JC156 Cruise Report

FRidge – GA13 GEOTRACES Section

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NERC SCIENCE OF THE ENVIRONMENT

GEOTRACES

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2. Brief cruise narrative and description of sampling stations

Mobilisation for JC156 (GEOTRACES section GA13) commenced on the 15th of December 2017 and was completed in time for an on time departure on the morning of the 20th of December 2017. Our cruise track took us out into the English Channel and west towards the continental shelf break and the Bay of Biscay. We first conducted some test stations off Biscay and then sailed south towards the Iberian Peninsula for a cross over station with the French GEOTRACES GA01 cruise off Portugal. Following this we celebrated Christmas as we sailed west towards the Azores plateau. After sailing north of the Azores islands we turned southward and began tracking along the mid Atlantic ridge. On the 3rd of January we came alongside at Ponte Delgado in the Azores to collect an additional technician. Following science stations along the mid Atlantic ridge we sailed for port at Guadeloupe and arrived on the morning of the 1st of February 2018. Demobilisation was rapid as we had packed and cleaned during the steam to port.

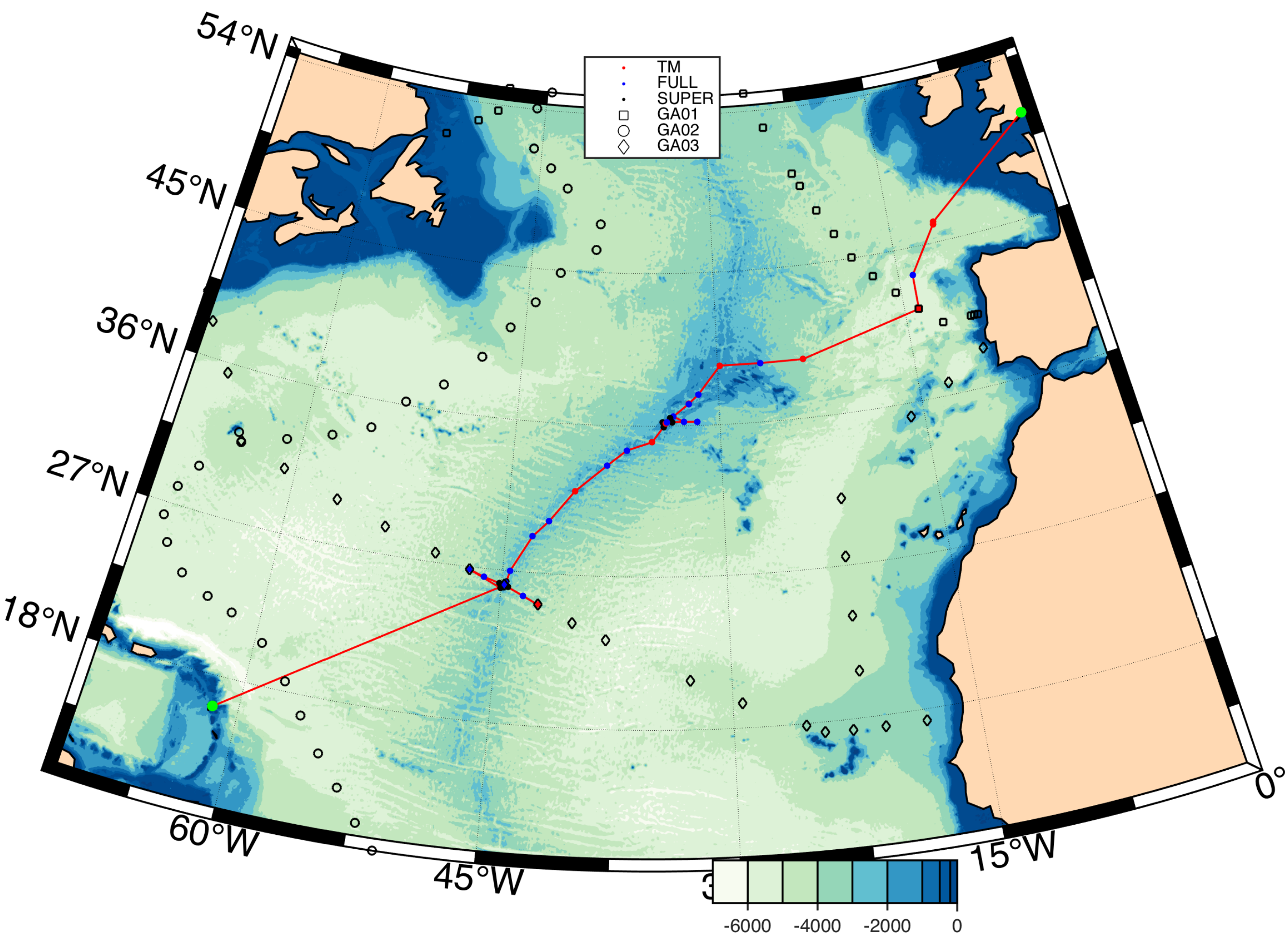

Figure 1. A basin scale map of the JC156-GA13 cruise. Including the different kinds of sampling stations, as well as the locations of three GEOTRACES cruises previously conducted in the area (GA01, GA02 and GA03).

During JC156 we conducted three types of station: a trace metal rosette deployment (denoted ‘TM’ and red circle on maps), a trace metal rosette and stainless steel rosette deployment (denoted ‘FULL’ and blue circle on maps), a trace metal rosette, stainless steel rosette and stand alone pump deployment (denoted ‘SUPER’ and black circle on the maps). At two stations (Rainbow and TAG hydrothermal sites) we redeployed the trace metal rosette a second time following a SUPER station. Around the Rainbow and TAG sites we conducted a set of ‘close’ stations (N, S, E and W), as well as bonus deployments that were guided by on board data analysis. Three tow-yo surveys were also conducted at the Lucky Strike, Rainbow and TAG hydrothermal systems.

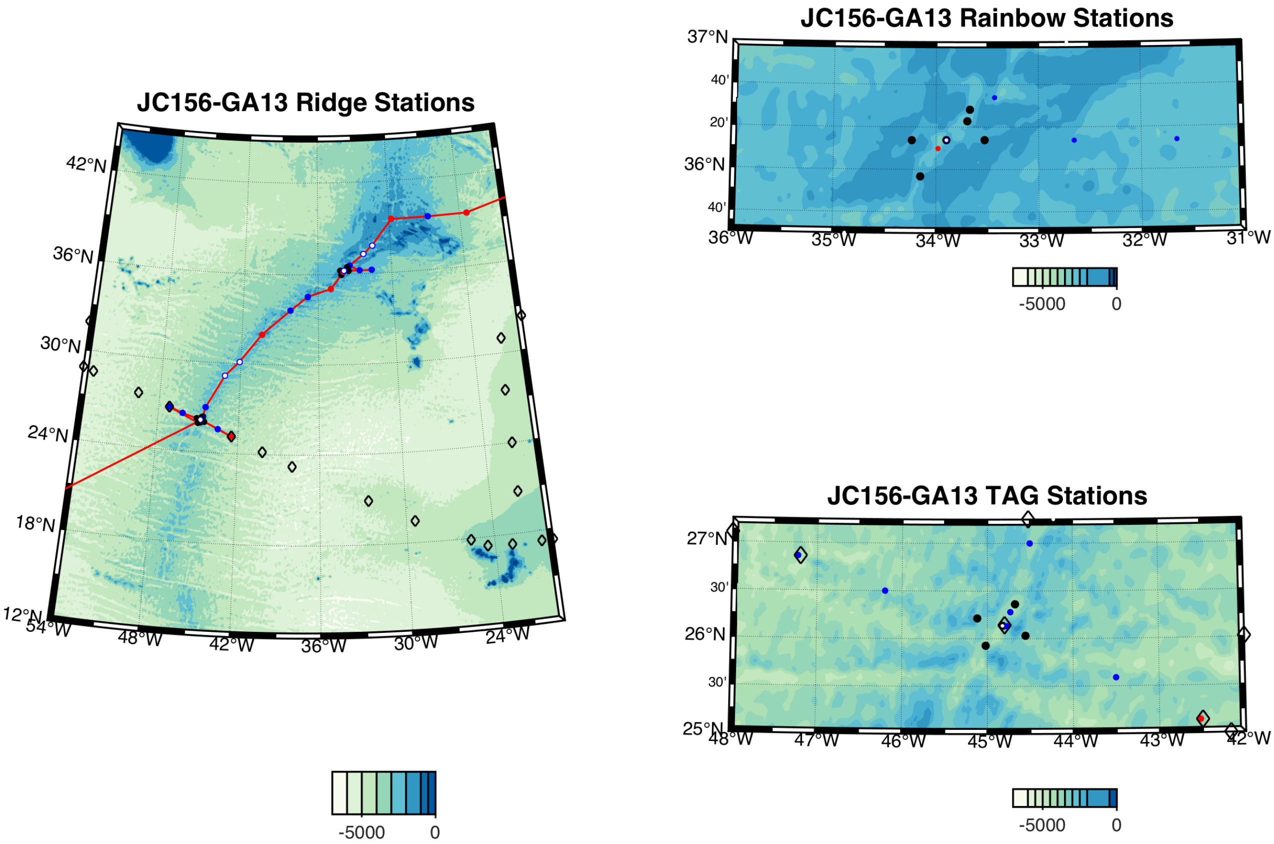

Figure 2. A zoom to show the station occupations along the Mid Atlantic Ridge and for the more detailed sampling around the Rainbow and TAG hydrothermal sites (station colouring is the same as Figure 1). White circles denote interridge hydrothermal vent sites.

Station Locations:

Latitude	Longitude	Station	TYPE	Location
50.90	-1.42		0	Southampton
46.18	-11.28		TEST	Bay of Biscay
46.06	-11.34		TEST	Bay of Biscay
43.40	-13.85	1	FULL	Shakedown
41.38	-13.89	2	TM	GA01 Crossover
39.50	-23.40	3	TM	Azores
39.50	-26.70	4	FULL	Azores
39.50	-29.80	5	TM	Azores
37.84	-31.52	6	FULL	Menez Gwen
37.30	-32.28	7	TM	Lucky Strike I
37.29	-32.28	8	FULL	Lucky Strike II
36.57	-33.43	9	FULL	Saldanha
36.23	-32.65	10	FULL	E off MAR
36.23	-31.65	11	FULL	E off MAR
36.23	-33.53	12	SUPER	Close E
36.23	-34.24	13	SUPER	Close W
36.47	-33.67	14	SUPER	Close N
35.95	-34.15	15	SUPER	Close S
36.23	-33.90	16	SUPER	Rainbow
36.17	-33.98	17	TM	S bonus
36.38	-33.69	18	SUPER	N Bonus
36.23	-33.90	16(2)/38	FULL	Rainbow II
35.04	-35.01	19	TM	Oceanographer Fracture Zone
34.53	-36.85	20	FULL	S-OH1
33.61	-38.23	21	FULL	Hayes Fracture Zone
32.00	-40.44	22	TM	MAR
30.12	-42.12	23	FULL	Lost City
29.17	-43.17	24	FULL	Broken Spur
27.00	-44.50	25	FULL	MAR27N
26.36	-44.68	26	SUPER	Close N
25.93	-45.02	27	SUPER	Close S
26.86	-47.23	28	FULL	W off MAR
26.50	-46.20	29	FULL	W off MAR
26.22	-45.12	30	SUPER	Close W
26.03	-44.55	31	SUPER	Close E
25.14	-42.52	32	TM	E off MAR
25.59	-43.50	33	FULL	E off MAR
26.14	-44.83	34	TM	TAG
26.14	-44.83	35	SUPER	TAG
26.14	-44.83	35(2)/39	SUPER	TAG
26.28	-44.73	36	FULL	N bonus
26.13	-44.77	37	FULL	TAG Valley wall
16.23	-61.54		0	Point au Pitre

Overall there were 83 CTD operations during JC156 (across both rosette systems) with a total wire distance of 429,156m.

Two vent sites were revisited during the cruise and numbered as such. 16(2) represented the second visit to Rainbow and 35(2) the second visit to TAG. In further analysis, these have now been renamed as stations 38 and 39, respectively.

The corresponding scientist for all material in this cruise report is named in each section unless it is contributed by NMF, in which case, no corresponding scientist is listed.

3. CTD operations

A total of 83 CTD casts were undertaken on the cruise, split between an NMF 24-way Stainless Steel CTD frame with 20L Niskin water samplers and a NMF 24-way Titanium CTD frame with 10L OTE water samplers.

Both CTD packages for the JC156 cruise were built at NOC and loaded onto the ship during mobilisation. Both CTD systems were loaded and secured into baseplates; the Stainless Steel CTD was loaded into the CTD Annex, whilst the Titanium CTD was left out on deck on the CTD railway track.

To protect the Titanium CTD a cover was used, this was removed prior to each cast allowing the CTD to be moved into position for deployment.

Between casts sensors were flushed with Milli-Q three times before installation of caps on the TC-duct inlet and pump exhaust of both sensor pairs. After the rosette had been sampled, the whole CTD package was rinsed with fresh water to prevent salt crystals forming in the sensors, associated tubing and particularly the carousel latch assembly.

Due to the frequent use of the CTD package, the TC-ducts were only cleaned once during the cruise with dilute bleach and Triton-X solutions.

The following sensors were installed on the Titanium CTD frame:

Instrument / Sensor:	Model:	Serial No:	Channel:	Casts Used:
Titanium 24-way frame	NOCS	SBE CTD TITA1	N/A	All casts
24-way Carousel	SBE 32	32-71442-0940	N/A	All casts
Primary CTD deck unit	SBE 11plus	11p-19817-0495	N/A	All casts
CTD Underwater Unit	SBE 9plus	09p-71442-1142	N/A	All casts
Primary Temperature Sensor	SBE 3P	3p-5660	F1	All casts
Primary Conductivity Sensor	SBE 4C	4c-4065	F2	All casts
Digiquartz Pressure sensor	Paroscientific	124216	F3	All casts
Secondary Temperature Sensor	SBE 3P	3p-5700	F4	All casts
Secondary Conductivity Sensor	SBE 4C	4c-4138	F5	All casts
Primary Pump	SBE 5T	05-4510	N/A	All casts
Secondary Pump	SBE 5T	05-5301	N/A	All casts
Dissolved Oxygen Sensor	SBE 43	43-0363	V0	All casts
Altimeter	Benthos 916T	47597	V3	All casts
Light Scattering Sensor	WETLabs BBRTD	BBRTD-759R	V2	All casts
Transmissometer	WET Labs C-Star	CST-1720TR	V6	All casts
Fluorometer	CTG Aquatracka MKIII	088244	V7	All casts
10L Water Samplers	OTE	1T – 24T	N/A	All casts
Down-looking Master LADCP	TRDI/WHM300kHz	13399	N/A	All Casts
LADCP Battery Pack	NOCS	WH009T	N/A	All Casts
USER SUPPLIED eH Sensor	N/A	N/A	V4	All Casts
USER SUPPLIED LSS Sensor	N/A	N/A	V5	All Casts

The following sensors were installed on the Stainless Steel CTD frame:

Instrument / Sensor:	Model:	Serial No:	Channel:	Casts Used:
Stainless steel 24-way frame	NOCS	SBE CTD9	N/A	All casts
24-way Carousel	SBE 32	32-19817-0243	N/A	All casts
Primary CTD deck unit	SBE 11plus	11p-19817-0495	N/A	All casts
CTD Underwater Unit	SBE 9plus	09p-87077-1257	N/A	All casts
Primary Temperature Sensor	SBE 3P	3p-4782	F1	All casts
Primary Conductivity Sensor	SBE 4C	4c-3698	F2	All casts
Digiquartz Pressure sensor	Paroscientific	134949	F3	All casts
Secondary Temperature Sensor	SBE 3P	3p-2674	F4	All casts
Secondary Conductivity Sensor	SBE 4C	4c-3873	F5	All casts
Primary Pump	SBE 5T	05-3609	N/A	All casts
Secondary Pump	SBE 5T	05-4539	N/A	All casts
Dissolved Oxygen Sensor	SBE 43	43-0862	V0	001 – 065
Dissolved Oxygen Sensor	SBE 43	43-0709	V0	065 - 083
USER SUPPLIED LSS Sensor	N/A	N/A	V1	All casts
Altimeter	Benthos 916T	41302	V3	All casts
Light Scattering Sensor	WETLabs BBRTD	BBRTD-182	V2	All casts
Transmissometer	WET Labs C-Star	CST-1654DR	V6	All casts
Fluorometer	CTG Aquatracka MKIII	88-2050-095	V7	All casts
20L Water Samplers	OTE	1A-24A	N/A	All casts
Down-looking Master LADCP (Aluminium)	TRDI/WHM300kHz	15288	N/A	All Casts
Up-looking Slave LADCP (Aluminium)	TRDI/WHM300kHz	12369	N/A	All Casts
LADCP battery pack pressure case	NOCS	WH005T	N/A	001-039
LADCP battery pack pressure case	NOCS	WH010	N/A	041-083

CTD Suite Technical Issues & Instrument Changes

There were some issues with various Niskin water samplers not closing on firing, to help minimise this, the rosette was washed with fresh water between casts.

A couple of the 20L Niskin's required replacement 0-rings and tap spares and one bottle screw cap. Any defects found with the Niskin's were reported to the NMF technicians by the scientific party allowing for replacements to be fitted.

Three TMR 10L OTE bottles had shown signs of leaking through the back fixing blocks, these were swapped out with spares and repairs undertaken when time allowed, fortunately the spares worked without issue and the repaired bottles were not required. All TMR bottles will be returned to NOC and given a full service prior to their next deployment.

JC156 experienced a number of issues with stainless steel wire terminations, which led to a number of stainless steel rosette deployments occurring with the TMR wire.

Cast Summary

Cast Number:	Julian Day:	Max Wire Out:
CTD001	356	10
CTD002	356	10
CTD003	356	10
CTD004	356	300
CTD005	356	10
CTD006	356	200
CTD007	357	4850
CTD008	357	1000
CTD009	358	5190
CTD010	360	3848
CTD011	361	2593
CTD012	361	2591
CTD013	362	2110
CTD014	363	840
CTD015	363	839
CTD016	363	1550
CTD017	363	1675
CTD018	363	1725
CTD019	364	1714
CTD020	364	2200
CTD021	364	300
CTD022	364	2210
CTD023	365	2470
CTD024	365	2475
CTD025	001	2864
CTD026	001	2870
CTD027	004	2360
CTD028	005	2350
CTD029	005	2340
CTD030	005	2340
CTD031	006	2608
CTD033	006	2611
CTD034	007	2360
CTD035	007	2350
CTD036	007	2280
CTD037	008	2277
CTD038	008	3159
CTD039	009	2615
CTD040	009	2631
CTD041	009	2480
CTD042	010	2240
CTD043	010	2280
CTD044	010	2275
CTD045	010	4225
CTD046	011	2286

CTD047	012	2280
CTD048	012	4452
CTD049	012	4475
CTD050	013	2618
CTD051	014	766
CTD052	014	762
CTD053	014	3033
CTD054	015	3037
CTD055	015	3911
CTD056	015	3500
CTD057	016	3965
CTD058	016	3910
CTD059	017	4156
CTD060	017	4152
CTD061	018	4223
CTD062	018	4224
CTD063	019	3899
CTD064	019	3891
CTD065	020	3070
CTD066	020	650
CTD067	020	3020
CTD068	021	3873
CTD069	021	3871
CTD070	022	3519
CTD071	022	4080
CTD072	023	2210
CTD073	023	3607
CTD074	024	3670
CTD075	024	0
CTD076	025	3689
CTD077	026	3650
CTD078	026	3637
CTD079	027	3409
CTD080	027	3960
CTD081	027	3900
CTD082	027	2482
CTD083	027	2506

Total Veer	**214578**	**m**
Total Haul	**214578**	**m**
Total Wire Distance	**429,156**	**m**

Data Processing

Standard Sea-Bird processing of the raw data was completed using Sea-Bird Data Processing software.
The processing order used for all casts was as follows;

- Data Conversion
- Bottle Summary
- Align CTD
- Cell TM

At the start of the cruise, each step was set up in co-operation with the scientific party using BODC's preferred settings where possible. After each cast, the raw data was immediately backed up to the network drive to avoid any data loss. Once backed up, processing of the cast data took place and this was also immediately backed up to the network drive to avoid data loss.

LADCP Operation

Instrument Configuration

Two self-logging Teledyne RDI Workhorse 300kHz ADCPs were installed on the Stainless Steel CTD frame prior to the start of the cruise, both units had the Lowered mode option installed and were used as an up/down pair with RDS3 synchronisation via the second serial interface via the star cable also installed on the CTD frame.
A single Teledyne RDI Workhorse 300kHz ADCP was installed on the Titanium CTD frame prior to the start of the cruise, this had the Lowered mode option installed and was used as downward looking ADCP.
The Master unit signals the pinging of the Slave by sending a synchronisation pulse over the second serial interface. The Slave unit pings immediately upon receipt of the synch pulse, whereas the Master unit waits 0.5 seconds after sending the synch pulse before it pings, i.e. for each ping the slave will ping first. This reduces acoustic interference between the two LADCPs.
On the Stainless Steel frame the down-looking unit SN: 15288 was sited at the centre of the frame with its transducers just above the bottom tube of the CTD frame. The up-looking unit SN: 12369 was located within an outrigger frame with its transducers just below the top tube of the CTD frame. The instruments were powered with NMF Workhorse Battery Pack serial number WH005T for casts 001 to 039, however on cast 040 WH005T suffered from water ingress and was swapped out with WH010 for the remainder of the cruise.
On the Titanium frame the down-looking unit SN: 13399 was sited at the centre of the frame with its transducers just above the bottom tube of the CTD frame. The instrument was powered with NMF Workhorse Battery Pack serial number WH010.
Due to cable routing constraints, the instrument heads did not have their beams aligned in azimuth and therefore an offset will be observed between the compass headings of the two units. By convention, the down-looking unit is deployed as the master, and the up-looking unit as the slave.

Pre-deployment
Prior to each deployment a standard checklist was followed:

- *Create a deployment terminal capture log file named in the form CTDxxxM.txt for the master and CTDxxxS.txt for the slave.*

- *Change baud rate to 9600 baud (CB411) to ensure correct parsing of command file.*
- *Check instrument time (TS?) by comparing to GPS time. Reset time if offset > 5s.*
- *Check free data storage available (RS?), reformatting the card if required.*
- *Record number of deployments on instrument storage card (RA?)*
- *Run pre-deployment tests (PA, PT200 and PC2)*

Note that a lot of these tests are intended to be run with the instrument submerged in still water and can be expected to fail in air.
The command script files are then sent to the instruments to deploy them.
The battery is then taken off charge and the deck-cables disconnected and blanking plugs fitted ready for deployment.

Post-deployment
Reconnect deck-cables. Start charging battery pack.

Upon recovery at the end of the cast, the instruments are stopped by sending a break in BBTalk.

- *The baud rate is changed to 115200 baud (CB811) to reduce the data download time.*
- *Record number of deployments on instrument storage card (RA?)*
- *Start download of data using BBTalk 'Recover Recorder' command, selecting appropriate file(s) and noting their number in the default filename sequence RDI_xxx.000.*
- *Rename the downloaded files using the form CTDxxxM.000 for master and CTDxxxS.000 for the slave.*
- *Backup the files to the network archive.*
- *Check both master and slave data files in WinADCP:*
- *Select a region of data with high echo intensity (near bottom for master, near surface for slave). Check for consistent levels for all four beams for echo intensity and beam correlation.*
- *Check that the start and stop times of the data files corresponds with the deployment and recovery times.*
- *Record the number of pings (ensembles) in each data file.*

For data downloading and battery pack recharging a pair of deck cables was run from the hanger and into the deck lab where we had a small bench top PSU and a laptop. In between casts the battery pack on the CTD was recharged, to ensure there was enough power to operate both LADCP's.

Deployment Command Scripts

Downlooking Master:

```
WV400             ; ambiguity velocity [cm/s]
WN25              ; number of depth cells; NBP0402
WS0800            ; bin size [cm]; NBP0402: WS1000
WF0               ; blank after transmit [cm]; NBP0402
WB1               ; narrow bandwidth mode
EZ0011101         ; Sensor source: (NBP0402: EZ0111111)
EX00100           ; coordinate transformation: (NBP0402: 11111)
WP1               ; single-ping ensembles; NBP0402: WP3 most of the time
TC2               ; ensembles per burst
TB 00:00:02.80    ; time per burst
TP 00:00.00       ; time between pings; NBP0402
TE 00:00:01.30    ; time per ensemble
CF11101           ; Flow control:
SM1               ; set to master
SA011             ; send pulse before ensemble
SW5500            ; master waits .5500 s after sending sync pulse
RNmast_
CK                ; keep params as user defaults (across power failures)
W?
T?
CS                ; start pinging
```

Uplooking Slave:

```
WV400             ; ambiguity velocity [cm/s]
WN25              ; number of depth cells; NBP0402
WS0800            ; bin size [cm]; NBP0402: WS1000
WF0               ; blank after transmit [cm]; NBP0402
WB1               ; narrow bandwidth mode
EZ0011101         ; Sensor source: (NBP0402: EZ0111111)
EX00100           ; coordinate transformation: (NBP0402: 11111)
WP1                     ; single-ping ensembles; NBP0402: WP3 most of the time
TP 00:00.00       ; time between pings; NBP0402
TE 00:00:01.30    ; time per ensemble
CF11101           ; Flow control:
SM2               ; set to slave
SA011             ; waits for pulse before ensemble
ST120             ; waits 120s for ma-signal before running single^M
RNslav_
CK                ; keep params as user defaults (across power failures)
W?
T?
CS                ; start pinging
```

4. CTD scientific processing and sensor calibrations

Carl Spingys (University of Southampton)

Underway Data

Introduction

Underway data was collected for a range of parameters throughout the cruise. The data can be broadly split into three categories: (1) ship position data, (2) meteorological data, and (3) sea surface data.

Processing

Initially the data is formatted in real time through the ship's techsas system. This system generates netCDF files of the raw data. These netCDF files were then ingested into the Mstar processing system to maintain complete data sets for the entire cruise and to perform some basic processing.

Specifically the following routines were used:

- mday 00 get all(day) Retrieves data from ship SCS system.
- mday 02 run all(day) Appends the days file to the running logs.
- mbest all(day) Calculates the 'best' position by combining the different navigation
- mtruewind 01 Calculate true wind data.

Running logs of the whole cruise were updated daily using the mday 02 command. The files must be added sequentially in order. The true wind direction was calculated by combining the measured relative wind speed and direction with the calculated 'best' navigation data. No calibrations were applied to the underway data.

CTD

Introduction

Two CTD systems were used on JC156, one a conventional Stainless Steel and the other a Trace Metal Clean Titanium Rosette. Both systems were routinely deployed at stations consecutively. A total of 29 profiles were obtained from the Stainless Steel system and 40 from the Trace Metal Clean system. In addition to conventional vertical profiles the Stainless Steel system was deployed as a Tow-Yo at three locations providing four high resolution sections. On these occasions a USBL beacon was also deployed on the frame to track the package at depth. In addition to the standard CTD setup, an eH and LSS sensor was added to each of the CTD systems to support the identification of hydrothermal plumes.

Calibration Sampling

Water samples were taken for the calibration of Conductivity, Oxygen and Chlorophyll.

Bottle samples for conductivity were taken from every CTD cast typically at 5 to 7 depths, dependant on the water budget. These samples were selected to sample regions with weak vertical salinity gradients and to sample the full range of pressure, due to the potential for a pressure dependence in the conductivity sensor. These samples were run on an AutoSal Salinometer. During the cruise it was noticed that there was often a large difference between standards run at the start and end of runs and between runs. Multiple re-standardisations were performed however, this did not seem to resolve the problems. As a result the Salinometer was taken out of action and the remaining samples returned with the ship to the National Oceanography Centre and run at the calibration lab there. In many cases the standards vary by 20e-5 between runs (Figure1). This provides an lower limit on our confidence in the output from the Autosal for the CTD samples. The samples run at NOC have far smaller variability and are close to zero (Figure. 1). An attempt has been made to remove some of the questionable samples by excluding samples where the difference between the sensors was 10 times smaller than that between the sensor and the bottle sample. The rationale behind this was that it is more likely that such bottle samples are bad rather than both sensors being incorrect in a very similar way. Given the large spread in the standards and the fact the standards at the start and end of a run have often have opposite sign corrections, no correction has been applied to the Autosal. The CTD salinity on this cruise is likely to have larger errors than is typical and should be handled with care.

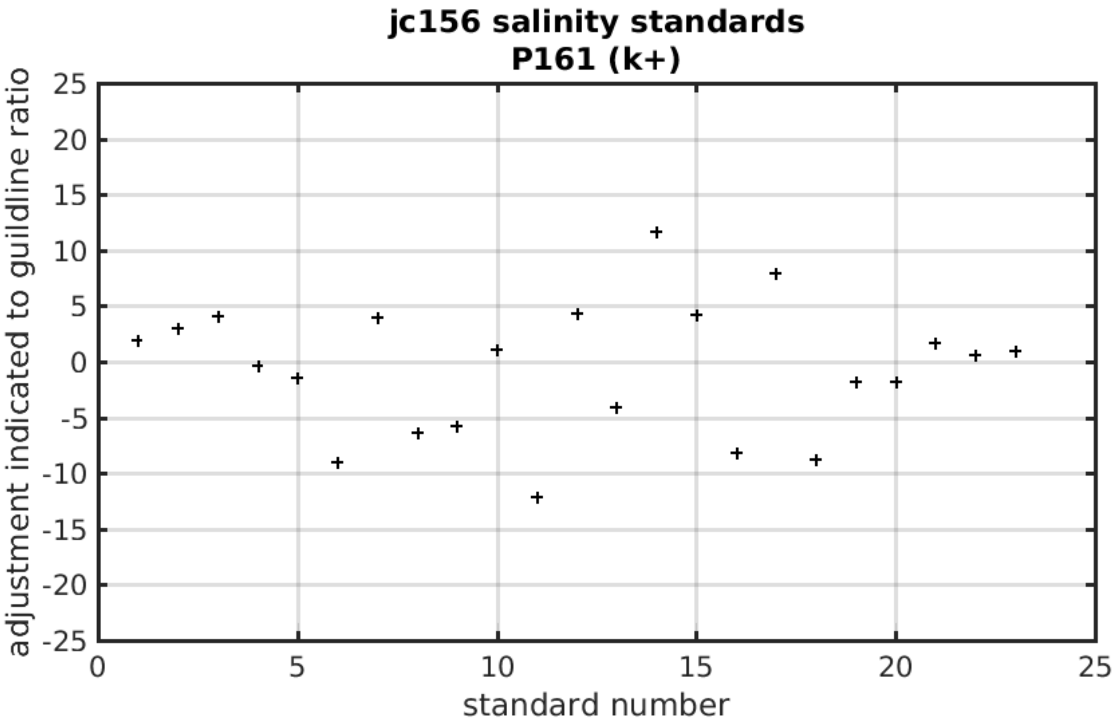

Figure 1 Adjustment indicated to the Autosal taken from the standards (P161) run both during the cruise and at NOC. The standards run on the cruise are 1:18 and the standards run at NOC at 19:23.

For details of the sampling for Oxygen and Chlorophyll see the relevant sections.

Instrumentation Issues

The oxygen sensor on the stainless steel rosette was displaying large spikes at around 3100 m depth therefore was replaced for CTD64 and onwards.

Processing

The data processing on JC156 has been performed in two stages. First, preliminary processing is performed using the SBE Data Processing tools on the CTD computer. Second, the data is processed using the MEXEC software developed by Brian King.

SeaBird Processing

Data were recorded and viewed using Seasave version V7.26.2.13. For each cast 4 files were created.

File Type	Description
.hex	Hexadecimal data file
.XMLCON	Configuration file with manufacture calibrations
.hdr	Header file containing sensor and deployment metadata
.bl	Bottle firing information

After each deployment the raw data files have been copied to the ship server. The data are then processed in three steps using SBE Data Processing version V7.26.2.14. Initially the data conversion routine is used to convert the hexadecimal to an ASCII file. The data is then passed through the Align CTD and Cell Thermal Mass routines to correct for the temporal offset between sensors and to correct for the thermal mass of the Conductivity sensor.

Mstar Processing

The network data drive, JC156, was linked to ctd/ASCII FILES/jcrfs ctd and ctd linkscript was used to copy files to bamba and set up additional symbolic links to filenames following mstar convention. At the beginning of processing, empty sample files sam jc156 nnn.nc for all casts were generated using msam 01. For each cast, the following m-files were then run, using wrapper script ctd all part1: mctd 01, mctd 02a, mctd 02b, mctd 03, mdcs 01, mdcs 02. The processes completed by these scripts include:

- Read ASCII cnv data from ctd/ASCII FILES/ctd jr16005 nnn.cnv.
- Convert variable names from SBE names to mexec names using jr16005 renamelist.csv in data/templates/ctd/ directory.
- Copy raw file to 24hz file.
- Average to 1hz.
- Calculate derived variables psal, potemp.
- Extract information from bottom of cast identified by maximum pressure.

Subsequently, mdcs 03g was run to inspect the profiles and hand-select cast start and end times. The way oxygen time lag is handled in the SBE align algorithm, and the weak dependence of oxygen calculation on salinity, means that when air is ingested into the conductivity cell at the end of the cast, the oxygen becomes biased a few seconds earlier than the psal. Care should therefore be taken to select a cast end time for which all the important variables are free from bias. The start, bottom and end data cycles are stored in files with names like dcs jc156 nnn.nc.

After selecting the limits for start and end, ctd all part2 was then run, executing mctd 04, mfir 01, mfir 02, mfir 03, mfir 04, mwin 01, mwin 03, mwin 04. The processes completed by these scripts include:

- Extract downcasts and upcasts using scan numbers stored in dcs jr16005 nnn, and average into 2 dbar files (2db and 2up).
- Read the data/ctd/ASCII FILES/ctd jr16005 nnn.bl file and extract scan numbers corresponding to bottle firing events.
- Add time from CTD file, merging on scan number.
- Add CTD upcast data (P, T1, T2, S1, S2, etc) corresponding to bottle firing events.
- Paste these data into the master sample file data/ctd/sam jr16005 nnn.nc.
- Load winch telemetry data from winch SCS file.
- Add winch wireout data to the fir jr16005 nnn file.
- Paste winch wireout data into the master sample file.

Processed data could then be examined using mctd checkplots to view sensor and up-down cast differences as well as compare nearby profiles, with particular attention paid to any drift in deep temperature or salinity (expected to be relatively stable) over time. The 24-Hz data were checked for spikes in either of the temperature or conductivity sensors using mctd rawshow and, if necessary, edited using mctd rawedit. A variety of extra steps is available after other processing has been carried out; these steps can be run in any order.

After navigation data processing has been completed, the file bst jr16005 01 will be available. mdcs 04 will generate files dcs jr16005 nnn pos.nc which include position at start, bottom and end of profiles. The script mdcs 05, which paste the position at the bottom of the cast into the header of all relevant files in data/ctd, was not run during the cruise. When temperature and conductivity calibrations are available, they are applied to the 24hz files using mctd tempcal and mctd condcal, as described below. A subset of scripts should now be rerun, specifically mctd 02b, mctd tempcal with senscal = 1, mctd tempcal with senscal = 2, mctd condcal with senscal = 1, mctd condcal with senscal = 2, mctd 03, mctd 04, mfir 03, mfir 04, msam updateall. This collection of calls can usefully be put in a script like smallscript.m. Selection of data cycle start and end points is preserved by smallscript, as well as edits to the raw file made using mctd rawedit. Water depth and position data will also be preserved and do not need to be re-entered after conductivity calibration.

Stainless Steel CTD Calibrations

Conductivity

There is an offset between the medians of the samples run on the ship and at NOC. The ship salinometer was noisy, although some data has been removed, however this did not show a clear bias. Whilst the NOC samples have been run on a more reliable salinometer they also spent a considerable amount of time being shipped and in storage. As such I see no clear reason to trust the results of the NOC samples more than those run at sea.

There does not appear to be a strong change in time or with pressure for either sensor on the Stainless Steel CTD. As a result we simply apply the median ratio from the combination of the ship and NOC run samples, as there does not appear to be a clear reason to pick on over the other despite their offset. Those medians are: for the primary sensor 1.000047, and for the secondary sensor 0.999982.

