National Oceanography Centre

RESEARCH EXPEDITION REPORT

RAPID 26N Report for RRS Discovery research Expedition DY186

10th Dec 2024 to 19th Dec 2024

B. I. Moat, T. Petit and Y. L. Firing

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Author
Moat, B. I., Firing, Y. L, Petit, T.

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Abstract

The purpose of *RRS Discovery* research expedition DY186 was to refurbish the Western Boundary of the RAPID 26°N array of moorings that span the Atlantic from the Bahamas to the Canary Islands. The expedition started in Fort Lauderdale, USA on Wednesday 10th December 2024 and ended on Thursday 19th December 2024 in Fort Lauderdale, USA.

The moorings are part of a purposeful Atlantic wide array that observes the Atlantic Meridional Overturning Circulation and the associated heat and freshwater transports. The RAPID-MOCHA-WBTS array is a joint UK- US programme.

During DY186 moorings were serviced at sites: WB1, WB1L, WB2, WB2L, WBADCP, WBAL. Bottom pressure data was downloaded from WB3LZ. The bottom pressure lander WB2LZ was faulty and was recovered. Sites with suffix 'L' denote landers fitted with bottom pressure recorders.

Moorings were equipped with instruments to measure temperature, conductivity and pressure, and a number of moorings were also equipped with current meters and/or oxygen sensors.

CTD stations were conducted throughout the cruise for purposes of providing pre- and post-deployment calibrations for mooring instrumentation.

Shipboard underway measurements were systematically logged, processed and calibrated, including: surface meteorology, 5m depth sea temperatures and salinities, water depth, and navigation. Water velocity profiles from 15 m to approximately 800 m depth were obtained using two vessel mounted Acoustic Doppler Current Profilers (one 75 kHz and one 150 kHz).

Keywords
Atlantic Meridional Overturning Circulation, AMOC, RAPID, moorings, mooring array, North Atlantic

Issuing Organisation
National Oceanography Centre, European Way, Southampton SO14 3ZH UK
Email: publications@noc.ac.uk nol@noc.soton.ac.uk
A pdf of this report is available for download at: http://eprints.soton.ac.uk

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Name	Position	Affiliation
Antonio Gatti	Master	
Thomas Williams	Chief Officer	
Jordon Greenhow	2nd Officer	
Jake Crosby	3rd Officer	
James Bills	Chief Engineer	
Dan Evans	2nd Engineer	
Elliot Draper	3rd Engineer	
Kai Foreman	3rd Engineer	
David Pascoe	ETO	
Glyndor Henry	ERPO	
Valerija Brown	Purser	
Ryan Paris	CPOS	
John Hopely	CPOD	
Steven Duncan	POD	
Gary Crabb	SG1A	
Joseph Brady	SG1A	
Andrew Whitehead	SG1A	
Michael Leigh	Head chef	
Monal Shah	Chef	
Michal Dwojewski	Steward	
David Arkley	A/Steward	
Harriet Harding	Cadet	
Ben Moat	Chief Scientist	NOC
Tillys Petit	Co-Chief Scientist	NOC
Yvonne Firing	Scientist	NOC
Adam Ward	Scientist	NOC
Chris Cardwell	Engineer	NOC
Benjamin Tiger	PhD student	WHOI/MIT
Jordan Atherton	Scientist	BODC
Joel Hedges	Engineer	NOC
Maria De La Fuente Ruiz	Scientist	Univ. of Brussels
Nick Harmon	Scientist	WHOI
Tina Thomas	Senior Technical Officer	NOC/NMFSS
Zoltan Nemeth	ITO	NOC/NMFSS
Chris Crowe	Technician (Moorings)	NOC/NMFSS
Dave Childs	Technician (Moorings)	NOC/NMFSS
Stephen Corless	Technician (Engineering)	NOC/NMFSS
Martin Weeks	Technician (Engineering)	NOC/NMFSS
Jade Garner	Technician (Moorings)	NOC/NMFSS
John Clarke	Technician (Moorings)	NOC/NMFSS
Jason Scott	Programme Manager	NOC/NMFSS
Paul Provost	Technician (Moorings)	NOC/NMFSS

2. Itinerary

The RAPID 26N expedition aboard the RRS Discovery DY186 departed Fort Lauderdale USA on 10^{th} December 2024 and concluded on 19^{rd} December 2024 in Fort Lauderdale USA. April. A full itinerary is given in Table 2.1.

Table 2.1 Cruise Itinerary (time in GMT).

Date	Operation	Start time	End time	Durat. (hrs)	Latitude (°N)	Long. (°W)	Notes
Tue 10 Dec	Depart Fort Lauderdale	23:00					Head to Nassau for Diplomatic clearance
Wed 11 Dec	Arrive Nassau	17:00					
	Depart Nassau	19:00					
	CTD 1						Test CTD. Oxygen reading low. Altimeter fault. Aborted cast
	CTD 2	22:57	23:43		25°37.97	77°05.94	Test CTD to 800m.
Thu 12 Dec	CTD 3	01:10	05:14		25°48.86	76°59.76	Calibration cast. 24 MicroCATs and 8 releases
	Recover WB2L14	13.40	14:02		25°30.21	76°44.62	
	Recover WB2	15.41	19:34		25°30.94	76°44.44	
	Download WB2LZ data	20:35	22:20		25°29.81	76°45.07	No comms to the WB2LZ
	CTD 4	23:04	02:43		26°29.67	76°45.13	Calibration cast. 24 MicroCATs and 8 Releases. Limited to 3500m shallow MCATS
Fri 13 Dec	Transit to WB3LZ				26°29.39	76°30.28	
	Download WB3LZ				26°29.39	76°30.28	
	Transit WB2				26°30.94	76°44.44	
	Deploy WB2	15:06	00:49				
Sat 14 Dec	Deploy WB2L16	01:20	01:20				
	CTD 5	02:44	06:41		26°29.35	76°40.44	Calibration cast. 24 MicroCATs

	CTD 6	07:55	09:22		26°29.98	76°48.41	Pre WB1 oxygen profile
Sun 15 Dec	WB2 Telemetry test	14:00	17:00				
	WB2LZ	17:40	20:35		26°29.81	76°45.07	Data download (failed: battery flat)
	Transit Abaco						Shelter behind the southern end of Abaco Island
Mon 16 Dec	Recover WB1L1	13:24	13:55		26°30.22	76°48.97	
	Recover WBAL9	14:59	15:26		26°32.29	76°51.98	
	Recovery WBADCP	16:36	16:39		26°31.80	76°52.06	
	Deploy WBADCP	19:29	19:38				
	Recover WB2LZ				26°29.81	76°45.07	
Tue 17 Dec	Recover WB1	13:29	15:59		26°29.89	76°48.91	
	Deploy WB1	17:02	19:47				
	Deploy WB1L2	20:21	20:27				
	Deploy WBAL11	21:33	21:37				
Wed 18 Dec	CTD7	00:05	03:47		26°29.85	76°42.32	
	CTD8	05:39	06:54		26°29.92	76°48.19	
	CTD9	17:02	18:28		26°30.49	76°42.90	1500m only to calibrate 1 MicroCAT
Thu 19th Dec	Arrive Fort Lauderdale	07:00					

3. Introduction

This cruise report is for cruise DY186 conducted aboard RRS *Discovery* in winter 2024. The primary purpose of the cruise was to service the UK contribution to the RAPID-MOC/MOCHA mooring array. The RAPID-MOC/MOCHA array was first deployed in 2004 to measure the Atlantic Meridional Overturning Circulation (AMOC) at 26°N and has been maintained by regular service cruises since then. The array and associated observations are funded by NERC, NSF and NOAA. The NERC contribution to the first four years of measurements was funded under the directed programme "RAPID Climate Change". Following an international review NERC continued funding to 2014 under the programme "RAPID-WATCH". The servicing and redeployment of the UK moorings on this cruise are conducted under the "RAPID-AMOC" programme, which is funded until 2020. NSF and NOAA have also continued funding and commitments so that the system can continue operating at the same level of activity.

RAPID-AMOC continues the measurements at 26°N and extends these to include biological and chemical measurements in order to determine the variability of the AMOC and its links to climate and the ocean carbon sink on interannual-to-decadal time scales.

For further information on the RAPID-MOC/MOCHA array, please see previous cruise reports (detailed in Table 3.1).

As on previous cruises, we deployed two Argo floats supplied by the UK Met Office. All Argo data is freely available online - see http://www.argo.net/ for further details.

3.1 Results and Data Policy

All data and data products from the RAPID 26°N project are freely available. The NERC data policy may be found at http://www.bodc.ac.uk/projects/uk/rapid/data policy/. Access to data and data products can be obtained via https://rapid.ac.uk and https://mocha.earth.miami.edu/mocha/results/index.html). Data may also be obtained directly from http://www.bodc.ac.uk/. A full list of published papers is available on the programme website at https://rapid.ac.uk/publications

3.2 Previous RAPID-MOC Cruises

Table 3.1 details the previous cruises completed as part of the RAPID-MOC project with information on the relevant cruise reports for reference, note this does not include all NOAA WBTS hydrography cruises.

Cruise	Vessel	Date	Objectives	Cruise Report
D277	RRS *Discovery*	Feb - Mar 2004	Initial Deployment of Eastern Boundary and Mid-Atlantic Ridge moorings.	Southampton Oceanography Centre Cruise Report, No 53, 2005
D278	RRS *Discovery*	Mar 2004	Initial Deployment of UK and US Western Boundary Moorings.	Southampton Oceanography Centre Cruise Report, No 53, 2005

D279	RRS *Discovery*	Apr – May 2004	Transatlantic hydrography (125 CTD stations).	Southampton Oceanography Centre, Cruise Report, No 54, 2005
P319	RV *Poseidon*	Dec 2004	Emergency deployment of replacement EB2 following loss.	Appendix in National Oceanography Centre Southampton Cruise Report, No. 2, 2006
CD170	RRS *Charles Darwin*	Apr 2005	Service and redeployment of Eastern Boundary and Mid-Atlantic Ridge moorings.	National Oceanography Centre Southampton Cruise Report, No. 2, 2006
KN182-2	RV *Knorr*	May 2005	Service and redeployment of UK and US Western Boundary Moorings and Western Boundary Time Series (WBTS) hydrography section.	National Oceanography Centre Southampton Cruise Report, No. 2, 2006
CD177	RRS *Charles Darwin*	Nov 2005	Service and redeployment of key Eastern Boundary moorings.	National Oceanography Centre Southampton Cruise Report, No. 5, 2006
WS05018	RV *F.G. Walton Smith*	Nov 2005	Emergency recovery of drifting WB1 mooring.	No report published
RB0602	RV *Ronald H. Brown*	Mar 2006	Service and redeployment of UK Western Boundary moorings and WBTS hydrography section.	National Oceanography Centre Southampton Cruise Report, No. 16, 2007
D304	RRS *Discovery*	May - Jun 2006	Service and redeployment of Eastern Boundary and Mid-Atlantic Ridge moorings.	National Oceanography Centre Southampton Cruise Report, No. 16, 2007
P343	RV *Poseidon*	Oct 2006	Service and redeployment of key Eastern Boundary moorings.	National Oceanography Centre Southampton

				Cruise Report No. 28, 2008.
P345	RV *Poseidon*	Nov – Dec 2006	Emergency redeployment of EB1 and EB2 following problems on P343.	National Oceanography Centre Southampton Cruise Report No. 28, 2008.
SJ-14-06	RV *Seward Johnson*	Sep – Oct 2006	Recovery and redeployment of WB2 and US Western Boundary moorings, and WBTS hydrography section.	Appendix G in National Oceanography Centre, Southampton Cruise Report, No 29
RB0701	RV *Ronald H. Brown*	Mar - Apr 2007	Service and redeployment of UK Western Boundary moorings and WBTS hydrography section.	National Oceanography Centre, Southampton Cruise Report, No 29
D324	RRS *Discovery*	Oct – Nov 2007	Service and redeployment of Eastern Boundary and Mid-Atlantic Ridge moorings.	National Oceanography Centre, Southampton Cruise Report, No 34
SJ0803	RV *Seward Johnson*	Apr 2008	Service and redeployment of the Western Boundary moorings.	National Oceanography Centre, Southampton Cruise Report, No 37
D334	RRS *Discovery*	Oct-Nov 2008	Service and redeployment of the Eastern Boundary and Mid-Atlantic Ridge moorings.	National Oceanography Centre, Southampton, Cruise Report No. 38, 2009
RB0901	RV *Ronald H. Brown*	Apr – May 2009	Service and redeployment of the UK and US Western Boundary moorings and the WBTS hydrography section.	National Oceanography Centre, Southampton Cruise Report, No 40, 2009
D344	RRS *Discovery*	Oct – Nov 2009	Service and redeployment of the Eastern Boundary and Mid-Atlantic Ridge moorings.	National Oceanography Centre, Southampton,

				Cruise Report No. 51, 2010
D345	RRS *Discovery*	Nov – Dec 2009	Recovery and redeployment of US Western Boundary moorings, and WBTS hydrography section.	RAPID/MOCHA Program Report (W. Johns, RSMAS).
D346	RRS *Discovery*	Jan – Feb 2010	Transatlantic hydrography (135 CTD stations).	National Oceanography Centre Cruise Report, No 16, 2012
OC459	RV *Oceanus*	Mar – Apr 2010	Service and redeployment of the Western Boundary moorings.	National Oceanography Centre Cruise Report, No 01, 2010
RB1009	RV *Ronald H. Brown*	Nov – Dec 2010	Recovery of WB4 and WB3L3. Redeployment of WB4.	Appendix in: National Oceanography Centre Cruise Report, No -01, 2010
D359	RRS *Discovery*	Dec 2010 – Jan 2011	Service and redeployment of the Eastern Boundary and Mid-Atlantic Ridge moorings.	National Oceanography Centre Cruise Report, No. 09, 2011
KN200-4	RV *Knorr*	Apr – May 2011	Service and redeployment of Western Boundary Moorings and WBTS hydrography section.	National Oceanography Centre Cruise Report, No 07, 2011
JC064	RRS *James Cook*	Sep – Oct 2011	Service and redeployment of the Eastern Boundary and Mid-Atlantic Ridge moorings.	National Oceanography Cruise Report, No. 14, 2012
RB1201	RV *Ronald H. Brown*	Feb – Mar 2012	Service and redeployment of Western Boundary Moorings and WBTS hydrography section.	National Oceanography Centre, Cruise Report No. 19, 2012
EN517	RV *Endeavor*	Sep – Oct 2012	Service of US moorings in Western Boundary.	RV Endeavor Cruise EN-517 Cruise Report
D382	RRS *Discovery*	Oct – Nov 2012	Service and redeployment of full UK RAPID array.	National Oceanography Centre Cruise

				Report No. 21, 2012
AE1404	RV *Atlantic Explorer*	Mar 2014	Service of US moorings in Western Boundary.	RV Atlantic Explorer Cruise AE-1404 Cruise Report
JC103	RRS *James Cook*	Apr – Jun 2014	Service and redeployment of full UK RAPID array.	National Oceanography Centre Cruise Report No. 30, 2015
EN570	RV *Endeavor*	Oct 2015	Service of US moorings in Western Boundary.	RV Endeavor Cruise EN-570 Cruise Report
DY039	RRS *Discovery*	Oct – Dec 2015	Service and redeployment of full UK RAPID array.	National Oceanography Centre Cruise Report, 37
DY040	RRS *Discovery*	Dec 2015 – Jan 2016	Transatlantic hydrography.	National Oceanography Centre Cruise Report, XX
EN598	RV *Endeavor*	May 2017	Service of US moorings in Western Boundary.	RV Endeavor Cruise EN-598 Cruise Report
JC145	*RRS James Cook*	Feb – Apr 2017	Service and redeployment of full UK RAPID array.	National Oceanography Centre Cruise Report, 52
JC174	*RRS James Cook*	Oct – Nov 2018	Service and redeployment of full UK RAPID array.	National Oceanography Centre Cruise Report, 59
JC192	*RRS James Cook*	March 2020	Service and redeployment of eastern boundary of the UK RAPID array.	National Oceanography Centre Cruise Report, 71
DY129	RRS *Discovery*	December 2020 – January 2021	Recovery of RAPID MAR array and recovery and redeployment of RAPID western boundary array.	National Oceanography Centre Cruise Report, 72
DY146	RRS *Discovery*	Feb – Mar 2022	Recovery and redeployment of RAPID Eastern Boundary.	National Oceanography Centre Cruise Report, 76
EN697	RV *Endeavor*	Mar – Apr 2023	Recovery and redeployment of UK	R/V Endeavor Cruise EN-697 Cruise Report

			Western Boundary moorings	
EN705	RV *Endeavor*	July 2023	Recovery and redeployment of UK Western Boundary moorings.	R/V Endeavor Cruise EN-705 Cruise Report
DY174	RRS *Discovery*	Mar – Apr 2024	Recovery and redeployment of RAPID Eastern Boundary.	National Oceanography Centre Cruise Report, 82
DY186	RRS *Discovery*	Dec 2024	Recovery and redeployment of UK Western Boundary moorings.	This report

Table 3.1 Cruises conducted as part of the RAPID 26°N project

4. Scientific Computing Systems and Data Processing

Yvonne Firing

4.1 Workstations and configuration

Three OCP Linux workstations were configured on DY186, all running Ubuntu. One, koaekea, was the primary workstation, while akeake and kolea were used to access koaekea via ssh. Shell scripts from the mexec_exec toolbox (git.noc.ac.uk/OCP/mexec_exec) were run by cron to sync data (CTD and VMADCP as well as .csv backups of the RVDAS data) from network drives to koaekea, and to sync data and software from koaekea to the other two workstations and to two external hard drives for backup. Mooring-specific backup scripts developed on DY181 were also used to sync selected processed data (only from moorings updated on this cruise) to the backup external hard drives.

Access to ship systems and data, via mounting shared drives and the RVDAS postgresql database, was similar to how it is described in the cruise reports for DY174 and DY181, relying on user credentials stored in a file under /data/pstar and accessed by Matlab and shell (cron) scripts.

4.2 Data Processing Tools

Data processing and plotting used the MATLAB Gibbs Seawater (gsw) toolbox (v3_06_15), neutral density (gamma_n) code (v3_05_10), and Seawater toolbox (ver3_3_1, used only for sw_dist.m). We also used the pyIGRF package to estimate magnetic declination for Nortek current meter processing. The psql package was used to get data from the RVDAS database.
Shipboard ADCP data are acquired by the UHDAS system and processed automatically using CODAS (https://currents.soest.hawaii.edu) installed on the UHDAS machine. Data were synced to koaekea and a locally installed version of CODAS was used to review and edit out additional bad data to reprocess.

4.3 Hydrographic data

Hydrographic data were processed using ocp_hydro_matlab (https://github.com/NOC-OCP/ocp_hydro_matlab) for CTD, bottle sample, and underway data, which was cloned into /data/pstar/programs/gitvcd/ocp_hydro_matlab on the workstation. Following changes to code on DY181, a copy of the lookup table constructed by the scripts for underway variables was stored in /data/pstar/projects/rpdmoc/cruise_data/dy186/mcruise/data/rvdas to enable working with underway data without access to the RVDAS postgresql database (after the cruise).

4.4 Moored data

Moored and calibration dip data were processed (stage1 and stage2 processing for microcats and Nortek, and stage1 processing for BPR data) using the dy186 branch of m_moorproc_toolbox (https://github.com/ScotMarPhys/m_moorproc_toolbox), cloned into /data/pstar/programs/gitvcd/m_moorproc_toolbox on the workstation. A few changes were made on this cruise to combine/simplify the plotting scripts; for other changes since DY174 see the DY181 report.

5. NMFSS Ship Systems Computing and Underway Instruments

Zoltan Nemeth

5.1 Overview

The information in this section has been taken from the NMF Scientific Ship Systems Cruise Report where full details can be found.

The ship-fitted instruments are listed in Table 5.1, the data were logged by the Techsas 5.11 data acquisition system. The system creates NetCDF and ASCII output data files. Data were additionally logged onto the legacy RVS Level-C format and raw NEMA strings from the instruments were time stamped and logged.

Manufacturer	Model	Function/data types	Logged? (Y/N)	Comments
Meinberg		GPS network time server (NTP)	N	Not logged
Applanix	POS MV	Primary GPS and attitude	Y	
C-Nav	3050	Correction service for primary and secondary GPS and dynamic positioning.	Y	
Kongsberg Seatex	Seapath 330+	Primary GPS and attitude	Y	
Fugro Seastar / MarineStar		Correction service for primary and secondary GPS and dynamic positioning.	Y	
Sperry Marine		Ship gyrocompasses x 2	Y	
Chernikeef Instruments	Aquaprobe Mk5	Electromagnetic speed log	Y	Needs Calibration
Kongsberg Maritime	Simrad EA640	Single beam echo sounder (hull)	Y	
Kongsberg Maritime	Simrad EM122	Multibeam echo sounder (deep)	Y	
NMFSS	CLAM	CLAM system winch log	Y	
NMFSS	Surfmet	Meteorology suite	Y	
NMFSS	Surfmet	Surface hydrography suite	Y	

		Skipper log (ship's velocity)	Y	
OceanWaveS GmbH	WaMoS II	Wave Radar	N	
Teledyne RD Instruments	Ocean Observer 75 kHz	UHDAS	Y	
Teledyne RD Instruments	Ocean Observer 150 kHz	UHDAS	Y	

Table 5.1 Ship-fitted instruments

There are several gaps in the data from the EA640 and EM122 due to isolation of the systems during release and ranging of moorings.

5.2 Position and Attitude

GPS and attitude measurement systems were run throughout the cruise.
The ***Applanix POSMV*** system is the vessel's primary GPS system, outputting the position of the ship's common reference point in the gravity meter room. The POSMV is available to be sent to all systems and is repeated around the vessel. The position fixes attitude and gyro data are logged to the Techsas system. True Heave is logged by the Kongsberg EM122 & EM710 systems.
The ***Kongsberg Seapath 330+*** system is the vessel's secondary GPS system. This was the position and attitude source that was used by the EM122 & EM710 due to its superior real-time heave data. Position fixes and attitude data are logged to the Techsas system.
The ***CNav 3050*** GPS system is the vessel's differential correction service. It provides the Applanix POSMV and Seapath330+ system with RTCM DGPS corrections (greater than 1m accuracy). The position fixes data are logged to the Techsas system.

