SAMS Report No. 288

RV Knorr Cruise KN221-02

9th July – 1st August 2014

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Abstract

This cruise report details the scientific programme for SAMS led by Professor Stuart Cunningham of the Scottish Association for Marine Science (SAMS) on R/V *Knorr* cruise 221-02. Cruise 221-02 is a contribution to the international Overturning in the Subpolar North Atlantic Programme (OSNAP). Three additional scientific teams (from Rosentield School of Marine and Atmospheric Sciences, Royal Netherlands Institute for Sea Research, and Woods Hole Oceanographic Institution) participated on this cruise. SAMS objectives were to deploy moorings in the Rockall Trough, measuring temperature, salinity, currents and bottom pressure and; deploy Seaglider SG604 "Jura" in the Hatton-Rockall Basin.

The OSNAP array as deployed between June and August 2014 is purposefully designed to provide a continuous record of the full-water column, trans-basin fluxes of heat, mass and freshwater in the subpolar North Atlantic, on a section from Newfoundland to Greenland to Scotland.

Keywords

Atlantic Ocean, North Atlantic, North Atlantic Current, subpolar gyre, meridional overturning circulation, MOC, AMOC, bottom pressure recorder, BPR, cruise KN221, CTD, current meter, *Knorr*, MicroCAT, mooring array, moorings, thermohaline circulation, glider, Seaglider, OSNAP, UK-OSNAP, Rockall Plateau, Rockall-Hatton Plateau, Rockall Trough, Reykjanes Ridge, Iceland Basin, Irminger Basin, Mid-Atlantic Ridge

Issuing Organisation

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Scientific and Ship's Personnel

Officers & Crew	
Kent Sheasley	Master
Derek Bergeron	Chief Mate
Max Kantor	Second Mate
Joshua Woodrow	Third Mate
Pete Liarikos	Botswain
Paul St. Onge	A/B
Leo Fitz	A/B
Kevin Roth	A/B
Clindor Cacho	O/S
Mark Anderson	O/S
Pete Marczak	Chief Engineer
Jean Lavache	First Engineer
Vassile Tudorn	Third Engineer
Nikolas Alexander	Electrician
Kyle Covert	Oiler
Marty Bronson	Oiler
Eric Witte	Steward
Teressa MacMartin	Cook
Thomas Leong	Mess Attendant
Amy Simoneau	SSSG
Robb Hagg	SSSG

Table 1 *Details of the ship's crew on cruise KN221-02*

Scientific and Technical	
Bill Johns	RSMAS – University of Miami
Mark Graham	RSMAS – University of Miami
Adam Houk	RSMAS – University of Miami
Thania Papapostolou	RSMAS – University of Miami
Yang Liu	RSMAS – University of Miami
Laura de Steur	NIOZ
Leon Wuis	NIOZ
Marco Stoffelen	IMAU – University of Utrecht
Maurits Kooreman	IMAU – University of Utrecht
Stuart Cunningham	UK- SAMS
John Beaton	UK- SAMS
Karen Wilson	UK- SAMS
Rachel Vezza	UK- SAMS
Clare Johnson	UK- SAMS
Amy Bower	WHOI
Heather Furey	WHOI
Sija Zou	Duke University

Table 2 *Details of science personnel on cruise KN221-02*

R/V Knorr

The research vessel *Knorr* is owned by the U.S. Navy and operated by WHOI for the ocean research community. Launched in 1968, delivered to Woods Hole in 1970, and completely overhauled in 1991. The ship can carry a crew of 22 and a scientific party of 32 to sea for as long as 60 days. She will be decommissioned at the end of 2014 and replaced by the R/V *Armstrong.*

R/V *Knorr* was named for Ernest R. Knorr, a distinguished hydrographic engineer and cartographer who was appointed Chief Engineer Cartographer of the U.S. Navy Hydrographic office in 1860. Knorr was one of the leaders of the Navy's first systematic charting and surveying effort from 1860 to 1885.

Itinerary

Reykjavik, Iceland Sunday 6th July to Reykjavik, Iceland Friday 1st August.

Acknowledgements

We thank Captain Kent Sheasley and the officers and crew of the R/V *Knorr* (Table 1) for their 'can do' attitude and proactive support of the science programme. Our best wishes go to you in this the last year of service for the *Knorr*. May the new R/V *Armstrong* go on to achieve as much and be such a happy ship. Professor William Johns as P.I. for this cruise ensured that the maximum science was achieved and perfectly balanced the demands from three science teams.

Introduction

This report details the scientific programme led by Professor Stuart Cunningham of the Scottish Association for Marine Science (SAMS) on R/V *Knorr* cruise 221-02 as a contribution to the international Overturning in the Subpolar North Atlantic Programme (OSNAP)[1]. Three additional scientific teams participated on this cruise (Table 2). Professor William Johns from the Rosenstiel School of Marine and Atmospheric Sciences (RSMAS), University of Miami led and planned the cruise. Also participating was a team from the Royal Netherlands Institute for Sea Research (NIOZ) led by Dr Laura De Steur. Dr Amy Bower led a team from the Woods Hole Oceanographic Institution (WHOI).

SAMS objectives were to: 1. deploy moorings in the Rockall Trough, measuring temperature, salinity, currents and bottom pressure and; 2. Deploy Seaglider SG604 "Jura" on the Hatton Plateau. One mooring was deployed on a second cruise in October 2014 (see Appendix 4).

RSMAS objectives were to: 1. Deploy moorings on the eastern flank of the Reykjanes Ridge and across the Iceland Basin measuring temperature, salinity and currents and; 2. Occupy a section of CTD/LADP stations from the Scottish continental shelf, through the Iceland Basin across the Reykjanes Ridge and part way across the Irminger Basin (Figure 1).

NIOZ objectives were to deploy moorings on the western flank of the Reykjanes Ridge and into the deeper parts of the Irminger Basin.

[1] www.o-snap.org

WHOI objectives were to: 1. Continue installing an array of sound source moorings for acoustically tracking RAFOS[2] floats; 2. Deploy RAFOS floats in the Irminger and Iceland Basins.

The International Overturning in the Subpolar North Atlantic Programme

The OSNAP array as deployed between June and August 2014 is purposefully designed to measure heat and fresh-water fluxes in the subpolar gyre (SPG) on a section from Newfoundland to Greenland to Scotland (Figure 1).

The initial phase of OSNAP will run for five years (Table 3), and involves scientists from seven countries (Appendix 1), including a team from the Scottish Association for Marine Science (SAMS).

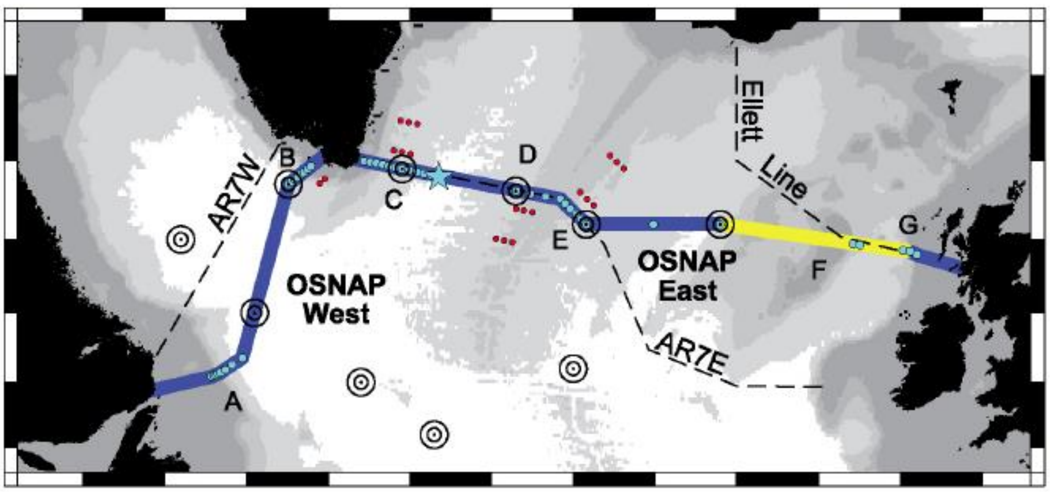

Figure 1: The OSNAP line, comprising: (A) German 53°N western boundary array and Canadian shelf-break array; (B) US West Greenland boundary array; (C) US/UK East Greenland boundary array; (D) Netherlands western Mid- Atlantic Ridge array; (E) US eastern Mid-Atlantic Ridge array; (F) UK glider survey (yellow) over the Hatton-Rockall Basin and Rockall Trough; (G) UK Rockall Trough and Scottish Slope Current array. Red dots: US float launch sites. Blue star: US OOI Irminger Sea global node. Black concentric circles: US sound sources.

Rockall Trough and Scottish Slope Current Array

The *array* (Figure 2) will (i) quantify the flux of northward-flowing warm and saline water through the Rockall Trough and across the Hatton-Rockall Basin (HRB), and (ii) determine the magnitude and variability of the cold overflow across the Wyville-Thomson Ridge. Measurement locations are determined by the long established section across Rockall Trough (62 occupations since 1975), which provides a multi-decadal context for our new observations ([*Holliday, N. P., and S. A. Cunningham, 2013*]).

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[2] http://www.whoi.edu/instruments/viewInstrument.do?id=1061

The array is designed for westward continuity with the US Iceland Basin measurements. Warm, saline water of subtropical origin enters the SPG between Greenland and Scotland, 8.5±1.0 Sv of which flows northward into the Nordic Seas ([*Østerhus et al.,* 2005]). Across the OSNAP line, three regions of warm water transport are found: in the Iceland Basin, over the Hatton-Rockall Basin (HRB), and in the Rockall Trough ([*Brambilla and Talley*, 2008]).

The Iceland Basin, to be measured by the US, supports eddy transports, recirculating components of the North Atlantic Current (NAC), and part of the NAC throughflow to the Nordic Seas. The Rockall Trough branch, which flows northward along the UK and European continental shelf, is warmer and more saline than the other two branches, so it dominates the freshwater budgets and heat supply to the Nordic Seas ([*Hansen et al.*, 2008] and [*Marzocchi et al. 2015*]).

Observations and models broadly agree with this description, but its variability and the division between the branches is poorly understood ([*Hansen et al.*, 2008]). A leading idea for the variability of this warm water path is that the strength and properties of the branches are driven by the horizontal expansion and contraction of the SPG due to multiannual thermohaline forcing over the gyre ([*Häkkinen and Rhines*, 2004] , [*Hátún et al.*, 2005]). When the SPG retreats to the west, the salinity of Rockall Trough Atlantic waters increases; this change propagates into the Nordic Seas, impacting its T and S structure ([*Holliday et al.*, 2008]).

The warm water path is subject to intra- to decadal forcing by both buoyancy and winds, impacting the subpolar Atlantic Meridional Overturning Circulation (AMOC) with downstream consequences for the Nordic Seas and Arctic Ocean. The net northward transport of 3-5 Sv through the Rockall Trough is mostly contained in a Shelf Edge Current (SEC) at depths <1200 m. The SEC, is hypothesized to be driven by the large-scale density distribution of the NE Atlantic. A meridional dynamic height difference between the southern entrance of the Rockall Trough and the Wyville-Thomson Ridge (to the north) provides a positive northward pressure gradient ([*Huthnance*, 1984]). Variability of the SEC on inter-annual timescales is therefore likely due to changes to the large-scale density distribution, particularly at the entrance to the Rockall Trough ([*Holliday*, 2003]). On shorter timescales (seasonal and sub-seasonal), variations in wind forcing are thought to dominate SEC variability ([*Souza et al.*, 2001]).

A smaller proportion of warm water flows northward through the mid-basin Rockall Trough: hydrographic estimates made over a 23-year period suggest between 0–8 Sv ([*Holliday et al.*, 2000]). The extent to which this range aliases short-term variability, or is describing decadal changes, is unknown. Observations suggest that the net northwards flux over the HRB is small and that the local circulation is weaker than in the Rockall Trough ([*Bacon*, 1997]). In contrast, the OSSE (Observing System Simulation Experiments) model shows a core of velocity at 100-500 m depth over the western Plateau slope with a core northward transport of 5 Sv, and an additional ~1 Sv transport over the HRB. Uncertainties over the presence and strength of these features are unresolved. The northern Rockall Trough is separated from the Faroe-Shetland Channel by the Wyville Thomson Ridge, limiting northward transport to depths <1200 m. Faroe-Shetland Channel Bottom Water is known to flow occasionally into the Rockall Trough as the Wyville-Thomson Overflow (WTO) ([*Sherwin et al.*, 2008]). The resulting water masses are identified by their T/S characteristics

([*Johnson et al.*, 2010]) but their transports have never been quantified. Evidence for the WTO can be found in bottom sediments along Feni Ridge ([*Howe et al.*, 2001]). In the model, 3.5 Sv flows southward above and along the Feni Ridge, with a velocity maximum around 1700 m (Figure 2). We use both observational evidence and the OSSE model to plan our observation programme.

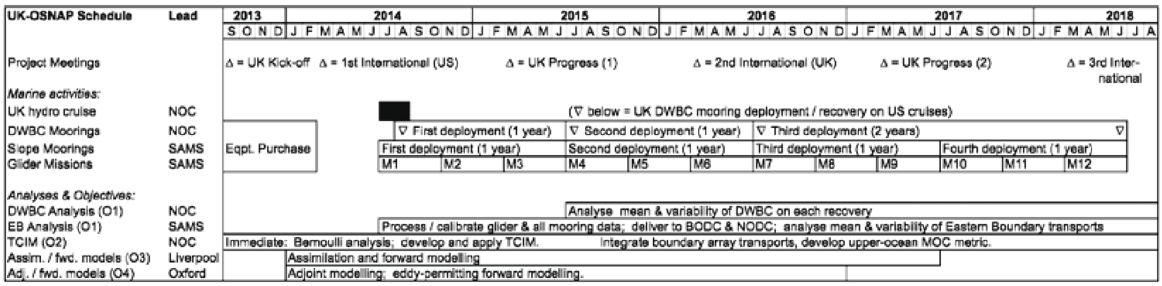

Table 3 *Schedule of project activities*

We will determine the volume, temperature and salinity transports across a line from the Scottish continental shelf to a full depth US mooring near 21°W in the eastern Iceland Basin. In the Rockall Trough, we will deploy an array comprising five moorings (Figure 2). It will continuously monitor the SEC and WTO with current meters. Two dynamic height end-point moorings will measure transports in the interior Rockall Trough. Uncertainties over the net circulation in this region lead us to plan a continuous glider patrol from the Scottish continental shelf across Rockall Trough to the HRB and as far west as the US Iceland Basin end-point mooring. The 4-month planned mission duration is based on battery life (high-latitude, cold-water endurance). Each mission will cross the Rockall Trough twice and the HRB four times, enabling the calculation of time-varying fluxes through the Trough (in conjunction with the moored data), and over the HRB.