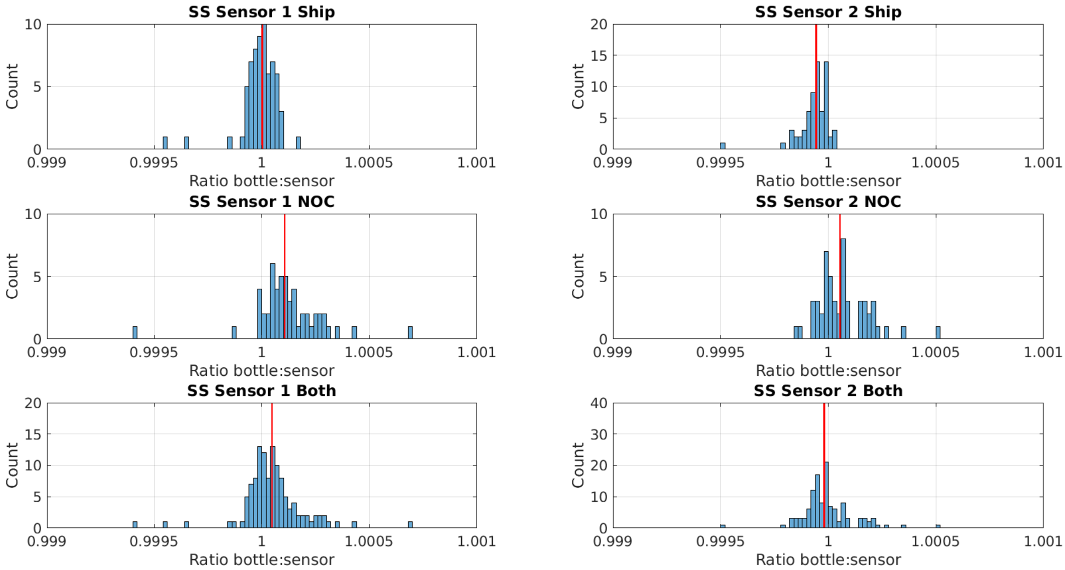

Figure 2 Histograms showing the distribution of the ratio of bottle sample to sensor conductivity. The rows indicate the samples run: on the ship, at NOC, and the combination respectively. The rows indicate the primary and secondary sensors. The red vertical lines are the median value of the ratio for each set.

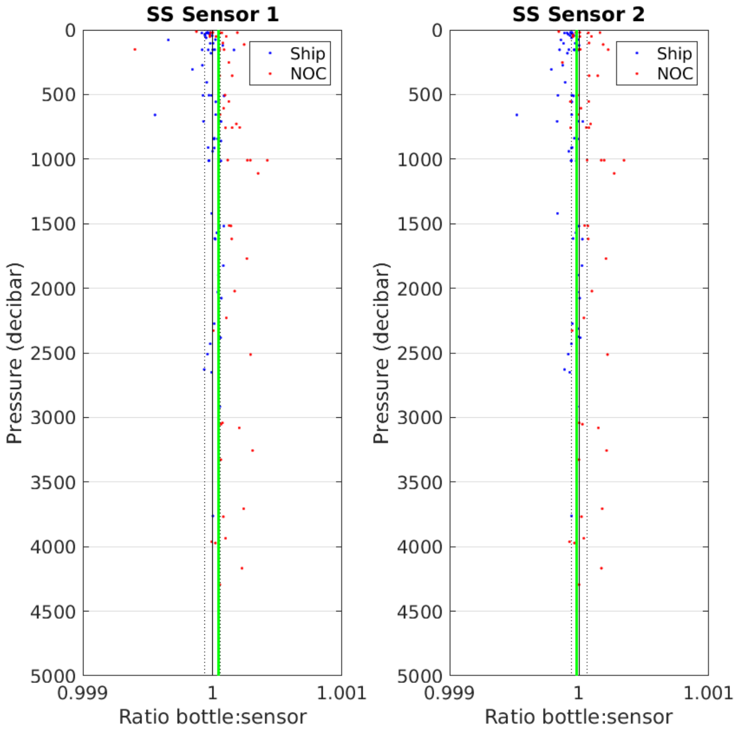

Figure 3 Vertical profiles of the ratio of bottle sample to sensor conductivity. The blue and red dots indicate the samples run on the ship and at NOC respectively. The green line is the median value.

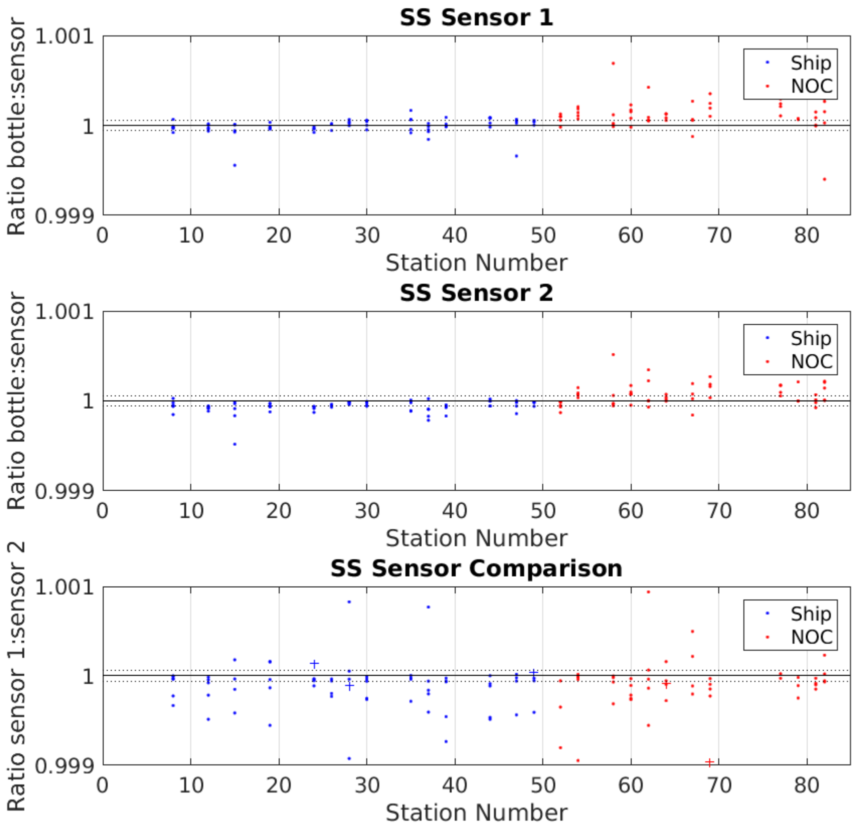

Figure 4 The ratio between bottle and sensor conductivity (a and b) and between the two sensors (c). The blue and red dots indicate the samples run on the ship and at NOC respectively.

Oxygen

Two calibrations were conducted for sensors on the stainless steel rosette. On 21 January 2018 the oxygen sensor on the stainless steel rosette was replaced as it was persistently recording a spurious spike in O_2 at around 3000 m depth.

Laboratory oxygen measurements begin for stations after the Azores pickup (station 12) due to a change in sampling methodology.

Stainless Steel Rosette – Stations 12 – 28

Figures Figure 5 and Figure 6 show the sensor O_2 against measured O_2 for all triplicates and stations in which oxygen was sampled. Black lines show a 1-to-1 fit, and red lines indicate the least squares calibration curve. For both Figure 5 and 6, dotted red lines indicate the 2*sigma(resid) threshold used to eliminate outliers; these outliers have been removed in Figure 6.

Stainless Steel Rosette – Stations 29 – end

The same protocol is followed for the second oxygen sensor as was made for the first, the results of which can be seen in Figures 7 and 8.

Derived Calibrations

Below are the slope, intercept, and R^2 values for both stainless steel oxygen calibrations (after outliers were removed). Calibrations were performed using μmol L^{-1} and converted to/from μmol kg^{-1} using *in situ* density.

$$O2(CTD \leq 66) = 0.9899 \times (CTDO2) + 7.4955$$
$$O2(CTD > 66) = 1.0034 \times (CTDO2) + 3.7244$$

The R^2 values for these two regressions are 0.9741 and 0.9961, respectively. Note that the R^2 for the second stainless calibration is abnormally high- this is from the use of a limited number of triplicates when sampling for the calibration.

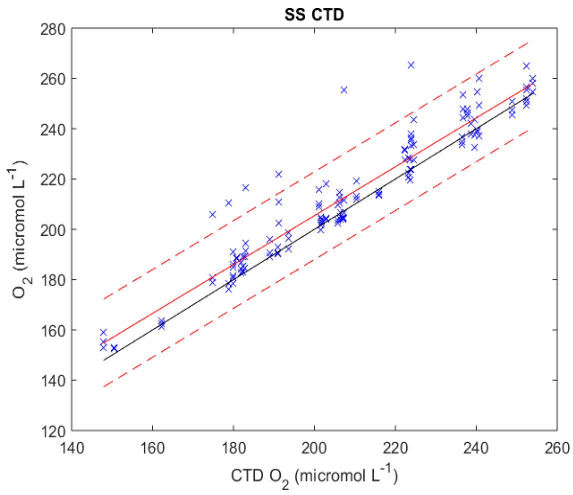

Figure 5 CTD oxygen against measured oxygen (blue Xs) for SS CTDs up to 67. Black line denotes a perfect 1-1 match, red line indicates the calibration regression, and red dotted lines show the thresholds for eliminating outliers

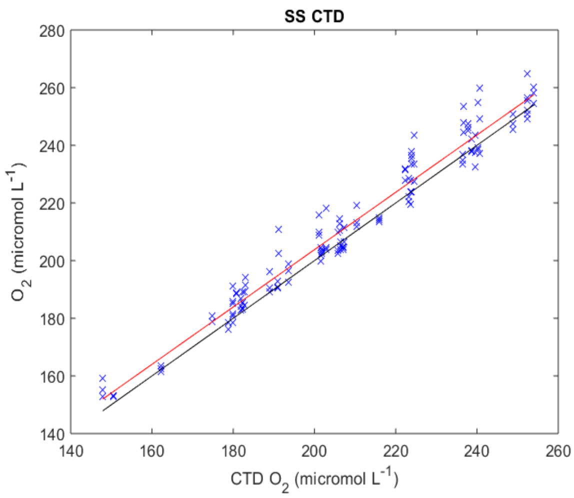

Figure 6 CTD oxygen against measured oxygen (blue Xs) for SS CTDs up to 67 after outliers are removed. Black line denotes a perfect 1-1 match, red line indicates the calibration regression.

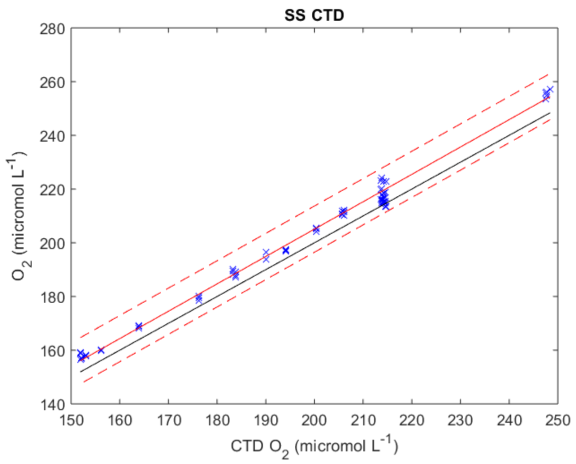

Figure 7 Oxygen sensor measurements plotted against laboratory measurements for SS CTDs after 66. All marks are the same as in Figure 6.

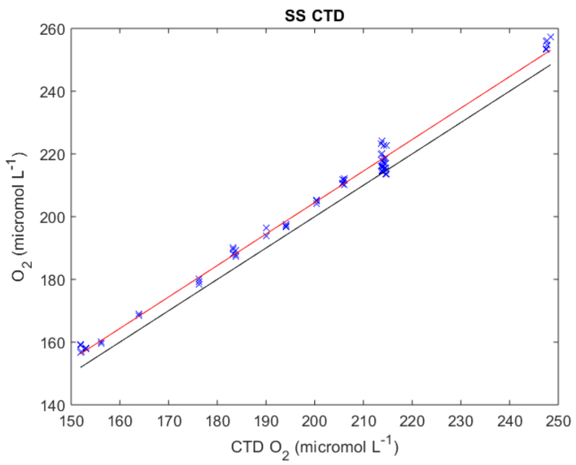

Figure 8 Oxygen sensor measurements plotted against laboratory measurements for SS CTDs after 64. All marks are the same as in Figure 6.

Chlorophyll

Chlorophyll was measured less often than oxygen and had single measurements rather than triplicates, no protocol for removing outliers was conducted.

It should be noted that the CTD chlorophyll sensor produces a relatively wide range of measurements for water samples that were tested to have very low chlorophyll concentrations.

Derived Calibration

The calibration regression line for the stainless steel rosette is:

$$Chla = 2.3697 \times (CTDChla) - 0.0007$$

For information on the fit of this correction, please reference the chlorophyll section of the cruise report.

Titanium CTD Calibrations

Conductivity

A similar situation exists when comparing the samples run at NOC and on the ship as was commented on above.

There does not appear to be a strong change in time, other than the change in salinometer, or with pressure for either sensor on the Trace Metal Clean CTD. As a result we simply apply the median ratio from the combination of the ship and NOC run samples, as there does not appear to be a clear reason to pick on over the other despite their offset. Those medians are: for the primary sensor 1.000008, and for the secondary sensor 1.000020.

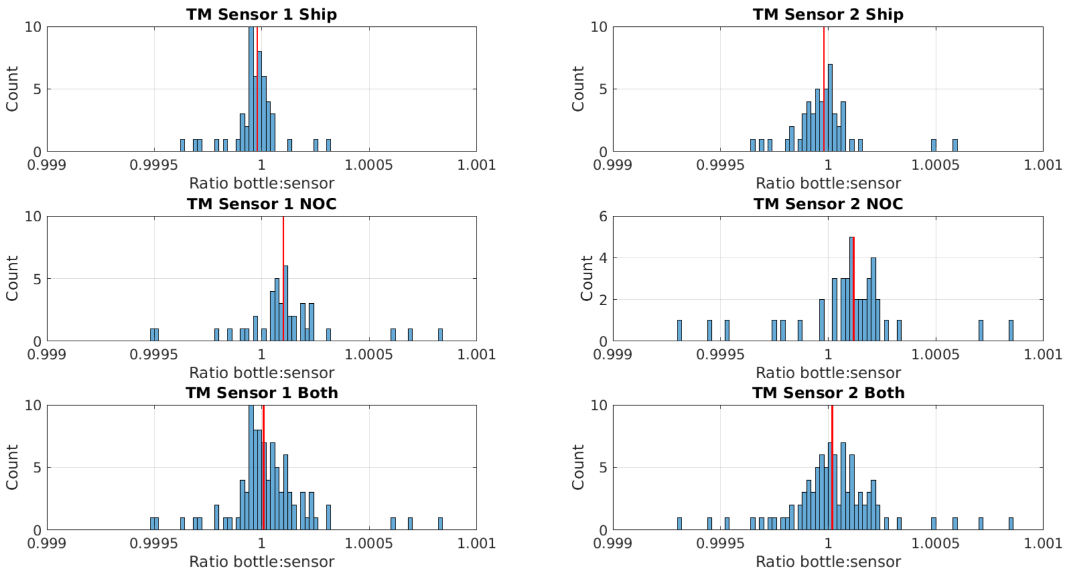

Figure 9 As figure 2 but for the trace metal clean CTD.

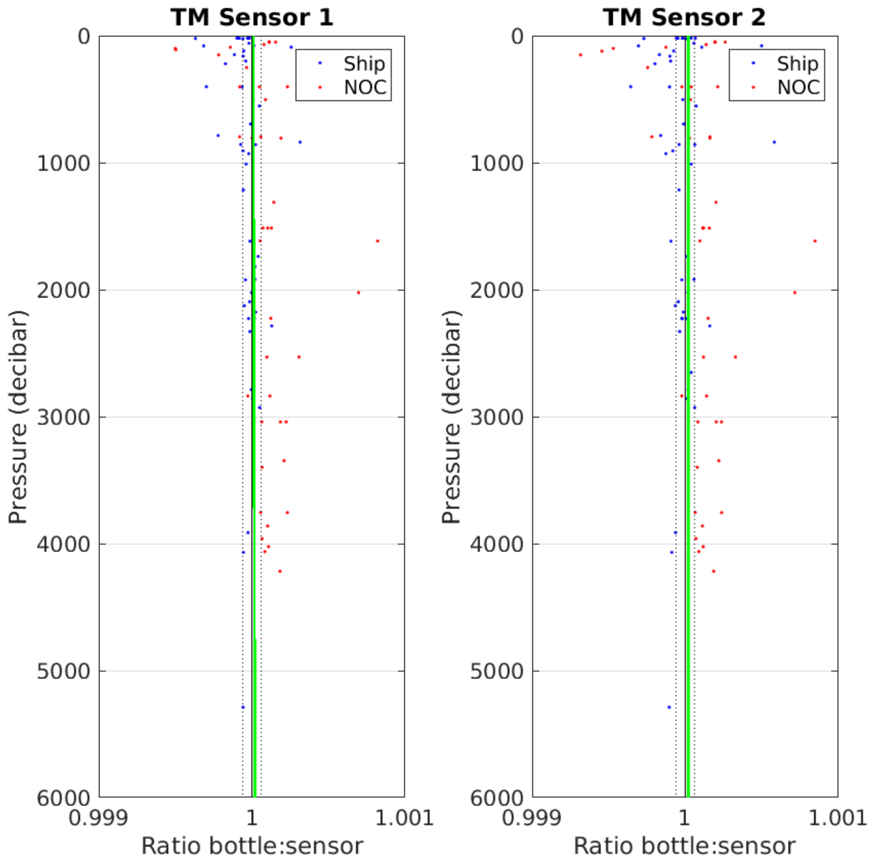

Figure 10 As for figure 3 but for the trace metal clean CTD.

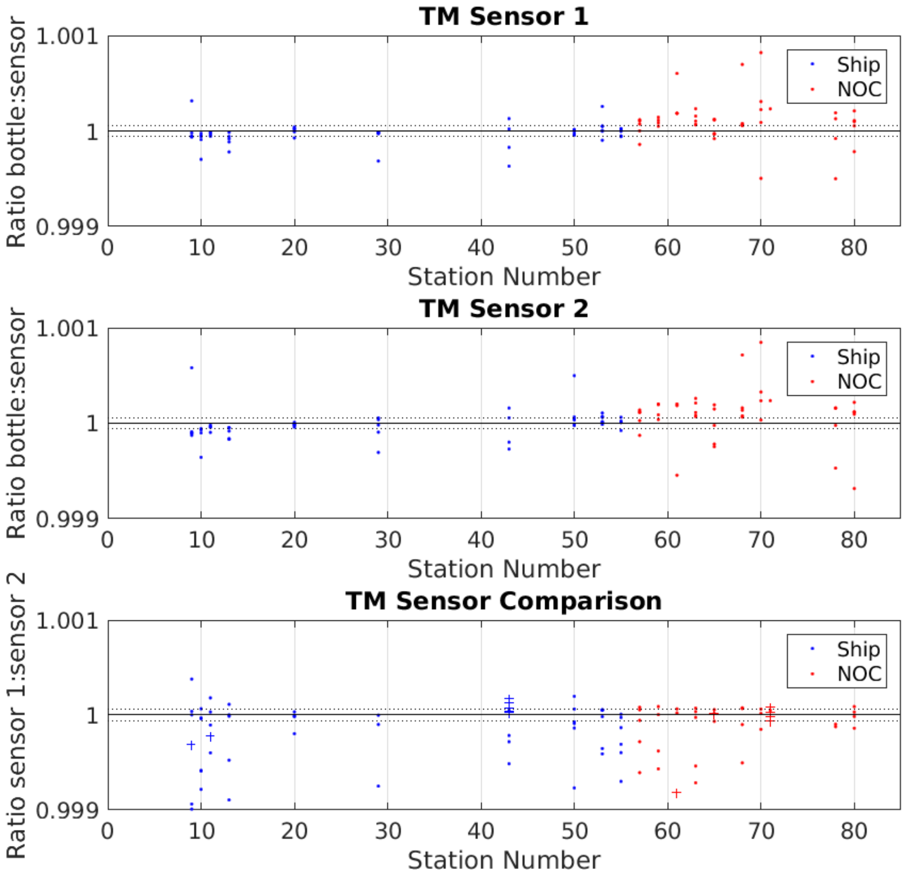

Figure 11 As for figure 4 but for the trace metal clean CTD.

Oxygen

One calibration was conducted for the oxygen sensor on the titanium rosette. As was done for the stainless steel sensor calibrations, a linear regression was made to determine which outliers should be removed, and once those outliers were removed a second regression was made to determine the calibration curve. Figures 12 and 13 show the first and second calibration regressions, respectively. Calibrations were performed using µmol L^{-1} and converted to/from µmol kg^{-1} using *in situ* density.

Derived Calibration

The equation for the TM oxygen calibration is:

$$O2 = 1.0403 \times (CTDO2) + 1.6036$$

The R^2 of this calibration regression is 0.9937 after outliers were removed.

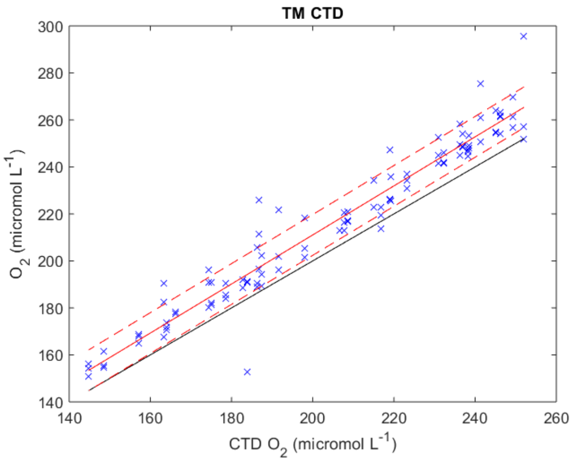

Figure 12 Oxygen sensor measurements plotted against laboratory measurements for all TM CTDs. All marks are the same as in Figure 6.

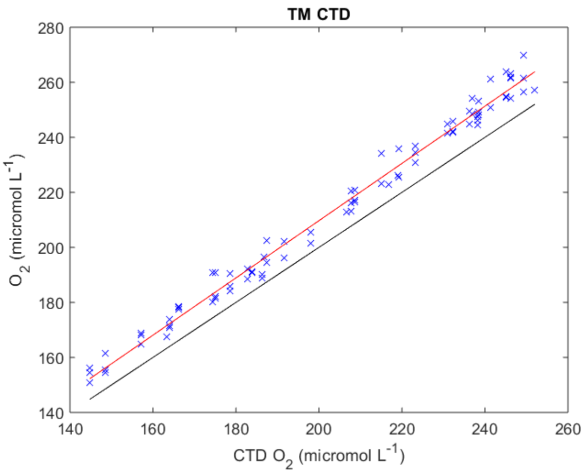

Figure 13 Oxygen sensor measurements plotted against laboratory measurements for the TM CTDs. All marks are the same as in Figure 6.

Chlorophyll

Chlorophyll was sampled from CTDs within the range CTD 7 – CTD 50. Outliers were determined via a visual check. For further information please reference the Chlorophyll section of the cruise report.

Derived Calibration

The calibration regression line for the trace metal rosette is:

$$Chl\alpha = 3.0312 \times (CTDChl\alpha) - 0.0618$$

For information on the fit of this correction, please reference the chlorophyll section of the cruise report.

LADCP

Introduction

LADCPs were deployed on both the Stainless Steel and Titanium frames to observe full ocean depth profiles of velocities. These were processed on board to allow identification of instrument issues.

Command Files

Master
CR1
RN SL119
$T
WM15
TC2
LP1
TB 00:00:02.80
TP 00:00.01.30
TE 00:00:00.00
LN25
LS0800
LF0
LW1
LV400
SM1
SA011
SB0
SW5500
SI0
EZ0011101
EX00100
CF11101
CK
CS
$I
Slave
CR1
RN SL119
$T
WM15
LP1
TP 00:00.00
TE 00:00:00.00
LN25
LS0800

LF0
WB1
LW1
LV400
SM2
SA011
SB0
EZ0011101
EX00100
CF11101
CK
CS
$I

Processing

RDI format binary files, recorded by the instrument, were downloaded after each cast and stored with the corresponding pre-deployment test log files. All data were processed using the latest version of the Lamont-Doherty Earth Observatory (LDEO_IX) software which calculates velocities using an inverse method. This package was also used to monitor the health of the beams on the instrument.

Navigation data, for use in the processing, were extracted from the NMEA stream stored within the CTD files.

1Hz CTD was extracted from the Mstar processing suite (see CTD section) and converted into an ascii file suitable for reading into the LDEO_IX software.

Parameters

Parameters changed from the ldeoIX default values were set in the set cast params.mscript and are given below:

Parameter	Value	Description
p.cut	20	Restrict time to ADCP depth below 20 m
p.edit_mask_dn_bins, p.edit_mask_up_bins	[1], [1]	Disregard data from 1st bin

fname = [‘Postimes/postime’ stnstr];
pstime = load(fname);
autocat = 1;
intlat = postime(4);
intlon = postime(6);
p.drot = magdev(intlat,intlon)
		Calculate magnetic deviation using matlab script magdev.m using latitude and longitude from pastime file constructed with CTD NMEA data.

p.nav_error	30	Allowable navigation error in metres
p.navtime_av	2/60/24	Average navigation over 2 minutes
ps.shear	1	Calculate a shear solution using raw data
ps.std_weight	1	Use super ensemble to weight data
ps.sadcpfac	1	Give equal weight to VMADCP
ps.shear_stdf	2	Average shear over two standard deviations
ps.dz	8	Profile vertical resolution
p.weightmin	0.05	Threshold for minimum weight of data
ps.outlier	1	Remove 1% of outlier data after solution

Cast List

Below is a table of CTD casts with their respective folders for (processed) ADCP data. Tow-yo and Yo-yo casts were not processed as the longer casts include more temporal variability and will be processed separately. Stainless steel casts that had an error message about M, S pings not aligning were reprocessed with M files only; the S files omitted can be found as ~S.000_junk.

CTD	**File Name**	**Comments**
007T	jc156007wctd	Profile OK
009T	jc156009wctd	Shear error message
010T	jc156010wctd	38 pressure spikes
011T	jc156011wctd	Profile OK
012	jc156012wctd	Slave data junk
013T	jc156013wctd	Profile OK
014T	jc156014wctd	50 pressure spikes
015	jc156015wctd	Slave data junk, 40 pressure spikes
016	N/A	Tow-yo #1
017T	jc156017wctd	Profile OK
018T	jc156018wctd	14 pressure spikes
019	jc156019wctd	No slave used, 50 pressure spikes
020T	jc156020wctd	94 pressure spikes

022		Missing M.000, S.000 files
023T	jc156023wctd	14 pressure spikes
024		Missing M.000, S.000 files
025T	jc156025wctd	Profile OK
026		Missing M.000, S.000 files
027T	jc156027wctd	Profile OK
028	jc156028wctd	Profile OK
029T	jc156029wctd	Profile OK
030	jc156030wctd	28 pressure spikes, shifted ADCP timeseries by 11 seconds
031T	jc156031wctd	32 pressure spikes
033		Missing postime header file
034T		Missing M.000 file
035	jc156035wctd	12 pressure spikes
036T	jc156036wctd	shear error message
037	jc156037wctd	Slave data junk, 54 pressure spikes
038T	jc156038wctd	62 pressure spikes
039	jc156039wctd	Measurements only for depths deeper than 1182 metres
040T	jc156040wctd	24 pressure spikes
041	N/A	Tow-yo #2 part 1
042	N/A	Tow-yo #2 part 2
043T	jc156043wctd	38 pressure spikes
044	jc156044wctd	32 pressure spikes
045T	jc156045wctd	46 pressure spikes
046T	jc156046wctd	24 pressure spikes
047	jc156047wctd	Slave data junk, shear error message
048T	jc156048wctd	354 pressure spikes
049	jc156049wctd	Slave data junk, 136 pressure spikes, shear error message
050T	jc156050wctd	Profile OK
051T	jc156051wctd	18 pressure spikes
052	jc156052wctd	Slave data junk
053T	jc156053wctd	144 pressure spikes
054	jc156054wctd	Slave data junk, shear error message
055T		Data appears to be of poor quality
056	jc156056wctd	Shear error message
057T	jc156057wctd	38 pressure spikes, large up/down bias

058	jc156058wctd	14 pressure spikes
059T	jc156059wctd	46 pressure spikes, large up/down bias
060	jc156060wctd	26 pressure spikes, shear error message
061T	jc156061wctd	shear error message
062	jc156062wctd	shear error message
063T	jc156063wctd	shear error message
064	jc156064wctd	shear error message
065T	jc156065wctd	shear error message
067	jc156067wctd	shear error message
068T	jc156068wctd	Profile OK
069	jc156069wctd	Slave data junk, 16 pressure spikes, shear error message
070T	jc156070wctd	16 pressure spikes
071T	jc156071wctd	42 pressure spikes, shear error message
072	jc156072wctd	No slave file, 36 pressure spikes, shifted ADCP timeseries by 15 seconds, shear error message
073T		Cannot find M.000 file, but there are two copies of CTD72
074	N/A	CTD Tow-yo
077	jc156077wctd	24 pressure spikes, shear error message
078T	jc156078wctd	24 pressure spikes, shear error message
079	N/A	CTD Yo-yo
080T	jc156080wctd	Profile OK
081	jc156081wctd	Slave data junk, shear error message
082	jc156082wctd	Slave data junk, shear error message
083T	jc156083wctd	Shear error message

5. SAPS operations

Six Challenger Oceanic Stand Alone Pumps were used on the cruise:

SN: 02-002, (Kitty) Mk2
SN: 03-03, (Daisy) Mk3
SN: 03-04, (Holly) Mk3
SN: 03-05, (Sophie) Mk3
SN: 04-11, (Bambi) Mk3
SN: 04-12, (Mindy) Mk3

Each SAP was fully charged on the bench in the Deck Lab, then once programmed taken out to the deck where members of the scientific party fitted the filters and primed the pumps as required prior to deployment.

All deployments used an NMF 500kg cast iron weight as ballast; this was deployed to a depth of 10m. At this point the first SAP was fitted to the wire using the wire clamps and a securing wire lanyard, once secured the SAP was lowered into the water, stopping at the surface to zero the wire out reading. Each additional SAP was then attached to the wire at depths given by the scientific party.

For more details on the SAPS deployments, including volume filtered etc please see the Radium chapter.

Configuration

293 mm double chamber pancake filter housings were used with a 90 deg elbow on the inlet and the outlet plumbed directly into the flow-meter.

All filter housing assembly and fitting to the SAPs as well as subsequent removal and disassembly were carried out by the scientific party.

Pump delay times were calculated by the scientific party, and each pump was programmed to pump for a maximum of 1.5 hours.

Sea-Bird SBE 39 Temperature & Pressure Loggers

Each SAP was fitted with a Sea-Bird SBE 39 Temperature and Pressure Logger to provide a record of the actual deployment depth of the SAP. A new Lithium battery pack was installed in each SBE 39 prior to the cruise.

The samp interval was set to 60 secs to sample as quickly as possible. The serial sync mode was disabled as this was not used. The real-time output was enabled to confirm logging pre and post deployment. The instruments were configured to record temperature and pressure.

After configuration, terminal captures were obtained of each instruments response to the DS (Display Settings) and DC (Display Calibrations) and saved as files in each instrument folder for reference.

Data was then uploaded using SeaSave, and saved into the corresponding cast folder.

Data from each cast was used to produce a list of the logged pressure from each SAP indicating the final deployed depth.

Deployment Summary

A total of 13 deployments were completed, details are listed for each cast below.

Cast	Kitty	Daisy	Holly	Sophie	Bambi	Mindy
1	852m/994l	837m/1023l	495m/1l	295m/1065l	133m/974l	43m/861l
2	2338m/381l	2211m/56l	2161m/438l	2110m/9l	1753m/332l	1502m/569l
3	2317m/562l	2185m/523l	2084m/529	1983m/0l	1729m/428l	N/A
4	530l	497l	1l	0l	390l	425l
5	379l	549l	173l	1l	353l	326l
6	602l	910	574l	N/A	812l	853
7	2007m/883l	2412m/877l	2211m/778m	2312m/1l	2510m/4l	2109m/923l
8	847l	826l	865l	904l	698l	14l
9	535l	849l	840l	859l	763l	933l
10	2919m/768m	3020m/905l	2615m/779l	2817m/940l	2410m/787l	3055m/3l
11	3889m/823	3578m/864l	3173m/930l	3375m/838l	3018m/793l	3732m/3l
12	3651m/811l	3330m/829l	3305m/550m	3255m/817m	3505m/768m	3585m/865l
13	710l	900l	849l	961l	794l	20l

6. VMP operations

Carl Spingys (University of Southampton)

The VMP6000 is an untethered microstructure instrument designed to measure small scale shear, temperature and conductivity indicative of turbulence and mixing manufactured by Rockland Scientific International. From these parameters rates of dissipation of turbulent kinetic energy (ε) and temperature variance (χ) are calculated following the methodology of Oakey 1982. On JC156 the intention was to collect microstructure data to understand how the chemical signal of hydrothermal fluid is able to leave the immediate plume to spread throughout the ocean. Unfortunately a series of problems with staffing and the instrument itself meant only a limited number of VMP casts were possible.

Stations with VMP Data

A total of three full depth VMP casts were performed on JC156. The details of these casts is given below.

Lat	Lon	Description	Comments
35 56.76 N	34 09.21 W	Testing 1	First series of VMP tests. VMP on bottom for 2 hours after failed to release.
26 12.90 N	45 07.10 W	Testing 2	Successful. Only sampled top 700m.
25 35.39 N	43 30.00 W	Station 33	Bad buffer 02:26 Offset between probes
26 08.203 N	44 49.601 W	Station 34a	Some time of surface due to over run of CTD
26 08.261 N	44 49.465 W	Station 34b	On bottom for 11 hours

Processing

All processing scripts used on this cruise were adaptations of those used in previous VMP cruises by the University of Southampton group. A summary of the processing steps are given below:

- vmp firstlook4 Produces a series of diagnostic plots for the raw un-calibrated VMP data (from XXX.P, produces XXX.mat) and calibrates data (XXX cal.mat)
- vmp process seabird4 Processes the VMP seabird data and applies various corrections (despike, filter, . . .). Output is saved as a separate matlab file, XXX dCTD.mat.
- vmp process micro4 Processes the VMP microstructure shear, temperature and conductivity are calibrated by regressing against the processed VMP seabird temperature and conductivity. Output saved as a separate matlab file, XXX micro.mat

7. Trace metal sampling

Maeve Lohan (University of Southampton)

Sample logs for all Ti-CTD casts are available in the Appendix. Samples were collected for trace metal analysis in both the dissolved and particulate fractions using the dedicated trace metal 10 L OTE bottles mounted on a Ti-frame rosette system.

1.1 Dissolved Trace metals

Sampling protocol: On recovery, the 10 L OTE bottles were transferred into a clean sampling laboratory where they were immediately sampled for Fe(II), pH, oxygen, nutrients, H_2S, and total dissolvable iron, manganese and aluminium before being pressurised to approximately 7 psi with 0.2 µm filtered air using an oil free compressor. After the collection of particulate samples (see section on Particulate Trace Metals), a Sartobran 300 (Sartorius) filter capsule (0.2 µm) was used to collect filtered seawater samples into clean LDPE sample bottles. Bottles and caps were rinsed 3 times with the filtered sample before being filled. All samples, including underway samples, were acidified to 0.024 M (UpA HCl, Romil) and stored, double bagged, for shore-based analysis.

Different trace metal fractions were collected and were either analysed on board ship or will be analysed in the laboratory:

Total dissolvable trace metals: Unfiltered and acidified. Will be analysed after 6 months of acidification by ICP-MS

Total dissolvable Mn and Al: Unfiltered and acidified and analysed onboard by Joe Resing.

Dissolved trace metals: filtered through 0.2 µm Sartobran filter and acidified. Will be analysed by ICP-MS at the University of Southampton.

Dissolved Iron: filtered through 0.2 µm Sartobran filter and acidified and analysed onboard by Alastair Lough

Dissolved Manganese: filtered through 0.2 µm Sartobran filter and acidified and analysed onboard by Joe Resing

Dissolved Aluminum: filtered through 0.2 µm Sartobran filter and acidified and analyzed onboard by Joe Resing

Iron II: Unfiltered and analysed onboard by David Gonzalez Santana.

pH: Unfiltered from every sample where Fe(II) was collected and analysed onboard by David Gonzalez Santana

H2S was either filtered through 0.2 µm Sartobran filter or unfiltered and analysed onboard by Pascal Salun.

Thiols: select depths were either filtered through 0.2 μm Sartobran filter or unfiltered and analsyed onboard by Pascal Salun.

Soluble Iron: Filtered firstly through 0.2 μm Sartobran filter and then 0.02 μm Anatop filter. Will be analyzed by flow injection back at the University of Southampton by Alastair Lough

Fe speciation: Filtered through 0.2 μm Sartobran filter and frozen at -20^{o}C until analyses at the University of Southampton.

Iron isotopes: Filtered through 0.2 μm Sartobran filter and acidified and will be analysed by Wenhao Wang at the University of Southampton.

Particulate trace metals: particles were collected directly from OTE bottles or by Stand Alone Pumps (SAPS) and will be analysed by either ICP-MS, synchtron or EXD.

Nutrients: nutrients samples were collected unfiltered from each bottle from each cast and analysed onboard by Malcolm Woodward and Sarah Breimann.

Samples were also collected for other parameters from select stations and depths (see Ti-CTD log sheets) using the Ti-CTD and are listed below alongside the analysts which will conducted after the crusie:

H_2S was either filtered through 0.2 μm Sartobran filter or unfiltered and analysed onboard by Pascal Salun.

Cr isotopes: Filtered through 0.2 μm Sartobran filter and acidified and will be analysed by Wenhao Wang at the University of Southampton.

Cd isotopes: Filtered through 0.2 μm Sartobran filter and acidified and will be analysed by Allison Byran at the University of Oxford.

Pb isotopes: Filtered through 0.2 μm Sartobran filter and will be analysed by Tina van der Fleridt at Imperial College London.

Nitrate isotopes: Filtered through 0.2 μm Sartobran filter and frozen at -20^{o}C until analysis by Scott Wankel at WHOI.

Cu speciation: Filtered through 0.2 μm Sartobran filter and frozen at -20^{o}C until analyses by Arthur Gourain at the Univeristy of Liverpool.