5.3 Meteorology and Sea Surface Monitoring Package

The NMF Surfmet system was run throughout the cruise, excepting times for cleaning, entering and leaving port and whilst alongside (Table 5.2).
The Surfmet system is comprised of:

- Hull water inlet temperature probe (SBE38).
- Sampling board conductivity, temperature salinity sensor (SBE45).
- Sampling board transmissometer (CST).
- Sampling board fluorometer (WS3S)
- Met platform temperature and humidity probe (HMP45).
- Met platform port and starboard ambient light sensors (PAR, TIR).
- Met platform atmospheric pressure sensor (PTB110).
- Met platform anemometer (Windsonic).

Date	Start Time	Stop Time	Cleaned	Transmissivity (v)	
				High	Low
06/Dec/2024	17:00	18:00	Yes	-	0.006
				Underway turned on	
				Underway turned off upon exit of international waters	
19/Dec/2024	17:00	18:00	Yes	-	-

Table 5.2 Underway water logging events

5.4 Hydro-acoustic Systems

The EA640 single-beam echo-sounder was run throughout the cruise apart from during release and ranging of moorings when it was turned off to avoid interference. Both the 10 kHz and 12 kHz were run in active mode triggered by K-Sync. Pulse parameters were altered during the cruise in response to changing depth. It was used with a constant sound velocity of 1500 ms^{-1} throughout the water column to allow it to be corrected for sound velocity in post processing.
The EM122 multibeam echo sounder was run throughout the cruise apart from during release and ranging of moorings triggered by K-sync. The position and attitude data were supplied from the Seapath 330+ due to its superior real-time heave. Applanix PosMV position and attitude data is also logged to the .all files as the secondary source and True Heave *.ath file are logged to allow for inclusion during reprocessing. Sound velocity profiles were derived from a statistical model using SHOM & Ifremer's DORIS programme, derived from CTD data. The surface Sound Velocity (SV) sensor (AML SmartSV) mounted on the drop keel was used throughout providing SV data to the EM122. The port drop keel remained flush with the hull for the duration of the cruise. Both the 75 and 150 kHz were run consistently during the cruise. The 75kHz Teledyne OS75 Acoustic Doppler Current Profiler (ADCP) was not run due to a transmit signal error. The 150kHz Teledyne OS150 ADCP was run continuously in self-triggering mode (not through the K-sync).
Four deployments of the USBL were completed as part of tests of a telemetry system.

5.5 Other Systems

The single axis bridge Skipper Log and the dual axis Chernikeef science log were logged throughout the cruise for navigational purposes.

6. Underway Data and Processing

Yvonne Firing

6.1 Overview

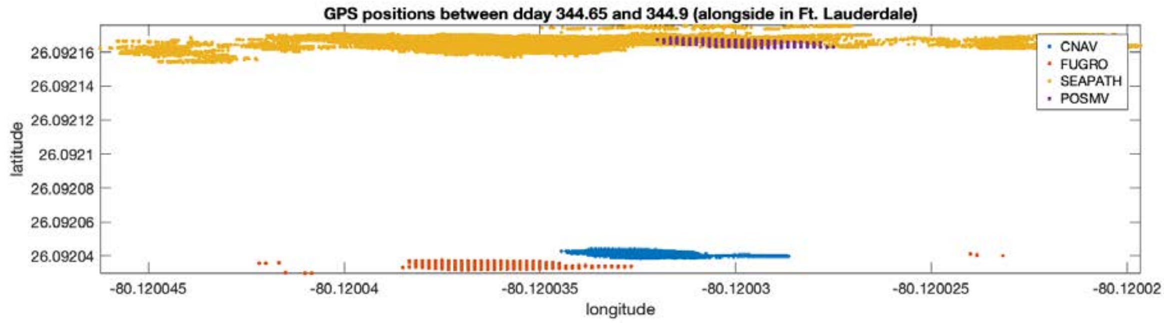
Most underway streams are logged by two systems, Techsas and RVDAS, and latest data as well as recent time series are displayed in several formats viewable in the main laboratory as well as on the ship intranet. Vessel-mounted Acoustic Doppler Current Profiler (VMADCP) data acquired by UHDAS are also viewable both online and on dedicated displays, while multibeam (swath) bathymetry data from the EM122 are viewable on displays of the manufacturer data acquisition software in the main lab. These displays were used by watchkeepers to monitor incoming data on a regular basis (checking that data were updating with reasonable values) by watchkeepers. Bottle samples from the underway system were taken every 4 hours between 0800 and 2000 local time.

6.2 Daily Processing of Underway Data Streams

Data were processed using the ocp_hydro_matlab (https://github.com/NOC-OCP/ocp_hydro_matlab) Matlab toolbox to read in data from each day, convert units where necessary (including conversion of radiative and optical parameters from engineering to scientific units by applying factory calibration coefficients (added to **opt_dy186.m**), and correction of the singlebeam echosounder data for speed of sound), combine data and average from 1 Hz to 30 s (navigation) or 60 s (TSG data), and edit out bad data.

6.3 Navigation

The posmv instrument is typically the preferred navigation data source on the Discovery, but there were some questions about calibration at the start of the cruise. The posmv mean position while alongside in one berth before the cruise (Figure 6.1, top) roughly agreed with the (high-scatter) seapath position, reading about 14 m away from the fugro and cnav instruments. This offset was consistent throughout (e.g. Figure 6.1, bottom). As the posmv appeared consistent with other instruments it was kept as the "best" data source and used as the primary source for VMADCP processing, as well as being averaged to 30 s and used to compute true wind (below).



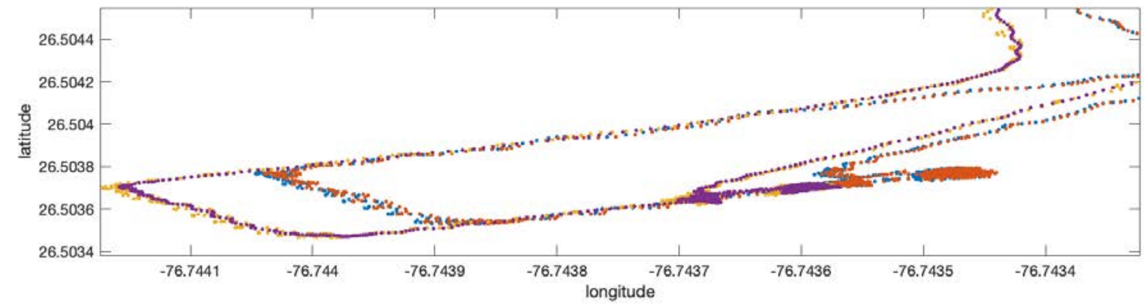


Figure 6.1 Comparison of navigation systems' data before leaving the dock (top) and underway (bottom).

6.4 Bathymetry Data

Bathymetry data were collected through most of the cruise, with the singlebeam (EA640) switched on in port and the multibeam (EM122) given a soft start following observing with no evidence of marine mammals in the area. Bathymetric echosounder pinging was stopped for less than 10 minutes at a time (following the Environmental Impact Assessment) when required for mooring release communications (comprising testing on cal dips, pinging and release for recovery, and trilateration), and where it had to be stopped for longer marine mammal observations were again made before restarting.

Spikes were edited out of 1-Hz data using an automatic despiking and range-editing (mostly removing bad singlebeam data reading as 0) before averaging to 60 s. EA640 data were corrected for regional speed of sound profile based on the Carter tables.

6.5 Meteorology and Ocean Surface

Relative wind data were combined with the best navigation data (interpolated from 30 s averages) to compute vector true wind and average to 60 s before recomputing speed and direction (Figure 6.2). Total incident and photosynthetically active radiometer data were converted to W/m^2. The port-side PAR sensor tended to read about 5% lower than the starboard side sensor, while the two TIR sensors were consistent with each other.

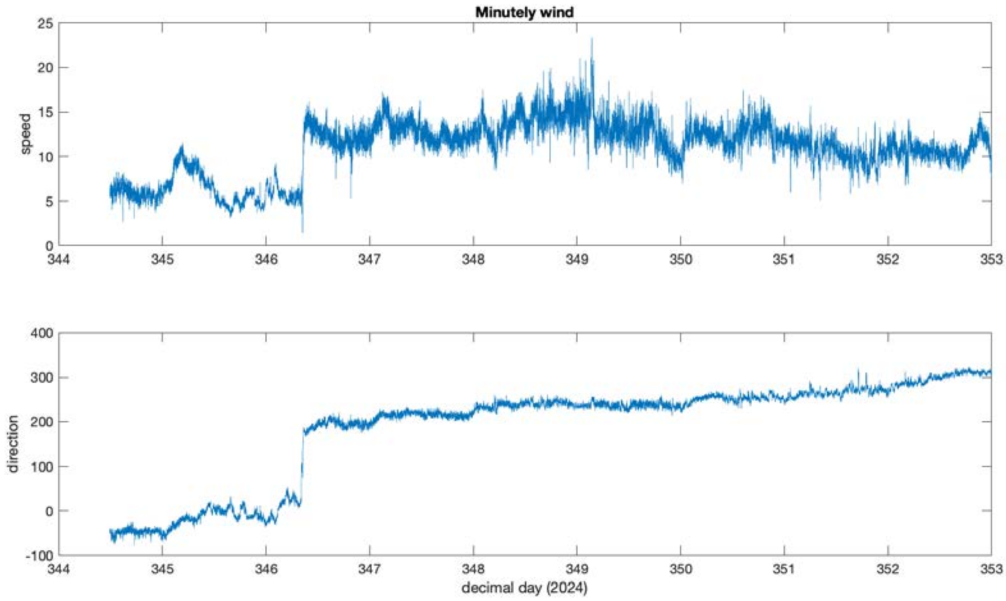


Figure 6.2 Wind data from DY186, vector-averaged to 60 s.

TSG, fluorometer, and transmissometer data from the start of the cruise before the underway seawater supply was switched on (and the first few minutes while the system was flushing) were edited out of the 60-s averages. TSG inlet was compared with drop keel temperature and near-surface CTD temperature (Figure 6.3, top), showing minimal warming from the outside to the inlet. Salinity data can be calibrated using bottle salinities. Samples for calibration of the TSG salinity were drawn from the underway uncontaminated seawater supply every four hours during the day (3-4 samples per day). The 28 samples were analysed together on the last day of the cruise. Unfortunately only the first 14 samples were recorded in the sampling eventlog, and could be used for calibration of the TSG salinity (Figure 6.3, bottom), by adding a constant offset of $2x10^{-3}$ psu.

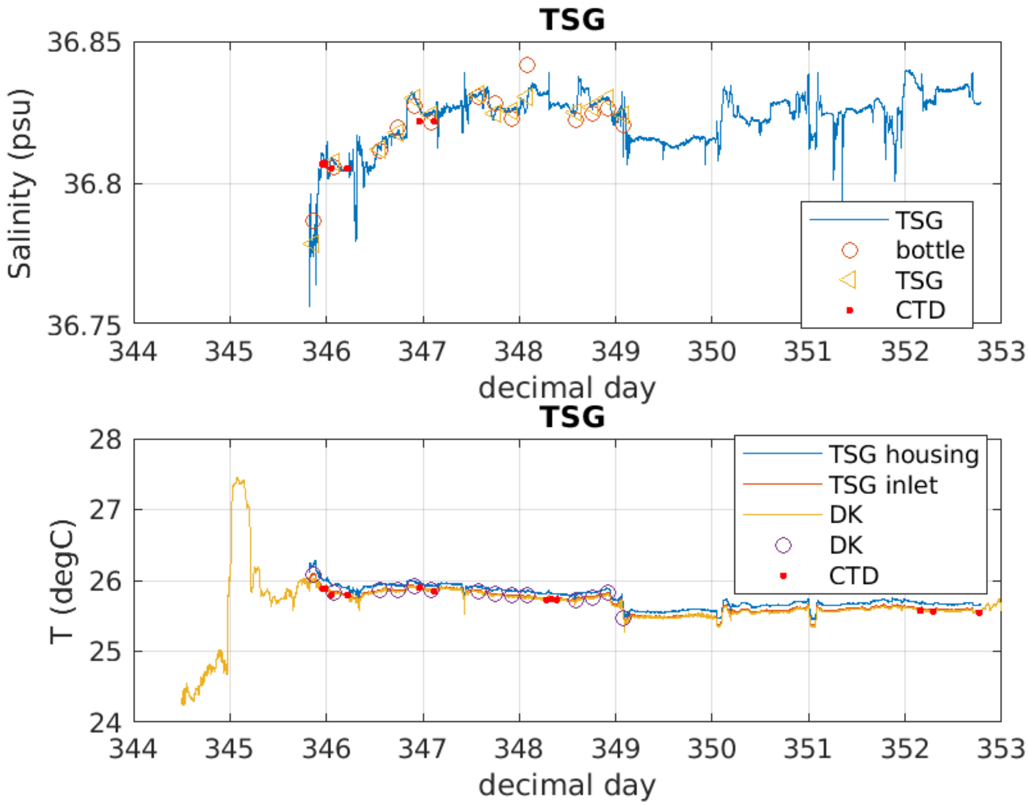


Figure 6.3 TSG temperature compared with CTD near-surface temperature (top) and calibrated TSG salinity compared with CTD near-surface salinity and bottle salinity (bottom).

7. Vessel-mounted Acoustic Doppler Current Profiler (ADCP)

7.1 Introduction

The *RRS Discovery* is fitted with 2 Teledyne RD Instruments Ocean Surveyor (OS) VMADCPs for measuring the horizontal velocity field: one at 150kHz (os150nb) and the other at 75kHz (os75nb). These are both mounted on the port drop keel. Communication problems with the 75kHz meant that only the 150kHz instrument was run on this cruise, operating in US waters at the start to test instrument communications, then in Bahamian waters from the point at which diplomatic clearance was received – operations were thus continuous during the mooring work part of the cruise. Data acquisition is done automatically by the University of Hawaii Data Acquisition system (UHDAS). The system was configured in narrowband (nb) mode with watertracking pings only, using calibrations derived by the UH currents group based on multiple past cruises. The 150kHz penetrates up to 400 m (depending on sea state and water properties).

7.2 Data Monitoring and Automatic Processing

The UHDAS interface displayed on a screen in the main lab has all the control and monitoring options. As part of the systems watchkeeping, the UHDAS monitor interface was checked for any errors or data acquisition problems. UHDAS/CODAS applies automatic quality control and automatically generates a series of contour and vector plots, which were also visually inspected for errors. Data quality of the 150kHz was generally good.

7.3 Data Processing

Throughout the cruise, several shell scripts on workstation akeake were used to sync data from the UHDAS server to a backup on the workstation, and then to a local processing directory. At the end of the cruise, CODAS utility dataviewer.py was used to inspect the 5-minute ensemble-averaged data from the two instruments separately and together. A small number of additional edits were made, including editing out data from the test periods at the start, and applied to a copy of the database. As for DY174, the pre-configured angle and amplitude calibration and transducer offsets were not changed as the number of watertrack calibration points available from this cruise alone is small, but it is notable that for amplitude and transducer offset, found in cal/watertrk/adcpcal.out and cal/watertrk/guess_xducerxy.out, the suggested values of 1.01 and (2, 15) are similar to those suggested from other recent DY cruises (DY174, DY180, DY181); it might be worth updating the default coefficients and/or recalibrating the DY174 as well as DY186 data. A NetCDF file of processed 150kHz data was generated using adcp_nc.py.

8. CTD Operations

Jade Garner and John Clarke

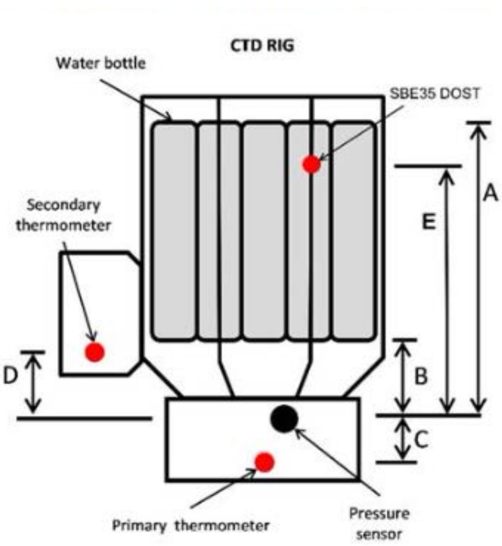
8.1 CTD Operation

All casts were carried out using CTD2 wire. The CTD wire was electrically tested prior to sailing and had an insulation resistance of > 999 MΩ at 250V. The. Active heave compensator (AHC) was used for the majority of the CTD casts. 9 CTD casts were undertaken with an NMF 24-way Stainless Steel CTD frame with 12 off 10l Niskin water samplers. Only the odd bottles were fitted leaving 12 bottle positions free for Microcat clamps which were utilised for calibration dips. Dual SBE 43 dissolved oxygen sensors were used. The primary temperature, conductivity and dissolved oxygen sensors were fitted to the 9 plus with the secondary sensors mounted on the vane. A SBE 35 was mounted to a vertical stanchion of the CTD frame and programmed to average 8 samples which supplemented the temperature data. There were no major technical issues with the Stainless Steel CTD suite during the cruise and no sensors required changing.

CTD cast 1 (the first test CTD) was aborted after 100m due to issues with the Oxygen sensors and Altimeter. This was rectified by changing cables. During CTD cast 2 (the second test CTD) the conductivity sensors had drifted. This was due to an error inputted with the calibrations. This was rectified and applied correct calibrations to CTD 2 to apply correction. During Cast 8 the altimeter did not work within 100m of bottom, we did not go further due to no requirement from PI. The Altimeter cable has a pressure fault. Noted we will need some more for future cruises. All bottles were leak tested before the start of science and again at the end of science, no issues noticed.

Instrument / Sensor	Manufacturer/ Model	Serial Number	Channel	Casts Used
Primary CTD deck unit	SBE 11plus	11p-24680-0588	n/a	All casts
CTD Underwater Unit	SBE 9plus	09p-34173-0758	n/a	All stainless casts
Stainless steel 24-way frame	NOCS	SBE CTD 6	n/a	All stainless casts
EM Swivel	MDS	1246-2	n/a	All stainless casts
Primary Temperature Sensor	SBE 3P	03P-4593	F0	All stainless casts
Primary Conductivity Sensor	SBE 4C	04C-2571	F1	All stainless casts
Digiquartz Pressure sensor	Paroscientific	90074	F2	All stainless casts
Secondary Temperature Sensor	SBE 3P	03P-4712	F3	All stainless casts
Secondary Conductivity Sensor	SBE 4C	04C-3054	F4	All stainless casts
Primary Pump	SBE 5T	5T-3085	n/a	All stainless casts
Secondary Pump	SBE 5T	5T-3086	n/a	All stainless casts
24-way Carousel	SBE 32	32-60380-0805	n/a	All stainless casts
Dissolved Oxygen Sensor	SBE 43	43-2722	V0	All stainless casts
Dissolved Oxygen Sensor	SBE 43	43-1882	V1	All stainless casts
Altimeter	Valeport VA500	81629	V5	All stainless casts
SBE 35 DOST	SBE 35	0037	n/a	All stainless casts
10L Water Samplers	OTE	1-24	n/a	All stainless casts

Table 8.1 The sensors fitted to the CTD frame.



ID	Vertical distance from pressure sensor (m positive-up)
A	1.2 (Top of water samplers)
B	0.34 (Bottom of water samplers)
C	-0.075 (Primary T mounted on 9p)
D	0.085 (Secondary T mounted on Vane)
E	1.025 (SBE35 DOST probe sheath tip)

Figure 8.1 CTD frame geometry

8.2 Salinity Measurement

A Guildline 8400B, s/n 71185 was installed in the Salinometer Room as the main Autosal for salinity analysis. The bath temperature was set to 21oC with the lab ambient temperature ranging between 18°C – 18.5°C. The salinometer was standardised during the mobilisation, then again prior to the start of analysis. 71185 was used for 5 crates with no issues. The Autosal was standardised using IAPSO Seawater batch P168 (K15 = 0.99993, 2 x K15 = 1.99986).

9. CTD Data

Tillys Petit, Yvonne Firing, Brian King

9.1 Introduction

A total of 9 CTD casts were completed during the cruise (Table 8.1). The majority of casts were for the purpose of calibration of the microcat CTDs, but some were completed before and after recovery of moorings with oxygen sensors to enable in water calibration of oxygen.
There were 12 bottles on the frame and on most deep casts they were all used to obtain samples to calibrate oxygen and salinity. Bottle stops were all 5 minutes each when MicroCATs were being calibrated, otherwise they were for 1 minute.

Station	Start Date	Start Time	End time	Latitude	Longitude	Water depth (corr. m)	Profile depth (m)	Number of bottle stops	Active Heave Compensation
1	Oxygen sensor and altimeter faulty. Cast aborted at 100 m.								
2	11-Dec	22:57	23:43	25°37.97	77°05.94	3083	725	12	Yes
3*	12-Dec	01:10	05:13	25°48.86	76°59.76	4581	4516	12	Yes
4*	12-Dec	23:04	02:43	26°29.70	76°45.13	3800	3500	12	Yes

5*	14-Dec	02:44	06:41	26°29.35	76°40.44	4625	4576	12	Yes
6	14-Dec	07:55	09:22	26°29.98	76°48.41	1411	1406	12	Yes
7*	18-Dec	00:05	03:47	26°29.85	76°42.32	-	4147	12	Yes
8	18-Dec	05:39	06:54	26°29.94	76°48.19	1364	1353	12	Yes
9*	18-Dec	17:02	18:28	26°30.50	76°42.90	4289	2000	2	Yes

Table 9.1 CTD station summary. An asterisk (*) next to the station number indicates that the cast was used for MicroCAT calibration.

9.2 Adjustment of Temperature to Reference SBE35

A SBE35 stable temperature sensor fitted to the outside of the CTD frame recorded a reading each time a Niskin was fired. These readings were compared to the two CTD temperature sensors, with 26 of the 80 comparison points from low-gradient regions primarily used to determine the offsets. An offset trending from +1 m°C at the surface to -1.3 m°C at 6000 m was applied to sensor S/N 34593, and a constant offset of +1.5m°C was applied to sensor S/N 34712. Residual negative offsets found in the thermocline (Figure 8.1) are ignored as likely to reflect the vertical offset between SBE35 and CTD sensors.

