SAMS Report No. 293

RRS Discovery Cruise DY053

26 JUNE – 23 JULY 2016

King George V Dock, Glasgow to Reykjavick, Iceland

OSNAP Mooring Cruise Report

Cruise Principal Scientist: Prof. Stuart A. Cunningham

Editor: Loïc Houpert

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Title
RSS Discovery DY053, 26th June to 23rd July 2016, King George V Dock, Glasgow to Reykjavick, Iceland. OSNAP Mooring Cruise Report.

Abstract
This cruise report details the scientific programme for the Scottish Association for Marine Science (SAMS) led by Professor Stuart Cunningham on RSS Discovery DY053. This cruise is a contribution to the international Overturning in the Subpolar North Atlantic Programme (OSNAP). Two additional scientific teams (from Rosenstiel School of Marine and Atmospheric Sciences, and Woods Hole Oceanographic Institution / Ocean University of China) participated in this cruise. SAMS objectives were to recover and redeploy moorings in the Rockall Trough, measuring temperature, salinity, currents and bottom pressure and; recover Seaglider SG605 ''Bowmore'' in the Hatton-Rockall Basin.   The OSNAP array deployed since July 2014 is purposefully designed to provide a continuous record of the full-water column, trans-basin fluxes of heat, mass and freshwater in the subpolar North Atlantic, on a section from Newfoundland to Greenland to Scotland.

Issuing Organisation	**Scottish Association for Marine Science**
	Scottish Marine Institute
	Oban, Argyll, PA37 1QA UK
	Tel: +44(0) 1631 559000
	Email: info@sams.ac.uk

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Scientific and Ship's Personnel

Table 1: Scientific and Ship's Personnel

	Family Name	Given Names	Rank or Rating	Institute
1	Cox	Joanna Louise	Master	
2	Hood	Michael Patrick	C/O	
3	Leggett	Colin James	2/O	
4	O'brien	Matthew James	3/O	
5	Lewtas	Andrew Nicholas	C/Eng	
6	Franklin	Nicholas Robert	2/E	
7	Collin	Ian Stuart Meldrum	3/E	
8	Hay	Derek Brian	3/E	
9	Brooks	Felix Robert Arthur	ETO	
10	Bullimore	Graham	PCO	
11	Deacy	Calum Nathan	Cadet	
12	Spensley-Corfield	Elliott	Cadet	
13	Macdonald	John	CPOS	
14	Lewis	Thomas Gregory	CPOD	
151	Spencer	Robert George	POD	
16	Mclennan	William	SG1A	
17	Lafferty	Raoul John	SG1A	
18	Lapsley	Craig James	SG1A	
19	Hopley	John Michael	SG1A	
20	Williams	Emlyn Gordon	ERPO	
21	Ashfield	Mark James	H/Chef	
22	Link	Walter John Thomas	Chef	
23	Orsborn	Jeffrey Alan	Stwd	
24	Tolton	John	A/Stwd	
25	Beaton	John	Scientist	SAMS[1]
26	Dumont	Estelle	Scientist	SAMS
27	Carrilho Bilo	Tiago	Scientist	RSMAS[2]
28	Christiansen	Cobi Miles	Scientist	RSMAS
29	Cunningham	Stuart Andrew	PI	SAMS
30	Graham	Mark J	Scientist	RSMAS
31	Furey	Heather Hunt	Scientist	WHOI[3]
32	Houpert	Loïc Alexandre	Scientist	SAMS
33	Houk	Adam Eric	Scientist	RSMAS
34	Johns	William Edward	Scientist	RSMAS
35	Koman	Gregory Edward	Scientist	RSMAS
36	Nie	Yunli	Scientist	OUC[4]
37	Wilson	Karen	Scientist	SAMS
38	Walicka	Kamila	Scientist	SAMS
39	Smith	Dominic Gearge	Scientist	RSMAS
40	Whittle	Stephen Paul	Tech	NOC[5]
41	Nemeth	Zoltan	SST	NOC
42	Leadbeater	Andrew John	Tech	NOC
43	Benson	Jeffrey Ray	Tech	NOC
44	Childs	David	Tech	NOC

[1] Scottish Association for Marine Science (SAMS);
[2] Rosenstiel School of Marine and Atmospheric Sciences, University of Miami (RSMAS);
[3] Woods Hole Oceanographic Institution (WHOI);
[4] Ocean University of China (OUC);
[5] National Oceanography Centre (NOC).

RRS *Discovery*

The RRS *Discovery* [IMO number 9588029] is a research vessel operated by the UK Natural Environment Research Council (Figure 1). *Discovery* was built at FREIRE shipyard, Spain and NERC assumed responsibility for Discovery on the 8th July 2013. Discovery is 99.7 m long, 18.0 m wide weighing 5954 tons gross. Four Warstila 1770kW transformers drive two Wartsila azimuth thrusters (5-bladed, fixed pitch, 3.6m diameter) and azimuth and water jet bow thrusters. Combining with a dynamic positioning system this gives *Discovery* precise control during over-side operations.

Discovery is a state-of-the-art research vessel fully fitted with scientific equipment and instrumentation and a range of dedicated laboratories. Shipboard fitted instrumentation includes: Applanix POS MV V4 position and attitude sensors; several other position and attitude sensors; Teledyne-RDI 150 and 75kHz ADCPS interfaced to a iXBlue PhiNS (Photonic Inertial Navigation System); a range of hydroacoustic systems by Kongsberg-Simrad including EM710 shallow water and
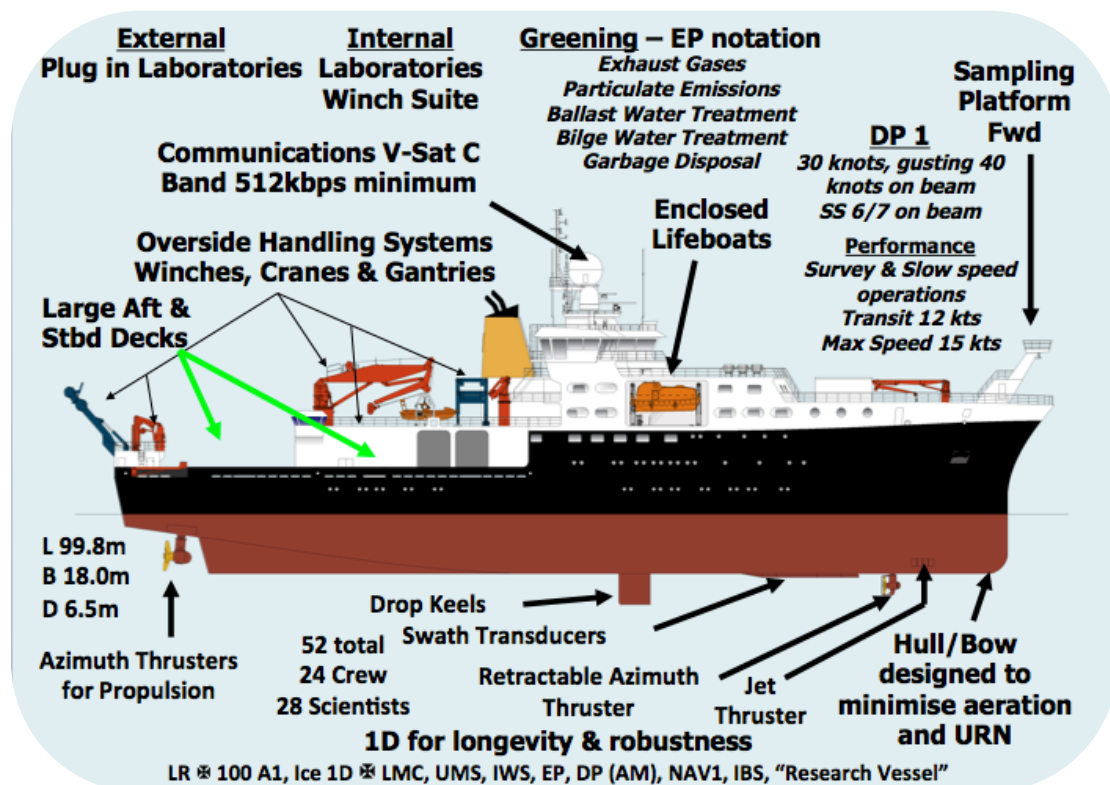
Figure 1: RRS Discovery in 2013

EM122 deep water multibeam echosounders (combined with OLEX 3D Seafloor

hydrographic mapping and visualisation software); a variety of single beam, fish-finding and subbottom profilers; surface meteorology; sea-surface properties and WaMoS II Wave Radar. Her scientific machinery and handling systems include a deep water coring traction system; fibre optic deep tow traction system; a tapered trawl traction winch, CTD traction winch; Aft and mid-ships "A" frames; port and starboard aft-quarter pedestal cranes; main crane.

Discovery provides accommodation for 52 persons (24 crew & 28 scientists) in single cabins. Endurance based on fuel consumption is around 66 days.

Itinerary

Depart King George V Dock, Glasgow 26th June 2016, arrive Reykjavick, Iceland 23rd July 2016.

Acknowledgements

I particularly wish to acknowledge the contribution of crew and officers to the success of the science programme. I also wish to acknowledge all involved in the medical evacuation: UK medical services, UK Coastguard and most of all to the Icelandic Coastguard who flew 150 nmiles into the subpolar Atlantic to effect this evacuation.

1   Introduction

Stuart Cunningham

This report details the scientific programme on RRS *Discovery* cruise DY053 led by Professor Stuart Cunningham of the Scottish Association for Marine Science (SAMS). The cruise is the 12th cruise contributing to the International Overturning in the Subpolar North Atlantic Programme (OSNAP) [*Lozier et al.,* 2016; http://www.o-snap.org/; http://www.ukosnap.org]. Two additional scientific teams participated on this cruise (Table 1). Professor William Johns from the Rosenstiel School of Marine and Atmospheric Sciences (RSMAS), University of Miami led and planned the US contribution to the cruise. Also participating was a team from the Woods Hole Oceanographic Institution (WHOI) and Ocean University of China led by Dr Heather Furey.

The work area is shown in Figure 2.

SAMSs' objectives were to: 1. Recover and deploy moorings in Rockall Trough instrumented for temperature, salinity, currents and bottom pressure; 2. Recovery

Seaglider SG605 *Bowmore* on the Hatton Plateau and; 3. Occupy a section of CTD/LADP stations from the Scottish continental shelf, through the Iceland Basin to the Reykjanes Ridge (Figure 2).

RSMAS objective was to: 1. Recover and deploy moorings on the eastern flank of the Reykjanes Ridge and across the Iceland Basin measuring temperature, salinity and currents.

WHOI objectives were to: 1. Deploy RAFOS floats in the Irminger and Iceland Basins and; 2. Recover and deploy a Slocum Glider.

In addition, Argos floats were deployed by the US and UK groups along the track and a CTD-LADCP section was conducted in the Bight Fracture Zone, repeating measurements made in 2012 (Cruise KN221).
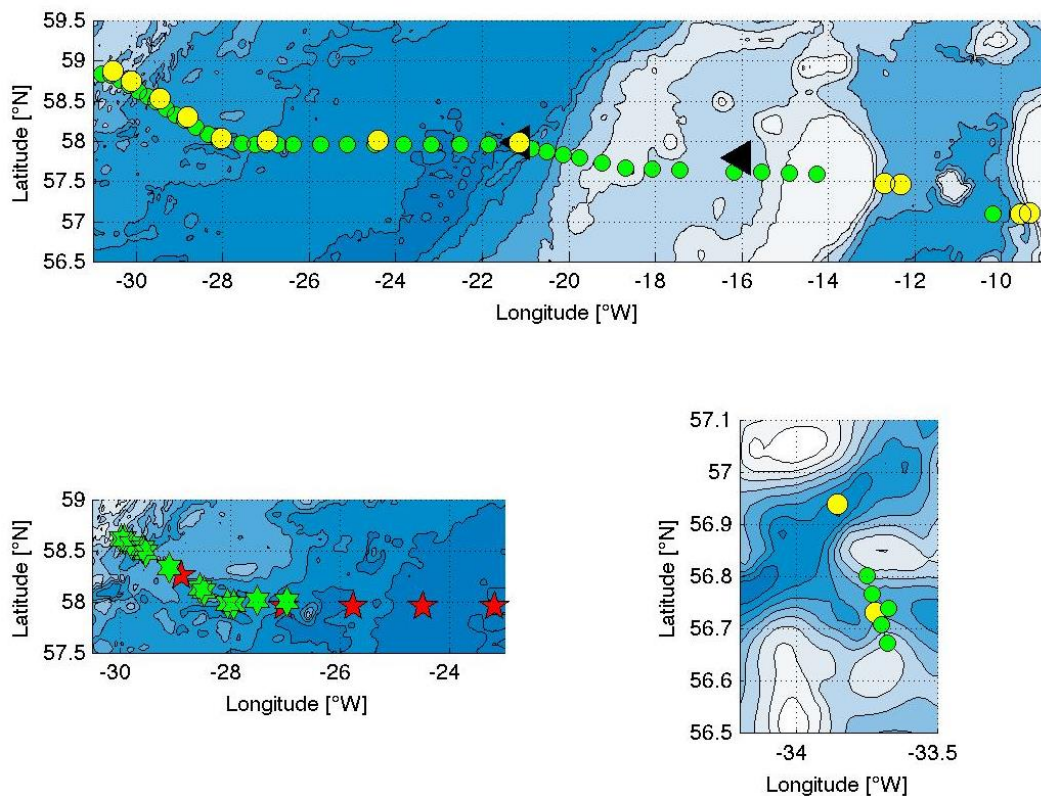
Figure 2: Top panel shows locations of moorings (yellow circles); CTD stations (green circles) and; Slocum deployment (black triangle near 21°W) and Seaglider recovery (black triangle near 16°W). Bathymetry: 0 500 1000 1500 2000 2500 3000 m. Bottom left panel shows Argo float deployments (red stars) and RAFOS float deployments (green pentangles). Bathymetry: 1000 1250 1500 1750 2000 2250 2500 2750 3000 m. Bottom right panel shows bathymetry of the Bight Fracture Zone with contours as middle panel. WHOI moorings (yellow circles) and CTD stations (green circles).

1.1 Scientific Background and Description of the OSNAP Programme

Earth's climate is governed by the meridional transports of energy by the atmosphere and ocean. These transports balance a net heating equatorward of 35° and cooling northward of 35°. The net heating is a balance between incoming solar short wave radiation and outgoing long wave radiation: with short wave solar heating exceeding long wave cooling equatorward of 35°. The ocean, through its large thermal mass, and by the globally interconnected thermohaline overturning circulation, is important for climate patterns and variability on longer timescales than the atmosphere.

The Atlantic Meridional Overturning Circulation transports warm water northward throughout the Atlantic in the upper 1km. Cold-water returns south at greater depth. By this mechanism, a meridional transport of heat is affected.

Anthropogenic warming of Earth's climate is shown in models to have a positive feedback on the overturning circulation. Warming at high latitudes results in more fresh water in the high latitude Atlantic, and this reduces the surface density inhibiting the conversion of the warm water to the cold deep return flow. Thus, the overturning slows and fresh water accumulates at high latitudes further inhibiting the overturning. It is a key prediction of anthropogenic climate change that the AMOC will slow by 30-50% over the 21st Century: the meridional heat transport is also reduced by this amount.

In 2004 the first purposefully designed observing system for continuous monitoring of the strength, structure, and heat transport of the AMOC was deployed across the subtropical Atlantic near 26.5°N - the RAPID-MOCHA array. This array is
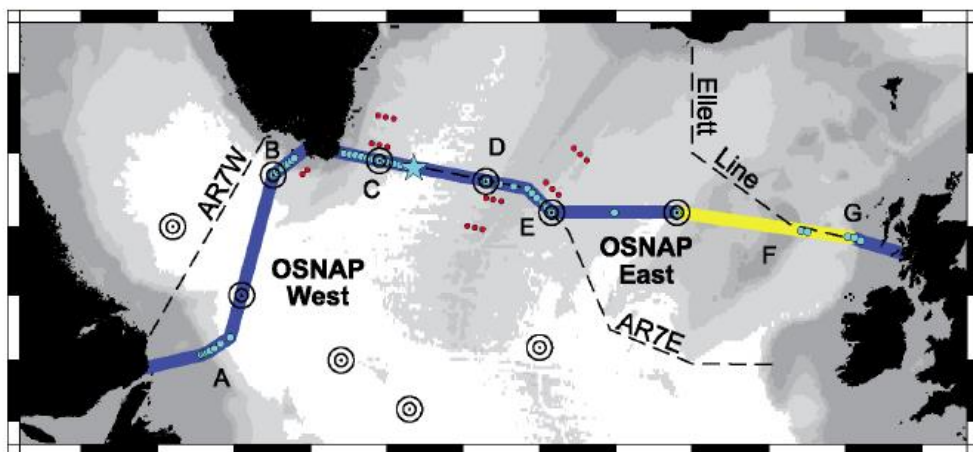
Figure 3: The OSNAP line, comprising: (A) German 53°N western boundary array and Canadian shelf-break array; (B) US West Greenland boundary array; (C) US/UK East Greenland boundary array; (D) Netherlands western Mid- Atlantic Ridge array; (E) US eastern Mid-Atlantic Ridge array; (F) UK glider survey (yellow) over the Rockall-Hatton Plateau and Rockall Trough; (G) UK Rockall Trough and Scottish Slope Current array. Red dots: US float launch sites. Blue star: US Ocean Observations Initiative Irminger Sea global node. Black concentric circles: US sound sources.

deployed near the latitude of maximum northward heat transport and one objective of this array is to provide the baseline measurements necessary to quantify any slowing in the AMOC. Now in its 12 year of continuous observations the array has revolutionized our view of AMOC dynamics and variability.

The OSNAP Programme is the subpolar counterpart of the subtropical RAPID-MOCHA array, and is also designed to continuously monitor circulation and heat transports. The OSNAP array is also designed to provide more direct measurements of the link between the conversion of the warm upper layers to colder deep layers and the strength and structure of the AMOC. This conversion is thought to be a critical mechanism in controlling the strength of the AMOC and its consequent impact on Earth's climate.
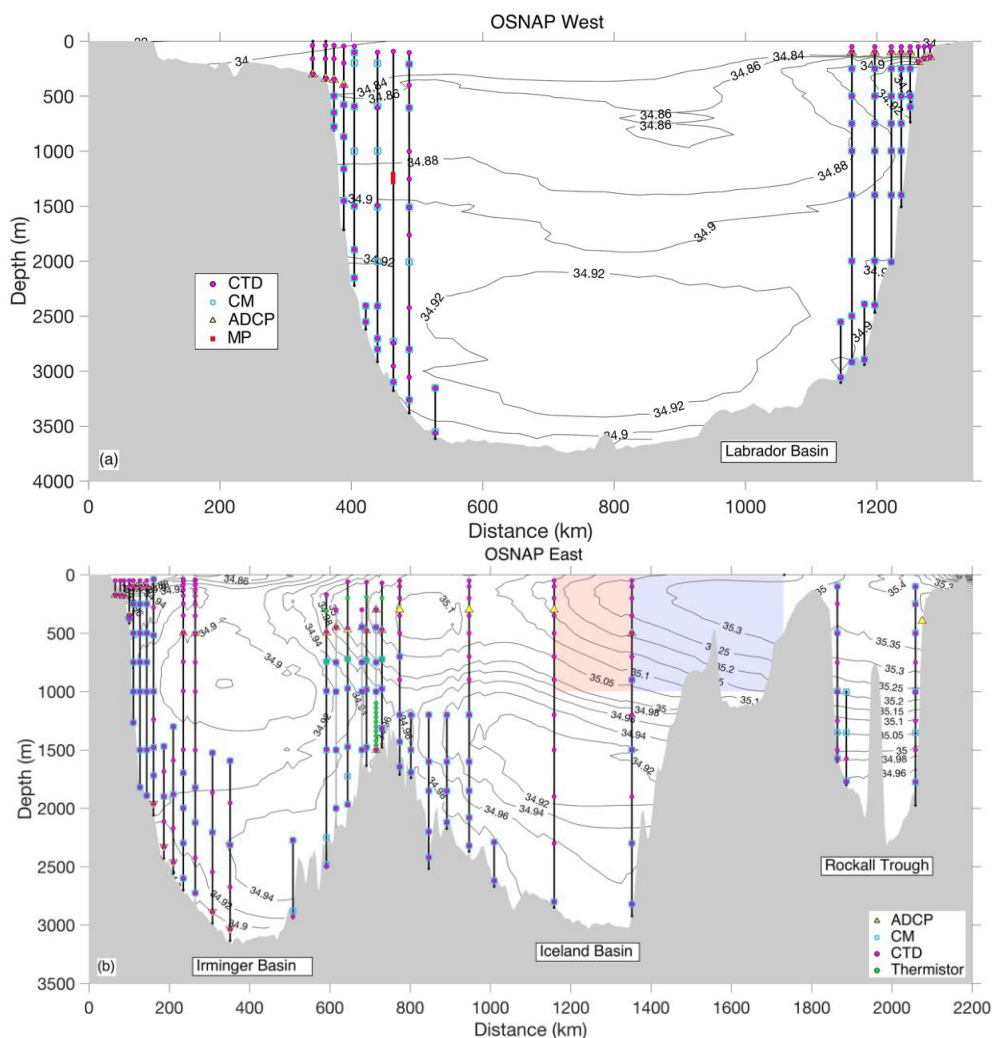
Figure 4: Schematic of moorings along (a) OSNAP West and (b) OSNAP East. The instrument types are as indicated by legend: CTD – Conductivity-Temperature-Depth; CM – Current Meter; ADCP – Acoustic Doppler Current Profiler; MP – Moored profiler. Glider domain is indicated by shaded box: red– Chinese glider, blue – UK glider. Vertical red lines over the western flank of the Reykjanes Ridge along OSNAP East illustrate three French moorings as part of the RREX program. Black contours are 2005-2012 mean salinity from WOA13.

1.2 Observing System

The OSNAP observing system (Figure 3 and Figure 4) is designed to capture all components of the circulation in the subpolar gyre. Arrays of current meter moorings measure directly the transports of boundary and overflow currents. Between boundary arrays the circulation is estimated by applying geostrophy between dynamic height moorings. In hard to observe regions autonomous gliders are used and RAFOS and Argo floats provide views of circulation pathways and of upper ocean temperatures and salinities [*Lozier et al.,* 2016].

The observing system is an international collaboration of seven countries (US, Canada, Germany, Netherlands, France, UK, and China). The array was deployed in 2012 and will make initially four years of measurements, with the intention that the array should continue for at least a decade.

2 Ship's Data Logging, Computing, Instrumentation and Sat-Comms

2.1 TechSAS

Zoltan Nemeth and Stuart Cunningham

"TechSAS is an integrated technical and scientific sensors acquisition system and is the primary datalogger on Discovery. The system allows monitoring and accurate time-stamping of each individual instrument with a graphical output. TechSAS saves data in the self-describing NetCDF (Network Common Data Format) format that can be easily read via MatLab or using freely available NetCDF libraries. TechSAS also broadcasts the logged data across the ship's network in UDP pseudo-NMEA0183 (i.e.: "NMEA-like") packets. Separate NetCDF documentation is available that explains the logged variables" [Nemeth, 2016].

We were concerned about the synchronization of the TechSAS clock with the NTP time-server. During the previous cruise DY052 it was thought that the TechSAS *hostsfile* did not have the correct DNS entry to refer to the time-server. The concern was that the time-stamps for data logged by TechSAS would be using the TechSAS DEL PC clock with its inherent drift characteristics.

To determine any time drift in the TechSAS files we computed the difference of the TechSAS time stamp to the *posmvpos* variable *measureTS*. The results of this comparison are shown in Figure 5 below for DY052 and DY053. Both cruises exhibit a drift in the time difference of 0.15s over a time period of 240s. There is then a step correction to the drift. DY052 has a difference between TechSAS and GPS time starting from +0.005s and drifting to -0.01 s. For DY053 the drift is from -0.035 s to -0.045 s. Zoltan examined statistics for the NTP time-server, showing no deviations of

the time-server from 'absolute' time, with jitter of very small fractions of a milli-second. Tolerances for TechSAS deviations from the NTS clock were set to 5 ms. My guess is that the DEL PC clock will be found to have a drift of 360s (6 min) per day if left unregulated. For this cruise, we do not believe this to be problematic for the intended data uses. No explanation was found for the time offset between the two cruises, and no suggestion for paths to investigate was received from Ifremer.

2.2   Data Share & Public Disks

Loïc Houpert

All scientific cruise data were stored on DISCOFS under the *dy053* folder and organised with a standard template of folders. All CTD, ADCP, LADCP and mooring data were backed up to DISCOFS on acquisition. In addition, the network drive *public* was used to shared data, figures, documents between the scientists
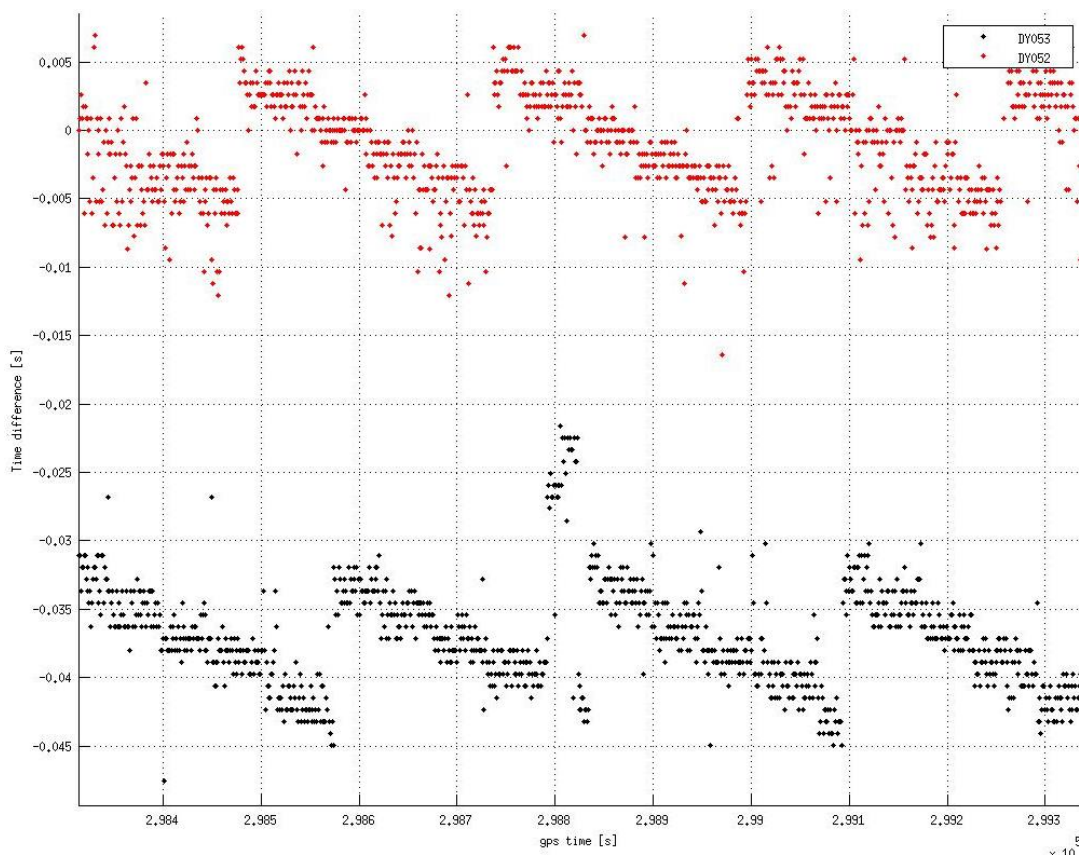
Figure 5: Time difference between the TechSAS time stamp for data streams and the time data from the posmvpos GPS stream *measureTS* plotted against *measureTS*. Results from two cruises DY052 (red) and DY053 (black) are shown for a short section of data. This pattern is consistent over the whole of each cruise. The data file analyzed is *pos_dynnn.01.nc*, where *nnn* is the cruise number.

2.3 Visiting Workstations from SAMS

Loïc Houpert

The SAMS workstation used for scientific processing and archiving of data were Linux workstations (Lubuntu 14.04) and was used on the DY052 cruise. Another Linux workstation used on the PE399 cruise was used as a remote terminal to access the main workstation and process the underway and the VMADCP data.

The ship network drives *techsas*, *public*, and *dy053* were mounted on the SAMS workstations using these commands:

- sudo mount -o vers=3 192.168.62.11:/home/techsas/Data/ /mnt/techsas (for TechSAS, the mounting point has to be ~/techsas/Data):
- sudo mount -t cifs //192.168.62.27/public /mnt/public -o username=sciguest,password=sciguest,iocharset=utf8,file_mode=0777,dir_mode=0777
- sudo mount -t cifs //192.168.62.27/dy053 /mnt/discofs -o username=sciguest,password=sciguest,iocharset=utf8,file_mode=0777,dir_mode=0777

2.3.1 Problems

Connections by ssh to the SAMS workstations worked well from Windows and Linux computers, it was impossible to connect from Mac due to an error related the keyboard parameters ("Error loading new keyboard description"). As an alternative solution, the SAMS workstation was turned into a Samba network drive, so Mac users could access the data by mounting directly the SAMS workstation on their computers through the ship's network. To do that we ran the following commands on SAMS workstations:

1) edit /etc/samba/smb.conf : add security=user and usershare owner only = false
2) add mstar as user : sudo smbpasswd -a mstar
3) enable mstar as user: sudo smbpasswd -e mstar
4) reload smb: sudo /etc/init.d/samba reload
5) net usershare add Mstarcomputer /home/mstar/ "Mstar computer" everyone:F guest_ok=n

After the cruise and by discussing with David Smith (NOC), the keyboard detection problem seemed to come from the .cshrc file on the SAMS workstation, and particularly the *setxkbmap* variable. The line *setxkbmap gb* has to be changed so *setxkbmap* is not set by ssh :

if $?DISPLAY then
 if $DISPLAY == ":0" then
  setxkbmap gb
 endif
endif

2.4   Backup/LAN based RAID

Loïc Houpert

Backup were made manually every day on external 2TB hard drives plug into the SAMS workstations. In addition, we used *Back In Time* (a free backup software similar to Time machine on Mac) on another Linux workstation which had the software installed to back up the system to and external hard drive every 30mins. Back In Time uses rsync as backend and has the characteristic feature of using hard links for files which are identical in snapshots at different times, thus using disk space just once for files that remained unchanged. Advantages of the hard link method are that it is easy to look at snapshots of the system at different times and also easy to remove old snapshots compared to incremental backup methods which save difference information between consecutive backup times.

3   VMADCP Processing

Kamila Walicka / Loïc Houpert

3.1   OS75

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 DY053.

During the cruise the 75 kHz data were processed every day, using CODAS version 2015.05.01_python. This new version of CODAS has the advantage to have powerful tools to edit, quality control and display the data. However, the recent version of CODAS no longer supports single ping data in the VMDAS format. It is possible to convert the data into UHDAS format and process them with CODAS, but a lot of processing stages are necessary before being able to process the data in CODAS. Conversion of single ping data takes a considerable time and is difficult to perform on a daily basis. During the cruise we processed the data in the STA format (short time averaging), which was a two-minute average of single ping data.

Table 2: List of the different VAMDCP files reprocessed with the corresponding time period.

ADCP	File number	Start date + time	End date + time raw data	Original end date + time LTA & STA	Reprocessed end date + time LTA & STA
75	OS75_DY053015	10/07/16 06:48	11/07/16 10:16	10/07/16 16:56	11/07/16 10:16
75	OS75_DY053020	15/07/16 07:50	15/07/16 17:18	15/07/16 16:00	15/07/16 17:15
150	OS150_DY053023	18/07/16 09:17	18/07/16 15:56	18/07/16 12:21	18/07/16 15:55
75	OS75_DY053025	19/07/16 08:27	19/07/16 23:45	19/07/16 19:24	19/07/16 23:44

On a few occasions during the cruise the VMADCP acquisition software stopped generating short and long-term average files (STA and LTA) in real-time. The raw data carried on being collected normally. When this happened the data were reprocessed on a different computer, using the same software version (VmDas v.1.46.5) and configuration parameters. The list of datasets affected is in Table 2.

