Scottish Association for Marine Science

Cruise Report No. ##
RRS Discovery Cruise DY120
8th October to 24th October 2020

Climate Linked Atlantic Sector Science & Overturning in the Subpolar North Atlantic Programme

Cruise Report No. ## for *RRS Discovery* Cruise DY120

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Editor: Stuart Cunningham

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ABSTRACT

Depart Southampton, Empress Dock Thursday 8th October. Steamed west along the English Channel, through the Irish Sea, passing Mull of Kintyre arriving at the eastern most mooring EB1 west of the Outer Hebrides. We then worked moorings westward to mooring IB3 in the central Iceland Basin, finally steaming to the Wville Thomson Ridge for a sediment trap mooring refurbishment (DMLTM). We then steamed to Dunstaffnage Castle where the scientific party disembarked by small boat transfer.
This cruise is the final cruise of four cruises in 2020 to recovery and redeploy all moorings in the OSNAP array, with the next planned mooring refurbishment in 2022.

The specific measurement objectives of the cruise were:

1. Recover and redeploy six existing moorings (RTEB1, RTWB2, RTWB1, IB5, IB4, IB3).
2. Deploy a new mooring RH ADCP to monitor a jet of the North Atlantic Current west of Rockall Bank.
3. Conduct CTD stations and capture water samples for oxygen, total carbon, alkalinity and nutrients analysis. Data from the CTD stations was provided in near-real time (<12 hours) to the UK Met. Office to be assimilated into their short-range ocean forecast models: global 0.25 degree, North Atlantic 1/12th degree and AMM15 (European NW Shelf, ~ 1.5 km).
4. Deploy ARGO floats to maintain the UK contribution to the global ARGO network.
5. Recover and redeploy a sediment trap mooring on the Darwin Sea Mounds (DMLTM) as part of the UK Marine Protected Area habitat monitoring programme. Data from this mooring was secured but not processed on this cruise.
6. Using ship-based instrumentation to measure underway meteorology, sea-surface temperature and salinity, ocean currents from the surface to ~400m depth and water-depth using a Kongsberg multibeam echo sounding system.

ISSUING ORGANISATION Scottish Association for Marine Science (SAMS)

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3 Scientific and Ship's Personnel

Table 3.1: Scientific and Ship's Personnel.

	Family Name	Given Names	Rank	Institute
1	GATTI	ANTONIO	Master	NOC
2	OVENDEN	ROBERT JOHN	C/O	NOC
3	STRINGFELLOW	GRAHAM ROBERT	2/O	NOC
4	ASTELL	RACHEL KATHLEEN	3/O	NOC
5	BILLS	JAMES	C/E	NOC
6	KEMP	CHRISTOPHER MARTIN	2/E	NOC
7	EVANS	DANIEL CHRISTOPHER	3/E	NOC
8	ROONEY	SEAN ROBERT	3/E	NOC
9	BRAZIER	THOMAS	ETO	NOC
10	FORBES-SIMPSON	VALERIJA	Purser	NOC
11	MACLEAN	ANDREW	CPOD	NOC
12	LAPSLEY	CRAIG JAMES	CPOS	NOC
13	MACKINNON	MARSHALL	POD	NOC
14	GILFILLAN	CRAIG ROSS	POS	NOC
15	DEVITT	CHRISTOPHER GERARD	SG1A	NOC
16	MCMASTER	COLIN	SG1A	NOC
17	WILLIAMS	EMLYN GORDON	ERPO	NOC
18	ASHFIELD	MARK JAMES	H/Chef	NOC
19	PIPER	CARL	Stwd	NOC
20	WILLIAMS	DENZIL	A/Stwd	NOC
21	CUNNINGHAM	STUART ANDREW	PI	SAMS
22	JONES	SAM CHARLES	Scientist	SAMS
23	HOUPERT	LOÏC	Scientist	NOC
24	DRYSDALE	LEWIS ANTHONY	Tech	SAMS
25	BURMEISTER	KRISTIN	Scientist	SAMS
26	DUMONT	ESTELLE	Tech	SAMS
27	REED	SARAH	Scientist	SAMS
28	NEMETH	ZOLTAN	Tech	NOC
29	ROBERTS	THOMAS	Tech	NOC
30	PHIPPS	RICHARD ANTHONY	Tech	NOC
31	PLATT	WILLIAM ROBERT	Tech	NOC
32	CHILDS	DAVID MATTHEW	Tech	NOC
33	POWELL	TIMOTHY DAVID	Tech	NOC
34	TWIGGE	OLIVER	Tech	NOC

Cruise Manager: Jon Short, National Marine Facilities.

Dr Clare Johnson from home, supported the day-to-day science programme, analysing data for quality assurance in real time. Richard Abell (SAMS) helped prepared the chemistry programme prior to sailing. Special thanks also to Richard Abell (SAMS) and Marillena Oltmans (NOC) who both completed their ENG1, PST and pre-cruise COVID testing and isolation so they could substitute into the cruise at the last minute if required.

3.1 PHOTO 1: Scientific Team

Photo 3.1: Left to Right: Lewis Drysdale, Estelle Dumont, Kristin Burmeister, Stuart Cunningham, Sarah Reed, Sam Jones, Loïc Houpert.

4 Itinerary

Depart Southampton, Empress Dock Thursday 8th October. Steamed west along the English Channel, through the Irish Sea, passing Mull of Kintyre arriving at the eastern most mooring EB1 west of the Outer Hebrides. We then worked moorings westward to mooring IB3 in the central Iceland Basin, finally steaming to the Wville Thomson Ridge for a sediment trap mooring refurbishment (DMLTM). We then steamed to Dunstaffnage Castle, Ardmuknish Bay where the scientific party disembarked by small boat transfer.

4.1 Cruise Track

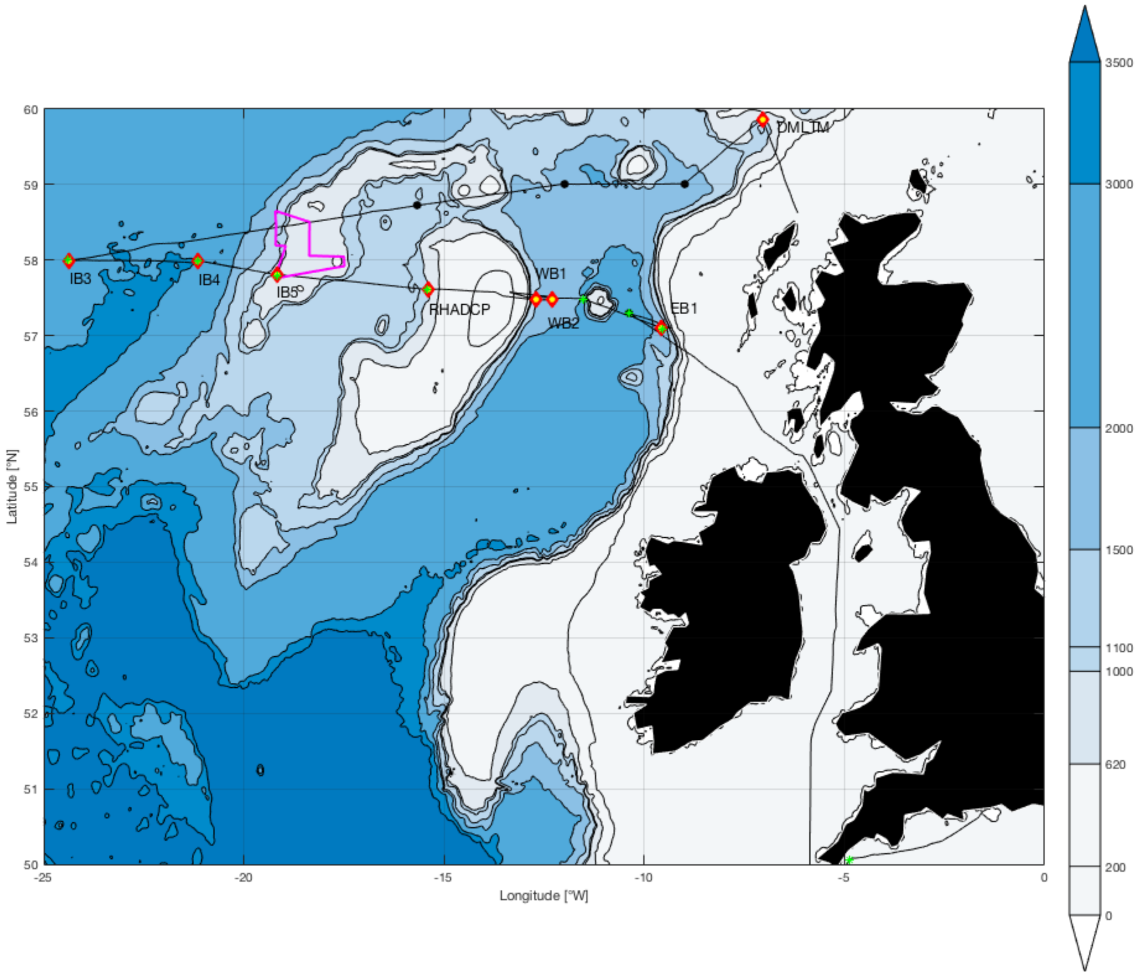


Figure 4.1: DY120 Cruise Track (black line), Mooring Positions (red diamond/yellow dot), Argo deployments (black dot). A limited number of CTD stations were conducted mainly close to moorings (green Asterix). In magenta the Hatton Bank region of Special Scientific Conservation is shown.

5 Introduction

This cruise contributes to the International Overturning in the Subpolar North Atlantic Programme (OSNAP, http://o-snap.org/), Figure 5.1. OSNAP began in 2014, with the aim of continuously measuring the strength and structure of the subpolar North Atlantic circulation between Newfoundland and Scotland using a purposefully designed mooring array. The array is supplemented by Seaglider missions and makes use of data from a number of measurement programmes such as Argo and satellite measured sea-surface heights.

Using these measurements, the OSNAP programme can quantify the strength of the Atlantic meridional overturning circulation and associated transports of energy and elements (fresh-water, carbon, nutrients). The AMOC is a major component of Earth's climate system and has been predicted to slow in 21st Century under the influence of global warming. Such a slowing represents a major shift in Earth's climate. Severe impacts throughout the North Hemisphere are expected on sea-levels, rainfall patterns, temperatures, sea-ice distribution, atmospheric weather patterns and agricultural productivity. It is considered vital to obtain a better understanding of the dynamics and variability inherent in this system and provide the data necessary for building confidence in predictions of climate evolution in the 21st Century.

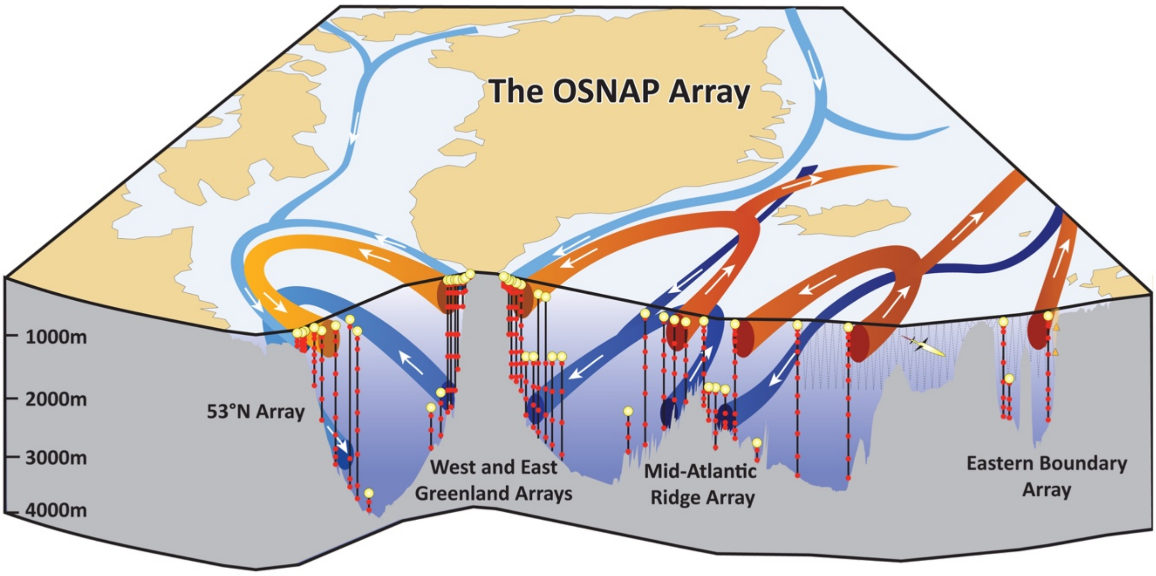


Figure 5.1: A schematic of the Overturning in the Subpolar North Atlantic Program Array. Warm currents in the upper one kilometre which flow north from the Gulf Stream and North Atlantic Current are shown in red. The warm water is made colder as it flows round the subpolar gyre and in the Nordic and Labrador Seas east and west of Greenland. The cold waters in blue return southward to the global ocean at depths of one to four kilometers. This is the overturning circulation. To continuously monitor the strength and structure of all these currents an array of moorings is continuously deployed between Newfoundland and West Greenland and East Greenland and Scotland. A mooring is a wire (black) from the seabed to just below the surface and is held taught and vertical by syntactic foam and glass buoyancy (yellow blob). Instruments such as current meters, and temperature and salinity sensors are fixed to the wires (red blobs). Every two years, over a period of three summer months all the moorings are recovered during research expeditions. The data from the instruments can be downloaded for analysis We then deploy new moorings and instruments for another two years. In the Eastern Boundary Array autonomous gliders (yellow vehicle with black wings), patrol regions where it is difficult to install moorings safely (mainly due to fishing). Gliders have an endurance of six to eight months and are deployed and piloted by the Scottish Association for Marine Science.

5.1 Cruise Objectives

This cruise is the final cruise of four cruises to recovery and redeploy all moorings in the OSNAP array, with the next planned mooring refurbishment in 2022.

The specific measurement objectives of the cruise were:

7. Recover and redeploy six existing moorings (RTEB1, RTWB2, RTWB1, IB5, IB4, IB3).
8. Deploy a new mooring RH ADCP to monitor a jet of the North Atlantic Current west of Rockall Bank.
9. Conduct CTD stations and capture water samples for oxygen, total carbon, alkalinity and nutrients analysis. Data from the CTD stations was provided in near-real time

(<12 hours) to the UK Met. Office to be assimilated into their short-range ocean forecast models: global 0.25 degree, North Atlantic 1/12th degree and AMM15 (European NW Shelf, ~ 1.5 km).

10. Deploy ARGO floats to maintain the UK contribution to the global ARGO network.
11. Recover and redeploy a sediment trap mooring on the Darwin Sea Mounds (DMLTM) as part of the UK Marine Protected Area habitat monitoring programme. Data from this mooring was secured but not processed on this cruise.
12. Using ship-based instrumentation to measure underway meteorology, sea-surface temperature and salinity, ocean currents from the surface to ~400m depth and water-depth using a Kongsberg multibeam echo sounding system.

5.2 Times of COVID

This cruise was postponed from its scheduled date in July because of the Coronavirus (COVID-19) pandemic. The first cruise impacted was the RAPID mooring cruise JC192 which was at sea during January 2020 and was terminated and the ship returned to the UK. For the period of 6-months measures to mitigate the risk of COVID during a cruise were put in place.

Crew and scientists took a Polymerase chain reaction (PCR) swab test prior to travelling to the ship. For the science team this was taken at home on 17th October, collected by courier on the 18th and taken to the Nottingham based laboratory. A clear test enabled us to travel to the ship on Monday 28th October. During these 10-days the science party underwent a voluntary isolation at home, minimising their social interactions. The five-person science party from SAMS travelled to the ship using a 45-seat private coach eliminating the requirement to enter service areas during the 12-hour journey and allowing socially distanced travel. Masks were worn if moving around the bus. The crew and one of the science party used personal or hire cars or public transport to make their way to the ship. The morning following arrival on 29th October onboard PCR tests were taken and results returned the following day. For 14-days we wore masks and as best we were able and practised social distancing. Rigorous mask wearing and social distancing declined with time and was effectively over after 10-days. The ship was set up with one-way routes, split meal-times and sanitising stations. The main science lab became a social centre with food and drink facilities for the science bubble. Mobilisation was completed by the crew and scientists without help from the shore.

6 Outreach

Kristin Burmeister

The public outreach onboard aims to boost the visibility of the science carried out on *RRS Discovery*, DY120, as we travelled along the eastern part of the OSNAP section. This is done by providing a summary of the scientific goals and day to day experiences of the expedition. The main approach involved posting highly visual eye-catching photos and videos along with an insight into the feelings of scientists and crews onboard in response to their time at sea.

The outreach approach combines pre-cruise and post-cruise news articles, the use of social media (Twitter) alongside with regular blog posting on the official UK CLASS (Climate Linked Atlantic Sector Science) project website (https://projects.noc.ac.uk/class-project/blog) and SAMS (Scottish Association for Marine Science) News page (https://www.sams.ac.uk/news/). Tags for social media post where distributed among the cruise participant before the start of the cruise. For the blog post, a coordinator was chosen at the beginning of the cruise, who created a blog schedule with topic suggestions. Cruise participants could sign in for certain dates and topics and the coordinator kept track of everything. This approach was perceived as successful and pleasant from all authors.

At the start of the cruise (28th Sept) a news article about the main research aim was published online at BBC (https://www.bbc.co.uk/news/uk-scotland-glasgow-west-54300065).

For daily updates about the cruise twitter was used. Used hashtags were #DY120 and #RRSDiscovery and the posts commonly tagged @uk_OSNAP, @UKRI_CLASS and @SAMSOceannews. Between 28th September – 27th October, altogether 111 tweets were published by cruise participants which resulted in 145 retweets, 80 replies and 1052 likes.

A more comprehensive update about the cruise were given in regular blog post (eight altogether) which were either published at the CLASS blog (six contributions) or at SAMS News page (three contributions). The blog posts were written by several authors and spanned topics from the mobilization of the *RRS Discovery* under Covid-19 restrictions, the history of the scientific aim of DY120, to a crews' perspective what is it like to work on a research vessel.

The end of DY120, the disembarking of the seven scientists in Ardmucknish Bay off SAMS on 24th Sept was covered by a news article in the Oban Times (https://www.obantimes.co.uk/2020/10/27/cruise-ship-returns-with-vital-climate-change-data/) which was followed by a comprehensive article in the Oban Times about the results of the cruise one week later.

7 Data Management Plan

The Data Management Plan was prepared in discussion the British Oceanographic Data Centre; BODC). BODC will be involved through the life of the project to ensure consistent and safe data management. For research expeditions, a BODC Data Manager will oversee the on-board completion of the *Cruise Summary Report* detailing the measurements. A cruise report (this report) will be published within six months of cruise end. Following appropriate quality control all data will be submitted to the BODC archive within 12 months of collection. BODC curates the UK-OSNAP mooring data (http://dx.doi.org/10/c7qv) and the Extended Ellet Line data set (https://www.bodc.ac.uk/resources/inventories/edmed/report/644/). Richenda Houseago-Stokes is the BODC Data Manager for this cruise.

8 Environmental Impact Assessment

An assessment of the interaction of NERC marine science with the environment (NERC Marine Environment Interaction Policy, 12/7/2018) was conducted prior to the cruise by Anna Bird, NERC Marine Environment Appraiser (March 2020). The purpose of the Environmental Impact Assessment (EIA) is to assess the environmental impacts associated with the scientific research activities during the research cruise DY120 occurring in the North East Atlantic Ocean RRS *Discovery.* A set of recommended mitigation measures Marine Environmental Mitigation Integration Policy (MEIP) was produced for the purpose of undertaking the project in a way that will be of minimal detriment to the marine environment, and in a way that is reasonable and commensurate with achieving the stated scientific objectives. This EIA and associated MEIP have been prepared based on the information provided by the Principal Investigator in the SME and associated questionnaire. A copy is available from Anna Bird.

NERC's Marine Environment Interaction Policy will ensure that:
• existing practise is clearly defined, documented and standardised across all marine research activities;
• all stakeholders are aware of their environmental responsibilities in planning and delivering research activities at sea;
• a standardised and uniform approach to environmental impact or interaction appraisal is defined and applied that reflects best practice;
• a clear and consistent approach to environmental impact or interaction mitigation is defined and applied that reflects best practise; and
• any process or procedure is compliant with diplomatic clearance, international convention or other specific regulation, and adheres to promoted best practice.

9 Diplomatic Clearance Requests and International Cabling Authority

Diplomatic Clearance was not required for this cruise as we operated in UK or International waters. Mooring locations were sent to the cabling authority. This process was managed by Sarah Hogger, Operations Support Officer (*RRS Discovery*), National Marine Facilities.

10 International Ship & Port Facility Security Code

The STCW Code (as amended by the Manila amendments (2010) contains new requirements regarding security awareness training. This training is required by all personnel employed or engaged onboard ships to which the International Ship & Port Facility Security Code (ISPS Code) applies and is a mandatory requirement from 1st July 2015. The MCA have determined that each member of the science team onboard should undertake security familiarisation which is covered during the onboard safety briefing. The Maritime and Coastguard Agency have determined that the Chief Scientist, as leader of the onboard science team, should undertake a Proficiency in Designated Security Duties (PDSD) course and the course must be carried out by a provider approved by the MCA.
Loïc Houpert was designated to undertake this training (with the agreement of Sarah Hogger, Operations Support Officer, *RRS Discovery*) NMF andcompleted a course provided by Warsash Maritime "*Proficiency in designated security duties*" (https://streammarinetraining.com/courses/webinar-stcw-proficiency-in-designated-security-duties/).

11 Funding Statement

This work contributes to U.K. Natural Environment Research Council National Capability program the Extended Ellett Line (EEL) and Climate Linked Atlantic Sector Science (CLASS) (NE/ R015953/1), and NERC grants U.K. Overturning in the Subpolar North Atlantic (OSNAP) (NE/K010875/1, NE/K010875/ 2, and NE/K010700/1) and U.K. OSNAP Decade (NE/T00858X/1 and NE/T008938/1) and to the European Union's Horizon 2020 Research and

Innovation Programme Grant Agreements: No. 678760 A Trans-AtLantic Assessment and deep-water ecosystem-based Spatial management plan for Europe (ATLAS); No. 210522255 Integrated Assessment of Atlantic Marine Ecosystems in Space and Time (iAtlantic) and; No. 727852 Arctic Impact on Weather and Climate (Blue-Action). CLASS & OSNAP finance the cruise, moorings and physical measurements and support staff time for SAC, SJ, ED, LD and LH. ATLAS and iAtlantic support the chemistry programme of oxygen, nutrient and carbon sampling, the purchase of SBE-ODO and DeepSeapHOx instrumentation for mooring EB1 and support staff time for SAC, KB, SZ and CJ. Blue-Action supports staff time for SAC.

12 Previous OSNAP-CLASS Cruises

Table 12.1: List of previous OSNAP & CLASS Cruises contributing to this programme. Reports available via BODC.

Cruise	Vessel	Year	Report
KN221-02	*R/V Knorr*	2014	Cunningham, S. A. (2015), R/V Knorr Cruise KN221-02, 9th July - 1st August 2014. OSNAP Mooring Cruise Report *Rep.*, 1-54 pp, Scottish Association for Marine Science.
DY017	*RRS Discovery*	2014	Painter, S. C. (2015), RRS Discovery Cruise DY017, 20 OCT -06 NOV 2014, Outer Hebrides process cruise, *Cruise Report Rep.*, National Oceanography Centre, Southampton.
JR302	*RRS James Clark Ross*	2014	King, B., and N. P. Holliday (2015), RRS James Clark Ross Cruise 302. 06 JUN - 21 JUL 2014. The 2015 RAGNARRoC, OSNAP and Extended Ellett Line cruise Report, *Cruise Report Rep. 35*, National Oceanography Centre.
PE399	*R/V Pelagia*	2015	Cunningham, S. A. (2016), R/V Pelagia Cruise PE399 16th June to 8th July 2015, Southampton, UK to Reykjavic, Iceland. Scottish Association for Marine Science, Oban.
DY053	*RRS Discovery*	2016	Cunningham, S. A. (2016), RRS Discovery Cruise DY053 16 JUNE - 23 JULY 2016. Scottish Association for Marine Science, Oban.
DY078	*RRS Discovery*	2017	Holliday, N. P. (2017), RRS Discovery Cruise DY078/079 06-28 May 2017. Extended Ellett Line 2017 occupation and OSNAP Rockall Trough mooring refurbishment cruise *Rep.*, National Oceanography Centre, Southampton.
AR30-04	*R/V Armstrong*	2018	Cunningham, S. A. (2018), RV Neil Armstrong Cruise AR30-04 01-29 JUL 2018 OSNAP moorings cruise report. Scottish Association for Marine Science, Oban.
DY108	*RRS Discovery*	2019	Huvenne, V. A. I., and B. Thornton (2020), RRS Discovery Cruise 108, 6 September - 2 October 2019. Darwin Mounds Marine Protected Area habitat monitoring, BioCAM equipment trials and BLT pilot study, *Cruise Rep.*, 224 pp, National Oceanography Centre, Southampton.
DY120	*RRS Discovery*	2020	THIS REPORT

13 OSNAP-CLASS Glider Missions

As part of the OSNAP sustained AMOC monitoring array, gliders are being used to monitor regions where moorings are difficult to sustain because of fishing activity (European Slope Current) or where Argo floats rarely transit because the water depth is relatively shallow compared to the drifting depth (1000m) of Argo floats (Hatton-Rockall Basin). From 2014 to 2020 gliders transited from Scotland to the western edge of the Hatton-Rockall Basin monitoring the section between OSNAP east and M4 and since 2020 have be used to continually monitor the shelf edge current EB1 east to EB1 west, Figure 13.1. A Hovmöller (time v longitude plot) of missions is shown in Figure 13.2. A summary of missions is included in Table 13.1.

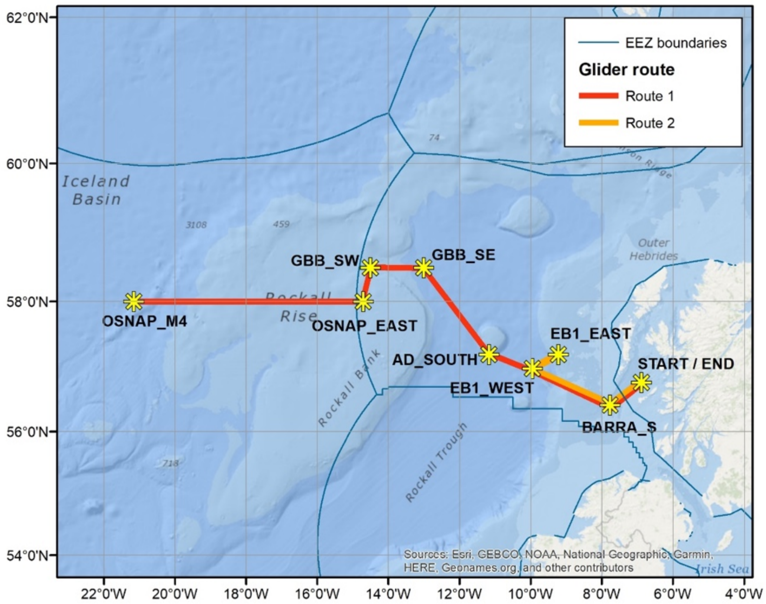


Figure 13.1: CLASS-OSNAP mission routes: Rockall-Hatton line in red, Shelf-break transects route in orange.