The Rockall Trough mooring array consists of five moorings (Appendix 2) with the following objectives: **RTWB1** & **RTEB1** are end-point density moorings measuring the baroclinic circulation across the width of the Rockall Trough using CTDs distributed in the vertical; **RTWB1** & **RTWB2** measure the Wyville-Thomson Ridge overflow current along the Feni Ridge using current meters; **RTEB1, RTADCP1 & RTADCP2** measure the Shelf Edge Current using current meters and 75khz long-ranger acoustic Doppler current profilers. **RTWB1** and **RTEB1** include bottom pressure recorders to determine the barotropic variability across the Rockall Trough. The Rockall Trough section will also be surveyed by **glider** up to 10 times per year as the glider transits to and from the Hatton Bank at the beginning and end of the 4-monthly glider missions. The distribution of CTDs, current meters, bottom pressure recorders and ADCPs is shown by the symbols marked on the key in Figure 2.

The array as deployed in July 2014 consists of three moorings and one bottom mounted ADCP in a trawl resistant frame (details about the mooring deployments are shown in Appendix 3). RTADCP1 was deployed in October 2014 (deployment report in Appendix 4). Figure 3 is a schematic showing each mooring, instrument, location beacons and releases by name and serial number.

A summary of the locations of the CTDs casts carried out during the cruise is shown on Figure 4, together with the moorings' locations deployed by the different scientific teams.

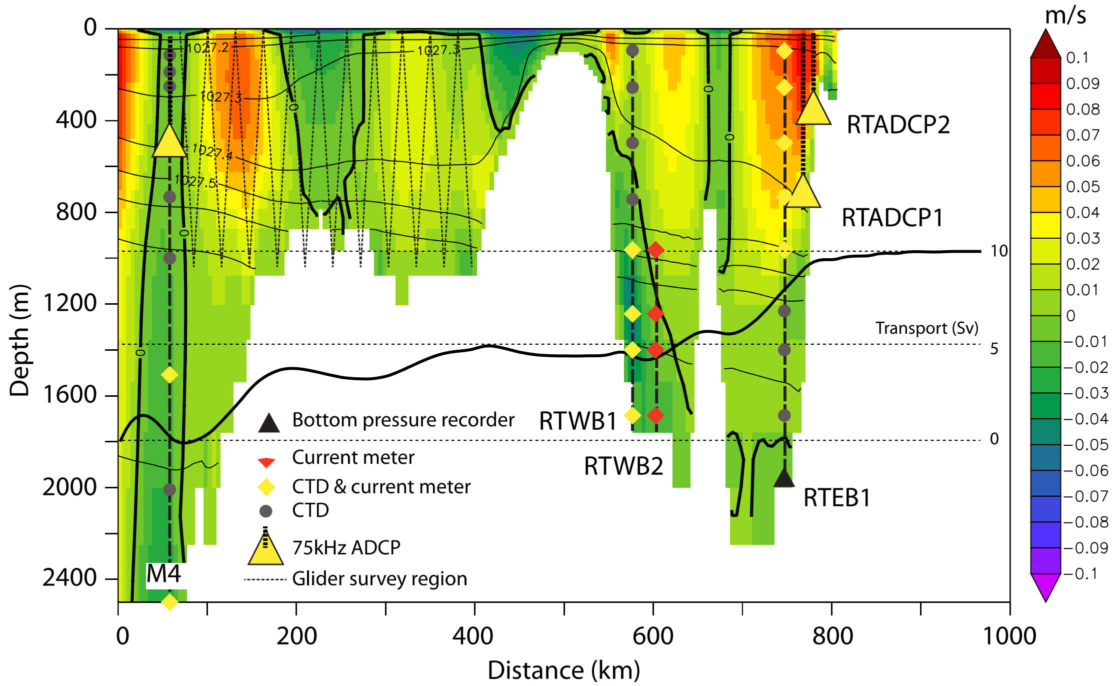

Figure 2: Schematic of the Rockall Trough and Scottish Shelf Edge Current array. Color contours: 15 year mean meridional velocity (m.s^{-1}, positive northward) from the FLAME 1/12° OSSE model. Thin black contours: potential density (kg m^{-3}). Thick black line: meridional transport integrated eastwards from zero in the west. Mooring M4: US Iceland Basin end-point mooring (not part of the UK proposal). Zig-zag line: glider patrol over Hatton-Rockall Basin. Rockall Trough moorings: RTWB1, RTWB2, RTEB1 measure endpoint density and the Wyville-Thomson Overflow; RTEB1, the Rockall Trough. RTADCP1, RTADCP2 measure the Shelf Edge Current. See key for instrument distribution. The Rockall Trough section will be surveyed by glider ~6 times per year.

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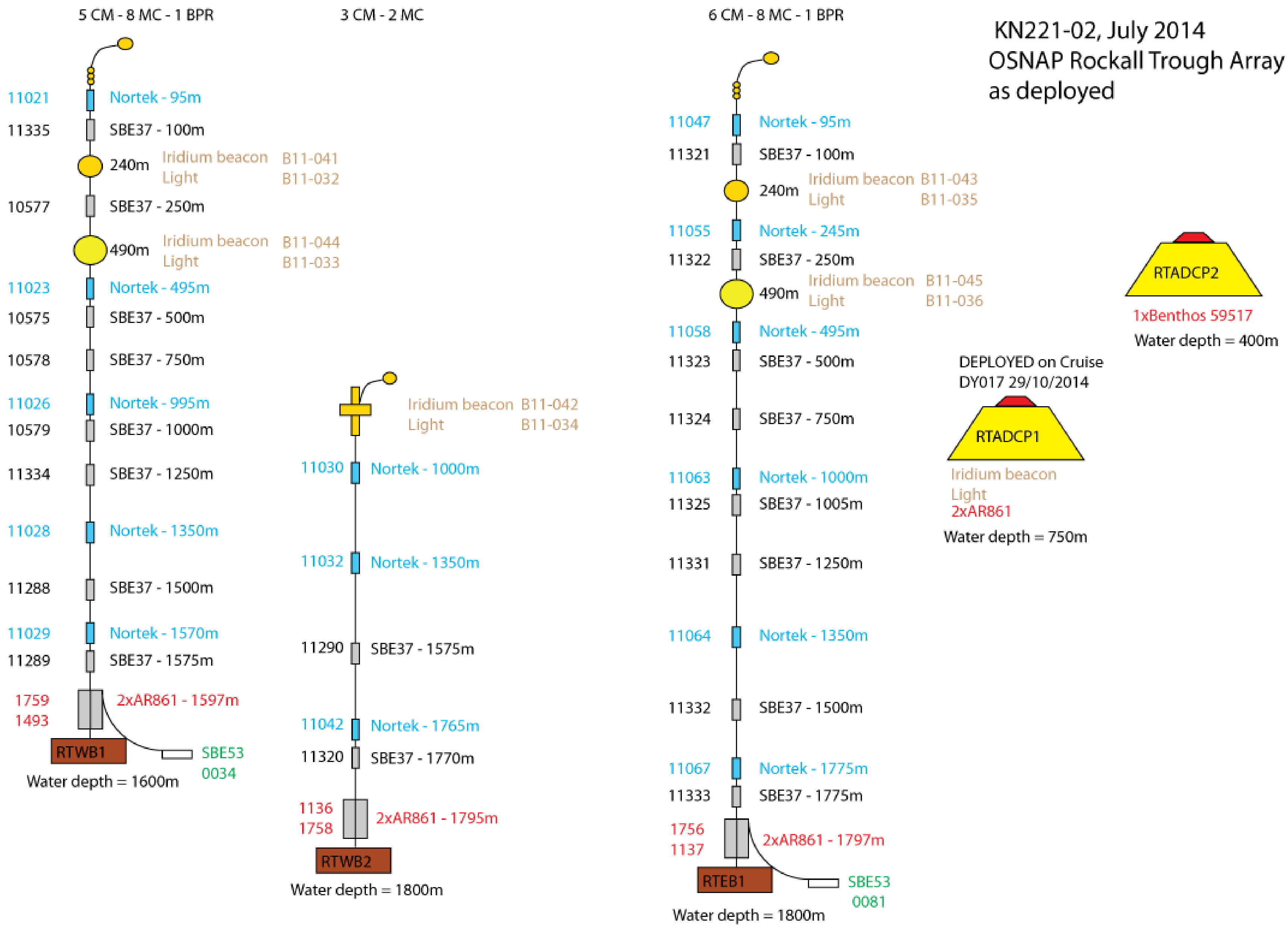


Figure 3: Rockall Trough and Scottish Slope Current Array as deployed in July 2014. RTADCP1 deployed in October 2014.

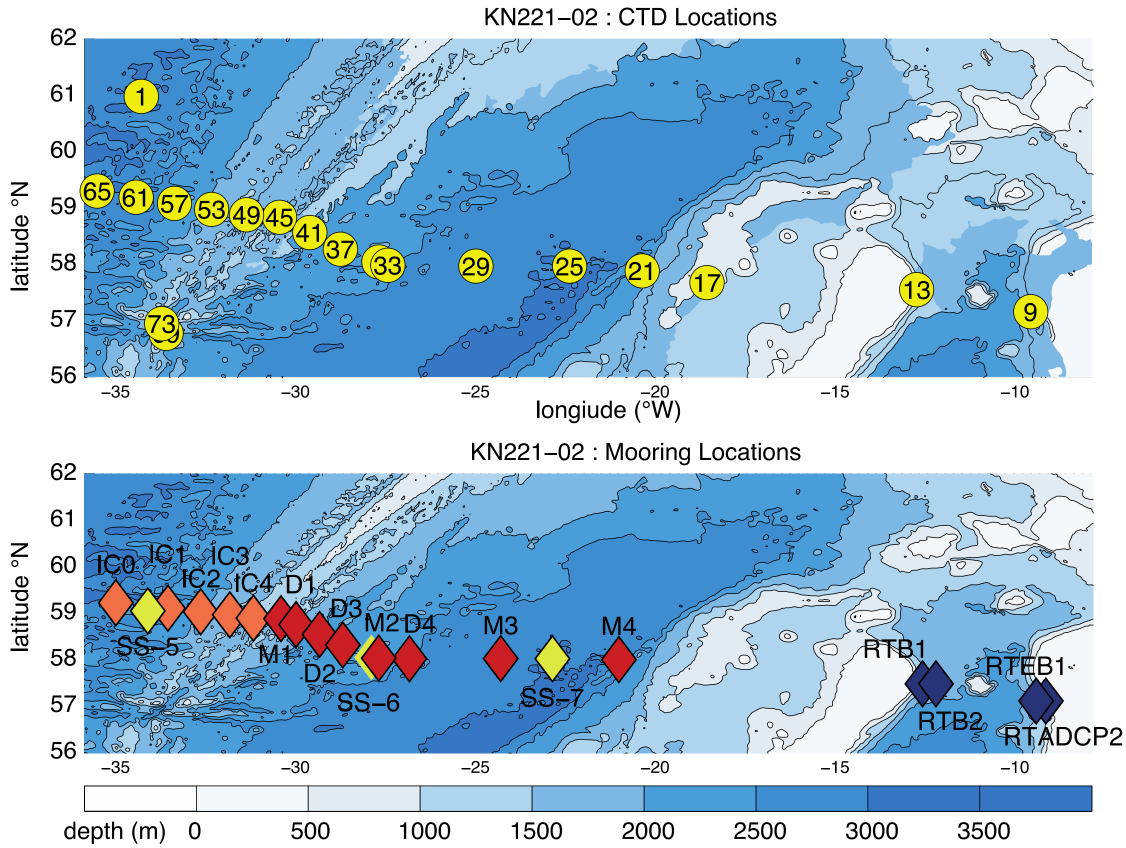


Figure 4: Bathymetry from ETOPO1 (m). Top panel, location of every 4th CTD station. Lower panel, location of deployed moorings. IC moorings (NIOZ Irminger Current moorings, orange); D & M (RSMAS Iceland Basin moorings, red); SS moorings (WHOI RAFOS sound source moorings, yellow); RT (SAMS Rockall Trough moorings, blue).

Mooring Operations

Mooring Deployment Method

Moorings (Appendix 2) were deployed anchor last using a Lebus double-barrelled winch from the Royal Netherlands Institute for Sea Research (NIOZ). This necessitated reverse winding of the wires as supplied by NOCS, because at the time of preparation it was thought the TSE direct winch would be used. Reverse winding was achieved using a pair of reelers, the receiving reeler, was electrically driven and controlled by a foot pedal, the donor reeler had adjustable hydraulic drag to keep the wire taught.

On deployments the donor reeler was also used to feed wire to the double-barrelled winch. NIOZ personnel operated the winch. From the winch the wire passed through a large-throated block suspended from a telescopic arm mounted centrally on the ship's moveable A-frame. This arrangement provided for a wide range of positioning to facilitate stopping off the wire and guiding instruments and buoyancy over the stern without damage. Stopping off was managed using a rope fastened to a large deck cleat and run through a block just below the fairlead on the outboard side of the Lebus winch. The rope was terminated with a small, crane-type hook with a safety catch that clipped into rings for stopping off. No problems were encountered with this method.

Heavy components such as syntactic buoys and anchors were lifted overboard using a quick release hook on a winch wire from the Royal Netherlands Institute for Sea Research. Tow speeds during deployments varied from 0.7 to 1.5 knots.