We used constant velocity heading and amplitude correction calibration values for the entire cruise, calculated using data obtained during DY052 cruise. The median amplitude correction estimated from the bottom track data is 1.0149 (std of 0.0064) and the median phase correction is 0.7604° (std of 0.4885°). Values should be constant because they are based on the physical mounting angle of the transducers.

3.1.1 CODAS 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$highernumber$

(3) Copy the new data files. The function that synchronizes the ship ADCP data is: *vmadcp_linkscript75*

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

adcptree.py dy053NNN --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:

gedit q_py.cnt

(7) Run the processing by loading the python script (Figure 6)

quick_adcp.py --cntfile q_py.cnt


```
## python processing

##### q_py.cnt is

--yearbase 2016          ## required, for decimal day conversion
                         ##     (year of first data)
--cruisename dy053       ## always required; used for titles
--dbname dy053NNN  ## database name; in adcpdb.  eg. dy053004
--datatype sta           ## datafile type
--sonar os75nb           ## instrument letters, frequency, [ping]
--ens_len  120           ## specify correct ensemble length
--datadir ../rawdataNNN  ##use this option to avoid
#  --rotate_angle 0.7604
#  --rotate_amp 1.0149
--auto

                         ## copying or linking files

#### end of q_py.cnt
```

Figure 6: Example of python processing file q_py.cnt used during processing step (7).

(8) Manually flag the bad data by using the *gautoedit* function: CODAS opens three windows (Figure 7), especially CODAS ADCP Editor (Figure 8 and Figure 9).

> *cd edit;*
> **gautoedit.py**
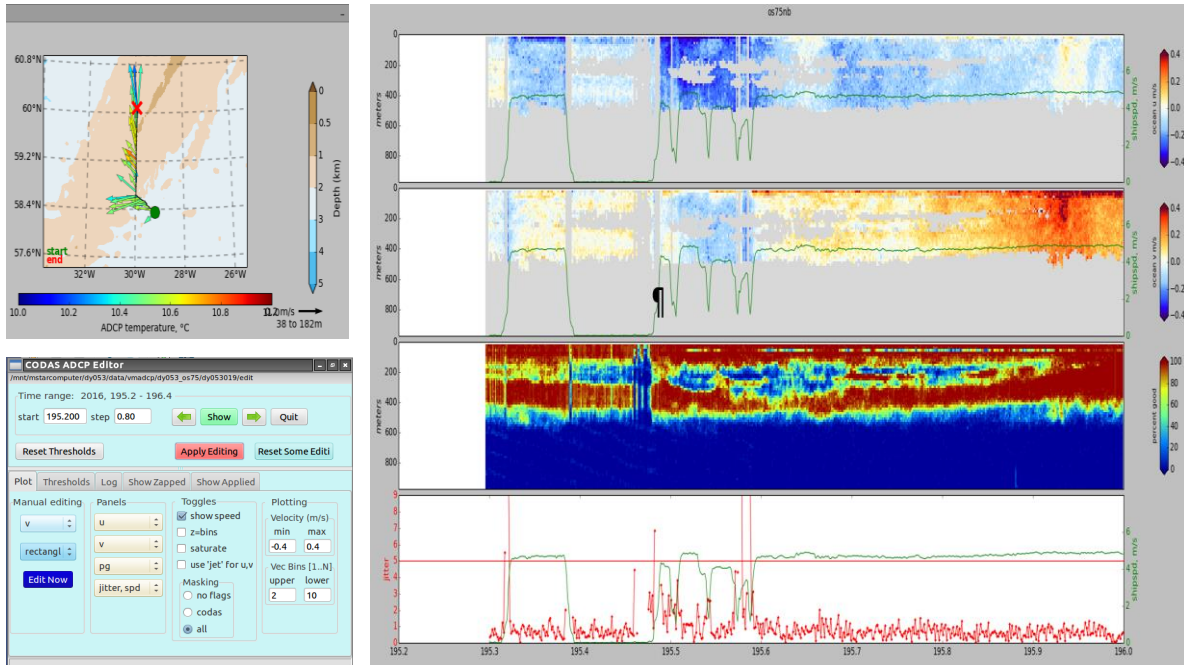
Figure 7: Example of the three gautoedit windows generated by CODAS during processing step (8). Top left: bathymetry map with transect and ADCP temperature; bottom left: *Editor* allows the user to set various parameters e.g. time range, range of velocity or showing speed; right: u and v velocity components, percent of good data and ship velocity with jitter (Figure 8-right).
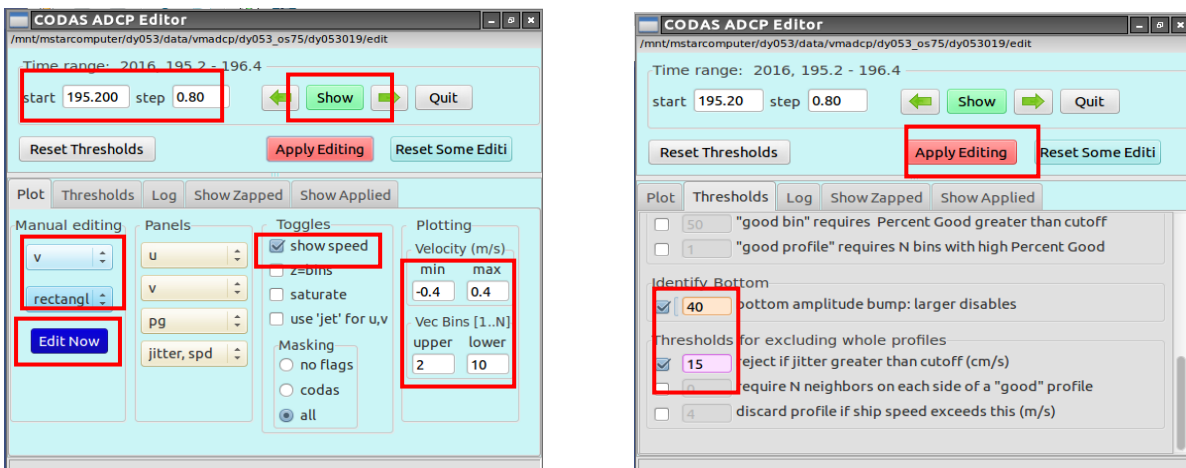
Figure 8: Example of the Editor window generated by CODAS during processing step (8). (left) - Bookmark *Plot* allows the choice of a particular parameter such as u, v velocity components, amplitude etc. *Plot* also includes a tool of manual editors like *profile, rectangular, polygon*. The *Edit now* button opens the window, where manual corrections can be made. The button *show* gets plots up on the screen. (right) - Bookmark *Thresholds* control threshold editing. Option *bottom amplitude bump: larger disables* is a useful tool to remove the fake bottom detection. Option *reject if jitter greater than cutoff* displays the range of jitter which is somewhat arbitrary indicator of "data smoothness". A high level of jitter indicates either rapidly changing velocities or navigational noise. The *Apply Editing* button must be selected before showing the next data otherwise changes will not be applied.
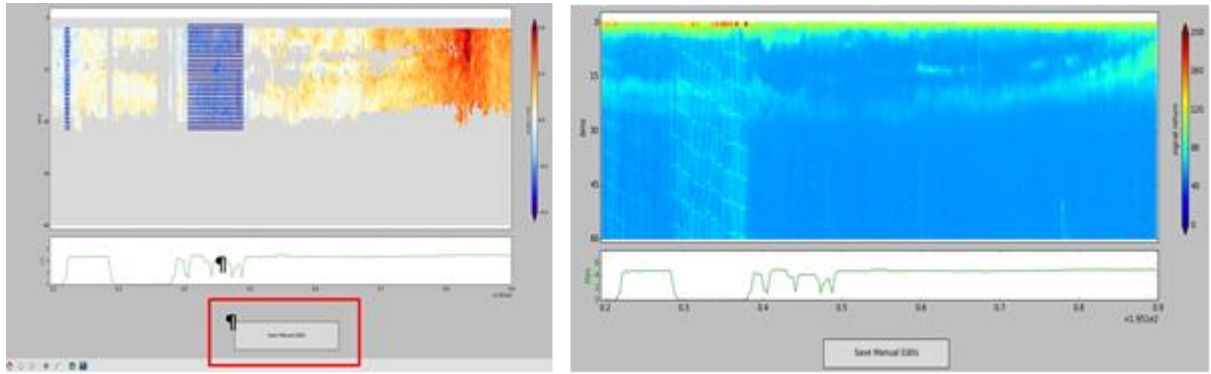
Figure 9: (Left) Manual edits window generated by use of the Edit Now button from *Editor* window, *Plot* bookmark. This window allow manual select bad data during processing step (8). After pressing *save manual edits,* changes will be applied to the data. (Right) The manual edits window showing the amplitude plot generated during processing step (8). This plot shows interference of the acoustic signal which may be generated by some of the other acoustic devices on the ship.

(9) To apply the flags and recalculate a calibration we used:

> *cd ..*
> *cp ../q_pyedit.cnt .*
> **quick_adcp.py --cntfile q_pyedit.cnt**
>
> > *##### q_pyedit.cnt is*
> > *--steps2rerun rotate:navsteps:calib*
> > *--auto*
> > *#### end of q_pyedit.cnt*

(10) 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 0.7604*
> > *--rotate_amp 1.0149*
> > *--steps2rerun rotate:navsteps:calib*
> > *--auto*
> > *#### end of q_pyrot.cnt*

(11) The CODAS data are exported into the matfiles by:

> **quick_adcp.py --steps2rerun matfiles --auto**

(12) The function below was used to select a particular part of the ships track which was then saved as a separate plot. Two plots (Figure 10) aid the selection.

> **quick_web.py --interactive** (or *quick_web.py --redo* if you already did it once)

After closing these windows, plots will be automatically generated in the subdirectory webpy. It also generates a webpage for quick view of data (Figure 11).
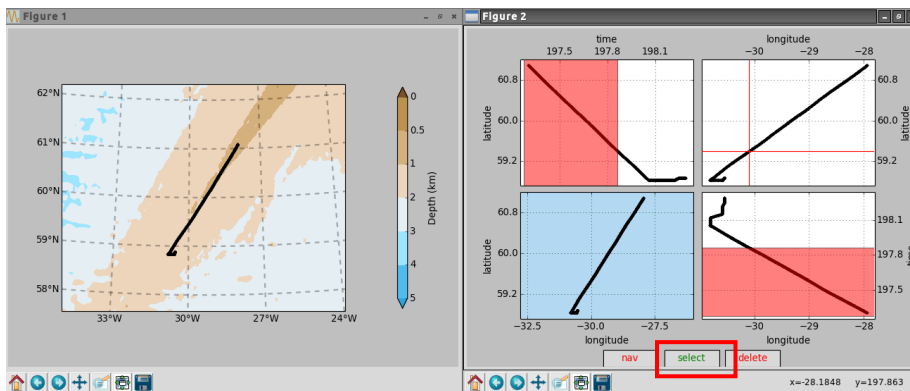
Figure 10: CODAS window during processing step (12). (Left panel) section and bathymetry. (Right panel) demonstrates selecting of particular part of section, which can be later displayed as separate plots.
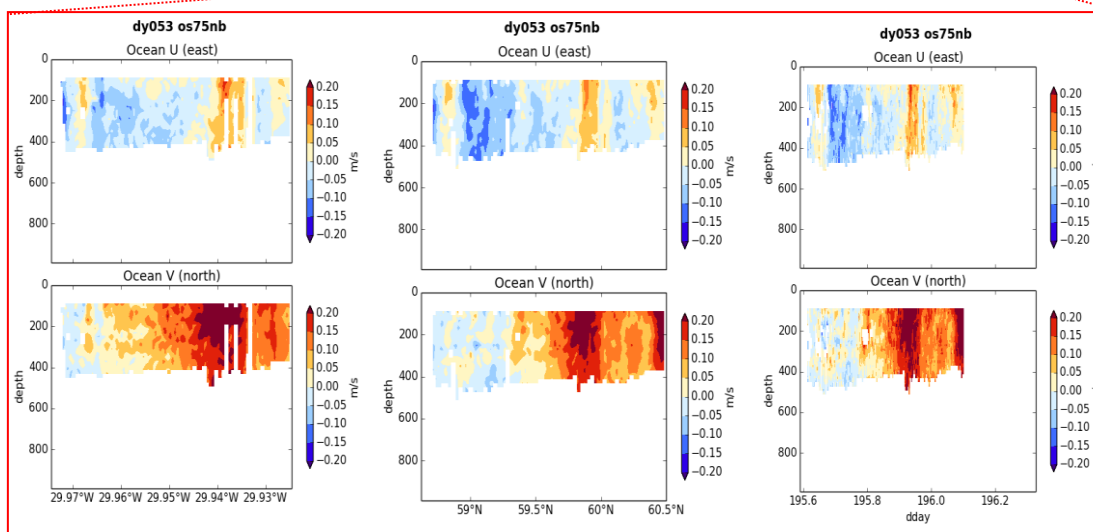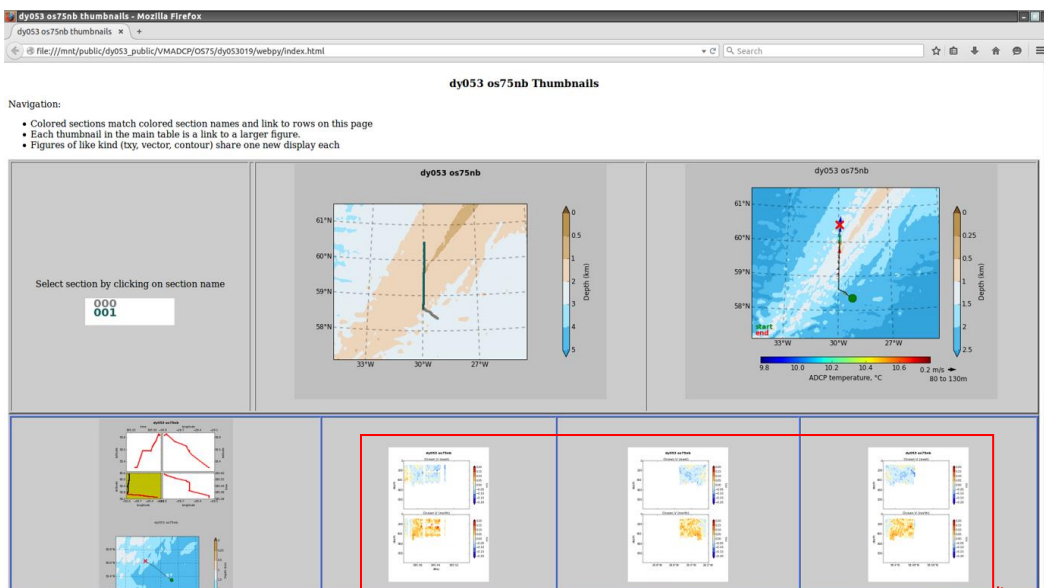
Figure 11: (Upper panel): The online version of saved plots generated by CODAS during processing step (12). (Lower panel): Online velocity plots generated by CODAS during processing step (12). Data are plotted as: depth vs longitude, depths vs latitude, and depth

(13) Edited data can be saved on the network drive public by:

cd ..
cp -R dy053NNN /mnt/public/dy053_public/VMADCP/OS75/.

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

cd cruise/data/vmadcp/v75/dy053NNN

and run the following functions in Matlab:

m_setup;

mcod_01new; - Produces output file os75_jr265NNNnnx.nc, which has a collection of variables of dimensions Nx1 1xM NxM.

mcod_02new; - calculates water speed and ship speed and get all the variables onto an NxM grid.

mcod_mapendnew; - appends individual files to create a single cruise file ("_01"). It does seem to depend on the files having the same bin number and bin depths.

A detailed description about CODAS editing function can be found in the programs directory or in the CODAS website:

http://currents.soest.hawaii.edu/docs/adcp_doc/codas_doc/index.html

3.2   OS150

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 *q_pyedit.cnt* script was used to apply the flags created by using the gautoedit.py function. The rotation angle and amplitude calibration were estimated to be 0.1721 and 0.9947 respectively, and were applied using the *q_pyrot.cnt* script. The final product of processed data was saved in: *cruise/data/vmadcp/v150.*

3.2.1   Processing scripts:

```
##### q_py.cnt is
--yearbase 2016        ## required, for decimal day conversion #    (year of first data)
--cruisename dy053      ## always required; used for titles
--dbname dy053all       ## 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_pyedit.cnt is
--steps2rerun rotate:navsteps:calib
--auto
#### end of q_pyedit.cnt
```

```
##### q_pyrot.cnt is
--rotate_angle 0.1721
--rotate_amp 0.9947
--steps2rerun rotate:navsteps:calib
--auto
#### end of q_pyrot.cnt
```

4 Underway Data Logging

Kamila Walicka

The following document includes the description of processing step for the data-streams navigation, echo sounding bathymetry, meteorological and sea surface observations. During the cruise the underway data were processed every day.

4.1 Retrieving Data from Techsas

(1) Run the TechSAS links script to create a directory of symbolic links to the netCDF files in the TechSAS stream.

~ /cruise/data/exec/techsas_linkscript_dy053.sh

(2) Check that system is automatically updating the links to the files on the network TechSAS server using MatLab to run function:

mtlookd

```
%  NumCycles StartDate StartJD StartTime EndJD EndTime EndDate DataStream Names
1904005  16/06/26  178 09:02:13 to  200 20:31:28  16/07/18  CLAM-CLAM_DY1.CLAM
784335  16/06/26  178 14:31:21 to  200 20:31:30  16/07/18  EA600-EA640_DY1.EA600
1934291  16/06/26  178 09:02:12 to  200 20:31:36  16/07/18  Light-DY-SM_DY1.SURFMETv2
1934295  16/06/26  178 09:02:12 to  200 20:31:40  16/07/18  MET-DY-SM_DY1.SURFMETv2
1868587  16/06/26  178 09:02:13 to  200 20:31:44  16/07/18  SBE45-SBE45_DY1.TSG
1934303  16/06/26  178 09:02:12 to  200 20:31:48  16/07/18  Surf-DY-SM_DY1.SURFMETv2
1941534  16/06/26  178 09:02:13 to  200 20:31:52  16/07/18  cnav-CNAV.GPS
1942108  16/06/26  178 09:02:13 to  200 20:31:55  16/07/18  gyro-GYRO1_DY1.gyr
9270136  16/06/26  178 09:02:12 to  200 20:31:59  16/07/18  gyro-SGYRO_DY1.gyr
4718025  16/06/26  178 09:02:13 to  200 20:32:03  16/07/18  logskippervdvbw-SkipLog.winch
1942120  16/06/26  178 09:02:13 to  200 20:32:06  16/07/18  position-Applanix_GPS_DY1.gps
1930482  16/06/26  178 09:02:13 to  200 20:32:10  16/07/18  position-Seapath330_DY1.gps
1231  16/07/05  187 15:59:48 to  187 19:48:54  16/07/05  position-usbl_DY1.gps
1942129  16/06/26  178 09:02:13 to  200 20:32:15  16/07/18  satelliteinfo-Applanix_GPS_DY1.gps
1941562  16/06/26  178 09:02:13 to  200 20:32:20  16/07/18  satelliteinfo-CNAV.gps
1930496  16/06/26  178 09:02:13 to  200 20:32:24  16/07/18  satelliteinfo-Seapath330_DY1.gps
1231  16/07/05  187 15:59:48 to  187 19:48:54  16/07/05  satelliteinfo-usbl_DY1.gps
107602  16/07/09  191 11:34:58 to  200 20:32:28  16/07/18  sb_depth-EM120_DY1.depth
1942148  16/06/26  178 09:02:13 to  200 20:32:34  16/07/18  shipattitude-Applanix_TSS_DY1.att
1942151  16/06/26  178 09:02:13 to  200 20:32:37  16/07/18  shipattitude_aux-Applanix_TSS_DY1.att
4586  16/06/29  181 06:44:50 to  200 20:29:05  16/07/18  wamos-WaMoS.wamos
```

The TechSAS server is producing 21 streams. If the stream end time is not close to the current time (GMT), then the linking is not automated. This may be due to one of the sensors having stopped working, or an error in the server configuration.
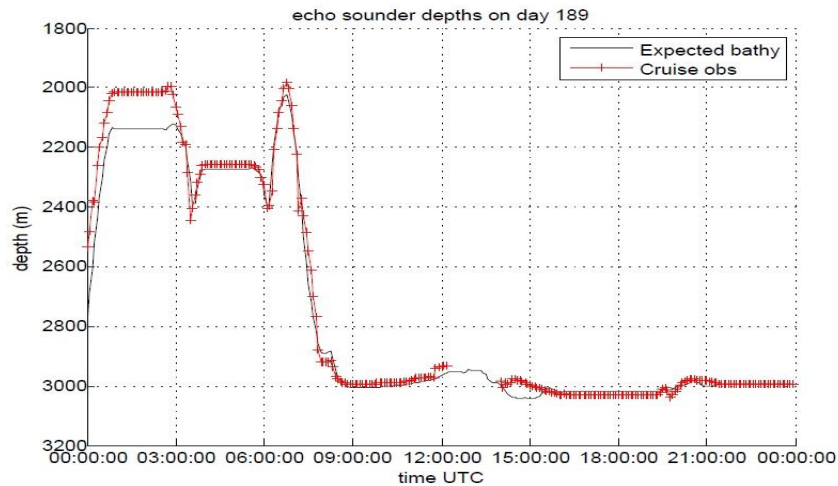
Figure 12: The bathymetry profile created by the EA 640 single beam echosounder (red) compared to lower resolution database bathymetry (black). The echosounder data includes gaps created when the spikes were removed during the processing. This plot is generated by *msim_plot.m* called within routine *m_dy053_daily_processing.*

(3) The appropriate **24 hours of raw data** are extracted from **TechSAS data stream** on a daily basis**.** This step is performed in MatLab using function:

> *m_dy053_daily_processing (nnn)*, where nnn describes number of Julian Day.

The m_dy053_daily_processing function includes six main functions:

- *mday_00_get_all* - extracts the appropriate 24 hours of raw data from the TechSAS stream. It loads only available data from the stream, and skips any data streams that do not exist.
- *mgyr_01* - removes any data cycles with non-monotonic times from the ship gyro data stream.
- *msim_01* - the first pass filter to remove bad data and create 5-min median averages of the EA650 echo sounder data.
- *msim_plot* - displays the bathymetry measurements (without spikes from echo sounder) and bathymetry data from the database (Figure 12). The database includes bathymetry data with lower resolution, located in:

> */home/mstar/cruise/data/tracks/n_atlantic.mat*

- *mmet_01* – converts the wind speed units from knots to m/s.
- *mday_02_run_all* - accumulates all daily data in one file (e.g. sim_dy053_01.nc) for each data stream (the size of the file is equal to the sum of all daily data).

Another two functions in m_dy053_daily_processing were run from the start of the cruise, each time it is required. They include:

- *mbest_all* – run a series of scripts to produce the master bestnav file:
- *mbest_01.m* - create 30-second nav file from 1-Hz positions,
- *mbest_02.m* - calculate speed, course, distance,

- ***mbest_03.m*** -create 30-second heading file from 1-Hz positions,
- ***mbest_04.m*** - merge vector-averaged heading onto average speed, course, speed make good (speed over ground).
- ***mtruew_01.m*** – calculation of the true wind based on smooth navigation and relative wind and ship speed.

4.2 Navigation: /nav

The navigation data are extracted from six TechSAS streams: Attposmv, Cnav, Gyropmv, Gyros, **Posmvpos,** seapos

Some of the streams include the same set of navigation data. However, the master position data are included in posmvpos (Figure 13). All available data can be found in:

/home/mstar/dy053/data/nav/posmvpos/pos_dy053_01.nc

These data don't include any additional edits, except those made by routine mgyr_01 during processing which removes any non-monotonic times.

The posmvpos data are used to obtain the master bestnav file, calculated in m_dy053_daily_processing, by ***mbest_all*** function. The output of these data includes data from the beginning of the cruise and is located in:

/home/mstar/dy053/data/nav/posmvpos/bst_dy053_01.nc
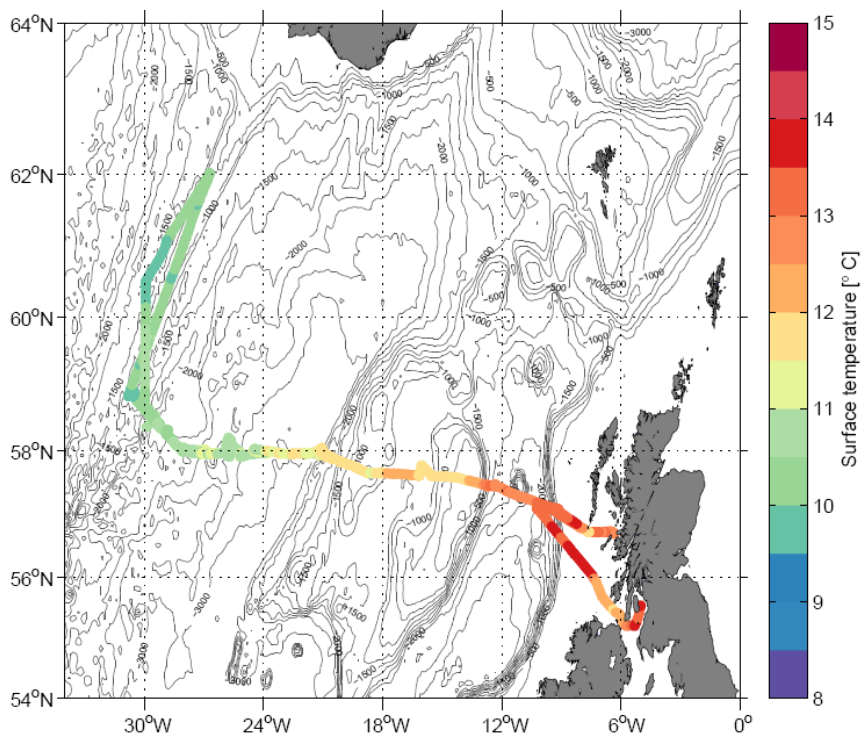
Figure 13: The sea surface housing temperature distribution along the ship pathway, displayed with the bathymetry map of the Rockall Trough, the Rockall Plateau and the Iceland Basin. A clear decrease in sea surface temperature can clearly be seen east to west. It reflects the typical distribution of surface currents in the observed region. The highest temperatures in the Rockall Trough reflect the Continental Slope Current, whilst the relatively colder waters are Modified North Atlantic Water in the subpolar gyre.

4.3   Bathymetry: /sim

Bathymetry data are collected by the EA640, EM122 and EM710 echosounders.

4.3.1   EA640 Single-beam Echosounder.

EA640 can operate at either 12 kHz or 10 kHz (Figure 14, left panel). They have a wide bandwidth that overlaps, and can be run at the same time. The 12 kHz was not used during the cruise because another echosounder (EA122) was working on the same frequency. The raw bathymetry data are saved in:

/home/mstar/dy053/data/sim/sim_dy053_01.nc

4.3.2   EA122 Deep Water Multibeam Echosounder.

This 12 kHz echosounder is rated to 11,000 m, but its range for good quality data is probably up to 8,000 m (Figure 14, right panel). The EM122 is viewed and operated via SIS (Seafloor Information Service). The EM122 echo sounder was not working in the beginning of the cruise until 09/07/2016. This multibeam echosounder was used for the mooring survey for the mooring D5.

4.3.3   EA710 Shallow Water Multibeam Echosounder

This 70-100 kHz echosounder is rated to 2,000 m, but in reality you might consider switching to the EM122 between 600-1500 metres. Within this range, the EM710 gives a broader swathe, with less detail, so which one you use depends on what data you need to generate.
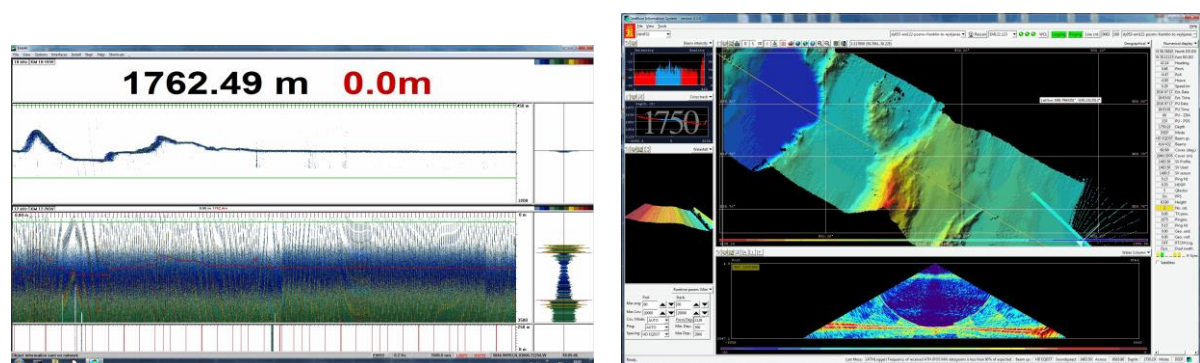
Figure 14:   Left panel: Example of the bathymetry map from the EM640 echo sounder data from 10 kHz showing the actual depth and the shape of the sea floor (top left), Data from 12 kHz echosounder (in the bottom left) are noisy, indicating an incorrect depth, hence the depth at the top of the screen is 0 m.
Right panel: Example of bathymetry map from the EM122 echo sounder collected on 18/07/2016 (top right). And vertical view of the backscattered signal in the water column (bottom right).

All echo sounders were turned off during the mooring operations, because their signal may disrupt communication with moorings releases.

4.4 Surface data :/met

These data are divided into four TechSAS streams:surfmet, surflight and surftsg and tsg.

4.4.1 surfmet

This TechSAS stream includes different variables:

- *speed* - the relative wind speed is stored in TechSAS in [m/s], whereas TechSAS states the variable units as knots. The unit correction to m/s is applied in daily processing, by the script mmet_01.
- *Direct*- wind direction
- *Airtemp* - air temperature
- *Humid* – humidity

These data can be found in: *data/met/surfmet/met_dy053_01.nc* , and an example is shown on Figure 15.

Another meteorological parameter in this directory is the *true wind*. The true wind is calculated in m_dy053_daily_processing, by **mtruew_01.m** function. This
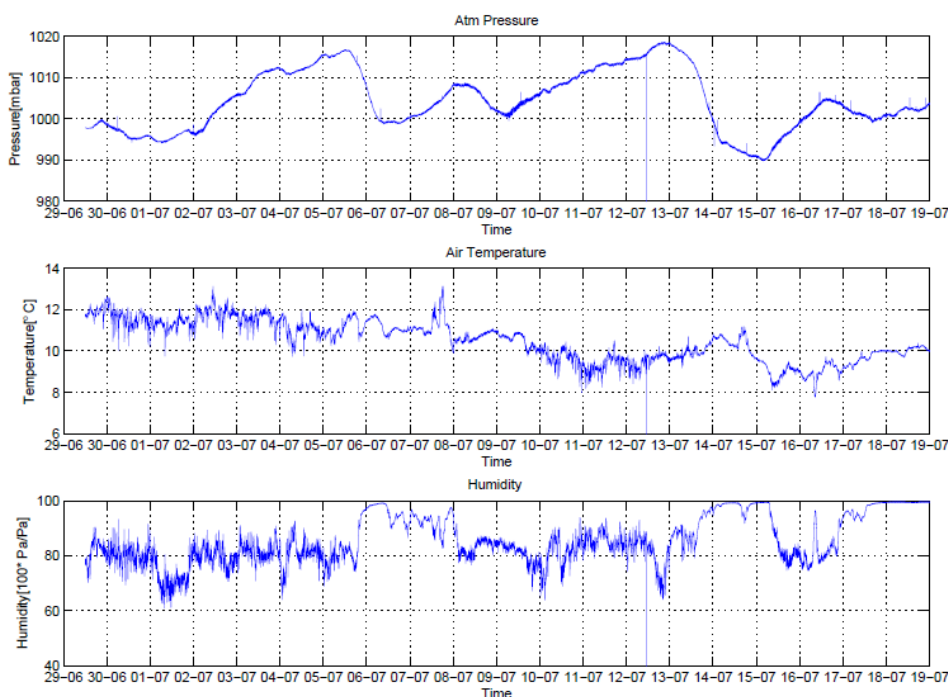
Figure 15: Time series of air pressure, air temperature and humidity. On the 11th July there was a spike in all measurements, which was a result of electric connection problems.

function is using data from bestnav file met wind and ship speed data. The output of

this calculation is located in two files: *data/met/surfmet/met_dy053_true.nc ; data/met/surfmet/met_dy053_trueav.nc*

The latter file is reduced to 1-minute averages, with correct vector averaging. In order to avoid ambiguity, variable units are explicit in whether wind directions are 'towards' or 'from' the direction in question. To test if the absolute wind speed is calculated correctly there should be no changes of true wind speed when the ship changes direction or speed (Figure 16).