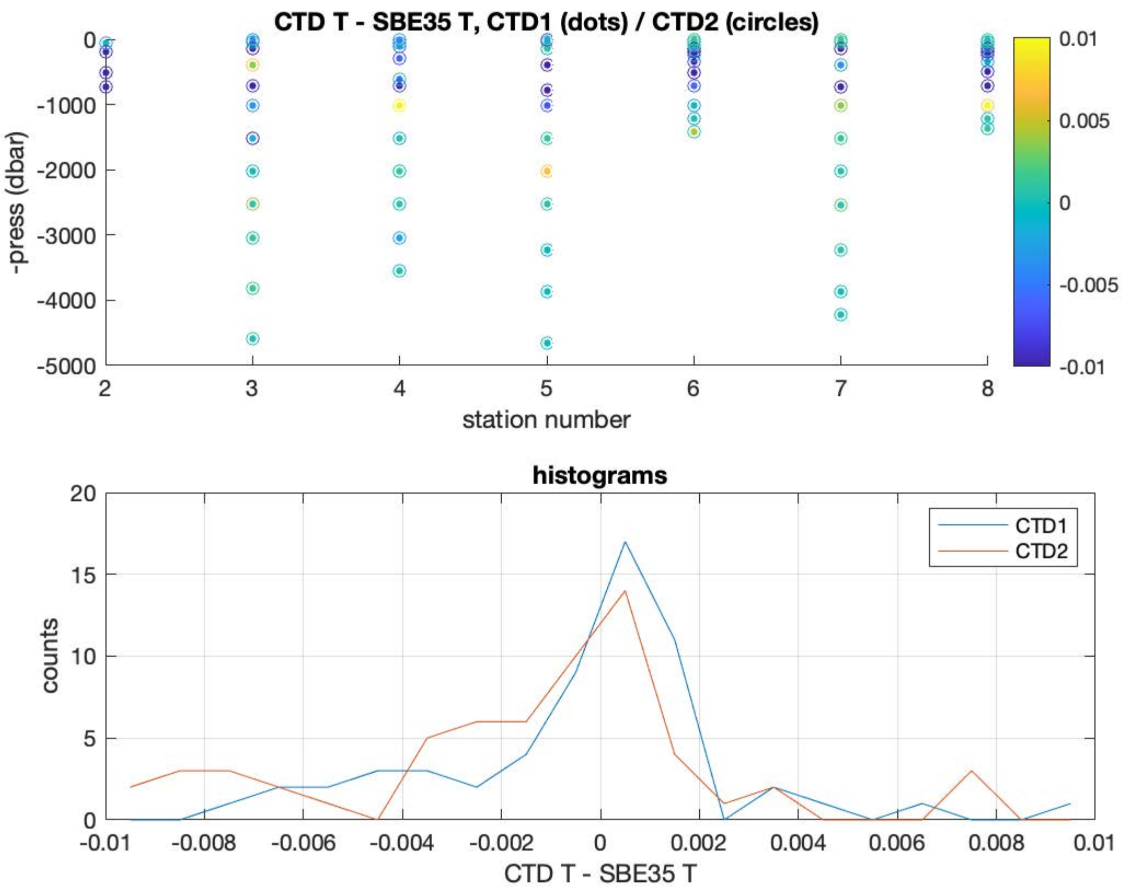


Figure 8.1 Comparison between SBE35 temperature and CTD temperature at bottle stops, after adjustment to CTD sensor temperatures.

9.3 Analysis of Standard Seawater Samples and Calibration of the Salinometer

A total of 10 standards were used to calibrate the bottle salinity measurements made by the salinometer. A standard was used before each crate of salinity samples, and at the completion of each salinometer session. All standard seawater samples were from batch P167 with K15 = 0.99988. Salinometer offsets were mostly negative, with a puzzlingly large trend over the third run (0 to -7×10^{-5}) but otherwise varying by a few 10^{-5} over each run. The apparent offsets were applied as trends between each pair of standards at the start and end of each crate. The last four samples were run immediately following the last full crate, and the salinometer offset from the end of the last full crate was applied as a constant. The three conductivity ratio readings from each sample bottle were checked for outliers before averaging, adding the offsets derived from standard seawater above, and converting to salinity based on the salinometer set bath temperature.

9.4 Calibration of Conductivity

Conductivity from each of the two CTD sensors was compared with conductivity derived from bottle salinity (above) and CTD temperature (for the corresponding CTD sensor), for stations 2-8, again emphasising points with a lower background gradient (deep points as well as the surface mixed layer). Conductivity sensor S/N 42571 was corrected for a drift with station number N as well as a piecewise linear pressure trend using
C_cal = C_uncal(1 + (interp([2 9],[-1e-3 1e-3],N) + interp([-10 1500 5000],[-2e-3 0.5e-3 -3e-3],P))/35), while conductivity sensor S/N 43054 was corrected for a piecewise linear pressure trend using C_cal = C_uncal(1 + interp([-10 2000 5000],[-2.5e-3 -1.5e-3 -3e-3],P)/35).

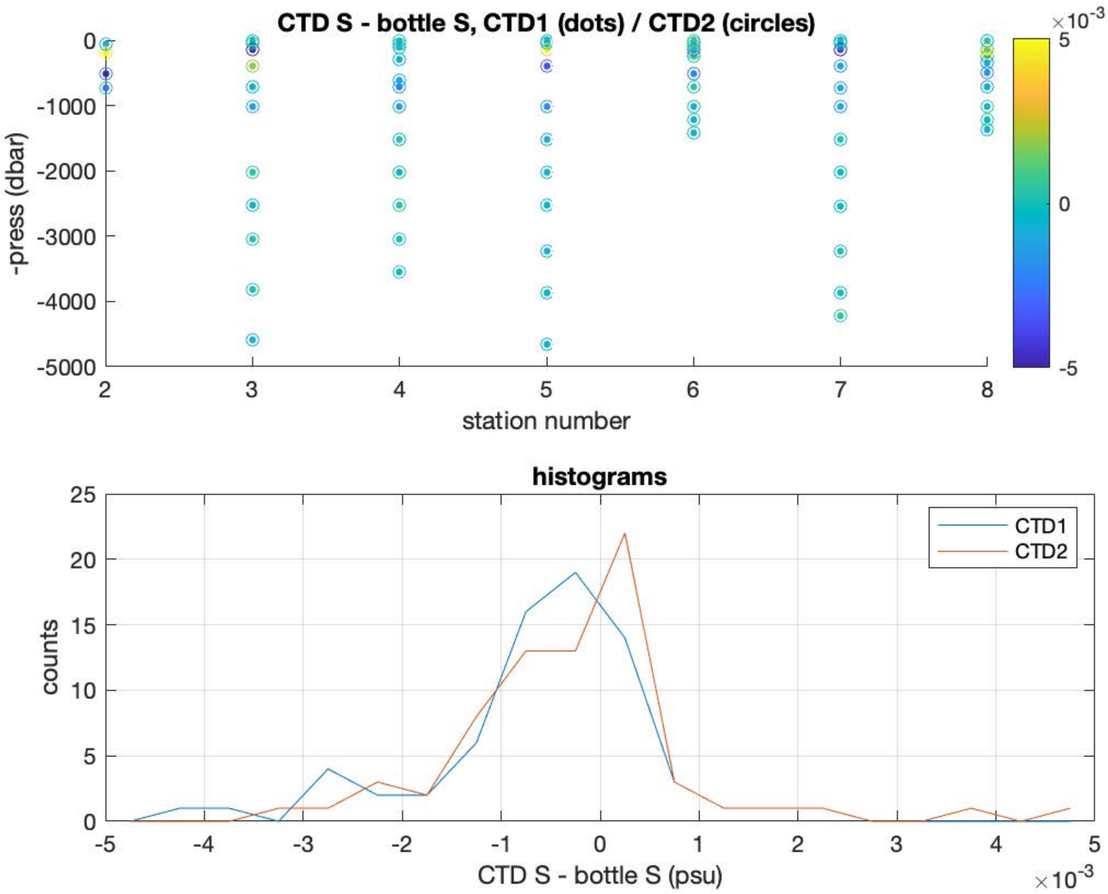


Figure 9.2 Comparison between CTD and bottle salinity after calibrating the CTD conductivity by comparison with conductivity derived from bottle salinity and CTD temperature.

9.5 Hysteresis Correction and Calibration of Oxygen

The defaults hysteresis correction applied to the two CTD oxygen sensors was not modified. Oxygen Winkler titration data (Section 10) were converted first to concentration in umol/L, using blanks and standards values set in opt_dy186, and then to umol/kg, using the CTD salinity at bottle stops and the sample fixing temperature. The blanks and standards values acquired by the analyst were used. One replicate sample was flagged as questionable. The oxygen sensor and bottle data from 77 Niskins were first compared in terms of their ratio, and the following factors were applied:

S/N 43-1882: O_cal = O_uncal (interp([-10 0 2000 5000], [1.045 1.045 1.075 1.09], P)

S/N 43-2722: O_cal = O_uncal (interp([-10 0 1500 3000 5000], [1.06 1.06 1.08 1.1 1.1],P)

The calibrated data compared to the bottle data are shown as residuals (differences) in Figure 8.3. While calibrations were derived based on upcast data, after calibration the density-matched downcast data were also compared (not shown), confirming no need to modify the default hysteresis correction.

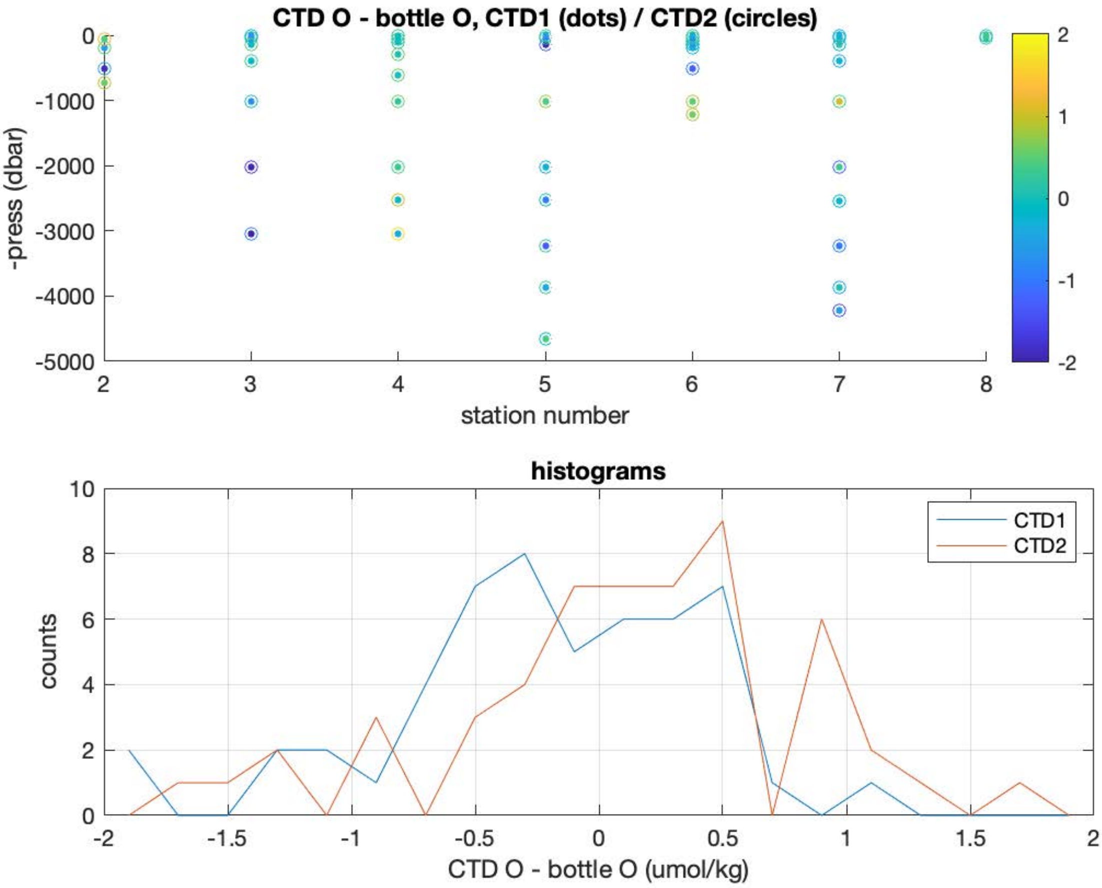


Figure 9.3 Comparison between CTD and bottle oxygen after calibrating the CTD sensors as above.

10. Argo Floats

Ben Moat

It was planned that we would deploy Argo floats during the expedition, but before the shipping of equipment from the UK it was found that the number of floats currently in the region was sufficient for the one Argo observational programme. Therefore, no Argo floats were deployed in USA or Bahamian waters.

11. Oxygen Analysis

Maria De La Fuente Ruiz and Yvonne Firing

Dissolved oxygen (DO) samples were collected during DY186 to calibrate CTD DO sensors, as well as to correct for drift, temperature and pressure influences. The calibrated CTD oxygen in turn will be used to calibrate oxygen sensors deployed on moorings.

Samples were taken from Niskin bottles on every CTD cast throughout the cruise, with the exception of known misfires and bottles observed to be leaking on CTD recovery. Numbers of DO samples and replicates on each CTD cast, as well as when they were analysed, are given in Table 9.1 and discrete sample depths and calculated concentrations are shown in Figure 9.4. Three sets of duplicate samples were collected for each CTD cast, except for CTD002, which was a test cast where only one sample from a Niskin bottle was taken, although depths were repeated. These duplicates included two samples from the Niskin bottles at maximum depth, two from the minimum oxygen depth, and two from randomly selected depths, resulting in a 20.45% duplicate rate. Discrete water samples collected were subsequently analysed by automatic Winkler titration using a Metrohm Ti-Touch titration system with amperometric endpoint detection.

CTD cast	Date	Total samples	Replicates	Date analysed
002	11.12.2024	12	0	12.12.24
003	11.12.2024	14	3	12.12.24
004	12.12.2024	15	3	13.12.23
005	14.12.2024	14	3	14.12.24
006	14.12.2024	14	3	14.12.24
007	17.12.2024	15	3	18.12.24
008	18.12.2024	14	3	18.12.24
Total		**88**	**18 (20.45%)**	

Table 10.1 Summary of CTD casts sampled for oxygen

10.1 Metrohm Ti-Touch Setup and De-bubbling

Two titration instruments were brought on board. The one used during DY186 had serial number S/N 32976. The sodium thiosulphate solution was made at 17:30 on Tuesday 8th December 2024. This was done by adding one vial of pre-weighed (27.33 g) sodium thiosulphate crystals to 1L of Milli-Q water. The titration system and dosing devices were subsequently set-up. The Ti-touch system was preloaded with programs for running blanks, standards, and samples. Initially, the system was tested by running a blank (see method in 9.3 below) and standards, followed by the analysis of test samples from the CTD002 cast. However, the initial blank result was too high (represented by the orange dot in Figure 9.2), due to large air bubbles present in the dosing chamber. Therefore, dosing units were de-bubbled, resulting in more consistent and acceptable readings from CTD003 onwards.
Following this, on Thursday, January 12th, a new series of blanks were run to prepare the instrument for analysing the first discrete water samples collected during the CTD003 cast. Blanks were checked at each sampling station following the GO-SHIP protocols (Langdon, 2010).
On Tuesday, December 17th, the titrator and standard dispensers were re-debubbled again before running any blanks, as multiple small bubbles had accumulated in the dispensing units due to a higher time interval between casts. Four standardizations (see method in 9.4 below) were also conducted before continuing with the analysis of CTD007 and CTD008.

Details of the de-bubbling process and changes made to the settings are described below:

- To get the bubbles off the dosing units, press the hand button from the icons, select Dosing and use manual dosing, dosing fixed vol (with automatic filling switched off) to partially empty the dosing unit. Remove the draw straw from liquid while refilling the dosing unit to draw up a larger air bubble that will subsume the smaller ones.

Importantly, return the draw straw to the liquid (reattach unit to bottle) before the end of the filling period. This is to ensure that liquid is fully drawn up the draw straw, and there are no bubbles left in that portion of the device. Start dosing again, then, plugging both vent ports, invert the dosing unit, tap it to dislodge the large bubble to the bottom of the dosing unit (currently the top), rotate so the outlet valve is at the top and dose so the bubble is pushed out the outlet valve, down the straw and out of the burette tip – this will hopefully collect any bubbles within the tubing as well as the bubbles in the piston. Ensure you have righted the dosing unit and bottle before refilling to ensure the base of the draw straw is submerged. This seemed to be successful at removing all bubbles except in some cases one tiny one. However, the dosing unit barrels accumulated more bubbles over the course of hours to a day (whether the machine is in use or not). It was not clear whether they were coming out of solution or being let into the barrel possibly due to uneven greasing of seals. The pistons and to some extent the corresponding cups at the bottoms of the barrels appear to be somewhat adhesive to bubbles. It was found most effective to wait 30 minutes between drawing in a larger air bubble and then dispensing again.

- To avoid (or reduce) drawing in new bubbles, reduce the maximum dosing and fill speeds from maximum (estimated this is 20-50 mL/min) to 5 mL/min or less. This was done in various parts of various programs, wherever dosing parameters were specified.
- Consistency of blanks and standards is also aided by more vigorous stirring than previously programmed, with the stirrer on a speed of 7 (for the particular magnetic stirrer used here). This is again adjusted in various parts of the different methods (including the method for samples).

10.2 Sample Collection

Water sampling was carried out according to the guidelines by Langdon (2010) with seawater being collected directly into pre-calibrated Pyrex iodine titration bottles (approximately 140 ml flasks with flared necks). This protocol is analogous to previous cruises (see RAPID cruise reports No. 30, 37, 52, 76 and 82 for more details). The key steps were:

- Prior to sampling each station, the reagent dispensers (Brand dispensettes set to 1 mL) were emptied and refilled 2-3 times to remove any bubbles that had formed in the chemical lines. This minimizes the risk of bubble injection into samples. This process was repeated if bubbles were noticed.
- Silicon Tygon tubing was attached to the Niskin spigot to transfer water to the flask. The tubing was kept submerged in Milli-Q water between stations to reduce the tendency of bubbles to form within it. The spigot was pushed in only after attaching the tubing, and the tap opened after that to allow checking for leaks (a good seal will not allow more than a small dribble of water to flow when the spigot is opened, if the top valve is still closed).
- Bottles and stoppers were rinsed three times with Niskin water, while filling the tubing completely by pressing and rolling it to push out any air bubbles.
- The tubing was inserted to the bottom of a bottle and the bottle was filled slowly, from the bottom, to minimize turbulence and bubble formation, with water flow decreased by

pinching the tubing. The bottles were overflowed by three flask volumes of water (approximately 15 seconds at full flow).

- During overfilling, the temperature of the sample was measured using a digital thermometer (HANNA Foodcare Thermistor thermometer S/N 07090C7N) whilst the bottle was being overflowed. This temperature is used to correct the bottle volume due to glass expansion/contraction, and to convert the oxygen concentration measured from μmol/L to μmol/kg.
- The bottles were held at the neck to minimise heat transfer to the water.
- 1mL of manganese chloride was carefully added to the bottle, immediately followed by 1mL of alkaline iodide solution. Dispenser tips were lowered beneath the water surface to eliminate the loss of chemical through splashing, and the entrainment of bubbles into the sample.
- Stoppers were inserted slowly and at an angle to stop bubbles getting trapped beneath.
- Bottles were vigorously shaken for 15-30 seconds (twisted about 20 times) to facilitate the mixing and formation of the precipitate (manganese hydroxides). A second shake was performed after 30 minutes.
- Milli-Q water was added to the necks of the conical flasks to act as an additional gas-tight seal. This was maintained until analysis. All bottles were kept in the dark in their crates until analysis.
- Each stopper is uniquely matched to a volume-calibrated flask. Regular checks were made to ensure each stopper/flask pair had the same number attached to them. Cracks and chips in both the bottles and stoppers were also regularly checked for.
- Analyses were conducted promptly, within 24 hours of sample collection.

Figure 11.1 Photograph of the lab bench set-up.

10.3 Blank Analysis

Prior to the analysis of seawater samples, the system blank was measured and calculated. This represents the signal produced by the addition of the chemical reagents. Bottles were filled with 90 ml of Milli-Q water and a stirrer bead. The reagents were added in reverse order with thorough stirring in between (1mL sulphuric acid, 1mL alkaline iodide solution, 1mL manganous chloride). 1mL of iodate standard solution (1.667 mol/L, OSIL) was then added by the Ti-Touch dosing unit and titrated with thiosulphate solution up to an endpoint of current $0.1x10^{-6}$ A; this endpoint was recorded. The titration of 1 further addition of 1 mL iodate standard was carried out. The blank is the difference between the volume of the second addition and the first titre value. Additional blanks were run until four acceptable estimates were obtained where the mean difference between the two blank volumes was less than 0.004. Figure 9.2 shows the blank values obtained during DY186 between 11th and 18nd of January, when oxygen sample analysis was carried out. The median value calculated from all the suitable blank titres during the cruise was negative 0.00102. Median blank volumes per analysis set are shown in Table 10.2.

