



**National  
Oceanography Centre**  
NATURAL ENVIRONMENT RESEARCH COUNCIL

## **National Oceanography Centre**

### **Cruise Report No. 48**

#### **RRS *Discovery* Cruise DY078/079**

06 - 28 MAY 2017

Southampton to Reykjavik

Extended Ellett Line 2017 occupation and  
OSNAP Rockall Trough mooring refurbishment cruise

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2017

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## DOCUMENT DATA SHEET

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<b>ABSTRACT</b> <p>Cruise DY078/079 (hereafter called DY078) was the 2017 occupation of the Extended Ellett Line (EEL) and the 2017 refurbishment cruise for the OSNAP Rockall Trough moorings (Overturning in the Subpolar North Atlantic Program).</p> <p>The core scientific objectives of DY078 were:</p> <ul style="list-style-type: none"><li>To service (recover and re-deploy) the 3 UK OSNAP moorings and 1 ADCP lander in the Rockall Trough (RTWB1, RTWB2, RTEB2 and RTADCP1).</li><li>To complete the Extended Ellett Line CTD/LADCP section across the eastern subpolar North Atlantic between Scotland and Iceland via the Rockall-Hatton Plateau.</li><li>To collect and freeze nutrient samples from CTD stations for later analysis at SAMS</li><li>To deploy four Argos floats for the UK Met Office.</li><li>To recover one WHOI OSNAP glider and one SAMS EEL glider.</li><li>To deploy one WHOI OSNAP glider and one SAMS OSNAP glider.</li><li>To collect water samples for isotopic analysis at Edinburgh and Cardiff Universities</li><li>To survey the seabed for sediments with the subbottom profiler.</li><li>To collect underway water samples for microplastics analysis</li><li>To survey for seabirds and marine mammals</li><li>To communicate the cruise work through social media</li><li>To collect underwater film footage for an artist</li></ul> <p>The opportunistic objectives, to be completed if weather conditions allowed were:</p> <ul style="list-style-type: none"><li>To collect megacores for palaeoceanographic and microplastics analysis</li><li>To collect water column water samples for microplastics analysis</li><li>To collect wind data for air-flow distortion analysis</li></ul> <p>Almost all objectives were achieved, including the opportunistic ones, along with 7 extra CTD stations. The OSNAP ADCP lander was not recovered or re-deployed.</p> <p>All OSNAP moorings were previously deployed in 2014, refurbished in 2015 and 2016, and will be recovered in 2018. The moorings and the CTD profiles will be used to measure the mean and variability of the surface-to-seafloor currents, and to compute the volume, heat and freshwater transport within the currents. They are part of a large international programme, OSNAP (Overturning in the Subpolar North Atlantic Programme) which has other moorings in the Labrador Sea, Irminger Sea and Iceland Basin.</p>	
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## 1. Personnel

### Scientific and Technical Personnel

HOLLIDAY	PENNY	PSO	NOC
BEATON	JOHN	Scientist	SAMS
McNEIL	SHARON	Scientist	SAMS
COURTENE-JONES	WINNIE	Scientist	SAMS PhD Student
DUMONT	ESTELLE	Scientist	SAMS
CUNNINGHAM	STUART	Scientist	SAMS
HOUPERT	LOIC	Scientist	SAMS
O'DONNELL	CHRIS	Scientist	SAMS
SALT	JASON	Scientist	SAMS PhD Student
SMILENOVA	ANGELINA	Scientist	Marine Institute, Galway
MOFFA SANCHEZ	PAOLA	Scientist	Cardiff University
DUYCK	ELODIE	Scientist	SAMS masters student
DONCILA	ANTONIA	Scientist	Edinburgh University PhD student
BRENNAN	DEBI	Scientist	SAMS
LA BIANCA	GIULIA	Scientist	Sea Watch Foundation
MCLACHLAN	ROB	STO	NMF
SHORT	JON	Tech	NMF
CHILDS	DAVID	Tech	NMF
NEMETH	ZOLTAN	SST	NMF



*Figure 1.1. DY078 Science and Technical Team  
(missing Rob and Dave who had gone ashore for fish and chips)*

## **Ships Personnel**

COX	JO	Master
MAHON	ANDY	C/O
MORROW	DECLAN	2/O
NORRISH	NICK	3/O
BILLS	JIM	C/E
O'SULLIVAN	GERALDINE	2/E
FRANKLIN	NICK	3/E
MURREN	MICK	3/E
WYTHE	VIV	D/E
BROOKS	FELIX	ETO
WATTERSON	IAN	PCO
FISHER	CHARLES	Cadet
FROST	GEORGE	Cadet
SMITH	STEVE	CPOS
MACLEAN	ANDY	CPOD
SPENCER	BOB	POD
McLENNAN	WILLIE	SG1A
LAPSLEY	CRAIG	SG1A
HOPLEY	JOHN	SG1A
SQUIBB	MARK	SG1A
WILLIAMS	EMLYN	ERPO
ASHFIELD	MARK	H/Chef
WHALEN	AMY	Chef
ORSBORN	JEFFREY	Stwd
BRACKENRIDGE	CHRIS	A/Stwd

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## 2. Cruise Narrative

*Penny Holliday*

**Sat 6 May (126):** Sailed from Empress Dock, Southampton at 0930 BST. Underway instruments switched on soon after sailing; non-toxic supply cleaned, flushed and operational by 1300. Emergency muster drill at 1600. Fair weather meant good progress towards Lands End.

**Sun 7 May (127):** Steaming towards working area via Celtic Sea and west of Ireland. Lovely weather. Seabird and marine mammal observations begin. Ship's clocks turned back to UTC tonight.

**Mon 8 May (128):** Steaming on passage to working area in good weather. Fire drill at 1030 and scientists practised using fire hoses.

**Tues 9 May (129):** Test CTD cast began at 0600, going to 1000m cast in deep water (CTD001). Samplers had their training and practice before the first mooring instrument calibration cast (CTD002) which had a long duration because of 5-20 minute bottle stops. At 0630 it was discovered that the EA echosounder had an incorrect pulse length, so all data prior to this time were noisy and should be ignored. Completed second calibration CTD cast (CTD003). Overnight ADCP survey across locations of WB2 and WB1 and up the slope of Rockall Bank.

**Weds 10 May (130):** Mooring recoveries (WB2 and WB1), followed by acoustic sediment survey overnight. The survey, at 4 knts, followed a triangular pattern to survey the sediments perpendicular to the track of the Extended Ellett line (around stations F and G), in order to ascertain the extent of thick deposits.

**Thursday 11 May (131):** Deployment of moorings WB2 and WB1, followed by trilateration for each new position. After that we steamed east to position of EB1, and commenced with a 4 knot ADCP survey across the moorings and up the continental slope.

**Friday 12 May (132):** Recovery of EB1, which had suffered trawler damage a few weeks ago. Proceeded to attempted recovery of RTADCP1 lander. Contact made with release, but did not rise on release command. Plan in place to attempt to recover on Saturday. Overnight another ADCP survey of the slope current.

**Saturday 13 May (133):** Deployment of EB1 (with RAS), followed by trilateration to fix the position. In the afternoon we carried out a drag manoeuvre in an attempt to "nudge" the ADCP lander and make it come to the surface. Unfortunately the lander remained stuck to the seafloor, and we proceeded to steam to the inshore station of the Extended Ellett Line CTD section.

**Sunday 14 May (134):** We started the EEL CTD section at IG at 0800 in good weather. Worked several CTD stations during the course of the day and night. We were treated to spectacular views of dolphin and birds today.

**Monday 15 May (135):** Worked more shelf stations in the early hours, then broke off at 0500 as wind speed picked up. Resumed CTDs at 1300 and continued overnight. Winds high but conditions workable.

**Tuesday 16 May (136):** Moved off the shelf into deeper stations. Did extra CTD 1 nm off EB1 position for calibration information. Worked stopped in the evening as weather conditions worsened.

**Wednesday 17 May (137):** CTDs resumed at Station M at 0815. Two casts at this station; the second to collect large volume water samples for filtering for microplastics. CTDs through the day and evening under brisk conditions. Deployed Argo floats at Stn N and L.

**Thursday 18 May (138):** Completed 3 successful megacores at Station M, continued with CTDs in good weather.

**Friday 19 May (139):** Completed 1 megacore just north of the line between F and E, continued with CTDs. Waved at Rockall as we steamed past in clear conditions.

**Saturday 20 May (140):** Continued with CTDs. After Station IB6 we broke off the section and headed southwest to the fragment of the OSNAP line between mooring site M4 and the top of Hatton Bank which we will occupy tomorrow.

**Sunday 21 May (141):** Arrived at station O1 at 1100. After CTD completed we deployed the OSNAP glider Bellatrix, and the WHOI slocum glider. Then we recommenced CTDs O2 to O7 over night.

**Monday 22 May (142):** In the morning, CTD059 at O7 was delayed with cable scrolling issues, and completed by 1130. Steamed at 8 knots over location of M4 to get swath bathymetry of location for mooring deployment in 2018. Set course for latest position of WHOI glider; recovered and on deck at 1500. Commenced steam to IB6.

**Tuesday 23 May (143):** Re-started EEL section by repeating IB6 (Hatton Bank). Continued CTDs in good weather. No further scrolling problems. Argo float deployment after station IB10

**Wednesday 24 May (144):** Continue with CTDs, deployed Argo floats after station IB12A. Good weather means that progress is also good.

**Thursday 25 May (145):** Continue with CTDs with excellent weather conditions.

**Friday 26 May (146):** CTDs over night as we worked towards Iceland. EEL seaglider (Bowmore) recovered just before 0800, final three CTD stations in foggy conditions. Section completed 1400. Proceeded to open water for airflow distortion experiments.

**Saturday 27 May (147):** Pilot at 1000, alongside at 1100, Reykjavik, Iceland. Tidying, packing, finishing data processing, cleaning labs and cabins.

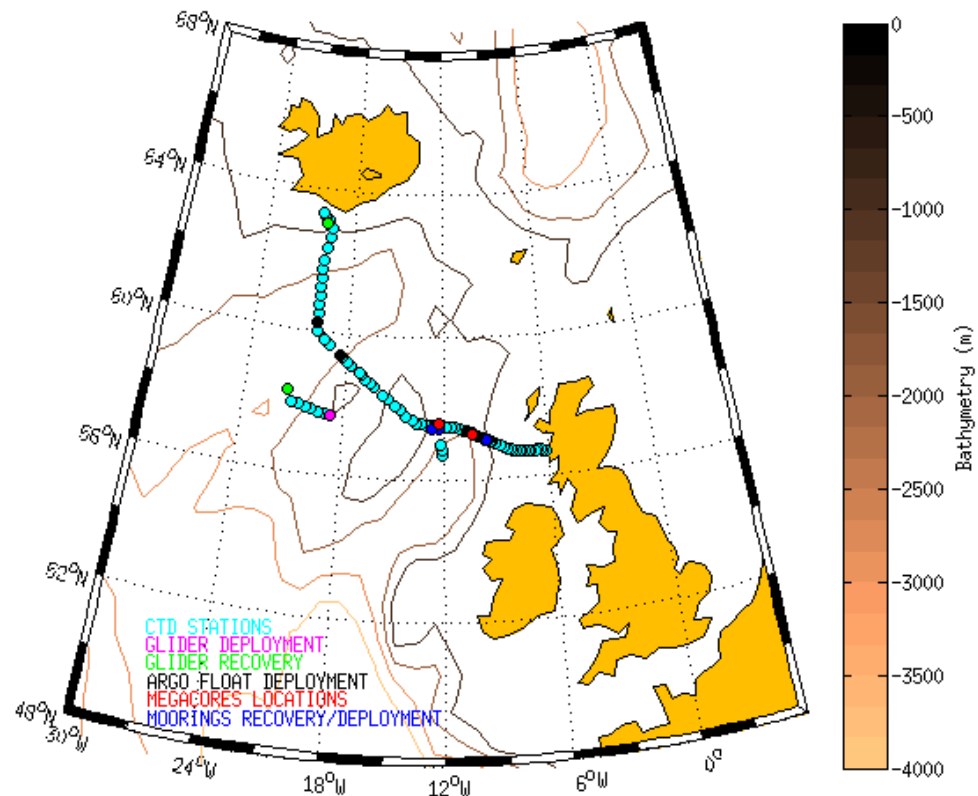
**Sunday 28 May (148):** Scientists and technicians left the ship. Giulia La Bianca stayed on the ship for continued seabird and marine mammal observations during the 5 day passage back to Southampton.

### 3. Station map and table

*Penny Holliday and Angelina Smilenova*

The order of work was as follows:

- i) Steam from Southampton towards the moorings on the western side of the Rockall Trough. Carry out a test CTD station in daylight in deep water, followed by a couple of casts for mooring release tests and microcat calibrations.
- ii) Recover and re-deploy the OSNAP moorings working from west to east
- iii) Steam to eastern end of Ellett Line CTD section and work the stations westwards towards Iceland. Sediment cores were taken in the central Rockall Trough
- iv) Glider operations in Rockall-Hatton Basin and just south of Iceland.



*Figure 3.1 DY078 CTD stations and other operations*





063	17/05/23	1610	59	20.04	N	18	13.86	W	1846	1838	9	0	1840	1863	17	14	14	14	0	10	IB9	
064	17/05/23	1904	59	24.02	N	18	24.91	W	2398	2388	10	-0	2390	2424	17	15	15	15	0	13	IB10	Argo8073
065	17/05/24	0017	59	40.02	N	19	07.00	W	2669	2661	9	1	2660	2703	20	17	17	17	0	13	IB11	
066	17/05/24	0432	59	48.61	N	19	29.97	W	2704	2695	9	0	2694	2739	17	17	17	17	0	0	IB11A	
067	17/05/24	0913	60	00.01	N	19	59.98	W	2717	2707	10	0	2708	2751	20	17	16	17	0	18	IB12	
068	17/05/24	1331	60	14.95	N	19	59.48	W	2641	2632	10	0	2630	2673	17	17	17	17	0	0	IB12A	Argo8072
069	17/05/24	1739	60	30.10	N	19	59.97	W	2523	2515	9	1	2515	2554	20	17	17	17	0	10	IB13	
070	17/05/24	2145	60	45.03	N	19	59.98	W	2361	2353	9	1	2355	2389	16	16	16	16	0	0	IB13A	
071	17/05/25	0134	61	00.08	N	19	59.87	W	2396	2390	7	1	2390	2426	19	16	16	0	0	0	IB14	
072	17/05/25	0545	61	15.12	N	20	00.05	W	2371	2362	10	1	2363	2398	19	13	15	15	0	10	IB15	
073	17/05/25	0943	61	29.99	N	19	59.86	W	2215	2207	9	1	2210	2241	18	14	14	14	0	10	IB16	
074	17/05/25	1328	61	45.02	N	19	59.96	W	1792	1779	14	1	1780	1804	17	0	13	14	0	10	IB16A	
075	17/05/25	1651	62	00.01	N	20	00.06	W	1799	1788	12	1	1790	1813	20	0	12	11	0	15	IB17	
076	17/05/25	2048	62	20.04	N	19	50.08	W	1793	1783	11	0	1785	1808	18	0	12	12	0	9	IB18S	
077	17/05/26	0046	62	40.04	N	19	40.19	W	1675	1666	10	1	1667	1689	12	0	11	11	0	0	IB19S	
Glider recovery 2																						
078	17/05/26	0405	62	55.04	N	19	33.14	W	1399	1390	9	1	1390	1409	14	0	11	11	0	13	IB20S	
079	17/05/26	0916	63	07.97	N	19	54.95	W	1039	1030	9	1	1029	1043	15	0	10	10	0	9	IB21S	
080	17/05/26	1147	63	12.97	N	20	03.96	W	664	655	10	1	656	662	8	0	0	7	0	0	IB22S	
081	17/05/26	1350	63	19.07	N	20	13.07	W	125	118	8	0	115	119	6	0	0	6	0	0	IB23S	End EEL

## **4. NMF-SS CTD and LADCP Operations**

*Dave Childs and Jon Short*

### **4.1 Introduction and Overview**

All CTD casts were undertaken with the stainless steel CTD frame and used 10l Niskin water samplers throughout. Before the start of the cruise the onboard CTD package was upgraded with additional sensors, these changes mainly consisted of adding an additional Sea-Bird 43 Oxygen sensor, the fitting of a Sea-Bird 35 temperature sensor and the fitting of two LADCP's and associated battery pack.

A Sea-Bird 35 Temperature sensor was installed on the 9Plus underwater unit with the sensor tip mounted as close as possible to the Sea-Bird 3P temperature sensor also installed on the 9Plus. A cable connected the Sea-Bird 35 to both the 9Plus and also to the Sea-Bird 32 Carousel. With this arrangement it is possible for the Sea-Bird 35 to trigger sampling once a bottle fire command has been detected, and to also download the data at the end of the cast using the Sea-Bird 11 Plus CTD Deck Unit and Sea-Bird Seaterm software.

An additional Sea-Bird 43 Oxygen sensor was installed on the vane and was connected to the V1 channel of the 9Plus underwater unit. Also housed on the vane were the secondary Sea-Bird 3P temperature and 4C conductivity sensors.

For each deployment the crew directed all deck operations and drove the winch, lines were attached to the frame to steady the package whilst it was either lifted off the deck overboard, or lifted on deck inboard. Crew deployed the package requiring little input from technician on watch. Once in the water, the crew lowered the package to an initial depth of 10m, allowing the Sea-Bird 5T pumps to prime and start operating, once this had occurred for most casts, and where weather allowed, the package was raised to near the surface then lowered to a depth given by the technician in the lab.

A keen eye was kept on the altimeter when approaching the bottom, and instructions were given to the crew with regards to how much wire to pay out until the package was as close to the bottom as possible, typically 10m off.

Input from the scientific party dictated the required bottle stops, and the number of bottles to fire at each depth.

Upon completion of the cast the package was either landed and secured on deck for the scientists to commence sampling, or moved into the hanger and stowed in the CTD deck plate. Due to the configuration of the lifting hoist and slow operating speed, this typically added a 10 minute delay to the scientists before they were able to start their sampling.

For longer steaming periods between stations sensors were flushed with MilliQ to reduce the risk of salt crystals forming in the sensors and associated tubing.

## 4.2 Sensors Used

Table 4.1 gives details of all of the sensors and instruments as used on the CTD system for the duration of the cruise. Fortunately, all sensors worked as expected and there were no failures. On cast 068 at approximately 2000m depth an anomaly in the secondary conductivity sensor occurred, however after 200m the sensor returned to normal, matching the primary sensor, the most likely cause would be a small temporary blockage in the conductivity sensor tubing.

*Table 4.1 DY078 CTD sensors and instruments*

<b>Instrument / Sensor:</b>	<b>Model:</b>	<b>Serial No:</b>	<b>Channel:</b>
Primary CTD deck unit	SBE 11plus	11p-0676	N/A
CTD Underwater Unit	SBE 9plus	09p-0943	N/A
Stainless steel 24-way frame	NOCS	SBE CTD1	N/A
Primary Temperature Sensor	SBE 3P	3p-2674	F0
Primary Conductivity Sensor	SBE 4C	4c-2571	F1
Digiquartz Pressure sensor	Paroscientific	110557	F2
Secondary Temperature Sensor	SBE 3P	3p-4383	F3
Secondary Conductivity Sensor	SBE 4C	4c-2580	F4
Primary Pump	SBE 5T	05-3085	N/A
Secondary Pump	SBE 5T	05-7371	N/A
24-way Carousel	SBE 32	32-0423	N/A
Dissolved Oxygen Sensor	SBE 43	43-1624	V0
Dissolved Oxygen Sensor	SBE 43	43-2575	V1
Altimeter	Benthos 916T	59494	V2
Light Scattering Sensor	WETLabs BBRTD	BBRTD-169	V3
PAR Up-looking DWIRR	Biospherical QCP Cosine PAR	70510	V4
PAR Down-looking UWIRR	Biospherical QCP Cosine PAR	70520	V5
Fluorometer	CTG Aquatracka MKIII	88-2615-126	V6
Transmissometer	WET Labs C-Star	1602TR	V7
10L Water Samplers	OTE	1-24	N/A
LADCP (Master)	TRDI WorkHorse Monitor 300kHz	13329	N/A
LADCP (Slave)	TRDI WorkHorse Monitor 300kHz	4275	N/A
Deep Ocean Standards Thermometer	SBE 35	0048	N/A

## 4.3 LADCP Operation

For this cruise two LADCP's were fitted to the CTD frame and used in a master and slave configuration. A master LADCP was fitted to the bottom of the CTD frame in a downward looking orientation whilst a slave LADCP was fitted to the side of the CTD frame in an upward looking orientation.

A battery pack was also fitted to the CTD frame and was used to power both LADCP's during deployments.

A star cable connected each LADCP to the battery pack, supplying power as well as providing a connection point for the deck cable which was used for the programming and subsequent downloading of the LADCP's as well as for charging the battery pack.

Prior to each deployment, a series of tests were run on each LADCP to check correct operation, these tests were logged to a capture file for each instrument and for each cast.

Two script files programmed the LADCP's to operate in a master / slave configuration, and set the instruments to sample as per the scientific party's requirements, these commands are detailed below:

Master:	Slave:
<b>WV250</b>	WV250
<b>WN25</b>	WN25
<b>WS1000</b>	WS1000
<b>WF0</b>	WF800
<b>WB1</b>	WB1
<b>EZ0011101</b>	EZ0011101
<b>EX00100</b>	EX00100
<b>WP1</b>	WP1
<b>TP 00:00.90</b>	TP 00:00.00
<b>TE 00:00:01.50</b>	TE 00:00:01.50
<b>CF11101</b>	CF11101
<b>SM1</b>	SM2
<b>SA011</b>	SA011
<b>SW5500</b>	ST120
<b>RNmast_</b>	RNslav_
<b>CK</b>	CK
<b>W?</b>	W?
<b>T?</b>	T?
<b>CS</b>	CS

Upon recovery of the CTD the deck cable was attached to the LADCP cable on the frame, BBTalk was then used to stop the LADCP's logging, and to download the cast data. Once completed, the data was checked using WinADCP to ensure all the beams aligned correctly, and to check the master and slave start times correlated.

#### **4.4 CTD Sea-Bird Processing**

Immediately after each cast the raw data was backed up to the network drive, to reduce the risk of data loss and to make the data available to the scientific party.

Basic Sea-Bird processing of the raw data then took place using Sea-Bird Data Processing software. Following input from the scientific party, three processing steps were completed for each cast, these being Data Conversion, Align CTD and Cell

Thermal Mass. No other processing steps were required, so once these three had been completed the processed data files were backed up to the network drive.

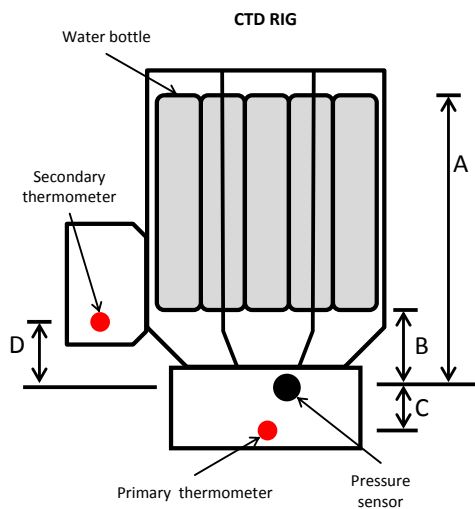
To download the Sea-Bird 35 data, Sea-Bird SeaTerm was used to connect to the sensor. A capture file was created, taking the form CTDXXX\_DATA and the command DD was issued to instigate the download process. Once complete and backed up, the command samplenum=0 was issued to clear the memory of the SBE 35 ready for the next cast.

#### 4.5 Software Used

Sea-Bird SeaTerm 1.59  
 Sea-Bird Seasave 7.26.2.13  
 RD Instruments BBTalk 3.06  
 RD Instruments WinADCP 1.13

TOTAL WIRE  
 184536 m  
 HAUL / VEER  
 184.54 km

#### 4.6 CTD Package Geometry



ID	Vertical distance from pressure sensor (m)
A	1.5
B	0.3 s/s system (with 10L samplers)
C**	0.07
D	0.00

\*\*NOTE: C & D may be minimal.

## 4.7 CTD Configuration Used

Listed below are the contents of the configuration file as used for all casts completed on the cruise, as saved in the Sea-Bird configuration file DY078\_SS.xmlcon.

```
s<?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>1</NmeaTimeAdded>
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        <TemperatureSensor SensorID="55" >
          <SerialNumber>03P-2674</SerialNumber>
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          <C>0.00000000e+000</C>
          <D>0.00000000e+000</D>
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          <G>4.35704908e-003</G>
          <H>6.42890429e-004</H>
          <I>2.39495498e-005</I>
          <J>2.41492992e-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-2571</SerialNumber>
          <CalibrationDate>17-Sept-2015</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>-9.93506765e+000</G>
            <H>1.54127601e+000</H>
            <I>1.31909516e-004</I>
            <J>9.53663714e-005</J>
            <CPcor>-9.57000000e-008</CPcor>
          </Coefficients>
        </ConductivitySensor>
      </Sensor>
    </SensorArray>
  </Instrument>
</SBE_InstrumentConfiguration>
```

```

        <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>110557</SerialNumber>
    <CalibrationDate>3-Nov-2016</CalibrationDate>
    <C1>-6.010548e+004</C1>
    <C2>-1.565601e+000</C2>
    <C3>1.823090e-002</C3>
    <D1>2.668300e-002</D1>
    <D2>0.000000e+000</D2>
    <T1>3.020528e+001</T1>
    <T2>-6.718318e-004</T2>
    <T3>4.457980e-006</T3>
    <T4>1.203850e-009</T4>
    <Slope>0.99999952</Slope>
    <Offset>-0.09301</Offset>
    <T5>0.000000e+000</T5>
    <AD590M>1.280700e-002</AD590M>
    <AD590B>-9.299640e+000</AD590B>
  </PressureSensor>
</Sensor>
<Sensor index="3" SensorID="55" >
  <TemperatureSensor SensorID="55" >
    <SerialNumber>03P-4383</SerialNumber>
    <CalibrationDate>17-Feb-2016</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>4.39869867e-003</G>
    <H>6.55422307e-004</H>
    <I>2.42112171e-005</I>
    <J>2.00242732e-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-2580</SerialNumber>
    <CalibrationDate>18-Feb-2016</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>-1.04721262e+001</G>
      <H>1.53914981e+000</H>
      <I>5.50311670e-004</I>
      <J>4.36265174e-005</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>43-2818</SerialNumber>
    <CalibrationDate>28 July 2016</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>4.6240e-001</Soc>
      <offset>-0.5009</offset>
      <A>-4.5114e-003</A>
      <B> 2.4363e-004</B>
      <C>-3.6665e-006</C>
      <D0> 2.5826e+000</D0>
      <D1> 1.92634e-004</D1>
      <D2>-4.64803e-002</D2>
      <E> 3.6000e-002</E>
      <Tau20> 1.5400</Tau20>
      <H1>-3.3000e-002</H1>
      <H2> 5.0000e+003</H2>
      <H3> 1.4500e+003</H3>
    </CalibrationCoefficients>
  </OxygenSensor>
</Sensor>
<Sensor index="6" SensorID="38" >
  <OxygenSensor SensorID="38" >
    <SerialNumber>43-2575</SerialNumber>
    <CalibrationDate>30 August 2016</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>4.4360e-001</Soc>
      <offset>-0.4749</offset>
      <A>-4.4596e-003</A>
      <B> 2.7428e-004</B>
      <C>-3.8655e-006</C>
      <D0> 2.5826e+000</D0>
      <D1> 1.92634e-004</D1>
      <D2>-4.64803e-002</D2>
      <E> 3.6000e-002</E>
      <Tau20> 1.5700</Tau20>
      <H1>-3.3000e-002</H1>

```



```

        <H2> 5.0000e+003</H2>
        <H3> 1.4500e+003</H3>
    </CalibrationCoefficients>
</OxygenSensor>
</Sensor>
<Sensor index="7" SensorID="0" >
  <AltimeterSensor SensorID="0" >
    <SerialNumber>59494</SerialNumber>
    <CalibrationDate></CalibrationDate>
    <ScaleFactor>15.000</ScaleFactor>
    <Offset>0.000</Offset>
  </AltimeterSensor>
</Sensor>
<Sensor index="8" SensorID="70" >
  <TurbidityMeter SensorID="70" >
    <SerialNumber>169</SerialNumber>
    <CalibrationDate>08-Sept-2016</CalibrationDate>
    <ScaleFactor>5.228e-003</ScaleFactor>
    <!-- Dark output -->
    <DarkVoltage>8.900e-002</DarkVoltage>
  </TurbidityMeter>
</Sensor>
<Sensor index="9" SensorID="42" >
  <PAR_BiosphericalLicorChelseaSensor SensorID="42" >
    <SerialNumber>70510</SerialNumber>
    <CalibrationDate>24-Jan-2017</CalibrationDate>
    <M>1.00000000</M>
    <B>0.00000000</B>
    <CalibrationConstant>20449897800.00000000</CalibrationConstant>
    <Multiplier>1.00000000</Multiplier>
    <Offset>-0.04979765</Offset>
  </PAR_BiosphericalLicorChelseaSensor>
</Sensor>
<Sensor index="10" SensorID="42" >
  <PAR_BiosphericalLicorChelseaSensor SensorID="42" >
    <SerialNumber>70520</SerialNumber>
    <CalibrationDate>24-Jan-2017</CalibrationDate>
    <M>1.00000000</M>
    <B>0.00000000</B>
    <CalibrationConstant>16835016800.00000000</CalibrationConstant>
    <Multiplier>1.00000000</Multiplier>
    <Offset>-0.06092372</Offset>
  </PAR_BiosphericalLicorChelseaSensor>
</Sensor>
<Sensor index="11" SensorID="71" >
  <WET_LabsCStar SensorID="71" >
    <SerialNumber>CST-1602DR</SerialNumber>
    <CalibrationDate>24-May-2016</CalibrationDate>
    <M>2.1304</M>
    <B>-0.1065</B>
    <PathLength>0.250</PathLength>
  </WET_LabsCStar>
</Sensor>
<Sensor index="12" SensorID="5" >
  <FluoroChelseaAqua3Sensor SensorID="5" >
    <SerialNumber>88-2615-126</SerialNumber>
    <CalibrationDate>22-July-2016</CalibrationDate>
    <VB>0.210900</VB>
    <V1>2.156000</V1>
    <Vacetone>0.303700</Vacetone>
    <ScaleFactor>1.000000</ScaleFactor>
    <Slope>1.000000</Slope>
    <Offset>0.000000</Offset>
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</Sensor>
</SensorArray>
</Instrument>
</SBE_InstrumentConfiguration>

```

## **5. NMF-SS Ships Systems**

*Zoltan Nemeth*

### **5.1 Equipment**

The equipment deployed is as follows:

#### *Networking:*

Servers, Computers, Displays, Printers,, Network Infrastructure  
A public network drive for scientists, updated via Syncback

#### *Datasystems:*

IFREMer TechSAS logged data and converted it to NetCDF format  
NetCDF Format given in: dy078\_netcdf\_file\_descriptions.docx  
Logged Instruments given in: dy078\_instrument\_logging.docx  
Data was also logged to NERC/RVS Level-C format, also described in:  
dy078\_netcdf\_file\_descriptions.doc  
NERC software: Level-A, Level-C; SurfMet Python; CLAM 2014; SSDS3;  
Near\_real\_time  
Olex

#### *Hydroacoustics*

Kongsberg echosounders (EM122, EA640, SBP120, OS75, OS150)

#### *Telecommunications*

GPS & DGPS (POS MV, PhINS; KB Seapath 330; CNAV 3050, Fugro Seastar)  
OceanWaves WaMoS II Wave Radar  
DartCom Polar Ingester  
NESSCo V-Sat; Thrane & Thrane Sailor 500 Fleet BroadBand

#### *Instrumentation*

SWS Underway & Met Platform instrumentation

### **5.2 Requested Services**

150 kHz hull mounted ADCP system  
75 kHz hull mounted ADCP system  
EM122 multi-beam echosounder  
Meteorology monitoring package  
Pumped sea water sampling system  
Sea surface monitoring system  
Ship scientific computing systems

### **5.3 Data Acquisition Performance**

All times given are in UTC.

#### *Ship Scientific Datasystems*

Data was logged and converted into NetCDF file format by the TechSAS 5.11 datalogger.

The format of the NetCDF files is given in the folder:  
Cruise\_Documentation/Data\_Description\_Documents.  
The instruments logged are given in dy078\_ship\_instrumentation\_overview.docx.  
Data was additionally logged in the RVS Level-C format.

### Position & Attitude

The main GNSS and attitude measurement system, Applanix POS MV was run throughout the cruise.

### *Kongsberg Seapath 330*

The Seapath is the vessel's primary GPS, it outputs the position of the ship's common reference point in the gravity meter room. Seapath position and attitude was used by the EM710, EM122 and SBP120.

Time gaps:

time gap : 17 127 17:38:59 to 17 127 17:39:41 (42 s)

time gap : 17 134 17:50:22 to 17 134 18:09:07 (18.8 mins)

time gap : 17 136 07:22:56 to 17 136 07:50:39 (27.7 mins)

time gap : 17 138 03:57:08 to 17 138 06:12:38 (2.3 hrs)

### *Applanix POSMV*

The POSMV is the secondary scientific GPS, and is used on the SSDS displays around the vessel.

### *PhINS*

PhINS supplies the ADCP OS75 and OS150 with position and attitude data.

### Instrumentation

#### *SurfMet*

Following changes to the serial connections, SurfMet ran without any problems. dy078\_surfmet\_sensor\_information.docx for details of the sensors used and the calibrations that need to be applied.

Calibration sheets are included in the directory:

`\ship_fitted_scientific_systems\SurfMet\SurfMet_calibration_sheets\fitted\`

Data is available in NetCDF in: `\ship_fitted_scientific_systems\TechSAS\SURFM`

The non-toxic water supply was active from 201705061300 to 20170527060000

There is temporarily switched off between 20170515 14:00 to 14:15 (15mins)

#### *SurfMet: Surface Water System*

The system operated normally throughout the majority of the cruise.

#### *SurfMet: Met Platform System*

No problems.

#### *SurfMet Python*

No problems.

#### *WaMoS II Wave Radar*

Not requested, but logged locally. The faulty HP Compaq 6800 PC replaced with a HP Compaq 6300 PC an incorrect setting in the Moxa corrected it.

Some data was logged, but I'm not sure of the quality of it. When data is logged, a summary of its output is given in the **PARA\*.ems** files.

### *Gravity Meter*

S-084 installed on the ship for this cruise and operated normally through the cruise with levelA the TechSAS module only logged the pseudo NMEA message not the NetCDF.

On 2017.05.16 jd136 at 19:06 gravimeter clamped because the bad weather, unclamped on 2017.05.18 at 06:00.

On 2017.05.20 jd140 at 15:48 gravimeter clamped because the bad weather, unclamped on 2017.05.23 at 14:15.

On 2017.05.26 jd146 at 16:32 gravimeter clamped.

### *Hydroacoustics*

Generally worked well. Data is available in: \ship\_fitted\_scientific\_systems\acoustics

### *Kongsberg EA640*

10kHz run; 12kHz run for a passive mode.

2017.05.26 about 09:30 during the CTD cast the engineers lift off the drop-keel the data collection stopped temporary. Later the drop-keel set back to flush with previous position.

### *Kongsberg EM122*

See table 5.1

*Table 5.1 EM122 Swath bathymetry surveys*

startdate	start JD	start time	sounder	survey name	draught	motion	motion Z pos	water line	Cell size	Total LogTime h:m:s	Lines
2017.05.06	126	08:30	EM122	Dy078-em122-soton-to-heb	6.6	Seapath 330	9.264	1.34	6.0	51:13:29	22
2017.05.08	128	13:19	EM122	Dy078-em122-002	6.6	Seapath 330	9.264	1.34	30.0	127:37:01	92
2017.05.14	134	09:04	EM122	Dy078-em122-eelt-from-1g	6.6	Seapath 330	9.264	1.34	30.0	163:04:26	102
2017.05.21	141	05:21	EM122	Dy078 em122 osnap-o1-to-o7	6.6	Seapath 330	9.264	1.34	63.0	19:40:51	18
2017.05.22	142	07:43	EM122	dy078 em122 hatton_bank-to-iceland	6.6	Seapath 330	9.264	1.34	65.0	104:29:11	64
2017.05.26	146	16:15	EM122	Dy078 em122 surtsey to reykjavik	6.6	Seapath 330	9.264	1.34	10.0	12:38:42	7

### *Sound Velocity Profiles*

Used manual setting of 1500m/s in the swathe and before the first profile taken off from the CTD data the surface sensor used.