4.4.2   surflight:

Variables included in the TechSAS stream are:

- *pres* - Barometer pressure
- *ppar* - Photosynthetically active radiation
- *ptir* – Total incoming radiation (port)
- *stir* – Total incoming radiation (starboard

These data are located in*: data/met/surfmet/met_light_dy053_01.nc*

The PA irradiance and thermal IR data are collected and stored, without further processing.
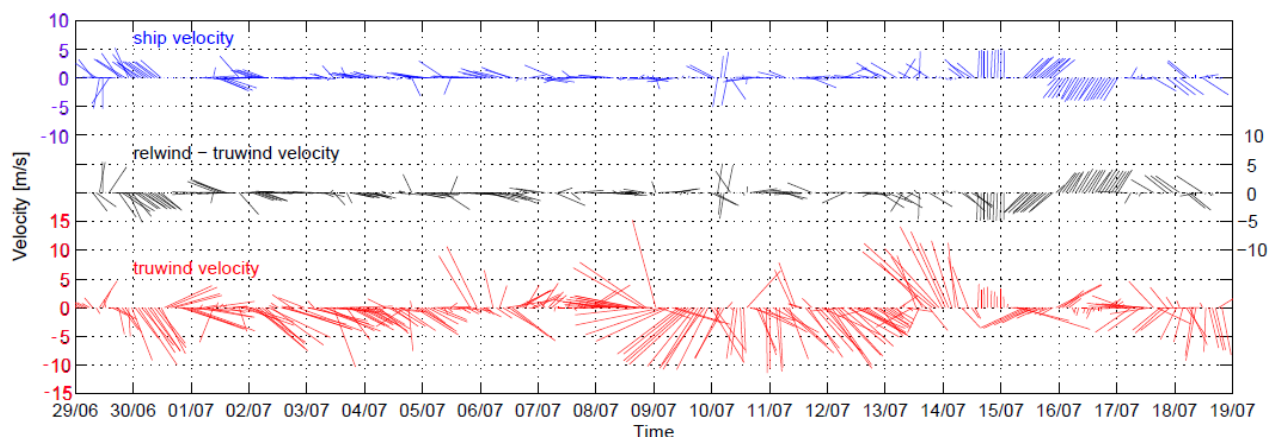
Figure 16: Velocity time-series comparison. Blue vectors show the ship velocity, black vectors show the difference between relative and true wind velocity and red vectors describe true wind velocity. The analysis of true wind shows that this is not related to the ship speed. Between 8th July and 14th July very strong true wind velocity of around 10 m/s were observed. From the 13-14th July strong wind disrupted CTD and mooring works.

4.4.3   surftsg

Variables extracted from the Surf-DYS SM_DY1.SURFMETv2 data stream are:

- *temp_h*
- *temp_r*
- *cond*- conductivity
- *fluo*- fluorescence
- *trans*- transmissance

These data are located in: *data/met/surfmet/surftsg _dy053_01.nc*

The surftsg data was not logged correctly since beginning of the cruise, except fluorescence and transmition. The temperatures were logged as constant values and there was no conductivity data.

4.4.4   tsg

Data are extracted from TechSAS data stream SBE45-SBE_DY1.TSG (Figure 17):

- temp_h – housing temperature- sea surface temperature measured at the TSG itself. This temperature is used with conductivity to calculate salinity.
- temp_r – remote temperature-sea surface temperature measured close to the pipe intake. They are used in further calculations.
- cond – conductivity
- salin- salinity
- sndspeed- sound of speed
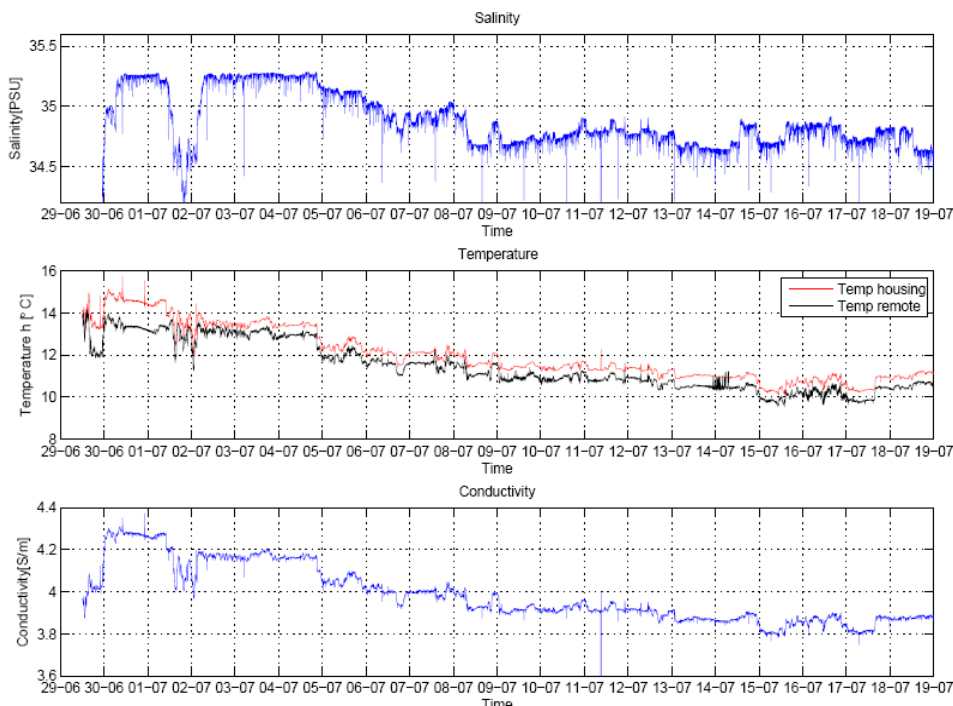
Figure 17: Time series of salinity, temperature and conductivity from the TSG system. In the beginning of the cruise there was around a 1.5° C difference between housing and remote temperature. It can result from aeration of the pipe during a bad weather. This difference reduced to round 0.5° C in the following days.

4.5 MetOcean instruments

4.5.1 Meteorological Instruments (Met)

-Vaisala HMP155 Temperature & Humidity Sensor

It measures thermal radiation and water vapour. These data are used to calculate ambient air temperature and relative humidity (Figure 18a).

-Gill Windsonic Anemometer (Figure 18b).

It measures ultrasonic sound waves via ultrasound transceivers. This sensor is used to calculate wind speed and direction.

-Vaisala BaroCap PTB110 Barometric Pressure sensor (Figure 18c).

It measures a change in electrical resistance via a deflectable diaphragm strain gauge within a pressure transducer. This sensor is used to calculate air pressure.

-Kipp & Zonen CM6B Pyranometer (Figure 18d).

It measures electromagnetic radiation Sunlight flux density by converting solar radiation into heat, and thence into a voltage. It is used to calculate total Irradiance.

-Skye Instruments SKE510 PAR (Photosynthetic Active Radiation) Pyranometer

It measures electromagnetic radiation flux density by converting solar radiation into heat, and thence into a voltage, passed through a bandpass filter. These data are used to calculate total irradiance within a fixed range of wavelengths for photosynthesis.

The location of the meteorological sensors on RS Discovery demonstrate on Figure 19.

Figure 18: Meteorological Instruments: (a) Temperature and Humidity Sensor, (b) Anemometer, (c) Barometric Pressure Sensor, (d) Pyranometer.

4.5.2 Surface Water Sampling Instruments

- SeaBird 45 Thermosalinograph: It measures temperature and conductivity of sea water. This is the main sensor to calculate salinity.

-SeaBird 38 Digital Oceanographic Thermometer: It measures changes in resistance via a thermistor. It's used to calculate the main temperature.

-WetLabs WetStar WS3S Fluorometer: It measures reflected light frequency difference between beams of light passed through water. These data are used to calculate fluorescence.

- WetLabs WetStar CST Transmissometer: This sensor measures the photon quanta (received light) in the sea water.

The surface water sampling instruments are located in the TSG room in the main deck.
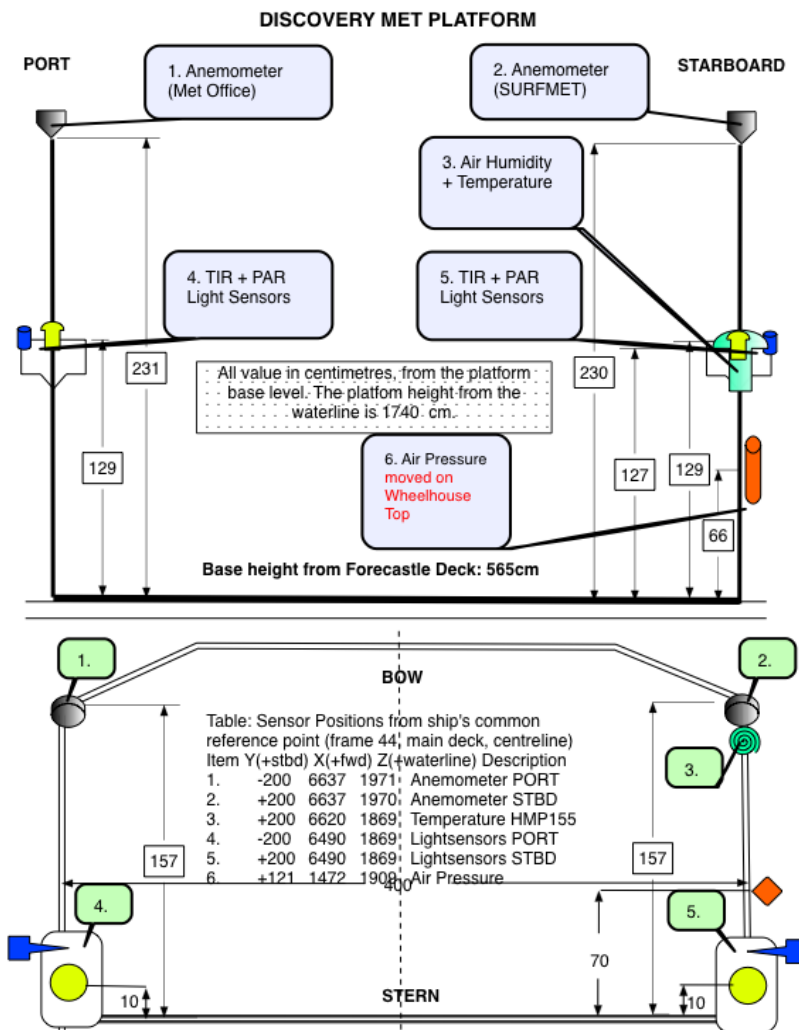
Figure 19: Schematic showing location of the meteorological sensors on RS Discovery. Sensors are located in the met platform near the forward mast about 10 m above sea level. There are two pairs of anemometer and light sensors on the both sites of the meteorological platform. The rest of the sensors are located on the starboard side.

5 DY053 TSG calibration

Estelle Dumont, SAMS (modified from the DY052 report by Rob King)

The calibration of the thermosalinograph (using the TSG data stream) broadly followed the procedure used on the previous cruise DY052 and consisted of the following steps:

1) **mcd('M_TSG')** to move to the TSG directory.

2) **mtsg_findbad_dy053.m:**

This routine was amended to first run a simple filter over the salinity variable (*qc_spike_detection_timeseries.m*) to automatically detect and flag single-point spikes over 0.01 psu, as shown in Figure 20.

The next part of the script allows the user to interactively remove larger 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 rather than overwritten every time this routine is run.

Input: *data/tsg/tsg_dy053_01.nc*
Output: *data/tsg/bad_time_limits.mat*

During DY053 we observed the same phenomenon as described in the DY052 cruise report: " *During the spike removal for DY052, a regular feature was noticed [..] approximately every 12 hours, the housing temperature (temp_h) logged by the SBE45 would sharply increase by ~1.5K (over 1 minute) and decrease back to the background level over a period of ~10 minutes. On several occasions this was followed by a smaller magnitude signal (around 15 minutes later) with the same features. Although this*
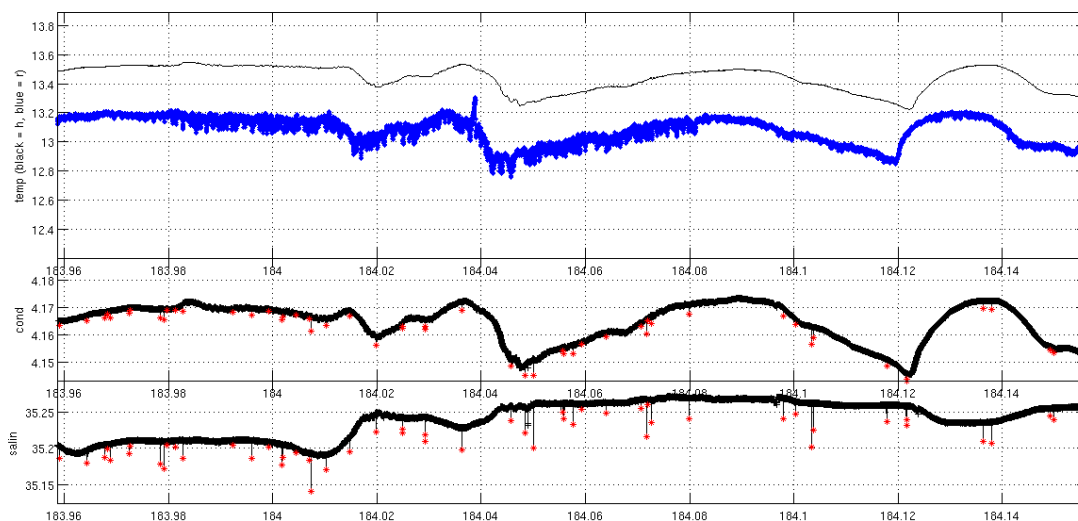
Figure 20: Example of mtsg_findbad_dy053.m plot window. The red crosses indicate spikes automatically detected by the filter.

feature was not observed in the remote temperature (temp_r), it was present in the conductivity and salinity. These data were therefore excluded from the final data-set using mtsg_findbad. "

During DY053 we noted a few occurrences of these temperature jumps, especially at the start of the cruise (see example in Figure 21), although not nearly as many as DY052. As per their protocol, we also removed these periods of dubious data.

3) **mtsg_cleanup.m** : this script needs to be edited to identify the times when the pumps were switched off, such as the start and end of the cruise, and any periods of maintenance. This routine is used in the next part of the processing.

4) **mtsg_medav_clean_cal_dy053.m** : removes known bad data identified in the previous steps (times stored in bad_time_limits.mat, and any time-periods listed in mtsg_cleanup.m), and creates 1-minute median-binned data.

> Input: *data/tsg/tsg_dy052_01.nc*
> Output: *data/tsg/tsg_dy052_01_medav_clean.nc*

5) The sample number for each underway salinity sample needs to be added manually to the Autosal spreadsheets, using the format DDDHHMMSS (recorded in the underway logsheets) for TSG samples, and sample number 99#### for the seawater standards, where #### is the bottle number. The final files need to be saved in the csv format in the directory *data/ctd/BOTTLE_SAL/*, with the naming convention tsg_dy052_nnn.csv_linux

6) **mtsg_01_dy053.m**: converts TSG salinity bottle samples from csv to NetCDF, adds the Autosal drift offset, and appends all the samples to the global tsg file. First the routine had to be updated with a cruise specific bath temperature (24°C on DY053), and with the Autosal offsets to be applied to each sample. On DY053, standard seawaters were run at the start, middle and end of each salt crate (see Salinometry
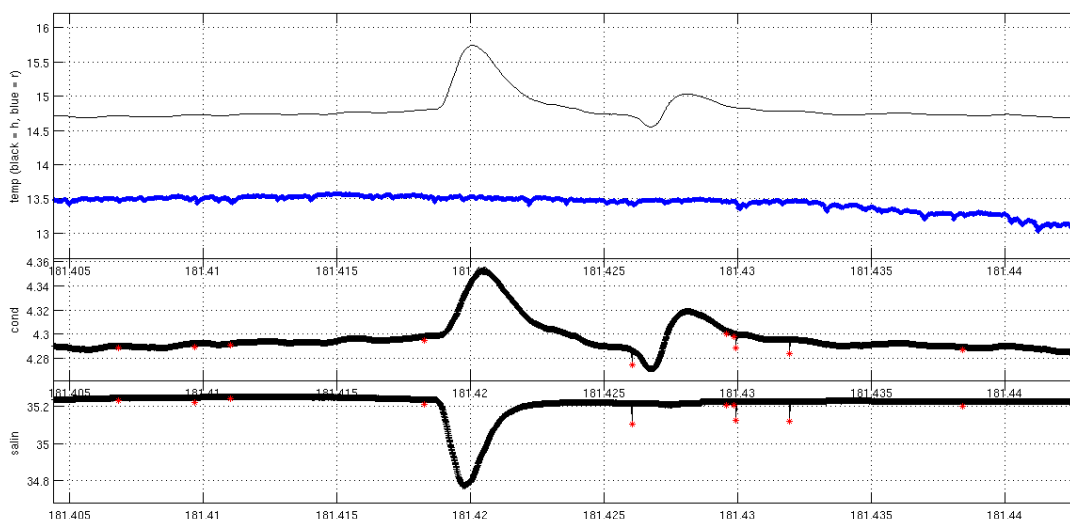
Figure 21: Example of the SBE45 housing temperature (top plot, black) and conductivity (middle plot) jumps from the DY053 TSG dataset. The remote temperature (top plot, blue remains unaffected).

section). We therefore "split" each TSG crates in two, creating a total of 7 files. For each file (i.e. half crate) we applied an offset equal to the average offset of the two standards run at the start and end.

Input: *data/ctd/BOTTLE_SAL/tsg_dy053_nnn.csv_linux*
Output: *data/ctd/tsg_dy053_nnn.nc*
Output: *data/ctd/tsg_dy053_all.nc*

7) **mtsg_bottle_compare_dy053.m:** merges the clean 1-minute data onto bottle samples. Running this script at this stage allows us to have a first look at the sample data versus the tsg readings by setting the switch at the top of the script to
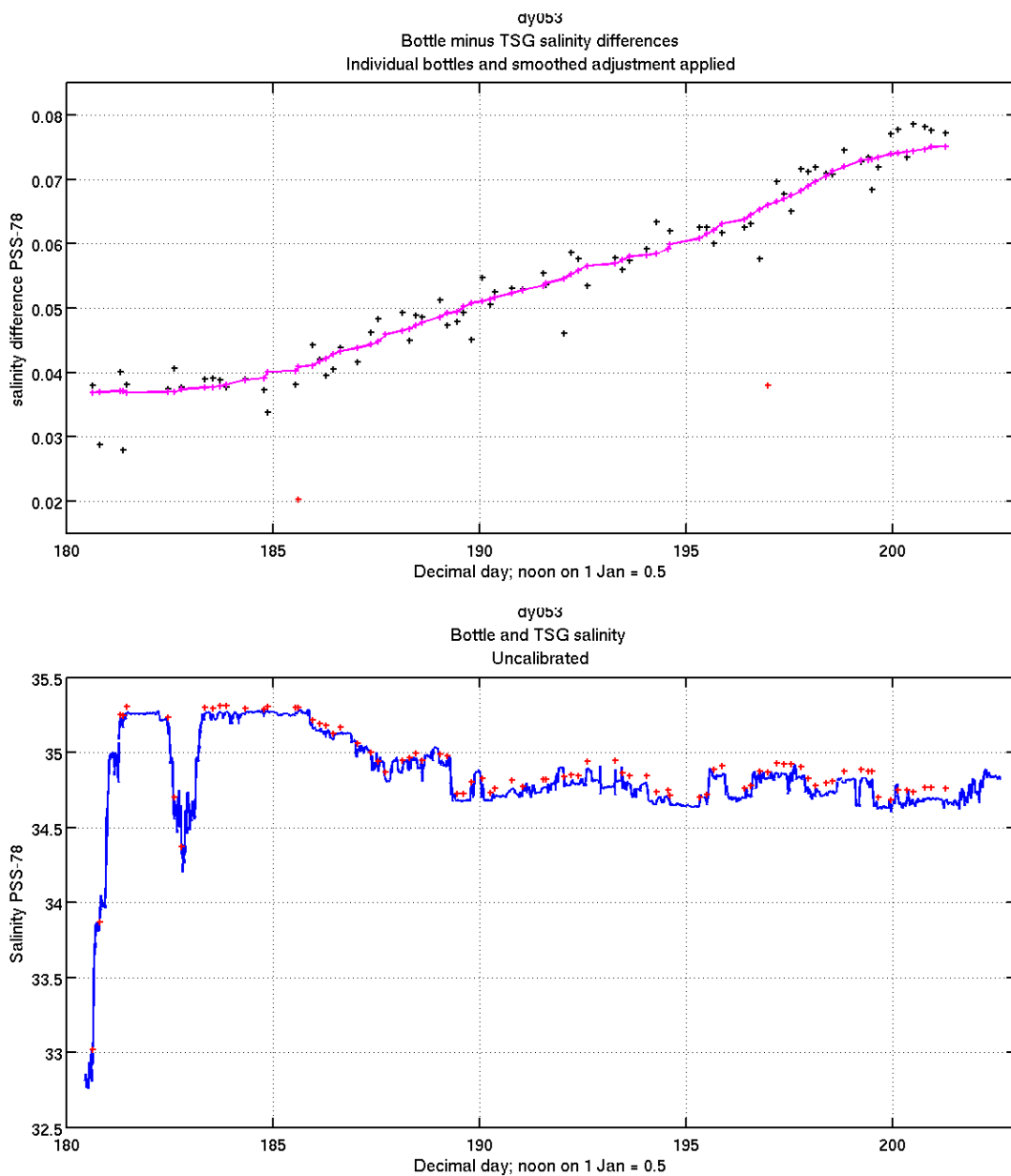
Figure 22: Top: Salinity difference (PSS-78) between underway bottle measurements and the SBE45 salinity measurement at each sample time (black crosses) and a smoothed fit (magenta line). The red crosses show data-points rejected from the smoothed fit. Bottom: Uncalibrated salinity from the SBE45 (blue line) along with the individual bottle samples (red crosses).

'uncalibrated'. Individual bottle residuals are plotted, as well as a smoothed time series of the residuals, (see Figure 22) which can then be used as a slowly-varying adjustment to the TSG salinity in the next step. Outliers can be detected using a simple filter, which parameters can be adjusted in the routine.

> Input: *data/ctd/tsg_dy053_01_medav_clean.nc*
> Output: *data/tsg/tsg_dy053_01_medav_clean _botcompare.nc*

8) **mtsg_apply_salcal_dy053.m**: interpolates the differences in bottle salinity using the same smoothing filter as shown in the previous step, and adds them to the uncalibrated salinity data. This script calls **mtsg_salcal_dy053.m.** Note: the outlier-removing filters parameters set in mtsg_bottle_compare_dy053.m need to be copied in this routine.

> Input: *data/tsg/tsg_dy053_01_medav_clean.nc*
> Input: *data/tsg/tsg_dy053_01_medav_clean_botcompare.nc*
> Output: *data/tsg/tsg_dy053_medav_clean_cal.nc*

9) **mtsg_bottle_compare_dy053.m**: merges the calibrated clean 1-minute data onto bottle samples. This should now be run with the switch at the top of the script set to 'calibrated'. Individual bottle residuals are plotted, as well as a smoothed time series of the residuals, (see Figure 23).

> Input: *data/ctd/tsg_dy053_all.nc*
> Input: *data/tsg/tsg_dy053_01_medav_clean_cal.nc*
> Output: *data/tsg/tsg_dy053_01_medav_clean_cal_botcompare.nc*

10) **met_tsg_av_addnav_dy053.m:** merges the calibrated SBE45 with the navigation data (lat and long) based on variable time. Note: if the bestnav file (bst_dy053_01.nc) is not up to date run **mbest_all.m** prior to this step.

> Input: *data/tsg/tsg_dy053_01_medav_clean_cal.nc*
> Input: *data/nav/posmvpos/bst_dy053_01.nc*
> Output: *data/tsg/tsg_dy053_medav_clean_cal_nav.nc*
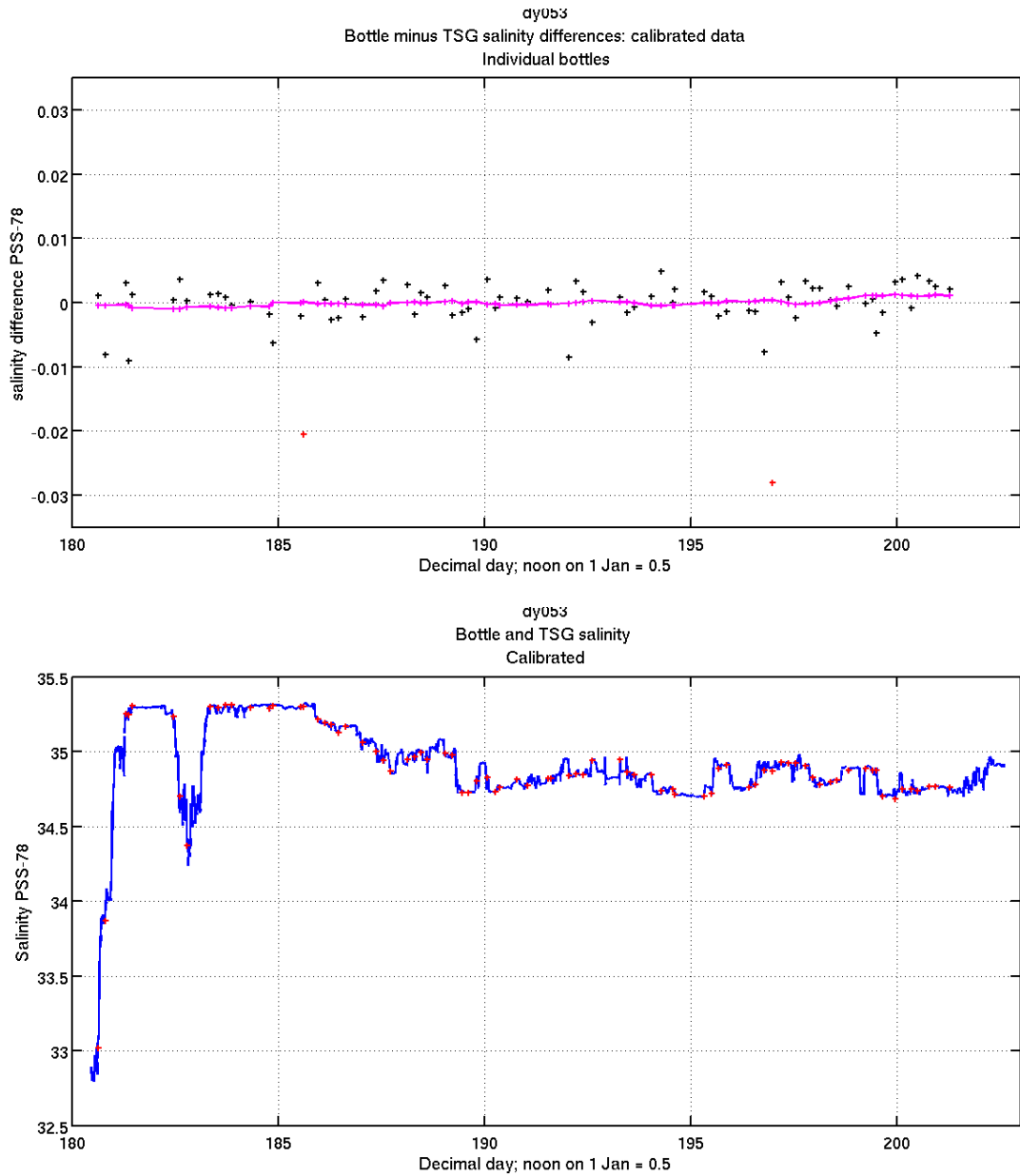
Figure 23: Top: Salinity difference (PSS-78) between underway bottle measurements and the calibrated SBE45 salinity measurement at each sample time (black crosses) and a smoothed fit (magenta line). The red crosses show data-points rejected from the smoothed fit. Bottom: calibrated salinity from the SBE45 (blue line) along with the individual bottle samples (red crosses).

6 Autonomous Glider Operations

6.1 UK Seaglider operations

Estelle Dumont

6.1.1 Recovery of SG605 'Bowmore'

One Seaglider, SG605 ('Bowmore'), belonging to the MARS pool and operated by SAMS, was recovered during DY053.

Bowmore had been deployed in the Hebrides on the 11th February 2016, and had travelled across the Scottish Shelf and the Rockall Trough before reaching the Eastern end of the UK OSNAP glider line on the Rockall-Hatton plateau (Figure 24). This line runs along the 58° 00.0'N parallel, from 14 42.0' W to 21 04.8'W (M4 mooring). Bowmore completed 3 full transects and one partial (~80%) transect. She was equipped with a Seabird CT sail measuring depth, temperature and conductivity. Although an Aanderaa oxygen optode and a Wetlabs puck (fluorescence, C-DOM, backscatter) were installed on the glider, these were not sampled during the mission due to battery limitations.
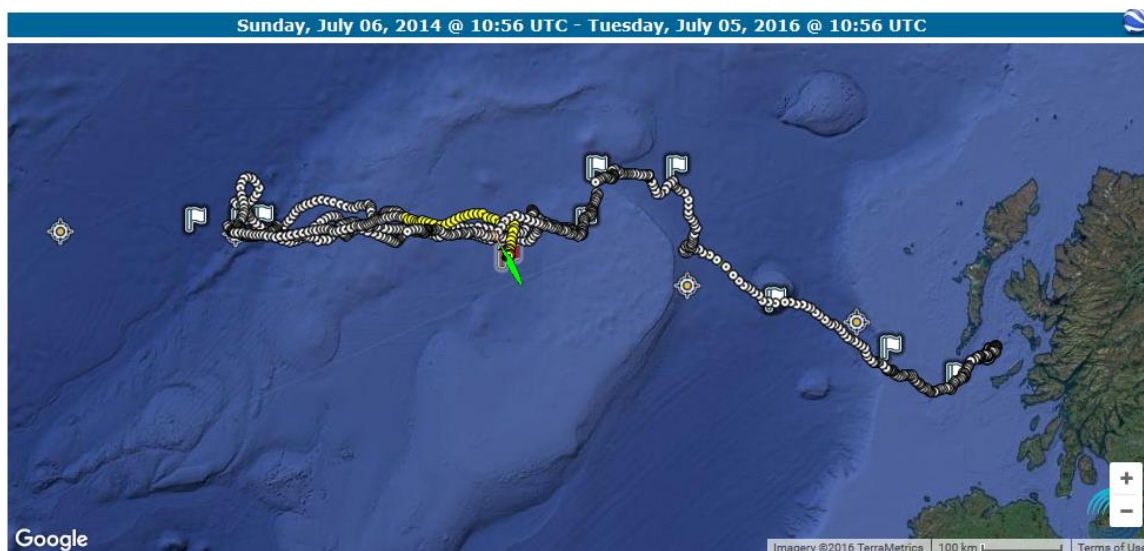
Figure 24: Bowmore's survey track, from 11th February to 5th July 2016. The yellow markers indicate the last 50 dives before recovery, and the green glider icon the recovery location. The yellow and white cross markers represent OSNAP mooring locations.