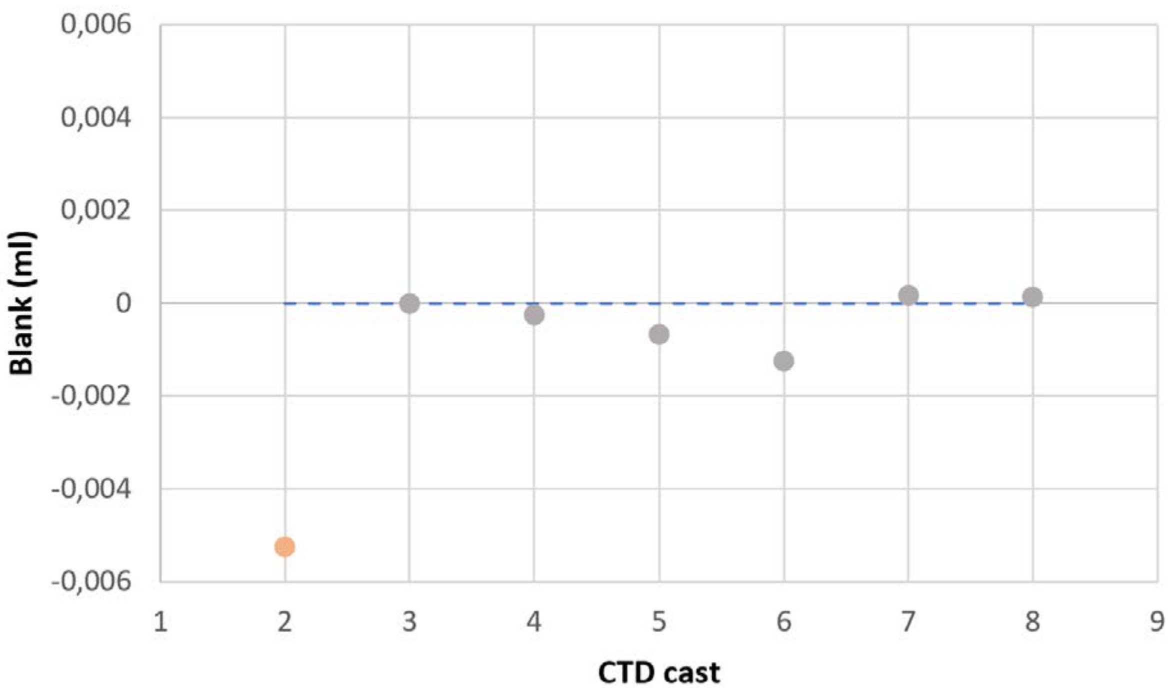


Figure 11.2 The titre volume (ml) from blank analyses during DY186 is shown, with the orange value indicating a slightly higher reading before the system was de-bubbled. The cruise median is represented by the blue dashed line.

10.4 Standard Analysis

After the blanks were measured, the thiosulphate molarity was checked against an iodate certified iodate standard of known molarity (1.667 mM, OSIL Scientific). The procedure is similar to that of the blank measurements except that exactly 5 mL of potassium iodate standard was added to a bottle in one injection and then titrated once. Four standard runs were performed per set of CTD casts (set 1: CTDs 002-006, and set 2: 007-008, see Table 10.2). The median value between the two standard titres during the cruise was 0.4586. Figure 10.3 shows the results of the standard analyses and median values of standard titres per analysis are shown in Table 10.2.

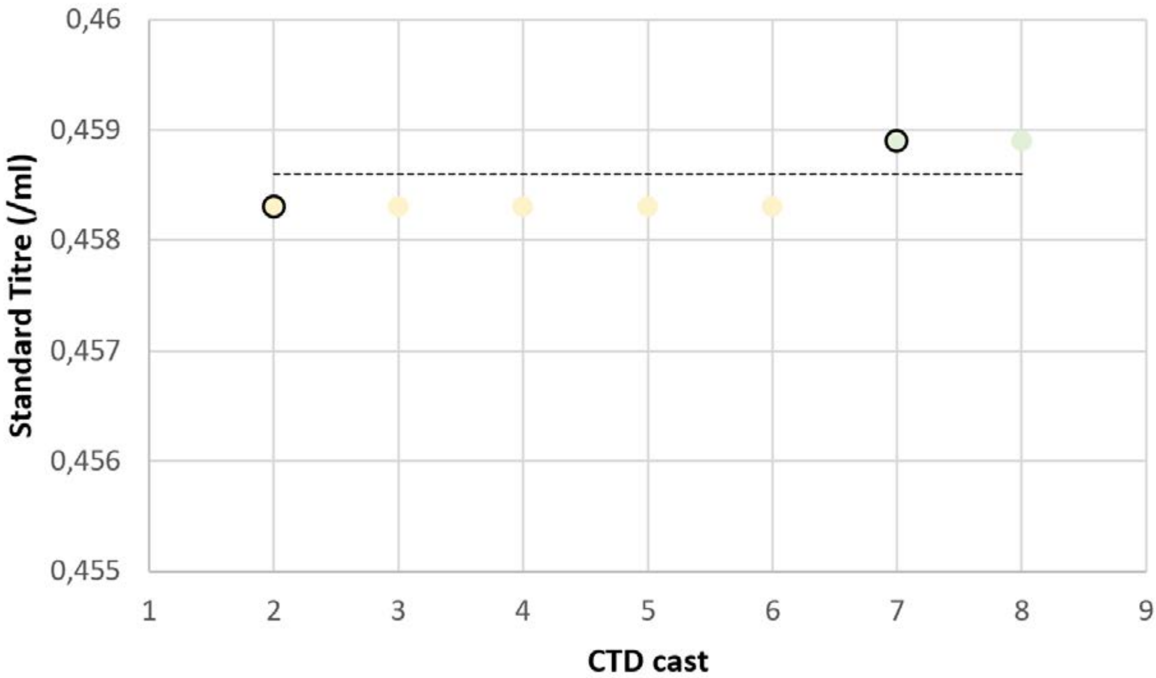


Figure 11.3 Results of the 5 mL iodate standard titre volumes from DY186 are presented, with colours representing the two different sets of CTD casts for which each value was used (casts (set 1-yellow: CTDs 002-006, and set 2-green: 007-008). Dots with a black line indicate the points at which standardization was performed.

The standard volumes obtained from the 2 set of analysis show minimum spread with a standard deviation of approximately 0.00003. Additionally, considering the short time span of the analysis (6 days), it is unlikely that the quality of the standard or titre changed.

Whole Cruise Blank Median	Analysis Number	Day	Blank	Standard	CTD Casts Analysed
- 0.00102	1	12.12.24	-0,00525	0.4583	CTD002
	2	12.12.24	0	0.4583	CTD003
	3	13.12.23	-0,00025	0.4583	CTD004
	4	14.12.24	-0,00067	0.4583	CTD005
	5	14.12.24	-0,00125	0.4583	CTD006
	6	18.12.24	0,000167	0.4589	CTD007
	7	18.12.24	0,000125	0.4589	CTD008

Table 20.2 Values for blanks and standards used in oxygen calculations over the course of the cruise. Colour legend match Figures 10.2 and 10.3.

10.5 Sample Analyses

Samples were stored and analysed within 24 hours following the method outlined by Langdon (2010). Before running each sample batch, blanks were run until satisfactory stability was achieved, standardizations were perform before CTDs 002 and 007 as shown in Figure 10.3. Between each flask (blank, standard, or sample), the burette tips, electrode and stirrer were rinsed with Milli-Q and the electrode tip carefully dried, checking for any contamination.

When ready to titrate, the Milli-Q water seal was poured away, the neck dried, and the stopper of the flask carefully removed. A 1 ml aliquot of 5 M sulfuric acid was dispensed, immediately followed by a clean magnetic stirrer. The flask was placed on the stir plate and the electrode and thiosulfate burette were carefully inserted to place the tips in the lower-middle depth of the sample flask. The initial volume of sodium thiosulphate for each sample was 0.3 ml before continuing to be titrated at 0.0005 ml intervals using the amperometic end-point detection electrode (Culberson and Huang, 1987) to the end current of 0.1 x 10^{-6} A. The resultant volume of titrant was recorded both by manual logging and automatically on the Ti-Touch. Following this the value was converted to a DO concentration within an Excel file, using bottle volumes, expansion coefficients and sample temperatures, blank and standard titres, and standard volume, and saved as *DY186_oxy_00X.xlsx*. (being "x" the CTD cast number, ranging from 2 to 8).

Figure 10.4 shows vertical profiles of oxygen concentrations measured on DY186 for the different CTD casts.

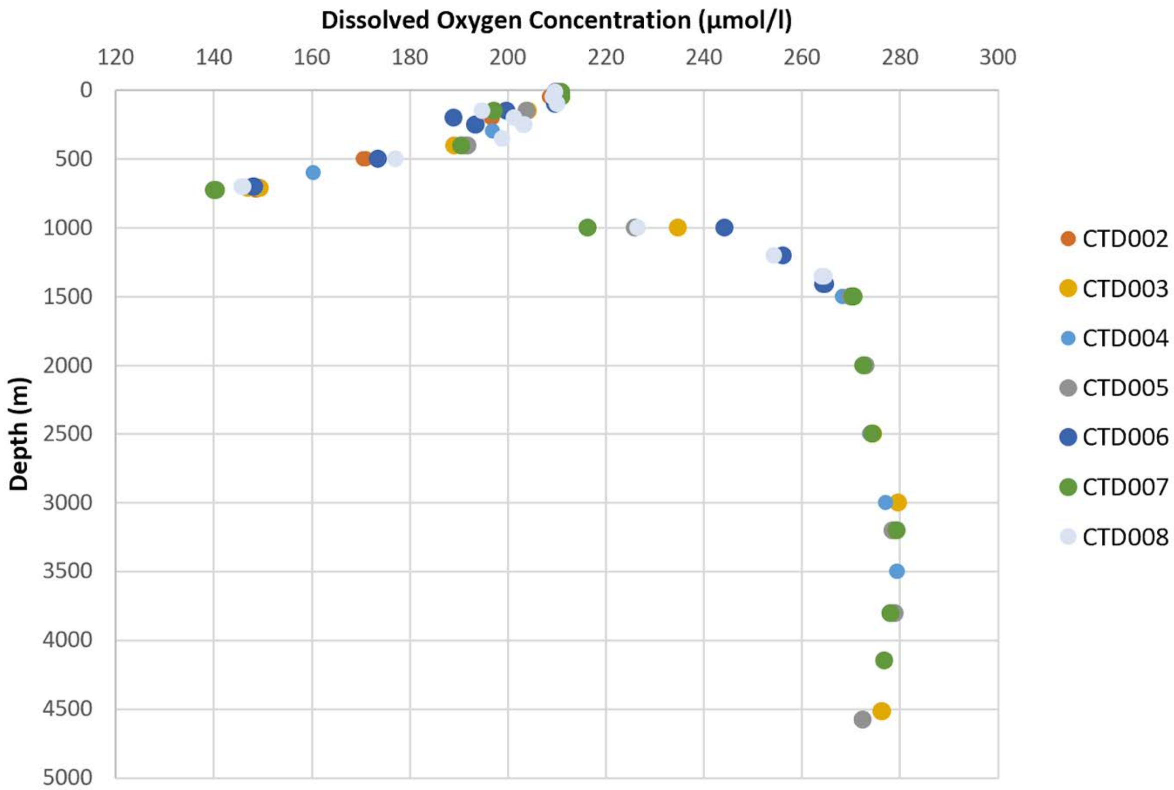


Figure 11.4 DY186 dissolved oxygen concentration profile. Colours correspond the CTD cast number.

10.6 Duplicate Sample Analysis

A total of 18 replicates were taken, following a strategy of collecting two samples from the Niskin bottles at maximum depth, two from the minimum oxygen depth, and two from randomly selected depths. The differences between sample and duplicate bottle results are shown in Figure 10.5, calculated by subtracting the duplicate oxygen concentration from the sample oxygen concentration. Among the 18 duplicates, only 16 differences were obtained, as the volume of two flask bottles was missing. From those, only one value was notably large (marked with a yellow cross in Figure 10.5) and considered questionable; this value was excluded from the median calculation, which was -0.181 µmol L^{-1}. There were slightly more negative differences than positive, indicating that the measured oxygen concentration in the duplicate was generally higher than in the sample. This suggests that the second sample from a Niskin bottle may have been slightly contaminated by exposure to air. Additionally, some of the largest differences coincide with the minimum oxygen concentrations, where atmospheric contamination could be more noticeable. However, the pattern remains unclear due to the limited number of duplicate samples.

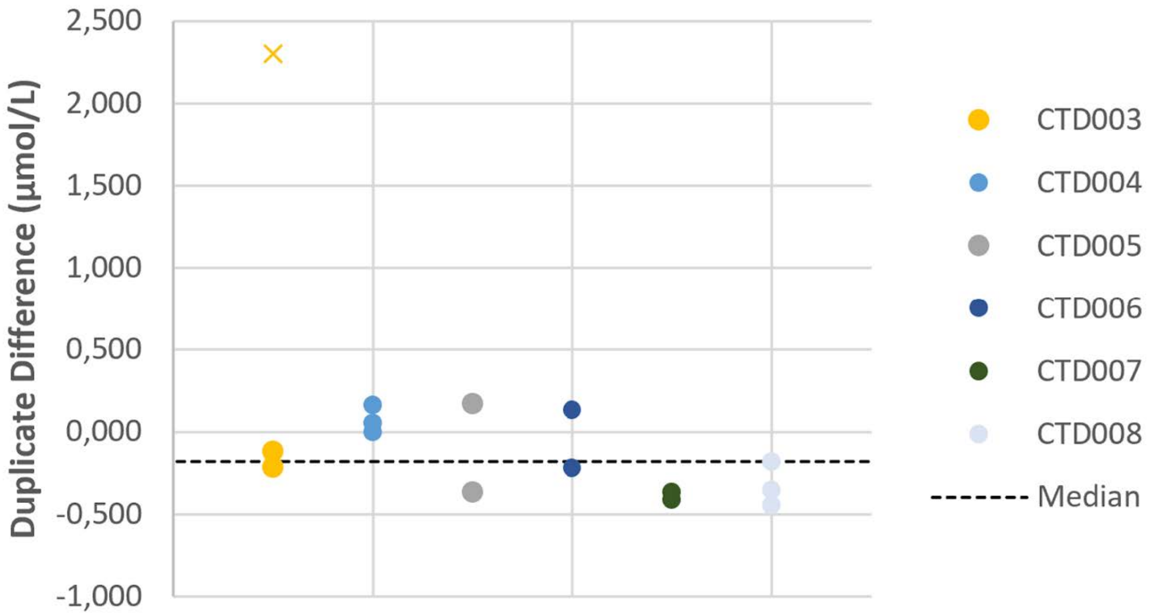


Figure 11.5 Differences between replicate oxygen concentrations on DY186. Yellow 'x' mark questionable duplicate difference in cast CTD003 not used to calculate the median. The black dotted line marks the median duplicate difference.

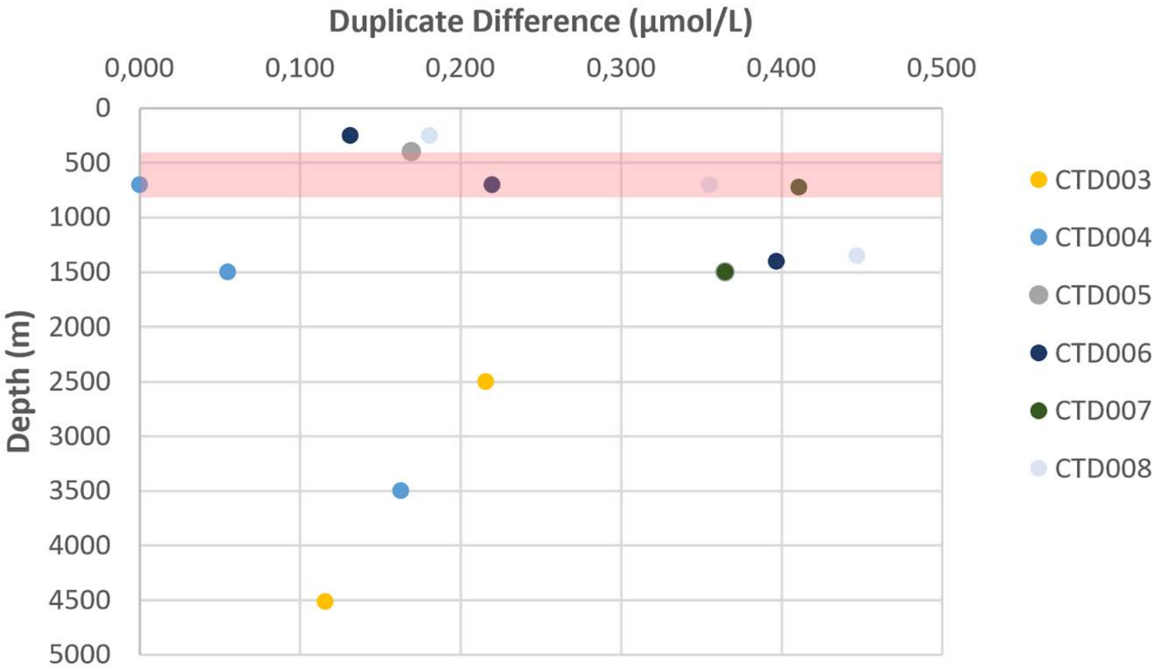


Figure 11.6 Differences between replicate oxygen concentrations on DY186 with depth. Red shade shows the duplicated taken at the Minimum of Oxygen.

10.7 References

Culberson, C.H. and Huang, S. (1987). Automated amperometric oxygen titration. Deep-Sea Res. Pt A 34(5-6), 875-880. doi:10.1016/0198- 0149(87)90042-2.

Langdon, C. (2010). Determination of dissolved oxygen in seawater by Winkler titration using the amperometric technique. The GO-SHIP repeat hydrographic manual, IOCCP report 14, version 1.

12. Telemetry system on mooring WB2

Chris Cardwell and Joel Hedges

12.1 introduction

This was the first long-term test deployment of the telemetry system and fitted to the WB2 mooring. The aim is to develop a robust, automated data download system for the RAPID array using surface autonomous vehicles to telemeter sample data from the instruments on the mooring to shore via satellite. We have done this in occasional RAPID trials before during 2015 and 2018 but the weakest link in the communication path has always been the acoustic telemetry between the surface autonomous vehicle and the subsea telemetry buoy on the mooring. The purpose of this cruise was to test the different techniques we have proposed for accessing the data on the mooring acoustically.

12.2 Telemetry system overview

The telemetry buoys are controlled by NOC OTE developed mooring controllers with the instruments sampling autonomously interrogated by the mooring controller hourly. The acoustic control is only used for data downloads and potential remote configuration. The USBL modem was controlled by Windows applications (see 0) on the USBL computer.

Two Mk3 49" syntactic foam buoys were fitted out with telemetry equipment as outlined in the diagram below.

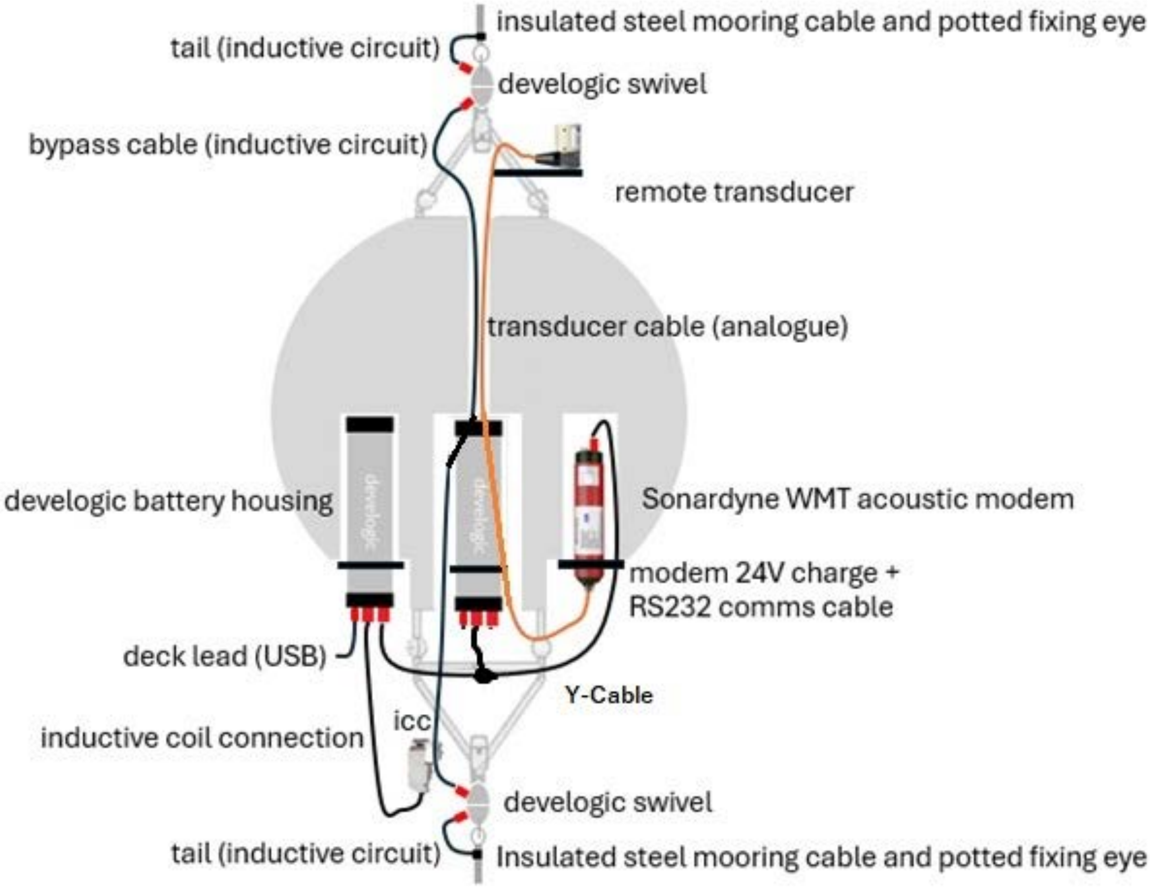


Figure 12.1 - Layout of the telemetry buoys fitted to WB2

The battery housings were Develogic DW.TH units (6000m-rated, titanium) fitted with SAFT LSH20 Lithium Primary cells. They are capable of holding a 7s7p (about 70Ah at 0°C, 91Ah at 22°C) arrangement of cells but we reduced that using in-series blanks to give a 4s7p (also 70Ah) arrangement at 14.4V which was then paralleled using a custom Y-cable to give 140Ah output. Both housings on each buoy were fitted internally with a CCROC A7398 v1.0b buoy controller printed circuit board designed by us, with one housing chosen as "Main" and the second housing set to power pass through. The Main controller was used to control the inductive data collection, the acoustics and telemetry. The acoustic modems were Sonardyne WMT 8190-3162 units (3000m rated) fitted with Sonardyne 641-0107 remote transducers with right-angled connectors. The transducers were mounted to plastic plates fitted to the horizontal bars of the longer lifting frames on the buoys so they could be offset from the mooring cable to provide a clearer acoustic path. The mooring was specified to have inductive instruments above and below the telemetry buoys so the upper and lower insulated mooring cables were secured to the telemetry buoys via mooring eyes insulated from the mooring cable and Develogic telemetry swivels which allowed them to be connected electrically to each other by an arrangement of bypass cables. The inductive connection from our electronics to the mooring cable was made using a Sea-bird 100-turn Inductive Cable Coupler clamped around the bypass cable and fastened to the buoy lifting frames. The ICC's coil was connected by a cable to the battery housings and from there to a Sea-bird inductive modem (IMM) mounted directly on our PCB. Finally, the battery housings were all fitted with a connector for a deck lead allowing us to configure and upgrade the firmware in our electronics by attaching to a laptop via a USB cable.