Table 5.2 Sound velocity profiles used for EM122

date	stn	cast number	time in water	time at bottom	pos at bottom	time on deck	max depth (m)	Water depth (m)	SVP
17129	CTD002	CTD002	09:14	09:55	56.50.98°N, 012°05.70W	14:15	2000	2236	from CTD
17136	N	CTD027	13:27	14:33	57°13.99N, 010°02.95W	16:56	2090	2110	from CTD
17140	IB4C	CTD050	19:19	19:58	58°45.28N, 016°44.96W	20:37	1150	1167	from CTD
15141	O1	CTD053	11:00	11:21	57°40.03N, 018°42.03W	11:59	700	717	From CTD
15141	O3	CTD055	17:04	17:27	57°45.68N, 019°29.73W	18:04	980	996	From CTD
15142	O6	CTD058	03:29	04:18	57°54.38N, 020°41.02W	05:26	2125	2146	From CTD
15143	IB8	CTD062	12:35	13:09	59°12.02N, 017°52.92W	13:54	1515	1525	From CTD
15145	IB16	CTD073	08:54	09:42	61°29.98N, 019°59.86W		2209	2234	From CTD

*Teledyne RDI Ocean Surveyor ADCPs*

ADCPs received data from the iXBlue PhINS system. There are no faults on the VMADCPs or K-Sync. Data recorded before between 20170506 and 20170508 may be suboptimal, and optimal after 20150509.

*Ocean Surveyor 75kHz*

No faults.

Data available at: \ship\_fitted\_scientific\_systems\acoustics\OS75kHz

From 20150506, I switched to Narrowband Mode, 100 Bins, 16m Bin Size and 8m Blanking Distance.

It is best used with narrowband in deeper water between 400m and 1200m depth. Crossing the shelf edge, there was limited data until the depth reduced to less than 1000m. Bottom tracking performed fine in the depths <500m.

The ship navigational echosounder GDS102 operational frequency is 50kHz caused some interference occasionally.

Table 5.3 OS75 surveys

nm	on date	on time	off date	off time	ens	pings /en	mode	remarks
1	20170506	8:06:15	20170506	12:04:17	120	25	BTnosync	first short test
2	20170506	12:05:42	20170506	16:25:43	131	20	BTsync	
3	20170506	16:26:51	20170506	16:26:51	1	2	FAILED	no data in STA
4	20170506	16:29:21	20170506	16:29:21	1	7	FAILED	no data in STA
5	20170506	16:32:03	20170507	5:30:04	390	20	BTsync	
6	20170507	5:31:41	20170507	21:03:47	467	13	BTnosync	datetime added to filename
7	20170508	2:40:02	20170508	10:04:03	223	20	BTnosync	006 crashed restarted at 02:40
8	20170508	10:06:25	20170508	10:06:25	1	8	TEST	test no data in STA 009 skipped
10	20170508	10:07:35	20170508	10:11:38	3	20	TEST	k-sync test
11	20170508	10:18:42	20170508	15:32:45	158	14	BTsync	switched to offshelf mode
12	20170508	15:34:25	20170509	18:26:27	807	33	NOBTsync	

13	20170509	18:28:04	20170510	7:54:06	404	26	NOBTsync	Rockall Through transect 4kn and after 10kn
14	20170510	7:57:00	20170510	11:49:00	117	35	NOBTsync	stopped because mooring recovery
21	20170510	12:05:05	20170511	10:29:07	673	36	NOBTsync	--"
22	20170511	12:27:42	20170511	16:13:44	114	31	NOBTsync	--"
24	20170511	16:21:17	20170511	16:49:19	15	35	NOBTsync	--"
25	20170511	17:49:55	20170512	8:13:57	433	45	NOBTsync	--"
26	20170512	8:20:36	20170512	11:16:38	89	34	NOBTsync	--"
27	20170512	14:41:06	20170513	11:17:10	619	41	NOBTsync	ADCP survey Rockall Through 5kn
28	20170513	12:30:59	20170513	19:49:02	220	32	BTsync	--"
29	20170513	20:18:15	20170514	18:16:20	660	13	BTsync	switched to bottom tracking mode
30	20170514	18:19:03	20170515	17:53:06	708	14	BTsync	--"
31	20170515	17:54:12	20170516	6:02:18	365	14	BTsync	--"
32	20170516	6:04:07	20170517	18:56:09	1107	41	NOBTsync	switched to no bottom tracking mode
33	20170517	18:57:34	20170519	7:45:35	1105	40	NOBTsync	--"
34	20170519	7:47:35	20170520	6:57:35	696	40	NOBTsync	--"
35	20170520	6:58:08	20170521	11:58:10	871	40	NOBTsync	Hatton Bank
36	20170521	12:00:05	20170522	6:14:08	548	41	NOBTsync	Hatton Bank
37	20170522	6:14:48	20170523	7:58:49	773	40	NOBTsync	Hatton Bank - IB6
38	20170523	7:59:04	20170524	6:09:04	666	41	NOBTsync	IB6 - IB11A
39	20170524	6:10:40	20170525	6:10:41	721	41	NOBTsync	IB12 - IB15 EK60 running: ens:136-185 and 270-300
40	20170525	6:11:05	20170526	6:23:06	727	40	NOBTsync	IB16 - IB20S
41	20170526	6:24:06	20170526	14:24:07	241	41	NOBTsync	IB21S - IB23S last one
42	20170526	14:26:01	20170527	5:30:02	453	40	NOBTsync	dy078 last ensembles

*Ocean Surveyor 150kHz*

No faults.

Data available at: \ship\_fitted\_scientific\_systems\acoustics\OS150kHz

Bottom tracking did not perform well in >500m depths, reporting false shallow depths so off shelf changed to non bottom tracking mode.

*Table 5.4 OS150 surveys*

nm	on date	on time	off date	off time	ens	ping s/en	mode	remarks
1	20170506	8:04:13	20170506	12:08:14	123	38	BTnosync	first test
2	20170506	12:16:05	20170506	16:24:08	125	34	BTsync	
3	20170506	16:26:00	20170507	5:28:02	392	30	BTsync	
4	20170507	5:30:11	20170508	10:04:15	858	20	BTsync	
5	20170508	10:06:43	20170508	15:08:46	152	20	BTsync	changed to offshelf mode
6	20170508	15:09:45	20170509	18:27:45	820	41	NOBTsync	
7	20170509	18:28:00	20170510	7:54:02	404	50	NOBTsync	Transect Rockall Through 4kn and

								after back 10kn
8	20170510	7:57:18	20170510	11:49:19	117	36	NOBTsync	data collection stopped because mooring recovery
9	20170510	11:52:04	20170511	10:28:04	679	43	NOBTsync	--"--
11	20170511	12:28:18	20170511	16:14:20	114	55	NOBTsync	--"--
13	20170511	16:21:19	20170511	16:49:19	15	42	NOBTsync	--"--
15	20170511	17:51:05	20170512	8:15:06	433	44	NOBTsync	--"--
16	20170512	8:20:29	20170512	11:16:30	89	41	NOBTsync	--"--
17	20170512	14:41:06	20170513	11:17:09	619	60	NOBTsync	Survey Rockall Through 5kn
18	20170513	12:31:08	20170513	19:49:09	220	42	NOBTsync	--"--
25	20170513	20:19:59	20170514	18:16:00	659	20	BTsync	switched to bottom tracking mode Nav. echosounder OFF
26	20170514	18:19:09	20170515	17:53:10	708	20	BTsync	--"--
27	20170515	17:54:10	20170516	6:02:14	365	20	BTsync	--"--
28	20170516	6:06:03	21070517	18:56:04	110 6	60	NOBTsync	switched to no bottom tracking mode
29	20170517	18:57:30	20170519	7:45:31	110 5	60	NOBTsync	--"--
30	20170519	7:47:46	20170520	6:57:46	696	61	NOBTsync	--"--
31	20170520	6:58:09	20170521	11:58:10	871	61	NOBTsync	Hatton Bank
32	20170521	11:59:52	20170522	6:13:52	548	61	NOBTsync	Hatton Bank
33	20170522	6:14:46	20170523	7:58:47	773	60	NOBTsync	Hatton Bank IB6
34	20170523	7:59:05	20170524	6:09:05	666	60	NOBTsync	IB6 - IB11A
35	20170524	6:10:45	20170525	6:10:45	721	60	NOBTsync	IB12 -IB15 EK60 running: ens:136-185 and 270-300
36	20170525	6:11:02	20170526	06:23:03	727	60	NOBTsync	IB16 - IB20S
37	20170526	6:24:19	20170526	14:24:19	241	60	NOBTsync	IB21S - IB23S last one!
42	20170526	14:27:33	20170527	5:07:34	441	61	NOBTsync	Last ensembles.

## **6. OSNAP Moorings**

### **8.1 Mooring Operations**

*Rob Mclachlan*

Mooring operations on deck were carried out using a combination of the double capstan barrel winch system and the aft pedestal cranes. A reeler positioned forward of the double barrel capstan is used to store wires under a constant tension. The wires lead from the reeler to the double barrel capstan drums, and from there the wires pass through a deck-mounted sheave and finally through a block hanging from the aft crane.

This method of recovery and deployment has been well proven and offers a safe and effective solution with the block on the crane offering maximum flexibility for handling packages over the transom. With multiple buoyancy/instrumentation packages in close configuration then both aft cranes can be employed.

An example of this being the top of mooring EB1, where the Remote Access Sampler (RAS) frame and the buoyancy package are both large and close to each other. A deck stopper, bolted to the deck with a length of chain, is used to transfer the outboard load to the deck enabling the instrument and buoyancy packages to be connected (or disconnected for recoveries) to the mooring.

The deployment method for these moorings was the anchor last method. The top of the mooring being deployed first and as the ship makes a slow steam ahead the rest of the mooring is deployed up to the anchor. The 5T deck winch is then used in conjunction with a Sea Catch release hook to deploy the anchor when on position. Two of the moorings underwent a design change for this year's deployment. EB1 has been extended to 50m from the surface and has the addition of the RAS sampler and ODO SBE 37's. WB1 has also been extended to 50m from the surface with an additional SBE 37.



## 6.2 Mooring Recoveries

*Stuart Cunningham*

Instrumentation and hardware deployed on DY053 in 2016 that were not recovered include part of RTEB1\_03\_2016, and RTADCP\_1\_03\_2016 (Table 8.1). Trawling activity separated the upper 500m of mooring RTEB1\_03\_2016, which drifted free and was lost. RTADCP1\_03\_2016 was not recovered. The SBE37 microcats and Nortek Aquadopps that were recovered all returned complete records.

*Table 6.1: Instruments and hardware not recovered on DY078.*

<b>Instrument</b>	<b>Serial number</b>	<b>Owner</b>	<b>Mooring</b>
SBE37-SMP	10558	OSNAP	RTEB1_03_2016
Nortek S55	200044	OSNAP	RTADCP1_03_2016
Deepwater Buoyancy AL500	AL500_4	OSNAP	RTADCP1_03_2016
Remote Head Iridium Beacon	M019AZ. IMEI: 300434060852640	OSNAP	RTADCP1_03_2016
Remote Head Light	D01-008	OSNAP	RTADCP1_03_2016
Ixsea Oceano A/R 861	1763	OSNAP	RTADCP1_03_2016
Ixsea Oceano A/R 861	1502	NMEP	RTADCP1_03_2016

### RTWB1\_03\_2016

Recovered successfully.

### RTWB2\_03\_2016

Recovered successfully.

### RTEB1\_03\_2016

The mooring was deployed on 3/7/16 (DY053).

Iridium reports from the beacon in the 31'' syntactic were first received on 29/3/17 indicating that this part of the mooring was on the surface. We tracked the drifting mooring for five days (Figure 8.2) until the 3/4/17 after which no further fixes were received. Storm force conditions on this day are the likely reason for failure of the beacon. Probably it was damaged by chain thrashing in the high sea-state.

Using VMS data from the marinetraffic.com website (Figure 6.1), we clearly identified a fishing vessel traversing the mooring position coincident with time of the first iridium position fixes. This fishing vessel belonged to the Norwegian Blue Whiting fleet. Their activities were being monitored by the Marine Scotland Grey Boats. We contacted them and the Celtic Explorer who was also in the area. Unfortunately none of these vessels were able to help recover the mooring.

On Saturday 20/5/17 (DOY 140) during this cruise an email was received at [found.instrument@sams.ac.uk](mailto:found.instrument@sams.ac.uk) indicating recovery of oceanographic equipment

3.5 nm east of the St. Kilda archipelago (approximately 3.5 nm east of Hirta at 57° 48.4'N, 5° 27.2'W). St. Kilda is 45 nm into the Atlantic from the Sound of Harris. Photographs show clearly this was the upper part of EB1 (pickup, 3x17" glass, Nortek (s/n: 11035), SBE37 (s/n: 9140), 31" syntactic (with light and Iridium beacon) and Nortek (s/n: 9867). Not recovered was the SBE37 (s/n: 10558) at 253 m. This instrument must have been lost when the wire parted. Seamus Morrison recovered the mooring (<http://seaharris.com>) from the vessel "The Enchanted Isle".

On 13/5/17 (DY078) we recovered the remainder of RTEB1. The wire had parted approximately 100m above the 40" syntactic. The jacket was stripped from the wire, probably by trawling wires. It seems likely that trawl wire caught the mooring wire above the 40" syntactic, running up the mooring until it hit the SBE37 MicroCAT at 253 m parting the mooring.

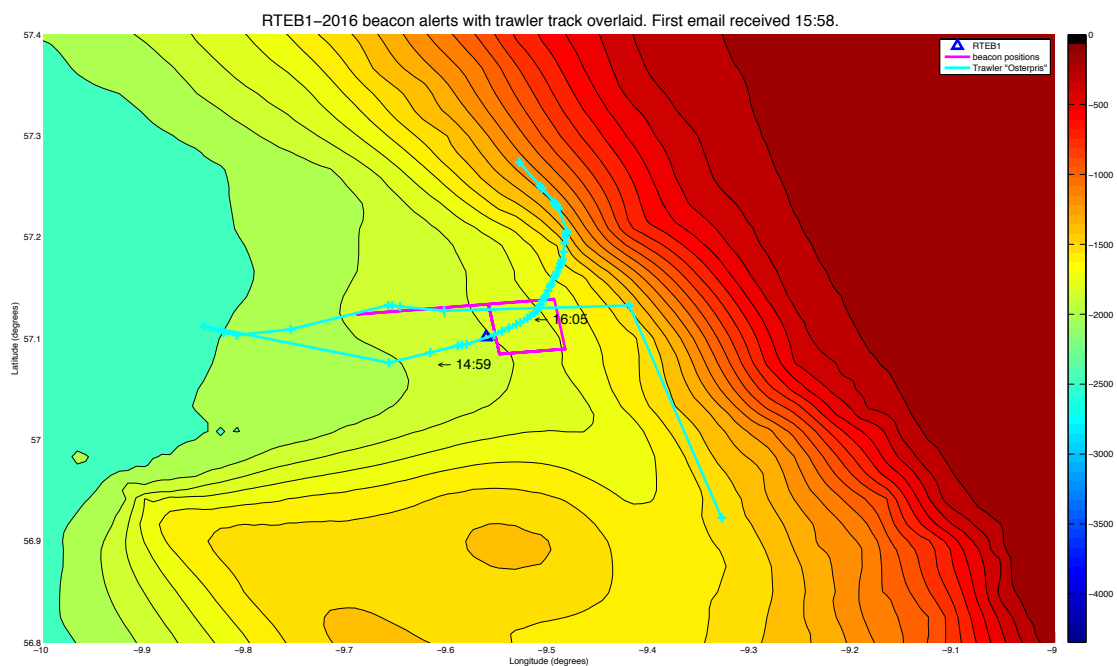


Figure 6.1: VMS positions showing track of trawler "Osterpris" ([marinetraffic.com](http://marinetraffic.com)) passing over the mooring. It looks as though it was deploying gear as it moved onto position for its preferred trawl depth along the depth contours. There are two times shown on the track, and the first beacon alert was received at 15:58, so right between these times. Darren Rayner, April 2017.

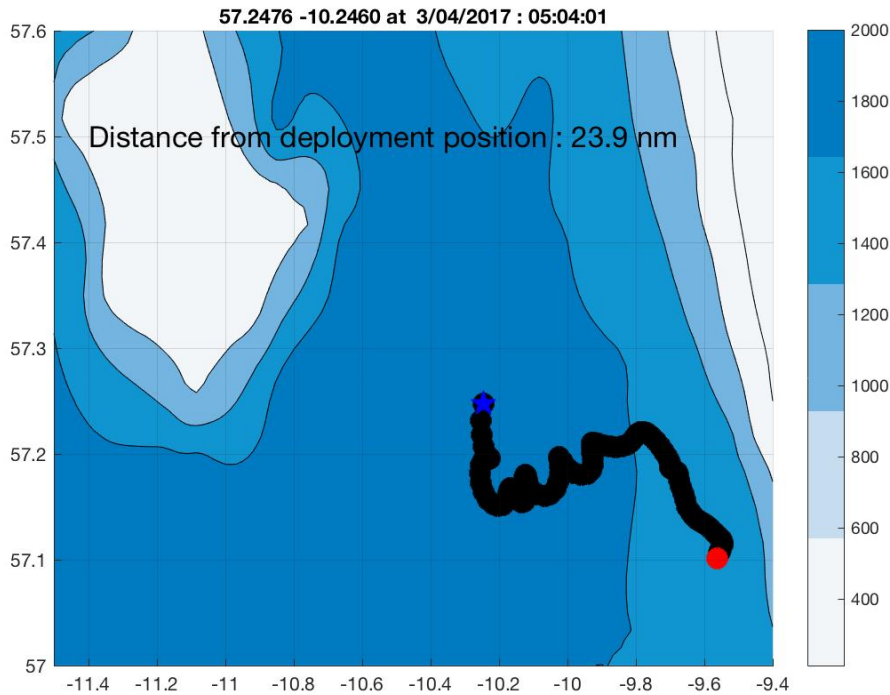


Figure 6.2: Iridium short burst data (SBD) from beacon with IMEI number 300234060471740 (black). Red is the mooring seabed position trilaterated after deployment (3/7/2016; 57° 05.91'N, 09° 33.74'W). First iridium position received at 57.10608°N -9.55638°W on 29/03/2017 at 15:58:01. Blue dot is the last received position at 57.24756N -10.24596W on 3/04/2017 at 05:04:01. Distance from deployment position to last received position is 23.9 nm.

Trilateration of the mooring indicated the remaining mooring was displaced by 28 m (tri\_pos\_rteb1\_recover\_dy078.txt) to the position 57.1016°N, -9.5625°W. Pressure records from the deep microcat (Figure 6.3) indicate a 0.25 dbar decrease in pressure between two sample values to a new mean shallower pressure.

The remaining portion of the mooring was recovered without incident.

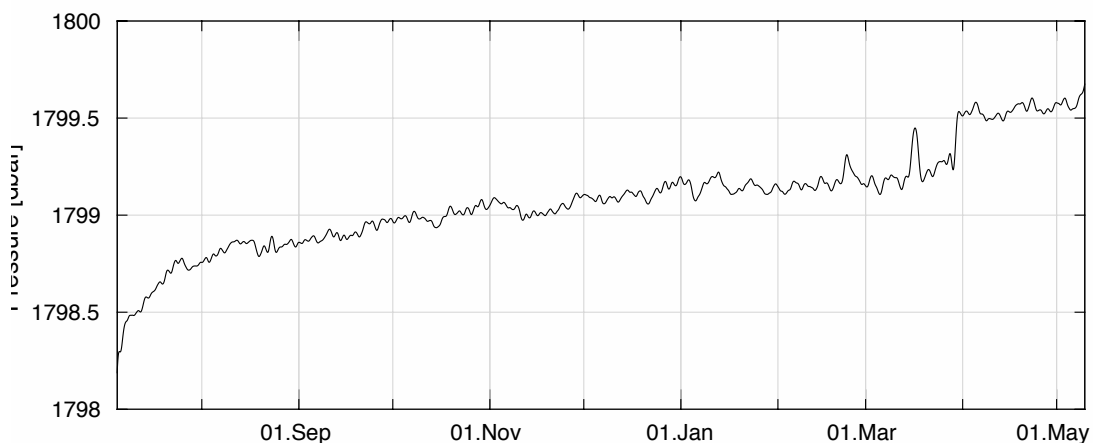


Figure 6.3: Two-day low-pass pressure record from the deepest SBE37 on EB1 (s/n: 11339). The 0.25 dbar step to shallower pressures is obvious at the end of Mar 2017.

RTADCP 03 2016

We arrived on site for recovery on Friday 12/5/17 at 11:27. Consistent ranges and confirmed releases were received from both releases but the ADCP did not leave the sea-bed (see Recovery log-sheet for details). After 100 minutes we concluded the lander was stuck on the sea-bed. We conducted a trilateration. This suggested the lander was 28m from the deployed sea-bed position.

We then left the site to deploy EB1 and returned on 13/5/17 to attempt a drag for this mooring.

The ship setup as shown in Figure 6.4. Two hundred meters of ground line with two grapnels and a weak link were deployed then attached to the deep tow cable. The deep tow cable was paid out until it reached the seabed at approximately 14:15 (Figure 6.5) and was then laid in a loop around the target. Shortly after 16:00 when 4000m of cable were paid out the ship continued to steam slowly. Note from Figure 6.5 that cableout and times are given in Table 6.2 so that the location of the cable on seabed can be judged. While we do not know the true location of the cable or the degree of catenary, the cable reached the seabed by 14:30, had even drag until the point veering was stopped. At this point the cable is likely to have been laid around the target from 1415 to 1600 ticks in Figure 6.4, enclosing the target.

As the ship continued to steam south after 16:10 with cable out constant, cable tension increased steadily then abruptly dropped (Figure 6.5). This perhaps indicates that the cable is dragging across the sea-bed at a tangent to the track line increasing tension. However tension reaches a point when the cable must rapidly change position to reduce tension. Without some means of monitoring the location of the end of the ground line it is difficult to know if this drag intersected the target. At 17:30 the cable out was 3000m, leaving maximum of 2000m on the seabed. From Figure 6.5 it can be appreciated that by this point the end of the ground line must have been south of the target.

The lander did not surface. A post drag trilateration gave a position only 9m from the seabed position established in 2016. This is within error of the trilateration method and we conclude the drag did not move the lander.

*Table 6.2: Cable out distance and time.*

<b>Cable out (m)</b>	<b>Time hh:mm</b>
0	14:10
1000	14:30
2000	15:00
3000	15:30
4000	16:10
3000	17:30

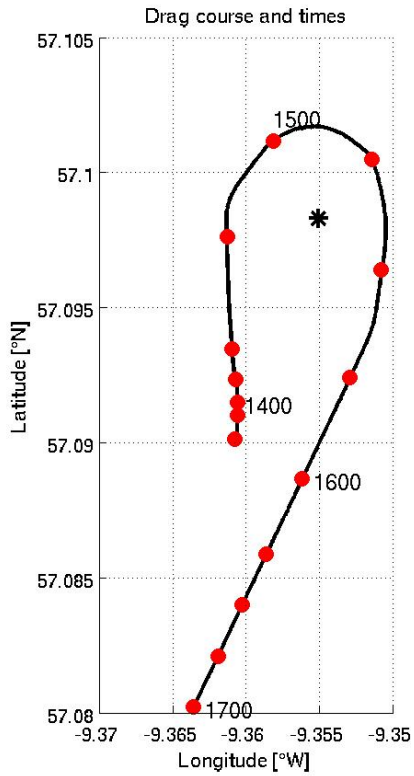


Figure 6.4: Ship's track during the drag operation, with time ticks shown every 15mins (red dots). The latitude ticks of  $0.005^\circ=556m$ .

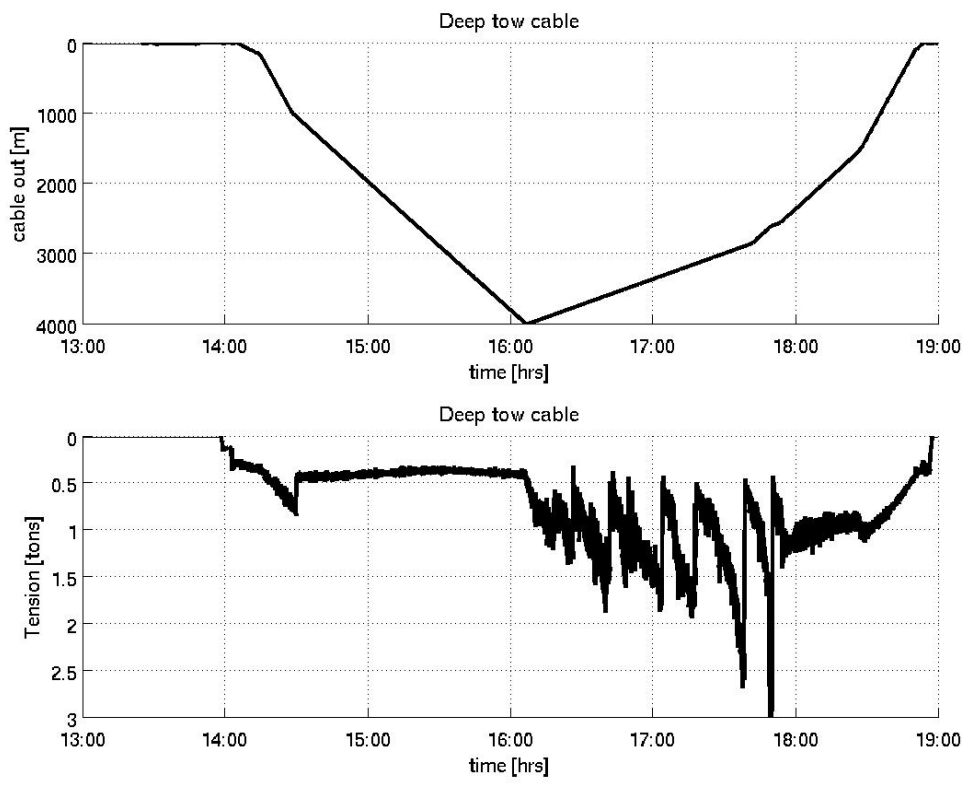


Figure 6.5: Cable out and tension for the deep tow cable.

### 6.3 Mooring Deployments

*Stuart Cunningham*

Three moorings were deployed: Positions and times in Table 6.4; Moorings as deployed schematics in Appendix A.

The UK Hydrographic Office were notified by email on 15/5/17 of the location of RTEB1 and its intended recovery date in September 2018 ([customerservices@ukho.gov.uk](mailto:customerservices@ukho.gov.uk); Reference CS-129550-L6V8). They confirm that they will issue an Admiralty Notice to Mariners to include it on their charts. On advice from UKHO we also advised Kingfisher (<http://www.seafish.org/industry-support/kingfisher-information-services>) who may include it in their bulletins – a lot of fishermen use their services.

*Table 6.4 Mooring deployments, times, depths and anchor seabed positions determined by trilateration*

Mooring Name	Date dd:mm:yy	Start deploy hh:mm:ss	Anchor Away hh:mm:ss	Setup nm	Tow min	Anchor Seabed Lat	Lon	wd at Anchor position m	Fallback m	Average descent rate m/min
RTEB1	13:05:17	08:58:00	11:13:48	2.0	21	57.1005	-9.5638	1817	330	96-67
RTWB2	11:05:17	08:47:00	10:27:12	1.5	59	57.4716	-12.3111	1801	341	120
RTWB1	11:05:17	14:11:00	16:05:41	1.5	17	57.4694	-12.7056	1601	168	

*Table 6.5: Nominal mooring target positions*

Mooring Name	Nominal Position						Nominal wd m
	Lat	Lon	Lat °	Lat '	Lon °	Lon '	
RTEB1	57.1000	-9.5630	57	06.00	-9	33.78	1810
RTWB2	57.47000	-12.31000	57	28.20	-12	18.60	1800
RTWB1	57.4700	-12.7042	57	28.20	-12	42.25	1600

*Table 6.6 : Iridium beacon IMEI codes*

Mooring	IMEI 1	IMEI 1
RTEB1	30" : 300234063561040	40 : 30023406475980
RTWB2	30023406477980	NONE
RTWB1	30" : 300234063561040	40" : 30023406475980

Allocation Schematic

Figure 6.6 is a schematic showing depths and serial numbers of deployed instruments and hardware. These data are also tabulated in Appendix B.

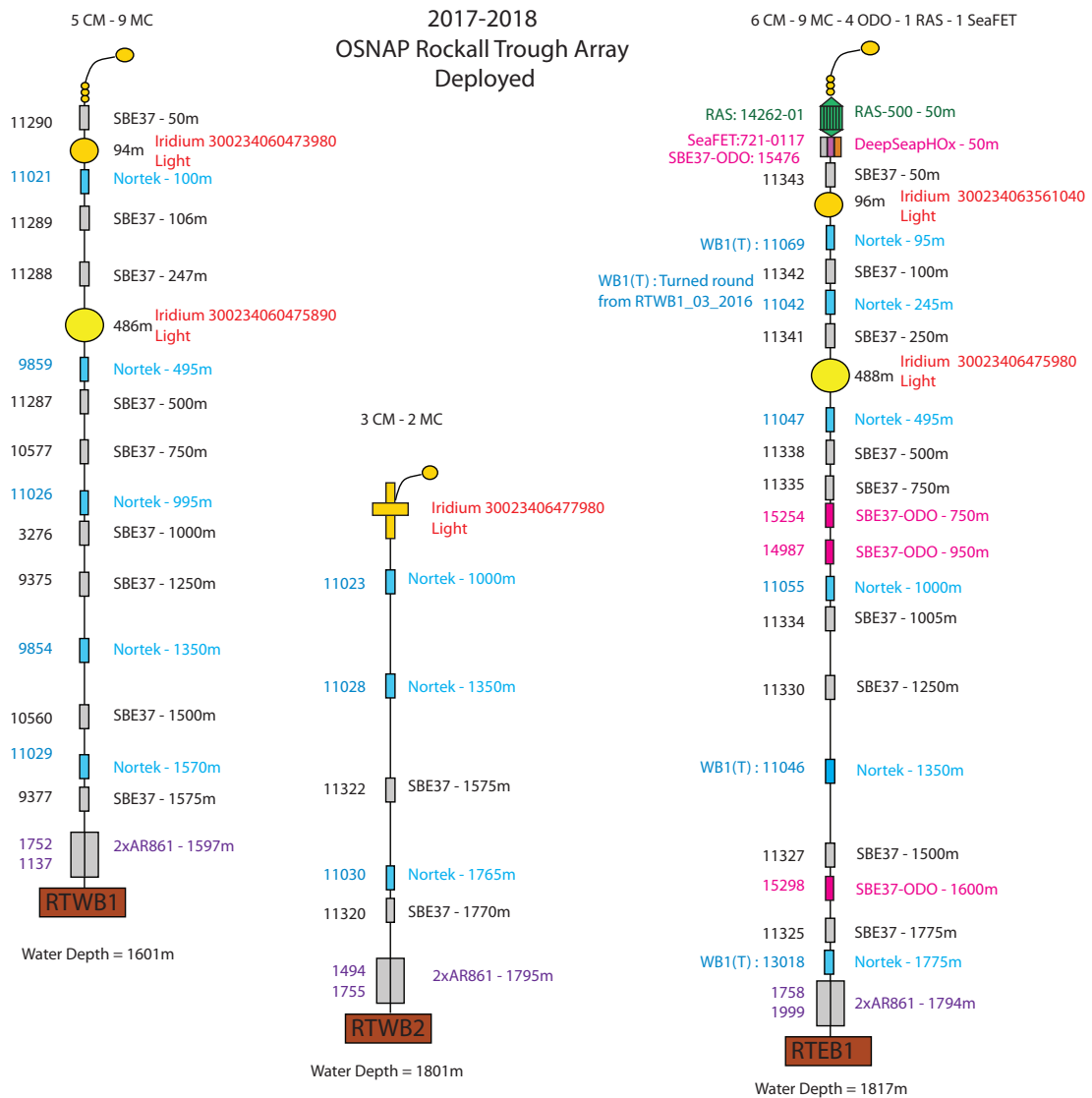


Figure 6.6: Mooring schematics showing serial numbers of deployed instruments and hardware during DY078.

OSNAP Instrumentation for Moorings EB1, WB1 and WB2

SBE37s MicroCATs and Nortek Aquadops were deployed on all three moorings.

The microcats were all cal-dipped and fitted with new batteries prior to deployment (standard Lithium cells provided by Seabird). Their clocks were synchronised with GPS time and the instruments set to sample every 1800s.

The Norteks' clocks were synchronised with GPS time, and new batteries were fitted prior to deployment (alkaline dual packs, nominal capacity 135Wh). They were set to

sample every 1800s, with an averaging period of 60s. Full setup parameters are available in the appendices.

### ATLAS & AtlantOS Instrumentation for Mooring EB1

Two EU programmes are funding biogeochemical sensors to extend the utility of North Atlantic transport monitoring arrays. Specifically here the UK-OSNAP array in the Rockall Trough (UK Natural Environment Research Council Grant number NEK010700/1). One of the objectives of this Rockall Trough portion of the OSNAP arrays relevant here, is to measure the warm-water pathway of the Atlantic thermohaline circulation to the Nordic Seas. The two EU programmes are: 1. Optimising and Enhancing the Integrated Atlantic Ocean Observing System (AtlantOS; Topic: BG-08-2014, Proposal number: SEP-210177333, Work Package 3 Enhancement of autonomous observing networks) and; 2. A Trans-Atlantic Assessment and Deep-Water Ecosystem-Based Spatial Management Plan for Europe (ATLAS; Topic: BG-01-2015, Proposal number: 67876-2, Work Package 1 Ocean Dynamics Driving Ecosystem Response). The principal goal of AtlantOS is transitioning loosely coordinated existing ocean observation activities to a sustainable and integrated Atlantic Ocean Observing System (IAOOS). AtlantOS in WP3 is contributing to the deployment of oxygen sensors to the physical observing network extending observing capability into biogeochemistry. ATLAS will assess the Atlantic's deep-sea ecosystems and Marine Genetic Resources to create integrated and adaptive planning products needed for sustainable Blue Growth. For WP1 ATLAS is funding new oxygen and pH sensors and a Remote Access Sampler (described elsewhere in this report). These will be integrated with the OSNAP Rockall Trough transport-monitoring array (mooring specifics are described elsewhere in this report). The goal is to determine the intra-annual variability of nutrient and carbon fluxes and relate these to high temporal and special measurements being made at cold-water coral gardens in Rockall Trough under WP2.

To optimise flux estimates combining the physical and biogeochemistry data we ran a series of calculations using existing data. From these we determined the optimal locations and depths for the new biogeochemical observations. From this we instrumented mooring RTEB1 with these new sensors (see other sections of this report for full details of instrument preparation and deployment).

The shipboard observing programme described elsewhere in this report (The Extended Ellett Line Programme; UK Natural Environment Research Council National Capability Programme; Proposal number R8-H12-85) provides underpinning measurements and staff time to the scientific objective of OSNAP, AtlantOS and ATLAS.

### **6.3 Mooring Oxygen Sensors**

*Estelle Dumont*

#### SBE37-ODO

SBE37-ODO MicroCATs are high-accuracy pumped CTDs, fitted with an SBE63 Optical Dissolved Oxygen sensor. The SBE63 requires a longer flushing time than the conductivity sensor in order to obtain the best accuracy possible. SBE37-ODOs have the option of using Adaptive Sampling, described in the Seabird manual as:



“If enabled (AdaptivePumpControl=Y), the MicroCAT calculates the pump time before each sample for best oxygen accuracy, as a function of the temperature and pressure of the previous sample (temperature and pressure influence the oxygen sensor time constant). Pump time increases with increasing pressure and decreasing temperature. The pump continues to run while sampling.”