During the evening of the 4th July Bowmore was set to do 3 hours dives (in order to be able to stop her sooner than planned if required, or in case of a missed call), 30 minutes dives in the early morning of the 5th July, and finally put into recovery at 09:15 after dive #996. The glider call interval was set to 5 minutes while Discovery approached the site. Bowmore was spotted easily from the bridge around 10:00 UTC, and the ship maneuvered alongside. The pilot checked the internal

pressure, humidity and battery levels prior to recovery, and deemed the glider safe to recover. A rope was lassoed around the tail of the glider (under the rudder) using a telescopic pole fitted with a rigid hoop and soft rope, and she was lifted on deck using the auxiliary winch on the starboard side at 10:30 (Figure 25).

Full recovery details:

SAMS Mission #19 - Recovery

Glider: SG605 - Bowmore

Glider mission: 2

Project: OSNAP #5

Date: 05-Jul-2016 10:30 UTC

Location: 57° 46.553' N, 16° 01.248'W

Vessel: RRS Discovery

Cruise: DY053

Weather: Wind force 3 / 4, sea state calm, sunny

Pilot: Estelle Dumont, Clare Johnson

Field team: Estelle Dumont, Karen Wilson

Following the cruise, Bowmore will be sent to the MARS glider team for refurbishment. The full mission's raw data can be viewed at: 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.
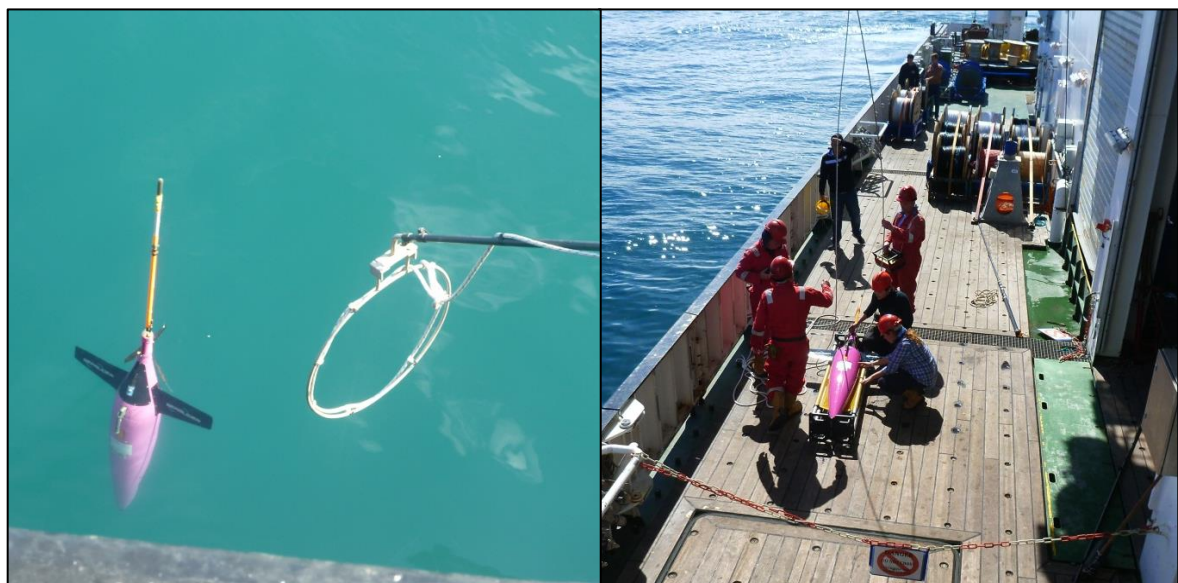
Figure 25: SG605 in the water with recovery pole system; SG605 on board.

6.1.2 Failed deployment of SG604 'Jura'

A second Seaglider, SG604 'Jura' was planned to be deploy from DY053 to take over from Bowmore on the OSNAP UK glider line. As for Bowmore, she belongs to the MARS pool and is operated by SAMS. She had been refurbished at MARS earlier this year, and had her VBD system repaired at Kongsberg in late 2015 / early 2016 after her first mission.

However, some cracks and marks were discovered on the external bladder during testing (Figure 26). These were not noticed after the last recovery, during the repairs at Kongsberg, during the refurbishment at NOC, or during the pre-deployment sea trials at SAMS; suggesting that these cracks were fairly new or had worsened recently. Their origin is unclear but they look like they could be a result of scratching by a sharp object/ tool, or due to a possible defect in the manufacturing of the bladder. The cracks did not appear very deep at this point, but there were some concerns as to how they would evolve over the course of a full length mission (about 6 months and 1,000 dives). After consultation with the instrument manufacturer Kongsberg, who also thought the state of the bladder was worrying, the deployment was cancelled.

Upon return in the UK, Jura's bladder will be inspected and replaced.

A replacement Seaglider will be deployed from Oban after the cruise. The added transit time to the OSNAP UK glider line (about 6 weeks) will mean a data gap of at least 10 weeks (Figure 27).

Figure 26: Clockwise from top-left: 1) Crack along the top of the bladder; 2) closer view of same crack with talcum powder to make it more visible; 3) marks underneath the bladder; 4) close-up of crack.
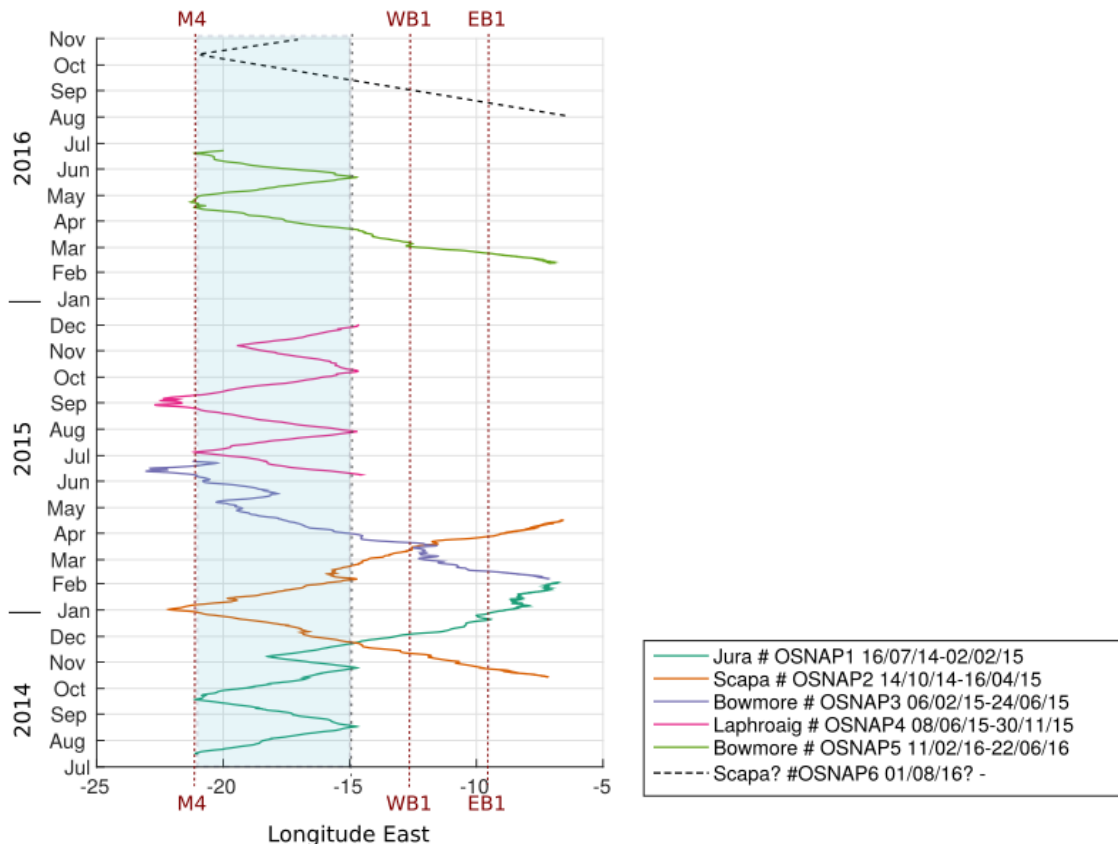
Figure 27: Time versus longitude trajectories for the UK-OSNAP glider missions over the period July 2014 to July 2016. Three mooring locations are shown: M4 (U.S.) in the Iceland Basin; WB1 & EB1 (U.K.) in the Rockall Trough. The Sea Glider is planned to survey the Rockall Hatton Plateau (RHP) in the shaded region. The planned deployment of *Scapa* is also indicated as a dashed line (with an estimated time of arrival on the RHP mid-September in a best case scenario)

6.2   US Slocum Operations

Heather Furey

One Teledyne Webb Research (TWR) Slocum Glider was deployed, identifier 'WHOUC1', during Leg 1 of the 2016 Discovery OSNAP cruise. This glider is one of three bought by Ocean University of China as part of the OSNAP program. The glider is intended to measure oceanographic properties between the central Iceland Basin and the west edge of Rockall Plateau, a ~200-kilometre section between moorings M3 and M4, and from 0-1000 meters depth. This glider program complements the SAMS glider program, which surveys from the west edge of the Rockall Plateau to the east side of the Rockall Trough. This same glider which was deployed last summer off the Pelagia during Leg 1 OSNAP, was recovered by the Walther Herwig III on November 12 2015. The Principal Investigator was Heino Fock, of the Thünen Institut, Germany. A second glider WHOUC2 was deployed November 6, 2015, from the Hannes Þ. Hafsteinn, operating out of Sangerdi, Iceland. We had originally intended to recover

this second glider during this cruise. However, the glider foundered due to low battery, was advected northward in an eddy off the OSNAP line, and the decision was made to recover it using a smaller search and rescue ship out of Reykjavik. This successful recovery attempt occurred on 28 June 2016, by Rescueboat Oddur V. out of Grindavík harbor, Iceland.

Slocum Glider WHOUC1 is equipped with a Seabird Pumped CTD system, Wet Labs 'Ecopuck' with FLBBCD-SLK, CDOM, and backscatter, Satlantic radiance sensor and Aanderaa oxygen optode. This glider includes an extended bay Lithium battery pack, for longer endurance, and a strobe light and nose recovery system for pickup. Details of deployment may be found in Table 3. The glider was ballasted for surface density of ~1026.6 kg/m^3, this value chosen after review of both smoothed historical hydrographic data from Hydrobase, and quasi-synoptic section data from the SAMS gliders. Although this value worked well for the July-November 2015 deployment, it appears to be a bit heavy from initial July 2016 engineering observations.

Table 3: Details of the deployment of Slocum glider WHOUC1 in July 2016.

s/n	Deployment Date (YYYY-MM-DD THH:MM)	Latitude (°N)	Longitude (°W)	Corrected Water Depth (m)	Station details
WHOUC1	2016-07-06 T18:30	58.0447	21.0625	2977	#23, At Mooring M4, CTD #16

This year, the glider went in immediately after re-deployment of M3, in calm seas with moderate swell. Using a FreeWave antenna and laptop set up on the bridge, the initial engineering checkout was performed. Vacuum and battery were within normal ranges, and the glider reported a normal prompt after the 'run WHOISTAT.MI' mission was completed. A bridle system was again used in deployment (Figure 28), and glider placement in the water went smoothly. The RRS Discovery ship's crane system had greater reach than off the Pelagia, and the quick release line was found to be a bit short during deployment. The glider was deployed without incident, a bit closer to the hull than was possible due to the short quick release. No buoy test was performed.

The ship remained on station for about two hours while we performed a 5-meter shallow dive and a 100-meter test dive. At that point, WHOI-based glider pilot Ben Hodges downloaded and checked the engineering and science data, took over control of the glider, and sent the glider on its science mission. He reported at that time that the glider seemed to fly a bit heavy, meaning the ballast was not quite perfect, and also that the science data had not downloaded correctly, but that he needed to send the glider on a deep dive to 1000 meters to know more. We proceeded with the cruise, with the understanding that the ship might need to perform a recovery mission the next day. After the deep dive, Hodges determined

Figure 28: Deployment of the extended bay Slocum Glider.

that the glider was slightly mis-ballasted, but that it was not enough to call for recovery. There were initial problems with glider science data delivery, and Hodges determined that the oxygen optode was malfunctioning. Once the optode was turned off, science data was transmitted as expected. WHOI and OUC decided it was better to keep the glider in water performing the essential CTD measurements, than to attempt a recovery, ballast adjustment, and redeployment.

7 Float Deployments

7.1 Argo

7.1.1 UK

Stuart Cunningham

On behalf of the UK Meteorological Office we deployed two Apex floats (Table 4). One float was fitted with a standard SeaBird CTD sensor package and the second with an RBR CTD sensor package. To obtain comparison data for the sensor packages the floats were deployed in the same location at CTD station 27.

Unfortunately, after deployment an email was received from the Met Office on 12th July at 13:00 HRS asking that the APEX-RBR not be deployed. The float type has an intermittent fault that requires a firmware upgrade, and some floats have failed. The float must be opened to install the upgrade.

Table 4: Serial numbers, dates, positions and times of UK Argo float deployments.

s/n	ddmmyy / hhmm	Lat	Lon	Type
7577/8	11/7/16 / 0035	57° 57.86'N	27° 00.80'W	APEX
7676/7	11/7/16 / 0035	57° 57.86'N	27° 00.80'W	APEX/RBR

7.1.2 US

Heather Furey

Four MRV S2A Autonomous Profiling Vehicles (S2As) were deployed for the Woods Hole Oceanographic Institution Argo Program. The S2As were initialized at the dock before we departed Glasgow, and were deployed across the OSNAP line to augment Argo observations in the Iceland Basin. Deployments were made according to instructions. Therefore, the instruments were deployed contained each in its own cardboard box. Deployments went smoothly, and details may be found in Table 5.

Table 5: Serial numbers, dates, positions and times of US Argo float deployments

s/n	Deployment Date (YYYY-MM-DD THH:MM)	Latitude (°N)	Longitude (°W)	Corrected water Depth (m)	Station Number	Closest CTD
WHOI S2A Float 7359	2016-07-08 T04:46	57.957	23.170	2998	26	CTD#21
WHOI S2A Float 7360	2016-07-08 T18:37	57.998	57.998	2842	At Mooring M3, Station 28	CTD #23
WHOI S2A Float 7365	2016-07-10 T12:09	57.965	25.421	2734	30	CTD#25
WHOI S2A Float 7358	2016-07-13 T06:48	58.260	28.881	2219	37	CTD #34

7.2 RAFOS

Heather Furey

A total of ~140 subsurface acoustically tracked RAFOS floats are being released during the 2014, 2015, and 2016 OSNAP cruises to directly observe pathways of Overflow Waters through the subpolar North Atlantic. An array of 10 260-Hz sound sources moored during the 2014 OSNAP cruises is being used to track the floats until all the moored arrays are recovered in 2018 (Figure 29, open bullets labeled 1:10). This is the final year of RAFOS deployments off the OSNAP line. A few adjustments are being made this year to the deployment scheme and sound source array, based on short-mission float results from the 2014 deployment.

The acoustic signals collected by the RAFOS floats so far have been of poorer quality than expected: the attenuation of the sound source signals due to the rough ocean surface was greater than expected. To combat this problem, we will deploy three additional sound source moorings this summer, at the positions indicated on Figure 29, black-centered bullets (sources labelled 11:13). The attenuation of a sound source signal increases with depth. The second change to the RAFOS deployment program in 2016 is to eliminate the 2800-dbar float level. Information on the additional sound sources is described in Table 6.
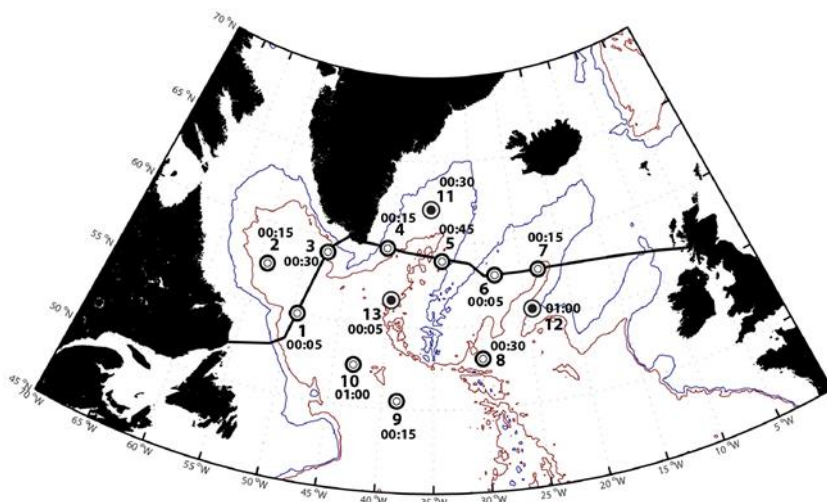
Figure 29: Sound source mooring positions and pong times (once daily) for 13 sound sources deployed as part of the OSNAP program. The 2000- and 3000-m isobaths are drawn

This year's float seeding was similar to the 2015 deployment, with a few differences. Out of 51 floats intended to be deployed in Summer 2016, ten RAFOS were held back and will be sent with Virginie Thierry in Summer 2017, to re-seed the deep Charlie-Gibbs Fracture Zone. These floats will have 1-year mission lengths only.

Table 6: Information on the additional sound sources due to be deployed in 2016.

s/n	Deployment Information	Latitude (°N)	Longitude (°W)	Source Depth (m)	Pong Schedule (UTC)
Sound Source 11: TWR S/N 50	To be deployed off R/V Armstrong OSNAP Leg 3; north central Irminger Basin.	57.957	23.170	1700	00:30
Sound Source 12: URI-WHOI S/N 22	To be deployed off RRS Discovery OSNAP Leg 2; southeast Iceland Basin.	57.998	57.998	1200	00:05
Sound Source 13: URI-WHOI S/N 23	Deployed off R/V Armstrong en route to OOI mooring turnaround, 08-July-2016 14:29 UTC. Corrected water depth 3194m.	56.601	40.998	1124	01:00

Deployments for 41 RAFOS Summer 2016 are as follows:

- DY053, East Reykjanes Ridge: 16 RAFOS on the eastern flank of the Reykjanes Ridge programmed for 730-day missions. No monitor floats were deployed, as all our sound source inventory is now in the water, no replacements for failed sources are possible.
- DY054, West Reykjanes Ridge: 11 RAFOS over the western flank of the Reykjanes Ridge programmed for 730-day missions. The single 2500-dbar station was removed from the deployment plan based on poor sound source acoustics at depth.

- DY054, East Greenland: 14 RAFOS floats over the east Greenland slope programmed for 730-day missions. All 2800-dbar East Greenland floats were removed from the deployment scheme due to poor source acoustics. One single 2500-dbar float was moved to a position off the East Reykjanes Ridge, reasoning described below. Four 1000-dbar floats, which were previously to be used as monitors, are to be deployed during Leg 2 at the discretion of F. de Jong in the East Greenland Current, and perhaps capture the downstream formation of an Irminger Ring off the west coast of Greenland.

Table 5 below lists the deployment information for the floats on DY053, OSNAP Year 3 Leg 1. Floats released on the eastern flank of the Reykjanes Ridge were ballasted for 1800, 2000, 2200, and 2500 decibars. The general deployment strategy was to release them 100-200 meters above the seafloor of the ridge flank to target the thin Iceland-Scotland Overflow Water layer flowing southward at that location, generally repeating the Year 2 deployment sites. Some positions were adjusted to better seed the two deep branches of the ISOW, using the mean 2014 along-slope mooring velocity as a guide. Figure 30 shows the three years' deployment locations over bathymetry.

Table 7: RAFOS float deployment metadata, Leg 1 RRS Discovery 2016, Iceland Basin.

s/n	Ballast / Target Depth m	wired float	mission length (days)	Deployment Date	Deployment Time GMT	decimal Latitude (N)	decimal Longitude (W)	Corrected Water Depth m	Iridium IMEI Number
1406	2200	n	730	11/07/16	06:18	58.019	27.920	2349	300234063535390
1410	2200	y	730	12/07/16	07:15	58.010	26.966	2673	300234063539380
1436	2500	y	730	12/07/16	07:17	58.010	26.963	2673	300234063739790
1411	2200	y	730	12/07/16	12:18	58.011	27.386	2320	300234063534390
1398	2000	n	730	12/07/16	19:05	57.993	28.040	2376	300234063539590
1412	2200	y	730	13/07/16	01:06	58.115	28.477	2313	300234063534390
1399	2000	n	730	13/07/16	01:30	58.144	28.545	2315	300234063530510
1413	2200	y	730	13/07/16	01:30	58.144	28.545	2315	300234063539320
1401	2000	y	730	13/07/16	17:18	58.343	29.115	2262	300234063530380
1402	2000	y	730	14/07/16	11:41	58.492	29.539	2520	300234063532510
1440	1800	n	730	14/07/16	11:41	58.492	29.539	2520	300234063739740
1403	2000	y	730	14/07/16	12:06	58.529	29.592	2158	300234063538580
1441	1800	n	730	14/07/16	12:09	58.529	29.593	2151	300234063737020
1396	1800	y	730	14/07/16	13:01	58.571	29.801	2142	300234063539600
1397	1800	y	730	14/07/16	13:47	58.627	29.935	2002	300234063530600
1400	1800	y	730	14/07/16	14:08	58.622	29.975	1945	300234063530390

The changes made to the RAFOS floats per-2015 deployments worked as intended: the ballasting adjustments were kept in place, and floats near to the bottom have tail-wires to prevent hard hits. On half the floats, thin two meter lengths of

plastic-coated SS wire weighing approximately 10 grams were added. This wire hangs vertically from the float bottom and will contact the seafloor first in case of bottom-brush. Because the wire is flexible, if a float gets near to the seafloor, it will partially rest on the seafloor, effectively lessening the weight of the float, thus increasing float buoyancy. The flexible wire prevents the float itself from coming in contact with the bottom and picking up sediments. On all deployments where a float was particularly close to the bottom, wired floats were chosen.

All of the RAFOS floats were released using the "holey tube" made out of ~0.25-m diameter, 2.5-m long PVC pipe. This year, as the Discovery deck is higher up off the water than on last year's Pelagia cruise, we deployed

Figure 30: RAFOS deployment locations over bathymetry, shaded at 1500 and 2000 m. Triangles mark the position of the 2016 deployment locations. Black pentagrams (2015 locations) and white circles (2014 locations) are drawn for comparison.

the floats using the float launch tube as intended. The float wire unwound along the side of the float, and both loaded into the tube. In this manner, the tail wire was not damaged, the glass housing had no contact with the deck, and the floats were gently released into the water.

8 CTD Measurements

J. Benson, E. Dumont

8.1 CTD System Configuration

1) One CTD system was prepared. The initial water sampling arrangement was an NMF 24-way stainless steel frame system (s/n SBE CTD8), and the initial sensor configuration was as follows:

> Sea-Bird 9plus underwater unit, s/n 09P-39607-0803
> Sea-Bird 3P temperature sensor, s/n 03P-4381, Frequency 0 (primary)
> Sea-Bird 4C conductivity sensor, s/n 04C-3054, Frequency 1 (primary)
> Digiquartz temperature compensated pressure sensor, s/n 93896, Frequency 2
> Sea-Bird 3P temperature sensor, s/n 03P-4712, Frequency 3 (secondary)
> Sea-Bird 4C conductivity sensor, s/n 04C-3529, Frequency 4 (secondary)
> Sea-Bird 5T submersible pump, s/n 05T-6320, (primary)
> Sea-Bird 5T submersible pump, s/n 05T-6916, (secondary)
> Sea-Bird 32 Carousel 24 position pylon, s/n 32-60380-0805
> Sea-Bird 11plus deck unit, s/n 11P-24680-0589 (main)
> Sea-Bird 11plus deck unit, s/n 11P-34173-0676 (back-up/spare)

ID	Vertical distance from pressure sensor (m)
A	1.50
B	0.30 s/s system (with 10L samplers)
C**	0.07
D	0.00

**NOTE: C & D may be minimal.
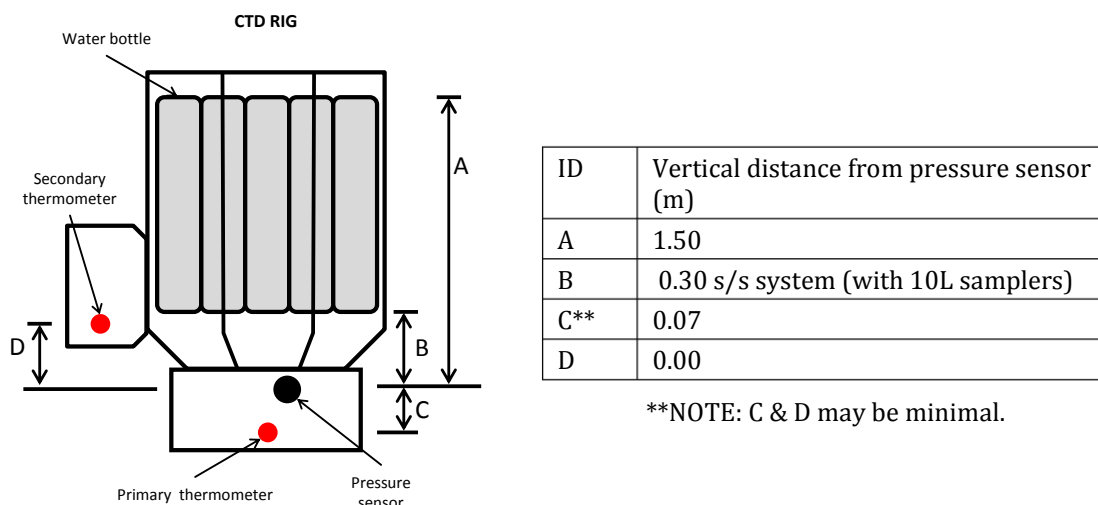
Figure 31: Rig geometry

2) The auxiliary input initial sensor configuration was as follows:

> Sea-Bird 43 dissolved oxygen sensor, s/n 43-2575 (V0, primary)
> Benthos PSAA-916T altimeter, s/n 59494 (V3)
> Chelsea Aquatracka MKIII fluorometer, s/n 088244 (V6)
> WETLabs C-Star transmissometer, s/n CST-1759TR (V7)

3) Additional instruments:

> TRDI WorkHorse Monitor 300kHz LADCP, downward-looking, s/n 13399
> TRDI WorkHorse Monitor 300kHz LADCP, upward-looking, s/n 10607
> NOCS LADCP battery pack, s/n WH005

SBE35 Deep Ocean Standards Thermometer, s/n 35-34173-0037

4) Changes to instrument suite:

LADCP battery pack s/n WH005 replaced with s/n WH006T prior to cast DY053_006.
SBE35 Deep Ocean Standards Thermometer, s/n 35-34173-0037 replaced with s/n 35-34173-0048 prior to cast DY053_045.

Sea-Bird 9plus configuration file DY053_0803_SS.xmlcon was used for all CTD casts.

The spare water sampling equipment was an NMF 24-way stainless steel frame system (s/n SBE CTD1), and the spare sensors were as follows:

Sea-Bird 9plus underwater unit, s/n 09P-71442-1142
Digiquartz temperature compensated pressure sensor, s/n 124216
Sea-Bird 9plus underwater unit, s/n 09P-34173-0758
Digiquartz temperature compensated pressure sensor, s/n 90074
Sea-Bird 3P temperature sensor, s/n 03P-4782
Sea-Bird 3P temperature sensor, s/n 03P-5660
Sea-Bird 3P temperature sensor, s/n 03P-5700
Sea-Bird 3P temperature sensor, s/n 03P-5785
Sea-Bird 4C conductivity sensor, s/n 04C-2571
Sea-Bird 4C conductivity sensor, s/n 04C-4138
Sea-Bird 4C conductivity sensor, s/n 04C-4139
Sea-Bird 4C conductivity sensor, s/n 04C-4140
Sea-Bird 5T submersible pump, s/n 05T-3085
Sea-Bird 5T submersible pump, s/n 05T-5301
Sea-Bird 5T submersible pump, s/n 05T-7371
Sea-Bird 5T submersible pump, s/n 05T-7514
Sea-Bird 32 Carousel 24 position pylon, s/n 32-24680-0346
Sea-Bird 32 Carousel 24 position pylon, s/n 32-34173-0493

The auxiliary spare sensors were as follows:

Sea-Bird 43 dissolved oxygen sensor, s/n 43-0619
Sea-Bird 43 dissolved oxygen sensor, s/n 43-0709
Sea-Bird 43 dissolved oxygen sensor, s/n 43-0363
Sea-Bird 43 dissolved oxygen sensor, s/n 43-2831
Benthos PSAA-916T altimeter, s/n 59493
Benthos PSAA-916T altimeter, s/n 62679
WETLabs C-Star transmissometer, s/n CST-1720TR
Chelsea Alphatracka MKII transmissometer, s/n 161-2642-002
Chelsea Aquatracka MKIII fluorometer, s/n 088195
Chelsea Aquatracka MKIII fluorometer, s/n 88-2050-095

Additional instruments:

TRDI WorkHorse Monitor 300kHz LADCP, s/n 4275
TRDI WorkHorse Monitor 300kHz LADCP, s/n 13400
TRDI WorkHorse Sentinel 300kHz LADCP, s/n 21028
TRDI WorkHorse Sentinel 300kHz LADCP, s/n 21029
NOCS LADCP battery pack, s/n WH006T
SBE35 Deep Ocean Standards Thermometer, s/n 35-34173-0048

8.2   CTD Operations

Total number of casts – 49

Casts deeper than 2000m - 26

Deepest cast – 3030m

8.2.1 CTD

SBE35 DOST set to sample for 9.9 seconds during water sampler closing period. Time reset prior to cast DY053_029. S/n 35-34173-0037 replaced with s/n 35-34173-0048 after cast DY053_044 to cross-check primary and secondary temperature sensor values.

CTD2 re-terminated after cast DY053_008 because of 'birdcaging'/kinks in sea cable. Deep Tow was used for casts DY053_009 through DY053_049. Problems with scrolling and wire-out readings on first deployment with the Deep Tow as parameters incorrectly entered into software control system. (Most likely caused by use of Plasma system on previous cruise and values defaulted on Deep Tow to Plasma.) Deep Tow cooling pump developed oil leak after cast DY053_049; changed selected winch back to CTD2.

Deep Tow CTD Lemo connections in Main Lab re-soldered prior to DY050, but movement of connections/wires still causes open circuit/underwater unit error on SBE 11P.

SBE35 file DY053_019_DATA.cap missing firing order identifier, time/date stamp and bottle number for 4th bottle.

Occasional "Unsupported Modem Message from SBE Carousel" displayed in SeaSave; possible cause noise interference on Deep Tow sea cable.

Transmissometer not calibrated in situ prior to DY052; values entered for M and B are factory default calculations.

During deployment DT053_049, secondary conductivity cell began to give erratic readings at 1058m on the upcast. No obvious biofouling or damage to cell found, however the quick connect fitting at the cell end was loose, and the o-ring was pinched. Connector tightened and o-ring replaced.

8.2.2 LADCP

Two different command files were used during the cruise; one provided by SAMS, and the other provided by RSMAS.

LADCP battery pack s/n WH005 exhibited a poor recharging rate for the first five deployments, and was as a consequence replaced with s/n WH006T prior to cast DY053_006.

S/n 13399 had high attitude temperature (internal electronics >24C) compared with s/n 10607 (<14C). S/n 10607 incremented deployments by 2 until cast DY053_016, then reverted to incrementing correctly by 1.

