Scottish Association for Marine Science

RV *Neil Armstrong* Cruise AR30-04

01 – 29 JUL 2018

Reykjavik - Reykjavik

OSNAP moorings cruise report

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This is a contribution to NERC programs UK OSNAP (NE/K010875/1 and NE/K010700/1), and the Extended Ellett Line under National Capability programme Climate Linked Atlantic Sector Science. SAC is funded in part by the European Union’s Horizon 2020 research and innovation programs: AtlantOS under grant agreement (SEP-210177333); by the Blue-Action project (7278520) and; by the ATLAS project (678760-2).

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1 Summary

The Overturning in the Subpolar North Atlantic Program (OSNAP) is an international program designed to provide a continuous record of the full-water column, trans-basin fluxes of heat, mass and freshwater in the subpolar North Atlantic. It is a collaborative program with scientists from several nations, including the U.S., U.K., the Netherlands, Germany, Canada, France, and China. The OSNAP observing system consists of two legs: one extending from southern Labrador to the southwestern tip of Greenland across the entrance of the Labrador Sea (OSNAP West), and the second from the southeastern tip of Greenland to Scotland (OSNAP East). The observing system also includes subsurface floats in order to trace the pathways of overflow waters in the basin and to assess the connectivity of currents crossing the OSNAP line.

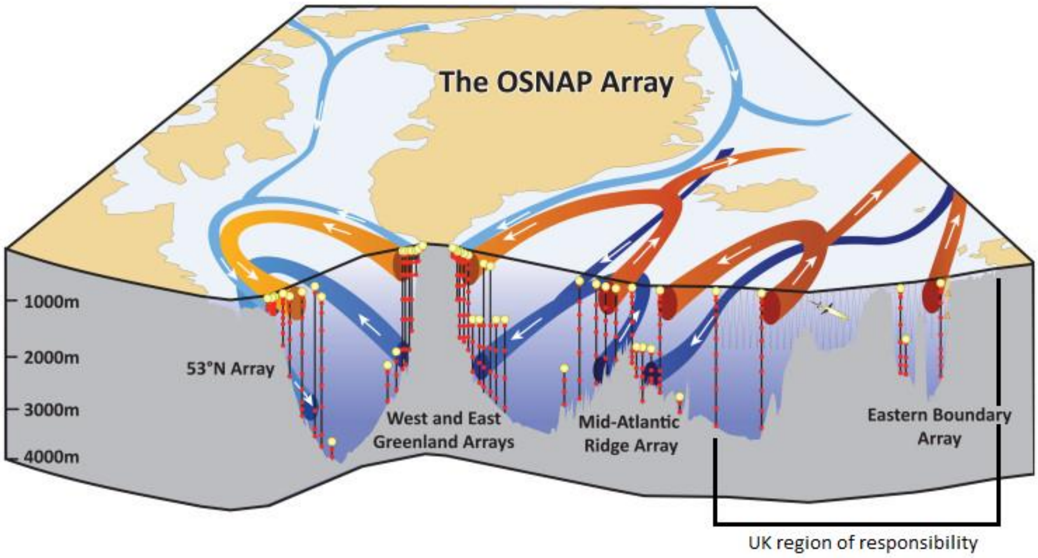


Figure 1. Schematic of the OSNAP moorings and glider occupations. Following a reorganization of international responsibilities for mooring operations the UK moorings and glider operations cover the eastern half of OSNAP East, from the middle of the Iceland Basin to the Scottish continental shelf. The UK also installed an additional mooring at the western edge of the Hatton Bank.

Cruise AR30-04 was the second U.S.-sponsored cruise across the OSNAP East line, following earlier cruises in 2014 (R/V Knorr), 2015 (R/V Pelagia), and 2016 (RRS Discovery). Scientists from the U.S., the U.K., and the Netherlands participated in the cruise.

This cruise noted a major reorganization of mooring responsibilities between countries along OSNAP East. The UK is now responsible for all moorings from the middle of the Iceland Basin to the continental shelf off Scotland, including deployment of an additional mooring in 1000m water depth on the western edge of the Hatton Bank. Prior to this cruise the UK had responsibility of moorings measuring the Deep Western Boundary Current off East Greenland and the US for moorings in the Iceland Basin extending to the Hatton Bank. These changes are part of a strategy for optimization of the array design, and rationalization of the field programme to reduce field programme costs.

2 Introduction

This report describes UK mooring and CTD operations only. US and Dutch activities are reported in Johns (2018)[1].

The UK objectives of cruise AR30-04 were to:

1. Recover and redeploy three moorings in the Rockall Trough; deploy three moorings in the Iceland Basin (two replacing US moorings and one new mooring).

2. Conduct standard CTDO2 (Conductivity-Temperature-Depth-Dissolved Oxygen) and Lowered ADCP (Acoustic Doppler Current Profiler) stations at approximately 80 stations along the same mooring line, with water sampling at selected sites for salinity, dissolved oxygen, dissolved inorganic carbon, nutrients (nitrate, silica, phosphate), and nitrogen and silica isotopes.

3. To deploy Argo floats at two locations along the section.

4. To collect invertebrates colonizing mooring hardware for micro-plastics analysis.

A full cruise synopsis is provided in Johns (2018)[1].

2.1 Scientific crew

Name	Position	Organisation
Bill Johns	Ch. Sci.	RSMAS/U.Miami
Adam Houk	Technician	RSMAS/U.Miami
Mark Graham	Technician	RSMAS/U.Miami
Cedric Guigand	Technician	RSMAS/U.Miami
Greg Koman	Student	RSMAS/U.Miami
Tiago Bilo	Student	RSMAS/U.Miami
Femke de Jong	Scientist	NIOZ
Lorendz Bloom	Technician	NIOZ
Roos Bol	Student	NIOZ
David Wichmann	Student	Utrecht Univ.
Stuart Cunningham	Scientist	SAMS

[1] Johns, W. (2018), RV Neil Armstrong, Cruise AR30-04: Reykjavik, Iceland to Reykjavik, Iceland, 1 July to 30 July 2018, pp. 30, RSMAS, Univ. of Miami, U.S.

Loic Houpert	Scientist	SAMS
Sarah Reed	Technician	SAMS
Jeanne Castille	Technician	SAMS
James Coogan	Student	SAMS
Robert McLachlan	Technician	NOC
Steve Whittle	Technician	NOC
Chris Crowe	Technician	NOC
Dean Cheeseman	Technician	NOC

2.2 Cruise map

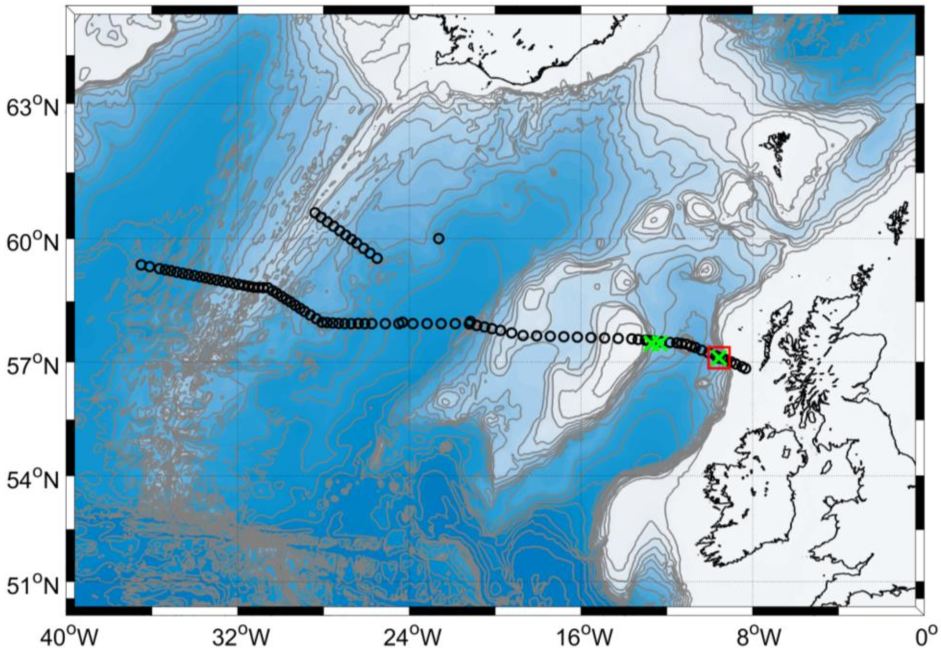


Figure 2. Chart of CTD stations (black circles, Section 14), moorings (green crosses, Sections 3, 4 and 5) and Remote Access Sampler deployment location (red square, Section 4.1).

3 Mooring Operations

Robert McLachan, Chris Crowe

3.1 Taut-Wire Moorings

The moorings were deployed and recovered using a Lebus double-capstan winch system (aka "double-barrel" winch) that was provided by the UNOLS winch pool. This system allows separate wire reels to be loaded on an auxiliary spooler and fed into the main double-barrel winch without having to pre-spool all the wire reels onto a traction winch before deployment, such as is required with commonly used mooring winches such as the TSE winch. This saves considerable time in on-deck preparation for new mooring deployments and was an extremely valuable asset on the cruise.

All of the taut-wire moorings were deployed in traditional fashion by laying out the mooring components from top to bottom while steaming into the wind at approximately 1.0 kt and dropping the anchors at selected "fallback" distances from the target site depending on the length of the moorings and observed ocean currents at the deployment sites. One mooring, a special trawl-resistant bottom lander deployed on the Scottish slope, was lowered to within a few meters of the bottom with the trawl winch and then dropped to the bottom using an acoustic release tethered to the bottom lander by a sling. Moorings were recovered by grapneling onto pickup lines at the tops of the moorings (usually from the starboard side of the vessel but occasionally on the port side depending on the layout of the mooring on the surface), and hauling in and sequentially removing mooring components from the top to the bottom of the moorings. All mooring operations were conducted safely and efficiently by the deck crew and mooring teams. On moorings that had anemones/bivalves or anything living on the sub-surface mooring components, samples were taken for microplastic analysis.

3.2 Trawl Resistant Seabed Lander - RTADCP1

The following details the deployment notes for RTADCP1 (Stuart Cunningham).

Nortek SignatureS55 s/n 200047; Iridium D03-036; Light CO5-005; Releases 2309 & 1757

Release for lowering s/n 1999 ARM 0B16, REL OB55

Release 7/7/18 @ 183545; Lat 57.097269 N ; Lon -9.335169 W [57° 5.836’N ; 9° 20.110’W]

The lander was lowered using the trawl wire over the aft A-frame. A 3-legged bridle was rigged using spare orange recovery line. The bridle was attached to a release whose height was 5m above the base of the lander (this height should be accurately measured on deck).

At the deployment position the EM122 corrected water depth was 750m. From Carter tables 750m corrected equals 747m uncorrected. Ranges to the bridle release were uncorrected ranges. Therefore, the lander would be just touching the seabed when the range is 750-3-5=742m. Therefore, we planned to lower the lander until the range was 741m, which should place the lander 1m height-off seabed.

During the lowering at a winch rate of 10m/min throughout we monitored range to the bridle release and winch wire-out.

We lowered to 700m wire-out, halted then assessed our estimate of lander height-off bottom. We then lowered until the bridle-release range was 741m and stopped the winch. We then released the bridle. Although noisy, back tension on the winch appeared to decrease. The winch then hauled at 10m/min.

We then ranged to the releases in the lander. We achieved consistent ranges of 745m. This is consistent with the height of the bridle release being 5m above the base of the lander.

We examined the winch tension data around the time of release (Figure 7). The package touches down on the seabed just before 18:35:40. At 18:35:45 the package is released from the wire. The low-pass tension data indicate that close to seabed the package and wire weight is around 900 kg. The package lands on seabed and full weight of package is removed from wire and tension drops to about 510 kg.

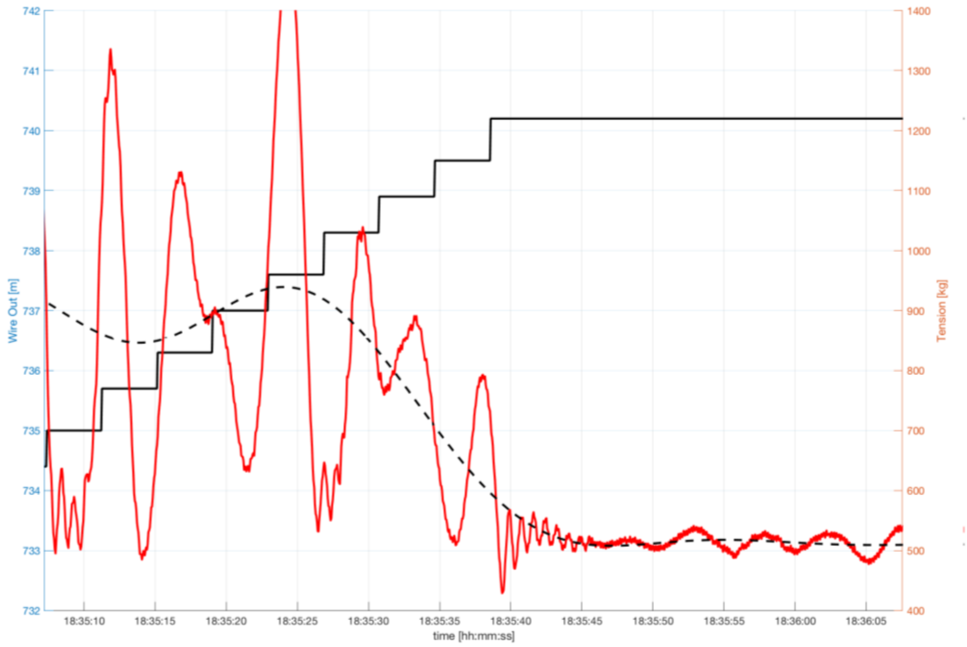


Figure 3. Winch tension [kg] (red) with 10s low-pass filter (black dashed), cable out [m] (black).

4 Mooring Recoveries

Stuart Cunningham, Loic Houpert

Table 1 shows the location and date of mooring recoveries on the cruise. For more information on the mooring recoveries, see recovery log sheets in Section 17.1.

Table 1. UK OSNAP Mooring recoveries. Moorings deployed on cruise DY078 in 2017.

Mooring	Lat (°N)	Lon (°W)	Depth (m)	Date of Recovery
RTWB1	57.46933	12.70566	1601	06/07/2018
RTWB2	57.47166	12.31116	1801	09/07/2018
RTEB1	57.10050	9.563830	1817	07/07/2018

4.1 Remote access sampler

John Beaton, Clare Johnson, Stuart Cunningham, Loic Houpert

A McLane Instruments Remote Access Sampler (s/n 14262) was deployed on RTEB1 on cruise DY078/079 on 13/5/2017, and recovered on AR30-04. Due to time pressures and the risk of sample loss, the decision was made to leave the sample bags on the RAS and return this to SAMS for sample removal. As the RAS multi-port valve ensures that all samples are isolated, the only step needed during the cruise was to stop the RAS and download the metadata file. The procedure for this is detailed below.

Pre-recovery preparation:

(1) Identify the wooden RAS crate and ensure it is accessible. Although the crate can be easily pushed around when empty, it will require an overhead crane once the RAS is in the crate.

(2) check the time and date on your camera and laptop is correct, and set to UTC.

(3) Equipment needed for recovery: RAS spares box, a laptop with the McLane terminal program ‘Motocross’,

Post-recovery steps:

(1) Place the RAS upright, on a pallet if possible, and move to a place where it can safely be worked on.

(2) If additional instruments have been added to the RAS frame (e.g. Deep SeapHOx) remove these. Remove any shackles, rings etc from the top and bottom eyes of the RAS frame.

(3) Photograph the RAS from each side, and take more detailed pictures of the top, bottom and tubing. Additionally, photograph any areas of damage, corrosion, or lose tubing. If any tubing is disconnected make a note of the multi-port valve number from the ring label on the tubing.

(4) Find the small red cap in the RAS toolbox, and cover the sample intake as in Figure 4.a.

(5) Gently wash the entire RAS with a light spray of freshwater. Do not use a power washer or a heavy hose. Wipe algal growth from the stainless steel frame.

(6) Open the ‘motocross’ programme which will launch a blue window (Figure 4.b).

(7) Start a capture file (select ‘transfer’, ‘capture text’, ‘start’). Ensure you know where the capture file is stored.

(8) Use the serial COM cable and USB adaptor from the RAS toolbox (Figure 4.c) to connect between your laptop and the comm connector (marked C, Figure 4.d) on the RAS controller. Motocross should be open while you connect.

(9) Deployment metadata is obtained by displaying it on screen whilst the capture function is active; this is the only way. Start communication with the RAS by pressing Ctrl & C three times. You may need to try this multiple times.

(10) From the main menu choose ‘Offload/Display Data File’, then from the offload menu choose ‘Display ALL data’. The metadata should be displayed as in Figure 5.

(11) Stop the file capture by selecting ‘transfer’, ‘capture text’, ‘stop’. Open the save capture file and check the contents are as expected. The offload procedure can be repeated if necessary as the data file remains in the memory until a new deployment schedule is created or the batteries are disconnected.

(12) From the main menu in motocross, choose ‘<4> Sleep’ to put the RAS into suspend mode. Disconnect the COM cable from the controller and reinstall the dummy plug.

(13) Pack the RAS in the crate. The easiest option is to lift the RAS into the crate from above, although the sides of the crate can be removed if this is not possible. As the foam padding in

the crate has been modified to accept the RAS frame modifications, you may need to rotate the RAS by 90 ° to get it to fit. Remember to screw the lid down to prevent it coming off during unloading by crane.

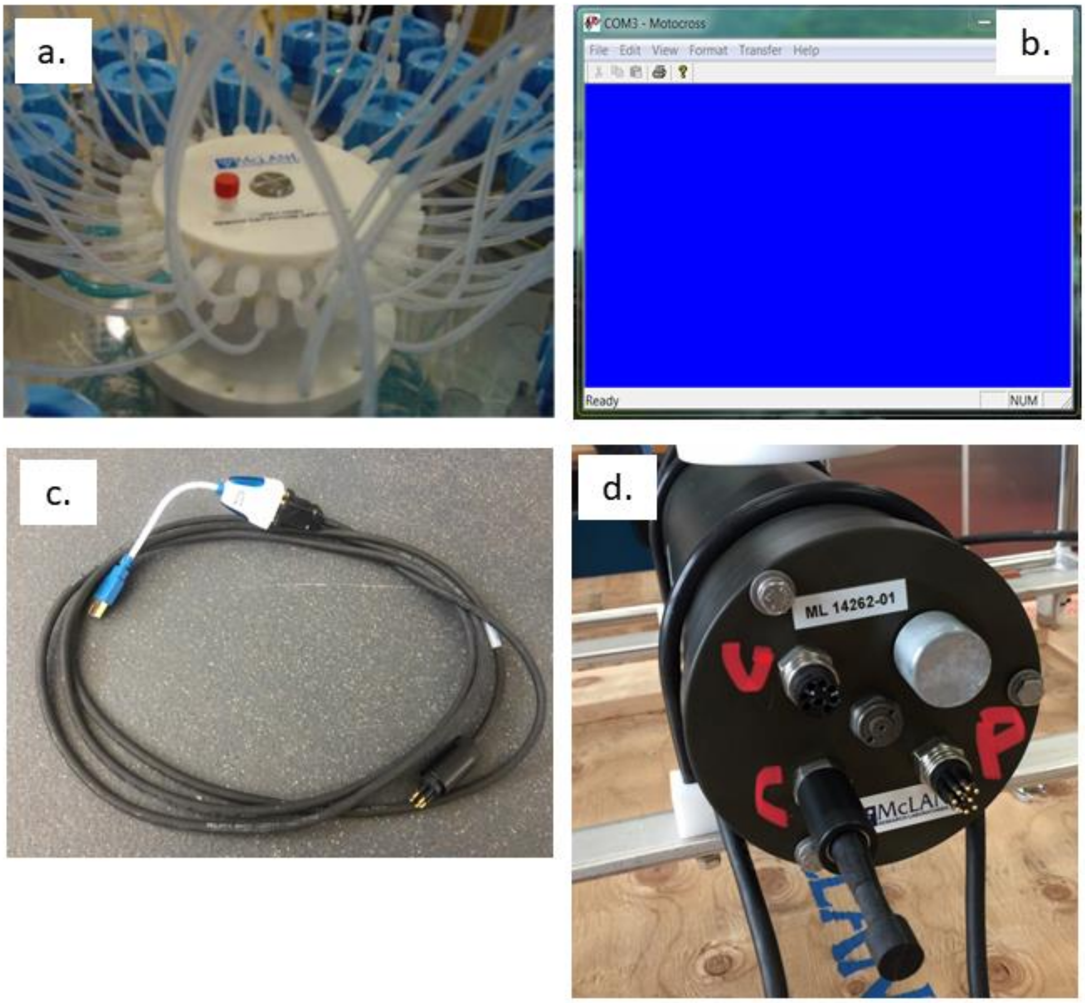


Figure 4. (a) replacement of sample intake cap (red), (b) motocross terminal, (c) RAS COM cable, (d) RAS comms port (C).

a.

```
______________________________________________________________
Configuration: RAS-125M500              CF2 V3_04 of Mar 17 2015
                _________________________________
                          Offload Menu
                _________________________________
                    Thu Mar 19 13:01:44 2015

                         Port=00 (home)

                 <1> Display ALL data
                 <2> Display event summary data
                 <3> Display pump data
                 <4> EEPROM data backup cache

                 <M> Main menu

                 Selection [M] ? 1

 Start the capture file now.
 Then, press any key to start the transfer.  The data
 file will remain in memory and is not erased by this
 offload procedure.

 Software version:  RAS-3_04.c
 Compiled:          Mar 17 2015 12:32:34
 Electronics S/N:   ML13278-05
 Temperature probe:     Internal


 Data recording start time = 03/18/15 10:29:55
 Data recording stop time  = 03/19/15 10:27:13
```

b.

```
     48         75     375     26.9         103.0        106.0
     48         75     394     26.9         103.0        108.0
     48         75     412     26.9         103.0        109.0
     48         75     431     26.9         103.0        108.0
     48         75     450     26.9         103.0        108.0
     48         75     469     26.9         103.0        106.0
     48         75     487     26.9         103.0        106.0

 End of instrument data file.

 Terminate file logging operation now

 Press any key to continue.
```

Figure 5. Screenshot of capture of RAS metadata from (a) the start, and (b) the end of the datafile.

5 Mooring Deployments

Loïc Houpert, Stuart Cunningham

Seven moorings were deployed, times and positions are indicated in Table 2. The mooring schematics as deployed are in Section 17.2.

5.1 Mooring Deployment locations and Iridium Beacon IMEI Codes

Table 2. Mooring deployments, times, depths, anchor seabed positions determined by trilateration.

Moor	Date	Start Deploy	Anchor Away	Anchor Seabed position and water depth							Fall-back
Name	**dd/mm/yy**	**hh:mm**	**hh:mm:ss**	**Lat (°N)**	**Lon (°W)**	**Lat (°N)**	**Lat (')**	**Lon (°W)**	**Lon (')**	**wd (m)**	**m**
IB3	03/07/18	14:14	16:28:00	57.99010	24.35340	57	59.41	24	21.20	2854	318
IB4	04/07/18	12:35	15:11:55	57.98990	21.14610	57	59.39	21	08.77	2920	152
IB5	05/07/18	08:48	10:23:20	57.80100	19.17070	57	48.06	19	10.24	951	93
RTWB1	06/07/18	12:44	15:04:50	57.47009	12.70431	57	28.21	12	42.25	1597	190
RTWB2	09/07/18	17:20	18:37:35	57.46928	12.31356	57	28.16	12	18.81	1801	9
RTEB1	08/07/18	10:03	12:42:08	57.09969	9.56322	57	05.98	9	33.79	1804	280
RTADCP1	07/07/18	17:15	18:35:45	57.09727	9.33517	57	05.84	9	20.11	750	n/a

Table 3. Nominal mooring target positions.

Moor	Nominal Target position						Nominal water depth
Name	**Lat (°N)**	**Lon (°W)**	**Lat (°N)**	**Lat (')**	**Lon (°W)**	**Lon (')**	**m**
IB3	58.01333	24.42283	58	00.80	24	25.37	2850
IB4	57.99233	21.14083	57	59.54	21	08.45	2920
IB5	57.76700	19.17267	57	46.02	19	10.36	900
RTWB1	57.47000	12.70417	57	28.20	12	42.25	1600
RTWB2	57.47000	12.31000	57	28.20	12	18.60	1800
RTEB1	57.10000	9.56300	57	06.00	9	33.78	1810
RTADCP1	57.10000	9.33833	57	06.00	9	20.3	750

Table 4. Iridium Beacons IMEI codes. See Figure 6 & Figure 7 for positions within each mooring.

Mooring	Beacon 1		Beacon 2	
Name	depth (m)	IMEI	depth (m)	IMEI
IB3	92	300234060476980		none
IB4	92	300234060572000		none
IB5	70	300234060475990		none
RTWB1	240	300234060571000	490	300234060475730
RTWB2	996	300234060479980		none
RTEB1	48	300234060474980	488	300234060573000
RTADCP1	750	300434060123920		none

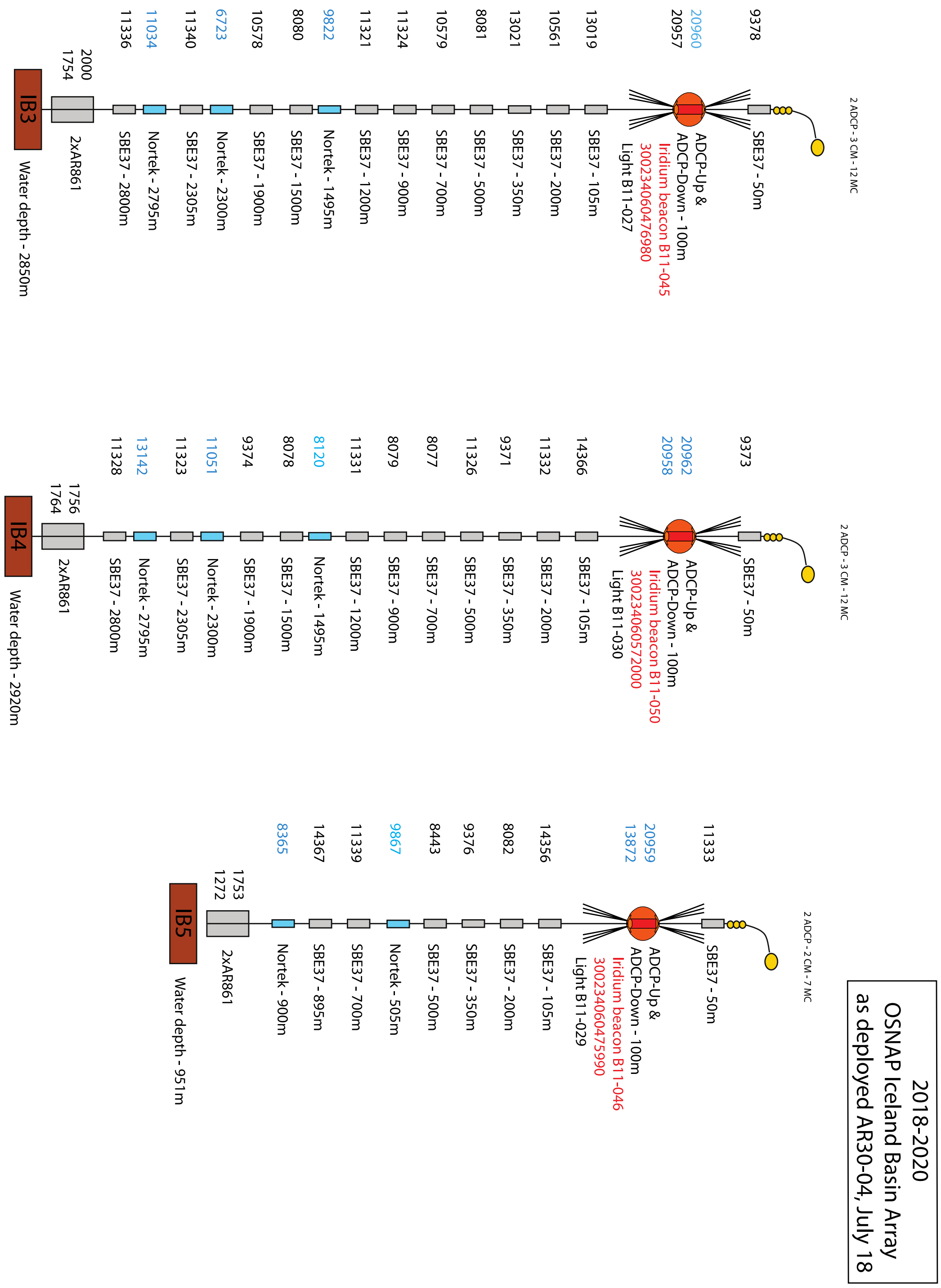


Figure 6. Iceland Basin mooring schematic and instrument allocations.