Deployment of the AL-500 Trawl-Resistant Bottom Mount

The AL-500 held a Teledyne RDI 75KHz remote head ADCP and external battery case fitted with a Benthos 866-A acoustic release (Table4), was deployed using a three-legged bridle and an IXSEA acoustic release, and lowered to near sea-bed using the ship's crane. The upper end of each leg was attached to a ring above the release, each leg led down and passed through a lifting point on the AL-500 Trawl-Resistant Bottom Mount (TRBM) base then led up to the jaw of the supporting IXSEA release (Appendix 2). During deployment the IXSEA's pinger function was activated in order to view its depth on an echo sounder. On nearing the seabed it was discovered that the vessel was 0.24 km off the target position and the target depth was 380m instead of 400m. The decision was made to reposition the ship without recovering the TRBM. The move was made at a speed of 10m/min. When on target the TRBM was lowered a further 20m to 400m. It was then raised 1m and the Ixsea release fired. During this time the ranges were also made to the Benthos release within the TRBM. On release no discernable change was seen in the ranges from the Benthos unit but the crane's wire tension display indicated a reduction of approximately 120kg. The calculated weight of the TRBM in seawater including instruments was 87kg so the weight reduction was considered to indicate that the TRBM was clear of the seabed when released. When the IXSEA release was recovered it was found that two legs of the bridle were intact but one was missing; only a short piece remained where it was attached to a ring above the IXSEA release. It was clear from the length of the remaining piece that one leg of the bridle had been in contact with a corner of the release lifting bail and that it had cut through by the contact.

Some discussion followed as to how and when the three-legged bridle had become two-legged and what effect this may have had on the attitude of the TRBM before and after release. Did it land upright or inverted? Ranges to the Benthos release had been made before and after release by the Ixsea unit and the number of acceptable returns was found to be very high and consistent throughout.

Examination of photographs taken at the start of deployment showed the failed bridle leg to have been one of the two going to corners of the square-based TRBM and not the one leading to the centre of the opposite side. Since a corner leg had failed the TRBM would have hung with the corner of the failed leg closest to the seabed (if the centre leg has failed it would have had the effect of hanging the TRBM from two corners with the opposite edge parallel to the seabed).

The manufacturer of the TRBM, Flotation Technology, describes the AL500 as a "free-fall deployable system" on its website however the product manual offers no detail on this method but does describe a method of lowering the TRBM to the seabed for release. Opinions and previous experiences varied as to the relative merits of each deployment method. Freefall deployment: less accurate positioning, unknown descent dynamics. Lowered deployment: more accurate positioning, possibilities of landing inverted.

Weights known

TRBM weight in air*	780kg (from Knorr crane)
TRBM weight in sea water*	87kg (from Knorr crane)

Recovery pod buoyancy in sea water* 214kg (calculated)
Base weight in sea water 301kg (calculated)
Includes instruments (ADCP, battery case & acoustic release)

Instrument Sampling Rates and Configuration Files

Details of Iridium beacons are indicated in Appendix 5. Instrument configuration files with mooring positions are detailed in Appendix 6.

Mooring Trilaterations

Post deployment mooring locations on the sea-bed were determined by acoustic trilateration of the releases (Appendix 7).

Table Of Acoustic Releases

Mooring	A/R model	Serial number	Originating
ADCP2	Benthos 866-A	59517	Marine Scotland
WB1	Ixsea AR861	1759	OSNAP
WB1	Ixsea AR861	1493	OSMOSIS
WB2	Ixsea AR861	1136	NMEP
WB2	Ixsea AR861	1758	OSNAP
EB1	Ixsea AR861	1137	DIMES
EB1	Ixsea AR861	1756	OSNAP
Spare	Ixsea AR861	899	SAMS
Spare	Ixsea AR861	1326	SAMS
Spare	Ixsea AR861	1272	NMEP
Spare	Ixsea AR861	1270	NMEP
Spare	Ixsea AR861	1753	OSNAP
Spare	Ixsea AR861	1763	OSNAP

Table 4: Acoustic releases, serial numbers, and previously associated project. Releases were selected with separated serial numbers and from different projects. Releases were all serviced on board and tested for communications and release function on CTD calibration dips to depths equal or greater than their operational depth.

CTD Microcat Calibration Dips

All microcats and acoustic releases (Table 4) deployed on the SAMS moorings were tested prior to deployment. The acoustic releases were test-fired at a depth similar to those to which they would be deployed. All fired successfully on the first cast with the exception of S/N 1136 which subsequently fired correctly on a repeat trial (see Appendix 8 for details of casts).

Microcats were calibrated on two cal-dips to 3085 and 2353 m respectively (casts 004 and 005, see Appendix 8 for details of casts). The microcats were attached to straps placed around the rosette frame, and compared to the rosette CTD sensors during several stops during the upcast, with each stop lasting approximately five minutes (see Appendix 9 for details about the processing and calibration for the ship-based CTD).

Microcat set-up

The microcats were set-up using *SeaBirds SeaTerm V2* software. For the calibration dips each microcat was programmed as below:

Sample interval (secs)	10
Data format	3
Transmit realtime	off
Sync mode	off

with the 'start date' and 'start time' appropriate to the date and time of the calibration cast. All commands were captured to a *.cap* file named in the format *XXXXX.cap* where *XXXXX* is the instrument S/N. These files were stored in */moor/raw/kn221/microcat_cal_dip/castY* where *Y* is the appropriate cast number.

Microcat data download

Immediately after each cal dip, the microcats were stopped using the 'STOP' command within *SeaTerm V2*. Data were then downloaded, again using *SeaTerm V2*, in a *.XML* and *.HEX* format. The *.HEX* file was then converted to a *.CNV* file using the *SBE3 Data Processing's Data Conversion Module* which was launched automatically from *SeaTerm*. Four data files were generated:

XXXXX_cal_dip_data.cnv
XXXXX_cal_dip_data.hex
XXXXX_cal_dip_data.xml
XXXXX_cal_dip_data.xmlcon

where *XXXXX* is the microcat S/N. These files are stored in */moor/raw/kn221/microcat_cal_dip/castY* where *Y* is the appropriate cast number.

Microcat conversion to .raw RDB format

The first step of the microcat processing converts the microcat data into the RDB format used within the RAPID project. This step creates .raw files that contain: header information, a standard date and time format, and SI units rather than imperial units. The conversion to *.raw* files is achieved using *mc_call_caldip_kn221.m*, which calls *microcat2rodb_3.m*. The converted data files are stored in the format: *castY_XXXXX.raw* in directory: */moor/proc_calib/kn221/cal_dip/microcat/castY*
where *Y* is the cast number, and *XXXXX* the microcat S/Ns. This step requires a file named *castYinfo.dat* where *Y* is the cast number, containing metadata for the caldip and serial numbers of the microcats deployed.

Mirocat comparison with rosette CTD sensors

The second step for microcat cal dips is the comparison of the microcat sensors with the CTD rosette sensors. Due to problems with the primary conductivity sensor on the rosette system (prior to replacement), the initial microcat calibration discussed here was carried out using the rosette primary temperature sensor, and rosette secondary conductivity sensor. This conductivity sensor has not currently been calibrated using bottle conductivity values; hence the calibration detailed here is not final and is therefore not discussed in detail. The secondary conductivity sensor, and replacement primary conductivity sensor for the rosette system, will be calibrated using bottle samples. The initial primary sensor is being returned to *SeaBird* for a post-cruise factory calibration.

The differences between the rosette system sensors and microcat sensors (rosette value minus microcat value) were calculated for each five minute stop on the upcast using *mc_ctd_compare_cond2_kn221.m*.

In general the microcats performed well. The difference between the rosette and microcat pressure sensors was depth dependent and ranged from +3 to -5 m (Figure 5). The standard deviation of differences within each calibration stop was small (around ±1-2 m) with the difference decreasing with time during the stop. The largest variability in differences was seen in calibration stops in the upper few hundred meters, and the stop nearest the seabed.

The mean difference between the rosette and microcat temperature sensors at each bottle stop varied between -0.005 and +0.005 °C but was often close to zero (Figure 5). Variability of the differences within each calibration stop was fairly small with values not exceeding -0.01 °C or +0.01 °C from the rosette sensor value. Again the largest variability was observed in calibration stops in the upper few hundred meters, and the stop nearest the seabed.

Slightly larger variability was observed in the differences between the rosette and microcat conductivity sensors. In general the mean difference at each stop ranged from zero to -0.005 ms/cm, with variability within a single stop not exceeding -0.01 or +0.01 ms/cm from the rosette sensor value (Figure 5). However, four microcats showed a larger mean offset: Microcat 11334 had a mean conductivity difference of around -0.012 ms/cm, whilst microcat 10578 had mean difference of +0.01 ms/cm, and microcat 10575 had a large mean offset of +0.04 ms/cm. As there was no associated increase in variability of the intra-stop differences however, a good calibration can still be applied despite the larger offsets.

A conductivity cap was accidently left on microcat 10576 causing a delay in both the conductivity and temperature sensors responding to changing water properties. However, once this delay was taken into account, the mean differences for both the temperature and conductivity sensors were near zero.

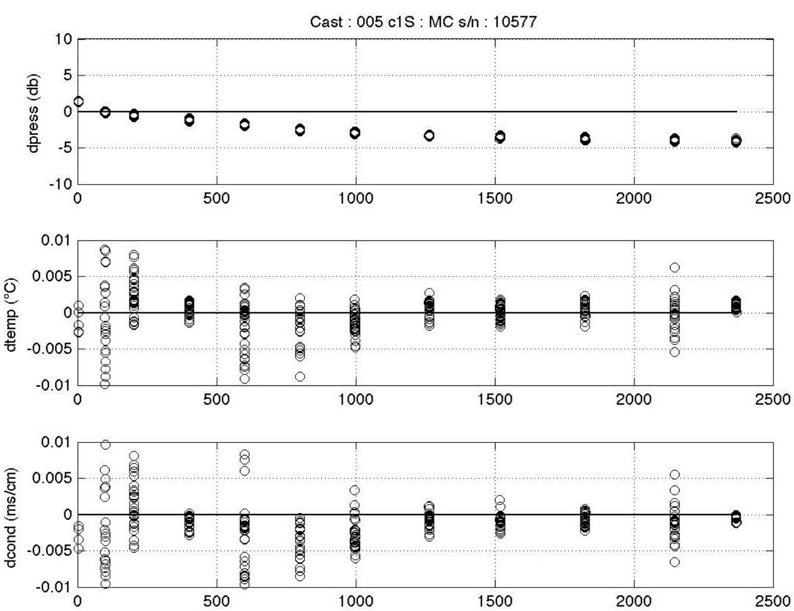


Figure 5: Example microcat calibration plot showing differences of pressure, temperature and conductivity against pressure. (CTD-microcat).

Although we originally planned to not use the two worst performing microcats (11334 and 10575), failure of two other microcats (10577 and 11287) during mooring deployment WB1 meant that these 'spares' were used - the logic being it was better to deploy a large offset microcat that had been cal-dipped than a microcat with no known calibration. Microcat 10577 had a damaged titanium thread, and microcat 11287 became difficult to communicate with. No other problems were encountered.

Final calibrations will be obtained post-cruise after final calibration of the shipboard CTD system.

Autonomous underwater vehicle: Seaglider

Serial number: SG604 Jura

Release position – 57° 59.0329' N, 21° 01.5287' W

Release time and date – 0941 16/07/2014 UTC

Weather conditions on the launch day were clear and calm with no wind, offering ideal conditions for operations from the aft deck of the R/V K*norr*.

The pre-deployment self-test was carried out on the evening before the launch date. Self-test was carried out in accordance with the 'Pre-Launch Self-Test and Set-Up Sequence' provided by North Atlantic Glider Base (NAGB) with the glider, encompassing the sea-level test, autonomous self-test and the internal pressure-test. All sections of the self-test were completed satisfactory and confirmation of glider to base communications was obtained from the pilot via email.

Pre-launch set-up was conducted immediately prior to the launch in accordance with the Final launch sequence provided. Confirmation that the set-up was complete and the glider was cleared for launch was received from the pilot at NAGB based at SAMS via satellite phone and email.

On reaching the launch site the ship came to a complete stop for the duration of the launch. The glider was lowered off the aft deck by the A-frame. It was secured by a soft rope around the rudder lifting point. On reaching the water the rope was slipped free and the glider maintained its position unaided. No buoyancy check was required before release as the glider had been tested in waters significantly fresher than the deployment location. The glider's orientation in the water was as expected, with the waterline at rudder-level and angle slightly off vertical. The ship moved away cautiously while the glider was observed until it began its first dive.

A CTD cast at the release position was not included in the ship's program and not carried out after the glider release. For future glider launches the CTD cast will be listed as a component of the launch procedure to ensure it is not over looked.

The launch procedure ran smoothly without incident, the favourable weather being a major factor contributing to the ease of launch. Confirmation of a successful first dive was received via email from the base pilot. After this progress of Jura was followed on the SAMS glider webpage.

Deployment piloting

Following the launch, the pilot first sent Jura on a shallow dive to 30m, then gradually increased the diving depth down to 1000m while adjusting the glider's flight parameters.
Once the glider was flying correctly, an in-flight compass calibration was performed. This involves making the glider do two dives, one at a shallow angle with the batteries fully rolled to port, and the other at a steep angle with the batteries to starboard, both at a high sensor sampling

rate. These were performed at dives 8 and 9. Compass calibration coefficients were then calculated in Matlab using a script provided by the Seaglider manufacturer (Kongsberg Underwater Technology, Inc.), and sent to the glider the following day before dive 13. Depth-average currents calculated for dives 1 to 12 should therefore be treated with caution.

Mission plan:

Jura's planned route is a succession of transects along the 58° parallel, between mooring M4 and the 500m contour on the west side of the Rockall Bank. The waypoints were set to:

M4	57° 59.56'N	21° 08.61'W (mooring site)
EAST	58° 0.0'N	14° 42.0'W

Jura was first sent to the waypoint "M4", which was reached at 03:10 UTC on the 17/07/2014, then started heading towards "EAST".

The glider is equipped with a Seabird CTD, an Aanderaa oxygen optode and a Wetlabs ECO-puck (fluorescence, 600nm backscatter and C-DOM). All sensors were turned on for the first few dives in order to check they were all functioning correctly, and to observe their energy usage. It was then decided to turn off the optode and ECO-puck to maximise the CTD sampling. For the next few days the pilot tested various sampling resolutions, and finally set the sampling rate to 5 seconds in the upper 150m (thermocline area), and 10s between 150 and 1000m. These sampling rates should ensure an endurance of 6 months (the planned recovery date is early January 2015).

The sampling rates and waypoints may be adjusted throughout the mission, according to environmental conditions, glider energy usage and science requirements.

Seaglider Data

SAMS glider self-test and launch procedures are held by NAGB. Progress of SAMS operated gliders and preliminary data can be viewed at: http://velocity.sams.ac.uk/gliders/. The data are transmitted to BODC in near real-time and forwarded onto the GTS.