8.2.3 AUTOSAL

A Guildline 8400B, s/n 68958, was installed in the Salinometer Room as the main instrument for salinity analysis. A second Guildline 8400B, s/n 71126, was installed in the Salinometer Room as a spare instrument. The Autosal set point was 24C, and samples were processed according to WOCE cruise guidelines: The salinometer was standardized at the beginning of the first set of samples, and checked with an additional standard analysed prior to setting the RS. Once standardized the Autosal was not adjusted for the duration of sampling, unless the set point was changed. Additional standards were analysed every 12 samples to monitor & record drift. These were labeled sequentially and increasing, beginning with number 9001. Standard deviation set to 0.00002

8.2.4 SBE Data Processing

The Table 8 below lists the Sea-Bird processing routines run by NMF staff. Note this is only the modules that were run by NMF, not by scientific staff.

Table 8: Sea-Bird processing routines run by NMF staff

Module	Run?	Comments
Configure	N	
Data Conversion	Y	As per BODC guidelines Version1.0 October 2010 (Beam Transmission, mS/cm Conductivity, Oxygen Concentration umol/kg and ml/l, Latitude and Longitude (degrees), Scan Count, Time, Pump Status and Pressure Temperature preferred by S. Cunningham)
Bottle Summary	Y	As per BODC guidelines Version1.0 October 2010, with above variables added (except not averaging Scan Count and Time); Data Setup changed to accommodate SBE35 comparisons.
Mark Scan	N	
Align CTD	Y	As per BODC guidelines Version1.0 October 2010 (dissolved oxygen advanced 6 seconds) (appended file name)
Buoyancy	N	
Cell Thermal Mass	Y	As per BODC guidelines Version1.0 October 2010 (appended file name)
Derive	Y	As per BODC guidelines Version1.0 October 2010 (appended file name)
Bin Average	Y	As per BODC guidelines Version1.0 October 2010 (appended file name)
Filter	N	Not applicable.
Loop Edit	N	Not applicable.
Wild Edit	N	Not applicable.
Window Filter	N	
ASCII In	N	

ASCII Out	N	
Section	N	
Split	N	
Strip	Y	As per BODC guidelines Version1.0 October 2010 (appended file name)
Translate	N	
Sea Plot	N	
SeaCalc II	N	

9   CTD Data Processing

E. Dumont / L. Houpert

9.1   CTD Processing

Our goal in calibrating CTD data is to achieve internationally agreed standards as laid out by the Global Ocean Ship-Based Hydrographic Program [www.go-ship.org] and detailed in [*Hood et al.*, 2010].

CTD data were collected in the Sea-Bird Seasave version 7.23.2 software, and the following file types saved as .hex (data in binary format), .bl (bottle firing record), .XMLCON (configuration file), and .hdr (header information input manually). Data were 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 7.23.2. The following modules were run:

- DatCnv: converts the raw frequency and voltage data from engineering units by applying the sensors manufacturer's calibrations stored in the XMLCON, and outputs the data in an ASCII format (cast data as a .cnv file, and bottle data as .ros). The oxygen hysteresis correction option was 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. A thorough investigation of the alignment to apply to the oxygen sensor was conducted during the previous cruise DY052. The same CTD package and sensors were used on that cruise, and the data were collected in an area with very similar oceanographic conditions. After a quick visual check, the DY052 value of +6s was deemed appropriate and applied here.

- CellTM: this module is run to remove conductivity cell thermal mass effects from the measured conductivity. Sea-Bird recommended constants of $\alpha=0.03$ and $1/\beta=7$ were used.

Processed CTD data were copied on the shared network drive DISCOFS. The script ctd_linkscript_dy053 was used to copy files from the network drive and set up additional symbolic links to filenames following mexec convention.

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_dy053_nnn.nc* for all casts *nnn*. These files were generated using the list of variables indicated in the file *~/cruise/data/templates/sam_dy053_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_dy053_renamelist.csv*.
- **mctd_02b**: applies oxygen hysteresis correction using the default Sea-Bird coefficients [-0.033 5000 1450].
- **mctd_03**: average to 1Hz and calculation of salinity and potential temperature.
- **msam_putpos**: adds GPS positions at the start of the cast to the files.
- **mdcs_01**: creates an empty data cycles file (*dcs_dy053_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 dcs_[cruise]_[station].

The script **mdcs_03g** was then run to inspect profiles, hand-select cast start and end times, and input the new values in the dcs 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***,:* 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.
- **mbot_00**, **mbot_01**, **mbot_02**: create bottle files (*bot_dy053_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_03new**: extracts VMADCP data during the CTD cast.
- **mcod_stn_out_new**: 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_dy053.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_dy053_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, or all at once using the wrapper script **msam_batch_dy053**, calling:

- **msal_01**, **msal_02**: (details in Conductivity Calibration below).
- **mnut_01_dy053**, **mnut_02_dy053**: for nutrient samples unique reference numbers were recorded in csv files for each cast (*/data/ctd/BOTTLE_NUT/nut_dy053_nnn.csv*). The two scripts read the csv file, create the nutrient netCDF file (*nut_dy053_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_dy053**, **msbe35_02**: see Temperature Calibration section below
- **msam_append_dy052** OR **msam_updateall**: if the cast sam file has not been added to the global sam file (*sam_dy053_all.nc*) then add it by running **msam_append_dy052**. In case of a reprocessing use **msam_updateall** so that the cast is not duplicated in the appended master SAM file.

A new script was added to the *mexec* suite during this cruise, **msam_check_dy053**, which allows the user to perform a quick visual check of the master SAM file, and ensure that salinity and nutrient sample data have been added. This script produces a figure summarising the bottle firings and associated samples data, as shown in Figure 32. This script can be edited easily on future cruises to include other discrete samples.
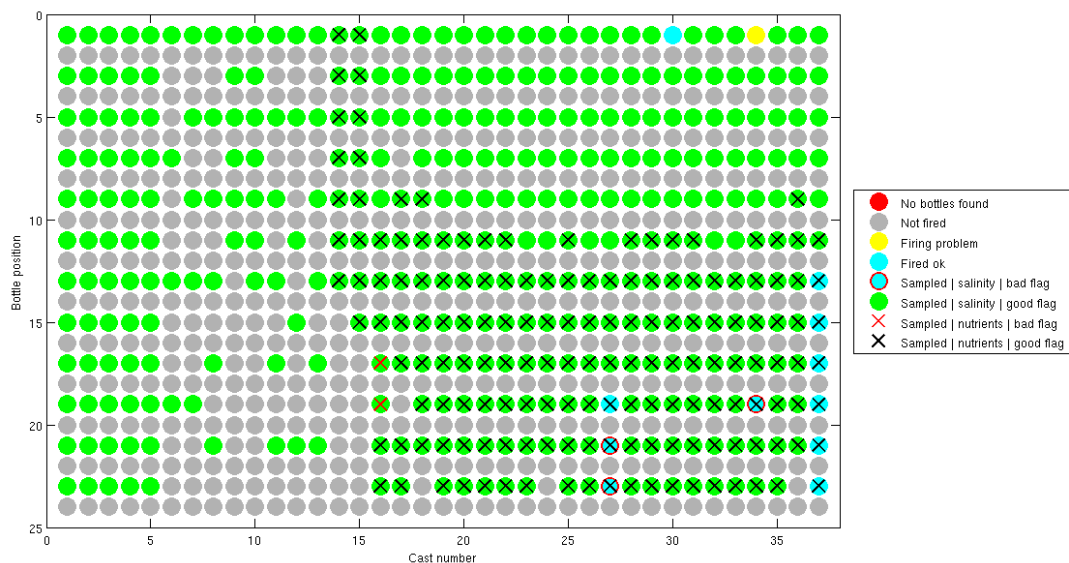
Figure 32: Figure output of *msam_check_dy053. Interpretations notes: 1) If a cast is missing from the list (no dots appearing), this means it has not been processed or individual SAM data have not been appended to the master file (fix: run msam_append_dy052); 2) Red dots mean that the cast has been added to the global file, but for some reason no bottles were recorded. This happened on a couple of occasions during this cruise, the origin of this error is unclear but likely to be due to a problem during one of the mbot_* script runs (fix: re-run the scripts mbot_*, msal_*, mnut_*, msbe35* and msam_updateall); 3) Yellow dots indicate firing issues (e.g. bottle not closed properly). These come from the bottle bad flags set by the user in mbot_00; 4) Blue dots indicate a bottle fired correctly, but that no salinity data are available. This could be due to several reasons: - Salinity was not sampled on that bottle; 5) The sample has not been analysed yet; 6) The salinity value is NaN (e.g. if a sample was not analysed because of a missing stopper in the sampling bottle); 7) A typo or formatting error in the manually compiled sample csv file sal_dy053_nnn.csv (fix: correct csv then rerun msal_01, msal_02 and msam_updateall); 8) Green dots indicate salinity data with a good flag.; 9) Red circles indicate salinity data with a bad flag. These come from the salinity bottle bad flags set by the user in msal_01; 10) Crosses indicate a nutrient sample. Black is for good samples, red for bad, using the flags manually set in the sample csv file (nut_dy053_nnn.csv). If a sample is not appearing the issue is likely to be a typo or formatting error in the csv file (fix: correct csv then rerun mnut_01_dy053, mnut_02_dy053 and msam_updateall).*

9.2 CTD Calibration

9.2.1 Temperature calibration

To provide independent assessment of the stability of the CTD temperature sensors, an SBE35 deep ocean standard thermometer was mounted on the rosette (http://www.seabird.com/sbe35-thermometer). The SBE 35 makes measurements each time a bottle fire confirmation is received, and stores the time, bottle position, and temperature, allowing comparison with CTD and water bottle data. The initial accuracy of the thermometer is ±0.001°C and has excellent stability of 0.001°C per year and precision of 0.0000025°C.

The SBE35 temperature data are logged when a Niskin bottle is fired. Data are stored internally and must be downloaded at the CTD deck unit as a separate process from the CTD data transfer. The SBE35 data are then transferred as an ASCII file one

per station. On DY053, this file is found in data/ctd/SBE35/ascii/. Then the script *sbe35_linkscript_dy053* is run and creates a link to the raw data in the SBE35 directory.

msbe35_01_dy053 reads the data for a single station, extracting data cycles for the station based on the start and end times.

msbe35_02 pastes the SBE35 data from one station (in *data/ctd/SBE35/sbe35_dy053_nnn.asc*) into the master SAM file (*data/ctd/sam_pe399_nnn.nc*).

ctd_evaluate_temp_dy053 compares the SBE35 temperature to 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 CTD primary sensor reads warm by
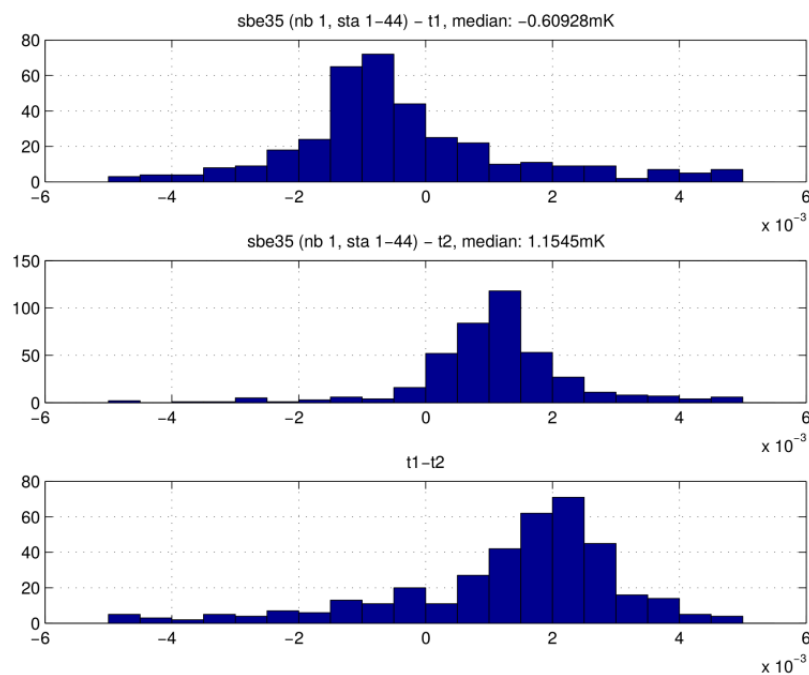
Figure 33: Histogram of the temperature difference between the reference thermometer SBE35 and the primary and secondary temperature sensors of the shipboard CTD

0.61 mK, and the CTD secondary sensor colder by 1.16 mK (Figure 33).

A second SBE35 unit was installed for the last six CTD stations of the cruise and give us similar differences. We conclude that the CTD temperature sensors were stable during the cruise. The cause of the median temperature differences was not resolved: whether genuine differences from the differing locations of sensors within the CTD frame or due to actual temperature differences. CTD temperature accuracy and stability is better than specified for GO-SHIP repeat hydrography. No corrections to the primary or secondary CTD temperatures were applied.

9.2.2 Conductivity calibration

Bottle salinities are added to the sample master file *sam_dy053_nnn.nc* using the scripts *msal_01_dy053* and *msal_02*, which read the csv files from the analysis of the salinity bottle (*data/ctd/BOTTLE_SAL/sal_dy053_nnn.csv*) and paste the data into the sample files.

The script *ctd_cal_dy053* can be used to examine the difference between the CTD conductivity sensors bottle conductivities. Plots are generated to reveal biases between sensors, and either pressure- or station-dependence of bottle minus sensor differences. Calibrations derived from these comparisons can be rapidly applied to the data and the results inspected.

When the calibration of the CTD conductivities results in a satisfactory agreement with the bottle samples (guided by standard outlined in Hood et al. 2010), the calibrations can be transferred to a switch/case in *cond_apply_cal*. The wrapper *smallscript_DY053* can be run on a set of stations. This will produce calibrated CTD profiles in all derived files (24hz, 1hz, psal, 2db, 2up) and paste the adjusted CTD data into the SAM bottle files (excluding c*td_dy053_nnn_raw.nc* file which contains raw data).

In the case of different sensor configurations during the cruise, the script *ctd_evaluate_sensors.m* can be used to examine the difference between the CTD cond1 and cond2 sensors, and the residuals with the bottle salinity. If sensors are changed during the cruise, subgroups of stations corresponding to sensor configurations can be declared in *ctd_evaluate_sensors*. Once a satisfactory set of residuals is obtained for both sensors, the calibration adjustment can be transferred to a switch/case in *cond_apply_cal.*

For this cruise conductivity measured by the primary conductivity sensor was adjusted for subgroups of stations with slightly different slope corrections (Table 9).

Table 9: Slope corrections applied to the conductivity data

Stations	Primary conductivity sensor	Secondary conductivity sensor
1	1.00011615	0.99986631
2-5	1.00011798	0.99991937
6-9	1.00012977	0.99993582
10-13	1.00011760	0.99990966
14-22	1.00013609	0.99993352
23-28	1.00015581	0.99994660
29-38	1.00013747	0.99993348
39-49	1.00015520	0.99993329
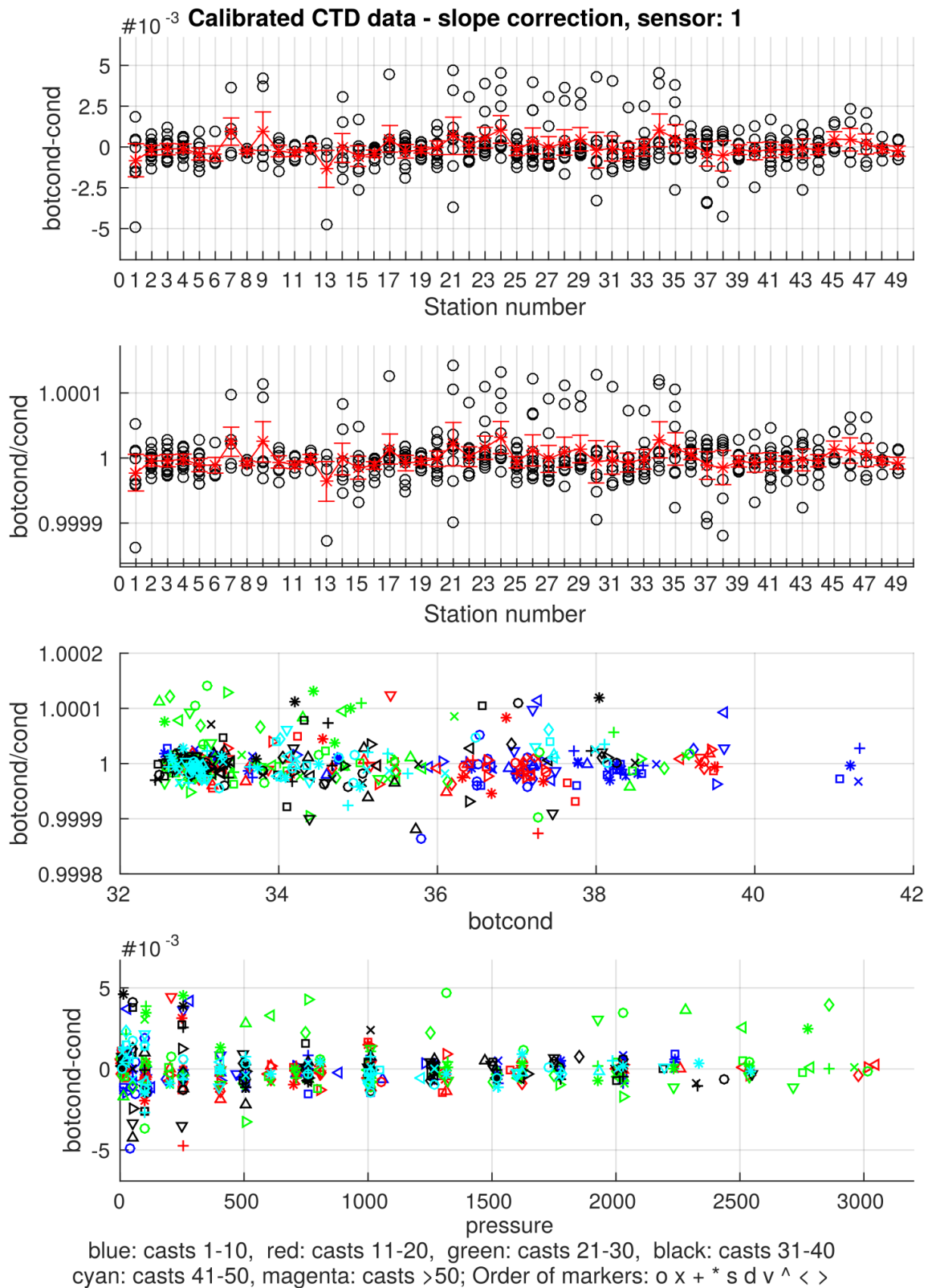
Figure 34: Comparison of the water sample analysis with the shipboard CTD measurements after calibration of the conductivity sensor. From top to bottom: conductivity differences as a function of the CTD stations; conductivity ratios as a function of the CTD stations; conductivity ratio as a function of the conductivity of the water sample; conductivity differences as a function of sampling depth. 450 good data points were retained from the 481 water samples (93.56%)

9.3   Salinometry

Estelle Dumont, Jeff Benson, John Beaton

9.3.1   Salinity sampling

Salinity samples were collected from the CTD Niskin bottles closed at each station. Up to 12 samples were drawn on the deepest stations. Sample depths start from within 10m of the seabed to 25m from the surface. Samples are further apart in the deep ocean where vertical conductivity gradients are small and closely spaced through the thermocline and upper ocean. The procedure for drawing the salinity sample was as follows: 1. Inspect the Niskin bottle for correct closure and leaks; 2. Open air vent and inspect spigot and bottom end cap for leaks; 3. Open spigot by hand, part fill and rinse the sample bottle three times to just above the shoulder of the sample bottle (at all times avoiding contact between the sample bottle and spigot); 4. Insert a new, clean plastic stopper; 5. Wipe the bottle's neck (to avoid the formation of salt deposits) and screw the bottle cap on. Samples were drawn into sequentially labelled bottles from numbered crates.

9.3.2   Salinity analysis

The samples equilibrated in a temperature-controlled laboratory for at least 24 hours before analysis. The temperature of the laboratory was kept around 21°C and was monitored by watchkeepers. The salinometer used was a Guildline Autosal 8400B s/n 8958, with its bath temperature set at 24°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 standard deviation requirement for samples was set to 0.00002'

The salinometer was standardised once only, before the first samples were analysed. The salinometer was set to read the standard sea-water labelled value. We monitored the salinometer drift through the cruise using the regularly analysed standard sea-water.

Salinity samples were analysed in batches of one to three crates per analytical session. A bottle of standard seawater (SSW) was analysed at the start, in the middle and at the end of each crate (24 bottles, covering typically two or three casts), with a new standard sea-water sample being used each time. The standard seawater used was OSIL, batch P159 (nominal K_{15}=0.99988, practical salinity of 34.995). A total of 481 samples were analysed. 450 data points were retained to calibrate the conductivity sensor. After calibration, the average residual (=SAL(salinometer) – SAL(ctd)) is $0.2*10^{-3}$ with a standard-deviation of $1.7*10^{-3}$.
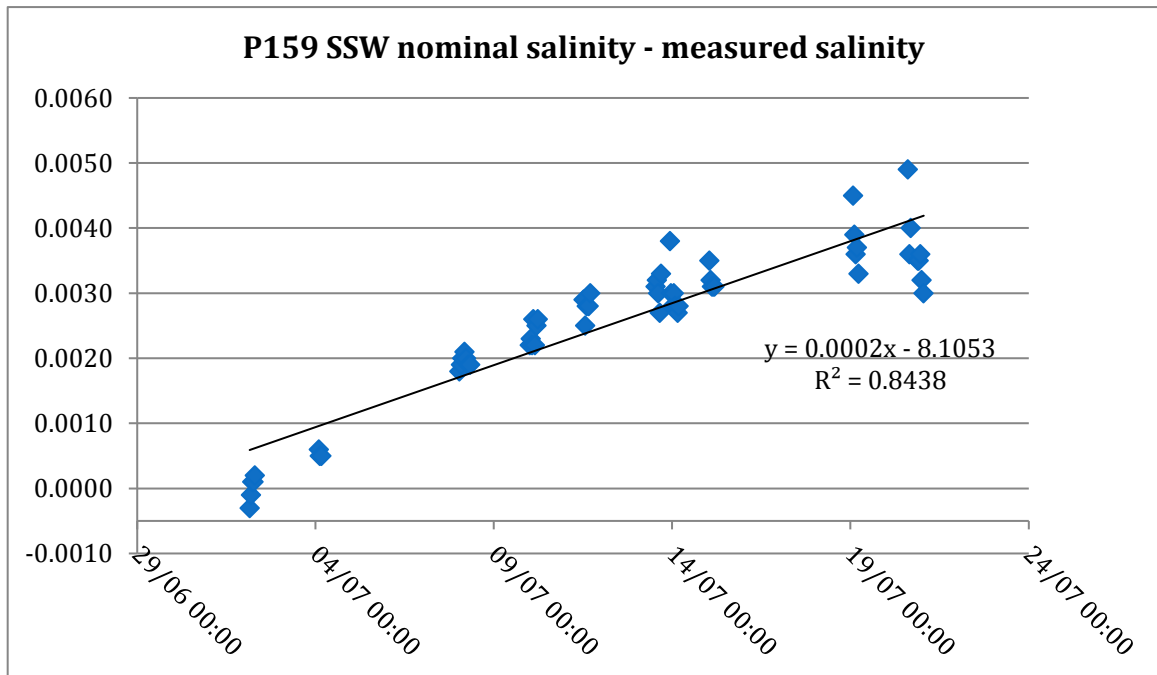
Figure 35: Differences between the labelled salinity value of the standard water and the measurement from the salinometer analysis

Over the course of the cruise the salinometer showed a linear upward drift (see Figure 35), calculated as the difference between the SSW nominal value and the salinometer readings. There was no clear offset trend visible during the individual batch runs.

Individual discrete salinity sample readings were then corrected for the salinometer drift by applying an offset (calculated as a weighted average of the offsets from the previous and next SSW analysed).

9.3.3   Nutrient Sampling

Nutrients were sampled in the Iceland Basin from surface to 1000 meters depth at each CTD station, usually at [10 50 100 250 500 750 1000]. The sampling was done according to instructions provided by Femke de Jong: the sample bottle was flushed (cap and bottle) three times, then water sample taken from Niskin bottle. A syringe was used to draw water from the larger sample bottle, and was flushed by using the filtered water to flush the small sample bottle and cap three times, then the final water sample was saved. The syringe filter was changed once per day. The smaller sample bottles were frozen in the -20°C freezers for future analysis on shore. Labeling scheme for the Nutrient bottles was CTD_Number-Niskin_Bottle_Number, so that a label reading '14-5' refers to CTD cast # 14, Niskin bottle number 5. Niskin bottle numbers are not fixed on each cast, the relation between Niskin bottle number and depth may be found in the CTD metadata for each cast.

Nutrient samples were taken from CTD #14 through #43, beginning at the eastern edge of the Iceland Basin at CTD #14 (57° 47.531'N 19° 44. 782'W) westward to CTD #37 (58° 29.447'N 29° 32.414'W), where the ship took a couple days off of work for weather and to transport an injured science member to the Reykjavik Coast Guard. Work then resumed at the westernmost end of the CTD line, at CTD #38 (58° 50.179'N 30° 48.358'W) back eastward until the line was complete, at CTD #43 (58° 33.278'N 29° 43.848'W). No nutrient samples were taken from the Rockall Trough CTD stations. Nutrients were taken at a single CTD station completed in the Bight Fracture Zone. CTD casts that included nutrient samples are plotted in Figure 32; notes specific to each cast's nutrient sampling may be found in Table 10.

Table 10: Nutrient cast depths, and notes particular to any samples.

CTD #	Date / Time_in_Water (YYYY-MM-DD THH:MM)	Notes
14-15		Depths ~[25 100 250 400 700 1000] meters.
14	2016-07-06 T07:12	Additional sample 14-1 was at deepest station, 1295 meters.
15	2016-07-06 T09:49	Additional sample 15-1 was at deepest station, 1570 meters.
16-22		Depths ~[surface or 10 m, 100 200 400 600 800 1000] meters.
16	2016-07-06 T20:33	Samples 16-09 (400 meters) and 16-10 (200 meters) are bad. Filter was not changed for these samples.
23-24		Depths ~[25 100 250 400 700 1000] meters.
24	2016-07-09 T20:40	Sample at 25 meters not taken, Niskin bottle not closed when pulled on deck.
25		Depths ~[20 100 200 400 600 800 1000] meters.
26		Depths ~[10 50 100 250 500 750 1000] meters.
27		Depths ~[25 100 250 400 700 1000] meters.
27	206-07-10 T22:28	Samples 27-10 (250 m), 27-11 (100 m), 27-12 (25 m) bad, remove from analysis. Sampler unsure about which bottles sampled.
28		Depths ~[10 50 100 250 500 750 1000] meters.
29		Depths ~[10 100 200 400 600 800 1000] meters.
30-44		Depths ~[10 50 100 250 500 750 1000] meters.
45		Bight Fracture Zone Station; Depths ~[25 100 400 1000] meters.

10 Lowered Acoustic Doppler Current Profiler Measurements

Loïc Houpert / Adam Houk

10.1 LADCP Setup

Full water column velocity profiles for the DY053 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 13399 (firmware v.51.40) and the primary upward-looking 300 kHz ADCP was s/n 10607 (firmware v.50.40). 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 (PE399). This configuration used 15 8-meter bins, a blanking distance of 1.76m, ambiguity velocity of 1.75m/s, and one ping per ensemble saved in beam coordinates. Both instruments were also initially configured in broadband mode, and in the customary master-slave configuration. After the 5th CTD cast, however, new command files were introduced in an attempt to improve overall data quality. These command files increased the number of depth bins to 25, and the size of the bins to 10 meters. The ambiguity velocity was increased to 2.50 m/s, and the blanking distance was changed to 8 meters on the upward-looking (slave) ADCP and set to zero meters on the downward-looking (master) ADCP. Both ADCP's 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.

At cast 9 the upward-looking ADCP was wrongly configured to act as master, resulting in the two ADCPs pinging synchronously which caused some acoustic interferences throughout this cast's dataset.

10.2 Data Processing

A total of 49 profiles were collected. 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.

A wrapper script *process_different_steps_LADCP.m* was created under */home/mstar/dy053/data/ ladcp/ix/data.* This script has several steps: 1) syncs the raw data from the network drive to the local computer; 2) executes the processing of the LADCP for each cast by calling the function *process_cast(nnn)*; 3) asks the user to select one of the three processing levels (LADCP data only, the LADCP with the navigation data from the 1hz CTD file, and the LADCP data with the CTD data and the data from the 75khz shipboard ADCP); 4) copy the processed data and plots on the public network drive (Figure 36).