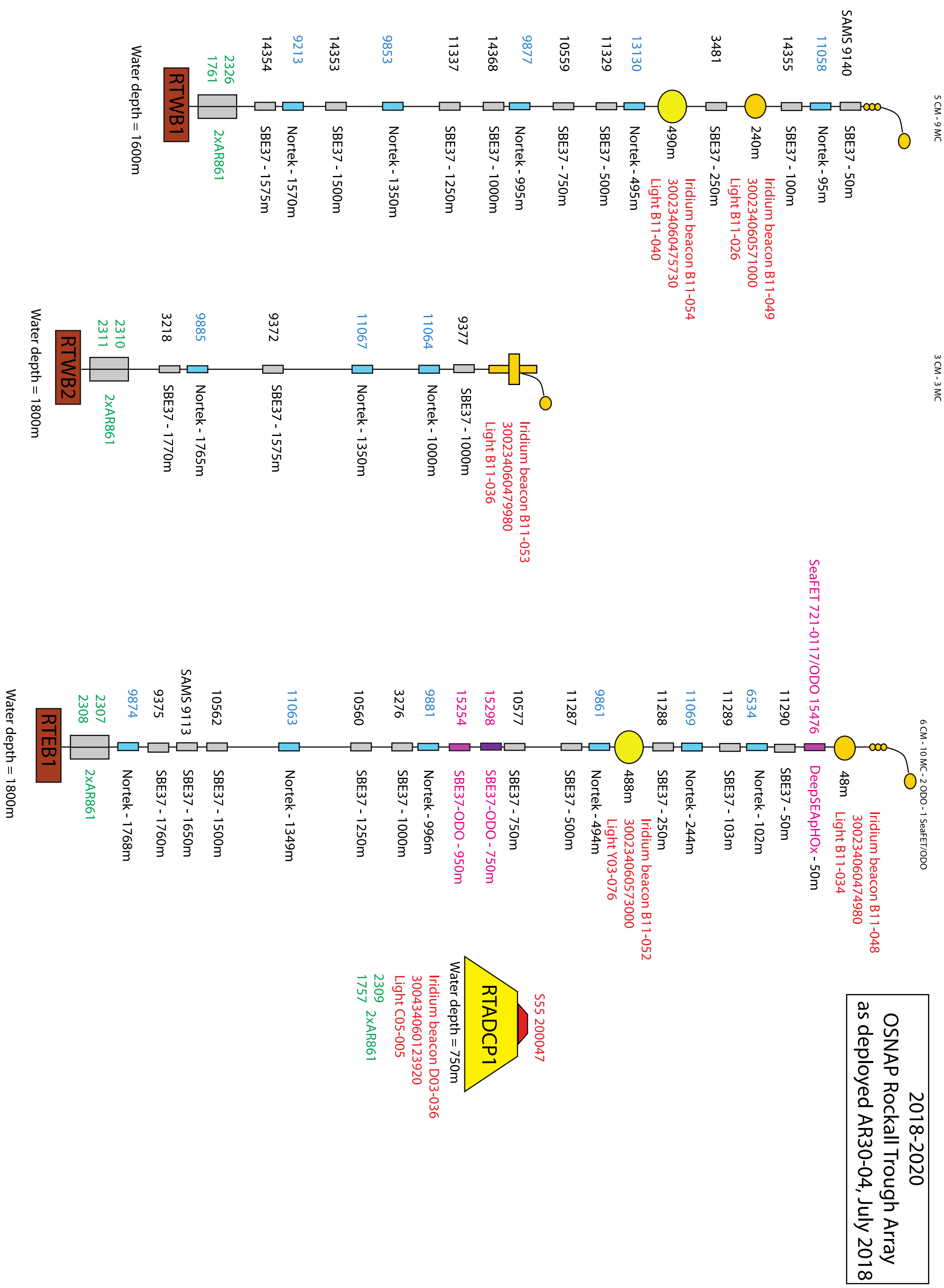


Figure 7. Rockall Trough mooring schematic and instrument allocations.

6 Instrument set-up Summaries

Note: For examples of setup files, see Section 17.4.

6.1 Summary of the instruments recovered and deployed

Note: for complete list of microcats see "Table 9": Table of SeaBird SMP37 and SMP37-ODO.

Table 5. List of Nortek current meters by serial number showing instruments recovered from moorings or brought from stores(B), instruments deployed on this cruise or returned ashore (R) and instrument owner.

s/n	Recovered	Deployed	Owner
6534	B	RTEB1	NMEP
6723	B	IB3	NMEP
8120	B	IB4	NMEP
8364	M2	R	NMEP
8365	B	IB5	NMEP
9213	B	RTWB1	NMEP
9822	B	IB3	NMEP
9853	M1	RTWB1	NMEP
9854	RTWB1	R	NMEP
9859	RTWB1	R	NMEP
9861	B	RTEB1	NMEP
9867	B	IB5	NMEP
9874	M5	RTEB1	NMEP
9877	B	RTWB1	NMEP
9881	B	RTEB1	NMEP
9885	M3	RTWB2	NMEP
11021	RTWB1	R	OSNAP
11023	RTWB2	R	OSNAP
11026	RTWB1	R	OSNAP
11028	RTWB2	R	OSNAP
11029	RTWB1	R	OSNAP
11030	RTWB2	R	OSNAP
11032	B	u/s	OSNAP
11034	M1	IB3	OSNAP
11035	B	u/s	OSNAP
11042	B	R	OSNAP
11046	B	R	OSNAP
11047	B	R	OSNAP
11048	B	R	OSNAP
11051	B	IB4	OSNAP

11055	B	R	OSNAP
11058	M4	RTWB1	OSNAP
11063	M1	RTEB1	OSNAP
11064	M1	RTWB2	OSNAP
11067	M1	RTWB2	OSNAP
11069	B	RTEB1	OSNAP
11069	B	R	OSNAP
13018	B	R	OSNAP
13130	B	RTWB1	OSNAP
13142	B	IB4	OSNAP

Table 6. RDI WH 300 kHz ADCPs serial number showing instruments recovered from moorings or brought from stores(B), instruments deployed on this cruise or returned ashore (R) and instrument owner.

s/n	Recovered	Deployed	Note
20962	M1	IB4	OSNAP
20957	M2	IB3	OSNAP
20961	M3	R (corroded)	OSNAP
20959	M4	IB5	OSNAP
20960	M5	IB3	OSNAP
20958	B	IB4	NMEP

6.2 OSNAP Instrumentation for Moorings EB1, WB1, WB2, IB3, IB4 and IB5

SBE37 MicroCATs and Nortek Aquadops were deployed on all six moorings. WorkHorse 300kHz ADCPs were deployed on IB3, IB4, IB5.

The microcats were cal-dipped and fitted with new batteries prior deployment. Their clocks were synchronized with GPS time, and the instruments set to sample every 1800s.

Norteks were synchronised with GPS time and new alkaline batteries (100 Wh). They were set to sample every 3600s, with an averaging period of 60s. With these settings, the battery utilisation for a deployment of 730 days was estimated to be 79%.

ADCP were set-up to ping 42 times per hour. The number of depth cells was set to 30 and the depth cell size to 4m. The battery usage for a two year deployment was estimated to be about 80%

Full setup parameters are available in Section 17.4.

6.3 Biogeochemical sensors on EB1

EB1 is equipped with three SBE37-ODO MicroCATs (SBE37 fitted with an SBE63 Optical Dissolved Oxygen sensor), Figure 6. Unfortunately, one of the SBE-ODO deployed in 2017 (s/n 14987) stopped working properly on June 9th. The oxygen sensor also returned bad oxygen data (< 300 µmol/kg) during the caldip cast and therefore was not redeployed in 2018. During the caldip cast, the timeseries of (bad) oxygen data appeared to be correlated to the pressure (the bad values were decreasing during downcast, increasing during the upcast, and stable during the bottle stop).

The adaptive pump control option (the MicroCAT calculates the pump time before each sample for best oxygen accuracy) was activated for both SBE37-ODOs redeployed in 2018. As the pumping time is significantly higher than on a standard MicroCAT, the energy usage had to be carefully estimated before setting the sampling intervals. According to the expected depth of deployment and the minimum temperature encountered by the instrument at that depth, a sampling interval of 3600s was set-up for the SBE37-ODO 15298 (deployed at 750m) and 4500s was set-up for the SBE37-ODO 15254 (deployed at 950m). Using these settings, the number of endurance days are estimated to be respectively 858 and 973 days.

The DeepSeapHOx comprises a SBE37-ODO, and a SeaFEt pH sensor. The two instruments are connected together, with the SeaFEt controlling the sampling and data merging. After recovery of EB1, the SBE37-ODO and the SeaFEt were fitted with new batteries. The DeepSeapHox was set-up in order to obtain the longest endurance possible (estimated to be 515 days): sample interval of 3600s, burst frame of 1 and sample average of 30s.

6.4 Signature S55 on RTADCP1

6.4.1 Pre-deployment Checks

Pre-deployment checks followed those outlined in the Signature55 Operations Manual Chapter 4. The instrument was loaded with test parameters from file RTADCP1_DY078_test.deploy. This file is derived from RTADCP1_DY078.deploy but sampling was set to an average of 6s with a measurement interval of 6s. The software was set to Online Data Collection displaying data to the PC. The blue LED on the instrument flashes every 2s corresponding to a single ping.

6.4.1.1 Temperature

14.12°C noted and appropriate for the location of the instrument in the aft hanger.

6.4.1.2 Pressure

We tested the pressure sensor by forming a mouth seal around the sensor and blowing to observe an increase in pressure. Pressure increases by a few tenths of a dbar. The pressure sensor outputs the absolute pressure value in units of dbar. During production, the sensor is adjusted to 9.5 dbar to output the gauge pressure (pressure relative to the atmospheric pressure). The pressure sensor cannot output negative values. The outcome is that when the instrument is in air, you will see a value of 0.2-0.7 dbar, depending on atmospheric conditions. The sensor reported values of 1.5 dbar so an offset was applied of 10.5 dbar, bringing the air values to a range of 0.1 to 0.5. The air-pressure readings were noisy varying by ±0.2-0.3 dbar, so fine adjustment did not seem possible.

6.4.1.3 Orientation (Heading, pitch and roll)

Full orientation checks were conducted according to Figure 8 and instructions in the Operations Manual:

1. Find the X mark located on the instrument and identify which direction it is pointing.

2. Hold the instrument as level as possible while aiming the X direction away from you. The values for "Pitch" and "Roll" should now be close to zero.
3. Tilt the instrument 10º to the right. The "Roll" value should read approximately 10.
4. Tilt the instrument 10º to the left. The "Roll" value should read approximately -10.
5. Tilt the instrument 10º forwards. The "Pitch" value should read approximately -10.
6. Tilt the instrument 10º backwards. The "Pitch" value should read approximately 10.
7. Now turn the instrument upside-down, still aiming the X direction away from you. Repeat steps 2 -6 and ensure you have the same values.
8. **Compass:** Point the X direction towards North. Rotate the instrument around the Z-axis and check the values at 0, 90, 180, 270 degrees corresponding to North, East, South and West respectively.

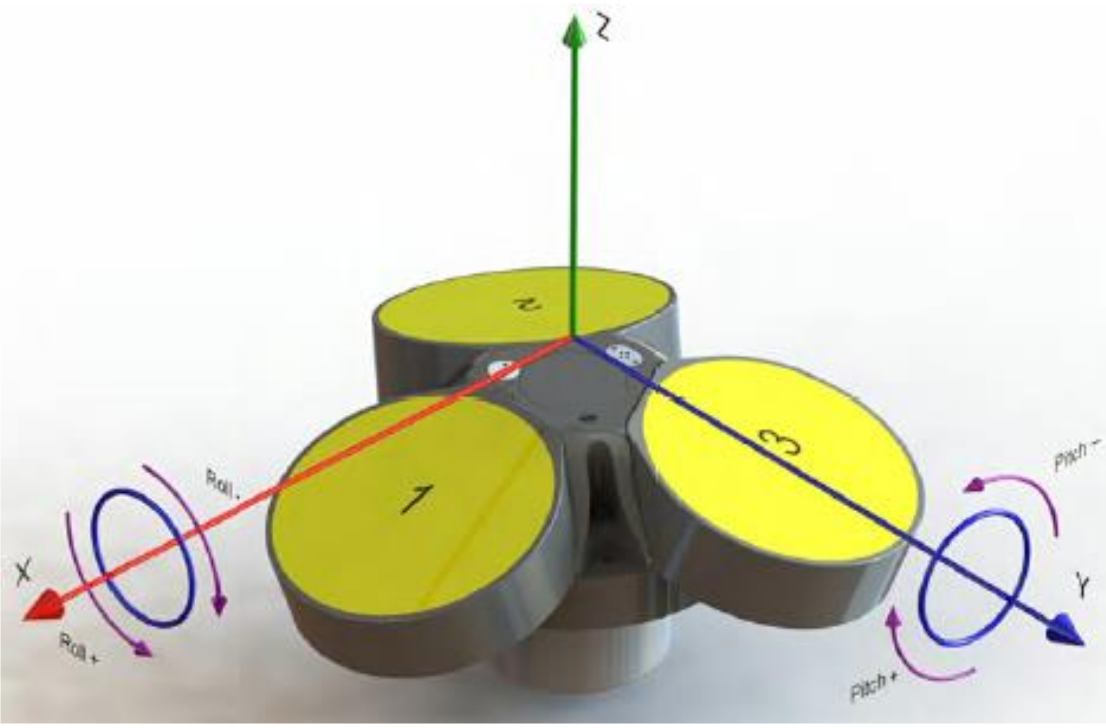


Figure 8: Definitions of beam number, pitch and roll. The X-mark and direction are distinctively engraved on the central boss of the transducer head.

6.4.1.4 Beam Amplitude

The manual recommends beam amplitude tests in water: this was not done. Starting with beam one in the x-direction and proceeding clockwise to beams two and three we tested beam amplitude by a vigorous rub and mild slapping on the head. A strong response in beam amplitude was noted for each beam.

6.4.1.5 Recorder/Memory

Three test files were written to memory, downloaded and translated. The memory was erased prior to deployment (Erase Recorder).

6.4.2 Compass Calibration

This was not performed as being impractical to arrange within the lander surrounded by a steel ship. The current being measured is strongly bathymetrically controlled, with along slope current speed variability 2.5 times larger than across slope. For scientific purposes the currents will be rotated to minimise the across slope flow so errors in the true current direction may be less important in this application.

It may be valuable to try and arrange compass calibrations ashore with the lander fully rigged.

6.4.3 Deployment Set-Up

The instrument was programmed according to Table 7. The estimated time for recovery is from July 2018 to September 2019 (~430 days). Planning for a 702 day deployment. First the Set-up PC clock was synchronized to network time server and the S55 synchronised to the PC clock. Instrument confirmed sampling via blue LED which is set to be on for 24 hours after start time. Release 7/7/18 @ 183600; Lat 57.097269 N ; Lon -9.335169 W [57° 5.836'N ; 9° 20.110'W].

Table 7. Summary data for RTADC1 Nortek S55. These data are typed from a screenshot after AD2CP_55kHz_osnap_S55_dep_2018.deploy was loaded into the instrument and delayed start set.

Performance	
Configured length (days)	702
Estimated max length (days)	703.9
Battery capacity (Wh)	3600
Power usage (Wh)	3590.4
Recorder capacity (MB)	15258.4
Memory usage (MB)	356.6
System Information	
Instrument name	Signature55
Nickname	Virtual Instrument
Serial number	900001
Head frequency (kHz)	55
Opt sensors	None
Firmware version	1.4.4010.2205_0
Recorder size (GB)	16 GB
Connection	Virtual Instrument
Orientation	Auto Z up/down
Application	
Type	Single
Plan	Average – Coarse profile
Deployment length (days)	702
Environment	
Geography	Open ocean
Sound velocity (m/s)	Measured
Mounting	Fixed frame
Orientation	Up-looking
Instrument depth (m)	1000
Salinity (ppt)	35
Tidal range (m)	1
Coarse profile	
Start of profile (m)	2
End of profile (m)	1000
Cell size (m)	20
Power level (dB)	-2
Measurement load (%)	100
Average interval	00:01:24
Measurement interval	00:30:00
Coordinate system	ENU

Serial telemetry	OFF
Telemetry format	DF100_NMEA
Data Sampling	
Power level (dB)	-2
Long range mode	ON
Multiplexing	ON
Number of pings	14
Slanted Beams	
Horizontal prec (cm/s)	1.77
Vertical prec (cm/s)	0.46
Velocity range (m/s)	1
Measurement Range	
Desired range (m)	1000
Configured range (m)	1082
Estimated range (m)	1022.3
Blanking distance (m)	2
Cell size	20
Number of cells	54
Number of beams	3

Table 8. AD2CP_55kHz_osnap_S55_dep_2018.deploy.

#$DeployFileVersion,3,1550633f1e1ba7b743bee44e81cf2ff2
#$SWSource,"Deployment-v3.4.7.2"
#$InstrumentId,{"InstrumentType":"Signature55","HeadFrequency":55,"FWVersion":"2205.0"}
#$DeploymentName,"osnap_S55_d"
#$Comment,"osnap 2018 armstrong deployment"
#$ApplicationConfig,[{"Enabled":true,"Application":"AvgCoarse","Mounting":"Fixedframe","Orientation":"UpLooking","Geography":"O$C
#$penOcean","SoundVelocity":"Measured","SoundVelocityValue":1500.0,"Salinity":35.0,"StrongWaves":false,"InstrumentDepth":1000.0$C
#$,"TidalRange":1.0},{"Enabled":false,"Application":"None","Mounting":"Fixedframe","Orientation":"UpLooking","Geography":"OpenO$C
#$cean","SoundVelocity":"Measured","SoundVelocityValue":1500.0,"Salinity":35.0,"StrongWaves":false,"InstrumentDepth":1000.0,"Ti$C
#$dalRange":1.0}]
#$AlternatingRatio,[3,1]
#$DeploymentConfigExtensions,[{"AvgDesiredRange":1000.0,"BurstDesiredRange":1000.0,"BurstHrDesiredRange":1000.0,"EchoSounderDes$C
#$iredRange":1000.0,"AvgEndProfile":1100.0,"BurstEndProfile":1100.0,"BurstHrEndProfile":1100.0,"EchoSounderEndProfile":1100.0,"$C
#$AIStep":6,"RangeStep":1.0,"BurstMeasurementContinuous":false,"AvgMeasurementLoad":100.0,"AvgAutoMeasurementLoad":true,"AvgMea$C
#$surementLoadTick":7.142857,"BurstMeasurementLoad":100.0,"BurstAutoMeasurementLoad":true,"BurstMeasurementLoadTick":1.0,"Pulse$C
#$DistanceAutoOption":3,"PulseDistance":3,"DistanceToBottom":2.0,"DistanceToSurface":2.0,"DesiredVelocityRange":0.25},{"AvgDesi$C
#$redRange":1000.0,"BurstDesiredRange":1000.0,"BurstHrDesiredRange":1000.0,"EchoSounderDesiredRange":1000.0,"AvgEndProfile":110$C
#$0.0,"BurstEndProfile":1100.0,"BurstHrEndProfile":1100.0,"EchoSounderEndProfile":1100.0,"AIStep":1,"RangeStep":0.1,"BurstMeasu$C
#$rementContinuous":false,"AvgMeasurementLoad":100.0,"AvgAutoMeasurementLoad":true,"AvgMeasurementLoadTick":1.0,"BurstMeasureme$C
#$ntLoad":100.0,"BurstAutoMeasurementLoad":true,"BurstMeasurementLoadTick":1.0,"PulseDistanceAutoOption":3,"PulseDistance":3,"D$C
#$istanceToBottom":2.0,"DistanceToSurface":2.0,"DesiredVelocityRange":0.25}]
#$BatteryItem,null
#$BatteryCombo,{"InternalBattery":{"Name":"None 0 Wh","Volume":0.0,"Voltage":0.0},"ExternalBattery":{"Name":"Lithium 3600 Wh","$C
#$Volume":3600.0,"Voltage":18.0},"Volume":3600.0,"Voltage":18.0}

```
#$RecorderItem,{"Name":"16 GB","Capacity":16000000000}
#$AhrsInstalled,false
#$DeploymentDays,702
SETDEFAULT,ALL
SETPLAN,MIAVG=1800,AVG=1,DIAVG=0,VD=0,MV=10,SA=35,BURST=0,MIBURST=120,DIBURST=0,SV=1500,FN="Data.ad2cp",SO=0,FREQ=55,NSTT=0
SETAVG,NC=54,CS=20,BD=2,CY="ENU",PL=-2,AI=84,VR=1,DF=3,NPING=14,NB=3,CH=0,MUX=1,BW="NARROW",ALTI=0,BT=0,ICE=0,ALTISTART=0.5,ALTIEND=150,RAWALTI=1
SETTMAVG,EN=0,CD=1,PD=1,AVG=84,TV=1,TA=1,TC=1,CY="ENU",FO=0,SO=1,DF=100
SAVE,ALL
```

7 Multibeam Survey of IB5 site

Stuart Cunningham

Opportunistically throughout the cruise the Kongsberg EM122 Multibeam Echosounder provided high-resolution imaging of seabed depths. In particular, for the deployment of mooring IB5, a survey was conducted to determine a suitable site. Data were corrected for sound-speed from an XBT-deployment at the beginning of the survey. Data were exported as good pings only, but without any manual processing, to an ASCII file containing positions and depths.

Raw data were transferred to file and directory: */home/mstar/ar304/em122/ar30—04_cellsize38_xyZ.DAF*

This file was processed in *vi* to a file suitable for reading into MATLAB by removing header lines and new line characters. In particular new-line characters (^M) were removed with the command :1,$ s/\r$//. After using the Import Data function, the file was saved as: */home/mstar/ar304/em122/ar30_04_em122_xyz.mat*

The matlab *script em122_ar304.m* reads *ar30_04_em122_xyz.mat,* selects the data relevant to the region of IB5, grids and then contours the data (Figure 9). Based on inspection of raw pings we gridded the raw data at a lat/lon resolution of 0.0002° [approximately 0.12nm latitude x 0.24nm longitude]. A more careful consideration of the raw data could allow gridding at finer horizontal resolution if required.

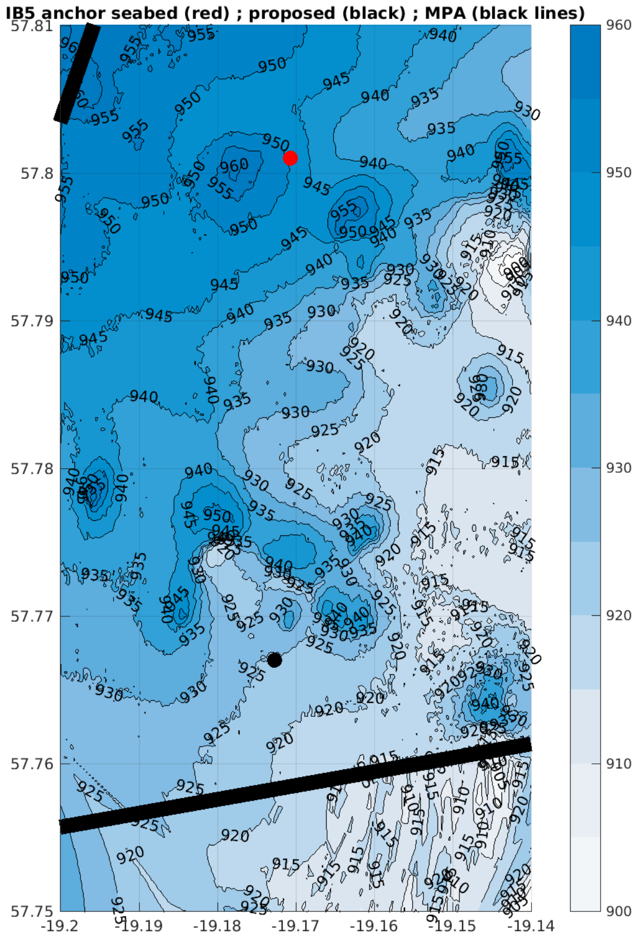


Figure 9. EM122 Multibeam Echosounder survey. The nominal position for planning is shown by the black dot and the final anchor seabed position is the red dot. The black lines indicate the boundaries of the Hatton Bank Marine Protected Area, and the mooring is located inside this region.

8 Mooring Data Processing

Loic Houpert, Stuart Cunningham

Before the processing of the different datasets, a control file is created for each mooring. Each mooring deployed has an associated ASCII info.dat file in the mooring directory. (e.g. *rtwb1_04_2017info.dat* is created in the directory *osnap/data/moor/proc/rtwb1_04_2017/*). The info.dat file contains metadata of mooring position, deployment period, and nominal depths and serial numbers of each instrument on the mooring. The SBE37 are identified by the RODB code 337, while the RODB code 335 is assigned to the SBE37-ODO. The Nortek are identified by the code 370 and the DeepSeapHOx by the code 375.

8.1 Microcat Data Processing

8.1.1 Stage 0 – Data Download

Raw instrument data are downloaded from the instrument after the recovery of the mooring. Data are downloaded in ASCII and cnv format. Record keeping of the download is done on paper and for each instrument a download sheet is completed. After download the data are copied onto the processing computer in the directory *osnap/data/moor/raw/ar30/microcat/*

8.1.2 Stage 1 – Conversion to standard RDB format

The script *mc_call_2_ar30* performs stage1 processing on microcat data. It converts microcat data from raw to RDB format for an entire mooring. The user needs to modify some information in the beginning of the script like the directory trees, the mooring name, the year of the first measurement. *mc_call_2_ar30* calls *microcat2rodb_6*, which saves the file downloaded by the instrument software (stage 0) to the RDB formatted file *.raw*. The stage1 processed data are stored in the directory *~/osnap/data/moor/proc/moor_04_2017/microcat*, which is created manually.

8.1.3 Stage 2 – Trimming of data, basic statistics and summary plots

To perform stage 2 processing, the script *microcat_raw2use_003_with_ODO.m* was used. This script uses the raw data file *mooring_serialnum.raw* generated by stage1 and the *mooringinfo.dat* file. It removes the launching and recovery period, creates a data overview sheet including basic statistics, and produces summary plots, including filtered data. The launching period is defined as the time from the start of the data logging until the mooring settles on the sea-bed. The recovery period is defined as the time from when the mooring is released from the seabed until the end of the data logging.

8.2 Nortek Current Meter Data Processing

8.2.1 Stage 0 – Data Download

Raw instrument data are downloaded from the instrument after the recovery of the mooring. Record keeping of the download is done on paper and for each instrument a download sheet is completed. After download the data are backed up and transferred to the network drive. Data (.data, .dat, .aqd and .hdr files) are copied to the processing computer in the directory e.g *osnap/data/moor/raw/ar30/nortek/*

8.2.2 Stage 1 – Conversion to standard RDB format

The script process_nors_ar30 performs stage1 and stage 2 processing on nortek data. It converts nortek data from raw to RDB format for an entire mooring. The user needs to modify some information in the beginning of the script like the directory trees, the mooring name, and the year of the first measurement. A text file containing the serial numbers of the Nortek on the mooring and the filenames containing the data is also created before running the script, e.g.*~/osnap/data/moor/raw/dy078/nortek/rteb1_04_2017 _filenames.txt.*

process_nors_dy078 calls *nortek2rodb_01*, which saves the files downloaded by the instrument software (stage 0) to the RDB formatted file *.raw*. in e.g. *~/osnap/data/moor/proc/rteb1_04_2017/nortek.*

8.2.3 Stage 2 – Trimming of data, basic statistics and summary plots

The script *process_nors_ar30* also performs stage 2 processing on nortek data by calling the script *nortek_raw2use_02.* This script uses the raw data file *mooring_serialnum.raw* generated by stage1 and the *mooringinfo.dat* file. It removes the launching and recovery period, creates a data overview sheet including basic statistics, and produces summary plots, including filtered data.