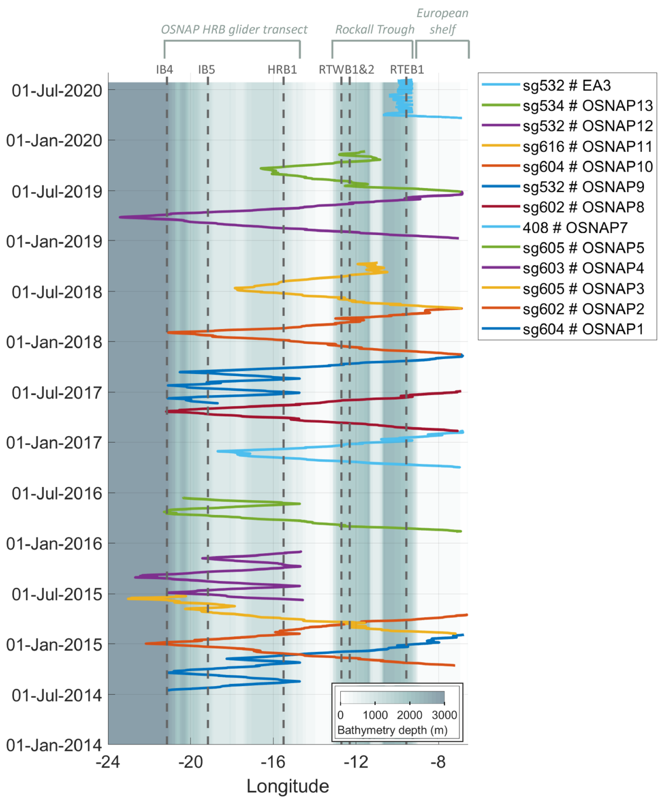


Figure 13.2: Longitude versus time Hovmöller plot showing OSNAP-CLASS glider missions across Rockall Trough and the Hatton-Rockall Basin to 21°W. The moorings along this section are Rockall Trough (RT) eastern boundary (EB) EB1; western boundary WB1 & WB2; the HR ADCP mooring (HR) deployed on this cruise; Iceland Basin (IB) moorings 5 and 4. In 2020 a new mission profile is focussing on monitoring the Shelf-Edge Current near mooring RTEB2 was initiated to provide continuous monitoring of the shelf edge current.

Table 13.1 OSNAP Glider Mission Summary

No	Mission	Glider S/N	Start date	End date	Days in water	Mission route (see map below)	Distance travelled (km)	No. of profiles	Comments
10	OSNAP #1	SG604	16-Jul-14	02-Feb-15	201	Rockall-Hatton line	3103	1864	Emergency recovery (battery wiring problem)
11	OSNAP #2	SG602	14-Oct-14	16-Apr-15	184	Rockall-Hatton line	2987	1597	
13	OSNAP #3	SG605	06-Feb-15	24-Jun-15	138	Rockall-Hatton line	2607	958	
16	OSNAP #4	SG603	08-Jun-15	01-Dec-15	176	Rockall-Hatton line	2911	886	Glider lost (pitch motor failure, put in recovery at the surface, loss of comms after a few days)
19	OSNAP #5	SG605	11-Feb-16	05-Jul-16	145	Rockall-Hatton line	2298	996	
20	OSNAP #6	SG545	23-Aug-16	09-Sep-16	17	Rockall-Hatton line	420	427	Glider "lost" (antenna failure, lost GPS and Iridium comms). Found by a fishing vessel in 2019.
22	OSNAP #7	U_408	01-Oct-16	10-Feb-17	132	Rockall-Hatton line	2200	1685	
24	OSNAP #8	SG602	10-Feb-17	04-Jul-17	144	Rockall-Hatton line	2410	1350	
25	OSNAP #9	SG532	21-May-17	14-Nov-17	177	Rockall-Hatton line	2888	1618	
27	OSNAP #10	SG604	14-Nov-17	30-Apr-18	167	Rockall-Hatton line	2923	1667	
32	OSNAP #11	SG616	30-Apr-18	13-Oct-18	166	Rockall-Hatton line	2209	1149	Glider lost (flying badly toward the end of the mission, possibly due to heavy biofouling. Put in recovery at the surface to maintain battery until an emergency recovery could be arranged, comms lost as it entered the Faroe-Shetland Channel - possible collision with ship)
36	Ellett Array #1	SG532	09-Jan-19	27-Jun-19	169	Rockall-Hatton line	3074	1674	
37	Ellett Array #2	SG534	27-Jun-19	20-Nov-19	146	Rockall-Hatton line	1898	1030	Additional O2, WetLabs puck (Chl-a, red backscatter, CDOM) and PAR sensors for a transect between the Anton Dohrn Seamount and Rockall Bank. Emergency recovery (flying badly toward the end of the mission, possibly due to heavy biofouling. Recovered by a fishing vessel on Rockall Bank)
39	Ellett Array #3	SG532	20-Mar-20	30-Aug-20	163	Shelf-break transects	2544	1491	
40	Ellett Array #4	SG605	24-Sep-20	ongoing	-	Shelf-break transects	-	-	

14 Scientific Computing Systems

Loïc Houpert, Sam Jones

14.1 Workstation Setup and Archiving

The Linux workstations used for scientific processing of data belong to NOC Southampton. The two workstations, running Centos 7, were *Koaekea* a Dell T5820, and, *Akeake* a Dell T3420. All processing was done on *Koaekea* and *Akeake* was kept as a backup. A script 'keep_akeake_in_sync' was run every six hours (using cron) to keep the directories: programs; cruise; osnap and; Desktop in sync. As for the JC192 cruise, both workstations were connected to one UPS which also powered one monitor that could be used if needed when turning the workstations on or off (it is not necessary to have a monitor and keyboard connected to each all of the time).

MATLAB v2015b was used. This was loaded using the 'module load matlab/2015b' command in the .login file.

Additional daily backups were run to a Mac mini using *rsync* embedded in two scripts: *back_dy120_v2_mac.csh* calling *backup_core_local,* using a Samba mount for *Koaekea.* An external disk enabled Time Machine to backup the Mac mini. This Mac mini also duplicated the MEXEC setup on *Koaekea* and the script *rsync_koaekea.csh* kept the two installations synchronized and adjusted symbolic links on the Mac. These three scripts are given in Appendix A.

14.2 Remote Desktop Connection

We encountered problems connecting from MacOS to the Linux workstation using ssh -X and using XQuartz 2.7.11 (xorg-server 1.18.4) to display MATLAB. Therefore, we used a remote desktop server. We installed a vncserver on the workstation following the guide https://www.howtoforge.com/vnc-server-installation-on-centos-7. Once installed, vncserver has to be run on the workstation and each instance can be accessed through the screen sharing tool in Mac ("Open Finder" then "Go", "Connect to Server", "Enter vnc://192.168.62.110:5902" to connect on Desktop:2). TightVNC Java Viewer can also be use (jar file available in the directory tvnjviewer-2.8.3-bin-gnugpl). To restart the vncserver, it needs to be killed first: "vncserver -kill :2". A configuration file to specify the default display size is found under pstar/.vnc/config.

For a mac: to copy paste between the Client and Server use : cmd+C/V on Client and control+C/V on Server.

Useful additional information on vnc can be found here: https://docs.01.org/clearlinux/latest/guides/network/vnc.html and https://archive.realvnc.com/products/vnc/documentation/4.6/docs/ah1025296.html.

14.3 Data Shares

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

sudo mount -o vers=3 192.168.62.11:/home/techsas/data/ /mnt/techsas
sudo mount -t cifs //192.168.62.131/public /mnt/public -o
sudo mount -t cifs //192.168.62.131/current_cruise /mnt/discofs -o
sudo mount -t cifs //192.168.62.131/sandm /mnt/sandm -o

Relevant usernames and passwords on board.

14.4 MEXEC Data Processing

MEXEC v3 software was used for most data processing. The three parts of the MEXEC software are maintained on the NOC gitlab server (git.noc.ac.uk):

MEXEC_processing_scripts: the MATLAB scripts

MEXEC: MATLAB functions called by the above

MEXEC-exec: contains associated c-shell scripts (e.g. ctd_linkscript, backup scripts).

A DY120 branch was created from the JC192 branch onshore, before the mobilization. Unfortunately, due to poor internet connection at the mobilization, it was not possible to copy the latest branch to the ship. Therefore, the three directories were replaced by an up-to-date copy, made onshore before joining the ship. Git was not used to keep track of changes to the software during the cruise, this will be done after the cruise when back onshore.

We followed the section "Setting up a new cruise" from the MEXEC user guide (v3.2) ([*Holliday and Firing*, 2020]). Key edits are to the techsas data stream names in *m_setudir.m* and *mt_names.m.*

Several link files were broken after our installation. The content of this file didn't correspond to the functions they were pointing to. For example, the nc_infoqatt.m file only contained four lines of text:

XSym

0018

30352edce73c86612e0644545a6b2de1

nc_infoqatt.m

We decided to clean the MEXEC snctools from link-files and replace the function calls to nc_infoqatt.m, nc_infoqdim, nc_infoq.m, nc_attputq.m by calls to the original function (nc_info.m and nc_attput.m).

A similar problem occurred for the UHDAS script aliases *UHDAS_00, UHDAS_01, UHDAS_02, UHDAS_03*, *UHDAS_04, UHDAS_05*. Therefore the aliases were removed and the original files (*UHDAS_00_linkmerge*, *UHDAS_01_syncraw*, *UHDAS_02_sync_postprocessing_from_raw*, *UHDAS_03_copy_asclog_for_editing*, *UHDAS_04_export_nc*, *05_sync_edited_to_archiv*) were renamed.

Several fixes done on DY113 to correct the true wind calculation were not implemented on the JC192 branch on MEXEC and we implemented these changes later in the cruise. Particularly DY113 fixes were applied to the scripts: m_daily_proc.m; mday_01_clean_av; m_setudir.m; mday_plots.m; msim_02.m; mem120_02.m; mtruew_01.m; mtsg_medav_clean_cal.m; mday_plots_all.

15 Ship Systems Computing/Data Logging and Underway Instruments

Zoltan Szuts

Section 15 is abstracted from the complete report: *DY120-2020-SSS-Cruise-Report.docx* by Zoltan Szuts.

The data acquisition systems used on this cruise are detailed in Table 15.1. The data and data description documents are filed per system in the *Data* and *Documentation* directories respectively within Ship Systems folder on the cruise data disk.

Table 15.1: Data acquisition systems used on this cruise.

Data acquisition system	*Usage*	*Data products*	*Directory system name*
Ifremer TechSAS	Continuous	NetCDF ASCII pseudo-NMEA	/TechSAS/
NMF RVDAS	Continuous	ASCII Raw NMEA SeaDataNet NetCDF	/RVDAS/
Kongsberg SIS (EM122)	Discrete	Kongsberg .all	/Acoustics/EM-122/
Kongsberg SIS (EM710)	Unused	Kongsberg .all	/Acoustics/EM-710/
Kongsberg SBP	Unused	None	/Acoustics/SBP-120/
Kongsberg EA640	Continuous	None, redirected to Techsas/RVDAS RAM	/Acoustics/EA-640/
Kongsberg EK60/80	Unused		/Acoustics/EK-60/
UHDAS (ADCPs)	Continuous	ASCII raw, RBIN, GBIN, CODAS files	/Acoustics/ADCP/
VMDAS (ADCPs)	Unused		/Acoustics/ADCP/
Sonardyne Ranger2	Simulation test	None, redirected to Techsas/RVDAS RAM	/Acoustics/USBL/

15.1 Ship-Fitted Instruments

Table 15.2: Logging status of ship-fitted instrumentation and suites.

Manufacturer	Model	Function/data types	Logged? (Y/N)	Comments
Meinberg	M300	GPS network time server (NTP)	N	Not logged but feeds times to other systems
Applanix	POS MV320 V5	Position/attitude	Y	Primary scientific GPS
C-Nav	3050	DGNSS	Y	DGNSS (for Applanix)
Kongsberg Seatex	Seapath 330	Position/attitude	Y	Secondary scientific GPS
Fugro	Fugro 9205 DGNSS Seastar	DGNSS	Y	DGNSS (for Seapath330)
iXSea	PHINSIII	Inertial Navigation System	Y	
Sonardyne	Fusion USBL	USBL	N	
Sperry Marine		Ship gyrocompasses x 3	Y	
Kongsberg Maritime	Simrad EA640	Single beam echo sounder (STDB Drop-Keel)	Y	10(active) & 12KHz (in passive mode) logged
Kongsberg Maritime	Simrad EM122	Multibeam echo sounder (deep)	Y	MMO rules, not continuous mode
Kongsberg Maritime	Simrad EM710	Multibeam echo sounder (shallow)	N	
Kongsberg Maritime	Simrad SBP120	Sub bottom profiler	N	
Kongsberg Maritime	Simrad EK60	Scientific echo sounder (fisheries)	N	
NMFSS	CLAM	CLAM system winch log	Y	
NMFSS	Surfmet	Meteorology suite	Y	
NMFSS	Surfmet	Surface hydrography suite	Y	
SKIPPER	DL850	Skipper log (ship's velocity)	Y	
OceanWaveS GmbH	WaMoS II	Wave Radar	Y (non calibrated)	Logged by Techsas and RAM
Teledyne RD Instruments	Ocean Observer 75 kHz	VM-ADCP	Y	UHDAS BT in shallow
Teledyne RD Instruments	Ocean Observer 150 kHz	VM-ADCP	Y	UHDAS BT in shallow
Microg Lacoste	Air-Sea System II	Gravity	N	

15.1.1 Bestnav Hierarchal Ordering

Table 15.3: Order of navigational systems in the *bestnav* process for positional fix.

Rank	Order of positional fixes	Comment
2	Seapath 330	Spathpos
1	PosMV V5	Posmvpos
3	Cnav 3050	gps_cnav

15.1.2 Relmov Source

Table 15.4: Navigational systems that are used in the *relmov* process for ship's motion.

Navigational source of ship's motion	Comment
Gyro	gyro_s
LOG	log_dysk

15.1.3 RVS Data Processing

Table 15.5: RVS Level-C Processing Programs.

Program	Was it run?	Comments
bestnav	Y	
*prodep***	Y	Singlebeam 1500m/s fixed, multibeam corrected with SV sensor and Sound Velocity Profiles derived from CTD.
protsg	N	
relmov	Y	
satnav	N	
windcalc	Y	

15.2 Internet Connection

The main ship-to-shore connectivity is supported by VSAT technology for two-way satellite communications for Internet, data and telephony. This provides connection speeds of up to 1.5 Mbytes/second and is shared by all users on the ship. A system of site white and black website listing attempts to preserve bandwidth. A new satellite dome was installed in refit immediately prior to this cruise. A second system Fleetbroadband by Inmarsat provides a limited connectivity at rates of 432 kbytes/second and is limited to 20 Gybtes per month. These systems use different antennae and different bands on the radio spectrum so are independent. Both operate line-of-sight to geostationary satellites.

During this cruise we had no or extremely limited connectivity from either system. NMF inform the internet provider of the ship's intended work area, departure and arrival ports, and then they inform the satellite operator. The satellite operator then programs the beams to ensure connectivity. However, to the surprise of the internet provider and NMF, the satellite operator limited the footprint to a narrow 100 mile corridor between Southampton and Rockall, which meant the ship lost internet as soon as it left that area (most of the cruise). The providers also advised that the secondary internet system, the Fleet Broadband, also failed because it is technically incapable of establishing/maintaining line of sight with the satellite in the combination of high latitudes and bad weather. Note this cruise did not experience bad weather and was always below 60°N.

Even when the connectivity is optimal, sharing between a number of active users severely limits available bandwidth per user. For work the internet is relied on to access data bases ashore; for problem solving; and routine email. It is normal to expect connectivity to enable a near normal maintenance of shore-based communications for management. We also found that some software relies on an internet connection to launch e.g. many institutions using Office 356 (Word and Outlook and OneDrive) insist on an internet connection and non-Office software such as Dropbox or other cloud storage applications. On this cruise when the we lost the internet connectivity the local area network on the ship also ground to a halt. DNS queries demand information sent from a user's computer (DNS client) to a DNS server. An attempt to reach a domain, is actually a DNS client querying the DNS servers to get the IP address, related to that domain. These requests built up to an extent that establishing ssh connections, samba links and file sharing because impossible. There is clearly a fundamental issue with the LAN and off-ship connections being on the same router so management of these traffic streams cannot easily be managed.

The current cost of the VSAT connection is £7500/month. An interesting discussion of costs can be found in the iDirect report "The Maritime VSAT Advantage: A cost analysis of VSAT broadband versus L-band pay-per-use service *Rep.*, iDirect www.idirect.net, Herndon, VA. The sharing of a 1.5 Mbyte/s link across many users both for work and social connectivity is a highly contentious issue.

15.3 Position, Attitude and Time

The ship's survey (Parker Maritime, 2013) defines two systems of reference point using two different central reference points (CRPs):

- (0,0,0) at Frame 0 (aft-most frame, 6m forward from stern), centreline (centre of keel), baseline (ship's bottom-most longitudinal).
- (0,0,0) at ship's centre of gravity (CG), Frame 44 (26.4m forward from Frame 0 at 0.6m frame spacing), centreline (centre of keel), main deck (7.4m up from baseline).

The survey coordinate sense is X is positive forward, Y positive starboard, and Z positive down. The coordinate order in the survey is (Y,X,Z), but unless otherwise noted, all coordinates are given elsewhere as (X,Y,Z).

For all scientific purposes, unless otherwise stated, the coordinate system is referenced using the second system, with the CRP at the CG.

The translations and rotations provided by Applanix PosMV have the following convention: Roll positive port up: Pitch positive bow up; Heading true; Heave positive up.

Table 15.6: Position, Attitude and Time Measurements.

System	**Navigation (Position, attitude, time)**		
Statement of Capability	*/Ship_Systems/Documentation/GPS_and_Attitude*		
Data product(s)	NetCDF: */Ship_Systems/Data/TechSAS/NetCDF/* Pseudo-NMEA: */Ship_Systems/Data/TechSAS/NMEA/* Raw NMEA: */Ship_Systems/Data/RVDAS/NMEA/*		
Data description	*/Ship_Systems/Documentation/TechSAS* */Ship_Systems/Documentation/RVDAS*		
Other documentation	*/Ship_Systems/Documentation/GPS_and_Attitude*		
Component	*Purpose*	*Outputs*	*Headline Specifications*
Applanix PosMV	Primary GPS and attitude.	Serial NMEA to acquisition systems and multibeam	Positional accuracy within 2 m.
Kongsberg Seapath 330	Secondary GPS and attitude.	Serial and UDP NMEA to acquisition systems and multibeam	Positional accuracy within 1 m.
Oceaneering CNav 3050	Correction service for primary and secondary GPS and dynamic positioning.	Serial to primary and secondary GPS	Positional accuracy within 0.15 m.
Fugro Seastar / MarineStar	Correction service for primary and secondary GPS and dynamic positioning.	Serial to primary and secondary GPS	Positional accuracy within 0.15 m.
Meinberg NTP Clock	Provide network time	NTP protocol over the local network.	Accuracy of pulse outputs ±100ns (TCXO, OCXO LQ)

15.4 Meteorology and Sea Surface Monitoring

Table 15.7: SURFMET (Surface water and atmospheric monitoring).

System	**SURFMET (Surface water and atmospheric monitoring)**	
Statement of Capability	*/Ship_Systems/Documentation/Surfmet*	
Data product(s)	NetCDF: */Ship_Systems/Data/TechSAS/NetCDF/* Pseudo-NMEA: */Ship_Systems/Data/TechSAS/NMEA/* Raw NMEA: */Ship_Systems/Data/RVDAS/NMEA/*	
Data description	*/Ship_Systems/Documentation/TechSAS* */Ship_Systems/Documentation/RVDAS*	
Other documentation	*/Ship_Systems/Documentation/Surfmet*	
Calibration info	See Ship Fitted Sensor sheet for calibration info for each sensor.	
Component	*Purpose*	*Outputs*
Inlet temperature probe (SBE38)	Measure temperature of water at hull inlet	Serial to Interface Box
Drop keel temperature probe (SBE38) (Not yet installed)	Measure temperature of water in drop keel space	Not yet installed
Thermosalinograph (SBE45)	Measure temp, sal and conductivity at sampling board	Serial to Interface Box
Interface Box (SBE 90402)	Signals management	Serial to Moxa
Debubbler	Reduces bubbles through instruments.	No output
Transmissometer (CST)	Measure of transmittance	Analogue to NUDAM
Fluorometer (WS3S)	Measure of fluorescence	Analogue to NUDAM
Air temperature and humidity probe (HMP155)	Temperature and humidity at met platform	Analogue to NUDAM
Ambient light sensors (PAR, TIR)	Ambient light at met platform	Analogue to NUDAM
Barometer (PTB210)	Atmospheric pressure at met platform	Analogue to NUDAM
Anemometer (Windsonic)	Wind speed and direction at met platform	Analogue to NUDAM
NUDAM	A/D converter	Serial NMEA to Moxa
Moxa	Serial to UDP converter	UDP NMEA to Surfmet VM
Surfmet Virtual Machine	Data management	UDP NMEA to TechSAS, RVDAS

15.5 Hydroacoustic Systems

Table 15.8: Echosounding/Hydroacoustic Systems.

System	**Acoustics**		
Statement of Capability	*/Ship_Systems/Documentation/Acoustics*		
Data product(s)	Raw: */Ship_Systems/Data/Acoustics* NetCDF (EA640, EM122cb): */Ship_Systems/Data/TechSAS* NMEA (EA640, EM122cb): */Ship_Systems/Data/RVDAS*		
Data description	*/Ship_Systems/Documentation/Acoustics*		
Other documentation	*/Ship_Systems/Documentation/Acoustics*		
Component	*Purpose*	*Outputs*	*Operation*
10/12 kHz Single beam (Kongsberg EA-640)	Primary depth sounder	NMEA over serial, raw files	Continuous Free running
12 kHz Multibeam (Kongsberg EM-122)	Full-ocean-depth multibeam swath.	Binary swath, centre-beam NMEA, *.all files, optional water column data	Discrete Free running
70 kHz Multibeam (Kongsberg EM-710)	Coastal/shallow multibeam swath.	Binary swath, centre-beam NMEA, *.all files.	Unused
Sub-bottom Profiler (Kongsberg SBP-120)	Multi-frequency echogram to provide along-track sub-bottom imagery.	BMP, raw files, optional water column data.	Unused
Drop keel sound velocity sensor	Provide sound velocity at transducer depth	Value over serial to Kongsberg SIS.	Continuous
Sound velocity profilers (Valeport Midas, Lockheed XBT)	Direct measurement of sound velocity in water column.	ASCII pressure vs sound velocity files. Manually loaded into Kongsberg SIS or Sonardyne Ranger2.	Discrete (See deployment event log, below)
75 kHz ADCP (Teledyne OS75)	Along-track ocean current profiler	(via UHDAS)	Continuous Free running
150 kHz ADCP (Teledyne OS150)	Along-track ocean current profiler	(via UHDAS)	Continuous Free running
USBL (Sonardyne Ranger2)	Underwater positioning system to track deployed packages or vehicles.	NMEA over serial	Discrete (See deployment event log, below)
CARIS	Post-processing	CARIS Project file. CARIS Vessel files	Unused
MB-System	Post-processing	XYZ, SegY files	Unused

15.6 Multibeam & Sea-Mammal Monitoring

Path to Marine Mammal Observation logs: /Ship_Systems/Documentation/Acoustics/MMOs.

Table 15.9: Sea-Mammal Monitoring Actions.

System	***Actions taken to protect mammals, in compliance with NERC and JNCC protocols***
12 kHz Multibeam (Kongsberg EM-122)	60-minute bridge observation. Marine mammal protection ramped start initiated at 45 minutes into observation if no mammals sighted. Clock restarted if mammals sighted.
Sub-bottom Profiler (Kongsberg SBP-120)	System not used.

15.7 Sound Velocity Profiles

Sound velocity profiles were collected with the Midas SVP probe (s/n: 41603, 22356), XBT, or derived from CTD or calculated from the WOA13 model using Ifremer DORIS.

Path of sound velocity profile data on the cruise datastore: /Ship_Systems/Data/Acoustics/Sound_Velocity

Details of when sound velocity profiles were taken and applied are shown in Table 15.10.

Table 15.10: Sound velocity profiles.

Datetime	*Method*	*Location (Lat/Lon)*	*Filename*	*Datetime SVP applied to SIS / Ranger2*
11/10/2020 23:00	CTD derived (Chen-Millero)	57.297, -10.385	DY120_002_align_CTM_Derive_50m_SVP_thinned.asvp	11/10/2020 23:00 EM122 Deep Water1 survey line17

16 Underway data & processing

Kristin Burmeister & Sarah Reed

16.1 Overview

Data from the suite of ship-fitted scientific instrumentation was aggregated onto a network drive on the ship's file server. This was available throughout the voyage in read-only mode to permit scientists to work with the data as it was acquired.

Shipboard underway measurements were logged, processed and calibrated, including surface meteorology, 5 m depth sea temperatures and salinities, water depth, and navigation. Below is an overview of the daily underway processing. The text in bold refers to MATLAB scripts in the MEXEC Suite. A log was filled out every two hours between 0800 and 2000 (UTC) checking several of the underway systems were functioning as expected and any issues were noted down and resolved. Salinity samples from the underway system were taken up to four times daily. No samples were taken while the supply was switched off, when the ship was in shallow waters, in port or on station. The time and date at which each sample was taken was recorded on a log sheet next to the supply tap.

From DY120 here are two main recommendations and issues with underway instruments:

- The data recorded by the TSG itself (temperature and conductivity) showed suspicious spikes. On *RRS Discovery*, the TSG was known to measure suspicious spikes which were assumed to be caused by the switch of the system's pumps twice a day. To test this only one pump was used during the rest of the cruise. For future cruises it is recommended to speak to the engineers at the start of the trip to ask for one pump instead of two to be used so that the data runs consistently from the same pump.
- However, during DY120 these spikes continued to occur more frequently than two times a day in the salinity, and housing temperature inboard measurements. It was found that a cheap power extension cable took power from the clean electricity supply

to the junction box housing the temperature and conductivity sensors. The problem was resolved by removing this extension cable on 18/10/20. No suspicious spikes were observed any longer.