This option was activated for all three SBE37-ODOs deployed on EB1. As the pumping time is significantly higher than on a standard MicroCAT energy usage had to be carefully estimated before setting the sampling intervals. To do this the endurance spreadsheet calculator from RAPID was used (which is based on the guidelines given in the SeaBird manual). The overall pumping time will be dependent of pressure and temperature during deployment, and lowest values for these (worst-case scenario) were used in the endurance calculations. The fastest sampling interval was then chosen for each SBE-ODO, allowing for an 18 months deployment. New batteries were fitted prior to deployment (standard Lithium cells provided by Seabird).

*Table 6.7 Summary of SBE37-ODO endurance estimates and sampling intervals*

S/N	Expected depth (m)	Expected minimum temperature (°C)	Pumping time (seconds)	Sampling interval (seconds)	Endurance (days)
15254	750	8.9	78	2,100	546
14987	950	7.3	84	2,400	564
15298	1,600	4.1	106	3,000	560

### *DeepSeapHOx*

The DeepSeapHOx comprises a SBE37-ODO (as described in previous section), and a SeaFET pH sensor. The two instruments are connected together, with the SeaFET controlling the sampling and data merging. As per the manufacturers recommendation the SeapHOx was powered on and placed in seawater several days prior to deployment.

Each instrument is powered by its own battery pack. The SeaFET’s battery is internally split into two packs, the main pack providing power during sampling, and the isolated pack during standby mode. Endurances of all three batteries must therefore be taken into account (setting a sampling interval too high would deplete the SBE37-ODO and SeaFET main batteries, but setting it too low would deplete the SeaFET isolated pack). The SeapHOx manual gives a thorough explanation of the endurance calculation and the effect of each sampling parameters, however from the experience on RAPID it seemed that the instruments did not always behave as expected (see DY039 and JC145 cruise reports). Bench tests and a functionality check on a CTD cast were carried out at the start of the cruise, and some uncertainty still remained regarding the exact behaviour of the instrument, namely:

- How long is the SBE37-ODO active for during a single measurement?

On the SeapHOx the SBE37-ODO adaptive sampling is disabled and the pumping time is instead set to a fixed value of 39 sec. This plus the additional 3s needed for the

reading would make the overall sampling event last 42s (for the SBE37-ODO), however it seems that the SeaFet burst and average parameters might ask for extra readings to be taken.

- Is the SeaFet “active” while the SBE37-ODO does the preliminary pumping and sampling?

- How long does the overall sampling take? In theory it should only be about 48.5s (42s for the SBE37-ODO, plus 6.5s for the SeaFet), however during testing data did not seem to appear on screen until after 1min 26s.

Two sets of endurances were calculated for all three battery packs, one with the theoretical “short” sampling time (48.5sec), one with the possible “long” sampling time (1min26s, worst case scenario), and endurances derived. A sampling interval of one hour (average 30, burst 1) seemed to be acceptable for both scenarios (to last 18 months), and was chosen for the deployment.

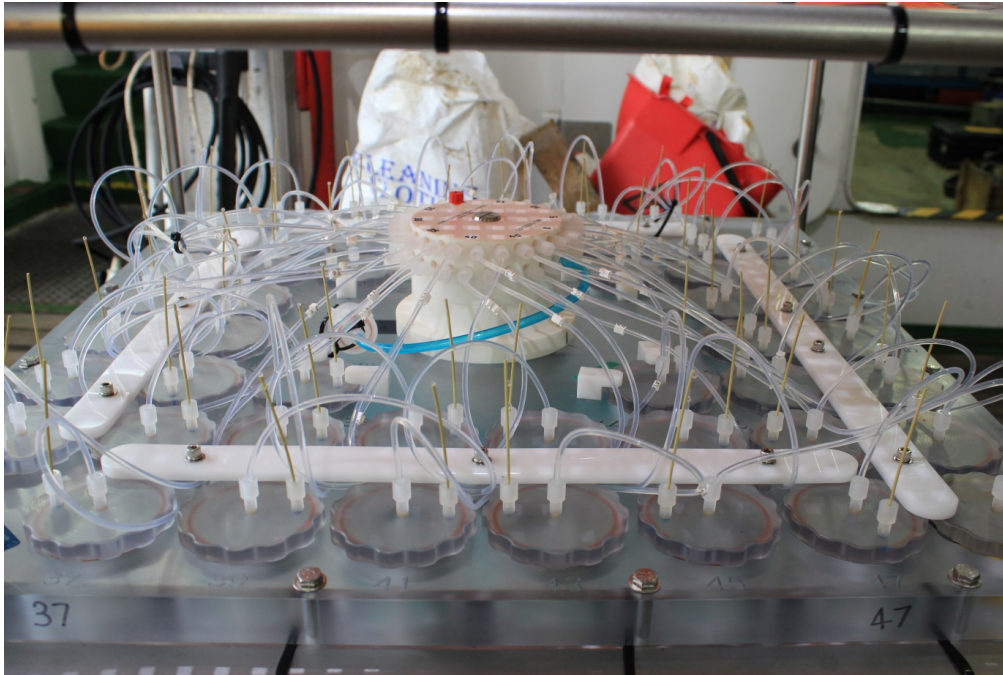
The SBE37-ODO was fitted with new batteries prior to the cruise. The casing of the SeaFet could not be opened without risk of damage, and it was decided to use the original batteries for the deployment. Energy used during testing was estimated and subtracted from the battery capacity before calculating the deployment endurances.

#### **6.4 McLane Remote Access Sampler**

*John Beaton, Sharon McNeill*

##### Introduction

The McLane Remote Access Sampler (RAS) was deployed on mooring EB1 for autonomous collection of seawater samples over a 15 month period for the analysis of dissolved inorganic carbon. A total of forty-eight 500ml samples will be collected remotely by the software initiating water to be removed from a selected tube creating a pressure gradient by which the sample bag contained within the tube will then be filled with local seawater. The seawater samples collected are preserved with mercuric chloride to prevent biological activity and each sample is sealed by the closure of the multi-port valve to prevent exchange of carbon dioxide to the surrounding water during the remainder of the mooring deployment.



*Figure 6.7 RAS showing multi-port valve (centre) and sample lines going to individual tube caps.*

#### Setup

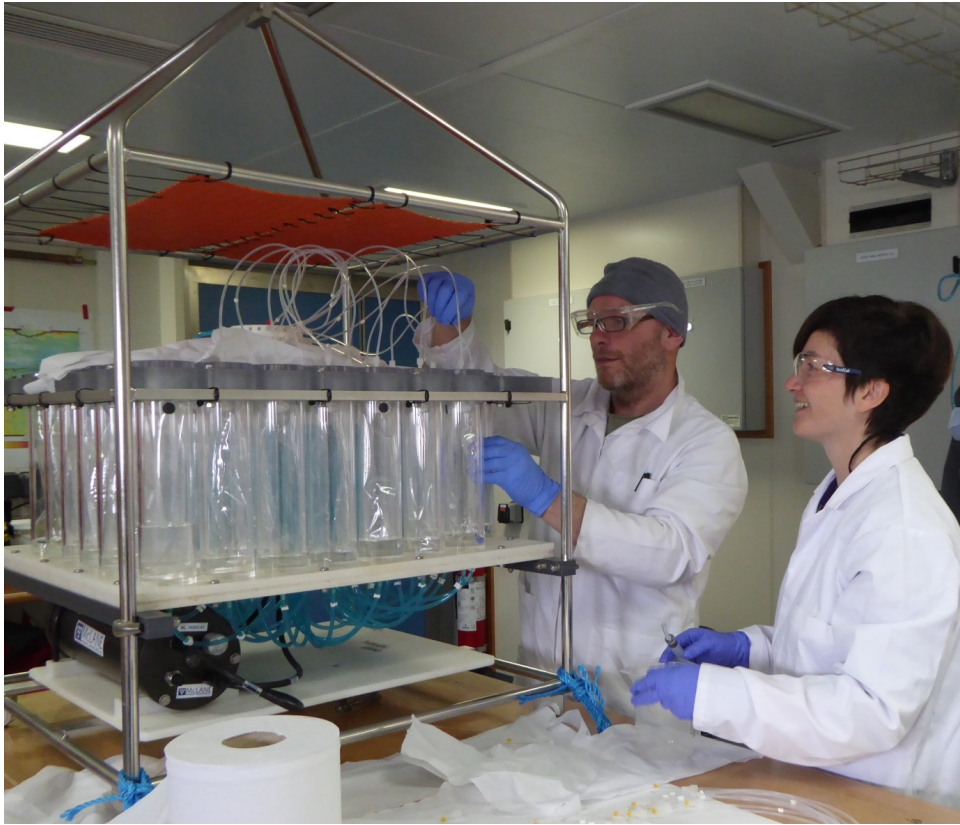
RAS s/n 14262-01, was modified from standard by adding two 12mm acetal plates drilled out to accommodate the bottom end of the 49 water-containing tube. The purpose of the plate was to limit the lateral movement of the tubes during the anchor last deployment during which the RAS would be towed bottom first through the water for two hours. The plate was attached to the four vertical frame posts by clamping with suitably isolated stainless steel U-bolts.

To reduce the possibility of mooring hardware components entering the frame and damaging the RAS, panels of plastic mesh were attached across the top of the frame. A full-width 12mm acetal plate was also added to the lower cross-members to provide a mounting point for a Seabird/Satlantic Deep SeapHOx in addition to the RAS controller.

#### Preparation

Sample bags used in deployment were 3MIL Aclar (PCTFE) manufactured by Plastic Film Enterprises, USA. The protocol followed was as described in SOP for pre-deployment setup of the McLane remote access sampler (RAS) – ABC fluxes by Peter Brown & Darren Rayner, NOC, Southampton.

Each sample line (the tubing between the valve head and sample cap) approx. 1.05ml volume was filled with a 25% saturated mercuric chloride solution giving a spiking volume of 0.05% volume for a 500ml seawater sample (Dickson et al, 2007:0.02-0.05% by volume).



*Figure 6.8 Dosing sample lines with mercuric chloride solution*

All 48 tubes were used and the ‘acid’ bag was filled with 500ml of de-ionised water. The flush setting was set to flush 10ml after sampling.

Bubble Measurement

After complete setup and sitting overnight any air bubbles visible in the sample lines were measured and recorded in the following table so an allowance could be made for any effect later.

*Table 6.8 Bubbles visible in RAS sample lines after setup*

<b>Sample line</b>	<b>Bubble length</b>
12	25mm
27	5mm
34	5mm
36	65mm
39	3mm
44	appeared to be dry at deployment

Damaged Tube

One sample tube was found to be damaged at the seal with its cap and as no spare was available the tube was moved to position 48 and a makeshift repair was carried out with Sikaflex 291 (marine sealant) and electrical tape.

Programming

The RAS was programmed with a schedule to sample at 10 day intervals between 0600 on 15 May 2017 and 0600 on 28 August 2018.

*Table 6.9 RAS Programmed sampling times*

Sample #	Date	Time	Sample #	Date	Time
1	15/05/2017	06:00:00	25	10/01/2018	06:00:00
2	25/05/2017	06:00:00	26	20/01/2018	06:00:00
3	04/06/2017	06:00:00	27	30/01/2018	06:00:00
4	14/06/2017	06:00:00	28	09/02/2018	06:00:00
5	24/06/2017	06:00:00	29	19/02/2018	06:00:00
6	04/07/2017	06:00:00	30	01/03/2018	06:00:00
7	14/07/2017	06:00:00	31	11/03/2018	06:00:00
8	24/07/2017	06:00:00	32	21/03/2018	06:00:00
9	03/08/2017	06:00:00	33	31/03/2018	06:00:00
10	13/08/2017	06:00:00	34	10/04/2018	06:00:00
11	23/08/2017	06:00:00	35	20/04/2018	06:00:00
12	02/09/2017	06:00:00	36	30/04/2018	06:00:00
13	12/09/2017	06:00:00	37	10/05/2018	06:00:00
14	22/09/2017	06:00:00	38	20/05/2018	06:00:00
15	02/10/2017	06:00:00	39	30/05/2018	06:00:00
16	12/10/2017	06:00:00	40	09/06/2018	06:00:00
17	22/10/2017	06:00:00	41	19/06/2018	06:00:00
18	01/11/2017	06:00:00	42	29/06/2018	06:00:00
19	11/11/2017	06:00:00	43	09/07/2018	06:00:00
20	21/11/2017	06:00:00	44	19/07/2018	06:00:00
21	01/12/2017	06:00:00	45	29/07/2018	06:00:00
22	11/12/2017	06:00:00	46	08/08/2018	06:00:00
23	21/12/2017	06:00:00	47	18/08/2018	06:00:00
24	31/12/2017	06:00:00	48	28/08/2018	06:00:00

*Deployment*

The RAS was deployed 7m below its supporting buoyancy to allow the buoyancy to be in the water while the RAS was lifted from the deck by crane. The RAS was lifted vertically into the water and freed by means of a Sea Catch mechanical release. A 1m long four-legged chain bridle was fitted below the RAS frame.





*Figure 6.9. RAS during deployment with controller (left) and Deep Seaphox (right).*

## **6.5 Mooring Instrument Calibration Dips**

*Loic Houpert & Stuart Cunningham*

Mooring instrument sensors deployed for long periods are usually subject to drift, either from physical factors (e.g. slow pressure responses) or from environmental contaminants (e.g. biological fouling). To improve the accuracy of these timeseries we use pre and post deployment calibrations in an attempt to characterise and correct these drifts.

CTD stations with calibrations to traceable standards provide data of high accuracy and precision for temperature, conductivity, pressure and oxygen. This provides suitable reference comparative data for mooring sensors. In addition on this cruise we obtained water samples for carbon analysis against a new electronic pH sensor.

The method to obtain comparative data is straightforward. Mooring instruments are lowered with the CTD package. Set to sample at their maximum rate we compare data at bottle stops during the upcast. Typically 12 to 16 depths with five-minute stops provide sufficient stable data for characterising mooring sensor performance.

For calibrating SBE37 MicroCAT CTD sensors five minute bottle stops provide enough samples at each bottle stop sampling at their maximum rate of 0.1Hz.

For SBE 37-SMP-ODO MicroCATs measuring concentrations of dissolved oxygen, longer bottle stops of 20 min duration were scheduled during the upcast. This was because the time required to obtain oxygen values from the optical dissolved oxygen sensor is a function of oxygen concentration, water temperature and pressure: sample time being longer for lower oxygen, higher pressure and colder temperature. The instrument computes the required sample time adaptively from ambient values. Using

the manufacturers predictive equation we set instrument sample interval at 110s. This was longer than the longest adaptive sampling time predicted for the in situ parameters at the location of the cast.

#### SBE37 & SBE37-ODO MicroCAT CTD Processing

1. Process CTD station data and create the 1s average up and down profile (file: *ctd\_dy078\_###\_psal.nc*).
2. Download MicroCATs, transfer to the processing computer (e.g. */osnap/data/moor/raw/dy078/microcat\_cal\_dip/cast*).
3. Setup info.dat file (e.g. *moor/proc\_calib/dy078/cast#info.dat*).
4. Run: *mc\_call\_caldip\_v4b.m*. This reads the info.dat and produces timeseries plots of CTD data against MicroCAT data.
5. This script produces summary statistics: *mc\_caldip\_check\_dy078.m*.

During the cruise the CTD data are not finally calibrated, so results from this processing are preliminary. It provides: a. A functionality check of the mooring instrumentation and; b Identifies instrument sensors that are returning data with unacceptable accuracy. In case of b these instruments are not deployed but returned to the laboratory calibration facility.

#### CTD002 (Calibration dip 1) Summary Statistics

MicroCATs 3276 & 9371 spares. The remainder allocated to EB1. 9371 rejected because conductivity reads low by 0.0095. Three SBE37-ODO all logged, showing continual drifts in oxygen values during 20 minute stops. They were all offset relative to the uncalibrated CTD oxygen by 5-15 mmol/kg. Summary statistics are logged in *moor/proc\_calib/dy078/cal\_dip/microcat/cast2/microcat\_check2.log*.

Table 6.10: Comparison of CTD sensor set 1 and microcat data at CTD cast 2. Mean and standard deviation of (SBE 37–CTD) values at maximum depth of CTD cast press = 2027.8 db std = 0.4. Outliers (F), upper case indicates a warning due to large mean difference and lower case indicates a warning due to large standard deviation relative to the CTD sensors. Outliers only calculated for temp, cond and press.

		CTD-Microcat difference during 5mins stops at maximum depth of the cast								
S/N	n	C (mS/cm)		T (degC)		P (db)		O2 (μmol/kg)		F
		mean	std	mean	std	mean	std	mean	std	
3276	70	-0.0036	0.00133	-0.0004	0.00119	-1.1	0.59	NaN	NaN	
9371	70	0.0095	0.00129	-0.0006	0.00132	0.5	0.5	NaN	NaN	C
11325	70	-0.0005	0.00116	-0.0004	0.00124	4.1	0.62	NaN	NaN	
11327	70	0	0.00128	-0.0009	0.00126	1.4	0.53	NaN	NaN	
11330	70	-0.0027	0.00152	-0.0014	0.00122	1.7	0.53	NaN	NaN	
11334	70	-0.003	0.00119	-0.0009	0.00121	1.8	0.51	NaN	NaN	
11335	70	0.0011	0.00184	-0.0006	0.00124	2.1	0.52	NaN	NaN	
11338	70	0.0006	0.00106	-0.0021	0.00121	1.9	0.51	NaN	NaN	
11341	70	0.0019	0.00178	0.0014	0.0017	-0.5	0.53	NaN	NaN	Tt
11342	70	-0.0013	0.00121	0.0001	0.00122	-1.7	0.53	NaN	NaN	
11343	70	-0.0039	0.00141	-0.0007	0.00135	-1	0.53	NaN	NaN	
14987	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	
15254	6	-0.0015	0.00147	-0.0002	0.00156	0.1	0.38	17	5.42	t
15298	5	0.0052	0.00116	-0.0001	0.00131	4.1	0.16	17	1.1	

Table 6.12: Same as Table 8.11 but at nominal pressure of instrument (taken from the info.dat file)  $P_{nom}$  and the actual pressure of comparison  $P_{comp}$ .

				CTD-Microcat difference during 5mins stops at maximum depth of the cast							
S/N	n	Pnom	Pcomp	C (mS/cm)		T (degC)		P (db)		O2 (μmol/kg)	
				mean	std	mean	std	mean	std	mean	std
3276	139	1000	1060	0.0042	0.00789	0.007	0.00602	-1.2	0.6	NaN	NaN
9371	139	1000	1060	0.0187	0.00839	0.0074	0.00804	-0.2	0.4	NaN	NaN
11325	126	1575	1620	-0.0009	0.00166	-0.0005	0.00154	4.5	0.6	NaN	NaN
11327	21	1500	1418	0.0036	0.00693	0.0032	0.00657	1	0.6	NaN	NaN
11330	30	1250	1214	-0.0005	0.00182	0.0021	0.00179	-0.1	0.5	NaN	NaN
11334	138	1005	1061	0.0058	0.00695	0.008	0.00684	0.8	0.4	NaN	NaN
11335	131	750	757	0.0008	0.00053	-0.0006	0.00053	0.7	0.5	NaN	NaN
11338	148	500	503	0.001	0.00055	-0.0016	0.00058	0.4	0.3	NaN	NaN
11341	134	250	202	0.0009	0.00033	-0.0005	0.00028	0.3	0.4	NaN	NaN
11342	123	100	51	-0.002	0.00517	-0.0012	0.0053	0.8	0.4	NaN	NaN
11343	123	50	50	-0.005	0.00854	-0.0016	0.00816	0.9	0.4	NaN	NaN
14987	7	950	1060.2	0.0125	0.00704	0.0113	0.00678	-0.5	0.15	6.3	0.5
15254	7	751	757	-0.0021	0.00016	-0.0015	0.00023	-0.3	0.4	6	0.9
15298	6	1600	1620	0.0043	0.00064	-0.0018	0.00057	3.1	0.2	11.5	0.2



*CTD003 (Calibration dip 2) Summary Statistics*

9372;9376;10575; 10576 all failed with bad conductivities.

*Table 6.13: Same as Table 6.11 for CTD003, cast press = 2110.0 db. Outliers only calculated for temp, cond and press. Upper case indicates a warning on the mean value; lower case on the standard deviation.*

		CTD-Microcat difference during 5mins stops at maximum depth of the cast								
S/N	n	C (mS/cm)		T (degC)		P (db)		O2 (μmol/kg)		F
		mean	std	mean	std	mean	std	mean	std	
9372	36	-0.012	0.00022	-0.002	0.00023	2.9	0.4	NaN	NaN	
9375	36	0.0002	0.00024	-0.0019	0.00026	2	0.3	NaN	NaN	
9376	36	0.0109	0.00026	-0.0022	0.00025	1.5	0.4	NaN	NaN	
9377	36	-0.0002	0.0002	-0.0024	0.00021	1.4	0.4	NaN	NaN	
10560	36	-0.0058	0.00022	-0.0023	0.00021	3.2	0.5	NaN	NaN	
10575	36	-0.0215	0.00023	-0.0015	0.00023	3.6	0.4	NaN	NaN	C
10576	36	-0.4843	0.00283	-0.0014	0.00026	3.2	0.4	NaN	NaN	Cc
10577	36	-0.0037	0.00029	-0.0021	0.00029	4.8	0.4	NaN	NaN	
11287	36	-0.0033	0.00022	-0.0023	0.00022	2.6	0.4	NaN	NaN	
11288	36	-0.0032	0.00021	-0.0025	0.00024	2.4	0.4	NaN	NaN	
11289	36	-0.0013	0.00022	-0.0022	0.00026	2.4	0.3	NaN	NaN	
11290	36	-0.0007	0.00026	-0.002	0.00029	-0.3	0.4	NaN	NaN	P
11320	36	-0.0042	0.00018	-0.0023	0.0002	2.2	0.4	NaN	NaN	
11322	36	-0.005	0.00021	-0.0013	0.00023	3.1	0.4	NaN	NaN	

*Table 6.14: Same as Table 6.13 but at nominal pressure of instrument (taken from the info.dat file)  $P_{nom}$  and the actual pressure of comparison  $P_{comp}$ .*

				CTD-Microcat difference during 5mins stops at maximum depth of the cast							
S/N	n	Pnom	Pcomp	C (mS/cm)		T (degC)		P (db)		O2 (μmol/kg)	
				mean	std	mean	std	mean	std	mean	std
9372	29	1000	960	-0.0115	0.00225	-0.0012	0.00212	1.6	0.3	NaN	NaN
9375	29	1000	960	0.0009	0.00107	-0.0006	0.00086	0.7	0.3	NaN	NaN
9376	29	1000	960	0.0131	0.00171	-0.0008	0.0018	0.1	0.3	NaN	NaN
9377	27	1575	1621	0.0031	0.00186	0.0013	0.00169	0.5	0.3	NaN	NaN
10560	32	1500	1419	0.0024	0.00222	0.0074	0.00268	2.5	0.3	NaN	NaN
10575	35	1250	1214	-0.0149	0.00716	0.0069	0.00699	1.8	0.3	NaN	NaN
10576	29	1000	960	-0.467	0.00312	0	0.00072	2.3	0.3	NaN	NaN
10577	51	750	808	-0.0028	0.00047	-0.0004	0.00042	3.2	0.3	NaN	NaN
11287	32	500	504	-0.0009	0.00141	-0.0003	0.00124	0.7	0.3	NaN	NaN
11288	36	250	203	-0.0029	0.00177	-0.0025	0.00149	1	0.2	NaN	NaN
11289	36	100	17	0.0023	0.0007	-0.0008	0.00075	0.7	0.1	NaN	NaN
11290	36	50	16	0.0006	0.00163	-0.0026	0.00144	1.1	0.2	NaN	NaN
11320	31	1770	1773	-0.0009	0.00342	0.0015	0.00394	1.6	0.4	NaN	NaN
11322	27	1575	1621	-0.0018	0.00218	0.0019	0.00201	2.3	0.3	NaN	NaN

*CTD027 (Calibration dip 3) Summary Statistics*

Post deployment calibration dip for all SBE37 MicroCATS

*Table 6.15: Same as Table 6.11 for CTD27, cast press = 2116.5 db.*

		CTD-Microcat difference during 5mins stops at maximum depth of the cast								
S/N	n	C (mS/cm)		T (degC)		P (db)		O2 (μmol/kg)		F
		mean	std	mean	std	mean	std	mean	std	
9113	23	-0.0022	0.00019	-0.003	0.00023	1.5	0.2	NaN	NaN	
9141	23	0.0155	0.00017	-0.002	0.00024	-317.9	0.9	NaN	NaN	CP
11337	23	-0.0042	0.00074	-0.0033	0.00038	-0.5	1.6	NaN	NaN	P
14367	23	-0.0036	0.0007	-0.003	0.00024	1.8	1.5	NaN	NaN	
10559	23	-0.0053	0.00067	-0.0024	0.0003	4.3	1.5	NaN	NaN	
14364	23	0.0001	0.00078	-0.0025	0.00026	2.2	1.7	NaN	NaN	
14368	23	-0.001	0.00068	-0.0018	0.0003	2.7	1.6	NaN	NaN	
14354	23	-0.004	0.00072	-0.0026	0.00025	3.3	1.7	NaN	NaN	
11339	23	-0.006	0.00073	-0.0018	0.00028	2.9	1.6	NaN	NaN	
14353	23	-0.0002	0.00064	-0.0024	0.00029	2.6	1.6	NaN	NaN	
14366	23	0.0002	0.00066	-0.0031	0.00029	2.5	1.6	NaN	NaN	
14356	23	-0.0013	0.00068	-0.0028	0.0003	2.2	1.6	NaN	NaN	
14355	23	3.4031	0.00201	-0.003	0.00038	3.8	1.6	NaN	NaN	Cc
14365	23	-0.0013	0.0007	-0.0029	0.00031	2.2	1.6	NaN	NaN	
10562	23	-0.0047	0.00074	-0.0026	0.00023	4.6	1.6	NaN	NaN	
11329	23	0.0057	0.00067	-0.0035	0.0003	2.8	1.6	NaN	NaN	C

*Table 6.16: Same as Table 8.15 but at nominal pressure of instrument (taken from the info.dat file)  $P_{nom}$  and the actual pressure of comparison  $P_{comp}$ .*

				CTD-Microcat difference during 5mins stops at maximum depth of the cast							
S/N	n	$P_{nom}$	$P_{comp}$	C (mS/cm)		T (degC)		P (db)		O2 (μmol/kg)	
				mean	std	mean	std	mean	Std	mean	std
9113	39	1005	1008	0.0028	0.00474	0.0026	0.00518	0	0.2	NaN	NaN
9141	57	100	101	0.0243	0.0065	0.0024	0.00718	1.1	0.1	NaN	NaN
11337	35	1500	1518	-0.0026	0.00165	-0.0011	0.00204	0.1	1.4	NaN	NaN
14367	35	1500	1518	-0.0032	0.00071	-0.0021	0.00086	1.3	1.4	NaN	NaN
10559	36	500	502	-0.0051	0.00239	-0.0012	0.00233	2.5	1	NaN	NaN
14364	34	750	755	0.0009	0.00106	-0.0014	0.00059	0.4	1.2	NaN	NaN
14368	35	1575	1516	0.0003	0.00131	-0.0002	0.00163	1.8	1.4	NaN	NaN
14354	36	1770	1770	-0.003	0.00064	-0.0012	0.00131	2.5	1.2	NaN	NaN
11339	37	1775	1769	-0.0052	0.00074	-0.0006	0.00095	2	1.2	NaN	NaN
14353	35	1575	1516	0.0006	0.00169	-0.0013	0.00172	1.6	1.4	NaN	NaN
14366	33	1250	1261	0.0034	0.00164	0.0008	0.00237	0.5	1.3	NaN	NaN
14356	36	500	502	-0.0004	0.00237	-0.002	0.00247	-0.2	1	NaN	NaN
14355	32	250	252	4.111	0.00427	-0.0015	0.00068	0.7	1.1	NaN	NaN
14365	38	1000	1008	0.0035	0.0043	0.0033	0.00467	0	1.5	NaN	NaN
10562	34	750	755	-0.0045	0.00082	-0.0012	0.00059	2.7	1.2	NaN	NaN
11329	33	1250	1261	0.0107	0.00215	0.0009	0.003	0.6	1.3	NaN	NaN

## DeepSeapHOx CTD Processing

1. Process CTD station data and create the 1s average up and down profile (file: *ctd\_dy078\_###\_psal.nc*).
2. Download DeepSeapHOx, transfer to the processing computer.
3. Setup info.dat file (e.g. *moor/proc\_calib/dy078/cast#info.dat*).
4. Run: *seaphox\_call\_caldip.m* to produce timeseries for each instrument, convert raw data to RODB format and produce individual summary statistics.
5. Run *seaphox\_caldip\_check.m* : this reads the info.dat and produces timeseries plots of CTD data against MicroCAT data and summary statistics are produced by the script.

DeepSeapHOx, oxygen concentrations are given in mL/L. To convert to  $\mu\text{mol/kg}$ , we use the following formula:  $O_2 (\mu\text{mol/kg}) = 44.661 * 1000 / sw\_dens(s,t,p) * O_2(\text{mL/L})$ , with the Molar Volume of  $O_2$  at STP = 22.391 L, ( $1 \mu\text{mol } O_2 = 22.391 \times 10^{-3} \text{ mL}$  ;  $1 \text{ mL/L} = 44.661 \mu\text{mol/L}$ ;  $1 \mu\text{mol/kg} = 1000 / sw\_dens(s,t,p) \mu\text{mol/L}$  (*sw\_dens* is the density of seawater for temperature *T*, salinity *S* and pressure *P*).

## Acoustic Releases

Acoustic releases were tested by lowering on the CTD to a depth exceeding their planned deployment depths and confirming their communication and operation.

## **6.6 Mooring Instrumentation Processing**

*Loïc Houpert*

Before the processing a control file is created for each mooring in the mooring directory. (e.g. *rtwb1\_03\_2016info.dat* is created in the directory *osnap/data/moor/proc/rtwb1\_03\_2016/*). This file contains metadata of mooring position, deployment period and for each instrument: nominal depth, serial number and RODB instrument type code. RODB codes are: SBE37 are identified by the RODB code 337; 335 for the SBE37-ODO; 370 for the Nortek aquadop and; 375 for the DeepSeapHOx.

## SeaBird SBE37 MicroCAT Data Processing

### **Stage 0: Data Download**

Raw instrument data are downloaded from the instrument in ASCII and *cnv* format. Record keeping of the download is recorded on a download log-sheet. After download the data are backed up and transferred to the network drive DISCOFS, where the data are then copied onto the processing computer in the directory *osnap/data/moor/raw/dy078/microcat/*.

### **Stage 1: Conversion to standard RDB format**

The script *mc\_call\_2\_dy078* performs stage1 processing. It converts data from raw to RDB format for each SBE37 on mooring. The user needs to modify some information in the beginning of the script like directory tree, mooring name and the year of the first measurement. *mc\_call\_2\_dy078* calls *microcat2rodb\_5*, which saves the file downloaded by the instrument software (stage 0) to the RDB formatted file *.raw*.

Stage1 processed data are stored in the directory  
~/osnap/data/moor/proc/moor\_03\_2015/microcat, which is created manually.

### **Stage 2: Trimming of data, basic statistics and summary plots**

The script *microcat\_raw2use\_003\_with\_ODO.m* performs stage 2 processing. This script uses the raw data file *mooring\_serialnum.raw* generated by stage1 and the *mooringinfo.dat* file. It removes launching<sup>1</sup> and recovery<sup>2</sup> periods, creates a data overview sheet including basic statistics, and produces summary plots, including filtered data.

### Nortek Aquadop Current Meter Data Processing

#### **Stage 0: Data Download**

Raw instrument data are downloaded from the instrument . Record keeping of the download is recorded on a download log-sheet. After download the data are backed up and transferred to the network drive. Then the data (.data, .dat, .aqd and .hdr files) are copied on the processing computer in the directory e.g  
*osnap/data/moor/raw/dy078/nortek/*.

#### **Stage 1: Conversion to standard RDB format**

The script *process\_nors\_dy053* performs stage 1 and stage 2 processing on Nortek Aquadop data. It converts data from raw to RDB format for all instruments on the mooring. The user needs to modify some information, directory tree, mooring name, and the year of the first measurement. A text file containing the serial numbers of the Norteks on the mooring and the filenames containing the data is also created before running the script, e.g.~/osnap/data/moor/raw/dy078/nortek/rteb1\_03\_2016\_filenames.txt. *process\_nors\_dy078* calls *nortek2rodb\_01*, saves the files downloaded by the instrument software (stage 0) to the RDB formatted file *.raw*. in e.g. ~/osnap/data/moor/proc/rteb1\_03\_2016/nortek.

#### **Stage 2: Trimming of data, basic statistics and summary plots**

The script *process\_nors\_dy078* also performs stage 2 processing on Nortek data, calling the script *nortek\_raw2use\_02*. This script uses the raw data file *mooring\_serialnum.raw* generated by stage1 and the *mooringinfo.dat* file. It removes the launching and recovery periods, creates a data overview sheet including basic statistics, and produces summary plots, including filtered data.

### DeepSeapHOx Data Processing

#### **Stage 0: Data Download**

After download the data are backed up and transferred to the network drive DISCOFS, then the data are copied onto the processing computer in the directory *osnap/data/moor/raw/dy078/seaphox\_caldip*.

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<sup>1</sup> The launching period is defined as the time from the start of the data logging until the mooring settles on the sea-bed.

<sup>2</sup> The recovery period is defined as the time from when the mooring is released from the seabed until the end of the data logging.

### **Stage 1: Conversion to RDB format**

The script *seaphox\_call\_caldip* performs stage 1 processing on DeepSeapHOx data. It converts the data from raw to RDB format. The user needs to modify some information in the beginning of the script like the directory trees, the mooring name or caldip cast number. This script calls *seaphox2rodb\_01*, which saves the file downloaded by the instrument software (stage 0) to the RDB formatted file *.raw* and produce summary plots and statistics for each instrument.

The stage1 processed data are stored in the directory *~/osnap/data/moor/proc/moor\_nn\_yyyy/seaphox* or in *~/osnap/data/moorproc\_calib/dy078/cal\_dip/seaphox/castnn*, if the input of the function is a cast number.

A text file containing the serial numbers of the DeepSeapHOx with the associated filenames containing the data has to be created before running the processing, e.g. *~/osnap/data/moor/raw/dy078/seaphox\_cal\_dip/cast1/cast1\_filenames.txt*

## 7. CTD data processing

Loic Houpert, Penny Holliday

CTD data were collected in the Sea-Bird Seasave version 7.26.2.13 software, and the following file types saved as .hex (data in binary format), .bl (bottle firing record), .XMLCON (configuration file), and .hdr (header information input manually). Data were then processed using Sea-Bird software and the mexec\_v2 software suite developed at NOC. Note that the NetCDF file and the metadata associated with the mexec processing suite are known as the mstar format. Here m refers to the use of MATLAB as the processing tool that implements mexec.

The first stage of the processing was carried out on the CTD computer using the Seabird software SBEDataProcessing-Win32 Version 7.26.2.14. The following modules were run:

- **DatCnv**: converts the raw frequency and voltage data from engineering units by applying the sensors manufacturer's calibrations stored in the XMLCON, and outputs the data in an ASCII format (cast data as a .cnv file, and bottle data as .ros). The oxygen hysteresis correction option was not selected, as this is done later on by mexec.
- **Align**: this script shifts selected sensors' data in time, relative to pressure. This is required for sensors with a slower response time, and when extra time is required for the water parcel to reach the sensor (e.g. going through additional lengths of hose). In our setup, only the oxygen SBE43 sensor required this step. The primary and secondary conductivities also require a small shift of 0.073 seconds, but this was done in real-time by the deck-unit. The standard alignment of 6s was applied to both oxygen sensors.
- **CellTM**: this module is run to remove conductivity cell thermal mass effects from the measured conductivity. Sea-Bird recommended constants ( $\alpha=0.03$  and  $1/\beta=7$ ) were used.
- 

Processed CTD data were copied on the shared network drive DISCOFS. The script `ctd_linkscript_dy078` was used to copy files from the network drive and set up additional symbolic links to filenames following mexec convention.

For the cruise DY078, two set of oxygen sensors were mounted on the CTD. The mexec scripts `mctd_02b_dy078`, `mctd_03_dy078`, `mdcs_03g_dy078`, `mctd_04_dy078` were edited to process and display the two set of oxygen sensors.

