one long profiler wire and additional adjustment wires as necessary.

Due to this construction it is essential that the mooring site is surveyed in prior to deployment to establish an accurate depth.

When preparing for deployment the long profiler wire is wound onto the storage drum through the DBC. Tensioning and correct laying on of this wire is essential. Winding on can take 2 to 3 hours for a 5000 metre mooring.

The mooring site is initially survey in to determine localised topography and courses to steer and speeds to determine start point with respect to wind direction.

The ship then proceeds to the start position and heaves to. All the upper mooring components are connected together to the MMP stop which is attached to the wire. This enables the buoy to be streamed quickly away to a safe distance on deployment. The upper 25 metres of wire is carefully flaked down on deck. In deployments EB2 and MAR4 the stop was attached after the buoy had been deployed, this took time and could cause undue tension on the wire as the buoy is close up to the ships stern at this point.

Deployment commences with the ship at 1/2 to 1 knot ahead on deployment course. The subsurface buoy and current meter are lifted outboard by crane using a load release hook. With the buoy in the water the load release hook is triggered and the buoy floats free. At this point care to pay out the flaked down 25 metres of mooring wire to the MMP stop is required, this is done by hand.

The mooring line is then paid away using the DBC with the line through a wide throat sheave on the crane. When 300 or more metres of wire are paid out, or the tension is consistent and adequate the crane is lowered bringing the mooring line down to deck level. This then allows the mooring line to be placed through the MMP which is lying on its side on the deck. It is best to have good tension and not to have the mooring line snatching form taut to slack. If this appears to be the case then more mooring line is paid out.

With the MMP correctly attached around the mooring wire a slip line of 6mm polyester is run through the rope loop on the lower casing of the MMP. This doubled line is then brought back through the crane eye at the widethroat sheave and one end secured to a strongpoint. The other end around a deck eye and controlled by hand. Thus as the crane raises the MMP control is maintained on the MMP and the control line is parallel to the mooring line. With the crane at an adequate height the MMP should be well off the deck and the crane then slews astern. Position of the MMP is maintained by the slip line and no winch operation is required.

The MMP is controlled by the slip line and as the MMP gets clear of the stern the slip line can be paid out allowing the MMP to slide gently down the wire into the water. The slip line is then slipped clear of the MMP and retrieved to the tied off strongpoint. The MMP then slides away down the mooring wire.

The winch then continues paying away the mooring wire to the bottom stop of the MMP and glass buoyancy. The mooring wire is stopped off to a chain deck stopper using a BOSS hook into the oval link. The arrangement of transfer of load from the buoyancy / current meter to the anchor release assembly is achieved using a slip line pulled back by the DBC. The anchor must be secured by tether lines to strongpoints as when towing is required the anchor must be secured.

Towing can then commence onto the final mooring position, this may take minutes or hours. Towing can be at speeds up to 3 knots dependent on weather conditions. In line tension for this mooring will not exceed 300 to 500 kg.

When near to position the acoustic release pinger is started on deck. The ship is normally then slowed to 1 to 1.5 knots for the final deployment. When close to position the anchor is swung outboard on the crane using the load release hook and lowered into the water. The anchor can then be released when on position.

As the anchor is released the ship heaves to such that observations can be made acoustically of mooring descent and on seabed time can be determined. The ARGOS transmission is monitored throughout using the GONIO receiver. This determines whether the top buoy has submerged.

Future deployments – The procedure above was evolved through the three mooring operations carried out and is the final version at WB4 which worked well in quite lumpy conditions. It should be noted that care has to be taken when doing the final deployment that the anchor is in the water and the acoustic release / BPR assembly can be seen quite clearly to be streaming above and clear of the anchor before anchor drop.

Telemetry buoy moorings
EB3 and initial WB4

This prototype mooring had not been deployed previously and as such required considerable planning as to how the mooring was deployed.

Winding on of the inductive mooring wire is prepared some hours in advance and great care taken not to damage the outer jacket. If damaged the induction telemetry could fail.

The initial EB3 mooring was deployed with the telemetry umbilical flaked out on deck in large loops. This worked but could have been hazardous.
For WB4 the telemetry section was flaked down in its large transit box and deployed from the box. Initially the Telemetry buoy is attached to its umbilical and to the subsurface sphere which is placed at the stern with the mooring wire laid back through a widethroat sheave to the DBC. The Telemetry buoy is lifted overside using the port crane and load release hook, when in the water the buoy is slipped free.
The umbilical tether and buoys are then deployed by hand with the ship making around 1 knot through the water.

As the tether has been previously attached to the subsurface buoy and the mooring wire on the winch as the load comes onto the subsurface buoy the starboard crane can lift the buoy using the widethroat sheave and DBC and deploy overside.

Deployment then continues as for a long wire mooring. In the case of the inductive mooring all the instruments and buoys are clamp on.

As with the previously described mooring towing and anchor deployment is the same procedure.

The mooring wire is stopped off to a chain deck stopper using a BOSS hook into the oval link. The arrangement of transfer of load from the buoyancy / current meter to the anchor release assembly is achieved using a slip line pulled back by the DBC. The anchor must be secured by tether lines to strongpoints as when towing is required the anchor must be secured.

Towing can then commence onto the final mooring position, this may take minutes or hours. Towing can be at speeds up to 3 knots dependent on weather conditions. In line tension for this mooring will not exceed 300 to 500 kg.

When near to position the acoustic release pinger is started on deck. The ship is normally then slowed to 1 to 1.5 knots for the final deployment. When close to position the anchor is swung outboard on the crane using the load release hook and lowered into the water. The anchor can then be released when on position.

As the anchor is released the ship heaves to such that observations can be made acoustically of mooring descent and on seabed time can be determined.

It may be possible to visually observe the surface Telemetry buoy and track its progress along the surface as the mooring descends. This was the case with EB3 where the mooring could be observed to settle on position and the umbilical support floats then return to the surface as the mooring becomes upright.

In the case of WB4 the failure of the mooring to deploy correctly was directly attributed to the extreme current conditions at the site.

Long wire replacement mooring
WB2 renamed due to position change deployed as replacement for WB4

This mooring was designed and built onboard to replace the failed WB4 inductive mooring. The design uses distributed buoyancy now on chains with instruments still as clamp to wire. The wire is now not continuous and is the spare 2005 wires.

The deployment is very similar to the inductive mooring but with stopping off being required to attach buoyancy. Anchor deployment and towing procedures as previous with the addition of an ARGOS beacon to the subsurface top floater. Thus submergence of the buoy could be monitored.

Long wire Current Meter mooring
WB1

The mooring is quite conventional in construction with the addition of distributed back up buoyancy in the form of glass spheres along the mooring. Deployment is conventional using stop off procedures to insert instruments and buoyancy.

Towing and anchor deployment is as detailed above. Due to the rapidity of deploying this mooring there was considerable towing onto site. This enabled in line tow tensions at various ships speeds to be recorded for future reference.

Mooring Locations and Depths

Table 4: Mooring locations, deployment dates and Argos beacon details

Mooring	Discovery Station Number	UKORS Mooring Number	Latitude (°N)	Longitude (°W)	Corrected Water Depth (m)	Deployment Date	Deployment Time (GMT)	Argos Platform i.d.
EBADCP	15253	2004/01	27.9005	13.3935	436	27/02/2004	06:27	23831
EBH5	15254	2004/02	27.8567	13.5207	1015	27/02/2004	08:10	n/a
EBH4	15255	2004/03	27.8322	13.7886	1510	27/02/2004	10:27	n/a
EBH3	15256	2004/04	27.6224	14.2054	2005	27/02/2004	13:11	n/a
EBH2	15257	2004/05	27.4880	14.6846	2510	27/02/2004	16:16	n/a
EBH1	15258	2004/06	27.2760	15.4166	3012	27/02/2004	20:32	n/a
EB3	15259	2004/07	26.9961	16.2306	3515	28/02/2004	14:50	n/a
EB2	15260	2004/08	26.8917	16.2339	3532	28/02/2004	21:17	42748
EB1	15261	2004/09	24.5239	23.4488	5000	01/03/2004	09:55	n/a
MAR3	15262	2004/10	24.4998	41.2153	5200	05/03/2004	03:40	n/a
MAR4	15263	2004/11	24.5019	41.3012	4730	05/03/2004	08:06	42749
MAR1	15264	2004/12	24.4914	50.2604	4760	07/03/2004	06:28	42747
MAR2	15265	2004/13	24.4760	50.5704	5050	07/03/2004	10:50	n/a
BJE (RSMAS)	15281	n/a	26.4945	71.9712	5295	21/03/2004	23:27	n/a
WB4	15285	2004/16	26.4907	76.0433*	4790	23/03/2004	21:11	42746
BJB (RSMAS)	15287	n/a	26.4992	76.4945	4846	24/03/2004	17:22	n/a
WBH2	15288	2004/17	26.5003	76.5992	4800	25/03/2004	15:31	n/a
WBH1	15289	2004/18	26.5003	76.6984	4287	25/03/2004	16:58	n/a
WB2	15291	2004/19	26.5153	76.7410*	3898	26/03/2004	18:19	42745
WB1	15297	2004/20	26.5027	76.8138	1382	27/03/2004	21:30	42750
BJA (RSMAS)	15292	n/a	26.5087	76.8410	1003	26/03/2004	23:15	n/a
WBADCP	15280	2004/15	26.5391	76.8810	395	20/03/2004	08:15	21442
Initial WB4§	15270	2004/14	n/a	n/a	n/a	13/03/2004	15:19	n/a

*All positions show anchor release positions except WB2 and WB4 where the seabed anchor position was determined by triangulation of the acoustic release pinger

§Initial WB4 deployment was recovered on the same day as deployment following submersion of the telemetry buoy, with the mooring design subsequently deployed as WB2

Instruments

Summary of Instruments Deployed

Table 5: Summary of instruments deployed (UK Moorings)

Instrument type	Manufacturer and Model	Total Number Deployed
CTD	Seabird SBE37 SMP Microcat Seabird SBE37 IMP Microcat RBR XR420 Idronaut Ocean Seven 304	68 (+1 lost) 15 2 2
Single Point Current Meter	Interocean S4AD (electromagnetic) Sontek Argonaut MD (acoustic) Aanderaa RCM11 (acoustic)	15 12 (+1 lost) 8
Bottom Pressure Recorder (BPR)	Seabird SBE26 Ixsea OT660C Aanderaa WLR8	15 2 2
Current Profiler	RD Instruments 150kHz BB ADCP	2
Current/CTD Profiler	McLane Moored Profiler	3

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

Problems encountered during instrument setup.

D. Rayner

When trying to set the date on the Seabird SBE26 tide gauges it was found that they do not recognise the 29th February 2004 as a leap year and skip on one day to give the date 1st March 2004. This was discovered after deploying 5 of these instruments. The date will therefore be incorrect from the 29th February 2004 in the data collected. Seabird were contacted about this and stated that the post-processing software will be modified to account for the missing date. The instruments that will be affected have serial numbers 391, 389, 390, 388 and 387 deployed on moorings EBH3, EBH2, EBH1, EB3 and EB2 respectively. The SBE26 deployed with mooring EB1 was setup on the 29th February 2004 but was set to 28th February 2004 so that when the date skips on at midnight it will be the correct date. This mooring was deployed on the 1st March 2004 and so the first day of logged data when the date is incorrect is when the instrument is out of the water and so will be removed during processing.

A number of the SBE37 SMP CTDs were deployed with the date set incorrectly. The time and date need to be set together but using different commands. If the date is set without subsequently setting the time then the change is not stored. If the time is set without first setting the date then the date reverts back to when the date was last set. This led to the date being wrong on 2 instruments when they were deployed, and will need correcting during processing. The SBE37 SMPs affected have serial numbers 3277 and 3269 and were deployed on moorings EBH2 and MAR2 respectively.

When setting the date on the inductive SBE37 IMP for mooring WB2 the global date and time commands were used to set the date and time on all the IMPs connected to the test loop. However during the subsequent set up procedures it was discovered that the date had not been set correctly on one of the instruments and the time was often a few seconds different between instruments. It is recommended that the global date and global time commands are not used in the future and instead the date and time should be set for each individual instrument.

During the cruise it was discovered that a number of the Interocean S4s were not set to average the collected samples over the 2 minute sampling period and that the memory of these instruments would become full after 7.5 months. Unfortunately this mistake in the setup procedure was not discovered until after 11 S4s had been deployed. The remaining S4s were set to average the 2 minutes of 2Hz sampling into 1 record to provide sufficient memory capacity.

The ADCP on the western boundary was set to have a sampling interval of 10 minutes instead of 15 as planned. This should cause the memory to be full after 384 days which may be before the planned recovery cruise. Data will therefore be lost at the end of the deployment.

The baud rate on the Sontek Argonauts needs to be 600 to be used with the inductive modem, but when it comes to downloading the Sontek recorder software requires that the instrument baud rate be set to at least 9600 before it can be downloaded. This is prior to the software setting the baud rate to a temporarily high value to enable faster download.

When the recovered instruments from the initial deployment of WB4 were redeployed on WB2 the Sontek Argonaut and SBE37 SMP couplings were set to log data individually, however the Sontek Argonaut requires the SBE37 to be connected when setting up the current meter. The SBE37 can be disconnected from the Sontek Argonaut after the instrument is started and can then be set up separately. It is not yet known whether the Sontek Argonaut will require a SBE37 connected to it during data download.

The Broadband ADCP with serial number 1184 experienced problems when running the pre-deployment tests on the recorder. This was attributed to a corrupted Flash memory card. Initial attempts to substitute the faulty Flash card with another failed due to the replacement card being of too high a capacity, meaning that it could not be read correctly by the ADCP. A second replacement card was poached from one of the Workhorse Sentinel ADCPs from the CTD package, and this solved the problem.

Acknowledgements

Captain Roger Chamberlain was ship's master for the four cruises associated with this project, departing Glasgow on the 11th Feb 2004 for Tenerife (D276) and finishing in Tenerife on the 10th May (D279), before returning the ship to Glasgow arriving on the 18th May. This continuity was important for achieving so much work so safely. Ian Waddington led the moorings group, who met all our objectives and worked in a highly professional manner.

Appendix A: Figures

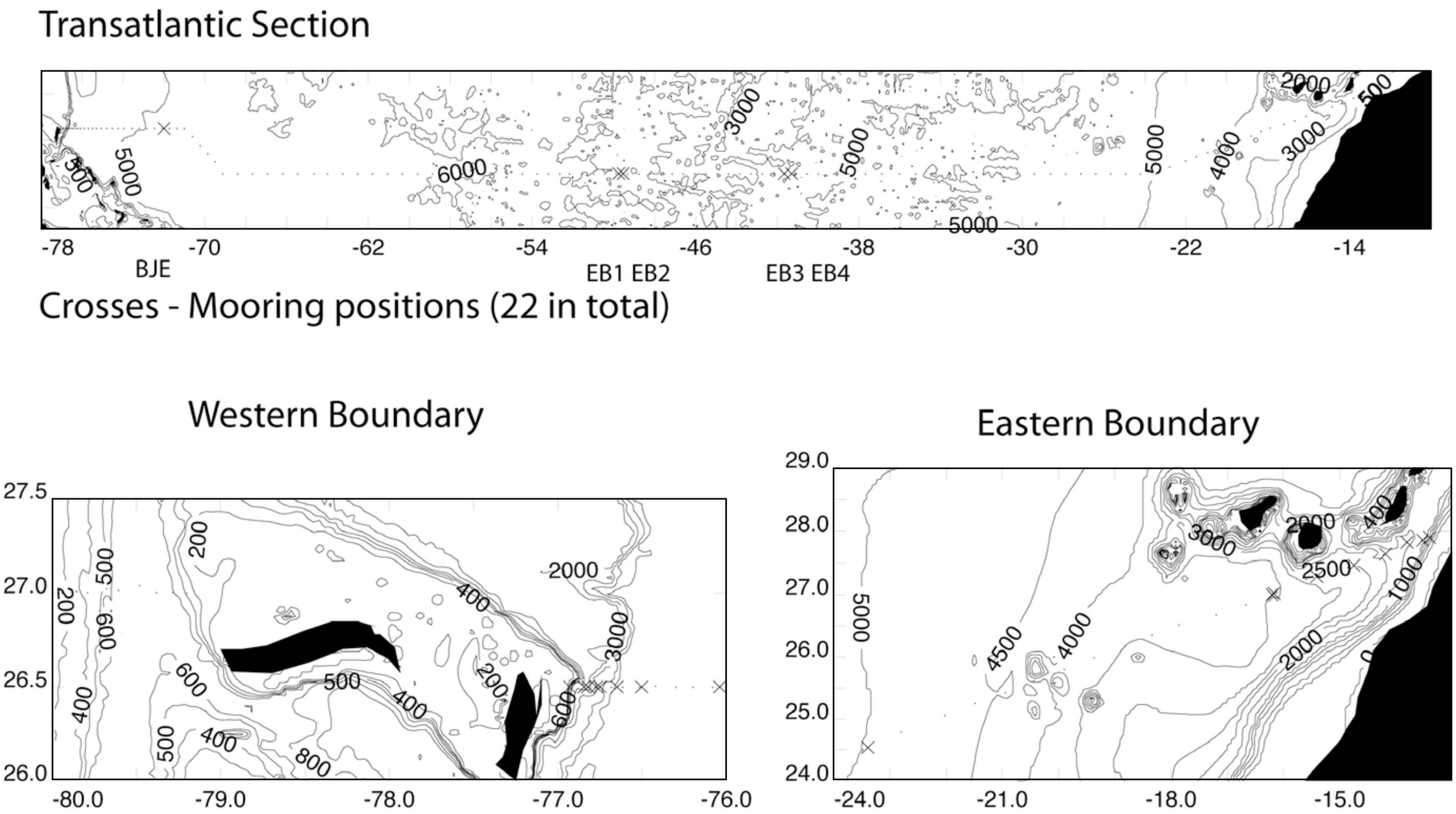


Figure 1: Chart of Array Area Showing Mooring Locations (crosses) with D279 CTD Stations (dots)

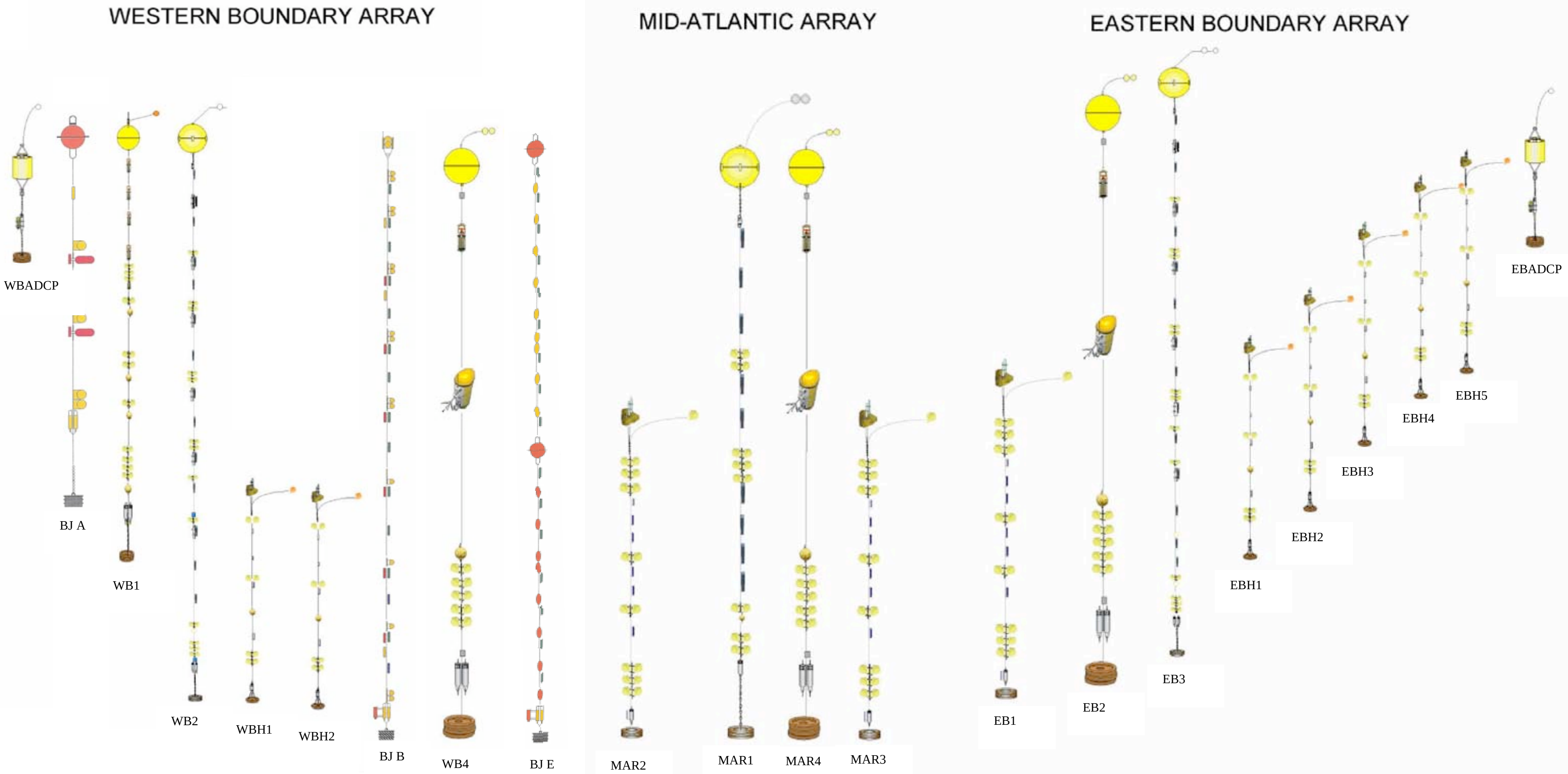


Figure 2: Schematic of Whole Array (SOC moorings begin with WB, MAR, EB - RSMAS moorings are BJA, BJB & BJE). Individual moorings schematics Figures 7 – 29.