- The barometer was installed outside on the foremast together with the other meteorological and navigation sensors. The first barometer flooded once, was replaced, and flooded two more times during the cruise. It is highly recommended, that the location of the barometer is changed to indoor, e.g. the main lab or the hangar for following cruises.

16.2 Daily Processing of underway data streams

For the processing of the underway data the MEXEC-toolbox V3 was used. Crucial updates of the MEXEC-MATLAB-toolbox which was used for processing CTD and Underway data were completed after the start of the cruise. To secure the function of the MEXEC-toolbox, these updates were placed in the appropriate scripts manually. It is recommended to ensure that changes of the MEXEC-toolbox are committed to the Git-repository and that the MEXEC-toolbox on the server is up to date before it goes onboard. The bandwidth onboard was too low to pull any updates from the repository (even in port).

Table 16.1 lists all variables and their corresponding data files of the underway data. The following steps were run each day to process the underway data during DY120:

Table 16.1: Overview of underway variables and the associated MSTAR-file observed during DY120.

Variable	MSTAR-files (in *~/dy120/mcruise/data/*)
Depth (EA122 multibeam echosounder)	*bathy/em120/em120_dy_01.nc*
Depth (the EA640 single beam echosounders)	*bathy/sim/sim_dy120_01.nc*
Air temperature	*met/surfmet/surfmet_dy120_01.nc* *met/surfmet/surfmet_dy120_true.nc* *met/surfmet/surfmet_dy120_trueav.nc*
Humidity	
Wind speed (relative to ship)	
Wind direction (relative to ship)	
Atmospheric pressure	*met/surflight/surflight_dy120_01.nc*
Photosynthetically Active Radiation (PAR)	
Toral Irradiance (TIR)	
Sea surface temperature (Hull, temp_r)	*ocl/tsg/tsg_dy120_01.nc* *ocl/tsg/tsg_dy120_01_medav_clean.nc* *ocl/tsg/tsg_dy120_01_medav_clean_cal.nc*
TSG sea surface temperature (temp_h)	
Conductivity	
Sound speed	
Fluorescence	*ocl/tsg/met_tsg_dy120_01.nc* *ocl/tsg/met_tsg_dy120_01_medav_clean.nc*
Transmittance	
Flow rate	

1. On a daily basis the **techsas_linksscript.sh** was run automatically to create a directory of symbolic links (*~/dy120/mcruise/data/techsas/netcdf_files_links/*) to the netCDF files in the TechSAS stream.

2. The previous day from UTC midnight to midnight of raw data was extracted from the TechSAS data. This step is performed in MATLAB using the routine **m_daily_proc.m.** It goes through the list of underway data streams found in **mtnames.m**, finds which ones are present in the techsas link directory, and calls the following routines applied to the daily data:

- **mday_01.m** to load them, producing a series of daily files from each data stream, located in their individual directories (e.g. *~/dy120/mcruise/data/bathy/sim/sim_dy120_dnnn_raw.nc, nnn* is day of the year).
- It then performs additional processing and cleaning steps on some streams by calling **mday_01_clean_av.m**, which has cases for different streams. The automatic processing includes renaming variables to standard names (e.g. head_gyr, depth) searching for and flagging backwards time steps or duplicate times in nav streams, NaNing out-of-range values, correcting echosounder depth for speed of sound variations based on the Carter tables, and averaging bathymetry to 30 s; output files are *stream_cruise_dnnn_edt.nc (*e.g**.** *sim_cruise_dnnn_edt.nc)*.
- The following updates from DY113 were manually added to **mday_01_clean_av.m**: old code to correct positions in the cnav streams has been removed and placed into **get_cropt.m**. A new section looks into the cruise option files (**get_cropt.m** and **opt_dy120.m**) for calibration functions to apply. In the case of DY120, we have added factory calibrations for the radiometers (PAR and TIR), fluorometer, and transmissometer. In addition, the checks for the cnav bug have been moved into **get_cropt.m**; a bug resulting in the fix never being applied when either latitude or longitude is negative has also been squashed. Variable names for underway salinity are updated to *psal* for consistency with CTD and the *RRS James Cook* setup. Acceptable seawater temperature ranges for all channels updated from [0 50] to [-2 50]. Code for calculating underway salinity cleaned up slightly. Even if salinity already exists (calculated with the SBE-45), it is renamed and recalculated using the GSW toolbox. Renaming the variable ensures that there is only one salinity variable in the file.
- The following updates from DY113 were manually added to **m_daily_proc.m**: On Discovery, temperature, conductivity, derived salinity and soundspeed are stored the tsg raw-files (*tsg_dy120_dnnn_raw.nc*), other variables like flow rate, fluorescence and transmittance are stored in met_tsg-raw-files (*met_tsg_dy120_dnnn_raw.nc*). A new feature was added to **m_daily_proc.m** based on the MEXEC-Update develop on DY113 to combine these streams into the met_tsg-edt-files (*met_tsg_dy120_dnnn_edt.nc*). If a TSG file does not exist, blank variables are added to the file, so later appending works necessary if the TSG is switched off at the start of a cruise.
- The final daily automatic processing step is to call **mday_02.m**, which appends the daily file to create a master cruise file for each data stream (e.g. *sim_cruise_01.nc*). The list of daily files appended into the master files is given in the header information of that file.

After all daily steps have been run, **m_daily_proc.m** calls the following routines:

- **mbest_all.m**: runs a series of scripts to produce the master bestnav file, *bst_dy120_01.nc*. The streams used for best position (*posmvpos*) and heading (*gyro*) are set in **m_setup.m**. Scripts merge heading and position so that there is a complete file containing position, heading, course and speed made good, and distance run. The data are reduced to a 30-second time base and heading is properly vector averaged. This is the 'definitive' cruise navigation file. To avoid the problem of housekeeping variables across daily files, the bestnav processing is rerun from the start of the cruise each time it is required. There is therefore only ever one *bst_dy120_01.nc* file.

- **mtruew_01.m**: Ship speed, position and heading from the bst navigation file are merged onto the wind data in the surfmet files. The absolute wind speed is calculated and vector averaged in one multi-step script **mtruew_01.m**. As in **mbest_all.m**, this is rerun for the entire cruise each time the data are updated. The output files from this processing are *met_ dy120_true.nc* and *met_ dy120_trueav.nc* The latter file is reduced to 1-minute averages, with correct vector averaging when required. In order to avoid ambiguity, variable units are explicit in whether wind directions are 'towards' or 'from' the direction in question. The result is a bit cumbersome but should be unambiguous if the units are read carefully. The following updates from DY113 were manually added to **mtruew_01.m**: updated the code to use the same variables as on James Cook. Previously the (hard- coded) variable numbers made the script swap wind speed and direction, resulting in wrong true wind being computed on Discovery.
- **mtsg_medav_clean_cal.m**: clean and calibrate SBE45 tsg data. First reduce data to 1-minute bins, using median rather than mean; then apply cleanup and calibration using **mcalib2.m**, using function **mtsg_cleanup.m**, which can be constructed for each cruise. For more details see section 16.3.
- The following updates from DY113 were manually added to **mtsg_medav_clean_cal.m**: added code to adjust the temperature; this is written to variable *temp_r_adj* similarly to the salinity calibration is applied to variable *psal_cal*. A new function **tsg_sal_apply_temp_cal.m** has been created, corresponding to **tsg_sal_apply_cal.m** for salinity.

Further updates from DY113 which were manually added to **m_daily_proc.m**: When **mtsg_medav_clean_cal** is called and no TSG data exist, it now fails more gracefully. The variable *restart_uway_append* is cleared after running **m_daily_proc.m** to prevent files to be inadvertently deleted the next time the script is run.

3. The plotting routine **mday_plots_all(***nnn***)**, with *nnn* being the Julian day of the year, creates plots for each of the streams of the underway data to check that the data are reasonable and highlight any issues.

16.3 TSG Processing and Salinity Calibration to Water Samples

Fluorescence and transmittance are calibrated using the calibrations coefficients provided by the manufacturer. For the fluorometer, this is y=(x-0.055)*14.8, where y is fluorescence in µg/l and x is the voltage-measurement of the fluorometer. For the transmissometer this is b=(a-0.010)/(4.698-0.010)*100, where b is transmittance in percent and a is the voltage-measurement by the transmissometer.

Salinity is the only variable from the TSG data that is calibrated against water samples. Before the calibration, bad data because of the defect cable at the junction box needed to be removed. The following steps were taken:

- **mtsg_medav_clean_cal.m** was run to average the appended file (*tsg_dy120_01.nc*) to 1-minutes bins (*tsg_dy120_01_medav_clean.nc*). As long as no option are set in the cruise option file (**opt_dy120.m**), no data clean-up (remove bad values) or calibration will take place.
- To remove the bad data spikes resulting from the defect cable of the TSG junction box, the 1-minute data was used to calculate the change of conductivity for each time step. When this change was larger than 0.0125 S/m the data point was marked as a bad value. To ensure, that the entire artificial signal was removed all data from one

data point before the spike to four data points after the spike were marked as bad values. The time period for each spike was set in **opt_dy120.m** in the section *mtsg_cleanup* for the option *kbadlims.*

- **mtsg_medav_clean_cal.m** was rerun to remove the bad values from the conductivity and temperature data.
- **mtsg_01.m** was run to load TSG bottle sample salinity data from the concatenated salinity cvs-file (*~/dy120/mcruise/data/ctd/BOTTLE_SAL/sal_dy120_01.csv*, see section 20) to an MSTAR-format file (*~/dy120/mcruise/data/ctd/BOTTLE_SAL/tsg_dy120_all.nc*).
- **mtsg_bottle_compare.m** was run to plot bottle and TSG salinities together and a simple time-dependent offset was calculated to calibrate the data (see Figure 16.1). The results were added to the *tsgsal_apply_cal* case in **opt_dy120.m**.
- **mtsg_medav_clean_cal.m** was rerun to apply the calibration (*tsg_dy120_01_medav_clean_cal.nc,* Figures 16.2 and 16.3).

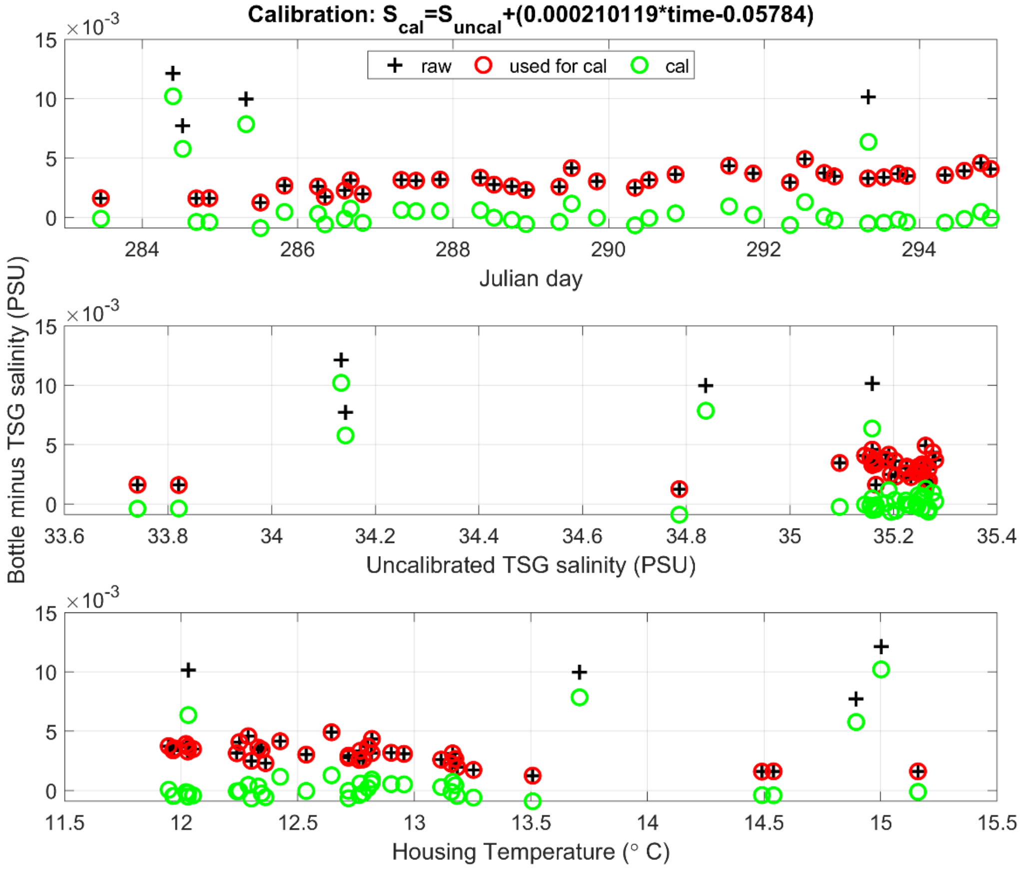


Figure 16.6: Comparison of the water sample analysis with the underway TSG salinity measurements. In all subplots, black crosses mark bottle uncalibrated TSG salinity, the red circles show data points used to estimate the time-dependent offset and green circles mark the difference of the bottle and the calibrated TSG salinities.

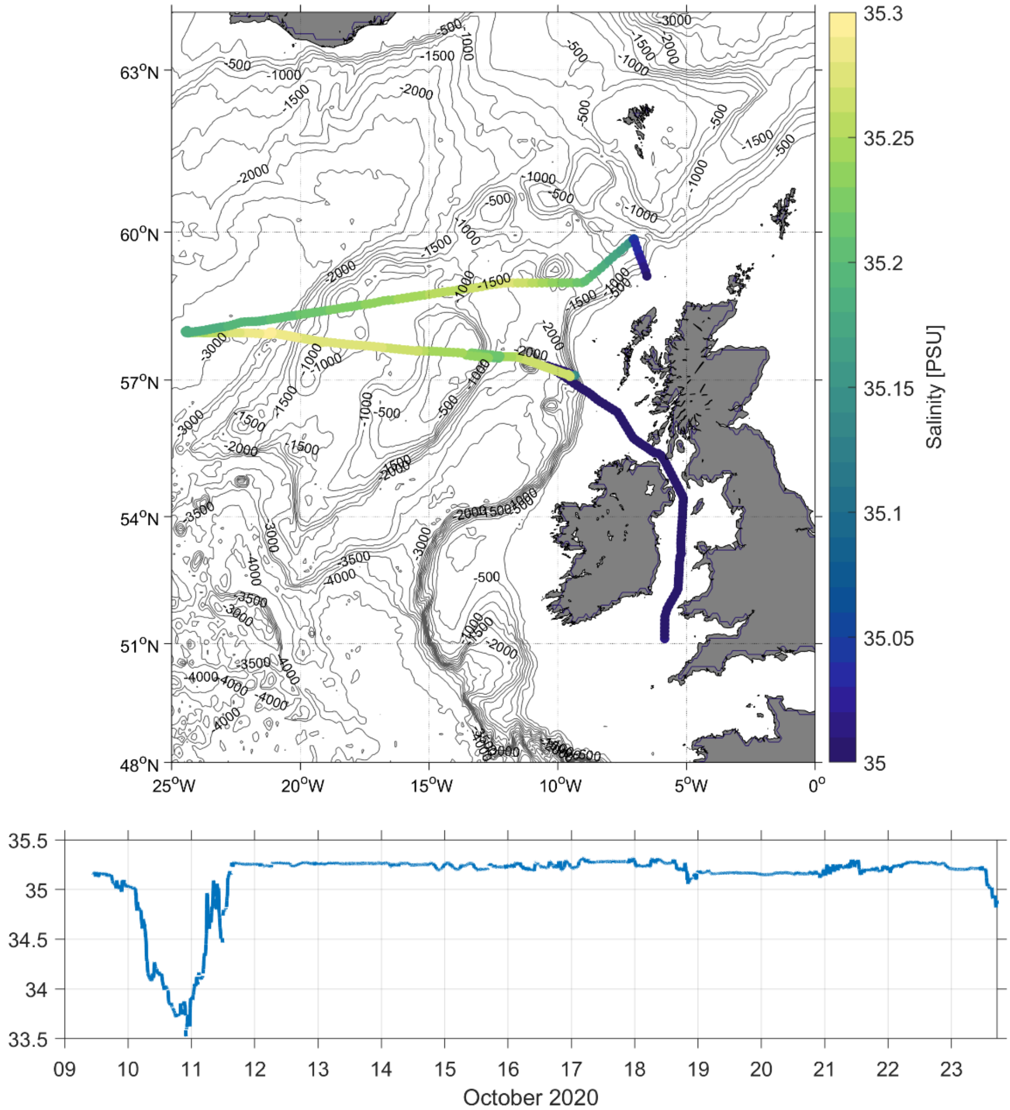


Figure 16.7: Calibrated TSG salinity data observed during DY120. Before calibration, the spikes resulting from a defective power cable to the junction box were removed.

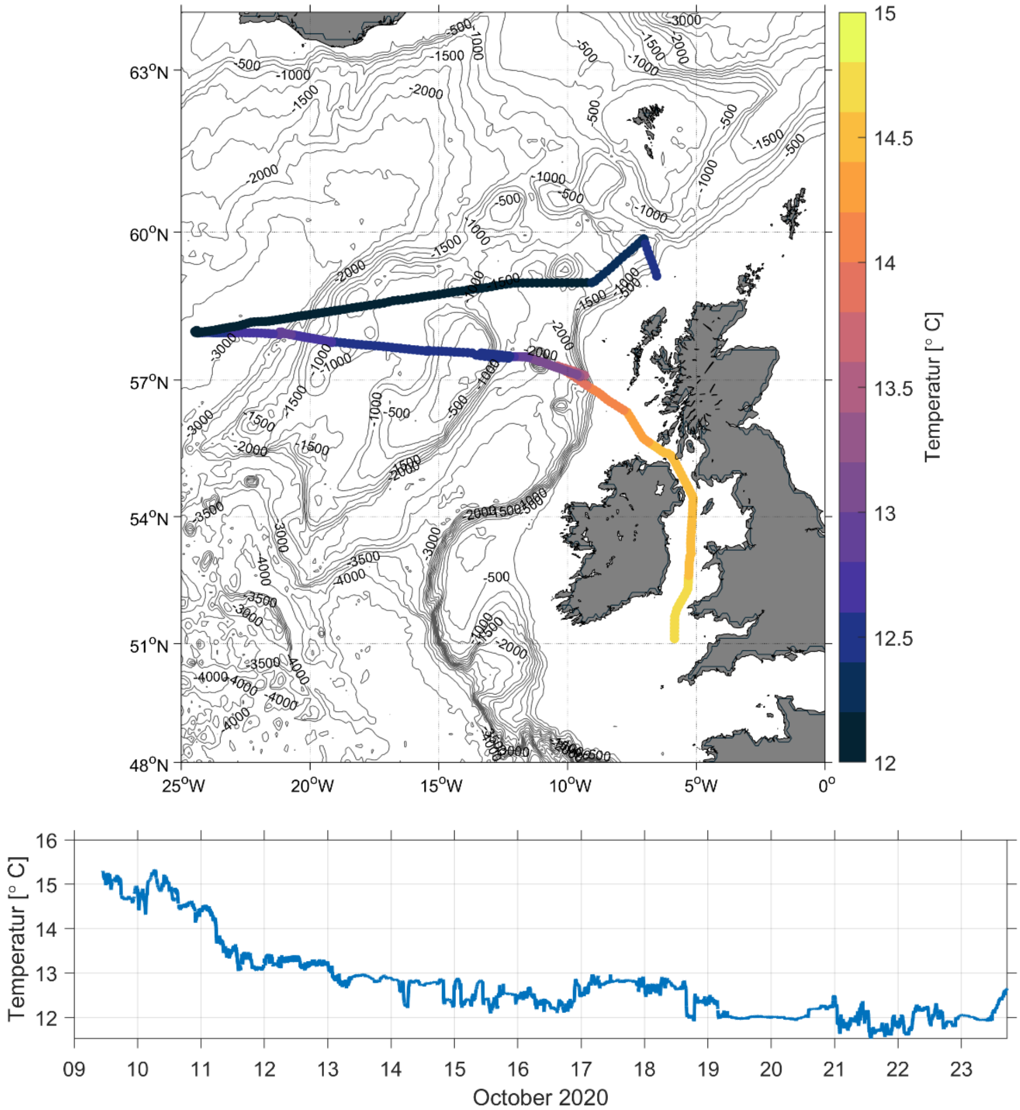


Figure 16.8: Cleaned TSG temperature data observed during DY120. The data are not calibrated but the spikes resulting from a defect cable of the junction box were removed.

16.4 Navigation

The data acquisition system was started whilst docked at Southampton during the mobilization and Covid-19 isolation. This allowed 10 days of data to be collected whilst the ship was stationary. Between the 28th Sep and 8th Oct. each of the three main navigation streams (POSMVPOS, SEAPATH and CNAV) were compared with the aim of deciding the most accurate system. Mean positions were very similar for the systems: 50.8917±1.6130e-06 °N, 1.3947±2.6293e-06 °W for POSMVPOS, 50.8917±3.6033e-06 °N (lat±0.1793m, lon±0.2490m), 1.3947±4.2313e-06 °W (lat±0.4004m, lon±0.4539m) for SEAPOS, and 50.8918±1.9840e-06 °N, 1.3949±3.6772e-06 °W (lat±0.2205m, lon±0.4246m). POSMVPOS was the system with the lowest standard deviation and was used as main navigation system (Figure 16.4).

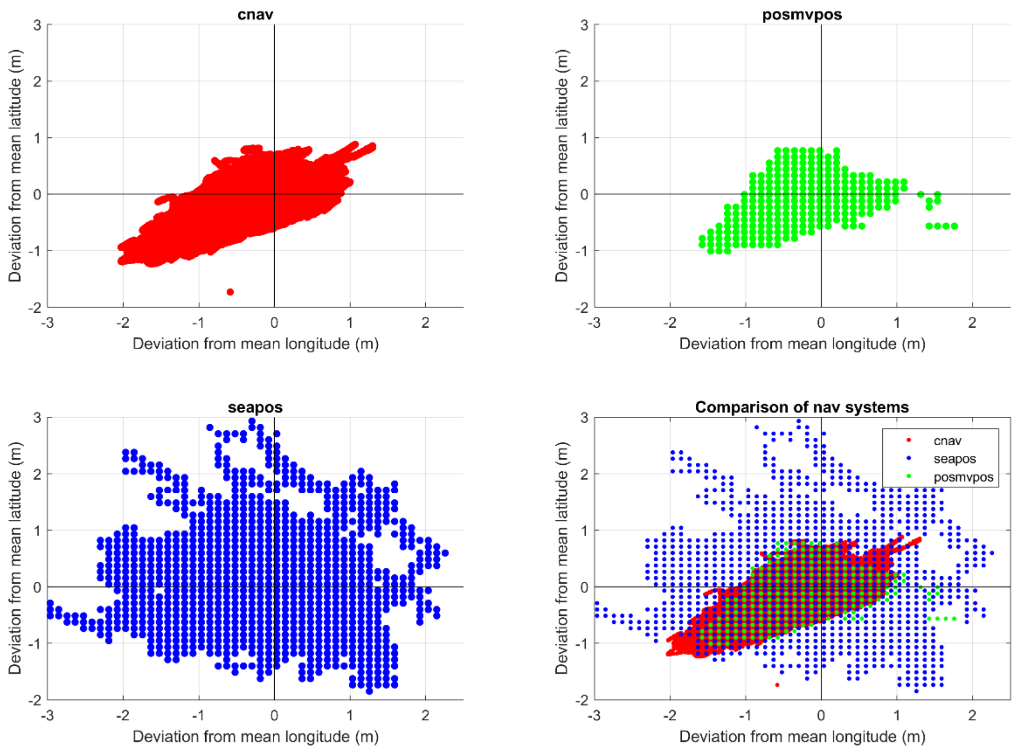


Figure 16.9: Comparison of navigation systems at RSS Discovery during harbour time (28th Sept-7th Oct 2020).

16.5 Bathymetric Data

Bathymetric data were collected by the EA640 single beam echosounders (10 kHz) and the EA122 multibeam echosounder (12 Khz). All echo sounders were turned off during the mooring operations, because their signal may disrupt communication with moorings releases. The raw bathymetry data are saved in *~/dy120/mcruise/data/bathy*.

16.6 Meteorology

True wind speed and direction was calculated using the **mtruew_01.m** routine. The one-minute averages are shown in Figure 16.5. The average wind speed during the cruise was 7.3 m/s with a maximum speed of 20.2 m/s on 18th Oct. Most of the time the weather allowed us to do the mooring turn arounds as planned as conditions were F4 or 5 for most of our period at sea. Only the turnaround of IB3 needed to be spread over two days (19th-20th Oct). Three engines were used to get ahead of a storm developing over the Iceland basin, before it was Force 8-10 for the last day of the cruise.

Photosynthetically Active Radiation (PAR) and Total Irradiance (TIR) where calibrated using the coefficients given by the manufacturer (linear relationship, y=x*coefficient). For the PAR sensors this was 1.011 for the port and 0.9398 for the starboard sensor. For the TIR sensors that was 1.017 (port) and 0.976 (starboard).

Air pressure measured by the barometer increased since the beginning of the cruise to suspicious high values. From 8th October onwards the data became suspicious noisy. As soon as the weather would allow the barometer on the mast was replaced (13:25 UTC on 12/10/20). The caused for the failure of the first barometer likely was flooding. The second barometer delivered reasonable data until 18:17 UTC on 18/10/20 when it was also flooded. Drying and replacing an O-ring put the second barometer back working until 06:04 on 23/10/20 when it was presumably flooded again.