8.3 DeepSeapHOx Data Processing

8.3.1 Stage 0 – Data Download

After download the data are backed up and transferred to the network drive, then copied onto the processing computer in the directory *osnap/data/moor/raw/ar30/seaphox_caldip*

8.3.2 Stage 1 – Conversion to standard RDB format

The script *seaphox_call_caldip* performs stage1 processing on DeepSeapHOx data. It converts the data from raw to RDB format. The user needs to modify some information in the beginning of the script like the directory trees, the mooring name or caldip cast number. This script calls seaphox2rodb_01, which saves the file downloaded by the instrument software (stage 0) to the RDB formatted file *.raw a*nd produce summary plots and statistics for each instrument.

Download DeepSeapHOx and transfer to the processing computer:

~/osnap/data/moor/raw/ar30/seaphox/ . For the 2017-2018 deployment of the SeapHOx 117 the data appear to have been written on several files C00000*.CSV, and several data files from the test on DY078 where still present on the memory of the DeepSeapHOx. After keeping a copy of all the original files, the data files were manually edited to make sure than only the data relevant for the 2017-2018 RTEB1 deployment were kept in this the seaphox raw directory.

If the relevant data are present in several C000*.CSV file, edit and run the script (with bash shell) *~/osnap/data/moor/raw/ar30/seaphox/merge_sort_CSVfiles.sh.* This script will sort the lines of several CSV files generated by the SeapHOx and merge them into a single file. The name of this file, containing all the data, has to be indicated in the moor_filenames.txt file (e.g. rteb1_04_2017_filenames.txt).

Make sure that the relevant info.dat file contains the serial number of the DeepseapHOx (e.g. moor/proc/rteb1_04_2017/rteb1_04_2017 info.dat).

Run process_seaphox_ar30.m producing timeseries for each instrument, converting raw data to RODB format and summary statistics.

9 Calibration Dips

Stuart Cunningham, Loic Houpert

SBE37s, SBE37-ODOs and a DeepSEApHOx-ODO were deployed on the CTD frame for direct comparison to CTD values at 5min (30m for the DeepSEApHOx) bottle stops. These calibration casts are listed in Tables 9 and 12. The comparisons provide calibration points for the mooring instrumentation either pre or post-deployment calibrations, instrument functioning and as a rapid assessment of whether to redeploy and instrument or return ashore for servicing and laboratory calibration. These calibration dips are a critical factor in tracing the instrument accuracy and stability back to a stable reference standard in the field. Final calibrations are obtained post final CTD calibration.

9.1 Microcat

mc_cal_caldip_ar30.m

Reads raw data, converts to RODB format and compares to the CTD profile. Produces timeseries plots for C,T,P which can be used to quickly assess instrument function and accuracy. Plots of CTP differencies at bottle stops are written to *cast#_serialnum_bottle_stops.jpg*.

mc_cal_caldip_check_ar30.m

Reads data from raw RODB files and compares to the CTD profile. Produces plots showing mean and standard deviation of SBE-CTD paramaters from the deepest bottle stop and also at the nominal instrument deployment depth (read from the info.dat file). Tables of statistics are recorded in file */osnap/data/moor/proc_calib/ar30/cal_dip/microcat/cast#/microcat_check_cast#.log.*

Table 9. Table of SeaBird SMP37 and SMP37-ODO calibration casts. Columns are: s/n instrument serial number, CALDIP CAST CTD station number of the calibration cast, where MER is from CTD cast 110 conducted on the R/V Merian Cruise on 17/6/18, **1** are the moorings from which instruments were recovered or brought from stores (B). RT are Rockall Trough Moorings and M are the East Greenland Current Moorings; **2** are the moorings on which instruments have been deployed or returned to stores; Owner is SAMS, National Marine Equipment Pool and OSNAP Programme. Some instruments have been caldip'd twice and calibration values could be compared. Caldip cast 6 was designed for the calibration of the DeepSEApHOxODO and SBE37-ODOs by including two 30minute bottle stops. For better SBE37 calibrations on this cast look to other dips.

s/n	CALDIP CAST	1	2	Owner	Notes
0117	006	RTEB2	RTEB1	SAMS	DeepSEApHOxODO s/n 15476
3218	002	M1	RTWB2	NMEP	
3218	MER	M1	RTWB2	NMEP	
3276	005	RTWB1	RTEB1	NMEP	
3481	002	M1	RTWB1	NMEP	
3481	MER	M1	RTWB1	NMEP	
8077	002	M1	IB4	NMEP	cdiff=0.013
8077	MER	M1	IB4	NMEP	
8078	002	M3	IB4	NMEP	
8078	MER	M3	IB4	NMEP	
8079	002	M3	IB4	NMEP	cdiff=0.011
8079	MER	M3	IB4	NMEP	
8080	001	M3	IB3	NMEP	
8080	MER	M3	IB3	NMEP	

8081	001	M4	IB3	NMEP	
8082	002	M1	IB5	NMEP	cdiff=0.012
8082	MER	M1	IB5	NMEP	
8443	002	M1	IB5	NMEP	
8443	MER	M1	IB5	NMEP	
9113	003	B	RTEB1	SAMS	
9140	003	B	RTWB1	SAMS	
9141	005	B	R	SAMS	pdiff=-32
9141	045	B	R	SAMS	pdiff=-32
9371	002	B	IB4	NMEP	cdiff=0.012
9372	003	B	RTWB2	NMEP	cdiff=0.014
9373	001	M1	IB4	NMEP	
9374	001	M4	IB4	NMEP	
9375	005	RTWB1	RTEB1	NMEP	
9376	002	B	IB5	NMEP	
9377	005	RTWB1	RTWB2	NMEP	
9378	001	M5	IB3	NMEP	
10559	003	B	RTWB1	OSNAP	
10560	005	RTWB1	RTEB1	OSNAP	
10561	001	M4	IB3	OSNAP	
10562	003	B	RTEB1	OSNAP	
10575	002	B	R	OSNAP	cdiff=0.016
10576	003	B	R	OSNAP	cdiff=0.051
10577	005	RTWB1	RTEB1	OSNAP	
10578	001	M5	IB3	OSNAP	
10579	001	M5	IB3	OSNAP	
11287	005	RTWB1	RTEB1	OSNAP	
11288	005	RTWB1	RTEB1	OSNAP	
11289	005	RTWB1	RTEB1	OSNAP	
11290	005	RTWB1	RTEB1	OSNAP	
11320	045	RTWB2	R	OSNAP	
11321	001	M1	IB3	OSNAP	
11321	MER	M1	IB3	OSNAP	
11322	045	RTWB2	R	OSNAP	
11323	001	M1	IB4	OSNAP	
11323	MER	M1	IB4	OSNAP	
11324	001	M1	IB3	OSNAP	
11324	MER	M1	IB3	OSNAP	
11325	006	RTEB1	R	OSNAP	
11325	045	RTEB1	R	OSNAP	
11326	001	M4	IB4	OSNAP	
11327	006	RTEB1	R	OSNAP	
11327	045	RTEB1	R	OSNAP	
11328	001	M4	IB4	OSNAP	

11329	003	B	RTWB1	OSNAP	
11330	006	RTEB1	R	OSNAP	
11330	045	RTEB1	R	OSNAP	
11331	001	M2	IB4	OSNAP	
11331	MER	M2	IB4	OSNAP	
11332	002	M2	IB4	OSNAP	
11332	MER	M2	IB4	OSNAP	
11333	002	M2	IB5	OSNAP	
11333	MER	M2	IB5	OSNAP	
11334	045	RTEB1	R	OSNAP	
11335	045	RTEB1	R	OSNAP	
11336	001	M5	IB3	OSNAP	
11337	003	B	R	OSNAP	
11338	045	RTEB1	R	OSNAP	
11339	002	B	IB5	OSNAP	cdiff=0.015
11340	001	M5	IB3	OSNAP	
11341	045	RTEB1	R	OSNAP	
11342	006	RTEB1	R	OSNAP	
11342	045	RTEB1	R	OSNAP	
11343	045	RTEB1	R	OSNAP	
13019	001	M2	IB3	OSNAP	
13019	MER	M2	IB3	OSNAP	
13020	045	M2	R	OSNAP	
13020	MER	M2	R	OSNAP	cdiff=0.081
13021	001	M3	IB3	OSNAP	
13021	MER	M3	IB3	OSNAP	
13022	000	M3	R	OSNAP	leaked & repaired
13022	MER	M3	R	OSNAP	cdiff=-1.4; leaked on 000 & repaired
14353	003	B	RTWB1	OSNAP	
14354	002	B	RTWB1	OSNAP	
14355	003	B	RTWB1	OSNAP	
14356	002	B	IB5	OSNAP	
14364	002	B	R	OSNAP	diff=0.019
14365	003	B	R	OSNAP	cdiff=0.011
14366	002	B	IB4	OSNAP	
14367	002	B	R	OSNAP	
14368	003	B	RTWB1	OSNAP	
14987	006	RTEB2	R	SAMS	ODO faulty O2
15254	006	RTEB2	RTEB1	SAMS	ODO
15298	006	RTEB2	RTEB1	SAMS	ODO cdiff=0.014

9.2 DeepSeapHOx

1. Process CTD station data and create the 1s average up and down profile (file: ctd_ar304_###_psal.nc).

2. Download DeepSeapHOx, transfer to the processing computer:

~/osnap/data/moor/raw/ar30/seaphox_cal_dip/cast6. Then a cast6_filenames.txt file needs to be created. Similar to the nortek filenames.txt files, the first column of each line contain the serial number of each SeapHOx instrument (e.g. 117) and the name of the data file (e.g. C0000001.CSV)

3. Make sure that the info.dat file contains the serial number of the DeepseapHOx (e.g. moor/proc_calib/ar304/cast#info.dat).

4. Run: seaphox_call_caldip.m to produce timeseries for each instrument, convert raw data to RODB format and produce individual summary statistics.

5. Run seaphox_caldip_check.m : this reads the info.dat and produces timeseries plots of CTD data against MicroCAT data and summary statistics are produced by the script.

10 Oxygen Sampling and Analysis

Jeanne Castille, Sarah Reed, Rich Abell and Clare Johnson

Collected and analysed by: Sarah Reed and Jeanne Castille
SAMS head quarter support*:* Dr Rich Abell and Dr Clare Johnson

Aim: to measure dissolved oxygen from the CTD casts for calibration of oxygen sensors on both the CTD rosette and the OSNAP mooring RTEB1.

Stations sampled: By the CTD station number we sampled 1-30, thereafter every even number CTD was analysed all the way to CTD 90 (Figure 11.)

Depth sampled: 10, 25, 50, 100, 150, 200, 250, 500, 800, 1000, 1600, 1800, 2000, 2500, 2800, 3000; these were the target depths but varied on the depth of water column and what other water samples needed to be taken and at what specific depth. The general aim was to get a full profile of the water column from 10 m from the surface to 10 m from the bottom at every station. Where important stations where highlighted, such as the EB1 pre and post calibration dip and a few of the Rockall stations, triplicate oxygen samples were taken for a higher precision where time allowed. Thereafter duplicates were taken due to the high amount of samples that needed to be processed.

Sample collection: The glass bottles used for collecting the water samples were calibrated for their volume prior to the cruise by Sarah Reed and Dr Richard Abell. During sampling around temperature of the niskin at the time sampled was taken, using a calibrated Thermo test 110 temperature probe. Oxygen samples were the first thing sampled from each niskins. Samples were taken using a short piece of silicon tubing into pre-calibrated glass bottles, glass bottles were rinsed then the silicon tubing was put to the bottom of the glass and slowly brought up with a reduced flow rate; care was taken to ensure no bubbles were added during sampling. Using pipettes we added 1 cm^3 of manganese sulphate, followed by 1 cm^3 of the alkaline iodide solution. During addition, the tip of the pipette was dipped below the water surface. The matching bottle top was added at a slight angle so that no air was added to the sample. The sample was then shaken and lid closed tightly. This was repeated as per the sampling plan. Samples were moved to the titration lab to warm up naturally to room temperature prior to analysis.

Analysis equipment: The equipment used to measure the dissolved oxygen samples was a new 848 Tritino plus automated Titrator (s/n 00141925), with the 5 ml pipette and 801 stirrers; all in working order with no issues. The backup machine which was a 702 SM Tritino was up and running with a standardisation being completed before leaving port. The method used follows the GO-SHIP protocols for (Langdon, C. 2010: Determination of dissolved oxygen in seawater by winkler titration using the amperometric technique; IOCCP Report No. 14, ICPO Publication Series No. 134, Version 1, 2010). Dr Richard Abell prepared chemicals prior to the cruise, following the GO-SHIP protocol, with the exception of the second batch of Thiosulphate which was prepared by Sarah Reed and the diluted Sulphuric acid which was prepared by Jeanne Castile (Figure 10).

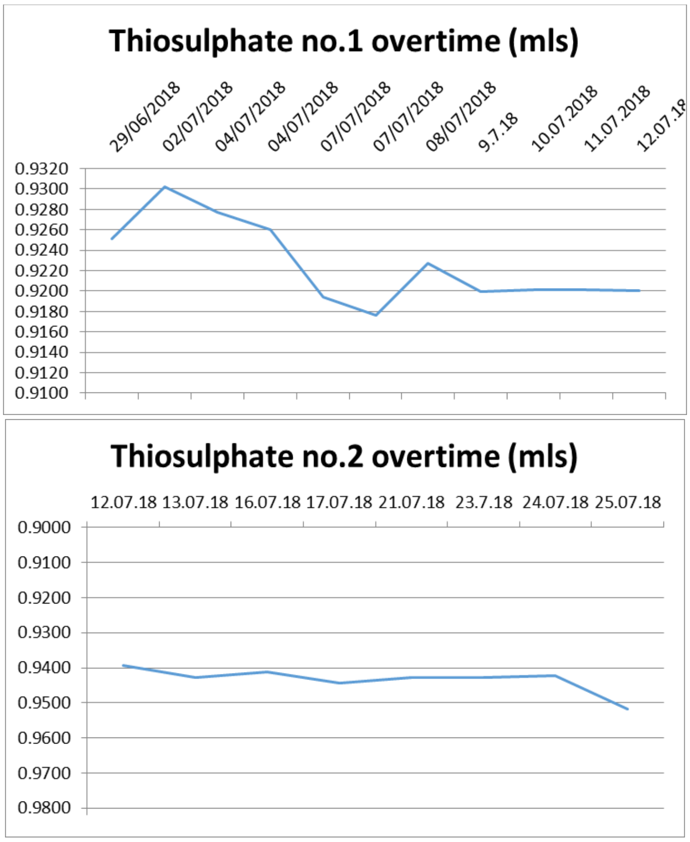


Figure 10. Volume of thiosulphate no.1 against time. 2a: Changeover of the thiosulphate occurred on 12/7/18, graph plotted presents Volume of thiosulphate no.2 against time.

Standardisation of the reagent thiosulphate: Standardisations using either the SAMs in-house or the OSIL standard was conducted before each set of samples/per day until there was a repeat of 0.005, this provided evidence that the machine and the thiosulphate were stable. The reagent thiosulphate concentration was plotted over time to check that it was still stable (Figure 10). After Rockall Bank (CTD 42) we needed to change the Thiosulphate, this was prepared on 10.7.18 (25.4877g of sodium thiosulphate crystals added to 1L of MILIQ) this was kept in the dark and shaken every few hours. The change over to Thiosulphate bottle no.2 happened on 12.7.18. The burette was well flushed with the new thiosulphate then standardisation of both in-house and OSIL standard was run before and after the first station sampled to ensure that the results we were getting were similar to the first bottle of thiosulphate; we are happy that it was stable and continued to be so for the rest of the cruise. The standardisations and comparing data to previous cruises confirmed that the method was working and there were no issues with equipment or chemicals during this cruise.

Analysis method: The method used was the SAMS and SAMS Research Services Limited approved method based on that of Holley and Hydes, 1994 and following GO-SHIP procedures. After a standardisation was completed and samples had naturally warmed up to room temperature (22 ^{0}C) and had been shaken twice since collection, samples were measured on the 848 Tritino plus machine. 1 ml of Sulphuric acid (75%) was added to the sample, a magnetic stirrer was added to the sample (slowly down the side to reduce bubble contamination) then when the solution was fully mixed the sample was added to the stirrer of the 848 machine. The automated 5 ml burette and probe were added to the solution, the Holley Hyde's method was selected on the machine and the samples run by automated Winkler titration. The sample is titrated with approximately 0.25 M sodium thiosulphate using the automated pipetting system. The volume of the titre in mls was recorded from the machine and C(O2) µmol/l per sample was calculated in the format below. This was repeated for each individual sample.

Calculating DO within the samples: A spreadsheet made by Dr Richard Abell was used to calculate the amount of dissolved oxygen in C(O2) µmol/l per sample, the mean was also calculated. This spreadsheet includes the standardisation that was measured that day, the burette and pipette calibration numbers, the temperature and depth of each sample, the bottle volume calibration, the iodate molarity; to ensure data was to the highest precision for each individual measurement.

Issues with samples**:** Where there were pipetting issues when sampling, then the contents were disposed of into a waste drum. A new sample was then collected. Jeanne and Saz were very cautious to not get any bubbles into the glass bottle when sampling and ensured that the samples were well mixed to allow all of the oxygen to bind and then being left to equilibriate to room temperature for analysis. The RSD percentage was worked out for each repeat, if there was a bad repeat that seemed to not fit the data, then the spreadsheet was checked for any errors such a bad formulae or a human error when typing error, if this did not rectify it then the sample was flagged with a particular number to say what we think went wrong with that sample. Any errors or questions were quickly picked up by Clare and Rich who had a fresh set of eyes on the data, any issues were dealt with, such as the aforementioned human error issues on the spreadsheet.

Clare's quality checks: Regular quality checks of the bottle oxygen data were carried out by means of comparison with sensor oxygen data outputs, and also by comparison with historical oxygen data from the Extended Ellett Line section. Bottle oxygen and sensor data profiles showed similar shapes, suggesting that both the sensor and Winkler analysis were operating well. A comparison of bottle oxygen against sensor oxygen showed a tight linear relationship with a value of r of 0.95. Residuals (bottle oxygen – sensor oxygen) were near constant throughout the cruise, providing further evidence that the both the autotitrator and rosette sensor were stable. Additionally, no sudden change in residuals were seen when a new batch of thiosulphate was applied. Finally, we compared the bottle data to bottle data from the 2015 Extended Ellett Line (DY031) to get an idea of accuracy. The oxygen data from the 2015 cruise compared extremely well to other Extended Ellett Line cruises, hence we believe that it has a good accuracy.

11 Nutrient, DIC and Isotope sampling protocols

Sarah Reed, Jeanne Castille and Clare Johnson

Water samples for nutrients, DIC and Isotopes were collected as per Figure 11. For reference: there were 12 bottles of 12 L niskins with position around the rosette as followed; 2 4 6 8 10 12 14 16 18 20 22 24. A CTD log was kept on the ship, the CTD number was used as the CTD event number (not the station number that was originally planned); therefore use the CTD number for sample locations on all samples collected.

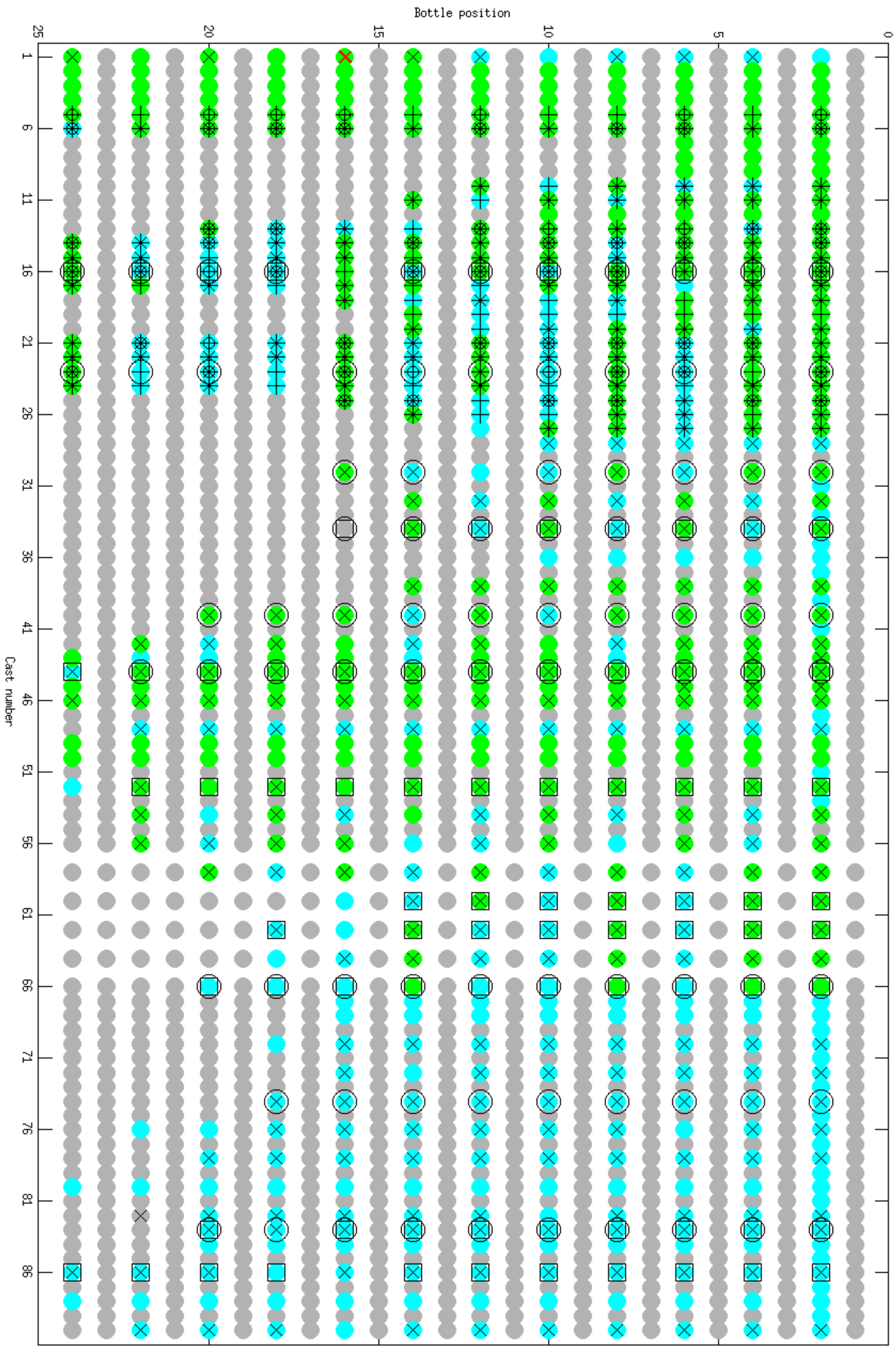
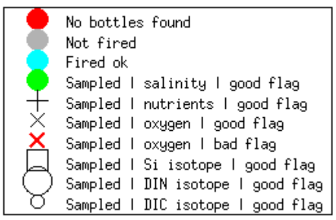


Figure 11. Summary of the water samples taken during the cruise (x axis corresponds to the station number and y axis to the bottle number). Note: no oxygen samples were taken on station 82, they were taken on station 80; other salinity sample were taken from station 68 to station 101 but data were not available at the time of this figure was made.



11.1 Dissolved inorganic nutrients

Sarah Reed, Jean Castille, Clare Johnson

Water samples for dissolved inorganic nutrient analysis were collected at the shake-down CTD (CTD 0) and the CTDs in the Rockall Trough only (CTDs 5-27). 60 ml polypropylene sample vials were acid washed prior to the cruise. Water for nutrient analyses were taken straight after oxygen and carbon samples (DIC, TA, if taken) to reduce contamination risk; nitrile gloves were worn whilst sampling. Silicon tubing with a mesh on the end, to prevent plankton getting into the samples, was attached over the niskin tap. Sample vials were rinsed three times from the specified niskin and then filled with an air gap at the top to allow for expansion when stored in the -20 °C freezer after sampling. Samples from one CTD station were stored in one plastic bag with information written on the outside to keep things organised. Samples were returned frozen for later shore-based analysis of nitrite, nitrate, silicate and phosphate.

11.2 DIC (Dissolved inorganic carbon) and total alkalinity

Saz Reed, Jean Castille, Clare Johnson

Water samples were collected for analysis of dissolved inorganic carbon and total alkalinity at station 0 and at selected stations in the Rockall Trough. Samples were taken straight after the oxygen samples to reduce contamination risk into borosilicate 250 ml glass stopper bottles. Silicon tubing was flushed before the sample bottle was slowly filled and first inverted and then turned upright. We slowly rotated the bottle as it filled to make sure no bubbles collected inside the bottle. The bottle was over filled, the silicon tubing slowly removed and the stopper was inserted. After sampling was completed, back in the lab under a fume cupboard Apieson L grease was placed lightly around the inside neck of the bottle. We withdrew 2.5 ml of seawater from the bottle and then pipetted 50 µl of 0.02 % mercuric chloride solution into the seawater sample. The tip of pipette was about half the length of the pipette tip below the surface of the seawater when doing this. The bottle of mercuric chloride was resealed securely straight away and the pipette tip ejected into a plastic bag. The stopper was replaced in the glass bottle and turned to improve the seal. The bottle was inverted to mix the sample before a loop of tightly stretched PVC tape was added around the bottle neck to seal the stopper. Details of the CTD station were added to the outside of the bottle and these were stored at room temperature. Samples were returned for later shore-based analysis of dissolved inorganic carbon and total alkalinity.

11.3 Isotopes: Delta-N-15 (δ^{15})

Samples for isotopic analysis of Nitrogen and Silica were collected for Antonia Doncila, University of Edinburgh.

The bottles that were acid washed prior to the cruise were rinsed bottle three times with seawater from the Niskin bottle. Then, seawater samples were collected in 65 ml acid clean bottles. Water was filtered with the Acropak filter from the Niskin bottle tap into the acid clean HDPE sample bottle. Once the Acropak was attached via the soft tube to the Niskin bottle tap, we left the water to flow through the Acropak filter for 10 seconds to ensure that there was no contamination from the previous sampling Once the water has been collected (with an airspace allowing for expansion), samples were stored in the -20 °C freezer immediately. It must be noted that Nitrile gloves need to be worn during the sampling and further handling of the samples.

11.4 Isotopes: Si

The samples were rinsed three times with seawater from the Niskin bottle. Then, seawater samples were collected in 250 ml acid clean bottles. Water was filtered with the Acropak filter from the Niskin bottle tap into the acid clean HDPE sample bottle. Once the Acropak was attached via the soft tube (provided) to the Niskin bottle tap, the water flowed through the Acropak filter for 10 seconds to ensure that there was no contamination from the previous sampling done. Back in the lab under the fume cupboard we added a 0.1% v/v of 6M HCl to each sample (in this case it means 250 microliter per 250ml bottle). Then samples were stored in the dark and refrigerated. It must be noted that it was very important that the samples were NOT frozen. It must be noted that Nitrile gloves need to be worn during the sampling and further handling of the samples.

11.5 Microplastic samples

On moorings that were available and had anemones/bivalves or anything that was living on the sub-surface mooring array then samples were taken for microplastic analysis. Gloves were worn and then a knife or scalpel was used to remove anemones or bivalves from any part of the sub-surface mooring array. Samples were folded within aluminium foil and then put in a plastic bag for each sampling event. Data is on the excel spreadsheet where water depth, depth of instrument/buoy sampled from/ how many years it has been deployed and the position was recorded.

12 Argo Float Deployments

Stuart Cunningham, James Coogan

Two Argo floats were deployed on behalf of the UK Met Office. These are detailed in Table 10.

Table 10. Dates and locations of Argo float deployments.

s/n	Date	Time	Lat °N	Lat ʺ	Lon °W	Lon ʺ
8460	12/7/18	1450	58	00.27	23	01.25
8459	16/7/18	1025	59	15.97	35	22.36

13 Shipboard Underway Data

James Coogan

13.1 Underway Data Logging

The R/V *Neil Armstrong* comes equipped with a comprehensive set of underway sensors which were used throughout the cruise which provide contextual meteorological, sea surface, sounder, and navigational data to accompany the oceanographic dataset. A full inventory of the shipboard sensors is provided in Table 11, along with the file extension where the data can be found. Full processing of these ancillary data was not possible onboard due to limited personnel. Further information about the data structures can be found within the text files in the */data/underway/doc* directory with the accompanying raw data in the */data/underway/raw* directory.

Table 11. R/V *Neil Armstrong* shipboard sensors, serial numbers, installation and file information.