For each cast, the first step of the MATLAB *mexec* processing was run using the wrapper script `ctd_all_part1`, which called the following scripts:

- **msam\_01**: creation of empty sample files `sam_dy078_nnn.nc` for all casts *nnn*. These files were generated using the list of variables indicated in the file `~/cruise/data/templates/sam_dy078_varlist.csv`.
- **mctd\_01**: conversion of raw 24Hz cnv data file to *mstar* netCDF format.
- **mctd\_02a**: converts variable names from SBE names to *mstar* names using `data/templates/ctd_dy078_renamelist.csv`.

- ***mctd\_02b\_dy078***: applies oxygen hysteresis correction using the default Sea-Bird coefficients [-0.033 5000 1450].
- ***mctd\_03\_dy078***: average to 1Hz and calculation of salinity and potential temperature.
- ***mdcs\_01***: creates an empty data cycles file (*dcy\_dy078\_nnn*), used to store the cast start, bottom and end metadata (positions, times, pressure, scan numbers and data cycle numbers.).
- ***mdcs\_02***: find scan number corresponding to bottom of file use this to populate the file *dcy\_[cruise]\_[station]*.

The script ***mdcs\_03g\_dy078*** was then run to inspect profiles, hand-select cast start and end times, and input the new values in the *dcy* file. The start of the cast was selected when the CTD package was about to start its descent after being brought back to near surface following the initial 10m soak. The end of the cast was chosen as the last point with a pressure value greater than 0.

Next the wrapper script ***ctd\_all\_part2*** was run, executing:

- ***mctd\_04\_dy078***,: averages data to 2db bins.
- ***mfir\_01, mfir\_02, mfir\_03, mfir\_04***: get bottle firing information from the Sea-Bird .bl file and extract the matching CTD data based on scan numbers.
- ***mwin\_01, mwin\_03, mwin\_04***: read in winch data corresponding to a CTD station, merge winch wireout onto fir file and paste winch fir data into sam file
- ***mbot\_00, mbot\_01, mbot\_02***: create bottle files (*bot\_dy078\_nnn*); add CTD data, bottle firing codes and quality flag at the time of the bottles firings in the BOT and SAM files.

1Hz-averaged data are then generated by the script ***list\_ctd\_1hz***, for use in the LADCP processing.

CTD data were visually checked using the script ***mctd\_checkplots***.

Once the processed underway and VMADCP data were available the following scripts were run:

- ***mcod\_03*** extracts VMADCP data during the CTD cast.
- ***mcod\_stn\_out***: generates VMADCP mat files for the cast.
- ***mdep\_01***: extracts the bottom depths from the LADCP data and from the CTD (using pressure and altimeter readings), and lets the user choose which one is the best representation of true water depth. The chosen depth gets copied as 'bestdep'. All bottom depth values are added to the station depth file (*cruise/data/station\_depths/station\_depths\_dy078.mat*). Finally, the chosen depth value is inserted into the metadata of all CTD files previously generated.
- ***mdcs\_04, mdcs\_05***: extract position from the bestnav file (*cruise/data/nav/posmvpos/pos\_dy078\_01.nc*) and adds it to the ctd files' metadata.

Discrete bottle sample data (salinity and nutrients) and discrete temperature data are inserted from their ASCII files into the *mstar* files. Appending the SBE35 and the discrete samples data to the BOT and SAM file can be done individually by calling:

- *msal\_01*, *msal\_02*: (details in Conductivity Calibration below).
- *mnut\_01\_dy078*, *mnut\_02\_dy078*: for nutrient samples unique reference numbers were recorded in csv files for each cast (*/data/ctd/BOTTLE\_NUT/nut\_dy078\_nnn.csv*). The two scripts read the csv file, create the nutrient netCDF file (*nut\_dy078\_nnn.nc*) and paste the nutrient sample reference number into to the SAM file. Thus after post cruise analysis of the nutrient samples, they can be simply referenced back to the physical data.
- *msbe35\_01\_dy078*, *msbe35\_02*: see Temperature Calibration section below
- *msam\_append\_dy078* OR *msam\_updateall*: if the cast sam file has not been added to the global sam file (*sam\_dy078\_all.nc*) then add it by running *msam\_append\_dy078*. In case of a reprocessing use *msam\_updateall* so that the cast is not duplicated in the appended master SAM file.



## 8. VM-ADCP setup and processing

Chris O'Donnell

### 8.1 V75 processing

*RRS Discovery* has two Vessel mounted acoustic Doppler profilers (VMADCP): the 150 kHz and the 75 kHz. Both were switched on at the start of DY078. During the cruise the raw data from the VMADCPs were processed daily. There are many acoustic instruments on the ship and their operation is coordinated through the k-sync system. During this cruise we quickly identified the quality of the ADCP data, in particular, the 75 kHz ADCP data, was not as good as that from last year's cruise (DY053), we believe the most likely cause was interference from the navigation echosounder which transmits at 50 kHz and is not synchronised by k-sync. When necessary, ZN would switch the ADCPs from 'on shelf' mode to 'off-shelf' mode.

The following tables summarise the raw data files for the entire cruise.

*Table 8.1 Data file information for the 75 kHz VMADCP. All files run within k-sync.*

File no.	start	end
001	20170506,08:06:15	20170506,12:04:17
002	20170506,12:05:42	20170506,16:25:43
003	20170506,16:26:51	20170506,16:26:51
004	20170506,16:29:21	20170506,16:29:21
005	20170506,16:32:03	20170507,05:30:04
006	20170507,05:31:41	20170507,21:03:47
007	20170508,02:40:02	20170508,10:04:03
008	20170508,10:06:25	20170508,10:06:25
010	20170508,10:07:35	20170508,10:11:38
011	20170508,10:18:42	20170508,15:32:45
012	20170508,15:34:25	20170509,18:26:27
013	20170509,18:28:04	20170510,07:54:06
014	20170510,07:57:00	20170510,11:49:00
021	20170510,12:05:05	20170511,10:29:07
022	20170511,12:27:42	20170511,16:13:44
024	20170511,16:21:17	20170511,16:49:19
025	20170511,17:49:55	20170512,08:13:57
026	20170512,08:20:36	20170512,11:16:38
027	20170512,14:41:06	20170513,11:17:10
028	20170513,12:30:59	20170513,19:49:02
029	20170513,20:18:15	20170514,18:16:20
030	20170514,18:19:03	20170515,17:53:06
031	20170515,17:54:12	20170516,06:02:18
032	20170516,06:04:07	20170517,18:56:09
033	20170517,18:57:34	20170519,07:45:35
034	20170519,07:47:35	20170520,06:57:35
035	20170520,06:58:08	20170521,11:58:10
036	20170521,12:00:05	20170522,06:14:08
037	20170522,06:14:48	20170523,07:58:49
038	20170523,07:59:04	20170524,06:09:04
039	20170524,06:10:40	20170525,06:10:41

Table 8.2 Data file information for the 150 kHz VMADCP. All files run within k-sync.

File no.	start	end
001	20170506,08:04:13,	20170506,12:08:14
002	20170506,12:16:05,	20170506,16:24:08
003	20170506,16:26:00,	20170507,05:28:02
004	20170507,05:30:11,	20170508,10:04:15
005	20170508,10:06:43,	20170508,15:08:46
006	20170508,15:09:45,	20170509,18:27:45
007	20170509,18:28:00,	20170510,07:54:02
008	20170510,07:57:18,	20170510,11:49:19
009	20170510,11:52:04,	20170511,10:28:04
011	20170511,12:28:18,	20170511,16:14:20
013	20170511,16:21:19,	20170511,16:49:19
015	20170511,17:51:05,	20170512,08:15:06
016	20170512,08:20:29,	20170512,11:16:30
017	20170512,14:41:06,	20170513,11:17:09
018	20170513,12:31:08,	20170513,19:49:09
025	20170513,20:19:59,	20170514,18:16:00
026	20170514,18:19:09,	20170515,17:53:10
027	20170515,17:54:10,	20170516,06:02:14
028	20170516,06:06:03,	21070517,18:56:04
029	20170517,18:57:30,	20170519,07:45:31
030	20170519,07:47:46,	20170520,06:57:46
031	20170520,06:58:09,	20170521,11:58:10
032	20170521,11:59:52,	20170522,06:13:52
033	20170522,06:14:46,	20170523,07:58:47
034	20170523,07:59:05,	20170524,06:09:05
035	20170524,06:10:45,	20170525,06:10:45

During the cruise we processed the data in the STA format (short time averaging), which was a two-minute average of single ping data. The following is an outline of the processing steps.

### Processing steps:

(1) Go to VMADCP directory in the terminal window

```
cd cruise/data/VMADCP/v75
```

(2) Remove the incomplete data. The incomplete data have the largest sequential number. It has to be done because the linkscript also copies data that is still being collected. These steps have to be done before syncing the new VMADCP data.

```
rm -r rawdata$highernumber$
```

*e.g. for file 020*

```
> /bin/rm -rf rawdata020
```

```
> /bin/rm -rf dy078020nbenx
```

(3) Copy the new data files. The function that synchronizes the ship ADCP data is:

## **vmadcp\_linkscript75\_dy078.sh**

(4) Create a new directory structure containing all the output files:

```
adcpree.py dy053$NNN$ --datatype sta
```

(where NNN is the number of processed file)

(5) Copy processing file (python script) into processing directory for each data file:

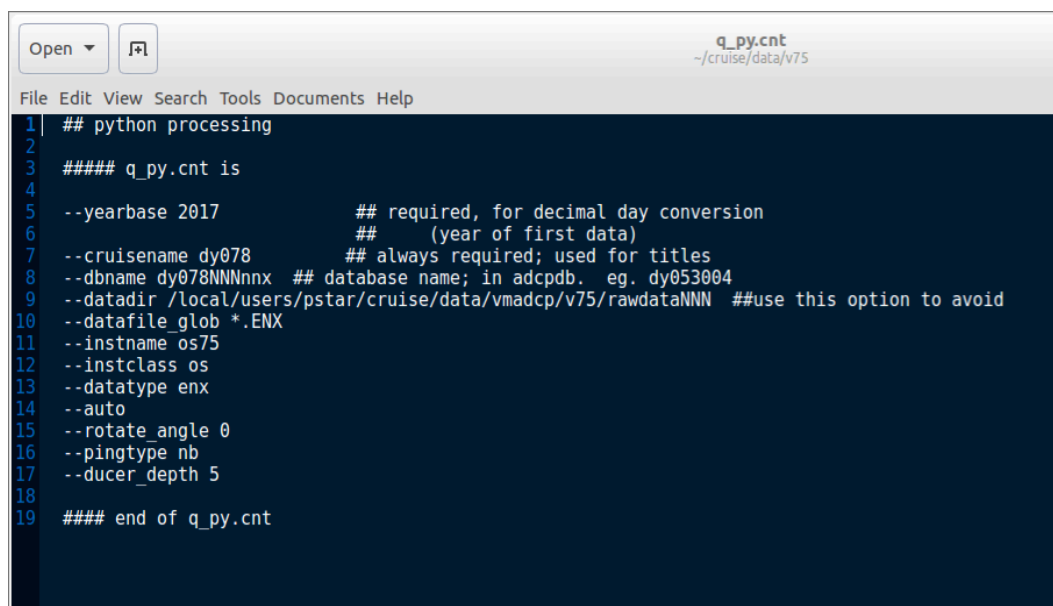
```
cp ../q_py.cnt
```

(6) Edit the calibration file by changing the dbname and datadir to the current number file  
(figure x):

```
gedit q_py.cnt
```

(7) Run the processing by loading the python script

```
quick_adcp.py -cntfile q_py.cnt
```



```
1 | ## python processing
2 |
3 | ##### q_py.cnt is
4 |
5 | --yearbase 2017          ## required, for decimal day conversion
6 |                          ## (year of first data)
7 | --cruisename dy078      ## always required; used for titles
8 | --dbname dy078NNNnnx  ## database name; in adcpdb.  eg. dy053004
9 | --datadir /local/users/pstar/cruise/data/vmadcp/v75/rawdataNNN ##use this option to avoid
10 | --datafile_glob *.ENX
11 | --instname os75
12 | --instclass os
13 | --datatype enx
14 | --auto
15 | --rotate_angle 0
16 | --pingtype nb
17 | --ducer_depth 5
18 |
19 | ##### end of q_py.cnt
```

Figure 8.1 Example of python processing file *q\_py.cnt* used during processing step 6

(8) Finding the ADCP misalignment angle (the calibration).

The calibration information can come from BT (bottom track) or WT (water track) files.

For both ADCPs we used the calibration coming from the BT files that can be found in the “cal” directories of the processing directories (e.g.

dy078011nbenx/cal/botmtrk/\*out). On the dy078 cruise, we used the calibration obtained from the bottom track data (tables 10.3, 10.4) acquired during the first 10 days of the cruise (spent for most of the time on the shelf/slope, < 1000m)

*Table 8.3: Calibrations obtained from bottom track mode for v75.*

	Time range	Num of points (edited)	Amplitude			Phase		
			Median	Mean	Std	Median	Mean	Std
001	125.45 to 125.50	4	1.0112	1.0107	0.0016	0.7328	0.7989	0.3457
002	125.51 to 125.68	34	1.0115	1.0115	0.0023	0.6747	0.6511	0.173
005	125.70 to 126.88	218	1.0131	1.0133	0.003	0.7811	0.7823	0.2091
011	127.44 to 127.64	40	1.0141	1.014	0.0023	0.9369	0.93	0.1601
029	132.85 to 133.76	112	1.0146	1.0143	0.0045	0.7394	0.7121	0.2754
030	133.77 to 134.74	49	1.0138	1.0121	0.0119	0.597	0.6042	0.6642
031	134.75 to 134.96	17	1.0143	1.0161	0.012	0.5202	0.6235	1.0561
<b>Mean</b>			<b>1.0132</b>	<b>1.0131</b>	<b>0.0054</b>	<b>0.7117</b>	<b>0.7289</b>	<b>0.4119</b>

*Table 8.4: Calibrations obtained from bottom track mode for v150.*

	Time range	Num of points (edited)	Amplitude			Phase		
			Median	Mean	Std	Median	Mean	Std
001	125.45 to 125.51	5	0.9982	0.9988	0.0013	0.0131	0.0633	0.2903
002	125.52 to 125.68	47	0.999	0.9991	0.0014	0.0889	0.0836	0.082
003	125.69 to 126.23	144	1.0018	1.0017	0.0016	0.1249	0.1241	0.0872
004	126.24 to 127.42	319	1.0046	1.0051	0.0028	0.2819	0.2824	0.1343
005	127.43 to 127.63	58	1.0026	1.0024	0.0025	0.3881	0.3942	0.1811
025	132.86 to 133.76	160	1.0021	1.0019	0.0029	0.1496	0.1395	0.1607
026	133.77 to 134.14	32	0.999	0.9997	0.0056	0.0231	0.085	0.4251
027	134.75 to 134.95	21	1.0004	1.0024	0.0061	0.2324	0.295	0.5923
Mean			1.0014	1.0018	0.0033	0.1841	0.2005	0.2375

The angle and amplitude calibrations were then applied by running quick\_adcp.py:

```
cp ../q_pyrot.cnt .
```

```
quick_adcp.py --cntfile q_pyrot.cnt
##### q_pyrot.cnt is
--rotate_angle 0.7117
--rotate_amp 1.0132
--steps2rerun rotate:navsteps:calib
--auto
##### end of q_pyrot.cnt
```

(9) The final step is to load the data into MSTAR:

```
cd cruise/data/vmadcp/v75/dy053$NNN$
```

and run the following functions in Matlab:

```
mcod_01_dy078 ; - Produces output file os75_dy078NNNnmx.nc, which has a
collection of
variables of dimensions Nx1 1xM NxM.
```

**mcod\_02**; - calculates water speed and ship speed and get all the variables onto an NxM grid.

**mcod\_checkplots**; -provides a quick visual display of the data for the previous day.

**mcod\_mapend**; - appends individual files to create a single cruise file ("\_01"). This function was edited as not all the files had the same bin number and bin depths.

## 8.2 V150 processing

The processing of the 150 kHz has been done in the end of the cruise. The processing steps were the same as in the os75. The function that synchronized the OS150 kHz ADCP data was:

### **vmadcp\_linkscript150.**

All available 150 kHz data were read in CODAS using the `q_py.cnt` script. The rotation angle and amplitude calibration were applied using the

`q_pyrot.cnt` script.

The final product of processed data was saved in:

**cruise/data/vmadcp/v150.**

### **Processing scripts:**

```
##### q_py.cnt is
--yearbase 2017      ## required, for decimal day conversion # (year of first data)
--cruisename dy078  ## always required; used for titles
--dbname dy078all   ## database name; in adcpdb. eg. a0918
--datatype sta      ## datafile type
--sonar os150nb     ## instrument letters, frequency, [ping]
--ens_len 120       ## specify correct ensemble length
--datadir ../rawdata_all ##use this option to avoid
--auto
##### end of q_py.cnt
```

```
##### q_pyrot.cnt is
--rotate_angle 0.1841
--rotate_amp 1.0014
--steps2rerun rotate:navsteps:calib
--auto
##### end of q_pyrot.cnt
```

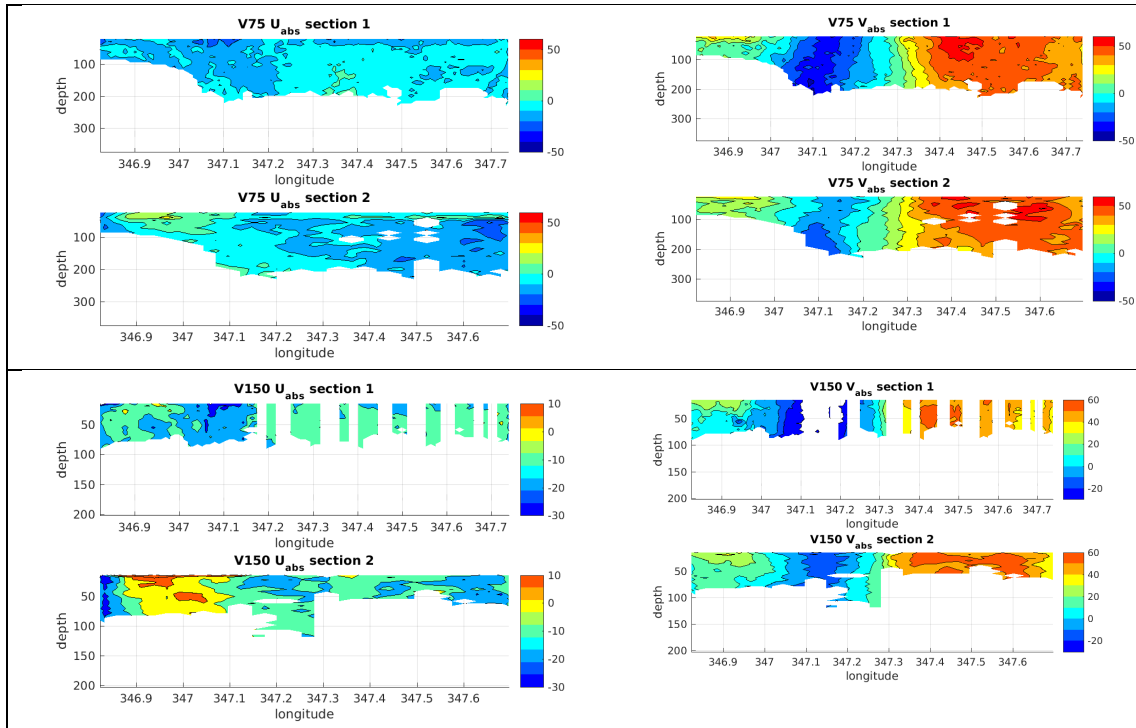


Figure 8.2. Western Boundary Surveys 1 and 2, as observed by both VM-ADCPs

### 8.3 Western Boundary (WB) and Shelf Edge Current (SEC) surveys

During the cruise we had the opportunity to conduct LADCP surveys of the SEC region (5 passes) and WB wedge region (2 passes). The net volume fluxes in both these regions make a significant contribution to the total volume flux in the Rockall Trough. However, the temporal evolution of the transport in these regions cannot be estimated by the hydrography from RTEB1 and RTWB1 and is not well represented by the current meters on the moorings. It is therefore important to directly measure the current velocities in these regions when the opportunity arises. Unfortunately the quality of the raw data acquired by both the 75 kHz and 150 kHz ADCPs was poorer than the data from DY053. Consequently, the depth of penetration of ‘good’ data on this occasion was limited to approximately 200 m for both instruments. Zonal (U) and meridional (V) velocities from both sections are displayed in the following figures. They include U and V measured by both the 75 kHz and 150 kHz ADCPs.

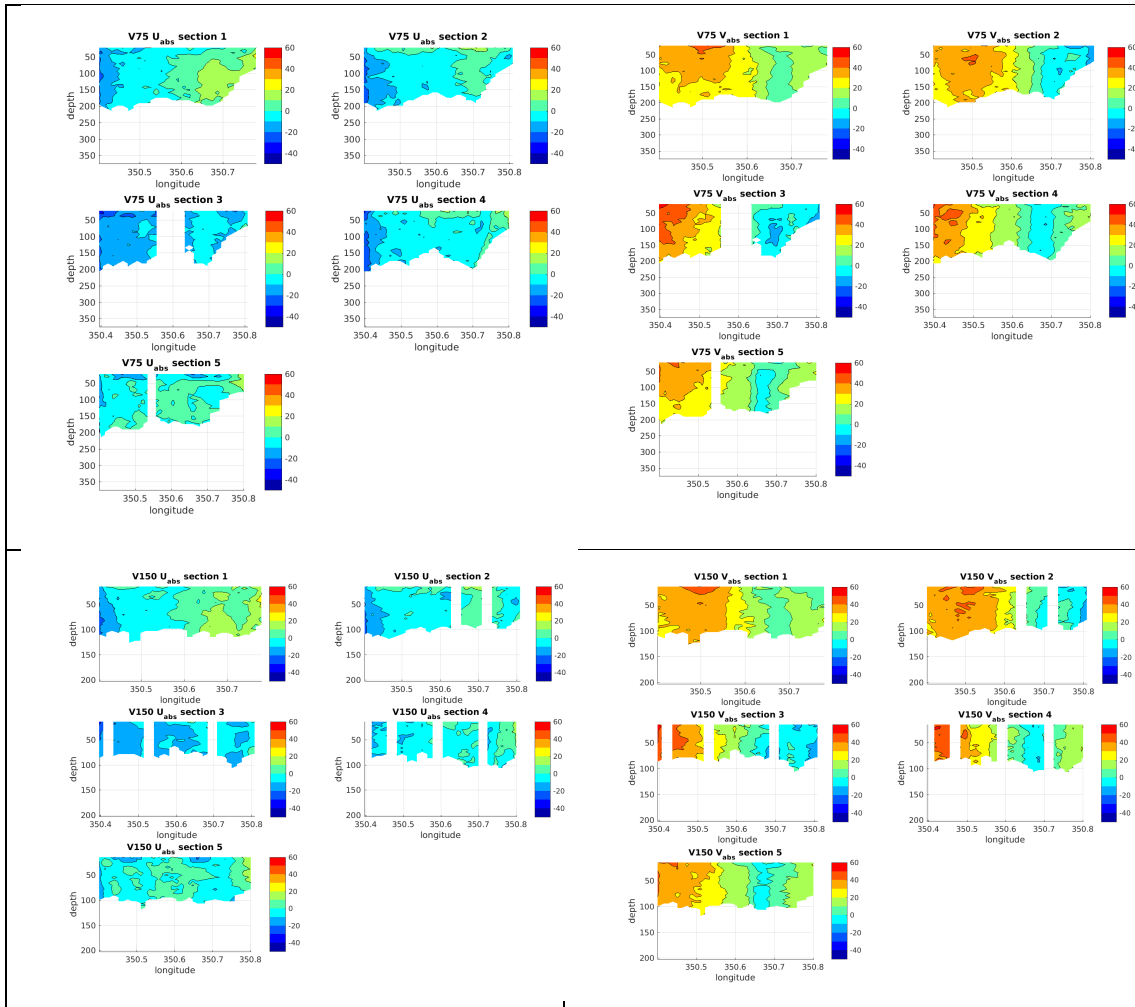


Figure 8.3. Shelf-edge current as observed by both VM-ADCPs

## 9. L-ADCP setup and processing

Loic Houpert, Chris O'Donnell

### 9.1 LADCP Setup

Full water column velocity profiles for the DY078 cruise were collected using a TELEDYNE RD Instruments dual 300 kHz Workhorse master/slave configuration ADCPs. The instruments, cables, and related equipment were provided by NMF. The primary downward-looking ADCP was s/n 13329 (firmware v.50.40 and the primary upward-looking 300 kHz ADCP was s/n 4275 (firmware v.50.41). The two Workhorse ADCPs were mounted on the CTD rosette using mounting brackets and hardware supplied by the National Marine Facilities (NMF) group. The brackets were bolted to a rigid vertical bar attached to the inner ring of the rosette. The upward-looking ADCP was positioned near the outer edge of the rosette, situated just above the upper rim of the frame. The downward-looking ADCP was positioned directly below; with the transducer face about 10 cm above the bottom plane of the rosette. Power was supplied to both instruments by an NMF ADCP rechargeable battery pack housing, mounted between the two ADCPs.

Both ADCPs were initially configured with parameters used in the previous year's cruise (DY053). This configuration used 25 10-meter bins, ambiguity velocity of 2.5m/s, one ping per ensemble saved in beam coordinates, and the blanking distance is set to 8 meters on the upward-looking (slave) ADCP and set to zero meters on the downward-looking (master) ADCP. Both instruments were configured to ping in narrowband mode every 1.5 seconds. The slave pings were synchronized to the master, with a delay of 0.55 seconds between the two. This configuration was kept for the remainder of the cruise.

### 9.2 Data Processing

A total of 60 profiles were collected (Figure 9.1). The two raw ADCP data files were first copied to the processing computer. Navigation data were extracted from the 1Hz ASCII data file generated by *mexec* (see underway processing). Once the files were in the proper directories, the "first-pass" processing could be executed. The initial processing of the raw ADCP data was done using version IX\_8 (May 2012) of the M. Visbeck & A. Thurnherr MATLAB toolbox. The *process\_cast(nnn)* script was run, with 'nnn' representing the station number, which called subroutines to copy, load, scan in, and run the shear and least-squares inverse methods. About a dozen graphics are generated with useful diagnostic information and the final water column profile.

Including ship VMADCP as an additional inversion constraint in the LADCP processing, does not improve the error on the final velocity profiles (Figure 11.2), as also observed during the DY053 cruise. Both methods, give a mean inversion-derived velocity error of  $4 \text{ cm}\cdot\text{s}^{-1}$  ( $4.1 \text{ cm}\cdot\text{s}^{-1}$  for the ctd only method,  $3.9 \text{ cm}\cdot\text{s}^{-1}$  for the CTD+VMADCP method).



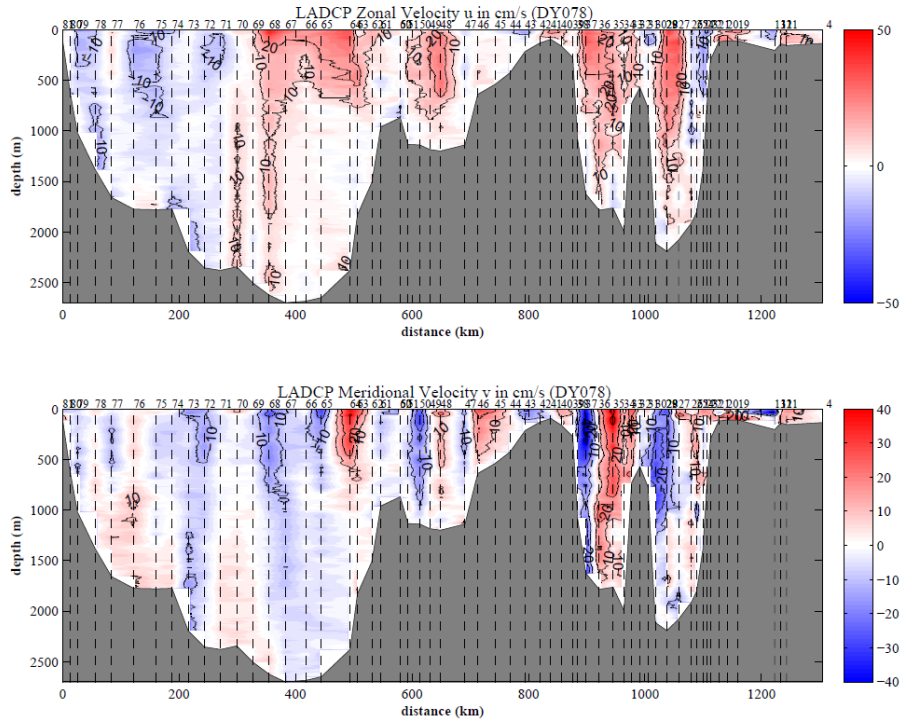


Figure 9.1: Eastward and Northward components from the LADC profiles (without using the VMADCP constraint)

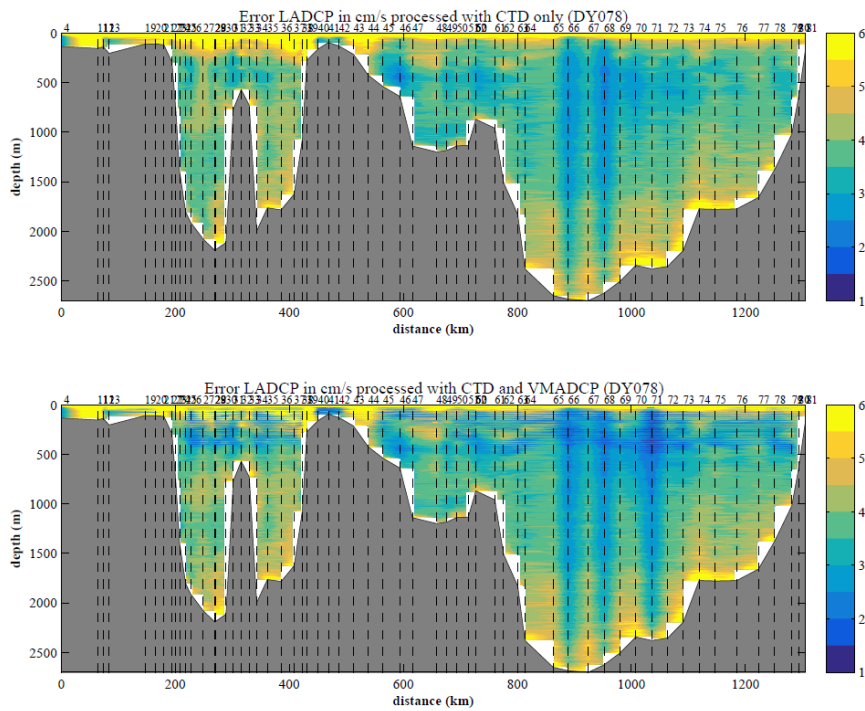


Figure 9.2: Inversion-derived velocity error from the LADC processing (in  $\text{cm s}^{-1}$ ). The top panel correspond to the processing where only CTD data were used to constrain the LADC processing. The bottom panel indicates result when the VMADCP and the CTD data are used to constrain the LADC processing

## 10. Underway processing

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The underway observations include data-streams from navigation, echo sounding bathymetry, meteorological observations, and sea surface observations.

### 10.1 Daily Processing (Stage A)

The daily processing for DY078 involved the following steps:

i) The techsas link script was run to create a directory of symbolic links to the netCDF files in the TechSAS stream.

```
~/mstar/dy078/data/exec/techsas_linkscript_dy078.sh
```

ii) To confirm that the linking script properly updated the available data-streams to process a full day, in Matlab run

```
>> mtlookd
```

iii) To extract the appropriate 24 hours of data from each stream run **m\_dy078\_daily\_processing(nnn)** where nnn is the Julian Day (DY078 start 125). This script calls the routine **mday\_00\_get\_all** and **mday\_00** for each data-stream, skipping any streams not present for the current cruise. The output will be a series of daily files with the raw data from each stream (e.g., attposmv\_dy078\_d125\_raw.nc) which will be stored in the following directories within /home/mstar/dy078/data/

```
/em120  
/log_skip  
/met/*  
/nav/*  
/sim  
/tsg
```

The daily processing script does some further processing of specific streams:

**mgyr\_01** is used to remove any data cycles with non-monotonic times from the ship gyro data-stream (nav/gyros)

**msim\_01** is used to run a median clean and 5-minute averaging of the EA640 echo sounder data and the EM122 (mem120\_01).

**msim\_plot** is used to interactively remove spikes from the echo sounder derived depths. Additional files were saved to log which data were rejected.

**mmet\_01** is used to correct the units of wind speed stored in the netCDF header. Although the header originally reported the speed in knots, comparison against the on-board live streams showed that the units were in fact m/s.

The script runs **mday\_02\_run\_all** to append the daily file onto the cruise master file for each stream (e.g., nav/gyros/gyp\_dy078\_01.nc).

Further details on individual streams is given below.

### Navigation (nav)

As part of the routine daily processing six navigation streams were extracted from TechSAS (attposmv, cnav, gyropmv, gyros, posmvpos, seapos). Note that there is duplicated information among some of the streams. On *Discovery*, the master position source is usually posmv. However on DY078 posmv frequently failed and contained bad data, so for this cruise our master navigation file is seapos (*seapos\_dy078\_01.nc*).

Seapos position information was streamed directly into the CTD and VMADCP units (replacing the posmv data).

There was no editing of positional information, except for the removal of any non-monotonic times with the routine **mgyr\_01**

Finally the "mbest" scripts were edited to generate a master bestnav file from the seapos position information (**mbest\_01\_seapos, mbest\_02\_seapos, mbest\_03\_seapos, mbest\_04\_seapos**). These generate a complete file containing position, heading, course and speed made good, and distance run. The data are reduced to a 30-second time base and heading is properly vector averaged. This is the definitive cruise navigation file. In order to avoid the problem of housekeeping variables like distrun across daily files, the bestnav processing is rerun from the start of the cruise each time it is required. There is therefore only ever one master file.

### Bathymetry

The EA640 data were read into mexec directory 'data/sim', and the EM122 data into the mexec directory 'data/em120'. The data were routinely processed within the script **m\_dy078\_daily\_processing.m**. Daily files of raw data and smoothed data were preserved. The key stages are:

**msim\_01 and mem120\_01** to read raw data for given day number and discard data outside the depth range 20m to 10000m, then take the median depth in 300 second bins to discard noise.

Input: data/sim/**sim\_dy078\_dnnn\_raw.nc**

Output: data/sim/**sim\_dy078\_dnnn\_smooth.nc**

Output: data/sim/**sim\_dy078\_dnnn\_edited.nc**

The **\_edited.nc** file is an exact copy of the **\_smooth.nc** file, for later use in **msimplot.m**.

**msim\_02** cross-merges bathymetric data streams, bringing em120 data into the **sim\*.nc** file.

Input: data/sim/**sim\_dy078\_dnnn\_edited.nc**  
Input: data/em120/**em120\_dy078\_dnnn\_edited.nc**  
Output: data/sim/**sim\_dy078\_dnnn\_edited.nc**

**msim\_plot** for graphical editing of the data for spike removal. This allows editing of both (sim and em120) data streams since they've already been merged.

Input: data/sim/**sim\_dy078\_dnnn\_edited.nc**

Output: data/sim/**sim\_dy078\_dnnn\_edited.nc** – selected values are changed to NaN

Output: data/sim/**mplxied\_<time>\_sim\_dy078\_dnnn** – records of which values were selected by the user.

Note: it is not necessary to run mem120\_plot.m since msim\_02 cross-merged the data.

**mday\_02** to append edited daily files are appended into a single file:

Input: data/sim/**sim\_dy078\_dnnn\_edited.nc**

Output: data/sim/**sim\_dy078\_01.nc** (with em120 as swath\_depth)

### Surface Atmosphere and Ocean Observations (met)

The 'met' streams are divided into three TechSAS streams: met/surfmet, met/surflight, and met/surftsg. The SeaBird SBE45 thermosalinograph data is logged in separate data stream (in the directory cruise/data/tsg or mexec abbreviation M\_TSG).

### SurfMet

Ship speed, position and heading from the seapos navigation file were merged onto the wind data in the surfmet stream.