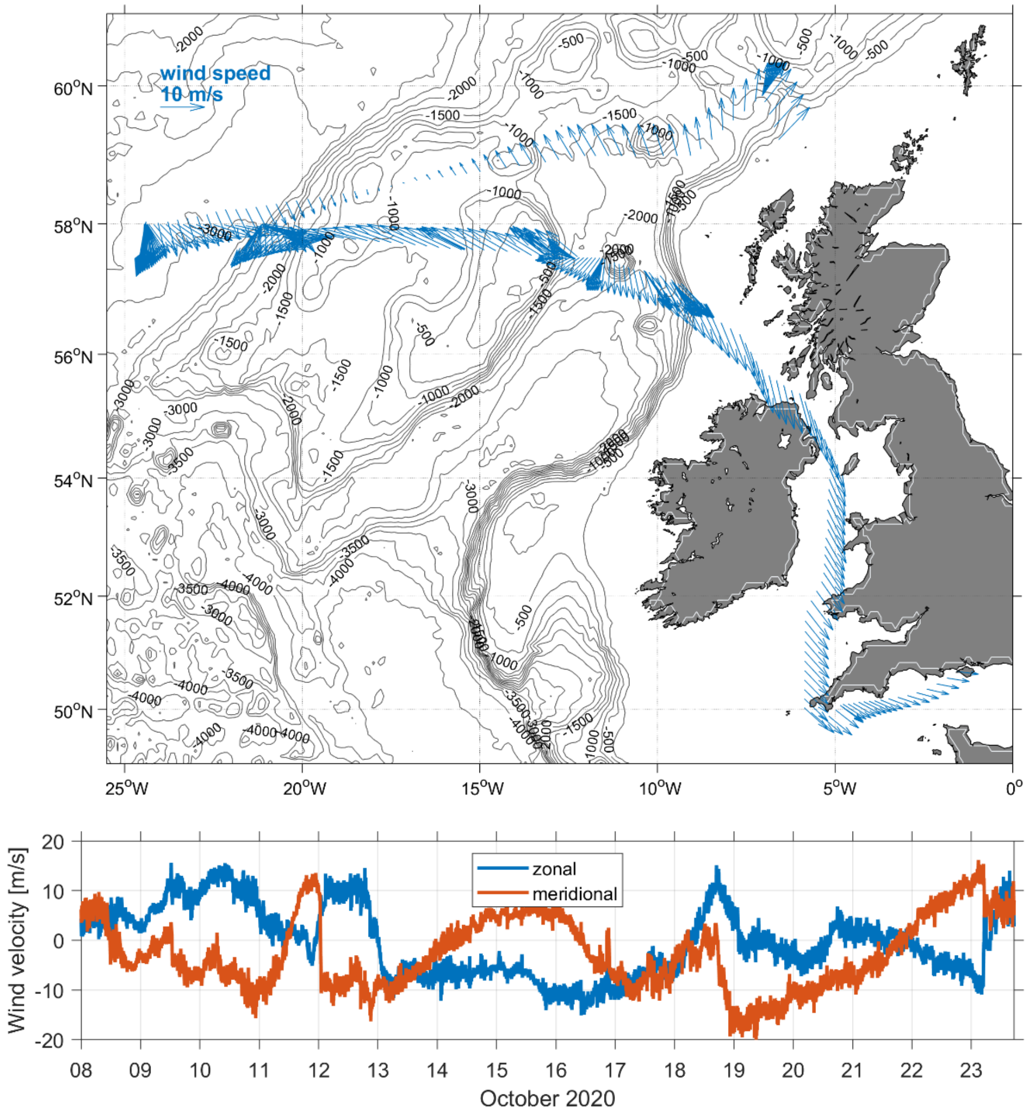


Figure 16.10: Along-cruise-track true wind speed (arrow length) and true wind direction during DY120 (top). Wind is blowing from the origin of and arrow to its peak. 1-minute averaged true wind velocities observed during DY120 (bottom).

17 Vessel Mounted Acoustic Doppler Current Profiler (ADCP)

Loïc Houpert

17.1 Introduction

The *RSS Discovery* is fitted with two Teledyne Ocean Surveyor VMADCPs for measuring the horizontal velocity field: one 150 kHz and one 75 kHz. Both VMADCPs were operated almost continuously for the duration of the DY120 cruise. Depending on the sea state and the water properties, the 150 kHz can penetrate up to 400 m and the 75 kHz up to 800 m. For this cruise, the average ranges for both ADCPs were respectively 250 m and 500 m.

17.2 Data Acquisition

Acquisition of VMADCP data was done automatically by the University of Hawaii Data Acquisition System (UHDAS). UHDAS refers to a suite of programs and processes developed at the University of Hawaii that perform data acquisition, data processing, and monitoring, at sea (Figures 17.1 and 17.2). In addition, access to documentation and code are provided on the ship's network. Both ADCP systems were activated on leaving the Port of Southampton (08 October 2020 14:00) in bottom tracking mode. Both were switched to water tracking mode using narrow band on 12 October 2020 at 19:22. On 23 October 2020 at 13:30, they were switched back to bottom tracking mode while steaming toward the Butt of Lewis. The ADCP systems remained active until the end of the cruise, when the ship returned to Southampton.

Figure 17.1: Screenshot of the UHDAS panel controlling the parameters of both ADCPs, as seen on the UHDAS server. Switching to bottom track mode is made by manually selecting the ON/OFF button.

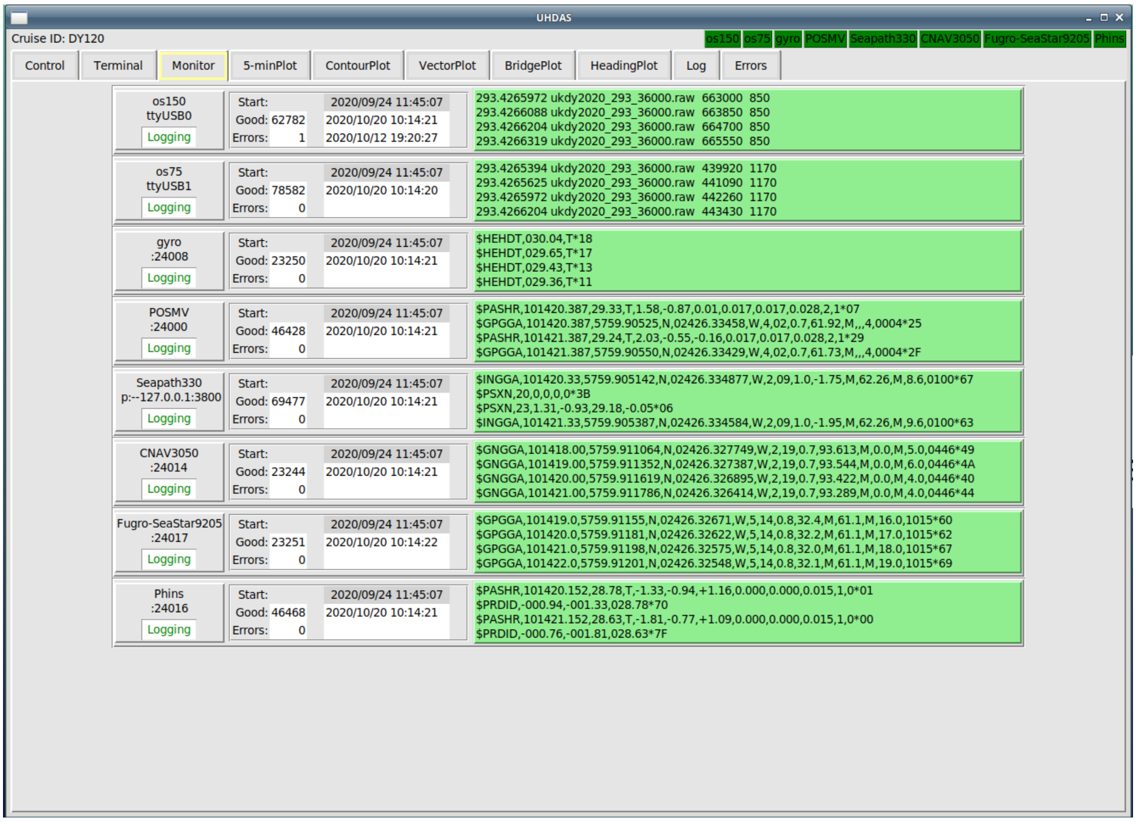


Figure 17.2: Screenshot of the UHDAS panel monitoring the logging of the ADCP data, as seen on the UHDAS server.

17.3 Real-Time Monitoring

The UHDAS interface displayed on a screen in the main lab has all the control and monitoring

options. The UHDAS monitor interface was checked for any errors or data acquisition problems, every hour as part of the watchkeeping system. UHDAS automatically generates a series of contour and vector plots, which were also visually inspected for errors. In addition, figures and diagnostics generated by UHDAS were accessible through any computers by accessing the address http://192.168.62.42/adcp/index.html from a web browser (Figure 17.3).

17.4 CODAS Data Processing (from UHDAS manual)

Processing code is written in C and Python (phasing out a long reliance on MATLAB). Final processed output is written as MATLAB and NetCDF format files on a regular basis. Processing is done using a CODAS database (Common Ocean Data Access System) as storage and retrieval system. The suite of programs designed to extract from, manipulate, and write to the database is known as “CODAS ADCP Processing” and has been free, maintained, and in use since the late 1980’s. (See the CODAS Processing section of the full CODAS documentation for more detail).

In a batch mode, CODAS processing can be applied to single-ping data gathered by UHDAS (or the commercial RDI software “VmDAS”), or averaged data collected by VmDAS or the original DAS2.48 (used with Narrowband ADCPs in the late 1980’s and through the 1990’s).

At sea, a UHDAS installation acquires data and uses CODAS processing to calculate ocean velocities from ADCP measured velocities, position, and heading (gyro, corrected to an accurate heading if one is available). The following three levels of processing combined are called **CODAS Processing**:

1. CODAS steps performed on single-ping data
    - make sure every ADCP ping has a position and a heading
    - gather the next T seconds of data (eg. 300 seconds)
    - screen the ADCP data to eliminate bad values (eg. acoustic interference)
    - average in earth coordinates
    - write to the disk
2. CODAS steps performed on averaged data
    - load measured velocities into the database
    - add navigation to the database

The following are steps automated on a ship with UHDAS but can be done afterwards with human intervention.

3. CODAS Post-processing (on averaged data)
    - correct the gyro heading to the accurate heading device (if there is one)
    - apply scale factor if specified (eg. NB150)
    - apply additional fixed rotation if specified
    - edit out bad bins or profiles (eg. data below the bottom)
    -

17.5 UHDAS Enhancements to CODAS Processing

UHDAS adds steps to the basic processing at sea by extracting (on a regular basis) processed, corrected, edited data for scientists to use during the cruise. These data and figures that are generated from them, are available on the ship's web.

Every 5 minutes

- get the last 5 minutes of new data
- rotate to earth coordinates using gyro as the primary heading device
- correct to the "accurate heading device" (if one exists)
- edit single-ping data (for this 5-minute chunk)
- average, write to disk (staging for addition to the codas database)
- save the 5-minute chunk of data as a MATLAB file (for plotting)

Every 15 minutes

- the CODAS database is updated with the staged averages
- scale factor and fixed rotation are applied if specified
- the averages in the database are also edited (to look for bad bins or bad profiles, and the bottom)
- after the codas database is updated
- the data are extracted and averaged (for plotting)
- the data are extracted with "every bin, every profile"
- data are stored as MATLAB files and netCDF files, accessible via ship's web site or via windows shares [samba] or nfs.

- Vector and contour plots of the last 3 days of data are updated, also available on the ship's web.

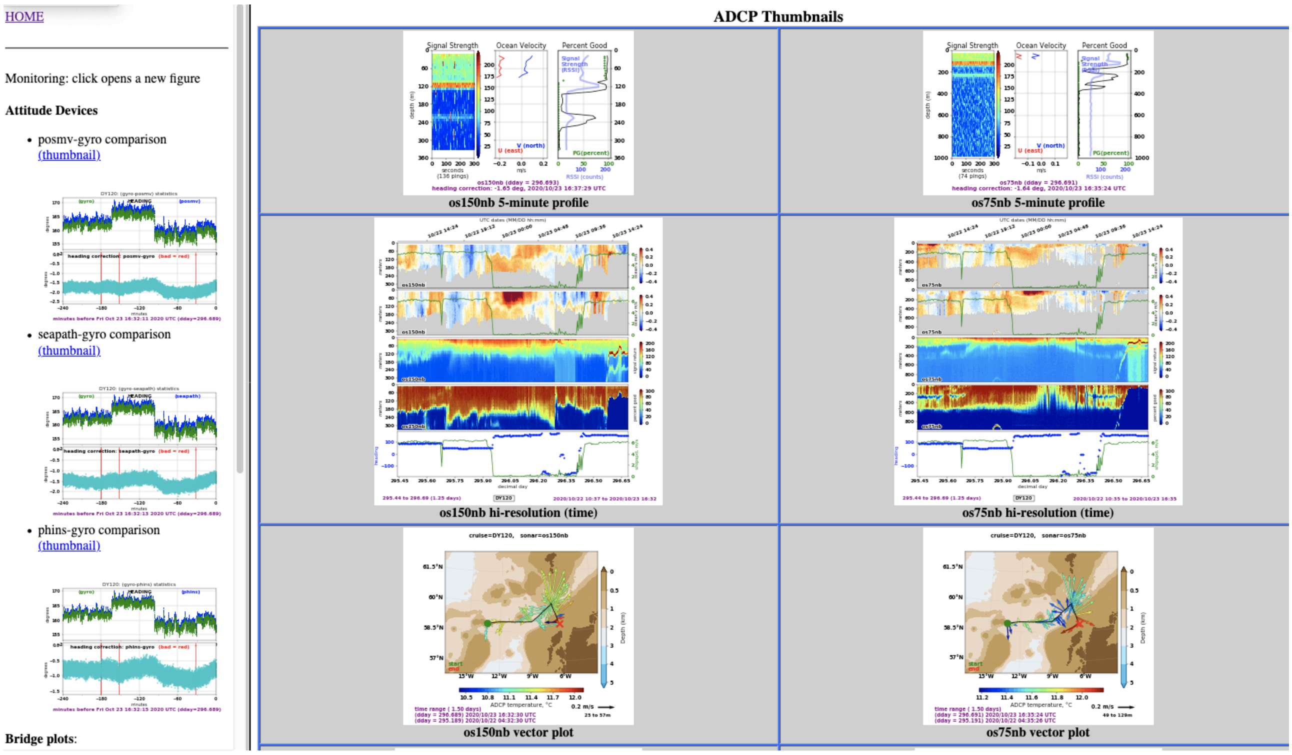


Figure 17.3: Screenshot of the monitoring panel available on the ship intranet (http://192.168.62.42/adcp/index.html).

17.6 Importing to MEXEC

First, the access to the UHDAS data directory was created. This directory was synchronized on the network folder "current_cruise" so no additional mounted was needed. We created an alias from */mnt/discofs/Ship_Systems/Data/Acoustics/ADCP* to *~/mounts/UHDAS_data.*

A set of scripts is used to synchronise the UHDAS severs files with the *Koaekea* machine (*UHDAS_0**). They are called in a wrapper script *~/programs/MEXEC_exec/UHDAS_linkscript.* No manual editing of the data was done during this cruise. If a manual editing of the data was needed, these commands should have been entered instead of running UHDAS_linkscript:

UHDAS_01
UHDAS_02
UHDAS_03
cd ~/cruise/data/vmadcp/postprocessing/DY120
cd proc_editing
cd osXXww where XX is the frequency (75/150) and ww is the bandwidth (bb/nb)
bash
dataviewer.py -e (Then, manual checking and editing within the interactive dataviewer GUI.)
exit
UHDAS_04
UHDAS_05

Then an option was added in the file *opt_dy120.m* to setup the names of directory and files for the adcp data (*case 'mvad_01'*).

Finally, to convert the archive files to MEXEC netCDF files, the MATLAB script mvad_01.m was run and the MEXEC netCDF files were saved in the directory *~/cruise/data/vmadcp/mproc.*

17.7 VMADCP configuration files

17.7.1 OS75

```
# An Ocean Surveyor configuration file
# for UHDAS must contain only the commands listed here,
# although the values may vary. This file is not
# necessary; defaults are set in rdi_setup.py,
# which is called by DAS.py. Additional commands may
# be specified in /home/adcp/config/sensor_cfg.py.
# Bottom tracking
BP0 # BP0 is off, BP1 is on
BX10000 # Max search range in decimeters; e.g. BX10000 for 1000 m.
# Narrowband watertrack
NP1 # NP0 is off, NP1 is on
NN60 # number of cells
NS1600 # cell size in centimeters; e.g. NS2400 for 24-m cells
NF800 # blanking in centimeters; e.g. NF1600 for 16-m cells
# Broadband watertrack
WP0 # WP0 is off, WP1 is on
WN45 # number of cells
WS800 # cell size in centimeters
WF800 # blanking in centimeters
# Interval between pings
TP00:01.80 # e.g., TP00:03.00 for 3 seconds

# Triggering
CX0,0 # in,out[,timeout]
```

17.7.2 OS150

```
# An Ocean Surveyor configuration file
# for UHDAS must contain only the commands listed here,
# although the values may vary. This file is not
# necessary; defaults are set in rdi_setup.py,
# which is called by DAS.py. Additional commands may
# be specified in /home/adcp/config/sensor_cfg.py.
# Bottom tracking
BP0 # BP0 is off, BP1 is on
BX5000 # Max search range in decimeters; e.g. BX10000 for 1000 m.
# Narrowband watertrack
NP1 # NP0 is off, NP1 is on
NN40 # number of cells
NS800 # cell size in centimeters; e.g. NS2400 for 24-m cells
```

NF400 # blanking in centimeters; e.g. NF1600 for 16-m cells
Broadband watertrack
WP0 # WP0 is off, WP1 is on
WN80 # number of cells
WS400 # cell size in centimeters
WF400 # blanking in centimeters
Interval between pings
TP00:01.10 # e.g., TP00:03.00 for 3 seconds
Triggering
CX0,0 # in,out[,timeout]

18 CTD operations

Billy Platt and Oliver Twigge

18.1 CTD system configuration

One CTD system was prepared with frame geometry and CTD sensor locations shown in Figure 18.1. The water sampling arrangement was a 24-way stainless steel frame system fitted with 12 off 10 ltr Ocean Test Equipment (OTE) Niskin bottles (positions 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21 and 23 with remaining positions reserved for 12 brackets for attaching SBE37's) and MDS titanium CTD swivel. Sensor information and serial numbers for all underwater components are given in Appendix B.

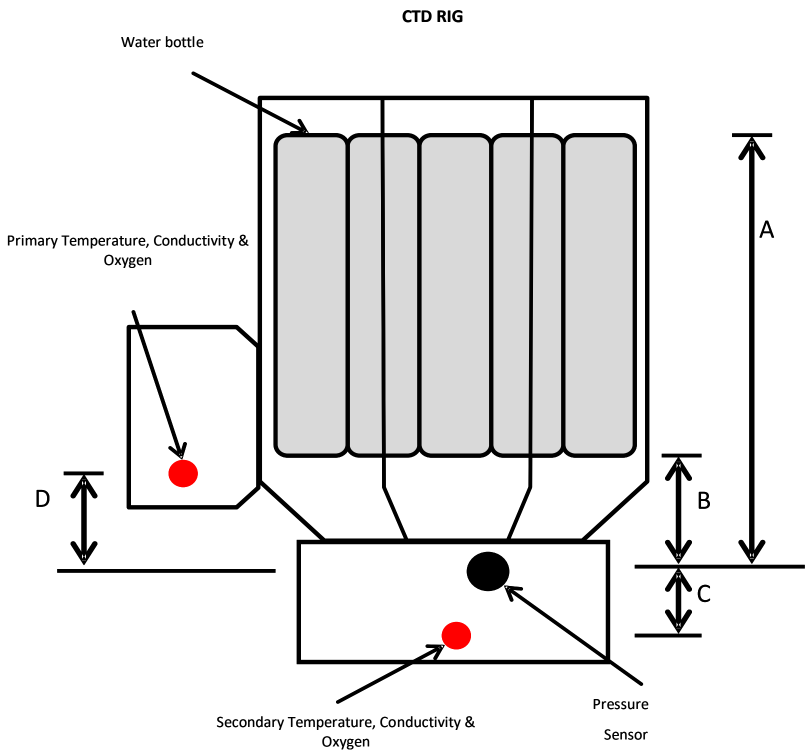


Figure 18.1: CTD system geometry. Vertical distance from pressure sensor [m]: A 1.50; B 0.10; C 0.07; D 0.07.

18.1.1 Primary Sensor Configuration:

Sea-Bird 9plus underwater unit, s/n 09P-54047-0943
Sea-Bird 3P temperature sensor, s/n 03P-4728, Frequency 1 (primary)
Sea-Bird 4C conductivity sensor, s/n 04C-4065, Frequency 2 (primary)
Digiquartz temperature compensated pressure sensor, s/n 110557 Frequency 3
Sea-Bird 3P temperature sensor, s/n 03P-4782, Frequency 4 (secondary)
Sea-Bird 4C conductivity sensor, s/n 04C-4138, Frequency 5 (secondary)
Sea-Bird 5T submersible pump, s/n 05T-6916, (primary)
Sea-Bird 5T submersible pump, s/n 05T-6320, (secondary)
Sea-Bird 32 Carousel 24 position pylon, s/n 32-31240-0423
Sea-Bird 11plus deck unit, s/n 11P-24680-0589 (main)
Sea-Bird 11plus deck unit, s/n 11P-34173-0676 (back-up logging)
Sea-Bird 35 Deep ocean thermometer, s/n 34173-0048
The auxiliary input sensor configuration was as follows:
Sea-Bird 43 dissolved oxygen sensor, s/n 43-1624 (V0) (Secondary)
Sea-Bird 43 dissolved oxygen sensor, s/n 43-0862 (V1) (Primary)
Benthos PSA-916T altimeter, s/n 47597 (V6)

Sea-Bird 9*plus* configuration file DY120_0943_SS_nmea.xmlcon was used for all casts (Appendix C).

Total number of casts: 10; Casts deeper than 2000m: 6; Deepest cast – 2915m.

18.1.2 Additional Sensors

Two new sensors were mounted on the CTD frame for this cruise: CONTROS CO_2 sensors and; AMT deep pH sensors. Both were connected to the 9plus although the CO_2 was powered by an external battery pack.

18.1.3 CONTROS CO_2 sensor

Contros Hydro-C CO2 sensor, S/n CO2T-1019-006 (cast 001, 002) s/n CO2T-1019-005 (cast 004).

The CO_2 sensor appeared to work on cast 001 (~60m) and the science party ashore were happy with the data they received. During cast 002, at a depth greater than 1000m (~1400m) the CO_2 sensor stopped working. For cast 004 the CO_2 instrument was swapped for another instrument, new cabling and a different battery pack. At a depth greater than 1000m (~1100m) this instrument also stopped working. Both instruments were opened up and showed no obvious signs of flooding, water damage or any other issue. The memory cards were removed so that the data could be retrieved and sent to the manufacturer who later confirmed that both instruments had suffered water ingress at the sensor head as shown in the data file by the rise in humidity and an error code that meant water ingress at the sensor head. The two further CO_2 instruments on board were not deployed for fear of the same issue reoccurring.

18.1.3.1 AMT deep pH sensor

AMT pH-combined sensor, s/n 347 (casts 001-003) S/n 346 (casts 004-010).

The pH sensor was connected to the 9plus on V7 and power this way. The initial setup involved turning the CTD on to power the pH instrument and soak the glass-electrode in a known buffer solution. The temperature of the solutions was noted. The raw voltage output is viewed in SeaSave and noted down. This was repeated for buffers 4, 7 and 10. SBEdata processing was then opened and 'pH fit' was run. The raw voltages and temperature were put into pH fit and this generated a slope and voltage offset. In SeaSave these values can be plugged into the pH sensor's calibration inputs in the config file.

The pH profiles seen throughout the CTD casts was reading far too high. Readings of pH12-13 were recorded. Checks on the setup of the instrument were carried out as well as re-running the buffer tests and then testing in pH7 after re-calibrating against the buffers. The instrument read ~7 in buffer 7. The next CTD cast generated pH of 12-13 again. A replacement instrument was fitted to the frame and run through the same calibration and ph fit process as above. The same results were obtained. AMT were contacted to ask for support and to confirm that nothing was being done incorrectly. Due to the repeated internet outages a reply was not received from them until after the last CTD cast had been carried out. Initially they advised that it could be a grounding issue caused by metal clamps. The instrument is mounted in a polymer clamp with tape wrapped around it. They then advised checking that the raw voltage output is ~2.5v when connected to 9-18VDC. This was done in the lab ashore only a few weeks prior to sailing and all four instruments gave readings of ~2.5v when powered with 12v, in-line with their calibration documents. No further trial of this has been possible due to the end of CTD operations on this cruise.

18.1.3.2 SBE35 Self-Recording Temperature Sensor

A SBE35 self-recording temperature sensor was fitted to the CTD and triggered (via a Y cable) when a water sampler was fired. It was set to average eight measurement cycles, the CTD being held at depth until this was completed after approximately 22 seconds.

The instrument was mounted vertically to a stanchion on the CTD frame diametrically opposite to the primary temperature sensor, which was mounted on the vane.

18.1.4 CTD Operations

All casts were carried out using underwater frame CTD6, which was terminated using the potting method during the mobilisation of DY120. Before electrically terminating the wire, it had a Megger value of 160 MOhms. The wire had been potted and streamed prior to the cruise. The CTD cable was electrically tested after terminating on 02/10/20 and had a 'Megger' value of > 550 MOhms. The wire resistance through just the CTD wire was 65.4 Ohms. It was tested again on 04/10/20 and had a Megger value of >550 MOhms and 65.0 Ohms.

The wire was load tested as per standard CTD load test of five minutes at 0.5 T, 1.0 T, 1.5 T and 2.0 T. During the mechanical test it was noticed that the load cell (calibrated 31/07/20) was reading lower than the load cell on the CLAM in a non-linear fashion. At the end of the load test the hook from the chain block was difficult to get off of the load shackle and was pressed against it. During discussions it was realised that the reason for the difference in load readings was due to some of the weight on the load cell being shared by the hook of the chain block. Due to this another load test was carried out a few days later once the CPOS had joined the vessel. The second load test showed the load cell and the CLAM having very similar readings. It was noted that the highest load the CTD termination was pulled to on the first load test was 2.63T as measured by the CLAM. This was deemed to still be within safe working limits and showed that the mechanical termination didn't slip at the higher load.

No issues were encountered with any of the standard CTD sensors that were mounted on the frame. The swivel seemed to work fine with no problems. The mechanical termination was checked with a torque wrench after most casts and no slipping of the mechanical termination was observed.

The primary T, C and O_2 sensors were on the vane. This caused some confusion during the first cast as the primary in SeaSave is defaulted as V0 but the Y cable used had the long leg as the odd channel so the primary O_2 is on V1. Going forward if we used a Y cable with two equal length legs then the chance for this to cause confusion would be removed.

The altimeter used on this cast was the Tritech altimeter. During DY113 it was reported that it gave false bottoms at bottom -300m and bottom -200m. During DY120 a false bottom of bottom -200m was experienced several times as well as a very strong false bottom ~140m from the bottom during cast 008. The signal looked very believable except for the odd spike in the data. The cast was paused while the EM122 data was checked, confirmed to be accurate and the terrain was flat for several miles either side of the ships position. The CTD package was then very slowly lowered, manually, for the remaining ~120m of the cast. Once the package had passed through the -20m range of the false bottom the altimeter signal went to >100m until it was ~98m from the actual bottom and tracked the bottom well from this point. A copy of the altimeter display during this part of the cast is included below.