Figure 3: Whole Mooring Array as Deployed 2004

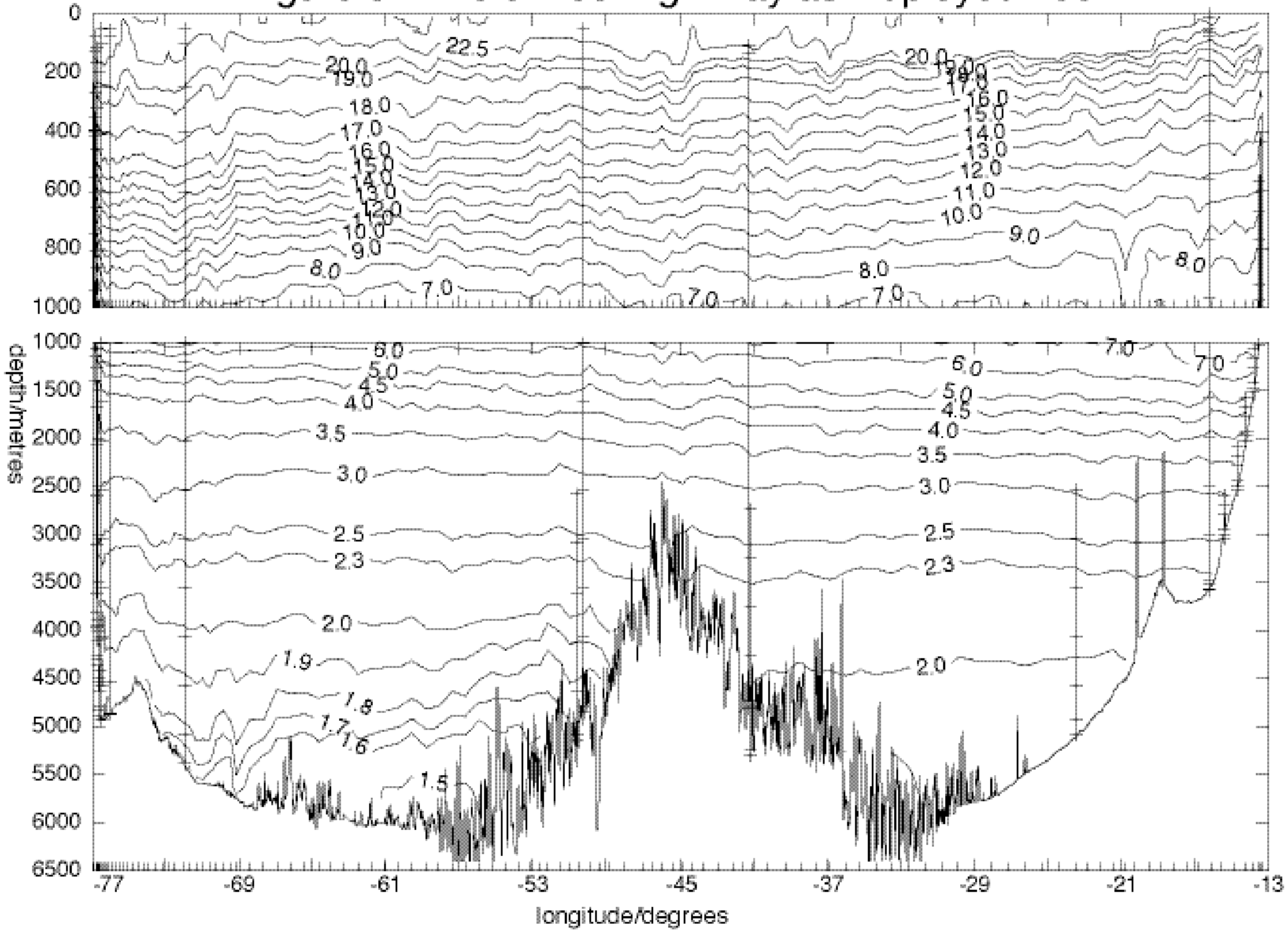


Figure 4: Eastern Boundary Mooring Array as Deployed 2004

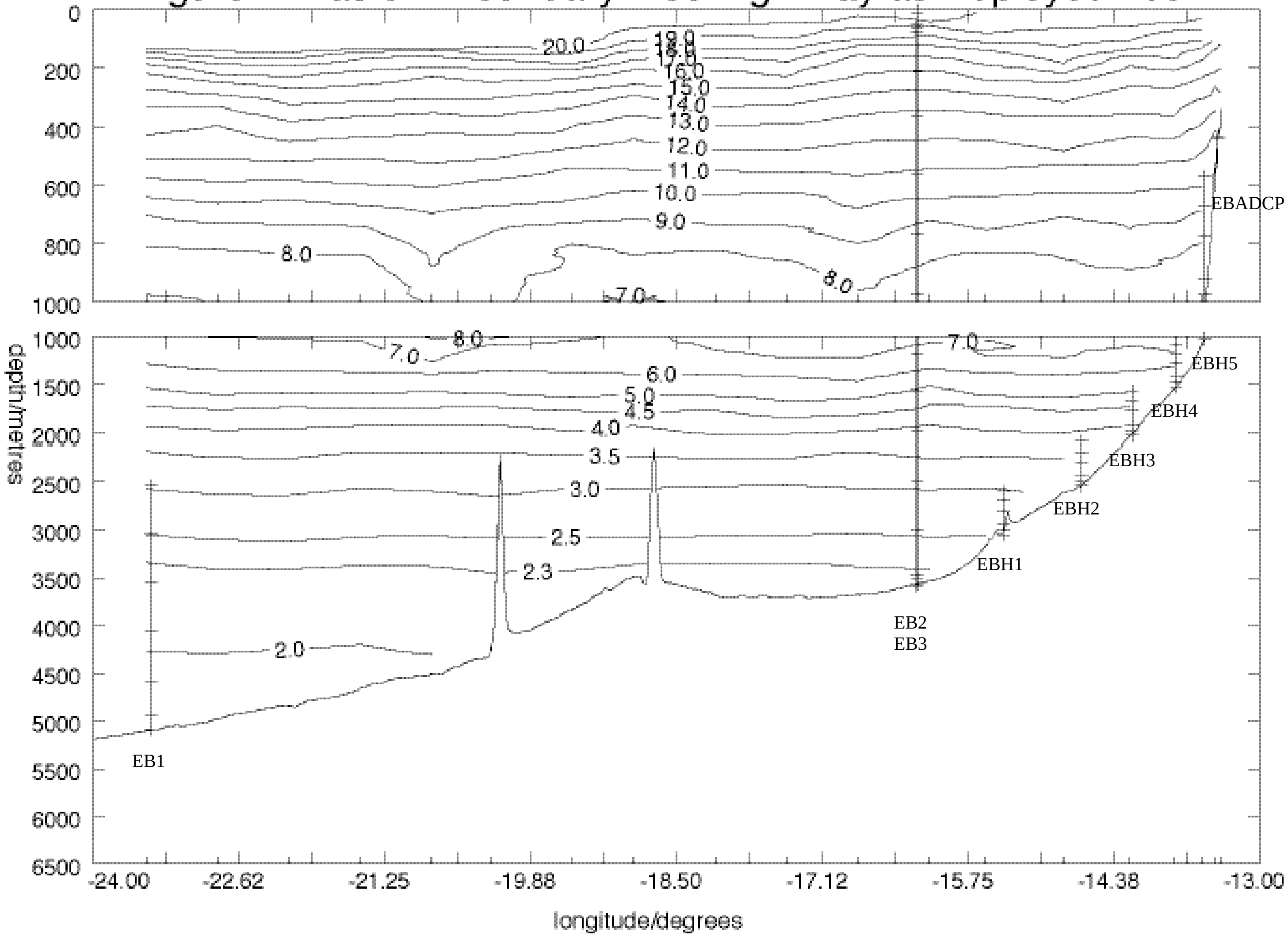


Figure 5: Mid Atlantic Ridge Mooring Array as Deployed 2004

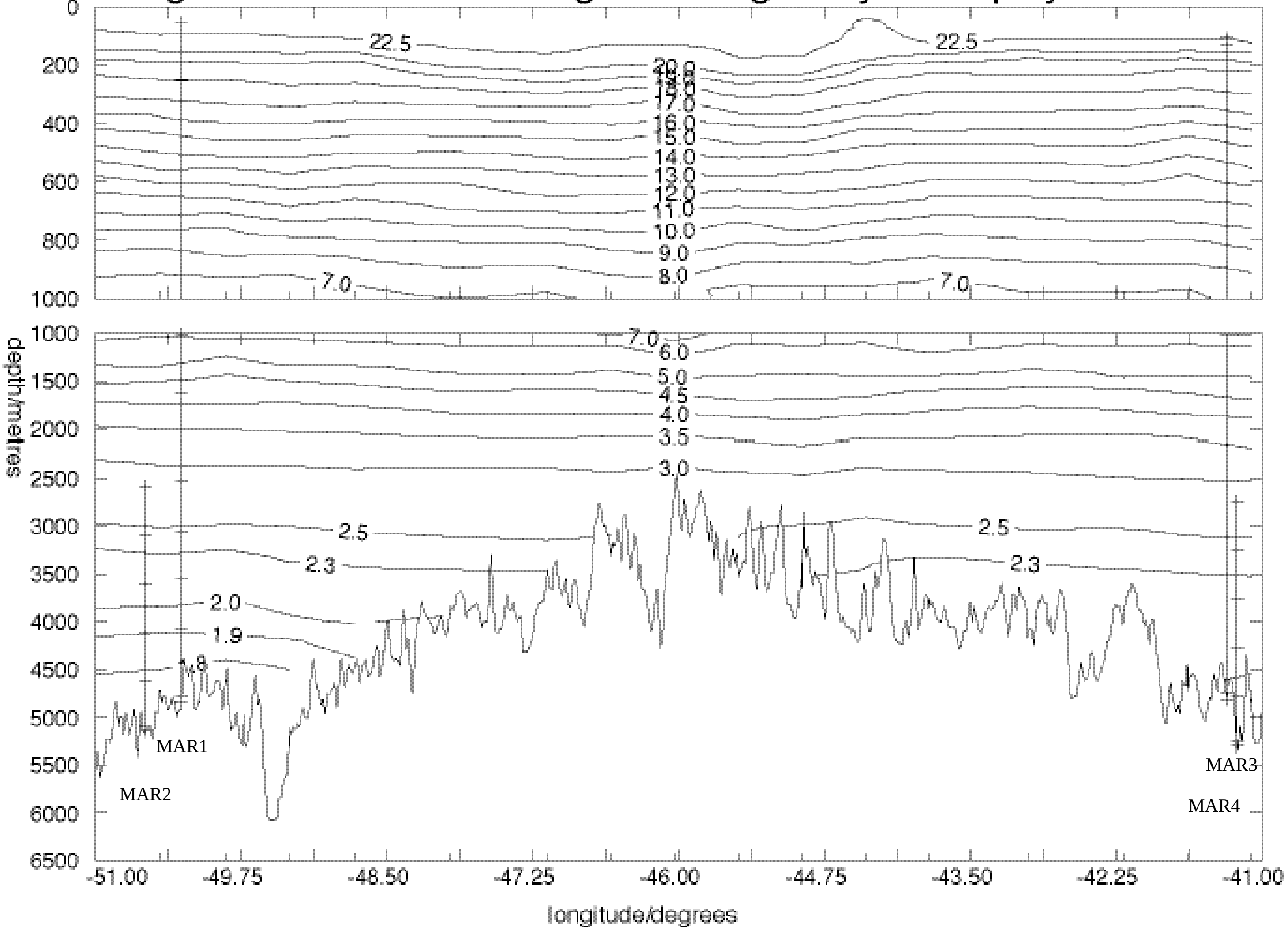


Figure 6: Western Boundary Mooring Array as Deployed 2004

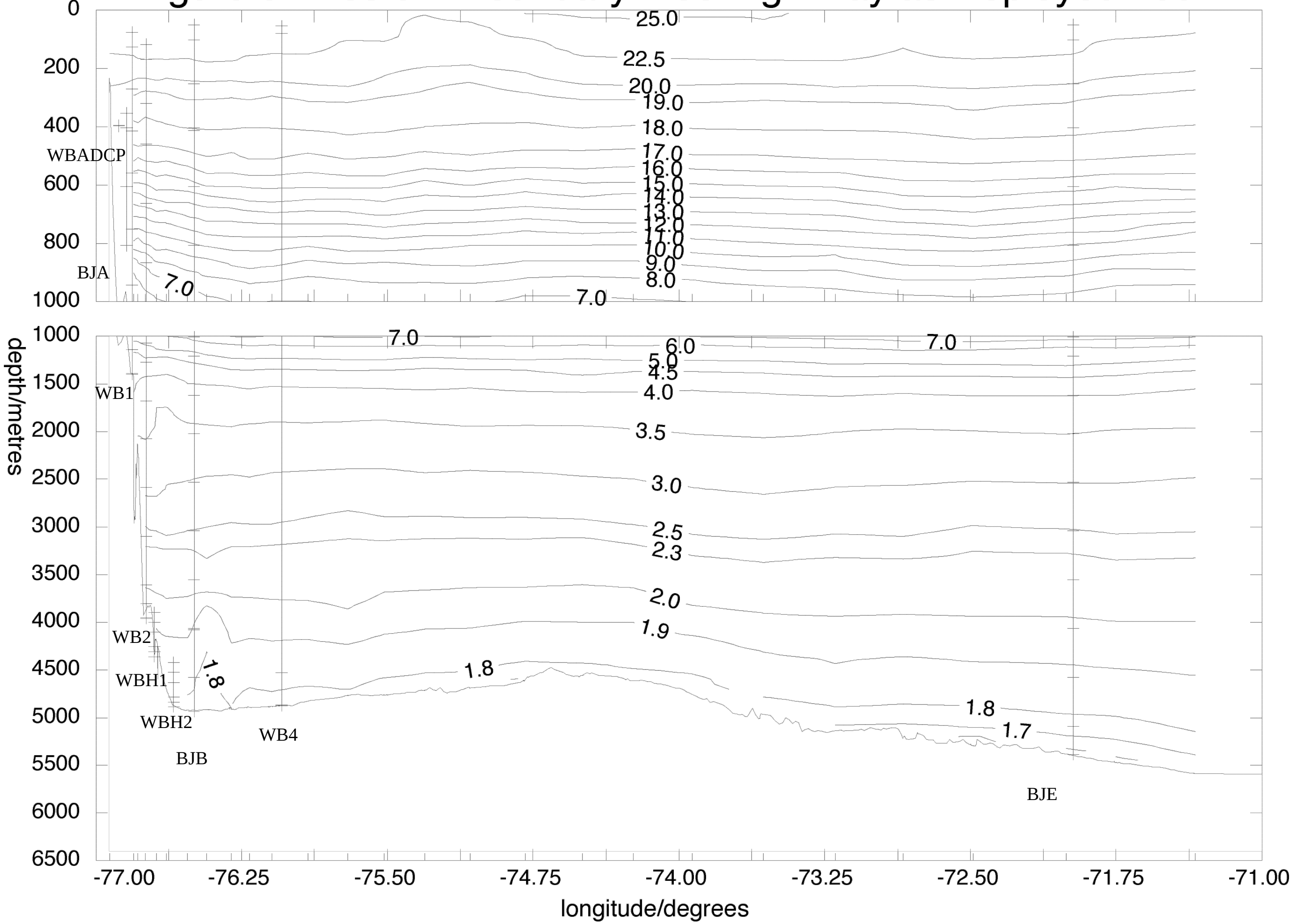