The absolute wind speed is calculated and vector averaged with **mtruew\_01\_dy078.m**. As with bestnav processing, this is rerun for the entire cruise each time the data are updated. The output files from this processing are

data/met/surfmet/met\_dy078\_true.nc

data/met/surfmet/met\_dy078\_trueav.nc

The latter file is reduced to 1-minute averages, with correct vector averaging when required. In order to avoid ambiguity, variable units are explicit in whether wind directions are 'towards' or 'from' the direction in question.

As stated earlier, **mmet\_01** is used to correct the units of wind speed stored in the netCDF header. Although the header originally reported the speed in knots, comparison against the on-board live streams showed that the units were in fact m/s.

### - SurfLight

PA irradiance and thermal-IR data are found in the surflight stream, which also contains surface pressure. These streams were ingested and stored, but no further

processing was undertaken.

#### - SurfTSG

The daily processing creates two sets of raw files and two concatenated cruise master files related to the underway thermosalinograph (TSG) stream:

data/met/surftsg/met\_tsg\_dy078\_d???.nc

extracted from TechSAS data stream Surf-DYS-SM\_DY1.SURFMETv2  
including variables time, temp\_h, temp\_m, cond, fluo, trans

data/tsg/tsg\_dy078\_d???.nc

extracted from TechSAS data stream SBE45-SBE45\_DY1.TSG  
including variables time, temp\_h, temp\_r, cond, sndspeed, salin

The surftsg steam doe not log the actual temperatures (temp\_h and temp\_m) or conductivity (cond). These data streams are logged as constant values

#### Thermosalinograph (TSG, SurfTSG)

The TSG stream contains the logged temperatures, conductivity, and derived salinity from the TSG. The salinity values were recalculated from the housing temperature and conductivity (using **mtsg\_make\_sal.m**) to confirm that the salinity values stored in the files was reliable and the conductivity units (S/m) as reported in the netCDF attributes.

### **10.2 Calibration of TSG salinity (Stage B)**

Calibration of TSG salinity used the followed steps:

i) Edit **mtsg\_cleanup.m** to hardcode the times when the pumps were switched off, such as the stat and end of the cruise, and any periods of maintenance. This routine will be run later as part of **mtsg\_medav\_clean\_sal.m**.

ii) Run **mcd('M\_TSG')** to move to the TSG directory within MatLab.

iii) Run **mtsg\_findbad\_dy078.m** to interactively remove spikes and bad data from the temp\_h, cond and salin variables. The commands to select periods to be marked as bad are explained on running the routine. Note the use of 'n' to store the start and end of the bad data and move on to the next segment. The output file with bad times is appended every time this routine is run, so can be done throughout the cruise.

Input: data/tsg/tsg\_dy078\_01.nc

Output: data/tsg/bad\_time\_lims.mat

iv) Run **mtsg\_medav\_clean\_cal\_dy078.m** to create 1-minute median-binned data and remove known bad data identified in the previous step (the times stored in bad\_time\_limits.mat).

Input: data/tsg/tsg\_dy078\_01.nc

Output: data/tsg/tsg\_dy078\_01\_medav\_clean.nc

v) Check for updates to the TSG salinity bottle samples, in data/ctd/BOTTLE\_SAL/. To this file, add a sample number for each underway salinity sample using the format DDDHHMMSS (recorded in the underway logsheets) for TSG samples, and sample number 99#### for standards, where #### is the bottle number.

Input: data/ctd/BOTTLE\_SAL/tsg\_dy078\_nnn.csv

Output: data/ctd/BOTTLE\_SAL/tsg\_dy078\_nnn.csv\_linux

vi) Run **mtsg\_01\_dy078.m** to convert TSG salinity bottle samples from ASCII to netCDF. First the routine had to be updated with a cruise specific bath temperature. For DY078, the same settings were used as had been agreed for the CTD salt sample processing. This step can be run as each TSG crate has been processed.

Input: data/ctd/BOTTLE\_SAL/tsg\_dy078\_nnn.csv\_linux

Output: data/ctd/tsg\_dy078\_nnn.nc

Output: data/ctd/tsg\_dy078\_all.nc

vii) Run **mtsg\_bottle\_compare\_dy078.m** to merge the clean 1-minute data onto bottle samples. This should first be run with the switch at the top of the script set to uncalibrated. Individual bottle residuals are plotted, as well as a smoothed time series of the residuals, (see Fig. 13.2) which can then be used as a slowly-varying adjustment to the TSG salinity in the next step.

Input: data/ctd/tsg\_dy078\_01\_medav\_clean\_cal.nc

Output: data/tsg/tsg\_dy078\_01\_medav\_clean\_cal\_botcompare.nc

viii) Run **mtsg\_apply\_salcal\_dy078.m** to smooth the differences in botcompare, interpolates and adds them to the uncalibrated salinity data. You can run **mtsg\_bottle\_compare\_dy078.m** after this to check the residuals are acceptable.

calls **mtsg\_salcal\_dy078.m**

Input: data/met/surftsg/met\_tsg\_dy078\_01\_medav\_clean.nc

Input: data/met/surftsg/met\_tsg\_dy078\_01\_medav\_clean\_botcompare.nc

Output: data/met/surftsg/met\_tsg\_dy078\_medav\_clean\_cal.nc

ix) Rerun **mtsg\_bottle\_compare\_dy078.m** to merge the clean 1-minute data onto bottle samples. This should now be run with the switch at the top of the script set to calibrated.

x) Run **met\_tsg\_av\_addnav\_dy078.m** to merge with navigation data (lat and long) on variable time. Run **mbest\_all.m** prior to this to update the best navigation file **bst\_dy078\_01.nc**.

Input: data/tsg/tsg\_dy078\_01\_medav\_clean\_cal.nc

Input: data/nav/posmvpos/bst\_dy078\_01.nc

Output: data/tsg/tsg\_dy078\_medav\_clean\_cal\_nav.nc (final file)

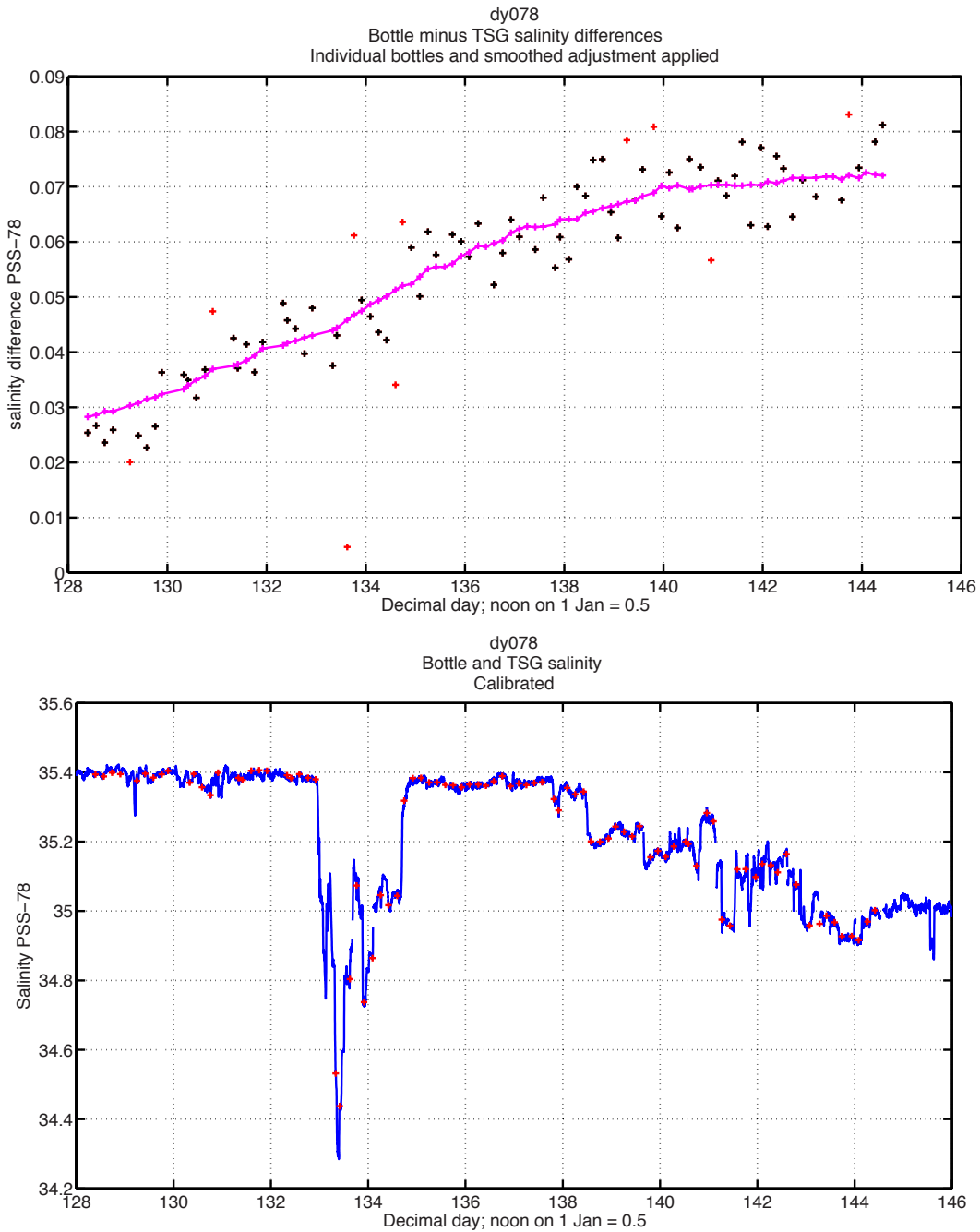


Figure 10.1 DY078 TSG salinity and bottle samples. Top panel is the salinity adjustment applied during the calibration (pink line) derived from the salinity bottle samples (black crosses) and excluding outliers (red crosses). Bottom panel is the calibrated TSG salinity against day number (blue line) with bottle samples (red crosses).

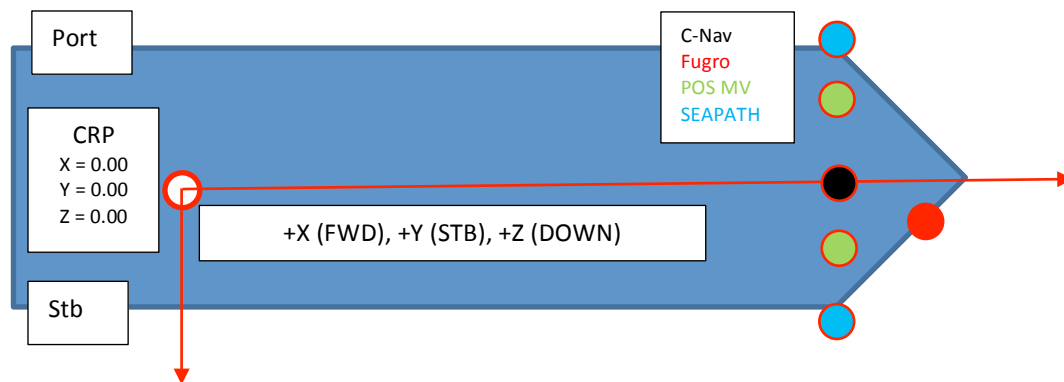
### 10.3 Navigation Streams

*RRS Discovery* has four navigation systems for scientific purposes: C-Nav 3050, Fugro, Trimble Applanix POS MV and Konsberg SEAPATH 330. All navigation data were transferred and logged to the TECHAS system. C-Nav 3050 and Fugro navigation systems provide position only information/data, i.e. differential GPS,

whilst Trimble Applanix POS MV and Konsberg SEAPATH 330 are both GPS and MRU (motion reference unit) instruments, providing position, pitch, roll, true heading, heave. Primary navigation system during DY078/79 was Trimble Applanix POS MV.

### GPS navigation systems accuracy/comparisons

High precision navigation data are fundamental and pre-requisite for the acquisition of accurate underway measurements of both hydrographic and meteorological parameters, such as ocean currents and wind velocities. In order to determine accuracy and performance of the on-board navigation systems, median positions and standard deviations of GPS data from all four systems were calculated and compared. The GPS data used for accuracy checks were acquired on 5<sup>th</sup> of May (Julian day 125), a ‘stationary day’, whilst *RRS Discovery* was at port in Southampton. Good agreement between C-Nav/Fugro, POS MV/SEAPATH 330 pairs GPS data was observed and evident (Figure 1, scatter plot). Similarities in data points distribution between the respective pairs is due to the location of systems instruments antennas on-board the ship in relation to the ships Central Reference Point (CRP) (Fig. 10.3, Table 10.1). C-Nav and Fugro navigation systems operate with the use of one antenna each, whilst POS MV and SEAPATH 330 have two antennas each, positioned on the ship’s port and starboard sides accordingly (Fig. 10.3).



*Fig. 10.3 Schematic representation of ship's CPR and axis orientations; centreline defined by centre keel, X = 0.00 at AP, X = 0.00 at centreline, Z = 0.00 at baseline; positive X axis is forward and along ship's centre keel, positive Y axis is Starboard, positive Z axis is downwards*

Navigation system antenna	X (+Fwd)	Y (+Stb)	Z (+Down)
C-Nav Centerline	13.758	0.053	-31.677
Fugro Stb	14.473	0.417	-31.609
POS MV Port	13.776	-0.947	-31.659
POS MV Stb	13.760	1.054	-31.679
SEAPATH Port	13.764	-1.245	-31.653
SEAPATH Stb	13.752	1.350	-31.658

*Table 10.1 Positions of navigation systems antennas in relation to ship's centre reference point; all coordinates in meters, probable general position accuracy ±2 mm*



The ship's primary navigation system POS MV proved most accurate, with mean longitude and latitude readings of 0.0704 m and 0.1799 m respectively, and corresponding longitude and latitude standard deviations of +/- 0.1246 m and 0.1610 m respectively (Fig. 10.3, Table 10.2, Table 10.3). Least accurate of all four systems happened to be the Fugro navigation system, median position longitude and latitude of 0.2932 m and 0.1669 m respectively and respective standard deviations of 0.2262 m and 0.2021 m. SEAPATH GPS readings exhibited largest scale of scatter, longitude and latitude standard deviations of 0.2766 m and 0.4906 m respectively. This is most likely due to the locations of the SEAPATH antennas being placed on the outer side of the x centreline axis (Fig. 10.3)

<b>Navigation system median</b>	<b>Longitude (m)</b>	<b>Latitude (m)</b>
C-Nav	0.1865	0.1799
Fugro	0.2932	0.1669
POS MV	0.0704	0
SEAPATH	0	-0.1112

*Table 10.2 Positions of median points for all navigation systems; signs representative of direction in relation to ship's CRP*

<b>Navigation system standard deviation (+/-)</b>	<b>Longitude (m)</b>	<b>Latitude (m)</b>
C-Nav	0.1717	0.1971
Fugro	0.2262	0.2021
POS MV	0.1246	0.1610
SEAPATH	0.2766	0.4906

*Table 10.3 Standard deviations for all navigation systems*

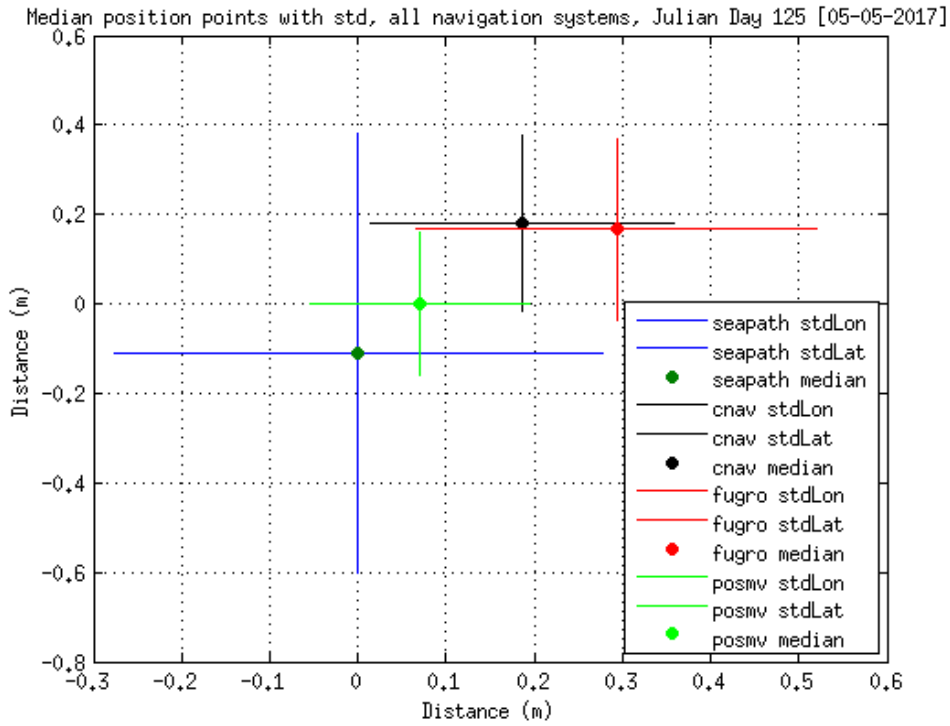


Figure 10.4 Median position and standard deviation of position recorded while RRS Discovery was alongside in Southampton on 5 May 2017.

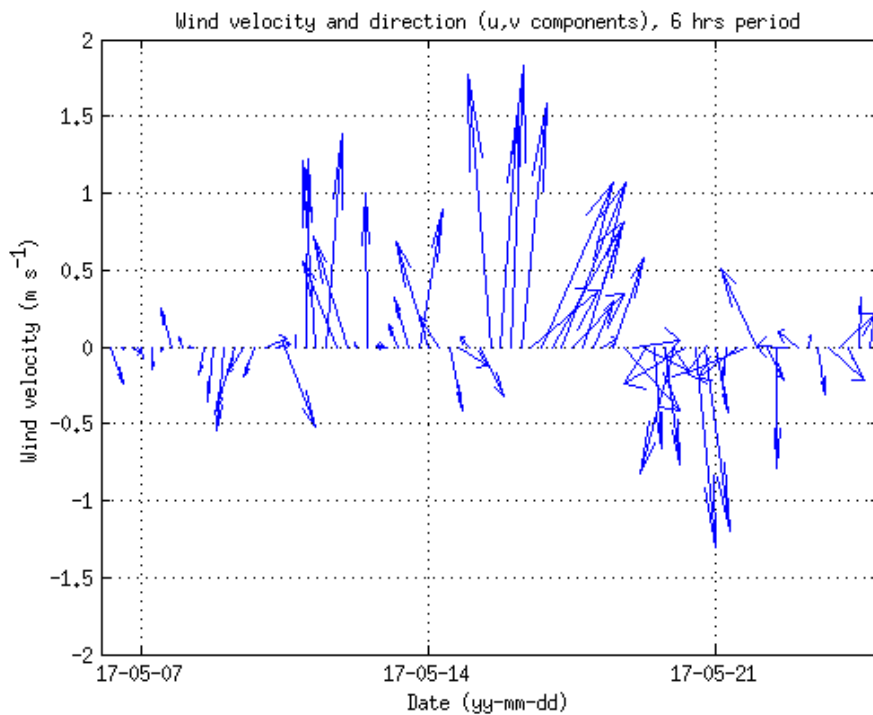


Figure 10.5 True wind speed and direction during DY078

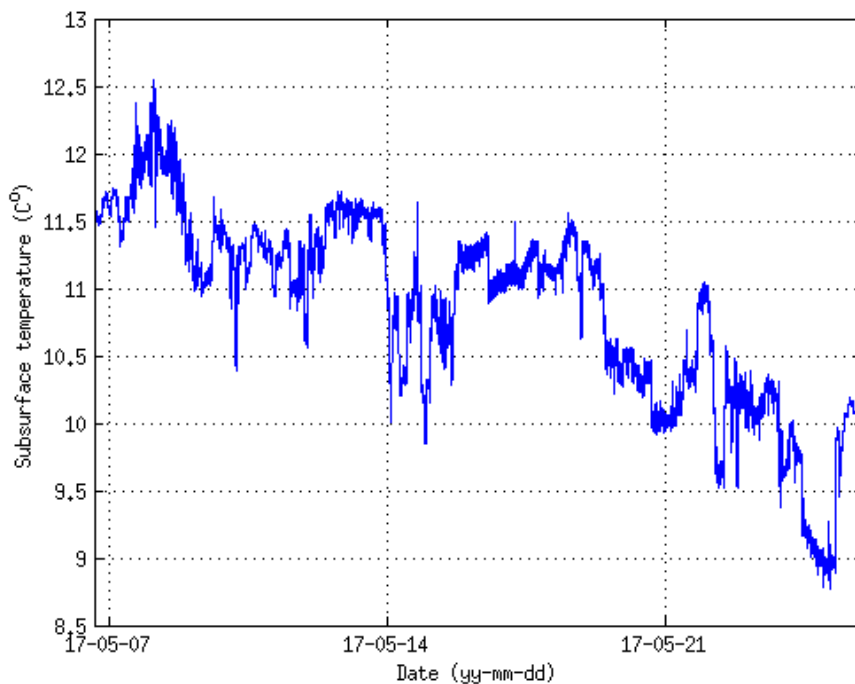


Figure 10.6 Underway near-surface temperature as recorded by the thermosalinograph during DY078 (*temp\_r*).

## 11. Salinity samples and Autosal

*Estelle Dumont, John Beaton, Penny Holliday*

### 11.1 Overview

Salinity samples from the CTD were collected from each of the 10 litre Niskin bottles fired at each station. The procedure was to rinse the sample bottle 3 times with water from the Niskin with cap on, fill bottle, insert a clean plastic stopper, wipe the bottle neck and inside of cap (to avoid the formation of salt deposits) and put the bottle cap on.

The samples were stored in crates in a temperature controlled laboratory for at least 24 hours before analysis. The temperature of the laboratory was kept around 18°C and was monitored by watchkeepers throughout the day. The salinometer used was a Guildline Autosal 8400B S/N 71185, with its bath temperature set at 21°C. It was connected to a computer via an Autosal computer interface (brand: OSIL). The data were recorded as Excel spreadsheets using the Labview 8.5 software.

The salinometer was standardised once at the start of the cruise. A bottle of standard seawater (SSW) was analysed at the start and end of each crate (24 bottles), with a new bottle being used each time. The standard seawater used was OSIL, batch P160 (nominal  $K_{15}=0.99983$ , practical salinity of 34.993). A total of nnn samples were analysed.

## 11.2 Salinity sample data

### *A. Prepare the bottle salinity files*

We need to edit the Autosol spreadsheets to give them a specific format, and to add the information to link the salinity samples with the CTD cast and niskin number.

1. Autosol spreadsheets can be found on the ship's server at

discofs/dy078/Sensors\_and\_Moorings/CTD/Data/CTD/Autosol\_data

The files will be named by crate number and the date they were analysed.

To work on them, drag and drop them onto your laptop

2. We need to produce one spreadsheet per CTD cast from the original spreadsheet. The original is saved as a new filename and edited as an .xls file.

For example "**DY031 CTD10 4 June 2015.xls**" may be saved twice as:

**sal\_dy031\_001.xls**

even though it contains data for stations 001 and 002 and 003.

3. Remove any blank header lines; there must be exactly 10 header lines in the new .xls file.

4. The first column should already include the CTD crate number (or cast number) and the salinity bottle number (ie the number written on the bottle in the crate).

For example   ctd001\_596  
                  ctd001\_597

5. A new last column (J) needs to be manually added to indicate the CTD station number and niskin bottle - this is the unique identifier for that sample and is called "**sampnum**". The format is **NNNnn** where NNN is cast number and nn is niskin number.

For example   sampnum  
                  00101  
                  00102  
                  00103

This information can be found on the CTD sampling logsheets.

SSW samples should be given sampnum starting at **999001** and increasing sequentially.

6. The corrected spreadsheet needs to be save as an xls file, and also as a single or as multiple comma-delimited files (.csv):

If the file contains more than one station's worth of samples save it as a csv for each of those stations eg

```
sal_dy078_001.csv contains data from stations 002:  
cp sal_dy078_001.csv sal_dy078_002.csv
```

The mstar scripts use the sampnum to identify data for each station, and expect one csv per station.

*B. Get the data files into the right place and format.*

7. The original autosal file, the new xls file and the new csv files should all be saved to:

```
//discofs/public/dy078_public/DY078_Salinity/
```

8. On workstation *sams-eel*, rsync **all** the files to ~/cruise/data/ctd/BOTTLE\_SAL

```
cd data  
cd ctd/BOTTLE_SAL  
rsync -av /mnt/public/dy078_public/DY078_Salinity/ .
```

(Note that if you want to replace a file already present BOTTLE\_SAL you will need to delete it first).

*C. Read the ascii data into mstar netcdf:*

At the start of the cruise, edit "msal\_01.m" to ensure the salinometer bath temperature is set to the correct temperature used on the cruise (24°C on DY078).

Next check the cruise-specific conductivity ratio offset to be applied to create a new adjusted salinity variable. The offset is derived from the SSW samples run through the salinometer. At the start of the cruise this should be set to zero for all stations, and you will change this later on when you have evaluated the salinometer performance with the SSW data.

```
> matlab &  
>> m_setup
```

```
>> msal_01_dy078.m reads the ascii file into matlab and saves as  
sal_dy078_nnn.nc.
```

```
>> msal_02.m pastes the bottle salinity into sam_dy078_nnn.nc.
```

*D. Evaluate the Autosal performance using the SSW samples*

Before using the salinity data to calibrate the CTD conductivity data, you need to see whether the bottle salinities need adjusting for the autosal offset.

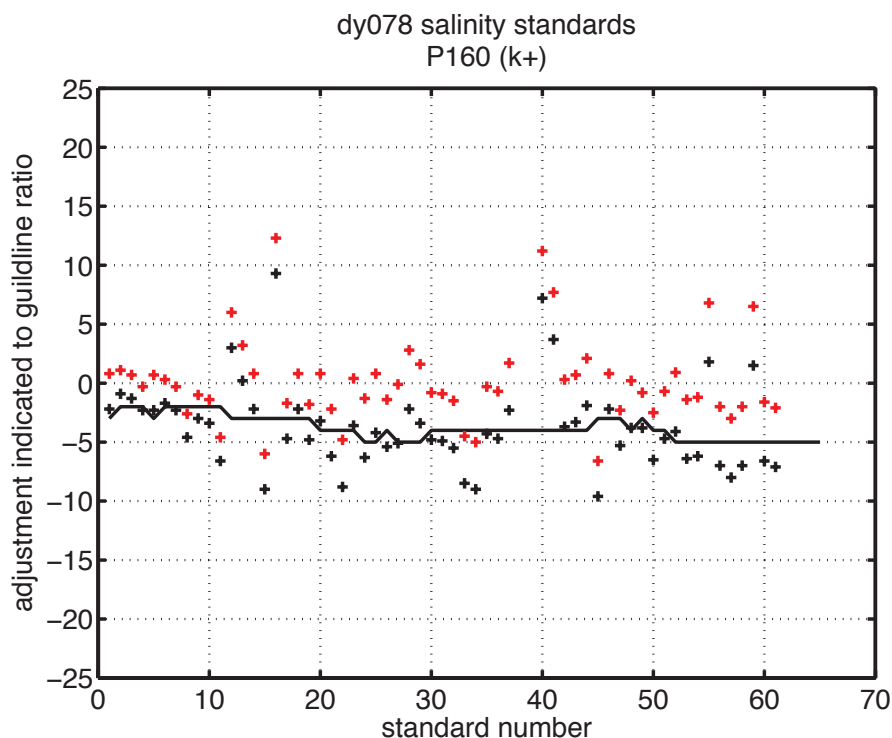
First pick out all the information from the standards:

```
>> msal_get_standards.m  
Output is text file sal_dy078_standards
```

```
>> msal_evaluate_standards.m
```

mevaluate\_standards generates a plot of the adjustment indicated by the samples to the Guideline Ratio of the SSW batch. The script can be edited to account for more than one batch of SSW used during the cruise. The figure allows the user to look for drift in the salinometer over time and to decide on an appropriate offset to use in **msal\_01.m**.

The performance of the salinometer on DY078 is shown in Figure 11.1. The black crosses indicate the uncorrected difference between the SSW batch ratio and the ratio measured by the Autosal. The black line indicates the suggested offset and the red crosses indicate the difference after than correction has been made.



*Figure 11.1 Salinometer performance as indicated by the standard seawater (SSW) bottles run at the start and end of crates of salinity samples. The variable plotted is the difference between the salinometer reading and the SSW ratio of the batch (listed on the bottle) ( $\times 10^{-5}$ ) (black crosses); the red line indicates the correction applied to the bottle sample data and the red crosses give the difference with the correction applied..*

*E. Apply the SSW-derived adjustment to bottle salinities*

Edit the cruise-specific case adjustments in **msal\_01.m**, then

run **msal\_01** and **msal\_02** for all the affected stations.

## **12. Oxygen samples and analysis: Determination of dissolved oxygen concentrations by Winkler titration**

*Debra Brennan, Winnie Courtene Jones and Sharon McNeill.*

### **12.1 Introduction**

Dissolved oxygen concentrations were measured in 898 seawater samples collected during DY078-9. Sampling and analysis were performed 24hrs a day from CTD casts using Winkler photometric auto-titration. Methodologies followed those documented in 'Go-Ships' protocols (Langdon, 2010) and based on the standard methodologies of Carpenter 1965 adapted for large scale hydrographic studies (eg Culberson, 1991 and Dickson, 1995).

Prior to analytical session the titration was standardised using an Osil 0.01N iodate standard. Precision of the analysis was estimated using duplicate measurements of samples collected from same the Niskin bottle at the deepest and shallowest depths.

### **12.2 Methodology**

Seawater samples were drawn from Niskin bottles via a short length of silicon tubing without allowing air bubbles to enter the individually calibrated sampling bottles. Excess seawater (at least three times the bottle volume) was flushed through the sample bottle to both clean it and remove any air bubbles. Samples were fixed immediately upon addition of 1ml of 3M MnCl<sub>2</sub> and 1ml of 8M NaOH + 4M NaI. The temperature of the sample during fixing was recorded using a digital thermometer ( $\pm 0.1^{\circ}\text{C}$ ) in a separate sample bottle. Reagents were dispensed below the surface of the sample so as not to introduce air bubbles and ensure all reacting species were contained within the sample. Ground glass lid stoppers were added tightly, again ensuring no air bubbles were trapped within the sample. Samples were shaken vigorously and transferred to a dark cool storage space in the lab. After half an hour samples were re-shaken and allowed to settle and equilibrate with lab temperature for at least another half an hour.

Before every analytical session the titrant (0.1M Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub>) was standardised using a commercially purchased OSIL 0.001667M KIO<sub>3</sub> standard. Reagent blanks were also measured during standardisation following the methodologies of Carpenter (1965) and subtracted during the titration calculation. From CTD casts 42 to 58 the reagent blank showed an increase which was much higher than on previous casts, the winkler settings were adjusted in titre data which gave a lower blank reading for the following casts. The data was then corrected with a 'true' blank reading for CTD casts 42 to 58 and flagged in the WOCE code as questionable data labelled 3.

## References

- Carpenter, J.H. 1965. The Chesapeake Bay Institute technique for the Winkler dissolved oxygen method. *Limnol. and Oceanogr.* 10:141-143.
- Culbertson, C.H. 1991. Dissolved Oxygen. WHPO Publication 91-1.
- Dickson, A.D. 1995. Determination of dissolved oxygen in sea water by Winkler titration. WOCE Operations Manual, Part 3.1.3 Operations & Methods, WHP Office Report WHPO 91 – 1.
- 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 reports and guidelines. IOCCP report No.14.

### 13. CTD Oxygen Calibration

*Jason Salt, Stuart Cunningham*

The CTD oxygen calibrations were not completed at the time of writing of this report, because of complexities in the oxygen bottle sample results.

The following analysis was completed onboard.

#### 13.1 Initial comparison of CTD sensors vs Bottle measurements

For casts 42-58, there was an issue with the bottle measurements that resulted in these being considerably higher & offset from both oxygen sensors and were therefore flagged as a 3 for questionable using the woce data flags and excluded from further analysis. These points and any others marked as having aflag other than 2 are coloured in cyan in all figures. At cast 59, the issue appeared to be resolved, although a slight offset was still occurring compared to both CTD oxygen sensors.

The initial analysis was carried out using *sbe43\_sam\_oxy\_cal02.m* individually for each oxygen sensor. Under the advice of SBE Application notes No. 64-2 (June 2012) & 64-3 (Aug 2014), the ratio between each CTD sensor & the bottle measurements was compared, with those points below a pressure of 1400db being highlighted. Figure 13.1 shows this data for the first oxygen sensor only.

It was clear for both sensors that the ratio was not constant with bottle oxygen concentration as it should have been. This approach therefore should not be considered further for this cruise.

Data for both bottle & each CTD sensor was plotted against pressure and fitted with a 4 degree polynomial curve using *polyfit.m* and plotted (figure 13.2 – oxygen sensor 1 only). The residual between each oxygen sensor & the bottle measurements was also plotted (figure 13.3 – oxygen sensor 1 only). A plot of CTD oxygen values against bottle values is shown for oxygen sensor 2 in figure 13.4.