The mooring diagram is presented elsewhere in this cruise report. It was fitted with 19 Seabird SBE-37 Microcat and 9 Nortek instruments. On advice from the crew, a bridle was fitted to both buoys to ease deployment via the rear cranes.
In addition to the equipment shown we used two further modems, firstly the ship's starboard USBL which had a licence to be used as a modem (i.e. for communications) and which we accessed from the computer displays in the main lab.
Finally, we borrowed from the RAPID scientists a Sonardyne iWand that had been purchased for use with a Sonardyne Fetch AZA lander. It is a small hand-held modem with a transducer that's held directly against the transducer of another modem allowing you to test and configure the larger device (especially helpful in breezy conditions on deck). It has a USB option for connecting to a laptop and presents itself as a virtual COM port to which we were able to connect our own GUI application and successfully download status and data records via the iWand from our own buoy controller electronics attached to one of the WMT modems.

12.3 Software

Both telemetry buoys on WB2 ran identical firmware written by us on their buoy controller PCBs (PCB v1.0b). We used versions CCROC_1_0_17 for all setup and testing, with CCROC_1_0_18 deployed. The only change between 17 and 18 was to reduce the IMM timeout from 30 minutes to 25 minutes to give less chance of contention on the IMM line (see 0). All versions of the software are available in the NOC OTEG subversion repositories at NOC.
The buoy controllers interact with the modems over a serial RS232 connection using text commands from Sonardyne Command Language that's common to all their 6G modems. Commands are sent either to the local modem or through the local modem to the remote modem. A specific command (MDFT) can send data beyond the remote modem (over its RS232 serial link) to any attached device. We used text commands sent using MDFT to our remote buoy controller for system status, data downloads and to interact with the inductive instruments on the mooring. For testing purposes our firmware on the test mooring buoy controller was able to return fake data records with any number of instruments but commands sent through to the actual instruments on the test mooring returned real data.
All systems were controlled with a single Windows Graphical User Interface (GUI) application written by us running on a laptop connected via a USB deck lead to a port on the battery housings, for this deployment we used CCROC_1_0_16. We also ran it standalone to control the ships USBL system and the iWand as a modem, and also standalone to decode received data from the mooring, both described later. The only other software we used was Sonardyne's 6G Terminal Lite program (v2.00.04.361) to do some of the testing with the USBL, along with Teraterm (v5.3).

12.4 Deployment

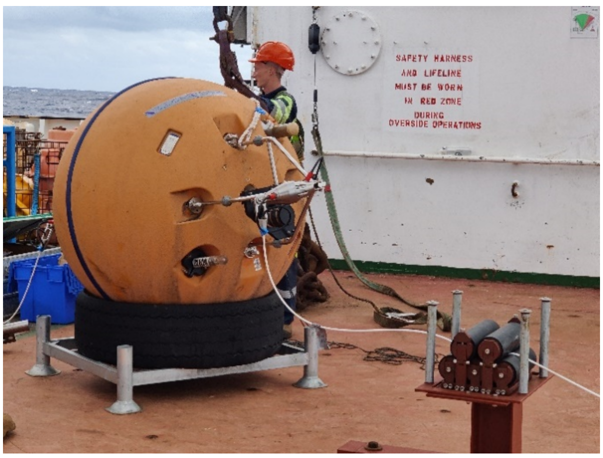
13 December 2024: Mooring was deployed. Due to the sleep power consumption of the modems, we had to implement a schedule with windows to power on the device to ensure full coverage for the duration of the mooring. These windows are set for 2 hours per buoy with split time across the buoys (1400-1559 GMT for the deep sphere, and 1500-1659 GMT for the upper sphere). After this we set the schedules for the buoy controllers and started them in mooring mode. We tested inductive comms with Seabird and Nortek instruments. The Nortek didn't have any stored measurements, so we couldn't check data, but we could check communications. Right before deployment the inductive addresses for all the Seabird and Nortek instruments were set. Once all Norteks were programmed the deployment was started whilst the last (deepest) seabirds were still being programmed. The inductive addresses are as follows:

Depth (m)	Serial No	Inductive Address
47	3239	01
99	7469	02
174	5989	03
249	4062	04
322	4066	05
496	4178	06
697	5992	07
810	4466	08
897	4725	09
1096	4464	10
1299	4184	11
1509	4468	12
1701	7362	13
1899	4710	14
2299	4719	15
2799	4795	16
3300	5991	17
3809	5982	18
3850	7361	19

Table 12.1 - Seabird Microcat Locations/ Inductive Address

Depth (m)	Serial No	Inductive Address
98	11846	30
173	11855	31
400	12701	32
796	12722	33
1199	8465	34
1504	13650	35
2049	14736	36
2999	14766	37
3810	14787	38

Table 12.2 - Nortek current meter Locations/ Inductive Address



14 December 2024: Due to higher sea state, planned work (WB1 deployment) was postponed so testing of the telemetry system was brought forward. Initially we struggled to communicate with the modems (ships USBL to

WB2), trying with the ship in several locations. After around an hour we started getting good communication when we used the 6G Terminal to "range" to the modem. After this it responded immediately. This we believe was due to the modems entering a "sleep" state and 6G Terminal appended a wake command (W1) to the range command. Due to the time taken to transit to site and get this initial communication working, the lower mooring controller had exited its powered-on window and the controller entered sleep, so all further testing was done with the upper mooring controller.

The communications worked perfectly thereafter, using 6G Terminal to type commands through the acoustic modems MDFT function to the mooring controller and all data has been logged with 6g terminal and saved to SVN.

Records were transferred acoustically from the SD Card of the buoy controller to the ship and this showed initial data from all Microcats and some Norteks. The fact we have communicated with all Microcats, showed that the inductive cable had been working ok (it was damaged during deployment, and fixed with self-amalgamating and electrical tape in a few places), however the latest data showed no communication from Microcats 01 to 04 and 09, so these data may have only been communicated during deployment when the cable was on the surface.

SBERAW.DAT File (CCROC SBE37 MicroCAT raw sample data)

Export...

hedule Timestamp	Device ID	Read Status	Serial Number	SBE Sample Timestamp	Temperature (C)	Conductivity (S/m)	Pressure (dbar)
/12/2024 16:04:00	01	ERR-XML	0	01/01/1970 00:00:00	0.0000	0.00000	0.000
/12/2024 16:04:00	02	ERR-IMM	0	01/01/1970 00:00:00	0.0000	0.00000	0.000
/12/2024 16:04:00	03	ERR-IMM	0	01/01/1970 00:00:00	0.0000	0.00000	0.000
/12/2024 16:04:00	04	ERR-XML	0	01/01/1970 00:00:00	0.0000	0.00000	0.000
/12/2024 16:04:00	05	OK	4066	14/12/2024 16:00:02	19.0189	4.90227	306.891
/12/2024 16:04:00	06	OK	4178	14/12/2024 16:00:01	16.0436	4.54849	487.771
/12/2024 16:04:00	07	OK	5992	14/12/2024 16:00:01	11.4484	4.02754	690.991
/12/2024 16:04:00	08	OK	4466	14/12/2024 16:00:01	8.6781	3.73905	807.384
/12/2024 16:04:00	09	ERR-IMM	0	01/01/1970 00:00:00	0.0000	0.00000	0.000
/12/2024 16:04:00	10	OK	4464	14/12/2024 16:00:01	5.2600	3.42528	1091.751
/12/2024 16:04:00	11	OK	4184	14/12/2024 16:00:01	4.5468	3.36325	1302.759
/12/2024 16:04:00	12	OK	4468	14/12/2024 16:00:01	4.1718	3.33542	1499.359
/12/2024 16:04:00	13	OK	7362	14/12/2024 16:00:01	4.0740	3.33493	1709.486
/12/2024 16:04:00	14	OK	4710	14/12/2024 16:00:01	3.9356	3.33059	1912.919
/12/2024 16:04:00	15	OK	4719	14/12/2024 16:00:01	3.4325	3.30184	2332.763
/12/2024 16:04:00	16	OK	4795	14/12/2024 16:00:02	3.0890	3.28850	2828.483
/12/2024 16:04:00	17	OK	5991	14/12/2024 16:00:01	2.6461	3.26608	3345.339
/12/2024 16:04:00	18	OK	5982	14/12/2024 16:00:02	2.3737	3.26121	3870.055
/12/2024 16:04:00	19	OK	7361	14/12/2024 16:00:01	2.3768	3.26082	3913.359

Figure 12.7 - Data from the mooring 24 hours after deployment

18 December 2024: Further data telemetry testing and acoustic signal testing. Theory of the need for a "wake" command from the 14th was tested. Both upper and lower telemetry buoys didn't respond until the wake command was sent and then worked as expected. Both upper and lower mooring controllers were commanded to download data acoustically to the ship, and on review we had mainly good data with errors shown for Microcats 01-04, 09 and the Nortek instruments. This is to be reviewed. We moved the ship to make acoustic power measurements before the power saving windows of the two controllers turned them and the modems off, moving the ship across the diameter of a 5km circle centred on the mooring. This line was chosen to be directly with and against the ocean current when we moved along it and back again. Preliminary results shown in 0

12.5 Acoustic signal measurements

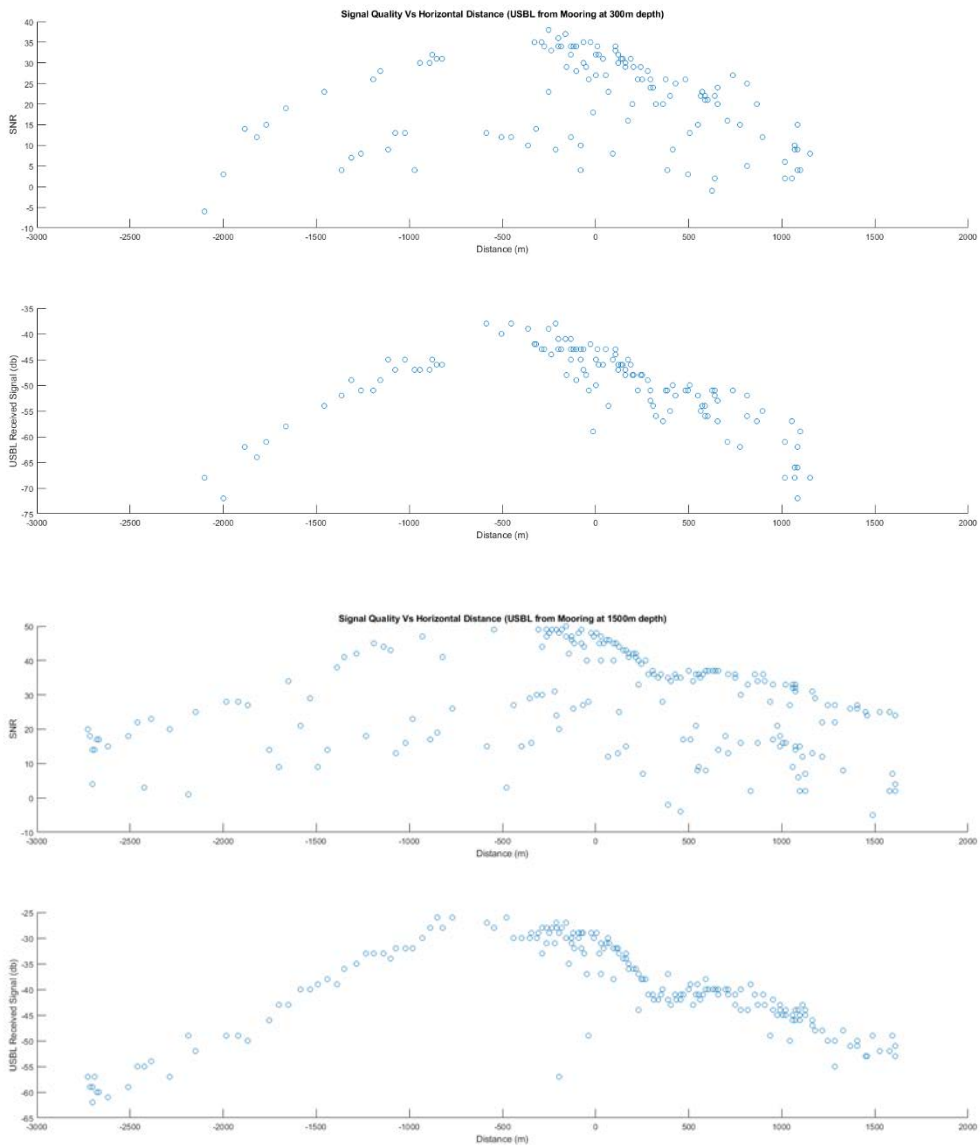


Figure 12.3 - Signal to Noise ratio and received signal power from 300m and 1500m mooring controllers

To test the required positioning of an unmanned vehicle, we took measurements of received signal power and signal to noise ratio (SNR) from both mooring controllers over a 5km line either side of the mooring (in line with the ocean current). As can be seen from Figure 12.3, the lower mooring gives a wider spatial area for communication, and a better SNR. This was expected due to the signal beam pattern from the transducer being a cone. We can also see that the optimum point is around 500m away from the mooring anchor in the direction of the current.

12.6 Issues/Improvements

12.6.1 Syntactic Floats

To allow for more protection of the cabling and housings, large stainless steel frames should be fitted to both ends of the buoys. In this deployment a large frame was fitted on the side with the acoustic transducer, but small on the side with Develogic housings, WMT and most cabling.

This made fitment of the equipment tight with cable runs harder to protect and both floats either got dragged over the threshold of the back deck or hit the stern.

12.6.2 Inductive Cable

As mentioned above, the main mooring line insulation got caught a couple of times and the deployment took longer than the normal rope mooring. Making this easier for deployment should be looked at with the Sensors and Moorings deployment team.

12.6.3 Modem Sleep Current

This was mentioned also in the DY181 report, but no improvements have been made. The modems have a sleep power draw of 650mW, which forced us to implement power saving "windows" of operation. When you have multiple deliverables on a ship, having to be on site, ready for a 3 hour open window in which all work needs to be completed is less than ideal.

12.6.4 LF Dunker

We initially used the lab system to talk directly to the LF dunker. This was successful, so tried setting P1 from RS485 to RS232, and back again. That worked fine, so appeared to have both options on the serial ports. Set P0 to RS232, disconnected from lab system and connected to CCROC PCB No9. No communication could be seen from the CCROC PCB and the dunker. We did have the full cable reel attached as the 8 pin Subconn was on the cable reel, and the connector on the dunker was different so had made sure that the RS232 baud rate was set low (9600) so should have been ok for 100m. We reconnected the dunker to the lab system and failed to get communication. We spent a few hours trying various things (serial breaks over both the main and aux ports, trying to load the firmware updater etc) but aside from one point where we did get received data when sending serial breaks over Aux, we didn't manage to re-establish communication.

12.6.5 Dual Redundancy / Two mooring controllers

We were asked by NERC to make the system with as much redundancy as possible, so included two mooring controllers that could talk to all instruments on the mooring. To be independent, these controllers had to both assume the role of master. Both communicate hourly over the inductive line to the instruments, so to avoid contention and conflict over this we have set them communication windows of 25 minutes each. This is slightly under the timing requirement if there are communication issues, but is required to clear the line for when the instruments themselves take samples. We feel the system would be more resilient if only one controller was used, even though this reduces the redundant feature, as the system will not be truly dual redundant without separating the inductive communications. If redundancy is required, a second mooring should be used.

12.7 Conclusion

We have found that remote download of data from the largest (in terms of depth and number of sensors) of the RAPID moorings is viable, including reading and adjusting the acoustic parameters of the local and remote modems remotely as necessary to achieve the best signal.

13. Data download from AZA landers

12.1 WB3AZA

Dunker Deployed as we came on to station at 00:02:52 local (05:02:52 UTC): First command sent. Acoustic Link all green. Pages 56-3706 needed to be downloaded. Baud Rate set at 3500 bps. Some interference observed, so EM122 and EK860 systems were turned off at 01:09:00 local (06:09:00 UTC) to reduce error in data download. With acoustics on, we repeatedly received "NO_DATA" with each reply. Telemetry started working as expected. Initially started with downloading 50 pages at a time. But eventually moved up to downloading all. For downloading 2900 pages I started at 06:35 UTC and ended at 08:31 UTC taking a total

of 1 hour and 56 min, or 25 pages/min download speed. I had 5 restarts, but was done with little latency. Battery looks like it is above 79% so should be good for another couple of years.
Time on station: December 13, 2024 05:00:00 UTC (00:00:00 Local)
Time off station: December 13, 2024 08:31:00 UTC (03:30:00 Local)
Met Conditions:
Swell: 2-3 m coming from 332
Winds: 15-25 knts
Station Lon: 76.5055 W
Station Lat: 26.4896 N

Data collected from WB3LZ includes, bottom pressure, time of flight from the pies measurement, temperature, AZA calibration measurements. Data from the rapid deployment exists from Feb 27, 2023 08:00:00 UTC – Dec 13, 2024 08:00:00 UTC.
Initial plots of the pressure, calibration and time of flight data set are shown in Figure 1. The data was converted to a CSV file from the native ".dat" using EXPORT in SAM software. The file Data_241213085403__007210_1907_.csv contains the full data download. The matlab script read_aza_data.m can parse the csv file into individual data streams.

12.2 WB2AZA

First Attempt
Time on station: December 12, 2024 20:35:00 UTC (15:35:00 local)
Time off station: December 12, 2024 22:20:00 UTC (17:20:00 local)
Met Conditions:
Swell: 3-4 m coming from 335 azimuth
Winds: 20-30 knts
Station Lon: 76.7500 W
Station Lat: 26.4951 N

Dunker deployed by 15:36 local and first command sent-No reply. We lowered the dunker by 10 m, still no reply. After consulting with Sonardyne we made a measurement of the noise characteristics (Figure 1). Julio Lopez at Sonardyne indicated that the noise was pretty high-might have to lower the dunker even further. At 16:00 local began to move ship to directly over the station location. Still no reply, but a response to a discovery command. Moved to **Lon:** 76.7510° W**, Lat:** 26.4971° N/
Dunker deployed to 30 m depth, 7 attempts made to communicate.
Last attempt made at 17:20:00 local 22:20:00 UTC. Recovered dunker, performed a test on deck to make sure the dunker was making noises.

Second Attempt
Time On Station: December 14, 2024 17:41:00 UTC (12:41:00 local)
Time off Station: December 14, 2024 20:35:00 UTC (15:35:00 local)
Met Conditions:
Swell: 3-4 m coming from 90 azimuth
Winds: 30-40 knts
Station Lon: 76.7522 W
Station Lat: 26.4969 N
Notes:
Dunker deployed upon arrival. Re-Attempted to communicate to WB2LZ, returned to area, planned to go at different azimuth angles relative to WB2LZ. We tried ranging from 5 different positions. Table below gives longitude, latitude and time. All normal ranges/link tests

unsuccessful. Dunker was deployed at 30 m depth each time. I sent another DISC command at the last position (5) and it came back with the address of the unit on the seafloor.
Sent volatile state command at position 5 at 20:43: 06 UTC, “VS:1906;W1”, and the instrument responded with its status:VS:1906,WKT1,HPR26,BT1;LI;VLT13.4;IDC-35.5;CAP180./0;T2.4,R5490000[XCR62,SNR28,DBV-21,TEL,TCS1,RPSKV_200,FEC0,0,0]
VLT indicate voltage is at 13.4 V, which is well below the 14 V operating range.
I spoke with Sonardyne (Colby) who said that it would be prudent to recover the instrument. Julio from Sonardyne called to confirm that. He said that the rise rate of the instruments is 60-70 m/min. The instrument can be commanded to ping back on the way up and that the direct command to initialize the release command and over ride sleep mode is “SC:1906, 007217, OV1” . We waited until early evening so the flasher can help us find the instrument.

Recovery of WB2LZ
Time on Station: December 16, 2024 21:09:00 UTC.
Station Lat: 26.4955 N
Station Lon: -76.7543 W
Met Conditions
Swell: 3-4 m from 74 azimuth
Winds: 20-30 knts
Time First Arm/Unscrew Command sent: 21:16:02 UTC
*had to send SC:1906;W1, OV1 command first to get the ARM/UNSCREW command to go.
Second command sent at 21:26:14 UTC sent manually “REL: 1906;W1,U007217, OPEN”
Time off Bottom: 21:39:37 UTC, determined using depths from “TRACK” in SAM. Was probably earlier but it was the first confirmed depth different from 3850 m (~2900) .
Time on Surface: 22:20:00 UTC (estimated 60-70 m/min).
Time on Deck/Off station: 22:45:00 UTC.
Notes:
Used VS:1906;W1 to determine if we were in range and had communication, which happened immediately. The range functionality did not work. Used the “track” to estimate the rise rate based on pressure measurements, allowed us to tell when it was near the surface and off bottom by the changes. VS:1906;W1 also returns a 1 way travel time in micro s (RXXXXXXX), so we were able to get ranges from that.

When the pressure suggested it was 300 m from the surface we pulled the dunker and began the search. The ranges were a little larger 573 m – suggesting it was away from the ship. WB2LZ was spotted immediately as the flasher was functional. It was about 300 m off the bow.

14. Moorings

Yvonne Firing, Darren Rayner

13.1 Mooring recoveries

All planned RAPID mooring recoveries were completed, including two tall moorings and three landers (Table 11.1). WB2 parted (on the surface) between the top two syntactic floats and was re-grappled at the second syntactic float to continue recovery. On WBAL9, the Billings sphere (with light and beacon) separated when grappled so the lander frame was hooked separately. WB2L14 took 1-2 minutes to start rising on release. On WB1 the only issue was an impact with the deck of one microcat, with no damage detected. Some issues were observed with microcat attachments including one missing clamp and a loose protector, while the 50 m microcat on WB2 had a bent guard and turned out to be flooded. The 400 m Nortek on WB1 was also flooded. One of the BPRs on WBAL9 failed to record. Otherwise data recovery (Table 11.2) was good.