The Active Heave Compensation system (AHC) was tested at some CTD stations for the purpose of gaining more data for the science community so as to attempt to better quantify the improvement in CTD data quality when using AHC. AHC tests were carried out during bottle stops by sitting for 5 minutes with AHC on and then a further five minutes with AHC turned off. This was done on CTD 005, 007, 008 and 009.

Cast 001 was a test cast to 60m as a shake down for all involved to test CTD operations.

CTD 002, 006 and 008 had releases on for testing.

CTD 003, 004, 005, 008 and 010 had SBE37's on for Cal dips.

18.2 Active Heave Compensation Tests

Sam Jones, Stuart Cunningham

We wished to investigate the change in CTD temperature, conductivity and oxygen data quality associated with winch Active Heave Compensation (AHC). On several CTD stations we tested AHC during extended bottle stops, collecting five minutes of data with AHC on then five minutes with AHC off. Typically, we conducted three experiments per CTD, at ~250 m, ~750 m and near the bottom of the water column to sample a range of vertical stratification regimes. Shallower than 250 m the vertical stratification is higher, but the AHC is switched off for recovery from typically 100 m.

Table 18.1: CTD station numbers, dates, and positions where AHC tests were conducted.

CTD Station No.	Date	Lat	Long
005	13/10/2020	57.48	-11.53
007	16/10/2020	57.79	-19.16
008	17/10/2020	57.98	-21.15
009	17/10/2020	57.98	-21.15

18.2.1 *Results*

We compared the 24 Hz CTD file with the winch file for each CTD and bottle stop. In general, the AHC performed well and had a positive impact on virtually all the regimes we tested under. Selected plots from the experiment are shown below. The AHC appeared to be most effective when presented with a large and well organised sea (e.g. Figure 18.1), presumably because its prediction skill was higher.

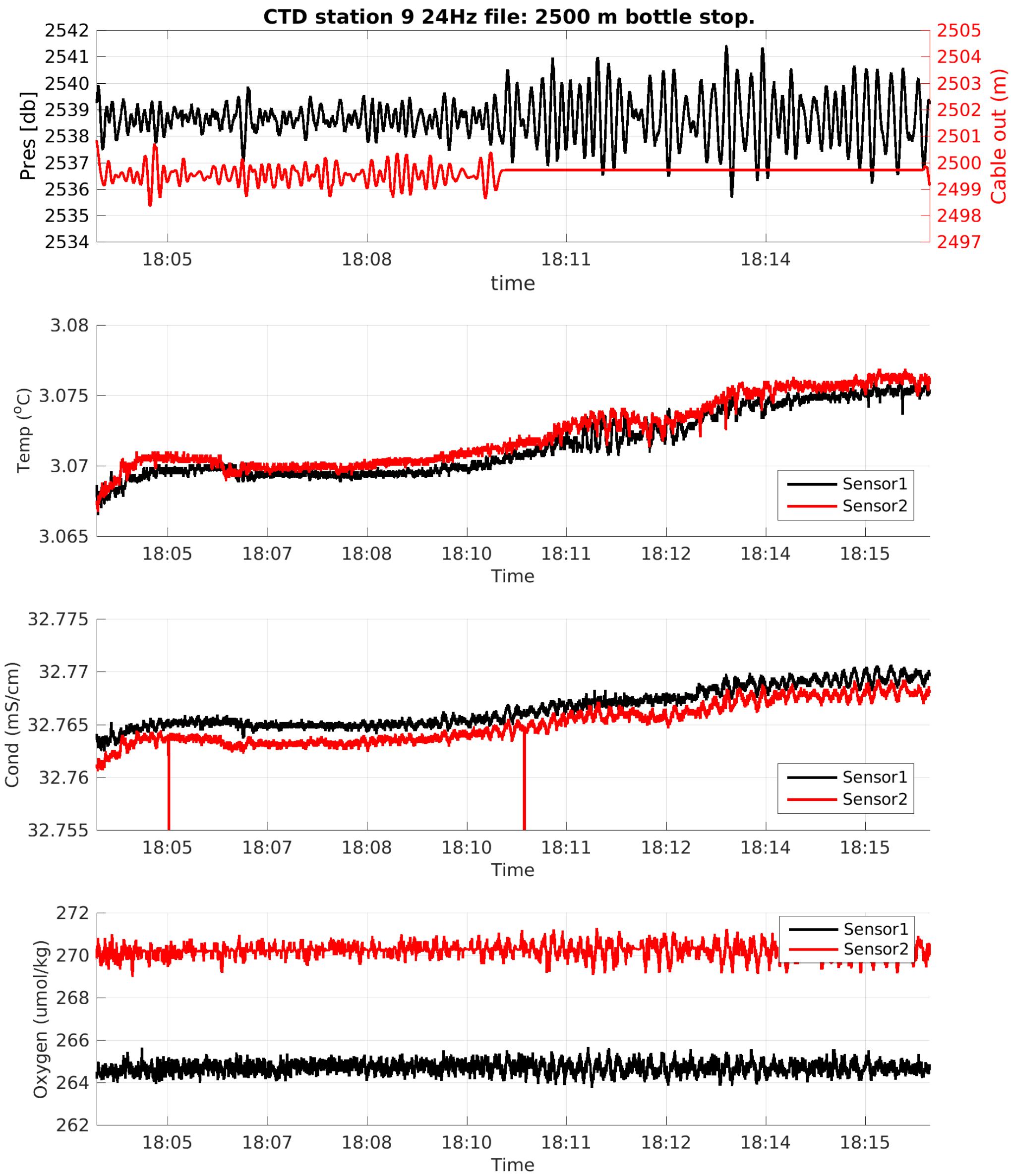


Figure 18.1: An example of AHC effectiveness in ~2.4 m swell. The standard deviation of CTD pressure observations is reduced by ~60 % when the AHC is activated in this example (see Table 18.2). For temperature and conductivity sensor 1 is fin mounted and sensor 2 is within the CTD frame. For oxygen sensor 2 is fin mounted and sensor 1 is within the frame.

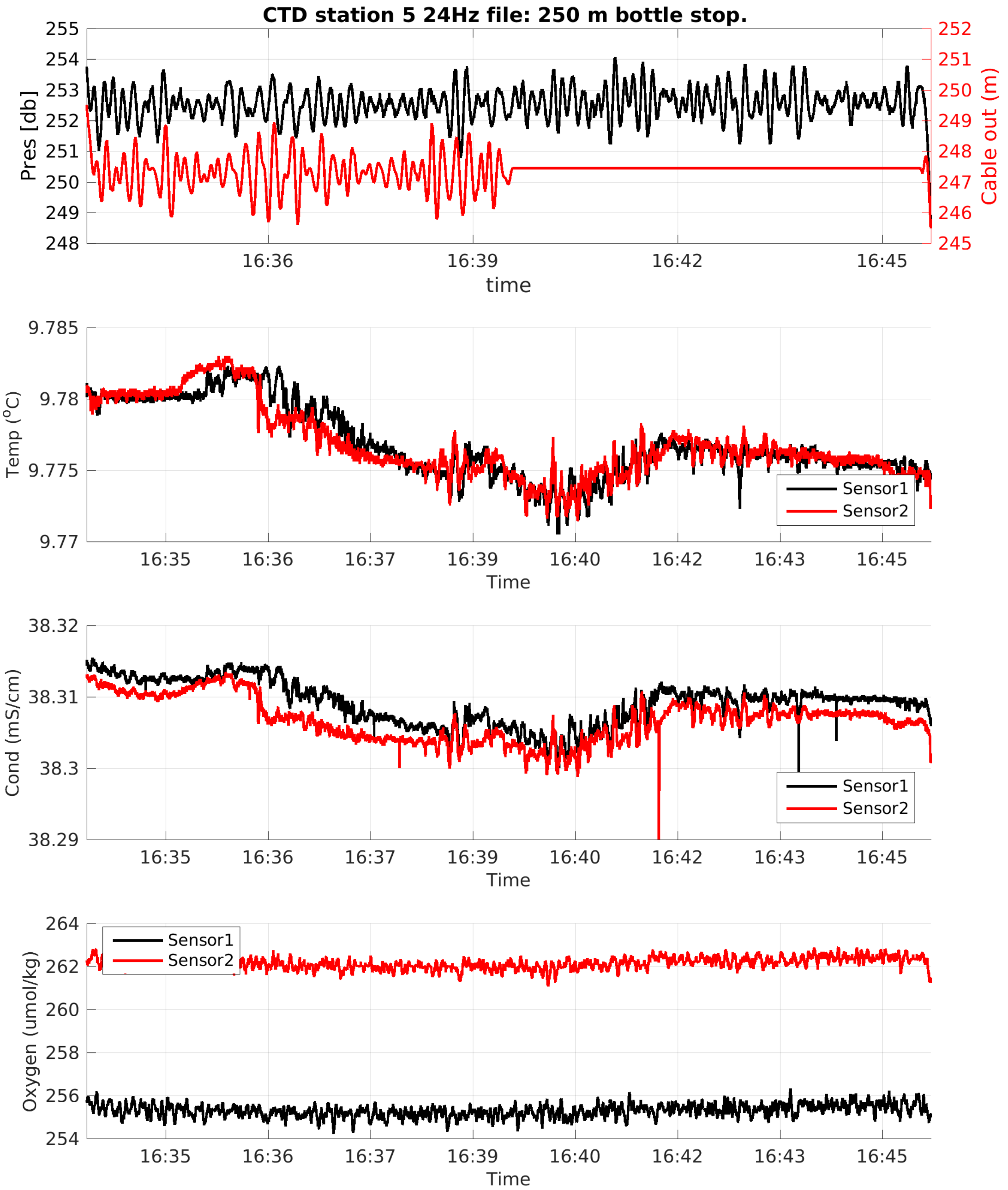


Figure 18.2: The AHC appeared to be less effective in smaller swell. The standard deviation of CTD pressure observations is reduced by 15% when the AHC is activated in this example (see Table 18.2).

18.2.2 Statistics of variability at each bottle stop

We calculate the mean and standard deviation for pressure, temperature, conductivity and oxygen for when the AHC was switched on and off (Table 18.2). The standard deviation is a good metric for the oscillations in pressure caused by ship heave. It is less effective for assessing data quality in T, C and O2 as these properties can feature temporal trends during or after AHC activation which increase the standard deviation and may not be related to ship heave.

More detailed statistical analysis should include removal of any longer-term temporal drift in T/C/O_2 during the botte stops. It is also evident that the C/T fin-mounted and internally mounted sensors show differences both trend over the bottle stop, but also differences at the roll frequency.

Table 18.2: Mean and standard deviation of pressure, temperature for each AHC experiment. Light grey AHC-ON, dark grey AHC-OFF.

	CTD 5			CTD 7		CTD 8			CTD 9		
	250 m	925 m	1500 m	150 m	750 m	100 m	850 m	2500 m	100 m	800 m	2500 m
AHC ON											
Num points	8616	8136	8447	8255	8279	7487	8975	8543	7847	5519	8592
Pres mean	252.478	928.929	1519.343	152.679	759.261	111.48	864.624	2538.773	107.494	799.835	2538.654
Pres sd	0.469	0.504	0.633	0.529	0.688	0.543	0.529	0.675	0.281	0.51	0.441
Temp mean	9.775	7.427	4.385	9.897	7.536	11.001	6.267	3.056	10.978	6.762	3.069
Temp sd	0.000246	0.0077	0.000735	0.00357	0.00531	0.00355	0.0122	0.0024	0.00593	0.000299	0.000513
Cond mean	38.31	36.272	33.551	38.328	36.252	39.473	35.049	32.751	39.464	35.489	32.765
Cond sd	0.00332	0.00761	0.000783	0.00254	0.00786	0.00356	0.0119	0.00213	0.00606	0.000492	0.000526
Oxy mean	255.211	211.804	258.828	247.845	213.215	236.189	219.034	264.124	237.961	216.142	264.694
Oxy sd	0.282	0.208	0.203	0.521	0.771	0.276	0.269	0.269	0.321	0.176	0.229
AHC OFF											
Num points	8471	8664	8687	8423	8328	7559	7391	8664	9048	8159	8736
Pres mean	252.606	929.459	1518.745	152.31	759.517	112.284	864.154	2538.21	107.425	798.898	2538.669
Pres sd	0.554	0.509	0.641	0.742	0.826	0.885	0.954	1.147	0.811	0.71	1.082
Temp mean	9.775	7.424	4.386	9.938	7.536	11.072	6.261	3.058	11.006	6.764	3.073
Temp sd	0.00128	0.00804	0.000345	0.0204	0.00491	0.055	0.0109	0.000478	0.0136	0.00113	0.00156
Cond mean	38.308	36.269	33.551	38.371	36.252	39.548	35.042	32.753	39.492	35.488	32.768
Cond sd	0.00255	0.00777	0.000338	0.0223	0.00697	0.0572	0.0103	0.000438	0.0139	0.000602	0.0012
Oxy mean	255.364	211.755	258.826	247.36	213.725	235.592	218.902	264.112	237.289	216.335	264.681
Oxy sd	0.291	0.218	0.205	0.262	0.345	0.439	0.222	0.284	0.389	0.234	0.295
How much standard deviation reduced (sd_ON / sd_OFF)											
Pres sd	0.85	0.99	0.99	0.71	0.83	0.61	0.55	0.59	0.35	0.72	0.41
Temp sd	0.19	0.96	2.13	0.18	1.08	0.06	1.12	5.02	0.44	0.26	0.33
Cond sd	1.30	0.98	2.32	0.11	1.13	0.06	1.16	4.86	0.44	0.82	0.44
Oxy sd	0.97	0.95	0.99	1.99	2.23	0.63	1.21	0.95	0.83	0.75	0.78

19 Salinometry and Water Sampling for Salinity

Billy Platt, Estelle Dumont, Lewis Drysdale

19.1 Salinometry

A Guildline Autosal 8400B, s/n 68958, was installed in the Electronics Workshop as the main instrument for salinity analysis. The Autosal temperature set point was 21°C and the temperature of the laboratory was kept around 18.5°C. A spare Autosal was also installed and setup but not used during this cruise. The salinometer was standardised at the beginning of the cruise. Once standardised the Autosal was not adjusted. Initially the Autosal stirrer pump would not run. It was opened up and confirmed that the belt was in good order and attached. It seemed to be slightly too tight to allow the motor to turn the stirrer. A gentle flick was enough to get it going and once it had run for a moment it was able to start itself ok when turned on. After this point the Autosal operated satisfactorily without any issues although there was an issue with the NMF LabView software not remembering the standardisation date and offset from the SSW and thus not being able to calculate salinity. As there was no requirement from the science party to have the salinity calculated for them this was left until the end of the cruise to be rectified.

The issue was caused by the Autosal machines being updated to Windows10 before the cruise and running a 64 bit operating system. The LabView software was designed to run on a 32 bit operating system. The way to fix this is to create a folder 'C:\Program Files\Autosal_2009' rather than letting the software try to read form 'C:\Program Files\(x86)\Autosal_2009'. Also, the software has been set to run as administrator and in compatibility mode 'windows XP pack3.

The PSO expressed a desire for the science party to be more involved in the processes on board so it was agreed that salinity samples would be run by a mixture of NMF techs and SAMS techs.

19.2 Salinity sampling

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

Salinity samples were taken from the ship's underway system three to four times a day (nominally at 08:00, 12:00, 16:00 and 20:00) throughout the cruise, following the same protocol as above. Samples were not taken while the ship was on station due to poor data quality at those times.

19.3 Salinity analysis

The salinometer was standardised once at the start of the cruise, then bottles of standard seawater (OSIL batch P163, K15 = 0.99985) were analysed throughout the salinometer runs to monitor instrument drift. The samples were stored in crates equilibrate to the temperature-controlled laboratory for at least 24 hours before analysis. For CTD samples, SSW was analysed at the start and end of each cast (7 to 12 bottles for each cast). For underway samples a SSW was run at the start and end of each crate (24 bottles). In total six CTD crates were run and two TSG crates. Thus, each crate of up to 24 salinity samples, three SSWs was used and each CTD station is tied to a start and end SSW. A total of 122 CTD samples were collected and analysed, and 43 underway/TSG samples.

20 CTD Processing and Calibration

Kristin Burmeister

A total of 11 CTD casts were completed during the cruise (Table 31.1, Appendix D). For each cast all 12 Niskin bottles mounted on the frame of the CTD rosette were fired although not every bottle was used to draw water samples. Salinity, oxygen, DIC and nutrients were sampled frequently but not on each CTD cast (Appendix C). Bottle stops were at least 30 seconds but could take as long as five minutes for MicroCats calibration stops or ten minutes for Active Heave Compensation (AHC) tests. The AHC was engaged on all casts from 100m depth to 100m off bottom. CTD 001 was too shallow for any AHC.

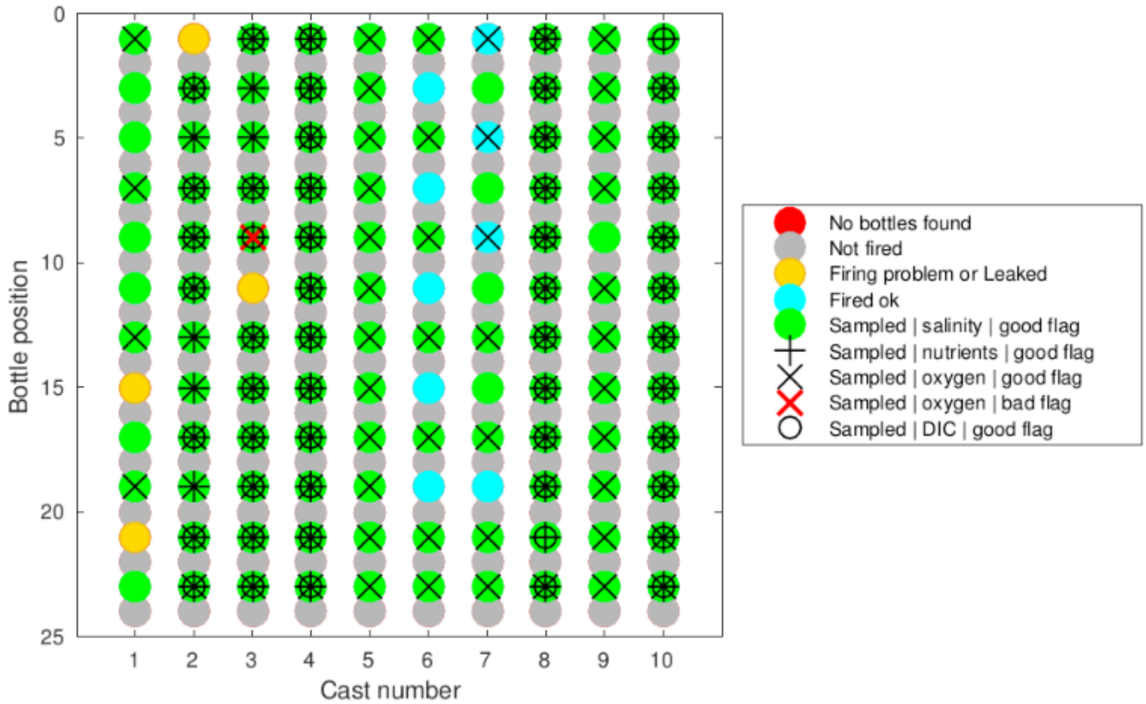


Figure 20.1: Overview of water samples drawn on each CTD cast.

20.1 CTD Data 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 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_v3 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 ([*Holliday and Firing*, 2020]). 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 data acquisition computer using the Seabird software. 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 commonly used 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 α=0.03 and 1/β=7 were used.

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

Before any cast is processed, ***msam_01.m*** was run once at the beginning of the cruise to create a *sam_sy120_00.nc* and *sam_dy120_template.nc* using the list of variables indicated in the files *sam_varlist.csv* (variable names of raw files) and *sam_varlist_out.csv* (variable names of nc-files) in the directory *~/dy120/mcruise/data/MEXEC_processing_scripts/templates/*.

1. For each cast, the first step of the MATLAB MEXEC processing was run using the wrapper script ***ctd_all_part1.m***, which called the following scripts and saves the output in the directory *~/dy120/mcruise/data/ctd/*:
   - ***msam_01b.m***: 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 *sam_dy120_template.nc*.
   - ***mctd_01.m***: conversion of raw 24Hz cnv data file to mstar netCDF format (ouput file is *ctd_dy120_nnn_raw.nc*).
   - ***mctd_02a.m***: converts variable names from SBE names to mstar names using *data/templates/ctd_dy053_renamelist.csv* (output file is *ctd_dy120_nnn_raw.nc*).
   - ***mctd_02b.m***: applies oxygen hysteresis correction using the default Sea-Bird coefficients [-0.033 5000 1450] and calculates turbidity from turbidity volts (output file is *ctd_dy120_nnn_24hz.nc*).
   - ***mctd_03.m***: average to 1Hz (output file is *ctd_dy120_nnn_1hz.nc*) and calculation of salinity and potential temperature (output file is *ctd_dy120_nnn_psal.nc*).
   - ***mdcs_01.m***: creates an empty data cycles file (*dcs_dy053_nnn.nc*), used to store the cast start, bottom and end metadata (positions, times, pressure, scan numbers and data cycle numbers.).
   - ***mdcs_02.m***: find scan number corresponding to bottom of file and use this to populate the file *dcs_dy120_nnn.nc*.
2. The script ***mdcs_03g.m*** was then run to inspect profiles, hand-select cast start and end times, and input the new values in *dcs_dy120_nnn.nc*. 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 were all, temperature, salinity and oxygen, had still reasonable data.

3. Next the wrapper script ***ctd_all_part2.m*** was run, executing:
   - ***mctd_04.m***: averages data to 2db bins (output file is *ctd_dy120_nnn_2db.nc*).
   - ***mfir_01.m, mfir_02.m, mfir_03.m, mfir_04.m***: get bottle firing information from the Sea-Bird .bl file and extract the matching CTD data based on scan numbers (output files are *fir_dy120_nnn_bl.nc, fir_dy120_nnn_time.nc, fir_dy120_nnn_ctd.nc, sam_dy120_nnn.nc*, respectively).
   - ***mwin_01.m, mwin_03.m, mwin_04.m***: get winch data (*win_dy120_nnn.nc*), merge winch wireout onto the fir file (*fir_dy120_nnn_winch.nc*) and paste winch fir data into *sam_dy120_nnn.nc*.
   - ***mbot_00.m, mbot_01.m, mbot_02.m***: create bottle files (*bot_dy120_nnn.nc*); add CTD data, bottle firing codes and quality flag at the time of the bottles firings in the *bot_dy120_nnn.nc* and *sam_dy120_nnn.nc*.
4. CTD data were visually checked using the script ***mctd_checkplots.m***.
5. On this cruise, the station depth for each CTD station is calculated based on the CTD maximum depth plus the altimeter height using the script ***populate_station_depth.m***:
   - First, we add a populate_station_depth section in ***opt_dy120.m*** and for case *'fnin'* we set *depmeth* to be 3 (calculate depth from CTD depth and altimeter reading)
   - Then we run ***populate_station_depth.m***, which prepare a mat-file (*~/dy120/mcruise/data/station_depths/station_depths_dy120.mat*) with station depths for all CTD stations.
   - CTD station three could not be estimated automatically, because the minimum altimeter height was above 20 m of the sea bottom (***populate_station_depth.m*** only uses altimeter data smaller than 20 m). We average altimeter and CTD depth for 30 seconds around maximum depth. The sum of both is the station depth which we added manually in the *populate_station_depth* section of ***opt_dy120.m*** (case *'bestdeps'*).
   - Rerun ***populate_station_depth.m*** to add depth of CTD station three to *station_depths_dy120.mat*
   - Run ***mdep_01.m***: add station depth from *station_depths_dy120.mat* to header of all ctd nc-files.
6. Discrete bottle sample data (salinity and nutrients) and SBE35 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_dy120.m***, calling:
   - ***moxy_01_OSNAP.m, moxy_02_OSNAP.m***: (details in Calibration of CTD Oxygen below)
   - ***msal_01.m***, ***msal_02.m***: (details in Calibration of CTD conductivity below).
   - ***mnut_01_dy120.m***, ***mnut_02_dy120.m***: for nutrient samples unique reference numbers were recorded in csv files for each cast (*~/dy120/mcruise/data/ctd/BOTTLE_NUT/ nut_dy120_nnn.csv*). The two scripts read the csv file, create the nutrient netCDF file (*nut_dy120_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.m***, ***msbe35_02.m*****:** (details in CTD temperature quality control below)
   - ***msam_append.m*** OR ***msam_updateal.m l***: if the cast sam file has not been added to the global sam file (*sam_dy120_all.nc*) then add it by running ***msam_append.m***. In

case of a reprocessing use ***msam_updateall.m*** so that the cast is not duplicated in the appended master SAM file.

20.2 CTD Temperature Quality Control

To provide independent assessment of the stability of the CTD temperature sensors, an SBE35 deep ocean standard thermometer was mounted on the rosette (*https://www.seabird.com/modular/sbe-35-deep-ocean-standards-thermometer/family?productCategoryId=54627473800).* The SBE35 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 has not been recently calibrated and is used here as a relative standard to assess the stability of primary and secondary temperature sensors and not as an absolute measure. The Gallium triple point cell was not available to check the stability and accuracy of the SBE35 during the cruise: we recommend the routine use of the Gallium cell at sea.

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 DY120, this file is found in *~/dy120/mcruise/data/ctd/ASCII_FILES/SBE35/.*

msbe35_01.m reads the data for a single station, extracting data cycles for the station based on the start and end times.

msbe35_02.m pastes the SBE35 data from one station (*sbe35_dy053_nnn.asc*) into the SAM file (~/dy120/mcruise/data/ctd/*sam_dy120_nnn.nc*).

ctd_evaluate_temp_dy053.m in *~/dy120/mcruise/users/kristin/* 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 2.02 mK, and the CTD secondary sensor colder by 1.54 mK (Figure 20.2).

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.