Figure 7 Mooring Diagram of EBADCP

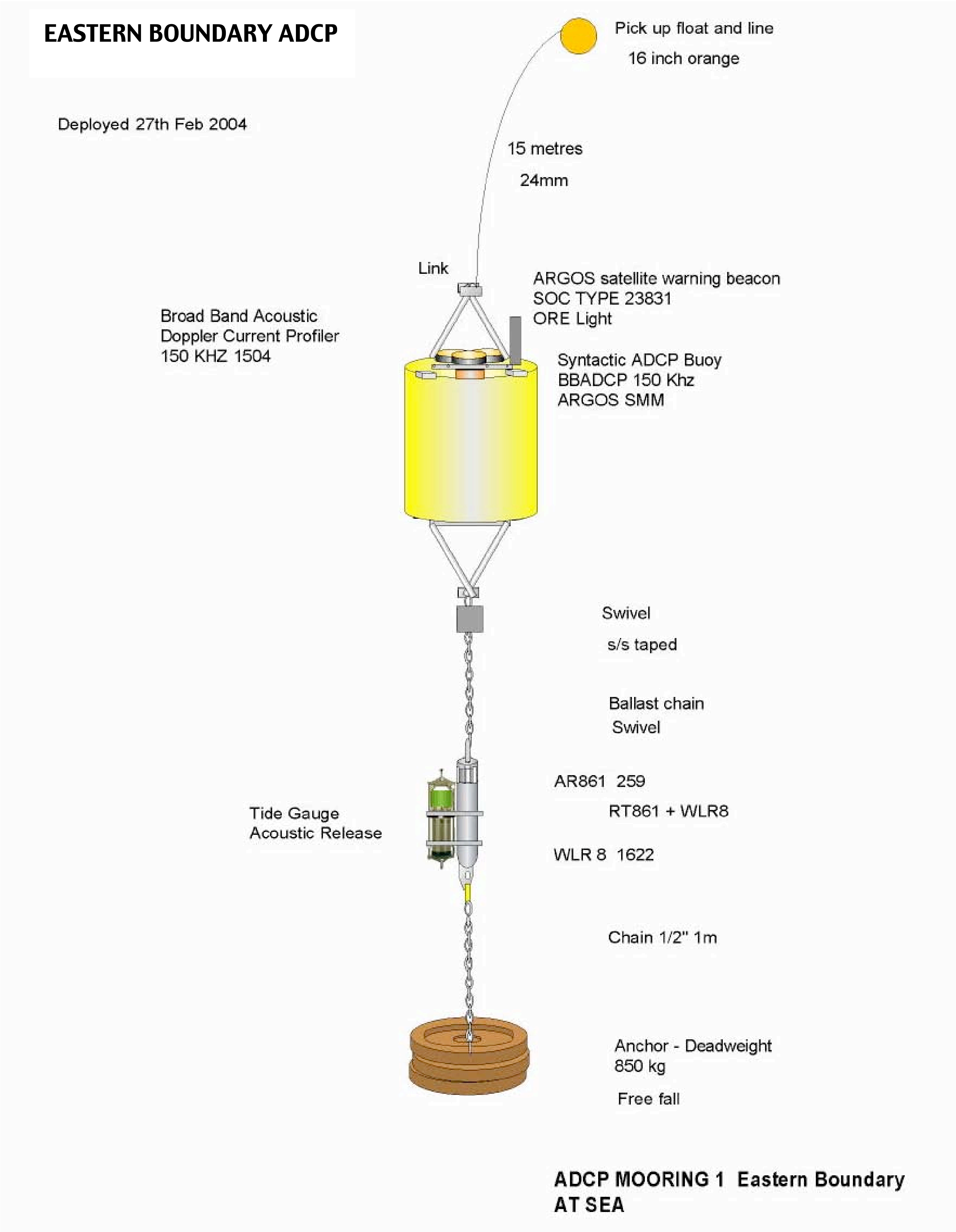


Figure 8: Mooring Diagram of EBH5

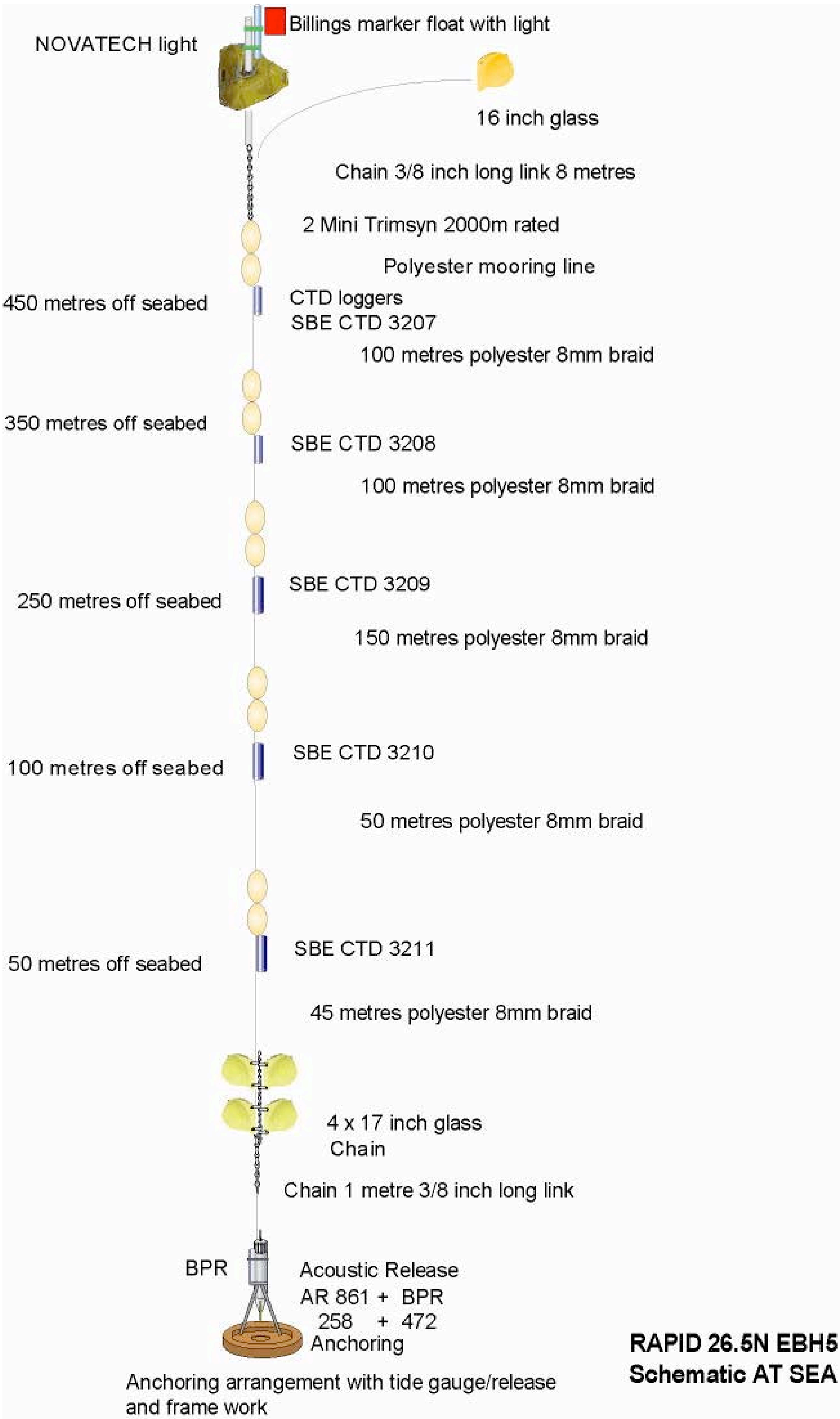


Figure 9: Mooring Diagram of EBH4

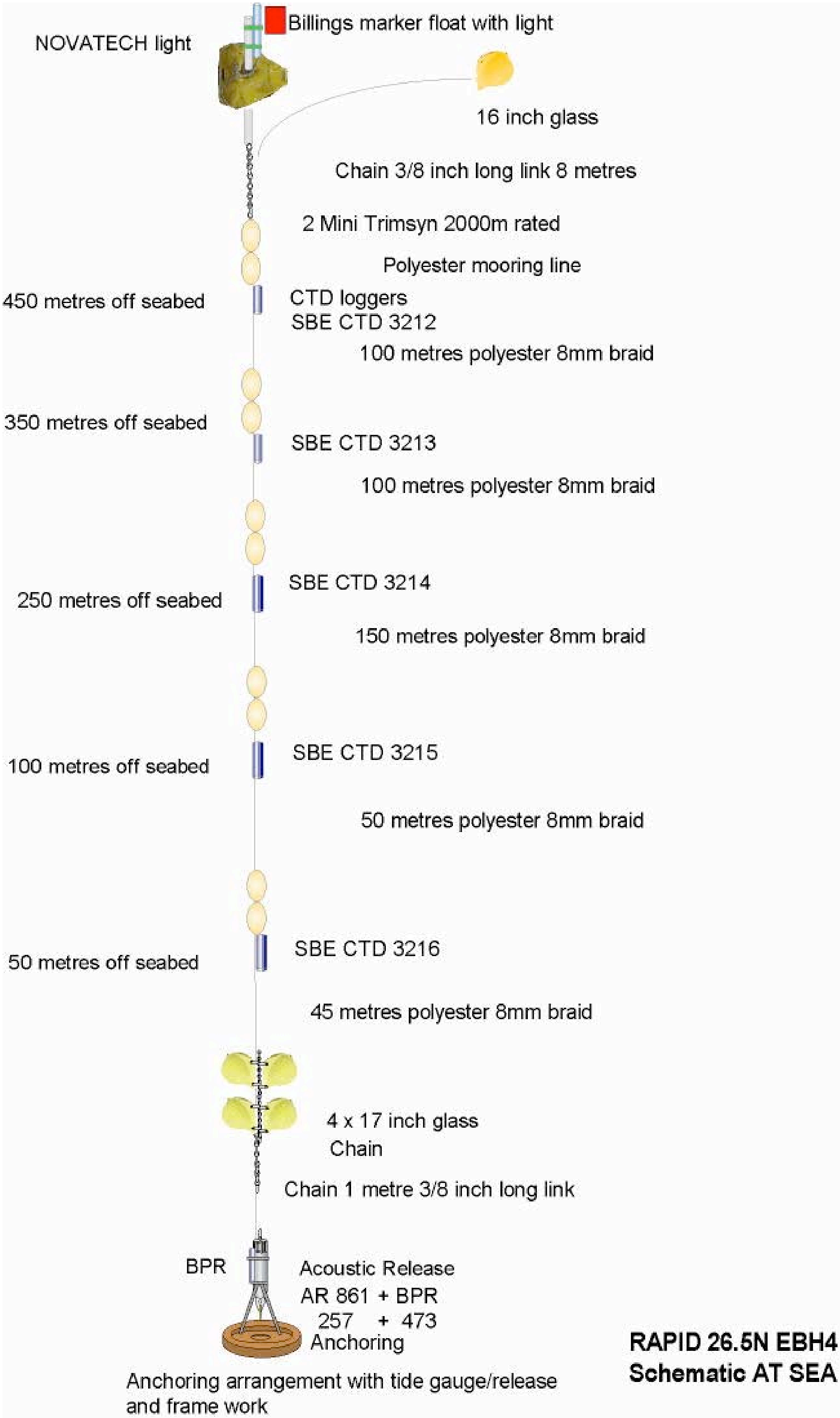


Figure 10: Mooring Diagram of EBH3

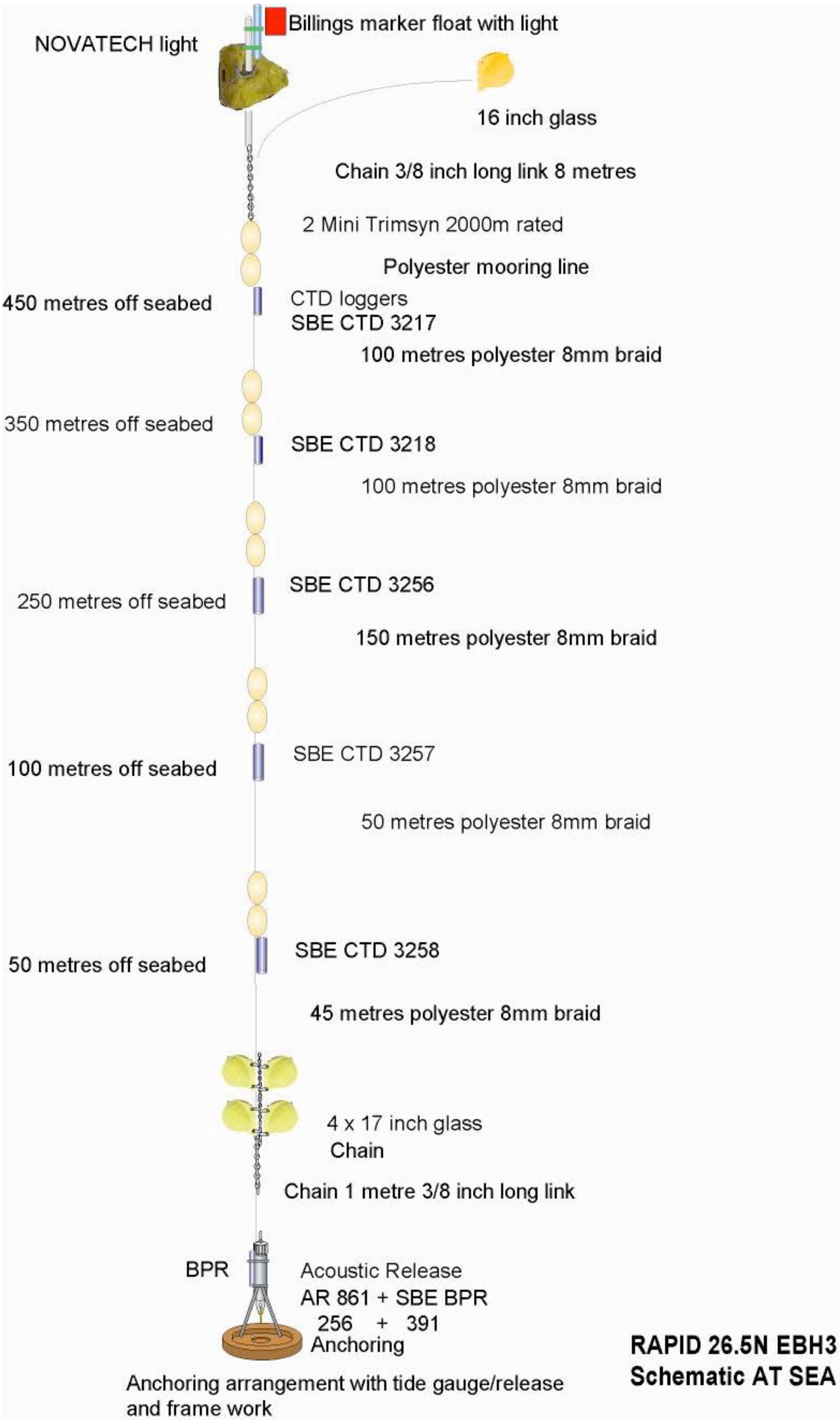


Figure 11: Mooring Diagram of EBH2

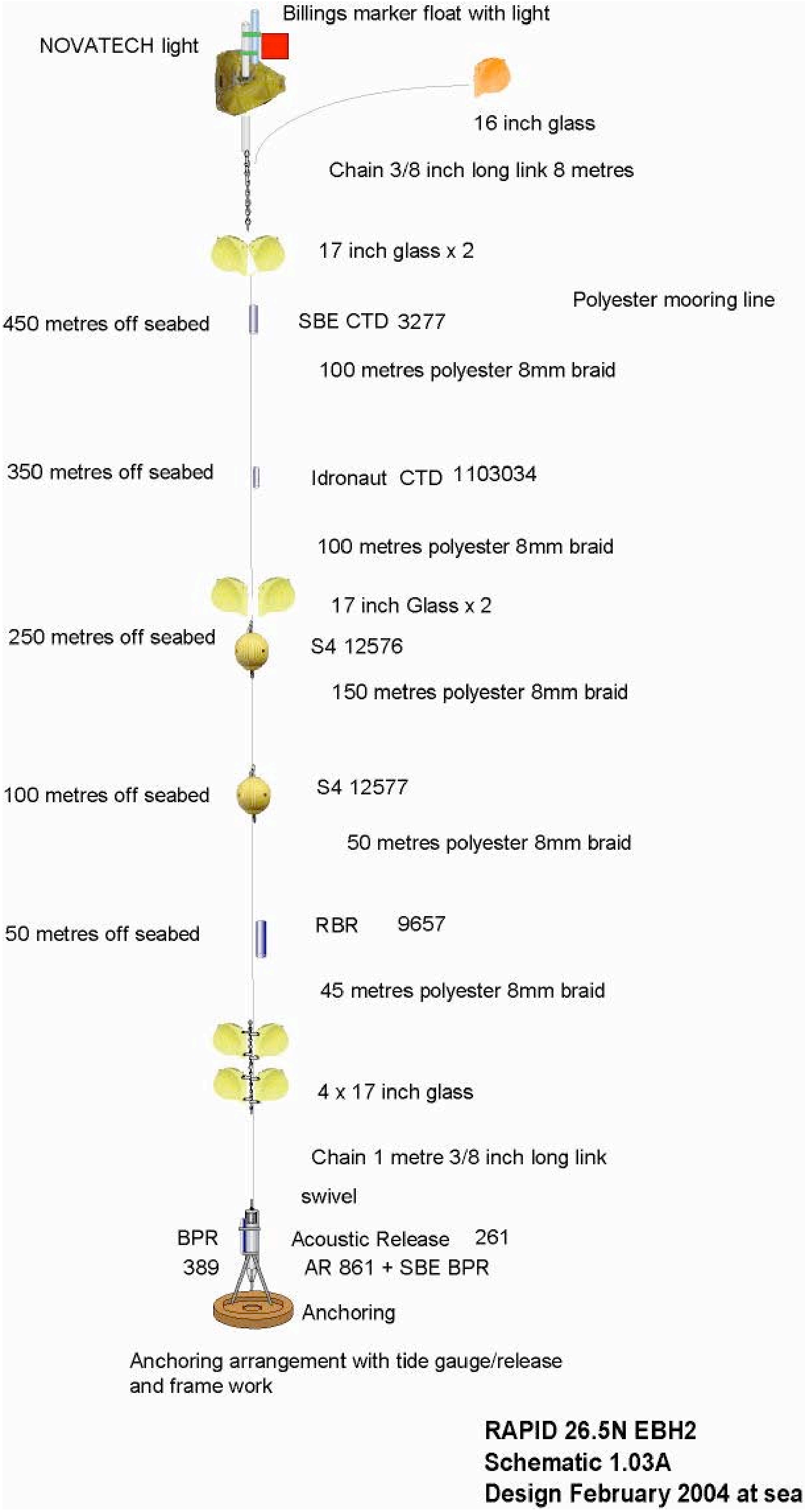