Sensor Type	Instrument Make and Model	Serial Number	Installation	File Information
Depth	Kongsberg EM122 RX2 x TX1 degree multibeam echosounder	121	Transducer Room 1x TX array 2x RX array	DEP_EM122 .txt
	Kongsberg EM710 RX1 x TX0.5 degree multibeam echosounder	230	Transducer Room 0.5x TX array 1x RX array	DEP_EM710 .txt
	Knudsen Chirp 3260	K2K-14-0211	Transducer Room 3.5 kHz 4x4 Array Tank - 16 Massa TR-1075 transducers 12 kHz Airmar CS229	DEP_KN326 0.txt
Gravimeter	Bell BGM-3 Gravimeter	S220 WHOI/UNOLS	Transceiver Room	GRAV_BMG .txt
Science Salt Water	SBE Hull Mounted Temperature Sensor SBE48	0040	Lower Bow Thruster Room	SSW_SBE48. txt
	Thermosalinograph SBE45 MicroTSG	4547129-0204	Wet lab, inboard bulkhead	SSW_SBE45. txt
	Wet Labs Fluorometer Chlorophyll WETStar	WS3S-900P	Wet lab, inboard bulkhead	SSW_FLR.txt
Surface Sea Water	Thiel Engineering Flowmeter Flowmeter impeller J	1114	Wet lab, inboard bulkhead	SSW_FLOW. txt
Surface Sound Velocity	AML SSV probe, AML Smart X-Series Instrument, P1S2, 500m Housing	20112	stainless velocimeter tank, transducer room	SSV_AML.tx t
Meteorological Sensor	Biospherical Instruments QSR2150A	50212	Met Mast	MET_PAR.tx t
	Radiometer Analog to Digital Interface with Eppley PSP and PIR	RAD_222	Met Mast	MET_RAD.tx t
	Vaisala WXT520	C3620001	Met Mast (port)	MET_XTP.tx t
	Vaisala WXT521	D0220001	Met Mast (starboard)	MET_XTS.tx t
Navigation	CNAV 3050	23177	Chart Room	NAV_CNAV. txt

	Kongsberg DPS 112 GPS	-	Bridge	NAV_DPS112.txt
	Sperry Marine Gyro 4914-CA	Gyro1 11424	Bridge void	NAV_HDT.txt
	Sperry Marine Gyro 4914-CA	Gyro2 11431	Bridge void	NAV_HDT.txt
Navigation Speed	Furuno Doppler DS-60	DS-600: 2780	Bridge, Transducer room	NAV_SPD.txt
Motion Reference Unit	Applanix POS/MV Motion Reference Unit MRU7	2592	Transducer room	MRU_POSMV.txt
ADCP	Teledyne RDI Ocean Surveyor 38khz	-	Transducer room	**
	Teledyne RDI Ocean Surveyor 150kHz	-	Transducer room	
	Teledyne RDI 300kHz Workhorse	-	Transducer room	

** Comprehensive ADCP information can be viewed at http://arcurrents01.armstrong.whoi.edu/adcp/programs/adcp_doc/index.html

13.2 Vessel Mounted ADCP

The R/V Neil Armstrong has three Teledyne RDI doppler sonars: a 300kHz Workhorse (WH300), a 150 kHz Ocean Surveyor ADCP(OS150), and a 38kHz Ocean Surveyor ADCP (OS38). These three ADCPs provide a comprehensive dataset of absolute water velocity up to 1200m in depth. The WH300 has a typical range of 80m in good conditions. Both the OS150 and the OS38 can operate in "high-resolution" broadband mode, with 4 metre bins, and "deep-profiling" narrowband mode, with 8 metre bins. In broadband mode, the OS150 has a typical range of 130-180 metres, and the OS38 has a range of 950-1200 metres. In narrowband mode, the OS150 has a typical range of 200-240 metres and the OS38 has a range of 1200-1700m. Both the OS38 and the OS150 were operated in narrowband mode throughout the cruise.

A suite of ancillary sensors (Table 11) provides measurements for heading, position, and beam angle, which are used to subtract the movements of the ship from the transducer data to reveal the ocean velocities below. Onboard data is collected and stored in a CODAS (Common Ocean Data Access System) database. A set of CODAS routines are implemented to process the raw ADCP data. First, an ocean reference layer is used to remove the ship's speed from the measurements, then a heading based on GPS corrected gyro measurements is implemented before calibration routines determine any misalignment from "bottom track" or "water track" data. Finally, bad data must be edited out before averaging the final dataset. The routines can automatically remove bad data, though a person must verify the data through inspection prior to final processing.

The University of Hawaii's data acquisition system (UHDAS) (http://currents.soest.hawaii.edu) is used to provide data processing and monitoring at sea. The UHDAS routines are automated to acquire the raw data and provide processed, corrected, edited data for scientists to use during the cruise.

Every 5 minutes the UHDAS system will:

- get the last 5 minutes of new data
- rotate to earth coordinates using gyro as the primary heading device
- correct to the "accurate heading device"
- edit single-ping data (for this 5-minute chunk)

- average, write to disk (staging for addition to the codas database)
- save the 5-minute chunk of data as a matlab file (for plotting)

Every 15 minutes:

- the CODAS database is updated with the staged averages
- scale factor and fixed rotation are applied if specified
- the averages in the database are also edited (to look for bad bins or bad profiles, and the bottom)
- after the codas database is updated:
    - the data are extracted and averaged (for plotting)
    - the data are extracted with “every bin, every profile”
    - data are stored as matlab files and netCDF files, accessible via ship’s web site or via windows shares [samba] or nfs.
    - Vector and contour plots of the last 3 days of data are updated, also available on the ship’s web.

Monitoring of the data takes place both on land and at sea. A daily email containing diagnostic information is sent to land and profiles of the most recent 5-minute sampling window, contour and vector plots of the last 3 days of data, and the last half-day of gyro and “accurate heading”. This system provides a useful tool for monitoring performance and allows for adaptive sampling if areas of interest are observed.

Data provided by UHDAS was used to create preliminary plots of VMADCP velocity for the transect. There are two types of data provided for onboard science: the *allbins_*.mat* files generated by *getmat*, and the *contour_xy.mt, contour_uv.mat, vector_xy.mat,* and *vector_uv.mat* generated by *adcpsect*. These outputs are located in the contour and vector folders in the processing directories for each sonar instrument and frequency (eg. *os38nb* or *os150nb*). The *getmat* files provide the CODAS native resolution data, with every bin and every profile. The *adcpsect* output provides averaged data at either 15 min or 1 hour resolutions.

14 CTD Calibration

Stuart Cunningham, Loic Houpert, Clare Johnson, James Coogan

A total of 101 CTD / LADCP stations were conducted during the cruise. These are detailed in Table 12.

Table 12. CTD/LADCP station information[2]

CTD	OSNAP	Date	Time	Lat DEG	Lat MIN	Lon DEG	Lon MIN	Depth
0+	N/A	Jul 2 2018	15:58:57	60	0.11	22	37.72	1012
1*	N/A	Jul 2 2018	18:17:06	60	0.11	22	37.72	2520
2*	N/A	Jul 3 2018	17:17:42	57	59.62	24	19.01	2864
3*	N/A	Jul 4 2018	17:19:06	58	0.8	21	8.97	2955
4*	N/A	Jul 4 2018	21:20:17	58	0.79	21	8.97	2959
5*	N/A	Jul 7 2018	03:08:39	57	6.13	9	34.67	1817
6*	N/A	Jul 7 2018	13:13:15	57	6.08	9	34.74	1813
7	1	Jul 7 2018	22:35:00	56	50.08	8	19.75	138
8	2	Jul 7 2018	23:56:26	56	52.9	8	29.75	128
9	3	Jul 8 2018	01:38:59	56	56.99	8	46.97	128
10	4	Jul 8 2018	03:01:02	57	0.02	8	59.95	133
11	5	Jul 8 2018	04:27:37	57	2.99	9	13	313
12	6	Jul 8 2018	05:32:11	57	4.49	9	19.01	778
13	7	Jul 8 2018	06:53:59	57	6.02	9	25	1399
14	8	Jul 8 2018	14:57:36	57	9	9	41.97	1927
15	9	Jul 8 2018	18:02:08	57	14.01	10	2.89	2099
16	10	Jul 8 2018	21:11:08	57	17.95	10	22.8	2205
17	11	Jul 9 2018	00:09:27	57	21.98	10	39.96	2089
18	12	Jul 9 2018	02:47:40	57	23.97	10	51.86	792
19	13	Jul 9 2018	04:38:53	57	26.98	11	4.89	588
20	14	Jul 9 2018	06:28:19	57	28.06	11	18.88	747
21	15	Jul 9 2018	08:20:13	57	28.97	11	31.9	2010
22	16	Jul 9 2018	11:28:02	57	29.53	11	50.95	1786
23	17	Jul 9 2018	20:08:33	57	30.44	12	15.17	1798
24	18	Jul 9 2018	23:20:31	57	32.03	12	37.8	1642
25	19	Jul 10 2018	01:52:56	57	32.51	12	51.97	1091
26	20	Jul 10 2018	03:41:38	57	33	12	59.94	298
27	21	Jul 10 2018	05:30:09	57	34	13	19.92	178
28	22	Jul 10 2018	07:16:01	57	34.97	13	37.87	113
29	23	Jul 10 2018	10:04:58	57	35.6	14	15.93	200
30	24	Jul 10 2018	12:48:27	57	36.23	14	54	483
31	25	Jul 10 2018	16:05:48	57	36.91	15	31.89	1052

[2] Johns, W. (2018), RV Neil Armstrong, Cruise AR30-04: Reykjavik, Iceland to Reykjavik, Iceland, 1 July to 30 July 2018, pp. 30, RSMAS, Univ. of Miami, U.S.

32	26	Jul 10 2018	19:13:51	57	37.51	16	10.08	1167
33	27	Jul 10 2018	22:38:52	57	38.17	16	47.82	1193
34	28	Jul 11 2018	01:52:39	57	38.82	17	25.8	1223
35	29	Jul 11 2018	05:21:29	57	39.4	18	3.92	1053
36	30	Jul 11 2018	08:38:12	57	39.98	18	41.95	713
37	31	Jul 11 2018	11:16:00	57	43.83	19	13.77	912
38	32	Jul 11 2018	14:02:33	57	47.52	19	44.92	1306
39	33	Jul 11 2018	16:39:52	57	50.17	20	8.58	1569
40	34	Jul 11 2018	19:10:10	57	52.8	20	29.76	2246
41	35	Jul 11 2018	22:16:57	57	54.9	20	51.27	1995
42	36	Jul 12 2018	01:05:42	57	57.28	21	12.08	2949
43*	37	Jul 12 2018	05:51:26	57	57.62	21	51.48	3020
44*	38	Jul 12 2018	16:45:49	57	57.59	22	30.98	2978
45*	39	Jul 12 2018	22:11:32	57	57.64	23	10.37	2985
46*	40	Jul 13 2018	03:39:10	57	57.6	23	49.78	2935
47	41	Jul 13 2018	09:03:10	57	57.56	24	29.28	2818
48	42	Jul 13 2018	13:32:13	57	57.65	25	7.04	2740
49*	80	Jul 15 2018	20:00:29	59	23	36	29.78	3100
50	79	Jul 16 2018	00:26:22	59	20.51	36	6.2	3089
51	78	Jul 16 2018	04:16:48	59	17.65	35	38.59	3100
52*	77	Jul 16 2018	07:25:08	59	15.98	35	22.36	2985
53	76	Jul 16 2018	14:40:44	59	14.59	35	6.8	3014
54	75	Jul 16 2018	17:34:42	59	12.73	34	50.08	2485
55	74	Jul 16 2018	20:38:56	59	11	34	33.95	2836
56	73	Jul 16 2018	23:31:56	59	9.38	34	17.77	2578
57	72	Jul 17 2018	02:33:01	59	7.73	34	1.14	2825
58	71	Jul 17 2018	15:52:32	59	6.01	33	45.22	2135
59*	70	Jul 17 2018	18:32:46	59	4.51	33	29.77	2280
60	69	Jul 17 2018	22:03:19	59	2.89	33	14.32	2207
61	68	Jul 18 2018	00:49:36	59	1.33	32	58.72	2234
62	67	Jul 18 2018	03:17:31	58	59.69	32	42.22	1838
63	66	Jul 19 2018	00:01:02	58	58.27	32	27.93	1855
64	65	Jul 19 2018	03:19:53	58	56.65	32	12.43	1475
65	64	Jul 19 2018	05:28:32	58	55.07	31	57.13	1768
66	63	Jul 19 2018	17:52:07	58	53.68	31	43.37	1620
67*	62	Jul 19 2018	20:08:14	58	52.35	31	29.66	1514
68	61	Jul 19 2018	22:58:26	58	50.88	31	15.89	1440
69	60	Jul 20 2018	01:08:24	58	50.5	31	2.22	1501
70	59	Jul 20 2018	03:08:37	58	50.18	30	48.32	1466
71	58	Jul 20 2018	14:37:26	58	50.02	30	34.91	1587
72	57	Jul 20 2018	19:21:59	58	45.78	30	21.99	1631
73	56	Jul 20 2018	21:32:33	58	42.01	30	10.31	1708
74	55	Jul 20 2018	23:44:50	58	37.57	29	56.9	1984
75	54	Jul 21 2018	02:19:53	58	33.38	29	44.13	1999
76	53	Jul 21 2018	20:44:11	58	29.45	29	32.02	2520
77	52	Jul 21 2018	23:29:18	58	24.7	29	18.79	2070
78	51	Jul 22 2018	01:48:48	58	20.1	29	5.46	2168
79	50	Jul 23 2018	00:15:54	58	15.7	28	53.01	2214
80	47	Jul 23 2018	04:59:16	57	59.69	28	4.41	2399

81	46.5	Jul 23 2018	19:00:18	57	59.22	27	50.35	2365
82	48	Jul 23 2018	22:40:23	58	5.03	28	20.52	2294
83	49	Jul 24 2018	01:57:29	58	10.43	28	37.03	2305
84	46	Jul 24 2018	23:02:43	57	58.59	27	34	2250
85	45.5	Jul 25 2018	01:49:40	57	58.01	27	17.88	2395
86	45	Jul 25 2018	04:31:10	57	57.63	27	0.62	2678
87*	44.5	Jul 25 2018	08:15:31	57	57.56	26	42.52	2740
88*	44	Jul 25 2018	13:08:37	57	57.9	26	22.79	2817
89*	43.5	Jul 25 2018	17:22:30	57	57.56	26	4.43	2785
90	43	Jul 25 2018	20:33:32	57	57.6	25	44.89	2725
91	N/A	Jul 26 2018	08:29:20	59	32.4	25	30.01	2462
92	N/A	Jul 26 2018	11:30:14	59	39.62	25	49.76	2401
93	N/A	Jul 26 2018	14:29:50	59	46.38	26	7.84	2105
94	N/A	Jul 26 2018	17:25:33	59	53.72	26	27.27	2293
95	N/A	Jul 26 2018	20:06:51	59	59.13	26	42.04	1994
96	N/A	Jul 26 2018	22:40:16	60	4.98	26	57.95	2026
97	N/A	Jul 27 2018	01:25:21	60	10.97	27	14.53	1732
98	N/A	Jul 27 2018	03:57:32	60	17.29	27	31.55	1649
99	N/A	Jul 27 2018	06:31:40	60	23.19	27	49.23	1392
100	N/A	Jul 27 2018	08:58:57	60	29.63	28	6.58	1538
101	N/A	Jul 27 2018	11:51:19	60	35.85	28	23.94	1007

+ Test cast

* Instrument calibration casts

CTD data were collected in the Sea-Bird Seasave version 7.23.2 software, and the following file types saved as .hex (data in binary format), .bl (bottle firing record), .XMLCON (configuration file), and .hdr (header information input manually). Data were processed using Sea-Bird software and the mexec_v2 software suite developed at NOC. Note that the NetCDF file and the metadata associated with the mexec processing suite are known as the mstar format. Here m refers to the use of MATLAB as the processing tool that implements mexec. The first stage of the processing was carried out on the CTD computer using the Seabird software SBEDataProcessing-Win32 Version 7.23.2. The following modules were run:

- DatCnv: converts the raw frequency and voltage data from engineering units by applying the sensors manufacturer's calibrations stored in the XMLCON, and outputs the data in an ASCII format (cast data as a .cnv file, and bottle data as .ros). The oxygen hysteresis correction option was selected, and therefore this correction was not done later in mexec.

- Align: this script shifts selected sensors' data in time, relative to pressure. This is required for sensors with a slower response time, and when extra time is required for the water parcel to reach the sensor (e.g. going through additional lengths of hose). The primary and secondary conductivities require a small shift of 0.073 seconds. In our setup, this was done in real-time by the deck-unit for the primary sensor and by the SeaBird software for the secondary sensor.

- CellTM: this module is run to remove conductivity cell thermal mass effects from the measured conductivity. Sea-Bird recommended constants (α=0.03 and 1/β=7) were used.

Processed CTD data were automatically copied on the shared network drive *data_on_memory*. The script *ctd_linkscript_ar304* was used to copy files from the network drive and set up additional symbolic links to filenames following mexec convention.
At the end of the cruise the 1hz and 2db mstar netcdf are convert into matlab format by using the script *convert_mexec_files_to_mat.m.*

The different steps of the MATLAB mexec processing are summarized in the table below.

Table 13. Matlab MEXEC processing steps.

		Script	Example outfiles	Description
		ctd_linkscript (in terminal)	ASCII_FILES/ ctd_ar304_nnn_ctm.cnv	copy files from the network drive and set up symbolic links to filenames following mexec convention.
	ctd_all_part1_ar304	msam_01	sam_ar304_nnn.nc	creation of empty sample files using *templates/sam_ar304_varlist.csv*
		mctd_01	ctd_ar304_nnn_raw.nc	conversion of raw 24Hz cnv data file to mstar netCDF format
		mctd_02a_ar304	ctd_ar304_nnn_raw.nc	converts variable names from SBE to mstar names using the file *ctd_ar304_renamelist.csv* and add the cast position from nav data
X		mctd_02b_ar304	ctd_ar304_nnn_24hz.nc	applies oxygen hysteresis correction
X		mctd_03_ar304	ctd_ar304_nnn_1hz.nc ctd_ar304_nnn_psal.nc	average to 1Hz and calculation of salinity and potential temperature
		mdcs_01	dcs_ar304_nnn.nc	creates an empty file to store the cast metadata (start, bot. and end)
		mdcs_02	dcs_ar304_nnn.nc	find scan number corresponding to bottom of file
		mdcs_03g_dy078	dcs_ar304_nnn.nc ctd_ar304_nnn_surf.nc	run to inspect profiles, hand-select cast start and end times
X	ctd_all_part2_ar304	mctd_04	ctd_ar304_nnn_2db.nc	averages data to 2db bins
		mfir_01	fir_ar304_nnn_bl.nc	get bottle firing information from the Sea-Bird .bl file and extract the matching CTD data based on scan numbers
		mfir_02	fir_ar304_nnn_time.nc	
X		mfir_03	fir_ar304_nnn_ctd.nc	
X		mfir_04	sam_ar304_nnn.nc	
		mbot_00	bot_ar304_01.csv	create bottle files; add CTD data, bottle firing codes and quality flag at the time of the bottles firings in the BOT and SAM files.
		mbot_01	bot_ar304_nnn.nc	
		mbot_02	sam_ar304_nnn.nc	
		mctd_checkplots	*Control-check plots*	Script to visually checked the CTD data
		mdcs_05		Populate ctd cast positions into various ctd files (fir_*.nc, sal_*.nc, sam_a*.nc, dcs_*.nc, ctd_*.nc)
		moxy_01_ar30	oxy_ar304_nnn.nc	Read bottle oxygen data from csv file (ctd/BOTTLE_OXY/) and create .nc file
		moxy_02_ar30	sam_ar304_nnn.nc	Paste oxygen data into mstar sample file
		moxy_02_oxykg_ar30	sam_ar304_nnn.nc	Convert bottle oxy data from umol/l to umol/kg and paste into sam file (to be run after moxy_02)

	Script		Example outfiles	Description
		msal_01	sal_ar304_nnn.nc	Read bottle salinity data from csv file (ctd/BOTTLE_SAL/) and create .nc file
		msal_02	sam_ar304_nnn.nc	Past salinity data into mstar sample file
		mnut_01_ar304	nut_ar304_nnn.nc	Read unique reference numbers from csv files (ctd/BOTTLE_NUT/) and create .nc file
		mnut_02_ar304	sam_ar304_nnn.nc	Paste nutrient reference sample number into the mstar sample file
		msam_apend_dy078 OR msam_update_all	sam_ar304_all.nc	Append the cast sample file into the global sample file. OR In case of reprocessing, the cast updated the appended global sample file

15 CTD Oxygen Calibration

Stuart Cunningham, Clare Johnson, Loic Houpert, 17th July 2018

Sensor raw voltages [V] are converted to dissolved oxygen concentrations [µmol/kg] using the Sea-Bird DO calibration (equation 1), which is a modified version of the Owens and Millard (1985) equation.

• The calibration slope term *(Soc)*, which changes as the sensor sensitivity is modified, typically by fouling.

• An electronic offset term (*Voffset*) related to the voltage output observed at a zero-oxygen signal is unique to each sensor and is constant.

• A third-order polynomial component that compensates for changes in the sensor's sensitivity as a function of temperature remains constant.

• An exponential term that compensates for the instantaneous changes in the sensitivity of the sensor with changes in pressure (*E*) can be modified to fine tune deep-ocean oxygen data.

Following recommendations in SBE Application Note No. 64-3 (Revised August 2014) *SBE 43 Dissolved Oxygen (DO) Sensor – Hysteresis Corrections* were also applied. In Seabird Data Processing Data Conversion module (DatCnv) we convert to DO applying both Tau in (equation 1) and hysteresis corrections (equation 2) using the default window size of two seconds for oxygen calculations. We did not investigate whether Tau improved or degraded signal-to-noise in deep water. Data Conversion first applies a hysteresis correction on SBE 43 voltage values, and then uses the corrected voltages to convert to DO. Therefore, both columns of output DO data (voltage and concentration) contain data that have been corrected for hysteresis.

SBE 64-3 states that default hysteresis coefficients are adequate for most applications and for higher accuracy (±1 µmol/kg), H1 and H3 can be fine-tuned if a complete profile (downcast and upcast) is available, preferably to greater than 3000 meters. We did not have adequate deep profile data to assess this and made polynomial corrections to oxygen hysteresis station-by-station to ensure zero bias between down and up oxygen profiles.

Output units for DO concentration are chosen to match those from the Winkler water sample analysis, here [μmol/kg].

Table 14. SBE 43 Sensors deployed on AR304. The SBE 43 is calibrated using SeaBirds' Equation (1) with the coefficients listed in this table (a modified version of the Owens & Millard (1985) equations). Hysteresis corrections (Equation 2) using the Nominal Coefficients.

Sensor s/n	Calibration Date	Sea-BIRD DO calibration COEFFICIENTS	NOMINAL COEFFICIENTS
0113 [stns 0 & 1;primary channel]	9/5/17	Soc = 0.4615 Voffset = -0.5045 Tau20 = 1.00 A = -3.4961e-003 B = 1.5746e-004 C = -2.3216e-006 E nominal = 0.036	D1 = 1.92634e-4 D2 = -4.64803e-2 H1 = -3.300000e-2 H2 = 5.00000e+3 H3 = 1.45000e+3
0930 [stns all]; secondary channel	17/1/18	Soc = 0.5407 Voffset = -0.4973 Tau20 = 1.37 A = -4.8314e-003 B = 2.4829e-004 C = -3.7331e-006 E nominal = 0.036	D1 = 1.92634e-4 D2 = -4.64803e-2 H1 = -3.300000e-2 H2 = 5.00000e+3 H3 = 1.45000e+3
0712 [stns 2 onward; primary channel]	24/3/17	Soc = 0.4732 Voffset = -0.5163 Tau20 = 0.97 A = -3.6809e-003 B = 1.8661e-004 C = -2.6322e-006 E nominal = 0.036	D1 = 1.92634e-4 D2 = -4.64803e-2 H1 = -3.300000e-2 H2 = 5.00000e+3 H3 = 1.45000e+3

Sea-Bird dissolved oxygen equation

$$O_2 = \left\{ S_{OC} \times \left(V + V_{offset} + tau(T,P) \times \frac{\partial V}{\partial t} \right) \right\} \times O_{xsol}(T,S) \times \left(1.0 + A \times T + B \times T^2 + C \times T^3\right) \times e^{\left(\frac{E \times P}{K}\right)}$$

(Equation 1)

Where: V is SBE43 output voltage signal [volts]; $\partial V / \partial t$ is the time derivative of SBE43 output signal [volts/second]; $tau(T,P) = tau20 \times e^{(D1 \times P + D2 \times [T-20])}$ is the sensor time constant; T,P,S = CTD temperature [°C], pressure (dbar), salinity (psu); $O_{xsol}(T,S)$ is oxygen saturation; K is absolute temperature [K]; Soc, Voffset (voltage at zero oxygen signal), A, B, C, E, tau20 are calibration coefficients fit to 18 point calibration at Factory; D1 and D2 are characteristics of the SBE43 sensor.

Hysteresis Algorithm using Oxygen Voltage Values:

D = 1 + H1 * (exponential(P(i) / H2) – 1)

C = exponential (-1 * (Time(i) – Time(i-1)) / H3)

$Oxygen_{volts}$ (i) = OxVolt(i) + Voffset

$Oxnew_{volts}$ (i) = {($Oxygen_{volts}$ (i) + ($Oxnew_{volts}$ (i-1) * C * D)) – ($Oxygen_{volts}$ (i-1) * C)} / D

$Oxfinal_{volts}$ (i) = $Oxnew_{volts}$ (i) – Voffset

(Equation 2)

where

• **i** = indexing variable (must be a continuous time series to work; can be performed on bin averaged data), where i = 1:end (end is largest data index point plus 1).

• **P(i)** = pressure (decibars) at index point i.

• **Time(i)** = time (seconds) from start of index point i.

• **OxVolt(i)** = SBE 43 oxygen voltage output directly from sensor, with no calibration or hysteresis corrections, at index point i.

• **Voffset** = correction for an electronic offset that is applied to voltage output of sensor. Voffset correction is always negative (see factory calibration sheet for this coefficient). Voffset is added to raw voltages prior to hysteresis correction. At end of hysteresis corrections, Voffset is removed prior to data conversion using SBE 43 calibration equation (see $Oxfinal_{volts}$(i)).

• **$Oxygen_{volts}$ (i)** = dissolved oxygen voltage value with Voffset correction (made prior to hysteresis correction) at index point i.

• **D** and **C** are temporary variables used to simplify expression in processing loop.

• **H1** = amplitude of hysteresis correction function. Default = -0.033, range = -0.02 to -0.05 (varies from sensor to sensor).

• **H2** = function constant or curvature function for hysteresis. Default = 5000.

• **H3** = time constant for hysteresis (seconds). Default = 1450, range = 1200 to 2000 (varies from sensor to sensor).

• **$Oxnew_{volts}$(i)** = hysteresis-corrected oxygen value at index point i.

• **$Oxfinal_{volts}$(i)** = hysteresis-corrected oxygen value at index point i with Voffset removed. This step is necessary prior to computing oxygen concentration using SBE 43 calibration equation.

Notes:

• Scan 0 –You cannot calculate $Oxfinal_{volts}$ (i) for scan 0, because the algorithm requires information about the previous scan, so skip scan 0 when correcting for hysteresis.

• Scan 1 - When calculating $Oxfinal_{volts}$ (i) for scan 1, make the following assumption about values from scan 0: $Oxnew_{volts}$ (0) = $Oxygen_{volts}$ (0).

15.1 CTD SBE43 Sensor Calibrations to Bottle Oxygens

Calibrations have been done with bottle and CTD oxygens in units of µmol/kg. Bottle oxygen samples were sampled on stations 1-30, thereafter every even number CTD was analysed (Figure 11).

Calibration of the SBE43 requires the computation of the botoxy/uxoy ratio as a correction, accounting for the change in output response of the sensor due to fouling. Here we compute this ratio and apply this to the SBE43 output values (rather than changing the Soc coefficient and rerunning the DatCnv module). Seabird state that a correction ratio > 1.0 indicates sensor is fouling (drifting low). Further if the correction factor is greater than 15-20% of original factory Soc (Table 15), the sensor may need to be returned for factory service.

Calibration Determination:

We used scripts: *sbe43_sam_oxy_cal_03.m* & *sbe43_sam_oxy_cal_stn1_primary.m*

1. Exclude data outliers
2. Examine bottle and uoxy data and oxy_diff (botoxy-uxoy) differencies as a function of pressure.
3. Plot oxy_ratio (botoxy/uoxy) against botoxy and; oxy_diff against station number.
4. Apply oxy_ratio correction to uxoy and replot.
5. Determine a final correction to uoxy as a function of pressure and plot final residuals against pressure.