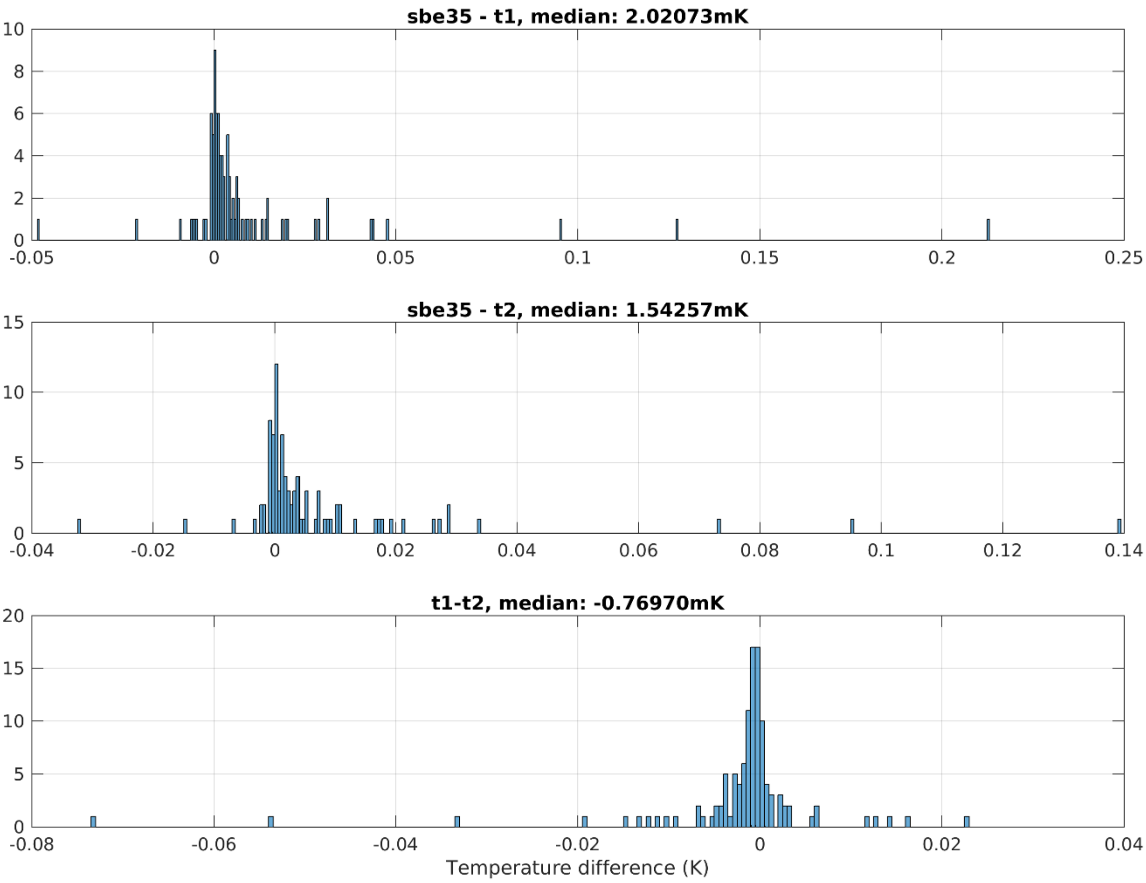


Figure 20.2: Histogram of the temperature difference between the reference thermometer SBE35 and the primary and secondary temperature sensors of the shipboard CTD.

20.3 CTD Conductivity Calibration

The results of the salinity bottle analysis are saved in excel-spreadsheets on the ship sever *(\\dynas1.discovery.local\sandm\DY120\Salinity*). Manually, data are copied into one excel spreadsheet for all station and the sample number consisting of the CTD number and the Niskin bottle number (e.g. 101 for CTD Station 1 and bottle number 01) are added.

The scripts ***msal_01.m*** and ***msal_02.m*** are used which read the csv files from the analysis of the salinity bottle *(~/dy120/mcruise/data/ctd/BOTTLE_SAL/sal_dy120_nnn.csv*) and paste the data into the sample files *sam_dy120_nnn.nc*.

The script ***ctd_cal_dy120.m*** in *~/dy120/mcruise/data/MEXEC_processing_scripts/* 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.m***. The wrapper ***smallscript_tccal.m*** can be run on a set of stations (defined in ***opt_cruise.m****,* section *'smallscript', case 'klist'*). 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_dy120_nnn_raw.nc* file which contains raw data).

For this cruise conductivity measured by the primary conductivity sensor was found to read higher conductivities and was adjusted by a slope correction of 0.99997559 (Figure 20.3). The secondary sensor was found to read higher conductivities and a station depended trend was found. The secondary senor was adjusted by a slop correction of 1.00004201 and the linear relationship between conductivity and station were subtracted (*nnn**-0.00012320+0.00067593, *nnn* is the number of the CTD station, Figure 20.4). Please note that the secondary sensors were suspicious for CTD-cast 006 because of noise on the upcast profile and therefore this cast was not use to in the evaluation of calibration parameters for the secondary sensor.

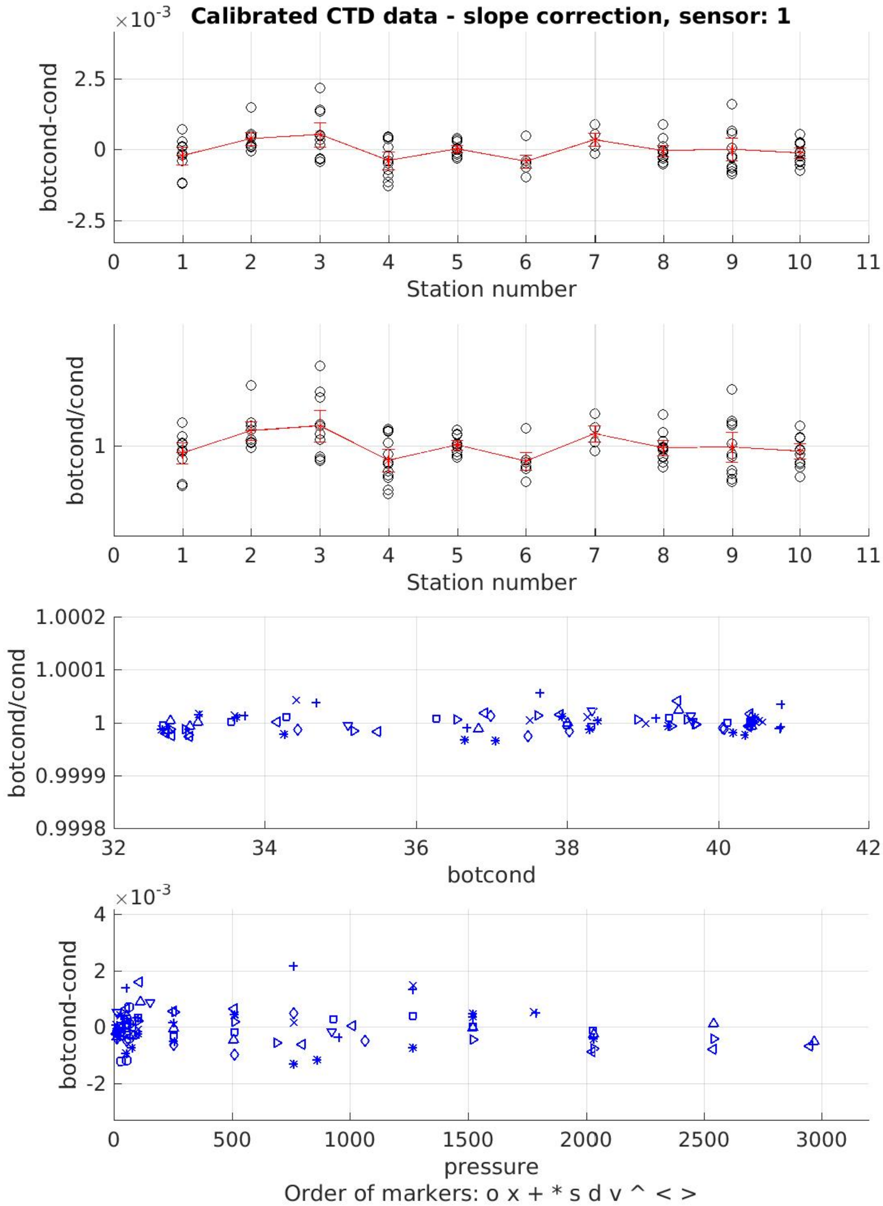


Figure 20.3: Comparison of the water sample analysis with the shipboard CTD measurements after calibration of the primary conductivity sensor. From top to bottom: conductivity differences as a function of the CTD stations; conductivity ratios as a function of the CTD stations; conductivity ratio as a function of the conductivity of the water sample; conductivity differences as a function of sampling depth. 107 good data points were retained from the 121 water samples (88.43%).

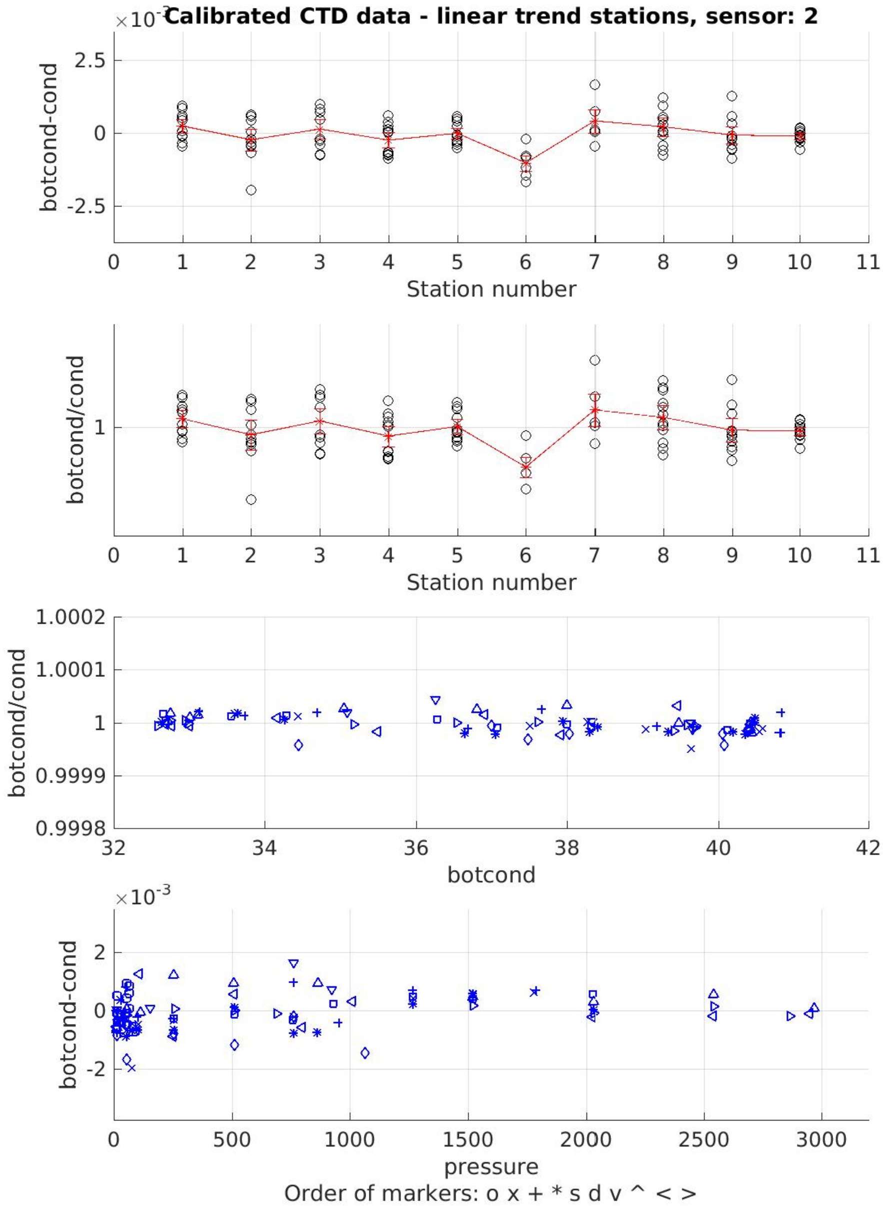


Figure 20.4: Comparison of the water sample analysis with the shipboard CTD measurements after calibration of the secondary conductivity sensor. From top to bottom: conductivity differences as a function of the CTD stations; conductivity ratios as a function of the CTD stations; conductivity ratio as a function of the conductivity of the water sample; conductivity differences as a function of sampling depth. 100 good data points were retained from the 121 water samples (82.64%).

20.4 CTD Oxygen Data Processing

Sam Jones, Kristin Burmeister

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

NOTE due to wiring constraints, on DY120 the oxygen primary channel mapped to the oxy 2 variable, and vice versa.

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

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

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

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

Following recommendations in SBE Application Note No. 64-3 (Revised August 2014) SBE 43 Dissolved Oxygen (DO) Sensor, Hysteresis Corrections were also applied. In Seabird Data Processing Data Conversion module (DatCnv) we convert to DO applying both Tau in (equation 1) and hysteresis corrections (equation 2) using the default window size of two seconds for oxygen calculations. We did not investigate whether Tau improved or degraded signal-to-noise in deep water. Data Conversion first applies a hysteresis correction on SBE 43 voltage values, and then uses the corrected voltages to convert to DO. Therefore, both columns of output DO data (voltage and concentration) contain data that have been corrected for hysteresis. SBE 64-3 states that default hysteresis coefficients are adequate for most applications and for higher accuracy (±1 μmol/kg), H1 and H3 can be fine-tuned if a complete profile (downcast and upcast) is available, preferably to greater than 3000 meters. We did not have adequate deep profile data to assess this and made polynomial corrections to oxygen hysteresis station-by-station to ensure zero bias between down and up oxygen profiles.

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

The SBE 43 is calibrated using SeaBirds' Equation (1) with the coefficients (Appendix C) (a modified version of the Owens & Millard (1985) equations). Hysteresis corrections (Equation 2) using the Nominal Coefficients (Appendix C).

Sea-Bird dissolved oxygen equation:

$$O_2 = \left\{S_{\mathrm{OC}} \times \left(V + V_{\mathrm{offset}} + \mathrm{tau}(T,P) \times \frac{\partial V}{\partial t}\right)\right\} \times O_{\mathrm{xsol}}(T,S) \times (1.0 + A \times T + B \times T^2 + C \times T^3) \times e^{\left(\frac{E \times P}{K}\right)}$$ (Equation 1)

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

Hysteresis Algorithm using Oxygen Voltage Values:

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

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

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

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

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

(Equation 2)

where

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

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

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

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

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

• **Oxygenvolts (i)** = dissolved oxygen voltage value with Voffset correction (made prior to hysteresis correction) at index point i.

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

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

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

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

• **Oxnewvolts(i)** = hysteresis-corrected oxygen value at index point i.

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

Notes:

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

• Scan 1 - When calculating Oxfinalvolts (i) for scan 1, make the following assumption about values from scan 0: Oxnewvolts (0) = Oxygenvolts (0).

20.5 CTD Oxygen Calibration

Calibrations have been done with bottle and CTD oxygens in units of μmol/kg. Bottle oxygen samples were taken on all CTD stations (1-10) (Figure 20.5).

Calibration of the SBE43 requires the computation of the botoxy/uxoy ratio as a correction, accounting for the change in output response of the sensor due to fouling. Here we compute this ratio and apply this to the SBE43 output values (rather than changing the Soc coefficient and rerunning the DatCnv module). Seabird state that a correction ratio >1.0 indicates sensor is fouling (drifting low). Further if the correction factor is greater than 15-20% of original factory Soc (Table 120.1), the sensor may need to be returned for factory service.

Note on units:

On DY120 the CTD oxygen was supplied in umol/kg, but the bottle data (as is common in chemistry) were supplied in umol/l. In order to compare like for like, we had to comment in the script ‘oxy_mll_to_mlkg.m’ in the CTD sample processing steps. Similarly, it is important to check the units of the variables read in at the start of *sbe43_sam_oxy_cal_03.m* (see below) to make sure that both the uoxygen and bottle oxygen variables are in umol/kg.

Calibration Determination:

We used the script sbe43_sam_oxy_cal_03.m which:

- Excludes data outliers
- Examines bottle and uoxy data and oxy_diff (botoxy-uxoy) differences as a function of pressure.
- Plots oxy_ratio (botoxy/uoxy) against botoxy and; oxy_diff against station number.
- Applys oxy_ratio correction to uxoy and replot.
- Determines a final correction to uoxy as a function of pressure and plot final residuals against pressure. These coefficients are printed to screen and need to be copied into the cruise options file (e.g. opt_dy120.m) under the heading: case 'oxy_apply_cal'.

Final calibration coefficients are given in Table 20.1 and residuals plotted in Figures 20.5 and 20.6.

Table 10.1. Corrections determined from comparison of upcast CTD oxygen to bottle oxygen. Apply Ratio correction then Press_corr. Botoxy-uoxy are the final residual statistics of calibrated CTD oxygen. Oxygen Units: μmol/kg.

Sensor s/n	Ratio (press>0dbar): (botoxy/uoxy) Mean±SD	Press Corr Uoxy_corr = P1 + P2 x press
43-0862 (oxy2)	1.0036 ± 0.013878	0.19 + -0.00029
43-1624 (oxy1)	0.9976 ± 0.010929	-0.93 + 0.00143

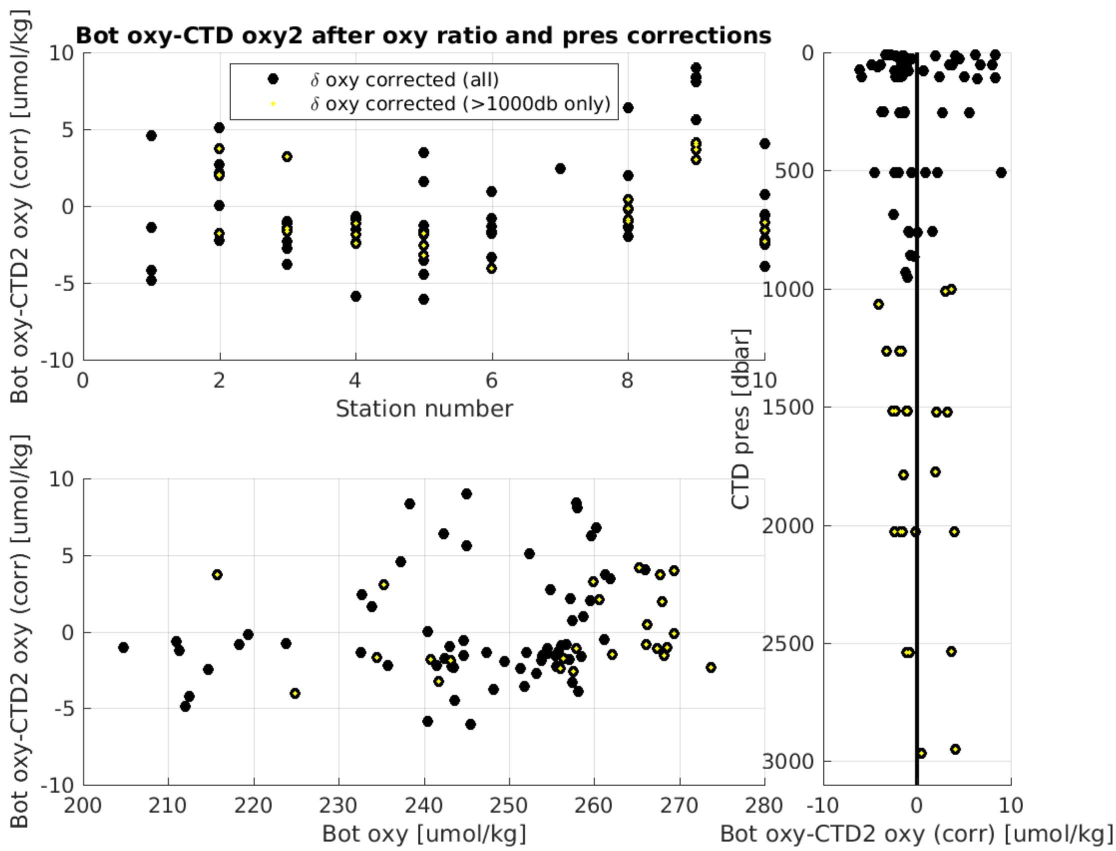


Figure 20.5. SBE43: Bottle oxygen – uoxygen 2 [Primary channel] after ratio and pressure residual calibrations. Ratio correction and pressure correction across full range of pressures.

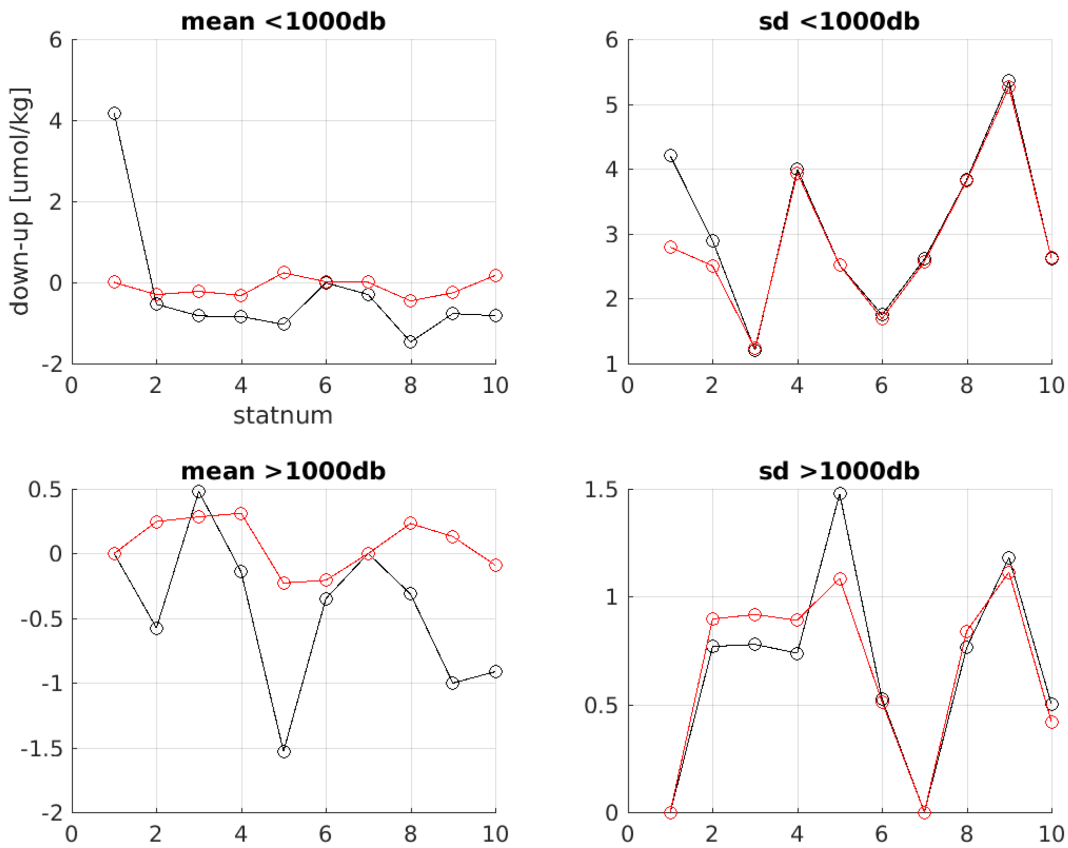


Figure 20.6. Comparison of CTD statistics for uncorrected (black) and corrected (red) data.

20.6 Residual Hysteresis Between CTD Oxygen Down and Upcast

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

We assessed the difference between up and down profiles using *seb43_oxy_cal_hysteresis.m.*

This performs the following actions:

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

We found the oxygen hysteresis to be small, with the only significant hysteresis occurring in the shallow test CTD cast (cast 1) which was as expected. Given its minimal impact, we decided not to apply hysteresis correction to the CTDs.

21 Chemistry

Sarah Reed

SAMS head quarter support*:* Dr Rich Abell and Dr Clare Johnson

Aim: to measure dissolved oxygen from the CTD casts for calibration of oxygen sensors on both the CTD rosette and the OSNAP moorings where ODO microcat sensors were deployed.

Stations sampled: Nomenclature by CTD station number, we sampled CTD001-012

21.1 Niskin Sampling Procedure

Target depths were: 10, 25, 50, 100, 150, 200, 250, 500, 800, 1000, 1600, 1800, 2000 and 2500. Depths varied on water column depth to get a full depth profile from the surface and then 10 m from the bottom at every station. Specific depths also varied depending on where sensors were placed on the moorings where CTD calibration depths were chosen to match the moored depths. Where important stations where highlighted, such as the EB1 mooring pre and post calibration dip and a few of the Rockall stations, triplicate oxygen samples were taken for a higher precision where time allowed. Thereafter duplicates or singular measurements were taken.

21.2 Oxygen analysis

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

21.2.1 Winkler Titration

The instrument used to measure the dissolved oxygen samples was the 848 Tritino plus automated Titrator (s/n 00141925), with a calibrated 5 ml pipette and 801 stirrers; all in working order with no issues. The backup instrument, which was the same model, an 848 Tritino. We also brought a third machine as an extra backup called a 702 SM Tritino. The method used follows the GO-SHIP protocols for ([*Langdon*, 2010]). Sarah Reed prepared chemicals prior to the cruise, following the GO-SHIP protocol.

21.2.2 Standardisation of sodium thiosulphate

Standardisations using both the SAMS in-house and the OSIL standard was conducted before each set of samples until there was a repeat of 0.005, this provided evidence that the machine and the thiosulphate were stable during analysis. The reagent thiosulphate concentration was plotted over time to monitor its stability (Figure 21.1). The standardisations and comparing data to previous cruises confirmed that the method was working and there were no issues with equipment or chemicals during this cruise.

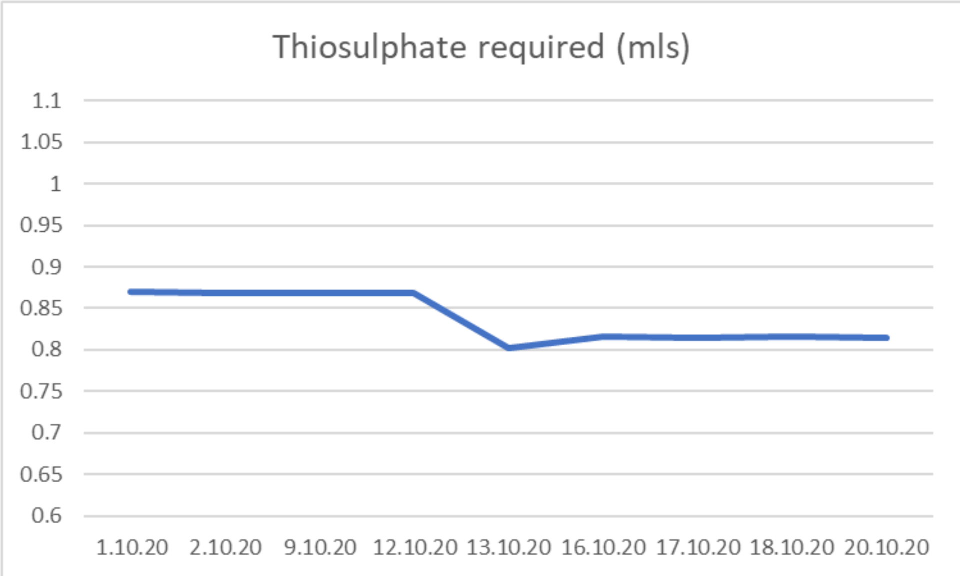


Figure 21.1. Volume of thiosulphate against time.