Figure 12: Mooring Diagram of EBH1

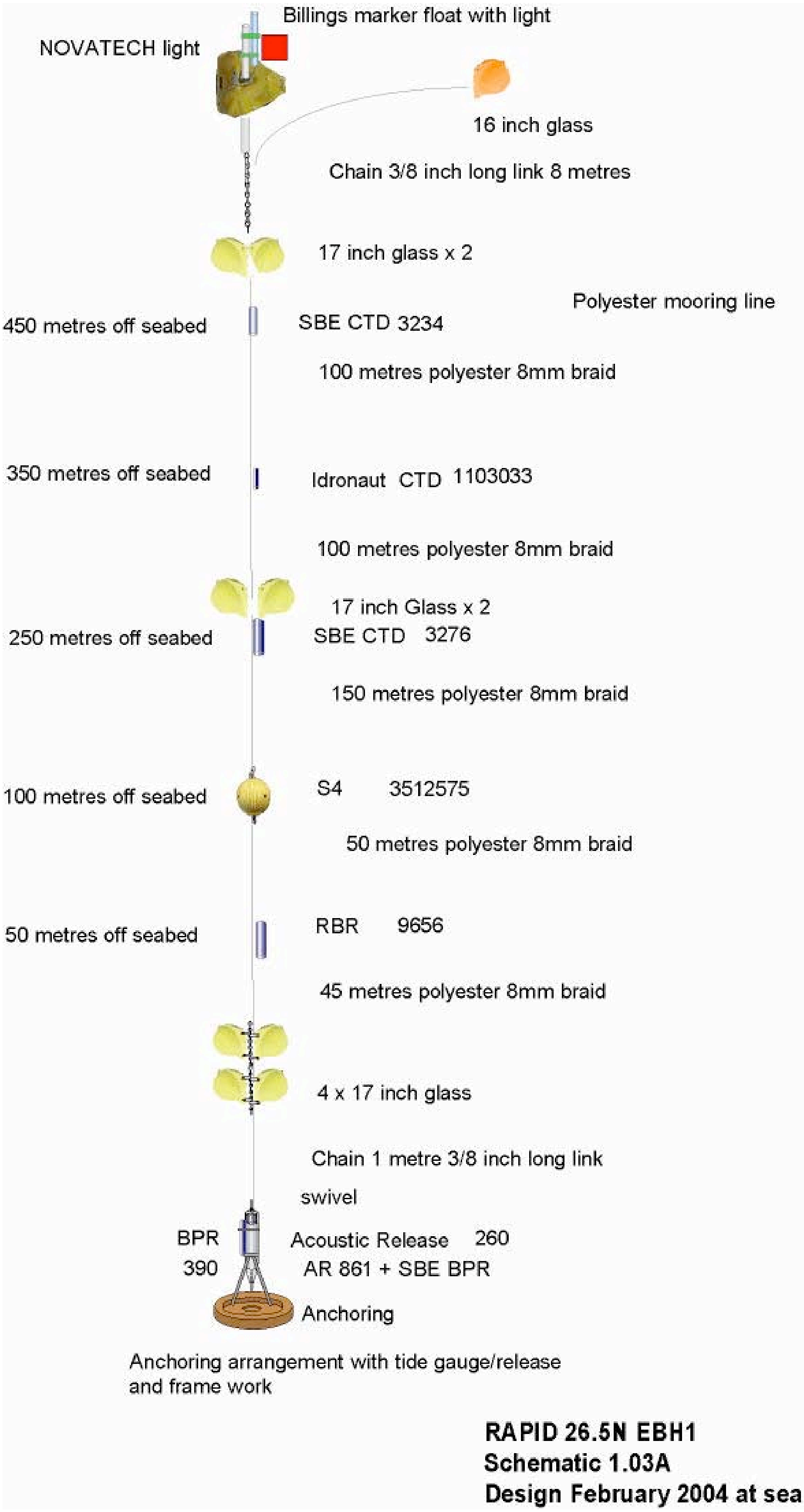


Figure 13: Mooring Diagram of EB3

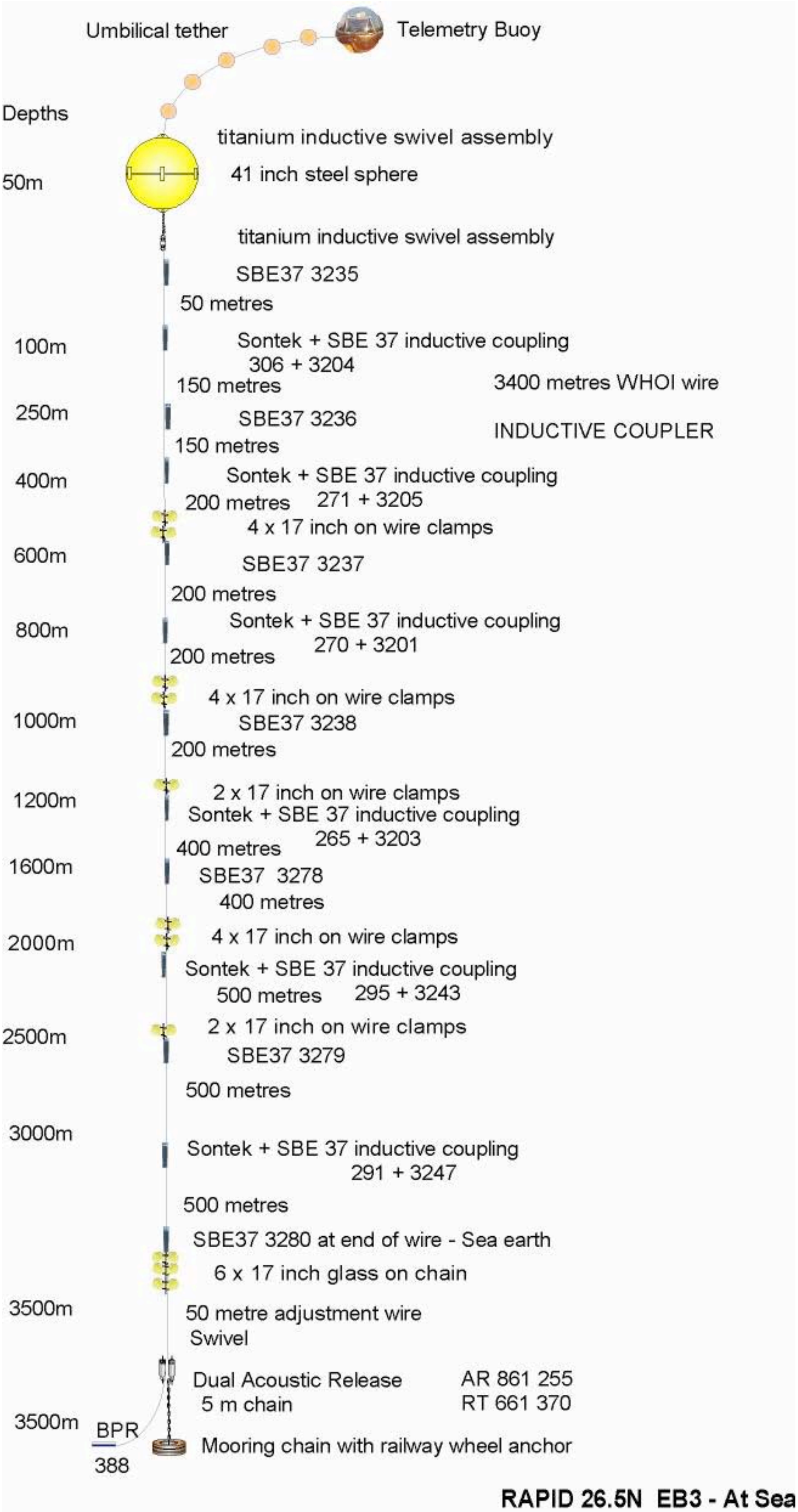


Figure 14: Mooring Diagram of EB2

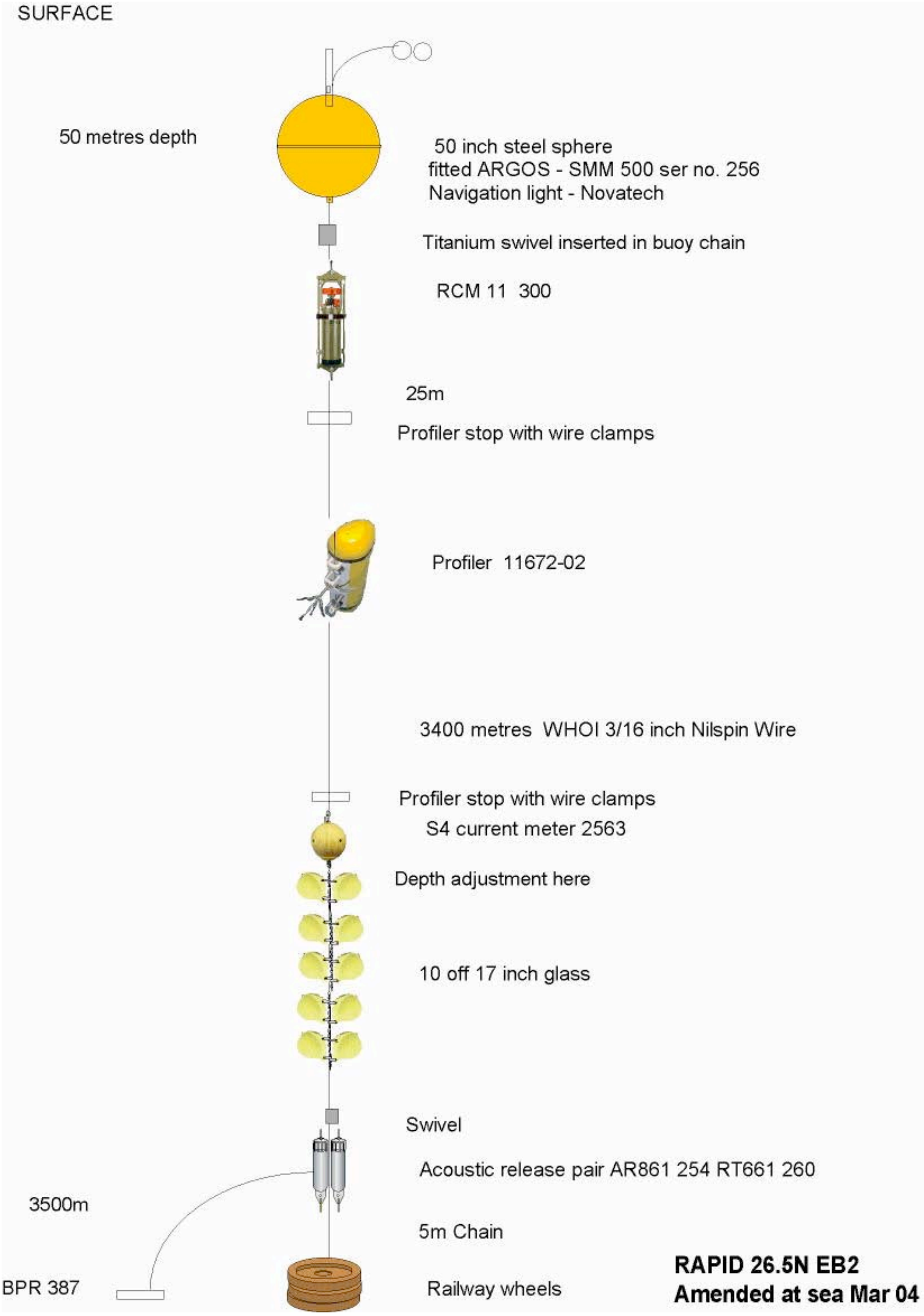


Figure 15: Mooring Diagram of EB1

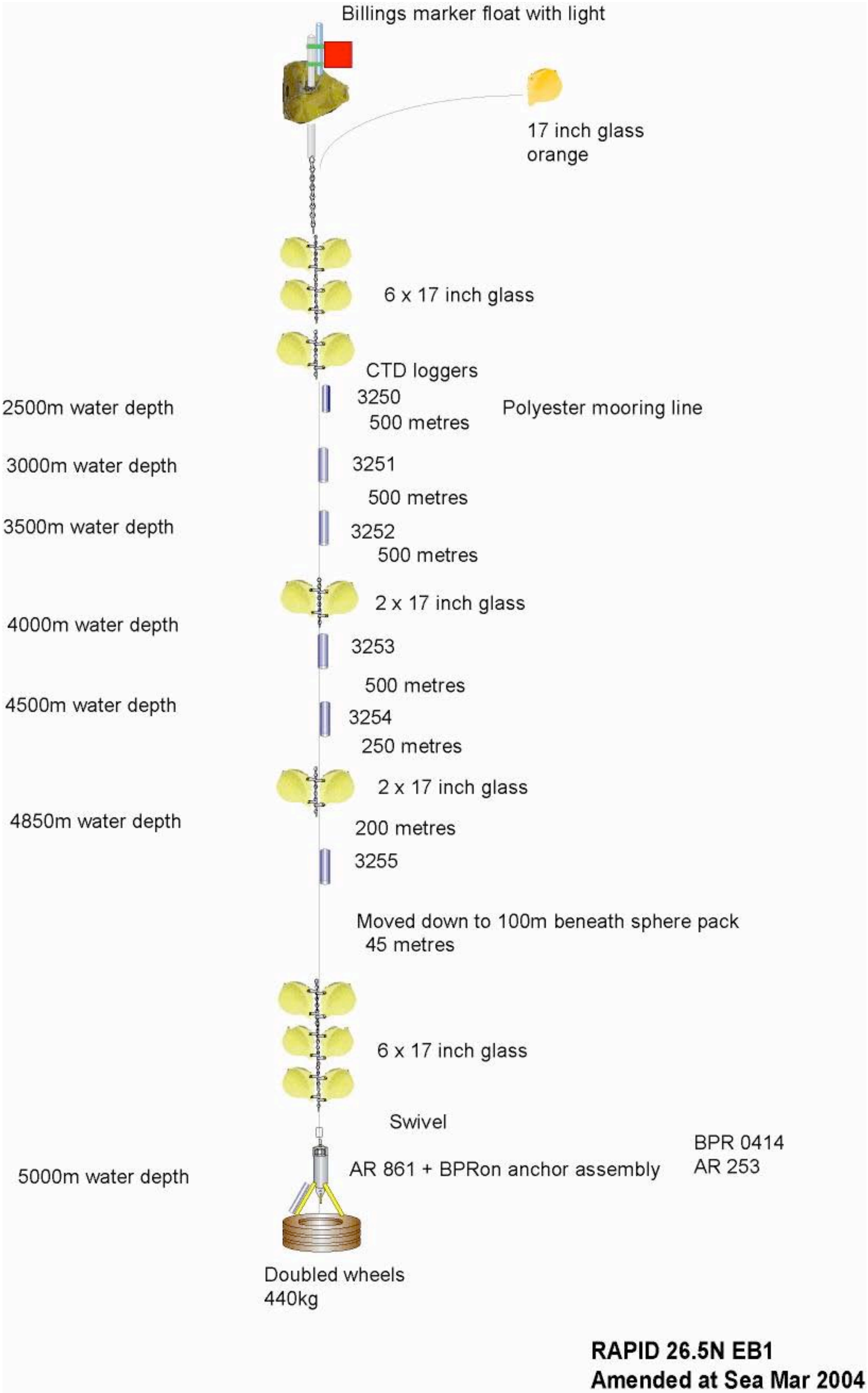


Figure 16: Mooring Diagram of MAR3

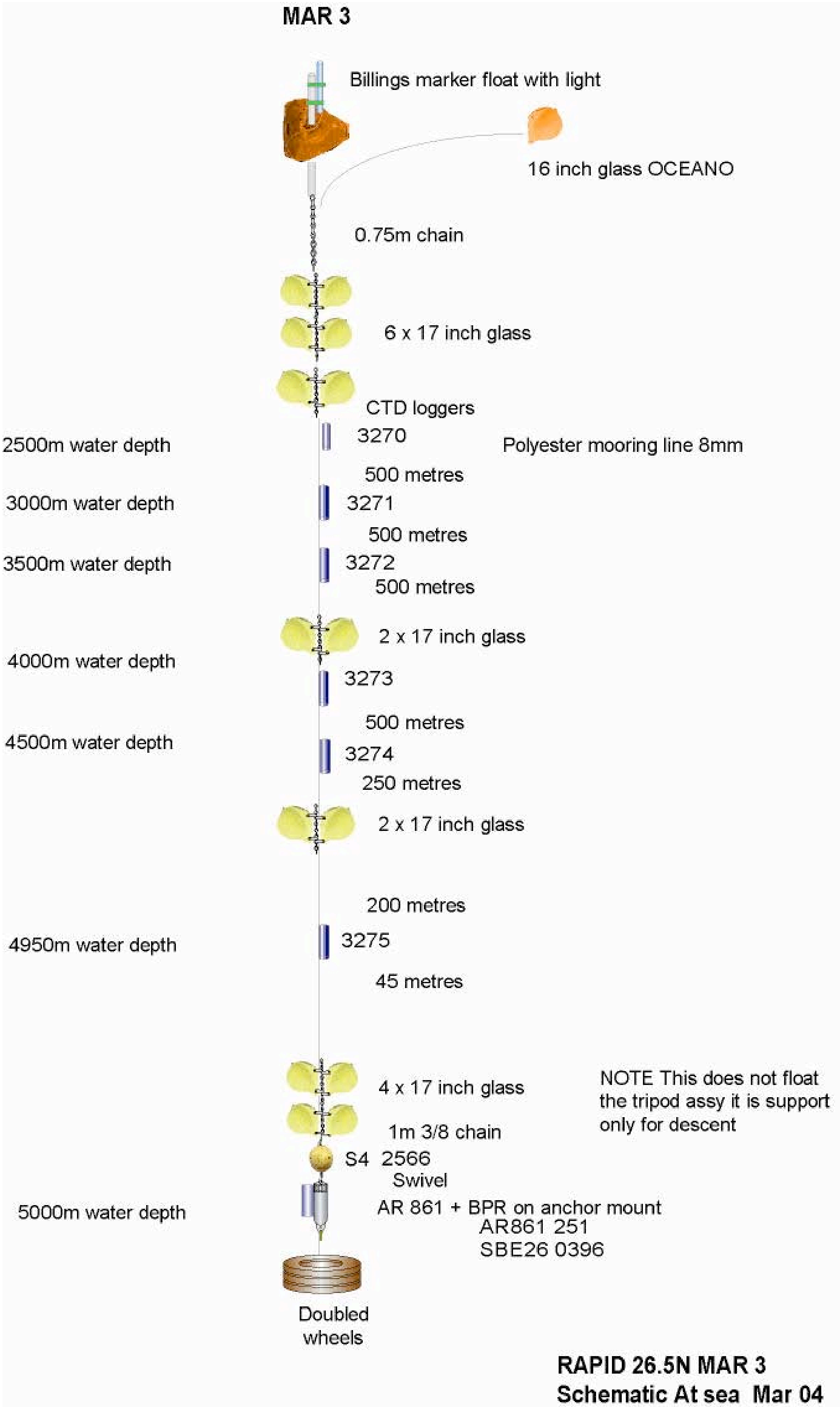