Mooring	**Deployment cruise**	**Deployment date**	**Recovery date**	**Recovery start time (UTC)**	**Recovery duration**
WB1	EN705	2023-07-20	2024-12-17	12:59	02:00
WB2	EN705	2023-07-19	2024-12-12	14:21	05:13
WBAL9	JC192	2020-12-17	2024-12-16	14:35	00:51
WB1L1	EN697	2023-03-04	2024-12-16	12:46	01:09
WB4L14	DY129	2021-01-01	2024-12-12	12:33	01:29
WBADCP	EN697	2023-03-06	2024-12-16	16:18	00:21

Table 13.1 DY186 Mooring recoveries. Recovery duration is time from acoustic command to releases on deck.

Mooring/ Lander	Instrument	S/N	Start Date	End Date	Records	Avg. P (dbar)
wb1_17_2023	MicroCAT-ODO	10555	20/07/2023	17/12/2024	3093	83.6
wb1_17_2023	MicroCAT	5763	20/07/2023	17/12/2024	12372	84.6
wb1_17_2023	Nortek	5889	20/07/2023	17/12/2024	12374	130.5
wb1_17_2023	MicroCAT	6126	20/07/2023	17/12/2024	12373	133.8
wb1_17_2023	MicroCAT	5782	20/07/2023	17/12/2024	12372	201.7
wb1_17_2023	MicroCAT-ODO	12833	20/07/2023	17/12/2024	3093	280.7
wb1_17_2023	MicroCAT	5768	20/07/2023	17/12/2024	12372	273.4
wb1_17_2023	MicroCAT	5243	20/07/2023	17/12/2024	12373	349.5
wb1_17_2023	MicroCAT-ODO	12835	20/07/2023	17/12/2024	3093	431.6
wb1_17_2023	MicroCAT	5239	20/07/2023	17/12/2024	12373	433.3
wb1_17_2023	Nortek	5890	20/07/2023	17/12/2024	flooded	
wb1_17_2023	MicroCAT	4305	20/07/2023	17/12/2024	12373	525.4
wb1_17_2023	MicroCAT-ODO	12910	20/07/2023	17/12/2024	3093	622.7
wb1_17_2023	MicroCAT	3270	20/07/2023	17/12/2024	12373	719.1
wb1_17_2023	Nortek	5893	20/07/2023	17/12/2024	12374	834.4
wb1_17_2023	MicroCAT-ODO	12963	20/07/2023	17/12/2024	3093	822.2
wb1_17_2023	MicroCAT	3934	20/07/2023	17/12/2024	12373	919.4
wb1_17_2023	MicroCAT-ODO	12965	20/07/2023	17/12/2024	3093	1016.3
wb1_17_2023	Nortek	6805	20/07/2023	17/12/2024	12374	1241.1
wb1_17_2023	MicroCAT	6326	20/07/2023	17/12/2024	12373	1225.5
wb1_17_2023	MicroCAT	3265	20/07/2023	17/12/2024	12373	1365.4
wb1_17_2023	Nortek	6049	20/07/2023	17/12/2024	12374	1398.7
wb2_18_2023	MicroCAT	6827	19/07/2023	12/12/2024	flooded	

wb2_18_2023	Nortek	5885	19/07/2023	12/12/2024	12279	155.8
wb2_18_2023	MicroCAT	6817	19/07/2023	12/12/2024	12277	139.7
wb2_18_2023	Nortek	6765	19/07/2023	12/12/2024	12279	211.9
wb2_18_2023	MicroCAT	6118	19/07/2023	12/12/2024	12277	213.5
wb2_18_2023	MicroCAT	6137	19/07/2023	12/12/2024	12277	284.1
wb2_18_2023	MicroCAT	6798	19/07/2023	12/12/2024	12277	360.5
wb2_18_2023	Nortek	5963	19/07/2023	12/12/2024	12279	441
wb2_18_2023	MicroCAT	5784	19/07/2023	12/12/2024	12278	537.2
wb2_18_2023	MicroCAT	5484	19/07/2023	12/12/2024	12278	737.6
wb2_18_2023	Nortek	6050	19/07/2023	12/12/2024	12279	841.2
wb2_18_2023	MicroCAT	6119	19/07/2023	12/12/2024	12278	832.6
wb2_18_2023	MicroCAT	4307	19/07/2023	12/12/2024	12278	937.9
wb2_18_2023	MicroCAT	5777	19/07/2023	12/12/2024	12278	1138.9
wb2_18_2023	Nortek	8483	19/07/2023	12/12/2024	12279	1236.6
wb2_18_2023	MicroCAT	5485	19/07/2023	12/12/2024	12278	1340.5
wb2_18_2023	Nortek	8492	19/07/2023	12/12/2024	12279	1537.5
wb2_18_2023	MicroCAT	6805	19/07/2023	12/12/2024	12278	1545.1
wb2_18_2023	MicroCAT	5247	19/07/2023	12/12/2024	12278	1746.3
wb2_18_2023	MicroCAT	5238	19/07/2023	12/12/2024	12278	1942.3
wb2_18_2023	Nortek	13588	19/07/2023	12/12/2024	12279	2106.5
wb2_18_2023	MicroCAT	5240	19/07/2023	12/12/2024	12277	2352.7
wb2_18_2023	MicroCAT	4549	19/07/2023	12/12/2024	12277	2862.4
wb2_18_2023	Nortek	8052	19/07/2023	12/12/2024	12279	3068
wb2_18_2023	MicroCAT	3932	19/07/2023	12/12/2024	12277	3360.5
wb2_18_2023	Nortek	9204	19/07/2023	12/12/2024	12279	3878.7
wb2_18_2023	MicroCAT	3911	19/07/2023	12/12/2024	12278	3882.5
wb2_18_2023	MicroCAT	3907	19/07/2023	12/12/2024	12278	3910.7
wbadcp_16_2023	MicroCAT	6808	06/03/2023	16/12/2024		
wbadcp_16_2023	ADCP		06/03/2023	16/12/2024		
wbal9_9_2020	SBE53	053	12/27/2020	16/12/2024	34105	627.6
wbal9_9_2020	SBE53	393	12/27/2020	16/12/2024	No data	
wb1l1_1_2023	SBE53	419	04/03/2023	16/12/2024	15402	1401.6
wb1l1_1_2023	SBE53	004	04/03/2023	16/12/2024	15401	1404.8
wb2l14_14_2020	SBE53	081	04/01/2021	12/12/2024	33991	3942.2
wb2l14_14_2020	SBE53	060	04/01/2021	12/12/2024	34011	3942.9

Table 23.2 DY186 moored instrument data recovery.

13.2 Mooring cal dips

Before deployment/after recovery, microCATs and microCAT-ODOs were dipped on CTD casts with extended (5-minute) bottle stops at a range of depths. Table 11.3 lists the results and final allocations. Several of the recovered sensors showed out-of-tolerance conductivity offsets and likely require factory recalibration before reuse.

CTD Cast	MicroCAT S/N	Recovered mooring	Recovered Depth (m)	Deployed mooring	Deployed Depth (m)	COMMENT
3	4723					P-4.5 at 150
3	4724					C+0.03
3	4178			WB2	500	
3	3282					C+0.021
3	4466			WB2	800	
3	4725			WB2	900	
3	4464			WB2	1100	
3	4184			WB2	1300	
3	4468			WB2	1500	
3	4473					C-0.03
3	4710			WB2	1900	
3	4719			WB2	2300	
3	4795			WB2	2800	
3	5981					C+0.021
3	5982			WB2	3800	
3	7361			WB2	3850	
3	5989			WB2	175	
3	5991			WB2	3300	
3	5992			WB2	700	
3	5993					
3	7362			WB2	1700	
3	7469			WB2	100	
3	3252					bad P response 700 or shallower, P+6 at 3800, okay middle, C okay deep
3	3255					P+5 at 3000, T-0.003
4	3239			WB2	50	
4	4062			WB2	250	
4	4066			WB2	325	
4	3900			WB1	50	P+4.5
4	3933			WB1	100	

4	4306			WB1	175	
4						
4	5772			WB1	1200	P-8 and slow response shallow
4	5779					C+0.025
4	5785			WB1	500	
4	6128			WB1	700	
4	6323					C+0.025
4	6803			WB1	325	
4	6825			WB1	1350	
4	3231			WB1	250	
4	3271					C+0.02
4	12901			WB1	50	O+22
4	12902			WB1	400	O+25
4	12966			WB1	250	O+25, slow C, P, O response
4	12998			WB1	600	O+24
4	14116			WB1	800	O+23
4	14145			WB1	1000	O+24
4	3277			WBADCP	525	
5	6827					N/A (flooded)
5	6817	WB2	100			C+0.025
5	6118	WB2	175			C+0.04
5	6137	WB2	250	WB1	900	
5	6798	WB2	325			C+0.02
5	5784	WB2	500			
5	5484	WB2	700			pin broken after caldip
5	6119	WB2	800			
5	4307	WB2	900			
5	5777	WB2	1100			
5	5485	WB2	1300			okay on caldip, no comms after
5	6805	WB2	1500			
5	5247	WB2	1700			
5	5238	WB2	1900			
5	5240	WB2	2300			
5	4549	WB2	2800			
5	3932	WB2	3300			
5	3911	WB2	3800			
5	3907	WB2	3840	WB1	400	
7	5763	WB1	50			C+0.039
7	6126	WB1	100			

7	5782	WB1	175		C+0.02
7	5768	WB1	250		C+0.027
7	5243	WB1	325		C+0.032, P+5 at 400
7	5239	WB1	400		C+0.03, P+5.5 at 400
7	4305	WB1	500		
7	3270	WB1	700		
7	3934	WB1	900		
7	6326	WB1	1200		P+5.5 at 1500
7	3265	WB1	1350		
7	10555	WB1	50		
7	12833	WB1	250		
7	12835	WB1	400		
7	12910	WB1	600		
7	12963	WB1	800		
7	12965	WB1	1000		
9	6808	WBADCP	525		

Table 33.3 DY186 Cal Dips, S/Ns highlighted in yellow are ODOs

13.3 Mooring deployments

Two tall moorings and four landers were deployed (Table N.4). On WB2, the sets of rugby floats slowed the deployment, and it was found to be easier to leave approximately 5m of wire between a set of rugby floats and the subsequent group of sensors, rather than deploying them close together. Anchor-drop positions are listed below and mooring ranges were taken after each reached the seabed to determine positions by trilateration (Figure 11.1).

	Deployment start	**Anchor drop time, position, depth**				**Trilaterated anchor seabed position**		**Fall-back [m]**
Mooring		**Time**	**Lat [N]**	**Lon [W]**	**Depth [m]**	**Lat [N]**	**Lon [W]**	
WB1	17 Dec 2024 17:02	17 Dec 2024 19:47:00	26° 29.89'	76° 48.77'	1392	26° 29.98'	76° 48.85'	236
WB1L2	17 Dec 2024 20:21	17 Dec 2024 20:27:00	26° 30.39'	76° 48.82'	1370	26° 30.44'	76° 48.84'	102
WB2L16	13 Dec 2024 01:18	13 Dec 2024 01:20	26° 30.22’	76° 44.62'	3868	26° 30.27'	76° 44.65'	169
WB2	13 Dec 2024 15:06	14 Dec 2024 00:49	26° 31.13'	76° 44.32'	3909	26° 31.10'	76° 44.35'	201
WBAL11	17 Dec 2024 21:33	17 Dec 2024 21:37	26° 32.23'	76° 51.28'	619	26° 32.31'	76° 51.91'	129
WBADCP	16 Dec 2024 19:29	16 Dec 2024 19:38	26° 31.80'	76° 52.03'	550	26° 31.84'	76° 52.03'	60

Table 43.4 DY186 moorings/landers deployed and deployment details

The MicroCAT and MicroCAT-ODOs deployed are listed in Table 11.4 above, while BPRs, Norteks, and ADCPs are listed in Table 11.5.

Instrument	Mooring	S/N	Deployed Depth (m)
SBE53	wb2l16	29	3850
SBE53	wb2l16	434	3850

SBE53	wbal11	12	610
SBE53	wbal11	447	610
SBE53	wb1l2	14	1360
SBE53	wb1l2	448	1360
ADCP	wbadcp	23642	525
Nortek	wb1	8502	100
Nortek	wb1	9427	400
Nortek	wb1	9435	800
Nortek	wb1	11024	1200
Nortek	wb1	13482	1350
Nortek	wb2	11846	100
Nortek	wb2	11855	175
Nortek	wb2	12701	400
Nortek	wb2	12722	800
Nortek	wb2	5885	1200
Nortek	wb2	13650	1500
Nortek	wb2	14736	2050
Nortek	wb2	14766	3000
Nortek	wb2	14787	3800

Table 53.5 DY186 BPRs and current meters deployed

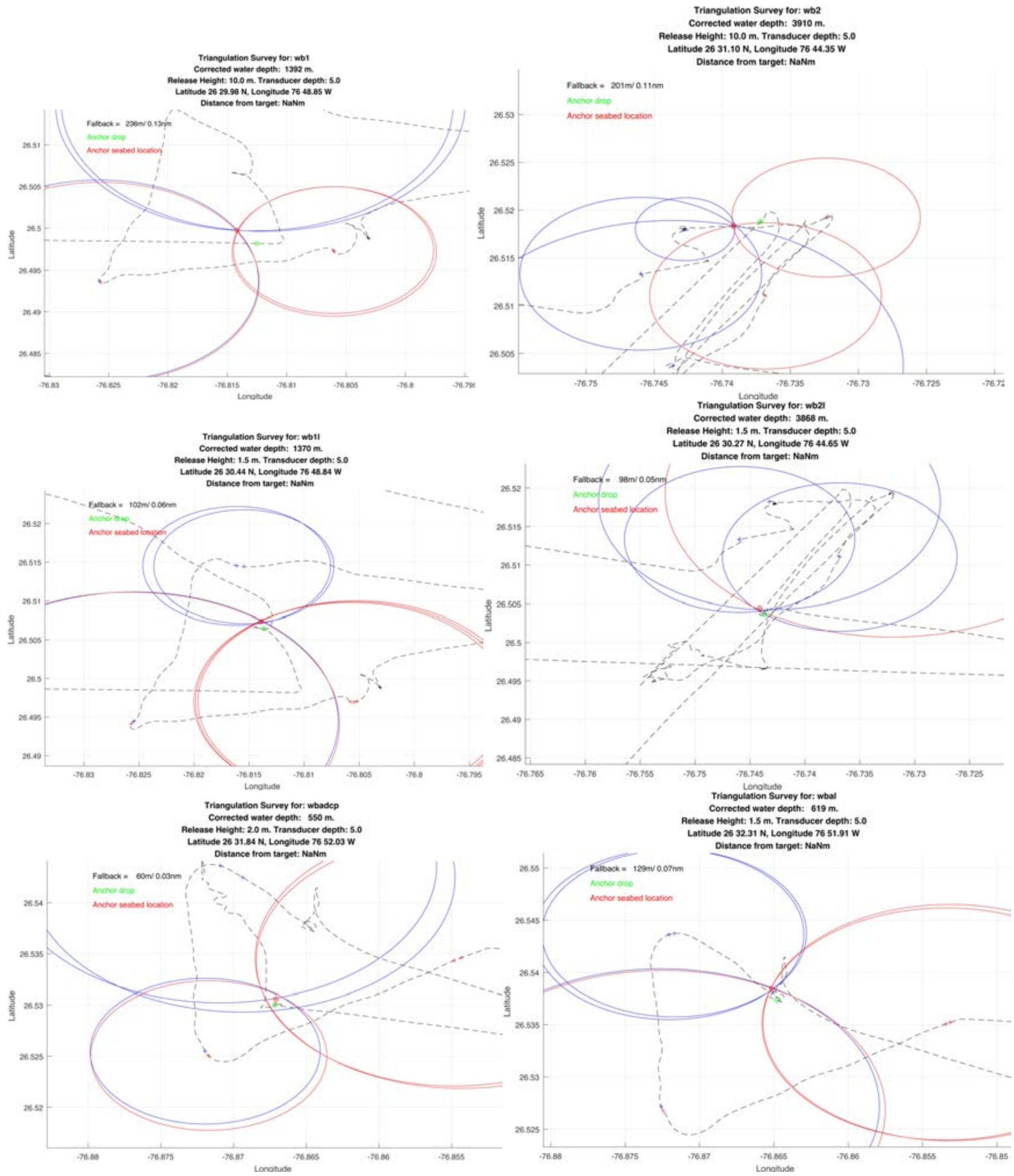
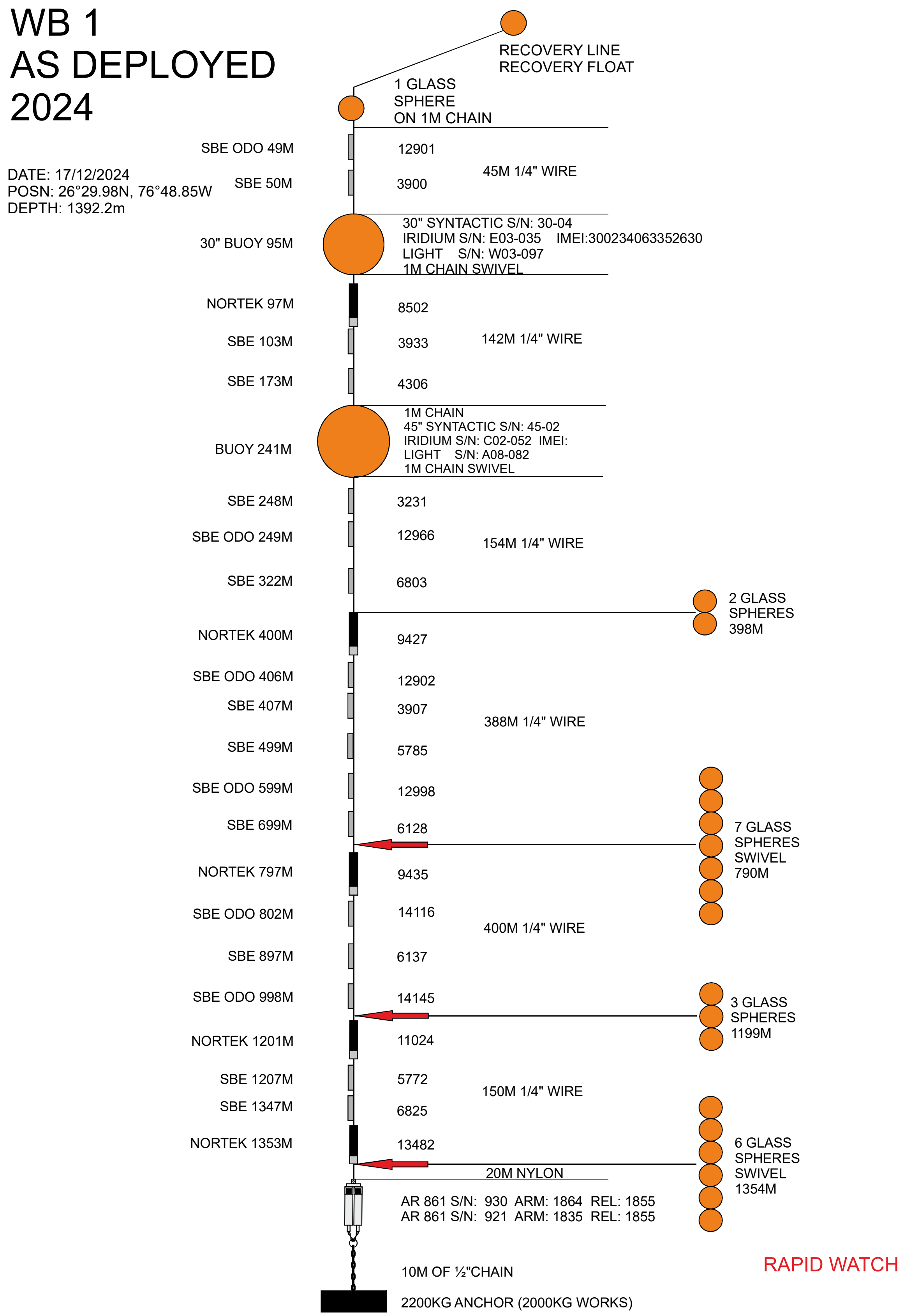
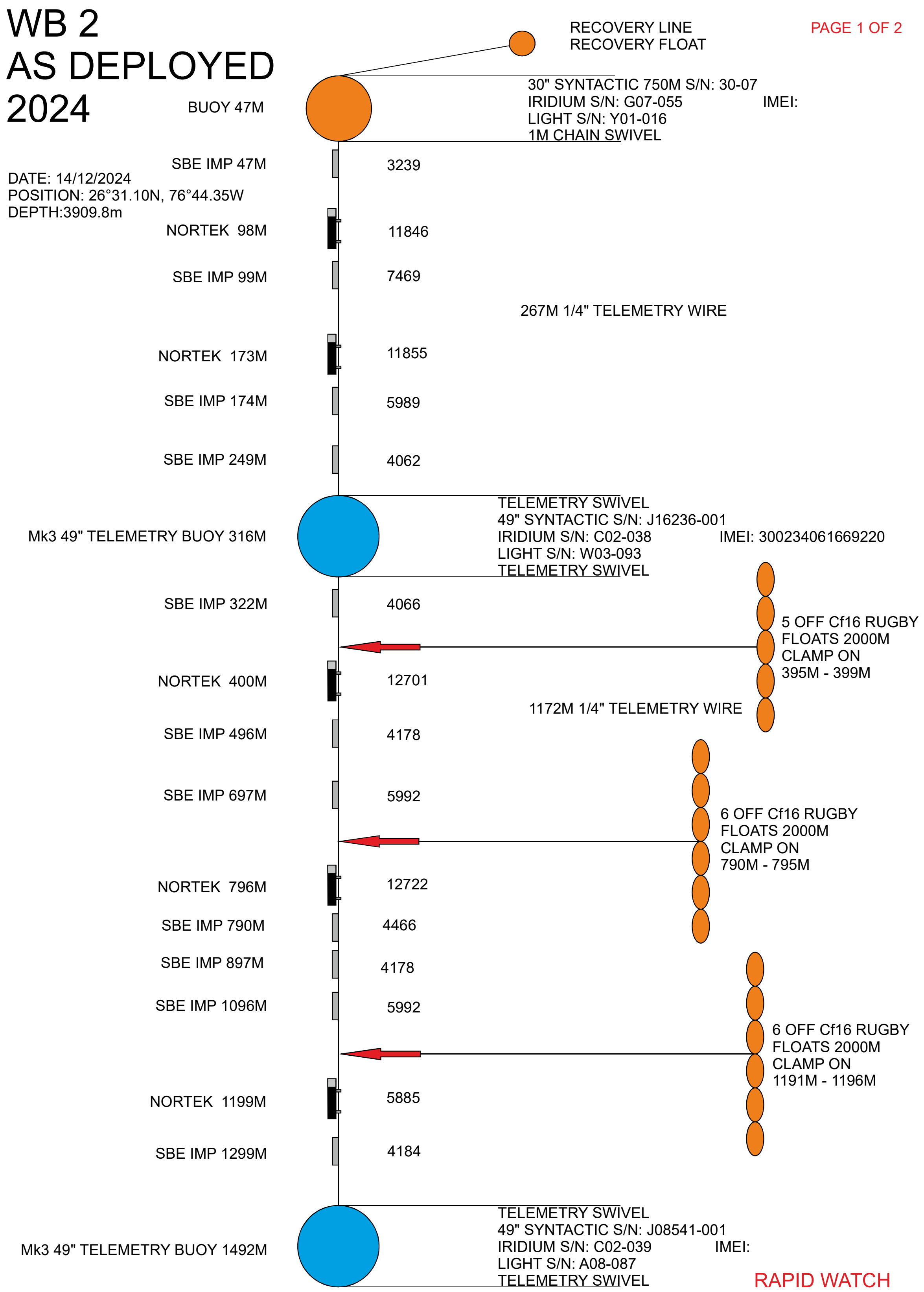
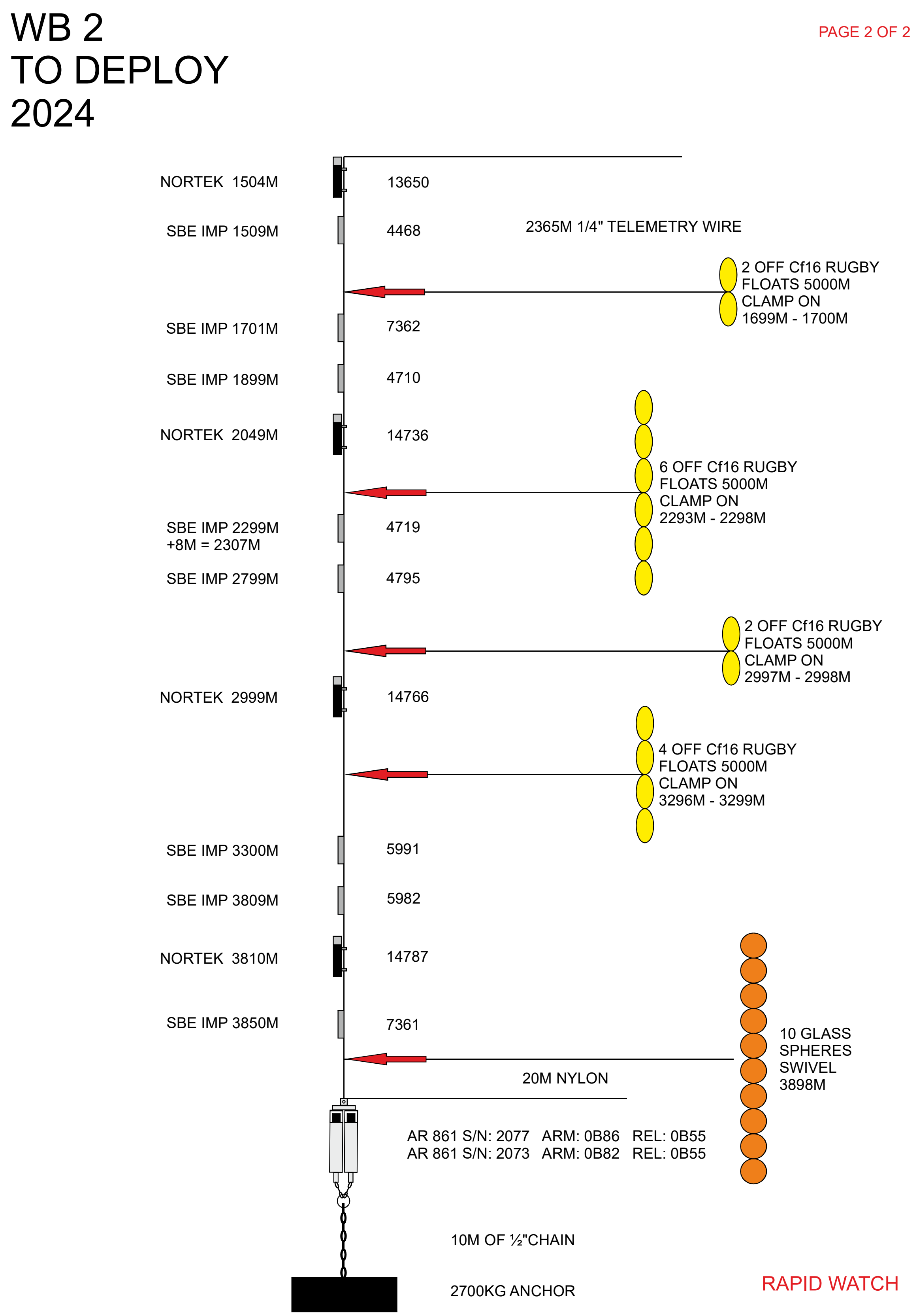