Delayed mode dataset will also be submitted to BODC within 6 months of the end of the mission. The full glider mission report will also be finalised within six months of the end of the mission and will be available at: http://velocity.sams.ac.uk/gliders/mission_list.php.

Shipboard underway data

A suite of underway data were collected onboard, and processed into 1 minute daily summary files which were downloaded from the ships drive as *.csv* files. Data include meteorological parameters, navigation data and seawater temperature and salinity data from 5 m. Data are named in the format: *KNYYMMDD_00.csv* and stored in */cruise_data/underway*. The data are not quality checked.

Thermosalinograph

Values of surface temperature and salinity were continuously monitored using a Sea-Bird temperature-conductivity recorder installed in the ship's seawater intake line, and logged by the vessel's underway recording system (Figure 6).

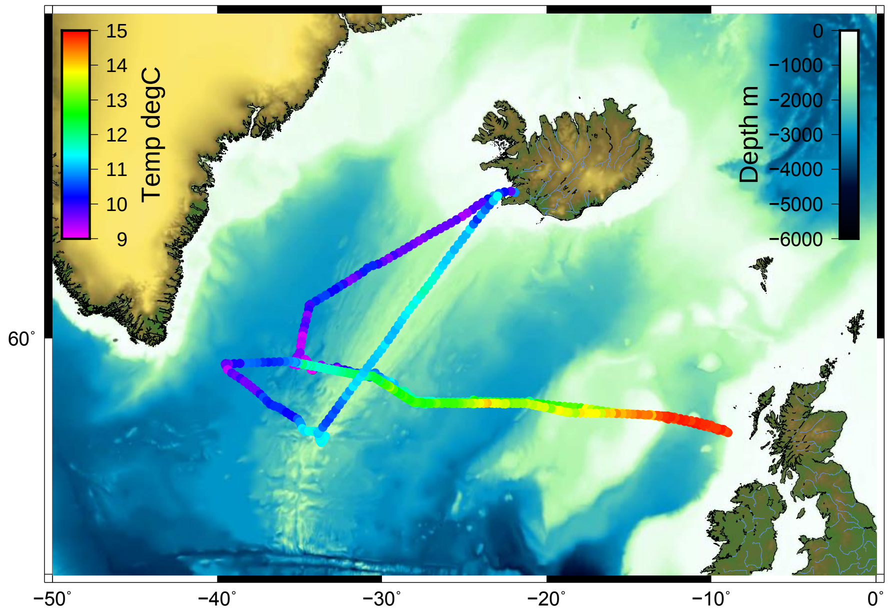


Figure 6: Bathymetry of the North Atlantic overlaid by temperature from the thermosalinograph.

Shipboard Acoustic Doppler Current Profiler

Upper ocean currents were continuously measured with a dual vessel-mounted Acoustic Doppler Current Profiler (ADCP) system consisting of a 300kHz and 75kHz Ocean Surveyor system. The depth range of good velocity data from the 300kHz system typically extended to 80m below the vessel, and to approximately 600-800m for the 75kHz system, depending on sea state conditions. Data were processed onboard in real time using the UHDAS acquisition system. Gyrocompass data were continuously corrected by a POS-MV inertial navigation system.

Appendices

Appendix 1: OSNAP Principal Investigators and responsibilities

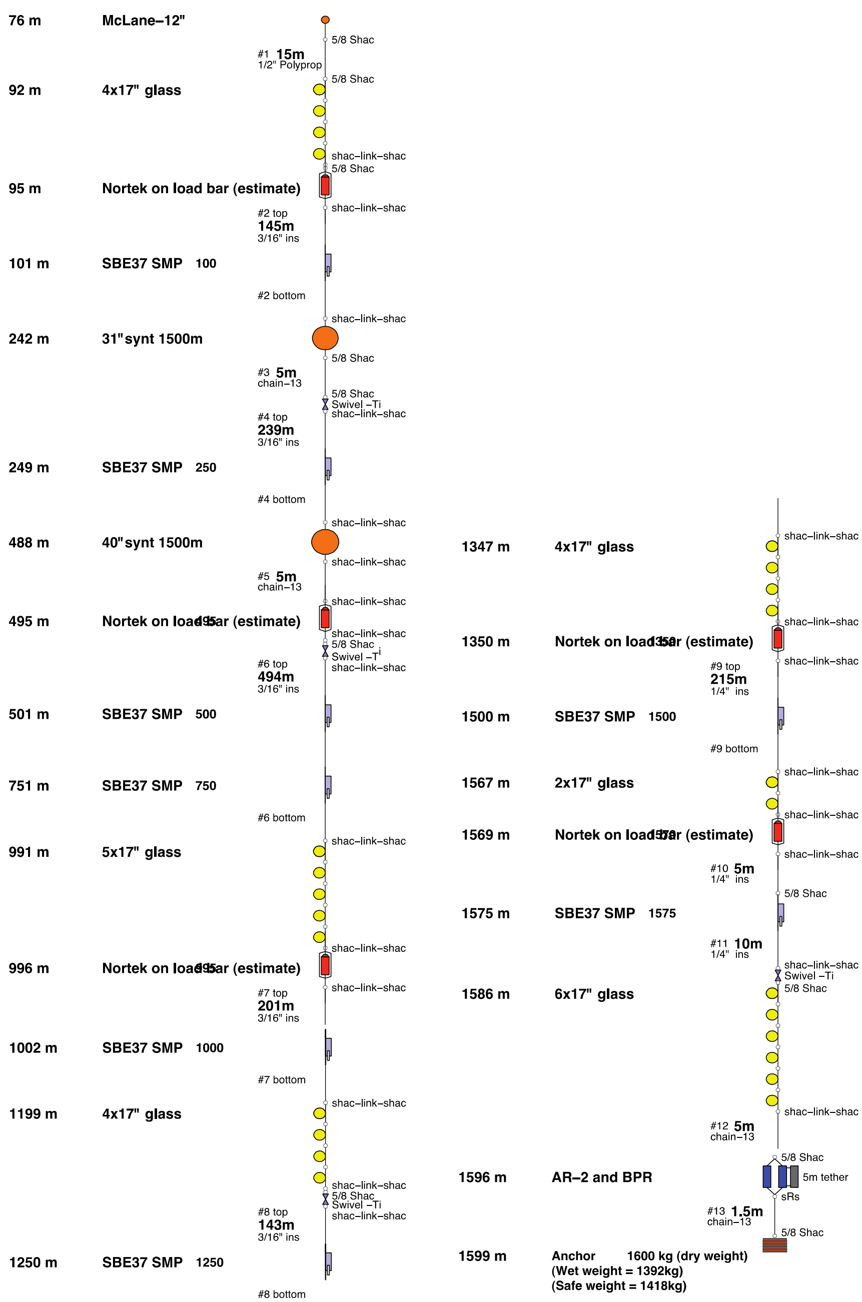
Principal Investigator	Laboratory	OSNAP array component
United States of America		
Susan Lozier	Duke University	Susan has responsibility for the coordination of international and national projects associated with OSNAP. As such, she has responsibility for integrating the measurements of OSNAP East and West to produce a continuous record of the North Atlantic subpolar AMOC, the overall goal of this international effort. Finally, Susan is responsible for program communication to international and U.S. OSNAP collaborators, the project website and the web-accessible OSNAP database maintained at Duke University.
Amy Bower	Woods Hole Oceanographic Institution	Amy Bower is responsible for the OSNAP Floats program, an effort designed to trace the pathways of overflow waters in the basin and to assess the connectivity of currents crossing the OSNAP line.
Fiamma Straneo	Woods Hole Oceanographic Institution	U.S. East Greenland boundary current array.
Robert Pickart	Woods Hole Oceanographic Institution	U.S. West Greenland boundary current array.
United Kingdom		
Sheldon Bacon	National Oceanography Centre	Sheldon is a Principal Investigator for UK-OSNAP and has overall responsibility for the project and linking with international partners.
Penny Holliday	National Oceanography Centre	Penny is leading the U.K. OSNAP Programme Manager and leads observations being made in the deep western boundary current near Greenland, and is Project Manager for UK-OSNAP.
Chris Wilson	National Oceanography Centre	Chris is leading the work to use Argo float data to make seasonal estimates of Subpolar Gyre circulation and mixing.
Stuart Cunningham	Scottish Association for Marine Science	Stuart is leading the observations of the eastern part of the monitoring array, using moorings to measure volume, heat and salt flux in the eastern gyre.
Mark Inall	Scottish Association for Marine Science	Mark is leading the observations of the eastern part of the monitoring array, with innovative use of gliders to measure volume, heat and salt flux in the eastern gyre.
David Marshall	University of Oxford	David is a Principal Investigator examining Subpolar Gyre forcing anomalies and teleconnections. With Dr Helen Johnson, the analysis will make use of adjoint modelling and theoretical analysis to identify the teleconnections between forcing anomalies and the strength and structure of the Subpolar Gyre.
Helen Johnson	University of Oxford	Helen is examining Subpolar Gyre forcing anomalies and teleconnections. This analysis will make use of adjoint modelling and theoretical analysis to identify the teleconnections between forcing anomalies and the strength and structure of the Subpolar Gyre.
Ric Williams	University of Liverpool	Ric is a Principal Investigator leading analysis of how ocean heat storage in the Subpolar Gyre varies over time. The analysis will use a combination of data assimilation and forward model integrations look at how changes in surface fluxes affect heat storage and heat transport.
Vassil Roussenov	University of Liverpool	NOCL researcher.
Canada		

Blair Greenan	Bedford Institute of Oceanography	Blair has responsibility for the coordination of the Canadian contribution to OSNAP on the Labrador Slope. As such, he is responsible for coordinating with other Canadian organizations involved in OSNAP West as well as with the German research group for the 53N line (Johannes Karstensen).
Brad de Young	Memorial University of Newfoundland	rad is the Canadian representative on the OSNAP steering committee. He works in partnership with Blair Greenan and Guoqi Han to coordinate the Canadian contribution to OSNAP on the Labrador Slope. He is also an investigator with the Vitals program in the Labrador Sea, deploying moorings in the Labrador Sea in 2015/16 and gliders there on the Labrador Shelf from 2014-2016.
Guoqi Han	Northwest Atlantic Fisheries Centre	(Northwest Atlantic Fisheries Centre, DFO) – Guoqi is responsible for deployment of moorings inshore of the OSNAP shelf-break array at 53N on the Labrador Slope. He works in partnership with Blair Greenan and Brad deYoung to coordinate the Canadian contribution to OSNAP.
Germany		
Johannes Karstensen Jürgen Fischer Martin Visbeck	GEOMAR	The GEOMAR group, Johannes Karstensen, Jürgen Fischer and Martin Visbeck are international contributors to OSNAP primarily via a mooring array (53°N array) that is located at the southern exit of the Labrador Sea, where the OSNAP west section intersects with the Labrador Shelf.The array is configured to measure transport and properties of the Deep Western Boundary Current in different water mass classes. Installed in 1997, it is maintained from Kiel since then (now by the GEOMAR Helmholtz Centre for Ocean Research Kiel, in Kiel, Germany).The GEOMAR group will further contribute to the larger scale hydrography and add their expertise on direct current observations (LADCP measurements).The group is also involved in the European Union "North Atlantic Climate" (NACLIM) project (www.naclim.eu) in the Workpackage on transports in the Subpolar North Atlantic (WP2.2).
Netherlands		
Laura de Steur	Royal Netherlands Institute for Sea Research (NIOZ)	Laura is primarily responsible for the mooring array in the northward flowing Irminger Current on the Reykjanes Ridge in the Irminger Sea and interpretation of the data obtained by it. The array consists of four tall moorings measuring the velocity, temperature and salinity of the Irminger Current. This data will provide volume and heat transport in this branch of the AMOC and the variability therein. The array will first be deployed in summer 2014 and will be serviced in 2015 and 2016 and 2018. In addition hydrographic measurements will be obtained during the yearly fieldwork providing near-synoptic high-resolution vertical profiles of temperature and salinity. Laura represents The Netherlands in the OSNAP steering committee.
France		
Herle Mercier Virginie Thierry Pascale Lherminier	Ifremer	Reykjanes Ridge moorings array to be deployed in 2015.
China		
Dexing Wu	Ocean University of China	Dexing Wu is a Principal Investigator for China-OSNAP and responsible for the gliders that will measure volume, heat and salt flux in the eastern subpolar gyre.
Xiaopei Lin	Ocean University of China	Xiaopei Lin is a Principal Investigator for China-OSNAP with overall responsibility for the Chinese contribution and for linkages with international partners.