DOC: Filtered through 0.2 μm Sartobran filter and stored in the fridge until analyses at the University of Liverpool by Robin Turnea and Claire Mahaffey.

kFe and TOC: samples were collected unfiltered from selected depths and frozen at -20oC until analyses by Magdalena Gonzalez Santana at QUIMA-University of Las Palmas de Gran Canaria.

Dissolved As: Filtered through 0.2 μm Sartobran filter and analyses by Pascal Salaun at the University of Liverpool.

Salinity samples were also taken from most casts for calibrating the salinity. Oxygen samples were collected from 9 casts and from 5 depths in triplicate to calibrate the oxygen sensor.

1.2 Particulate metals

Samples will be analysed by Maeve Lohan and Alastair Lough at the University of Southampton, National Oceanography Centre, Southampton

Sampling protocol: Profiles were collected from varying depths through the whole water column using twenty-four 10 L OTE bottles mounted on a Ti rosette. On recovery, the OTE bottles were transferred into a clean sampling container where they were immediately sampled for Fe (II), nutrients and H_2S. The OTE bottles were inverted three times to gently mix the seawater and re-suspend particulates before being pressurised to approximately 7 psi with 0.2 µm filtered air using an oil free compressor. Acid clean filter holders (Swinnex, Millipore) were attached to the Teflon taps of the OTE bottles using acid cleaned Bev-A-Line (Cole Parmer) tubing and luer lock fittings. Up to a maximum of 7 L of seawater from each depth was then filtered through acid washed 25 mm (0.2 µm) polyethersulfone filters (PES, Supor, Pall Gellman) housed in the clean filter holders. Following filtration, the filter holders were removed and placed in a laminar flow bench. Using an all polypropylene syringe attached to the top of the filter holder, residual seawater was forced through the filter using air from within the flow hood. The filter holders were gently opened and the PES filter was placed in acid clean petri slide and frozen at -20^{o}C until analysis. Filtration was completed in approximately four hours.

In addition, particulate samples were collected from 12 stations around the Rainbow and TAG hydrothermal vent sites using 4 Stand Alone Pumps (SAPS). The filter housings of the SAPs were fitted with acid washed nylon mesh (10 µm) and a 293 mm PES filter (0.8 µm, Pall Gelman) and deployed to varying depths targeting the plume. On recovery, the filter housings were placed in a laminar flow hood for removal of the nylon mesh and PES filters. The nylon mesh was rinsed with UHP water into a clean plastic jug. This water was then filtered over a 25 mm PES filter (0.2 µm, Supor, Pall Gellman) housed in a clean filter holder (Swinnex, Millipore) using an all polypropylene syringe attached to the top of the filter holder. Residual water was forced through the filter using air from within the flow hood, the filter was then folded in half and placed in acid clean 2 mL LDPE vial. The 293 mm PES filter was cut into 6 sections and placed into clean zip-lock plastic bags. Both the 25 mm and 293 mm PES filters were frozen at -20^{o}C until analysis.

Samples collected:
<u>Particulates from OTE bottles</u>: a total of 294 samples were collected from 37 stations spanning the whole water column from 20 m to approximately 5200 m. The amount of samples collected at each station varied between 6 and 15.

Particulates from SAPS: a total of 47 samples were collected from varying hydrothermal plume depths.

Sample analysis: Samples will be analysed for both labile and refractory particulate Fe, Mn, Al, Co, Zn, Cd, Ba, Ni, Cu, Ti and potentially other trace elements using ICP-MS at the University of Southampton. For labile particulate trace elements the filter is subjected to a weak acid leach (25% acetic acid at pH 2) with a mild reducing agent (0.02 M hydroxylamine hydrochloride) and a short heating step (10 min 90-95°C). This approach is fully detailed in Berger et al. (2008). After the labile fraction has been determined the refractory trace elements will be determined. Briefly, the filters will be placed in 15 mL Savillex vials and 1 mL of 50 % HNO_3 & 10 % HF added, the vials are then heated to 130°C for 4 hours. This solution is dried down on a hot plate and 100 µM of concentrated HNO_3 added, the dry down procedure is then repeated. The residue is brought back into solution with 5 % HNO_3 for analysis by ICP-MS. The samples are then spiked with an internal reference material such as In for drift correction.

In addition some filters will be analysed at the Diamond Light Source Facility to investigate Fe, C and S speciation at the nanoscale by using synchrotron microprobe X-ray adsorption near edge structure (XANES). Scanning electron microscopy (SEM) EDX analyses will also be carried out to characterize nanoparticles at the University of Southampton.

1.3 Dissolved Iron

Sampling – Dissolved Fe (dFe) samples were obtained Ti-CTD casts at 37 stations across the transect. All sampling took place in a clean van and samples were collected in acid-cleaned (one week soaked in 3 M HCl, one week in 0.5 M HCl, stored in 0.024 M HCl) LDPE bottles by attaching a 0.2 µm Sartobran filter to pressurized OTE bottles. All sampling bottles were rinsed three times with seawater prior to filling. The samples were acidified to pH 1.7 with ultrapure HCl (Romil, UpA) and left to equilibrate for at least twelve hours before analysis.

Analysis – Flow injection analysis with chemiluminescence detection (FIA-CL) was used to determine nanomolar concentrations of dFe (Obata et al. 1993; Obata et al. 1997). At least 15 min prior to analysis samples were spiked with 1 µl 0.01 M H_2O_2 per 1 ml of sample to allow any present Fe(II) to be oxidized to Fe(III). The sample was then buffered to pH 3.5 and pre-concentrated on a Toyopearl resin. Upon elution by HCl, the Fe entered a reaction stream with luminol, NH_4OH and H_2O_2 to induce the chemiluminescent oxidation of luminol detected by a photomultiplier tube. Each sample was measured in triplicate with a column loading time of 220 s, resulting in a total of approximately 16 min per run.

1.4 Iron II

Sampling – Unfiltered samples from selected depths were collected into acid cleaned LDPE bottles which had been previously soaked in ultra high purity water. Bottles and caps were rinsed 3 times with sample before being filled from the bottom up using clean silicon tubing. The collection of 18 samples took approximately 1 h from the time the Ti rosette was recovered from the water.

Analysis –Flow Injection with Chemiluminescence detection (FI-CL) was used for the determination of both Fe(II). Samples for Fe(II) were filtered either in-line or just prior to analsyes (0.2 µm PES syringe filter, Nalgene) and buffered (pH 5.5) in-line prior to extraction and preconcentration using a column filled with 8-HQ chelating resin. Measurements were made on board and started immediately after the collection of samples. All sample handling and analyses took place in a laminar flow bench using clean handling techniques within the clean bubble in the main laboratory.

1.5 Dissolved and Total Mn and Al

Joe Resing (University of Washington)

Dissolved manganese and aluminium (DMn and DAl) were collected at all stations and generally (with a few exceptions) at all depths sampled. In addition, total dissolvable (TMn and TAl; whole water acidified), were collected from a subset of depths at all stations and at a subset of depths for the stainless steel rosette. Additional samples were collected of surface seawater from the “fish” by Amber Annett. All samples were collected into a single 100 mL low density polyethylene (LDPE) bottles with LDPE caps (Bel-Art). All samples were acidified to pH ~1.7-1.8 with ~10 N ultrapure hydrochloric acid (Romil Ultra).

Preliminary trends show an increase in Al and Mn in the surface ocean over the course of the cruise from North to South. Dissolved Al and DMn seemed, at times, to provide reflection of past mixed layers, with Al reflecting the deeper relict mixed layers and Mn more recent shallower ones. A ten day incubation of 100 m water revealed no decay in the Mn signal, providing some constraint on this process. At depth, there were several locations where DAl was quite elevated with respect to the surrounding seawater. These DAl values often correlated with Actinium and Radium activity. DMn and TMn were generally offset by ~ 0.1 nM in background seawater and were generally indistinguishable from one another in areas of elevated Mn levels. This was true for DAl as well. There was generally good agreement between Mn and Al values for both rosette packages.

Analytical methods.

DMn was determined at sea by flow injection analysis with in-line pre-concentration on resin-immobilized 8-hydroxyquinoline and colorimetric detection (Resing and Mottl, 1992). This report takes a “snapshot” view of the data from 12 of 33 analysis days. A drift standard was analysed multiple times each day and a preliminary examination of 72 analyses conducted over the 12 analysis days indicated that it had a Mn ≈ 0.5nM ± 0.038 nM (7.8%). The remaining analysis days need to be included in this analysis and the entire data set still awaits quality control. The SAFe reference samples were analysed simultaneously during sample analysis with the following results: for SAFe S, 0.82 ± 0.059 nM (n = 19; consensus value = 0.79 ± 0.06 nM); for SAFe D2, 0.41 ± 0.031 nM (n = 18; consensus value = 0.35 ± 0.05). The drift sample was run > 150 times and the Geostandards approximately 40 times each. However, this subset provides a reasonable glimpse at the statistical relevance and quality of the data set.

DAl was determined at sea by flow injection analysis (Resing and Measures, 1994). Method modifications to Resing and Measures included replacing resin-immobilized 8-hydroxyquinoline with sample loop. A drift standard was analyzed multiple times each day and a preliminary examination of 65 analyses conducted over 12 analysis days yielded Al ≈ 13.5nM ± 0.26 nM (2%).

The SAFe reference samples were analyzed simultaneously during sample analysis with the following results: for SAFe S, 2.07 ± 0.20 nM (n = 20; consensus value = 1.67 ± 0.06 nM); for SAFe D2, 1.32 ± 0.23 nM (n = 17; consensus value 1.03 ± 0.1 nM). There were no reference standards available at more suitable concentrations. These data are only a subset of the total data coming from 12 of 33 analysis days. The drift sample was run > 150 times and the Geostandards approximately 40 times each. However, this subset provide a reasonable glimpse at the statistical relevance of the data set. Our estimated limit of detection is 0.3 nM based on daily precision estimates is low and might more conservatively be estimated to be > 0.6 nM.

8. Aerosol Sampling

Sean Selzer (University of Oxford)

Trace metal clean filter paper was fixed in an aluminium cassette in a laminar flow hood before an aluminium cover was attached and the cassette was placed in a zip-lock bag before being taken to the aerosol sampling apparatus on the monkey island forward of the exhaust stack. The cassette was then removed from the bag and fixed to the sampling motor before the aluminium cover was removed.

Samples were taken over periods of 22-48 hours. At the end of a sampling period the aluminium cover was placed over the cassette before it was detached and placed in a zip-lock bag. The sample filter paper was then removed in a laminar flow hood before being placed in a zip-lock bag within another ziplock bag and placed in a freezer (-20 °C). Samples will be analysed at UEA by Alex Baker.

Samples will be analysed by Alex Baker (UEA)

Sample Name (JC156TM..)	Date	Time	Latitude (N)	Longitude (W)	Counter Reading	Count diff.	Air Temperature	Pressure	Wind Direction	Wind Speed	Ship Direction	Ship Speed
1 (Exposure Blank)	23/12/2017	13:07	43° 23.82'	13° 50.19'	414317	-	13.4	1035.2	11	8.8	267.03	9.6
1 (Exposure Blank)	24/12/2017	11:12	41° 22.97'	13° 53.26'	414317	0	14.6	1028.5	201	2.3	76.21	0
2	26/12/2017	10:53	39° 37.69'	22°43.62'	414317	0	16.1	1026.5	262	24.7	255.55	9.8
2	27/12/2017	11:40	39° 29.99'	26° 40.00'	416793	2476	16.8	1028	239	17.8	270.27	0
3	27/12/2017	12:10	39° 29.99'	26° 40.00'	416793	0	16.9	1028.1	242	16.8	268.58	0
3	28/12/2017	11:28	39° 30.00'	26° 48.04'	419101	2308	17.7	1022.2	234	21.4	245.48	0
4	28/12/2017	11:57	39° 27.61'	26° 50.77'	419101	0	17.8	1021.7	233	21.8	218	10.3
4	29/12/2017	11:46	37° 18.19 '	32° 17.99'	421412	2311	18.6	1018.7	190	20.9	210.12	0
5	29/12/2017	12:02	37° 18.19 '	32° 17.99'	421412	0	18.6	1018.1	198	26.5	204.53	0
5	30/12/2017	14:47	36° 35.90'	33° 26.26'	423996	2584	16.6	1020.2	327	24.7	261	4.8
(Aluminium Cover left on mistakenly) 6	30/12/2017	15:13	36° 33.99'	33° 26.80'	423996	0	16.7	1021.1	316	26.5	186	5.5
(Aluminium Cover left on mistakenly) 6	31/12/2017	14:39	36° 13.80'	32° 39.10'	425549	1553	18.1	1025.9	169	17	135.92	0
7	31/12/2017	15:07	36° 13.80'	32° 39.10'	425549	0	18.4	1025.9	175	17	134.32	0
7	02/01/2018	11:26	37° 27.35'	26° 45.63'	427693	2144	18.3	1032	203	15.2	71.23	12.6
8	02/01/2018	11:57	37° 29.35'	26° 37.91'	427693	0	18.4	1032.3	208	14.1	71.25	13
8	03/01/2018	15:16	37° 32.76'	26° 35.75'	429867	2174	16.4	1029.9	233	21.6	256	11.9
9	03/01/2018	15:43	37° 31.62'	26° 42.25'	429867	0	16.6	1029.6	208	14.2	251	11.9
9	04/01/2018	16:15	36° 28.14'	32° 16.60'	432278	2411	16.6	1029.9	36	11	256	11.8
10	04/01/2018	16:34	36° 27.25'	32° 21.28'	432278	0	16.8	1029.9	22	16.7	256	12.2
10	05/01/2018	23:28	36° 13.80'	34° 14.18'	433762	1484	16.2	1030.2	166	10.5	154.87	0
11	05/01/2018	23:55	36° 13.80'	34° 14.18'	433762	0	16.3	1030.8	140	7	213	0
11	07/01/2018	13:01	35° 56.76'	34° 9.21'	436252	2490	18.5	1025.9	235	13.3	330	0
12	07/01/2018	13:22	35° 56.76'	34° 9.21'	436252	0	18.5	1025.6	238	16.9	307	0
12	08/01/2018	17:50	36° 14.13'	33° 56.36'	438769	2517	17.1	1018.3	321	12	205	8.4
13	08/01/2018	18:12	36° 10.69'	33° 58.52'	438769	0	17.3	1018.1	318	10.8	209.43	10.8
13	09/01/2018	20:58	36° 13.59'	33° 53.22'	441279	2510	16.4	1026.6	292	9.5	141	0
14	09/01/2018	21:09	36° 13.59'	33° 53.22'	441279	0	16.4	1026.8	277	5.5	303.94	0
14	11/01/2018	21:21	34° 31.98'	36° 51.00'	444642	3363	15.5	1024.5	335	24.9	327.48	0
15	11/01/2018	21:42	34° 31.98'	36° 51.00'	444642	0	15.5	1025.6	324	25.9	355.29	0
15	13/01/2018	12:00	32° 11.41'	40° 10.83'	446760	2118	17.6	1035.4	56	16.5	230.73	12.6
16	13/01/2018	12:22	32° 8.53'	40° 14.94'	446760	0	17.3	1035.3	64	18.2	230	12.2
16	14/01/2018	14:30	30° 0.62'	42° 14.63'	447660	900	19.8	1031.9	60	22.1	220.46	10.6
17	14/01/2018	14:52	29° 57.99'	42° 17.50'	447660	0	19.8	1031.6	67	24	226	10.4
17	16/01/2018	13:02	26° 21.60'	44° 40.50'	449947	2287	21.5	1020.9	79	14.3	95.27	0
18	16/01/2018	13:21	26° 21.60'	44° 40.50'	449947	0	21.4	1021.4	63	16.2	96.17	0
18	17/01/2018	15:21	25° 55.78'	45° 1.12'	451873	1926	21.6	1018.5	188	6.7	75.7	0
19	17/01/2018	15:38	25° 55.78'	45° 1.12'	451873	0	22	1018.2	192	5.7	75.23	0
19	18/01/2018	16:00	26° 51.60'	47° 13.81'	453206	1333	21	1019	155	7.6	79.8	0
20	18/01/2018	16:19	26° 51.60'	47° 13.81'	453206	0	21.1	1018.8	157	8.2	79.98	0
20	19/01/2018	19:48	26° 22.78'	45° 44.58'	455490	2284	22.1	1018.8	204	2.7	106	8.1
21	19/01/2018	20:17	26° 21.71'	45° 40.52'	455490	0	22	1018.9	180	2.7	106	8.2
21	21/01/2018	21:27	25° 50.06'	44° 6.37'	458115	2625	20.7	1018.3	328	7.5	116	8.9
22	21/01/2018	21:57	25° 48.17'	44° 2.02'	458115	0	20.8	1018.5	343	12.5	116	8.4
22	22/01/2018	19:35	25° 35.02'	43° 29.17'	459236	1121	21.3	1017.2	31	16	297	10.5
23	22/01/2018	19:54	25° 35.40'	43° 30.00'	459236	0	21.3	1017.9	43	11.9	254	0
23	24/01/2018	22:12	26° 8.34'	44° 49.55'	462752	3516	21.8	1020.7	65	21.2	83.33	0
24	24/01/2018	22:32	26° 8.33'	44° 49.55'	462752	0	21.9	1020.8	77	21.7	81.9	0
24	26/01/2018	15:45	26° 8.27'	44° 49.53'	466836	4084	20.9	1020	119	18.8	116	0
25	26/01/2018	15:57	26° 8.27'	44° 49.53'	466836	0	20.3	1019.8	110	23.2	94.99	0
25	27/01/2018	15:54	26° 16.69'	44° 43.87'	468990	2154	22	1018	141	4.8	98.73	0
26	27/01/2018	16:14	26° 16.69'	44° 43.87'	468990	0	22.1	1017.7	161	4.1	98.71	0
26	29/01/2018	15:02	22° 33.60'	50° 40.26'	469690	700	21.1	1017.5	22	19.4	238.75	11.6
27 (Casette Blank)	29/01/2018	15:31	22° 30.95'	50° 45.01'	469690	0	21.1	1017.5	22	14.7	236.68	10.1
27 (Casette Blank)	30/01/2018	16:28	20° 3.54'	54° 44.55'	469698	8	22.4	1012.9	8	9.3	233	10.5
28 (Motor Blank)	30/01/2018	17:17	19° 58.88'	54° 52.04'	469698	0	22.6	1012.4	13	10.2	238	10.5
28 (Motor Blank)	30/01/2018	17:17	19° 58.88'	54° 52.04'	469698	0	22.6	1012.4	13	10.2	238	10.5

9. Major nutrient sampling

Malcolm Woodward (Plymouth Marine Laboratory)

OBJECTIVES:
The overall aim of the FRidge project is to investigate and quantify two components associated with supply of Fe from the Mid-ocean Ridge: 1) Does greater turbulent mixing at the mid-ocean ridge alter the vertical Fe supply over the Atlantic basin? and 2) What determines the longevity of Fe directly supplied by the Ridge?
The cruise transect from the Rainbow mid-Atlantic vent site along the Ridge down to the TAG site and then headed west towards the Caribbean Islands. Stations occupied along this transect will be sampled using Trace metal clean and Stainless Steel CTD profiles. Samples for the macromolar nutrients (Nitrate, Phosphate etc.) were taken and analysed alongside the trace metal measurements to act as important supporting parameters in helping to understand the water column and the water masses involved around the Mid Ocean Ridge and around the vent sites. Nanomolar measurements for ammonium and Nitrite were be taken for the first time around these vent sites to see the chemical concentrations of these around the hydrothermal features.

SAMPLING and ANALYTICAL METHODOLOGY:

Sampling procedure

Acid clean 60m ml HDPE Nalgene bottles were used for all the nutrient sampling, these were aged, acid washed and cleaned initially, and stored with a 10% acid solution between sampling. Water column depth profile samples were taken from the OTE bottles from the Trace Metal CTD system and sub-sampled into the Nalgene nutrient bottles from within the ultra-clean trace metal laboratory on-board the RRS James Cook. Water column samples were also taken from the Stainless Steel CTD Rosette using the same sampling technique. The sample bottle was washed 3 times before taking the final sample, and capping tightly. These were then taken immediately to the nutrient analysers in the chemistry lab and analysis conducted as soon as possible after sampling. Nutrient free (Semperguard) gloves were used and other clean handling protocols were adopted as close to those according to the GO-SHIP protocols.

Analytical methods

The micro-molar segmented flow colorimetric auto-analyser used was the PML 4- channel (nitrate, nitrite, phosphate, and silicate) Bran and Luebbe AAIII system, using classical proven analytical techniques.
The instrument was calibrated with home produced nutrient stock standards and then compared regularly against Nutrient Reference Materials, from KANSO Technos, Japan for quality control and checking of analytical standardisation. Specifically batches CA, BW and BU were used during the cruise.

The analytical chemical methodologies used were according to Brewer and Riley (1965) for nitrate, Grasshoff (1976) for nitrite, and Kirkwood (1989) for silicate and phosphate.

Nanomolar analysis was carried out for Ammonia using a fluorimetric detection differential gas diffusion technique, based on Jones R.D, 1991. Nanomolar Nitrate, Nitrite and Phosphate were analysed using segmented flow colorimetric techniques with 2 metre Liquid waveguides as the analytical flow cells to improve the analytical detection limits. Nitrate and Nitrite used the same colorimetric methods as for the micromolar system and for Phosphate we used the Zhang and Chi (2002) method.

References:

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SAMPLES ANALYSED:

CTD Samples Analysed by AAIII Micromolar analysis, and Nanomolar analysis where concentrations required it:

Date	CTD /Station	Position	CTD bottle numbers analysed, and depths
23/12/17	CTD_007 T Station 1	43⁰23.841' N 13⁰50.863' W	24,23,22,21,20,12,11,10,9,8,7,6,5,4,3,2,1.(depths:20, 50,80,100,150,200,750,900,1100,1350,1600,2100,2500,3000,3500,4000,4500,4850)
23/12/17	CTD_008 S Station 1	43⁰23.845' N 13⁰50.854' W	24,22,20,18,16,14,12,10,8,6,4,2,(depths:3,30,60,120, 150,400,500,600,700,800,900,1000)
24/12/17	CTD_009 T Station 2	41⁰22.970' N 13⁰53.262' W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,50,90,150,200,300,400,500,700, 800,830,850,920,1200,1450,1750,2100,2900,3500,4000,4500,5000,5190)
26/12/17	CTD_010 T Station 3	39⁰30.050' N 23⁰23.142' W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,50,90,125,160,200,250,300,400, 500,600,700,800,960,1100,1300,1500,1800,2100,2500,3200,3600,3810,3848)
27/12/17	CTD_011 T Station 4	39⁰30.013' N	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,50,80,120,200,400,500,700,750,

		$26^0$29.687’ W	800,850,930,1000,1200,1350,1560,1820,2080,2300,2500,2543,2563,2583,2593)
27/12/17	CTD_012 S Station 4	$39^0$29.995’ N $26^0$40.007’ W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:5,20,40,60,100,150,200,300,400,500,700,750,850,930,1000,1200,1350,1500,1750,2000,2250,2400,2541,2591)
28/12/17	CTD_013 T Station 5	$39^0$30.027’ N $29^0$48.423’ W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,30,40,60,100,150,247,400,500,600,700,780,810,900,1000,1200,1400,1600,1810,1900,2000,2070,2100,2110)
29/12/17	CTD_014 T Station 6	$37^0$50.502’ N $31^0$31.249’ W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,30,40,60,80,150,150,225,300,400,500,500,650,720,740,750,760,775,800,820,830,835,840,840)
29/12/17	CTD_015 S Station 6	$37^0$50.501’ N $31^0$31.251’ W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,30,40,60,80,100,150,225,300,400,500,600,650,650,700,700,715,725,780,790,810,810,839,839)
29/12/17	CTD_018 T Station 8	$37^0$17.544’ N $32^0$16.882’ W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,40,60,70,80,100,200,350,550,720,800,1000,1200,1300,1550,1550,1620,1650,1675,1675,1690,1700,1725,1725)
29/12/17	CTD_019 S Station 8	$37^0$17.545’ N $31^0$16.883’ W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,40,50,70,80,100,120,150,200,350,550,720,800,1000,1200,1550,1600,1625,1650,1670,1690,1750,1755,1814)
30/12/17	CTD_020 T Station 8	$36^0$33.874’ N $33^0$25.766’ W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,40,60,80,100,200,300,500,600,690,800,850,920,1100,1200,1500,1720,1750,1800,1900,2000,2150,2185,2200)
30/12/17	CTD_022 S Station 9	$36^0$33.900’ N $33^0$25.809’ W	10,9,8,7,6,5,4,3,2,1(depths:1200,1500,1800,1900,2000,2150,2150,2200,2210,)
31/12/17	CTD_023 T Station 10	$36^0$13.80’N $32^0$39.10’W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,40,60,90,150,270,410,540,670,720,800,850,900,1000,1200,1350,15501769,2000,2222,2350,2440,2460,2470)
31/12/17	CTD_024 S Station 10	$36^0$13.799’ N $32^0$39.099’ W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,40,60,75,85,95,110,150,270,540,780,900,1000,1250,1500,1750,2000,220,2350,2380,2400,2425,2450,2475)
01/01/18	CTD_025 T Station 11	$36^0$13.797’ N $31^0$39.088’ W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,40,60,90,150,250,300,400,500,600,811,930,1200,1400,1517,1700,1800,2100,2400,2624,2700,2750,2844,2864)
01/01/18	CTD_026 S Station 11	$36^0$13.792’ N $31^0$39.090’ W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,40,60,100,150,250,350,500,600,700,830,1000,1200,1400,1600,1800,1950,2050,2250,2450,2600,2700,2770,2870)
03/01/18	CTD_027 T Station 12	$36^0$13.80’N $33^0$31.638’ W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,40,60,70,110,200,400,550,650,700,750,900,1200,1500,1750,1900,2000,2000,2100,2150,2200,2320,2350,2360)

03/01/18	CTD_028 S Station 12	36^{0}13.801' N 33^{0}31.636' W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,40,60,70,80,110,250,400,550,700,720,850,100,1200,1500,1750,1900,2000,2100,2150,2200,2320,2340,2350)
05/01/18	CTD_029 T Station 13	36^{0}13.800' N 34^{0}14.182' W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,40,60,70,80,120,250,400,500, 675,750,970,1150,1350,1500,1600,1650,1750,2000,2100,2200,2325,2340,2340)
05/01/18	CTD_030 S Station 13	36^{0}13.801' N 34^{0}14.180' W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,40,50,60,70,80,150,300,500,700, 700,850,850,1000,1350,1500,1600,1750,1875,2000,2100,2200,2325,2340)
06/01/18	CTD_031 T Station 14	36^{0}28.236' N 33^{0}40.225' W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,40,50,60,70,80,120,250,400,500, 720,960,1000,1300,1400,1500,1700,1900,2100,2250, 2400,2500,2550,2608,2608)
06/01/18	CTD_033 S Station 14	36^{0}28.248' N 33^{0}40.264' W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,40,50,60,70,80,120,250,400,400, 600,725,960,1300,1500,1700,2100,2250,2260,2350,2450,2550,2611)
07/01/18	CTD_034 T Station 15	35^{0}56.767' N 34^{0}09.267' W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,40,60,80,90,100,150,250,520,715,850,1100,1350,1500,1730,1860,1900,1925,1950,1977,2100,2200,2320,2360)
07/01/18	CTD_035 S Station 15	35^{0}56.753' N 34^{0}09.211' W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,40,60,80,90,100,150,400,550,720,720,850,1100,1400,1730,1860,1900,1925,1950,2100,2250,2350)
08/01/18	CTD_036 T Station 16	36^{0}13.600' N 33^{0}54.119' W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,50,75,120,175,300,375,500,650, 750,1100,1300,1600,1850,1950,1970,1980,1985,2000,2051,2069,2108,2200,2280)
08/01/18	CTD_037 S Station 16	36^{0}13.795' N 33^{0}54.116' W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,50,60,75,120,175,175,300,500,700,700,1100,1400,1600,1800,1900,1950,2000,2100,2150,2175,2200,2240,2277)
08/01/18	CTD_038 T Station 17	36^{0}09.949' N 33^{0}59.000' W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,40,60,80,100,150,500,500,690,900,1500,1900,2000,2000,2000,2050,2150,2200,2400, 2600,2800,3000,3159)
09/01/18	CTD_039 S Station 18	36^{0}22.833' N 33^{0}41.659' W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,40,80,120,150,250,350,500,690, 900,1100,1200,1400,1800,2050,2200,2250,2300,2350,2400,2450,2500,2550,2615)
09/01/18	CTD_040 T Station 18	36^{0}22.832' N 33^{0}41.657' W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,40,60,80,130,160,165,250,500,680,720,1000,1250,1600,1775,1800,1950,2050,2100,200,2300,2450,2550,2631)
10/01/18	CTD_043 T Station 16, Part 2	36^{0}13.801' N 33^{0}54.119' W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,60,80,120,200,350,550,770,980, 1300,1600,1750,1900,1997,2149,2241,2241,2241,2241,2247,2252,2254,2260,2280)
10/01/18	CTD_044 S	36^{0}13.800' N	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,60,80,120,220,350,550,770,1000

	Station 16, Part 2	33⁰54.119' W	,1300,1500,1600,1750,1800,1850,1884,1925,1966,2058,2139,2257,2268,2274,2275)
11/01/18	CTD_045 T Station 19	35⁰02.40'N 35⁰00.60'W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,60,80,100,12,200,400,550,650,850,1100,1600,1800,2000,2200,2400,2600,2800,3000,3500,3754,4000,4225)
11/01/18	CTD_046 T Station 20	35⁰02.40'N 35⁰00.60'W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,40,60,80,100,125,150,300,550,650,850,970,990,1000,1200,1500,1750,1900,2050,2075,2100,2246,2276,2286)
11/01/18	CTD_047 S Station 20	34⁰31.981' N 36⁰51.00'W	12,11,10,9,8,7,6,5,4,3,2,1(depths:20,75,300,650,960,1500,1750,2050,2050,2100,2200,2250,2380)
12/01/18	CTD_048 T Station 21	33⁰36.463' N 38⁰13.721' W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,40,60,80,100,125,200,370,500,780,820,950,1350,2100,2500,2700,2850,3000,3200,3500,3700,4200,4400,4452)
12/01/18	CTD_049 S Station 21	33⁰36.463' N 38⁰13.721' W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,40,60,80,100,125,250,350,500,650,835,960,1350,1900,2875,3020,3020,3550,3700,4150,4385,4475)
13/01/18	CTD_050 T Station 22	32⁰00.002' N 40⁰26.532' W	Surface FISH, 24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:4,20,40,60,80,100,150,50,400,500,600,700,820,900,100,1100,1300,1500,1700,1900,2100,2300,2500,2571,2618)
14/01/18	CTD_051 T Station 23	30⁰07.448' N 42⁰07.199' W	Surface FISH, 24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:4,20,40,60,80,90,100,110,120,130,150,200,300,400,500,600,685,700,721,730,740,751,756,766,766)
14/01/18	CTD_052 S Station 23	30⁰07.444' N 42⁰07.193' W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,40,60,80,90,100,110,120,130,150,250,350,400,450,500,600,650,700,714,724,730,737,743,752,762)
14/01/18	CTD_053 T Station 24	29⁰10.012' N 43⁰10.438' W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:20,40,60,90,110,250,550,710,900,1100,1500,2000,2500,2797,2809,2819,2829,2833,2838,2841,2887,2930,2983,3033)
14/01/18	CTD_054 S Station 24	29⁰10.150' N 43⁰10.282' W	Surface FISH, 24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths: 4,20,50,80,100,150,300,500,720,1000,1550,2000,2200,2500,2751,2794,2800,2815,2838,2843,2863,2879,2982,3015,3037)
15/01/18	CTD_055 T Station 25	27⁰0.00'N 44⁰29.998' W	Surface FISH, 24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:4,20,40,60,80,100,120,150,250,500,500,700,850,1100,1500,1800,2000,2200,2750,3000,3300,3600,3800,3911)
15/01/18	CTD_056 S Station 25	27⁰0.001'N 44⁰29.999' W	16,15,14,13,12,11,10,9,8,7,6,5(depths:20,40,60,80,100,120,150,250,500,500,700,850,1100,1500,1800,2000,2200,2750,3000,3300,3600,3800,3911)

16/01/18	CTD_057 T Station 26	$26^0$21.762' N $44^0$40.459' W	Surface FISH, 24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:4,20,50,90,100,110,130,150,250,400,650,800,1000,1800,2200,2400,2800,3000,3200,3400,3600,3800,3965)
16/01/18	CTD_058 S Station 26	$26^0$21.601' N $44^0$40.499' W	Surface FISH, 24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:4,20,50,90,130,150,400,650,820,1000,1500,1900,2300,2600,2750,2990,3090,3190,3290,3390,3490,3590,3790,3850,3910)
17/01/18	CTD_059 T Station 27	$22^0$55.773' N $45^0$01.124' W	Surface FISH, 24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:4,20,50,90,110,120,140,200,600,800,1000,1300,1500,2000,2500,2750,3000,3200,3400,3600,3800,4000,4000,4156)
17/01/18	CTD_060 S Station 27	$25^0$55.776' N $45^0$01.115' W	Surface FISH, 24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:4,20,50,80,90,100,120,150,300,500,750,815,950,1300,1600,2000,2500,3000,3200,3400,3600,3800,4000,4100,4152)
18/01/18	CTD_061 T Station 28	$26^0$51.600' N $47^0$13.809' W	Surface FISH, 24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:4,20,50,80,100,115,120,150,200,350,550,800,1000,1500,1750,1850,2100,2500,3000,3500,3800,3900,4000,4150,4223)
18/01/18	CTD_062 S Station 28	$26^0$51.600' N $47^0$13.810' W	Surface FISH, 24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:4,20,50,80,100,120,150,350,550,800,1000,1500,2000,2500,3000,3300,3400,3500,3600,3700,3800,3900,3970,4150,4224)
19/01/18	CTD_063 T Station 29	$26^0$30.05'N $46^0$12.001' W	Surface FISH, 24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:4,20,50,70,80,100,120,150,200,400,650,780,1000,1500,1700,2000,2500,2750,3000,3200,3400,3600,3700,3800,3899)
19/01/18	CTD_064 S Station 29	$26^0$30.001' N $46^0$12.000' W	Surface FISH, 24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:4,20,50,70,100,120,150,350,550,800,1000,1500,2000,2250,2500,2750,3000,3200,3300,3400,3500,3600,3700,3800,3891)
20/01/18	CTD_065 T Station 30	$26^0$12.900' N $45^0$07.100' W	Surface FISH, 24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:4,20,50,70,100,110,135,180,250,350,550,650,790,1000,1500,2000,2200,2300,2400,2500,2600,2700,2800,2900,3070)
20/01/18	CTD_067 S Station 30	$26^0$12.900' N $45^0$07.100' W	Surface FISH, 24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:4,20,50,75,100,110,130,150,250,350,550,650,800,1000,1500,1800,2200,2300,2400,2500,2600,2700,2800,2900,3020)
21/01/18	CTD_068 T Station 31	$26^0$01.730' N $44^0$13.171' W	Surface FISH, 24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:4,20,50,70,90,110,130,170,350,500,

			650,790,1100,1500,1800,2000,2400,2600,2800,3000,3150,3350,2550,3700,3873)
21/01/18	CTD_069 S Station 31	$26^0$01.720' N $44^0$33.168' W	Surface FISH, 24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:4,20,50,70,90,110,150,350,500,650,800,1100,1500,2000,2500,2800,3018,3173,3275,3375,3480,3578,3700,3871,3871)
22/01/18	CTD_070 T Station 32	$25^0$08.509' N $42^0$31.223' W	Surface FISH, 24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:4,20,50,70,90,110,115,150,300,500,700,835,1000,1500,1600,1900,2200,23500,2650,2800,3000,3200,3400,3519)
22/01/18	CTD_071 T Station 32	$25^0$35.100' N $43^0$30.001' W	Surface FISH, 24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:4,20,50,90,120,135,148,250,500,790,1250,1550,1750,2050,2300,2600,3900,3100,3300,3400,3600,3700,3800,4000,4080)
25/01/18	CTD_076 T Station 35	$26^0$08.328' N $44^0$49.554' W	Surface FISH, 24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:4,1500,1750,2000,2500,3000,3100,3194,3236,3263,3277,3292,3314,3321,3334,3343,3345,3349,3428,3453,3471,3500,3550,3600,3689)
26/01/18	CTD_077 S Station 35	$26^0$08.308' N $44^0$49.532' W	Surface FISH, 24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:4,50,80,100,125,350,750,100,1500,2250,2500,2750,3000,3100,3150,3200,3250,3300,3325,3374,3437,3450,3500,3575,3650)
26/01/18	CTD_078 T Station 35	$26^0$08.308' N $44^0$49.531' W	Surface FISH, 24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:4,20,50,100,115,124,150,250,400,600,700,800,800,950,1050,1200,1500,1750,2000,2750,3100,3200,3300,3400,3637)
27/01/18	CTD_079 S Station 35	$26^0$08.328' N $44^0$49.554' W	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:3000,3128,3144,3163,3210,3230,3230,3230,3230,3230,3250,3270,3270,3270,3270,3270,3270,3280,3295,3310,3320,360,3409)
27/01/18	CTD_080 T Station 35	$26^0$16.689' N $44^0$43.866' W	Surface FISH, 24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:4,20,50,100,125,150,200,400,600,800,1000,1400,1600,2000,2500,2750,3000,3200,3300,3400,3500,3600,3800,3900,3960)
27/01/18	CTD_081 S Station 35	$26^0$16.688' N $44^0$43.866' W	Surface FISH, 24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:4,20,50,70,90,110,150,250,450,600,800,1000,1400,1600,2000,2500,2750,3000,3200,3300,3400,3500,3600,3800,3900)
27/01/18	CTD_082 S Station 35	$26^0$07.850' N $44^0$46.199' W	Surface FISH, 24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6(depths:4,50,100,130,150,250,350,600,800,1000,1200,1500,1750,2000,2200,2300,2350,2400,2443,2482)
27/01/18	CTD_081 S Station 35	$26^0$07.849' N $44^0$46.200' W	Surface FISH, 24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1(depths:4,20,50,90,110,125,160,200,400,60