Figure 17: Mooring Diagram of MAR4

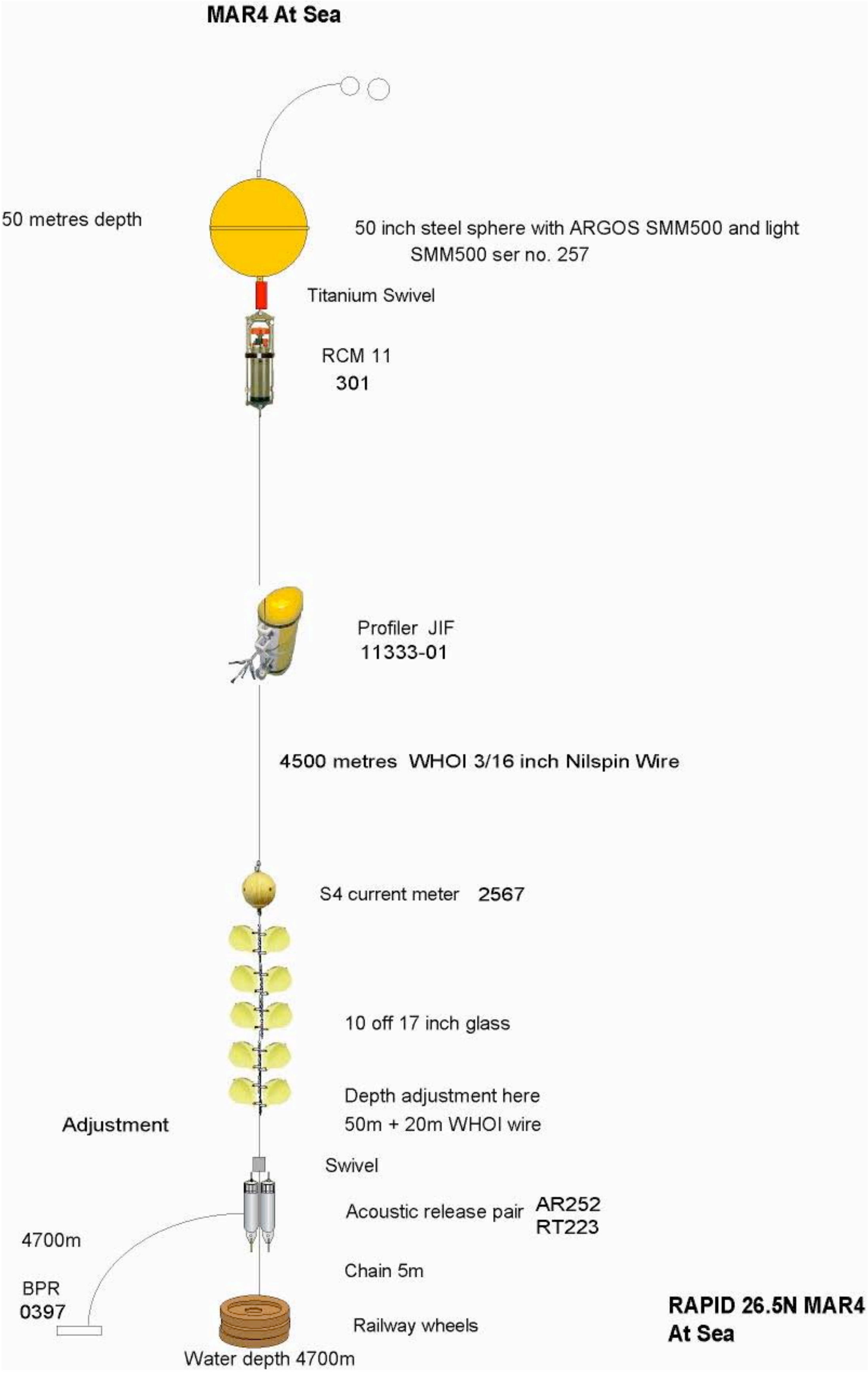


Figure 18: Mooring Diagram of MAR1

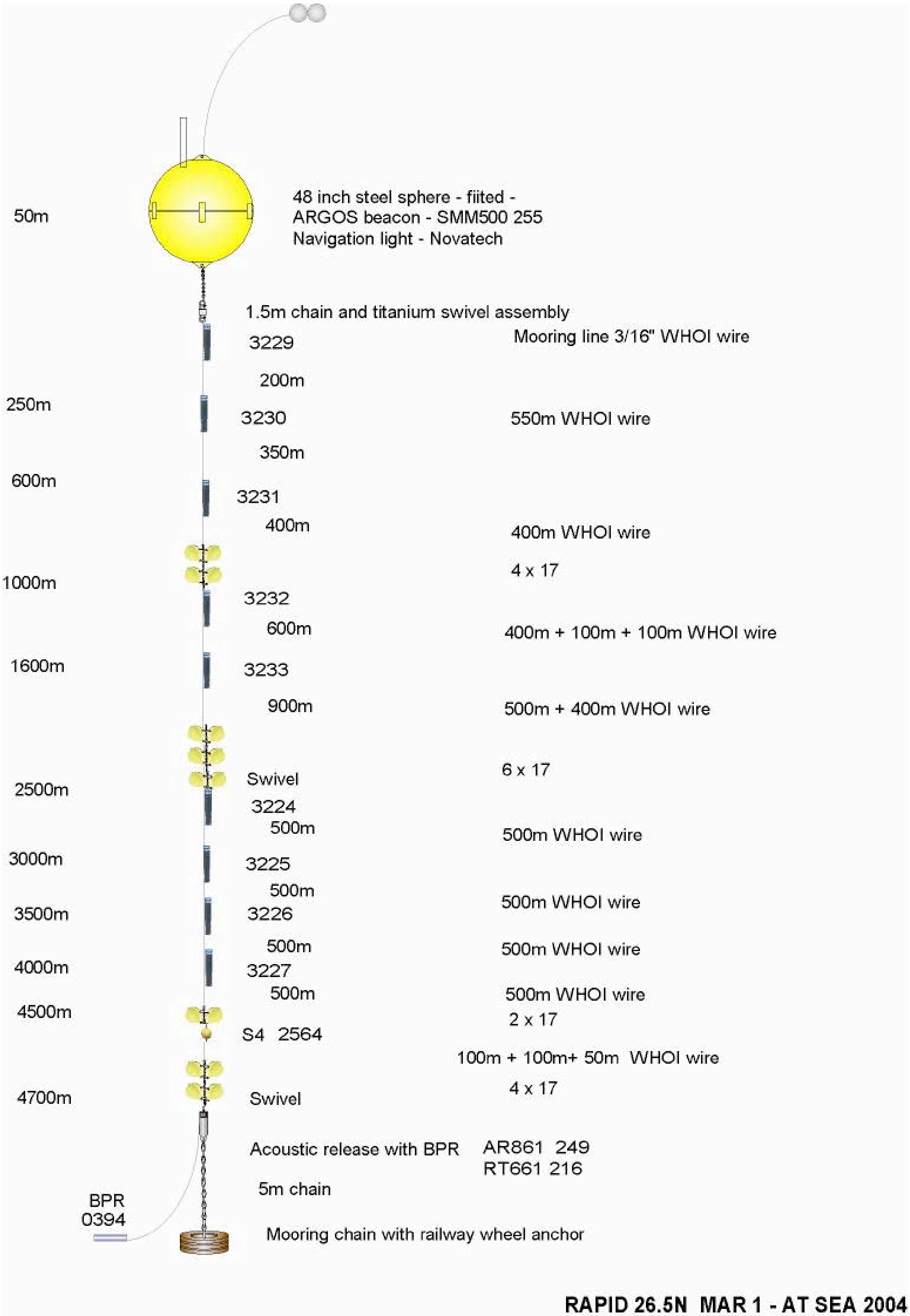


Figure 19: Mooring Diagram of MAR2

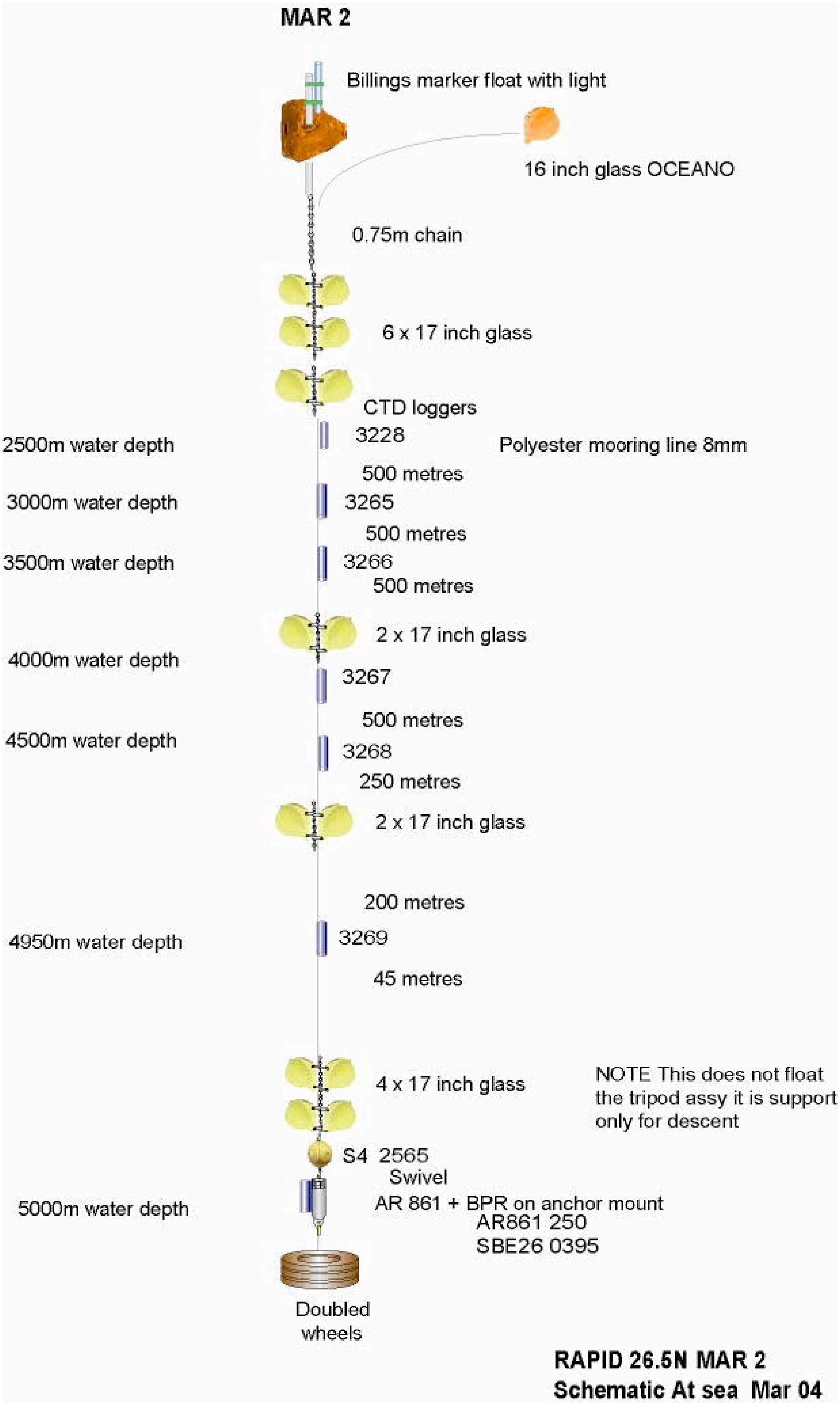


Figure 20: Mooring Diagram of WB4

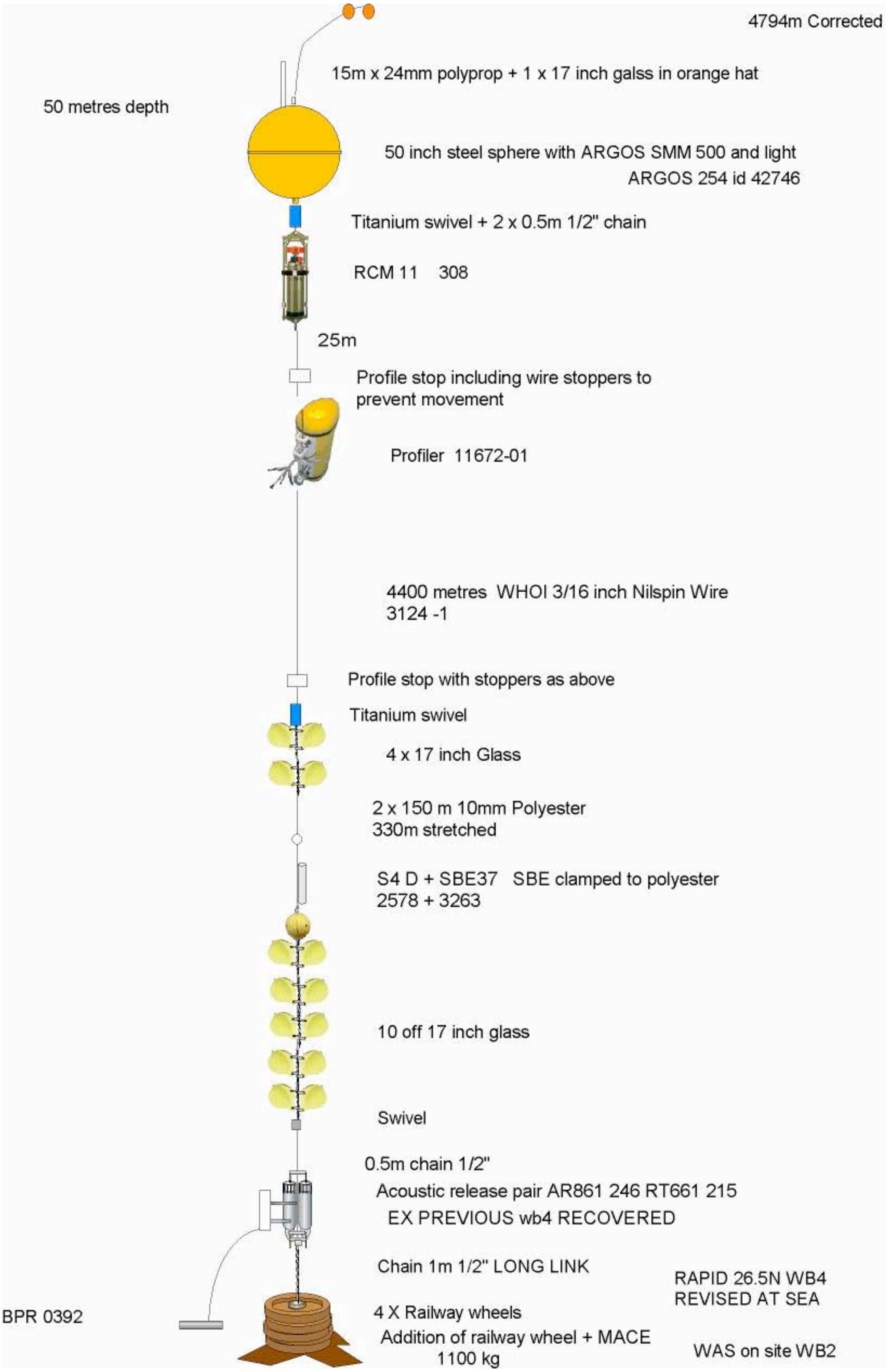


Figure 21: Mooring Diagram of WBH2

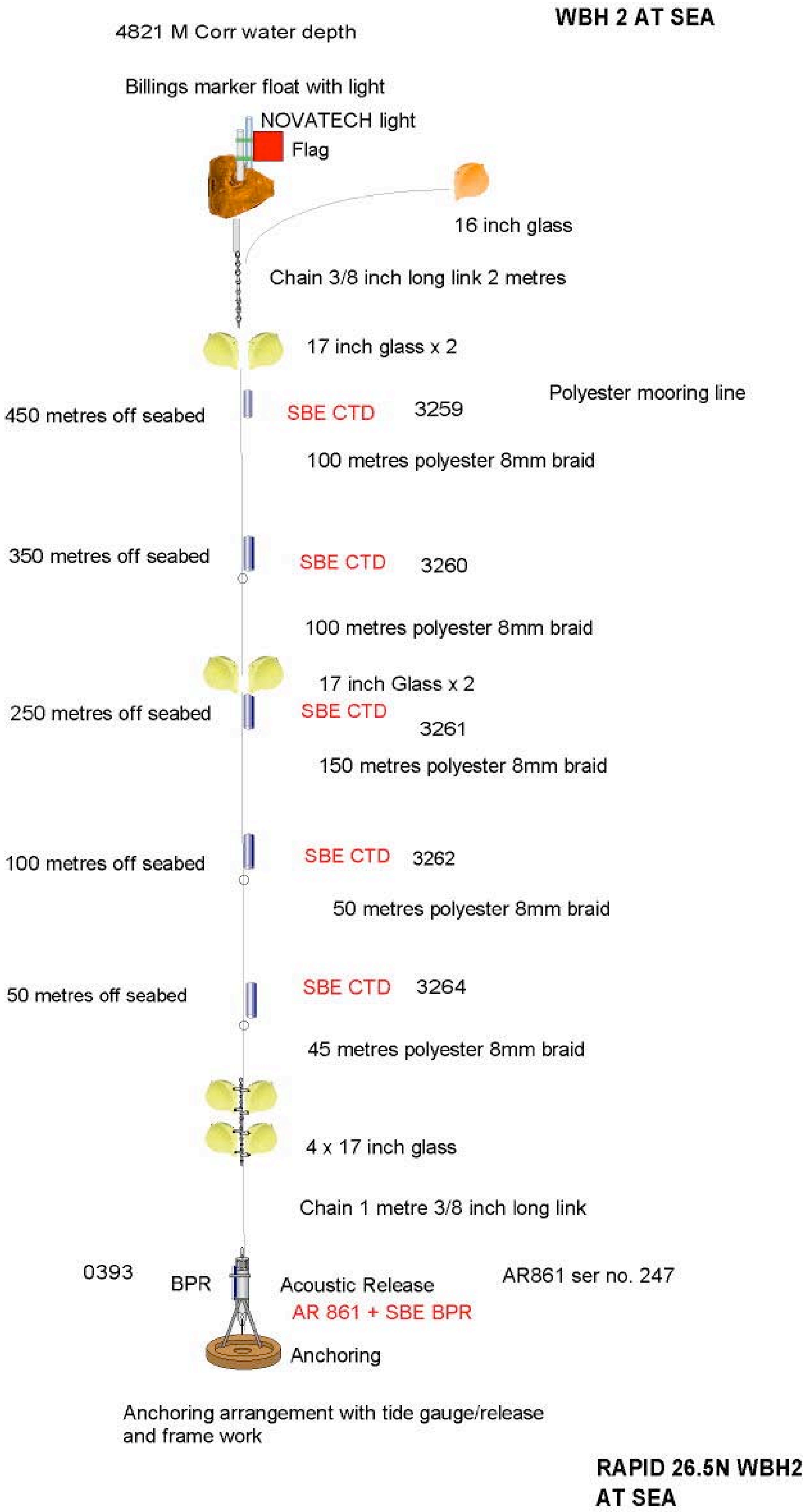