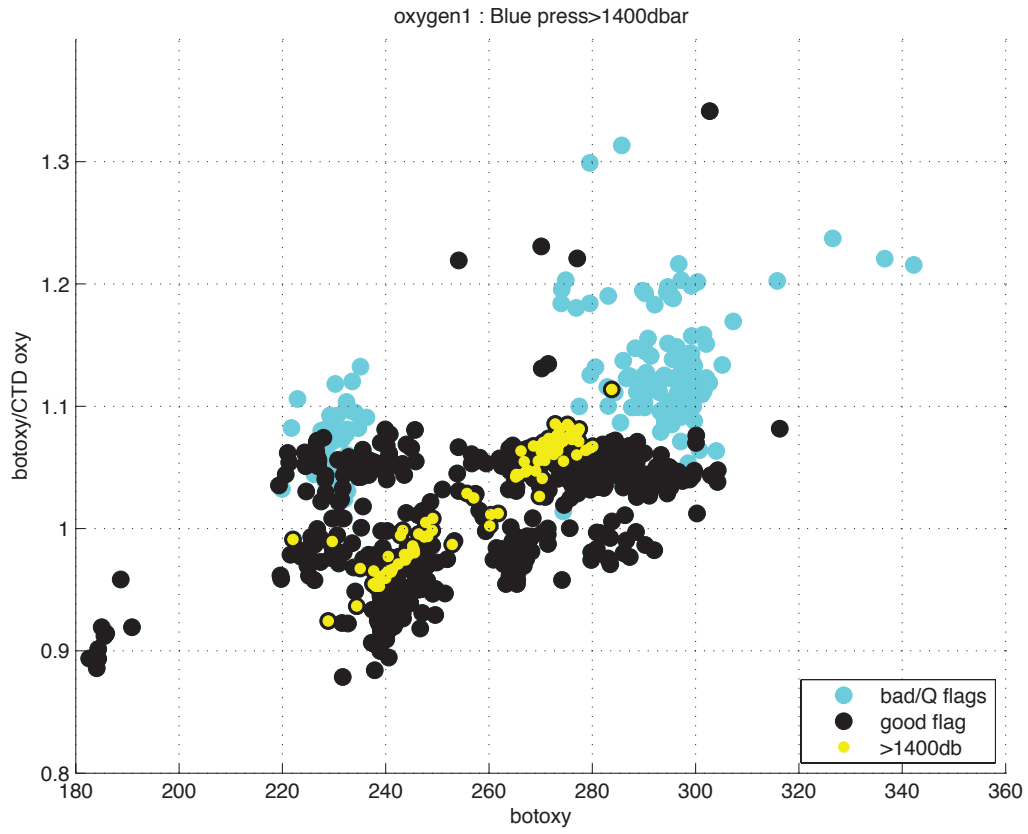


Figure 13.1

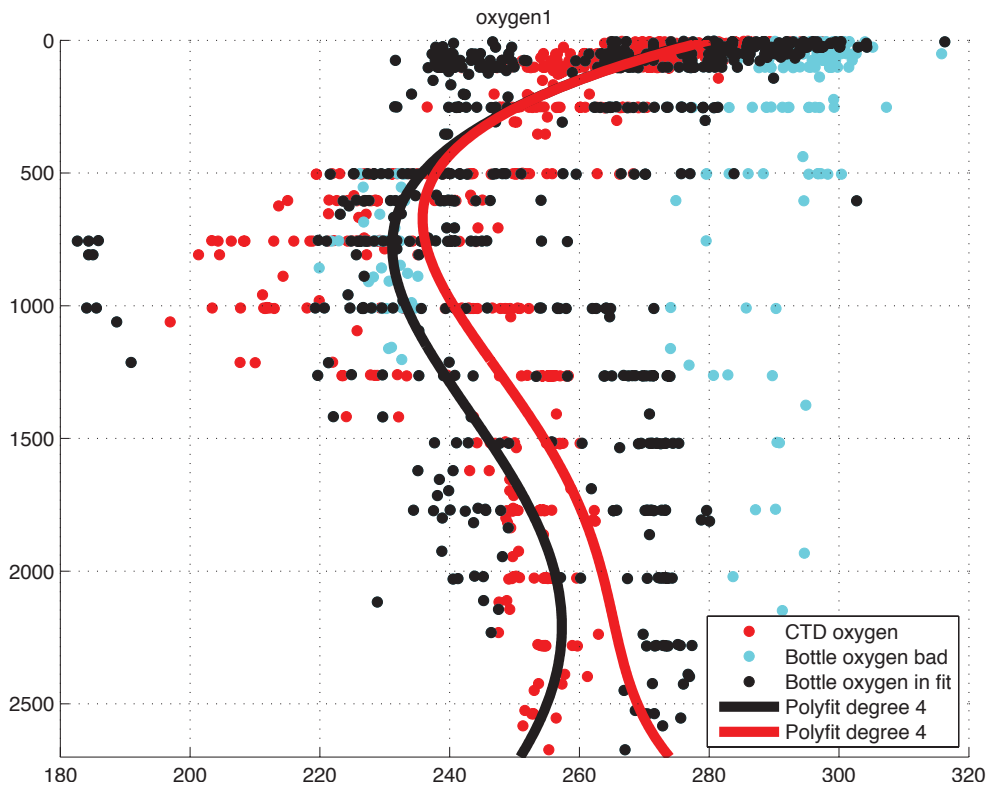


Figure 13.2

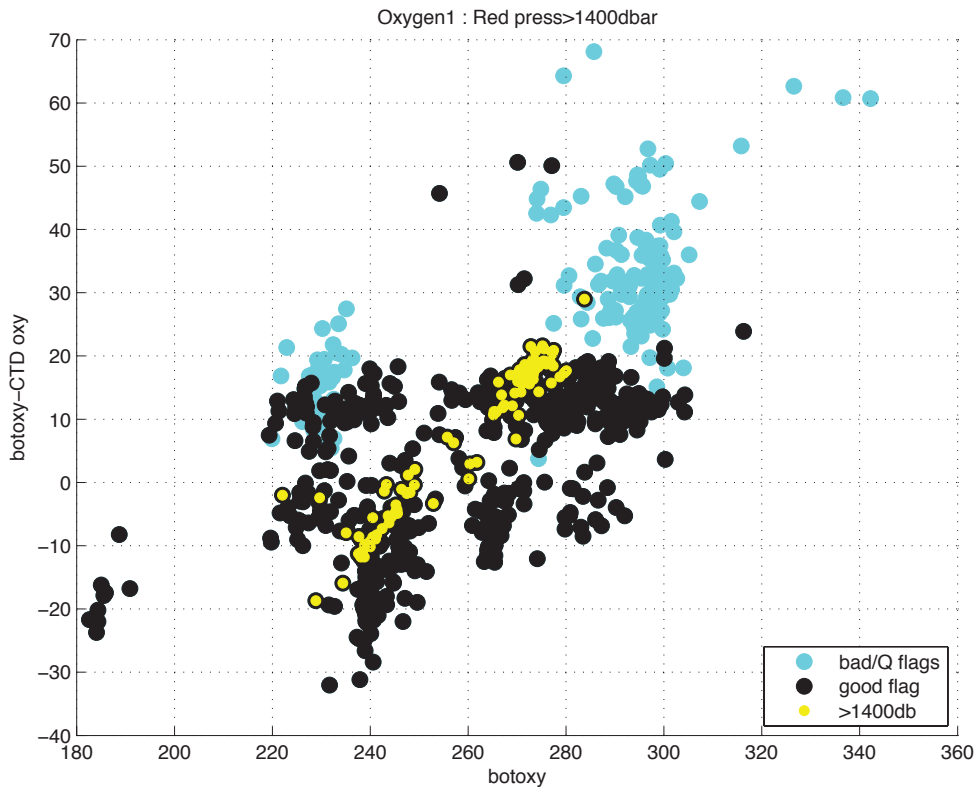


Figure 13.3

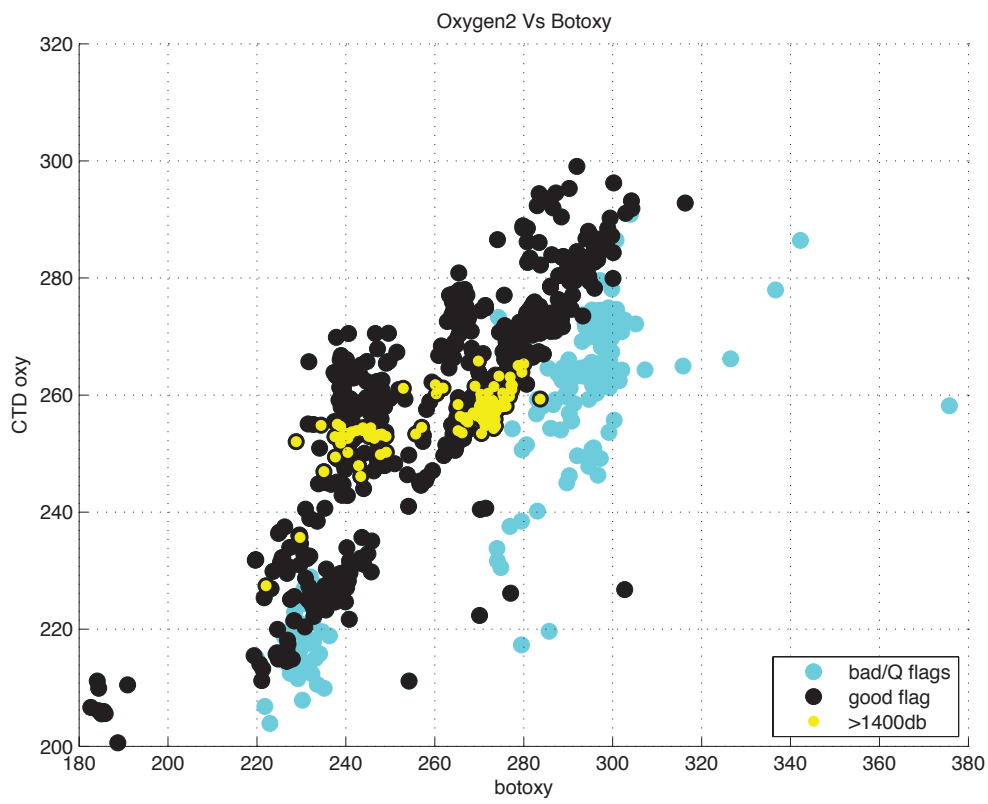


Figure 13.4

Finally, the residual values were plotted against station number for an indication of any temporal drift that may have occurred to the sensors.

### 13.2 Analysis of Rockall/Iceland Basin independently

It became clear from the prior analysis that the bottle oxygen measurements should be split into 2 subsets: up to cast 41 (Rockall Trough) & after cast 58 (Iceland Basin). Means and standard deviations of the residuals of the those points greater than 1400db were calculated and plotted for each oxygen sensor using the matlab script *sbe43\_sensor\_drift.m* (figure 13.5). The residual difference between these two subsets was above -20 (table 13.1) clearly indicating that these two subsets need to be treated separately.

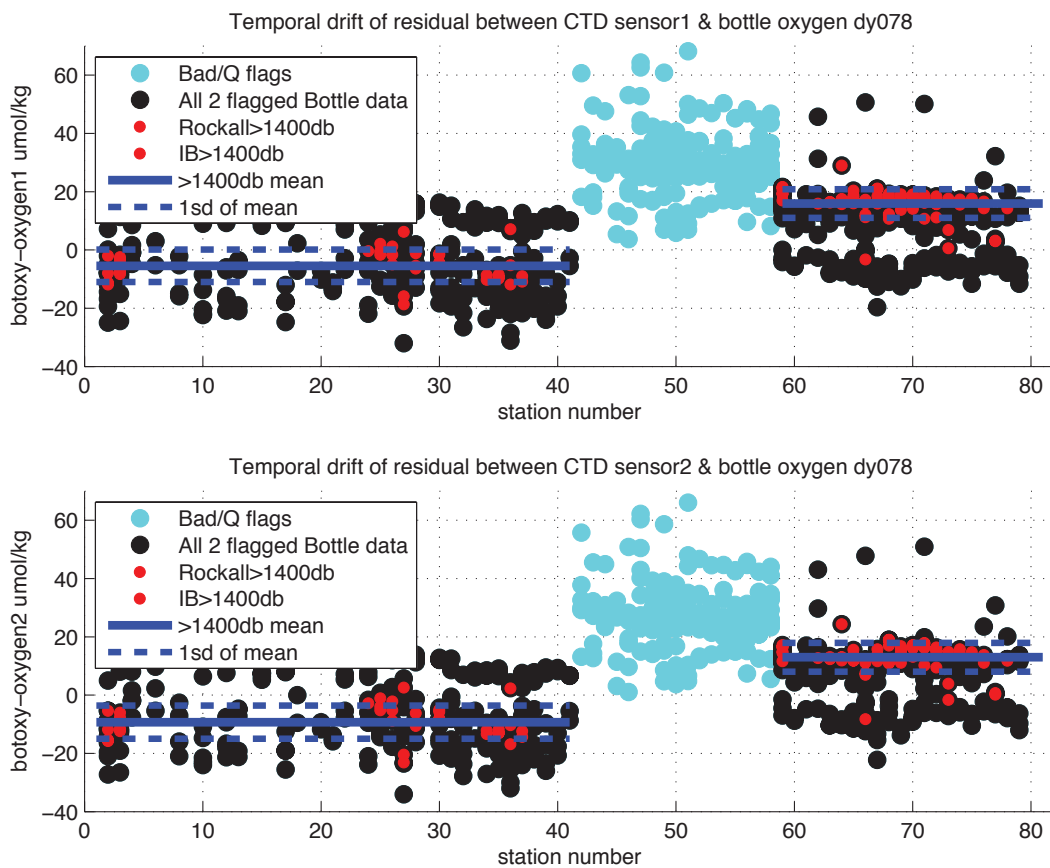


Figure 13.5

Table 13.1 Residuals (bottle oxygen minus CTD oxygen) for groups of stations

Parameter/Sensor	Uoxygen1	Uoxygen2
Rockall-IB (mean)	-21.3583	-22.2860
Bottle-CTD Rockall mean	-5.4280	-9.2870
Bottle-CTD IB mean	15.9303	12.999
Bottle-CTD Rockall std	5.5807	5.7091
Bottle-CTD IB std	4.9308	4.9428

Following this revelation, a repeat of the previous analysis was carried out using matlab script *sbe43\_sam\_oxycal03.m* only treating each subset and sensor independently. First the 4 degree polynomial fit was applied (figure 13.6), then a 5

degree polynomial fit was applied to the residuals with 1 standard deviation of the fit marked (figure 13.7) and finally an independent plot of CTD oxygen vs bottle oxygen highlighted the difference in between the mean deep (>1400db) residual (figure 13.8).

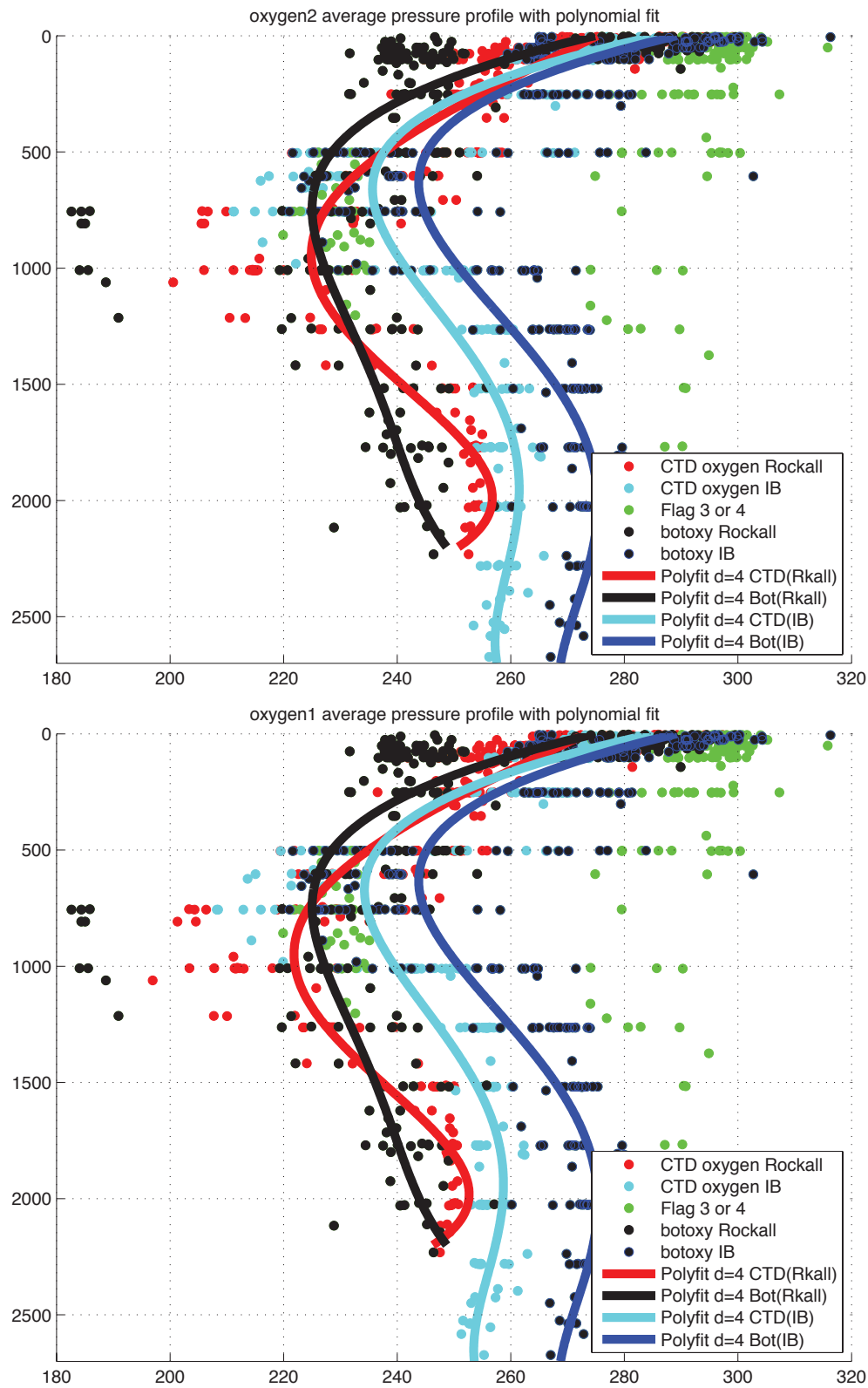


Figure 13.6

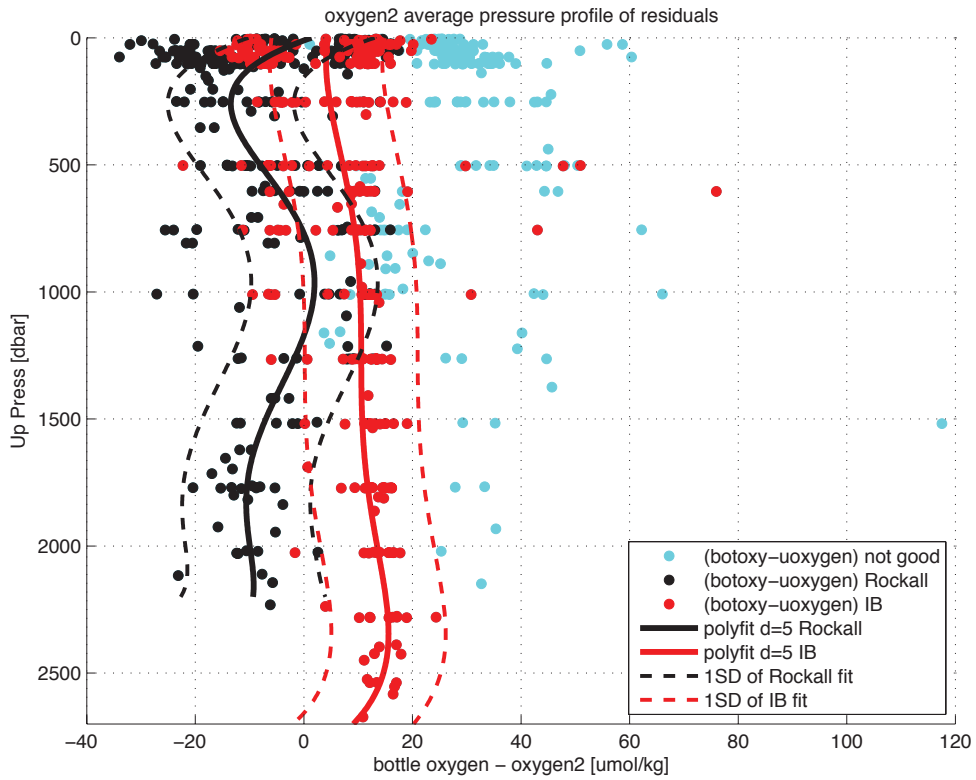


Figure 13.7



Figure 13.8

### 13.3 CTD sensors vs Each other

Both sensors behaved similarly throughout the cruise until cast 69, where oxygen sensor 1 noticeably drifted (figure 13.9). A quantification of this can also be seen in figure 13.5. This analysis was carried out using *Sbe43\_oxy\_cal\_ctd.m*. This drift must now be quantified (mean,std residual casts <69 & >69) before any further progress is made.

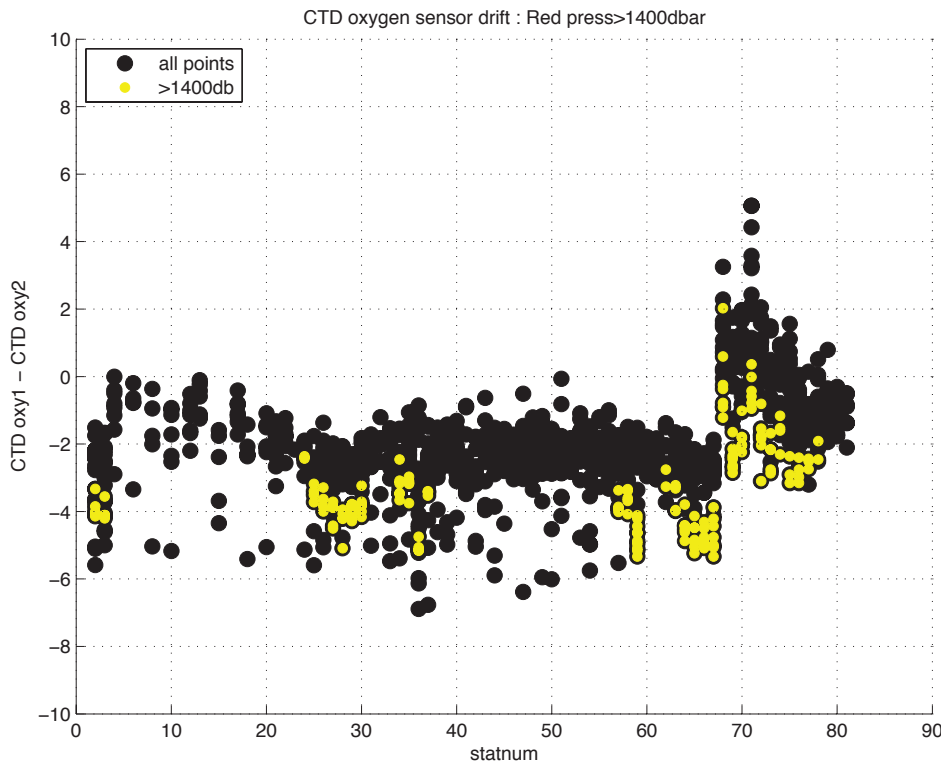


Figure 13.9

### 13.4 Advised action going forward

The issue that occurred at cast 42 needs to be resolved before any calibration can be made. If the data from casts 42-58 cannot be transformed or corrected, then the data either side of this needs to be treated as 2 separate calibrations. Due to concerns over having enough data points, I did not add a filter to the residuals for the above analysis. Before any final fits/ corrections are made, I think at least a 2sd residual filter should be used to exclude big outliers in a similar manner as is done in *ctd\_evaluate\_oxygen\_dy078.m*. Finally, if the drift in oxygen sensor 1 is quantified it may be corrected for.

## 14. CTD Temperature check and Conductivity Calibration

*Penny Holliday*

We used the script *ctd\_evaluate\_temp\_dy078* to compare the SBE35 temperature measurements taken each time a bottle is fired with the coincident measurements by the CTD temperature sensors. The CTD and the SBE35 were found to be in acceptable agreement. The median SBE35 minus CTD value suggested that the SBE35 readings are generally slightly cooler than the primary CTD sensor, by -

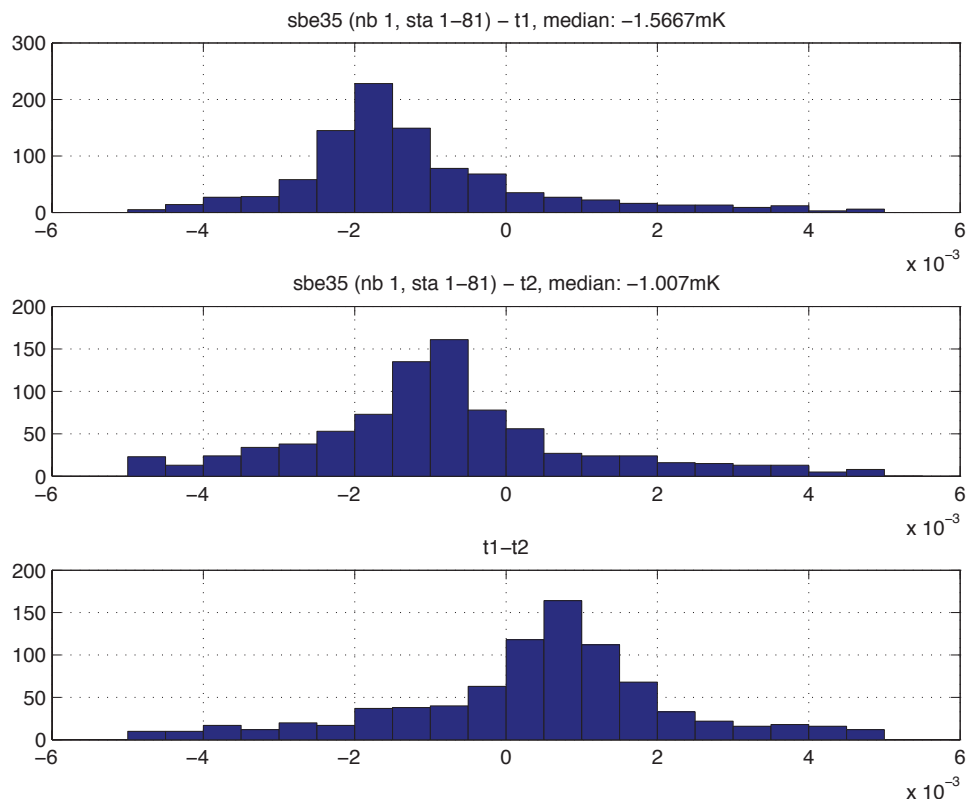
$1.5667 \times 10^{-3}$  K and cooler than the secondary CTD sensor, by  $-1.007 \times 10^{-3}$  K. This may be attributed to the accuracy of each sensors ( $0.002$  °C for the SBE3,  $0.0005$  °C for the SBE35) and the fact the thermometers are mounted some distance apart.

In the case of the conductivity calibration, the conductivity observation for each bottle was subtracted from the conductivities measured by the primary and secondary conductivity sensors. The residuals were plotted versus station number and pressure to check for any possible temporal drifts or pressure effects on the conductivity calibration. This was done using the script `ctd_evaluate_sensors_dy078`.

A small pressure dependence was detected in the DY078 residuals for sensor pair 2 (which changed after a fouling incident at CTD068). For sensor 1 the offset had no clear pressure dependence or change over time.

The offsets were applied to the data with the wrapper script `mctd_condcal`, which, in turn, calls `cond_apply_cal`, a script designed to hold the exact parameters of the conductivity calibration. The calibration was applied to the 24 Hz data for each station which then had to be reprocessed with `mctd_03`, `mctd_04`, `mfir_03`, and `mfir_04` (using `smallscript_dy078.m`).

After calibration the mean  $\pm$  stdev salinity residuals for primary and secondary sensors were  $0.000 \pm 0.0012$  and  $0.000 \pm 0.0015$  respectively (excluding outliers).



*Figure 14.1 Distribution of temperature difference between SBE35 and CTD temperature sensors. Top panel: SBE35 minus temp1. Mid panel: SBE35 minus temp2. Bottom panel: temp1 minus temp2.*

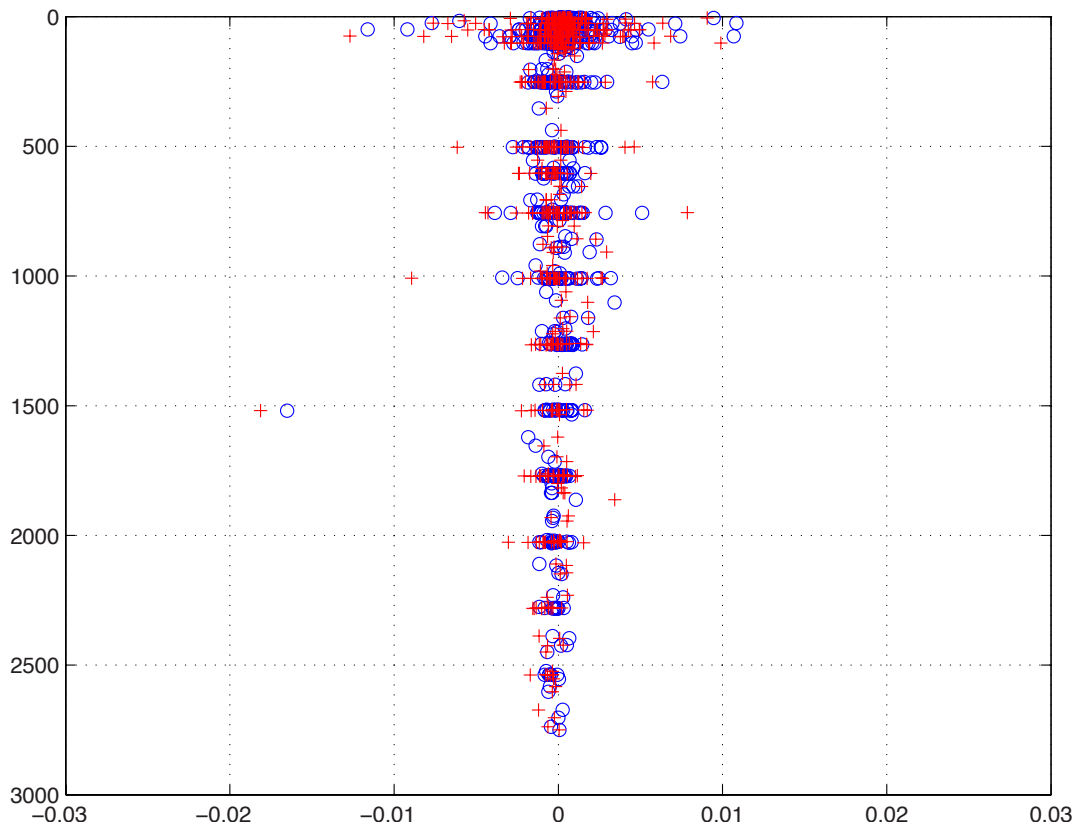


Figure 14.2 Salinity residuals (bottle minus CTD, after conductivity calibration) against pressure. Primary sensor pair in blue, secondary sensor pair in red.

## 15. Inorganic nutrient sampling.

*Sharon McNeill*

Samples were collected for inorganic nutrient analysis over 24hr CTD sampling on DY078-9. The samples were collected into 50ml acid washed centrifuge tubes labelled with cruise details, CTD no and niskin no and stored in the -20°C freezer. They will be transported in dry ice back to SAMS to be analysed on the Lachat flow injection analyser for phosphate, silicate and nitrite/nitrate values.

## 16. Microplastic sampling

*Winnie Courtene-Jones*

### 16.1 Overview

Microplastics are small pieces of synthetic plastic less than 5 mm in size. These result from the fragmentation of larger plastics or are intentionally manufactured to be of small size, such as exfoliating beads in cosmetics and industrial abrasives. Plastics are



extremely durable meaning they do not mineralise but persist in the environment, indeed microplastic pollution has been identified throughout terrestrial, freshwater and marine systems. As a major source of marine pollution, plastic debris meets ocean health index criteria and has been recognised as a global threat (Halpern et al, 2012).

A number of fundamental questions exist about the long-term fate and accumulation of marine microplastics. During DY78-79 four different microplastic sampling procedures were undertaken to develop knowledge of microplastic pollution in the North East Atlantic Ocean from sea surface to seafloor.

## 16.2 Underway water system filtering

### *Method*

Microplastics were filtered from the underway seawater during the entire research cruise. The underway system, also known as ‘clean seawater’ or ‘non-toxic seawater’, draws water into the ship from a depth of 5 m. The inlet is located on the underside of the hull on the starboard side forward to limit contamination from the ship. The water initially passes through a 5 mm pore size stainless steel filter housed within a medium density polyethylene (MDPE) housing, before being pumped at a constant pressure of 2.5 bar throughout the ship. All the ships pipework is made from ABS or PVC to avoid metallurgic contamination of water.

A grey PVC custom built ‘housing’ encasing a clean 80 µm mesh nylon filter was fitted to one of the underway water system taps via a length of silicon tubing (Figure 16.1). The housing prevents airborne contamination of the mesh while filtering over prolonged periods of time, but can be unscrewed to enable the filter to be changed regularly. The water flow rate was set to flow at 1 litre per minute and this was checked several times each day to ensure flow rate remained constant. The water passing through the filtration system drained directly into one of the laboratory sinks. Filters were changed every 12 hours (at 08:00 and 20:00) and placed into sterile falcon tubes which were frozen at -20°C to reduce any biological growth. Notes on water depth, Beaufort force and cruising speed were taken along with detailed GPS positions from the ships tracking system.

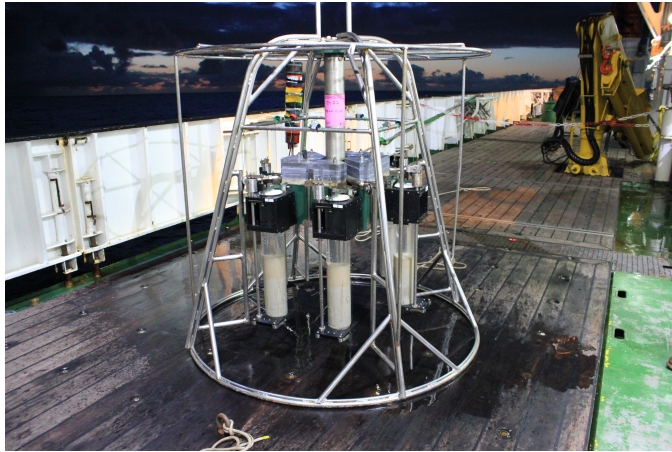


*Figure 16.1. Microplastic filtration of ships underway water system. A 80µm mesh filter is sealed within the grey PVC housing to avoid filter contamination, water delivered via the clear silicone tubing and discharged into ships sink.*

### 16.3 Sediment cores

#### Method

The Scottish Association of Marine Science (SAMS) has a long history of deep-sea sampling at Station M (57.300°N, 10.383°W) in the Rockall Trough, with operations here dating back to 1973. An OSIL megacore was utilised to obtain sediment cores from three sites around Station M. The megacore was rigged with six 60 cm long x 10 cm internal diameter core tubes to allow for a 50 % redundancy. The megacore was deployed at a rate of  $0.8 \text{ ms}^{-1}$  until 50 m from the seabed, upon where the winch rate was slowed to  $0.3 \text{ ms}^{-1}$ . When the cable tension slackened indicating the megacore was on the seabed an extra 5 m of cable was let out to allow the core tubes to sink into the sediment, the megacore remained on the seabed for 5 minutes before recovery. During the recovery hauling rate was limited to  $0.2 \text{ ms}^{-1}$  for the first 50 m from the seabed then increased to a rate of  $0.6 \text{ ms}^{-1}$  to the surface. Once on deck the core tubes were carefully removed from the megacore frame and transferred to wooden stands where they were sealed firmly with rubber bungs at each end of the tube (Figure 16.2 and 16.3).



*Figure 16.2. The megacore on deck after a successful deployment .*



*Figure 16.3. The six core tubes filled with sediment, typical sediment depths were between 27 - 30 cm, with 30 – 33 cm of supernatant water.*

### *Sample processing*

The supernatant water from each of the sediment cores was carefully siphoned off so as not to disturb any of the underlying sediment, this was passed through a pre-cleaned 80 µm mesh gauze. The gauze was retained in a sterile sealed petri dish for later analysis.

Cores were slowly extruded from their tubes using a SAMS custom built wooden extruder. Three cores from each of the three deployments were sliced at regular intervals: 0.5cm horizons for the top 5 cm, 1 cm horizons for sediment depths 5 -10 cm, and 5 cm horizons thereafter (Figure 16.4). The edges of each of the sediment slices were removed to avoid contamination from other sediment depths. Sediment horizons were transferred to labelled clean polyethylene zip lock bags, sealed immediately and frozen at -20°C for later analysis of microplastic concentrations.



*Figure 16.4. Sediment core on the wooden extruder, cores are slicing using a stainless steel cutter into depth horizons.*

### *Results*

All megacore operations were successful , a total of three sediment cores were sampled from each of the three deployments to study microplastics in deep-sea sediments (Table 16.1).

*Table 16.1. Deployment details, position and depth of the three megacore deployments along with the unique SAMS identification code.*

<b>Date</b>	<b>Start</b>	<b>End</b>	<b>SAMS code</b>	<b>Latitude (N)</b>	<b>Longitude (W)</b>	<b>Depth (m)</b>
<b>18<sup>th</sup> May 2017</b>	00:39	02:58	MGC 1697	57° 18.27	10° 22.95	2224
<b>18<sup>th</sup> May 2017</b>	03:45	05:55	MGC 1698	57° 17.88	10° 22.49	2230
<b>18<sup>th</sup> May 2017</b>	06:30	08:36	MGC 1699	57° 17.88	10° 23.40	2223

## 16.4 Deep water sampling

### *Method*

A CTD was used to collect water at two depths at Station M (57° 17.99 N, 10° 22.78 W). 12 niskin bottles were fired at a depth of 2195 m and 12 bottles at 1200 m, each bottle holds a volume of 10 litres. One of the niskin bottles fired at the deeper depth failed to seal adequately, thus 110 litres and 120 litres were collected at depths of 2195 m and 1200 m respectively. Once on deck, the spigots of each niskin bottle were cleaned with deionised water and individual 80 µm mesh filter were fitted. The spigot was opened and the entire volume of water was allowed to pass through the filter (Figure 16.5). Upon completion, each filter was carefully removed and transferred to individual sterile petri dishes and sealed for later analysis.



*Figure 16.5. Filtering water collected by the CTD for microplastics.*

## 16.5 Biological sampling

Opportunistic macroinvertebrates which had colonised the 40 inch syntactic buoys from the Rockall Trough 'WB1' and 'EB1' mooring sites from the OSNAP project were collected (Figure 16.6). At both sites the buoys were at a depth of 488 m and had been deployed on the 3<sup>rd</sup> (mooring EB1) and 4<sup>th</sup> July (mooring WB1) 2016. Individuals were carefully removed intact from the buoys, anemones were placed in individual clean zip lock bags and frozen at -20°C and cold water coral was preserved using 70% ethanol.