21.2.3 Oxygen Sample Analysis

The method used was the SAMS and SAMS Research Services Limited approved method based on that of Holley and Hydes, 1994 and following GO-SHIP procedures. After a standardisation was completed and samples had naturally warmed up to room temperature (~22^{o}C) and had been shaken twice since collection, samples were measured on the 848 Tritino plus machine. 1 ml of Sulphuric acid (75%) was added to the sample, a magnetic stirrer was added to the sample (slowly down the side to reduce bubble contamination) then when the solution was fully mixed the sample was added to the stirrer of the 848 machine. The automated and calibrated 5 ml burette and probe were added to the solution, the Holley Hyde's method (preloaded) was selected on the machine and the samples run by automated Winkler titration. The sample is titrated with 0.25 sodium thiosulphate using the automated pipetting system. The volume of the titre in mls was recorded from the machine and C(O2) mol/l per sample was calculated. This was repeated for each individual sample. The RSD percentage was worked out for each repeat, if there was a bad repeat that seemed to not fit the data, then the spreadsheet was checked for any errors such a bad formulae or a human error when typing, if this did not rectify it then the sample was flagged.

Regular quality checks of the bottle oxygen data were carried out by means of comparison with CTD sensor oxygen data outputs, and also by comparison with historical oxygen data from the Extended Ellett Line. Bottle oxygen and sensor data matched plotted profiles, suggesting that both the sensor and Winkler analysis were operating well. A comparison of bottle oxygen against sensor oxygen showed a tight linear relationship with a value of r of 0.98. Residuals (bottle oxygen – sensor oxygen) were near constant throughout the cruise, providing further evidence that the both the autotitrator and rosette sensor were stable. Oxygen data from the 2015 and the 2018 cruise were compared to other Extended Ellett Line cruises and had a good match presenting good accuracy with limited drift.

21.3 Dissolved Inorganic Carbon & Total Alkalinity

Sarah Reed

Water samples were collected for analysis of dissolved inorganic carbon and total alkalinity. Samples were taken straight after the oxygen samples to reduce contamination risk into borosilicate 250 ml glass stopper bottles. Silicon tubing was flushed before the sample bottle was slowly filled and first inverted and then turned upright. We slowly rotated the bottle as it filled to make sure no bubbles collected inside the bottle. The bottle was over filled, the silicon tubing slowly removed and the stopper was inserted. After sampling was completed, back in the lab under a fume cupboard 2.5 ml of seawater was removed from the bottle and then 50 µl of 0.02 % mercuric chloride was added into the seawater sample. The tip of pipette was about half the length of the pipette tip below the surface of the seawater when doing this. Apieson grease was placed lightly around the inside neck of the bottle. With the glass bottle top on, the bottle was inverted to mix the sample before a loop of tightly stretched PVC tape was added around the bottle neck to seal the stopper. Details of the CTD station were added to the outside of the bottle with the seven digit code and these were stored at room temperature (e.g. 0103002 where: 1=sample 1, 03=Niskin number, 002 = CTD station number). Samples were returned for shore-based analysis of dissolved inorganic carbon and total alkalinity.

21.4 Inorganic & Organic Nutrients

Sarah Reed

60 ml polypropylene sample vials were acid washed prior to the cruise by Tim Brand. Water for nutrient analyses were taken straight after oxygen and carbon samples (DIC if taken) to reduce contamination risk; nitrile gloves were worn whilst sampling. Silicon tubing with a mesh on the end, to prevent plankton getting into the samples, was attached over the Niskin tap. Sample vials were rinsed three times from the specified Niskin and then filled with an air gap at the top to allow for expansion when stored in the -20 ^{o}C freezer after sampling upright. All samples were given a seven-digit identifying code. Once samples were fully frozen, each sample from one CTD station were stored in one plastic bag with information written on the outside to keep things organised. Samples were returned frozen for later shore-based analysis of nitrite, nitrate, silicate and phosphate.

22 Argo Float deployments

Four ARGO floats were deployed on behalf of the UK Met. Office (Table 22.1).

Table 22.1: ARGO Float serial numbers and positions. 8985 Iridium float with 2-way communications to allow mission profile changes.

Serial number	Date & time (UTC)	Latitude (N)	Longitude (W)	Depth (m)
8589	11/10/2020 19:17:50	57° 17.9946'	010° 23.1876'	2216
8985	21/10/2020 22:07:30	58° 43.1094'	015° 39.6103'	1161
8462	22/10/2020 08:14:30	59° 00.0270'	012° 00.2149'	1768
8461	22/10/2020 16:30:50	59° 02.0145'	008° 56.0041'	1639

23 Moorings

We successfully completed six refurbishments of moorings that were deployed in 2018: RTEB1, RTWB2, RTWB3, IB5, IB4 and IB3. The RT moorings were first deployed in 2014. IB4 and IB3 were also first deployed in 2014 and managed by B. Johns (RSMAS, University of Miami) until 2018 when the UK programme took up the management of these moorings. IB5 was first deployed by the UK in 2018. We also installed a new mooring: RHADCP at 57° 36.89’ N, 15° 24.66’ W.

23.1 Deck Setup

The NMF double barrel winch was setup on the middle of the deck to be used for all mooring recovery and deployment operations. A North Sea five Tonne winch was setup on the starboard aft section of the working deck and used with the ships aft gantry and a hanging block for anchor deployments.

23.2 Recoveries

Moorings were released with an Ixsea deck box setup in the main lab. For most recoveries and trilaterations the drop keel was not used however the port drop keel was used twice to enable better communications with the releases. Once the mooring was on the surface and alongside the vessel the moorings were recovered on the starboard side of the vessel using a recovery line from the double barrel winch, paid out aft around the back off the vessel and led up the starboard waist.

A Seacatch 5 tonne hook was used to attach the recovery line on board to the recovery line on the mooring. In a few instances it was not possible to hook into the recovery line of the mooring as weather/entanglement meant the mooring had to be hooked in another place.

23.3 Crane Setup

The port crane was used for the first two moorings, EB1 and WB2, with a fixed hook. During both these operations there were intermittent problems with the crane stopping and cutting out. An oil leak was then found, and the crane was unable to be fixed. The rest of the mooring operations had to be done using the starboard crane once the runner had been switched to a fixed hook.

23.4 Deployments

All moorings were wound onto wire drums using the double barrel winch. Every link in the mooring was wrapped in thick plastic groundsheet to ensure that no damage to the outer sleeve would happen. When the mooring was being deployed this wrap was removed to enable the mooring to be connected together fully.

During the deployment of IB5 the angle of the mooring leading aft out of the block on the crane caused the outer sleeve of the wire to rub against the side of the block. This caused some abrasion to the outer sleeve leading to a pause in deployment while this was rectified. The section of damaged sleeve was tightly wrapped in amalgamating tape including above and below to ensure sufficient protection was built up around the wire. This also happened during the deployment of IB3 and the same remedial work was carried out. To try and reduce the chance of this happening after the first instance some sections of hose were cut, split and taped to the sides of the block in the crane. These were further wrapped with addition thick tape to help build up a layer on protection. This damage resulted from the lack of the second crane to lift the heavy floatation elements overboard, so the full weight of the flotation transferred to the mooring wire running over the block at an angle greater than 90°.

Mooring deployments were all started a sufficient distance away from the target mooring site so as to leave enough time to deploy the mooring and tow it at 0.5 knots the last few hundred meters. The anchors were lifted off deck ~50 m from the target site using the 5T winch described above. All anchors were connected up using a Seacatch quick release which enabled a quick, safe and reliable method of letting go of the anchor once the ship was in the target position.

23.5 Trilateration

Mooring trilaterations (true range multilateration) for each mooring establish a precise seabed location for the mooring using multiple range measurements from the ship to the releases. This is important for safe ship positioning for recovery and potentially for dragging should releases fail. After every deployment an NMF technician setup the Ixsea deck box and ranged the mooring all the way down to the bottom. This was then handed over to the science party to carry out the trilateration which was done for each mooring.

The main steps to get the trilateration processing are:

- Measure the range from the ship to the releases from three locations around the nominal mooring location.
- Find the ship's position and water depth at these points using the script *get_position_depth_dy120.m* found in the directory */local/users/pstar/dy120/mcruise/users/Processing_scripts*
- Go into the trilateration working directory:
- */local/users/pstar/osnap/exec/dy120/mfiles/triangulation_with_tgt/SAMS_moorings.* Create a .txt file containing the meta-data for the trilateration. The first row contains the target position. The second row is uncorrected water depth at anchor drop, the release height above bottom and the transducer depth. The third row indicates the position at the anchor drop. The row 4 to 6 indicates the range of the acoustic release, the latitude and the longitude for each trilateration position. See Figure 23.1 for an example.
- Run the script */local/users/pstar/osnap/exec/dy120/mfiles/triangulation_with_tgt/SAMS_moorings/anchor4.m.* A GUI window will open asking for the name of the file to be loaded and the program will generate and save a figure with the results of the trilateration.

Trilateration results are given in Appendix K.

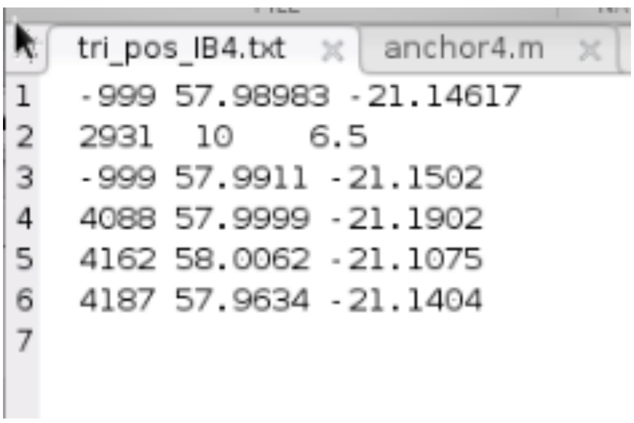

```
tri_pos_IB4.txt    anchor4.m
1  -999 57.98983 -21.14617
2  2931  10    6.5
3  -999 57.9911 -21.1502
4  4088 57.9999 -21.1902
5  4162 58.0062 -21.1075
6  4187 57.9634 -21.1404
7
```

Figure 23.1: Example of trilateration metadata file for used by the script anchor4.m.

23.6 Recovery, Deployment and Calibration Deployments

Appendices C, D, E, and F list the serial numbers of all instruments recovered, deployed and calibration dipped on this cruise, including which moorings they were recovered from and deployed to.

24 Mooring Instrumentation

Estelle Dumont, Lewis Drysdale

Setup capture files listed in Appendix P.

24.1 SeaBird SBE37

24.1.1 Recoveries

SBE37s Microcats SMP were recovered on all moorings. All were still operational and collecting data at the time of recovery after being deployed for 27 months. No significant clock drift was reported (most within 1 minute of UTC time, with the oldest instruments (serial numbers in the 3000s) showing a larger offset of two to five minutes). They were cal-dipped post-deployment. Raw data were converted to .cnv in SBEDataProcessing (DatCnv module) for SBE37's v≥3.0, and in SeaTerm using the "Convert" button for SBE37s v≤3.0.

24.1.2 Deployments

SBE37s Microcats SMP were deployed on all moorings. The microcats were all cal-dipped and fitted with new batteries (SAFT 3.6V Lithium AA cells) prior to deployment, endurance listed in Table 24.1. Their clocks were synchronised to GPS time and the instruments set to sample every 1800s.

Table 24.1: Estimated endurances (from SeaBird's Deployment Endurance calculator).

SBE37 version	SBE37 S/N	Estimated endurance (days)	Recovered instruments endurance (days)
V 4.0 and higher	> 9000	4507	839+
V 3.0 and higher	8000's	1243	839+
V 2.6	3218	1999	839+
V 2.5	3481	1816	839+

24.2 SeaBird SBE37-ODO

24.2.1 Recoveries

SBE37-ODOs are Microcats fitted with an additional SBE63 Optical Dissolved Oxygen sensor.

Three ODOs were recovered on EB1: s/n 15476 paired with SeaFET s/n 117 at 60m, and s/n 15298 and 15254 stand-alone at 750m and 950m respectively. s/n 15254 was found to have leaked, with some water on the batteries and signs of condensation and corrosion in the electronics compartment. No communication could be established, the unit will be sent back to SeaBird for repairs and hopefully data retrieval.

Data were downloaded from the two remaining instruments and clocks checked (no significant offset found). The raw data were converted to cnv in SBEDataProcessing.

Large conductivity offsets were detected on s/n 15476 and 15298 during the post-deployment cal-dip (see details in the cal-dip section). The conductivity sensor on s/n 15298 started showing unrealistic values from December 2019. The conductivity data from s/n 15476 appeared reasonable until the record stopped on the 10th March 2020 when SeaFET 117 ran out of battery. The pressure, temperature and oxygen sensors were found to be working as expected during the cal-dips. Both ODOs were redeployed on IB4 despite the conductivity offset, next to SBE37s which will provide the salinity data required to correct the ODO's oxygen data.

24.2.2 Deployments

SBE37-ODOs were deployed on EB1 and IB4.

The SBE63 sensor requires a longer flushing time than the conductivity sensor for the readings to stabilise. SBE37-ODOs have the option of using Adaptive Sampling, described in the instrument manual as:

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

This option was activated for all SBE37-ODOs deployed stand-alone. As the pumping time is significantly higher than on a standard Microcat energy usage was carefully estimated before setting the sampling intervals for deployment in 2018 (using SeaBird's Deployment Endurance software and checked against the RAPID calculatorspreadsheet). "Worst-case" scenario values (i.e. lowest temperature expected) were used in the calculations. The two functional SBE37-ODOs recovered from EB1 during this cruise were still recording, confirming the original endurance estimates. Unfortunately, the SBE37-ODO located deepest and coldest was the one which leaked, and its endurance could not be confirmed. The same endurance calculations were carried for this year's deployments, and instrument sampling rates set accordingly (Table 24.2).

New batteries were fitted prior to deployment (SAFT 3.6V Lithium AA cells), and the clocks synchronised to GPS time.

Table 24.2: Summary of endurance estimates and sampling intervals.

Mooring	S/N	Expected depth (m)	Expected minimum temp (°C)	Expected max pumping time (sec)	Sampling interval (sec)	Estimated endurance (days)	Recovered instruments endurance (days)
EB1	21560	500	9.1	69	3600	923	827+
EB1	21320	750	8.0	76	3600	858	827+
EB1	21319	950	4.5	92	4500	890	Unknown (instrument leaked)
IB4	15298	50	9.1	65	3600	973	N/A
IB4	15476	500	8.2	73	3600	891	N/A

24.3 DeepSeapHOx

The DeepSeapHOx is a SeaFEt pH sensor combined with a SBE37-ODO (as described in the previous section). The two instruments are powered internally by their own internal battery pack, connected together via a Y-cable, with the SeaFET controlling the sampling and data recording.

24.3.1 Recovery

One DeepSeapHOx was deployed on EB1 in 2018 (SeaFET 117 + SBE37-ODO 15476). The SeaFET battery ran out after 613 days (10/03/2020), and the SBE37-ODO after only 436 days (17/09/2019), most likely due to its battery running out. Salinity data from the adjacent SBE37 (s/n 11290) will be used to correct the O2 data after the ODO data record stopped.

The SeaFET was turned-around for immediate redeployment and did not undergo a post-deployment cal-dip. The SBE37-ODO was cal-dipped later during the cruise and showed a significant conductivity offset (see cal-dip section) although this offset was not visible in the data. External power was applied to the DeepSeapHOx after recovery for data download while placed in a sink of underway seawater, and the SBE37-ODO took a few readings before it was stopped which showed erroneous conductivity values similar to the ones observed during the cal-dip. This suggests the conductivity sensor became faulty sometime after the DeepSeapHOx stopped recording and before recovery.

24.3.2 Endurance

Endurance estimate calculations for the DeepSeapHOx V1 are still a bit uncertain (see discussions in RAPID cruise reports DY039 and JC145, and OSNAP cruise reports DY053 and DY078), and need to balance power usage across the ODO battery, the SeaFET main pack (used for sampling) and the SeaFET isolated pack (used for standby mode). Below (Table 24.3) is a comparison of the estimated endurances for a sampling rate of one hour (values corrected for actual battery capacity 0f 16.500mAh instead of 19,800mAh) and actual endurances after recovery:

Table 24.3: DeepSeapHOx estimated and actual endurance.

	Sampling interval (sec)	Estimated endurance (days)	Actual endurance (days)
SBE37-ODO	3600	1405	436
SeaFET main pack	3600	716	613
SeaFET isolated pack	3600	428	613+ (?)

The voltage readings from the recovered data seem to indicate the main pack was the one which ran out of battery first, reading 7.2V (minimum operational value in the manual = 8V, vs the isolated pack reading 4.2V with a nominal minimum value of 4.0V). This would suggest the standby energy usage has been overestimated in the SeaBird calculations and the sampling energy usage or duration underestimated. Overall decreasing the SeapHOx sampling rate might increase the endurance. This would also increase the ODO's endurance, although the extremely reduced endurance observed here (a third of the estimate) could suggest issues in the SeaBird calculation of endurance estimates. The calculation method for the ODO energy usage seems correct as the recovered stand-alone ODOs on EB1 were still recording after over 800 days. It would seem that it is rather the instrument behaviour which is not very well understood: the calculations were based on the assumption that the ODO would pump for a set value of 42s (39s pumping time + 3s sampling) every hour, however bench tests in 2017 showed that it took about 90s for the SeapHOx to produce a reading so potentially doubling the pumping time. This would still not explain the very early cut-off date seen here, which would require a pumping/sampling time of nearly three minutes per sample. This seems highly improbable, especially since there should be a timeout of two minutes for the ODO reading. There is also the possibility of faulty batteries, or other technical issues with this ODO.

24.3.3 Deployments

24.3.3.1 SeaFET s/n 117 (V1) + SBE37-ODO s/n 21318

Fresh batteries were installed in both instruments (Duracell Industrial D-cells – nominal capacity 15,476mAh – and SAFT AA Lithium AA cells), and their clocks synchronised to GPS time.

ODO s/n 21318 did not fit in the SeapHOX bracket perfectly due to the cell guard screws being in a different (lower) location than on older models. The screws from the bracket into the ODO body could therefore not be installed, although the clamps fitted tightly, and additional tape was added for security. Another ODO onboard (s/n 21560) had another slightly different design, lower screws in the conductivity guard again but also a shorter guard meaning the SeapHOx bracket physically blocked the CTD intake and exhaust. SeaBird and Planet Ocean were contacted about the issue and will be looking to produce new brackets for the different ODO designs, or a new universal bracket to fit all.

The SBE37-ODO was configured for pairing with the SeaFET in SeaTerm using the parameters given in the SeaFET-1.2.4 manual. The two were linked together using a Y-cable and briefly tested in a sink of underway seawater (testing the two instruments had been paired correctly, checking data output and that the values in the correct order of magnitude). The SBE37-ODO was cal-dipped pre-deployment but due to time constraints the SeaFET was not. The DeepSeapHOx could not be placed in seawater to stabilise before deployment for the recommended period (as instructed in the manual, necessary each time it is powered down), therefore we expect it might take up to three days for the instrument to give stable pH readings after being deployed.

As the recovered data was not analysed before redeployment the same sampling settings as in 2018 were used (periodic mode, 1h sampling interval, 30 samples in average, 1 burst per frame), which will probably result in an endurance of less than 2 years again.

24.3.3.2 SeaFET s/n 004 (V2) + SBE37-ODO s/n 14987

Fresh batteries were installed in both instruments (Duracell Industrial D-cells – nominal capacity 15,476mAh – and SAFT AA Lithium AA cells), and their clocks synchronised to GPS time.

SeaFET s/n 004 was upgraded to V2 in 2018, which meant significant changes in operation mode and endurance. SeaBird removed the frame averaging and burst function, replacing it with a single measurement instead. This promises to improve the endurance greatly – the calculator provided estimated the SeaFET could sample for thousands of days at a sampling rate of one hour. Although those figures were not very believable this suggested the limiting battery would now be the SBE37-ODO, so the sampling interval (1h) was chosen by using the standard ODO DeploymentEndurance calculator, using the planned deployment pressure and minimum temperature expected. The adaptive pump sampling was disabled but unlike the V1 the pumping time could be set in the software. Pumping time was set to 65s, to match the pump time that would have been calculated by the adaptive sampling mode (see formula in SBE37-ODO manual).

V2 also meant changes in the setup procedure:

- The V1 USB cable is NOT compatible with the DeepSeapHox V2. A serial cable for a different instrument was rewired on the ship for communicating with s/n 004.
- V1 requires SAtlantic SeaFETCom (v.1.2.4 used here), V2 uses SeaBird UCI (v. 2.0.3 used here).

- For V1 DeepSeapHOx the SBE37-ODO needs to be setup first in SeaTerm (using parameters given in the SeaFET-1.2.4 manual) before being physically connected to the SeaFET. In V2 the two instruments are first connected together, and the pairing is done in the UCI software by issuing the command "Resync" in the command line interface. The software will then automatically extract the ODO's information and calibration coefficients and send commands to set it up to use as part of a DeepSeapHOx. There is a warning in the DeepSeapHOx V2 manual that this needs to be done every time the ODO has been connected to SeaTerm (even if parameters have not been changed).
- In V1 the deployment parameters are set in the SeaFET Settings tab, then need to be sent to the SeaFET using the "Upload" button. The clock needs to be synchronised in the Sensor menu, and the memory erased via the File Manager. The deployment is initiated using the "Start" button. Note: there is a bug in the software and the report says the CTD is not enabled and the power to the CTD is enabled despite the parameters being set the other way around.

  In V2 the UCI Deployment Wizard goes through the whole setup process, except for the pumping time. <u>This parameter needs to be set in the SeaFET settings before going through the wizard</u> as it is greyed out unless the "External pump" option is ticked. This option is for a separate external pump for a stand-alone SeaFET (not applicable here) and does not refer to the ODO pump. However, during bench tests, we found out that the pumping time parameter is actually the pumping time commanded to the ODO (+3s for sampling) so it is essential to set a suitable value.

Table 24.4: The setup differences between V1 and V2.

	V1	V2
Communication cable	SeapHOx V1 serial or USB cable	Serial cable only
Software	SeaFETCom	UCI
SBE37-ODO setup for pairing with SeaFET	Setup ODO in SeaTerm first then connect the two instruments	Connect the two instrument first, then pair them in the UCI software using the "Resync" command
Setup parameters and procedure	Mix of menus and buttons in SeaFETCom – refer to manual	Amend pump time in SeaFET settings All other parameters via Deployment Wizard
LED light meaning	Green short flashes = Activating internal batteries Green short flash = Starting continuous sampling mode OR Sampling Green long flash = Starting periodic mode Green long and short flash = Starting polled mode Red long flash = Deactivating internal batteries	Green flash = sampling or waiting to begin sampling Red flash = has not received a sampling command

As per the manufacturer's recommendation the DeepSeapHOx was powered on and placed in seawater several days prior to deployment for the pH sensor to stabilise. It was also cal-dipped before deployment.

The battery calculator for the DeepSeapHOx V2 (provided by SeaBird) estimated endurances much longer than the V1 (thousands of days). These figures seemed overestimated, but the bottom line is that the overall DeepSeapHOx endurance should be limited by the ODO battery. A pump time of 65s was chosen, which would be the pump time that would have been applied if the adaptive sampling mode was on (calculated using the calculations in the SBE37-ODO manual for 50db and an expected minimum temperature of 9°C). A sampling rate of one hour gave an endurance of 969 days for the ODO and 3491 (!) days for the SeaFET V2.

24.4 Nortek Aquadopp

Nortek Aquadopps were recovered and deployed on all moorings.

After recovery the data were downloaded, and clock offsets checked (no significant drift found). One instrument (s/n 11069 on EB1) had not been started before deployment and did not contain any data.

The Norteks' clocks were synchronised with GPS time, and new batteries were fitted prior to deployment (alkaline dual packs, nominal capacity 100Wh). A functional check was performed. They were set to sample every 3600s, with an averaging period of 60s. Full setup parameters are available in the appendices.

24.5 Nortek S55 ADCP

24.5.1 Pre-deployment Checks

Pre-deployment checks followed those outlined in the Signature55 Operations Manual by using the help section accessed through the instrument software – Nortek SignatureDeployment. While connected to mains power and using communication via ethernet cable, the instrument was loaded with test parameters from file AD2CP_55kHz_DY120_test.deploy. This file was generated according to the instructions in the software, with using a sampling frequency of 6 s. Parameters observed during the functionality check are summarised in Table 24.5. Compass calibration was not attempted due to the abundance of metals on the ship.

Table 24.5. Sensor outputs observed during functionality check.

Temperature	14.17 °C
Pressure	0.64 db
Amplitude – air (db)	
Beam 1	40
Beam 2	30
Beam 3	30
Amplitude – rub (db)	
Beam 1	70
Beam 2	70
Beam 3	70

24.5.2 Deployment

Deployment Set-Up The instrument was programmed according to Table 24.6. The estimated time deployment was two years. By "playing" with the measurement interval, sampling interval, power, and cell size we were able to manage a deployment period of this length. This can be done in advance using the deployment wizard in the software.

The PC clock was synchronized to ship time and the S55 synchronised to the PC clock. Instrument confirmed sampling via blue LED which is was to be on for 24 hours after start time. The instrument was set to deploy at 11:30 UTC on 15/10/2020. Visual checks on deck after setting the instrument in the housing showed sampling was happening at the correct allotted time.

Table 24.6: Summary of S55 deployment set up for RHADCP on cruise DY120.

Performance		**Coarse profile**	
Configured length (days)	730	Start of profile (m)	2
Estimated max length (days)	976.3	End of profile (m)	1022
Battery capacity (Wh)	3600	Cell size (m)	20
Power usage (Wh)	2961.7	Power level (dB)	-2
Recorder capacity (MB)	15258.8	Measurement load (%)	Max 100%
Memory usage (MB)	281.6	Average interval	00:30:00
System information		Measurement interval	00:01:00
Instrument name	S55	Coordinate system	ENU
Serial number	44	Serial telemetry	off
Head frequency (KHz)	55	Telemetry format	DF100_NMEA
Opt sensors	None	**Data sampling**	
Firmware version	2211.4	Power level (dB)	-2
Recorder size (MB)	15258.8	Long range mode	ON
Application		Multiplexing	ON
Type	Single	Number of pings	10
Plan	Coarse profile	**Slanted beams**	
Deployment length (days)	730	Horizontal prec (cm/s)	2.09
Environment		Vertical prec (cm/s)	0.54
Geography	OpenOcean	Velocity range (m/s)	1
Sound Velocity (m/s)	Fixed = 1500	**Measurement range**	
Mounting	Subsurface buoy	Desired range (m)	1022
Orientation	Upward looking	Configured range (m)	1122
Instrument depth (m)	1000	Estimated range (m)	1022.3
Salinity (ppt)	n/a	Blanking distance (m)	2
Tidal range (m)	1.0	Cell size	20
		Number of cells	56
		Number of beams	3

24.6 RDI WorkHorse ADCP

24.6.1 Recoveries

Six RDI WorkHorse ADCPs 300KHz were recovered from IB3, IB4 and IB5. s/n 20959 showed signs of corrosion on the transducer head and was not redeployed.