Including ship VMADCP as an additional inversion constraint in the LADCP processing, does not make a significant difference to the final velocity profiles, as also observed during the DY052 cruise. The use of the VMADCP reduces the inversion-derived velocity error in the mid-water column but doesn't improve the error near the bottom of the profile (Figure 37). Occasionally the VMADCP constraint can led to bigger errors close to the bottom (Figure 37, 16^0W). Both methods, give a mean inversion-derived velocity error of 4.0cm.s^{-1}.
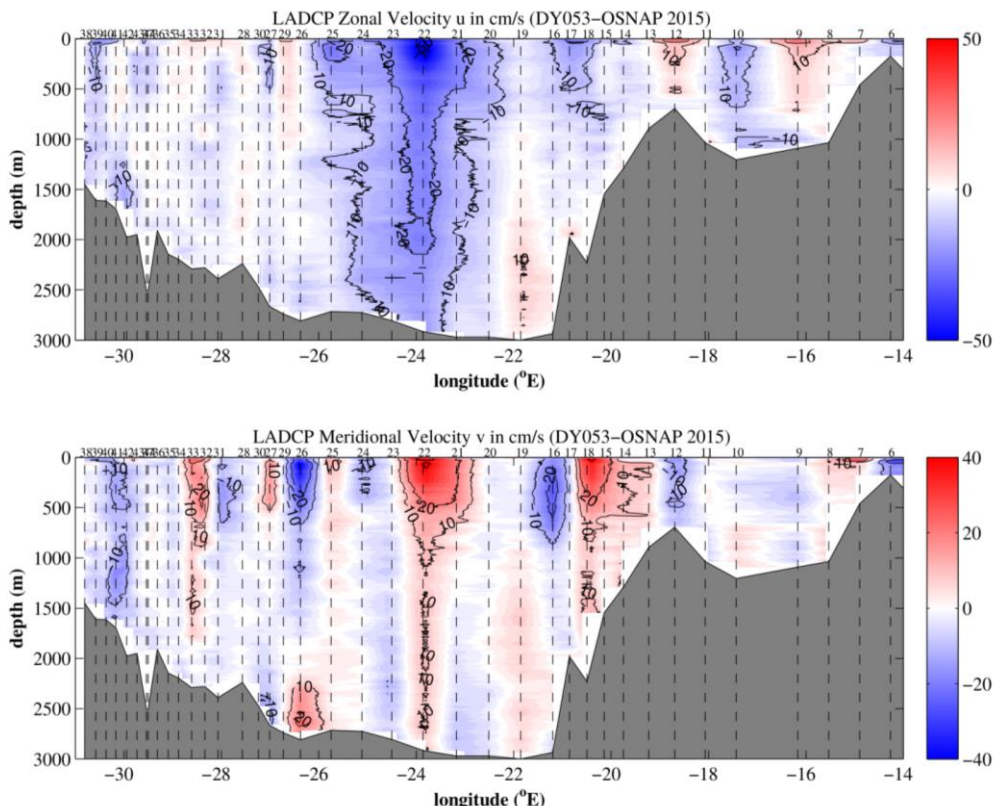
Figure 36: Eastward and Northward components from the LADCP profiles (without using the VMADCP constraint)
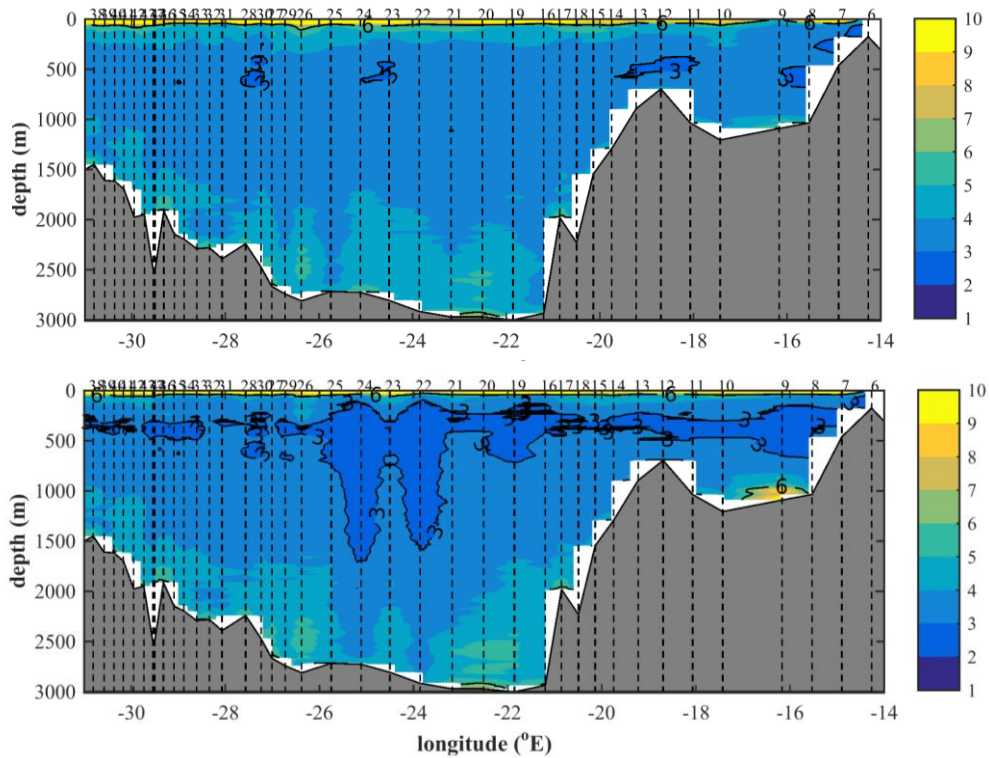
Figure 37: 50m running average of the inversion-derived velocity error from the LADCP processing (in cm.s-1). The top panel correspond in a processing where CTD data were used to constrain the LADCP processing. The bottom panel indicates result when the VMADCP and the CTD data are used to constrain the LADCP processing

11 US Mooring Operations

Bill johns

Seventeen mooring operations (eight mooring recoveries, nine mooring deployments) were performed between 6-18 July, 2016 to service the U.S. (University of Miami) mooring array across the Iceland Basin (

Table 11 and Table 12). The array consists of a basin-wide array of four full-water column "dynamic height" moorings (M1-M4) carrying vertical arrays of moored T/S sensors, to monitor geostrophic transports across broad segments of the Iceland Basin, and a closely-spaced Deep Western Boundary Current (DWBC) array along the eastern flank of the Reykjanes Ridge made up of five additional deep (>1200 m) moorings (D1-D5). Mooring D5 was added to the array in 2016 to help resolve offshore branches of the ISOW. In all, the array deployed in 2016 contains 34 current meters, 64 temperature/salinity recorders, and 4 acoustic Doppler current profilers.

The array is designed to capture several key elements of the North Atlantic subpolar gyre (NASPG) circulation: (1) the DWBC along the eastern flank of the Reykjanes Ridge, composed of Iceland-Scotland overflow water and its entrainment products; (2) the northward flow of upper ocean waters transported by the main branch of the North Atlantic Current toward the Norwegian Seas; and (3) the southward recirculation of the Iceland basin sub-gyre of the NASPG along the eastern flank of the Reykjanes Ridge.

Half of the mooring turnarounds (recovery and redeployment) were accomplished on the same day, and the other half were done on successive days. The moorings were deployed in typical fashion where the mooring was streamed out starting at the top elements of the mooring, with the ship steaming toward the target site at about 1.0 kt. through the water, and the anchor then being deployed after passing over the target site to allow for the estimated fall-back of the mooring on its way to the bottom. The mooring deployment times ranged from 3 hours to about one hour, and in most cases ended with a tow of between 15-45 minutes to the target site before launching the anchor. Most of the moorings were landed very close to the intended bottom site. All moorings were acoustically surveyed after settling to the bottom by obtaining at least two - and typically three - lateral ranges from the ship through communication with the mooring releases (triangulation). Acoustic communications with the mooring releases was done in two ways, the preferred method being through the hull-mounted IXSEA transducer connected via junction box to a Benthos UDB-9400 deck unit, and as a backup using an EdgeTech 8011-M deck unit with matched, cabled transducer lowered over the side of the ship. Through-hull communications is a more efficient method for both mooring release and post-deployment triangulation operations.   Communications through the IXSEA

transducer tended to be noisier (probably due to external sources or electronic interference between the transducer and wired connections to the deck unit), but functional at ranges up to 3500 m. In especially noisy environments it was necessary to switch to the over the side transducer.

Mooring recoveries were commenced by positioning the ship 500-700 m from the moorings triangulated (on-bottom) location. Acoustic communications were then established with the mooring releases and the moorings were released after confirming their acoustic ranges. Once all mooring components were visible on the surface the ship moved in to bring the mooring alongside. Recovery was commenced by grappling the surface pick-up line off the starboard side of the ship and then tending the recovery line aft to retrieve the rest of the mooring through the stern. In one case the pick-up line was badly wrapped around the mooring top float and a grab hook had to be used to latch onto the top float to initiate recovery. All of the mooring operations were performed smoothly and safely on the aft deck without incident.

Table 11: U.S. Moorings recovered on DY053

Mooring_#	Site	Latitude	Longitude	Depth(m)	Recov. date
M431	M1	58° 52.33' N	30° 31.73' W	1710	07/17/2016
M435	D1	58° 44.75' N	30° 07.23' W	1740	07/17/2016
M436	D2	58° 31.93' N	29° 27.53' W	2513	07/18/2016
M437	D3	58° 18.36' N	28° 48.97' W	2175	07/13/2016
M432	M2	58° 02.28' N	28° 01.39' W	2370	07/11/2016
M438	D4	58° 00.59' N	26° 58.09' W	2670	07/11/2016
M433	M3	58° 01.04' N	24° 25.09' W	2850	07/08/2016
M434	M4	57° 59.54' N	21° 08.49' W	2920	07/06/2016

Table 12: U.S. Moorings deployed on DY053 (final triangulated mooring positions)

Mooring_#	Site	Latitude	Longitude	Depth(m)	Depl. date
M450	M1	58° 52.33' N	30° 31.76' W	1710	07/17/2016
M454	D1	58° 44.72' N	30° 07.09' W	1740	07/18/2016
M455	D2	58° 32.02' N	29° 27.57' W	2513	07/18/2016
M456	D3	58° 18.34' N	28° 49.00' W	2180	07/13/2016
M451	M2	58° 02.17' N	28° 01.20' W	2370	07/12/2016
M457	D4	58° 00.62' N	26° 58.04' W	2680	07/12/2016
M458	D5	58° 00.37' N	25° 40.67' W	2705	07/10/2016
M452	M3	58° 00.78' N	24° 25.32' W	2850	07/08/2016
M453	M4	57° 59.49' N	21° 08.49' W	2920	07/07/2016

12 UK Mooring Operations

John Beaton, Stuart

12.1 BPR Drop-Off Mechanism

The BPR drop-off mechanism prematurely released the BPR during deployment of EB1 just after the releases and anchor were lifted outboard. An attempt was made to attach the BPR to chain above the release with dissolving links. However, this link broke and the BPR again dropped free on its deployment cable. Approaching the drop point a rapid decision was made to recover the BPR to deck, and release the mooring. The risk of the mooring being deployed with the BPR hanging free is that it could end up under the anchor.

Some improvements were made to the mechanism (Figure 38), but we decided not to deploy at WB2. The practical reason being that the risk of accidentally anchoring the mooring to the seabed was still high and scientifically the value of the measurements is in trans-basin observations which could not be achieved by a single instrument.

Overall this is still a relatively flimsy arrangement, even if we make further improvements to this system.
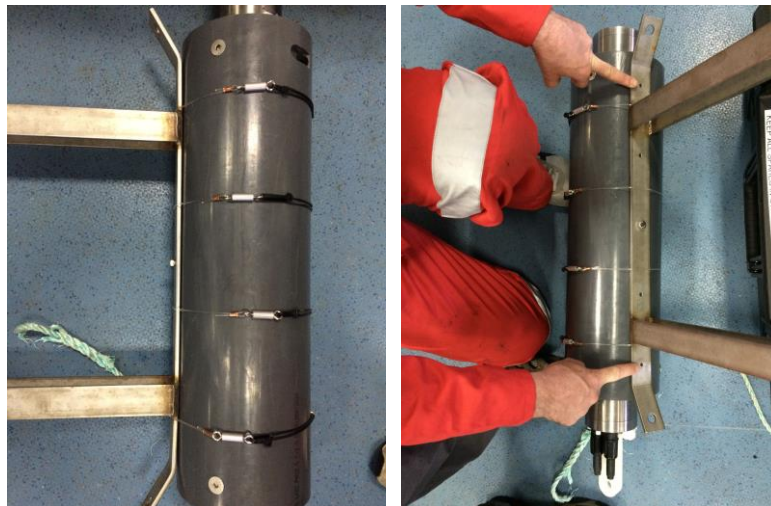
Figure 38: Left panel: new attachment method. A longer locating stud, between stainless frame and grey tube has been inserted, keeping the tube less likely to slip its restraints if the frame is jostled during deployment. The previous arrangement of securing the tube with rope bands with dissolving link has been replaced. This shows four dissolving links. On one side is crimped nylon fishing line and on the other side a rubber o-ring. The fishing line and o-ring are linked by cable tie. The cable tie enables the loop to be drawn taught, with the o-ring providing a good grip.

Right Panel: Possible improvements are: 1. Two further locating studs (at the points indicated); a shelf from the stainless frame, taking the weight under the tube

12.2 Diary of Events

12.2.1 Cruise Preparation

In the months leading up to the cruise all moored instrumentation were evaluated and fully serviced back at NOC in Southampton by Sensors and Moorings technicians, any instruments returned from the 2015 PE399 and PE400 cruises with faults were returned to the manufacturers for evaluation and repair or calibration as required. All other instrumentation, once serviced, were boxed and packed ready for shipping.

Spares kits were checked to ensure they contained all the relevant spare parts, data leads and modems. Additionally, the CTD fame mounting clamps for use on SBE 37 Microcat calibration dips, were packed as these speed up the loading and unloading of Microcats undergoing either pre or post deployment calibration dips. Unfortunately, not all SBE 37 Microcats are compatible with the frame clamps, notably, newer versions have slightly different instrument housings, in these instances the Microcats were attached to the CTD frame using stainless steel ratchet straps.

All acoustic releases were serviced and new batteries fitted back at NOC in Southampton, and each release underwent a deck test to ensure functionality. These were then boxed and packed, ready for shipping.

All moorings hardware was prepared at NOC in Southampton, including the purchase of new chain, shackles, links and mooring rope and wire, glass buoyancy was checked and loaded into shipping cages, recovery lines were measured, cut and spliced. Each mooring was pre wound onto wooden shipping drums using the wire winding facility at NOC in Southampton, where each mooring was wound and measured using a laser counter, instrument deployment locations were pre measured and marked with tape.

All equipment was then loaded into wire shipping cages and taken to the stores department at NOC in Southampton ready for loading onto lorries which were then driven to Glasgow to meet the ship for the cruise mobilisation.

12.2.2 Cruise Mobilisation

All National Marine Facilities Sea Systems staff made their way to Glasgow on Saturday the 25th of June, and mobilisation for the cruise started on Sunday the 26th of June. All equipment arrived to the quayside via lorry and was unloaded by port forklifts, the ship's crew and technicians then loaded the equipment onto the ship, using the ships cranes. Items were carried into relevant labs or placed out on deck as

required. Work on setting up instrumentation in the lab started, with instruments having new battery packs fitted.

On Monday the 27th of June both the American moorings container and the Dutch moorings container arrived at the ship, these were both unloaded on the quayside and again all equipment loaded onto the ship using the ships cranes. Due to space restrictions on the aft deck, we were unable to store the Dutch mooring container on the working deck, so this was placed in one of the container slots above the working deck. Prior to its stowage, the Dutch mooring container was emptied as far as possible, the contents were then placed in the aft hold in preparation for DY054.

Wire winding operations commenced on the 28th of June, taking the wire off the wooded storage drums and wound onto steel drums fitted to the reeling winch. Moorings EB1, WB1 and WB2 were wound ready for deployment. After winding, the drums were secured ready for sailing.

Mobilisation for DY053 finished on the 28th of June, and the vessel set sail the following morning, on the 29th of June.

12.2.3 Mooring Operations

All mooring recoveries and deployments were carried out in the same way using the NMFSS supplied and operated double barrel winch system, with the exception of the Lander deployment.

All communication with the deployed acoustic releases was carried out using the ship's fitted transducer and a Sensors and Moorings supplied TT801 deck unit. This set up proved extremely reliable for both mooring operations and release tests on the CTD frame. We did bring over the side transducers for use in the event of the ship's system not working, however these were not needed.

For mooring recoveries, after the mooring had been released and surfaced, the vessel was repositioned to allow the mooring to be grapnelled by the ship's crew along the starboard side of the ship, the recovery float is then brought on board and removed, and a recovery line attached to the moorings 15m of polyprop recovery rope. This recovery line is fed along the starboard side of ship, around the stern, then through a block on the port aft crane, through a diverter sheave, round the double barrel winch and finally onto a recovery drum located on the reeling winch. This line is then used to wind on the mooring, once the first buoyancy package is brought onboard, it is stopped off on deck using a chain stopper, the recovery line is removed from the system and then the mooring wire is attached and wound on through the system.

For clamped on instrumentation the aft crane was lowered and the double barrel winch stopped so those working in the Red Zone on the stern of the vessel

could remove the instrument. For glass buoyancy packages and instruments housed in clamps and in line load bars, the mooring line was stopped off on deck using a chain stopper, the mooring line was then disconnected allowing instrumentation or glass to be removed and then mooring line reconnected.

For mooring deployments, the mooring wire was fed through the system, from the reeling winch, round the double barrel winch, through a diverter sheave and then through a block on the port aft crane. All moorings were deployed top first, with large top syntactic buoys being lowered to the surface and released using a quick release hook attached to the starboard aft crane.

For glass buoyancy packages and instruments housed in clamps and in line load bars, the mooring line was stopped off on deck using a chain stopper, the mooring line was then disconnected allowing instrumentation or glass to be fitted and then mooring line reconnected. For clamped on instrumentation the aft crane was lowered and the double barrel winch stopped so those working in the Red Zone on the stern of the vessel could fit the instrument.

To deploy smaller anchor weight's the ship's starboard crane and quick release hook was used to lower the anchor to the surface, then once the vessel was in position the anchor was released. For larger anchors a 5T deck winch was used and fed through a block on the A-frame and lowered to the surface and released in the same way as the smaller anchors.

Wednesday 29th June,

DY053 set sail on Wednesday the 29th of June, at 07:30, and preparation work continued both in the lab with the setting up of instrumentation and on deck with the building of glass buoyancy packages for EB1, WB1 and WB2.

Thursday 30th June

A series of test CTD casts were undertaken on Thursday the 30th of June, firstly to test the CTD to ensure everything was working correctly then additional casts were completed to test the acoustic releases and to calibrate the SBE 37 Microcats prior to their deployment.

Friday 1st July

On Friday the 1st of July the first UK mooring operation commenced, with the attempted recovery of the ADCP Lander. Unfortunately, despite good communications from the acoustic releases, the Lander failed to release and surface, and after a period of trilateration is was concluded that the Lander had, in all likelihood, been trawled and possibly inverted.

On deck, work continued to build the ADCP Lander frame, however, this was held up due to the incorrect ADCP housing being supplied by the manufacturer and a detour to Tobemory was required to complete a boat transfer of the correct housing.

Saturday 2nd July

Poor weather conditions on Saturday the 2nd of July meant that no mooring operations could take place, so tested releases were doubled up and prepared for deployment

Sunday 3rd July

Lander deployment took place at around 06:00. For the Lander deployment, a special rope bridle had to be designed and made on board, this was used to attach to the Lander via three eyes in the Lander concrete base, a quick release hook was then attached to the bridle and this was in turn attached to a ships aft crane. At the correct deployment location, the Lander was lifted and slewed outboard, over the ships stern and gently lowered to the surface where the quick release was released and the Lander fell away.

After the deployment, the deck was set up for recovery operations and EB1 recovery took place just after breakfast. All recovered instrumentation was taken directly to the lab for cleaning in fresh water and then for data downloading. No instrumentation was lost however some instrumentation had unfortunately stopped logging data.

EB1 was redeployed in the afternoon, and this went well, although the BPR fell off the drop kit frame, and after two failed attempts to secure the BPR's it was decided to finish the mooring deployment without them.

In the evening an attempt was made to improve the method of attaching the BPR's to the frame, and a new design was drawn up making use of monofilament line, o-rings, a fizz link and a cable tie to make a band that wrapped around the BPR and frame, and tightened with a cable tie. Four bands were made, and produced a much improved fixing to the frame.

Monday 4th July

Moorings WB1 and WB2 were both recovered, turned around and redeployed in the same day, all instrumentation was again take straight to the lab after recovery, and was brought from the lab to the back deck for deployments. A few tangles were encountered during the recovery process; these were dealt with by stopping the mooring wire off on the deck and then cutting the tangles out.

12.2.4 Additional Support

Having completed all of the UK mooring operations, the NMFSS technical party assisted in all of the US mooring recoveries and deployments by operating the double barrel winch system and assisting on deck as required.

NMFSS technicians also operated the CTD for all operations in between moorings, working in two, 12 hour shifts. Details of all of the CTD operations can be found elsewhere in this report.

Towards the end of the cruise preparation for the DY054 cruise got underway, instrumentation was serviced and new batteries fitted. Recovered releases were serviced and had new batteries fitted followed by a bench test, and out on deck glass buoyancy packages were made with all of the available glass. Finally, three moorings were wound on to steel deployment drums.

12.3 Deployment of AL500 trawl-resistant bottom mount

The AL500 buoyancy unit was mated with the non-recoverable, concrete base option. The AL500 housed a gimbaled Nortek Signature S55, remote head ADCP and external battery case and was fitted with fitted with twin Ixsea AR861 acoustic releases. Recovery aids fitted were one Novatech strobe beacon and one Novatec Iridium beacon. Both were remote head devices pressure-activated at the surface.

Deployment was achieved by lowering the unit into the water followed by release and subsequent freefall to the seabed. Overboard lifting was made using a three-legged bridle and a Seacatch mechanical load release. The upper end of each bridle leg was attached to a ring above the Seacatch, each leg led down and passed through a lifting point on the TRBM's base then led up to the jaw of the Seacatch. The deployment proceeded as planned.

During assembly of the buoyancy, base and instruments some problems were encountered.

The securing bolts for the top of the twin Ixsea releases were found to be too large a diameter to pass through the eye on the releases. This was remedied by replacing each bolt with a 170mm long, M20, 316 stainless steel threaded rod with double (locked) nuts below and a nylock locking nut above. The new arrangement was isolated from both the aluminium base and the acoustic releases.

On fitting the instrument tray to the concrete base it was found that one corner of the tray was 50mm too high. Complete mating was prevented by fouling of the head of one of the release bolts on the inner edge of the concrete casting. This was remedied by removing a small amount of concrete with a hammer and chisel.

The twinning rings and chain for the release hooks appeared to be made from a stainless steel grade thought to be incompatible with that of the release hooks. This was remedied by replacing it with a spliced strop of 10mm polypropylene rope. Tightening the release mechanism was still made using the stainless steel turnbuckle supplied.

Mounting blocks for the remote head beacons were supplied in place but it was found that the space allowed in the buoyancy moulding was insufficient for one of the battery cases. This was remedied by cable-tying both beacon battery cases one on top of another. The remote head cable was long enough to reach the head.

12.4 Lost Instruments and Hardware

12.4.1 Failure to recover RTADCP1

We arrived on site for recovery at 7am. Both releases talking, but ranges were longer than expected. We fired the first release, which was confirmed. No change of range. Fired second release no change of range. Trilaterated mooring (Figure 1). Lander seabed position was found to be 981m to the south-east from the seabed position when deployed (Table 13). Around two hours were devoted to triangulation and to confirm that the lander remained on the sea-bed, before we left the site.

Table 13:Trilaterated seabed location of RTBADCP1.

Year	latitude	longitude
20/6/2015	57° 06.24'N	9° 20.32'W
1/7/2016	57° 05.75'N	9° 19.94'W

Corrected water depth: 746m. Release Height: 0m. Transducer depth: 12m. Red = anchor seabed position. 57.0959N –9.3323W.
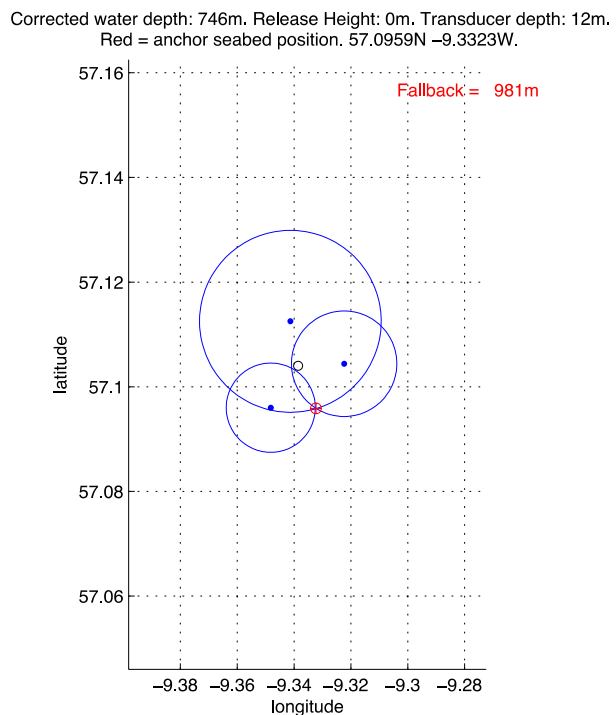
Figure 39: Trilateration of RTADCP1 conducted on 1/7/16 (open red circle). Open circle is the seabed location determined by trilateration after deployment on 20/6/15.

13 Microcat Data Processing

Loïc Houpert / Estelle Dumont

Before the processing of the different datasets, a control file is created for each mooring. Each mooring deployed has an associated ASCII info.dat file in the mooring directory. (e.g. *rtwb1_02_2015info.dat* is created in the directory *osnap/data/moor/proc/rtwb1_02_2015/*). The info.dat file contains metadata of mooring position, deployment period, and nominal depths and serial numbers of each instrument on the mooring.

13.1 Stage 0 – Data Download

Raw instrument data are downloaded from the instrument after the recovery of the mooring. Data are downloaded in ASCII and cnv format. Record keeping of the download is done on paper and for each instrument a download sheet is completed. After download the data are 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/dy053/microcat/*

13.2 Stage 1 – Conversion to standard RDB format

The script *mc_call_2_dy053* performs stage1 processing on microcat data. It converts microcat data from raw to RDB format for an entire mooring. The user needs to modify some information in the beginning of the script like the directory trees, the mooring name, the year of the first measurement. *mc_call_2_dy053* calls *microcat2rodb_4*, which saves the file downloaded by the instrument software (stage 0) to the RDB formatted file *.raw*. The stage1 processed data are stored in the directory *~/osnap/data/moor/proc/moor_02_2015/microcat*, which is created manually.

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

To perform stage 2 processing, the script *microcat_raw2use_003.m* was used. This script uses the raw data file *mooring_serialnum.raw* generated by stage1 and the *mooringinfo.dat* file. It removes the launching[1] and recovery[2] period, creates a data overview sheet including basic statistics, and produces summary plots, including filtered data.

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

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

14 MicroCAT Calibration Dips

Estelle Dumont / Loïc Houpert

Cross-calibration data from the CTD were collected for all the moored Microcat SBE37 (pre-deployment and post-recovery). During these casts, the Microcats were set to sample at the highest rate possible (10 seconds) and attached to the CTD frame in brackets or on straps. During the upcast, the CTD package was stopped for five minutes at twelve depths throughout the water column. This procedure allows us to assess the quality of the Microcats' sensors before and after deployment (Table 14), and to correct any potential offset or drift in the conductivity, temperature or pressure sensors during the post-processing stage.

14.1 A/R testing

Acoustic releases were lowered on the CTD frame and tested on deep cast (>2000m). No problem was encountered.

14.2 Processing

The script *osnap/exec/dy053/stage1/microcat/mc_call_caldip_dy053.m* loads the raw microcat data located in *osnap/data/moor/raw/dy053/microcat_cal_dip/castnnn/* (the raw data are first copied over manually from the network drive) *,* the CTD data files for the cast*nnn* (*osnap/data/dy053/ctd_dy053_nnn_raw.nc* and *osnap/data/dy053/ctd_dy053_nnn_psal.nc)*, and the *castnnninfo.dat* file located in *osnap/data/moor/proc_calib/dy053/cal_dip/*, which is a control file summarising the type and the serial of the different instruments on the caldip cast. The control file is edited with the information for each cal dip. The script writes to a directory *~/osnap/data/moor/proc_calib/cal_dip/dy053/microcat/castnn/* which is created manually.

The script *mc_call_caldip_ dy053* also plots all microcat data from one CTD cast, with the CTD data. The program *mc_caldip_check_ dy053* provides a quick quantitative comparison of Microcat cal-dip data with the SBE911 data from the CTD. For each instrument differences of conductivity, temperature and pressure between the instrument and the CTD sensor were calculated.

Table 14: Summary table: Mean differences in conductivity, temperature and pressure of the SBE37 lowered on the shipboard CTD during the calibration casts.

CTD cast		Location before and after the caldip		CTD-Microcat difference during 5mins stops at maximum depth of the cast					
	S/N	Before	After	C (µS/cm)		T (mK)		P (db)	
				mean	std	mean	std	mean	std
4	5240	ship	ship	0.0037	0.0004	-0.0009	0.00043	1.2	0.36
4	5785	ship	ship	-0.0001	0.00062	-0.0044	0.00059	2.6	0.22
4	5779	ship	ship	0.0137	0.00041	-0.001	0.00045	1	0.29
4	6840	ship	ship	0.0062	0.00052	-0.0016	0.00055	1.1	0.25
4	8078	ship	ship	0.0019	0.00046	-0.0011	0.00067	1.9	0.29
4	8079	ship	ship	0.0076	0.00034	-0.0015	0.00036	2.2	0.4
4	9113	ship	RTEB1	0.0007	0.00044	-0.0017	0.00053	-0.3	0.24
4	9140	ship	RTEB1	-0.0016	0.00039	-0.0011	0.00049	-453	0.39
4	10558	ship	RTEB1	-0.0006	0.0005	-0.0011	0.0006	3.2	0.39
4	10559	ship	RTEB1	-0.0013	0.00056	-0.0011	0.00066	3.2	0.29
4	10562	ship	RTEB1	0.0012	0.00049	-0.0013	0.00059	3	0.26
4	11329	ship	RTEB1	0.0024	0.00051	-0.0022	0.00061	1.7	0.28
4	11337	ship	RTEB1	-0.0005	0.00043	-0.0021	0.00051	-1.9	0.22
4	11339	ship	RTEB1	-0.0007	0.00037	-0.0007	0.00047	0.9	0.41
4	14353	ship	RTWB2	0.0041	0.00051	-0.0013	0.0006	2	0.42
4	14354	ship	RTWB2	0.0043	0.0005	-0.0015	0.00058	2.6	0.26
5	9141	ship	RTWB1	0.0008	0.00189	-0.0005	0.00234	-438	0.46
5	14355	ship	RTWB1	0.0038	0.00211	-0.0006	0.00254	2.5	0.48
5	14356	ship	RTWB1	0.0031	0.00187	-0.0012	0.00219	1.3	0.59
5	14364	ship	RTWB1	0.004	0.00177	-0.0012	0.00213	0.9	0.59
5	14365	ship	RTWB1	0.0042	0.0019	-0.0012	0.00238	1.1	0.51
5	14366	ship	RTWB1	0.0032	0.00193	-0.0019	0.00229	1	0.64
5	14367	ship	RTWB1	0.0032	0.00196	-0.0014	0.0024	0.5	0.38
5	14368	ship	RTWB1	0.0043	0.00192	-0.0007	0.00242	1.9	0.33
22	3218	RTWB2	ship	0.0006	0.00036	-0.0022	0.00031	1.6	0.15
22	3279	RTEB1	ship	0.008	0.00071	0.0009	0.00042	3.5	0.93
22	3481	RTWB2	ship	-0.0034	0.00021	-0.0006	0.0003	-6.1	0.32
22	4463	RTEB1	ship	-0.0036	0.00068	-0.0027	0.00046	-3.5	0.82
22	8077	RTEB1	ship	0.0092	0.00035	-0.0018	0.00039	2.1	0.25
22	8082	RTWB1	ship	0.0098	0.00028	-0.0034	0.00028	10.6	0.37
22	8443	RTWB1	ship	0.0039	0.00035	-0.0025	0.00042	4.5	0.22
22	9373	RTEB1	ship	0.004	0.0004	-0.0022	0.0004	-0.2	0.32
22	11321	RTEB1	ship	0.0127	0.00031	-0.0015	0.00029	3.6	0.15
22	11323	RTWB1	ship	0.0072	0.00031	-0.0012	0.00031	4.1	0.17
22	11324	RTWB1	ship	0.0043	0.00034	-0.0013	0.00031	1.8	0.25
22	11331	RTWB1	ship	0.0015	0.00034	-0.0015	0.00031	2.9	0.5
22	11332	RTWB1	ship	0.0033	0.00035	0.0002	0.00034	3.4	0.31
22	11333	RTWB1	ship	0.0033	0.00036	0.0005	0.00035	2.5	0.45
22	13019	RTEB1	ship	-0.0022	0.00026	-0.0015	0.00023	2.4	0.4
22	13020	RTEB1	ship	-0.0015	0.00039	-0.0018	0.0004	1.7	0.32
22	13021	RTEB1	ship	-0.0062	0.00042	-0.0015	0.00042	2.5	0.23
22	13022	RTEB1	ship	0.0437	0.00035	-0.0016	0.00036	2.9	0.46

15 BPR Processing

Stuart Cunningham

Two SBE53 bottom pressure gauges were deployed utilizing a drop-off mechanism from the mooring. The BPR is mounted in a protective tube attached to a jig above the releases. After several days in water a dissolving link allows the BPR to drop from the jig and deploy to the seabed. By this means the BPR is decoupled from mooring motion. A rope secures the BPR to the mooring so it is recovered with the mooring. For BPR 0035 on rteb1 we recovered a year-long record. BPR 0013 stopped recording after eight months and did not deploy correctly so mooring motion contaminates the data (Table 15, **Error! Reference source not found.**).

Table 15: Summary of SBE53 instruments, serial and mooring numbers and basic data recovered.