Appendix 2: Mooring Diagrams

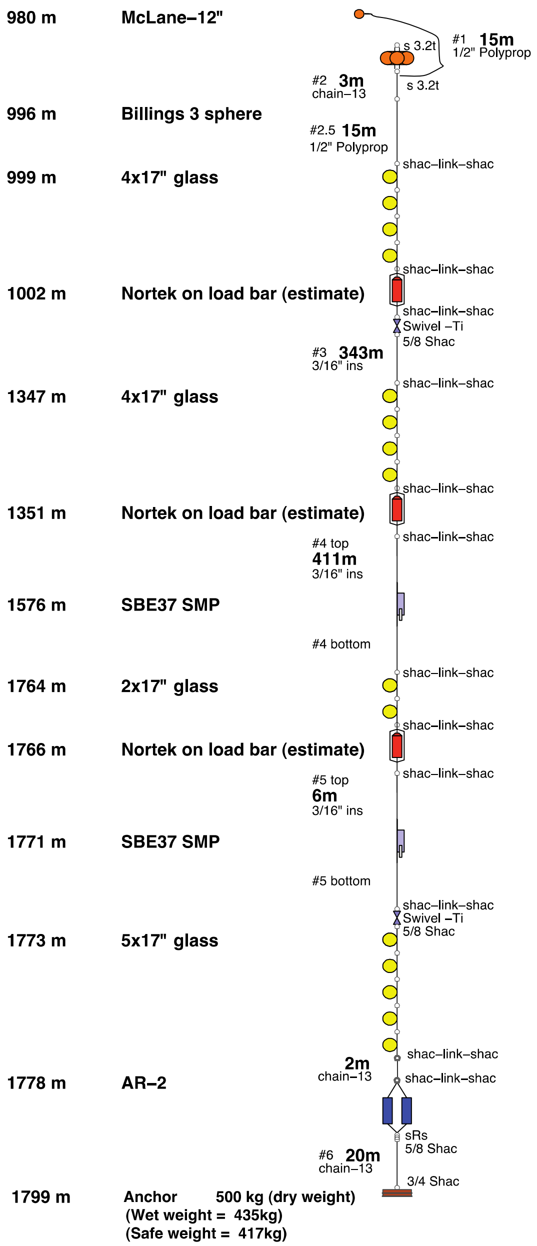
Rockall Trough WB1 deployed

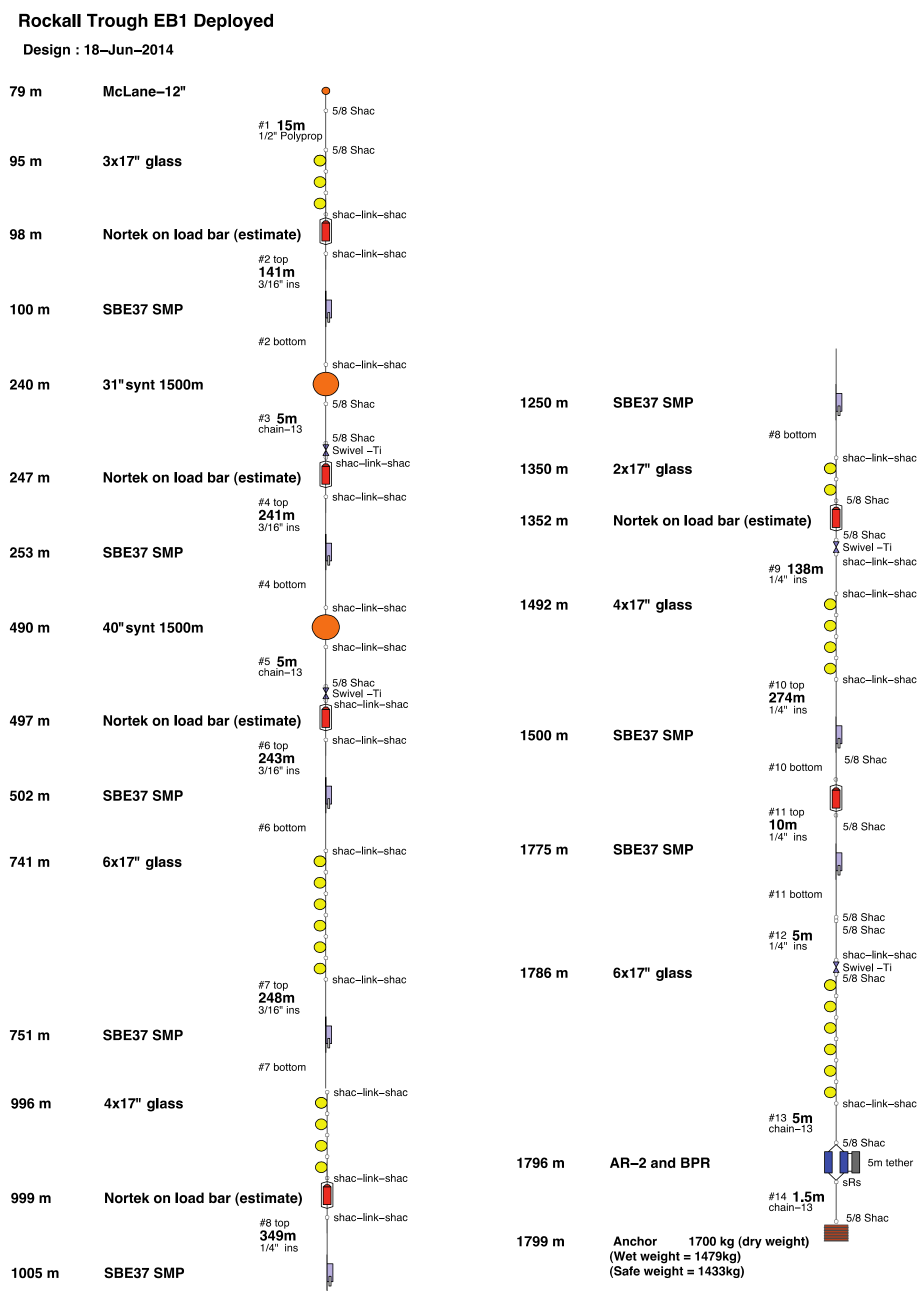
Design : 18–Jun–2014



Rockall Trough WB2 deployed

Design : 13–Nov–2013



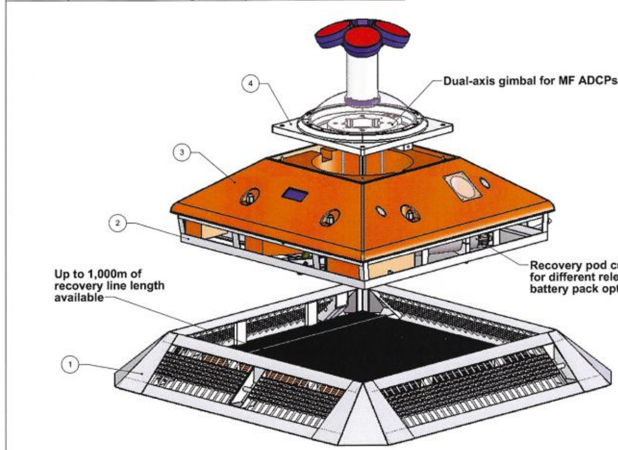

Rockall Trough EB1 Deployed
Design : 18–Jun–2014
79 m McLane–12"
5/8 Shac
#1 15m
1/2" Polyprop
5/8 Shac
95 m 3x17" glass
shac–link–shac
98 m Nortek on load bar (estimate)
shac–link–shac
#2 top
141m
3/16" ins
100 m SBE37 SMP
#2 bottom
shac–link–shac
240 m 31"synt 1500m
5/8 Shac
#3 5m
chain–13
5/8 Shac
Swivel –Ti
shac–link–shac
247 m Nortek on load bar (estimate)
shac–link–shac
#4 top
241m
3/16" ins
253 m SBE37 SMP
#4 bottom
shac–link–shac
490 m 40"synt 1500m
shac–link–shac
#5 5m
chain–13
5/8 Shac
Swivel –Ti
shac–link–shac
497 m Nortek on load bar (estimate)
shac–link–shac
#6 top
243m
3/16" ins
502 m SBE37 SMP
#6 bottom
shac–link–shac
741 m 6x17" glass
shac–link–shac
#7 top
248m
3/16" ins
751 m SBE37 SMP
#7 bottom
shac–link–shac
996 m 4x17" glass
shac–link–shac
999 m Nortek on load bar (estimate)
shac–link–shac
#8 top
349m
1/4" ins
1005 m SBE37 SMP
1250 m SBE37 SMP
#8 bottom
shac–link–shac
1350 m 2x17" glass
5/8 Shac
1352 m Nortek on load bar (estimate)
5/8 Shac
Swivel –Ti
shac–link–shac
#9 138m
1/4" ins
shac–link–shac
1492 m 4x17" glass
shac–link–shac
#10 top
274m
1/4" ins
1500 m SBE37 SMP
5/8 Shac
#10 bottom
#11 top
10m
1/4" ins
5/8 Shac
1775 m SBE37 SMP
#11 bottom
5/8 Shac
5/8 Shac
#12 5m
1/4" ins
shac–link–shac
Swivel –Ti
5/8 Shac
1786 m 6x17" glass
shac–link–shac
#13 5m
chain–13
5/8 Shac
1796 m AR–2 and BPR
5m tether
sRs
#14 1.5m
chain–13
5/8 Shac
1799 m Anchor 1700 kg (dry weight)
(Wet weight = 1479kg)
(Safe weight = 1433kg)

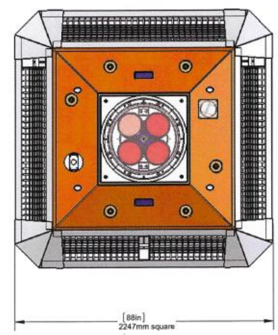
RTADCP 1 & 2

ITEM NO.	Description	Qty
1	AL-500 base assembly	1
2	AL-500 pan assembly	1
3	AL-500 float assembly	1
4	AL-500 gimbal assembly	1

REVISIONS

REV.	DESCRIPTION	DATE	DRAWN BY	CHECKED BY
A	Initial Release	09-Sep-12	MDS	





Float with pan and instrument mounts*:

Measurement	Calculated value (lbs)	Tol (lbs)	Actual MIN	Actual MAX
Buoyancy in SW	470	+/- 37		
Weight in air	708			

Full unit with base*:

Measurement	Calculated value (lbs)	Tol (lbs)	Actual MIN	Actual MAX
Weight in SW	192	n/a		
Weight in air	1,716			

****Weight & buoyancy values below DO NOT include instruments!***

Dimensions - mm (inches)
x ± 25.4 (1.00)
x.x ± 12.7 (0.50)
x.xx ± 06.4 (0.25)
x.xxx ± 01.5 (0.06)
x/xx ± 1/8
Angular ± 1°
UNLESS OTHERWISE SPECIFIED

Original Designer: MDS

AL-500 Trawl-Resistant Bottom Mount

Material: **See BOM**

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Dwg. No. 16027 | Rev. 00
DO NOT SCALE DRAWING Scale: 1:16 | Sheet 1 OF 1 | Size: B

Appendix 3: Mooring Deployment Locations and water depths

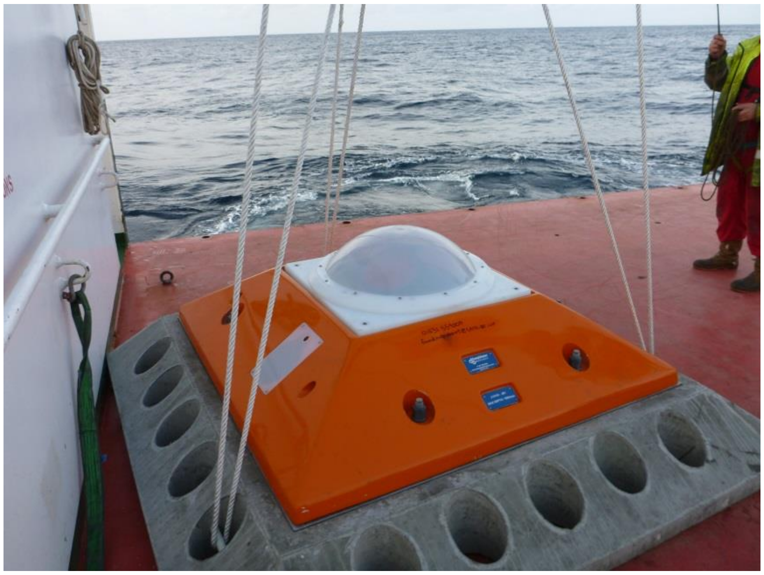
Mooring	Date	Start Deploy	End Deploy	Anchor Seabed				wd at Ancr posn (m)	Fall back (m)	Av descent rate	Irridium Beacons	AR s/n
	dd:mm:yy	hh:mm:ss	hh:mm:ss	Lat°	Lat'	Lon°	Lon'	m	m	m/ min	Depth: s/n; IMEI	
RTWB1	17/07/2014	09:31:00	11:45:24	57	28.24	12	42.30	1600	180	155	240m : B11-041 : 300234060475980 490m : B11-044 : 300234060471960	1759 1493
RTWB2	17/07/2014	14:41:40	15:40:40	57	28.22	12	19.87	1800	152	92	980m : B11-042 : 300234060477980	1136 1758
RTEB1	18/07/2014	08:14:24	11:34:00	57	05.96	9	32.88	1975	237	165	240m : B11-047 : 300234060478980 490m : B11-043 : 300234060473980	1756 1137
RTADCP1[3]	29/10/2014	15:31		57	06.18	9	20.28	1546	147	50	none	AL-500 J14110 -001
RTADCP2	18/07/2014	14:03:30	16:12:00	57	05.98	9	16.52	396	0	10	none	Benthos 59517
Seaglider SG604 Jura	16/07/2014	09:41:00	09:41:00									

[3] Deployed the 29/10/2014, see Appendix 4 for details.

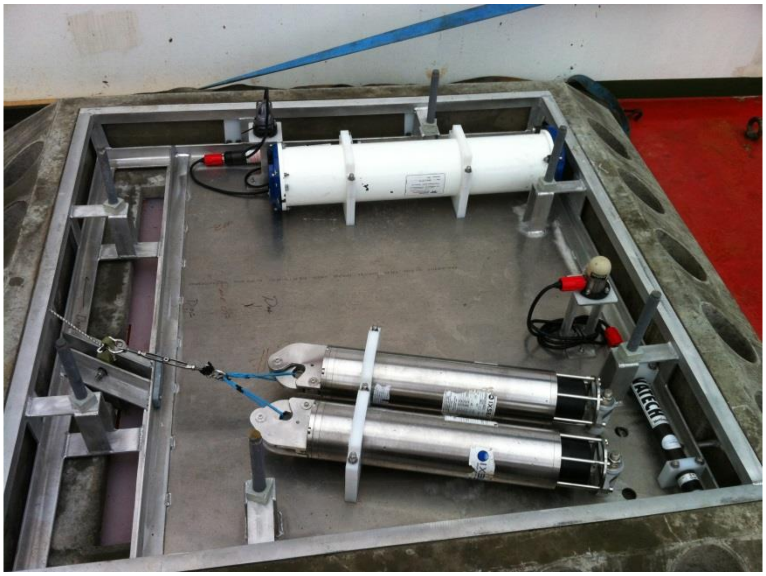
Appendix 4: RTADCP1 Deployment Report from RRS *Discovery* Cruise DY017

Mooring description

One mooring was deployed during cruise RRS *Discovery* Cruise DY017. On 29/10/2014 an acoustic current meter was deployed in support of the OSNAP project by John Beaton for Stuart Cunningham of SAMS. The deployment was named RTADCP1.


AL-500 with concrete base ready for deployment, ADCP heads protected by white dome.

The plan was to deploy the 75KHz ADCP in a low profile seabed mount at latitude 57.1°N and depth 750m at an expected longitude of approximately 9.33°W.
The deployment consisted of a Teledyne RD Instruments 75KHz ADCP in a DeepWater Buoyancy AL-500 Trawl Resistant Bottom Mount (TRBM) with a non-recoverable concrete base.
The AL-500 was fitted with a pair of Ixsea AR861 acoustic releases to provide redundancy in the event of individual failure. Recovery aids fitted were a Novatech Iridium beacon and a Novatech strobe, both pressure activated on surfacing.