Table 15. Corrections determined from comparison of upcast CTD oxygen to bottle oxygen. Apply Ratio correction then Press_corr. Botoxy-uoxy are the final residual statistics of calibrated CTD oxygen. Oxygen Units: µmol/kg. Note that the correction ratios imply that sensors 0113, 0712 and 0930 are within 4%, 7% and 1% of factory calibrations respectively.

Sensor s/n	Ratio (press>0dbar): (botoxy/uoxy) Mean±SD	Press Corr Uoxy_corr = P1 + P2xpress	Ratio (press>1400dbar): (botoxy/uoxy) Mean±SD	Press Corr Uoxy_corr = P1 + P2xpress	Botoxy-uoxy (final calibration) Mean±SD
0113 (1)	1.0479±0.01611	-0.56, +0.00049	1.0507±0.02647	-1.26, +0.00049	0.0±4.08
0712 (1)	1.0729±0.01212	-0.99, +0.00115	1.0782±0.012802	-2.29, +0.00160	0.0±2.84
0930 (2) STNS: 1-19	1.0152±0.009578	-0.6, +0.0010	1.0177±0.012034	-1.23, +0.00102	0.0±2.36
0930 (2) 20-90	1.0085±0.012547	-1.74, +0.00190	1.0167±0.011771	-3.88, +0.00190	0.0±2.92

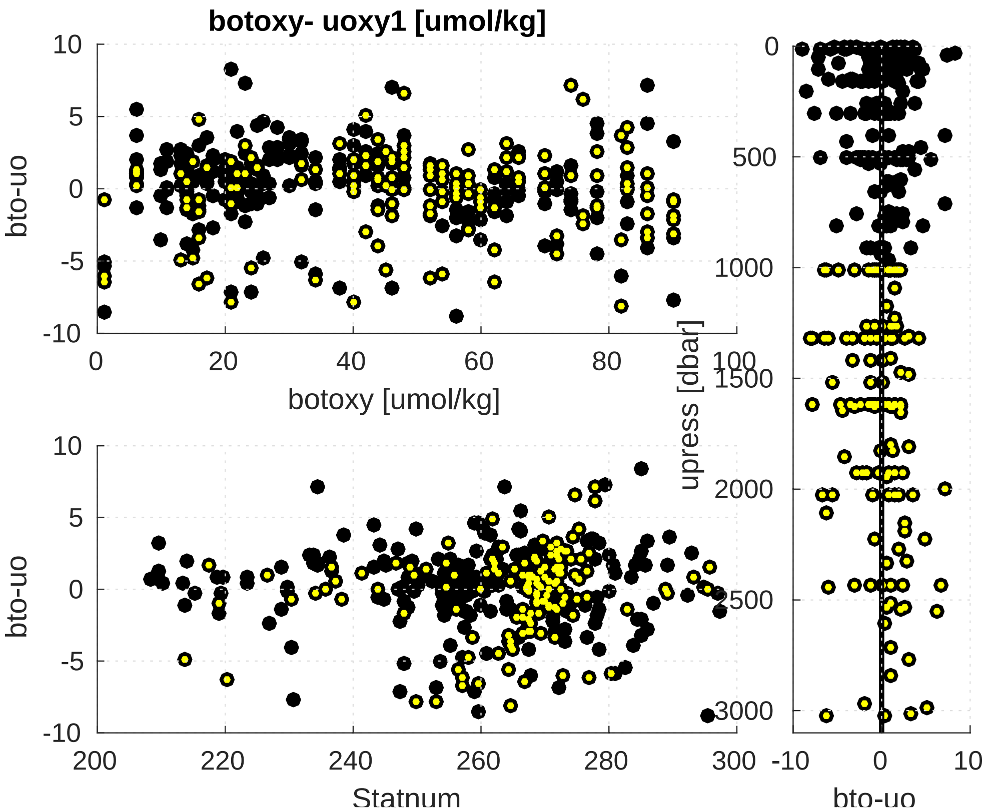


Figure 12. SBE43: Bottle oxygen – uoxygen 1 after ratio and pressure residual calibrations. Ratio correction uses bottles > 1400 dbar. Pressure correction across full range of pressures.

15.2 Correction of Residual Hysteresis Between CTD Oxygen down and upcast

Calibration of the CTD oxygen is developed by a comparison of bottle oxygens to upcast CTD oxygens at bottle stops. For this to be applied to the down cast CTD oxygen it is important that there is no hysteresis between down and up CTD profiles.

After application of the default SeaBird hysteresis corrections as described above, we noted a small difference remained between down and upcast CTD oxygens as evaluated at equivalent pressures on down and up. This residual was of order ±1.5 μmol/kg in the mean, but could be two or three times this value at mid-depth (~1000-2500 dbar).

The principal improvement is to remove any mean oxygen bias between up and down profiles.

seb43_oxy_cal_hysteresis.m

1. Match down and upcast CTD profiles on press and compute oxygen differences.
2. Fit a second order polynomial to the oxygen difference.
3. Plot the parameters of this fit as a function of depth and station number.
4. Apply the fit and plot the new oxygen residuals.

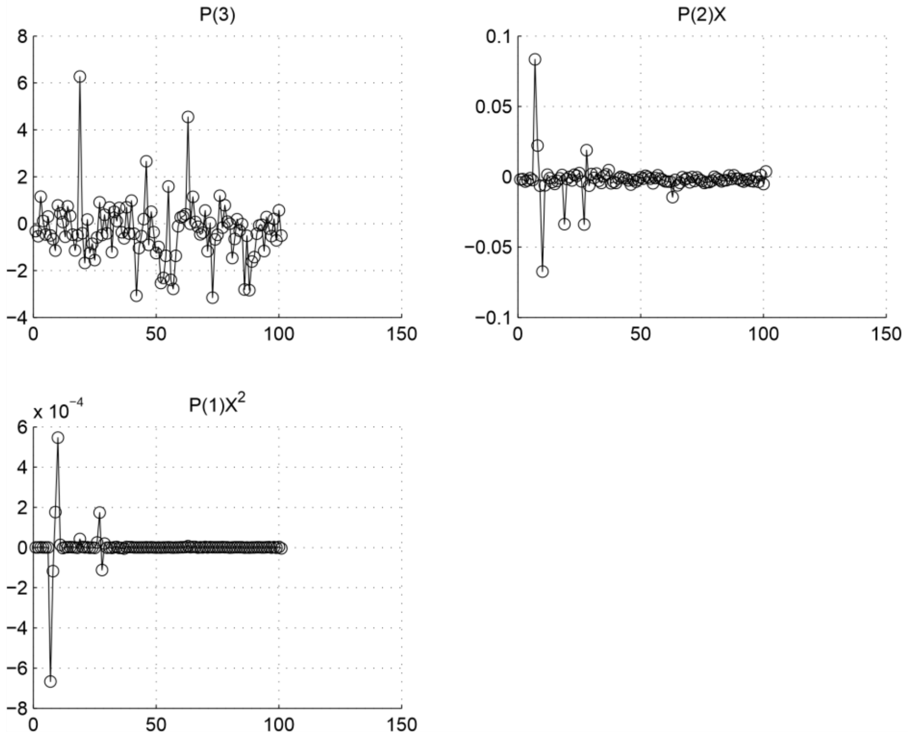


Figure 13. Polynomial coefficients for the oxygen differences between up and down casts. CTD station number on x axis.

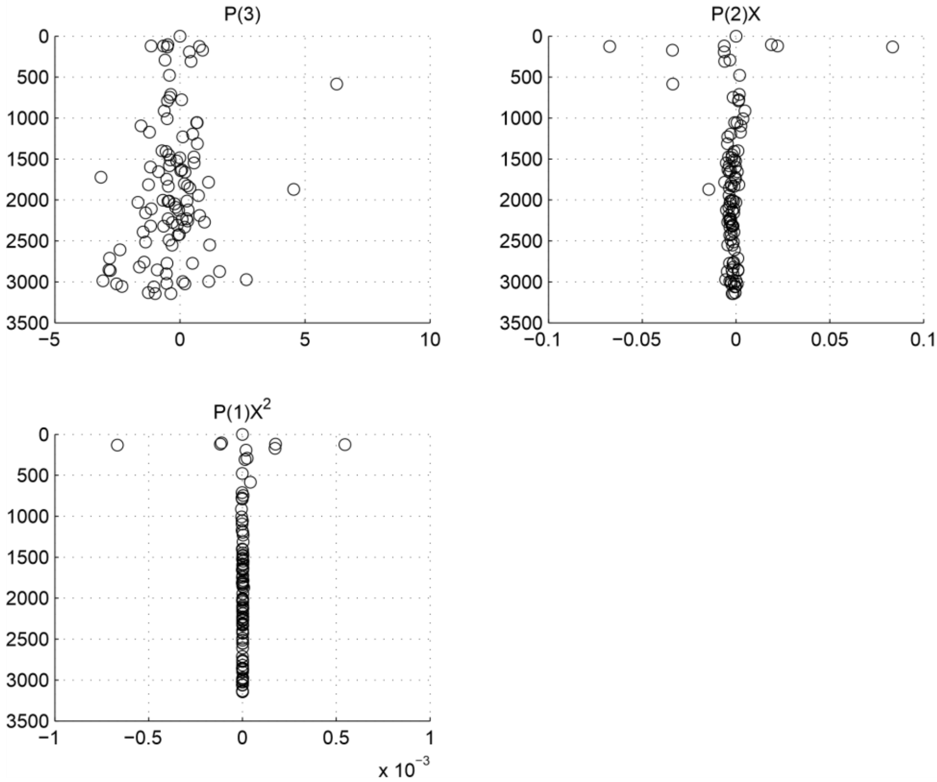


Figure 14. Polynomial coefficients for the oxygen differences between up and down casts, plotted against maximum CTD pressure

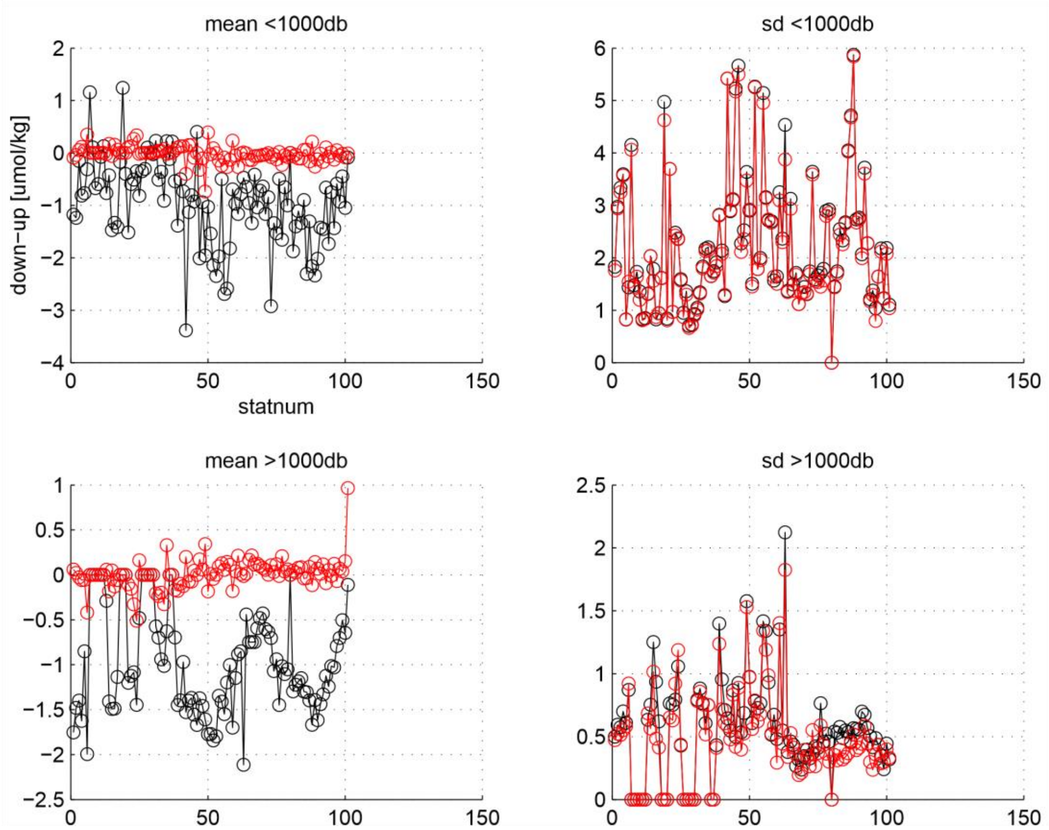


Figure 15. Comparison of CTD statistics for uncorrected (black) and corrected (red) data.

16 MSTAR computer setup & Data archiving/backups

Loic Houpert

16.1 Data Share & Public Disks

All scientific cruise data were stored on a network drive *data_on_memory* organised with a standard template of folders. All the CTD and underway data (ADCP, multibeam, echosounder, metocean,…) were backed up at the end of the cruise on the SAMS workstation and on external hard drive. In addition the network drive *science_share* was used to shared data, figures, documents between the scientists.

16.2 Visiting Workstations from SAMS

The SAMS workstation used for scientific processing and archiving of data was a Linux workstation (running OS Lubuntu 16.04) and was installed on shore before the AR304 cruise. A clone of the hard drive was installed on a second Linux workstation which was brought on board as a backup system.

The ship network drives *science_share and data_on_memory* were mounted on the SAMS workstation using these commands:

sudo mount -t cifs //10.100.100.30/science_share /mnt/public -o username=science,rw

sudo mount -t cifs //10.100.100.30/data_on_memory /mnt/armstrong -o username=science

Backups were made automatically every hour on external 2TB hard drives attached to the SAMS workstations, by using Back In Time (a free backup software similar to Time Machine on Mac). Back In Time uses rsync as a backend and has the characteristic feature of using hard links for files that are identical in snapshots at different times, thus using disk space just once for files that remained unchanged. Advantages of the hard link method are that it is easy to look at snapshots of the system at different times and to remove old snapshots.

17 Appendix

17.1 Mooring Recovery Log sheets

17.1.1EB1

OSNAP – MOORING LOGSHEET **RECOVERY EB1**

Cruise AR30-04 **Mooring id Rockall Trough EB1**
[NB all times recorded in GMT, all dates dd/mm/yyyy]

Anchor drop position:
Latitude: 57.1005°N Longitude: -9.5638°E
Corrected water depth (at anchor launch): 1817m

Date 07/07/2018 Site arrival time 7:45
Start time 0800 End time
Start position:
Latitude Longitude

Item	S/N	Comments	Time
McLane 12" ✓	/		0805
15 m polyprop ✓	/		
10 x 17" glass	/		0824
5m chain	/		
RAS-500 14262 RAS-500-frame SeaFET/ODO SBE37 SMP ✓	14262-01 ✓ ✓ 721-0117 ✓ 11343 ✓	Heavy fouling	0836
40 m wire ✓	/		
1 m chain ✓	/		
31" syn 1500 m and Iridium beacon and Light ✓	B11-044 B11-035		0842
4 m chain ✓	/		"
Nortek on load bar ✓	11069		"
41 + 100 m wire	/		
SBE37 SMP (2 m down wire) ✓	11342		0845
Nortek on load bar ✓	11042	Anenome on one transducer	0850
241 m wire	/		
SBE37 SMP (6 m down wire) ✓	11341		0852
1 m chain ✓			
40" synt 1500 m and	/		0858

OSNAP – MOORING LOGSHEET **RECOVERY EB1**

Iridium beacon **and** Light	B11-047 B11-028	Big funkles of 3/16 round	
4 m chain		bouy	
Nortek on load bar	11047	6 × 3/16 lines on deck !	
65 + 78 m wire	/	1× 1/4 line on deck !	
SBE37 SMP (5 m down wire)	11338 ✓	No additional MC-ODO instrument for this depth (500 m)	0915
6 x 17" glass	✓		0916
248 m wire	/		
SBE37 SMP (7 m down wire)	11335 ✓		0904
SBE37-ODO (1 m down wire)	15254 ✓		0911
SBE37-ODO (200 m down wire)	14987 ✓		0924
4 x 17" glass			
Nortek on load bar	11055 ✓		0926
349 m wire	/		
SBE37 SMP (6 m down wire)	11334 ✓		0928
SBE37 SMP (245 m down wire)	11330 ✓		0933
2 x 17" glass	/		
Swivel	/		
Nortek on load bar	11046 ✓		0946
138 m wire	/		
4 x 17" glass	/		
274 m wire	/		
SBE37 SMP (6 m down wire)	11327 ✓		0942
SBE37-ODO (100 m down wire)	15298 ✓		0948
SBE37 SMP (165 m down wire)	11325 ✓		0953
Nortek on load bar	13018 ✓		0955
10 + 5 m wire	/		
8 x 17" glass			
A/R **and** A/R	1999 ✓ 1758 ✓	ARM 0B16 ARM 1A0D	

5 m chain	/		
Anchor – 2100 kg		Ponged 1887m	

Comments to be written overleaf

07:45:05 1887m.
07:45:30. 1843.2m.
0748:00. 1769.5m
07:47:00 no ans. no ans.
0747:45 1602.1m 1597.7m
:49:00. 1484.5 1474.9m.
52:00 1311.7m 1307.7m

17.1.2 WB1

OSNAP – MOORING LOGSHEET **RECOVERY WB1**

Cruise AR30-04 **Mooring id** Rockall Trough WB1
[NB all times recorded in GMT, all dates dd/mm/yyyy]

Anchor drop position:

Latitude: 57.4694°N Longitude: -12.7056°E

Corrected water depth (at anchor launch): 1601m

Date 06/07/2018 Site arrival time 07:30

Start time Released 7:41, Top buoy 8:08 End time

Start position:

Latitude Longitude

Item	S/N	Comments	Time
McLane 12"	/		8:08
15 m poly prop	/		
4 x 17" glass	/		8:24
45 m wire			
SBE37 SMP (4 m down wire)	11290		8:24
31" synt 1500 m and Iridium Beacon and Light	/ J1OJL1 B11-049		8:32
5 m chain			
Nortek on load bar	11021		8:37
145 m wire	/		
SBE37 SMP (6 m down wire)	11289		8:39
234 m wire	/		
SBE37 SMP (2 m down wire)	11288		8:42
40" synt 1500 m and Iridium beacon and Light	/ J01NK1 B11-032		
5 m chain	/		
Swivel	/		
Nortek on load bar	9859		
65 m wire	/		
SBE37 SMP (5 m down wire)	11287		8:53
364 m wire	/		
SBE37 SMP	10577		8:59

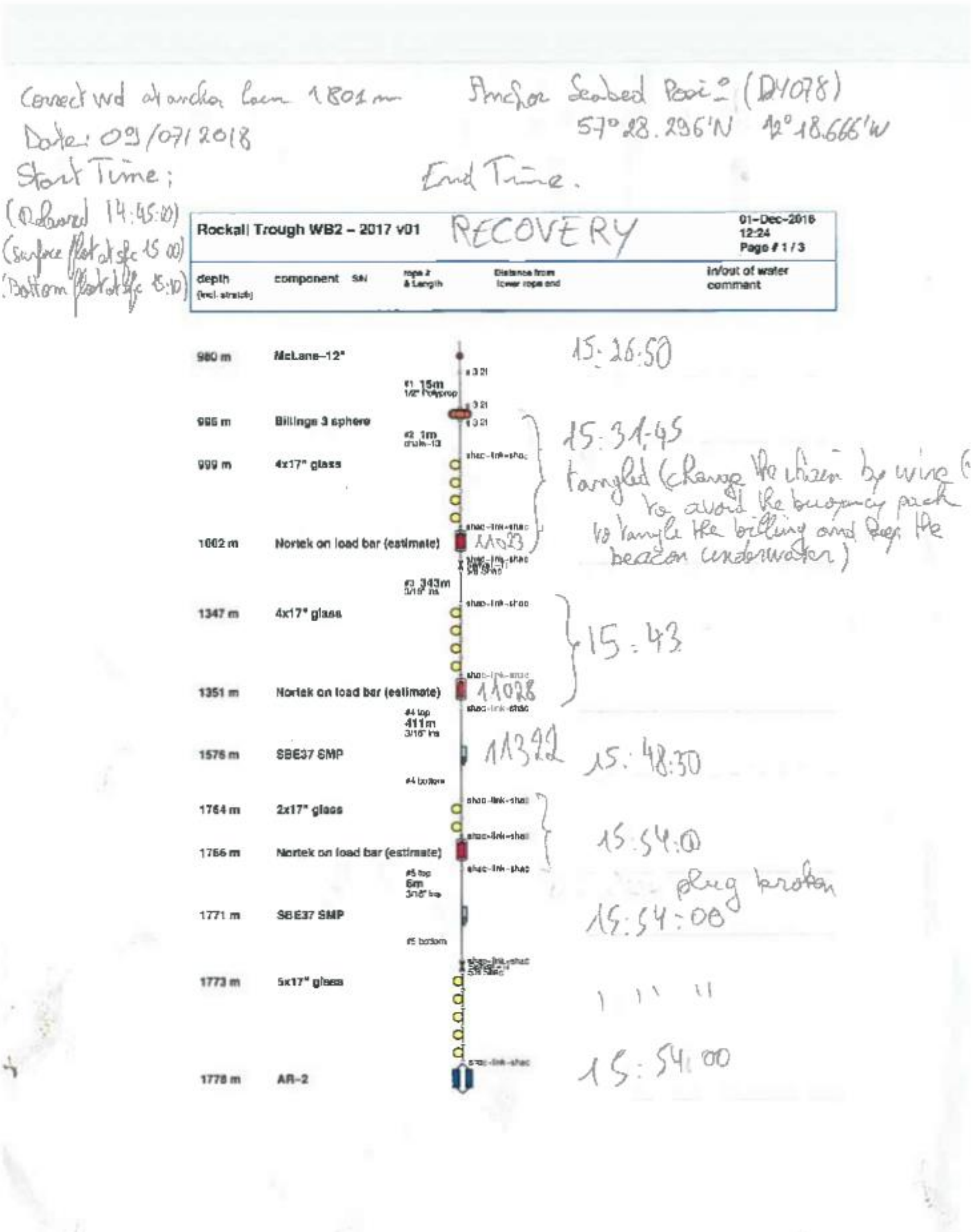
OSNAP – MOORING LOGSHEET RECOVERY WB1

(192 m down wire)			
65 m wire	/		
5 x 17" glass	/		9:04
Nortek on load bar	11026	lanyarded	
201 m wire	/	with 10560	
SBE37 SMP (6 m down wire)	3276		
4 x 17" glass	/		9:16
Swivel	/		
143 m wire	/		
SBE37 SMP (48 m down wire)	9375	lanyarded	9:16
4 x 17" glass	/		
Nortek on load bar	9854		0930
(*) 215 m wire	/		
SBE37 SMP (149 m down wire)	10560		9:04
2 x 17" glass	/		
Nortek on load bar	11029	Baby mussels & photo	0935
15 m wire	/		
SBE37 SMP (5 m down wire)	9377		0937
8 x 17" glass	/		
A/R and A/R and	1137 1752	ARM 0825 ARM 1A07	0939
5 m chain	/		
Anchor – 2100 kg	/		

Comments to be written below or overleaf

(*) red wire mark! no instrument, but no clamp marks on wire (previous mark) ours are black

17.1.3 WB2



Connect wd at anchor from 1801 m
Anchor Seabed Posi: (DY078)
57°28.296'N 12°18.666'W
Date: 09/07/2018
Start Time:
End Time.
(Released 14:45:00)
(Surface float at sfc 15:00)
(Bottom float at sfc 15:10)
Rockall Trough WB2 – 2017 v01
RECOVERY
01-Dec-2016
12:24
Page # 1 / 3
depth (incl. stretch)
component SN
rope # & Length
Distance from lower rope end
in/out of water comment
980 m
McLane-12"
15:26:50
#1 15m 1/2" Polyprop
995 m
Billings 3 sphere
15:31:45
#2 1m chain-13
999 m
4x17" glass
tangled (change the chain by wire to avoid the buoyancy pack to tangle the billing and keep the beacon underwater)
1002 m
Nortek on load bar (estimate)
11023
#3 343m 3/16" ns
1347 m
4x17" glass
15:43
1351 m
Nortek on load bar (estimate)
11028
#4 top 411m 3/16" ns
1576 m
SBE37 SMP
11322
15:48:30
#4 bottom
1764 m
2x17" glass
1766 m
Nortek on load bar (estimate)
15:54:00
#5 top 6m 3/16" ns
plug broken
1771 m
SBE37 SMP
15:54:00
#5 bottom
1773 m
5x17" glass
1778 m
AR-2
15:54:00

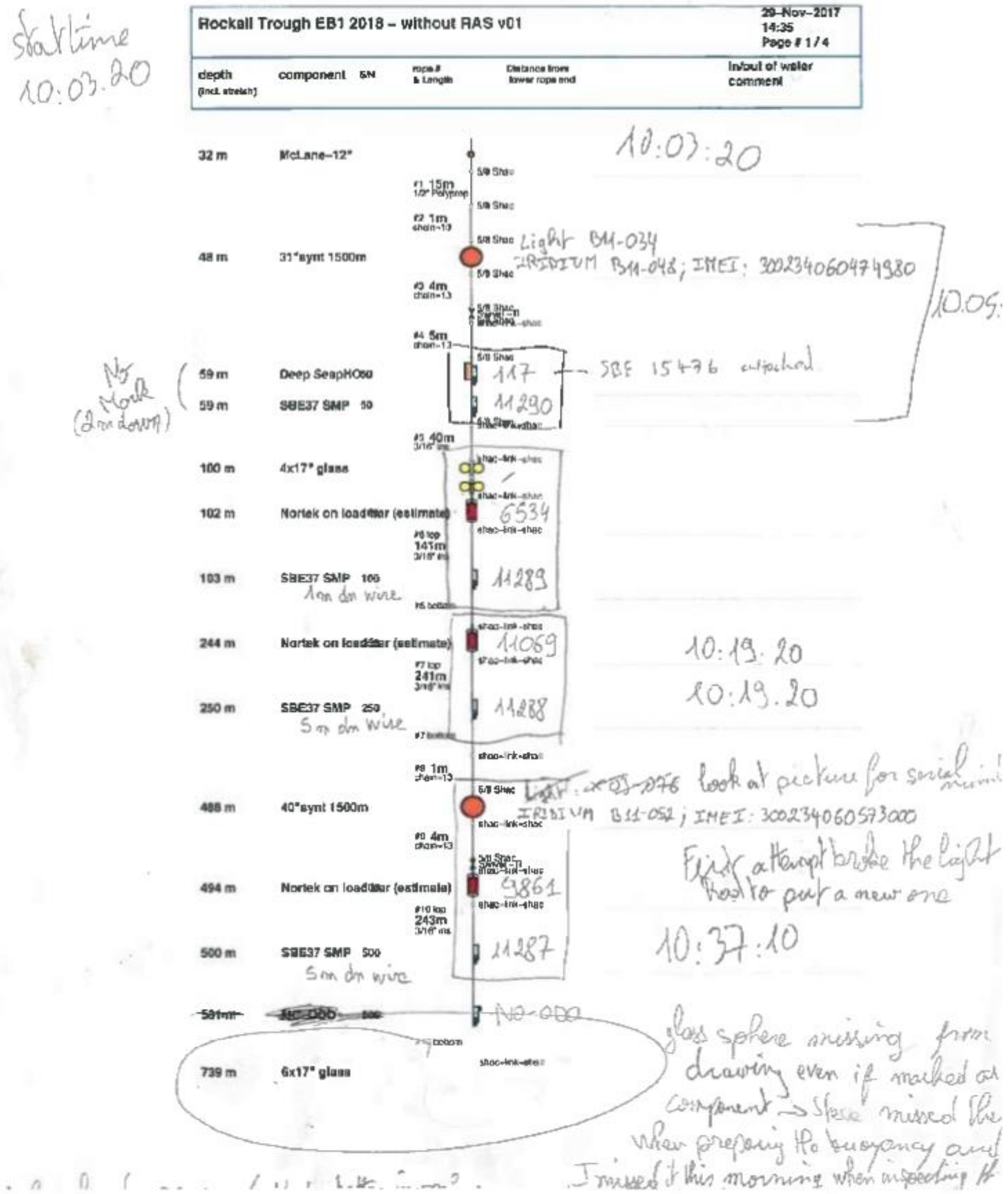
Rockall Trough WB2 – 2017 v01

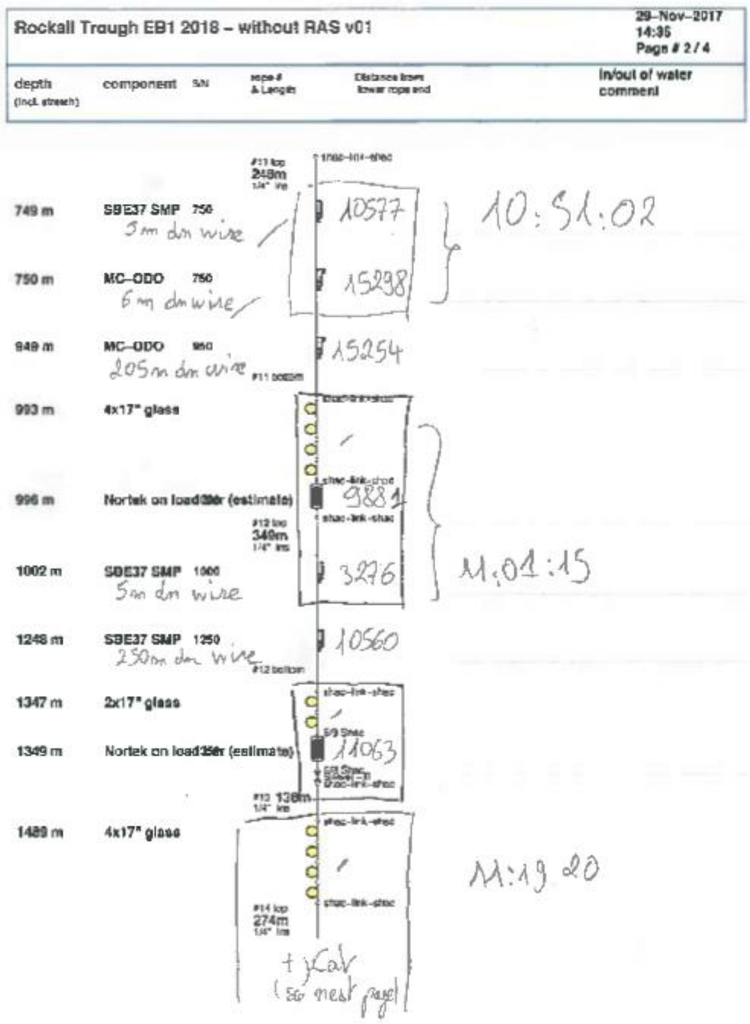
01–Dec–2016
12:24
Page # 2 / 3

depth (incl. stretch)	component	S/N	rope # & Length	Distance from lower rope end	in/out of water comment
			#6 20m chain – 13	3/4 Shac / 3/4 Shac	
1799 m	Anchor 790 kg (dry weight) (Wet weight = 609kg) (Safe weight = 704kg)				