			0,800,1000,1200,1400,1500,1600,1700,1800,1900,2000,2100,2200,2300,2400,2506)

Nutrient Analysis of Experimental samples:

1. **Sarah Breimann**

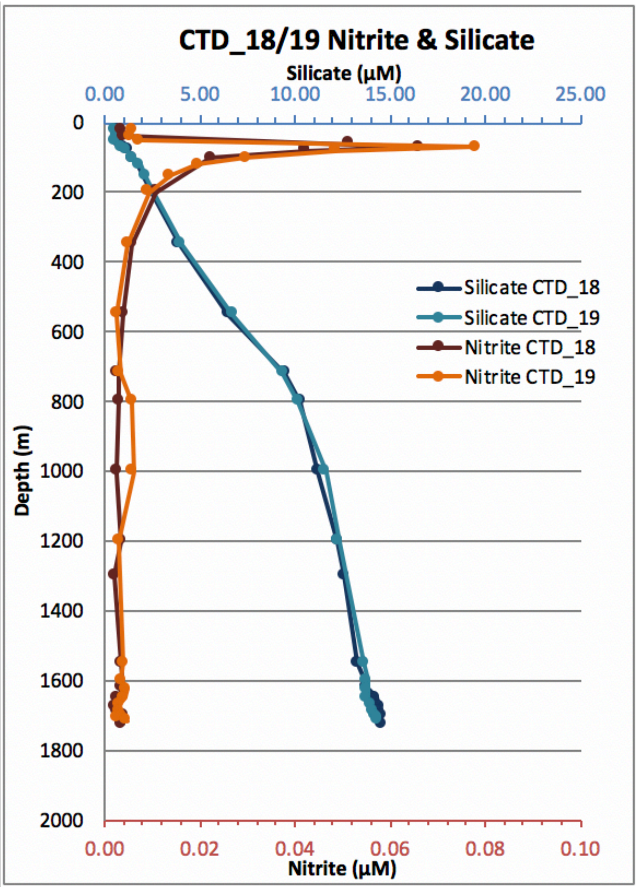
21st December 2017: 180 samples analysed from previous trawling experiments
22nd December 2017: 140 samples analysed from previous trawling experiments

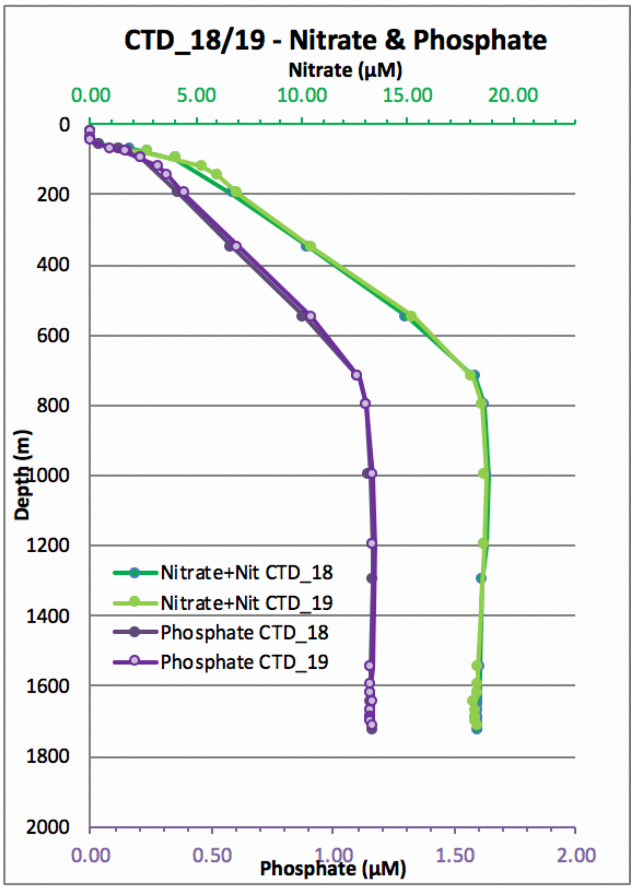
2. **Travis Mellett**

27th December 2017: 2 experimental samples
29th December 2017: 1 experimental sample
30th December 2017: 1 experimental sample
1st January 2018: 1 experimental sample
6th January 2018: 1 experimental sample
10th January 2018: 2 experimental samples
11th January 2018: 3 experimental samples
13th January 2018: 2 experimental samples
15th January 2018: 2 experimental samples
22nd January 2018: 1 experimental sample
24th January 2018: 4 experimental samples
26th January 2018: 2 experimental samples
27th January 2018: 4 experimental samples

Cruise Summary, initial results.
The 4-channel autoanalyser, Nanommonium and Waveguide analysers worked generally well throughout the cruise. KANSO nutrient reference materials (Batches BU, BW and CA) were run regularly to check the auto-analyser integrity and analytical continuity from one day to the next, demonstrating good overall analytical performance.

An initial results for a set of Stainless and Titanium water column CTD profiles (CTD 18 and 19) for Nitrate, Nitrite, Phosphate and Silicate at Station 8 is shown below. Excellent agreement is seen between the 2 CTD's, with a classical north Atlantic water column nutrient profile.





Thanks:
To the officers, crew and engineers of the RRS James Cook for a safe and enjoyable voyage, especially the catering team who continually produced high quality food. Thanks also to the NMF technical support team team on board.

Malcolm Woodward and Sarah Breimann 29th January 2018

10. Oxygen sampling

Azyatti Abdul Aziz (University of Malaysia Terengganu)

Objectives:

The objective of the dissolved oxygen (DO) analysis was to provide a calibration for the oxygen sensor mounted on the frame of the CTD for cruise JC156, which undertook for both rosettes (stainless steel and titanium). Analysis of the samples based on modified Winkler titration method (Carpenter, 1965).

Sampling procedure

DO samples were collected as soon as the rosette arrived on deck and the second sample drawn from the Niskin bottles after helium. The triplicate samples were collected from the same Niskin bottles. Samples were drawn through silicon tubing into pre-calibrated glass bottles (125 ml nominal volume). Before the samples were drawn, care was taken to avoid bubbles inside the silicon tubing by allowed water to run freely and squeezing the tube to remove the bubbles. The tube was inserted to the bottom of the bottle and overflowed with sample for several seconds (approximately 3 times the volume of the bottle) to rinse the bottle and to ensure no bubbles. Samples were filled all the way to the top of the bottle and without stopper the bottle. Immediately the samples placed in a reagent caddy on the deck (Langdon, 2010). Samples were then fixed with 1 ml manganese chloride followed by 1 ml alkaline iodide (NaOH/NaI) and the stopper added with care to avoid any air bubbles. The samples bottles were shaken thoroughly and transferred to deck laboratory. The samples were then left to settle for 30 minutes before being shaken again and stored in a dark container until the precipitate had settled. Samples were analysed within 24 hours of collection.

Oxygen samples were also collected from the TMR to calibrate the oxygen sensor on this package. Samples for oxygen were taken after Fe(II) and sampled in a similar manner to above. However, the fixing of the samples took place in the main laboratory and after all samples were collected.

Analytical method

The samples were analysed onboard based on modified Winkler method (Carpenter, 1965) by using computer controlled potentiometric titration system (Metrohm Titrando 888). Prior to analysis, reagent blank and standardization were runs. The reagent blank accounts for the oxygen in the reagents by added the fixing reagent in reverse order and 5 ml of 0.025 N potassium iodate standard. The volume of sodium thiosulphate required for titrated was noted and the process was repeated for five times. The average blank was taken and used in the final calculation of DO concentration.

The normality of the sodium thiosulphate titrant was regularly checked, as it degrades with time. Sodium thiosulphate standardization was carried out by added the fixing reagent in reverse order and 5 ml of certified OSIL iodate standard (0.01 N). The volume of sodium thiosulphate required for titrated was noted and this process was repeated until reproducible results were achieved. This standardization was then used in the final calculation of DO concentration.

Prior to analysis 1 ml sulphuric acid (10N) was added to each sample in order to dissolved the precipitate and release the iodate ions. Immediately the sample was titrated against sodium thiosulphate after the precipitate was dissolved and stirred using a magnetic stirrer. Calculation of dissolved oxygen concentration was according to HOT protocol and Grasshoff (1983). The final results of DO concentration in µmol l^{-1} and the data were then used to calibrate the oxygen sensor.

Results

Samples were collected from 30 CTDs (Table 1). Replicate samples were carried out in order to test for reproducibility and the coefficient of variation was mostly better than 0.83%. Mean reagent blank was 0.007 ± 0.005 ml and all standardization data for all the analyses produced an average of 0.1933 ± 0.003 N. In total 470 samples were analysed for dissolved oxygen and the oxygen concentration measured was in the ranged between 150 to 276 µmol O_2 l^{-1}. All the data were forward to physical team for calibrating the oxygen sensor on the CTD.

Observations

During the early stages of the cruise (Figure 1a), a poor relationship between CTD oxygen and bottle oxygen was observed. However, after improved methodology a good regression between both the bottle oxygen data and sensor data was obtained. This was possibly due to the delay during fixing the samples with chemical reagent.. It was also found that the type of magnetic stirrer play important role to produce the accuracy of the end-point during the titration. After the magnetic stirrer was changed from ball shape to bar shape during titration, the sample mixed well with sodium thiosulphate and produced the most consistent results (Figure 1d and 1f). It was noted that new oxygen sensor was used (CTD 67) and this would be potential reason the regressions between oxygen bottle and CTD oxygen improved.

Table 1. List of rosette casts which were sampled for dissolved oxygen.

Date	CTD /Station	Position	CTD bottle numbers analysed, and depths
23/12/17	CTD_007T Station 1	$43^0$23.841'N $13^0$50.863'W	Bottle no. 24,22,13,11,8 5 depths:20, 80,400, ,900 ,1600
23/12/17	CTD_008S Station 1	$43^0$23.845'N $13^0$50.854'W	Bottle no. 20,16,10,6,2 5 depths: 60, 150, 600 ,800, 1000
26/12/17	CTD_010T Station 3	$39^0$30.050'N $23^0$23.142'W	Bottle no. 24, 19, 16, 11, 7 5 depths:20, 200, ,400, 960, 1800
27/12/17	CTD_012S Station 4	$39^0$29.995'N $26^0$40.007'W	Bottle no. 23, 18, 15, 13, 4 5 depths: 20, 200, ,500 ,750, 2250

28/12/17	CTD_013T Station 5	39^{0}30.027’N 29^{0}48.423’W	Bottle no. 24, 20, 13, 10, 8 5 depths:20, 100, 780, 1000, 1400
29/12/17	CTD_015S Station 6	37^{0}50.501’N 31^{0}31.251’W	Bottle no. 24,18, 15, 13, 9 5 depths:20, 150, 400 ,600, 700
29/12/17	CTD_019S Station 8	37^{0}17.545’N 31^{0}16.883’W	Bottle no. 24, 18, 15, 13, 9 5 depths:20 ,100, 150, 1000, 1550
31/12/17	CTD_024S Station 10	36^{0}13.799’N 32^{0}39.099’W	Bottle no. 24, 22, 20,19, 17, 14, 12, 11 8 depths:20, 60, ,85,95, ,150, ,780, 1000,1250
03/01/17	CTD_028S Station 12	36^{0}13.801’N 33^{0}31.636’W	Bottle no. 23, 18, 16, 14,13,12, 10 7 depths: 40, ,250, 550, ,720,850,1000, 1500
05/01/17	CTD_030S Station 13	36^{0}13.801’N 34^{0}14.180’W	Bottle no. 24, 16,15, 12,8, 6, 1 7depths: 20, 500,700, 850, 1600,1875, 2340
06/01/17	CTD_033S Station 14	36^{0}28.248’N 33^{0}40.264’W	Bottle no. 22,19,15, 12, 1 5 depths: 50, 80, 400, ,725 ,2611
07/01/17	CTD_035S Station 15	35^{0}56.753’N 34^{0}09.211’W	Bottle no. 23, 18, 16, 12, 1 5 depths: 40, 150, 250, 720, 2350
08/01/17	CTD_037S Station 16	36^{0}13.795’N 33^{0}54.116’W	Bottle no. 24, 18, 16, 14,11 5 depths: 20 ,175, 500, 700, 1600
11/01/17	CTD_046T Station 20	35^{0}02.40’N 35^{0}00.60’W	Bottle no. 22, 16, 15, 14, 7 5 depths: 60, 550, 650, 850, 1980)
12/01/17	CTD_048T Station 21	33^{0}36.463’N 38^{0}13.721’W	Bottle no. 22, 17, 14, ,12, 11, 7 6 depths: 60, 370, 820, 1350, 2100, 3000
13/01/17	CTD_050T Station 22	32^{0}00.002’N 40^{0}26.532’W	Bottle no. 23, 17, 15, 13, 8 5 depths: 40, 400, 600, 820, 1500
14/01/17	CTD_052S Station 23	30^{0}07.444’N 42^{0}07.193’W	Bottle no. 24, 16,13, 8, 1 5 depths: 20 ,150, 400,700,762
14/01/17	CTD_053T Station 24	29^{0}10.012’N 43^{0}10.438’W	Bottle no. 23, 18,17,14,13 5 depths: 40, 550,710, 1500,2000
15/01/17	CTD_055T Station 25	27^{0}0.00’N 44^{0}29.998’W	Bottle no. 23, 17, 13, 8, 3 5 depths: 40, 250, 850, 2200, 3600
16/01/17	CTD_058S Station 26	26^{0}21.601’N 44^{0}40.499’W	Bottle no. 23, 19, 17, 15, 14 5 depths: 50, 400, 820, 1500,1900
17/01/17	CTD_060S Station 27	25^{0}55.776’N 45^{0}01.115’W	Bottle no. 24, 20, 13, 10, 8 5 depths: 20,100,950, 2000, 3000
18/01/17	CTD_062S Station 28	26^{0}51.600’N 47^{0}13.810’W	Bottle no. 21, 19, 16,15, 13 5 depths: 100, 150, 800,1000, 2000
19/01/17	CTD_064S Station 29	26^{0}30.001’N 46^{0}12.000’W	Bottle no. 24, 20, 17,16, 12 5 depths: 20, 120, 550,800,2250
20/01/17	CTD_067S Station 30	26^{0}12.900’N 45^{0}07.100’W	Bottle no. 24, 22, 16,13, 9, 4 6 depths: 20, 75, 350,800,2200,2700
21/01/17	CTD_069S Station 31	26^{0}01.720’N 44^{0}33.168’W	Bottle no. 23, 17, 16, 15, 11 5 depths: 50, 500, 800, 2500, 3275
22/01/17	CTD_070T Station 32	25^{0}08.509’N 42^{0}31.223’W	Bottle no. 23, 16, 14, 9, 2 5 depths: 50, 500, 835, 2200, 3400

22/01/17	CTD_071T Station 32	$25^0$35.100'N $43^0$30.001'W	Bottle no. 23, 18, 16, 13, 6 5 depths: 50, 250, 790, 1750,3400
26/01/18	CTD_077S Station 35	$26^0$08.337'N $44^0$49.532'W	Bottle no. 24, 23, 22, 20, 18 5 depths: 50, 80, 100, 350, 1000
27/01/18	CTD_081S Station 36	$26^0$16.688'N $44^0$43.893'W	Bottle no. 24, 23, 18, 17, 15 5 depths: 20, 50, 250, 450, 800
27/01/18	CTD_082S Station 37	$26^0$07.850'N $44^0$46.199'W	Bottle no. 24, 22, 21, 17, 15 5 depths: 50, 130, 150, 800, 1200

References

Carpenter, J.H. (1965). The Chesapeake Bay Institute Technique for the Winkler oxygen method*. Limnol. Oceanogr*., **10**, 141–143.

Grasshoff, K. Ehrhardt, M, and K. Kremling (1983). Methods of Seawater Analysis. Grasshoff, Ehrhardt and Kremling, eds. Verlag Chemie GmbH. 419 pp.

HOT protocol : http://hahana.soest.hawaii.edu/hot/protocols/chap5.html

Langdon. C. (2010). Determination of Dissolved Oxygen in Seawater by Winkler Titration using the Amperometric Technique. The GO-SHIP Repeat Hydrography Manual: A Collection of Expert Report and Guidelines, IOCCP Report No. 14, ICPO Publication Series No. 134, Version 1.

11. Chlorophyll a sampling

Valerie Le Guennec (University of Liverpool)

OBJECTIVES
Chlorophyll a measurements were done along the cruise (JC156) in order to calibrate the fluorometer sensor of the two CTD rosettes (Stainless Steel and Trace Metal).

SAMPLE COLLECTION and ANALYTICAL METHODOLOGY:

Sample collection

Bottles of 1L were used to collect surface water from the two CTD sampling Rosette (Stainless Steel and Trace Metal Rosette). The bottles used for the sampling were numbered from 1 to 24, matching therefore the Niskin numbers. For the OTE bottles from the TMR sample labels were used to identify the bottles Once the Stainless Steel Rosette arrived on deck, chlorophyll *a* sample were taken nearly at the end of the sampling (usually before salinity which was the last parameter to be measured). A tubing was used to collect the water on the small spigot of the Niskin bottles. The sampling technique consisted on 3 rinses before filling the sample bottle entirely and capping tightly.

Analytical methodology

A) Chlorophyll a filtration and extraction

Measuring cylinders were rinsed three times with the sampled water before pouring a precise amount of water into the filter rig. Samples were then directly filtered through GF/F filters using a vacuum of 16 mbar. Filters were then fold in half and placed inside vials and chlorophyll-*a* pigments were extracted in 5mL of 90% acetone. The vials with the filters were then wrapped in aluminium foil, labelled and stored for 24 hours in a fridge.

B) Fluorescence measurement

24 hours after the addition of acetone, the fluorescence was measured with a Turner Design fluorometer. The fluorometer was always switched on 30 min prior each measurement. The calibration of the fluorometer was previously done in Liverpool by Claire Mahaffey.

Blanks of 90% acetone and the standard were analysed before each measurements of the samples.

SAMPLES ANALYSED:

Table 1 : Stainless Steel Log Events (in brown are the deep-water samples)

Date	CTD /Station	Position	CTD bottle numbers analysed, and depths

23/12/17	CTD_008S Station 1	43⁰23.845’ N 13⁰50.854’ W	14,16,18,20,22,24(depth: 400,150,120,60,30,3)
27/12/17	CTD_012S Station 4	39⁰29.996’ N 26⁰40.007’ W	18,19,20,21,22,23 (depth: 200,150,100,60,40,20)
29/12/17	CTD_015S Station 6	37⁰50.5048’N 31⁰31.250’ W	17,18,19,20,21,22,23,24 (depth: 225,150,100,80,60,40,30,20)
30/12/17	CTD_019S Station 8	37⁰17.545’ N 32⁰16.883’ W	16,18,19,20,21,22,23,24 (depth: 200,120,100,80,70,50,40,20)
31/12/17	CTD_024S Station 10	36⁰13.799’ N 32⁰39.099’ W	16,18,19,20,21,22,23,24 (depth: 270,110,95,85,75,60,40,20)
01/01/18	CTD_026S Station 11	36⁰13.797’ N 31⁰39.090’ W	18,19,20,21,22,23,24 (depth: 350,250,150,100,60,40,20)
06/01/18	CTD_033S Station 14	36⁰28.248’ N 33⁰40.264’ W	16,17,18,19,20,21,22,23,24 (depth: 400,250,120,80,70,60,50,40,20)
07/01/18	CTD_035S Station 15	35⁰56.753’ N 34⁰09.211’ W	17,19,20,21,22,23,24 (depth: 250,100,90,80,60,40,20)
08/01/18	CTD_037S Station 16	36⁰13.795’ N 33⁰54.116’ W	19,20,21,22,23,24 (depth: 175,120,75,60,50,20) + 4,5,6,7,8 (depth: 2175,2150,2100,2000,1950)
09/01/18	CTD_039S Station 18	36⁰22.835’ N 33⁰41.657’ W	18,19,20,21,22,23,24 (depth: 350,250,150,120,80,40,20)
10/01/18	CTD_044S Station 16, Part 2	36⁰13.800’ N 33⁰54.119’ W	1,2,3,4,5,6,7,8 (depth: 2275,2274,2268,2257,2139,2058,1966,1925)
14/01/18	CTD_052S	30⁰07.442’ N	16,17,18,19,20,21,22,24 (depth: 150,130,120,110,100,80,60,20)

	Station 23	42^{0}07.193’ W	
15/01/18	CTD_054S Station 24	29^{0}10.149’ N 43^{0}10.281’ W	18,19,20,21,22,23,24 (depth: 500,300,150,100,80,50,20)
16/01/18	CTD_058S Station 26	26^{0}21.601’ N 44^{0}40.499’ W	19,20,21,22,23,24 (depth: 400,150,130,90,50,20)
17/01/18	CTD_060S Station 27	25^{0}55.776’ N 45^{0}01.115’ W	18,19,20,21,22,23,24 (depth: 150,120,100,90,80,50,20)
18/01/18	CTD_062S Station 28	26^{0}51.600’ N 47^{0}13.810’ W	19,20,21,22,23,24 (depth: 150,120,100,80,50,20)
19/01/18	CTD_064S Station 29	26^{0}30.000’ N 46^{0}12.000’ W	19,20,21,22,23,24 (depth: 150,120,100,70,50,20)
20/01/18	CTD_067S Station 30	26^{0}12.904’ N 45^{0}07.092’ W	17,18,19,20,21,22,23,24 (depth: 250,150,130,110,100,75,50,13)
21/01/18	CTD_069S Station 31	26^{0}01.720’ N 44^{0}33.168’ W	18,19,20,21,22,23,24 (depth: 350,150,110,90,70,50,20)

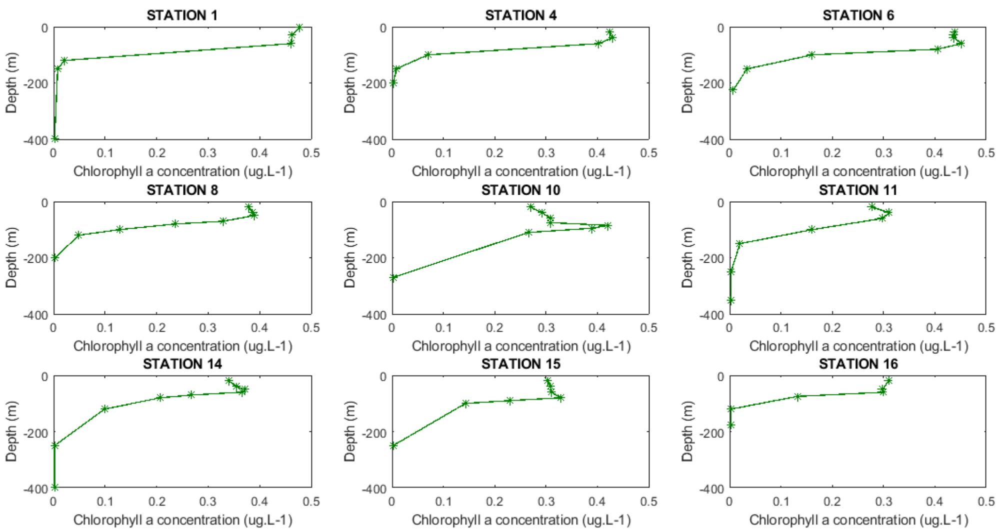
Table 2 : Trace Metal Log Events

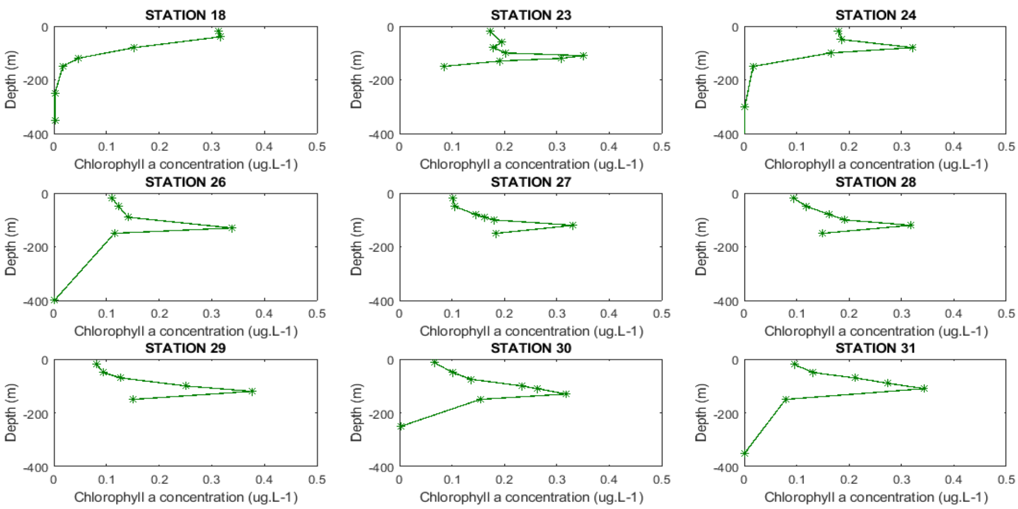
Date	**CTD /Station**	**Position**	**CTD bottle numbers analysed, and depths**
26/12/17	CTD_010T Station 3	39^{0}29.98’N 23^{0}23.06’ W	16,19,20,21,22,23,24(depth: 400,200,160,125,90,50,20)
28/12/17	CTD_013T Station 5	39^{0}30.00’N 29^{0}48.47’ W	18,20,21,22,23,24 (depth: 247,100,60,40,30.20)
11/01/18	CTD_046T Station 20	34^{0}31.980’ N 36^{0}51.0018’W	18,19,20,21,22,23 (depth: 150,125,100,80,60,40)

12/01/18	CTD_048T Station 48	33^{0}36.51'N 38^{0}13.699'W	20,21,22,23,24 (depth: 100,80,60,40,20)
13/01/18	CTD_050T Station 22	32^{0}0.002'N 40^{0}26.532'W	18,19,20,21,22,23,24 (depth: 250,150,100,80,60,40,20)

EXAMPLE PROFILES:

STAINLESS STEEL ROSETTE :





12. Helium sampling

Ric Williams and Shaun Rigby (University of Liverpool)

1) Objectives

Helium was included in the elements to be measured during the FRidge GA13 research cruise. The sampling strategy consisted of multiple depths within the seasonal thermocline and suspected hydrothermal plume waters, as well as a mid-depth ‘anchor point’ to measure background conditions. Using correlations between helium and nutrients across the seasonal thermocline, we will attempt to quantify the vertical flux of nutrients to the surface ocean. Helium measurements will also be valuable when identifying hydrothermal plume waters, as these waters are characteristically high in helium concentrations. During the cruise there was a crossover station where the GA03 cruise had measured helium previously, thus allowing a comparison in analytical techniques.

2) Setup

Copper tubes were stored in the deck lab, inside foam lined pelican cases until required. All equipment was setup in the water sampling room on-board the *RRS James Cook*. Air was compressed to 80 psi to drive the foot pump, which was calibrated to produce 9000 psi on the hydraulic side. The hydraulic side was connected to the cold weld device. The flattener and re-rounder were fixed on an adjacent wooden work bench. Green fibreglass trays were used to store seawater filled and waste copper tubes during sampling and located by the cold weld device.

3) Prior to sampling

Firstly, the foot pump was disconnected on air-intake side then a few drops of hydraulic oil added before each sampling station. Copper tubing was then cut into 30” lengths, with solid black lines at 3”, 15” and 27” to denote crimping locations. Dashed lines were added at 9” and 21” where the piping would be flattened and re-rounded. Sample information was written on the pipes in waterproof black permanent marker pen in the following order: “JC156, station – cast – Niskin bottle A”, replacing the ‘A’ for a ‘B’ on the B sample. The unique GEOTRACES sample ID was added to both A and B samples on the other side of the dashed line. Copper tubes were flattened at the 9” and 21” marks. To keep the interior of the copper pipes as fresh as possible, tubing was not cut into 30” lengths more than 1 hour prior to sampling.

4) Sampling Procedure

The deepest fired Niskin bottle was sampled first. Tygon tubing was attached to both ends of the 30” copper pipe, and cable tied at the waste end to prevent the tygon slipping. The copper pipe was held above the Niskin with the B end above the A end, tygon attached to the Niskin and the spigot opened. The valve on the top of the Niskin was then opened. The copper pipe was then slowly lowered to minimise air bubbles trapped in the pipe as water began to flow from the A sample end to the B waste end. While the seawater was flowing through the pipe, the tubing was rapped until all air bubbles were dislodged. Pinch values on the tygon tubing were closed and tygon tubing detached from the Niskin bottle. With the tygon tubing still attached, copper tubes were crimped at the 3”, 15” and 27” lines to give sealed A and B samples. Copper residue was cleaned from the surface of the crimper after each use. Both A and B samples were then immediately re-rounded. A simple click-test was performed on each sample by sharply accelerating and decelerating the sample. This test was performed to check the quality of the seal. Any samples which failed (did not click) the click test were noted. Samples were then placed in the fibreglass tray until all desired Niskin bottles had been processed. Then samples were rinsed in fresh water and dried. Samples were stored in boxes with bubble wrap separating layers, where each layer contained 6 samples a minimum of 3” apart. At the end of the cruise, samples were unpacked, checked for leaks, organised by station and repacked.

5) Maintenance

After storing samples, the foot pump and crimper were wiped with damp towel (freshwater) and dried. Moving parts were sprayed with WD-40. Water used for storing the tygon tubing was changed daily.

6) Recommended practice

While crimping samples there was a clear build-up of pressure in the waste end of the tygon tubing. This caused the tubing to slip off the copper pipe on occasion, even when cable tied. To prevent this, the pinch valve was place as far away from the crimp as possible, maximising the length of tygon tubing between the sample and pinch value. This solution distributed the pressure over a large volume and prevented the tygon tubing slipping.

There were a few instances where the copper pipe would not split effectively during crimping. This was resolved by checking the alignment of the jaws on the crimper and ensuring the sample was place in the middle of the jaws while the seal was made. In all cases, a click-test was performed to check the seal and any failures noted.

To get a louder, clearer ‘click’ during the click-test, the re-rounding of samples was completed by sharply pressing down on the re-rounder with force. A slow gradual re-rounding seemed to produce a quiet click which was difficult to distinguish from background noise of the ship.

7) Summary of sampling

A total of 315 individual depths were sampled across 27 unique stations. The highest resolution of sampling was at the Trans-Atlantic Geotraverse (TAG) hydrothermal vent site, where 24 samples were taken. At the other focussed study hydrothermal vent site visited during the cruise, Rainbow, 16 samples were taken. Samples were taken at other hydrothermal vents, including Lucky Strike, Menez Gwen, Lost City, Saldanha and Broken Spur. The sampling strategy was designed to give higher resolution in the potential plume waters and seasonal thermocline. As such, 87 samples were taken from the upper 500m and 128 samples were taken within 500m of the seabed.

8) Samples taken

Date	Station	Cast	Lat (deg. N)	Lon (deg. W)	Depth (m)	Niskin Bottle	GEOTRACES ID	Notes
23/12/2017	1	8	43.24	13.51	1000	1	169	None
23/12/2017	1	8	43.24	13.51	900	3	171	B failed click test
23/12/2017	1	8	43.24	13.51	800	5	173	None
23/12/2017	1	8	43.24	13.51	700	7	175	None
23/12/2017	1	8	43.24	13.51	600	9	177	B failed click test
23/12/2017	1	8	43.24	13.51	500	11	179	None
23/12/2017	1	8	43.24	13.51	400	13	181	None
23/12/2017	1	8	43.24	13.51	150	15	183	None
23/12/2017	1	8	43.24	13.51	120	17	185	B failed click test
23/12/2017	1	8	43.24	13.51	60	19	187	None
23/12/2017	1	8	43.24	13.51	30	21	189	None
23/12/2017	1	8	43.24	13.51	3	23	191	None
27/12/2017	4	12	39.3	26.4	2250	4	268	None
27/12/2017	4	12	39.3	26.4	2000	5	269	None
27/12/2017	4	12	39.3	26.4	1750	6	270	None
27/12/2017	4	12	39.3	26.4	1500	7	271	None
27/12/2017	4	12	39.3	26.4	1350	8	272	None
27/12/2017	4	12	39.3	26.4	1200	9	273	None
27/12/2017	4	12	39.3	26.4	1000	10	274	None
27/12/2017	4	12	39.3	26.4	750	13	277	Leaky Niskin
27/12/2017	4	12	39.3	26.4	500	15	279	None
27/12/2017	4	12	39.3	26.4	300	17	281	None
27/12/2017	4	12	39.3	26.4	150	19	283	None
27/12/2017	4	12	39.3	26.4	60	21	285	None
29/12/2017	6	15	37.51	31.31	839	2	338	None
29/12/2017	6	15	37.51	31.31	810	4	340	None
29/12/2017	6	15	37.51	31.31	790	5	341	None
29/12/2017	6	15	37.51	31.31	780	6	342	None
29/12/2017	6	15	37.51	31.31	725	8	344	Leaky Niskin
29/12/2017	6	15	37.51	31.31	700	10	346	None

29/12/2017	6	15	37.51	31.31	650	12	348	None
29/12/2017	6	15	37.51	31.31	500	14	350	None
29/12/2017	6	15	37.51	31.31	300	16	352	None
29/12/2017	6	15	37.51	31.31	225	17	353	None
29/12/2017	6	15	37.51	31.31	100	19	355	None
29/12/2017	6	15	37.51	31.31	60	21	357	None
30/12/2017	8	19	37.18	32.17	1711	1	433	None
30/12/2017	8	19	37.18	32.17	1705	2	434	B failed click test
30/12/2017	8	19	37.18	32.17	1700	3	435	None
30/12/2017	8	19	37.18	32.17	1690	4	436	None
30/12/2017	8	19	37.18	32.17	1670	5	437	None
30/12/2017	8	19	37.18	32.17	1650	6	438	B failed click test
30/12/2017	8	19	37.18	32.17	1200	10	442	None
30/12/2017	8	19	37.18	32.17	720	13	445	None
30/12/2017	8	19	37.18	32.17	550	14	446	None
30/12/2017	8	19	37.18	32.17	200	16	448	None
30/12/2017	8	19	37.18	32.17	80	20	452	A sample failed
30/12/2017	8	19	37.18	32.17	50	22	454	None
31/12/2017	9	22	36.34	33.26	2214	1	505	None
31/12/2017	9	22	36.34	33.26	2204	2	506	None
31/12/2017	9	22	36.34	33.26	2150	3	507	None
31/12/2017	9	22	36.34	33.26	2100	4	508	None
31/12/2017	9	22	36.34	33.26	2050	5	509	None
31/12/2017	9	22	36.34	33.26	2000	6	510	None
31/12/2017	9	22	36.34	33.26	1900	7	511	None
31/12/2017	9	22	36.34	33.26	1800	8	512	None
31/12/2017	9	22	36.34	33.26	1500	9	513	B failed click test
31/12/2017	9	22	36.34	33.26	1200	10	514	None
31/12/2017	10	24	36.14	32.39	2487	1	533	None
31/12/2017	10	24	36.14	32.39	2450	2	554	None
31/12/2017	10	24	36.14	32.39	2425	3	555	None
31/12/2017	10	24	36.14	32.39	2400	4	556	None
31/12/2017	10	24	36.14	32.39	2380	5	557	None
31/12/2017	10	24	36.14	32.39	2350	6	558	None
31/12/2017	10	24	36.14	32.39	2000	8	560	None
31/12/2017	10	24	36.14	32.39	900	13	565	None
31/12/2017	10	24	36.14	32.39	540	15	567	None
31/12/2017	10	24	36.14	32.39	270	16	568	None
31/12/2017	10	24	36.14	32.39	110	18	570	None
31/12/2017	10	24	36.14	32.39	75	21	573	None
00/01/1900	11	26	36.14	31.39	2700	3	603	None
01/01/2018	11	26	36.14	31.39	2450	5	605	None
01/01/2018	11	26	36.14	31.39	2050	7	607	None
01/01/2018	11	26	36.14	31.39	1800	9	609	None
01/01/2018	11	26	36.14	31.39	1400	11	611	None
01/01/2018	11	26	36.14	31.39	1000	13	613	Leaky Niskin
01/01/2018	11	26	36.14	31.39	830	14	614	None
01/01/2018	11	26	36.14	31.39	600	16	616	None
01/01/2018	11	26	36.14	31.39	350	18	618	None
01/01/2018	11	26	36.14	31.39	150	20	620	None
01/01/2018	11	26	36.14	31.39	100	21	621	None