Internal view of TRBM showing twin acoustic releases, recovery aids and ADCP battery case.

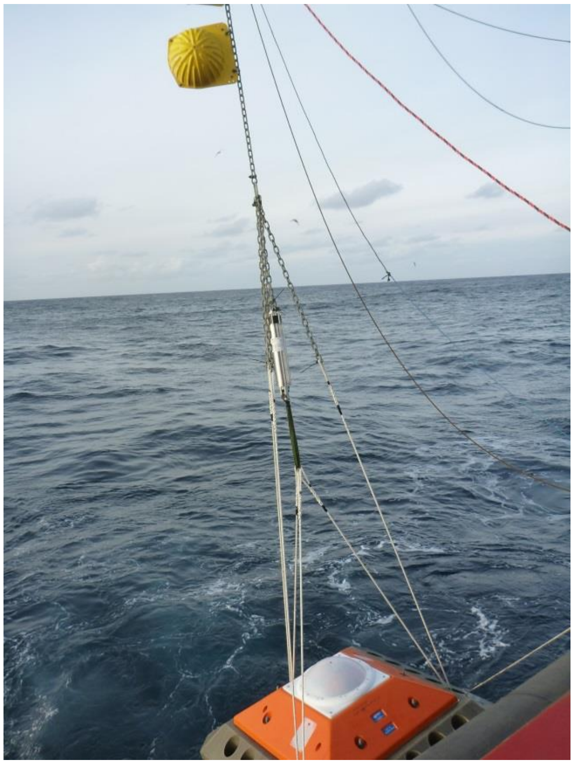
Deployment method

Deployment was by freefall from the surface with a detachable 'buoyancy parachute' consisting of three 17" Benthos glass spheres on ½" chain above an Ixsea acoustic release that could be released once the frame was confirmed on the seabed. Pre-deployment tests included a pressure and function test of all three acoustic releases by attaching to a CTD frame and lowering to 1000m then firing at 800m.

The entire package was lifted with the port-hand crane and swung out over the stern inside the extended stern gantry. With the entire package under the surface of the water a Seacatch quick release was used to release it from the crane at 1531 (57.10179°N, 9.33682°W). The TRBM and parachute were tracked, using an Ixsea TT801 deck unit, at a descent rate of about 50m/min and was on the bottom at 1546 with a slant range of 789m. Before release was attempted the vessel moved off the drop zone by several hundred meters.

Parachute failure

At 1602 the parachute was released and release confirmations received but it failed to surface maintaining a steady slant range of 935m. Multiple release attempts were made returning slight variations in range but due to the swell and position keeping it was not possible to say whether the height the parachute had changed. At 1608 a diagnostic test was made that confirmed the release was vertical and the battery voltage was 8.9V.


AL-500 showing three-legged bridle and part of buoyancy parachute (top).

It was thought the most likely reason the parachute did not detach successfully was one or more of the eyes of the three-legged bridle suspending the TRBM becoming trapped after the acoustic release was activated.

Trilateration

Confirmation of the TRBM's location was carried out by trilateration.

Position 1	57.09818°N, 9.32464°W	slant range	1227m
Position 2	57.09843°N, 9.35067°W	slant range	1184m
Position 3	57.11046°N, 9.34013°W	slant range	1110m

The position of RTADCP1 was fixed at 57.10302°N, 9.33799°W which is 147m NNW of the drop position.

Two days later at 0125 on 31/10/2014 communication was again made with the parachute acoustic release s/n 1916 from position 57.10239°N, 9.32892°W and slant range 938m. The release was confirmed as still in place and in the vertical orientation. Range and diagnostic commands were made to the TRBM's internal releases, s/n 899 & 1326, to confirm realistic ranges and correct horizontal orientations.

Instrument serial numbers

AL-500 TRBM	s/n J14110-001				
Teledyne RDI 75KHz ADCP	s/n 20467	512Mb memory card			
Ixsea AR861 acoustic release	s/n 899	A:1A7A	R:1A55	D:1A49	
Ixsea AR861 acoustic release	s/n 1326	A:18B4	R:1855	D:1849	
Ixsea AR861 acoustic release	s/n 1916	A:090D	R:0955	D:0949	
Novatech strobe beacon	no serial number				

Novatech Iridium beacon s/n M00146 IMEI: 300434060123920 on at 1405 29/10/2014
One email alert was received from the Iridium beacon at 1418 prior to deployment.
The anticipated recovery date for this mooring is during June 2015.

ADCP pre-deployment test.

```
[BREAK Wakeup B]
WorkHorse Broadband ADCP Version 50.40
Teledyne RD Instruments (c) 1996-2010
All Rights Reserved.
>DEPLOY?
Deployment Commands:
CF = 11111 --------------- Flow Ctrl (EnsCyc;PngCyc;Binry;Ser;Rec)
CK ----------------------- Keep Parameters as USER Defaults
CR # --------------------- Retrieve Parameters (0 = USER, 1 = FACTORY)
CS ----------------------- Start Deployment
EA = +00000 -------------- Heading Alignment (1/100 deg)
EB = +00000 -------------- Heading Bias (1/100 deg)
ED = 00000 --------------- Transducer Depth (0 - 65535 dm)
ES = 35 ------------------ Salinity (0-40 pp thousand)
EX = 11111 --------------- Coord Transform (Xform: Type,Tilts,3 Bm,Map)
EZ = 1111101 ------------- Sensor Source (C,D,H,P,R,S,T)
RE ----------------------- Recorder ErAsE
RN ----------------------- Set Deployment Name
TE = 01:00:00.00 --------- Time per Ensemble (hrs:min:sec.sec/100)
TF = **/**/**,**:**:** --- Time of First Ping (yr/mon/day,hour:min:sec)
TP = 01:20.00 ------------ Time per Ping (min:sec.sec/100)
TS = 14/10/20,17:46:18 --- Time Set (yr/mon/day,hour:min:sec)
WD = 111 100 000 --------- Data Out (Vel,Cor,Amp; PG,St,P0; P1,P2,P3)
WF = 0704 ---------------- Blank After Transmit (cm)
WN = 030 ----------------- Number of depth cells (1-128)
WP = 00045 --------------- Pings per Ensemble (0-16384)
WS = 1600 ---------------- Depth Cell Size (cm)
WV = 175 ----------------- Mode 1 Ambiguity Vel (cm/s radial)
>SYSTEM?
System Control, Data Recovery and Testing Commands:
AC ----------------------- Output Active Fluxgate & Tilt Calibration data
AF ----------------------- Field calibrate to remove hard/soft iron error
AR ----------------------- Restore factory fluxgate calibration data
AX ----------------------- Examine compass performance
AZ ----------------------- Zero pressure reading
CB = 411 ----------------- Serial Port Control (Baud; Par; Stop)
CP # --------------------- Polled Mode (0 = NORMAL, 1 = POLLED)
CZ  ---------------------- Power Down Instrument
FC ----------------------- Clear Fault Log
FD ----------------------- Display Fault Log
OL ----------------------- Display Features List
```

```
PA ----------------------- Pre-Deployment Tests
PC1 ---------------------- Beam Continuity
PC2 ---------------------- Sensor Data
PS0 ---------------------- System Configuration
PS3 ---------------------- Transformation Matrices
RR ----------------------- Recorder Directory
RF ----------------------- Recorder Space used/free (bytes)
RY ----------------------- Upload Recorder Files to Host
>TS?
TS 14/10/20,17:46:32 --- Time Set (yr/mon/day,hour:min:sec)
>PS0
  Instrument S/N:  20467
       Frequency:  76800 HZ
   Configuration:  4 BEAM, JANUS
     Match Layer:  10
      Beam Angle:  20 DEGREES
    Beam Pattern:  CONVEX
     Orientation:  DOWN
       Sensor(s):  HEADING  TILT 1  TILT 2  DEPTH  TEMPERATURE  PRESSURE
Pressure Sens Coefficients:
              c3 = +1.773849E-10
              c2 = -1.369659E-06
              c1 = +1.395053E+00
          Offset = -1.095539E+02
Temp Sens Offset:  -0.03 degrees C
    CPU Firmware:  50.40 [0]
   Boot Code Ver:  Required:  1.16   Actual:  1.16
    DEMOD #1 Ver:  ad48, Type:  1f
    DEMOD #2 Ver:  ad48, Type:  1f
    PWRTIMG  Ver:  85d3, Type:   6
Board Serial Number Data:
   48  00 00 07 68 CA 30  09 REC727-1004-06A
   25  00 00 07 28 4B 4E  09 HPA727-3009-00B
   3C  00 00 07 68 C9 DE  09 CPU727-2011-00E
   AB  00 00 07 68 B6 41  09 DSP727-2001-06H
   8B  00 00 07 68 DC 8F  09 TUN727-1005-06A
   5D  00 00 07 68 DF FF  09 HPI727-3007-00A
>PA
PRE-DEPLOYMENT TESTS
CPU TESTS:
  RTC......................................PASS
  RAM......................................PASS
  ROM......................................PASS
RECORDER TESTS:
  PC Card #0...............................DETECTED
    Card Detect............................PASS
    Communication..........................PASS
```

```
    DOS Structure..........................PASS
    Sector Test (short)....................PASS
  PC Card #1..............................NOT DETECTED
DSP TESTS:
  Timing RAM..............................PASS
  Demod  RAM..............................PASS
  Demod  REG..............................PASS
  FIFOs...................................PASS
SYSTEM TESTS:
  XILINX Interrupts... IRQ3  IRQ3  IRQ3 ...PASS
  Wide Bandwidth........................***FAIL***
  Narrow Bandwidth........................PASS
  RSSI Filter.............................PASS
  Transmit..............................***FAIL***
SENSOR TESTS:
  H/W Operation...........................PASS
>RS  ERR 005:  EXTRA PARAMETERS ENCOUNTERED
>PC1
BEAM CONTINUITY TEST
When prompted to do so, vigorously rub the selected
beam's face.
If a beam does not PASS the test, send any character to
the ADCP to automatically select the next beam.
Collecting Statistical Data...
  26  26  31  28
Rub Beam 1 = PASS
Rub Beam 2 = PASS
Rub Beam 3 = PASS
Rub Beam 4 = PASS
>CZ
Powering Down
```

ADCP program log file.

```
>>>>>> Function starting 10/26/14 15:28:06 >>>>>>

[BREAK Wakeup B]
WorkHorse Broadband ADCP Version 50.40
Teledyne RD Instruments (c) 1996-2010
All Rights Reserved.
>CR1
[Parameters set to FACTORY defaults]
>CQ255
>CF11101
>EA0
>EB0
>ED0
```

```
>ES35
>EX11111
>EZ1111111
>WA50
>WB1
>WD111100000
>WF704
>WN50
>WP30
>WS1600
>WV175
>TE01:00:00.00
>TF14/10/26 16:00:00
>TP02:00.00
>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 = 11101 --------------- Flow Ctrl (EnsCyc;PngCyc;Binry;Ser;Rec)
>CF11101
>RN RTAD1
>cs
```

Appendix 5: Details of iridium beacons

Mooring	Position on mooring	S/N	IMEI
WB1	Upper (240 m)	B11-041	300234060475980
WB1	Lower (490 m)	B11-044	300234060471960
WB2	~ 980 m	B11-042	300234060477980
EB1	Upper (240 m)	B11-047	300234060478980
EB1	Lower (490 m)	B11-045	300234060476980
Spare		B11-052	300234060573000
Spare		11-051	300234060471740
Spare		11-048	300234060474980
Spare		11-054	300234060475730
Spare		11-053	300234060479980
Spare		11-052	300234060573000

Appendix 6: Instrument Setup Details

MOORING RTWB1

SeaBird SBE37 Microcat

S/N 11335, 10577, 10575, 10578, 10579, 11334, 11288, 11289

Sample interval (secs)	1800
Data format	3
Transmit realtime	off
Sync mode	off
Start date (dd/mm/yy)	17/07/14
Start time (hh:mm:ss)	08:00:00

Nortek Aquadopp

S/N 11021, 11023, 11026, 11028, 11029

Measurement interval (secs)	1200
Average interval (secs)	180
Blanking distance (m)	0.50
Measurement load (%)	4
Diagnostics interval (min)	720
Diagnostics samples	20
Compass update rate (secs)	1
Co-ordinate system	ENU
Speed of sound (m/s)	1500
Analog input 1	none
Analog output	disabled
File wrapping	off
TellTale	off
AcousticModem	off
Serial output	off
Baud rate	9600
Start date (dd/mm/yy)	17/07/14
Start time (GMT, hh:mm:ss)	06:00:00

SeaBird SBE53 BPR

S/N 34

Header	kn221-02: rtwb1 sa02sc
Tide measurement interval (mins)	30
Tide measurement duration (mins)	30
Frequency of reference measurement	every 96 tide samples
Start date (dd/mm/yy)	17/07/2014
Start time (GMT, hh:mm:ss)	06:00:00

MOORING RTWB2

SeaBird SBE37 Microcat

S/N 11290, 11320

Sample interval (secs)	1800

Data format	3
Transmit realtime	off
Sync mode	off
Start date (dd/mm/yy)	17/07/14
Start time (hh:mm:ss)	14:00:00

Nortek Aquadopp
S/N 11030, 11032, 11042

Measurement interval (secs)	1200
Average interval (secs)	180
Blanking distance (m)	0.50
Measurement load (%)	4
Diagnostics interval (min)	720
Diagnostics samples	20
Compass update rate (secs)	1
Co-ordinate system	ENU
Speed of sound (m/s)	1500
Analog input 1	none
Analog output	disabled
File wrapping	off
TellTale	off
AcousticModem	off
Serial output	off
Baud rate	9600
Start date (dd/mm/yy)	17/07/14
Start time (GMT, hh:mm:ss)	06:00:00

MOORING RTEB1

SeaBird SBE37 Microcat
S/N 11321, 11322, 11323, 11324, 11325, 11331, 11332, 11333

Sample interval (secs)	1800
Data format	3
Transmit realtime	off
Sync mode	off
Start date (dd/mm/yy)	18/07/14
Start time (hh:mm:ss)	06:00:00