Figure 13.1 Mooring trilaterations and fallback distances.

Appendix A: Diagrams of Deployed Moorings

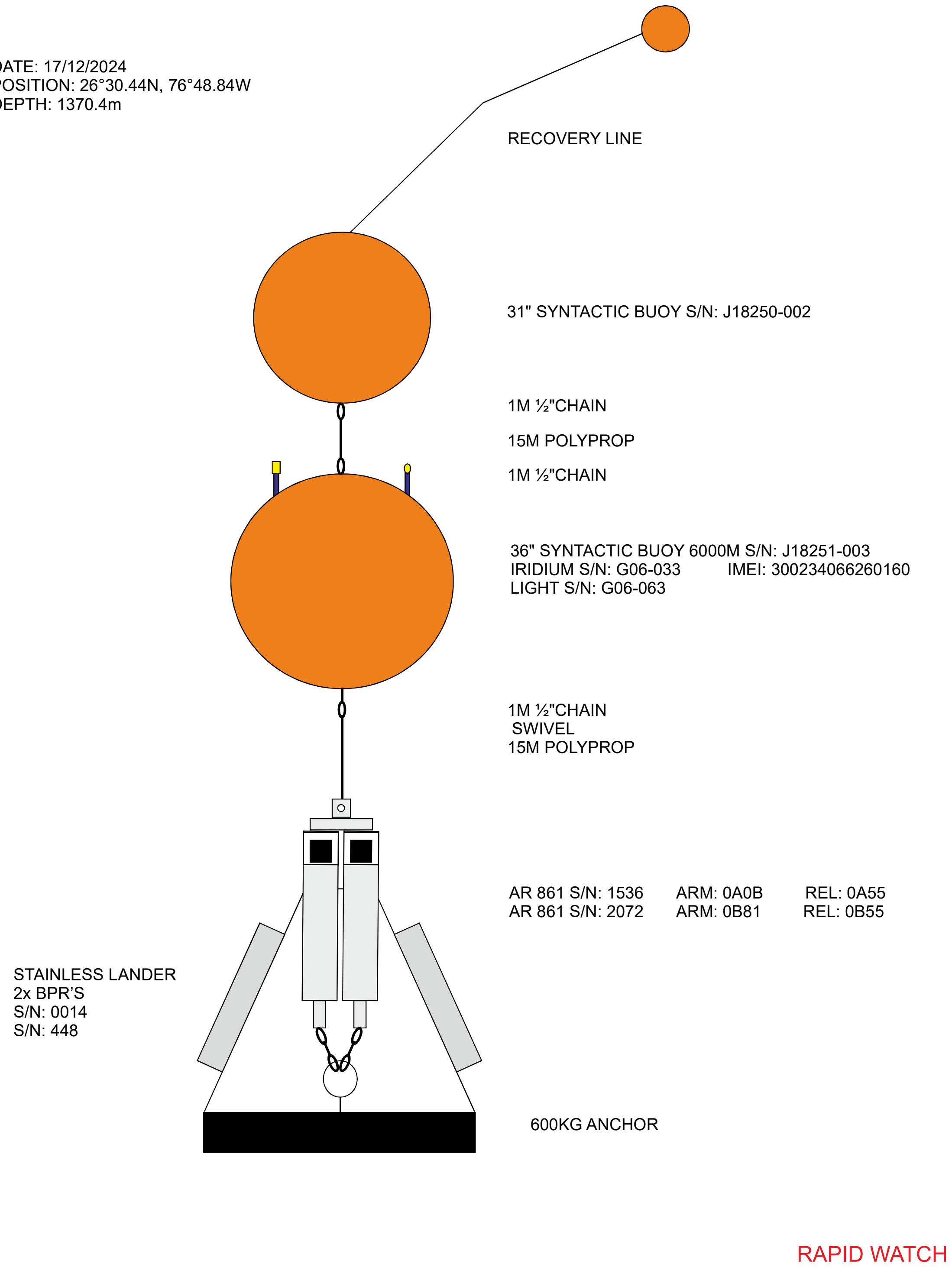



WB 2
AS DEPLOYED
2024
PAGE 1 OF 2
RECOVERY LINE
RECOVERY FLOAT
BUOY 47M
30" SYNTACTIC 750M S/N: 30-07
IRIDIUM S/N: G07-055
IMEI:
LIGHT S/N: Y01-016
1M CHAIN SWIVEL
SBE IMP 47M
3239
DATE: 14/12/2024
POSITION: 26°31.10N, 76°44.35W
DEPTH:3909.8m
NORTEK 98M
11846
SBE IMP 99M
7469
267M 1/4" TELEMETRY WIRE
NORTEK 173M
11855
SBE IMP 174M
5989
SBE IMP 249M
4062
TELEMETRY SWIVEL
49" SYNTACTIC S/N: J16236-001
IRIDIUM S/N: C02-038
IMEI: 300234061669220
LIGHT S/N: W03-093
TELEMETRY SWIVEL
Mk3 49" TELEMETRY BUOY 316M
SBE IMP 322M
4066
5 OFF Cf16 RUGBY
FLOATS 2000M
CLAMP ON
395M - 399M
NORTEK 400M
12701
1172M 1/4" TELEMETRY WIRE
SBE IMP 496M
4178
SBE IMP 697M
5992
6 OFF Cf16 RUGBY
FLOATS 2000M
CLAMP ON
790M - 795M
NORTEK 796M
12722
SBE IMP 790M
4466
SBE IMP 897M
4178
SBE IMP 1096M
5992
6 OFF Cf16 RUGBY
FLOATS 2000M
CLAMP ON
1191M - 1196M
NORTEK 1199M
5885
SBE IMP 1299M
4184
TELEMETRY SWIVEL
49" SYNTACTIC S/N: J08541-001
IRIDIUM S/N: C02-039
IMEI:
LIGHT S/N: A08-087
TELEMETRY SWIVEL
Mk3 49" TELEMETRY BUOY 1492M
RAPID WATCH


WB 2
TO DEPLOY
2024
PAGE 2 OF 2
NORTEK 1504M
13650
SBE IMP 1509M
4468
2365M 1/4" TELEMETRY WIRE
2 OFF Cf16 RUGBY
FLOATS 5000M
CLAMP ON
1699M - 1700M
SBE IMP 1701M
7362
SBE IMP 1899M
4710
NORTEK 2049M
14736
6 OFF Cf16 RUGBY
FLOATS 5000M
CLAMP ON
2293M - 2298M
SBE IMP 2299M
+8M = 2307M
4719
SBE IMP 2799M
4795
2 OFF Cf16 RUGBY
FLOATS 5000M
CLAMP ON
2997M - 2998M
NORTEK 2999M
14766
4 OFF Cf16 RUGBY
FLOATS 5000M
CLAMP ON
3296M - 3299M
SBE IMP 3300M
5991
SBE IMP 3809M
5982
NORTEK 3810M
14787
SBE IMP 3850M
7361
10 GLASS
SPHERES
SWIVEL
3898M
20M NYLON
AR 861 S/N: 2077 ARM: 0B86 REL: 0B55
AR 861 S/N: 2073 ARM: 0B82 REL: 0B55
10M OF ½"CHAIN
2700KG ANCHOR
RAPID WATCH

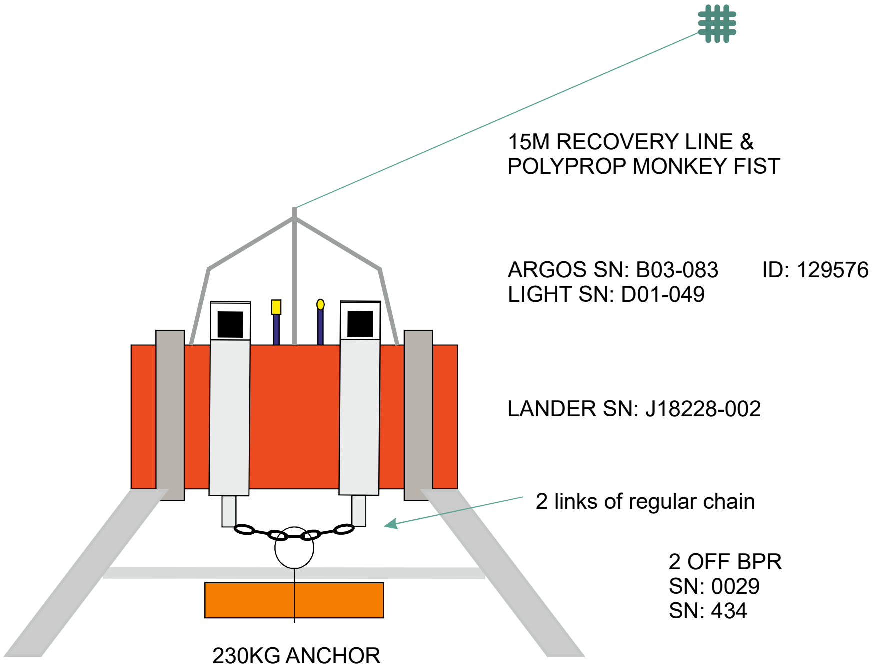
WB1L2
AS DEPLOYED
2024

DATE: 17/12/2024
POSITION: 26°30.44N, 76°48.84W
DEPTH: 1370.4m



WB2L16
TO DEPLOY
2024

DATE: 14/12/2024
POSN: 26°30.27N, 76°44.65W
DEPTH:3868.0m

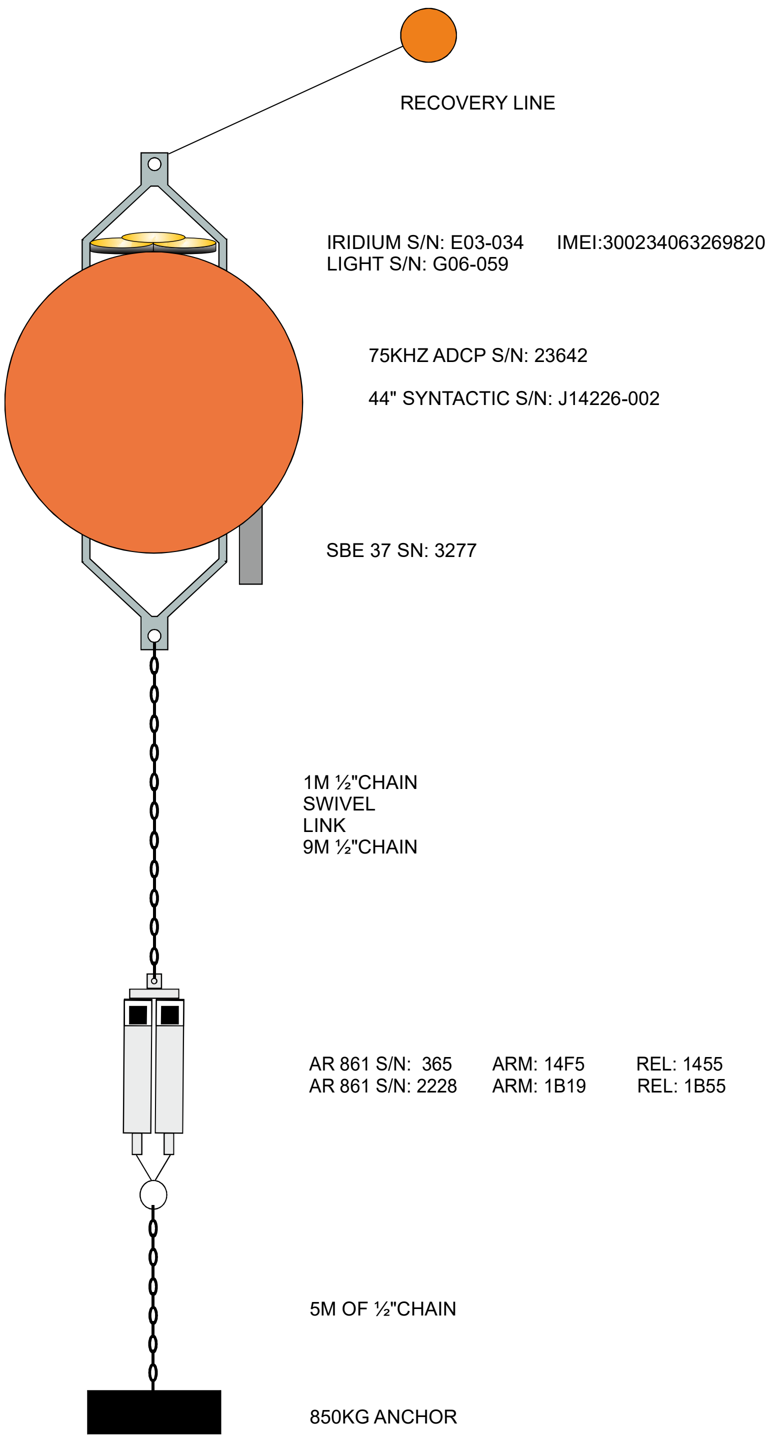


AR 861 SN: 251 ARM: 14A8 REL: 1455
AR 861 SN: 2076 ARM: 0B85 REL: 0B55

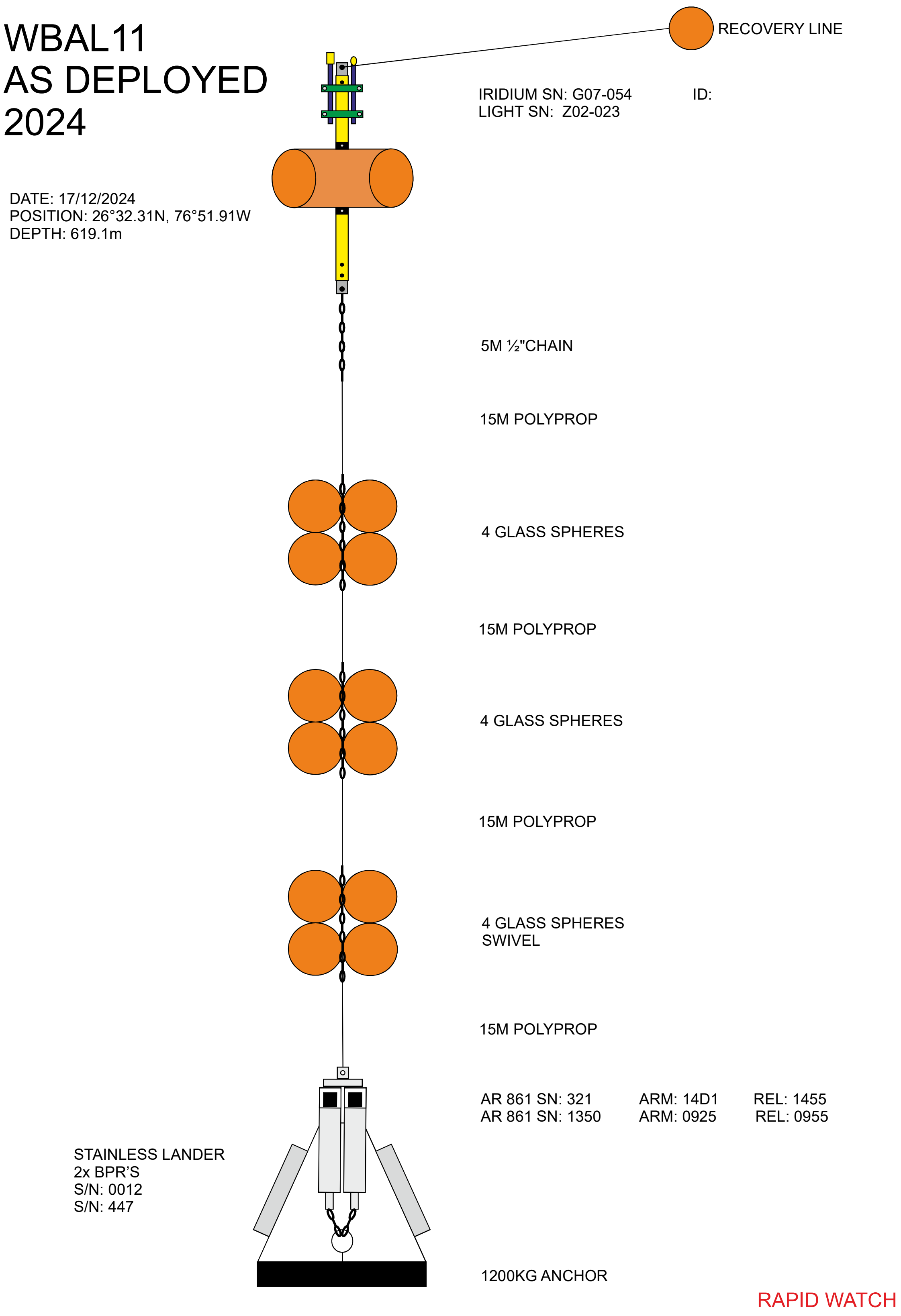
RAPID WATCH

WB ADCP
AS DEPLOYED
2024

DATE: 17/12/2024
POSN: 26°31.84N, 76°52.03W
DEPTH:550.4m



RAPID WATCH


WBAL11
AS DEPLOYED
2024
RECOVERY LINE
IRIDIUM SN: G07-054
ID:
LIGHT SN: Z02-023
DATE: 17/12/2024
POSITION: 26°32.31N, 76°51.91W
DEPTH: 619.1m
5M ½"CHAIN
15M POLYPROP
4 GLASS SPHERES
15M POLYPROP
4 GLASS SPHERES
15M POLYPROP
4 GLASS SPHERES
SWIVEL
15M POLYPROP
AR 861 SN: 321
ARM: 14D1
REL: 1455
AR 861 SN: 1350
ARM: 0925
REL: 0955
STAINLESS LANDER
2x BPR'S
S/N: 0012
S/N: 447
1200KG ANCHOR
RAPID WATCH