17.2 Mooring Deployment Log sheets

17.2.1 EB1





Rockall Trough EB1 2018 – without RAS v01
29-Nov-2017
14:35
Page # 2/4
depth (incl. stretch)
component
S/N
rope # & Length
Distance from lower rope end
in/out of water comment
#11 top 248m 1/4" line
shac-link-shac
749 m
SBE37 SMP 750
5 m dn wire
10577
10:51:02
750 m
MC–ODO 750
6 m dn wire
15298
949 m
MC–ODO 950
205 m dn wire
15254
#11 bottom
993 m
4x17" glass
shac-link-shac
996 m
Nortek on load (estimate)
9881
shac-link-shac
#12 top 340m 1/4" line
1002 m
SBE37 SMP 1000
5m dn wire
3276
11:01:15
1248 m
SBE37 SMP 1250
250m dn wire
10560
#12 bottom
1347 m
2x17" glass
shac-link-shac
1349 m
Nortek on load (estimate)
11063
#13 138m 1/4" line
1489 m
4x17" glass
shac-link-shac
11:19 20
#14 top 274m 1/4" line
+ μCat (see next page)

Rockall Trough EB1 2016 – without RAS v01

29–Nov–2017
14:35
Page # 3 / 4

depth (incl. stretch)	component	S/N	rope # & Length	Distance from lower rope end	In/out of water comment
1497 m	SBE37 SMP 5 m dn wire	1600		10562	11:20:35
1598 m	SMP 105m dn wire	1630		9113	11:23:30
1762 m	SBE37 SMP 269 m dn wire	1780	#14 bottom	9375	11:28:11
1765 m	Nortek on load bar (estimate)		#15 15m 1/4" wire	shac-lnk-shac 9874 shac-lnk-shac	11:30:32
1784 m	8x17" glass			shac-lnk-shac 2x4 shac-lnk-shac	11:35:10
1796 m	AR-2		1.5m chain	5/8 Shac 2307 ARM 1B7F 2308 ARM 1B80	Anchor ready on deck at 11:53 Need extra 50 mins to reach anchor drop posi ? (at 1 knot)
1799 m	Anchor 2100 kg (dry weight) (Wet weight = 1827kg) (Safe weight = 1745kg)		5m #17 chain	5/8 Shac	

Anchor drop time : 12:42:08
Depth : 1817m

17.2.2 IB3

OSNAP – MOORING LOGSHEET DEPLOYMENT IB3

Cruise AR30-04 **Mooring id** Iceland Basin IB3

[NB all times recorded in GMT, all dates dd/mm/yyyy]

Date 3/7/18 Site arrival time 1411

Setup distance 4nm

Start time 1414 End time 1628

Start position:

Latitude ________ Longitude ________

Item	S/N	Comments	Time
McLane 12"	/		1415
15 m polyprop	/		"
2 x 17" glass	/		"
44 m 3/16" ins	/		" (1/2 km)
SBE37 SMP 50 (4m down wire)	9378		1416
2x ADCP – 1500m 44" 95 (xm down wire) (UP 20960, DN 20957)	B11-045 B11-027	IMEI 300234060476980	1424 (3/4 km)
5 m chain	/		"
Swivel	/		"
197 m 3/16" ins	/	Two lengths.	" (1 km)
SBE37 SMP 100 (5 m down wire)	13019	← join	"
SBE37 SMP 200 (100 m down wire)	10561		1428
8 x 17" glass	/		1437
Swivel	/		"
587 m 3/16" ins	/	Two lengths	"
SBE37 SMP 350 (44 m down wire)	13021		1439
SBE37 SMP 500 (194 m down wire)	8081	← wire join	1442
SBE37 SMP 700 (394 m down wire)	10579		1449
4 x 17" glass			1455
594 m 3/16" ins	/	Two lengths	
SBE37 SMP 900 (5 m down wire)	11324		1456 30
SBE37 SMP 1200 (304 m down wire)	11321		15 04
4 x 17" glass			15 10 30

OSNAP – MOORING LOGSHEET **DEPLOYMENT IB3**

Nortek on load bar 1496	9822		151030
395 m 1/4" ins			
SBE37 SMP 1500 (5 m down wire)	8080		1513
4 x 17" glass			1521
Swivel	/		
395 m 1/4" ins	/	Two Lengths	
SBE37 SMP 1900 (5 m down wire)	10578		1522
4 x 17" glass			1532
Nortek on load bar 2297	6723		1532
495 m 1/4" ins	/		
SBE37 SMP 2300 (5 m down wire)	11340		1534
2 x 17" glass	/		1546
Nortek on load bar 2746	11034		1546
5 m 1/4" ins	/		
20 m 1/4" ins	/		
SBE37 SMP 2800 (5 m down wire)	11336		1548
6 x 17" glass			1552
1.5 m chain			
A/R and A/R (*)	~~SN1753~~ ~~SN1272~~	~~ARM 1A08 REL 1A55~~ ~~ARMORED 0855~~	1559
10 m chain	/		
Anchor – 1900 kg (dry weight)			162750

Anchor drop position:

Latitude 57°59.564 Longitude 24°21.325 (Time 16:27:30)

Uncorrected water depth (at anchor launch) 2864 m

Corrected water depth (at anchor launch) 2854 m

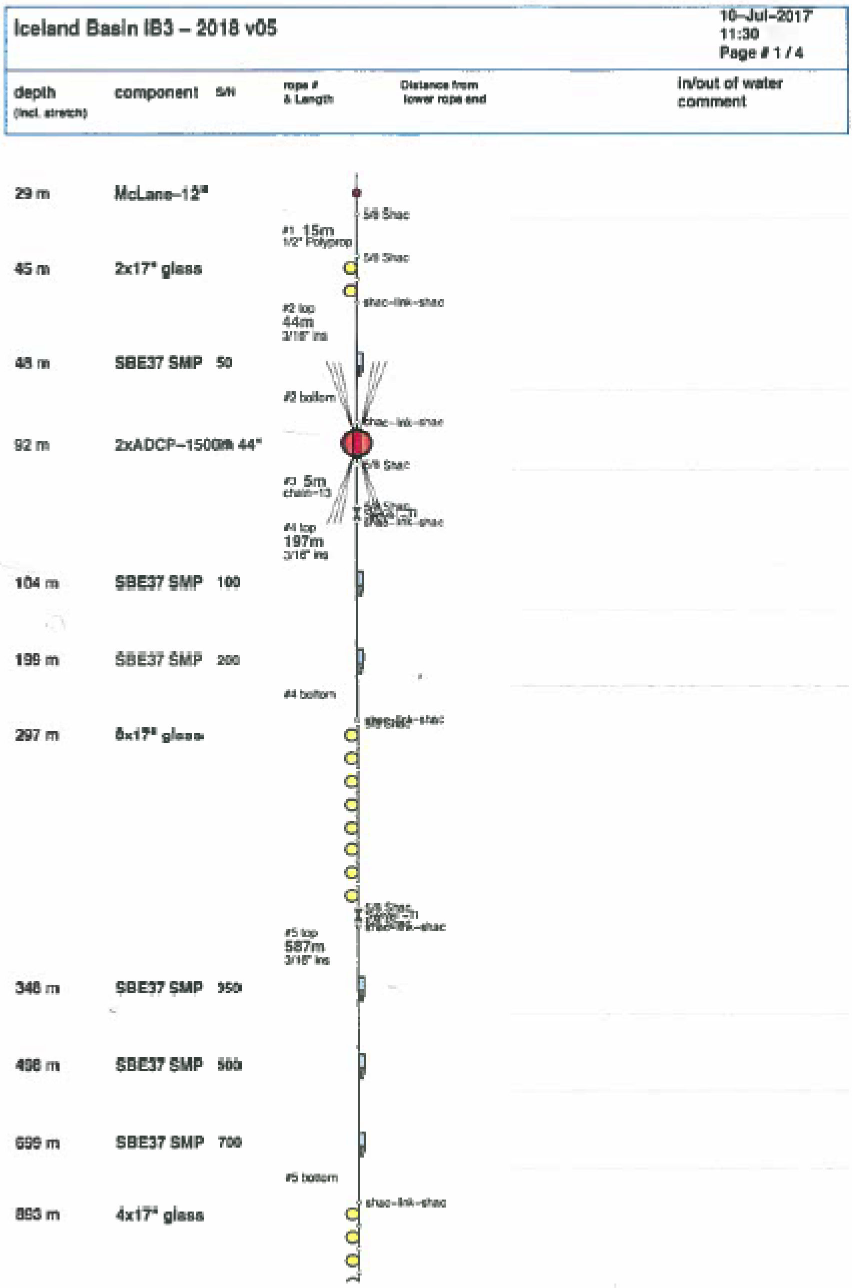
Comments to be written overleaf

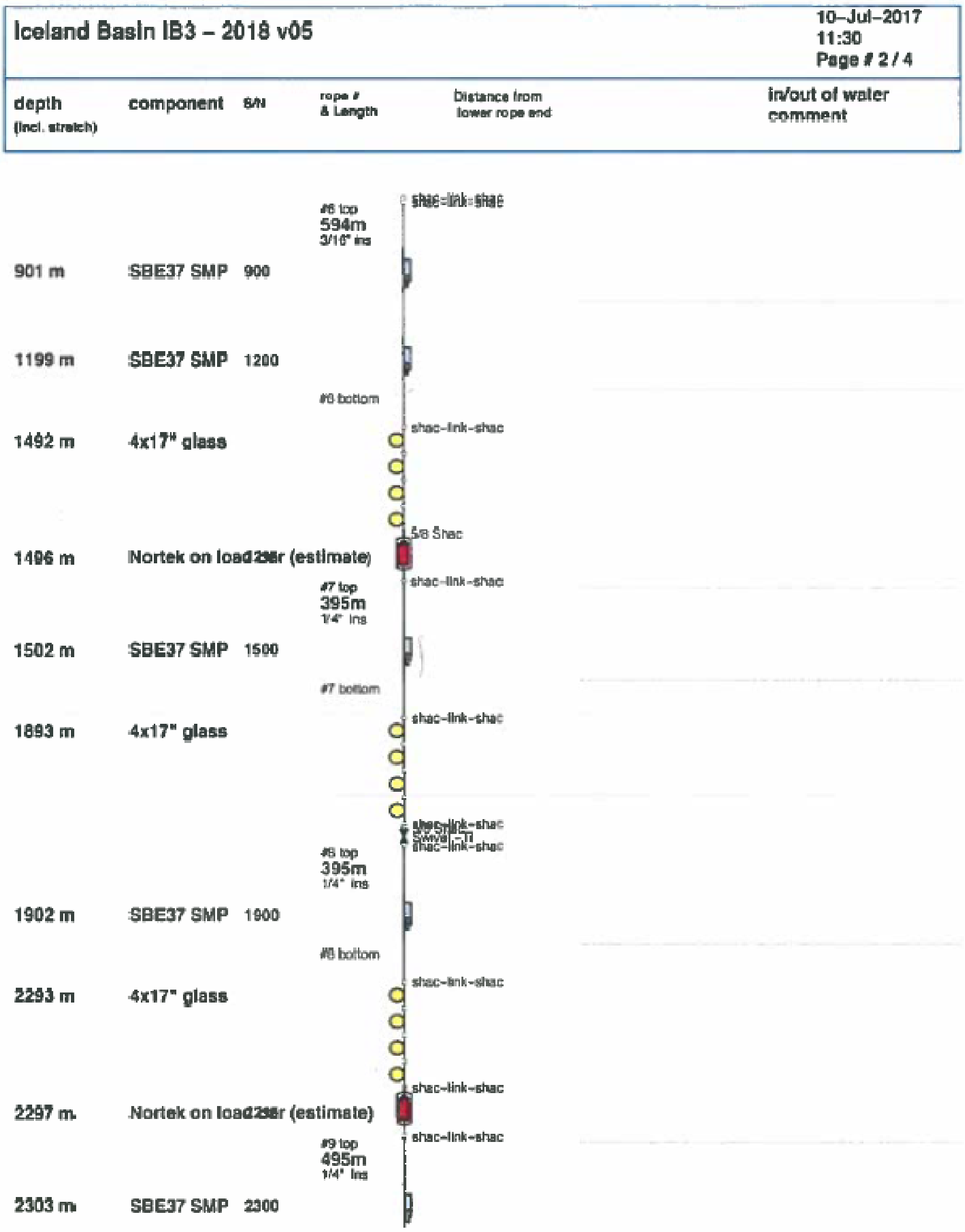
(*) SN 2000 ARM 0B17
SN 1759 ARM 1A03

IB3 trilateration - 20:14 20
East position: Lat 57°59.615 | 3609.1 m
Lon 24°19.007 | 3609.1 m
20:14:45s
3609.1 m
3609.1 m

Anchor Seabed 57.9901 N 57° 59.406' N
-24.3534 W 24° 21.204' W

Fallback 318m

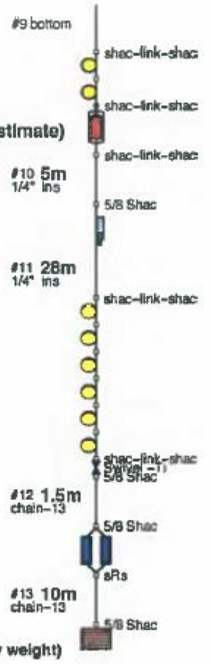

Iceland Basin IB3 – 2018 v05
10-Jul-2017
11:30
Page # 1 / 4
depth
(incl. stretch)
component
S/N
rope #
& Length
Distance from
lower rope end
in/out of water
comment
29 m
McLane-12"
5/8 Shac
#1 15m
1/2" Polyprop
5/8 Shac
45 m
2x17" glass
shac-link-shac
#2 top
44m
3/16" ins
48 m
SBE37 SMP
50
#2 bottom
shac-link-shac
92 m
5/8 Shac
#3 5m
#4 top
197m
3/16" ins
104 m
SBE37 SMP
100
199 m
SBE37 SMP
200
#4 bottom
297 m
#5 top
587m
3/16" ins
348 m
SBE37 SMP
499 m
SBE37 SMP
699 m
SBE37 SMP
700
#5 bottom
shac-link-shac
893 m
4x17" glass


Iceland Basin IB3 – 2018 v05
10–Jul–2017
11:30
Page # 2 / 4
depth
(incl. stretch)
component
S/N
rope #
& Length
Distance from
lower rope end
in/out of water
comment
shac–link–shac
#6 top
594m
3/16" ins
901 m
SBE37 SMP
900
1199 m
SBE37 SMP
1200
#6 bottom
shac–link–shac
1492 m
4x17" glass
5/8 Shac
1496 m
Nortek on load
(estimate)
shac–link–shac
#7 top
395m
1/4" ins
1502 m
SBE37 SMP
1500
#7 bottom
shac–link–shac
1893 m
4x17" glass
shac–link–shac
Swivel – Ti
shac–link–shac
#8 top
395m
1/4" ins
1902 m
SBE37 SMP
1900
#8 bottom
shac–link–shac
2293 m
4x17" glass
shac–link–shac
2297 m
Nortek on load
(estimate)
shac–link–shac
#9 top
495m
1/4" ins
2303 m
SBE37 SMP
2300

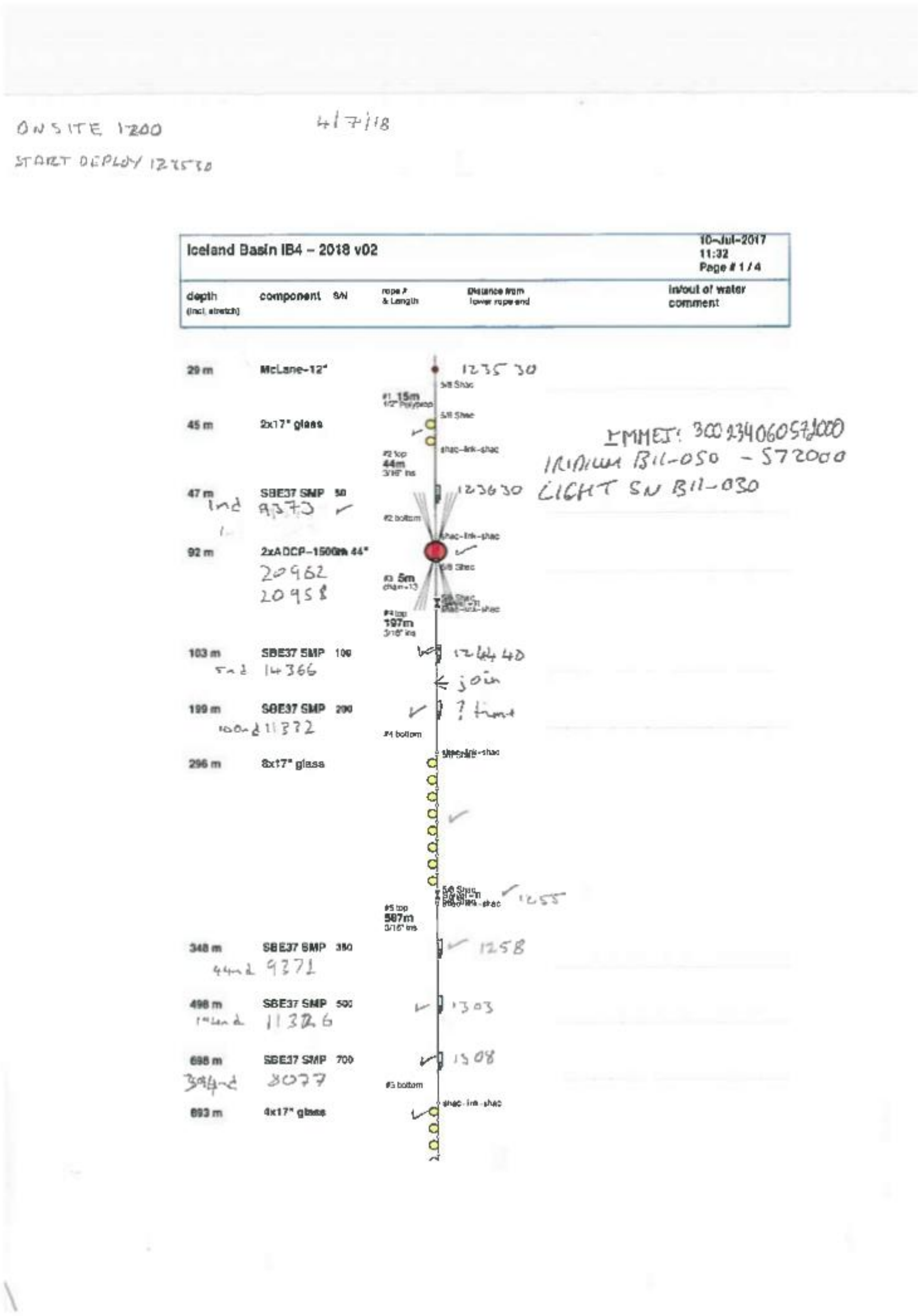
Iceland Basin IB3 – 2018 v05

10–Jul–2017
11:30
Page # 3 / 4

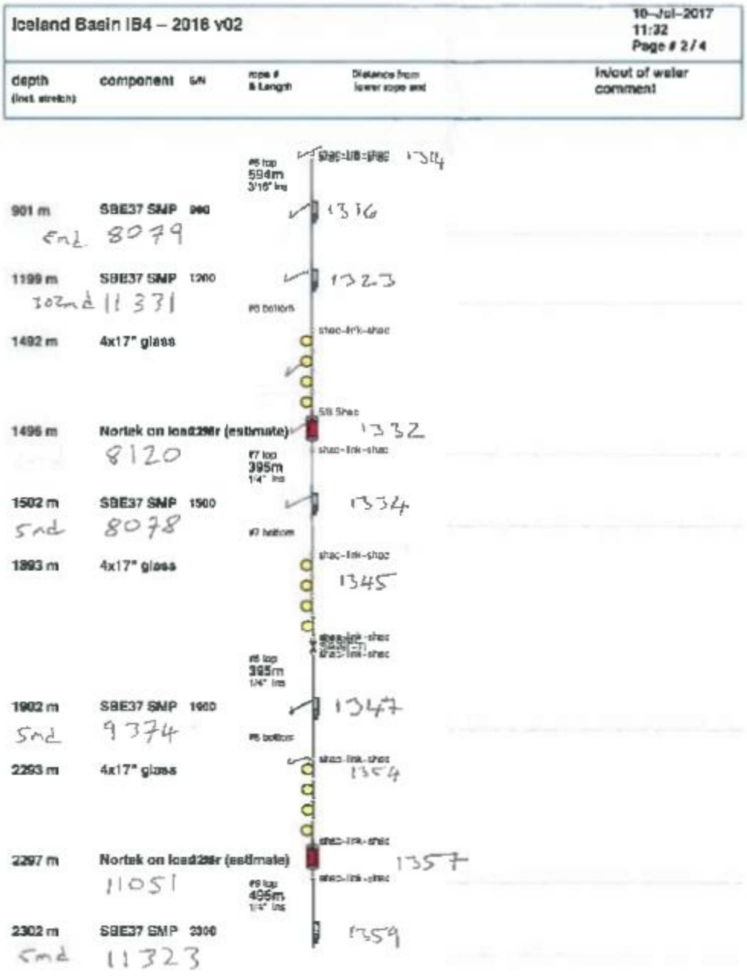
depth (incl. stretch)	component	S/N	rope # & Length	Distance from lower rope end	in/out of water comment
2794 m	2x17" glass				
2796 m	Nortek on load 7??			r (estimate)	11034
2802 m	SBE37 SMP	2800			11336
2831 m	6x17" glass				
2838 m	AR-2				2000 / 11754
2849 m	Anchor 1900 kg (dry weight) (Wet weight = 1653kg) (Safe weight = 1695kg)				

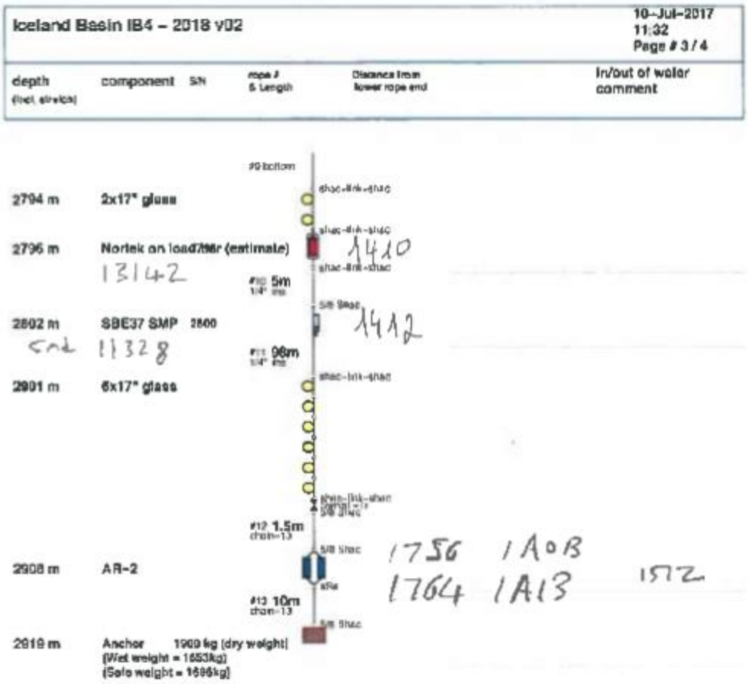


17.2.3 IB4



ONSITE 1200
4/7/18
START DEPLOY 123530
Iceland Basin IB4 – 2018 v02
10-Jul-2017
11:32
Page # 1 / 4
depth (incl. stretch)
component S/N
rope # & Length
Distance from lower rope end
in/out of water comment
29 m McLane-12"
123530
45 m 2x17" glass
IMMEI: 300234060572000
IRIDIUM B11-050 - 572000
LIGHT SN B11-030
47 m SBE37 SMP 50
92 m 2xADCP-1500m 44"
20962
20958
103 m SBE37 SMP 100
124440
199 m SBE37 SMP 200
296 m 8x17" glass
1255
348 m SBE37 SMP 350
1258
498 m SBE37 SMP 500
1303
698 m SBE37 SMP 700
1308
893 m 4x17" glass


Iceland Basin IB4 – 2016 v02
10-Jul-2017
11:32
Page # 2 / 4
depth
(incl. stretch)
component
S/N
rope #
& Length
Distance from
lower rope end
In/out of water
comment
594m
901 m
SBE37 SMP
8079
1316
1199 m
SBE37 SMP
1200
11371
1323
1492 m
4x17" glass
1496 m
Nortek on load2Mr (estimate)
8120
1332
395m
1502 m
SBE37 SMP
1500
8078
1334
1893 m
4x17" glass
1345
395m
1902 m
SBE37 SMP
1900
9374
1347
2293 m
4x17" glass
1354
2297 m
Nortek on load2Mr (estimate)
11051
1357
495m
2302 m
SBE37 SMP
2300
11323
1359



Bills M4 had long. wire wrapped around top 100m.