Nortek Aquadopp
S/N 11047, 11055, 11058, 11063, 11064, 11067

Measurement interval (secs)	1200
Average interval (secs)	180
Blanking distance (m)	0.50
Measurement load (%)	4
Diagnostics interval (min)	720
Diagnostics samples	20
Compass update rate (secs)	1

Co-ordinate system	ENU
Speed of sound (m/s)	1500
Analog input 1	none
Analog output	disabled
File wrapping	off
TellTale	off
AcousticModem	off
Serial output	off
Baud rate	9600
Start date (dd/mm/yy)	17/07/14
Start time (GMT, hh:mm:ss)	06:00:00

SeaBird SBE53 BPR

S/N 81

Header	kn221-02 rteb1 sa02sc
Tide measurement interval (mins)	30
Tide measurement duration (mins)	30
Frequency of reference measurement	every 96 tide samples
Start date (dd/mm/yy)	17/07/14
Start time (GMT, hh:mm:ss)	06:00:00

MOORING RTADCP2

Workhorse Broadband ADCP

S/N 20466

Copy of RTAD2.whp

```
;Set PC clock to GMT
CR1
CQ255
CF11111
EA0
EB0
ED4000
ES35
EX11111
EZ1111101
WA50
WB1
WD111100000
WF704
WN31
WP20
WS1600
WV175
TE01:00:00.00
TP03:00.00
TF14/07/17 09:00:00
CK
CS
```

```
;
;Instrument          = Workhorse Long Ranger
;Frequency           = 76800
;Water Profile       = YES
;Bottom Track        = NO
;High Res. Modes     = NO
;High Rate Pinging   = NO
;Shallow Bottom Mode= NO
;Wave Gauge          = NO
;Lowered ADCP        = NO
;Beam angle          = 20
;Temperature         = 5.00
;Deployment hours    = 9600.00
;Battery packs       = 4
;Automatic TP        = YES
;Memory size [MB]    = 32
;Saved Screen        = 2
;
;Consequences generated by PlanADCP version 2.02:
;First cell range    = 24.33 m
;Last cell range     = 504.33 m
;Max range           = 630.71 m
;Standard deviation = 1.36 cm/s
;Ensemble size       = 768 bytes
;Storage required    = 7.03 MB (7372800 bytes)
;Power usage         = 1582.03 Wh
;Battery usage       = 3.5
;
; WARNINGS AND CAUTIONS:
; Advanced settings has been changed.
```

Copy of WinSc[RTAD2].pdf

```
[BREAK Wakeup B]
WorkHorse Broadband ADCP Version 50.40
Teledyne RD Instruments (c) 1996-2010
All Rights Reserved.
>DEPLOY?
Deployment Commands:
CF = 11111 ---------------- Flow Ctrl (EnsCyc;PngCyc;Binry;Ser;Rec)
CK ----------------------- Keep Parameters as USER Defaults
CR # --------------------- Retrieve Parameters (0 = USER, 1 = FACTORY)
CS ----------------------- Start Deployment

EA = +00000 --------------- Heading Alignment (1/100 deg)
EB = +00000 --------------- Heading Bias (1/100 deg)
ED = 00000 ---------------- Transducer Depth (0 - 65535 dm)
ES = 35 ------------------- Salinity (0-40 pp thousand)
EX = 11111 ---------------- Coord Transform (Xform: Type,Tilts,3 Bm,Map)
EZ = 1111101 -------------- Sensor Source (C,D,H,P,R,S,T)

RE ----------------------- Recorder ErAsE
RN ----------------------- Set Deployment Name

TE = 01:00:00.00 --------- Time per Ensemble (hrs:min:sec.sec/100)
TF = **/**/**,**:**:** --- Time of First Ping (yr/mon/day,hour:min:sec)
TP = 01:20.00 ------------ Time per Ping (min:sec.sec/100)
TS = 14/07/14,10:40:01 --- Time Set (yr/mon/day,hour:min:sec)
```

```
WD = 111 100 000 --------- Data Out (Vel,Cor,Amp; PG,St,P0; P1,P2,P3)
WF = 0704 ---------------- Blank After Transmit (cm)
WN = 030 ----------------- Number of depth cells (1-128)
WP = 00045 --------------- Pings per Ensemble (0-16384)
WS = 1600 ---------------- Depth Cell Size (cm)
WV = 175 ----------------- Mode 1 Ambiguity Vel (cm/s radial)

>SYSTEM?
System Control, Data Recovery and Testing Commands:
AC ----------------------- Output Active Fluxgate & Tilt Calibration data
AF ----------------------- Field calibrate to remove hard/soft iron error
AR ----------------------- Restore factory fluxgate calibration data
AX ----------------------- Examine compass performance
AZ ----------------------- Zero pressure reading

CB = 411 ----------------- Serial Port Control (Baud; Par; Stop)
CP # --------------------- Polled Mode (0 = NORMAL, 1 = POLLED)
CZ  ---------------------- Power Down Instrument

FC ----------------------- Clear Fault Log
FD ----------------------- Display Fault Log

OL ----------------------- Display Features List

PA ----------------------- Pre-Deployment Tests
PC1 ---------------------- Beam Continuity
PC2 ---------------------- Sensor Data
PS0 ---------------------- System Configuration
PS3 ---------------------- Transformation Matrices

RR ----------------------- Recorder Directory
RF ----------------------- Recorder Space used/free (bytes)
RY ----------------------- Upload Recorder Files to Host

>TS?
TS 14/07/14,10:40:11 --- Time Set (yr/mon/day,hour:min:sec)
>PS0
  Instrument S/N:  20466
       Frequency:  76800 HZ
   Configuration:  4 BEAM, JANUS
     Match Layer:  10
      Beam Angle:  20 DEGREES
    Beam Pattern:  CONVEX
     Orientation:  DOWN
       Sensor(s):  HEADING  TILT 1  TILT 2  DEPTH  TEMPERATURE  PRESSURE
Pressure Sens Coefficients:
              c3 = +1.404564E-10
              c2 = -9.991955E-07
              c1 = +1.257229E+00
          Offset = +7.763256E+01
Temp Sens Offset:  -0.08 degrees C
CPU Firmware:  50.40 [0]
Boot Code Ver:  Required:  1.16   Actual:  1.16
DEMOD #1 Ver:  ad48, Type:  1f
DEMOD #2 Ver:  ad48, Type:  1f
```

```
PWRTIMG  Ver:  85d3, Type:   6

Board Serial Number Data:
5A  00 00 07 68 D8 00  09 REC727-1004-06A
DD  00 00 07 68 F9 06  09 HPI727-3007-00A
C3  00 00 07 68 C2 86  09 CPU727-2011-00E
2E  00 00 07 68 F8 CE  09 DSP727-2001-06H
6F  00 00 07 28 4B 43  09 HPA727-3009-00B
F6  00 00 07 68 E2 9F  09 TUN727-1005-06A
>PAPRE-DEPLOYMENT TESTS

CPU TESTS:

RTC.....................................PASS

RAM.....................................PASS
ROM.....................................PASS
RECORDER TESTS:
Card Detect...........................PASS
Communication.........................PASS
DOS Structure.........................PASS
Sector Test (short)...................PASS
DSP TESTS:

Timing RAM..............................PASS
Demod  RAM..............................PASS
Demod  REG..............................PASS
FIFOs...................................PASS
SYSTEM TESTS:
XILINX Interrupts... IRQ3  IRQ3  IRQ3 ...PASS
Wide Bandwidth.......................***FAIL***
Narrow Bandwidth........................PASS
RSSI Filter.............................PASS
Transmit.............................***FAIL***
SENSOR TESTS:
H/W Operation...........................PASS
>PC2

Press any key to quit sensor display ...
All Sensors are Internal Only.
>RS
>PC1
BEAM CONTINUITY TEST
beam's face.
the ADCP to automatically select the next beam.
>CZ
Powering Down
```

Appendix 7: Mooring Trilaterations

Mooring RTWB1

Trilateration point	A/R S/N	Latitude (°N)	Longitude (°W)	Slant range (m)
1	1759	57.5005	12.7068	3709
1	1493	57.5009	12.7067	3741
2	1759	57.4471	12.7461	3956
2	1493	57.4472	12.7463	3947
3	1759	57.4466	12.6704	3755
3	1493	57.4467	12.6703	3756

Trilateration mooring position: 57.471 °N, 12.705 °W
Fallback: 180 m

Mooring RTWB2

Trilateration point	A/R S/N	Latitude (°N)	Longitude (°W)	Slant range (m)
1	1136	57.5074	12.3302	4502
1	1758	57.5076	12.3302	4515
2	1136	57.4510	12.3717	3735
2	1758	57.4510	12.3716	3726
3	1136	57.4503	12.2872	3918
3	1758	57.4505	12.2871	3921

Trilateration mooring position: 57.470 °N, 12.331 °W
Fallback: 152 m

Mooring RTEB1

Trilateration point	A/R S/N	Latitude (°N)	Longitude (°W)	Slant range (m)
1	1137	57.13345	9.5528	4223
2	1137	57.0791	9.5897	3851
3	1137	57.0792	9.5035	3964

Trilateration mooring position: 57.099 °N, 9.548 °W
Fallback: 237 m

Mooring RTADCP2

As this mooring was lowered to around 1 m above the seabed before release, no trilateration was carried out.

Appendix 8: Details of Instruments Lowered on CTD Calibration Cast

CTD Cast Number	Instrument Details		
	Type	**s/n**	**Comments**
002 (Cal dip 2)	A/R	1759	
	A/R	1137	
	A/R	1493	
003 (Cal dip 3)	A/R	1136	Didn't fire
	A/R	1758	
	A/R	1756	
004 (Cal dip 4)	Microcat	11322	
	Microcat	11321	
	Microcat	11323	
	Microcat	11324	
	Microcat	11325	
	A/R	1136	Retest, fired ok
N/A (400 m)	BPR	0034	
	BPR	0081	
	Benthos	59517	
005 (Cal dip 5)	microcat	11331	
	Microcat	11332	
	Microcat	11290	
	Microcat	11320	
	Microcat	10575	
	Microcat	10576	1 conductivity cap still on
	Microcat	10577	
	Microcat	10578	
	Microcat	10579	
	Microcat	11287	
	Microcat	11288	
	Microcat	11289	
	Microcat	11333	
	Microcat	11334	
	microcat	11335	

Appendix 9: CTD and calibration processing

Station Number	MMM DD YYYY HH:MM:SS	Lat DEG	Lat MIN	Lon DEG	Lon MIN	Pmin DBAR	Pmax DBAR	Depth m	Bottle samples
0	Jul 07 2014 13:41:20	61	31.80	32	36.66	2	999	2329	12
1	Jul 07 2014 20:48:20	60	58.36	34	25.50	3	3024	3014	12
2	Jul 08 2014 15:59:13	59	15.20	35	7.11	2	3096	3092	12
3	Jul 08 2014 20:44:01	59	20.36	34	39.90	2	3129	3116	12
4	Jul 09 2014 01:15:10	59	20.10	34	39.54	3	3114	3105	12
5	Jul 13 2014 18:05:15	58	2.08	27	48.11	4	2369	2373	12
6	Jul 18 2014 17:39:54	57	0.09	85	99.70	2	117	134	3
7	Jul 18 2014 18:53:32	57	3.02	91	29.80	2	292	313	4
8	Jul 18 2014 20:08:59	57	5.93	92	50.10	1	1410	1416	7
9	Jul 18 2014 22:16:50	57	8.87	94	21.00	2	1937	1943	10
10	Jul 19 2014 01:07:46	57	14.13	10	2.96	2	2111	2111	9
11	Jul 19 2014 10:15:37	57	30.26	12	15.02	4	1807	1812	12
12	Jul 19 2014 13:09:46	57	32.12	12	38.12	3	1638	1645	12
13	Jul 19 2014 15:30:07	57	32.58	12	51.93	2	1067	1079	12
14	Jul 19 2014 17:13:15	57	33.04	12	59.98	2	282	298	5
15	Jul 19 2014 18:45:16	57	33.96	13	19.73	3	159	178	3
16	Jul 19 2014 20:03:40	57	34.99	13	37.84	1	97	114	3
17	Jul 20 2014 10:36:59	57	39.94	18	41.86	2	700	716	6
18	Jul 20 2014 13:03:29	57	43.72	19	13.72	2	902	917	7
19	Jul 20 2014 15:33:47	57	47.50	19	44.82	3	1301	1316	12
20	Jul 20 2014 18:07:48	57	50.12	20	8.37	3	1552	1573	12
21	Jul 20 2014 20:35:05	57	52.68	20	29.85	2	2247	2257	12
22	Jul 20 2014 23:25:52	57	54.91	20	51.31	2	2006	2015	12
23	Jul 21 2014 02:19:06	57	57.30	21	11.97	2	2978	3001	12
24	Jul 21 2014 06:45:17	57	57.58	21	51.40	2	3048	3029	12
25	Jul 21 2014 11:04:29	57	57.47	22	30.72	2	3013	2994	12
26	Jul 21 2014 15:17:44	57	57.62	23	10.37	2	3018	3002	11
27	Jul 21 2014 19:24:10	57	57.67	23	49.82	2	2967	2949	11
28	Jul 21 2014 23:28:16	57	57.66	24	29.41	3	2851	2840	12
29	Jul 22 2014 03:44:18	57	57.56	25	6.95	2	2766	2758	12
30	Jul 22 2014 07:55:32	57	57.66	25	44.73	2	2760	2749	12
31	Jul 22 2014 11:41:40	57	57.68	26	22.72	4	2851	2844	12
32	Jul 22 2014 15:44:04	57	57.67	27	0.69	3	2706	2697	10
33	Jul 22 2014 19:23:09	57	58.63	27	34.11	2	2269	2274	12
34	Jul 22 2014 23:10:40	57	59.70	28	4.25	3	2423	2426	12
35	Jul 23 2014 02:12:52	58	4.97	28	20.44	2	2311	2316	12
36	Jul 23 2014 05:26:15	58	10.34	28	36.77	2	2323	2325	12
37	Jul 23 2014 08:11:30	58	15.64	28	52.85	2	2222	2229	12
38	Jul 23 2014 10:42:09	58	20.07	29	5.44	3	2179	2184	11