01/01/2018	11	26	36.14	31.39	40	23	623	None
05/01/2018	12	28	36.14	33.32	2320	3	651	Bubbles in B sample
05/01/2018	12	28	36.14	33.32	2200	4	652	None
05/01/2018	12	28	36.14	33.32	2150	5	653	None
05/01/2018	12	28	36.14	33.32	2100	6	654	None
05/01/2018	12	28	36.14	33.32	1900	8	656	None
05/01/2018	12	28	36.14	33.32	1750	9	657	None
05/01/2018	12	28	36.14	33.32	1500	10	658	None
05/01/2018	12	28	36.14	33.32	1200	11	658	None
05/01/2018	12	28	36.14	33.32	700	15	663	None
05/01/2018	12	28	36.14	33.32	400	17	665	None
05/01/2018	12	28	36.14	33.32	110	19	667	None
05/01/2018	12	28	36.14	33.32	70	21	669	None
05/01/2018	13	30	36.14	34.18	2325	2	698	None
05/01/2018	13	30	36.14	34.18	2200	3	699	None
05/01/2018	13	30	36.14	34.18	2100	4	700	None
05/01/2018	13	30	36.14	34.18	2000	5	701	None
05/01/2018	13	30	36.14	34.18	1750	7	703	None
05/01/2018	13	30	36.14	34.18	1500	9	705	None
05/01/2018	13	30	36.14	34.18	1000	11	707	None
05/01/2018	13	30	36.14	34.18	700	14	710	None
05/01/2018	13	30	36.14	34.18	300	17	713	None
05/01/2018	13	30	36.14	34.18	150	18	714	None
05/01/2018	13	30	36.14	34.18	80	19	715	None
05/01/2018	13	30	36.14	34.18	50	22	718	None
06/01/2018	14	33	36.28	33.4	2550	2	770	None
06/01/2018	14	33	36.28	33.4	2450	3	771	None
06/01/2018	14	33	36.28	33.4	2260	5	773	None
06/01/2018	14	33	36.28	33.4	2250	6	774	None
06/01/2018	14	33	36.28	33.4	2100	7	775	None
06/01/2018	14	33	36.28	33.4	1700	8	776	Tygon slipped, no click on A or B
06/01/2018	14	33	36.28	33.4	2500	9	777	None
06/01/2018	14	33	36.28	33.4	960	11	779	None
06/01/2018	14	33	36.28	33.4	725	13	781	None
06/01/2018	14	33	36.28	33.4	400	15	783	Tygon slipped
06/01/2018	14	33	36.28	33.4	120	18	786	None
06/01/2018	14	33	36.28	33.4	60	21	789	None
07/01/2018	15	35	35.57	34.09	2100	3	819	None
07/01/2018	15	35	35.57	34.09	1950	4	820	None
07/01/2018	15	35	35.57	34.09	1925	5	821	None
07/01/2018	15	35	35.57	34.09	1900	6	822	None
07/01/2018	15	35	35.57	34.09	1860	7	823	None
07/01/2018	15	35	35.57	34.09	1730	8	824	None
07/01/2018	15	35	35.57	34.09	1100	10	826	None
07/01/2018	15	35	35.57	34.09	720	13	829	None
07/01/2018	15	35	35.57	34.09	250	17	833	None
07/01/2018	15	35	35.57	34.09	100	19	835	None
07/01/2018	15	35	35.57	34.09	80	21	837	None
07/01/2018	15	35	35.57	34.09	60	22	838	B failed click test

08/01/2018	16	37	36.14	33.54	2240	2	866	None
08/01/2018	16	37	36.14	33.54	2200	3	867	None
08/01/2018	16	37	36.14	33.54	2175	4	868	None
08/01/2018	16	37	36.14	33.54	2150	5	869	None
08/01/2018	16	37	36.14	33.54	2100	6	870	None
08/01/2018	16	37	36.14	33.54	2000	7	871	None
08/01/2018	16	37	36.14	33.54	1950	8	872	None
08/01/2018	16	37	36.14	33.54	1850	9	873	None
08/01/2018	16	37	36.14	33.54	1800	10	874	None
08/01/2018	16	37	36.14	33.54	1400	12	876	None
08/01/2018	16	37	36.14	33.54	700	15	879	None
08/01/2018	16	37	36.14	33.54	500	16	880	None
08/01/2018	16	37	36.14	33.54	300	17	881	None
08/01/2018	16	37	36.14	33.54	175	19	883	None
08/01/2018	16	37	36.14	33.54	75	21	886	None
08/01/2018	16	37	36.14	33.54	20	23	887	None
09/01/2018	18	39	36.23	33.42	2550	2	914	None
09/01/2018	18	39	36.23	33.42	2500	3	915	None
09/01/2018	18	39	36.23	33.42	2400	5	917	None
09/01/2018	18	39	36.23	33.42	2300	7	919	None
09/01/2018	18	39	36.23	33.42	2200	9	921	None
09/01/2018	18	39	36.23	33.42	2050	10	922	None
09/01/2018	18	39	36.23	33.42	1800	11	923	None
09/01/2018	18	39	36.23	33.42	900	15	927	None
09/01/2018	18	39	36.23	33.42	690	16	928	None
09/01/2018	18	39	36.23	33.42	250	19	931	None
09/01/2018	18	39	36.23	33.42	40	23	935	None
10/01/2018	16P2	44	36.14	33.54	2275	1	1033	None
10/01/2018	16P2	44	36.14	33.54	2274	2	1034	None
10/01/2018	16P2	44	36.14	33.54	2268	3	1035	None
10/01/2018	16P2	44	36.14	33.54	2257	4	1036	None
10/01/2018	16P2	44	36.14	33.54	2139	5	1037	None
10/01/2018	16P2	44	36.14	33.54	2058	6	1038	None
10/01/2018	16P2	44	36.14	33.54	1966	7	1039	None
10/01/2018	16P2	44	36.14	33.54	1925	8	1040	None
10/01/2018	16P2	44	36.14	33.54	1800	11	1043	None
12/01/2018	20	47	34.32	36.51	2280	1	1105	None
12/01/2018	20	47	34.32	36.51	2250	2	1106	None
12/01/2018	20	47	34.32	36.51	2200	3	1107	None
12/01/2018	20	47	34.32	36.51	2100	4	1108	None
12/01/2018	20	47	34.32	36.51	2050	5	1109	None
12/01/2018	20	47	34.32	36.51	1750	6	1110	None
13/01/2018	21	49	33.36	38.14	4375	2	1154	None
13/01/2018	21	49	33.36	38.14	4150	3	1155	None
13/01/2018	21	49	33.36	38.14	3900	4	1156	None
13/01/2018	21	49	33.36	38.14	3550	5	1157	None
13/01/2018	21	49	33.36	38.14	3250	6	1158	None
13/01/2018	21	49	33.36	38.14	1900	11	1163	None
14/01/2018	23	52	30.07	42.07	752	2	1226	None
14/01/2018	23	52	30.07	42.07	743	3	1227	None
14/01/2018	23	52	30.07	42.07	737	4	1228	None

14/01/2018	23	52	30.07	42.07	730	5	1229	None
14/01/2018	23	52	30.07	42.07	724	6	1230	None
14/01/2018	23	52	30.07	42.07	600	10	1234	None
15/01/2018	24	54	29.1	43.1	2879	4	1276	None
15/01/2018	24	54	29.1	43.1	2843	6	1278	None
15/01/2018	24	54	29.1	43.1	2815	8	1280	None
15/01/2018	24	54	29.1	43.1	2794	10	1282	None
15/01/2018	24	54	29.1	43.1	2751	11	1283	Tygon slipped
15/01/2018	24	54	29.1	43.1	2500	12	1284	None
15/01/2018	24	54	29.1	43.1	1000	16	1288	None
15/01/2018	24	54	29.1	43.1	720	17	1289	None
15/01/2018	24	54	29.1	43.1	500	18	1290	None
15/01/2018	24	54	29.1	43.1	150	20	1292	Bad crimp on A end
15/01/2018	24	54	29.1	43.1	80	22	1294	None
16/01/2018	25	56	27	44.3	3500	5	1325	None
16/01/2018	25	56	27	44.3	3000	6	1326	None
16/01/2018	25	56	27	44.3	2750	7	1327	None
16/01/2018	25	56	27	44.3	2500	8	1328	None
16/01/2018	25	56	27	44.3	2200	9	1329	None
16/01/2018	25	56	27	44.3	2000	10	1330	None
17/01/2018	26	58	26.21	44.4	3910	1	1369	None
17/01/2018	26	58	26.21	44.4	3790	3	1371	None
17/01/2018	26	58	26.21	44.4	3590	4	1372	None
17/01/2018	26	58	26.21	44.4	3390	6	1374	None
17/01/2018	26	58	26.21	44.4	3190	8	1376	None
17/01/2018	26	58	26.21	44.4	2990	10	1378	None
17/01/2018	26	58	26.21	44.4	2600	12	1380	None
17/01/2018	26	58	26.21	44.4	2300	13	1381	None
17/01/2018	26	58	26.21	44.4	650	18	1386	Bad crimp on A end
17/01/2018	26	58	26.21	44.4	400	19	1387	None
17/01/2018	26	58	26.21	44.4	150	20	1388	None
17/01/2018	26	58	26.21	44.4	90	22	1390	None
17/01/2018	27	60	25.56	45.01	4100	2	1418	None
17/01/2018	27	60	25.56	45.01	4000	3	1419	None
17/01/2018	27	60	25.56	45.01	3800	4	1420	None
17/01/2018	27	60	25.56	45.01	3600	5	1421	None
17/01/2018	27	60	25.56	45.01	3400	6	1422	None
17/01/2018	27	60	25.56	45.01	3200	7	1423	None
17/01/2018	27	60	25.56	45.01	2500	9	1425	None
17/01/2018	27	60	25.56	45.01	1600	11	1427	None
17/01/2018	27	60	25.56	45.01	815	14	1430	None
17/01/2018	27	60	25.56	45.01	300	17	1433	None
17/01/2018	27	60	25.56	45.01	120	19	1435	None
17/01/2018	27	60	25.56	45.01	80	22	1438	None
17/01/2018	27	60	25.56	45.01	50	23	1439	First sample failed, took 5 minutes later, no one sampled from bottle inbetween

18/01/2018	28	62	26.52	47.14	4223	1	1465	None
18/01/2018	28	62	26.52	47.14	3970	3	1467	None
18/01/2018	28	62	26.52	47.14	3800	5	1469	None
18/01/2018	28	62	26.52	47.14	3500	8	1472	None
18/01/2018	28	62	26.52	47.14	3300	10	1474	None
18/01/2018	28	62	26.52	47.14	2500	12	1476	None
19/01/2018	29	64	26.3	46.12	3800	2	1514	None
19/01/2018	29	64	26.3	46.12	3500	5	1517	None
19/01/2018	29	64	26.3	46.12	3300	7	1519	None
19/01/2018	29	64	26.3	46.12	2500	11	1523	None
19/01/2018	29	64	26.3	46.12	1500	14	1526	None
19/01/2018	29	64	26.3	46.12	350	18	1530	None
19/01/2018	29	64	26.3	46.12	150	19	1531	None
19/01/2018	29	64	26.3	46.12	100	21	1533	None
19/01/2018	29	64	26.3	46.12	70	22	1534	None
20/01/2018	30	67	26.13	45.07	3010	1	1585	None
20/01/2018	30	67	26.13	45.07	2900	2	1586	None
20/01/2018	30	67	26.13	45.07	2800	3	1587	Took a long time to clear bubbles
20/01/2018	30	67	26.13	45.07	2600	5	1589	None
20/01/2018	30	67	26.13	45.07	2400	7	1591	None
20/01/2018	30	67	26.13	45.07	1000	12	1596	None
20/01/2018	30	67	26.13	45.07	650	14	1598	None
20/01/2018	30	67	26.13	45.07	250	17	1601	None
20/01/2018	30	67	26.13	45.07	150	18	1602	None
20/01/2018	30	67	26.13	45.07	130	19	1603	None
20/01/2018	30	67	26.13	45.07	100	21	1605	None
20/01/2018	30	67	26.13	45.07	50	23	1607	None
21/01/2018	31	69	26.02	44.33	3871	2	1634	None
21/01/2018	31	69	26.02	44.33	3578	4	1636	None
21/01/2018	31	69	26.02	44.33	3375	6	1638	None
21/01/2018	31	69	26.02	44.33	3173	8	1640	None
21/01/2018	31	69	26.02	44.33	3018	9	1641	None
21/01/2018	31	69	26.02	44.33	2000	12	1644	None
21/01/2018	31	69	26.02	44.33	1100	14	1646	None
21/01/2018	31	69	26.02	44.33	350	18	1650	None
21/01/2018	31	69	26.02	44.33	150	19	1651	None
21/01/2018	31	69	26.02	44.33	110	20	1652	None
21/01/2018	31	69	26.02	44.33	90	21	1653	None
21/01/2018	31	69	26.02	44.33	70	22	1654	None
26/01/2018	35	77	26.83	44.5	3650	1	1825	None
26/01/2018	35	77	26.83	44.5	3575	2	1826	None
26/01/2018	35	77	26.83	44.5	3500	3	1827	None
26/01/2018	35	77	26.83	44.5	3450	4	1828	None
26/01/2018	35	77	26.83	44.5	3437	5	1829	None
26/01/2018	35	77	26.83	44.5	3374	6	1830	None
26/01/2018	35	77	26.83	44.5	3325	7	1831	None
26/01/2018	35	77	26.83	44.5	3300	8	1832	None
26/01/2018	35	77	26.83	44.5	3250	9	1833	None
26/01/2018	35	77	26.83	44.5	3200	10	1834	None
26/01/2018	35	77	26.83	44.5	3150	11	1835	None

26/01/2018	35	77	26.83	44.5	3100	12	1836	None
26/01/2018	35	77	26.83	44.5	3000	13	1837	None
26/01/2018	35	77	26.83	44.5	2750	14	1838	None
26/01/2018	35	77	26.83	44.5	2500	15	1839	None
26/01/2018	35	77	26.83	44.5	2250	16	1840	None
26/01/2018	35	77	26.83	44.5	1500	17	1841	None
26/01/2018	35	77	26.83	44.5	1000	18	1842	None
26/01/2018	35	77	26.83	44.5	750	19	1843	None
26/01/2018	35	77	26.83	44.5	350	20	1844	None
26/01/2018	35	77	26.83	44.5	125	21	1845	None
26/01/2018	35	77	26.83	44.5	100	22	1846	None
26/01/2018	35	77	26.83	44.5	80	23	1847	None
26/01/2018	35	77	26.83	44.5	50	24	1848	None
27/01/2018	36	81	26.17	44.44	3900	1	1921	None
27/01/2018	36	81	26.17	44.44	3600	3	1923	Seal on waste end of B leaked, not the sample
27/01/2018	36	81	26.17	44.44	3500	4	1924	None
27/01/2018	36	81	26.17	44.44	3400	5	1925	None
27/01/2018	36	81	26.17	44.44	3300	6	1926	None
27/01/2018	36	81	26.17	44.44	3200	7	1927	None
27/01/2018	36	81	26.17	44.44	1600	12	1932	None
27/01/2018	36	81	26.17	44.44	250	18	1938	None
27/01/2018	36	81	26.17	44.44	150	19	1939	None
27/01/2018	36	81	26.17	44.44	110	20	1940	None
27/01/2018	36	81	26.17	44.44	90	21	1941	None
27/01/2018	36	81	26.17	44.44	70	22	1942	None
27/01/2018	37	82	26.08	44.46	2443	7	1951	None
27/01/2018	37	82	26.08	44.46	2400	8	1952	None
27/01/2018	37	82	26.08	44.46	2350	9	1953	None
27/01/2018	37	82	26.08	44.46	2300	10	1954	None
27/01/2018	37	82	26.08	44.46	2200	11	1955	None
27/01/2018	37	82	26.08	44.46	1500	14	1958	None
27/01/2018	37	82	26.08	44.46	1000	16	1960	None
27/01/2018	37	82	26.08	44.46	600	18	1962	None
27/01/2018	37	82	26.08	44.46	350	19	1963	None
27/01/2018	37	82	26.08	44.46	250	20	1964	None
27/01/2018	37	82	26.08	44.46	150	21	1965	None
27/01/2018	37	82	26.08	44.46	130	22	1966	None
27/01/2018	37	82	26.08	44.46	100	23	197	None
27/01/2018	37	82	26.08	44.46	50	24	1968	None

Thanks:
To the crew of the RRS James Cook for making the voyage a pleasant one and endeavouring to solve any problem which emerged. Particularly to the gally staff who managed to produce a variety of fresh meals for the duration of the expedition.

13. Sulfide and Thiol sampling

Pascal Salaun (University of Liverpool)

Sulfide and Thiols

Hydrothermal vents are made of reduced species and concentrations of sulfide in the mM range and have been measured in several hydrothermal fluids. Increased concentration of thiols in the fluids have also been reported. Although unstable in oxygenated water, kinetics are relatively slow and sulfide is found in water in presence of oxygen. Such stability is responsible for the removal of a large proportion of iron by precipitation of FeS minerals, in the immediate vicinity of the vent. However, iIt is unclear how rapidly the concentration of sulfide is decreasing in the buoyant and neutrally buoyant plume and therefore, how it may still affect the precipitation, complexation and transport of iron and other metals at further distance from the vents. The aim here is therefore to measure sulfide within and in the vicinity of the plumes.

Sulfide and thiols were measured on-board by P. Salaun. They were measured by stripping voltammetry at amalgam wire electrodes using a three electrodes set-up (A/AgCl//KCl 3 M reference electrode, carbon auxiliary electrode and Au or Ag amalgam working electrodes) incorporated into a flow cell (Figure 1). The flow cell is connected to a peristaltic pump. The analytical method consists in first the accumulation of sulfide and/or thiols (family of organic compounds that contain a sulfhydryl group) at the surface of the mercury working electrode at a given potential (-0.5 V for free sulfide, 0.05 V for thiols). The method was developed on board the ship and is based on previous studies made on the mercury drop electrode and on Luther's work who used a Hg-amalgam gold disk electrode to measure sulfidic compounds in hydrothermal fluids. During the accumulation, the electrode is vibrated and the solution is flowing through the cell to increase the flux of analytes to the working electrode. Secondly, after a certain accumulation time (dependent on the analyte concentration, ranged between 15s and 15 min), the accumulated sulfidic species are quantified by stripping the current from anodic to cathodic potentials (usually from -0.2 to -1.1 V) through the intensity of the reduction peak that appear at a potential of around -0.65 V. Both thiols and free sulfide gives the same peak and differentiation between these two groups of species was done by using different accumulation potentials.

Stripping scanned voltammetry, that consists in a series of stripping analysis at varying deposition potentials, was carried out on few selected samples. This method can provide some insights into the composition and possibly nature of the thiols being measured.

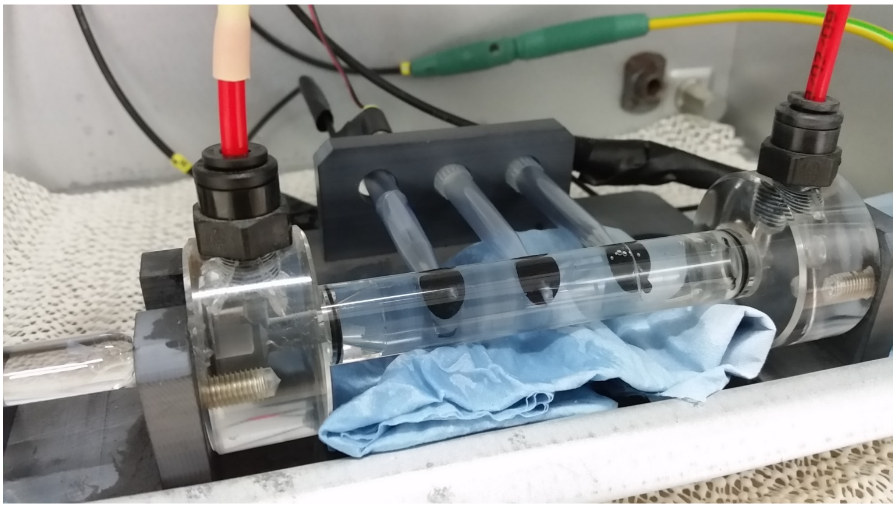


***Fig 1**: Voltammetric flow cell*

Quantification were done either by the method of standard additions or using the method of calibration curve.

Unfiltered samples were obtained from the trace metal and/or stainless steel rosettes and were collected into usually 50 ml acid-cleaned polyethylene tubes. Sulfide analysis were carried out immediately after while analysis for thiols were achieved at the earliest convenience. Samples for thiols were stored in the fridge or at room temperature until analysis. Maximum storing time was 3 weeks. Surface samples were also collected from the "fish".

The presence of sulfide in the plume was confirmed and detected at all hydrothermal sites, in agreement with variations of reducing potential detected in-situ by the Eh sensor. Concentrations of free sulfide was found up to c.a. 160 nM at the hydrothermal site of Rainbow. Figure 2 shows an example of obtained profile at the Lucky Strike station

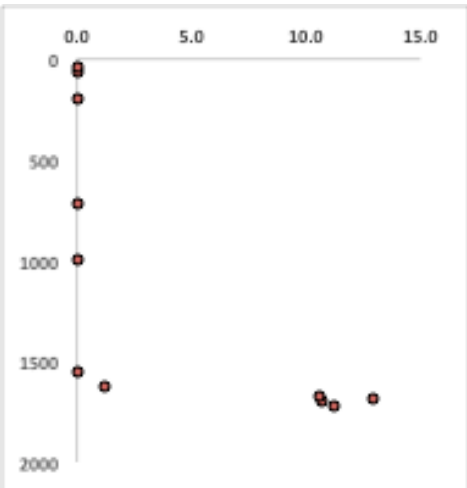


Figure 2: *Free sulfide concentration at Lucky Strike – Unit of x axis is nM. Y axis the depth in metres.*

Thiols were found to be present at nM levels (thiourea equivalent) with only relatively slight variations along the water column. A persistent feature of each profile is an increase of the signal in surface waters, that seems to follow chlorophyll levels, suggesting and/or confirming that some of the detected thiols are produced by the biology. However, the thiol signal was detected in the all water column.

Samples that were analysed for sulfide or thiols, in chronologic order of analysis, are:

Station 01: ID212, 218, 228, 235, 239, 240.
Station 04: ID241, 242, 245, 247, 248, 258, 259, 260, 261, 262, 263, 264, 286, 287
Station 05: ID305, 307, 303, 300, 297, 292, 291, 290, 289, 311, 312, 308, 309, 310, 316;
Station 06: ID321, 319, 322, 320, 318, 317, 316, 314, 315, 341, 323, 342, 340, 338, 319, 341
Station 07: ID385, 386, 387, 388, 389, 390, 391, 392, 386, 387, 388, 390, 391, 392,
Station 08: ID409, 411, 412, 416, 418, 421, 423, 426, 429, 431
Station 09: ID457, 459, 465, 458, 460, 462, 468, 475, 470, 472, 479, 473, 476, 477, 478, 480, 467, 464, 463
Station 10: ID564, 565, 566, 567, 568, 569, 570, 571, 572, 573, 574, 575, 576, 559, 558, 557, 556, 555, 554, 553, 561, 562, 563
Station 13: ID688, 689, 690, 693, 694, 695, 696
Station 14: ID722, 723, 724, 725, 726, 727, 728, 729, 730, 731, 732, 733, 734, 735, 736, 737, 738, 739, 740, 741, 7422, 743, 744
Station 15: ID793, 794, 795, 796, 797, 798, 799, 800, 801, 802, 803, 804, 805, 806, 807, 808, 809, 810, 811, 812, 813, 814, 815, 816
Station 16: ID843, 844, 845, 846, 842, 847, 848, 849, 850, 841, 867, 865, 868, 869, 871, 872
Station 16b: ID1010, ID1011, ID1012, ID1013, ID1018, ID1020
Station 23: ID1202, 1203, 1204, 1205, 1206, 1207, 1208, 1209, 1228, 1225, 1226, 1227, 1229, 1232, 1230
Station 24: ID1254, 1255, 1256, 1257, 1258, 1259, 1252, 1250, 1249, 1251, 1260, 1253
Station 25: ID1297, 1300, 1303, 1306, 1309, 1313, 1314, 1315, 1316, 1317, 1318, 1319, 1320
Station 26: ID1345, 1346, 1347, 1348, 1349, 1350, 1351, 1352, 1353, 1354, 1355, 1356, 1357, 1358, 1359, 1360, 1361, 1362, 1363, 1364, 1365, 1366, 1367, 1368
Station 27: ID1417, 1419, 1424, 1426, 1428, 1430, 1432, 1433, 1434, 1435, 1436, 1437, 1438, 1439, 1440, 1421
Station 30: ID1537, 1538, 1539, 1540, 1542, 1541
Station 35: ID1801, 1802, 1803, 1804, 1806, 1807, 1808, 1811, 1812, 1813, 1814, 1817, 1818, 1819, 1820, 1826, 1828, 1827, 1829, 1830, 1831, 1832, 1833, 1834, 1835, 1836, 1873, 1874, 1875, 876, 1877, 1878, 1884, 1885, 1891, 1892, 1893, 1894, 1895, 1896,1842, 1844, 1845, 1846, 1847, 1848.

Station 30: ID1544, 1551, 1545, 1547, 1543, 1548, 1558, 1554, 1560, 1557, 1556, 1559, 1553, 1555, 1550, 1546, 1552, 1549
Station 28: ID441, 1444, 1448, 1451, 1452, 1453, 1454, 1455, 1456, 1457, 1458, 1459, 1460, 1461, 1462, 1463
Station 21: ID1158, 1161, 1162, 1163, 1164, 1166, 1168, 1170, 1171, 1172, 1173, 1174, 1175, 1176

Solutions that have been collected but not yet analysed are:

Station 18: ID938, 941, 942, 943, 944, 945, 946, 947,
Station 16: ID1021, 1022, 1023, 1028
Station 22: ID1177, 1181, 1183, 1187, 1191, 1193, 1195, 1196, 1197, 1198, 1199, 1200;

Arsenic and antimony:

The aim here is to look at the variation of concentration of both arsenic and antimony in and around the hydrothermal plumes. They are both present in seawater as oxyanions and are known to both adsorb strongly on iron oxides, properties that make iron oxides as a material of choice for arsenic removal in freshwater. If such adsorption is also occurring at a significant level in seawater, lower dissolved arsenic concentrations should be observed in the plume. Samples were obtained from the titanium trace metal rosette, filtered through a 0.2 um polycarbonate filter in a clean tank and collected in 125 ml acid-cleaned LDPE bottles. Samples were then acidified with HCl to a final concentration of c.a. 8 mM (pH 2.3) for arsenic and antimony analysis that will be carried out later on in Liverpool.

Samples that were collected for future analysis are:

Station 02: ID193, 214, 205, 206, 215, 211, 204, 216, 209, 213, 198, 196, 194, 201, 203,
Station 06: ID316, 319, 314, 321, 323, 322, 336, 315, 316, 328, 334, 318, 317, 320
Station 08: ID423, 414, 415, 26, 429, 421, 416, 412, 409, 431, 411
Station 09: ID480, 462, 472, 458, 466, 468, 460, 474, 478, 470, 476, 464, 463
Station 10: ID546, 534, 538, 532, 544, 542, 550, 548, 552, 530, 540, 536
Station: ID627, 629, 633, 626, 630
Station 15: ID800, 801, 802, 803, 798, 793, 795, 796, 811, 815, 797, 799, 804, 807
Station 16a: ID849, 847, 851, 860, 848, 842, 841, 843, 844, 845, 846, 864, 850
Station 17: ID890, 895, 906, 897, 911, 892, 893, 896, 889, 891, 901, 900, 894
Station 18: ID946, 945, 939, 944, 947, 937, 941, 942, 955, 959, 943, 940
Station 16b: ID1032, 1012, 1025, 1009, 1010,
Station 19 : ID1061, 1072, 1073, 1076, 1079, 1080, 1057, 1069, 1063, 1060, 1059, 1066
Station 22: ID1182, 1190, 1192, 1196, 1194, 1198, 1180, 1178, 1188, 1184, 1200, 1186
Station 23: ID1202, 1203, 1204, 1220, 1222, 1224, 1212, 1214, 1206, 1218, 1210, 1216
Station 25: ID1305, 1307, 1320, 1315, 1299, 1317, 1297, 1309, 1206, 1312, 1364, 1314, 1303
Station 26: ID1356, 1346, 1348, 1360, 1358, 1362, 1350, 1354, 1366, 1352, 1368

Station 35: ID1813, 1818, 1807, 1804, 1821, 1802, 1811, 1823,
Station 35: ID1870, 1868, 1867, 1869, 1871, 1872, 1864, 1859, 1861
Station 36: ID1983, 1988, 1989, 1987, 1991.

14. Protactinium and Thorium sampling

Haley Spaid and Chris Hayes (USM)

To sample for ^{230}Th, ^{232}Th, and ^{231}Pa, samples were taken from the stainless steel rosette and filtered directly from the Niskin bottle through a 0.45 micron AcroPak 500 filter. Tygon tubing was used to attach the filter to the opening of the niskin bottle. The samples were collected into 4-L cubitainers. These cubitainers were then double bagged into plastic bags. These samples will then be shipped back to the lab, and stored until analysis.

Once in the lab, the samples will be acidified to a pH < 2. After 8 weeks of sample acidification, Th and Pa isotopes are first pre-concentrated by co-precipitation with Fe(oxy)hydroxide and the added tracers Th-229 and Pa-233. The pre-concentrated samples are acid digested (HNO3/HCl/HF) and then purified using ion chromatography. Supor filter samples will undergo a strong HNO_3/HF leach and the leachate is then preconcentrated and purified as with water samples. Radionuclide concentrations are determined by isotope dilution inductively-coupled plasma mass spectrometry (Hayes et al., 2015, Deep Sea Research, Part II).

Cruise	Sample Type	Event	CTD	Station	Depth	Rosette	SamID	USMID
JC156	Pa/Th	17	15	6	810	4	340	17
JC156	Pa/Th	17	15	6	780	6	342	18
JC156	Pa/Th	17	15	6	725	8	344	21
JC156	Pa/Th	31	28	12	2320	3	651	52
JC156	Pa/Th	31	28	12	2200	4	652	53
JC156	Pa/Th	31	28	12	2150	5	653	42
JC156	Pa/Th	31	28	12	2100	6	654	44
JC156	Pa/Th	31	28	12	1750	9	657	30
JC156	Pa/Th	31	28	12	1500	10	658	51
JC156	Pa/Th	34	30	13	2325	2	698	143
JC156	Pa/Th	34	30	13	2200	3	699	144
JC156	Pa/Th	34	30	13	2100	4	700	54
JC156	Pa/Th	34	30	13	2000	5	701	140
JC156	Pa/Th	34	30	13	1750	7	703	141
JC156	Pa/Th	34	30	13	1500	9	705	142
JC156	Pa/Th	38	33	14	2450	3	771	145
JC156	Pa/Th	38	33	14	2260	5	773	146
JC156	Pa/Th	38	33	14	2250	6	774	147
JC156	Pa/Th	38	33	14	2100	7	775	130
JC156	Pa/Th	38	33	14	1700	8	776	149
JC156	Pa/Th	41	35	15	2250	2	818	135

JC156	Pa/Th	41	35	15	2100	3	819	136
JC156	Pa/Th	41	35	15	1950	4	820	137
JC156	Pa/Th	41	35	15	1925	5	821	138
JC156	Pa/Th	41	35	15	1900	6	822	133
JC156	Pa/Th	41	35	15	1860	7	823	132
JC156	Pa/Th	41	35	15	1730	8	824	134
JC156	Pa/Th	41	35	15	1400	9	825	131
JC156	Pa/Th	48	37	16	2240	2	866	165
JC156	Pa/Th	48	37	16	2175	4	868	167
JC156	Pa/Th	48	37	16	2150	5	869	162
JC156	Pa/Th	48	37	16	2100	6	870	139
JC156	Pa/Th	48	37	16	2000	7	871	164
JC156	Pa/Th	48	37	16	1950	8	872	163
JC156	Pa/Th	48	37	16	1900	9	873	166
JC156	Pa/Th	57	44	16.2	2274	2	1034	156
JC156	Pa/Th	57	44	16.2	2139	5	1037	159
JC156	Pa/Th	57	44	16.2	2058	6	1038	154
JC156	Pa/Th	57	44	16.2	1850	10	1042	153
JC156	Pa/Th	51	39	18	2550	2	914	150
JC156	Pa/Th	51	39	18	2500	3	915	152
JC156	Pa/Th	51	39	18	2400	5	917	151
JC156	Pa/Th	51	39	18	2300	7	919	168
JC156	Pa/Th	51	39	18	2200	9	921	171
JC156	Pa/Th	51	39	18	2050	10	922	170
JC156	Pa/Th	51	39	18	1800	11	923	169
JC156	Pa/Th	60	47	20	2281	1	1105	215
JC156	Pa/Th	60	47	20	2250	2	1106	214
JC156	Pa/Th	60	47	20	2200	3	1107	216
JC156	Pa/Th	60	47	20	2100	4	1108	213
JC156	Pa/Th	60	47	20	2050	5	1109	220
JC156	Pa/Th	60	47	20	1750	6	1110	217
JC156	Pa/Th	60	47	20	1500	7	1111	218
JC156	Pa/Th	60	47	20	960	8	1112	219
JC156	Pa/Th	60	47	20	650	9	1113	161
JC156	Pa/Th	60	47	20	300	10	1114	212
JC156	Pa/Th	60	47	20	75	11	1115	160
JC156	Pa/Th	60	47	20	20	12	1116	158
JC156	Pa/Th	62	49	21	4475	1	1153	227
JC156	Pa/Th	62	49	21	4375	2	1154	228
JC156	Pa/Th	62	49	21	3900	4	1156	226
JC156	Pa/Th	62	49	21	3550	5	1157	225
JC156	Pa/Th	62	49	21	3250	6	1158	224
JC156	Pa/Th	62	49	21	2875	10	1162	222
JC156	Pa/Th	62	49	21	1900	11	1163	221
JC156	Pa/Th	62	49	21	1350	12	1164	223
JC156	Pa/Th	62	49	21	960	13	1165	65
JC156	Pa/Th	62	49	21	835	14	1166	230

JC156	Pa/Th	62	49	21	500	16	1168	231
JC156	Pa/Th	62	49	21	60	22	1174	229
JC156	Pa/Th	65	52	23	762	1	1225	69
JC156	Pa/Th	65	52	23	743	3	1227	68
JC156	Pa/Th	65	52	23	730	5	1229	66
JC156	Pa/Th	65	52	23	724	6	1230	67
JC156	Pa/Th	65	52	23	700	8	1232	70
JC156	Pa/Th	65	52	23	600	10	1234	71
JC156	Pa/Th	67	54	24	3015	2	1274	50
JC156	Pa/Th	67	54	24	2982	3	1275	74
JC156	Pa/Th	67	54	24	2879	4	1276	75
JC156	Pa/Th	67	54	24	2843	6	1278	77
JC156	Pa/Th	67	54	24	2800	9	1281	57
JC156	Pa/Th	67	54	24	2794	10	1282	58
JC156	Pa/Th	67	54	24	2751	11	1283	59
JC156	Pa/Th	67	54	24	2500	12	1284	55
JC156	Pa/Th	72	58	26	3910	1	1369	192
JC156	Pa/Th	72	58	26	3790	3	1371	64
JC156	Pa/Th	72	58	26	3590	4	1372	62
JC156	Pa/Th	72	58	26	3390	6	1374	63
JC156	Pa/Th	72	58	26	3190	8	1376	61
JC156	Pa/Th	72	58	26	2990	10	1378	60
JC156	Pa/Th	75	60	27	4100	2	1418	195
JC156	Pa/Th	75	60	27	4000	3	1419	194
JC156	Pa/Th	75	60	27	3800	4	1420	193
JC156	Pa/Th	75	60	27	3600	5	1421	196
JC156	Pa/Th	75	60	27	3400	6	1422	197
JC156	Pa/Th	75	60	27	3200	7	1423	195
JC156	Pa/Th	85	67	30	3010	1	1585	203
JC156	Pa/Th	85	67	30	2900	2	1586	199
JC156	Pa/Th	85	67	30	2800	3	1587	202
JC156	Pa/Th	85	67	30	2600	5	1589	201
JC156	Pa/Th	85	67	30	2400	7	1591	200
JC156	Pa/Th	88	69	31	3871	2	1634	207
JC156	Pa/Th	88	69	31	3700	3	1635	208
JC156	Pa/Th	88	69	31	3578	4	1636	209
JC156	Pa/Th	88	69	31	3375	6	1638	206
JC156	Pa/Th	88	69	31	3173	8	1640	205
JC156	Pa/Th	88	69	31	3018	9	1641	204
JC156	Pa/Th	101	77	35	3650	1	1825	174
JC156	Pa/Th	101	77	35	3575	2	1826	176
JC156	Pa/Th	101	77	35	3500	3	1827	175
JC156	Pa/Th	101	77	35	3450	4	1828	211
JC156	Pa/Th	101	77	35	3325	7	1831	210
JC156	Pa/Th	101	77	35	3300	8	1832	173
JC156	Pa/Th	101	77	35	3250	9	1833	172
JC156	Pa/Th	101	77	35	3200	10	1834	184

JC156	Pa/Th	101	77	35	3100	12	1836	183
JC156	Pa/Th	101	77	35	3000	13	1837	281
JC156	Pa/Th	101	77	35	2250	16	1840	180
JC156	Pa/Th	101	77	35	1500	17	1841	179
JC156	Pa/Th	101	77	35	750	19	1843	178
JC156	Pa/Th	101	77	35	125	21	1845	181
JC156	Pa/Th	101	77	35	50	24	1848	177
JC156	Pa/Th	106	81	36	3300	6	1926	83
JC156	Pa/Th	106	81	36	3200	7	1927	79
JC156	Pa/Th	106	81	36	450	17	1937	191
JC156	Pa/Th	106	81	36	250	18	1938	188
JC156	Pa/Th	106	81	36	150	19	1939	186
JC156	Pa/Th	106	81	36	90	21	1941	190
JC156	Pa/Th	106	81	36	70	22	1942	186
JC156	Pa/Th	106	81	36	50	23	1943	187
JC156	Pa/Th	106	81	36	20	24	1944	185
JC156	Pa/Th	107	82	37	2482	6	1950	101
JC156	Pa/Th	107	82	37	2350	9	1953	100
JC156	Pa/Th	107	82	37	2000	12	1956	97
JC156	Pa/Th	107	82	37	800	17	1961	96
JC156	Pa/Th	107	82	37	350	19	1963	98
JC156	Pa/Th	107	82	37	250	20	1964	99
JC156	Pa/Th	107	82	37	150	21	1965	88
JC156	Pa/Th	107	82	37	130	22	1966	94
JC156	Pa/Th	107	82	37	100	23	1967	95
JC156	Pa/Th	107	82	37	50	24	1968	85

15. Neodymium sampling

Rachel Mills (University of Southampton)

Isotopic ratios of the rare earth element, neodymium ($^{143}Nd/^{144}Nd$) have been widely used as a tracer of open ocean circulation because of the characteristic isotopic compositions of different water masses. The application of this tracer is however limited by a lack of understanding of Nd transport fluxes, and a full understanding of how water masses acquire their Nd isotopic signature. There is a clear decoupling of Nd concentration and isotopic composition in the oceans that demonstrates there are significant input or output fluxes at ocean boundaries not yet included in our understanding of Nd in the ocean. One of these key overlooked boundaries is the mid-ocean ridge and hydrothermal system.