[1417. 0,3 miles from target posit, speed 1,5 knots]

Anchor drop position:

Time: 15:11:55

Lat: 57°59.425'N

21°08.910'N

Water Depth uncorrected (292

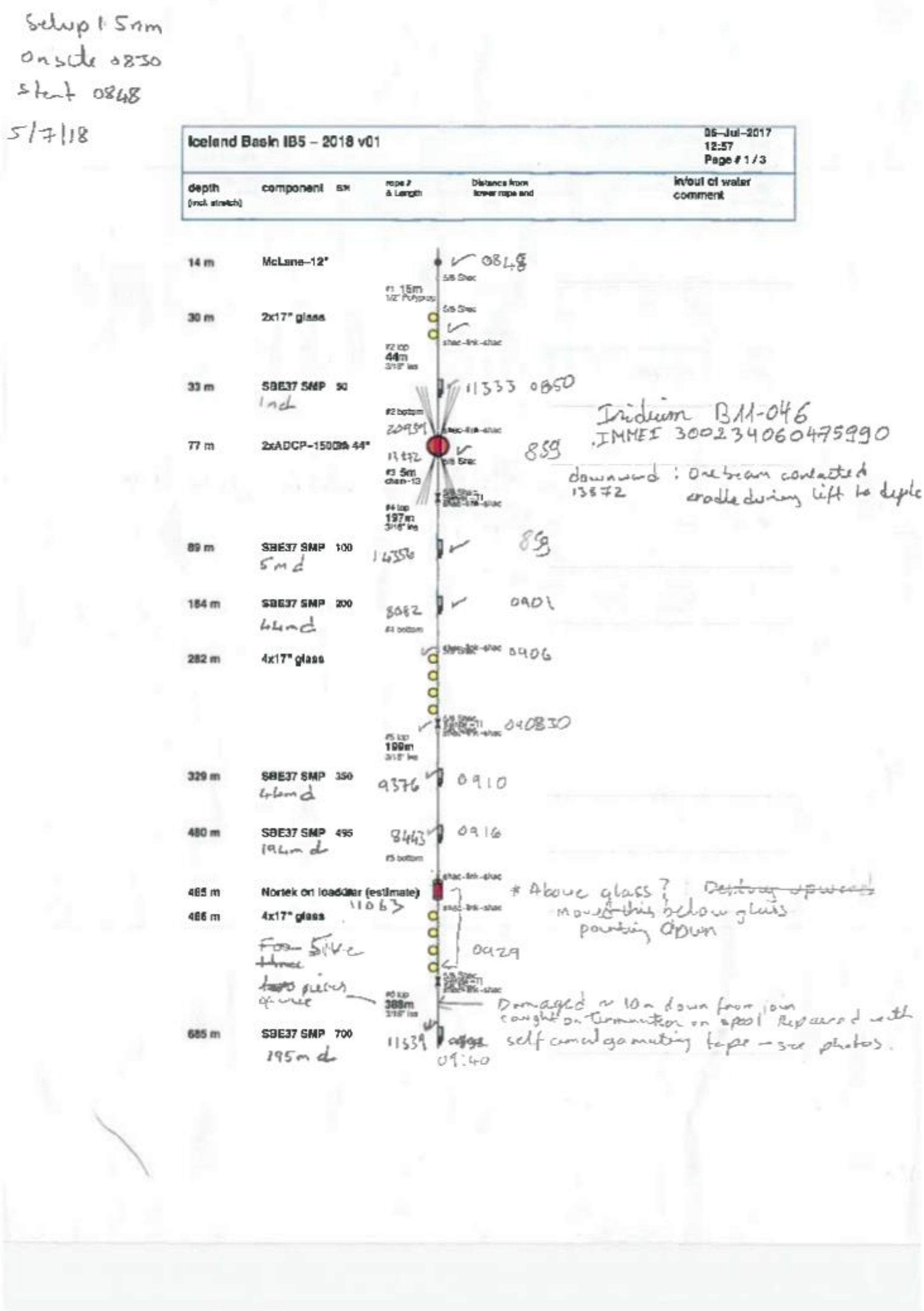
correction (-9 m)

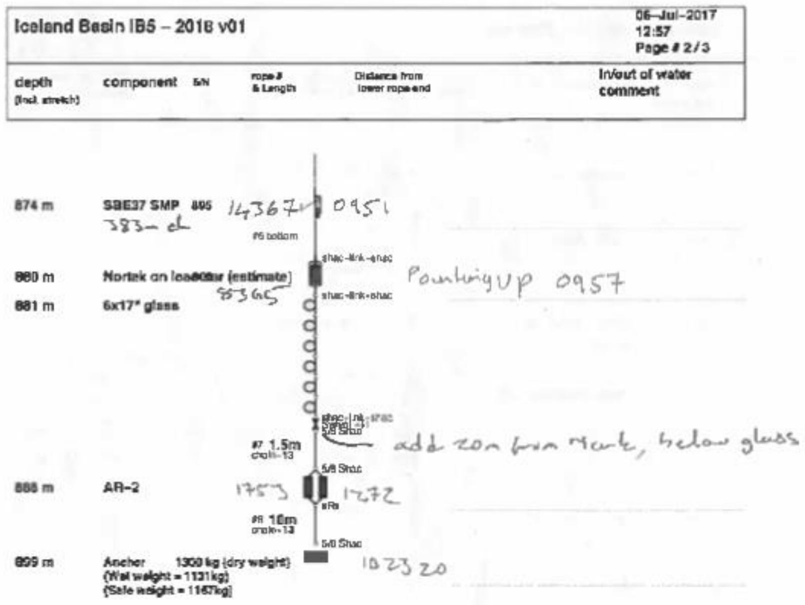
Anchor Seabed Position (after trilateration)

Lat: 57.9899°N Lon: -21.1461°W Uncorrected wd 2929 m

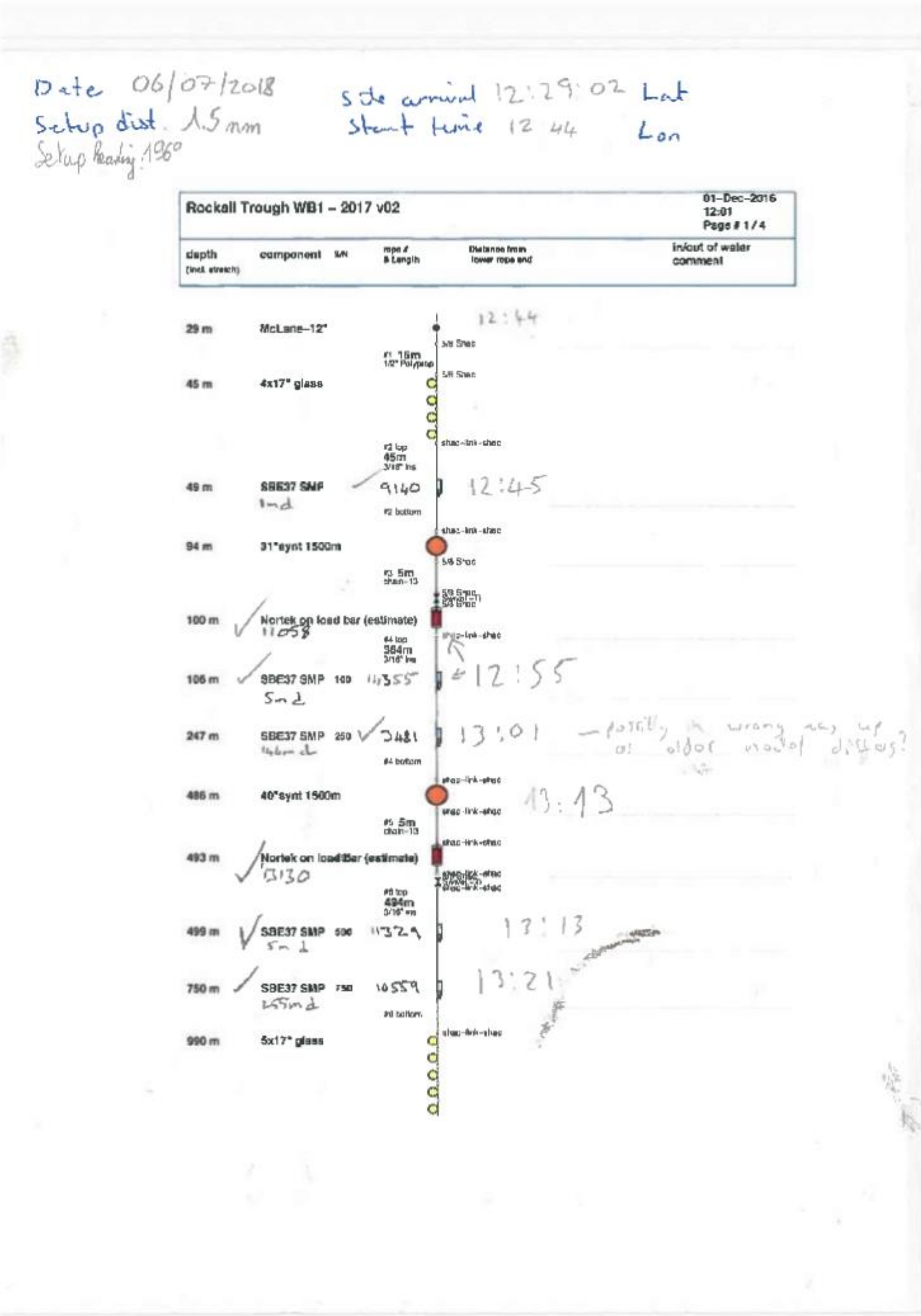
Fallback 152 m

17.2.4 IB5


Setup 1 5nm
Onsite 0830
Start 0848
5/7/18
Iceland Basin IB5 – 2018 v01
06–Jul–2017
12:57
Page # 1 / 3
depth (incl. stretch)
component SN
rope # & Length
Distance from lower rope end
in/out of water comment
14 m McLane–12"
0848
30 m 2x17" glass
33 m SBE37 SMP 50
11333 0850
77 m 2xADCP–150
Iridium B11-046
IMMEI 300234060475990
downward : One beam contacted cradle during lift to deploy
89 m SBE37 SMP 100
14356
184 m SBE37 SMP 200
8082
0901
282 m 4x17" glass
0906
329 m SBE37 SMP 350
9376
0910
480 m SBE37 SMP 495
8443
0916
485 m Nortek on loadcell (estimate)
11063
486 m 4x17" glass
* Above glass? Destroy upwards
Moved this below glass pointing down
0929
Damaged ~ 10m down from join caught on termination on spool. Repaired with self amalgamating tape – see photos.
685 m SBE37 SMP 700
11539
09:40


Iceland Basin IB5 – 2018 v01
06–Jul–2017
12:57
Page # 2/3
depth (incl. stretch)
component
S/N
rope # & Length
Distance from lower rope-end
In/out of water comment
874 m
SBE37 SMP 895
#6 bottom
shac-link-shac
880 m
Nortek on load bar (estimate)
shac-link-shac
881 m
6x17" glass
#7 1.5m
5/8 Shac
888 m
AR-2
#8 10m
5/8 Shac
899 m
Anchor 1300 kg (dry weight)
(Wet weight = 1131kg)
(Safe weight = 1167kg)
Pointing UP 0957
add 20m from Mark, below glass

17.2.5 WB1



Date 06/07/2018
Setup dist. 1.5 nm
Setup Reading: 196°
Site arrival 12:29:02 Lat
Start time 12 44 Lon

Rockall Trough WB1 – 2017 v02

01–Dec–2016
12:01
Page # 1 / 4

depth (incl. stretch)	component	S/N	rope # & Length	Distance from lower rope end	in/out of water comment
29 m	McLane–12"			5/8 Shac	12:44
			#1 15m 1/2" Polyprop	5/8 Shac	
45 m	4x17" glass			shac–link–shac	
			#2 top 45m 3/16" ins		
49 m	SBE37 SMP 1md	9140	#2 bottom	shac–link–shac	12:45
94 m	31"synt 1500m			5/8 Shac	
			#3 5m chain–13	5/8 Shac, Swivel–11, 5/8 Shac	
100 m	Nortek on load bar (estimate) 11058			shac–link–shac	
			#4 top 384m 3/16" ins		
106 m	SBE37 SMP 100 5md	11355			12:55
247 m	SBE37 SMP 250	3481	#4 bottom	shac–link–shac	13:01 – possibly in wrong way up as older model differs?
486 m	40"synt 1500m			shac–link–shac	13:13
			#5 5m chain–13	shac–link–shac	
493 m	Nortek on load bar (estimate) 13130			shac–link–shac, Swivel, shac–link–shac	
			#6 top 494m 3/16" wire		
499 m	SBE37 SMP 500 5md	11329			13:13
750 m	SBE37 SMP 750 255md	10559	#6 bottom	shac–link–shac	13:21
990 m	5x17" glass				

WB1 DEPLOY.

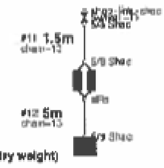
Setup DUST.
SITE ARRIVAL
DATE

Rockall Trough WB1 – 2017 v02

01-Dec-2016
12:01
Page # 2 / 4

depth (incl. stretch)	component	S/N	rope # & Length	Distance from lower rope end	in/out of water comment
				shac-link-shac	
994 m	✓ Nortek on load95ar (estimate) 9877				13:32
			#7 top 201m 3/16" line	shac-link-shac	
1000 m	✓ SBE37 SMP 5m d	1000	14368		13:33
			#7 bottom	shac-link-shac	
1197 m	4x17" glass				
				shac-link-shac	
			#8 top 143m 1/4" line	shac-link-shac	
1248 m	✓ SBE37 SMP 47m d	1250	11337		13:46.
			#8 bottom	shac-link-shac	
1345 m	4x17" glass				
				shac-link-shac	
1349 m	✓ Nortek on load35ar (estimate) 9853				1353
			#9 top 215m 1/4" line	shac-link-shac	
1499 m	✓ SBE37 SMP 149m d	1500	14353		13:58
			#9 bottom	shac-link-shac	
1566 m	2x17" glass				
				shac-link-shac	
1566 m	✓ Nortek on load55ar (estimate) 9213				14:04
			#10 top 15m 1/4" line	shac-link-shac	
1573 m	✓ SBE37 SMP 5m d.	1575	14354		14:05
			#10 bottom	shac-link-shac	
1584 m	8x17" glass				

Rockall Trough WB1 – 2017 v02					01–Dec–2016 12:01 Page # 3 / 4
depth (incl. stretch)	component	S/N	rope # & Length	Distance from lower rope end	In/out of water comment



			S/N	Arm
14:17.	1593 m	AR–2 ✓	2326	~~1B85~~ 1B85
			1761	1A10
	1599 m	Anchor 2100 kg (dry weight) (Wet weight = 1827kg) (Safe weight = 2006kg)		

Anchor drop time = 15:04:50

wd : 1597 m   wd uncorr 1599m

[illegible]

① 15:39:00.
2582.9 m
2893.6m
15:39:30
2583.4
2582.9m.

② 16:05:00
2334.5m
2334.0m.
16:05:30.
2333.3m
2333.4.

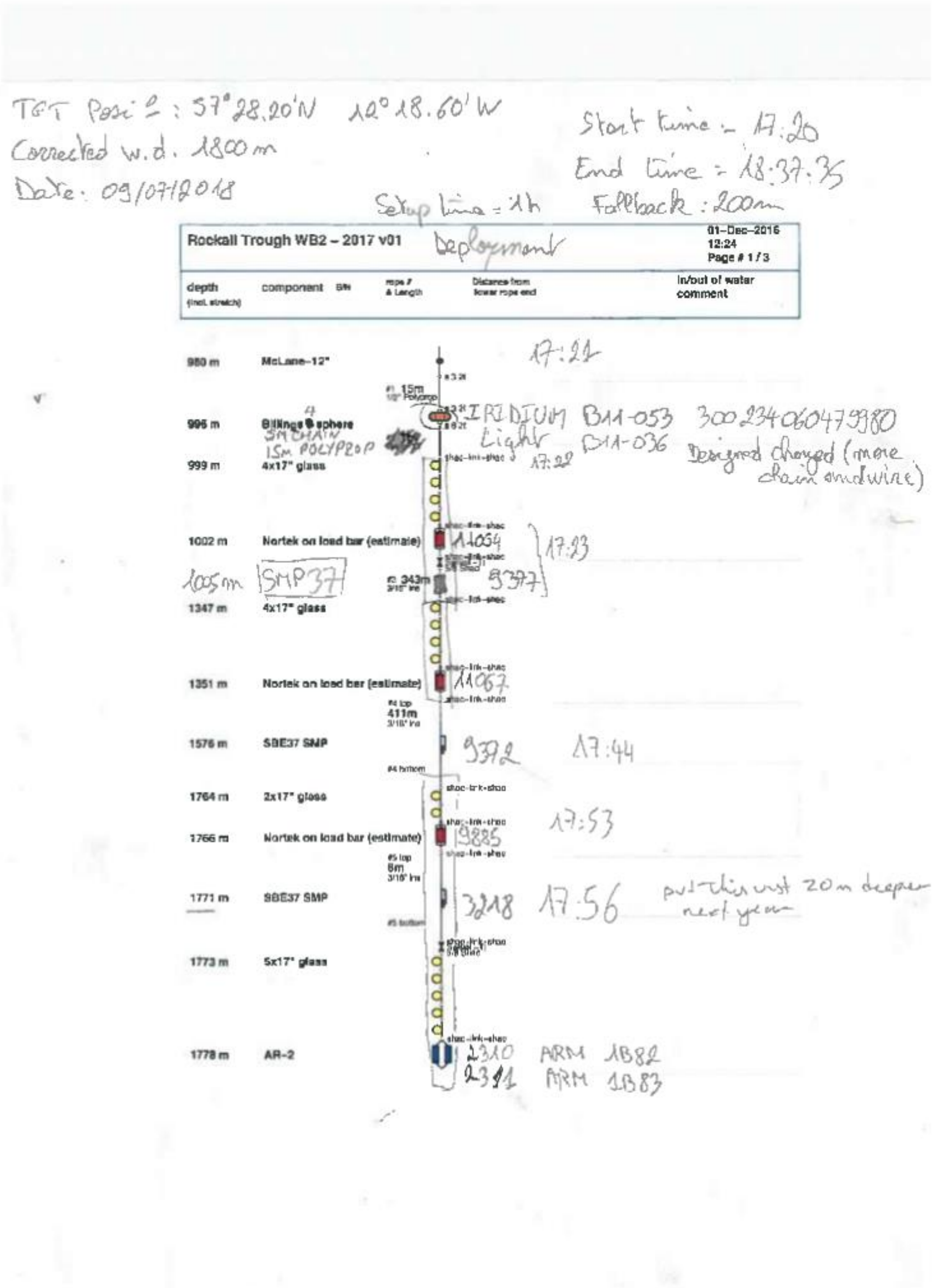
③ 16:26:00
2474.6m
2481.4m
16:26:30
2478.4m
[illegible]

16:27:30.
2688.4
2687.8

15:14:00 1625.8m ←
1625.7m
14:30. 1025.8
1625.5m.
15:00 1626.8m
1625.8m
Set!

15:07:00	Range
	479.9
	1369.9
	530.7m
07:30	609.9m
08:00.	669.8
	688.9
08:30	762.2
	780.1
09:00	854.4
	872.4
09:30.	944.0m
	983.5
10:00.	1032.7
	1051.4
10:30	1126.2
	1142.2
11:00	1265
	1222
11:30.	1292
	1309.3
12:00	1368
	1384
13:00	1525
	1541

17.2.6 WB2



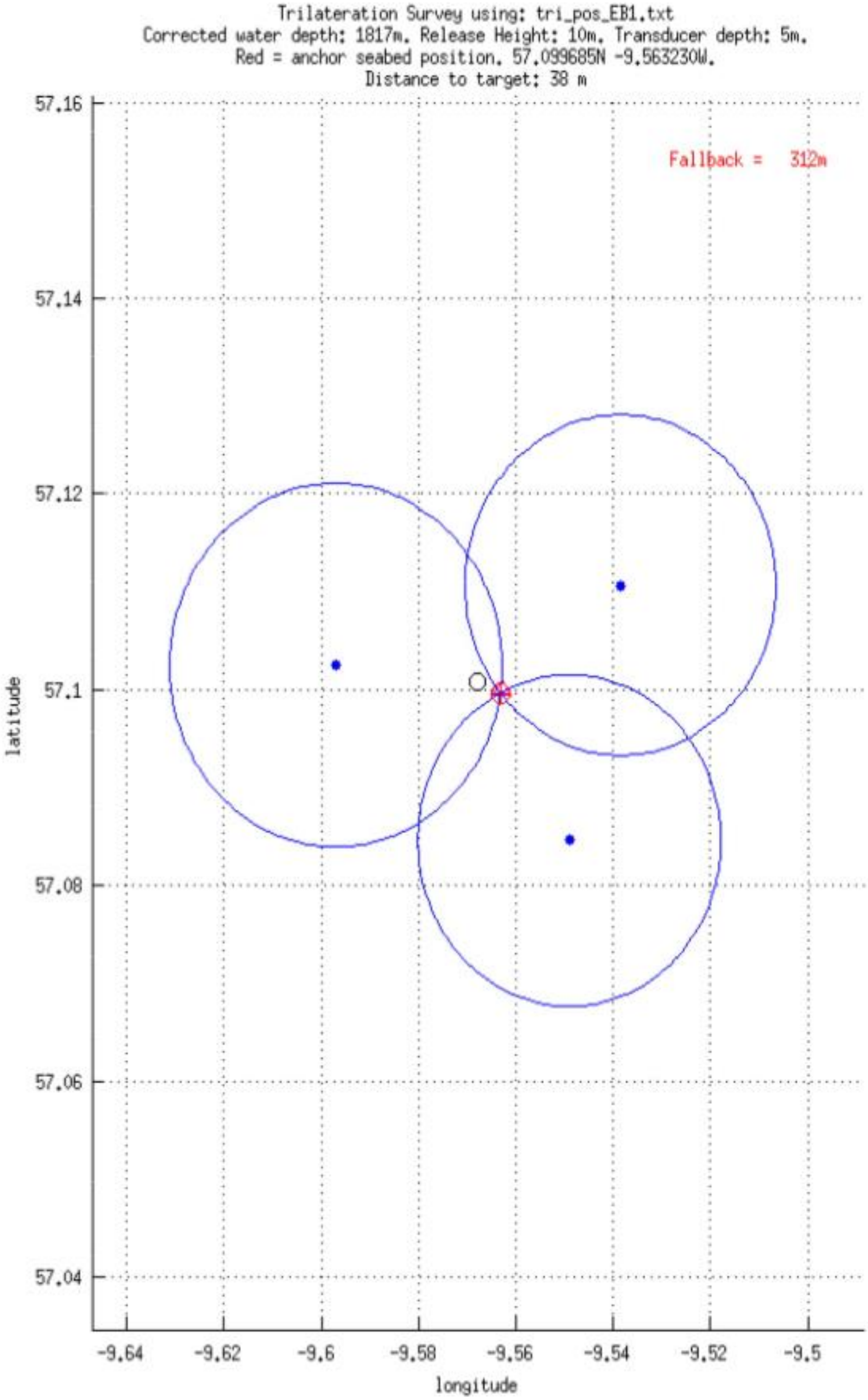
TGT Posi : 57°28.20'N 12°18.60'W
Corrected w.d. 1800 m
Date: 09/07/2018
Start time: 17:20
End time: 18:37:35
Setup time = 1h
Fallback: 200m
Rockall Trough WB2 – 2017 v01
Deployment
01–Dec–2016
12:24
Page # 1 / 3
depth (incl. stretch)
component S/N
rope # & Length
Distance from lower rope end
In/out of water comment
980 m McLane-12"
17:21
995 m Billings 4 sphere
5M CHAIN
15M POLYPROP
IRIDIUM B11-053 300234060479980
Light B11-036
Designed changed (more chain and wire)
999 m 4x17" glass
17:22
1002 m Nortek on load bar (estimate) 11054
17:23
1005 m SMP37 9377
1347 m 4x17" glass
1351 m Nortek on load bar (estimate) 11067
411m
1576 m SBE37 SMP 9372 17:44
1764 m 2x17" glass
1766 m Nortek on load bar (estimate) 9885 17:53
1771 m SBE37 SMP 3218 17:56
put this inst 20m deeper next year
1773 m 5x17" glass
1778 m AR-2 2310 ARM 1B82
2311 ARM 1B83

Rockall Trough WB2 – 2017 v01					01-Dec-2016 12:24 Page # 2 / 3
depth (incl. stretch)	component	S/N	rope # & Length	Distance from lower rope-end	in/out of water comment
			20m chain-13	3/4 Shac	
1799 m	Anchor (Wet weight = 609kg) (Sale weight = 704kg)	700 kg (dry weight)			18:37:35

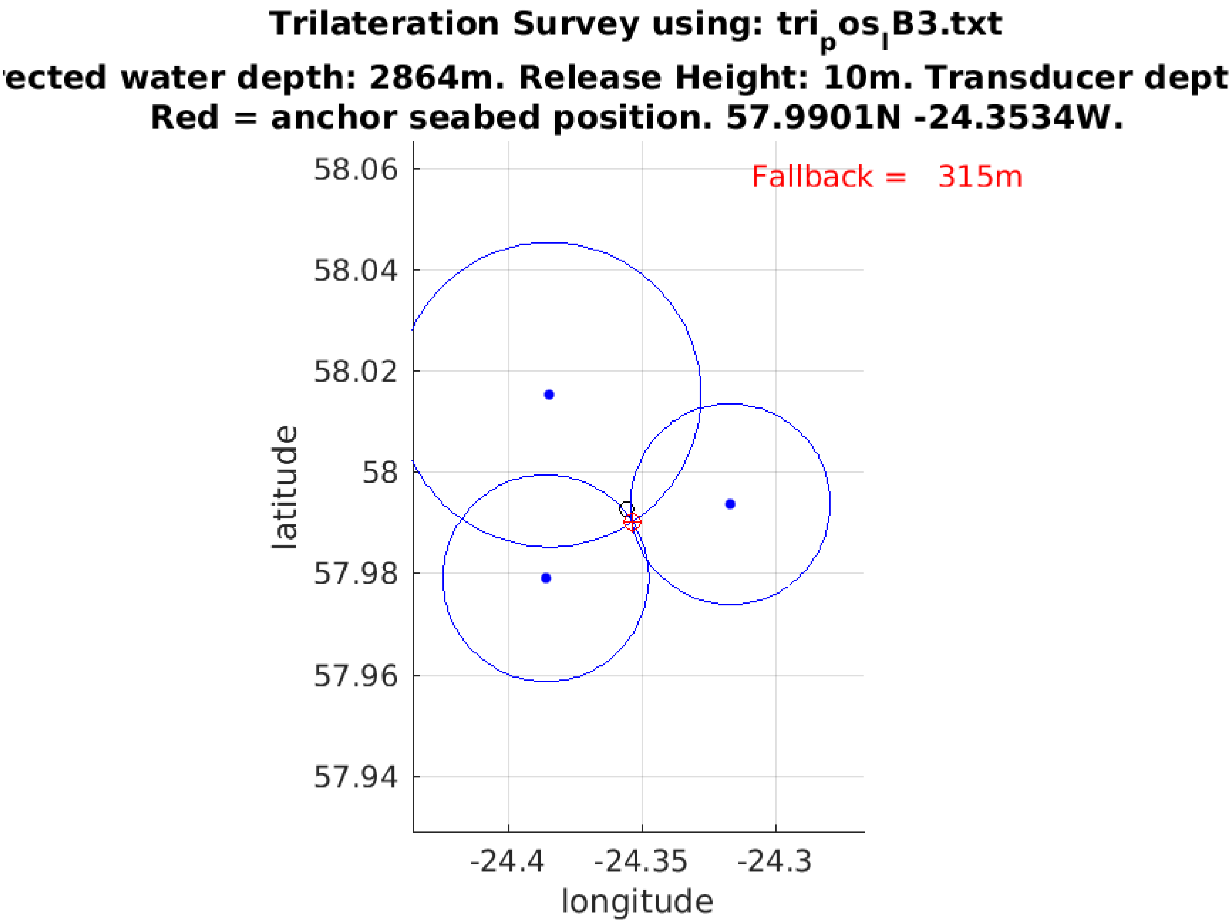
18:41:00	588m	602m
18:42:00	720m	731m
18:43:00	834m	848m
18:44:00	950m	963m
18:45:00	1065m	1076m
18:46:00	1178m	1192m
18:47:00	1292m	1304m
18:48:00	1410m	1421m
18:49:00	1526m	1539m
18:50:00	1644m	1655m
18:51:00	1760m	1771m
18:52:00	1800m	1800m