Serial Number	0035	0013
Mooring	rteb1_02_2015	rtwb1_02_2015
Instrument data file	0035_data.tid	0013_data.tid
RDB file	rteb1_02_2015_0035.raw	rtwb1_02_2015_0013.raw
Processed file	rteb1_02_2015_0035.use	rteb1_02_2015_0013.use
Median press [dbar]	1833.8	1626.7
Median temp [°C]	3.8	4.0
Time Offset	+49s	+47s
Start	27/6/15 05:00:00	22/6/15 17:00:00
End	3/7/16 08:00:00	15/3/16 013:30:00
Sampling frequency [/day]	48	48
Number of samples / expected	17863 / 17863	15162 / 15162
Exponential-linear pressure fit to be stored with data $$p_{fit} = c_1 \acute{} \left(1 - e^{-c_2 \acute{} t}\right) + c_3 \acute{} t + c_4$$	C1= 0.094721 db C2=34.756443 days C3= 0.000194 db/day C4=1833.650841 db	C1=0.657390 db C2=5.778775 days C3=.002891 db/day C4=1625.587032 db

15.1 Stage 0

Data were uploaded in binary format using the SeatermW terminal launched via Seasoft for Waves. Data logging was stopped then careful note of the instrument clock drift was made. After uploading, hex data were converted to ascii using the routines in Seasoft from Waves. Slope and offset corrections of 1 and 0 were applied respectively.

15.2 Stage 1

Save raw ASCII data from SBE53 to RDB format. Basic data checks, apply clock offset.

> *>stage1/bpr /seagauge2rdb_003.m*
> *Infiles: moor_02_2015info.dat ; clock_offset.dat ; nnnn_data.tid*
> *Outfile: moor_02_2015_nnn.raw ; stage1_log*

15.3 Stage 2

Add linear clock drift and determine the functional form of the pressure sensor drift (exponential-linear or linear). Cut-off deployment and recovery periods.

> *>seagauge_processing_003.m and function purge_bp_003.m.*
> *infile: moor_02_2015info.dat ; clock_offset.dat; moor_02_2015_nnnn.raw*
> *Outfile: moor_02_2015_nnnn.use ; stage2_log*

15.4 Comments

For mooring wb1 (BPR s/n 0013) the BPR drop-off mechanism probably deployed during the mooring deployment. The raw pressure data (**Error! Reference source not found.**) show large and oceanographically unreasonable fluctuations, indicating the data are contaminated by mooring motion. On recovering the mooring, the BPR recovery rope was entangled above the releases with the instrument suspended a short distance. This instrument also stopped before completing a year of measurements (Table 15). The capture file on download indicated 'low battery' of 13V for the main battery. It is unlikely any environmental signal can be extracted from the data.

For mooring eb1 (BPR s/n 0035) the BPR drop-off mechanism deployed to the
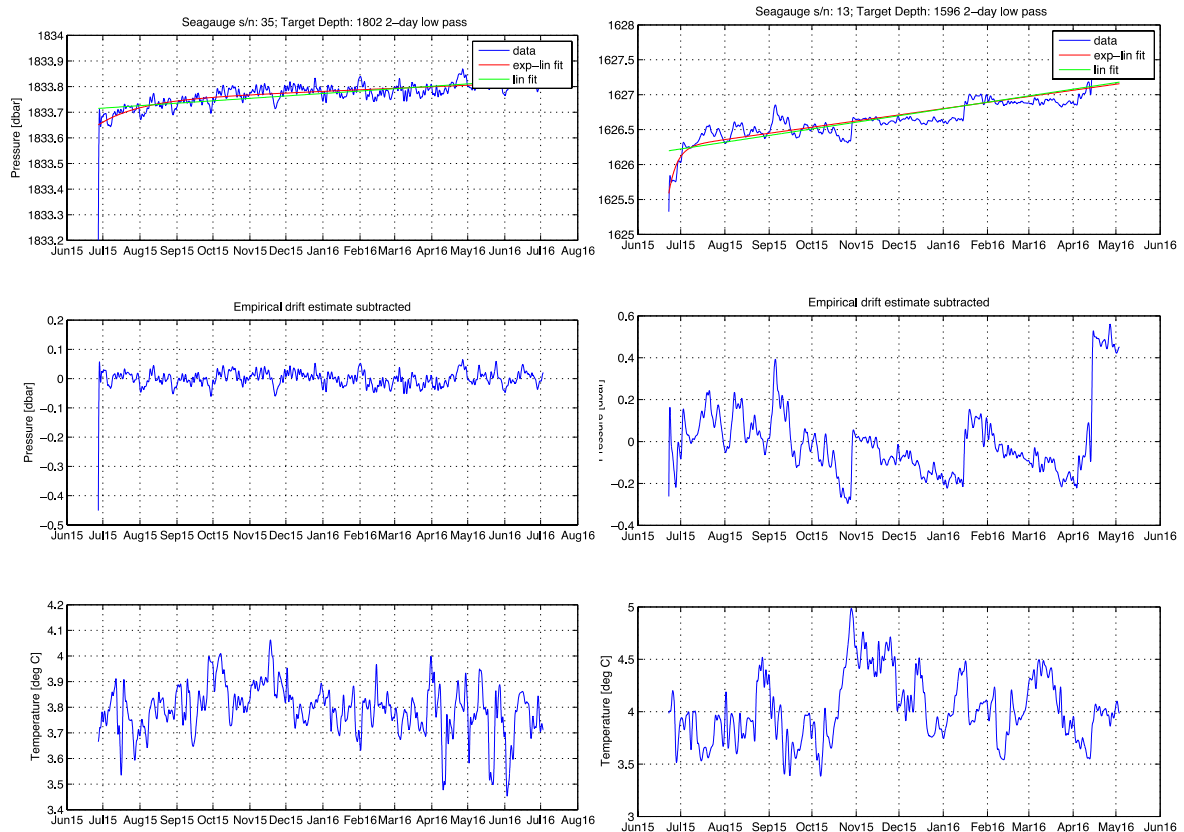
Figure 40: Top panel: Processed data from SBE53 s/n 0035, showing de-spiked, 2-day low-pass data with the two forms of functional fit for drift removal. Middle panel: with exponential-linear drift removed (Table 15). Bottom panel: temperature.

Figure 41: Top panel: Processed data from SBE53 s/n 0013, showing de-spiked, 2-day low-pass data with the two forms of functional fit for drift removal. Middle panel: with exponential-linear drift removed (Table 15). Bottom panel: temperature

sea-bed after six days in the water. This can be seen in the raw data (not presented here). It is notable to compare the smooth drift characteristics and signal of one to two dbar of bottom pressure variability compared to BPR s/n 0013 which has several abrupt jumps of 0.2-0.3dbar throughout the record.

16 Nortek Current Meter Data Processing

Loïc Houpert

16.1 Stage 0 – Data Download

Raw instrument data are downloaded from the instrument after the recovery of the mooring. Record keeping of the download is done on paper and for each instrument a download sheet is completed. After download the data are backup 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/dy053/nortek/*

16.2 Stage 1 – Conversion to standard RDB format

The script process_nors_dy053 performs stage1 and stage 2 processing on nortek data. It converts nortek data from raw to RDB format for an entire mooring. The user needs to modify some information in the beginning of the script like the directory trees, the mooring name, and the year of the first measurement. A text file containing the serial numbers of the Nortek on the mooring and the filenames containing the data is also created before running the script, e.g. *~/osnap/data/moor/raw/dy053/nortek/ EB1_recovery/rteb1_02_2015_filenames.txt.*

process_nors_dy053 calls *nortek2rodb_01*, which saves the files downloaded by the instrument software (stage 0) to the RDB formatted file *.raw.* in e.g. *~/osnap/data/moor/proc/rteb1_02_2015/nortek.*

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

The script *process_nors_dy053* also performs stage 2 processing on nortek data by calling the script *nortek_raw2use_02.* This script uses the raw data file *mooring_serialnum.raw* generated by stage1 and the *mooringinfo.dat* file. It removes the launching and recovery period, creates a data overview sheet including basic statistics, and produces summary plots, including filtered data.

16.4 Data Problems

All the Nortek stopped early (April-May), due to battery issues. Alkaline batteries were installed instead of Lithium.

17 References

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A Appendices

A.1 CTD Summary table

Station	Date dd/mm/yyyy	Time HH:MM	Longitude [degrees_east]	Latitude [degrees_north]	Max. CTD Depth [m]	Altimeter [m]
1	29/06/2016	11:53	-5.002	55.544	108	11
2	30/06/2016	13:18	-10.2	57.1	2209	41
3	30/06/2016	16:54	-10.2	57.1	2205	11
4	30/06/2016	19:54	-10.2	57.1	2205	11
5	01/07/2016	00:28	-10.2	57.1	2207	10
6	05/07/2016	01:48	-14.266	57.593	183	12
7	05/07/2016	04:38	-14.898	57.604	466	12
8	05/07/2016	07:38	-15.532	57.615	1045	11
9	05/07/2016	13:02	-16.167	57.624	879	NaN
10	05/07/2016	19:15	-17.432	57.646	1216	9
11	05/07/2016	22:30	-18.069	57.656	1043	11
12	06/07/2016	01:50	-18.697	57.666	699	10
13	06/07/2016	04:50	-19.228	57.73	901	11
14	06/07/2016	07:37	-19.746	57.792	1295	11
15	06/07/2016	10:20	-20.14	57.837	1553	14
16	06/07/2016	21:32	-21.199	57.955	2933	22
17	07/07/2016	01:41	-20.855	57.915	1979	20
18	07/07/2016	04:46	-20.497	57.879	2224	22
19	07/07/2016	17:14	-21.857	57.959	3001	18
20	07/07/2016	22:32	-22.512	57.958	2966	18
21	08/07/2016	03:18	-23.177	57.96	2968	22
22	08/07/2016	22:28	-23.85	57.973	2917	17
23	09/07/2016	04:32	-24.503	57.966	2815	12
24	09/07/2016	21:33	-25.116	57.959	2733	9
25	10/07/2016	09:20	-25.747	57.96	2712	20
26	10/07/2016	18:47	-26.377	57.961	2811	16
27	10/07/2016	23:20	-27.012	57.961	2673	11
28	11/07/2016	03:38	-27.568	57.977	2246	11
29	11/07/2016	18:50	-26.727	57.959	2743	15
30	11/07/2016	23:53	-27.242	57.963	2477	10
31	12/07/2016	20:14	-28.069	57.994	2399	9
32	12/07/2016	23:19	-28.34	58.083	2289	10
33	13/07/2016	02:46	-28.612	58.172	2295	12
34	13/07/2016	05:44	-28.882	58.261	2201	10
35	13/07/2016	16:10	-29.092	58.335	2155	9
36	13/07/2016	19:12	-29.315	58.413	1830	NaN

37	14/07/2016	10:18	-29.539	58.49	2512	22
38	17/07/2016	02:08	-30.806	58.836	1456	12
39	17/07/2016	04:21	-30.579	58.83	1594	NaN
40	17/07/2016	19:44	-30.366	58.761	1623	10
41	17/07/2016	22:09	-30.168	58.698	1704	10
42	18/07/2016	00:51	-29.946	58.625	1981	10
43	18/07/2016	03:36	-29.731	58.555	1959	11
44	18/07/2016	19:50	-29.504	58.512	2508	19
45	19/07/2016	15:39	-33.677	56.673	1037	14
46	19/07/2016	17:22	-33.7	56.708	1759	21
47	19/07/2016	19:16	-33.673	56.74	2166	21
48	19/07/2016	21:37	-33.733	56.767	1908	NaN
49	19/07/2016	23:31	-33.749	56.801	1200	11

A.2 Moorings Summary table

Moor	Name	RTADCP1	RTEB1	RTWB2	RTWB1
Date	dd:mm:yy	03/07/2016	03/07/2016	04/07/2016	04/07/2016
Nominal position	Latitude	57.1000	57.1000	57.4700	57.4700
	Longitude	-9.3367	-9.5630	-12.3100	-12.7100
	Water depth [m]	950	1800	1800	1600
Anchor Drop Position	Latitude	57.0976	56.9420	57.4707	57.4710
	Longitude	-9.3555	-9.5653	-12.3120	-12.7109
Anchor Seabed	Latitude	57.0983	57.1014	57.4679	57.4699
	Longitude	-9.3551	-9.5623	-12.3122	-12.7108
	Water depth [m]	947	1813	1799	1585
Fallback	[m]	87	251	311	125

A.3   UK Mooring Diagrams as deployed in 2016

5 CM - 8 MC - 1 BPR

8365	Nortek - 95m
9141(S)	SBE37 - 100m
240m	Iridium beacon J01KIF Light
14355	SBE37 - 250m
490m	Iridium beacon J01NKE Light
11051(t)	Nortek - 495m
14356	SBE37 - 500m
14364	SBE37 - 750m
11069(t)	Nortek - 995m
14365	SBE37 - 1000m
14366	SBE37 - 1250m
11046	Nortek - 1350m
14367	SBE37 - 1500m
13018	Nortek - 1570m
14368	SBE37 - 1575m
1272 1753	2xAR861 - 1597m
RTWB1	

Water depth = 1600m

3 CM - 2 MC

	Iridium beacon J01NEX Light
9881(t)	Nortek - 1000m
9861	Nortek - 1350m
14353	SBE37 - 1575m
9877	Nortek - 1765m
14354	SBE37 - 1770m
1754 1757	2xAR861 - 1795m
RTWB2	

Water depth = 1800m

6 CM - 8 MC - 1 BPR

9867	Nortek - 95m
9140(S)	SBE37 - 100m
240m	Iridium beacon J01KMN Light
11035	Nortek - 245m
10558	SBE37 - 250m
490m	Iridium beacon J01NKJ Light
11048	Nortek - 495m
10559	SBE37 - 500m
10562	SBE37 - 750m
13130	Nortek - 1000m
9113(S)	SBE37 - 1005m
11329	SBE37 - 1250m
13142	Nortek - 1350m
11337	SBE37 - 1500m
9868	Nortek - 1775m
11339	SBE37 - 1775m
1761 1764	2xAR861 - 1797m
RTEB1	

Water depth = 1800m

DY053, July 2016
OSNAP Rockall
Trough Array
As Deployed

RTADCP1
S55 s/n 200044

Iridium beacon M019A2
Light:
2xAR861: 1763/1502

Water depth = 950m

(S): SBE37 from SAMS
(t): Nortek Turned round

Rockall Trough EB1 Deployed 2016

Design : 13-Nov-2013 (v05)

79 m	McLane–12"	5/8 Shac
		#1 15m 1/2" Polyprop
		5/8 Shac
95 m	3x17" glass	
		shac–link–shac
98 m	Nortek on load bar (estimate) S/N 9867	shac–link–shac
		#2 top 141m 3/16" ins
100 m	SBE37 SMP S/N 9140	
		#2 bottom
		#3a 1m chain-13 shac–link–shac
240 m	31" synt 1500m Iridium S/N J01KMN Light S/N ?	5/8 Shac
		#3b 4m chain-13
		5/8 Shac Swivel –Ti shac–link–shac
247 m	Nortek on load bar (estimate) S/N 11035	shac–link–shac
		#4 top 241m 3/16" ins
253 m	SBE37 SMP S/N 10558	
		#4 bottom #5a 1m chain-13 shac–link–shac
490 m	40" synt 1500m Iridium S/N J01NKJ Light S/N ?	shac–link–shac
		#5b 4m chain-13
		5/8 Shac Swivel –Ti shac–link–shac
496 m	Nortek on load bar (estimate) S/N 11048	shac–link–shac
		#6 top 243m 3/16" ins
502 m	SBE37 SMP S/N 10559	
		#6 bottom
		shac–link–shac
741 m	6x17" glass	
		#7 top 248m 3/16" ins shac–link–shac
751 m	SBE37 SMP S/N 10562	
		#7 bottom
		shac–link–shac
995 m	4x17" glass	
		shac–link–shac
999 m	Nortek on load bar (estimate) S/N 13130	shac–link–shac
		#8 top 349m 1/4" ins
1005 m	SBE37 SMP S/N 9113	

1250 m	SBE37 SMP S/N 11329	
		#8 bottom shac–link–shac
1350 m	2x17" glass	
		5/8 Shac
1352 m	Nortek on load bar (estimate) S/N 13142	5/8 Shac Swivel –Ti shac–link–shac
		#9 138m 1/4" ins
		shac–link–shac
1492 m	4x17" glass	
		#10 top 274m 1/4" ins shac–link–shac
1500 m	SBE37 SMP S/N 11337	
		#10 bottom 5/8 Shac
1769 m	Nortek on load bar (est) S/N 9868	#11 top 10m 1/4" ins 5/8 Shac
1775 m	SBE37 SMP S/N 11339	
		#11 bottom
		#12 5m 1/4" ins 5/8 Shac 5/8 Shac shac–link–shac Swivel –Ti 5/8 Shac
1786 m	8x17" glass	
		shac–link–shac
		#13 5m chain–13 shac–link–shac
		5/8 Shac
1798 m	AR–2 S/N 1761 S/N 1764	sRs
		#14 1.5m chain-13 5/8 Shac
1799 m	Anchor 1700 kg (dry weight) (Wet weight = 1479kg) (Safe weight = 1433kg)	

Rockall Trough WB1 deployed 2016

Design : 13-Nov-13 (v07)

Depth	Description	S/N
76 m	McLane–12"	
	#1 15m 1/2" Polyprop	
91 m	4x17" glass	
	shac–link–shac	
95 m	Nortek on load bar (estimate)	S/N 8365
	#2 top 145m 3/16" ins	
101 m	SBE37 SMP	S/N 9141
	#2 bottom	
	shac–link–shac	
242 m	31" synt 1500m	Iridium S/N J01KIF Light S/N ?
	#3 5m chain–13	
	Swivel –Ti shac–link–shac	
	#4 top 239m 3/16" ins	
249 m	SBE37 SMP	S/N 14355
	#4 bottom	
	shac–link–shac	
488 m	40" synt 1500m	Iridium S/N J01NKE Light S/N ?
	#5 5m chain–13	
494 m	Nortek on load bar (estimate)	S/N 11051
	Swivel –Ti	
	#6 top 494m 3/16" ins	
501 m	SBE37 SMP	S/N 14356
751 m	SBE37 SMP	S/N 14364
	#6 bottom	
991 m	5x17" glass	
	shac–link–shac	
996 m	Nortek on load bar (estimate)	S/N 11069
	#7 top 201m 3/16" ins	
1002 m	SBE37 SMP	S/N 14365
	#7 bottom	
1199 m	4x17" glass	
	shac–link–shac	
	Swivel –Ti	
	#8 top 143m 3/16" ins	
1250 m	SBE37 SMP	S/N 14366
	#8 bottom	

Depth	Description	S/N
1347 m	4x17" glass	
	shac–link–shac	
1350 m	Nortek on load bar (estimate)	S/N 11046
	#9 top 215m 1/4" ins	
1500 m	SBE37 SMP	S/N 14367
	#9 bottom	
1567 m	2x17" glass	
1569 m	Nortek on load bar (estimate)	S/N 13018
	#10 5m 1/4" ins	
1575 m	SBE37 SMP	S/N 14368
	#11 10m 1/4" ins	
1586 m	8x17" glass	
	shac–link–shac	
	Swivel –Ti	
	#12 1.5m chain–13	
1594 m	AR–2	S/N 1272 S/N 1753
	#13 5m chain–13	
1599 m	Anchor 1600 kg (dry weight) (Wet weight = 1392kg) (Safe weight = 1418kg)	

Rockall Trough WB2 deployed 2016

Design : 13–Nov–2013 (v05)

Depth	Component	
980 m	McLane–12"	s 3.2t
		#1 15m 1/2" Polyprop
996 m	Billings 3 sphere Iridium S/N J01NEX Light S/N ?	s 3.2t #2 1m chain–13 s 3.2t shac–link–shac
999 m	4x17" glass	
		shac–link–shac
1002 m	Nortek on load bar (estimate) S/N 9881	shac–link–shac Swivel –Ti 5/8 Shac
		#3 343m 3/16" Ins
		shac–link–shac
1347 m	4x17" glass	
		shac–link–shac
1351 m	Nortek on load bar (estimate) S/N 9861	shac–link–shac
		#4 top 411m 3/16" Ins
1576 m	SBE37 SMP S/N 14353	
		#4 bottom
		shac–link–shac
1764 m	2x17" glass	
		shac–link–shac
1766 m	Nortek on load bar (estimate) S/N 9877	shac–link–shac
		#5 top 6m 3/16" Ins
1771 m	SBE37 SMP S/N 14354	
		#5 bottom
		shac–link–shac
1773 m	5x17" glass	
		shac–link–shac Swivel –Ti 5/8 Shac
		#6 2m chain–13 shac–link–shac
1778 m	AR–2 S/N 1754 S/N 1757	sRs 5/8 Shac
		#7 20m chain–13 3/4 Shac
1799 m	Anchor 500 kg (dry weight) (Wet weight = 435kg) (Safe weight = 417kg)	2m chain–13

A.4   UK Mooring Recovery Logsheets

OSNAP – MOORING LOGSHEET

RECOVERY EB1

Cruise   DY053
[NB all times recorded in GMT, all dates dd/mm/yyyy]

Mooring id   Rockall Trough EB1

Range: M33m

Release: 08:38:54
Lat: 57° 05.915'N
Lon: 9° 33.121'W

Anchor drop:

Date	21/06/2015	Time	0833
Latitude	57° 05.988'N	Longitude	9° 33.894'W
Depth	1809m		

SEABED POSITION   57.1016, -9.5626

Date 03/07/16

(Grappled →) Start time 09:12

End time 1053

Latitude 57° 06.12 'N

Longitude 9° 33.37 'W

Depth 1804 m

Item	S/N	Comments	Time
McLane 12"			09:12
15 m polyprop			
3 x 17" glass			09:23
Nortek on load bar	8364 ✓		09.23
141 m wire			
SBE37 SMP (1 m down wire)	8077 ✓		09.23
31" syn 1500 m **and** iridium beacon **and** Light	B11-051 B11-055		0930
5m chain			0935
swivel			
Nortek on load bar	9853 ✓		0935
241 m wire			
SBE37 IMP (5 m down wire)	3279 ✓		0936
40" synt 1500 m **and** iridium beacon **and** Light	B11-053 B11-007		0944
5m chain			0944
Swivel			
Nortek on load bar	11034 ✓		0951
243 m wire			
SBE37 SMP (5 m down wire)	9373 ✓		0951

Release

OSNAP – MOORING LOGSHEET   **RECOVERY EB1** ✓

6 x 17" glass		small tangle on Glass	1002
248 m wire			
SBE37 SMP (5 m down wire)	13019 ╱		1002
4 x 17" glass			1013
Nortek on load bar	9881 ✓	⎫ Tangled.	
349 m wire		⎬	
SBE37 SMP (5 m down wire)	13020 ✓	⎭ Tangle cleared 1018	
SBE37 IMP (250 m down wire)	4463 ✓		1025
2 x 17" glass			
Nortek on load bar	11051 ╱		1030
Swivel			
138 m wire			
4 x 17" glass			
274 m wire			
SBE37 SMP (5 m down wire)	10321 ✓	13021	1033
Nortek on load bar	11069 ✓		1048
10 m wire			
SBE37 SMP (5 m down wire)	10322	13022	1049
5 m wire			
Swivel			
6 x 17" glass			1050
5 m chain			
A/R and	1766 ╱		
A/R and	1497 ╱		1053
SBE53 (BPR)	0035 ✓		
1.5 m chain			
Anchor – 1700 kg			

OSNAP – MOORING LOGSHEET

RECOVERY WB1

Cruise DY053

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

Release: Time: 13:53.05
Lat: 57° 28.384'N
Lon: 120 41.090'W
Depth: ~1653m

Anchor drop:

Date	22/06/2015	Time	1640
Latitude	57° 28.6068'N	Longitude	12° 41.5704'W
Depth	1608m		

SONSOD POSITION 57.4764, -12.6953

Date 04/07/2016

Start time R=13:53, Grappled = 14:24   End time 16:03

Latitude 57° 28.188'N   Longitude 12° 41.660'W

Depth 1615m

Item	S/N	Comments	Time
McLane 12"			
15 m poly prop			
4 x 17" glass			
Nortek on load bar	11055		14.35
145 m wire			
SBE37 SMP (5 m down wire)	8082		14:39
31" synt 1500 m and Iridium Beacon and Light	B11-036	JOLKIF	14:45
5m chain			
Swivel			
239 m wire			
SBE37 SMP (1 m down wire)	8443		14:49
40" synt 1500 m and Iridium beacon and Light	35	Light serial number B11-035 JOLNKE	14:58
5 m chain			
Nortek on load bar	11058		15.04
Swivel			
494 m wire			

E

OSNAP – MOORING LOGSHEET   **RECOVERY WB1**

SBE37 SMP (5 m down wire)	11321		15:06
SBE37 SMP (255 m down wire)	11323		15.14
5 x 17" glass		WIRE TANGLE BEFORE GLASS	
Nortek on load bar	11063		15.20
201 m wire			
SBE37 SMP (5 m down wire)	11324		15:20
4 x 17" glass		Tangle	15:48
Swivel			
143 m wire			
SBE37 SMP (47 m down wire)	11331		15:20
4 x 17" glass			15:45
Nortek on load bar	11064		15:45
215 m wire			
SBE37 SMP (149 m down wire)	11332		15.54
2 x 17" glass			
Nortek on load bar	11067		15:57
5 m wire			
SBE37 SMP (1 m down wire)	11333		15:57
10 m wire			
Swivel			
6 x 17" glass			16:02
5 m chain			
A/R and	1755		16:03
A/R and	1492		
SBE53 (BPR)	0013		
1.5 m chain			
Anchor – 1600 kg			

OSNAP – MOORING LOGSHEET

RECOVERY WB2

Cruise DY053

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

Anchor drop:

Date	22/06/2015	Time	0854
Latitude	57° 28.327'N	Longitude	12° 19.8726'N
Depth	1803m		

Mooring id Rockall Trough WB2

Release: 07:30:59   Range:1878   07:30:21
04/07/16   Release OK.

Position: 57° 28.078'N
          12° 19.322'E

SEABED POSITION   57.4707, -12.3312 (estimate)

GRAPPLED → Date __04/07/16__
Start time __08.18.25__
                57 28 38
Latitude ·57-28·07868
Depth __1806 m, (based on uncorr'd)__
        1805

End time __0852__
                       -12 23 28
Longitude -12 19·32+68

Item	S/N	Comments	Time
McLane 12"			
15 m poly prop			
McLane 3 sphere and iridium beacon and Light	II11-052 II11-028		0824
3 m chain		Tangled	
15 m poly prop			
4 x 17" glass	*		
Nortek on load bar	9822 ✓		0824
swivel			
343 m wire			
4 x 17" glass			0837
Nortek on load bar	9874 ✓		0837
411 m wire			
SBE37 SMP (224 m down wire)	3218 ✓		0843
2 x 17" glass			
Nortek on load bar	9885 ✓		0849
6 m wire			
SBE37 SMP (5 m down wire)	3481 ✓	Tangle with releases & photos	0852

OSNAP – MOORING LOGSHEET   **RECOVERY WB2**

Swivel			
5 x 17" glass			
A/R **and** A/R	1765 1142		0852
20 m chain			
Anchor – 500 kg			

OSNAP – MOORING LOGSHEET   RECOVERY RADCP1

Cruise DY053   **Mooring id Rockall Trough RADCP1**

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

Deployment:

Date	20/06/2015	Time	1633	
Latitude	57° 06.168'N	Longitude	9° 20.269'W	
Depth	745.5m			

Date 01/07/16

Start time 07:05   End time 09:45

Latitude 57° 06.147'N   Longitude 09° 19.780'W

Depth 699 m

Item	S/N	Comments	Time
Iridium beacon	unknown		
Light	C05-005		
A/R	1138		
A/R	1762		
Workhorse ADCP	22867		

SEABED LOCATION.
57 - 1040
- 9 - 3386

EAGO + ETT#0 off at ~07:05.
White Noise → power cable disconnected.
Shell noir → cable to transducer disconnected down below → Reconnected @ ~07:20

Diagnostics OK @ 07:25 → S/N 1138 1,045m , Hor, Vbatt = 8.6V
        S/N 1762 07:34 → 1046 m , Hor, Vbatt = 8.4V.

Release command sent to first A/R @ ~07:35, frame not ascending. Second A/R
released, shell not ascending.
Abandonned Recovery -

Continued overleaf ↗

Release of S/N 1762 @ 07:37:27 (command sent)
Reply 1048.1m @ 07:37:35
Release OK @ 07:37:45

Release S/N 1138:
Cmd sent 07:46:30/07:47:12
Reply 07:47:20
Release OK 07:47:30

Ranging:
Time	Range
07:38:45	1047.6 m.
39:15	1047.0
39:45	1047.9
40:15	1048.4
40:45	1047.8
41:15	1046.6
41:45	1046.5
42:15	1047.5
42:45	—
43:15	1049.1
43:45	
44:15	
44:45	
45:15	
45:45	
46:15	
46:45	
47:15	
47:45	
07:48:15	1046.7
48:45	1047.3
49:15	1048.0
49:45	1047.1
50:15	—
50:45	1046.8
51:15	—
51:45	
52:45	
53:45	
55:00	1047.9 m.
08 00	— ship relocated.
08 03 30	1071.2 m
05:00	1092.7 m
00:32	1345.3

Pos ? ①

② ③

Triangulation of mooring location:
appears to have moved ~0.5 nm
SE (along contour line).

Talked to A/R on 2nd Jul 16,
still there, same voltage, still
horizontal —

Ranging:
S/N	Range	Time
1138	809.5 m	13:00
1762	809 m	13:03

Ship location: 57° 05.787' N
9° 19.621' W

Ⓐ 57 06.174 } 715 m.
09 19.949 }

↳ See page ② for next triangulation pos.