Figure 22: Mooring Diagram of WBH1

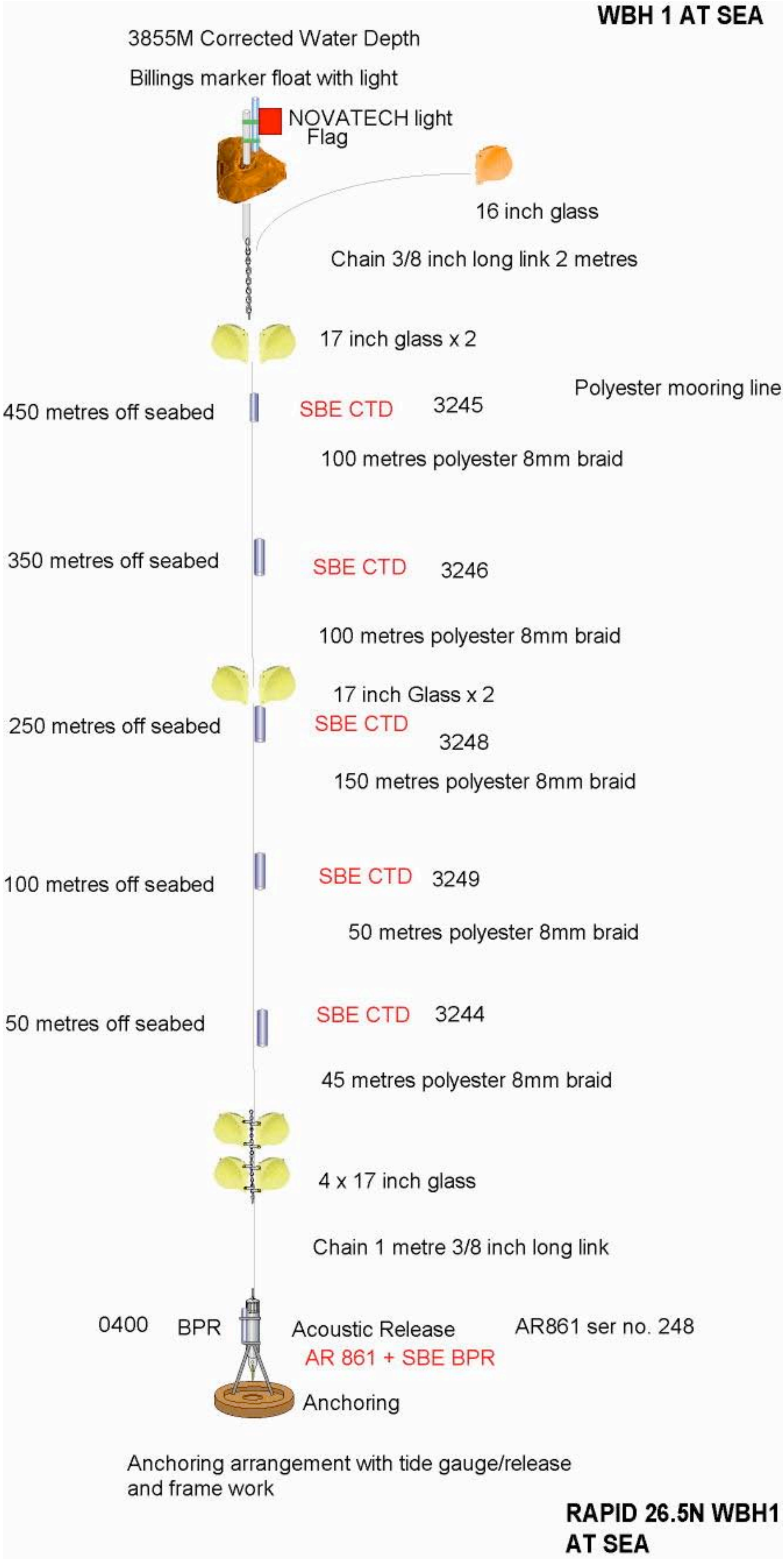


Figure 23: Mooring Diagram of WB2

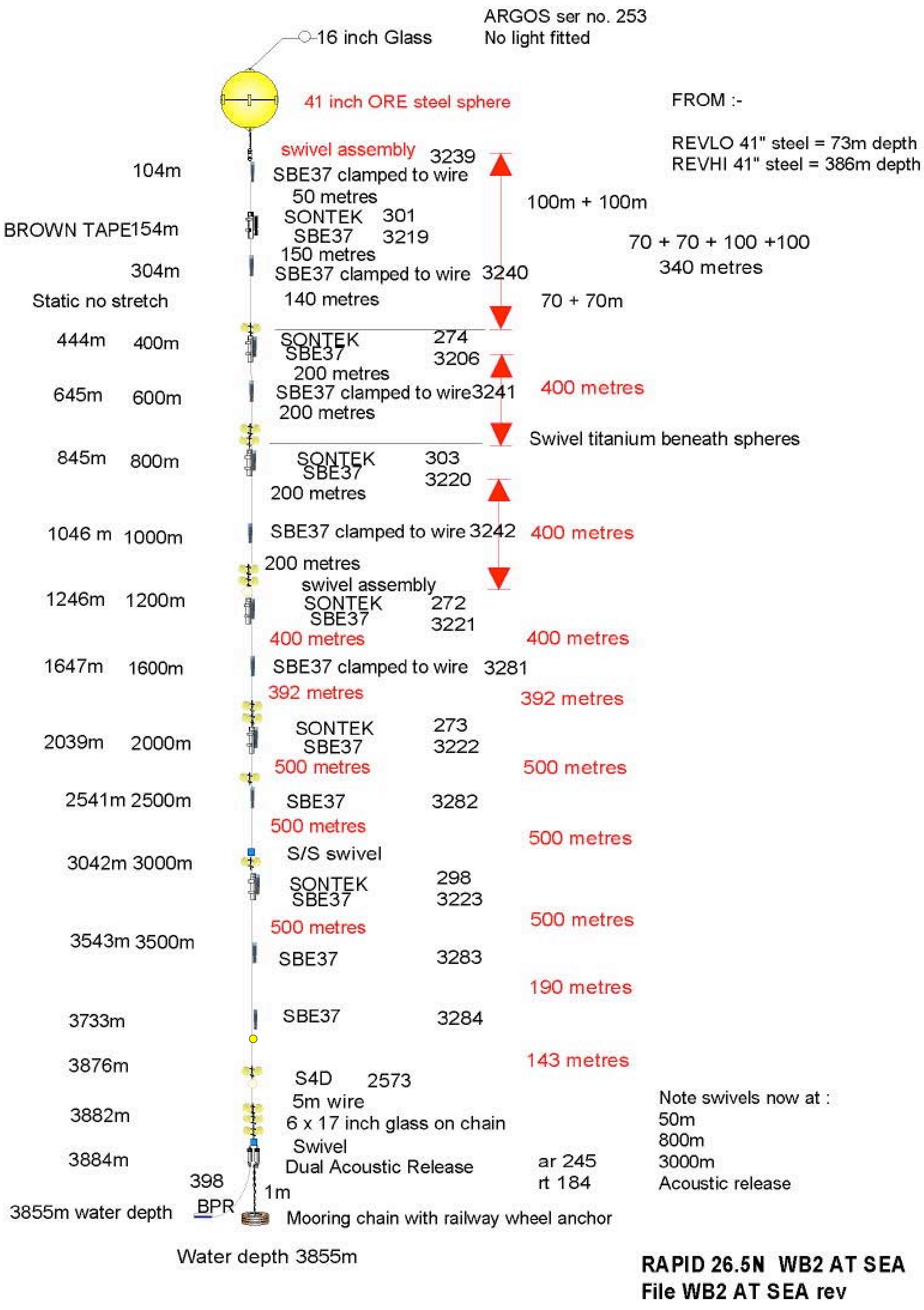


Figure 24: Mooring Diagram of WB1

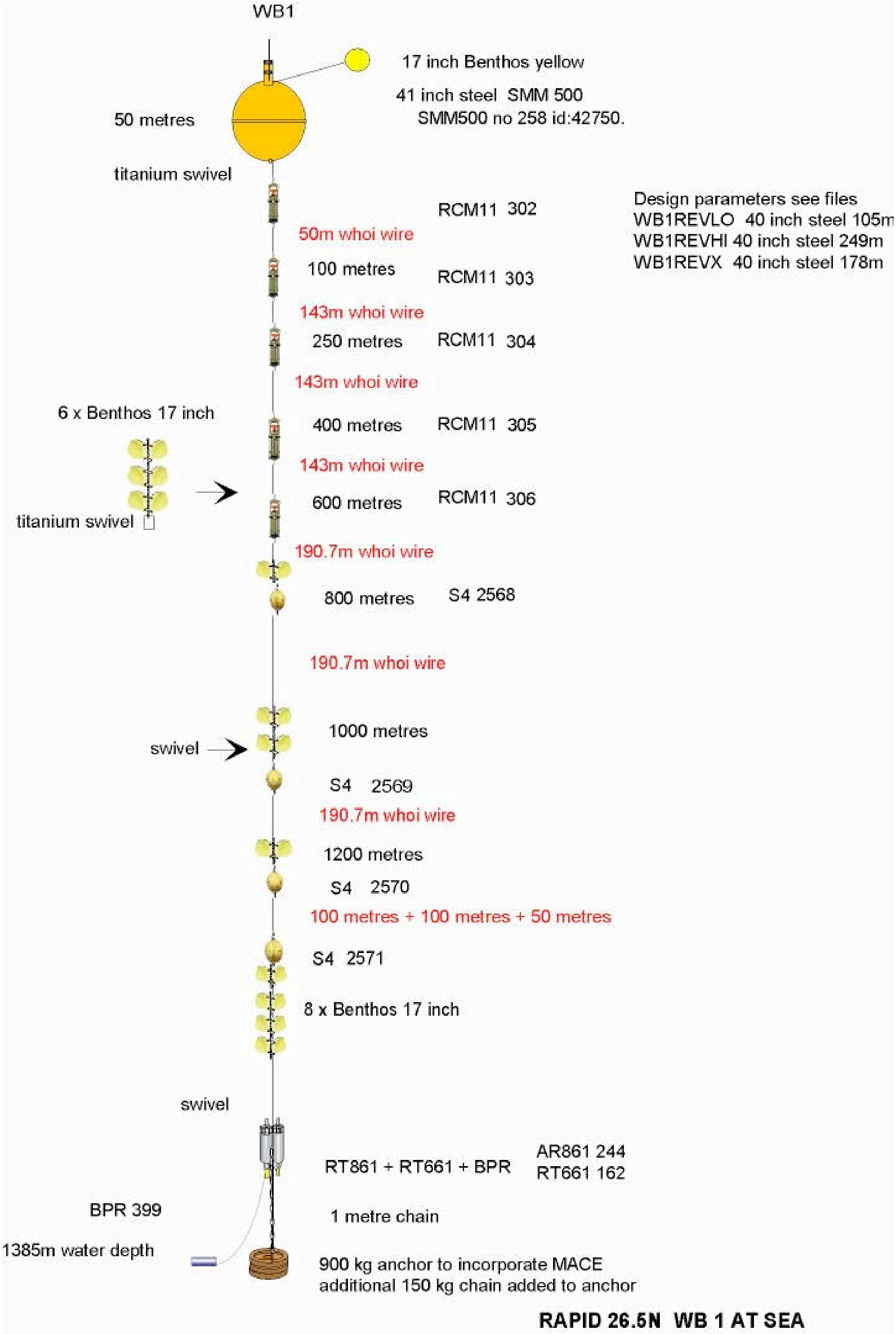


Figure 25: Mooring Diagram of WBADCP

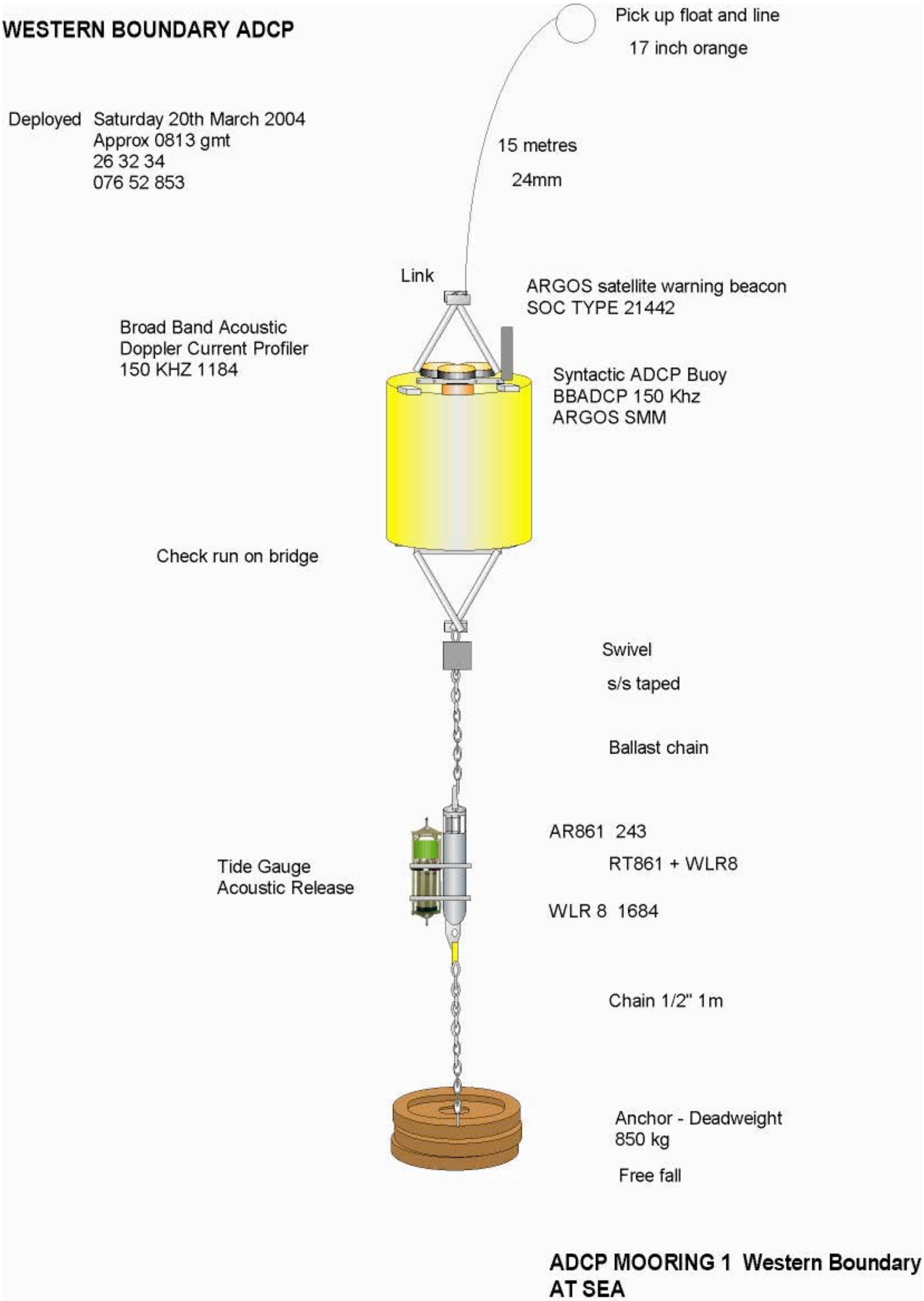


Figure 26: Mooring Diagram of Initial WB4 (deployed and recovered)