^{143}Nd originates from the alpha decay of its long-lived (half-life = 10^6 Gyr) parent, ^{147}Sm. Samarium is preferentially sequestered into the mantle during the Earth's formation and therefore continental crust and ocean crust have significantly different $^{143}Nd/^{144}Nd$ ratios; younger, continental and volcanic mantle-derived rock at the Earth's surface have relatively high $^{143}Nd/^{144}Nd$ ratios. The fact that seawater $^{143}Nd/^{144}Nd$ ratios are systematically lower than those of the mantle illustrate that REE fluxes to the ocean are largely derived from the continents. Higher ratios have been observed in authigenic phases associated with mid-ocean ridge hydrothermal circulation.

Early studies suggested that hydrothermal systems made no contribution to seawater $^{143}Nd/^{144}Nd$ composition, and hydrothermal systems were inferred to be a sink rather than a source of radiogenic Nd. More recent observations of the variability in vent and plume dynamics and persistence of hydrothermally derived material through ocean basins from GEOTRACES suggests that these assumptions need to be challenged and the impact of mid-ocean ridge boundary exchange processes should be included in the oceanic Nd mass balance. In addition, $^{143}Nd/^{144}Nd$ is a potentially useful tracer of plume particle-seawater interactions both in the ocean and in the authigenic phases accumulating on the seafloor (sediments and Mn crusts).

69 5-7L filtered (0.45 micron) samples were collected from near-field plumes observed at Menez Gwen, Lucky Strike, Rainbow, Broken Spur and TAG. In addition samples were collected from particle-rich near bottom regions where observed around Rainbow and Saldanha. Samples will be analysed for $^{143}Nd/^{144}Nd$ at the National Oceanography Centre Southampton. In brief the acidified samples will be pH adjusted, pre-concentrated and Nd will be separated via two stages of reverse phase chromatography. $^{143}Nd/^{144}Nd$ will be analysed using a Thermo Scientific Neptune multi-collector inductively coupled plasma mass spectrometer (MC-ICP-MS) using standard mass bias and interference corrections.

STNNBR	CTDNBR	Event Description	Bottle number	Sample number	Depth (m)
6	15	Menez Gwen	4	340	810

			6	342	780
			8	344	725
8	19	LuckyStrike 2	1	433	1710
			3	435	1700
			9	441	1550
9	22	Saldanha	1	505	2210
			2	506	2200
10	24	1x E of Rainbow	1	553	2475
			2	554	2450
11	26	2x E of Rainbow	1	601	2874
			2	602	2774
12	28	Close E of Rainbow	3	651	2320
			6	654	2100
			9	657	1750
13	30	Close W of Rainbow	2	698	2325
			4	700	2100
14	33	Close N of Rainbow	2	770	2550
			6	774	2250
15	35	Close S of Rainbow	3	819	2100
			4	820	1950
			8	824	1730
16	37	Rainbow	2	866	2240
			5	869	2150
			7	871	2000
			8	872	1950
			9	873	1900
18	39	N bonus Rainbow	2	914	2550
			10	922	2050
16(2)	44	Rainbow part 2	2	1034	2274
			3	1035	2268
			7	1039	1966
			8	1040	1925
23	52	Lost City	5	1229	730
			6	1229	724

24	54	Broken Spur	2	1274	3015
			7	1279	2838
			9	1281	2800
			11	1283	2751
26	58	Close N of TAG	3	1371	3790
			8	1376	3190
27	60	Close S of TAG	4	1420	3800
			7	1423	3200
35	77	TAG	5	1829	3437
			6	1830	3374
			7	1831	3325
			8	1832	3300
			9	1833	3250
TOWYO4	79	TAG	6	1878	3280
			13	1885	3250
			20	1892	3210

16. Radium Sampling

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Objectives:

Radium (Ra) is present in the ocean as four naturally-occurring radioactive isotopes: ^{223}Ra, ^{224}Ra, ^{226}Ra and ^{228}Ra, with half-lives (11.4 d, 3.66 d, 1600 y and 5.75 y, respectively) spanning a range of time scales. Radium is produced continuously from lithogenic material by the decay of thorium (Th) and thus displays elevated concentrations near any sediment-water interface, including hydrothermal vent fluids. Due to the decay rates of the four Ra isotopes, Ra can be used to investigate the fate of solutes sourced from the same hydrothermal vent source. As Ra is not particle reactive, the decrease in concentration of each short-lived isotope away from the vent can be used to trace pathways of advection as well as constrain time scales of transport.

The primary objective of the radium (Ra) work done during the FRidge cruise is to investigate the time-scale of the loss and transformation of iron within the neutrally buoyant plume. To achieve this, large volumes of water were pumped over MnO_2-impregnated cartridges mounted on the Stand-Alone Pump Systems (SAPS) at depths within and around the neutrally-buoyant plume. The Ra isotopes, as well as thorium

(Th) and actinium (Ac) parents, adsorb strongly to the MnO_2 and are retrieved for analysis on board.

A secondary objective was to investigate the relationship between the shortest-lived Ra isotope (^{224}Ra, half life = 3.66d) and dust input. Surface water samples were collected with the tow-fish, and will be compared to dust proxies from aerosol sampling, as well as dissolved Fe, manganese and aluminium.

Sampling Protocols:

Ra sampling requires very large volumes of water, as Ra activities are typically very low away from sediment sources. We used the trace-metal clean towfish and SAPS pumps to collect these large volume samples. On two occasions, water was also collected from multiple Niskin bottles closed at single depth during the CTD cast.

Towfish sampling

The towfish was deployed from the aft port crane, to a depth of ~8m (depth when stationary). When underway at 10-12 knots we estimate the sampling depth to be ~2m. The pump was run almost continuously while the fish was underwater, including when on station to allow us to collect large volumes from one location. Acid-clean tubing was run from the fish into the clean lab container on the aft deck where it could be sampled for contamination-prone elements such as iron. From there, surface water was then directed into the Ra container at the back of the deck lab, which was not trace-metal clean but was suitable for Ra isotope work. The flow was only stopped to allow for discharge of grey water, as stopping the flow for significant periods of time can allow thorium, a parent isotope of Ra, to accumulate on the walls of the tubing. This can lead to contamination of Ra, and is why a towfish must be used for Ra sampling rather than the ship's underway system, where thorium can build up during port calls.

Samples of ~300 L were collected from the towfish, initially into 20 L collapsible plastic containers. Each 20 L bottle was weighed using a beam scale, and passed through a column holding 20 g of MnO_2-coated acrylic fiber, which strongly binds Ra. During the cruise we improved the sampling strategy to involve an in-line flow meter coupled to the Ra column, which we attached directly to the surface water flow. This negated the need for weighing of individual 20 L containers, which made processing larger sample volumes possible. The Mn-fiber was then rinsed with Milli-Q to remove salts and dried for 5-7 minutes using compressed air.

SAPS sampling

SAPS were deployed a total of 13 times from the main winch system on the starboard deck. Each deployment consisted of 6 SAPS that were fixed to a steel coring wire at intervals before being lowered to depths in and around the neutrally buoyant plume. Each SAPS was fitted with a filter housing containing a pre-filter mesh (51 micron) followed by either a Poly-Ether Sulfone (PES) (0.8 micron) or Glass-Fibre

(GF/F) (0.7 micron) filter. Two Mn-impregnated fibre cartridges were fitted in series between the filter housing and the pump system, such that the second cartridge would bind any Ra, Ac or Th that the first cartridge did not. Immediately before deployment the pumps were filled with Milli-Q to minimise backward flow before the pumps started. Each SAPS pumped between 300-1000L over a period of approximately 1.5 hours before being retrieved.

Once the SAPS were on deck the filter housings were disconnected and drained using a vacuum pump, those containing PES filters were then processed in the clean lab container at the back of the deck lab while those with GF/F filters were processed in the Ra container. GF/F filters were then photographed and air-dried, please see the trace-metal cruise report for PES filter processing. All Mn-impregnated cartridges were drained under gravity before being washed with approximately 1L of Milli-Q water and dried for 1 hour using a compressed air system.

CTD sampling

For samples collected from the CTD, each Niskin from a given depth was drained into a 20 L bottle and weighed, and then passed over the Mn fiber as for towfish samples.

For all samples, a subsample was collected into acid-clean 250 mL LDPE bottles for analysis of the long-lived ^{226}Ra isotopes by mass spectrometry for calibration. For towfish and CTD samples the ^{226}Ra sample was collected at the same time, whereas for SAPS the ^{226}Ra sample was collected from the stainless steel rosette cast immediately preceding or following the SAPS deployment.

Sample processing

When dry, the fiber or cartridge samples were then loaded into a Ra Delayed Coincidence Counter (RaDeCC; Scientific Computer Instruments, USA) system purged with He gas, and decay of Ra was counted for 6-10 h to quantify ^{223}Ra and ^{224}Ra content. Initial counting at sea provides combined activities for the short-lived isotope and its parent. Following decay of these short-lived isotopes, the fibers will be re-analysed in the UK using the RaDeCCs to determine the activity of the parent isotopes (^{227}Ac and ^{228}Th), allowing calculation of the "excess" or unsupported ^{223}Ra and ^{224}Ra activities.

Long-lived Ra isotopes will be measured on shore, through a combination of mass spectrometry and alpha counting techniques.

Samples collected:

A total of 34 towfish samples were collected for Ra isotopes, of which 2 were collected for both dissolved, particulate and total activities by filtering one parallel sample through a 142mm GF/F filter. The samples span the GEOVIDE crossover station (station 2) to the transit towards Guadeloupe after the TAG site. In total, over 13000L of surface seawater were processed for Ra isotope measurements (Table 1).

Table 1: Summary of Ra sampling events from the towfish

FishID	Station	Date	Start time (GMT	End time	Mid time	Start Lat.	Start Long.	End Lat.	End Long.	Depth (m)	Volume (L)	Notes
2	1	23/12/2017	18:29	20:28	19:28	43.3975	13.8417	43.35	13.8517	4957	393.1	
3	2	24/12/2017	16:50	18:25	17:37	41.3828	13.8877	41.3828	13.8877	5291.5	321.16	
5	3	26/12/2017	14:24	16:17	15:20	39.4992	23.3835	39.4997	23.3845	3834.5	325.85	
7	4	27/12/2017	11:08	12:57	12:02	39.4998	26.6667	39.4998	26.6667	2596	260.47	
7F	4	27/12/2017	11:08	12:57	12:02	39.4998	26.6667	39.4998	26.6667	2596	386.43	*filtered
9	5	28/12/2017	08:54	10:40	09:47	39.5	29.8082	39.5	29.8007	2104.5	321.34	
10	6	29/12/2017	00:19	02:00	01:09	37.8417	31.5208	37.8417	31.5208	814	326.12	
12	7	29/12/2017	13:02	14:40	10:00	37.3015	32.2968	37.2917	32.2802	1646	327.44	
14	9	30/12/2017	15:56	17:29	16:42	36.5645	33.4297	36.565	33.4302	2225	360	
15	10	31/12/2017	08:03	09:51	08:57	36.23	32.6517	36.23	32.3183	2450.5	329.58	
16	11	01/01/2018	08:03	09:59	09:01	36.2313	31.6515	36.23	31.6515	2875	329.7	
17	PD	02/01/2018	16:24	17:05	16:44	37.7257	25.6577	37.7257	25.6577		112.23	
20	12	03/01/2018	16:39	17:55	17:17	37.485	26.9157	37.4337	27.1748	2510	220.88	
23	14	06/01/2018	13:35	15:35	14:35	36.4708	33.671	36.4725	33.671	2514.5	335.47	
26	15	07/01/2018	10:15	12:20	11:17	35.946	34.1535	35.946	34.1535	2258	336.46	
27	17	08/01/2018	09:30	11:30	10:30	36.2298	33.902	36.2298	33.902	2205	334.61	
30	19	11/01/2018	01:34	03:30	02:32	35.04	35.01	35.0293	35.0507	2616	370	
31	20	11/01/2018	21:02	01:01	23:01	34.533	36.85	34.533	36.85	2268	377	
33	21	12/01/2018	14:55	21:23	18:09	33.6058	38.2295	33.605	38.2298	4602	544	
36	22	13/01/2018	13:01	18:47	15:54	32.0555	40.3693	31.7738	40.6448	3225.5	398	
41	23	14/01/2018	08:00	14:00	11:00	30.1252	42.1195	30.0865	42.161	2367	498	
44	24	14/01/2018	21:51	04:32	01:00	29.1665	43.1742	29.1692	43.1713	3171	408	
47	25	15/01/2018	19:40	03:30	23:35	27.002	44.5002	27	44.5	3660	426	
49	26	16/01/2018	11:06	21:11	16:08	26.36	44.675	26.36	44.675	3877.5	676	
51	27	17/01/2018	09:25	19:30	14:27	25.9297	45.0187	0	0	4083	639	
54	28	18/01/2018	12:58	21:40	17:19	26.86	47.2302	26.8588	47.5263	4190.2	623	
56	29	19/01/2018	09:12	00:00	00:00	26.5	46.2	26.4876	46.1436	3935.5	325	
59	30	19/01/2018	21:37	12:43	05:10	26.215	45.1183	26.215	45.1183	2836	515	
60	31	21/01/2018	04:54	14:22	09:38	26.0287	44.5523	26.0287	44.5528	3815	526	
63	32	22/01/2018	05:38	10:23	08:00	25.142	42.5213	25.1417	42.5202	3501	337	
64	34	23/01/2018	15:34	00:33	20:03	26.1367	44.8267	26.1368	44.8263	3023.5	379	*filtered
65	35	24/01/2018	12:45	00:08	18:26	26.1388	44.8258	26.1388	44.8258	3636	386	
66	35	27/01/2018	19:11	03:15	23:13	0	0	0	0	#DIV/0!	326	
68	40	00/01/1900	00:00	00:00	00:00	0	0	0	0	#DIV/0!	0	
70	41	00/01/1900	00:00	00:00	00:00	0	0	0	0	#DIV/0!	0	
											Total:	
											12773.8	

Table 2. A summary of SAPS deployments on JC156.

Date	Deployment	Latitude	Longitude	Station	Time into water (GMT)	Time out of water (GMT)
24/12/17	SAPS001	41.382833	13.886667	2	16:20	18:05
05/01/18	SAPS002	36.23	33.526667	12	05:04	10:04
05/01/18	SAPS003	36.23	34.235	13	22:11	05:03
06/01/18	SAPS004	36.470833	33.67	14	18:22	23:02
07/01/18	SAPS005	35.944667	34.153333	15	15:55	21:00
08/01/18	SAPS006	36.229833	33.901667	16	10:25	15:04
09/01/18	SAPS007	36.3805	33.693333	18	12:49	18:04
16/01/18	SAPS008	26.36	44.675	26	16:30	22:03
17/01/18	SAPS009	25.929667	45.018667	27	12:27	19:00
20/01/17	SAPS010	26.215	45.118333	30	05:35	11:03
21/01/18	SAPS011	26.028667	44.551667	31	05:14	12:02
25/01/18	SAPS012	26.13895	44.825	35	16:58	23:05
26/01/18	SAPS013	26.13895	44.825	35	16:49	23:01

Preliminary results:

Preliminary data from surface water sampling shows an increase in measured activity southwards along the mid-Atlantic Ridge (Fig. 1). This could be consistent with our hypothesis of dust-derived ^{224}Ra, although it is likely that the concentration of the parent isotope ^{228}Th also increases along the ridge. Although we cannot tell what proportion of the increase in activity is due to short-lived, excess ^{224}Ra until parent isotope activities are constrained, the initial data suggests that Ra is a promising proxy for recent dust inputs in this environment.

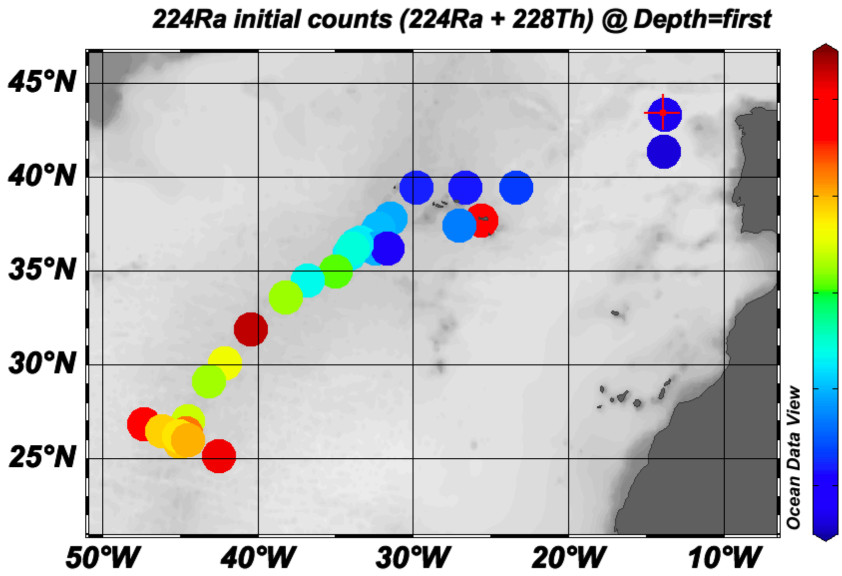

Figure 1: Preliminary results from Ra analysis of surface waters.

Acknowledgements

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Last but not least, thank you very much to the officers, engineers and crew of RRS James Cook.

SAP001	Kitty	Daisy	Holly	Sophie	Bambi	Mindy
Prefilter	Mesh	Mesh	Mesh	Mesh	Mesh	Mesh
Filter	GF/F	GF/F	GF/F	GF/F	GF/F	GF/F
Ra A	E	G	I	K	C	A
Ra B	F	H	J	L	D	B
Start Vol	263346	29416	313342	81605	96113	275780
Time Unplugged	15:50	15:50	15:50	15:50	15:50	15:50
Delay (min)	01:00:00	01:00:00	01:00:00	01:00:00	01:00:00	01:00:00
Start Time	16:50:00	16:50:00	16:50:00	16:50:00	16:50:00	16:50:00
Pump Time	01:30:00	01:30:00	01:30:00	01:30:00	01:30:00	01:30:00
End Time	18:20:00	18:20:00	18:20:00	18:20:00	18:20:00	18:20:00
Target Depth	850	840	500	300	140	50
Wire Posn.	0	10	350	550	710	800
Time on Wire	16:20:00	16:30:00	16:45:00	16:50:00	16:56:00	17:00:00
Time off Wire	18:59:00	18:57:00	18:50:00	18:44:00	18:41:00	18:36:00
Actual Depth	852	837	495	295	133	43
End Volume	264339.5	30439	313343	82670	97086	276642
Volume Pumped	993.5	1023	1	1065	973	862

SAP002	Kitty	Daisy	Holly	Sophie	Bambi	Mindy
Prefilter	Mesh	Mesh	Mesh	Mesh	Mesh	Mesh
Filter	PES	PES	PES	PES	GF/f	GF/F
Ra A	E	G	I	K	C	A
Ra B	F	H	J	L	D	B
Start Vol	264339.5	30439	313343	82670	97086	276642
Time Unplugged	04:28	04:29	04:30	04:31	04:33	04:34
Delay (min)	02:00:00	02:00:00	02:00:00	02:00:00	02:00:00	02:00:00
Start Time	06:28:00	06:29:00	06:30:00	06:31:00	06:33:00	06:34:00
Pump Time	01:30:00	01:30:00	01:30:00	01:30:00	01:30:00	01:30:00
End Time	07:58:00	07:59:00	08:00:00	08:01:00	08:03:00	08:04:00
Target Depth	2320	2200	2150	2100	1750	1500
Wire Posn.	0	120	170	220	570	820
Time on Wire	05:01:00	05:11:00	05:13:00	05:18:00	05:31:00	05:39:00
Time off Wire	10:45:00	10:35:00	10:30:00	10:24:00	10:12:00	10:03:00
Actual Depth	2338	2211	2161	2110	1753	1502
End Volume	264721	30495	313781	82679	97418	277211
Volume Pumped	381.5	56	438	9	332	569

SAP003	Kitty	Daisy	Holly	Sophie	Bambi	Mindy(NOT DEPLOYED)
Prefilter	Mesh	Mesh	Mesh	Mesh	Mesh	Mesh
Filter	PES	PES	PES	PES	GF/F	GF/F

Ra A	E	G	I	K	C	A
Ra B	F	H	J	L	D	B
Start Vol	264721	30495	313781	82679	97418	277211
Time Unplugged	21:45	21:46	21:47	21:47	21:48	21:49
Delay (min)	02:00:00	02:00:00	02:00:00	02:00:00	02:00:00	02:00:00
Start Time	23:45:00	23:46:00	23:47:00	23:47:00	23:48:00	23:49:00
Pump Time	01:30:00	01:30:00	01:30:00	01:30:00	01:30:00	01:30:00
End Time	01:15:00	01:16:00	01:17:00	01:17:00	01:18:00	01:19:00
Target Depth	2325	2200	2100	2000	1750	1500
Wire Posn.	0	125	225	325	575	825
Time on Wire	22:11:00	22:37:00	22:47:00	22:52:00	23:03:00	
Time off Wire	05:26:00	05:18:00	05:13:00	05:06:00	04:55:00	
Actual Depth	2317	2185	2084	1983	1729	
End Volume	265283	31018	314310	82673	97846	
Volume Pumped	562	523	529	-6	428	-277211
Actual Pump Time						

SAP004	Kitty	Daisy	Bambi	Holly	Sophie	Mindy
Prefilter	Mesh	Mesh	Mesh	Mesh	Mesh	Mesh
Filter	PES	PES	GF/F	PES	PES	GF/F
Ra A	E	G	C	I	K	A
Ra B	F	H	D	J	L	B
Start Vol	265284	31018	97847	314310	82673	277217
Time Unplugged	17:42	17:43	17:43	17:44	17:44	17:44
Delay (min)	02:30:00	02:30:00	02:30:00	02:30:00	02:30:00	02:30:00
Start Time	20:12:00	20:13:00	20:13:00	20:14:00	20:14:00	20:14:00
Pump Time	01:30:00	01:30:00	01:30:00	01:30:00	01:30:00	01:30:00
End Time	21:42:00	21:43:00	21:43:00	21:44:00	21:44:00	21:44:00
Target Depth	2510	2410	2220	2210	2060	1660
Wire Posn.	0	100	290	300	450	850
Time on Wire	18:25:00	18:31:00	18:39:00	18:42:00	18:48:00	18:59:00
Time off Wire	23:20:00	23:16:00	23:10:00	23:08:00	23:02:00	22:51:00
End Volume	265814	31515	98237	314311	82673	277642
Volume Pumped	530	497	390	1	0	425
Actual Pump Time						

SAP005	Sophie	Kitty	Mindy	Daisy	Holly	Bambi
Prefilter	Mesh	Mesh	Mesh	Mesh	Mesh	Mesh
Filter	PES	PES	GF/F	PES	PES	GF/F
Ra A	K	E	A	G	I	C
Ra B	L	F	B	H	J	D
Start Vol	82673	265814	277642	31515	314311	98237
Time Unplugged	15:39	15:36	15:40	15:38	15:38	15:39

Delay (min)	02:20:00	02:20:00	02:20:00	02:20:00	02:20:00	02:20:00
Start Time	17:59:00	17:56:00	18:00:00	17:58:00	17:58:00	17:59:00
Pump Time	01:30:00	01:30:00	01:30:00	01:30:00	01:30:00	01:30:00
End Time	19:29:00	19:26:00	19:30:00	19:28:00	19:28:00	19:29:00
Target Depth	2100	1950	1925	1900	1860	1730
Wire Posn.	0	150	175	200	240	370
Time on Wire	15:57:00	16:05:00	16:09:00	16:12:00	16:15:00	16:22:00
Time off Wire	21:01:00	20:57:00	20:54:00	20:50:00	20:47:00	20:43:00
End Volume	82674	266193	277968	32064	314484	98590
Volume Pumped	1	379	326	549	173	353

SAP006	Bambi	Kitty	Holly	Daisy	Mindy	Sophie (repairs)
Prefilter	Mesh	Mesh	Mesh	Mesh	Mesh	
Filter	GF/F	PES	PES	PES	GF/F	
Ra A	C	E	I	G	A	
Ra B	D	F	J	H	B	
Start Vol	98590	266193	314484	32064	277968	
Time Unplugged	10:10	10:09	10:11	10:09	10:10	
Delay (min)	02:20:00	02:20:00	02:20:00	02:20:00	02:20:00	
Start Time	12:30:00	12:29:00	12:31:00	12:29:00	12:30:00	
Pump Time	01:30:00	01:30:00	01:30:00	01:30:00	01:30:00	
End Time	14:00:00	13:59:00	14:01:00	13:59:00	14:00:00	
Target Depth	2220	2175	2150	2100	1950	
Wire Posn.	0	45	70	120	270	
Time on Wire	10:30:00	10:35:00	10:38:00	10:42:00	10:49:00	
Time off Wire	15:42:00	15:39:00	15:37:00	15:32:00	15:27:00	
End Volume	99402	266795	315058	32974	278821	
Volume Pumped	812	602	574	910	853	

SAP007	Bambi	Kitty	Sophie	Daisy	Mindy	Holly
Prefilter	Mesh	Mesh	Mesh	Mesh	Mesh	Mesh
Filter	GF/F	PES	GF/F	PES	GF/F	PES
Ra A	C	E	K	G	A	I
Ra B	D	F	L	H	B	J
Start Vol	99402	266795	82682	32974	278821	315058
Time Unplugged	12:27	12:26	12:27	12:27	12:28	12:27
Delay (min)	02:20:00	02:20:00	02:20:00	02:20:00	02:20:00	02:20:00
Start Time	14:47:00	14:46:00	14:47:00	14:47:00	14:48:00	14:47:00
Pump Time	01:30:00	01:30:00	01:30:00	01:30:00	01:30:00	01:30:00
End Time	16:17:00	16:16:00	16:17:00	16:17:00	16:18:00	16:17:00
Target Depth	2500	2000	2300	2400	2100	2200
Wire Posn.	0	500	200	100	400	300
Time on Wire	12:53:00	13:22:00	13:08:00	13:03:00	13:17:00	13:12:00
Time off Wire	18:35:00	18:06:00				

End Volume	99406	267678	82683	33851	279744	315836
Volume Pumped	4	883	1	877	923	778

SAP008	Mindy	Kitty	Bambi	Holly	Daisy	Sophie
Prefilter	Mesh	Mesh	Mesh	Mesh	Mesh	Mesh
Filter	GF/F	PES	GF/F	PES	PES	PES
Ra A	A	E	C	I	G	K
Ra B	B	F	D	J	H	L
Start Vol	279744	267678	99406	315836	33851	82683
Time Unplugged	16:06	16:01	16:05	16:03	16:02	16:04
Delay (min)	03:10:00	03:10:00	03:10:00	03:10:00	03:10:00	03:10:00
Start Time	19:16:00	19:11:00	19:15:00	19:13:00	19:12:00	19:14:00
Pump Time	01:30:00	01:30:00	01:30:00	01:30:00	01:30:00	01:30:00
End Time	20:46:00	20:41:00	20:45:00	20:43:00	20:42:00	20:44:00
Target Depth	3920	3800	3600	3400	3200	3000
Wire Posn.	0	120	320	520	720	920
Time on Wire	16:34:00	16:43:00	16:53:00	16:59:00	17:05:00	17:15:00
Time off Wire	22:55:00	22:50:00	22:45:00	22:35:00	22:30:00	22:22:00
End Volume	279758	268525	100104	316701	34677	83587
Volume Pumped	14	847	698	865	826	904

SAP009	Daisy	Bambi	Sophie	Mindy	Holly	Kitty
Prefilter	Mesh	Mesh	Mesh	Mesh	Mesh	Mesh
Filter	PES	GF/F	PES	GF/F	PES	PES
Ra A	G	C	K	A	I	E
Ra B	H	D	L	B	J	F
Start Vol	34677	100104	83587	279758	316701	268525
Time Unplugged	12:00	12:05	12:02	12:05	12:02	12:00
Delay (min)	03:10:00	03:10:00	03:10:00	03:10:00	03:10:00	03:10:00
Start Time	15:10:00	15:15:00	15:12:00	15:15:00	15:12:00	15:10:00
Pump Time	01:30:00	01:30:00	01:30:00	01:30:00	01:30:00	01:30:00
End Time	16:40:00	16:45:00	16:42:00	16:45:00	16:42:00	16:40:00
Target Depth	4100	4000	3800	3600	3400	3200
Wire Posn.	0	100	300	500	700	900
Time on Wire	12:30:00	12:35:00	12:44:00	12:52:00	13:02:00	13:09:00
Time off Wire	19:00:00	18:53:00	18:48:00	18:40:00	18:35:00	18:30:00
End Volume	35526	100867	84446	280691	317541	269060
Volume Pumped	849	763	859	933	840	535

SAP010	Mindy	Daisy	Kitty	Sophie	Holly	Bambi
Prefilter	Mesh	Mesh	Mesh	Mesh	Mesh	Mesh
Filter	GF/F	PES	PES	PES	PES	GF/F
Ra A	A	G	E	K	I	C
Ra B	B	H	F	L	J	D

Start Vol	280691	35526	269060	84446	317541	100867
Time Unplugged	05:15	05:17	05:17	05:17	05:17	05:10
Delay (min)	02:50:00	02:50:00	02:50:00	02:50:00	02:50:00	02:50:00
Start Time	08:05:00	08:07:00	08:07:00	08:07:00	08:07:00	08:00:00
Pump Time	01:30:00	01:30:00	01:30:00	01:30:00	01:30:00	01:30:00
End Time	09:35:00	09:37:00	09:37:00	09:37:00	09:37:00	09:30:00
Target Depth	3030	3000	2900	2800	2600	2400
Wire Posn.	0	30	130	230	430	630
Time on Wire	05:37:00	05:42:00	05:47:00	05:55:00	06:02:00	06:09:00
Time off Wire	11:20:00	11:17:00	11:13:00	11:10:00	11:05:00	11:01:00
Actual Depth	3055	3020	2919	2817	2615	2410
End Volume	280694	36431	269828	85386	318320	101654
Volume Pumped	3	905	768	940	779	787

SAP011	Kitty	Mindy	Daisy	Sophie	Holly	Bambi
Prefilter	Mesh	Mesh	Mesh	Mesh	Mesh	Mesh
Filter	PES	GF/F	PES	PES	PES	GF/F
Ra A	E	A	G	K	I	C
Ra B	F	B	H	L	J	D
Start Vol	269828	280694	36431	85386	318320	101654
Time Unplugged	05:00	05:03	05:00	05:01	05:01	05:02
Delay (min)	02:50:00	02:50:00	02:50:00	02:50:00	02:50:00	02:50:00
Start Time	07:50:00	07:53:00	07:50:00	07:51:00	07:51:00	07:52:00
Pump Time	01:30:00	01:30:00	01:30:00	01:30:00	01:30:00	01:30:00
End Time	09:20:00	09:23:00	09:20:00	09:21:00	09:21:00	09:22:00
Target Depth	3850	3700	3550	3350	3150	3000
Wire Posn.	0	150	300	500	700	850
Time on Wire	05:17:00	05:27:00	05:34:00	05:40:00	05:47:00	05:53:00
Time off Wire	12:28:00			11:56:00		10:58:00
Actual Depth	3889	3732	3578	3375	3173	3018
End Volume	270651	280697	37295	86316	319158	102447
Volume Pumped	823	3	864	930	838	793

SAP012	Kitty	Mindy	Bambi	Daisy	Holly	Sophie
Prefilter	Mesh	Mesh	Mesh	Mesh	Mesh	Mesh
Filter	GF/F	GF/F	GF/F	PES	PES	PES
Ra A	E	A	C	G	I	K
Ra B	F	B	D	H	J	L
Start Vol	270620	283773	102449	37295	319159	86318

Time Unplugged	16:43	16:40	16:40	16:42	16:41	16:41
Delay (min)	02:45:00	02:45:00	02:45:00	02:45:00	02:45:00	02:45:00
Start Time	19:28:00	19:25:00	19:25:00	19:27:00	19:26:00	19:26:00
Pump Time	01:30:00	01:30:00	01:30:00	01:30:00	01:30:00	01:30:00
End Time	20:58:00	20:55:00	20:55:00	20:57:00	20:56:00	20:56:00
Target Depth	3650	3575	3500	3325	3300	3250
Wire Posn.	0	75	150	325	350	400
Time on Wire	17:01:00	17:06:00	17:12:00	17:17:00	17:23:00	17:26:00
Time off Wire	23:50:00	23:46:00	23:43:00	23:36:00	23:30:00	22:50:00
Actual Depth	3651	3585	3505	3330	3305	3255
End Volume	271431	284638	103217	38124	319709	87235
Volume Pumped	811	865	768	829	550	917

SAP013	Kitty	Daisy	Holly	Sophie	Bambi	Mindy
Prefilter	Mesh	Mesh	Mesh	Mesh	Mesh	Mesh
Filter	GF/F	GF/F	GF/F	GF/F	GF/F	GF/F
Ra A	E	G	I	K	C	A
Ra B	F	H	J	L	D	B
Start Vol	271431	38124	319709	87235	103217	284638
Time Unplugged	16:37	16:37	16:38	16:38	16:38	16:39
Delay (min)	02:35:00	02:35:00	02:35:00	02:35:00	02:35:00	02:35:00
Start Time	19:12:00	19:12:00	19:13:00	19:13:00	19:13:00	19:14:00
Pump Time	01:30:00	01:30:00	01:30:00	01:30:00	01:30:00	01:30:00
End Time	20:42:00	20:42:00	20:43:00	20:43:00	20:43:00	20:44:00
Target Depth	3300	3250	3200	3000	2250	1500
Wire Posn.	0	50	100	300	1050	1800
Time on Wire	16:52:00	16:58:00	14:01:00	14:08:00	14:29:00	14:50:00
Time off Wire	23:10:00	23:06:00	23:00:00	22:56:00	22:27:00	21:59:00
End Volume	272141	39024	320558	88196	104011	284658
Volume Pumped	710	900	849	961	794	20

17. Nitrate isotope and DNA sampling

Noah Glushankoff (UCSB), Alyson Santoro (UCSB) and Scott Wankel (WHOI)

Sampling Method:

On average, 12 samples were collected from each selected station. DNA and NO_3^- isotope sampling was done on the SSR and TMR, respectively. Sample depths were selected as follows: 2 below the plume, 3 in the plume, 2 above the plume and the remaining 5 samples were distributed throughout the rest of the water column. At certain stations with significant plume signals, an upper water column sample was substituted for an additional plume sample. Non-plume related water column samples were generally selected equidistant from each other, while also attempting to select major features such as the OMZ and DCM. For DNA, most depths were sampled in volume of 2L, but when possible, plume depths were sampled up to 4L. All bottles were pre-rinsed with 10% HCl, then triple rinsed with DI water, then triple rinsed with seawater from the appropriate niskin bottle before being filled to the selected volume. To the best of our ability, sampling for DNA and NO_3^- isotopes were performed such that their depths would overlap. After sampling for DNA on the SSR, each bottle was brought back into the Deck Lab and placed in an empty ice chest – kept in the dark and not exposed to outside environment.