39	Jul 23 2014 13:22:43	58	24.74	29	18.81	2	1848	1870	12
40	Jul 23 2014 15:51:19	58	29.38	29	32.35	3	2541	2540	12
41	Jul 23 2014 18:48:42	58	33.30	29	44.02	2	1999	2005	8
42	Jul 23 2014 21:38:06	58	37.49	29	56.77	2	1992	2010	8
43	Jul 24 2014 00:02:40	58	41.92	30	10.05	3	1717	1728	8
44	Jul 24 2014 02:13:29	58	45.70	30	21.90	2	1625	1648	8
45	Jul 24 2014 04:22:43	58	49.81	30	34.65	2	1607	1620	8
46	Jul 24 2014 06:21:42	58	50.18	30	48.32	3	1467	1481	7
47	Jul 24 2014 08:12:48	58	50.49	31	2.07	2	1388	1380	8
48	Jul 24 2014 10:09:02	58	50.94	31	16.01	3	1447	1454	0
49	Jul 24 2014 12:04:30	58	52.32	31	29.66	3	1506	1529	8
50	Jul 24 2014 14:02:41	58	53.66	31	43.30	3	1624	1645	8
51	Jul 24 2014 16:06:04	58	55.01	31	57.02	3	1774	1788	8
52	Jul 24 2014 18:13:49	58	56.69	32	12.54	3	1478	1501	8
53	Jul 24 2014 20:06:33	58	58.22	32	27.93	2	1869	1869	8
54	Jul 24 2014 22:10:43	58	59.68	32	42.11	1	1848	1874	4
55	Jul 25 2014 00:27:34	59	1.38	32	58.64	4	2248	2252	12
56	Jul 25 2014 03:03:03	59	2.85	33	14.03	3	2191	2200	8
57	Jul 25 2014 05:25:54	59	4.46	33	29.53	3	2310	2313	12
58	Jul 25 2014 07:51:15	59	6.03	33	45.33	2	2152	2164	12
59	Jul 25 2014 10:17:13	59	7.64	34	1.15	3	2847	2855	12
60	Jul 25 2014 13:05:38	59	9.32	34	17.71	4	2597	2607	12
61	Jul 25 2014 15:48:20	59	10.98	34	33.85	3	2860	2854	12
62	Jul 25 2014 18:43:14	59	12.62	34	49.94	2	2506	2508	12
63	Jul 25 2014 21:24:39	59	14.59	35	6.77	2	3049	3016	12
64	Jul 26 2014 01:05:18	59	16.09	35	21.91	4	3041	3026	12
65	Jul 26 2014 04:33:57	59	17.64	35	38.55	3	3136	3124	12
66	Jul 27 2014 21:58:13	56	40.40	33	40.61	1	1051	1070	8
67	Jul 27 2014 23:22:57	56	42.48	33	41.96	3	1768	1828	8
68	Jul 28 2014 01:21:08	56	43.96	33	43.02	3	2183	2191	8
69	Jul 28 2014 05:02:15	56	46.01	33	43.98	4	1890	1843	7
70	Jul 28 2014 07:08:25	56	48.09	33	44.94	1	1100	1120	7
71	Jul 28 2014 08:41:33	56	51.18	33	47.18	2	1530	1524	8
72	Jul 28 2014 10:30:16	56	53.75	33	49.12	3	2339	2335	8
73	Jul 28 2014 12:45:51	56	56.41	33	51.18	4	2446	2474	8
74	Jul 28 2014 15:02:45	56	58.48	33	52.95	4	1946	1988	8

Table A8: *Summary of CTD stations, times, positions and bottle sample numbers.*

CTD System Configuration

One CTD system was prepared; the main water sampling arrangement was a WHOI made, 24-way stainless steel frame system, (WHOI-01), and the sensor configuration was as follows:

Sea-Bird 9*plus* underwater unit, s/n 09P-462
Sea-Bird 3P temperature sensor, s/n 03P-4195, Frequency 0
Sea-Bird 4C conductivity sensor, s/n 04C-2147, Frequency 1
Digiquartz temperature compensated pressure sensor, s/n 63505, Frequency 2
Sea-Bird 3P temperature sensor, s/n 03P- 4252, Frequency 3
Sea-Bird 4C conductivity sensor, s/n 04C-2768, Frequency 4
Sea-Bird 5T submersible pump, s/n 05T-2148-3K
Sea-Bird 5T submersible pump, s/n 05T-3107-3K
Sea-Bird 32 Carousel 24 position pylon, s/n 3231095-0450
Sea-Bird 11*plus* deck unit, s/n 11P-0462

Additional Instruments

Ocean Test Equipment 10 litre water samplers were used in positions 2, 4, 6, 8, 10, 12, 13, 17, 18, 20, 22, 24. For each cast 3-12 bottles were used, the amount determined by depth (shallower water depth=less bottles, Figure 7.1).
WET Labs ECO-AFL/FL, Fluorometer, s/n FLNTURTD-304, A/D voltage 0
WET Labs, ECO-NTU, Turbidity Meter, s/n FLNTURTD-304, A/D voltage 1
WET Labs C-Star, Transmissometer, s/n CST-118DR, A/D voltage 2
Altimeter, s/n PSA916-1632, A/D voltage 4
Sea-Bird 43 oxygen sensor, s/n 1679, A/D voltage 5
SPAR/Surface Irradiance, s/n 20313
Knudsen 320 B/R Echosounder, s/n K2K-90-0224

Sea-Bird 9plus configuration

Sea-Bird 9*plus* configuration file C:\Data\ctd\KN221-02.xmlcon was used for all CTD casts, and details are as follows:

Frequency channels suppressed : 0
Voltage words suppressed : 0
Computer interface : RS-232C
Deck unit : SBE11*plus* Firmware Version >= 5.0
Scans to average : 1
NMEA position data added : Yes
NMEA depth data added : No
NMEA time added : No
NMEA device connected to : deck unit
Surface PAR voltage added : Yes
Scan time added : No
1) Frequency 0, Temperature
  Serial number : 4195
  Calibrated on : 11-Oct-13
  G : 4.37157395e-003

H : 6.44649362e-004
I : 2.28880376e-005
J : 1.96120418e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

2) Frequency 1, Conductivity

2.1. 07/05/2014 – 07/20/2014
Serial number : 2670
Calibrated on : 17-Oct-13
G : -9.76268941e+000
H : 1.30602044e+000
I : -9.98006005e-005
J : 7.62793708e-005
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

2.2. 07/20/2014 – end
Serial number : 2147
Calibrated on : 10-Oct-13
G : -1.00444181e+001
H : 1.40306110e+000
I : -2.56196619e-003
J : 2.42588888e-004
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC
Serial number : 63505 SBE090462
Calibrated on : 2012-03-15
C1 : -4.872453e+004
C2 : 2.143123e-002
C3 : 1.347220e-002
D1 : 3.959500e-002
D2 : 0.000000e+000
T1 : 2.994567e+001
T2 : -2.488396e-004
T3 : 3.985300e-006
T4 : 7.998620e-010
T5 : 0.000000e+000
Slope : 0.99989000
Offset : -1.74580
AD590M : 1.282050e-002
AD590B : -9.111540e+000

4) Frequency 3, Temperature, 2

Serial number : 4252
Calibrated on : 10-Oct-13
G : 4.35853437e-003
H : 6.46918839e-004
I : 2.28013364e-005
J : 1.87007817e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

5) Frequency 4, Conductivity, 2
Serial number : 2768
Calibrated on : 10-Oct-13
G : -1.06579210e+001
H : 1.52215584e+000
I : -1.41086542e-003
J : 2.16929308e-004
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

6) A/D voltage 0, Fluorometer, WET Labs ECO-AFL/FL
Serial number : FLNTURTD-304
Calibrated on : 2008-03-10
Dark output : 0.0710
Scale factor : 1.00000000e+001

7) A/D voltage 1, Turbidity Meter, WET Labs, ECO-NTU
Serial number : FLNTURTD-304
Calibrated on : 20080310
ScaleFactor : 5.000000
Dark output : 0.048000

8) A/D voltage 2, Transmissometer, WET Labs C-Star
Serial number : CST-1118DR
Calibrated on : 2008-04-30 20140131update
M : 21.8770
B : -1.3560
Path length : 0.250

9) A/D voltage 3, Free

10) A/D voltage 4, Altimeter

10.1. 07/05/2014 – 07/24/2014
Serial number : PSA916-1162
Calibrated on :
Scale factor : 15.000
Offset : 0.200

10.2. 07/24/2014 – end
Serial number : PSA916-1632
Calibrated on :
Scale factor : 15.000

Offset : 0.200
11) A/D voltage 5, Oxygen, SBE 43
Serial number : 1679
Calibrated on : 23-Oct-13
Equation : Sea-Bird
Soc : 4.55930e-001
Offset : -4.97100e-001
A : -3.66900e-003
B : 1.91110e-004
C : -2.62760e-006
E : 3.60000e-002
Tau20 : 2.23000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003
12) A/D voltage 6, Free
13) A/D voltage 7, Free
14) SPAR voltage, Unavailable
15) SPAR voltage, SPAR/Surface Irradiance
Serial number : 20313
Calibrated on : 2/20/2013
Conversion factor : 1563.22000000
Ratio multiplier : 1.00000000
Scan length : 40

Water Sampler Data:
Water Sampler Type: SBE Carousel
Number of bottles: 24
Port: COM2/ COM4
Enable remote firing: NO
Firing sequence: Table driven
Fire order Bottle position:
1 2
2 4
3 6
4 8
5 10
6 12
7 13
8 17
9 18
10 20
11 22
12 24

Sea-Bird Data Processing

CTD cast data was post-processed according to the SBE Data Processing guidelines. Bottle fire scan was set to 36 scans.

Autosal Salinometer

One salinometer, a Guildline Autosal 8400B, s/n 59210, was configured for salinity analysis. It was installed in the R/V Knorr analytical lab (1-57-2) with a temperature between 23° and 24° C. The Autosal set point was 24° C. The Salinometer was initially calibrated to read 24+ 6760. For each run a new file was opened. Temperature reading was first taken by a digital thermometer and later by a Sea-Bird SBE37 Microcat (which was more accurate). During the time in which the salinometer is not used (also in a longer break between casts), a DI water bottle is attached to the instrument and the flow rate is turned to the lowest speed. After removing the DI water, the tube is rinsed 3 times with left over standard solution.

Standardisation

Each new file is started with a Standardisation of the Instrument with a new (unopened) bottle of standard solution. OSIL IAPSO Standard seawater was used. Batch: P155, K_{15}= 0.99981, Practical Salinity 34.993, Expiration Date: 19th Sept 2015. The standard seawater bottle is shaken, opened and attached to the Salinometer. A good seal is important. The beacon sign on the computer opens a pop up window. The Salinometer is flushed 3 times with the solution and the fourth filling stays in the tube. The 'get ratio' button prompts a switch of the handle to read. After the ratio is taken it is important to turn the handle back to Standby. Then the water is flushed once more and another reading is taken. This procedure is continued until 3 readings of similar values are achieved, the last of which is accepted. The water is flushed out once more (and the tube left empty) before removing the bottle. After removal, the remaining seawater on the sample intake tube is wiped with a 'delicate task wipe'.

Seawater Sample

Water samples for calibration of the profiles were collected using a 24-bottle Rosette system containing 10 liter Niskin bottles. For most of the stations, 12 bottle samples were collected; however on very shallow stations as few as three bottles were fired, and during periods of the cruise that had a very close station spacing (e.g., over the top of the Reykjanes Ridge and in Bight Fracture zone), only 8 bottles were fired.

Each sample is shaken thoroughly before opening and attaching it to the Salinometer. The Salinometer is flushed 3 times and refilled a 4th time. The function handle is then switched to read, which prompts a pop up window with a 10 second countdown. It is essential that no flushing or minus sign appear at the reading on the Salinometer. If either does appear, turn the suppression handle until the flushing stops or the minus sign turns to plus. After the readings are taken the water is flushed out and refilled again and the handle switched to read. This procedure is continued once more to get 3 readings in total. For none of the samples an additional reading was necessary.

After the values appear in the program's spread sheet, the bottle number is entered manually. The number is entered as three digit cast, space, and bottle number (e.g. 003 1 for the first seawater sample of the third cast).

Then the water is flushed out and the tube left empty before removing the bottle. After the removal, the remaining seawater on the sample intake tube is wiped with a 'delicate task wipe'. Before closing the file, another standardisation is completed as described above.
Notes:
- if there are any air bubbles in the tube, the reading is not viable. Please flush the water and try again.
- if the bubble persists, the decreasing of the inflow speed may remove it.

CTD Data Processing

Raw data from the CTD were directly logged to a PC from the Sea-Bird deck unit using the Sea-Bird software Seasave Win 32 V7.21k. The data then underwent the following routines in SBE Data Processing to apply instrument calibrations and convert from frequency data to physical units.

Data conversion modules

1. *Data conversion*: Converts raw data from a .hex file to engineering units and stores converted data in a .cnv file and a .ros file. Data from the Upcast and downcast were converted. Output format was selected as ASCII output. The scan range offset was set to be -4 and the scan range duration to be 8s.
2. *Bottle Summary:* Summarizes data from the water sampler bottle .ros file storing results in .btl file.

Data processing modules

1. *Align CTD:* Align data relative to pressure
2. *Wild Edit*: Mark data value with *badflag* to eliminate wild points.
3. *Window Filter:* Filter data with triangle, cosine, boxcar, Gaussian, or median window. Low pass filter A (lat, lon, Beam Attenuation, Beam Transmission, Fluorescence, Turbidity, time constant 0.03s. Low pass filter B (depth, pressure), time constant 0.15s.
4. *Cell Thermal Mass*: Perform conductivity thermal mass correction. Primary conductivity values corrected with primary temperature sensor. Thermal anomaly amplitude [alpha] 0.03. Thermal anomaly time constant [1/beta] =7. Secondary conductivity values are corrected with the secondary temperature sensor. Same alpha and 1/beta.
5. *Derive:* Calculate derived variables, such as salinity, density, sound velocity, oxygen, potential temperature, dynamic height etc. The thermodynamic properties are based on EOS-80. Average sound Velocity: min pressure 20db, minimum salinity 20psu. Potential Temperature Anomaly A0=0, A1=0, A1 Multiplier= Salinity. Oxygen window size= 5s and Tau corrections are applied. Descent and Acceleration window size= 2s.
6. *Bin average*: Average data into bins based on pressure of 1db and time of 1s. Both times the number of scans per bin are included, the scans marked bad are excluded. 0 scans are skipped over. Upcast and downcast are processed. Surface bin is not included.

File manipulation modules

Translate: Convert data format in .cnv file from ASCII to binary.