*Figure 16.6. (a) Recovering the syntactic buoy on the mooring line, (b) anemone and (c) cold water coral colonising the buoy.*



## References

Halpern, B.S., Longo, C., Hardy, D., McLeod, K.L., Samhour, J.F., Katona, S.K., Kleisner, K., Lester, S.E., O'Leary, J., Ranelletti, M., Rosenberg, A.A., Scarborough, C., Selig, E.R., Best, B.D., Brumbaugh, D.R., Chapin, F.S., Crowder, L.B., Daly, K.L., Doney, S.C., Elfes, C., Fogarty, M.J., Gaines, S.D., Jacobsen, K.I., Karrer, L.B., Leslie, H.M., Neeley, E., Pauly, D., Polasky, S., Ris, B., St Martin, K., Stone, G.S., Sumaila, U.R., Zeller, D., 2012. An index to assess the health and benefits of the global ocean. *Nature* 488, 615–620. doi:10.1038/nature11397

## 17. Sub-Bottom Profiling and Sediment Coring

*Paola Moffa Sanchez*

We used sub-bottom echosounder profiling SBP120 Kongsberg to survey some areas with known high sedimentation rates and potentially spanning the most recent time-scales. The frequency used was 2.5-6.5KHz and was run on burst mode (4 continuous chirps), which improved the resolution. The regions surveyed include Rockall Trough, Hatton Bank and South Iceland Rise. The survey was mostly run during steaming and between stations (at 10knts) and hence the speed of the boat was probably not optimal for high quality surveying (4-7knts) but allowed us to obtain some basic information about the sediment structures under the sediment-water interface.

A small survey was run on the west side of Anton-Dohrn seamount in Rockall Trough on the 10<sup>th</sup> May as we had some spare time between mooring deployment/recovery. This was done at 5nts and the data showed around 60ms of penetration from the seafloor with very continuous horizontal expanded layers particularly between 57.55N-57.45N and 12.6W-11.9W (Figure 17.1). On the 19<sup>th</sup> May, we cored one of these sites close to Station F MGC4 (57°36.869N, 12°18.541). We recovered six 40cm-long multicores from this site, which contained light brown silty clay material with some traces of bioturbation particularly noticeable in the bottom 10cm of these cores. The two best cores were sliced at 0.5cm and stored in the cold room and will be dated and processed after the cruise in order to assess their suitability for paleoceanographic reconstructions.

Additionally, the sub-bottom profiler results also showed some interesting areas on Hatton Bank and South Iceland Rise presenting clear expanded layering and approximately 40ms and 80ms of penetration, respectively.

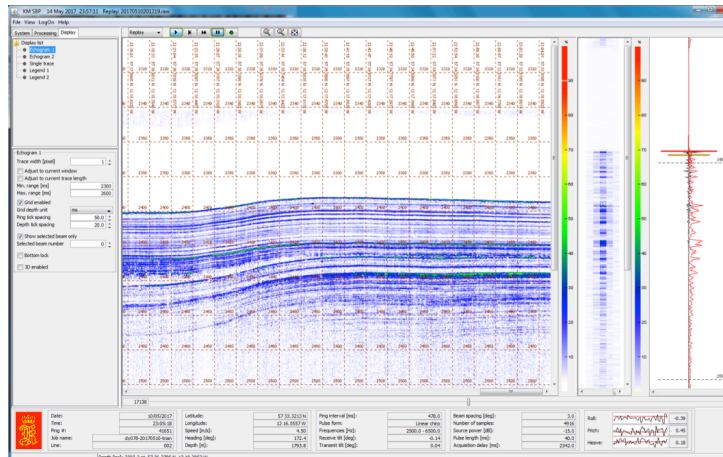


Figure 17.1. Example from the sub-bottom profiler survey from the core site west of Anton Dohn, showing parallel horizontal and hence probably continuous and homogeneous deposition of sediment with approximately 60ms of penetration into the sediments (right).

## 18. Isotopes

*Antonia Doncila, Paola Moffa Sanchez*

Water samples were collected for subsequent laboratory analysis of stable isotopes of  $\delta^{15}\text{N}$  and  $\delta^{18}\text{O}$  within nitrate ( $\text{NO}_3^-$ ),  $\delta^{18}\text{O}$  of water,  $\delta^{13}\text{C}$  and silica isotopes. The use of coupled nitrogen ( $\delta^{15}\text{N}$ ) and oxygen ( $\delta^{18}\text{O}$ ) isotopic data enables a clear analysis of the processes controlling fixed nitrogen supply, uptake and recycling in the ocean. The Extended Ellett Line transect represents the southernmost part of a latitudinal gradient ( $80^\circ$ - $57^\circ\text{N}$ ) which covers a primary export route of water and nutrients from the Arctic Ocean into the North Atlantic via Fram Strait. Combining stable isotopic data with mooring data collected across Fram Strait, the fixed nitrogen export from the Arctic can be traced and quantified as well as the processes modifying this output on its course into the North Atlantic. On a large scale, this information can further aid determining if the Arctic nitrogen budget is internally balanced, how the nutrient exports can change in a warming Arctic and what is the ultimate effect of these exports on the primary productivity of the North Atlantic (with particular focus on biological nitrogen fixation).

Sampling for  $\delta^{15}\text{N}$  and  $\delta^{18}\text{O}$  of nitrate was done at a total of 12 stations, approximately evenly spread across the transect, with a particular focus on the deep water stations in the Rockall Through and the Iceland Basin. The stations were: CTD021, CTD027, CTD035, CTD037, CTD044, CTD048, CTD051, CTD064, CTD067, CTD071, CTD075 and CTD078.

The depths sampled at each station coincide with the depths of nutrient samples. This is because the isotopic analytical procedure requires knowledge of the nitrate concentration for each sample. The sampling protocol involved attaching an Acropak filter ( $0.8/0.45\mu\text{m}$ ) to each Niskin bottle and collecting the filtered water in 125ml

HDPE acid washed bottles. Duplicate samples were taken from 3 out of the 12 stations to check for method precision. To complement water isotopic data, particulate matter was also collected onto glass microfiber filters (GF/F, 24mm diameter). This was done using a compressed air filtering system set at 2bars. Approximately 5L were filtered at each station from ship's underway system (5m depth) and from the chlorophyll maximum depth (established based on the fluorescence levels registered by the CTD). The concentration of particulate matter at these depths will be calculated and its C/N ratio and isotopic content will be analysed. All the aforementioned analyses will be done by Antonia Doncila at the University of Edinburgh ([antonia.doncila@ed.ac.uk](mailto:antonia.doncila@ed.ac.uk)) using a gas chromatography-mass spectrometer.

Water samples for silica isotopes study were collected from the same stations and depths as the  $\delta^{15}\text{N}(\text{NO}_3^-)$  and  $\delta^{18}\text{O}(\text{NO}_3^-)$  samples. The same protocols for water sampling and particulate matter collection were followed. The only exception to the former isotope samples is that particulate matter was collected onto nucleopore filters (47mm) instead of GF/F. Water and particulate samples for silica will be analysed by Dr. Laetitia Pichevin at the University of Edinburgh ([lpichevi@staffmail.ed.ac.uk](mailto:lpichevi@staffmail.ed.ac.uk)) using the ICP mass spectrometer.

$\delta^{18}\text{O}$  values of water are required for two research purposes:

- to aid computing of  $\delta^{18}\text{O}(\text{NO}_3^-)$  data:  $\delta^{18}\text{O}(\text{NO}_3^-) = \delta^{18}\text{O}(\text{H}_2\text{O}) + 1.1\text{‰}$
- to improve comprehension of the salinity effect on oceanic  $\delta^{18}\text{O}$  and thus improve pale-oceanographic salinity reconstructions.

Water samples were collected in 12ml glass vials from 29 stations across the transect including both waters overlying the Scottish continental shelf and deep water stations in the Rockall Through and Iceland basin (CTD04, CTD06, CTD010, CTD015, CTD020, CTD021, CTD024, CTD027, CTD028, CTD029, CTD030, CTD034, CTD036, CTD041, CTD049, CTD051, CTD055, CTD063, CTD065, CTD067, CTD069, CTD071, CTD072, CTD073, CTD074, CTD075, CTD076, CTD077, CTD078). In addition water samples were collected following the same procedure and once collected poisoned using potassium iodine from six sites (CTD024, CTD027, CTD028, CTD029, CTD030, CTD036) in order to measure  $\delta^{13}\text{C}$ . The depths of these were the same as the bottles sampled for DIC.

Analysis of a subset of these collected samples for  $\delta^{18}\text{O}$  and  $\delta^{13}\text{C}$  will be done by Dr. Paola Moffa-Sanchez and Dr Alexandra Nederbragt at Cardiff University using the one of the mass spectrometers in the stable isotope analysis facility in the Earth and Ocean Science Department ([MoffaSanchezP1@cardiff.ac.uk](mailto:MoffaSanchezP1@cardiff.ac.uk)).

## **19. Seabird and marine mammals**

*Giulia La Bianca*

### **19.1 Aim**

On behalf of Seawatch Foundation, sea bird and marine mammal individuals were recorded from the *RRS Discovery* as part of a long term monitoring programme that aims to record the distribution of sea birds and marine mammals on the North East Atlantic Ocean.

### **19.2 Viewing Platforms**

Sea birds and marine mammals observations were conducted from the bridge and from the monkey island, respectively 17.6m and 22.5m above sea level. The viewing platform was decided daily depending on weather conditions, i.e. in raining and foggy conditions observations were performed from the bridge.

### **19.2 Methodology**

The observations have been performed using the following method:

- The watch was performed on the track line of the vessel;
- Field of view was 180°;
- Every watch lasted 60, 100 or 110 minutes depending on sea state and visibility;
- The observer rested at least 1 hour between watches;
- During dedicated search for seabirds and marine mammals, observer logged time, position, sea state, visibility, and boat activity every 15 minutes;
- To avoid double counting of marine individuals, the observer completed the observation of 180° in 1 minute from the track line to 90° starboard side in 30 seconds and from the track line to 90° port side in 30 seconds;
- When possible, pictures of spotted individuals were taken to confirm species identification, consequently images were copied in two storage devices;
- Two species ID books were used to confirm species identification, for sea birds Mullarney, *et al.* (1999) and for marine mammals Shirihai and Jarrett (2005);
- Opportunistic sightings were added to the recording forms.

All observations have been conducted using binoculars with compass and rangefinder and logs were annotated in the recording forms provided by Seawatch Foundation. Each recording form was updated daily between watches and copied twice in two storage devices.

### **19.3 Recording forms**

The records of sea birds and marine mammals were kept separately in two different layouts.

The effort recording form stored basic data information of the observation: start time, end time, total time, observer height above sea level, field of view (i.e. 180°), latitude and longitude (i.e. in degrees and decimal minutes), boat course, speed (knots), effort type (i.e. dedicated search), sea state (Beaufort Force), swell height (m), visibility



(km) and boat activity. When observed from the bridge, these variables were updated every 15 minutes. When observed from the monkey island, time, position, sea state, visibility and boat activity were recorded every 15 minutes, and the rest of the variables every hour due to the lack of meteorological data instrumentation on the monkey island.

The sea bird recording form included information related to the seabirds sighted within 15 minutes interval. For each sighting, time, species, number of individuals, distance from the bird, direction of flight and behaviour were recorded.

The marine mammals recording forms included the following variables for each sighting: date, time, latitude, longitude, species, confidence, total number of individuals, total number of calves and juveniles, bearing animal, distance to the animal, behaviour, reaction to the vessel, animal heading, associated birds and observer name.

#### 19.4 Species encountered, their abundance and distribution

From the 6<sup>th</sup> of May to the 25<sup>th</sup> of May, after circa 104.5 hours of observation, a total of 1,466 sea birds were spotted.

This is a list of sea bird species with an estimated count of individuals:

- Northern Fulmar, *Fulmarus glacialis* (464) (Fig. X.1),
- Black Legged Kittiwake, *Rissa tridactyla* (404) (Fig. X.2),
- Northern Gannet, *Morus bassanus* (324) (Fig. X.3),
- Lesser Black Backed Gull, *Larus fuscus* (201),
- Greater Black Backed Gull, *Larus marinus* (37),
- Common Guillemot, *Uria aalge* (24)
- Great Skua, *Stercorarius skua* (6) (Fig. X.4),
- Atlantic Puffin, *Fratercula arctica* (3),
- Parasitic Skua, *Stercorarius parasiticus* (1) (Fig. X.5),
- Great Cormorant, *Phalacrocorax carbo* (1),
- European Shag, *Phalacrocorax aristotelis* (1).

Surprisingly, 16 terrestrial birds landed on our vessel, including

- Whimbrel, *Numenius phaeopus* (5) (Fig. X.6),
- House Martin, *Delichon urbica* (3),
- Barn Swallow, *Hirundo rustica* (3),
- Pied Wagtail, *Motacilla alba* (2),
- Redshank, *Tringa totanus* (1),
- Golden Plover, *Pluvialis apricaria* (1) (Fig. X.7)
- Dunlin, *Calidris alpina* (1).

A total of 210 marine mammals were sighted. The following marine mammal species were identified:

- Short-beaked common dolphin, *Delphinus delphis* (Fig. X.8);
- Long-finned pilot whale, *Globicephala melas* (Fig. X.9);
- Sperm whale, *Physeter macrocephalus* (Fig. X.10);
- Grey seal, *Halichoerus grypus*;
- Minke whale, *Balaenoptera acutorostrata* (Table 1).

Table 19.1. Abundance of marine mammal species encountered from the 6<sup>th</sup> of May 2017 to the 25<sup>th</sup> of May 2017 on board of RRS Discovery from 56.8463 N, -12.1011 W to 62.7503 N, -20.0103 W.

Species	Lat (start)	Lat (end)	Long (start)	Long (end)	Best estimated number (individuals)
Short-beaked common dolphin	56.7133	57.1398	-6.3599	-10.2207	113
Long-finned pilot whale	56.8463	62.7503	-12.1011	-20.0103	92
Sperm whale	57.2817	57.2817	-12.1856	-12.1856	3
Grey seal	57.1025	57.1025	-9.3592	-9.3592	1
Minke whale	57.4972	57.4972	-11.8577	-11.8577	1

### References

Mullarney, K., Svensson, L., Zetterstrom, D. and Grant, P. (1999) Bird Guide, the most complete field guide to the birds of Britain and Europe, *HarperCollins*, London.

Shirihai, H. and Jarrett, B. (2006) Whales, dolphins and seals. A field guide to the Marine Mammals of the World. *Black Publishers*, London.

## 20. Argo floats

### *Penny Holliday*

The UK Met Office requested that we deploy 4 Argo APEX profiling floats for them. We deployed 2 in the Rockall Trough and 2 in the Iceland Basin. The floats were lowered on a line from the port quarter while the ship was steaming at 1.5 knots. In normal circumstances the floats are deployed in pressure-activated mode, but on this occasion it was discovered that 3 of the 4 floats were already in mission mode as we left Southampton. Under advice from the Met Office we proceeded with deployments as normal.

Table 20.1. Argo float deployment

Date	Time (UTC)	Lat (N)	Lon (W)	Serial No.	CTD	Depth
16/05/17	1707	57.2328	-10.0503	8070	027	2050m
17/05/17	1827	57.3612	-10.3612	8071	030	2000m
23/05/17	2010	59.4004	-18.4155	8073	064	2415m
24/05/17	1449	60.2465	-19.9845	8072	068	2648m

## 21. Glider Operations

*Estelle Dumont*

*Table 21.1 Summary of glider activities*

Glider S/N	Operator	Activity	Cruise event number	Date + time (UTC)	Latitude	Longitude
SG532	SAMS	Deployment	068	21/05/17 12:06	57° 40.03'N	18° 42.03'W
unit_526	WHOI	Deployment	069	21/05/17 12:30	57° 39.90'N	18° 41.50'W
unit_620	WHOI	Recovery	075	22/05/17 15:06	58° 14.85'N	21° 43.00'W
SG605	SAMS	Recovery	097	26/05/17 07:52	63° 03.76'N	20° 00.06'W

### 21.1. Deployment of Seaglider SG532 ‘Bellatrix’

Seaglider SG532 (‘Bellatrix’), belonging to the MARS pool and operated by SAMS, was deployed on the 21<sup>st</sup> May 2017 at 12:06 UTC, at station O1. The initial plan was to deploy closer to the mooring M4 (near station O7), but due to the worsening weather forecast it was decided to deploy at station O1 instead while conditions were still good.

Bellatrix is equipped with an unpumped Seabird CT sail, Aanderaa oxygen optode, and Wetlabs triplet. Due to endurance requirements, only the CT will be activated during the deployment.

Pre-launch testing was carried out onboard, and deemed satisfactory. The glider was lifted (underneath the rudder) over the side in a custom-made harness using the aft crane on the port side, and deployed using a sea-catch release. The safety pin on the release proved hard to remove, and the final forceful pull of the pin made the whole release open at the same time, a couple of metres above the sea surface. The glider avoided getting tangled in the harness and plunged into the water smoothly. No damage was observed following the launch.

The mission’s real-time raw data can be viewed at: [vocal.sams.ac.uk/gliders](http://vocal.sams.ac.uk/gliders), and is available from BODC.



*Figure 21.1 Bellatrix in the water after deployment.*

## 21.2. Deployment of Slocum S/N 526 ‘WH\_OUC2’

The G2 Slocum WH\_OUC2 was deployed on the 21<sup>st</sup> May 2017 at 12:30 UTC, just after SG532. This glider is owned by the Woods Hole Oceanographic Institution, and operated jointly with the Ocean University of China along a section of the OSNAP line (West of the SAMS section). The glider is fitted with an extended endurance bay and the following sensors: Sea-bird GPCTD, Aanderaa optode, WET Labs ECO triplet, and Satlantic OCR504 irradiance. All testing was done remotely by WHOI staff prior to deployment.

The glider was lifted over the side using the aft crane on the port side, and deployed using a quick-release hook. It took several attempts to release, but the glider did not suffer any damage.

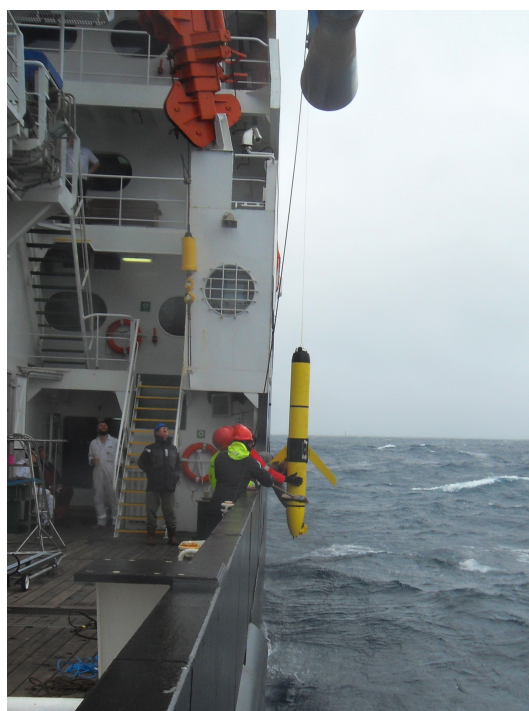


*Figure 21.2 WH\_OUC2 deployment*

## 21.3. Recovery of Slocum S/N 620 ‘WH\_OUC3’

A second G2 Slocum, WH\_OUC3, also owned and operated by WHOI / OUC, was recovered on the 22<sup>nd</sup> May 2017 at 15:06 UTC. The pilot back at WHOI stopped the glider from diving in the morning, and relayed positions to the ship every 5 minutes. The glider was spotted from the bridge, and the ship moved alongside. The pilot released the nose cone and line via Iridium, which took about 10 minutes to complete. The line was then grappled, and the glider lifted onboard using the auxiliary winch on the starboard side.

The glider had conducted a mission along the OSNAP line (West of mooring M4), and was fitted with an extended endurance bay, Sea-bird GPCTD and Aanderaa optode. Following the cruise, the glider will be returned to WHOI.



*Figure 21.2 WH\_OCU3 recovery*

#### **21.4. Recovery of SG605 ‘Bowmore’**

Seaglider SG605 (‘Bowmore’), belonging to the MARS pool and operated by SAMS, was recovered on the 26<sup>th</sup> May 2017 at 07:52 UTC.

Bowmore had been deployed in the Hebrides on the 9<sup>th</sup> February 2017, and had travelled along the Extended Ellett Line. She is equipped with an unpumped Seabird CT sail measuring depth, temperature and conductivity, an Aanderaa oxygen optode and a Wetlabs puck (fluorescence, CDOM, backscatter). Extra time was spent on the Scottish shelf at the start of the mission to debug an issue with the pump system, which caused a significant energy usage (about 10% of the battery). It was uncertain whether the glider would be able to travel back to Scotland with the energy left, hence the decision to recover during DY078.

Bowmore was put into recovery after dive 770, at 04:56 UTC on the 26<sup>th</sup> May 2017. The call interval was set to 10 then 5 minutes while *Discovery* approached the site. Bowmore was spotted from the bridge around 06:45, and the ship manoeuvred alongside. A rope was lassoed around the tail of the glider (under the rudder), and she was lifted on deck using the auxiliary winch on the starboard side at 07:52.

Following the cruise, Bowmore will be returned to the MARS glider team for refurbishment.

The full mission's raw data can be viewed at: [vocal.sams.ac.uk/gliders](http://vocal.sams.ac.uk/gliders), and is available from BODC. Delayed-mode data will be submitted to BODC within the next few months. The full glider technical mission report will also be finalised within the next few months and will be available from BODC and SAMS.



*Figure 21.4. Bowmore recovery*

## **22. Outreach**

*Penny Holliday, John Beaton and DY078 scientists*

We wrote for the UK OSNAP blog throughout the cruise ([ukosnap.wordpress.com](http://ukosnap.wordpress.com)), posting an entry with photos for almost every day of science. The blog attracted 614 visitors and 8000 views during the course of May 2017.

The blog posts were tweeted, and added to with further tweets and photographs, in the @uk\_osnap twitter feed. Our tweets were frequently re-tweeted and 'liked' by our ~500 followers, gaining us 23,000 impressions and ~50 new followers during May 2017.

John Beaton collected some video footage of 6 CTD casts using a GoPro camera and 4000m pressure casing lent to us by Kerry Howell of Plymouth University. The footage will be utilised by artist Emma Critchley on her Human/Nature project ([info@emmacritchley.com](mailto:info@emmacritchley.com), [www.emmacritchley.com](http://www.emmacritchley.com)).

### 23. Airflow distortion experiments

*Penny Holliday for Margaret Yelland (NOC)*

We conducted an experiment to assess the distortion (acceleration/deceleration) of the air flow to the anemometer on the foremast. This distortion biases the measured wind speed, and the bias depends on (a) the angle of the ship to the wind and b) the speed of the ship relative to the wind speed. So to quantify the distortion we requested that the ship go round in circles according to the following instructions:

ii) Ideally the ship would do a number (lots!) of circles at different speeds, say 0, 4 and 8 knots depending on what the crew decide is feasible given the weather conditions. If time is limited, the zero knot speed would be highest priority and the fastest feasible speed the second priority. Intermediate ship speeds if time permits.

ii) For the 0 knot circle, previously it has been found that the best way to do it was to use the DP system, putting a marker on the position of the ship's anemometer on the bow, and getting the ship to rotate about the anemometer.

iii) A steady rate of change of heading would be better than a hexagon or dodecadon or whatever, i.e. would prefer a smooth circle rather than stepped changes in heading. A complete geographical circle is NOT necessary when the ship is steaming round. We just need a full range of relative wind directions at a steady rate of change of heading (and ship speed if possible). So if that means a spiral that is fine.

iv) For the circles at 4 or 8 knots, a steady ship speed would be good, as well as a steady heading, but I realise that the ship speed might vary a bit with the wind and waves. The size of the circle/spiral does not matter.

v) A circle takes about an hour or 90 minutes. If the "spare" ship time happened to come in 60 minute chunks then that would be OK. It's definitely best to do the circle in one go if at all possible.

These operations were carried out after the final CTD of the cruise.



## 24. Dissolved Inorganic Carbon and Alkalinity samples

*Debra Brennan, Winnie Courtene Jones and Sharon McNeill*

### *Introduction*

Samples were collected during DY078-9 for dissolved inorganic carbon and total alkalinity measurements at the following stations.

Station	Sampling depths	No of sample bottles
D	10, 25*, 100, 500, 1000, 1085	8
F	10, 25, 100, 200, 750, 1250, 1800	7
H	10, 25, 50, 100, 500, 1000, 1250, 1500*, 2005	11
L	10, 25, 50, 100, 500, 1000*, 1250, 1500, 2120	11
M	10, 25, 50, 80, 100, 500, 1000, 1250, 1500, 2215*	12
O	10, 25, 80, 250, 750, 1200, 1900	7
P	10, 25, 50, 100, 250*, 750, 1000, 1450	10
cal-dip 1		7
	* samples taken in triplicate	Total
		73

*Table 24.1. Sampling plan for DIC/Alkalinity on DY078*

### *Methodology*

Seawater samples were drawn from Niskin bottles via a length of silicon tubing into 250ml glass stopper bottles, the bottle was rinsed twice with seawater by half filling and shaking vigorously and then emptied. Silicone tubing was then inserted to the base of the bottle and slowly filled by first inverting the sample bottle then turning upright. Slowly rotating the bottle as it filled ensuring no air bubbles were collected in the sample. The bottle was then allowed to overflow by the volume of the bottle before removing the tubing and inserting the glass stopper. Samples were preserved with 0.02% saturated mercuric chloride solution, 2.5ml of sample was removed to allow for water expansion of 1% and sealed with Apieson L grease on a ground glass stopper, then twisted to ensure the bottle is gas-tight to prevent exchange of carbon dioxide or water vapour to the atmosphere. The stopper was then secured with tightly stretched PVC tape and bottle inverted to disperse the mercuric chloride. Samples were stored in the cold room in the dark.

### *Analysis*

Samples are to be returned to SAMS for analysis after the cruise.



## 25. Gravity

*Stuart Cunningham*

RRS *Discovery* is fitted with a LaCoste & Romberg Air-Sea Gravity System II. This instrument makes highly accurate gravity measurements from a moving ship.

At present these data are not included in a TechSAS stream but have been formatted to a TechSAS NMEA ASCII output  
(*Cruise\_Documentation/Data\_Description\_Documents/AirSeaII Gravity Description.docx*).

To archive these data a cshell script (*copy\_data.csh*) copies data from */mnt/techsas/dy078/NMEA/Grvt2* to */DY078/data/grav*. A matlab script *mgravity01.m* can read the *.asc* gravity files one by one. Variables in the *.asc* files are assigned names as per the description documentation. This script is not complete.

The gravity meter logged data continuously during the cruise but was occasionally clamped (Table 25.1) during bad weather to prevent damage to the sensitive springs:

<b>clamped</b>	<b>unclamped</b>
2017.05.16 jd136 at 19:06	2017.05.18 at 06:00.
2017.05.20 jd140 at 15:48	2017.05.23 at 14:15.
2017.05.26 jd146 at 16:32	

*Table 25.1: Dates and times when the gravity meter was clamped during bad weather.*

## 26. TechSAS

*Stuart Cunningham*

### 26.1 TechSAS Version

On this cruise DY078 we were using TechSAS V5.11. However, this version is not recorded correctly in the TechSAS file metadata for reasons unknown at the time of writing. One example of metadata from a GPS file is show below. All other NetCDF files have the same entry of TECHAS V5.10. Confirmation of the TechSAS V5.11 in use during this cruise is given in Figure 26.1a & 1b below.

e.g. Output of the metadata from a FUGRO.GPS file listing the source file and the History noting TechSAS V5.10.

```
>>ncdisp('20170518-010000-satelliteinfo-FUGRO.GPS')
```

```
Source:
```

```
/mnt/techsas/dy078/NetCDF/GPS/20170518-010000-satelliteinfo-FUGRO.GPS
```

```
Format: classic
```

```
Global Attributes:
```

```
History = 'TECHSAS V5.10 2017-05-18T01:00:00Z'
```

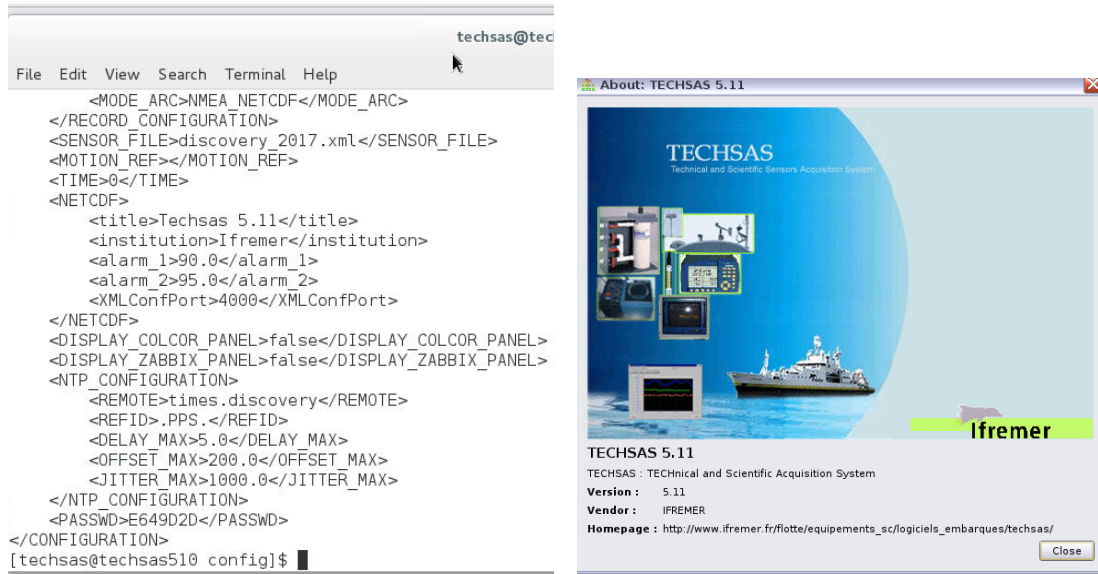


Figure 26.1. Left panel: Screenshot showing the TechSAS configuration file for DY078 and confirms TechSAS V5.11. Right panel: This screenshot is the output from the command `About:` confirming TechSAS V5.11. The date this command was issued was Thur 18 May 2017, 06:34:15.

## 26.2 TechSAS Time Stamping

### Introduction

A key principle of TechSAS is to time-stamp incoming data streams so that they are time synchronous. This is called Level A and is a primary data logging function. Subsequently, TechSAS Level A time stamps appears in Level B NetCDF data streams with the variable name *time*. Numerous data streams include their own time stream and these appear under the variable name *measureTS*. This is described in the Data Description files for each instrument (e.g. `/Cruise_Documentation/Data_Description_Documents/CNAV 3050 Data Description.docx`). TechSAS is running under Linux Centeos V7.2.

Time is provided to TechSAS via a networked ship's time-server. Monitoring of this time-server indicates very small differences  $\ll 0.1$  ms to GPS time. Some data showing this comparison are logged in `Cruise_Documentation/ntp/loopstats.tgz` (tar, gzip directory). TechSAS uses a NTP client from MEINBERG running a Time Adjustment Service in the background, keeping the system time synchronised with the ship's NTP time-server. Technical reports on NTP protocols and implementation are documented at <https://www.meinbergglobal.com/english/info/ntp.htm#overview>.

The NTP client in the kernel polls the NTP ship's time-server, dynamically selecting an optimal poll interval between minimum and maximum poll values specified by the user. The dynamic adjustment to find the optimal poll interval varies with changing conditions and requires several days of continuous operation to converge on an optimal adjustment value.

NTP polling synchronises the local system clock via a complex algorithm that calculates an adjustment value for each tick of the local system clock. Shorter poll intervals mean less accurate calculations and larger adjustments to the system clock that never stabilise and cause the local clock system to wander. Longer polling intervals allow the NTP client to calculate smaller tick adjustments that stabilize to a more accurate value, reducing wander in the local system clock.

The default minimum and maximum poll values (expressed as powers of two) are 6 (64s) and 10 (1024s) respectively, and changes to these values are not recommended and are discouraged.

On this cruise the minimum poll value was set to 4 (16s).

#### *Comparison of NTP synchronised TechSAS time-stamps and GPS time*

Last year during cruises DY052 and DY053 differences in the time between TechSAS time-stamps and GPS time had been noted and reported in the DY053 cruise report. The time difference had a drift of  $\sim 0.015$ s over a period of 240s, with a sharp adjustment at the end of the drift. The difference in time at the rapid adjustment was not to zero however. During DY052 it was to  $+0.005$ s and on DY053 to  $-0.08$ s. However, the time drift was smooth and repeatable.

On these cruises we were using TechSAS V5.9 and the minimum NTP poll value was the default 6 (64s).

Repeating this analysis for this cruise we find quite a different behaviour of the time differences (Figure 26.2). Figure 26.2a shows that the time differences are as large as 0.1s. Figure 26.2b shows that the differences are extremely noisy and deviate from smaller to maximum difference over about 10 minutes (600s) then back to smaller difference over another 10 minutes.

On this cruise we were using TechSAS V5.11 and the minimum NTP poll value was 4 (16s). From the description of the response of the Time Adjustment Service for the MEINBERG NTP client to the minimum poll value it is possible that the lower than recommended minimum poll value causes the noisy time differences. To test this we would need to reset the TechSAS system, and we plan this at end-of-science.

Figure 26.3 is a histogram of the first time difference of (GPS time – TechSAS time). This is an indication of the distribution of the difference between the two times for one second time stamps. The median value is very close to zero, however the distribution has substantial occurrences of time differences larger than  $\pm 0.05$ s. Repeating this analysis with differences over farther apart time-stamps did not appreciably change this conclusion.

Are there any consequences for data analysis? None of the analysis on cruise (such as merging gyro heading corrections for ADCP analysis) are likely to be impacted by this time-stamp issue.

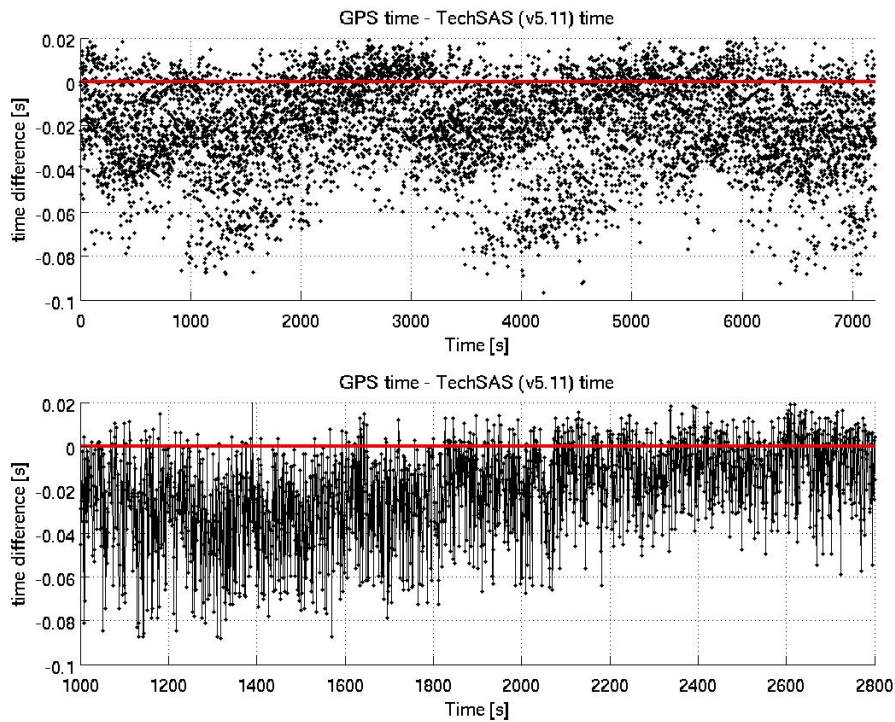


Figure 26.2: Time difference between the TechSAS NTP controlled time stamp time and posmvpos GPS time measureTS. (a) A two hour period (7200s); (b) A 30 minute period (1800s). Analysis programme: TechSAS\_v\_GPS\_time\_comparison.m.