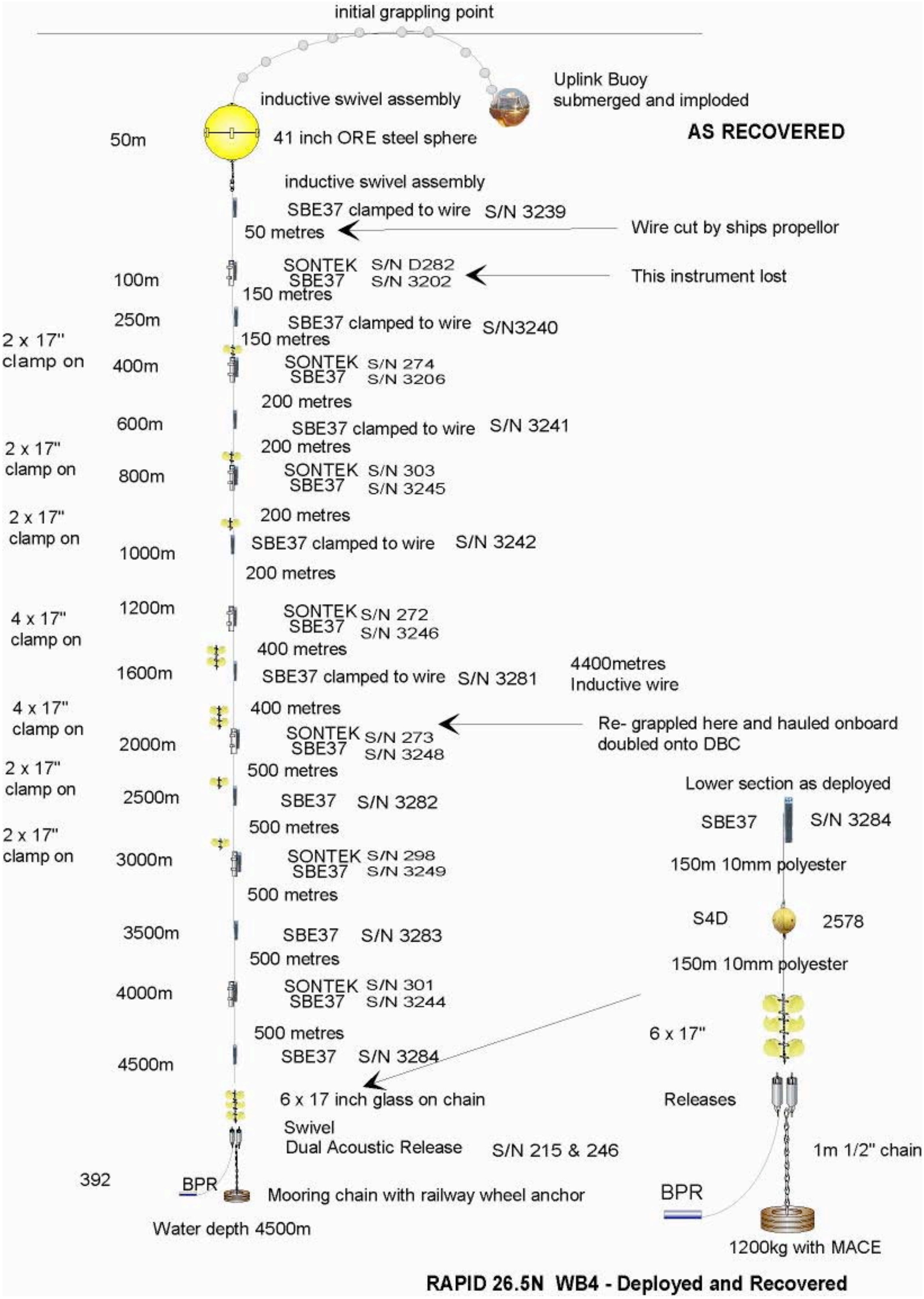


Figure 27: Mooring Diagram of BJA

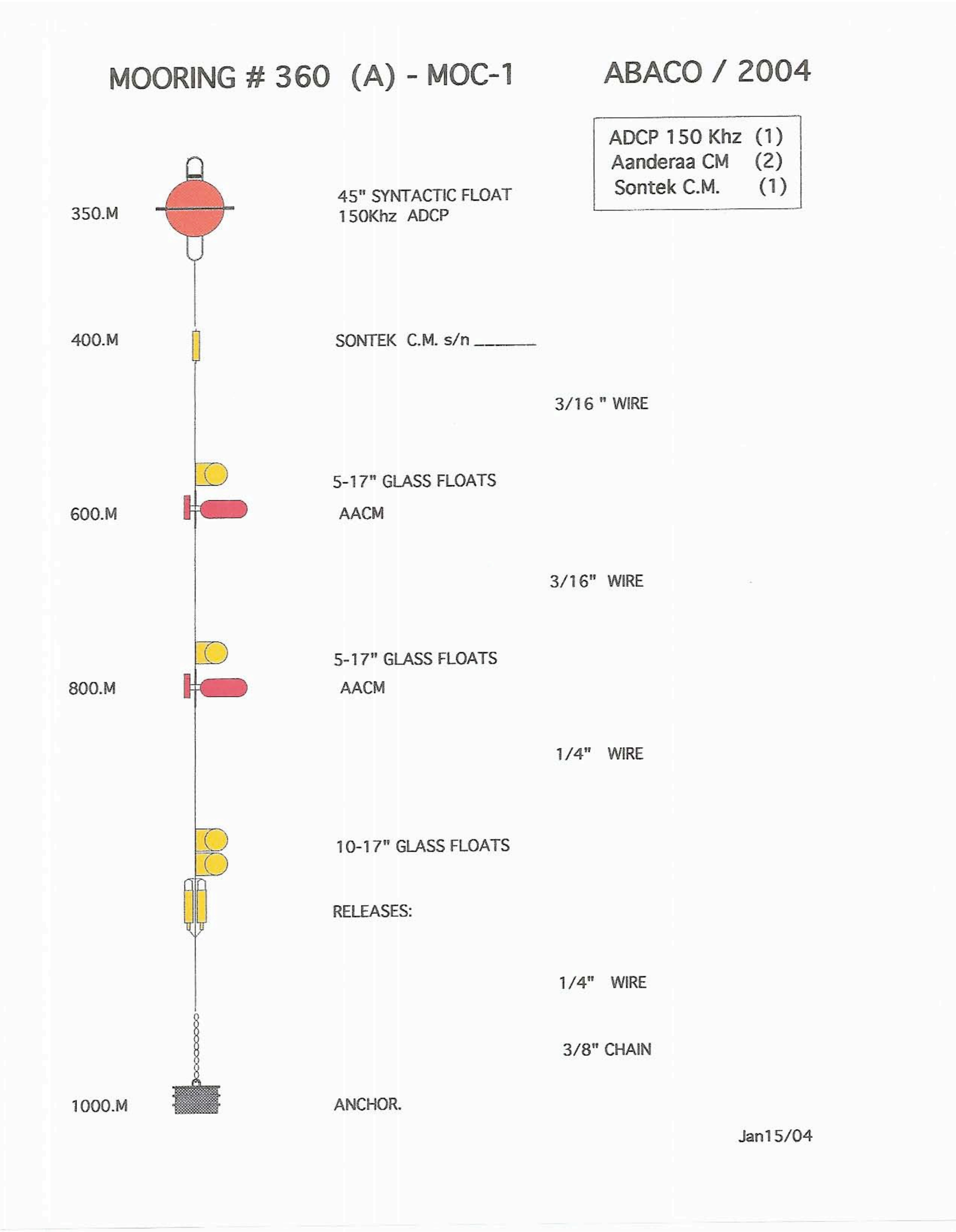


Figure 28: Mooring Diagram of BJB

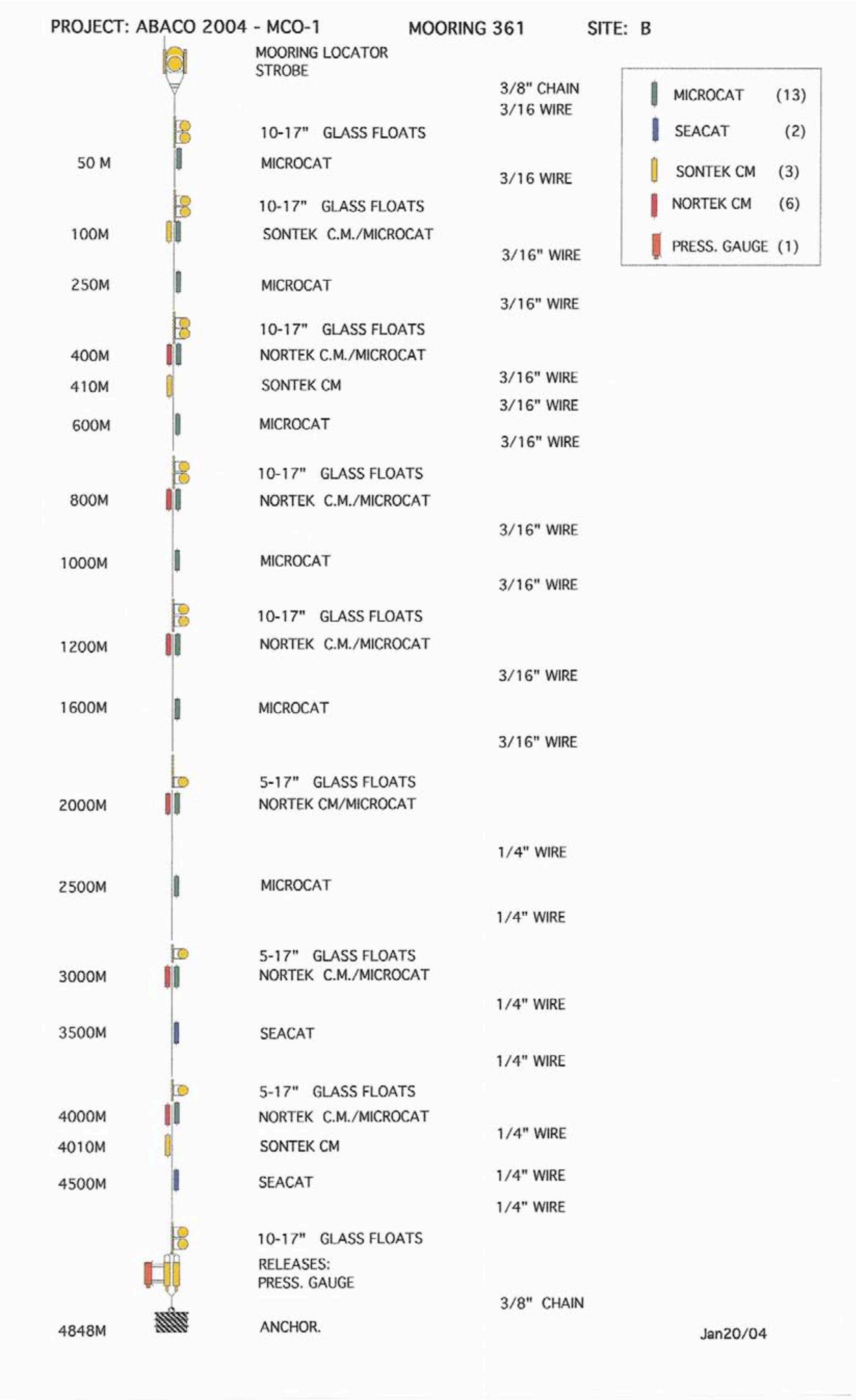
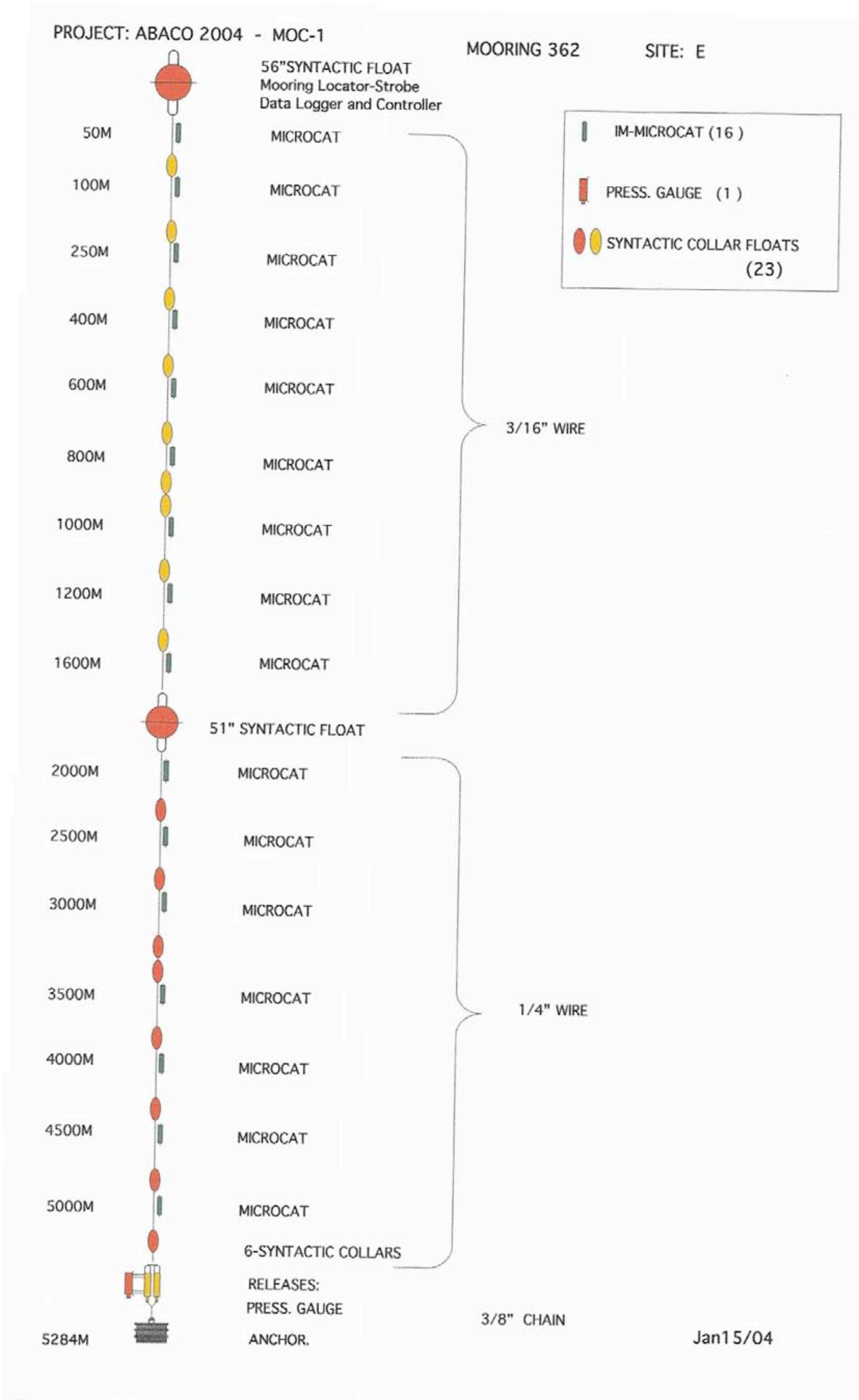


Figure 29: Mooring Diagram of BJE



Appendix B: Instrument Setup Details

EBADCP

150kHz Broadband ADCP – Serial Number **1504**
Transducer serial number **2569**

System frequency	150kHz
Beam angle	20 degrees
System Power	Low
Water temperature	10 deg C
Water salinity	35ppt
Depth of transducer	500m
WT Pings per ensemble	10
Depth cell size	8.00m
Number of depth cells	30
Blank after transmit	2.00m
WT profiling mode	4
WT ambiguity velocity	480cm/s
BT pings per ensemble	0
Time between ping groups	0.00s
Time per ensemble	00:15:00:00
Deployment length	425 days
Coordinate system	Earth
Baud rate	38400
Start Date	26/02/2004
Start Time	14:00:00

Aanderaa WLR8 – serial number **1622**

Sampling interval	15 mins
Date switched on	26/2/04
Time switched on	16:30
Barometric pressure when switched on	1018.44 (from met system)

EBH5

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

Sample interval	900 seconds
Start date	26/02/2004
Start time	10:00:00

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

Sample interval	900 seconds
Start date	26/02/2004
Start time	10:00:00

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

Sample interval	900 seconds
Start date	26/02/2004
Start time	10:00:00

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

Sample interval	900 seconds
Start date	26/02/2004
Start time	09:45:00

Seabird SBE37 SMP CTD – serial number **3211**

Sample interval	900 seconds
Start date	26/02/2004
Start time	09:45:00

Ixsea OT660C BPR – serial number **472**

Sampling rate	10 mins
Integration - temp	4 secs
Integration – tide	4 mins
Start date	27/2/2004
Start time	00:00:00
Duration	426 days

EBH4

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

Sample interval	900 seconds
Start date	25/02/2004
Start time	18:00:00

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

Sample interval	900 seconds
Start date	25/02/2004
Start time	18:00:00

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

Sample interval	900 seconds
Start date	25/02/2004
Start time	18:00:00

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

Sample interval	900 seconds
Start date	25/02/2004
Start time	18:15:00

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

Sample interval	900 seconds
Start date	25/02/2004
Start time	18:15:00

Ixsea OT660C BPR – serial number **473**

Sampling rate	10 mins
Integration - temp	4 secs
Integration – tide	4 mins
Start date	27/2/2004
Start time	00:00:00
Duration	426 days

<u>EBH3</u>

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

Sample interval	900 seconds
Start date	25/02/2004
Start time	17:00:00

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

Sample interval	900 seconds
Start date	25/02/2004
Start time	16:00:00

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

Sample interval	900 seconds
Start date	25/02/2004
Start time	16:30:00

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

Sample interval	900 seconds
Start date	25/02/2004
Start time	16:00:00

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

Sample interval	900 seconds
Start date	25/02/2004
Start time	16:45:00

Seabird SBE26 BPR – serial number **0391**

Tide interval	10 minutes
Wave burst every N tide measurements	9999
Wave samples per burst	128
No. of 0.25 sec periods to integrate waves	33
Instrument started	25/2/2004 13:40:00

SBE26 found not to recognise 29th February 2004 as leap year, so data will be advanced by 1 day from the 1st March 2004. Fault with SBE26s found after deployment of EBH3.

EBH2

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

Sample interval	900 seconds
Start date	27/02/2004
Start time	14:30:00

After deployment, date on instrument found to be set incorrectly. First record will have date 27/2/2004 but is actually 11/3/2004. Need to advance all dates by 13 days during processing. Instrument started logging 13 days after deployment.

Idronaut Ocean Seven 304 CTD – serial number **1103034**

Sample interval	15 mins
Dataset per acquisition	1
Number of acquisition cycles	99999
Start date (cannot differ from day of setup)	27/2/2004
Start time	14:00:00

Interocean S4AD – serial number **35612576**

Header	EBH2 250m
On time	2 mins
Cycle time	30 mins
Average count	1
Channels at average	Hx, Hy, Cond., Temp., Depth
Special Record Block Count	0
Start date	27/2/2004
Start time	14:00:00

Interocean S4AD – serial number **35612577**

Header	EBH2 100m
On time	2 mins
Cycle time	30 mins
Average count	1
Channels at average	Hx, Hy, Cond., Temp., Depth
Special Record Block Count	0
Start date	27/2/2004
Start time	13:00:00

RBR XR420 CTD – serial number **9657**

Start date	27/2/2004
Start time	13:00:00
End date	5/6/2005
End time	00:00:00
Sampling period	10 mins

Seabird SBE26 BPR – serial number **0389**

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	25/2/2004 12:00:00

SBE26 found not to recognise 29th February 2004 as leap year, so data will be advanced by 1 day from the 1st March 2004. Fault with SBE26s found after deployment of EBH2.

EBH1

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

Sample interval	900 seconds
Start date	27/02/2004
Start time	17:00:00

Idronaut Ocean Seven 304 CTD – serial number **1103033**

Sample interval	15 mins
Dataset per acquisition	1
Number of acquisition cycles	99999
Start date (cannot differ from day of setup)	27/2/2004
Start time	18:00:00

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

Sample interval	900 seconds
Start date	27/02/2004
Start time	17:00:00

Interocean S4AD – serial number **35612575**

Header	EBH1 100m
On time	2 mins
Cycle time	30 mins
Average count	1
Channels at average	Hx, Hy, Cond., Temp., Depth
Special Record Block Count	0
Start date	27/2/2004
Start time	17:00:00

RBR XR420 CTD – serial number **9656**

Start date	27/2/2004
Start time	17:00:00
End date	5/6/2005
End time	00:00:00
Sampling period	10 mins

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	25/2/2004 11:30:00

SBE26 found not to recognise 29th February 2004 as leap year, so data will be advanced by 1 day from the 1st March 2004. Fault with SBE26s found after deployment of EBH1.

EB3

Seabird SBE37 IMP CTD – serial number **3235**

ID number	10
Sample interval	900 seconds
Start date	27/02/2004
Start time	23:00:00

Sontek Argonaut MD and Seabird SBE37 SMP pairing – serial numbers **D306** and **3204**

ID number	30
Averaging interval	120 seconds
Sampling interval	1200 seconds
Salinity	35.0 ppt
Blanking distance	1.5m
Cell size	1.5m
Deployment name	EB330
Start date	27/2/2004
Start time	20:00:00
Baud rate	600

Seabird SBE37 IMP CTD – serial number **3236**

ID number	11
Sample interval	900 seconds
Start date	27/02/2004
Start time	23:00:00

Sontek Argonaut MD and Seabird SBE37 SMP pairing – serial numbers **D271** and **3205**

ID number	31
Averaging interval	120 seconds
Sampling interval	1200 seconds
Salinity	35.0 ppt
Blanking distance	1.5m
Cell size	1.5m
Deployment name	EB331
Start date	27/2/2004
Start time	20:00:00
Baud rate	600

Seabird SBE37 IMP CTD – serial number **3237**

ID number	12
Sample interval	900 seconds
Start date	27/02/2004
Start time	23:00:00

Sontek Argonaut MD and Seabird SBE37 SMP pairing – serial numbers **D270** and **3201**

ID number	32
Averaging interval	120 seconds
Sampling interval	1200 seconds
Salinity	35.1 ppt
Blanking distance	1.5m
Cell size	1.5m
Deployment name	EB332
Start date	27/2/2004
Start time	21:00:00
Baud rate	600

Seabird SBE37 IMP CTD – serial number **3238**

ID number	13
Sample interval	900 seconds
Start date	27/02/2004
Start time	23:00:00

Sontek Argonaut MD and Seabird SBE37 SMP pairing – serial numbers **D265** and **3203**

ID number	33
Averaging interval	120 seconds
Sampling interval	1200 seconds
Salinity	35.0 ppt
Blanking distance	1.5m
Cell size	1.5m
Deployment name	EB333
Start date	27/2/2004
Start time	20:00:00
Baud rate	600

Seabird SBE37 IMP CTD – serial number **3278**

ID number	14
Sample interval	900 seconds
Start date	27/02/2004
Start time	23:00:00

Sontek Argonaut MD and Seabird SBE37 SMP pairing – serial numbers **D295** and **3243**

ID number	34
Averaging interval	120 seconds
Sampling interval	1200 seconds
Salinity	35.0 ppt
Blanking distance	1.5m
Cell size	1.5m
Deployment name	EB334
Start date	27/2/2004
Start time	21:00:00
Baud rate	600

Seabird SBE37 IMP CTD – serial number **3279**

ID number	15
Sample interval	900 seconds
Start date	27/02/2004
Start time	23:00:00

Sontek Argonaut MD and Seabird SBE37 SMP pairing – serial numbers **D291** and **3247**

ID number	35
Averaging interval	120 seconds
Sampling interval	1200 seconds
Salinity	35.0 ppt
Blanking distance	1.5m
Cell size	1.5m
Deployment name	EB335
Start date	27/2/2004
Start time	21:00:00
Baud rate	600

Seabird SBE37 IMP CTD – serial number **3280**

ID number	16
Sample interval	900 seconds
Start date	27/02/2004
Start time	23:00:00

Seabird SBE26 BPR – serial number **0388**

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	28/2/2004 06:50:00

SBE26 found not to recognise 29th February 2004 as leap year, so data will be advanced by 1 day from the 1st March 2004. Fault with SBE26s found after deployment of EB3.

EB2

Aanderaa RCM11 – serial number **300**

Pings per ensemble	600
Temperature range	Low
Conductivity range	0-74mS
Recording interval	30 mins
No of channels	8
Mode	Normal
Instrument started	28/2/2004 16:00:00

McLane Moore Profiler – serial number **11672-02**

Comprising
MMP electronics – serial number **5237**
Seabird SBE41 CP – McLane V1.0 – serial number **0701**
FSI ACM – serial number **1667**

Start date	29/2/2004
Start time	04:00:00
Profile start interval	2 days 20 hours
Reference date	21/3/2004
Reference time	00:00:00
Burst interval	Disabled
Paired profiles	Enabled
Shallow pressure limit	100 dbar
Deep pressure limit	3400 dbar
Shallow pressure error	150 dbar
Deep pressure error	3300 dbar

Interocean S4AD – serial number **35612563**

Header	EB2 3500m
On time	2 mins
Cycle time	30 mins
Average count	1
Channels at average	Hx, Hy, Cond., Temp., Depth
Special Record Block Count	0
Start date	28/2/2004
Start time	16:00:00

Seabird SBE26 BPR – serial number **0387**

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	28/2/2004 06:50:00

SBE26 found not to recognise 29th February 2004 as leap year, so data will be advanced by 1 day from the 1st March 2004. Fault with SBE26s found after deployment of EB2.

EB1

Seabird SBE37 SMP CTD – serial number **3250**

Sample interval	900 seconds
Start date	26/02/2004
Start time	10:15:00

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

Sample interval	900 seconds
Start date	26/02/2004
Start time	10:15:00

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

Sample interval	900 seconds
Start date	26/02/2004
Start time	10:30:00

Seabird SBE37 SMP CTD – serial number **3253**

Sample interval	900 seconds
Start date	29/02/2004
Start time	13:00:00

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

Sample interval	900 seconds
Start date	29/02/2004
Start time	13:15:00

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

Sample interval	900 seconds
Start date	29/02/2004
Start time	13:00:00

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	29/2/2004 16:20:00

SBE26 found not to recognise 29th February 2004 as leap year. Date entered as 28/2/2004 on 29/2/2004 so that subsequent data will have correct date stamp. 1st day of data will read 28/2/2004 instead of 29/2/2004 but this was before deployment so will be removed during processing.