17.3 Trilateration

17.3.1 EB1

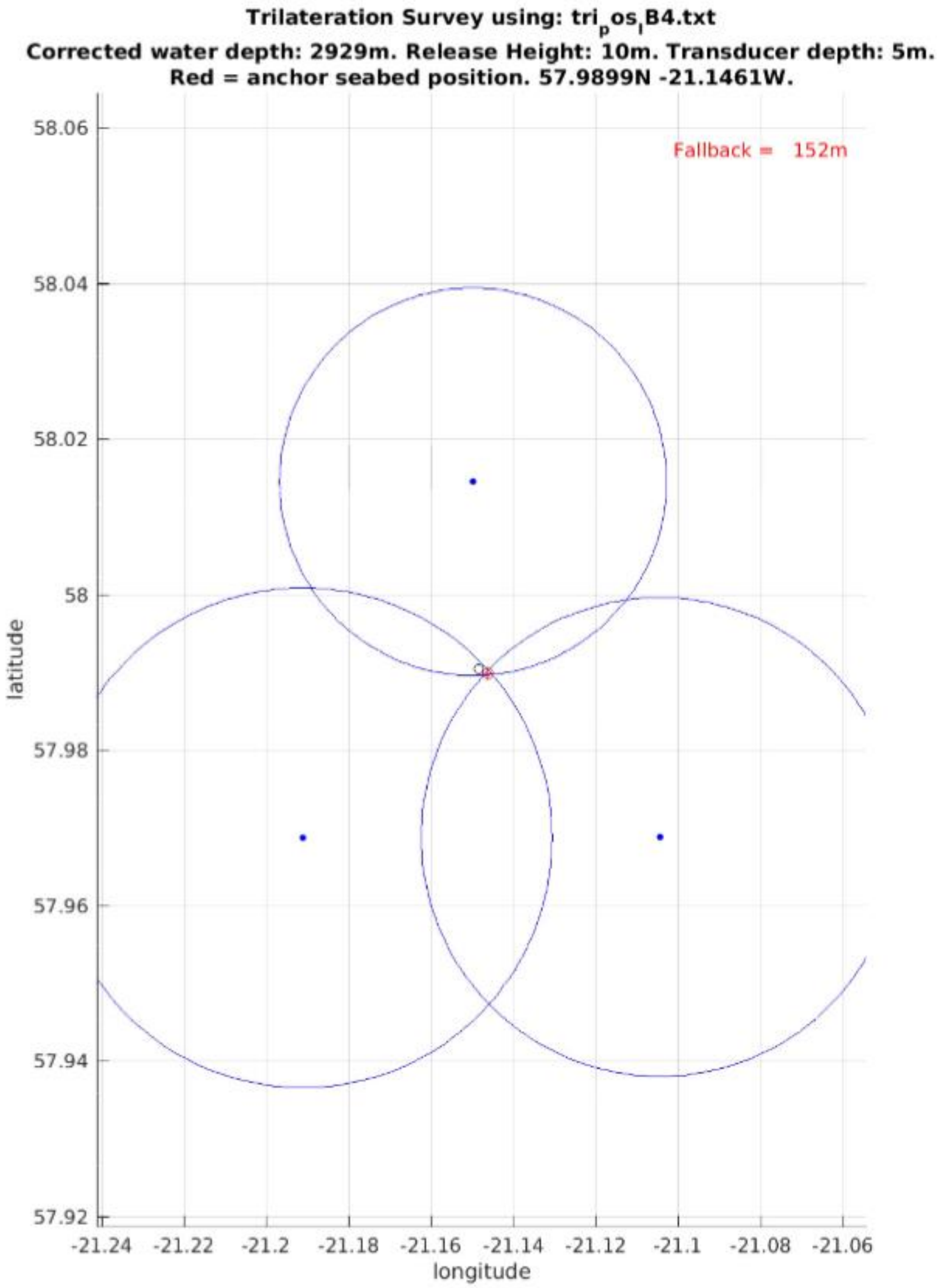


17.3.2 IB3



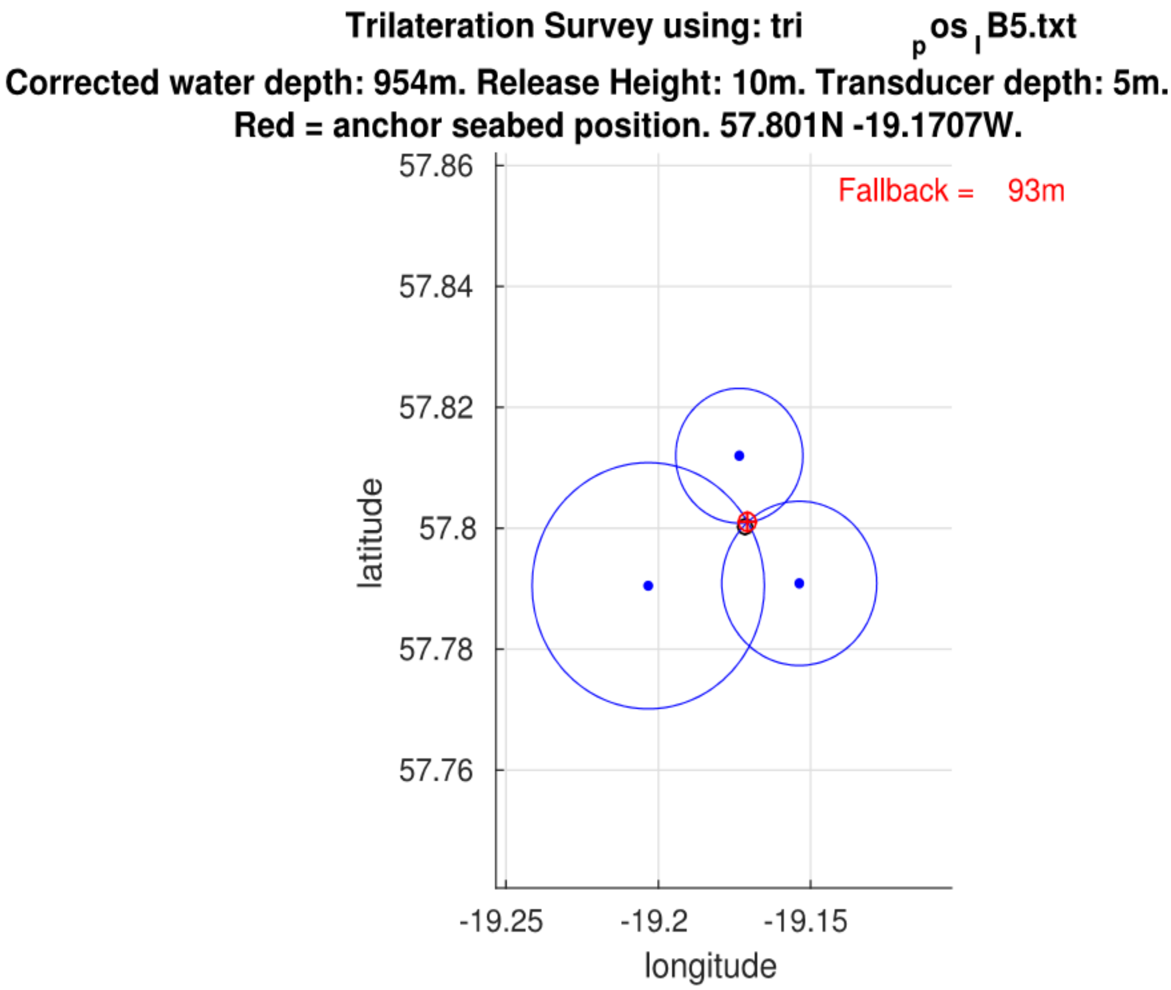
Trilateration Survey using: tri_pos_IB3.txt
'ected water depth: 2864m. Release Height: 10m. Transducer dept
Red = anchor seabed position. 57.9901N -24.3534W.
Fallback = 315m
58.06
58.04
58.02
58
57.98
57.96
57.94
latitude
-24.4
-24.35
-24.3
longitude

17.3.3 IB4



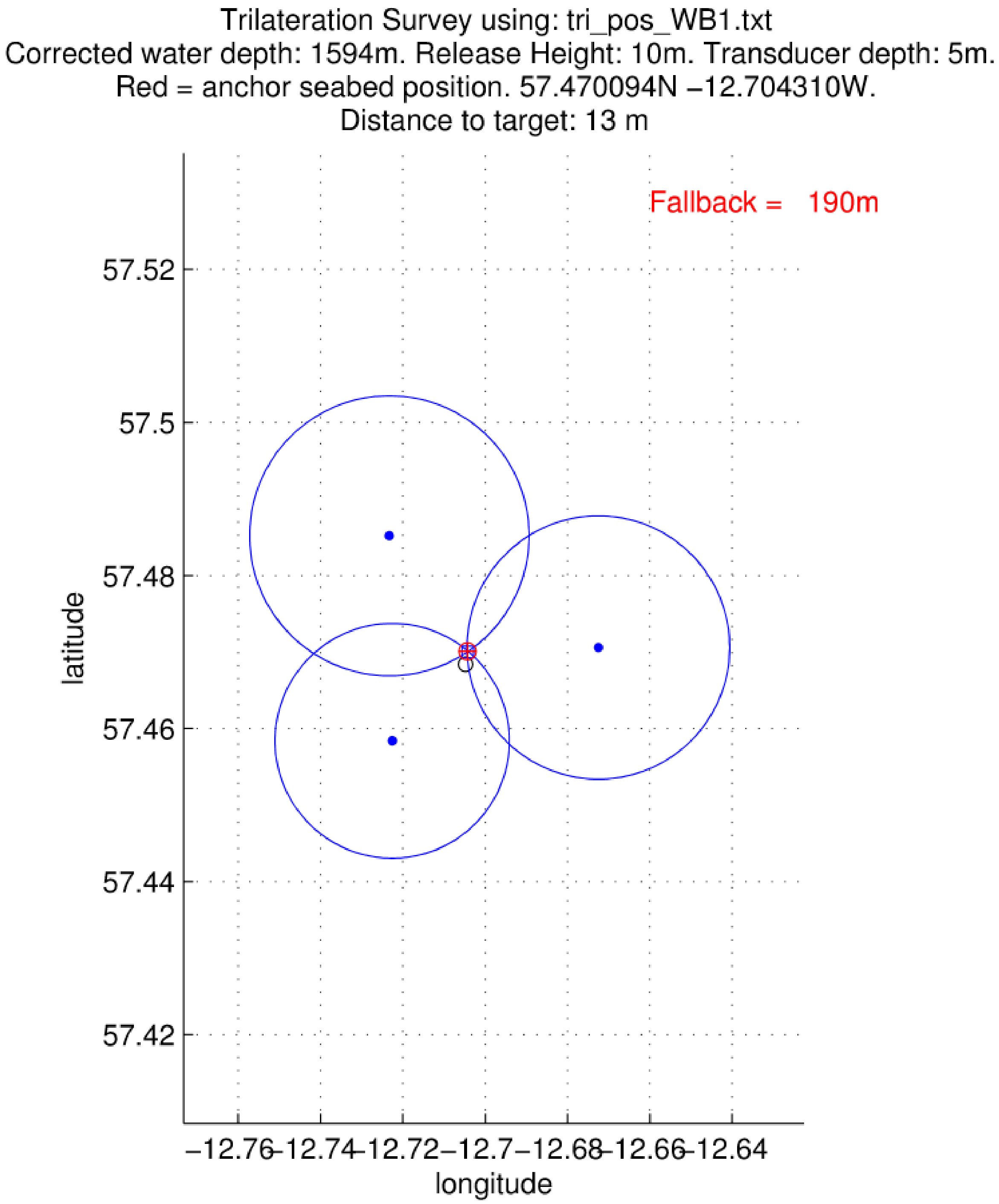
Trilateration Survey using: tri_pos_IB4.txt
Corrected water depth: 2929m. Release Height: 10m. Transducer depth: 5m.
Red = anchor seabed position. 57.9899N -21.1461W.
Fallback = 152m
58.06
58.04
58.02
58
57.98
57.96
57.94
57.92
latitude
-21.24 -21.22 -21.2 -21.18 -21.16 -21.14 -21.12 -21.1 -21.08 -21.06
longitude

17.3.4 IB5

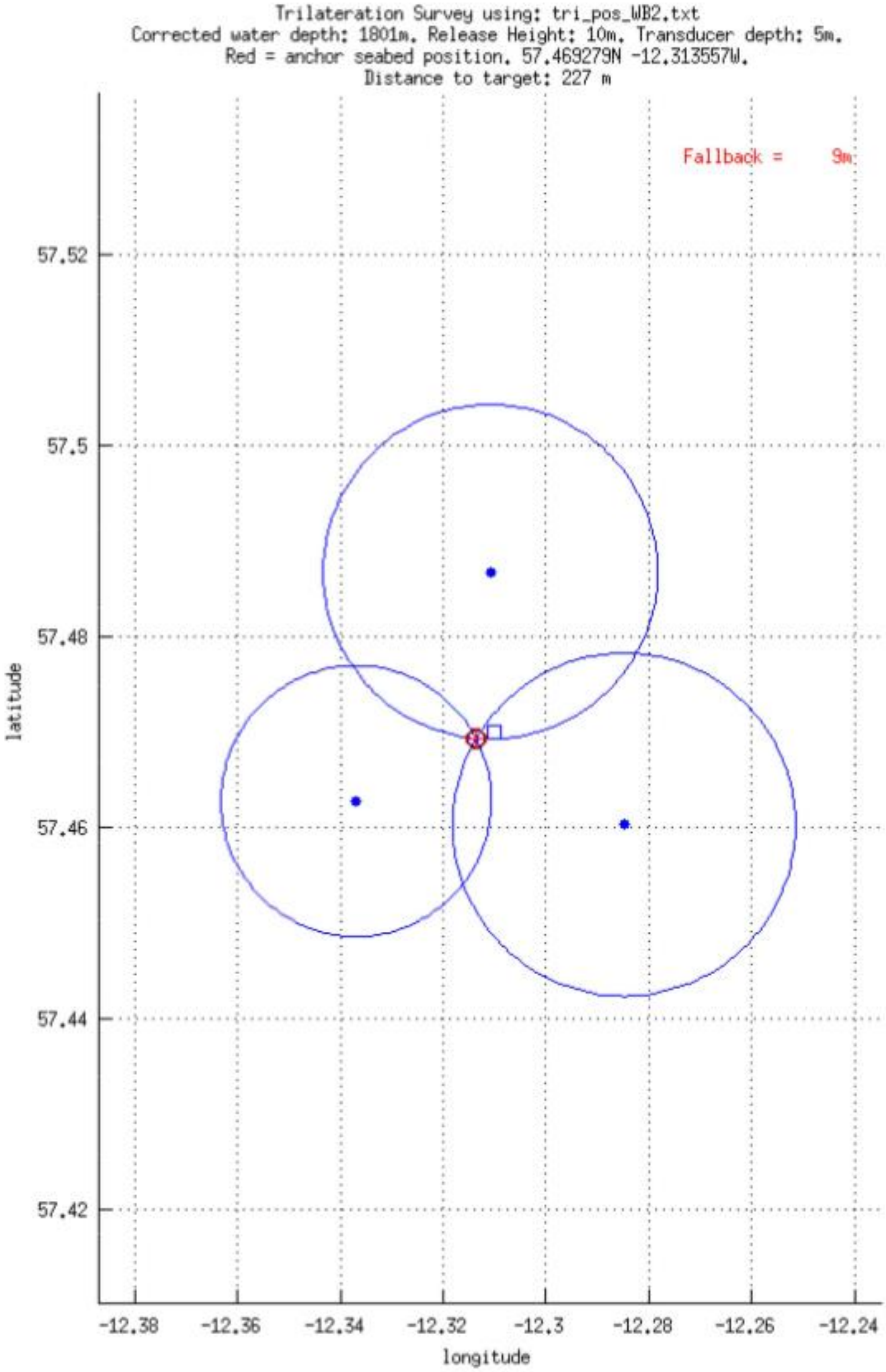


Trilateration Survey using: tri pos I B5.txt
Corrected water depth: 954m. Release Height: 10m. Transducer depth: 5m.
Red = anchor seabed position. 57.801N -19.1707W.
Fallback = 93m
57.86
57.84
57.82
57.8
57.78
57.76
latitude
-19.25
-19.2
-19.15
longitude

17.3.5 WB1


Trilateration Survey using: tri_pos_WB1.txt
Corrected water depth: 1594m. Release Height: 10m. Transducer depth: 5m.
Red = anchor seabed position. 57.470094N −12.704310W.
Distance to target: 13 m
Fallback = 190m
57.52
57.5
57.48
57.46
57.44
57.42
latitude
−12.76
−12.74
−12.72
−12.7
−12.68
−12.66
−12.64
longitude

17.3.6 WB2



Trilateration Survey using: tri_pos_WB2.txt
Corrected water depth: 1801m. Release Height: 10m. Transducer depth: 5m.
Red = anchor seabed position. 57.469279N -12.313557W.
Distance to target: 227 m
Fallback = 9m
latitude
57.52
57.5
57.48
57.46
57.44
57.42
-12.38
-12.36
-12.34
-12.32
-12.3
-12.28
-12.26
-12.24
longitude

17.4 Examples of instrument setup files

17.4.1 SeaBird SBE-37

```
OutputExecutedTag=n
S>
S>Outputformat=3
S>
S>DS
SBE37SM-RS232 v4.1 SERIAL NO. 9372 08 Jul 2018 18:34:41
vMain = 13.53, vLith = 2.98
samplenumber = 0, free = 559240
not logging, stop command
sample interval = 1800 seconds
data format = converted engineering alternate
transmit real-time = no
sync mode = no
pump installed = yes, minimum conductivity frequency = 3318.4
S>
S>Datetime=07082018183445
S>
S>
S>SAMPLENUMBER=0
this command will modify memory pointers
repeat the command to confirm
SAMPLENUMBER=0
S>
S>OUTPUTSAL=N
S>
S>SAMPLEINTERVAL=3600
S>
S>BAUDRATE=38400
repeat the command at 38400 baud to confirm
BAUDRATE=38400
baud rate change is confirmed
S>
S>OUTPUTSV=N
S>
S>SYNCMODE=N
S>
S>TXREALTIME=N
S>
S>SAMPLEINTERVAL=1800
S>
S>STARTDATETIME=07092018120000
<start dateTime = 09 Jul 2018 12:00:00/>
S>
S>STARTLATER
<!--start logging at = 09 Jul 2018 12:00:00, sample interval = 1800 seconds-->
 S>
S>DS
SBE37SM-RS232 v4.1 SERIAL NO. 9372 08 Jul 2018 18:35:51
vMain = 13.51, vLith = 2.98
samplenumber = 0, free = 559240
not logging, waiting to start at 09 Jul 2018 12:00:00
```

```
sample interval = 1800 seconds
data format = converted engineering alternate
transmit real-time = no
sync mode = no
pump installed = yes, minimum conductivity frequency = 3318.4
S>
```

17.4.2 Nortek Aquadopp

```
============================================================
Deployment : osnap
Current time : 04/07/2018 10:09:01
Start at : 04/07/2018 11:00:00
Comment:

------------------------------------------------------------
Measurement interval (s) : 3600
Average interval (s) : 60
Blanking distance (m) : 0.50
Measurement load (%) : 4
Power level : HIGH
Diagnostics interval(min) : 720:00
Diagnostics samples : 20
Compass upd. rate (s) : 1
Coordinate System : ENU
Speed of sound (m/s) : 1500
Salinity (ppt) : N/A
Analog input 1 : NONE
Analog input 2 : NONE
Analog input power out : DISABLED
Raw magnetometer out : OFF
File wrapping : OFF
TellTale : OFF
AcousticModem : OFF
Serial output : OFF
Baud rate : 9600
------------------------------------------------------------
Assumed duration (days) : 730.0
Battery utilization (%) : 79.0
Battery level (V) : 13.8
Recorder size (MB) : 9
Recorder free space (MB) : 8.973
Memory required (MB) : 1.9
Vertical vel. prec (cm/s) : 1.4
Horizon. vel. prec (cm/s) : 0.9
------------------------------------------------------------
Instrument ID : AQD 9877
Head ID : A6L 5240
Firmware version : 3.37
------------------------------------------------------------
Aquadopp Deep Water Version 1.40.14
Copyright (C) Nortek AS
```

17.4.3 Workhorse ADCP

```
[BREAK Wakeup A]
WorkHorse Broadband ADCP Version 50.36
Teledyne RD Instruments (c) 1996-2009
All Rights Reserved.
>RR
Recorder Directory:
Volume serial number for device #0 is a4ae-2016

 No files found.

 Bytes used on device #0 = 0
Volume serial number for device #1 is a4ae-2016

 No files found.

 Bytes used on device #1 = 0
Total capacity = 2045181952 bytes
Total bytes used = 0 bytes in 0 files
Total bytes free = 2045181952 bytes

>
[BREAK Wakeup A]
WorkHorse Broadband ADCP Version 50.36
Teledyne RD Instruments (c) 1996-2009
All Rights Reserved.
>CR1
[Parameters set to FACTORY defaults]
>CF11111
>EA0
>EB0
>ED19700
>ES35
>EX11111
>EZ1111101
>WA50
>WB0
>WD111100000
>WF176
>WN28
>WP42
>WS400
>WV175
>TE01:00:00.00
>TP01:25.71
>TF18/07/02 18:00:00
>CK
[Parameters saved as USER defaults]
>The command CS is not allowed in this command file. It has been ignored.
>The following commands are generated by this program:
>CF?
CF = 11111 --------------- Flow Ctrl (EnsCyc;PngCyc;Binry;Ser;Rec)
>CF11111
>RN ib5dn
>cs
```

17.5 Post-cruise extraction and chemical analysis of RAS samples

Clare Johnson, John Beaton

Due to time pressures and the risk of sample loss, the decision was made to leave the sample bags on the RAS and return this to SAMS for sample removal. The hope being that because it was essentially a closed system, that this would be less risky than trying to remove the samples on board.

17.5.1 Sample removal

Two people are required for the sample removal. After removing the sample bags from the RAS, water was decanted for nutrient analysis. Two 60 ml acid-cleaned vials were rinsed and then filled. These samples were frozen until analysis for nitrite, nitrate, phosphate and silicate. The remaining water was allocated to carbon analysis. Unfortunately the RAS sample bags are permeable to gas; as such the sample bags were stored inside a second plastic bag filled with DI water. (DI water was chosen due to its low carbon chemistry). Samples were stored in the cool and dark before analysis within 7 days of removal. The RAS sample bags can be removed and processed at a rate of three to five per hour on shore; however, if bags are difficult to remove (e.g. due to a larger sample volume), or have leaks that need to be sealed, this can slow the process considerably. The removal procedure is described in detail below, we thank Pete Brown (NOC) for his help in establishing this procedure.

Equipment needed: (1) PPE – samples are spiked with mercuric chloride, and any unfilled sample bags have concentrated mercuric chloride in the RAS tubing; (2) 60 ml plastic syringe with tubing and connector for RAS sample tube (provided in RAS spares kit); (3) acid-cleaned nutrient vials; (4) ~30 cm silicon tubing; (5) 140x382 mm plastic bag, twist seal (VWR 129-9815); (6) plastic caps, ¼”-28 flat bottom, ETFE (Kinesis Ltd P-755); (7) weighing scales; (8) electrical tape; (9) bucket; (10) paper, pencil, marker pen, blue roll etc.
Removal steps:

(1) remove 4 white plastic bars, and 8 short white plastic bars at the top of the RAS to get access to the RAS sample containers.
(2) For each RAS sampling container in turn:

> (a) check sample container number on: (i) top-plate of frame, (ii) white tags on upper tubing, (iii) white tags on lower tubing, (iv) central multi-port valve. These should all be the same. Note number on log sheet.
> (b) unscrew tubing at bottom of RAS sampling container.
> (c) gently lift RAS sampling container out through the top plate
> (d) tip RAS sampling container so top is slightly downward.
> (e) loosen sampling container cap by twisting RAS sampling container, not the cap. Remaining DI water in the sampling container will drain.
> (f) slide the sample bag slightly out of the RAS sample container and close the screw-valve at the top of the RAS sample bag.
> (g) slide the sample bag out the sampling container, any remaining DI water will drain. If the bag is stuck, use the syringe with the RAS connector to ‘push’ the sample bag out the container.

(h) gently dry the sample bag and carefully inspect for any leaks [during this deployment, small leaks occurred at the top or bottom of the sample bags along the heat seals (6/40 samples) and around the on/off valve join (1/40 samples)]
(i) if any leaks are found, carefully seal with electrical tape and note on log sheet.
(j) weigh RAS sample bag, and photograph. Note any bubbles on log sheet. Bubbles are easier to spot when the RAS sample bag is horizontal and dry.
(k) Take subsamples for nutrient analysis (we took two vials)
(i) rinse a 30 cm length of silicon tubing in DI water and attach to sample bag spigot.
(ii) lightly press on the sample bag and then open screw-valve so sample flows through the silicon tubing. Take care that no air flows back up the tubing and into the sample bag when opening and closing the valve. This can be avoided by maintaining light pressure on the sample bag.
(iii) rinse nutrient sample vials in sample and fill leaving room for expansion if freezing. Ensure nutrient containers are labelled (e.g. RAS xxx).
(iv) close sample bag screw-valve, remove silicon tubing and screw black plastic cap onto sample bag spigot.
(l) save remaining sample for carbon analysis by storing under water to reduce gas exchange through the permeable plastic sample bag
(i) ensure that black plastic cap has been added to sample bag spigot.
(ii) place sample bag upside down into labelled (e.g. RAS xxx) swirl-top plastic bag. Add second pencil label in outer bag as back-up. Gently fill plastic bag with DI water trying to avoid bubbles until it just covers the sample bag.
(iii) tightly roll over the swirl-top plastic bag top once, squeeze it gently to exclude air, roll over the top a second time, relax the pressure on the plastic bag, and roll over the top another 1-2 times. Twist together wire to seal.
(iv) place filled swirl-top plastic bags vertically inside a small rigid plastic case. Do not pack the bags too tightly or the seal at the top of the plastic bag can fail.
(3) Repeat step 2 for all RAS sample containers (1-48).
(4) Store the nutrient vials in a freezer unless immediate analysis. Store the carbon samples in a cool dark place and analyse as soon as possible.

17.5.2 RAS performance

The modifications made to the RAS frame prior to deployment worked well, no sample containers were broken and all tubing was intact. We thank Darren Rayner (NOC) with his help in these modifications. A plate was added to support the sample containers from the bottom rather than rely on them being held in place by the top plate only. Additionally, all tubing, which is only connected using a quarter-turn, was taped and the tubing carefully cable-tied to the RAS frame. Despite these modifications making the RAS much more robust, I feel that using the RAS in a deep sea mooring is pushing the RAS right to the limits of its capability. This is particularly true for anchor-last tall moorings where the RAS is deployed near the top of the mooring: the deployment necessitates the RAS being towed through the water whilst the remainder of the mooring is deployed.

40 out of the 42 scheduled samples collected the full ~500 ml, sample volumes ranged from 454-573 ml, with an average of 511 ml. Sample volumes were estimated by (mass full sample bag – mass empty sample bag)/1.027. One sample (26) only partially collected (~250 ml) due to the screw-valve at the top of the sample bag not being fully opened, and an additional sample (25) did not collect at all due to the intake tubing being trapped and pinched below the screw-down restraining bars on the top of the RAS. The RAS was recovered before samples 43-48 were due to collect. Worryingly some of the sample bags that were in positions 43-48, that should have been empty, had water in them (43: 19 ml; 44: 136 ml; 45: 93 ml; 46: 0 ml; 47: 101 ml; 48:53 ml). This raises the possibility that other sample bags could have been filled at multiple times and therefore samples are cross-contaminated.

Analysis of the RAS metadata showed that the pump worked extremely hard during samples 25 and 26 (mean I during pumping 197 and 187 mA respectively compared to 75-95 mA for other samples). Correspondence with McLane suggests that during samples 25 and 26 the seal in the central multi-valve was overcome enabling water to simultaneously enter multiple sample bags; however, they were unable to replicate the high pump currents and multi-port valve failure in their laboratory despite blocking intake tubing. Additionally, tests at SAMS confirmed that the multi-port valve on our RAS was performing correctly. Although this does not mean that the seal was not temporarily overcome during samples 25 and 26, it does tell us that our multi-port valve itself is not broken. We continue to investigate this, for example to see if there is any pattern to samples relative to the port positions on the multi-port valve. Additionally, we are hoping that the nutrient and carbon data will help identify if there was or was not cross contamination.

The performance of the RAS bags was also patchy. We did not use the bags provided by McLane because these are unsuitable for carbon analysis (Pete Brown, NOC, personal communication). As such we used the same modified bags used by the NERC ABC project from Plastic Film Enterprizes. One or two small leaks were found in 8 out of the 40 sample bags: 7 bags had small leaks at the heat seal either at the top or bottom of the bag, with the remaining bag having a leak around the join between the bag and the screw-valve. One bag had severe multiple leaks and the sample was lost. Additionally, 13 out of 40 bags has small bubbles in. Both the leaks and bubbles were only spotted by carefully drying and examining the sample bags. Further leaks were noted during sample analysis.