DNA Filtration Method:

Once all 4L niskin bottles were filled to the necessary volume, seawater samples were filtered using a peristaltic pump and a series of two filters. Tubing with a serological pipette on one end is placed in the sample bottle, and at the other end, a set of two filters were used to capture the microbial DNA. The first filter, a pre-filter, is a 3μm polycarbonate membrane filter and the second filter in series is a 0.2 μm polycarbonate membrane filter. The purpose of the pre-filter is to remove large particles and or anything that may impact analysis. Once filtration was completed, excess water in the filter holders was removed, filters were placed in individual 2mL tubes, and moved to a -80C freezer within 20 minutes.

DNA Analysis:

In the Santoro Laboratory at the University of California, Santa Barbara, microbial DNA will be extracted from the filters and we will use sequencing of the 16s rRNA gene to identify microbes present in each sample. qPCR, quantitative polymerase chain reaction, will also be conducted to quantify genes specific to microbes.

NO_3^- Isotope Analysis:

In the Wankel Laboratory at Woods Hole Oceanographic Intuition, NO_3^- isotope analysis will be done using the 'denitrifier method' (Casciotti et al 2002) on an IRMS. This method effectively converts NO_3^- to N_2O gas using lab grown bacteria and can measure both the nitrogen and oxygen isotopes. Using the nutrient analysis performed during the cruise, appropriate measurements and action will be taken to ensure accurate analysis.

NO_3^- Isotope Filtration Method:

These samples were done in the Class 100 Clean Sampling Van using a 0.2μm 0.2 μm Sartobran filter. OTE bottles were clamped and pressurized to ~ 7 psi with clean filtered compressed air. 30mL bottles were triple rinsed then filled. They were then placed in a -20C freezer within 2 hours of filtering. A more detailed description of this can be found on the TMR cruise report.

18. Dissolved barium and REE sampling

Alison Bryan (University of Oxford)

The Ba cycle is dominated by the formation and dissolution of barite ($BaSO_4$). Barite is precipitated within decaying organic matter, thus forming an important link between barium and the carbon cycle. On a global scale, the Ba cycle is influenced by inputs of Ba to the oceans from three main sources: rivers, sediments, and hydrothermal vents. Hydrothermal vents are a critical component in Ba cycling. The collection of samples for dissolved and particulate Ba at and near hydrothermal vents allows us to study the Ba-isotopes composition of plume waters and to track the change in Ba-isotopes that accompany the mixing of these waters with open ocean seawater along the mid-ocean ridge.

<u>Sample collection</u>
Seawater samples were collected from selected 20 L Niskin bottles fitted on a stainless steel CTD frame. Dissolved Ba and rare earth elements (REEs) samples were collected from between 3 to 24 depths at each station (see stainless steel CTD log sheets).

Seawater samples were filtered through an Acropak (0.45 μm) into 250 ml low density polyethylene Nalgene bottles. The bottles were acidified with ultra-pure HCl under a class 100 laminar flow hood in a lightly pressurized, class 100 clean air container. The acidified samples were double bagged in plastic bags and stored in plastic storage boxes at room temperature. The Acropak filters were stored in a refrigerator between stations.

<u>Sample analysis</u>
Dissolved Ba and REEs will be analysed by inductively coupled plasma mass spectrometer (ICP-MS) at the Department of Earth Sciences, University of Oxford. Additionally, Ba-isotopes will be analysed by thermal-ionisation mass spectrometer (TIMS) at the University of Oxford.

<u>References</u>

Anderson, R.F., E. Mawji, G.A. Cutter, C.I. Measures, and C. Jeandel. *Oceanography.* **27(1)**, 50-61 (2014).

Horner, T.J., Kinsley, C.W., and Nielsen, S.G. *Earth Planet Sci. Lett.* **430**, 511-522 (2015).

Hsieh, Y.-T. and Henderson, G.M. *Earth Planet Sci. Lett*. **473**, 269-278 (2017).

19. Anthropogenic radionuclide sampling

Samples to be analysed by Jixin Qiao
(DTU NUTECH, Center for Nuclear Technologies, Technical University of Denmark)

Nuclear accidents (e.g., Chernobyl, Fukushima), weapons production and reprocessing plants (e.g., Sellafield (UK), La Hague (France)) have released large amounts of man-made radioactive contaminants to the environment. These radioisotopes are considered persistent threats to the environmental safety owning to their radiological radiotoxicity. On the other hand, some radioisotopes have relatively high mobility and bioavailability in oxic waters, making them rather valuable tracers in oceanographic studies. The samples collected through the FRidge cruise will be analyzed for ^{236}U and ^{233}U as part of oceanographic tracer studies to further understand water movement and mixing patterns.

<u>Sample collection</u>
Seawater samples (approx. 40 L each) were collected from the surface water supply, Fish (see Fish underway log sheets) and from 20 L Niskin bottles fitted to a stainless steel CTD frame at selected depths from seven stations into 40 L blue barrel sampling containers (see stainless steel CTD log sheets). The samples were not filtered or acidified on board.

20. Incubation experiments

Travis Mellet and Kristen Buck (USF)

Introduction and Objectives

Over the course of JC156 five incubations experiments were carried out to observe the evolution of iron (Fe) and other trace metals from hydrothermally sourced water between particulate, colloidal, and soluble phases. Incubations were carried out in 20 L polycarbonate (PC) carboys that had been acid cleaned 10% v/v with Super Purity™ (Romil) hydrochloric acid (HCl) and filled with Mili-Q (MQ) until use. Upon sampling, MQ was drained and the carboy was rinsed three times with either unfiltered water from and Ocean Test Equipment (OTE) bottle or water that had been inline filtered using a 0.2 µm Acropak filter under 1 bar of pressure using nitrogen gas. Once filled, the carboys were wrapped in heavy-duty black construction bags and brought to a temperature controlled room maintained at ~ 13°C for the remainder of the incubation.

When each carboy was first sampled it was removed from the black construction bag and moved into a clean flow-hood where it was fitted with a spigot that had been cleaned in 10% v/v HCl and rinsed with MQ before use. At each sampling time point, which varied between one to three weeks depending on the incubation, the carboy was inverted at least 3 times to homogenize particles and subsampled into a HCl cleaned 2.5 L PC bottle specific to the carboy. The sub-sampled bottle was filtered through a two-stage custom-built filtration rig through a 3 µm and 0.4 µm polycarbonate track etched (PCTE) filter for dissolved samples, which were then frozen to analyze later for particulate trace metals. After, the remaining subsampled water was filtered through 0.02 µm Anodisc filter for soluble samples. Each time point was sampled every time for dissolved trace metals (TM), soluble TMs, dissolved organic speciation, and soluble speciation. Periodically, the incubations were sampled for nutrients (nitrate+nitrite, silicate, and phosphate), Fe (II), H_2S, thiols, Fe isotopes (incubations 3 and 5), total dissolvable trace metals, and bacteria community composition from DNA analyses (Incubations 2, 3, and 4). The following subsections will briefly describe the objectives and starting conditions of each of the incubations as well as a table of samples collected at various time points.

Incubation 1: Control

The primary purpose of this incubation was to act as a control and be used to account for any potential bottle effects that could be observed in the others. As such, this incubation was sampled very limitedly to allow more resources to be put towards the remaining experiments. Incubation 1 was started at the shake-out station located 43°23.85 N and 13°50.86 W from 200 m water depth and sampled four times over a three week period.

Sampling plan for Incubation 1 (Filtered and Unfiltered treatments)

Time	Nuts	Fe(II)	H2S	Thiols	TMs	Spp	DvbTM	FeIso	DNA
1 h	X				X	X	X		
3 d					X	X	X		
6 d					X	X	X		
21 d	X				X	X	X		

*TMs represents both dissolved and soluble trace metal measurements
*Spp represents both dissolved and soluble Fe speciation samples

Incubation 2: Lucky Strike

This incubation in particular was not explicitly planned, but started opportunistically in the bonus cast (Station 7) at the Lucky Strike site located at 37°17.352 N and 32°16.575 W. The incubation was started from the remainder of three OTE bottles tripped within 20 m apart from inside the plume indicated by eH and LSS anomalies. The depths of each bottle were 1678 m (T1), 1670 m (T2), and 1660 m (T3). Due to volume constrains, a single unfiltered carboy was collected and sampled over a three-week period.

Sampling plan for Incubation 2 (Unfiltered treatment only)

Time	Nuts	Fe(II)	H2S	Thiols	TMs	Spp	DvbTM	FeIso	DNA
1 h	X	X	X	X	X	X	X		X
12 h	X	X	X		X	X	X		
2 d		X	X	X	X	X	X		
3 d	X			X	X	X	X		
7 d	X			X	X	X	X		
14 d	X			X	X	X	X		X
21 d	X			X	X	X	X		

*TMs represents both dissolved and soluble trace metal measurements
*Spp represents both dissolved and soluble Fe speciation samples

Incubation 3: Rainbow Buoyant Plume

The primary objective of Incubation 3 was to observe the evolution of an ultra mafic, high Fe vent system and capture particle dynamics over time. The incubation was started at the Rainbow vent site located at 36°13.800 N and 33°54.120 W from the bonus cast (Station 16.2). Water was collected using four OTE bottles from a single depth at 2241 m inside a large eH and LSS anomaly. Water from these bottles was separated into two separate carboys, one with filtered (0.2 μm) and one left unfiltered. This incubation was sampled over a period of one week, with higher resolution sampling in the first 24 h and coarser resolution for the remaining days to capture anticipated changes in dissolved metals and particle transformations.

Sampling plan for Incubation 3 (Filtered and Unfiltered treatments)

Time	Nuts	Fe(II)	H2S	Thiols	TMs	Spp	DvbTM	FeIso	DNA
1 h	X	X	X	X	X	X	X	X	X
3 h		X	X		X	X	X	X	
6 h					X	X	X	X	
12 h		X	X		X	X	X	X	
24 h	X	X	X	X	X	X	X	X	
2 d					X	X		X	
3 d	X			X	X	X			
5 d					X			X	
7 d	X			X	X	X	X		X

*TMs represents both dissolved and soluble trace metal measurements
*Spp represents both dissolved and soluble Fe speciation samples

Incubation 4: Rainbow Far-field

The primary objective of this incubation was to assess the transformation processes that happen over a longer period of time further away from the vent point source. The incubation was started at the southern Rainbow bonus site (Station 17) located 36°9.950 N and 33°59.00 W. Two OTE bottles were filled from 2000 m depth to form a single unfiltered treatment in an LSS anomaly, but with no eH anomaly. This incubation was sampled over a period of three weeks to capture particulate transformation that may be happening over longer time scales from the Rainbow vent site.

Sampling plan for Incubation 4 (Unfiltered treatment only)

Time	Nuts	Fe(II)	H2S	Thiols	TMs	Spp	DvbTM	Felso	DNA
1 h	X	X	X	X	X	X	X		X
12 h			X		X	X	X		
24 h				X	X	X	X		
3 d	X			X	X	X	X		
7 d	X			X	X	X	X		
14 d	X			X	X	X	X		X
21 d	X			X	X	X	X		

*TMs represents both dissolved and soluble trace metal measurements
*Spp represents both dissolved and soluble Fe speciation samples

Incubation 5: TAG Near-field Non-buoyant plume

The primary objective of Incubation 5 was to perform a similar experiment to the near-field Rainbow to compare how different source rock impacts the vent fluid and particle transformations within the plume of a well-studied vent site. The incubation was started at the TAG vent site located 26°08.307 N and 44°49.531 W. Four OTE bottles were tripped within the non-buoyant plume indicated by a LSS and eH anomalies and a negative temperature anomaly. The plume sampled for this incubation spanned a vertical region of ~ 200 m and water depths between bottles were 3344 m (9T), 3346 (10T), 3277 m (15T), and 3263 (16T). To account for any possible changes in particles and/or chemistry the two carboys filled were combination of bottles from the bottom and top of the plume. As such, combining bottles 9T and 15T created the unfiltered treatment, and combining bottles 10T and 16T created the filtered treatment. Due to time constrains, the incubation was sampled over a 6 day time span and some periodic measurements could not be made in the final time point.

Sampling plan for Incubation 5 (Filtered and Unfiltered treatments)

Time	Nuts	Fe(II)	H2S	Thiols	TMs	Spp	DvbTM	Felso	DNA
1 h	X	X	X	X	X	X	X	X	
3 h		X	X		X	X		X	
6 h					X	X		X	
12 h					X	X		X	
24 h	X			X	X	X		X	
2 d	X				X	X		X	
3 d				X	X	X		X	
5 d					X	X		X	
6 d					X	X	X	X	

21. Tow Yo Surveys

Carl Spingys (University of Southampton)

Each tow yo was performed at typically 0.3 to 0.1 knots while veering and hauling the CTD package at 60 m/min (both variable within each tow-yo). All were performed on the SS CTD.

Tow yos were conducted at the Lucky Strike, Rainbow and TAG hydrothermal vent fields, with details in Table 1.

Table 1. ***Tow Yo survey details***

Location	Distance	Depth range	Duration
Lucky Strike	3.37km	1198-1725m	7.6h
Rainbow	2.33km	1700-2537m	7.4h
TAG1	1.69km	2998-3683m	7.2h
TAG2	0.82km	2912-3683m	5.9h

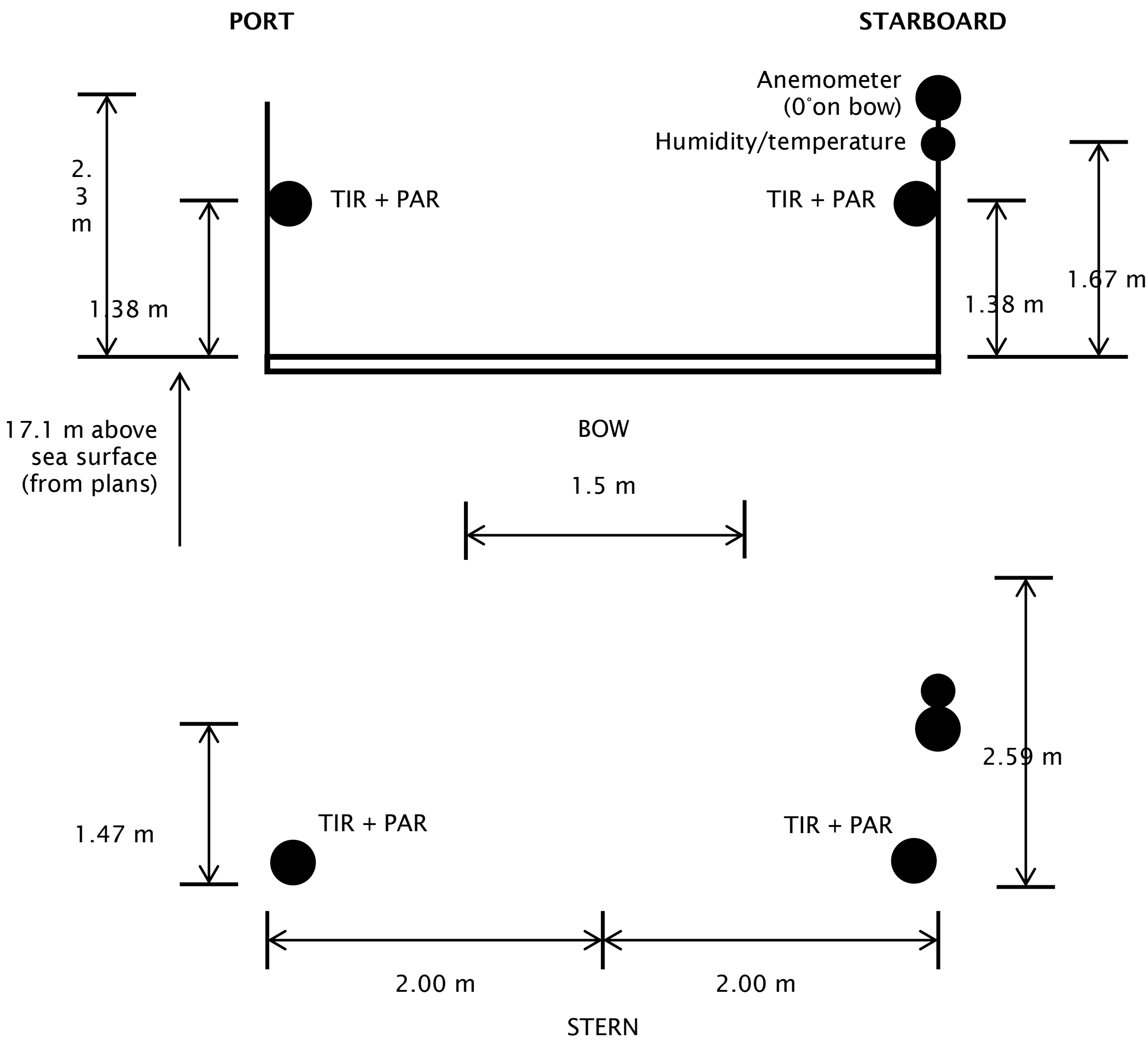
21. Surfmet sensors

Surfmet Sensor Information Sheet (James Cook)

Cruise	JC156
Technician	Juan Ward, Jennifer Ward Neale
Date	20 December 2017 – 1 February 2018

Meteorology platform (Foremast)

JAMES COOK MET PLATFORM



Pumped seawater flow rates (ml/min):	1500
Anemometer orientation on bow (deg):	0
Seawater intake depth (m):	5.5

Niche	Manufacturer	Sensor	Serial Number	Notes	Cal-Applied	Last Cal Date	Cal Due Date
Hull SVP	AML	Micro.X	010629/204242		No	11 Nov 2017	10 Nov 2018
Light 1, Starboard	Skye	PAR	28558		No	08 Nov 2017	07 Nov 2019
Light 1, Port	Skye	PAR	28563		No	13 May 2016	10 May 2018
Light 2, Starboard	Kipp & Zonen	TIR	994133		No	03 Nov 2016	03 Nov 2018
Light 2, Port	Kipp & Zonen	TIR	994132		No	15 Jul 2016	15 Jun 2018
Wind Speed & Dir	Gill	Windsonic	064537		No		
Air Temp & Humidity	Vaisala	HMP45	E1055002		No	20 Oct 2017	19 Oct 2018
Air Pressure	Vaisala	PTB110	L2240581		No	20 Oct 2017	19 Oct 2018
Surf Fluorometer	WetLabs	WS3S	WS3S-134		No	27 Oct 2017	26 Oct 2018
Surf Transmissometer	WetLabs	CST	CST-114PR		No	19 Dec 2016	19 Dec 2018

Niche	Manufacturer	Sensor	Serial Number	Notes	Cal-Applied	Last Cal Date	Cal Due Date
Surf Temperature	SeaBird	SBE38	3854115-0489		No	25 Oct 2017	24 Oct 2018
Surf TSG	SeaBird	SBE45	4548881-0485	Installed 28 Jul 2017	No	28 Sep 2016	28 Jul 2018
Lowered SVP 1	Valeport	Midas SVP	22355			23 Nov 2017	22 Nov 2019
Lowered SVP 2	Valeport	Midas SVP	22241			14 Sep 2016	14 Sep 2018
Spare Hull SVP	AML	Micro.X	010156/204889			17 Oct 2017	16 Oct 2018
Spare Light 1, Stbd	Skye	PAR	28556			08 Nov 2017	07 Nov 2019
Spare Light 1, Port							
Spare Light 2, Stbd	Kipp & Zonen	TIR	047462			04 Oct 2017	03 Oct 2019
Spare Light 2, Port	Kipp & Zonen	TIR	047463			04 Oct 2017	03 Oct 2019
Spare Wind	Gill	Windsonic	064538				
Spare Air Temp Hum	Vaisala	HMP45	B4950011			20 Oct 2017	19 Oct 2018

Niche	Manufacturer	Sensor	Serial Number	Notes	Cal-Applied	Last Cal Date	Cal Due Date
Spare Air Pressure	Vaisala	PTB110	J0710001			20 Oct 2017	19 Oct 2018
Spare Fluorometer	WetLabs	WS3S	WS3S-351P			27 Oct 2017	26 Oct 2018
Spare Transmissometer	WetLabs	CST	CST-1131PR			10 Sep 2017	09 Sep 2019
Spare Surf Temp	SeaBird	SBE38	3853440-0475			25 Oct 2017	24 Oct 2018
Spare TSG	SeaBird	SBE45	0232			27 Oct 2017	26 Oct 2019

22. Ship systems report

Cruise overview

Cruise	Departure	Arrival	Technicians
JC156	20/12/17 (GBSOU)	01/02/2018 (GPPTP)	Juan Ward (juan.ward@noc.ac.uk), Jennifer Ward Neale (jennifer.ward.neale@noc.ac.uk)

Scientific Ship Systems (SSS) is responsible for managing the Ship's network infrastructure, data acquisition, compilation and delivery, the email system and a range of ship-fitted instruments and sensors.

All times in this report are UTC

Scientific Computer Systems

Acquisition

Network drives were setup on the on-board file server; firstly a read-only drive of the ships instruments data and a second scratch drive for the scientific party. Both were combined at the end of the cruise and copied to disks for the PSO and BODC.
The data was logged by the Techsas 5.11 data acquisition system. The system creates NetCDF and ASCII output data files. The format of the data files is given per instrument in the "Data Description" directory:

Data descriptors: ***'JC156/Ship_Systems/TECHSAS/Data Description/'***

The format of the raw NMEA ASCII which Techsas uses to build its data products is also included in the Data Description documents. This raw data set is also stored on the disk should the scientists wish to reprocess these themselves.

Raw data: ***'JC156/Ship_Systems/Raw_NMEA'***

Main Acquisition Events/Data Losses

1. There was a loss of surface water and meteorological sampling data when the SURFMET acquisition service crashed: **25/01/2018 18:25 – 19:35**.

Instrumentation

Position and attitude

GPS and attitude measurement systems were run throughout the cruise.
The ***Applanix POSMV*** system is the vessel's primary GPS system, outputting the position of the ship's common reference point in the gravity meter room. The POSMV is available to be sent to all systems and is repeated around the vessel. The position fixes attitude and gyro data are logged to the Techsas system. True Heave is logged by the Kongsberg EM122 & EM710 systems.
The ***Kongsberg Seapath 300+*** system is the vessel's secondary GPS system. This was the position and attitude source that was initially used by the EM122 & EM710 due to its superior real-time heave data. It also provides an input to the Gravity meter due to the POSMV not having vessel course available in its RMC NMEA message. Position fixes and attitude data are logged to the Techsas system.
The ***CNav 3050*** GPS system is the vessel's differential correction service. It provides the Applanix POSMV and Seapath330+ system with RTCM DGPS corrections (greater than 1m accuracy). The position fixes data are logged to the Techsas system.

Meteorology and sea surface monitoring package

The NMF Surfmet system was run throughout the cruise, excepting times for cleaning, entering and leaving port and whilst alongside. Please see the separate information sheet for details of the sensors used and whether calibrations values have been applied:

'JC156_Surfmet_sensor_information_sheet.docx'
Cruise Disk Location: ***'JC156/CRUISE_REPORTS/'***

Instrument calibration sheets are included in the directory:

Calibration files: ***'JC156/Ship_Systems/Met/SURFMET/calibrations/'***

Events

Date/ Time	Event	Before			High/Low Signal			After		
UTC		Trans	Fluo	Sal	Trans	Fluo	Sal	Trans	Fluo	Sal
21/12/2017	Start							4.4765	0.138	35.579
28/12/2017 14:45-15:40	Clean	4.4760	0.0960	36.120	4.6350 0.0595	0.073	0.010	4.4720	0.095	36.173
31/12/2017 10:43-11:00	Stop									
02/01/2018 13:58 – 03/01/2018 12:55	Stop	4.4598	0.0838	36.167				4.445	0.092	36.243
04/01/2018 13:57-14:42	Clean	4.4695	0.0739	36.268	4.6100 0.0595	0.079	0.011	4.513	0.076	36.272
12/01/2018 15:40-16:18	Clean	4.1917	0.0800	36.635	4.6742 0.0589	0.075	0.011	4.505	0.081	36.629
19/01/2018 19:02-19:44	Clean	4.4334	0.0667	37.196	4.6320 0.0586	0.076	0.013	4.5117	0.069	37.382
25/01/2018 16:23-17:00	Clean	4.4995	0.0726	37.274	4.6082 0.0587	0.079	0.012	4.5178	0.068	37.272
25/01/2018 18:25-19:35	Crash									
31/01/2018 12:47	Stop	4.492	0.0695	36.815						

Trans and fluo in volts, Sal in PSU.

Samples were taken from the underway system 3-4 times per day to monitor the salinity readings of the thermosalinograph against the Autosal. These comparisons are stored in the SURFMET salinities folder.

> TSG salinities: ***'JC156/Ship_Systems/Met/SURFMET/tsg_salinities/'***

Due to an issue with the on-board Autosal, the last two crates of TSG samples (Crate 4 and Crate 3, sheets 4 and 5) were returned to shore for analysis. The results from these will be sent on to Principal Scientist when they are available.

Kongsberg EA640 10/12 kHz Single-beam

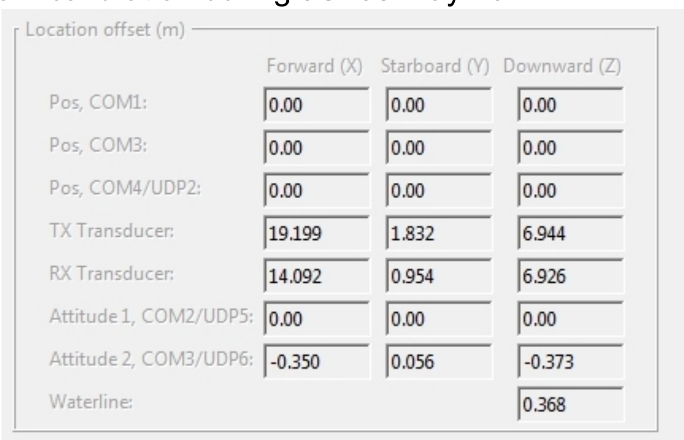
The EA640 single-beam echo-sounder was run throughout the cruise to provide depths for CTD operations.
It was used with a constant sound velocity of 1500 ms^{-1} throughout the water column to allow it to be corrected for sound velocity in post processing. Kongsberg Raw files and History BMP files are logged and depths were logged to Techsas NetCDF and Raw NMEA.

Kongsberg EM122 multi-beam echo sounder.

The EM122 multibeam echo-sounder was run throughout the cruise to provide depths for CTD operations, corroborate the hydrothermal vent sites against known bathymetry and produce surveys of vent sites. The sound velocity profile was updated at intervals after deployment of the Midas Sound Velocity profiler:

- 03.01.2018 15:32 20180101_thinned
- 19.01.2018 18:00 20180112_02_thinned
- 23.01.2018 12:54 20180119_thinned

The following figures show the system installation configuration. The values are from the ships Parker survey report, which is included on the data disk. The attitude angular corrections for use with the Seapath 300 system were derived from a post refit trial calibration on JC108 Sept 2014. The attitude angular corrections for use with the Applanix Posmv system are from calibration during JC103 May 2014.



Location offset (m)

	Forward (X)	Starboard (Y)	Downward (Z)
Pos, COM1:	0.00	0.00	0.00
Pos, COM3:	0.00	0.00	0.00
Pos, COM4/UDP2:	0.00	0.00	0.00
TX Transducer:	19.199	1.832	6.944
RX Transducer:	14.092	0.954	6.926
Attitude 1, COM2/UDP5:	0.00	0.00	0.00
Attitude 2, COM3/UDP6:	-0.350	0.056	-0.373
Waterline:			0.368

FIGURE 1 - EM122 TRANSDUCER LOCATIONS

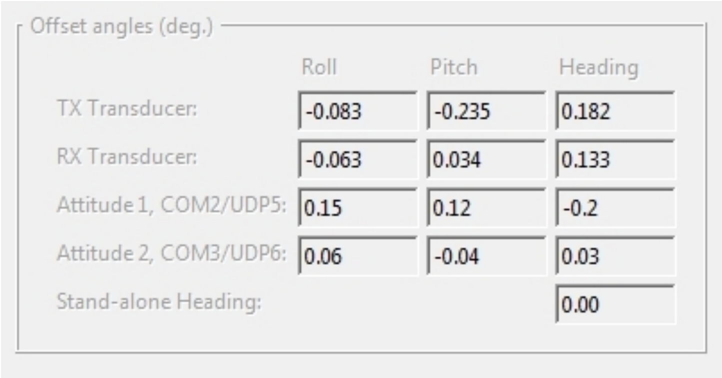


FIGURE 2 - EM122 TRANSDUCER OFFSETS

EM Speed logs

The single axis bridge Skipper Log and the dual axis Chernikeef science log were logged throughout the cruise. The Chernikeef log was calibrated in November 2017, in the North Atlantic.

Ultra-short baseline (USBL) underwater positioning system

USBL beacons were deployed with the VMP and the several CTD deployments to record their positions relative to the ship. These are saved in the Ranger2/USBL NetCDF (and corresponding Raw NMEA) files in the directories defined above.
The data should be cross-referenced against the expedition event logs to determine which deployment event is associated with data at any given time.

75 kHz and 150 kHz Acoustic Doppler current profiler (ADCP)

The ADCPs were initially run in encoded broadband mode, without bottom tracking and in synchronisation with the other echo-sounders.
On 28/12/2017 Carl Spingys asked for them to be changed to narrowband mode without bottom tracking and free-running. They were left in this configuration for the remainder of the cruise.
On the 19/01/2018, both ADCPs developed Nav IO errors. Carl checked the integrity of the navigation data and could not find any issues. The ADCPs were restarted several times while diagnostics were carried out.

Data sharing

Surface water and meteorological data was summarised and daily sent to BODC. From 11/01/2018, CTD summary data was automatically sent to the Met Office to improve short-term weather forecasting models, as part of the PML/NMF/Met Office CTD2Met collaboration, coordinated between Tim Smyth (PML), Fiona Carse (Met Office) and Andrew Moore (NMF).

Appendix

Summary Event Log

STATION NUMBER	EVENT NUMBER	CTD NUMBER	Gear Description	Event Description
TEST	1	1	SSR	Test
TEST	2	NA	FISH	Fish deployed
TEST	3	2	SSR	Test
TEST	4	3T	TMR	Test of TMR
TEST	5	4T	TMR	Soak for TMR
TEST	6	5	SSR	test SSR with TMR wire
TEST2	7	6	SSR	Test with components fixed
1	8	7T	TMR	TMR deployed to 100m off bottom
1	9	8	SSR	SSR deployed to 1000m
2	10	9T	TMR	GA01 crossover
2	11	SAPS01	SAPS	Test deployment of 6x SAPS
3	12	10T	TMR	TMR full depth
4	13	11T	TMR	TMR full depth
4	14	12	SSR	SSR ful depth
5	15	13T	TMR	TMR full depth
6	16	14T	TMR	Menez Gwen
6	17	15	SSR	Menez Gwen
SURVEY	18	SURVEY	Survey	Survey
TOWYO1	19	16	SSR	Tow yo
7	20	17T	TMR	LuckyStrike 1
8	21	18T	TMR	LuckyStrike 2
8	22	19	SSR	LuckyStrike 2
9	23	20T	TMR	Saldanha
9	24	21	SSR	Saldanha
9	25	22	SSR	Saldanha
10	26	23T	TMR	1x E of Rainbow
10	27	24	SSR	1x E of Rainbow
11	28	25T	TMR	2x E of Rainbow
11	29	26	SSR	2x E of Rainbow
12	30	27T	TMR	Close E of Rainbow
12	31	28	SSR	Close E of Rainbow
12	32	SAPS02	SAPS	Close E of Rainbow
13	33	29T	TMR	Close W of Rainbow
13	34	30	SSR	Close W of Rainbow
13	35	SAPS03	SAPS	Close W of Rainbow
14	36	31T	TMR	Close N of Rainbow
14	37	32	SSR	Close N of Rainbow
14	38	33	SSR	Close N of Rainbow
14	39	SAPS04	SAPS	Close N of Rainbow
15	40	34T	TMR	Close S of Rainbow
15	41	35	SSR	Close S of Rainbow
VMPTEST	42	VMPTEST	VMP	Vmp testing
VMPTEST	43	VMPTEST	VMP	Vmp testing
VMPTEST	44	VMPTEST	VMP	Vmp testing

15	45	SAP05	SAPS	Close S of Rainbow
VMPTEST	46	VMPTEST	VMP	VMP recovery
16	47	36T	TMR	Rainbow
16	48	37	SSR	Rainbow
16	49	SAPS06	SAPS	Rainbow
17	50	38T	TMR	S bonus Rainbow
18	51	39	SSR	N bonus Rainbow
18	52	40T	TMR	N bonus Rainbow
18	53	SAPS07	SAPS	N bonus Rainbow
TOWYO2	54	41	SSR	Rainbow tow yo
TOWYO2	55	42	TOWYO2	Rainbow tow yo
16(2)	56	43T	TMR	Rainbow part 2
16(2)	57	44	SSR	Rainbow part 2
19	58	45T	TMR	Oceanographer Fracture Zone
20	59	46T	TMR	Site S-OH1
20	60	47	SSR	Site S-OH1
21	61	48T	TMR	Hayes Fracture Zone
21	62	49	SSR	Hayes Fracture Zone
22	63	50T	TMR	Bump in the Ridge
23	64	51T	TMR	Lost City
23	65	52	SSR	Lost City
24	66	53T	TMR	Broken Spur
24	67	54	SSR	Broken Spur
25	68	55T	TMR	MAR 27N
25	69	56	SSR	MAR 27N
26	70	57T	TMR	Close N of TAG
26	71	SAPS08	SAPS	Close N of TAG
26	72	58	SSR	Close N of TAG
27	73	59T	TMR	Close S of TAG
27	74	SAPS09	SAPS	Close S of TAG
27	75	60	SSR	Close S of TAG
28	76	61T	TMR	1.5x W of TAG
28	77	62	SSR	1.5x W of TAG
29	78	63T	TMR	1x W of TAG
29	79	64	SSR	1x W of TAG
30	80	65T	TMR	Close W of TAG
30	81	SAPS10	SAPS	Close W of TAG
30	82	66	SSR	Close W of TAG
VMPTEST	83	VMPTEST2	VMP	Close W of TAG
VMPTEST	84	VMPTEST2	VMP	Close W of TAG
30	85	67	SSR	Close W of TAG
31	86	68T	TMR	Close E of TAG
31	87	SAPS11	SAPS	Close E of TAG
31	88	69	SSR	Close E of TAG
32	89	70T	TMR	1.5 x E of TAG
33	90	71T	TMR	1 x E of TAG
33	91	VMP01	VMP	1 x E of TAG
33	92	72	SSR	1 x E of TAG
34	93	VMP02	VMP	TAG
34	94	73T	TMR	TAG
TOWYO3	95	74	SSR	TAG
34	96	VMP03	VMP	TAG
35	97	75T	TMR	TAG
35	98	76T	TMR	TAG
35	99	76T	TMR	TAG
35	100	SAPS12	SAPS	TAG
35	101	77	SSR	TAG

35.2	102	78T	TMR	TAG
35.2	103	SAPS13	SAPS	TAG
TOWYO4	104	79	SSR	TAG
36	105	80T	TMR	N bonus TAG
36	106	81	SSR	N bonus TAG
37	107	82	SSR	Low T slope
37	108	83T	TMR	Low T slope

CTD Instrument Configuration

Two Seasave Instrument Configuration files were used throughout the cruise, one for the Stainless Steel frame and the other for the Titanium frame.