(A) 57° 06.174   1071.2   Depth: 715 m
    9° 19.949   1072.7

(B) 57° 06.221   1801
    9° 19.632   1183.5

    57° 06.2475   1345.3   Depth 642.9 m
    9° 19.34145   1345.9
                  1346.2
    57.10144
    -9. 14540
       .3224
(C) 57° 05.81580 1204.6   Depth 875.6
    9° 20.25972   1201.9
    57. 0969   1204.1
    -9. 3482

(D) 57° 074476   2078.8   Depth 712 m
    9° 20.675242 # She release
                  2077.8
    57. 011125   2075.6
    -9. 3413   2075.4

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TRIANGULATION   RTADCP 1
   01 - Jul - 16   Page (2)

A.5 UK Mooring Deployment Logsheets

OSNAP – MOORING LOGSHEET   DEPLOYMENT EB1

Cruise DY053   **Mooring id   Rockall Trough**
EB1
[NB all times recorded in GMT, all dates dd/mm/yyyy]

Date _03/07/2016_   Site arrival time _____

Setup distance _2nm_

Start time _12:58_   End time _14:59_

Start position:

Latitude _57° 06.016'N_   Longitude _9° 30.157'W_

Item	S/N	Comments	Time
McLane 12"	/		
15 m polyprop	/		
3 x 17" glass	/		
Nortek on load bar	9867		12:59
141 m wire	/		
SBE37 SMP (1 m down wire)	9140		13:00
31" syn 1500 m and Iridium beacon and Light	/ ? ?	~~beacon~~ JØIKMN	13,2
3m chain	/		
swivel	/		
Nortek on load bar	11035		1313
241 m wire	/		
SBE37 SMP (5 m down wire)	10558		1313
40" synt 1500 m and Iridium beacon and Light	/ ? ?	~~beacon~~ JØINKJ	13.25
3m chain	/		
Swivel	/		
Nortek on load bar	11048		1325
243 m wire	/		
SBE37 SMP (5 m down wire)	10559		1325
6 x 17" glass	/		1336
248 m wire	/		
SBE37 SMP (5 m down wire)	10562		13:38

OSNAP – MOORING LOGSHEET   **DEPLOYMENT EB1**

4 x 17" glass	/		1348
Nortek on load bar	13130		1348
349 m wire	/		
SBE37 SMP (5 m down wire)	9113		1350
SBE37 SMP (250 m down wire)	11329		1400
2 x 17" glass	/		1403
Nortek on load bar	13142		1403
Swivel	/		
138 m wire	/		
4 x 17" glass	/		1409
274 m wire	/		
SBE37 SMP (5 m down wire)	11337		1411
Nortek on load bar	9868		1421
10 m wire	/		
SBE37 SMP (5 m down wire)	11339		1423
5 m wire	/		∪
Swivel	/		
8 x 17" glass	/	(6 x 17" glass + shac - link - shac + 2 x 17 glass)	1421
5 m chain	/		
A/R and	1761		
A/R and	1764		14:58
SBE53 (BPR)	0433	Not deployed	
1.5 m chain	/		
Anchor – 1700 kg	/		14:58

Anchor drop position: 14:58:27

Latitude 57° 05.99' N   Longitude 9° 33.92' W

Uncorrected water depth (at anchor launch) 1813 m

Corrected water depth (at anchor launch) _____

Comments to be written overleaf

After trilateration

Seabed 57.1014   Fallback 251m
        -9.5623
        57° 06.24' N
        9° 33.738' W

OSNAP – MOORING LOGSHEET

DEPLOYMENT WB1

Cruise DY053
WB1

Mooring id   Rockall Trough

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

Date 04/07/16

Site arrival time ⱱ16.55

Setup distance 1.5 nm

Start time 16:57

End time

Start position:

Latitude 57°26.908'N

Longitude 12° 41.581'W

Item	S/N	Comments	Time
McLane 12"	/		
15 m poly prop	/		
4 x 17" glass	/		
Nortek on load bar	8365		16:58
145 m wire	/		
SBE37 SMP (5 m down wire)	9141		16.58
31" synt 1500 m and Iridium Beacon and Light	/ ✗ JØIKIF ?		17:07
5m chain	/		
Swivel	/		
239 m wire	/		̶1̶7̶:̶0̶7̶
SBE37 SMP (1 m down wire)	14355		17:07
40" synt 1500 m and Iridium beacon and Light	/ ✗ JØINKE ?		
5 m chain	/		
Nortek on load bar	11051		17:18
Swivel	/		
494 m wire	/		
SBE37 SMP (5 m down wire)	14356		17:18
SBE37 SMP (255 m down wire)	14364		ⱱ17:25
5 x 17" glass	/		
Nortek on load bar	11069		17.34
201 m wire	/		

OSNAP – MOORING LOGSHEET   DEPLOYMENT WB1

SBE37 SMP (5 m down wire)	14365			17:36
4 x 17" glass	/			
Swivel	/			
143 m wire	/			
SBE37 SMP (48 m down wire) → unsure, looks a bit flooded maybe? TBC at recovery.	14366	Probably ok		17:45
4 x 17" glass	/			
Nortek on load bar	11046			17:50
215 m wire	/			
SBE37 SMP (149 m down wire)	14367			~17:55
2 x 17" glass	/			
Nortek on load bar	13018			~18:03
5 m wire	/			
SBE37 SMP (1 m down wire) ~1.5m down wire (no mark)	14368			~18:05
10 m wire	/			
Swivel	/			
8 x 17" glass	/			
3 m chain	/			
A/R and	1272			
A/R and	1753			
SBE53 (BPR)	0431 0435			
1.5 m chain	/			
Anchor – 1600 kg	/			

Anchor drop position: Time 18.41.45

Latitude 57°28.26N / 57,4710 N   Longitude 12°42.65 W / 12,7108 W

Uncorrected water depth (at anchor launch) 1590,1

Corrected water depth (at anchor launch) 1585,1

Comments to be written below or overleaf

Anchor seabed
57° 28.194' N
12° 42.648' W

OSNAP – MOORING LOGSHEET   DEPLOYMENT WB2

Cruise DY053   Mooring id   Rockall Trough
WB2
[NB all times recorded in GMT, all dates dd/mm/yyyy]

Date ___ 04/07/16 ___   Site arrival time _____

Setup distance ___ 1·5 ___
Start time ___ 09: 52: 48 ___   End time __ 11:13.33 _____

Start position:

Latitude ___ 57.4584 ___   Longitude ___ -12.2631 ___

Item	S/N	Comments	Time
McLane 12"	/		
15 m poly prop	/		
Billings 3 sphere and Iridium beacon and Light	?Spine? ?Bi!???	Tube runno from Recovered.	0953
1 m chain	/		
4 x 17" glass	/		
Nortek on load bar	9881		0954
swivel	/		
343 m wire	/		
4 x 17" glass	/		
Nortek on load bar	9861		1007
411 m wire	/		
SBE37 SMP (224 m down wire)	14353		
2 x 17" glass	/		
Nortek on load bar	9877		1020
6 m wire	/		
SBE37 SMP (4 m down wire)	14354	Next year put the microcat 2 m down the wire (see note)	1022
Swivel	/	Swivel after the 5 floats	
5 x 17" glass	/		1027
A/R and A/R	1754 1757	2m of chain top of the ARs	1032
20 m chain	/		
Anchor – 500 kg	/		

Anchor drop position:
11:13:33

OSNAP – MOORING LOGSHEET   **DEPLOYMENT WB2**

Latitude ___57.4707___   Longitude ___-12.3120___
Uncorrected water depth (at anchor launch) ___1805.4___
Corrected water depth (at anchor launch) ___1798.4___

Comments to be written below or overleaf

Trilateration : Anchor Seabed
      57.6679 N   Fall back 311m
     -12.3122 W

    57° 28.074' N
    12° 18.732' W

OSNAP – MOORING LOGSHEET   DEPLOYMENT RADCP1

Cruise DY053   **Mooring id   Rockall Trough RADCP1**
[NB all times recorded in GMT, all dates dd/mm/yyyy]

Date _Sunday 3/7/16 DOY 161_   Site arrival time _0530 GMT_
Setup distance _0_
Start time _~06.00_   End time _06.07_
Start position:
Latitude _____/_____   Longitude _____/_____

Item	S/N	Comments	Time
Iridium beacon	M019A2		
Light	D01-008		
Nortek S55 ADCP	200044		
A/R	1502		
A/R	1763		

Anchor drop position: _06:08:52_
Latitude _57° 05.86'N_   Longitude _9° 21.34'L_
Uncorrected water depth (at anchor launch) _945m_
Corrected water depth (at anchor launch) _____

Comments to be written below or overleaf

```
        S/N      ARM      DIAG
A/R    1763     IA12     IA49
       1502     0900
```

0555 : Lights & Iridium on, panels screwed into place,
using post pedestal.
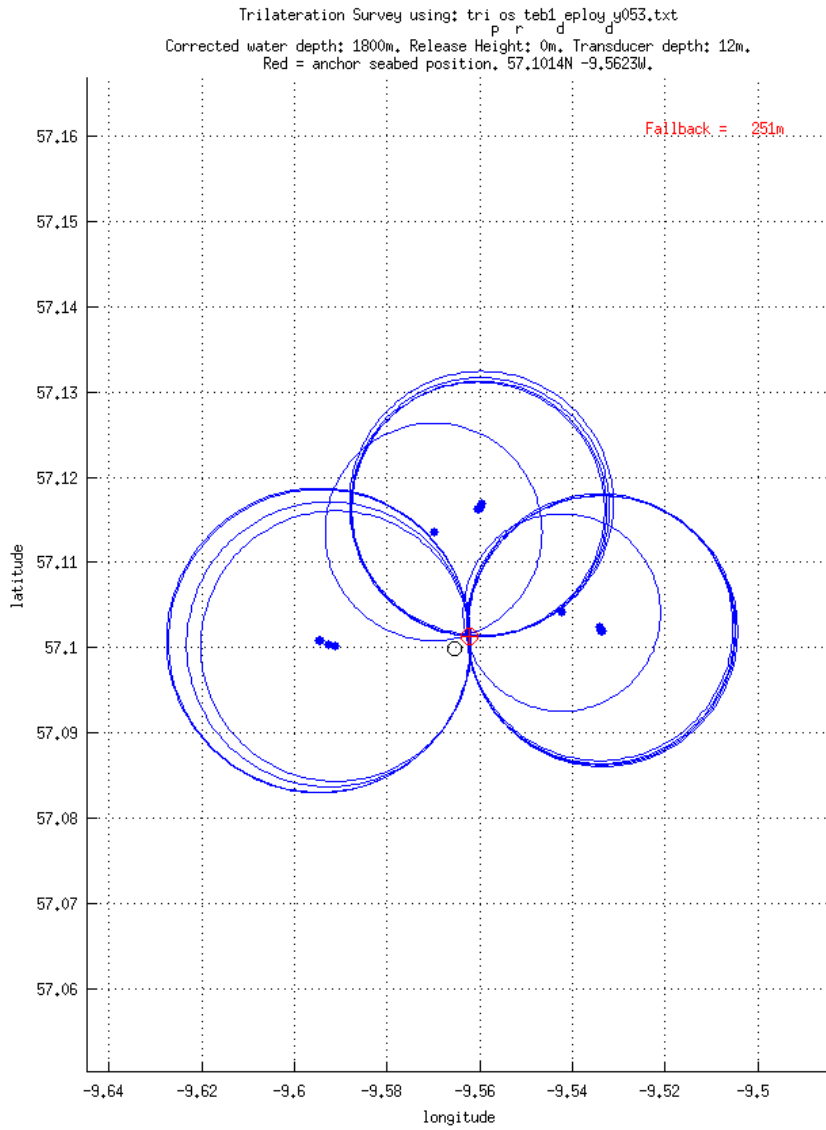
A.6 Trilateration

Trilateration Survey using: tri_os_teb1_eploy_y053.txt
p r d d
Corrected water depth: 1800m. Release Height: 0m. Transducer depth: 12m.
Red = anchor seabed position. 57.1014N -9.5623W.

Trilateration Survey using: tri_os_twb1_eploy_y053.txt
Corrected water depth: 1585m. Release Height: 5m. Transducer depth: 7m.
Red = anchor seabed position. 57.4699N -12.7108W.

Fallback = 125m
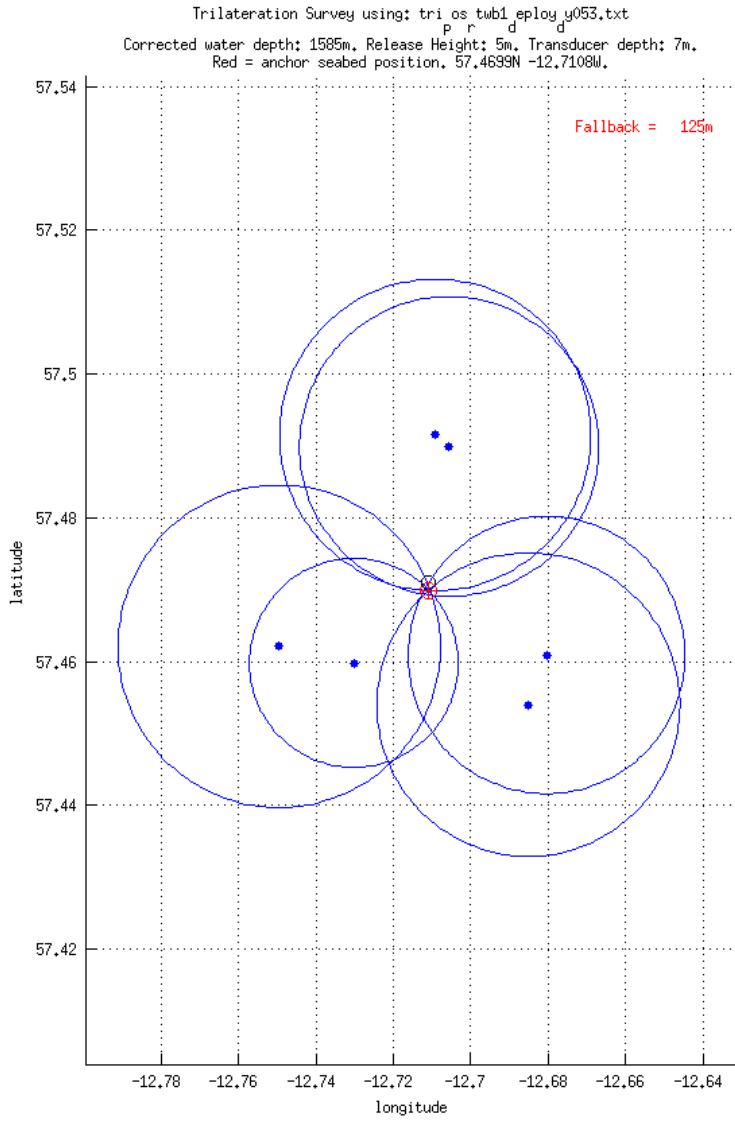
Trilateration Survey using: tri_os_twb2_eploy_y053.txt
p r d d
Corrected water depth: 1799.4m. Release Height: 20m. Transducer depth: 7m.
Red = anchor seabed position. 57.4679N -12.3122W.

Fallback =   311m

Trilateration Survey using: tri_os_tadcp1_eploy_y053.tx
p   r   d   d
Corrected water depth: 950m. Release Height: 0m. Transducer depth: 12m.
Red = anchor seabed position. 57.0983N -9.3551W.

Fallback =   87m
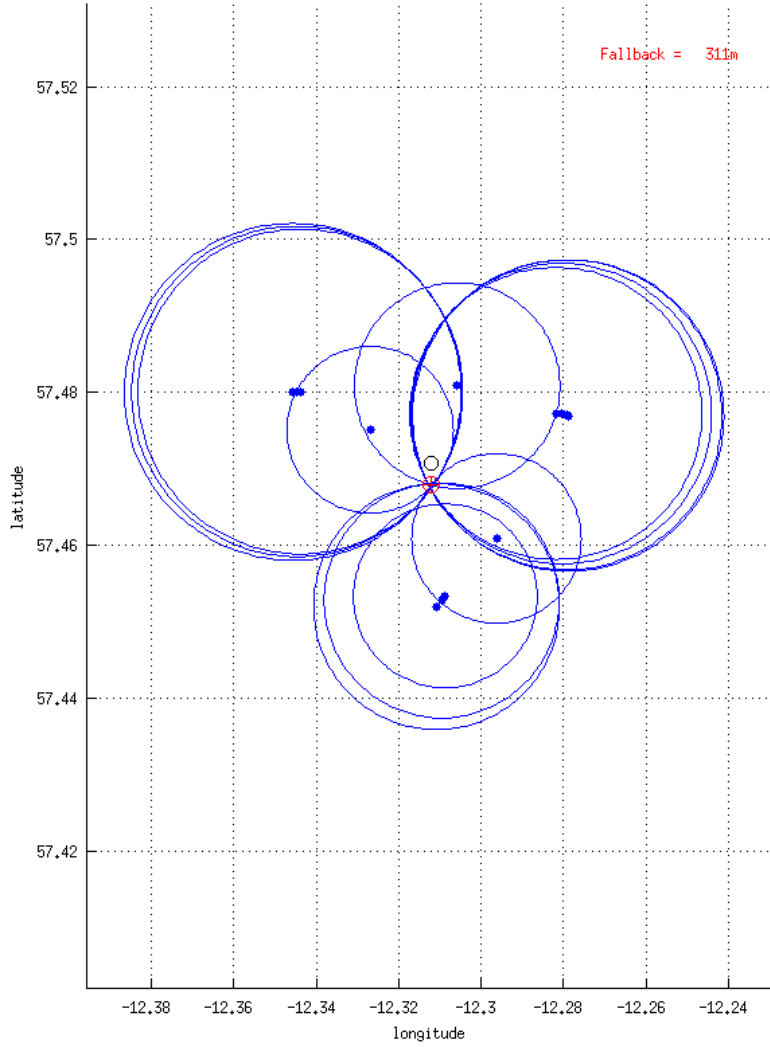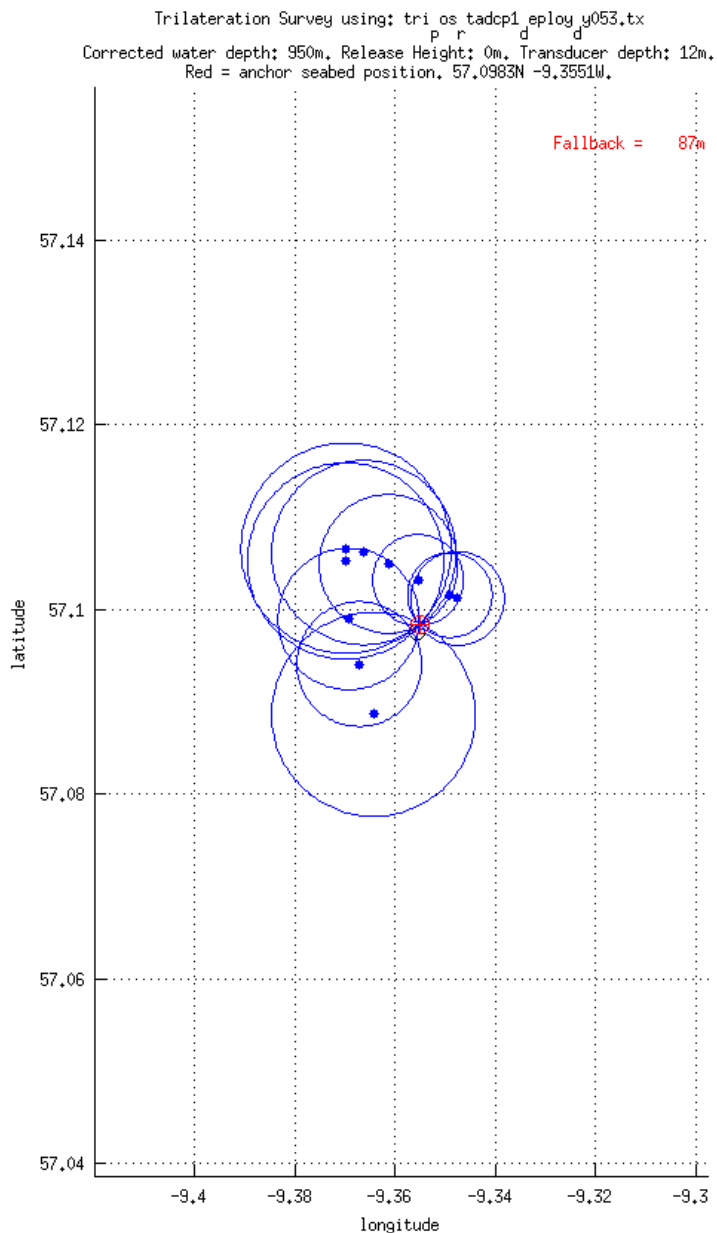
A.7   Configuration files

A.7.1   CTD

Date: 06/29/2016
Instrument configuration file: C:\Users\sandm\Documents\Cruises\DY053\Data\Seasave Setup Files\DY053_0803_SS.xmlcon
Configuration report for SBE 911plus/917plus CTD
--
Frequency channels suppressed : 0
Voltage words suppressed   : 0
Computer interface   : RS-232C
Deck unit   : SBE11plus Firmware Version >= 5.0
Scans to average   : 1
NMEA position data added   : Yes
NMEA depth data added   : No
NMEA time added   : Yes
NMEA device connected to   : PC
Surface PAR voltage added   : No
Scan time added   : Yes

1) Frequency 0, Temperature
  Serial number : 03P-4381
  Calibrated on : 21 July 2015
  G   : 4.42359050e-003
  H   : 6.44917114e-004
  I   : 2.26674159e-005
  J   : 1.97655514e-006
  F0   : 1000.000
  Slope   : 1.00000000
  Offset   : 0.0000

2) Frequency 1, Conductivity
  Serial number : 04C-3054
  Calibrated on : 16 June 2015
  G   : -9.80759366e+000
  H   : 1.42268693e+000
  I   : -2.32442769e-004
  J   : 8.20502779e-005
  CTcor   : 3.2500e-006
  CPcor   : -9.57000000e-008
  Slope   : 1.00000000
  Offset   : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC
  Serial number : 93896
  Calibrated on : 9 July 2014
  C1   : -8.331332e+004
  C2   : -3.281962e+000
  C3   : 2.216060e-002
  D1   : 2.906000e-002
  D2   : 0.000000e+000
  T1   : 3.005232e+001

      T2   : -3.843669e-004
      T3   : 4.436390e-006
      T4   : 0.000000e+000
      T5   : 0.000000e+000
      Slope   : 1.00001000
      Offset   : -1.35810
      AD590M   : 1.289250e-002
      AD590B   : -8.106440e+000

4) Frequency 3, Temperature, 2
   Serial number : 03P-4712
   Calibrated on : 21 July 2015
   G   : 4.40403756e-003
   H   : 6.33214711e-004
   I   : 1.90723282e-005
   J   : 1.14981012e-006
   F0   : 1000.000
   Slope   : 1.00000000
   Offset   : 0.0000

5) Frequency 4, Conductivity, 2
   Serial number : 04C-3529
   Calibrated on : 21 July 2015
   G   : -9.91877058e+000
   H   : 1.57004159e+000
   I   : -2.20163146e-003
   J   : 2.65000201e-004
   CTcor   : 3.2500e-006
   CPcor   : -9.57000000e-008
   Slope   : 1.00000000
   Offset   : 0.00000

6) A/D voltage 0, Oxygen, SBE 43
   Serial number : 43-2575
   Calibrated on : 31 July 2015
   Equation   : Sea-Bird
   Soc   : 4.41200e-001
   Offset   : -4.67000e-001
   A   : -4.32580e-003
   B   : 2.14910e-004
   C   : -2.87190e-006
   E   : 3.60000e-002
   Tau20   : 1.00000e+000
   D1   : 1.92634e-004
   D2   : -4.64803e-002
   H1   : -3.30000e-002
   H2   : 5.00000e+003
   H3   : 1.45000e+003

7) A/D voltage 1, Free

8) A/D voltage 2, Free

9) A/D voltage 3, Altimeter

Serial number : 59494
Calibrated on : 29 November 2012
Scale factor : 15.000
Offset   : 0.000

10) A/D voltage 4, Free

11) A/D voltage 5, Free

12) A/D voltage 6, Transmissometer, WET Labs C-Star
Serial number : CST-1759TR
Calibrated on : 22 December 2015
M   : 21.3083
B   : -0.1705
Path length   : 0.250

13) A/D voltage 7, Fluorometer, Chelsea Aqua 3
Serial number : 088244
Calibrated on : 6 August 2014
VB   : 0.236800
V1   : 2.151000
Vacetone   : 0.305900
Scale factor : 1.000000
Slope   : 1.000000
Offset   : 0.000000
Scan length   : 45

A.7.2 LADCP

```
;slave WH300 LADCP for OSNAP June 2016
;modified EX from 11111 to 00100
; removed commands already set by default
; 6/29/2016 AEH
;
WV250                    ; ambiguity velocity [cm/s]
WN25                     ; number of depth cells; NBP0402
WS1000                     ; bin size [cm]; NBP0402: WS1000
WF800                    ; blank after transmit [cm]; NBP0402
WB1                        ; narrow bandwidth mode
EZ0011101                ; Sensor source: (NBP0402: EZ0111111)
EX00100                    ; coordinate transformation: (NBP0402: 11111)
WP1          ; single-ping ensembles; NBP0402: WP3 most of the time
TP 00:00.00      ; time between pings; NBP0402
TE 00:00:01.50    ; time per ensemble
CF11101                    ; Flow control:
SM2                        ; set to slave
SA011        ; waits for pulse before ensemble
ST120                    ; waits 120s for ma-signal before running single^M
RNslav_
CK                         ; keep params as user defaults (across power failures)
W?
T?
CS                          ; start pinging
```

```
; master WH300 LADCP for OSNAP June 2016
; modified EX from 11111 to 00100
; removed commands already set by default
; 6/29/2016 AEH
;
WV250                    ; ambiguity velocity [cm/s]
WN25                     ; number of depth cells; NBP0402
WS1000                        ; bin size [cm]; NBP0402: WS1000
WF0                      ; blank after transmit [cm]; NBP0402
WB1                      ; narrow bandwidth mode
EZ0011101                ; Sensor source: (NBP0402: EZ0111111)
EX00100                  ; coordinate transformation: (NBP0402: 11111)
WP1           ; single-ping ensembles; NBP0402: WP3 most of the time
TP 00:00.90              ; time between pings; NBP0402
TE 00:00:01.50           ; time per ensemble
CF11101                  ; Flow control:
SM1          ; set to master
SA011        ; send pulse before ensemble
SW5500       ; master waits .5500 s after sending sync pulse
RNmast_
CK                       ; keep params as user defaults (across power failures)
W?
T?
CS                       ; start pinging
```

A.7.3   SAMS mooring

S55

Instrument type: Nortek S55
Mooring: RTADCP1
Serial number(s):   200044
Start date & time: 02 Jul 2016 14:20:00

Setup: ADCP1_DY053.deploy

DeployFileVersion: 2,84bd4aba6f5914c447aa7762edcc129f
SWSource: "Deployment-v3.4.4.0"
InstrumentId: {"InstrumentType":"Signature55","HeadFrequency":55,"FWVersion":"2195.1"}
DeploymentName: "ADCP1_DY053"

ApplicationConfig:
[{"Enabled":true,
"Application":"AvgCoarse",
"Mounting":"Fixedframe",
"Orientation":"UpLooking",
"Geography":"OpenOcean",
"SoundVelocity":"Fixed",
"SoundVelocityValue":1500.0,

"Salinity":35.0,
"StrongWaves":false,
"InstrumentDepth":1000.0,
"TidalRange":1.0}
 {"Enabled":false,
"Application":"None",
"Mounting":"Fixedframe",
"Orientation":"UpLooking",
"Geography":"OpenOcean",
"SoundVelocity":"Fixed",
"SoundVelocityValue":1500.0,
"Salinity":35.0,
"StrongWaves":false,
"InstrumentDepth":1000.0,
"TidalRange":1.0}]
AlternatingRatio:[3,1]

DeploymentConfigExtensions:
 [{"AvgDesiredRange":1000.0,
"BurstDesiredRange":1000.0,
"AvgEndProfile":1100.0,
"BurstEndProfile":1100.0,
"AIStep":6,
"RangeStep":1.0,
"BurstMeasurementContinuous":false,
"AvgMeasurementLoad":100.0,
"AvgAutoMeasurementLoad":true,
"AvgMeasurementLoadTick":5.0,
"BurstMeasurementLoad":100.0,
"BurstAutoMeasurementLoad":true,
"BurstMeasurementLoadTick":1.0},
 {"AvgDesiredRange":1000.0,
"BurstDesiredRange":1000.0,
"AvgEndProfile":1100.0,
"BurstEndProfile":1100.0,
"AIStep":1,
"RangeStep":0.1,
"BurstMeasurementContinuous":false,
"AvgMeasurementLoad":100.0,
"AvgAutoMeasurementLoad":true,
"AvgMeasurementLoadTick":1.0,
"BurstMeasurementLoad":100.0,
"BurstAutoMeasurementLoad":true,
"BurstMeasurementLoadTick":1.0}]
BatteryItem,null
BatteryCombo:
{"InternalBattery":{"Name":"None 0Wh","Volume":0.0,"Voltage":0.0},
 "ExternalBattery":{"Name":"Lithium 3600Wh","Volume":3600.0,"Voltage":18.0},
 "Volume":3600.0,"Voltage":18.0}

RecorderItem,{"Name":"16 GB","Capacity":16000000000}

DeploymentDays,400

SETDEFAULT,ALL
SETPLAN,MIAVG=1200,AVG=1,DIAVG=0,VD=0,MV=10,SA=35,BURST=0,MIBURST=120,DIBURST=0,S
V=0,FN="ADCP1_DY053.ad2cp",SO=0,FREQ=55
SETAVG,NC=68,CS=16,BD=2,CY="ENU",PL=-
2,AI=120,VR=1,DF=3,NPING=20,NB=3,CH=0,MUX=1,BW="NARROW",ALTI=0,BT=0,ICE=0,ALTISTAR
T=2,ALTIEND=150
SETTMAVG,EN=0,CD=1,PD=1,AVG=120,TV=1,TA=1,TC=1,CY="ENU",FO=0,SO=1,DF=100
SAVE,ALL

Note: parameters in grey apply to the fine profiling, which was disabled on this deployment.

	Coarse profile
Performance	
Configured length (days)	400
Estimated max length (days)	421.1
Battery capacity (Wh)	3600
Power usage (Wh)	3419.7
Recorder free space (MB)	14844.3
Memory usage (MB)	495.5
Data sampling	
Power level (dB)	-2
Long range mode	ON
Multiplexing	ON
Number of pings	20
Slanted beams	
Horizontal prec. (cm/s)	2.09
Vertical prec. (cm/s)	0.54
Velocity range (m/s)	1
Measurement range	
Desired range (m)	1000
Configured range (m)	1090
Estimated range (m)	1001.8
Blanking distance (m)	2
Cell size	16
Number of cells	68
Number of beams	3
Altimeter	OFF
Ice drift	OFF
Sampling rate	
Measurement interval	00:20:00
Average interval	00:02:00

Deployment name: ADCP1_DY053

Deployment time: ☑ Now 2016-07-02 14:03:34

☑ Synchronize clock to PC time   LED   On for 24 hours

S55 configuration and estimated performance at deployment

Nortek Aquadopp

Instrument type: *Nortek Aquadopp*
Mooring(s):   *RTEB1, RTWB1, RTWB2*
Serial number(s):   **RTEB1** *= 9867, 9868, 11035, 11048, 13130, 13142*
RTWB1 = *8365, 11046, 11051, 11069, 13018*
                 RTWB2 = *9861, 9877, 9881*
Start date & time: **RTEB1** *= 01 Jul 2016 14:00:00*
                 RTWB1 = *03 Jul 2016 19:00:00 or 20:00:00*
                 RTWB2 = *03 Jul 2016 19:00:00*
Setup: *.log files (example from Aquadopp S/N 9861)*

```
========================================================
Deployment   : 9861
Current time : 03/07/2016 18:33:42
Start at     : 03/07/2016 19:00:00
Comment:  wb2_dy053_2016
Measurement interval  (s) : 1200
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) : 400.0
Battery utilization   (%) : 64.0
Battery level       (V) : 14.8
Recorder size      (MB) : 9
Recorder free space  (MB) : 8.973
Memory required     (MB) : 1.8
Vertical vel. prec (cm/s) : 1.4
Horizon. vel. prec (cm/s) : 0.9
--------------------------------------------------------
Instrument ID        : AQD 9861
Head ID           : A6L 5302
Firmware version       : 3.37
--------------------------------------------------------
Aquadopp Deep Water Version 1.40.14
Copyright (C) Nortek AS
========================================================
```

DY053 Cruise Report [Configuration files]

Microcat

Instrument type: *SeaBird SBE37 'Microcat'*
Mooring(s):   *RTEB1, RTWB1, RTWB2*
Serial number(s):   **RTEB1**   = *9113, 9140, 10558, 10559, 10562, 11329, 11337, 11339*
RTWB1 = *9141, 14355, 14356, 14364, 14365, 14366, 14367, 14368*
          RTWB2 = *14353, 14354*
Start date & time: **RTEB1**   = *03 Jul 2016 12:00:00*
          RTWB1 = *04 Jul 2016 15:00:00*
          RTWB2 = *04 Jul 2016 09:00:00*

Setup:
Sample interval   =   1800 seconds
Data format   =   converted engineering alternate
Transmit real-time =   no

.cap file example from Microcat S/N 10558:
S>OutputExecutedTag=n
S>Outputformat=3
S>DS
SBE37SM-RS232 v4.1 SERIAL NO. 10558 03 Jul 2016 06:43:08
vMain = 13.51, vLith = 3.11
samplenumber = 1146, free = 558094
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 = 3101.5
S>Datetime=07032016064314
S>SAMPLENUMBER=0
this command will modify memory pointers
repeat the command to confirm
SAMPLENUMBER=0
S>OUTPUTSAL=N
S>SAMPLEINTERVAL=3600
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>STARTDATETIME=07032016120000
<start dateTime = 03 Jul 2016 12:00:00/>
S>STARTLATER
<!--start logging at = 03 Jul 2016 12:00:00, sample interval = 1800 seconds-->
S>DS
SBE37SM-RS232 v4.1 SERIAL NO. 10558 03 Jul 2016 06:44:20
vMain = 13.49, vLith = 3.11
samplenumber = 0, free = 559240
not logging, waiting to start at 03 Jul 2016 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 = 3101.5