Appendix B: Log Sheets of Recovered Moorings

RAPID-AMOC MOORING LOGSHEET **RECOVERY**

Mooring **WB1** Cruise ~~EN705~~ DY186

NB: all times recorded in GMT

Date 17/Dec/2024 **Site arrival time** overnight

Time of first ranging 12:57

ITEM	SER NO	COMMENT	TIME
Recovery line	n/a	grapple	1329
1 x glass on 1 m chain	n/a		1332
MicroCAT-ODO	10555 ✓	Heavy fouling	"
MicroCAT	5763 ✓	"	"
30" syntactic float	n/a		1338
with Light	Z02-023 ✓		"
and Beacon	C02-040 ✓	IMEI = 300234061660210	"
Nortek	5889 ✓	Fouling	1339
MicroCAT	6126 ✓		1342
MicroCAT	5782 ✓		1346
45" syntactic float	n/a		1349
with Light	A08-86 ✓		"
and Beacon	G07-054 ✓	IMEI = 300234065334270	"
MicroCAT	5768 ✓		1357
MicroCAT-ODO	12833 ✓		1358
MicroCAT	5243 ✓	Missing Clamp	1400
2 x 17" glass			1402
Nortek (Flooded)	5890 ✓		"
MicroCAT-ODO	12835 ✓		1405
MicroCAT	5239 ✓		"
MicroCAT	4305 ✓		1409
MicroCAT-ODO	12910 ✓		1412
MicroCAT	3270 ✓	Protector loose	1415
7 x 17" glass			1420
Nortek	5893 ✓		"
MicroCAT-ODO	12963 ✓	Impacted deck	"
MicroCAT	3934 ✓		1429
MicroCAT-ODO	12965 ✓		1431
3 x 17" glass	n/a		1438
Nortek	6805 ✓		"
MicroCAT	6326 ✓		1441
MicroCAT	3265 ✓		1445
Nortek	6049 ✓		1447
6 x 17" glass	n/a		"
Acoustic Release #1	1346	Record codes below	1459
Acoustic Release #2	2223	Record codes below	"

Ascent Rate Ranging

117 m/min at start

Time	Range 1	Range 2	Command/comment
~ 1257	1469		
12:58:30	1467	1467	REL, ok
12:59:00	1432	1419.	
13:00:00	1315	1302	
13:01:00	1202	1192	

RAPID-AMOC MOORING LOGSHEET **RECOVERY**

Mooring **WB2** Cruise **DY186**

NB: all times recorded in GMT

Date 12/Dec/2024 **Site arrival time** 14:00

Time of first ranging 14:12

ITEM	SER NO	COMMENT	TIME
Recovery line	n/a	Missing	15:41
1 x 17" glass	n/a		15:48
Flooded MicroCAT (50m)	6827 ✓	Mild Growth // Bent Guard	15:48
30" Syntactic Float (100m)	n/a	"	15:54
with Light	A08-087 ✓		"
Iridium Beacon	E03-034 ✓	Beacon ID = 300234063269820	"
Nortek (102m)	5885 ✓	MG	15:55
SBE (108m)	6817 ✓	// Wire Parted	15:57
51" Syntactic Float (174m)	n/a	Second Recovery grappled 16:40	~~16:23~~ 16:5
With Light	G06-059		
Iridium Beacon	C02-039	Beacon ID = 300234061660230	
Nortek (176m)	6765 ✓	MG	16:50
MicroCAT (182m)	6118 ✓		16:55
MicroCAT (252m)	6137 ✓		16:58
MicroCAT (327m)	6798 ✓		17:01
ERROR→ ~~MicroCAT (323m)~~	~~4466~~		~~17:01~~
2 x 17" glass (398m)	n/a		17:04
Nortek (400m)	5963 ✓		17:04
MicroCAT (501m)	5784 ✓		17:09
MicroCAT (701m)	5484 ✓		17:14
2 x 17" glass (792m)	n/a		17:17
Nortek (794m)	6050 ✓		17:17
MicroCAT (800m)	6119 ✓		17:18
MicroCAT (900m)	4307 ✓		17:24
MicroCAT (1100m)	5777 ✓		17:28
10 x 17" glass (1192m)	n/a		17:32
Nortek (1200m)	8483 ✓		17:32
MicroCAT (1301m)	5485 ✓		17:51
Nortek (1498m)	8489 P492		17:56
MicroCAT (1503m)	6805 ✓		17:56
5 x 17" glass (1695m)	n/a		18:04
MicroCAT (1699m)	5247 ✓		18:04
MicroCAT (1899m)	5238 ✓		18:14
Nortek (2050m)	13588 ✓		18:17
5 x 17" glass (2298m)	n/a		18:25
MicroCAT (2302m)	5240 ✓		18:25
MicroCAT (2803m)	4549 ✓		18:54

RAPID-AMOC MOORING LOGSHEET **RECOVERY**

Mooring **WB1L1** Cruise **DY186**

NB: all times recorded in GMT

Date 16/12/24 **Site arrival time** 0740

Time of first ranging 0743

ITEM	SER NO	COMMENT	TIME
Recovery line	n/a	grapple	1324
Billings float:	n/a		1329
With Iridium beacon	G06-033	Beacon ID =	"
And light	G06-063		"
4 x 17" glass	n/a		1329
4 x 17" glass	n/a		1341
4 x 17" glass	n/a		1348
Stainless steel lander			1355
BPR	419 ✓		"
BPR	0004 ✓		"
Acoustic Release #1	2222		"
Acoustic Release #2	319		"

Ascent Rate 30m/min

Ranging

Time	Range 1	Range 2	Command/comment
	1452		
~~12:45:58~~			
12:45:33	1451	1452	REL
			REL OK
12:46.10	1420	1411	
12:47:10	1339	—	
12:48:10	1262		

RAPID-AMOC MOORING LOGSHEET **RECOVERY**

Mooring **WB2L14** Cruise **DY186**

NB: all times recorded in GMT

Date Dec 12 2024 **Site arrival time** overnight.

Time of first ranging 12:32.

ITEM	SER NO	COMMENT	TIME
Recovery line	n/a	graded	13:40
31" Syntactic Buoy	n/a		13:44
With Argos	Y01-012 ✓	Beacon ID = 46494/3FA28E1	
36" Syntactic Buoy	n/a		13:52
With light	A08-078		
Iridium Beacon	C02-052 ✓	Beacon ID = 300234061662220	
SBE53	0081 ✓	Recovery Rope wrapped around BPR	14:07
SBE53	0060 ✓		
Acoustic Release #1	821		
Acoustic Release #2	248		

Ascent Rate 74 m/min

Ranging

Time	Range 1	Range 2	Command/comment
12:32:30	2889	3889	range
12:33:30	3889	2889	release ok.
12:34:30	3889	3889	not moved!
12:35:30	~~3883~~ 3835	3825	
12:36:30	3760	3751	
12:37:30	3686	3677	74 m/min

RAPID-AMOC MOORING LOGSHEET **RECOVERY**

Mooring **WBADCP second deployment** Cruise **DY186**

NB: all times recorded in GMT

Date 16/12/2024 **Site arrival time** 1616

Time of first ranging 1617

ITEM	SER NO	COMMENT	TIME
Recovery line (wrapped round)	n/a		~~1634~~
44" syntactic float	3974/3	hooked 1634	1636
With ADCP			"
And light	W03-097		"
And Iridium beacon	C03-035		"
MicroCAT	6808 ✓		1636
Acoustic Release #1	2226		1639
Acoustic Release #2	320		

Ascent Rate 75 m/min approach

Ranging

Time	Range 1	Range 2	Command/comment
161723	799		
161823	797	797	REL, OK
161853	766	754	
161955	681	677	
162055	685	622	

RAPID-AMOC MOORING LOGSHEET RECOVERY

Mooring **WBAL9** Cruise **DY186**

NB: all times recorded in GMT

Date 16/12/24 **Site arrival time** 1433

Time of first ranging 1434

sighted 1449

ITEM	SER NO	COMMENT	TIME
mini-trimsyn	n/a	grapple	1459
Recovery line	n/a		"
Billings 3 sphere	n/a		~~1505~~
With XEOS beacon ✓	0057	Beacon ID = 300434061882180	1545
And light ✓	S01-182		
4 x 17" glass	n/a		1505
4 x 17" glass	n/a		1518
4 x 17" glass	n/a		1518
SBE26/53	0393 ✓		1526
SBE26/53	0053 ✓		"
Acoustic Release #1	1535		"
Acoustic Release #2	262		"

came off at surface on grapple

landers → low power no data

Ascent Rate 30 m/min towards,

Ranging

Time	Range 1	Range 2	Command/comment
1434	912		
143510	911	911	REL, OK
143610	883	877	
143710	849	845	
143845	790	788	

910 / 600 ~ / ←800

Appendix C: Log Sheets of Deployed Moorings

RAPID-AMOC MOORING LOGSHEET — DEPLOYMENT

Mooring **WB1** — Cruise **DY186**

NB: all times recorded in GMT

Date 17/Dec/2024 — **Site arrival time** 16:00
Setup distance 2.5 N miles
Start time 1654 — **End time**
Start Position
Latitude 26° 29.939'N — **Longitude** 76° 51.698'W

ITEM	SER NO	COMMENT	TIME
Recovery line + float	n/a		
~~3 x Mini Trimsyns~~ glass	n/a		
MicroCAT-ODO (49m)	12901 ✓		17 02
MicroCAT (50m)	3900 ✓		〃
30" syntactic float (95m)	n/a		17:17
with Light	W03-097		〃
and Beacon	E03-035	Beacon ID =	〃
Nortek (97m)	8502 ✓		〃
MicroCAT (~~103m~~ 99m)	3933 ✓		〃
MicroCAT (173m)	4306 ✓		17:22
45" syntactic float (241m)	n/a ✓		17:35
with Light	N08-082		〃
and Beacon	C02-051	Beacon ID =	〃
MicroCAT (248m)	3231 ✓		〃
MicroCAT-ODO (249m)	12966 ✓		〃
MicroCAT (322m)	6803 ✓		17:43
2 x 17" glass			17:51
Nortek(400m)	9427 ✓		〃
MicroCAT-ODO (406m)	12902 ✓		17:52
MicroCAT (407m)	~~5485~~ 3940 ✓		〃
MicroCAT (499m)	5785 ✓		17:57
MicroCAT-ODO (599m)	12998 ✓		18:01
MicroCAT (699m)	6128 ✓		18:02
7 x 17" glass			18:15
Nortek (797m)	9435 ✓		18:16
MicroCAT-ODO (802m)	14116 ✓		18:18
MicroCAT (897m)	6137 ✓		18:24
MicroCAT-ODO (998m)	14145 ✓		18:28
3 x 17" glass	n/a		18:36
Nortek (1201m)	11024 ✓		18:39
MicroCAT (1207m)	5772 ✓		〃
MicroCAT (1347m)	6825 ✓		18:46
Nortek (1353m)	13482 ✓		18:52

6 x 17" glass	n/a		18:52
Acoustic Release #1	930		18:57
Acoustic Release #2	921		18:57
Anchor	n/a		19:47:00

Release #1 arm code
Release #1 release code
Release #2 arm code
Release #2 release code
Iridium beacon #1 ID
Iridium beacon #2 ID

[redacted]

Anchor Drop Position
Latitude 26° 29.84'N **Longitude** 76° 43.77'W

Uncorrected water depth 1384 (at anchor launch)
Corrected water depth ______ (at anchor launch)

[redacted]

Time (UTC)	Range
043750	2171, 2166
043816	2150, 2146
045835	1908, 1908
045903	1902, 1901
051359	, 1601
051430	1604, 1611
051450	1613, 1615

RAPID-AMOC MOORING LOGSHEET — DEPLOYMENT

Mooring **WB2** — Cruise **DY186**

NB: all times recorded in GMT

Date 13/12/2024 — **Site arrival time** 1200

Setup distance 6nm

Start time 1500 — **End time**

Start Position

Latitude 26° 25.374' N **Longitude** 076° 48.038' W

ITEM	SER NO	COMMENT	TIME
Recovery line	n/a ✓		
30" syntactic float (47m)	n/a		1506
with Light	G07-055		"
and Beacon	Y01-016	IMEI =	"
MicroCAT (47m)	3239 ✓		1506
Nortek(98m)	11846 ✓		1516
MicroCAT (99m)	7469 ✓		1516
Nortek (173m)	11855 ✓		1523
MicroCAT (174m)	5989 ✓		1523
MicroCAT (249m)	4062 ✓		1528
49" syntactic float (316m)	n/a		1558
with Light	W03-093		"
and Beacon	C02-038	IMEI =	"
MicroCAT (322m) 317m	4066 ✓		1558
5 x rugby floats (395m)	n/a		1652
Nortek (400m)	12701 ✓		1652
MicroCAT (496m)	4178 ✓		1658
MicroCAT (697m)	5992 ✓		1710
6 x rugby floats (790m)	n/a		1804
Nortek (796m)	12722 ✓		"
MicroCAT (798m)	4466 ✓	5m deeper due to deployment difficulties	1809
MicroCAT (897m)	4725 ✓		18:15
MicroCAT (1096m)	4464 ✓		1826
6 x rugby floats (1191m)	n/a		1854
Nortek (1199m)	~~8465~~	5885 ✓ deeper, as above	1902
MicroCAT (1299m)	4184 ✓	Minor impact with deck	1912
49" syntactic float (1492m)	n/a		1951
with Light W08-057	[illegible]		
and Beacon	C02-039	IMEI=	
Nortek(1504m)	13650 ✓	right below float	"
MicroCAT (1509m)	4468 ✓	right below Nortek	"
2 x rugby floats (1699m)	n/a		2021
MicroCAT (1701m)	7362 ✓		2021
MicroCAT (1899m)	4710 ✓		2030
Nortek (2049m)	14736 ✓		2035

6 x rugby floats (2293m)	n/a		2103
MicroCAT (2299m)	4719 ✓		2107
MicroCAT (2799m)	4795 ✓		2121
2 x rugby floats (2997m)	n/a		2138
Nortek (2999m)	14766 ✓		2188
4 x rugby floats (3296m)	n/a		2202
MicroCAT (3300m)	5991 ✓		2202
MicroCAT (3809m)	5982 ✓		2224
Nortek (3810m)	14787 ✓		2224
MicroCAT (3850m)	7361 ✓		2227
10 x 17" glass	n/a		2237
Acoustic Release #1	2077 ✓	Record codes below	
Acoustic Release #2	2073 ✓	Record codes below	
Anchor	n/a		00:49

Towing from ~2300

WBL2: Light 001-049, Ogos 303-033, HEX ID: 12 9576

Release #1 arm code
Release #1 release code
Release #2 arm code
Release #2 release code
Iridium beacon #1 ID
Iridium beacon #2 ID

[redacted]

Anchor Drop Position
Latitude 26° 31.13 **Longitude** 76° 49.23

Uncorrected water depth 3890 (at anchor launch)
Corrected water depth ____________ (at anchor launch)

12/14

Time (UTC)	Range
01:36:21	4221.9, 4221.4
01:37:23	4220.7, 4221.
01:38:23	4221.8
15:00:50	3976, 3977
15:01:40	—, —
15:02:29	—, —
15:03:45	3974, —
15:04:30	3973, 3973
17:03:00	3892, 3893
17:03:50	~~32029, 12012~~
17:04:48	1977, ~~489~~
17:06:20	3892, ~~287~~
17:12:05	3894, 3895
17:31:50	3965, 3966
17:32:22	3968, 3966
17:33:50	3966, 3966
22:00:10	—, 3936
22:00:50	3935, 3935
22:01:20	3933, ~~34~~ —

RAPID-AMOC MOORING LOGSHEET **DEPLOYMENT**

Mooring **WB1L2** Cruise **DY186**

NB: all times recorded in GMT

Date 17 Dec 2024 **Site arrival time** 2015

Setup distance on Target

Start time 2020 **End time** 2027

Start Position

Latitude 26° 30.40' N **Longitude** 76° 49.88 W

ITEM	SER NO	COMMENT	TIME
Recovery line	n/a		2021
31" syntactic buoy	518250-002		2022
36" syntactic buoy	518251-003		2025
With light	606-063		"
Iridium Beacon	G06-033	IMEI =	"
Stainless lander	n/a		2027
With SBE53	0014 ✓	hit stern on deployment (one of	"
With SBE53	448 ✓	the BPRs)	"
Acoustic Release #1	1536		"
Acoustic Release #2	072		"

Release #1 arm code
Release #1 release code
Release #2 arm code
Release #2 release code
Iridium beacon #1 ID
[redacted]

Anchor Drop Position

Latitude 26° 30.39' N **Longitude** 76° 48.82' W

Uncorrected water depth 1362 (at anchor launch)

Corrected water depth ______ (at anchor launch)

12118

Time (UTC)	Range
043911	1571
043945	1579, 1583
044010	1597, 1600
045717	2285, 2293
045750	2314, 2314
051530	1957
051606	1967, 1968
051632	1971, 1971

RAPID-AMOC MOORING LOGSHEET **DEPLOYMENT**

Mooring **WB2L16** Cruise **DY186**

NB: all times recorded in GMT

Date 19/12/2024 **Site arrival time** 0118
Setup distance on Location
Start time 0118 **End time** 0120
Start Position
Latitude 26° 30.219 N **Longitude** 76° 44.620 W

ITEM	SER NO	COMMENT	TIME
Recovery line	n/a		
Lander	~~n/a~~ 5 18227-002		0120
With light	D01-049		
Argos ~~Iridium~~ Beacon	B03-083	~~IMEI~~ = HEX ID = 129576	
With SBE53	0029		
With SBE53	434		
Acoustic Release #1	251		
Acoustic Release #2	2076		

Release #1 arm code
Release #1 release code
Release #2 arm code
Release #2 release code
Iridium beacon #1 ID
Iridium beacon #2 ID

[redacted]

Anchor Drop Position
Latitude 26° 30.219 N **Longitude** 76° 44.621 W

Uncorrected water depth 3849 (at anchor launch)
Corrected water depth ______ (at anchor launch)

Time (UTC)	Range
15:05:50	3981, 2535
15:07:30	3474, 3980
15:08:10	3981, 3976
17:14:10	4140, 4142
17:15:10	4140, 4141
17:20:40	— 4241
17:21:30	— 4029
17:22:10	~~2892, 716~~
17:23:00	— 4177
17:24:15	3985, 3986
17:29:50	3986, 3985
~~22:02:51~~	
22:03:12	4352, 4353
22:04:00	4358, —
22:04:35	4357, 4357

RAPID-AMOC MOORING LOGSHEET **DEPLOYMENT**

Mooring **WBADCP (third deployment)** Cruise **DY186**

NB: all times recorded in GMT

Date 16/12/24 **Site arrival time** ~1820
Setup distance 0
Start time 1922 **End time** 1938
Start Position
Latitude 26° 31.794' N **Longitude** 76° 52.038' W

ITEM	SER NO	COMMENT	TIME
Recovery line	n/a		1929
44" syntactic float	23642 ✓	J14226-002	1931
With light G06-059	E08-034		"
Iridium Beacon	E03-034	IMEI =	"
With ADCP	23642		"
With MicroCAT (595m)	3277 ✓		"
Acoustic Release #1	365		1936
Acoustic Release #2	2228		1936
Anchor	n/a		1938

Release #1 arm code
Release #1 release code
Release #2 arm code
Release #2 release code
Iridium beacon #1 ID
[redacted]

Anchor Drop Position
Latitude 26° 31.802' N **Longitude** 76° 52.027' W

Uncorrected water depth 542 (at anchor launch)
Corrected water depth (at anchor launch)

12/17

Time (UTC)	Range
220106	1531, 1536
220236	1556, 1560
221830	943, 948
221900	960, 961
223403	1439, 1451
223430	1490, 1501

RAPID-AMOC MOORING LOGSHEET **DEPLOYMENT**

Mooring **WBAL11** Cruise **DY186**

NB: all times recorded in GMT

Date 17/Dec/2024 **Site arrival time** 21:00
Setup distance on Target
Start time 2133 **End time**
Start Position
Latitude 26° 32.25'N **Longitude** 76° 51.41'W

ITEM	SER NO	COMMENT	TIME
Recovery line and float	n/a		2133
Billings 3 sphere	n/a		2134
With light	702-023		"
Iridium Beacon	607-054	IMEI =	"
4 x 17" glass	n/a		2135
4 x 17" glass	n/a		2135
4 x 17" glass	n/a		2136
Stainless lander	n/a	hit hull on deployment	2137
With SBE53	0012 ✓		"
With SBE53	447 ✓		"
Acoustic Release #1	321		"
Acoustic Release #2	1350		"

Release #1 arm code
Release #1 release code
Release #2 arm code
Release #2 release code
Iridium beacon #1 ID
[redacted]

Anchor Drop Position
Latitude 26°32.23'N **Longitude** 76°51.28'W

Uncorrected water depth 610 (at anchor launch)
Corrected water depth (at anchor launch)

12/17th

Time (UTC)	Range
220335	1061, 1064
220406	1075, 1076
221642	1562, 1570
221705	1586, 1593
223530	1355, 1360
223555	1374, 1379

National Oceanography Centre, European Way, Southampton, SO14 3ZH
United Kingdom +44 (0)300 131 2321

Joseph Proudman Building 6 Brownlow Street, Liverpool, L3 5DA
United Kingdom +44 (0)151 795 4800

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