MAR3

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

Sample interval	900 seconds
Start date	02/03/2004
Start time	23:00:00

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

Sample interval	900 seconds
Start date	02/03/2004
Start time	23:00:00

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

Sample interval	900 seconds
Start date	02/03/2004
Start time	23:00:00

Seabird SBE37 SMP CTD – serial number **3273**

Sample interval	900 seconds
Start date	02/03/2004
Start time	23:00:00

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

Sample interval	900 seconds
Start date	02/03/2004
Start time	23:00:00

Seabird SBE37 SMP CTD – serial number **3275**

Sample interval	900 seconds
Start date	02/03/2004
Start time	23:00:00

Interocean S4AD – serial number **35612566**

Header	MAR3
On time	2 mins
Cycle time	30 mins
Average count	1
Channels at average	Hx, Hy, Cond., Temp., Depth
Special Record Block Count	0
Start date	2/3/2004
Start time	14:30:00

Seabird SBE26 BPR – serial number **0396**

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	2/3/2004 13:30:00

MAR4

Aanderaa RCM11 – serial number **301**

Pings per ensemble	600
Temperature range	Low
Conductivity range	0-74mS
Recording interval	30 mins
No of channels	8
Mode	Normal
Instrument started	2/3/2004 17:00:00

McLane Moore Profiler – serial number **11333-01**

Start date	5/3/2004
Start time	08:00:00
Profile start interval	1 day 20 hours
Reference date	21/3/2004
Reference time	00:00:00
Burst interval	Disabled
Paired profiles	Disabled
Shallow pressure limit	100 dbar
Deep pressure limit	4630 dbar
Shallow pressure error	150 dbar
Deep pressure error	4580 dbar

Interocean S4AD – serial number **35612567**

Header	MAR4
On time	2 mins
Cycle time	30 mins
Average count	1
Channels at average	Hx, Hy, Cond., Temp., Depth
Special Record Block Count	0
Start date	2/3/2004
Start time	15:00:00

Seabird SBE26 BPR – serial number **0397**

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	2/3/2004 13:50:00

MAR1

Seabird SBE37 SMP CTD – serial number **3229**

Sample interval	900 seconds
Start date	06/03/2004
Start time	13:00:00

Seabird SBE37 SMP CTD – serial number **3230**

Sample interval	900 seconds
Start date	06/03/2004
Start time	13:00:00

Seabird SBE37 SMP CTD – serial number **3231**

Sample interval	900 seconds
Start date	06/03/2004
Start time	13:00:00

Seabird SBE37 SMP CTD – serial number **3232**

Sample interval	900 seconds
Start date	06/03/2004
Start time	13:00:00

Seabird SBE37 SMP CTD – serial number **3233**

Sample interval	900 seconds
Start date	06/03/2004
Start time	13:00:00

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

Sample interval	900 seconds
Start date	06/03/2004
Start time	15:00:00

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

Sample interval	900 seconds
Start date	06/03/2004
Start time	15:00:00

Seabird SBE37 SMP CTD – serial number **3226**

Sample interval	900 seconds
Start date	06/03/2004
Start time	15:00:00

Seabird SBE37 SMP CTD – serial number **3227**

Sample interval	900 seconds
Start date	06/03/2004
Start time	15:00:00

Interocean S4AD – serial number **35612564**

Header	MAR1
On time	2 mins
Cycle time	30 mins
Average count	1
Channels at average	Hx, Hy, Cond., Temp., Depth
Special Record Block Count	0
Start date	2/3/2004
Start time	14:30:00

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	6/3/2004 13:30:00

MAR2

Seabird SBE37 SMP CTD – serial number **3228**

Sample interval	900 seconds
Start date	6/3/2004
Start time	13:00:00

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

Sample interval	900 seconds
Start date	6/3/2004
Start time	23:00:00

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

Sample interval	900 seconds
Start date	6/3/2004
Start time	23:00:00

Seabird SBE37 SMP CTD – serial number **3267**

Sample interval	900 seconds
Start date	6/3/2004
Start time	23:00:00

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

Sample interval	900 seconds
Start date	6/3/2004
Start time	23:00:00

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

Sample interval	900 seconds
Start date	6/3/2004
Start time	23:00:00

After deployment, date on instrument found to be set incorrectly. First record will have date 6/3/2004 but is actually 27/3/2004. Need to advance all dates by 21 days during processing. Instrument started logging 20 days after deployment (21 days after intended start).

Interocean S4AD – serial number **35612565**

Header	MAR2
On time	2 mins
Cycle time	30 mins
Average count	1
Channels at average	Hx, Hy, Cond., Temp., Depth
Special Record Block Count	0
Start date	3/3/2004
Start time	12:30:00

Seabird SBE26 BPR – serial number **0395**

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	6/3/2004 13:50:00

WB4

Aanderaa RCM11 – serial number **308**

Pings per ensemble	600
Temperature range	Low
Conductivity range	0-74mS
Recording interval	30 mins
No of channels	8
Mode	Normal
Instrument started	21/3/2004 15:00:00

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

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

Start date	24/3/2004
Start time	01:00:00
Profile start interval	3 days 18 hours
Reference date	24/3/2004
Reference time	08:00:00
Burst interval	Disabled
Paired profiles	Enabled
Shallow pressure limit	106 dbar
Deep pressure limit	4536 dbar
Shallow pressure error	156 dbar
Deep pressure error	4485 dbar

Seabird SBE37 SMP CTD – serial number **3263**

Sample interval	900 seconds
Start date	22/3/2004
Start time	14:00:00

Interocean S4AD – serial number **35612578**

Header	2578 S4
On time	2 mins
Cycle time	30 mins
Average count	1
Channels at average	Hx, Hy, Cond., Temp., Depth
Special Record Block Count	0
Start date	22/3/2004
Start time	15:30:00

Seabird SBE26 BPR – serial number **0392**

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	20/3/2004 20:00:00

<u>WBH2</u>

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

Sample interval	900 seconds
Start date	24/3/2004
Start time	13:45:00

Seabird SBE37 SMP CTD – serial number **3260**

Sample interval	900 seconds
Start date	24/3/2004
Start time	13:45:00

Seabird SBE37 SMP CTD – serial number **3261**

Sample interval	900 seconds
Start date	24/3/2004
Start time	13:45:00

Seabird SBE37 SMP CTD – serial number **3262**

Sample interval	900 seconds
Start date	24/3/2004
Start time	14:00:00

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

Sample interval	900 seconds
Start date	24/3/2004
Start time	14:00:00

Seabird SBE26 BPR – serial number **0393**

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	24/3/2004 19:10:00

WBH1

Seabird SBE37 SMP CTD – serial number **3245**

Sample interval	900 seconds
Start date	24/3/2004
Start time	12:00:00

Seabird SBE37 SMP CTD – serial number **3246**

Sample interval	900 seconds
Start date	24/3/2004
Start time	14:00:00

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

Sample interval	900 seconds
Start date	24/3/2004
Start time	14:00:00

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

Sample interval	900 seconds
Start date	24/3/2004
Start time	14:00:00

Seabird SBE37 SMP CTD – serial number **3244**

Sample interval	900 seconds
Start date	24/3/2004
Start time	12:00:00

Seabird SBE26 BPR – serial number **0400**

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	24/3/2004 14:30:00

WB2

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

ID number	20
Sample interval	900 seconds
Start date	24/3/2004
Start time	23:00:00

Sontek Argonaut MD – serial number **D301**

Averaging interval	120 seconds
Sampling interval	1200 seconds
Salinity	35.0 ppt
Blanking distance	1.5m
Cell size	1.5m
Deployment name	WB2
Start date	24/3/2004
Start time	12:00:00
Baud rate	9600.

Seabird SBE37 SMP CTD – serial number **3219**

Sample interval	900 seconds
Start date	24/3/2004
Start time	12:00:00

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

ID number	21
Sample interval	900 seconds
Start date	24/3/2004
Start time	23:00:00

Sontek Argonaut MD – serial number **D274**

Averaging interval	120 seconds
Sampling interval	1200 seconds
Salinity	35.0 ppt
Blanking distance	1.5m
Cell size	1.5m
Deployment name	DEF
Start date	24/3/2004
Start time	12:00:00
Baud rate	9600

Seabird SBE37 SMP CTD – serial number **3206**

Sample interval	900 seconds
Start date	24/3/2004
Start time	12:00:00

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

ID number	22
Sample interval	900 seconds
Start date	24/3/2004
Start time	23:00:00

Sontek Argonaut MD – serial number **D303**

Averaging interval	120 seconds
Sampling interval	1200 seconds

Salinity	35.0 ppt
Blanking distance	1.5m
Cell size	1.5m
Deployment name	WB2
Start date	24/3/2004
Start time	12:00:00
Baud rate	9600

Seabird SBE37 SMP CTD – serial number **3220**

Sample interval	900 seconds
Start date	24/3/2004
Start time	23:00:00

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

ID number	23
Sample interval	900 seconds
Start date	24/3/2004
Start time	23:00:00

Sontek Argonaut MD – serial number **D272**

Averaging interval	120 seconds
Sampling interval	1200 seconds
Salinity	35.0 ppt
Blanking distance	1.5m
Cell size	1.5m
Deployment name	WB2
Start date	24/3/2004
Start time	12:00:00
Baud rate	9600

Seabird SBE37 SMP CTD – serial number **3221**

Sample interval	900 seconds
Start date	24/3/2004
Start time	23:00:00

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

ID number	24
Sample interval	900 seconds
Start date	24/3/2004
Start time	23:00:00

Sontek Argonaut MD – serial number **D273**

Averaging interval	120 seconds
Sampling interval	1200 seconds
Salinity	35.0 ppt
Blanking distance	1.5m
Cell size	1.5m
Deployment name	WB2
Start date	24/3/2004
Start time	12:00:00
Baud rate	9600

Seabird SBE37 SMP CTD – serial number **3222**

Sample interval	900 seconds
Start date	24/3/2004
Start time	23:00:00

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

ID number	25
Sample interval	900 seconds
Start date	24/3/2004
Start time	23:00:00

Sontek Argonaut MD – serial number **D298**

Averaging interval	120 seconds
Sampling interval	1200 seconds
Salinity	35.0 ppt
Blanking distance	1.5m
Cell size	1.5m
Deployment name	WB2
Start date	24/3/2004
Start time	12:00:00
Baud rate	9600

Seabird SBE37 SMP CTD – serial number **3223**

Sample interval	900 seconds
Start date	24/3/2004
Start time	23:00:00

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

ID number	26
Sample interval	900 seconds
Start date	24/3/2004
Start time	23:00:00

Interocean S4AD – serial number **35612572**

Header	2572 S4
On time	2 mins
Cycle time	30 mins
Average count	1
Channels at average	Hx, Hy, Cond., Temp., Depth
Special Record Block Count	0
Start date	22/3/2004
Start time	15:30:00

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

ID number	27
Sample interval	900 seconds
Start date	24/3/2004
Start time	23:00:00

Interocean S4AD – serial number **35612573**

Header	2573 S4
On time	2 mins
Cycle time	30 mins
Average count	1

Channels at average	Hx, Hy, Cond., Temp., Depth
Special Record Block Count	0
Start date	21/3/2004
Start time	15:30:00

Seabird SBE26 BPR – serial number **0398**

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	24/3/2004 20:00:00

<u>WB1</u>

Aanderaa RCM11 – serial number **302**

Pings per ensemble	600
Temperature range	Low
Conductivity range	0-74mS
Recording interval	30 mins
No of channels	8
Mode	Normal
Instrument started	27/3/2004 01:00:00

Aanderaa RCM11 – serial number **303**

Pings per ensemble	600
Temperature range	Low
Conductivity range	0-74mS
Recording interval	30 mins
No of channels	8
Mode	Normal
Instrument started	26/3/2004 21:00:00

Aanderaa RCM11 – serial number **304**

Pings per ensemble	600
Temperature range	Low
Conductivity range	0-74mS
Recording interval	30 mins
No of channels	8
Mode	Normal
Instrument started	26/3/2004 22:00:00

Aanderaa RCM11 – serial number **305**

Pings per ensemble	600
Temperature range	Low
Conductivity range	0-74mS
Recording interval	30 mins
No of channels	8
Mode	Normal
Instrument started	26/3/2004 21:30:00

Aanderaa RCM11 – serial number **306**

Pings per ensemble	600
Temperature range	Low
Conductivity range	0-74mS
Recording interval	30 mins
No of channels	8
Mode	Normal
Instrument started	26/3/2004 23:30:00

Interocean S4AD – serial number **35612568**

Header	WB1 800m
On time	2 mins
Cycle time	30 mins
Average count	240
Channels at average	Hx, Hy, Cond., Temp., Depth
Special Record Block Count	0
Start date	27/3/2004

Start time	01:00:00

Interocean S4AD – serial number **35612569**

Header	WB1 1000m
On time	2 mins
Cycle time	30 mins
Average count	240
Channels at average	Hx, Hy, Cond., Temp., Depth
Special Record Block Count	0
Start date	27/3/2004
Start time	01:00:00

Interocean S4AD – serial number **35612570**

Header	WB1 1200m
On time	2 mins
Cycle time	30 mins
Average count	240
Channels at average	Hx, Hy, Cond., Temp., Depth
Special Record Block Count	0
Start date	27/3/2004
Start time	01:00:00

Interocean S4AD – serial number **35612571**

Header	WB1 1408m
On time	2 mins
Cycle time	30 mins
Average count	240
Channels at average	Hx, Hy, Cond., Temp., Depth
Special Record Block Count	0
Start date	27/3/2004
Start time	01:00:00

Seabird SBE26 BPR – serial number **0399**

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	27/3/2004 01:20:00

WBADCP

150kHz Broadband ADCP – Serial number **1184**

System frequency	150kHz
Beam angle	20 degrees
System Power	Low
Water temperature	10 deg C
Water salinity	35ppt
Depth of transducer	500m
WT Pings per ensemble	10
Depth cell size	8.00m
Number of depth cells	30
Blank after transmit	2.00m
WT profiling mode	4
WT ambiguity velocity	480cm/s
BT pings per ensemble	0
Time between ping groups	0.00s
Time per ensemble	00:10:00:00
Deployment length	425 days
Coordinate system	Earth
Baud rate	38400
Start Date (from log file)	18/03/2004
Start Time (from log file)	19:22:00 (approx)

Time per ensemble set wrong. Should be 15 minutes instead of 10. The memory will be full after 384 days as only has 46MB of memory installed. This corresponds to a date of 6/4/05. No delayed start was entered so the start date and time is taken from the date in the deployment log file – exact time not known.

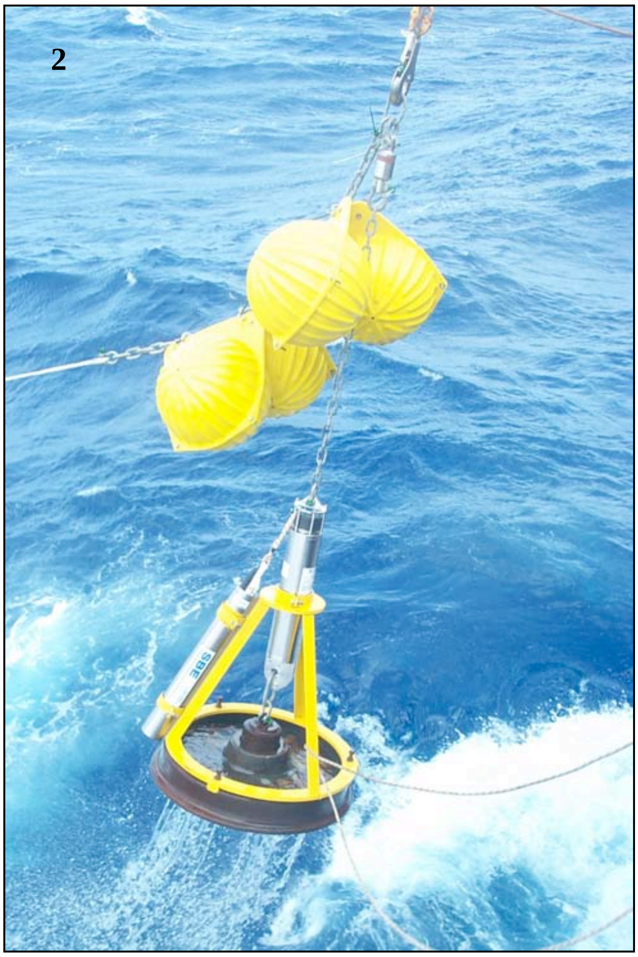
Aanderaa WLR8 – serial number **1684**

Sampling interval	15 mins
Date switched on	18/3/04
Barometric pressure when switched on	1020.41
Time switched on	17:00

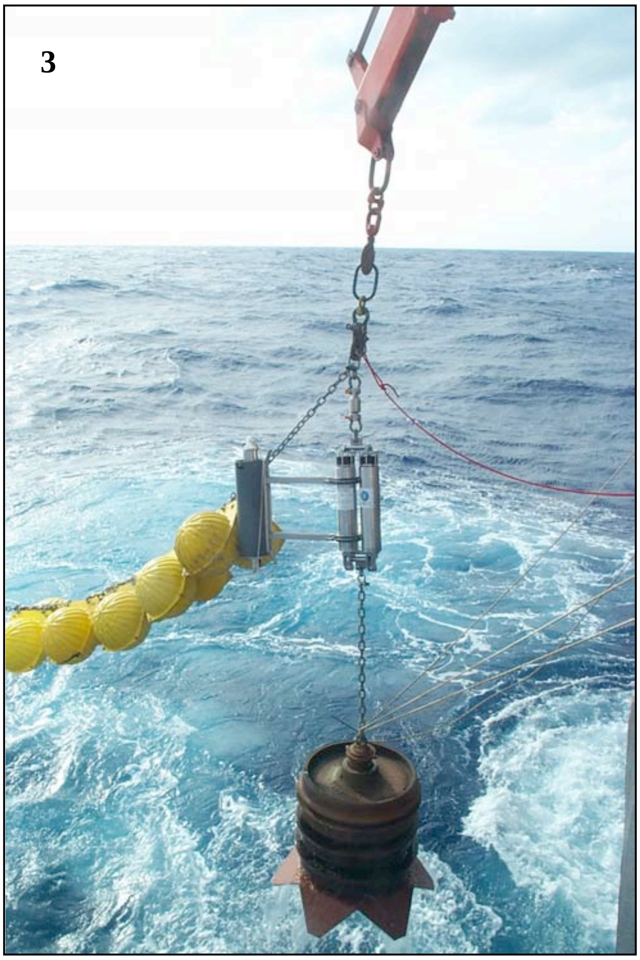
Appendix C: Photographs

Photograph 1: A WBH mooring flaked into fish baskets ready for deployment

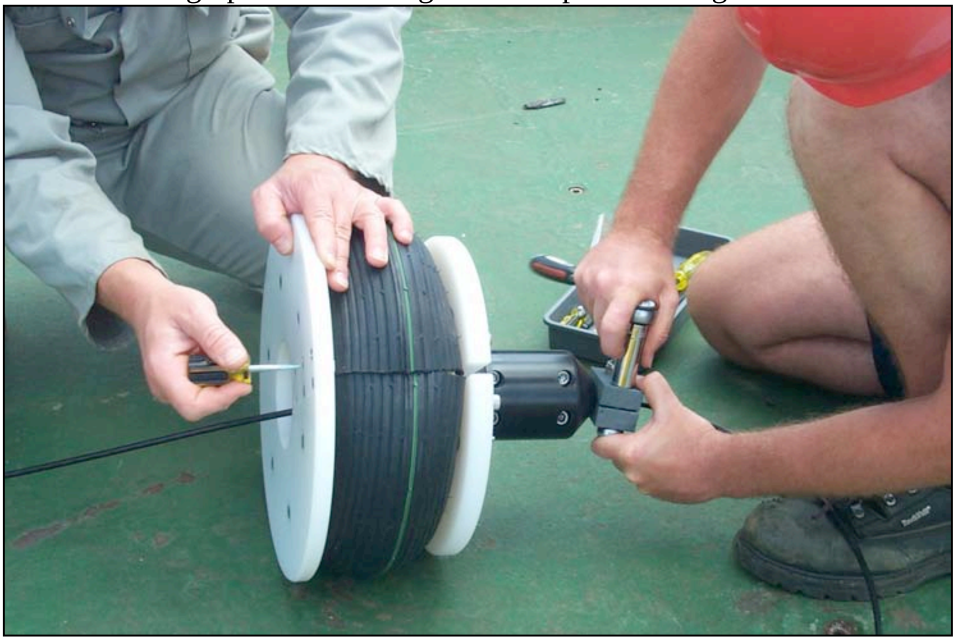
Photograph 2: Deployment of small anchor with BPR and acoustic release tripod



Photograph 3: Deployment of large anchor with Dual release and BPR drop off kit



Photograph 4: Attaching MMP stop to mooring wire



Photograph 5: Deployment of MMP on WB4 mooring

Photograph 6: Inductive swivel as deployed on EB3

Photograph 7: EB3 inductive mooring umbilical flaked on deck prior to deployment