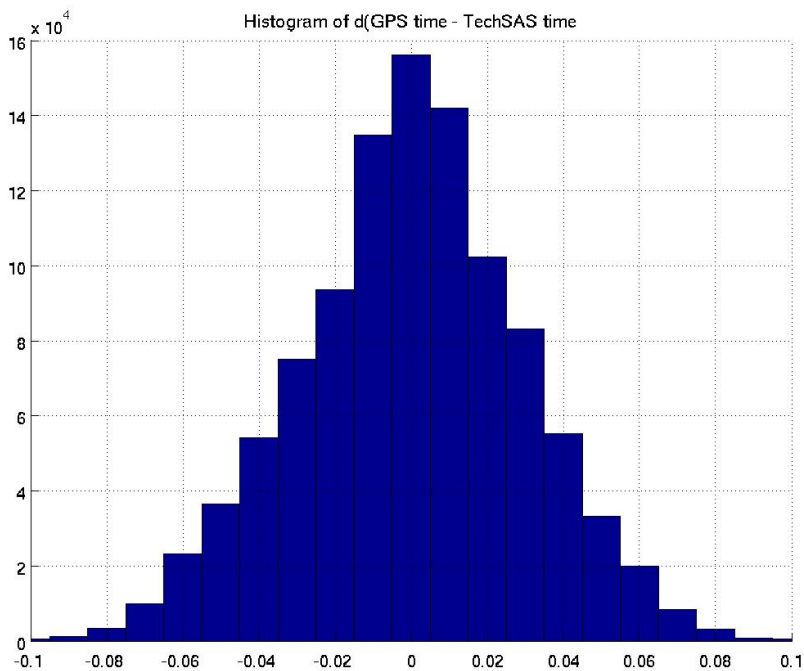


Figure 26.3: Histogram of the difference in time of (GPS time – TechSAS time) for a 12-day period.

## 27. Acknowledgements

Grateful thanks for all the support that we received from people in our labs and universities who helped us with the preparations for the cruise. Special thanks to Colin Day, Sally Heath and Paul Provost at NOC; Clare Johnson, Tim Brand, Rich Abel and Stefan Gary at SAMS; Ian Hall at Cardiff, Martin White at Galway, and Raja Ganeshram at Edinburgh.

The PSO also wishes to thank the ship's personnel for a very comfortable and enjoyable cruise, with great food, good company, and skilled and efficient working. Special thanks to Viv and Steve for keeping the winch working smoothly.

The cruise report is dedicated to Colin Griffiths, who finally retired in 2017 - we missed you on this trip, Colin, and Ellett Line cruises will not be the same without you.

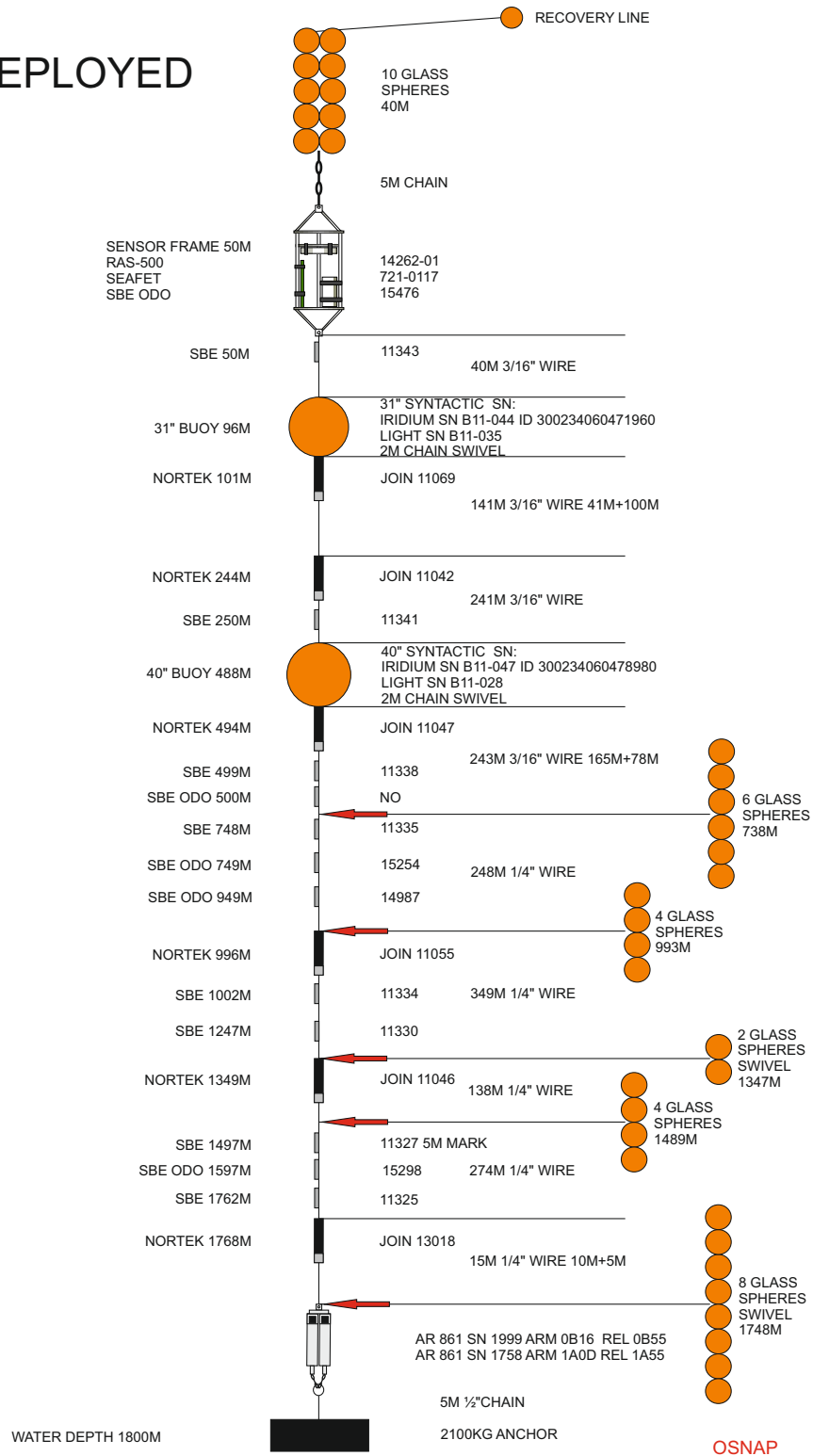


*Figure 27.1 Rockall*

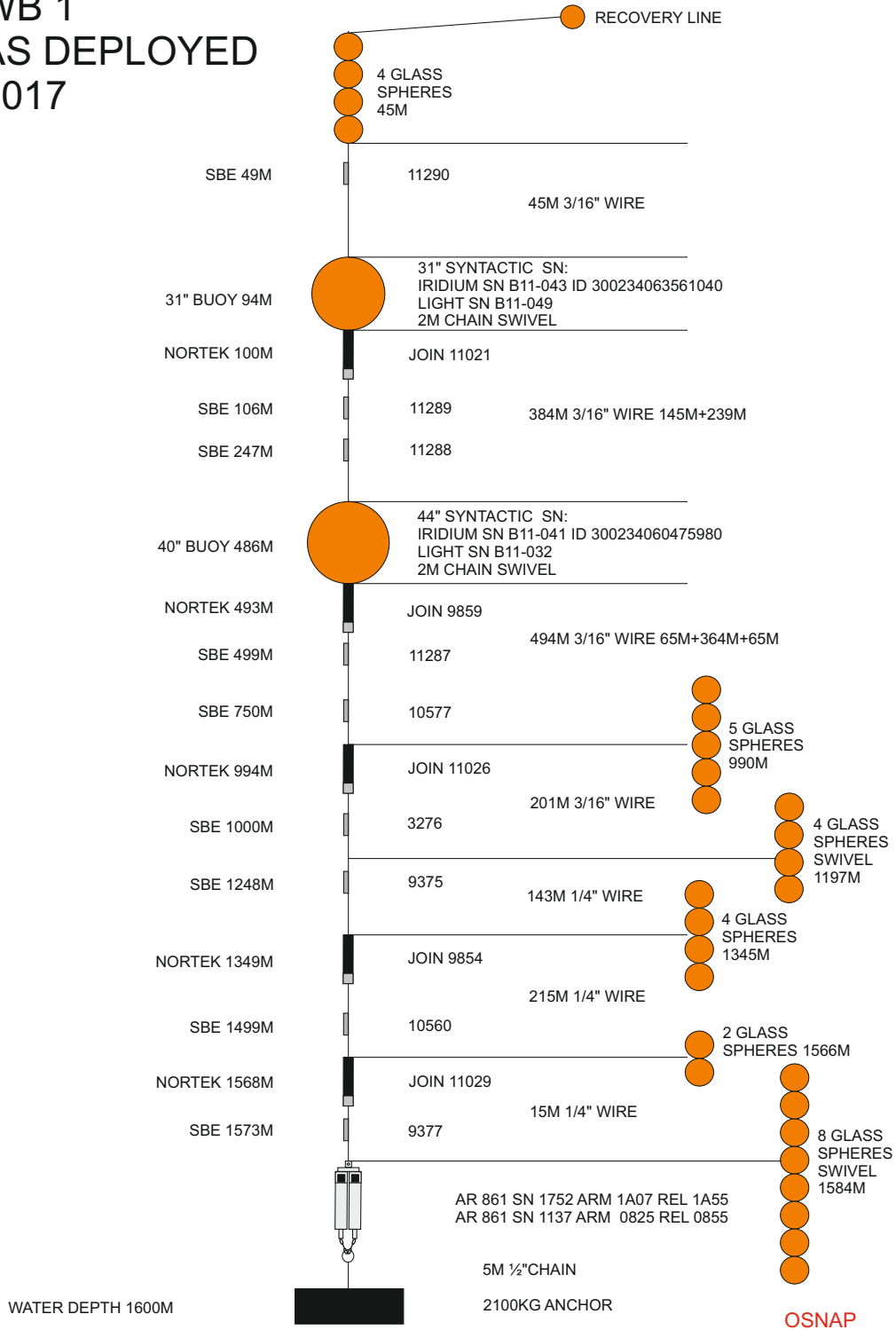
# Appendices

## Appendix A: Mooring Schematics as Deployed

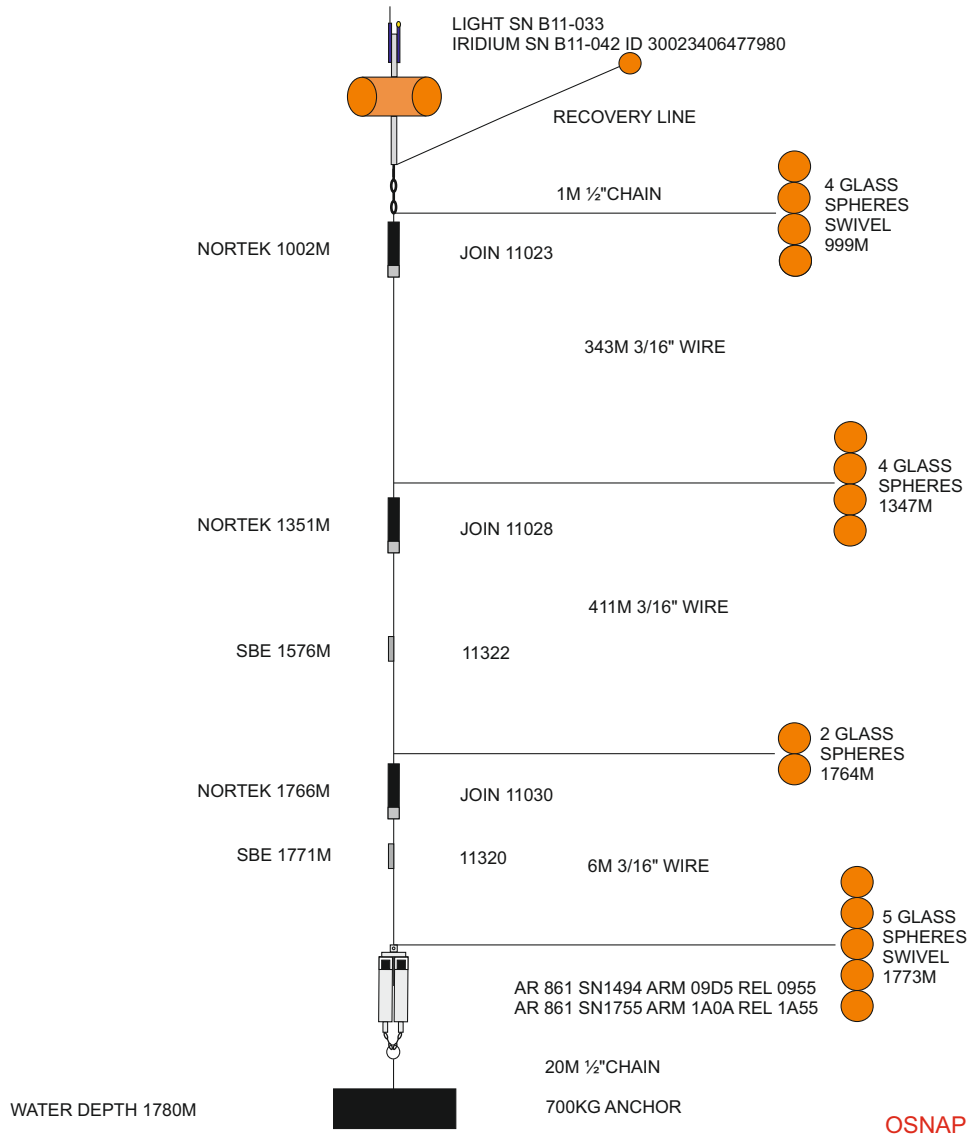
### EB 1 AS DEPLOYED 2017



# WB 1 AS DEPLOYED 2017



# WB 2 AS DEPLOYED 2017





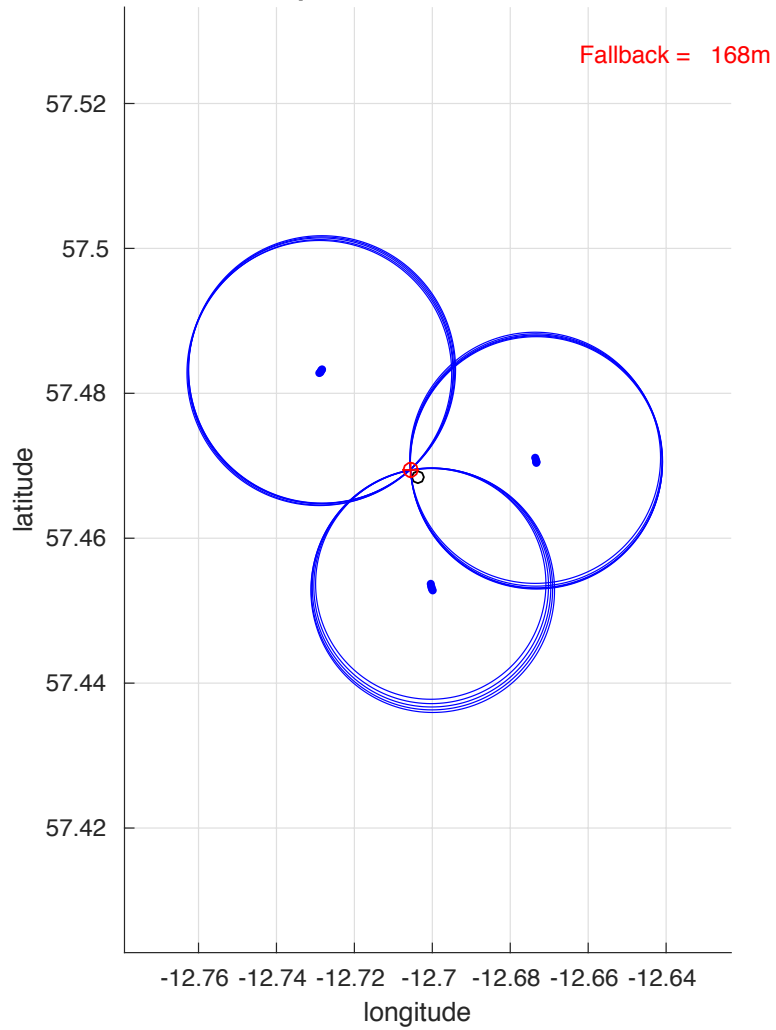
## Appendix B

Allocated instrument and hardware serial numbers, programme/owner and nominal deployment depths

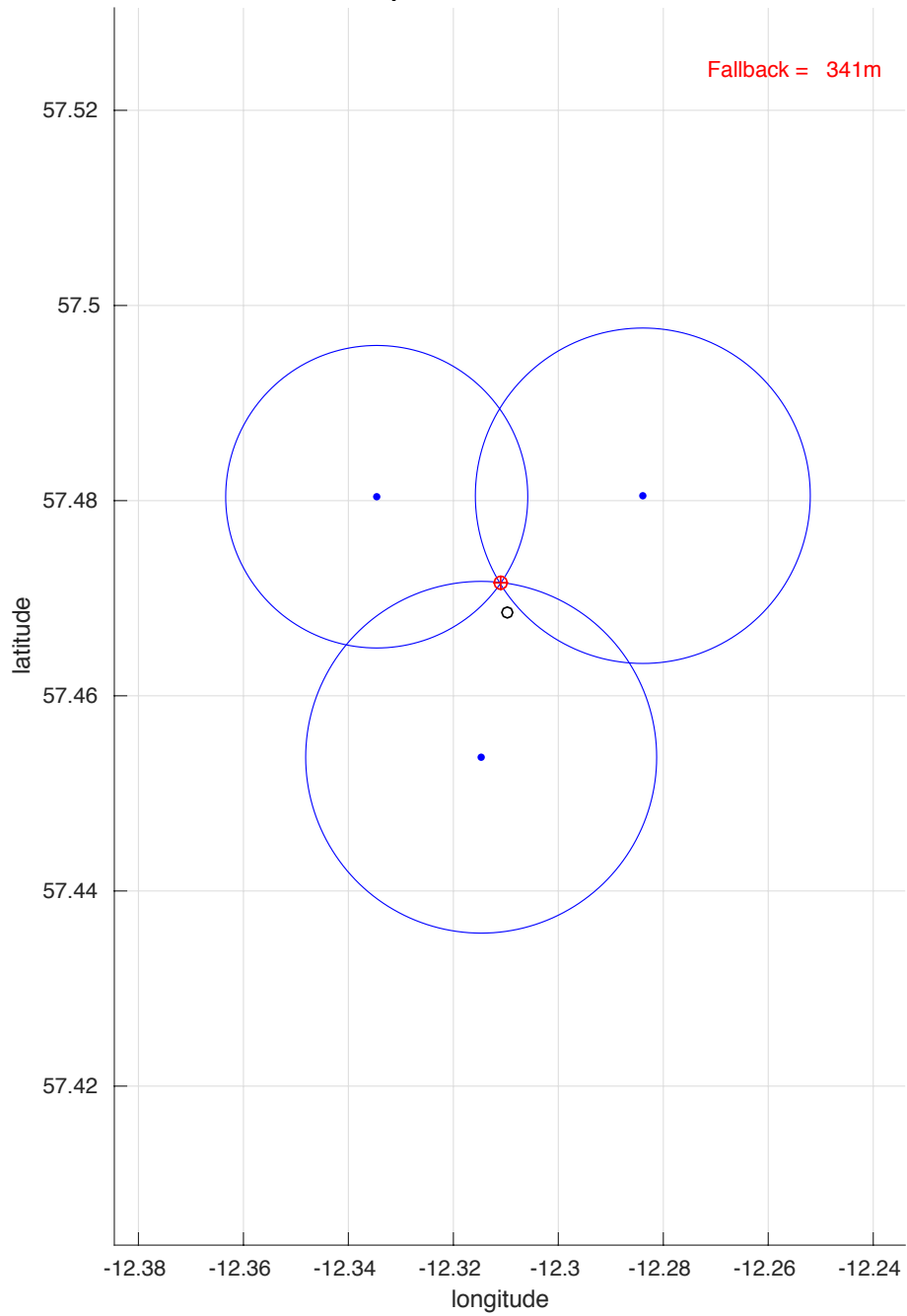
Moor	Depth	Inst	s/n : IMEI	Owner
WB1	50	SBE37	11290	OSNAP
WB1	106	SBE37	11289	OSNAP
WB1	247	SBE37	11288	OSNAP
WB1	500	SBE37	11287	OSNAP
WB1	750	SBE37	10577	OSNAP
WB1	1000	SBE37	3276	NMEP
WB1	1250	SBE37	9375	NMEP
WB1	1500	SBE37	10560	OSNAP
WB1	1575	SBE37	9377	NMEP
WB1	100	Nortek	11021	OSNAP
WB1	495	Nortek	9859	NMEP
WB1	995	Nortek	11026	OSNAP
WB1	1350	Nortek	9854	NMEP
WB1	1570	Nortek	11029	OSNAP
WB1	94	Iridium 30"	300234060473980	OSNAP
WB1	486	Iridium 40"	300234060475890	OSNAP
WB1	1597	A/R	1752	OSNAP
WB1	1597	A/R	1137	NMEP
WB2	1575	SBE37	11322	OSNAP
WB2	1770	SBE37	11320	OSNAP
WB2	1000	Nortek	11023	OSNAP
WB2	11028	Nortek	11028	OSNAP
WB2	11030	Nortek	1030	OSNAP
WB2	995	Iridium 40"	30023406477980	OSNAP
WB2	1795	A/R	1752	OSNAP
WB2	1795	A/R	1137	NMEP
EB1	50	SBE37	11343	OSNAP
EB1	100	SBE37	11342	OSNAP
EB1	250	SBE37	11341	OSNAP
EB1	500	SBE37	11338	OSNAP
EB1	750	SBE37	11335	OSNAP
EB1	1005	SBE37	11334	OSNAP
EB1	1250	SBE37	11330	OSNAP
EB1	1500	SBE37	11327	OSNAP
EB1	1775	SBE37	11325	OSNAP
EB1	750	SBE37-ODO	15254	ATLAS
EB1	950	SBE37-ODO	14987	ATLAS
EB1	1600	SBE37-ODO	15298	AtlantOS
EB1	95	Nortek	11069	OSNAP
EB1	495	Nortek	11047	OSNAP
EB1	1000	Nortek	11055	OSNAP
EB1	1350	Nortek	11046	OSNAP
EB1	1775	Nortek	13018	OSNAP
EB1	50	RAS	14262-01	ATLAS
EB1	50	DeepSeapHOx SBE37-ODO	721-0117 15476	ATLAS
EB1	96	Iridium 30"	300234063561040	OSNAP
EB1	488	Iridium 40"	30023406475980	OSNAP
EB1	1794	A/R	1758	OSNAP
EB1	1794	A/R	1999	OSNAP

## Appendix C: Mooring Trilateration Results

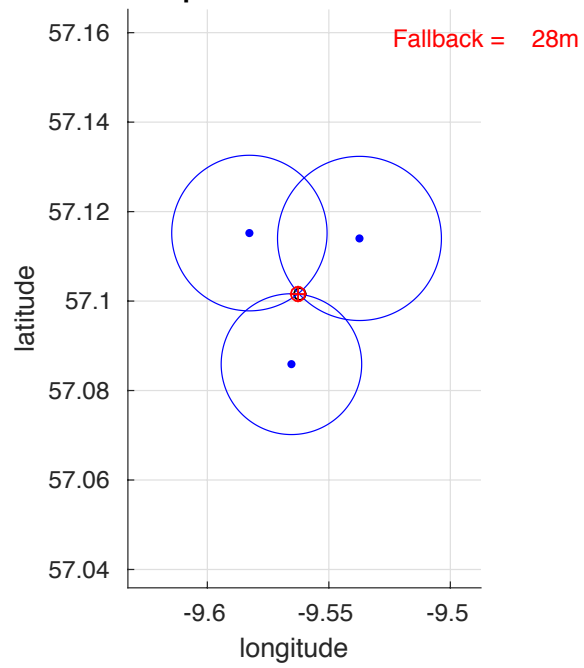
Trilateration Survey using: tri\_pos\_rtwb1\_deploy\_dy078.txt  
Corrected water depth: 1606.3m. Release Height: 7m. Transducer depth: 7m.  
Red = anchor seabed position. 57.4694N -12.7056W.



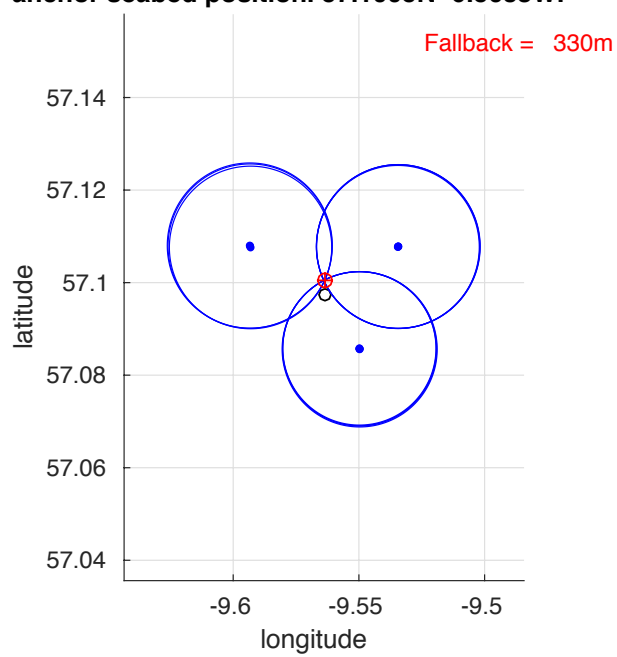
Trilateration Survey using: tri\_pos\_r\_twb2\_deploy\_d\_y078\_v2.txt  
Corrected water depth: 1807.1m. Release Height: 20m. Transducer depth: 7m.  
Red = anchor seabed position. 57.4716N -12.3111W.



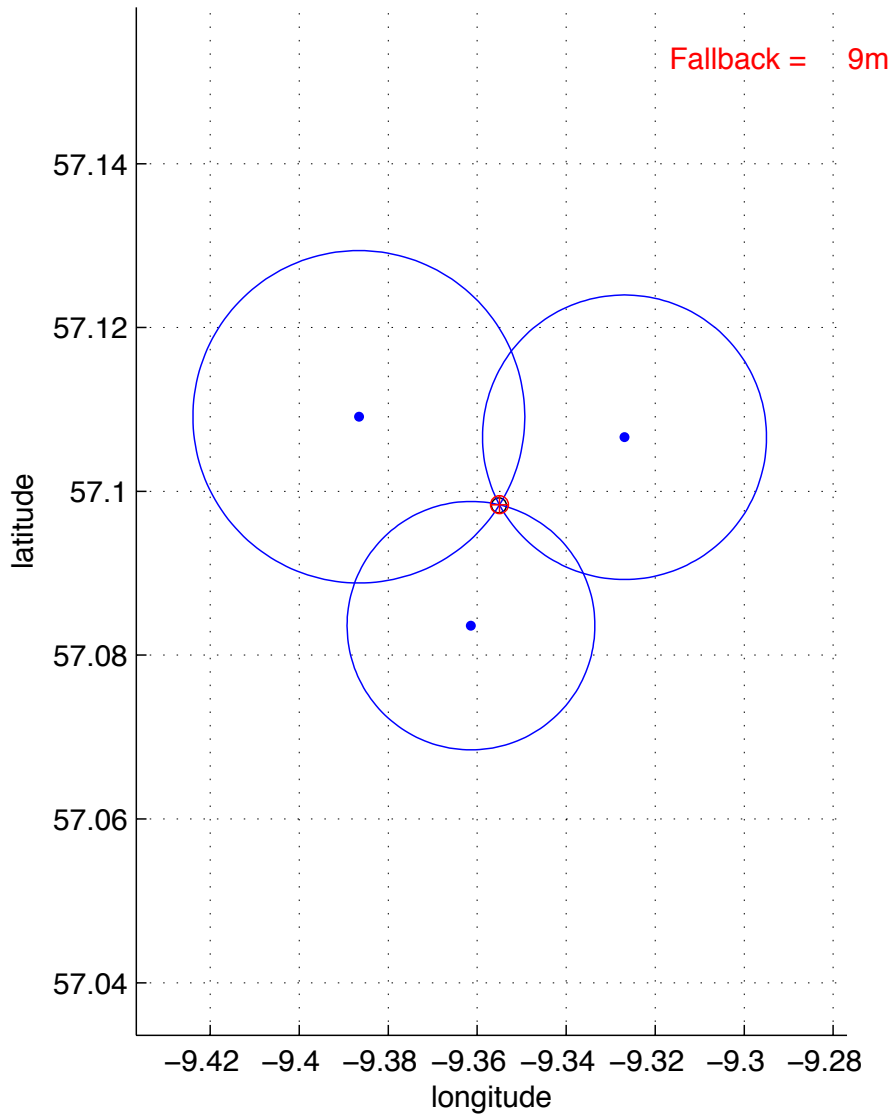
**Trilateration Survey using: tri\_pos\_rteb1\_recover\_dy078.txt**  
**Corrected water depth: 1800m. Release Height: 0m. Transducer depth: 12m.**  
**Red = anchor seabed position. 57.1016N -9.5625W.**



Trilateration Survey using: tri\_pos\_rteb1\_deploy\_dy078.txt  
Corrected water depth: 1800m. Release Height: 1m. Transducer depth: 10m.  
Red = anchor seabed position. 57.1005N -9.5638W.



Trilateration Survey using: tri\_pos\_rtadcp1\_recovery2\_dy078.txt  
Corrected water depth: 950m. Release Height: 0m. Transducer depth: 6.5m.  
Red = anchor seabed position. 57.098354N -9.354981W.



## Appendix D: Instrument Configuration Files

Example of SBE37-SMP setup log:

```
S>OutputExecutedTag=n
S>Outputformat=3
S>DS
SBE37SM-RS232 v4.1 SERIAL NO. 10577 10 May 2017 15:41:38
vMain = 13.38, vLith = 3.16
samplenumber = 1046, free = 558194
not logging, stop command
sample interval = 10 seconds
data format = converted engineering alternate
transmit real-time = no
sync mode = no
pump installed = yes, minimum conductivity frequency = 3256.3
S>Datetime=05102017154142
S>SAMPLENUMBER=0
this command will modify memory pointers
repeat the command to confirm
SAMPLENUMBER=0
S>OUTPUTSAL=N
S>BAUDRATE=38400
repeat the command at 38400 baud to confirm
BAUDRATE=38400
baud rate change is confirmed
S>OUTPUTSV=N
S>SYNCMODE=N
S>TXREALTIME=N
S>SAMPLEINTERVAL=1800
S>
S>STARTDATETIME=05112017120000
<start dateTime = 11 May 2017 12:00:00/>
S>STARTLATER
<!--start logging at = 11 May 2017 12:00:00, sample interval = 1800 seconds-
->
S>DS
SBE37SM-RS232 v4.1 SERIAL NO. 10577 10 May 2017 15:42:48
vMain = 13.35, vLith = 3.16
samplenumber = 0, free = 559240
not logging, waiting to start at 11 May 2017 12:00:00
sample interval = 1800 seconds
data format = converted engineering alternate
transmit real-time = no
sync mode = no
pump installed = yes, minimum conductivity frequency = 3256.3
```

Example of SBE37-SMP-ODO setup log:

```
S>ds
SBE37SMP-ODO-RS232 v2.3.1 SERIAL NO. 15254 12 May 2017 14:32:09
vMain = 13.50, vLith = 3.23
samplenumber = 161, free = 399296
not logging, stop command
sample interval = 105 seconds
data format = converted engineering
output temperature, Celsius
output conductivity, S/m
output pressure, Decibar
output oxygen, ml/L
output salinity, PSU
transmit real time data = no
sync mode = no
minimum conductivity frequency = 3320.6
adaptive pump control enabled
<Executed/>
```

```

OutputExecutedTag=n
S>OutputTemp=1
S>OutputCond=1
S>OutputPt_ress=1
S>OutputOx=1
S>OutputSal=1
S>AdaptivePumpControl=y
S>OutputFormat=1
S>DateTime=05122017143345
S>SampleInterval=2100
S>TxRealTime=n
S>SampleNumber=0
memory pointers will be modified
repeat command to confirm:
SampleNumber=0
S>StartDate_eTime=05132017090000
<start dateTime = 13 May 2017 09:00:00/>
S>StartLater
<!--start logging at = 13 May 2017 09:00:00, sample interval = 2100 seconds-
->
S>ds
SBE37SMP-ODO-RS232 v2.3.1 SERIAL NO. 15254 12 May 2017 14:35:35
vMain = 13.36, vLith = 3.23
samplenum = 0, free = 399457
not logging, start at 13 May 2017 09:00:00
sample interval = 2100 seconds
data format = converted engineering
output temperature, Celsius
output conductivity, S/m
output pressure, Decibar
output oxygen, ml/L
output salinity, PSU
transmit real time data = no
sync mode = no
minimum conductivity frequency = 3320.6
adaptive pump control enabled
S>

```

### Example of Nortek Aquadop setup log:

```

=====
Deployment      : 9854
Current time   : 11/05/2017 12:48:29
Start at      : 11/05/2017 13:30:00
Comment:
-----
Measurement interval (s) : 1800
Average interval      (s) : 60
Blanking distance     (m) : 0.50
Measurement load      (%) : 4
Power level           : HIGH
Diagnostics interval(min) : 720:00
Diagnostics samples   : 20
Compass upd. rate     (s) : 1
Coordinate System     : ENU
Speed of sound        (m/s) : 1500
Salinity              (ppt) : N/A
Analog input 1        : NONE
Analog input 2        : NONE
Analog input power out : DISABLED
Raw magnetometer out  : OFF
File wrapping         : OFF
TellTale              : OFF
AcousticModem         : OFF
Serial output         : OFF
Baud rate             : 9600
-----

```





Assumed duration (days) : 550.0  
 Battery utilization (%) : 66.0  
 Battery level (V) : 13.9  
 Recorder size (MB) : 9  
 Recorder free space (MB) : 8.972  
 Memory required (MB) : 2.0  
 Vertical vel. prec (cm/s) : 1.4  
 Horizon. vel. prec (cm/s) : 0.9

-----  
 Instrument ID : AQD 9854  
 Head ID : A6L 5275  
 Firmware version : 3.37  
 -----

Aquadopp Deep Water Version 1.40.14  
 Copyright (C) Nortek AS  
 =====

SeapHOx setup log

	<h2>SeaFET Summary Report</h2>	
Serial Number: 117	Firmware Rev: 3.8.0	
Operator: ED		
Comment: Setup for EB1 dep		

Ancillary	Value	Setting	Value
Total Disk Space (byte)	3954802688	Serial Baud Rate	57600
Free Disk Space (byte)	3952148480	Operation Mode	Periodic
Main Voltage (V)	12.836	Transmitted Frame Format	FULL_ASCII
Main Battery Voltage (V)	12.6	Logging Frame Format	FULL_ASCII
Isolated Battery Voltage (V)	5.8	Periodic Interval	1 hr
Clock Time	2017/05/13.08:08:21	Periodic Offset (s)	0
Supports External Pump	true	Samples in Average	30
Supports Integrated CTD	true	Frames in Burst	1
		Sampling Window Enabled	false
		Sampling Window Start	2017-05-08
		Sampling Window End	2019-05-04
		Data Log File Type	By File Size
		Data Log File Max Size (KB)	1024
		Message Logging Level	INFO
		Message Log File Max Size (KB)	1024
		Transmit Diagnostic Messages	false
		External Pump Enabled	false
		External Pump Pumping Time (s)	5
		External Pump Flushing Time (s)	5
		SBE37-SMP-ODO CTD Enabled	false
		SBE37-SMP-ODO Power CTD	true
		SBE37-SMP-ODO Output CTD Frames	false
		SBE37-SMP-ODO Sampling Timeout (s)	120
		ISFET Sample Delay (s)	0
		On-Board Salinity (PSU)	35.0

Serial Number: 117

Firmware Rev: 3.8.0

Operator: ED

Comment: Setup for EB1 dep

Ancillary	Value	Setting	Value
Internal Reference Coefficients (V.V/K)			0.0,-0.0015
External Reference Coefficients (V.V/K)			-1.416523,-9.9E-4
Thermistor Coefficients			340.982,-9.10257E-5,-95.08807,0.9653703

Note: the report generated by the software contains an error at the lines:

SBE37-SMP-ODO CTD Enabled false  
SBE37-SMP-ODO Power CTD true

These parameters were in reality set up the other way around, i.e. CTD enabled, not powered by the SeaFet.