JC156_SS.xmlcon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  <FrequencyChannelsSuppressed>0</FrequencyChannelsSuppressed>
  <VoltageWordsSuppressed>0</VoltageWordsSuppressed>
  <ComputerInterface>0</ComputerInterface>
  <!-- 0 == SBE11plus Firmware Version >= 5.0 -->
  <!-- 1 == SBE11plus Firmware Version < 5.0 -->
  <!-- 2 == SBE 17plus SEARAM -->
  <!-- 3 == None -->
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  <SurfaceParVoltageAdded>0</SurfaceParVoltageAdded>
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  <NmeaDepthDataAdded>0</NmeaDepthDataAdded>
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     <J>1.75265893e-006</J>
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      <D>0.00000000e+000</D>
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     </Coefficients>
     <Coefficients equation="1" >
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      <H>1.43885628e+000</H>
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  </NotInUse>
</Sensor>
<Sensor index="11" SensorID="71" >
  <WET_LabsCStar SensorID="71" >
    <SerialNumber>CST1654DR</SerialNumber>
    <CalibrationDate>16-April-2017</CalibrationDate>
    <M>20.2175</M>
    <B>-0.1233</B>
    <PathLength>0.250</PathLength>
  </WET_LabsCStar>
</Sensor>
```

```
            <Sensor index="12" SensorID="5" >
              <FluoroChelseaAqua3Sensor SensorID="5" >
                <SerialNumber>88-2050-095</SerialNumber>
                <CalibrationDate>13-October-2017</CalibrationDate>
                <VB>0.294700</VB>
                <V1>2.036300</V1>
                <Vacetone>0.420200</Vacetone>
                <ScaleFactor>1.000000</ScaleFactor>
                <Slope>1.000000</Slope>
                <Offset>0.000000</Offset>
              </FluoroChelseaAqua3Sensor>
            </Sensor>
          </SensorArray>
        </Instrument>
      </SBE_InstrumentConfiguration>
```


JC156_SSb.xmlcon


```
<?xml version="1.0" encoding="UTF-8"?>
<SBE_InstrumentConfiguration SB_ConfigCTD_FileVersion="7.26.2.0" >
  <Instrument Type="8" >
    <Name>SBE 911plus/917plus CTD</Name>
    <FrequencyChannelsSuppressed>0</FrequencyChannelsSuppressed>
    <VoltageWordsSuppressed>0</VoltageWordsSuppressed>
    <ComputerInterface>0</ComputerInterface>
    <!-- 0 == SBE11plus Firmware Version >= 5.0 -->
    <!-- 1 == SBE11plus Firmware Version < 5.0 -->
    <!-- 2 == SBE 17plus SEARAM -->
    <!-- 3 == None -->
    <DeckUnitVersion>0</DeckUnitVersion>
    <ScansToAverage>1</ScansToAverage>
    <SurfaceParVoltageAdded>0</SurfaceParVoltageAdded>
    <ScanTimeAdded>1</ScanTimeAdded>
    <NmeaPositionDataAdded>1</NmeaPositionDataAdded>
    <NmeaDepthDataAdded>0</NmeaDepthDataAdded>
    <NmeaTimeAdded>0</NmeaTimeAdded>
    <NmeaDeviceConnectedToPC>1</NmeaDeviceConnectedToPC>
    <SensorArray Size="13" >
      <Sensor index="0" SensorID="55" >
        <TemperatureSensor SensorID="55" >
          <SerialNumber>03P-4782</SerialNumber>
          <CalibrationDate>28-Apr-17</CalibrationDate>
          <UseG_J>1</UseG_J>
          <A>0.00000000e+000</A>
          <B>0.00000000e+000</B>
          <C>0.00000000e+000</C>
          <D>0.00000000e+000</D>
          <F0_Old>0.000</F0_Old>
          <G>4.34992096e-003</G>
          <H>6.36468108e-004</H>
          <I>2.08558312e-005</I>
          <J>1.75265893e-006</J>
          <F0>1000.000</F0>
          <Slope>1.00000000</Slope>
          <Offset>0.0000</Offset>
        </TemperatureSensor>
      </Sensor>
      <Sensor index="1" SensorID="3" >
        <ConductivitySensor SensorID="3" >
          <SerialNumber>04C-3698</SerialNumber>
          <CalibrationDate>01-Jun-16</CalibrationDate>
          <UseG_J>1</UseG_J>
          <!-- Cell const and series R are applicable only for wide range sensors. -->
          <SeriesR>0.0000</SeriesR>
          <CellConst>2000.0000</CellConst>
          <ConductivityType>0</ConductivityType>
          <Coefficients equation="0" >
            <A>0.00000000e+000</A>
            <B>0.00000000e+000</B>
            <C>0.00000000e+000</C>
            <D>0.00000000e+000</D>
            <M>0.0</M>
            <CPcor>-9.57000000e-008</CPcor>
          </Coefficients>
          <Coefficients equation="1" >
            <G>-1.01550437e+001</G>
            <H>1.43885628e+000</H>
            <I>-3.19202629e-003</I>
            <J>3.20870665e-004</J>
```

```
      <CPcor>-9.57000000e-008</CPcor>
      <CTcor>3.2500e-006</CTcor>
      <!-- WBOTC not applicable unless ConductivityType = 1. -->
      <WBOTC>0.00000000e+000</WBOTC>
    </Coefficients>
    <Slope>1.00000000</Slope>
    <Offset>0.00000</Offset>
  </ConductivitySensor>
</Sensor>
<Sensor index="2" SensorID="45" >
  <PressureSensor SensorID="45" >
    <SerialNumber>134949</SerialNumber>
    <CalibrationDate>09-Nov-15</CalibrationDate>
    <C1>-3.695717e+004</C1>
    <C2>-2.691791e-001</C2>
    <C3>1.143300e-002</C3>
    <D1>3.349300e-002</D1>
    <D2>0.000000e+000</D2>
    <T1>3.049225e+001</T1>
    <T2>-3.372510e-004</T2>
    <T3>3.990980e-006</T3>
    <T4>3.875890e-009</T4>
    <Slope>1.00000000</Slope>
    <Offset>0.00000</Offset>
    <T5>0.000000e+000</T5>
    <AD590M>1.280300e-002</AD590M>
    <AD590B>-9.092836e+000</AD590B>
  </PressureSensor>
</Sensor>
<Sensor index="3" SensorID="55" >
  <TemperatureSensor SensorID="55" >
    <SerialNumber>03P-5494</SerialNumber>
    <CalibrationDate>14-Jul-17</CalibrationDate>
    <UseG_J>1</UseG_J>
    <A>0.00000000e+000</A>
    <B>0.00000000e+000</B>
    <C>0.00000000e+000</C>
    <D>0.00000000e+000</D>
    <F0_Old>0.000</F0_Old>
    <G>4.35688826e-003</G>
    <H>6.42425090e-004</H>
    <I>2.35801337e-005</I>
    <J>2.32408572e-006</J>
    <F0>1000.000</F0>
    <Slope>1.00000000</Slope>
    <Offset>0.0000</Offset>
  </TemperatureSensor>
</Sensor>
<Sensor index="4" SensorID="3" >
  <ConductivitySensor SensorID="3" >
    <SerialNumber>04C-3873</SerialNumber>
    <CalibrationDate>01-Feb-17</CalibrationDate>
    <UseG_J>1</UseG_J>
    <!-- Cell const and series R are applicable only for wide range sensors. -->
    <SeriesR>0.0000</SeriesR>
    <CellConst>2000.0000</CellConst>
    <ConductivityType>0</ConductivityType>
    <Coefficients equation="0" >
      <A>0.00000000e+000</A>
      <B>0.00000000e+000</B>
      <C>0.00000000e+000</C>
      <D>0.00000000e+000</D>
      <M>0.0</M>
      <CPcor>-9.57000000e-008</CPcor>
    </Coefficients>
    <Coefficients equation="1" >
      <G>-1.01901674e+001</G>
      <H>1.35648858e+000</H>
      <I>-8.07817645e-004</I>
      <J>1.28644243e-004</J>
      <CPcor>-9.57000000e-008</CPcor>
      <CTcor>3.2500e-006</CTcor>
      <!-- WBOTC not applicable unless ConductivityType = 1. -->
      <WBOTC>0.00000000e+000</WBOTC>
    </Coefficients>
    <Slope>1.00000000</Slope>
    <Offset>0.00000</Offset>
  </ConductivitySensor>
</Sensor>
```

```xml
<Sensor index="5" SensorID="61" >
  <UserPolynomialSensor SensorID="61" >
    <SerialNumber>1234</SerialNumber>
    <CalibrationDate></CalibrationDate>
    <SensorName>eH</SensorName>
    <A0>0.00000000</A0>
    <A1>1.00000000</A1>
    <A2>0.00000000</A2>
    <A3>0.00000000</A3>
  </UserPolynomialSensor>
</Sensor>
<Sensor index="6" SensorID="27" >
  <NotInUse SensorID="27" >
    <SerialNumber></SerialNumber>
    <CalibrationDate></CalibrationDate>
    <OutputType>2</OutputType>
    <Free>1</Free>
  </NotInUse>
</Sensor>
<Sensor index="7" SensorID="70" >
  <TurbidityMeter SensorID="70" >
    <SerialNumber>BBRTD-182</SerialNumber>
    <CalibrationDate>6-March-2017</CalibrationDate>
    <ScaleFactor>3.343e-003</ScaleFactor>
    <!-- Dark output -->
    <DarkVoltage>6.600e-002</DarkVoltage>
  </TurbidityMeter>
</Sensor>
<Sensor index="8" SensorID="0" >
  <AltimeterSensor SensorID="0" >
    <SerialNumber>41303</SerialNumber>
    <CalibrationDate>13-March-2006</CalibrationDate>
    <ScaleFactor>15.000</ScaleFactor>
    <Offset>0.000</Offset>
  </AltimeterSensor>
</Sensor>
<Sensor index="9" SensorID="38" >
  <OxygenSensor SensorID="38" >
    <SerialNumber>43-0709</SerialNumber>
    <CalibrationDate>29-Sept-2017</CalibrationDate>
    <Use2007Equation>1</Use2007Equation>
    <CalibrationCoefficients equation="0" >
      <!-- Coefficients for Owens-Millard equation. -->
      <Boc>0.0000</Boc>
      <Soc>0.0000e+000</Soc>
      <offset>0.0000</offset>
      <Pcor>0.00e+000</Pcor>
      <Tcor>0.0000</Tcor>
      <Tau>0.0</Tau>
    </CalibrationCoefficients>
    <CalibrationCoefficients equation="1" >
      <!-- Coefficients for Sea-Bird equation - SBE calibration in 2007 and later. -->
      <Soc>4.3530e-001</Soc>
      <offset>-0.5017</offset>
      <A>-3.1943e-003</A>
      <B> 2.2019e-004</B>
      <C>-3.1910e-006</C>
      <D0> 2.5826e+000</D0>
      <D1> 1.92634e-004</D1>
      <D2>-4.64803e-002</D2>
      <E> 3.6000e-002</E>
      <Tau20> 1.3400</Tau20>
      <H1>-3.3000e-002</H1>
      <H2> 5.0000e+003</H2>
      <H3> 1.4500e+003</H3>
    </CalibrationCoefficients>
  </OxygenSensor>
</Sensor>
<Sensor index="10" SensorID="27" >
  <NotInUse SensorID="27" >
    <SerialNumber></SerialNumber>
    <CalibrationDate></CalibrationDate>
    <OutputType>2</OutputType>
    <Free>1</Free>
  </NotInUse>
</Sensor>
<Sensor index="11" SensorID="71" >
  <WET_LabsCStar SensorID="71" >
    <SerialNumber>CST1654DR</SerialNumber>
```

```
      <CalibrationDate>16-April-2017</CalibrationDate>
      <M>20.2175</M>
      <B>-0.1233</B>
      <PathLength>0.250</PathLength>
    </WET_LabsCStar>
  </Sensor>
  <Sensor index="12" SensorID="5" >
    <FluoroChelseaAqua3Sensor SensorID="5" >
      <SerialNumber>88-2050-095</SerialNumber>
      <CalibrationDate>13-October-2017</CalibrationDate>
      <VB>0.294700</VB>
      <V1>2.036300</V1>
      <Vacetone>0.420200</Vacetone>
      <ScaleFactor>1.000000</ScaleFactor>
      <Slope>1.000000</Slope>
      <Offset>0.000000</Offset>
    </FluoroChelseaAqua3Sensor>
  </Sensor>
 </SensorArray>
</Instrument>
</SBE_InstrumentConfiguration>
```


JC156_TITA.xmlcon


```
<?xml version="1.0" encoding="UTF-8"?>
<SBE_InstrumentConfiguration SB_ConfigCTD_FileVersion="7.26.2.0" >
 <Instrument Type="8" >
  <Name>SBE 911plus/917plus CTD</Name>
  <FrequencyChannelsSuppressed>0</FrequencyChannelsSuppressed>
  <VoltageWordsSuppressed>0</VoltageWordsSuppressed>
  <ComputerInterface>0</ComputerInterface>
  <!-- 0 == SBE11plus Firmware Version >= 5.0 -->
  <!-- 1 == SBE11plus Firmware Version < 5.0 -->
  <!-- 2 == SBE 17plus SEARAM -->
  <!-- 3 == None -->
  <DeckUnitVersion>0</DeckUnitVersion>
  <ScansToAverage>1</ScansToAverage>
  <SurfaceParVoltageAdded>0</SurfaceParVoltageAdded>
  <ScanTimeAdded>1</ScanTimeAdded>
  <NmeaPositionDataAdded>1</NmeaPositionDataAdded>
  <NmeaDepthDataAdded>0</NmeaDepthDataAdded>
  <NmeaTimeAdded>0</NmeaTimeAdded>
  <NmeaDeviceConnectedToPC>1</NmeaDeviceConnectedToPC>
  <SensorArray Size="13" >
   <Sensor index="0" SensorID="55" >
    <TemperatureSensor SensorID="55" >
     <SerialNumber>03P-5660</SerialNumber>
     <CalibrationDate>21-Jul-15</CalibrationDate>
     <UseG_J>1</UseG_J>
     <A>0.00000000e+000</A>
     <B>0.00000000e+000</B>
     <C>0.00000000e+000</C>
     <D>0.00000000e+000</D>
     <F0_Old>0.000</F0_Old>
     <G>4.33135720e-003</G>
     <H>6.25298893e-004</H>
     <I>1.90859973e-005</I>
     <J>1.40047606e-006</J>
     <F0>1000.000</F0>
     <Slope>1.00000000</Slope>
     <Offset>0.0000</Offset>
    </TemperatureSensor>
   </Sensor>
   <Sensor index="1" SensorID="3" >
    <ConductivitySensor SensorID="3" >
     <SerialNumber>04C-4065</SerialNumber>
     <CalibrationDate>01-Feb-17</CalibrationDate>
     <UseG_J>1</UseG_J>
     <!-- Cell const and series R are applicable only for wide range sensors. -->
     <SeriesR>0.0000</SeriesR>
     <CellConst>2000.0000</CellConst>
     <ConductivityType>0</ConductivityType>
     <Coefficients equation="0" >
      <A>0.00000000e+000</A>
      <B>0.00000000e+000</B>
      <C>0.00000000e+000</C>
      <D>0.00000000e+000</D>
      <M>0.0</M>
```

```
      <CPcor>-9.57000000e-008</CPcor>
    </Coefficients>
    <Coefficients equation="1" >
      <G>-9.85528941e+000</G>
      <H>1.48698206e+000</H>
      <I>-2.24676429e-003</I>
      <J>2.52595414e-004</J>
      <CPcor>-9.57000000e-008</CPcor>
      <CTcor>3.2500e-006</CTcor>
      <!-- WBOTC not applicable unless ConductivityType = 1. -->
      <WBOTC>0.00000000e+000</WBOTC>
    </Coefficients>
    <Slope>1.00000000</Slope>
    <Offset>0.00000</Offset>
  </ConductivitySensor>
</Sensor>
<Sensor index="2" SensorID="45" >
  <PressureSensor SensorID="45" >
    <SerialNumber>124216</SerialNumber>
    <CalibrationDate>26 February 2016</CalibrationDate>
    <C1>-6.193577e+004</C1>
    <C2>-2.149353e-001</C2>
    <C3>1.865100e-002</C3>
    <D1>2.627600e-002</D1>
    <D2>0.000000e+000</D2>
    <T1>3.027244e+001</T1>
    <T2>-3.411760e-004</T2>
    <T3>4.320610e-006</T3>
    <T4>0.000000e+000</T4>
    <Slope>1.00010000</Slope>
    <Offset>-1.14700</Offset>
    <T5>0.000000e+000</T5>
    <AD590M>1.279600e-002</AD590M>
    <AD590B>-9.557250e+000</AD590B>
  </PressureSensor>
</Sensor>
<Sensor index="3" SensorID="55" >
  <TemperatureSensor SensorID="55" >
    <SerialNumber>03P-5700</SerialNumber>
    <CalibrationDate>17-Sep-15</CalibrationDate>
    <UseG_J>1</UseG_J>
    <A>0.00000000e+000</A>
    <B>0.00000000e+000</B>
    <C>0.00000000e+000</C>
    <D>0.00000000e+000</D>
    <F0_Old>0.000</F0_Old>
    <G>4.34148783e-003</G>
    <H>6.28276015e-004</H>
    <I>1.85718886e-005</I>
    <J>1.12802080e-006</J>
    <F0>1000.000</F0>
    <Slope>1.00000000</Slope>
    <Offset>0.0000</Offset>
  </TemperatureSensor>
</Sensor>
<Sensor index="4" SensorID="3" >
  <ConductivitySensor SensorID="3" >
    <SerialNumber>04C-4138</SerialNumber>
    <CalibrationDate>17-Sep-15</CalibrationDate>
    <UseG_J>1</UseG_J>
    <!-- Cell const and series R are applicable only for wide range sensors. -->
    <SeriesR>0.0000</SeriesR>
    <CellConst>2000.0000</CellConst>
    <ConductivityType>0</ConductivityType>
    <Coefficients equation="0" >
      <A>0.00000000e+000</A>
      <B>0.00000000e+000</B>
      <C>0.00000000e+000</C>
      <D>0.00000000e+000</D>
      <M>0.0</M>
      <CPcor>-9.57000000e-008</CPcor>
    </Coefficients>
    <Coefficients equation="1" >
      <G>-9.83601773e+000</G>
      <H>1.45179051e+000</H>
      <I>-1.78119605e-003</I>
      <J>2.29347417e-004</J>
      <CPcor>-9.57000000e-008</CPcor>
      <CTcor>3.2500e-006</CTcor>
```

```
      <!-- WBOTC not applicable unless ConductivityType = 1. -->
      <WBOTC>0.00000000e+000</WBOTC>
    </Coefficients>
    <Slope>1.00000000</Slope>
    <Offset>0.00000</Offset>
  </ConductivitySensor>
</Sensor>
<Sensor index="5" SensorID="38" >
  <OxygenSensor SensorID="38" >
    <SerialNumber>43-0363</SerialNumber>
    <CalibrationDate>02-Mar-16</CalibrationDate>
    <Use2007Equation>1</Use2007Equation>
    <CalibrationCoefficients equation="0" >
      <!-- Coefficients for Owens-Millard equation. -->
      <Boc>0.0000</Boc>
      <Soc>0.0000e+000</Soc>
      <offset>0.0000</offset>
      <Pcor>0.00e+000</Pcor>
      <Tcor>0.0000</Tcor>
      <Tau>0.0</Tau>
    </CalibrationCoefficients>
    <CalibrationCoefficients equation="1" >
      <!-- Coefficients for Sea-Bird equation - SBE calibration in 2007 and later. -->
      <Soc>4.5170e-001</Soc>
      <offset>-0.5113</offset>
      <A>-3.7841e-003</A>
      <B> 1.7975e-004</B>
      <C>-2.5777e-006</C>
      <D0> 2.5826e+000</D0>
      <D1> 1.92634e-004</D1>
      <D2>-4.64803e-002</D2>
      <E> 3.6000e-002</E>
      <Tau20> 1.1400</Tau20>
      <H1>-3.3000e-002</H1>
      <H2> 5.0000e+003</H2>
      <H3> 1.4500e+003</H3>
    </CalibrationCoefficients>
  </OxygenSensor>
</Sensor>
<Sensor index="6" SensorID="27" >
  <NotInUse SensorID="27" >
    <SerialNumber></SerialNumber>
    <CalibrationDate></CalibrationDate>
    <OutputType>2</OutputType>
    <Free>1</Free>
  </NotInUse>
</Sensor>
<Sensor index="7" SensorID="70" >
  <TurbidityMeter SensorID="70" >
    <SerialNumber>BBRTD-759R</SerialNumber>
    <CalibrationDate>12-Sept-2016</CalibrationDate>
    <ScaleFactor>3.221e-003</ScaleFactor>
    <!-- Dark output -->
    <DarkVoltage>4.100e-002</DarkVoltage>
  </TurbidityMeter>
</Sensor>
<Sensor index="8" SensorID="0" >
  <AltimeterSensor SensorID="0" >
    <SerialNumber>47597</SerialNumber>
    <CalibrationDate>22-Feb-2010</CalibrationDate>
    <ScaleFactor>15.000</ScaleFactor>
    <Offset>0.000</Offset>
  </AltimeterSensor>
</Sensor>
<Sensor index="9" SensorID="61" >
  <UserPolynomialSensor SensorID="61" >
    <SerialNumber></SerialNumber>
    <CalibrationDate></CalibrationDate>
    <SensorName>eH</SensorName>
    <A0>0.00000000</A0>
    <A1>1.00000000</A1>
    <A2>0.00000000</A2>
    <A3>0.00000000</A3>
  </UserPolynomialSensor>
</Sensor>
<Sensor index="10" SensorID="61" >
  <UserPolynomialSensor SensorID="61" >
    <SerialNumber></SerialNumber>
    <CalibrationDate></CalibrationDate>
```

<SensorName>LSS</SensorName>
<A0>0.00000000</A0>
<A1>1.00000000</A1>
<A2>0.00000000</A2>
<A3>0.00000000</A3>
</UserPolynomialSensor>
</Sensor>
<Sensor index="11" SensorID="71" >
<WET_LabsCStar SensorID="71" >
<SerialNumber>CST-1720TR</SerialNumber>
<CalibrationDate>16 April 2015</CalibrationDate>
<M>21.4550</M>
<B>-0.1824</B>
<PathLength>0.250</PathLength>
</WET_LabsCStar>
</Sensor>
<Sensor index="12" SensorID="5" >
<FluoroChelseaAqua3Sensor SensorID="5" >
<SerialNumber>088244</SerialNumber>
<CalibrationDate>29 September 2016</CalibrationDate>
<VB>0.185700</VB>
<V1>2.079400</V1>
<Vacetone>0.342300</Vacetone>
<ScaleFactor>1.000000</ScaleFactor>
<Slope>1.000000</Slope>
<Offset>0.000000</Offset>
</FluoroChelseaAqua3Sensor>
</Sensor>
</SensorArray>
</Instrument>
</SBE_InstrumentConfiguration>

VMP Troubleshooting Narrative

Prior to sailing NMF technicians were informed that the use of VMPSN107 should be avoided as, it has previously exhibited noise across the microstructure sensors to such a degree that the data was unusable. A scientist on board who had sailed on and analysed the VMP data from the previous cruise further confirmed this.

Building of VMP SN016 began 21 December 2017 by Peter Keen, David Childs and Chris Crowe. Candice Cameron joined the vessel on 3rd January 2018 to assist with science and contribute VMP experience.

Construction of SN016 was completed and bench tests performed on 4th January 2018. The bench tests exhibited some noise across the microstructure sensors when the blank/dummy plugs were fitted. This was reduced when sensors were fitted and the scientist in charge of VMP data was happy that the VMP looked to be performing correctly at this stage.

Bench test 1 = dummy sensors > BT001.P
Bench test 2 = with sensors, 2min > BT002.P

All times are in GMT unless otherwise stated.

Initial Trials

As discussed on the 3rd January it was confirm to the PSO on the afternoon of the 4th January that the VMP was ready for sea trials. These tests required approximately 4hrs to encompass; a buoyancy test, tethered test, a shallow free-fall dive and include contingency time for problems.

It was requested that this be allowed to take place over the midday shift change of the technicians so that no-one would be breaking their hours more than absolutely necessary and both shifts would be familiar with the setup, launch and recovery procedure.

Testing of SN016 took place on 7th January beginning at 1000.

A toolbox talk was delivered by Candice Cameron to technicians, deck crew and officers prior to work commencing.

VMP CONFIGURATION	
SITE:	Test – 07/01/2018
VMP:	SN016
USBL:	Yes - 3005
ARGOS:	Yes
FLASHER:	Yes
BRUSHES:	2 x small
SEA-BIRD TEMP:	04-5916
SEA-BIRD COND:	03-3240

RELEASE:	Charity
LED:	Yes
uCOND:	C201
TEMP 1:	T1187
TEMP 2:	T1188
SHEAR 1:	M1042
SHEAR 2:	M1408
WEIGHTS:	3 x 7kg

Buoyancy test: It was agreed among technicians and experienced scientists that the VMP was positively buoyant and sitting at the correct height relative to the water surface.
A tethered dive to 50m was completed. During recovery the hook that the VMP was recovered on (standard recovery hook) was discovered to be bent as it came out of the water. At first this was suspected to be due to a faulty hook and any other "old" hooks were marked with red tape to identify them as not for use. Later viewing of the Go-Pro footage that a scientist had attached to the bail of the VMP showed that the VMP had got caught under the ship during ascent and this was the reason for the hook failing.

This was discussed with the bridge prior to the next deployments and reiterated that the ship should not allow the VMP (trackable by USBL relay) to come up beneath it.

VMP DEPLOYMENT	
SITE:	Test – 07/01/2018
LOCATION:	35 56.77919 N 34 09.27996 W (on bottom)
WATER DEPTH (m):	
MAX_PRESSURE:	3600
MAX_TIME:	500
ACQUISITION START:	15:02
TIME DEPLOYED:	15:35

Subsequent to the tethered test a free-fall dive to 500m was conducted. The deployment proceeded smoothly however the VMP surpassed 500m and kept going. Using the USBL it could be seen that there was no decrease in fall-rate as should be expected having reached the specified max_pressure.

According to the USBL the VMP was falling at 0.7-0.8m/s – double what was anticipated and therefore meaning that the VMP would impact with the sea-bed prior to the time-out release.

At 14:20 the VMP hit the sea-bed at which point a fall-rate release should have been triggered an the VMP should have begun to ascend. It did not.
SN016 sat on the sea floor until 18:05. It was on the surface at 18:51 and following recovery of the SAPs the VMP was recovered to deck at approximately 21:45

VMP USBL	
SITE:	Test – 07/01/2018
13:25	In water at 14m
13:36	At 500m and falling at ~0.7m/s
14:20	On sea-bed at ~2347m
18:05	Ascending at ~0.8m/s
18:51	On the surface

VMP RECOVERY	
SITE:	Test – 07/01/2018

TIME ON SURFACE:	18:51
TIME ON DECK	21:45

VMP LOGFILE.TXT	
SITE:	Test – 07/01/2018
ACQUISITION START:	13:23
PRESSURE RELEASE:	13:36
TIMEOUT RELEASE:	14:23
FALL RATE RELEASE:	18:41
OFF:	21:47
COMMENT:	None worked. Why did fall rate release not occur sooner (as soon as hit the bottom).

Troubleshooting

The reason for the VMP hitting the sea-bed was initially unknown. According to the logfile.txt the VMP had attempted to release its weights in the expected manner, the timings of which matched those anticipated. However, on reflection it was noted that a fall-rate release was not triggered until the VMP was already ascending – this should have occurred shortly after the VMP had hit the sea floor.

Logfile.txt
5a521f4c 0b 0000 TST_001.p --- Sun Jan 7 13:23:24 2018 - "acquisition start" Setup File:'SETUP.CFG'
5a522265 01 0319 TST_001.p --- Sun Jan 7 13:36:37 2018 - "pressure release"
5a5222e5 0d 0399 TST_001.p --- Sun Jan 7 13:38:45 2018 - "bad buffer"
5a5224e6 0d 0599 TST_001.p --- Sun Jan 7 13:47:18 2018 - "bad buffer"
5a5226b9 0d 076b TST_001.p --- Sun Jan 7 13:55:05 2018 - "bad buffer"
5a522d56 03 0e08 TST_001.p --- Sun Jan 7 14:23:18 2018 - "timeout release"
5a5269d1 02 4a84 TST_001.p --- Sun Jan 7 18:41:21 2018 - "fall rate release"
5a529586 06 763b TST_001.p --- Sun Jan 7 21:47:50 2018 - "switch is off"
5a529587 0c 763b TST_001.p --- Sun Jan 7 21:47:51 2018 - "acquisition stop" switch is off

Due to lack of suitable manning, the intensity of the science programme and problems with other pieces of kit troubleshooting of the VMP was not possible until 16th January.

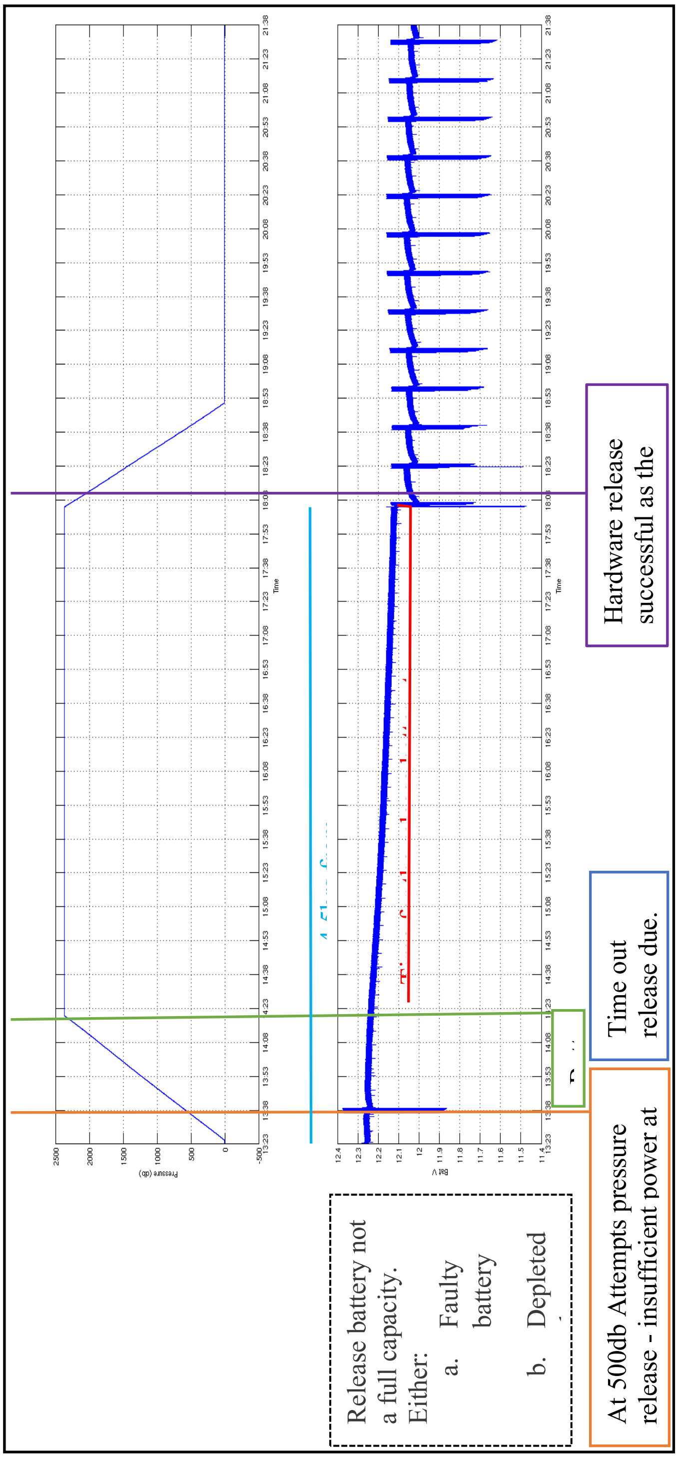
Other science was prioritised by the PSO until the 15th January when it was agreed that the VMP would be more highly prioritised from the 16th. Investigation into the problem was achieved by slotting time in between other science and in lieu of conducting a CTD1 termination. If repairs were successful, re-testing was anticipated for 20th January.

As time allowed testing of the VMP was conducted on the 15th – 16th January prior to opening of the pressure housing. This, along with analysis of the VMP voltage spike data seemed to indicate that there could possibly be a problem with the release battery.

Local Time	GMT	Voltage	

19:31	22:31	5.484	Deployment (deck) started – 2hrs
19:41	22:41	5.604	
19:56	22:56	5.598	
20:01	23:01	5.596	
20:31	23:31	5.583	
20:57	23:57	5.565	
22:00	01:00	5.546	Deployment (deck) ended – 00:31
23:39	02:39	5.282	Stopped, disconnected. NOT charging
23:40	02:40	5.273	
23:53	02:53	5.227	
00:01	03:01	5.223	
00:08	03:08	5.218	
11:50	14:50	5.53	
12:06	15:06	5.555	

NMF VMP6000 SN016 500db test dive 07/01/2018 – theory - C.Cameron



The manufacturer - Rockland Scientific Instruments (RSI) – was consulted and following their advice, the following maintenance was conducted:

- Release battery replaced
- Whilst the pressure housing was open the circuit board were checked for loose wire, connectors or components
- Functional check on the release – in particular checking the solenoid for pressure balance and excess friction at the release shaft

- The CF card was formatted following manufacturer procedure.

Whilst the unit was open various power and current readings were taken to test the old release battery and ensure the one newly installed was operating correctly.
The troubleshooting, open bench testing and rebuild was begun on 16th January and completed on the 18th.
On the 19th January the following bench tests were conducted; both successful:
Bench test 1 – without sensors (dummy plugs) – run for 90seconds as recommended by RSI > BN7_001.P
Bench test 2 - with sensors – run for 180seconds > BN7_002.P

Trials 2.

As the VMP had already been successfully buoyancy tested and there had been no significant change to the physical construction of the VMP a second buoyancy test was not conducted.

Due to the higher than ideal fall-rate two extra brushes had been added during rebuild.

This was to compensate for the fact that 2.5 weights had been used on the previous cruise to achieve a fall rate of 0.6m/s but no half weights had been provided for JC156 and there was no easy means by which to cut the weights available on board.

A 150m tethered dive was conducted. Following the VMP getting stuck under the ship's hull previously the bridge were given clear instructions to set the ship up so that the wind would push us away from the VMP. A shackle was used to secure the tethering line rather that a hook.

VMP DEPLOYMENT	
SITE:	Tethered test – 20/01/2018
LOCATION:	26 12.900 N 45 07.099 W
MAX_PRESSURE:	150
MAX_TIME:	600
ACQUISITION START:	14:24
TIME DEPLOYED:	14:26

VMP RECOVERY	
SITE:	Tethered test – 20/01/2018
TIME ON SURFACE:	14:41
TIME ON DECK	14:46

VMP LOGFILE.TXT	
SITE:	Tethered test – 20/01/2018
ACQUISITION START:	
PRESSURE RELEASE:	14:31

FALL RATE RELEASE:	14:32
TIMEOUT RELEASE:	14:34
OFF:	14:46
COMMENT:	As expected.

A 500m free-fall test dive had been planned but in consultation with the scientists this was increased to 700m as they analyse their data in 500m bins and so a “clean” 500m free-fall is required to properly ascertain that all the sensors are functioning correctly.

The 700m free-fall/untethered dive was successfully deployed and recovered.

VMP DEPLOYMENT	
SITE:	700m test – 20/01/2018
LOCATION:	26 12.900 N 45 07.100 W
MAX_PRESSURE:	700
MAX_TIME:	1800
ACQUISITION START:	15:36
TIME DEPLOYED:	15:37

VMP RECOVERY	
SITE:	700m test – 20/01/2018
TIME ON SURFACE:	16:15
TIME ON DECK	16:33

VMP LOGFILE.TXT	
SITE:	700m test – 20/01/2018
ACQUISITION START:	
PRESSURE RELEASE:	15:57
FALL RATE RELEASE:	15:58
TIMEOUT RELEASE:	16:06
OFF:	16:39
COMMENT:	As expected.

Deployment 1.

Shear 1 swapped prior to this dive to rectify and offset between the shears – detail to be added.

VMP DEPLOYMENT	
SITE:	STN033 Event 091 Dive 001 22/01/2018 23:52
LOCATION:	25 35.39 N 43 30.00 W
WATER DEPTH (m):	4103 (bottom pressure = 4170dbar)
MAX_PRESSURE:	4100
MAX_TIME:	10467
ACQUISITION START:	00:59
TIME DEPLOYED:	01:01
ETA TURNAROUND:	02:58 (4057m)

VMP RECOVERY	
SITE:	STN033 Event 091 Dive 001 23/01/2018
LOCATION:	25 35.204 N 43 30.994 W
TIME ON SURFACE:	05:24
TIME ON DECK	11:46

VMP LOGFILE.TXT	
SITE:	STN033 Event 091 Dive 001 23/01/2018
ACQUISITION START:	
PRESSURE RELEASE:	
FALL RATE RELEASE:	
TIMEOUT RELEASE:	
OFF:	
COMMENT:	As expected.

Shear 2 s
wapped following this deployment as a slight offset between the two shears remains– detail to be added.

Deployment 2.

VMP DEPLOYMENT	
SITE:	STN034a Event 093

	Dive 002 23/01/2018 13:30
LOCATION:	26 08.203 N 44 49.601 w
WATER DEPTH (m):	3699 (bottom pressure = 3756dbar)
MAX_PRESSURE:	3683
MAX_TIME:	9738
ACQUISITION START:	14:14
TIME DEPLOYED:	14:15
ETA TURNAROUND:	15:57 (3650m)

VMP RECOVERY	
SITE:	STN034a Event 093 Dive 002 23/01/2018
LOCATION:	26 08.227 N 44 51.684 W
TIME ON SURFACE:	05:24
TIME ON DECK	19:52 (CTD issues delay recovery)

VMP LOGFILE.TXT	
SITE:	STN034a Event 093 Dive 002 23/01/2018
ACQUISITION START:	
PRESSURE RELEASE:	
FALL RATE RELEASE:	
TIMEOUT RELEASE:	
OFF:	
COMMENT:	As expected.

Deployment 3.

VMP DEPLOYMENT	
SITE:	STN034b Event 096 Dive 003 24/01/2018 11:32
LOCATION:	26 08.261 N 44 49.465 W
WATER DEPTH (m):	3656 (bottom pressure = 3712dbar)
MAX_PRESSURE:	3639
MAX_TIME:	9665
ACQUISITION START:	12:01
TIME DEPLOYED:	12:02

ETA TURNAROUND:	13:14 (3607)

VMP RECOVERY	
SITE:	STN034b Event 096 Dive 003 25/01/2018 02:08
LOCATION:	26 08.486 N 44 49.687 W
TIME ON SURFACE:	02:07
TIME ON DECK	02:16

VMP LOGFILE.TXT	
SITE:	STN034b Event 096 Dive 003 25/01/2018 02:08
ACQUISITION START:	
PRESSURE RELEASE:	
FALL RATE RELEASE:	
TIMEOUT RELEASE:	
OFF:	
COMMENT:	All probes questionable due to bottom contact. Temperature (T2) smash resulting from impact. An Initial look at logfile.txt and voltage data suggests that the likely cause of bottom impact may be due to same reason as the initial 500m untethered test dive. No time was left during cruise to troubleshoot and resolve the issue. Needs to be investigated at base. No more VMPs on JC156