Raw instrument data were downloaded from the instrument after the recovery of the mooring. After download the data were backed up and transferred to the network drive \\dyans1.dsicovwery.local\sandm on the cruise.

The raw data file ****.000 was converted to .mat file format, by using WinADCP (''Export'' option, select ''Series'', tick all the Series Data Types, all the Ancillary Data Types, the Bottom track and all the bins. Make sure and enter the number of the last ensemble). The MATLAB file was saved as *ADCPSerialNumber*_data.mat (e.g. *20467_data.mat)*

Then the data (.000 and .mat files) were copied on the processing computer directory pstar/osnap/data/moor/raw/adcp ready to be processed.

24.6.2 Deployments

Six ADCPs were deployed on IB3, IB4 and IB5. Before deployment new batteries were installed, clocks synchronised to GPS time, and functional tests performed. The setup parameters were:

Ensemble interval = 1 hour
Water pings = 42
Ping interval = auto (00:01:25.7)
Number of depth cells = 28
Depth cell size = 4m

The full setup information is available in Appendix P.

25 Mooring Deployment Summary Table

Appendix J.

26 Mooring Data Processing

Lewis Drysdale, Loïc Houpert.

The mooring processing toolbox RODB was made using a carbon copy of both the exec and the data directories from the previous cruise directory (AR30), along with other associated folders from the *osnap* directory (documents, users, MATLAB_diaries, etc.). A new data directory was created for all cruise data (*/osnap/data/moor/raw/dy120*) and calibration data (*/osnap/data/moor/proc_calib/dy120*) . Directories for each mooring and a metadata file were created for each mooring to be recovered (e.g. *osnap/data/moor/proc/rtwb1_04_2017/rteb1_05_2018info.dat*). The information required for these was taken from the previous cruise report and Table 26.1.

Table 26.1. RODB codes for instruments recovered and deployed during DY12O.

Instrument	**RODB code**
SBE microCAT	337
SBE ODO	335
SeaFet	375
Nortek Aquadopp	370

26.1 MicroCAT Data Processing

The steps from instrument recovery to date processing are summarised in Table 26.2. 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 copied onto the processing computer in the directory *osnap/data/moor/raw/dy120/microcat/*.

At the beginning of stage 1 and 2, the user is required to modify information at the beginning of the script such as the directory trees, the mooring name, and year of the first measurement. Output directories may need to be created manually as required. The launching period is defined as the time from the start of the data logging until the mooring settles on the sea-bed. The recovery period is defined as the time from when the mooring is released from the seabed until the end of the data logging.

Table 26.2: Summary of microCAT processing steps from instrument to low pass filtered data.

Stage 0 (Seabird software)	
Seaterm and SBEDataProcessing	Convert .hex and.xml files to .cnv.
Stage 1 (MATLAB)	
mc_call2_dy120.m *[calls micrcat2rodb_6.m]*	Converts .cnv file to .raw file and stores in proc/ folder.
Stage 2 (MATLAB)	
microcat_raw2use_003_with_ODO.m	Reads .raw files Removes the launching and recovery period, creates a data overview sheet including basic statistics, and produces summary plots, including filtered data.
Stage 3 (MATLAB)	
grid_osnap_mcat_data.m	Grid calibrated or uncalibrated microCAT data to 20 m vertical and 12 hour horizontal product. Requires .dat file with order of instruments and serial numbers to be gridded.

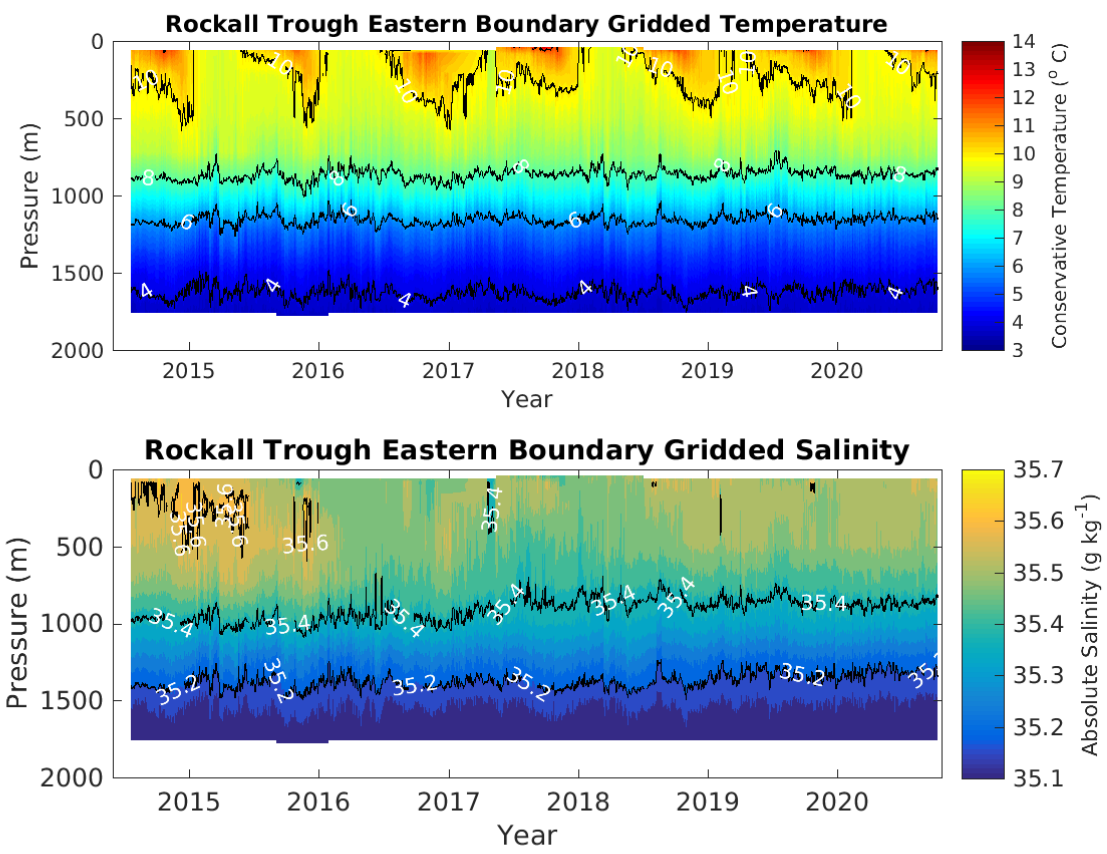


Figure 26.1 Temperature and salinity data from RTEB mooring updated with data from (uncalibrated) SBE37 MicroCATs recovered on DY120.

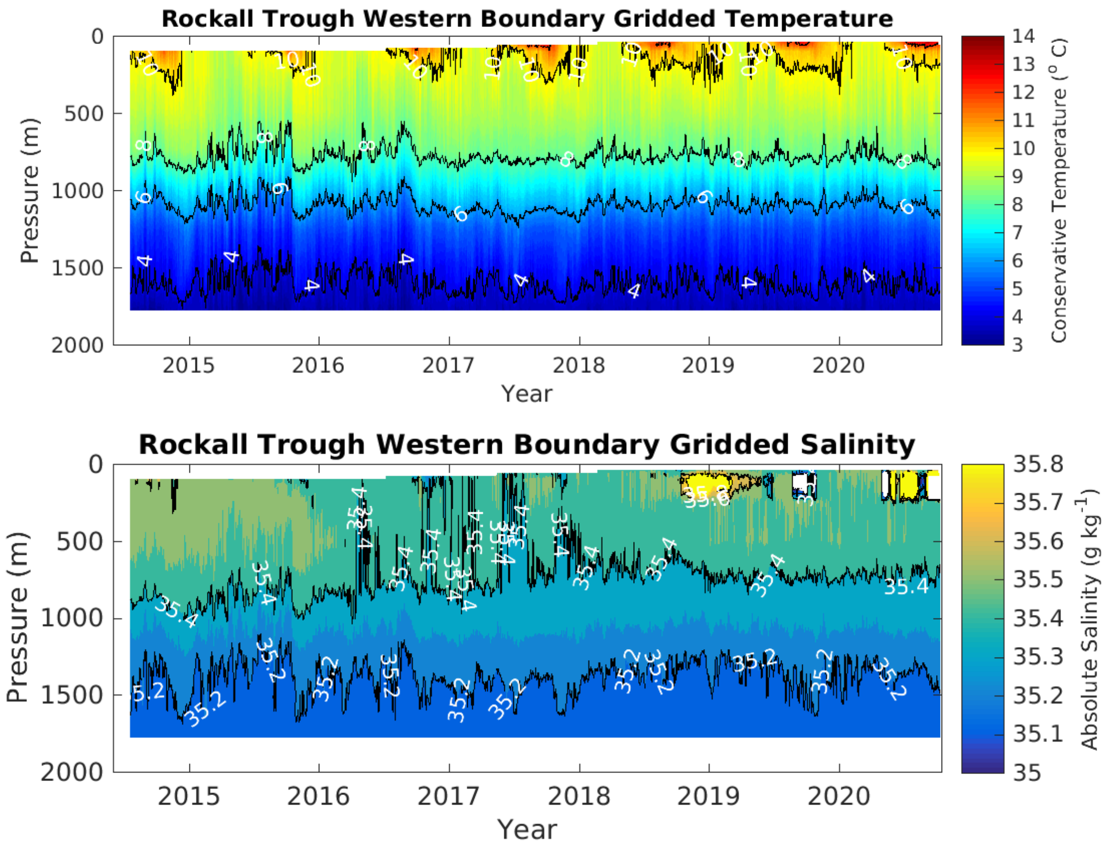


Figure 26.2: Temperature and salinity data from RTWB mooring updated with data from (uncalibrated) SBE37 MicroCATs recovered on DY120. These figures include unreliable conductivity data (e.g. around 100 m depth), which will be removed post-calibration.

26.2 Nortek Current Meter Data Processing

The steps from instrument recovery to date processing are summarised in Table 26.3. Raw data were downloaded from each instrument after recovery of the mooring. Record keeping of the download was done on paper log sheets. After download the data were backed up and transferred to the network drive. Data were then copied to the processing computer (*osnap/data/moor/raw/dy120/nortek/)*.

As in the case of the microCATs, the user is required to modify information at the beginning of the script such as the directory trees, the mooring name, and year of the first measurement. A text file containing the serial numbers of the Nortek on the mooring and the filenames containing the data was created before running the stage 1 and 2 (e.g.*~/osnap/data/moor/raw/dy120/nortek/rteb1_05_2018 _filenames.txt*).

Table 26.3: Summary of microCAT processing steps from instrument to low pass filtered data

Stage 0 (Nortek)	
Data download using instrument software	Produces .dat, .aqd,.dia, and .hdr
Stage 1 and 2 (MATLAB)	
Process_nors_dy120.m	Sets paths and calls *nortek2rodb_01.m* *Nortek_raw2use_02.m*
nortek2rodb_01.m	Converts data to .raw files
Nortek_raw2use_02.m	Removes launching and recovery, print basic statistics, and produces summary plots.

26.3 DeepSeapHOx Data Processing

The steps from instrument recovery to date processing are summarised in Table 26.4. The data were downloaded and transferred to the network drive, then copied onto the processing computer in the directory *osnap/data/moor/raw/dy120/seaphox*. The data output from the instrument was to .CSV and .CTD file format. Data from the previous deployment as well as previous calibration dips was still on the files and in some cases had been partially overwritten with the most recent deployment data. A text file containing the serial number of the instrument and each data filename was created before running the stage 1 (e.g.*~/osnap/data/moor/raw/dy120/seaphox/rteb1_05_2018 _filenames.txt*).

Table 26.4: Summary of Seaphox processing steps from instrument to low pass filtered data

Stage 0 (Seabird software)	
Data download	Produces .CSV and .CTD files
Stage 1	
Process_seaphox_dy120.m calls *seaphox2rodb_01.m*	Reads data into RODB format and plots

26.4 ADCP Data Processing

The data being processed here were recovered from three pairs of downward and upward looking Nortek RD Sentenial 300kHz ADCPs mounted in a syntactic buoy on moorings IB3, IB4 and IB5. The nominal depth of the buoy was 100 m.

26.4.1 Data Download and conversion to MATLAB file format

Raw instrument data were downloaded from the instrument after the recovery of the mooring. After download the data were backed up and transferred to the network drive \\dyans1.dsicovery.local\sandm on the cruise.

The raw data file ****.000 was converted to .mat file format, by using WinADCP (''Export'' option, select ''Series'', tick all the Series Data Types, all the Anclliary Data Types, the Bottom track and all the bins. Make sure and enter the number of the last ensemble). The MATLAB file was saved as *ADCPSerialNumber*_data.mat (e.g. *20467_data.mat)*

Then the data (.000 and .mat files) were copied on the processing computer directory pstar/osnap/data/moor/raw/adcp ready to be processed.

26.4.2 Overview of the data and manually flag bad data

In order to have an overview of each ADCP dataset and manually flagging bad data, the function *read_flag_raw_adcp.m* can be run from the *osnap/exec/dy120/stage1/adcp/*. An example on how to call this function can be found in the script *osnap/exec/dy120/stage1/adcp/process_adcps_IB.m*. The function displays the northward component of the velocity and the percent of good measurements with four-beam solution and three-beam solutions PG1+PG4 (Figure 26.3). Good ADCP measurements have generally a PG1+PG4>75%. The user can define the limits of the good data domain by clicking on the figure (see for example red shape on Figure 26.4). The index delimitating the time-bin domain for the good data is saved as at .mat file which can be loaded at the stage 3 of the processing when generating the final version of the ADCP time-series

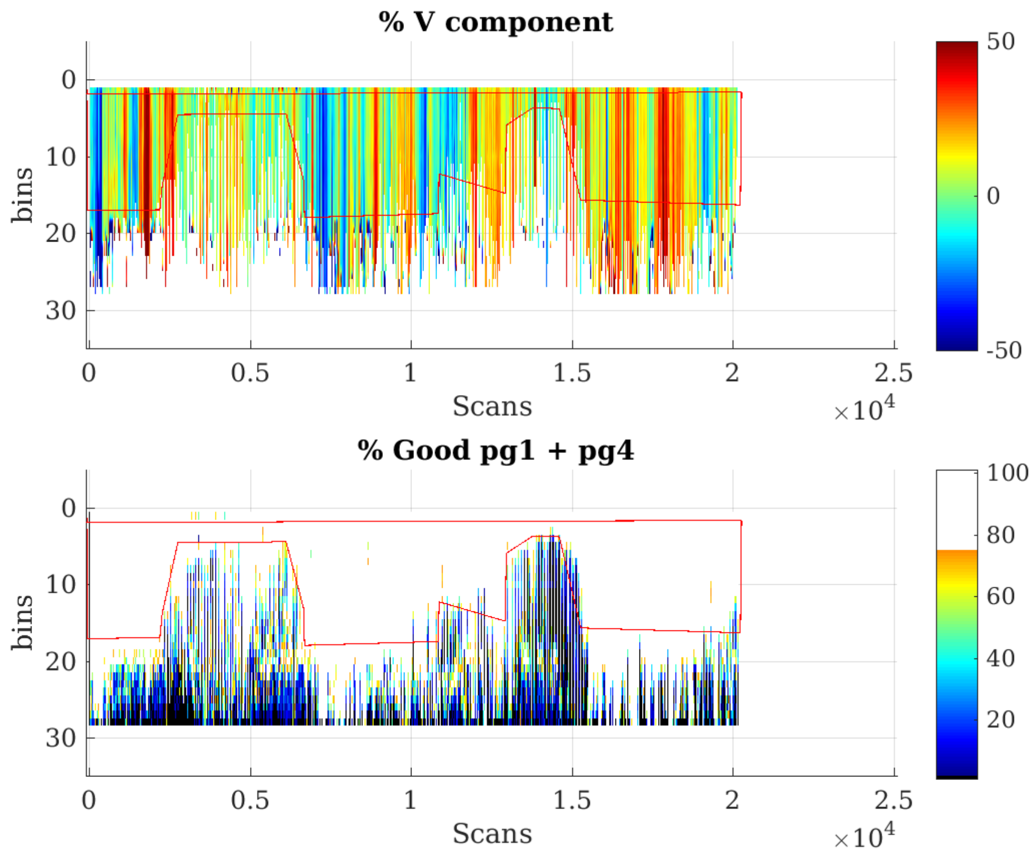


Figure 26.3: Example of figure generated by the function *read_flag_raw_adcp.m.*

26.4.3 Stage 1: Conversion to standard RDB format

The script *process_adcps_IB.m* performs stage 1 and stage 2 processing on ADCP data. It converts RDI ADCP data from raw ADCP data in .mat format to RODB format. The user needs to modify some information in the beginning of the script like the directory trees and the mooring name. *process_adcps_IB.m* calls *adcp2rodb_02.m*, which saves the files downloaded by the instrument software (stage 0) to the RDB formatted file *.raw*. in e.g. *osnap/data/moor/proc/ib5_01_2018/adcp*. This function can also remap bin depths for different speed of sound as input by user or from a CTD profile. The velocities were corrected for speed of sound during the stage 3. The script *adcp2rodb_02* also creates data overview sheet including basic statistics (*file moor_ADCP_stage1.log*).

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

The script *process_adcps_IB.m* also performs stage 2 processing on RDI ADCP data by calling the script adcp_*raw2use_01.m.* This script uses the raw data file *mooring_serialnum_binYY.raw* generated by stage 1 and the *mooringinfo.dat* file and produces a *.use* file for each bin. As for the Nortek, it removes the launching and recovery period, and produce summary plots, including filtered data.

26.4.5 Stage 3: Data editing, speed of sound correction, magnetic declination correction, data filtering

Script */local/users/pstar/osnap/exec/dy120/delayed_processing_script/adcp/cm_edit_NOCS_v4.m* is used to perform stage 3 processing on stage2 ADCP data (*.use* files). Once the data trimming procedure and an initial data control were completed, the data can be corrected for speed of sound and magnetic declination. Magnetic deviation value has to be defined in the *$mooring_info.dat* file (in *osnap/data/moor/proc/$moor/*) by adding a line like "*MagDeviation = -19.66".* Finally, corrected data files that have been de-spiked and interpolated onto 12 hour time steps were saved in *.edt* files. The script asks the user for the acceptable lower limit of percent good for the data. In our case we choose a value of 75% (PG1+PG4). The ADCP deployed on the IB moorings were using a measured speed of sound to calculate the current speeds. The measured sound speed is obtained by using measured values of pressure and temperature data from the ADCP at the transducers' depth and a predefined value for salinity of 35. For the 2018-2020 period, a mean salinity of 35.2 was chosen for the upward and downward looking ADCPs on IB5 and IB4 and 35.1 for the ADCPs deployed on IB3. Using this fixed salinity and the measured temperature and pressure from the ADCP sensors, the sound of speed is calculated at the transducers depth to get the corrected velocities for all the bins. Corrected velocities were obtained by multiplying the uncorrected velocities with the ratio of the salinity-corrected sound speed with the original measured sound speed.

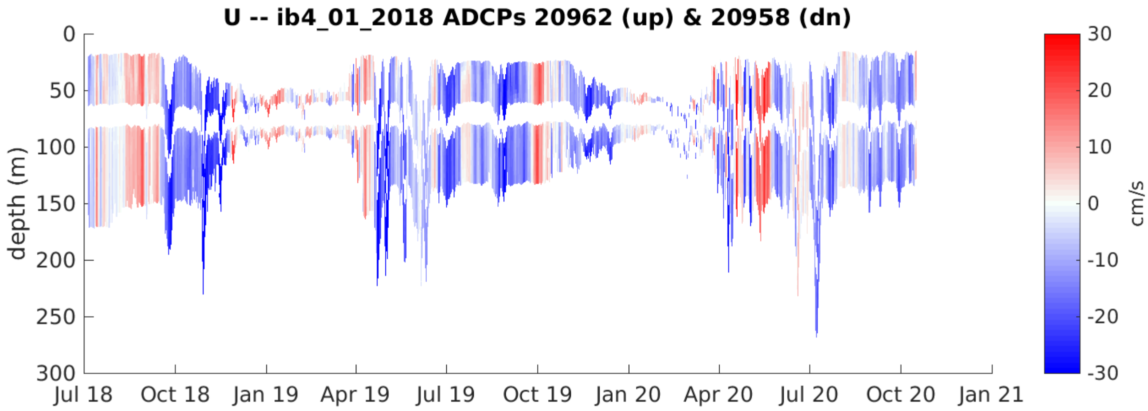
Then, as from the Nortek current meter, the recorded velocity components were transformed into true east and north components using the local magnetic declination estimated on the median of the deployment and recovery times of each mooring from the NOAA's National Geophysical Data Center (http://www.ngdc.noaa.gov/geomag-web/).

Spikes on U and V for each bin, were removed using a spike/mean ratio criterion of 10. If data gaps were less than 24 hours, they were interpolated linearly in time, otherwise flag values were inserted. Despiked data were low-pass-filtered using a 40-hour Butterworth filter to remove tidal and inertial oscillations and were then interpolated onto 12-hour time steps.

If a MATLAB file delimitating the time-bin domain of the good data exists, the function cm_edit_NOCS_v4.m will ask the user if they want to use it. This MATLAB file is generated by the function *read_flag_raw_adcp.m* (cf previous subsection "Overview of the data and manually flag bad data"**).**

26.4.6 Contour plots of the final version of the ADCP data

The function */local/users/pstar/osnap/exec/dy120/delayed_processing_script/adcp/plot_ADCP_data_IB.m* can be run to generate contour plot of the final ADCP data (upward and downward). See Figure 26.4



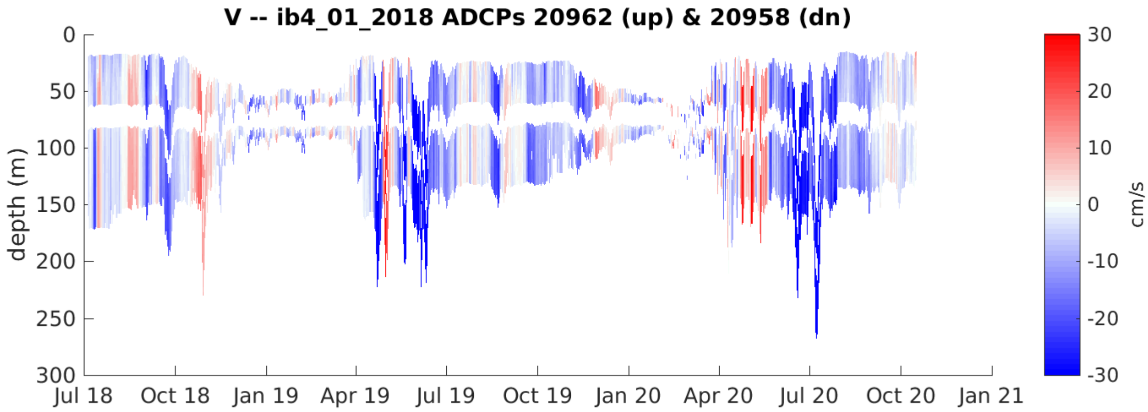


Figure 26.5: Example of figure generated by the function *plot_ADCP_data_IB.m.*

26.5 Data Report Tools

A set of scripts can be used to quickly generated summary statistics and figures for each mooring. These scripts can be run for stage 2 data (.use files) or stage 3 data (.microcat and .edt files). The scripts and functions were under *osnap/exec/dy120/data_report_tool/.* The wrapper script *batch_all.m* can be run for a list of mooring and for a specific deployment periods. It generated multiple figures which were saved under *osnap/Documents/datareports.* As an example, the list of figures generated for IB4 is indicated below:

ib4_01_2018_conductivity_overlay_proclvl_2_unfilt.png
ib4_01_2018_currents_stacked_hordirection_plot_proclvl_2_unfilt.png
ib4_01_2018_currents_stacked_horspeed_plot_proclvl_2_unfilt.png
ib4_01_2018_currents_stacked_u_plot_proclvl_2_unfilt.png
ib4_01_2018_currents_stacked_v_plot_proclvl_2_unfilt.png
ib4_01_2018_currents_stacked_w_plot_proclvl_2_unfilt.png
ib4_01_2018_horcurrents_overlay_dir_proclvl_2_unfilt.png
ib4_01_2018_horcurrents_overlay_speed_proclvl_2_unfilt.png
ib4_01_2018_pden1000_overlay_proclvl_2_unfilt.png
ib4_01_2018_plot_stacked_conductivity_plot_proclvl_2_unfilt.png
ib4_01_2018_plot_stacked_pden1000_plot_proclvl_2_unfilt.png
ib4_01_2018_plot_stacked_pressure_plot_proclvl_2_unfilt.png
ib4_01_2018_plot_stacked_ptmp1000_plot_proclvl_2_unfilt.png

ib4_01_2018_plot_stacked_salinity_plot_proclvl_2_unfilt.png
ib4_01_2018_plot_stacked_temperature_plot_proclvl_2_unfilt.png
ib4_01_2018_pres_vs_v.png
ib4_01_2018_pressure_overlay_proclvl_2_unfilt.png
ib4_01_2018_pro_vec_proclvl_2.png
ib4_01_2018_ptmp1000_overlay_proclvl_2_unfilt.png
ib4_01_2018_sal_vs_u.png
ib4_01_2018_salinity_overlay_proclvl_2_unfilt.png
ib4_01_2018_stick_plot_proclvl_2_unfilt.png
ib4_01_2018_temperature_overlay_proclvl_2_unfilt.png

One of the main advantages of running *batch_all.m* after processing the stage 2 data (.use) is the ability to see on a single figure a specific variable (temperature, conductivity, pressure, horizontal current) measured by all the mooring instruments. The subpanels for "stacked" figures were created from the info.dat file, therefore a missing instrument will clearly appear as a blank subpanel (Figure 26.6). In addition, the wrapper script *batch_all.m* is calling the function *stats_table.m* which produces a summary table with statistics for every instrument (Figure 26.7). The output ascii files were saved under *osnap/Documents/datareports/stats/. batch_all_severalyr.m* is also a useful wrapper script as it allows to plot time-series of multiple deployments on a same figure (Figure 26.8). It can particularly be useful to check the coherence between several deployment (e.g conductivity) and spot any anomalies.

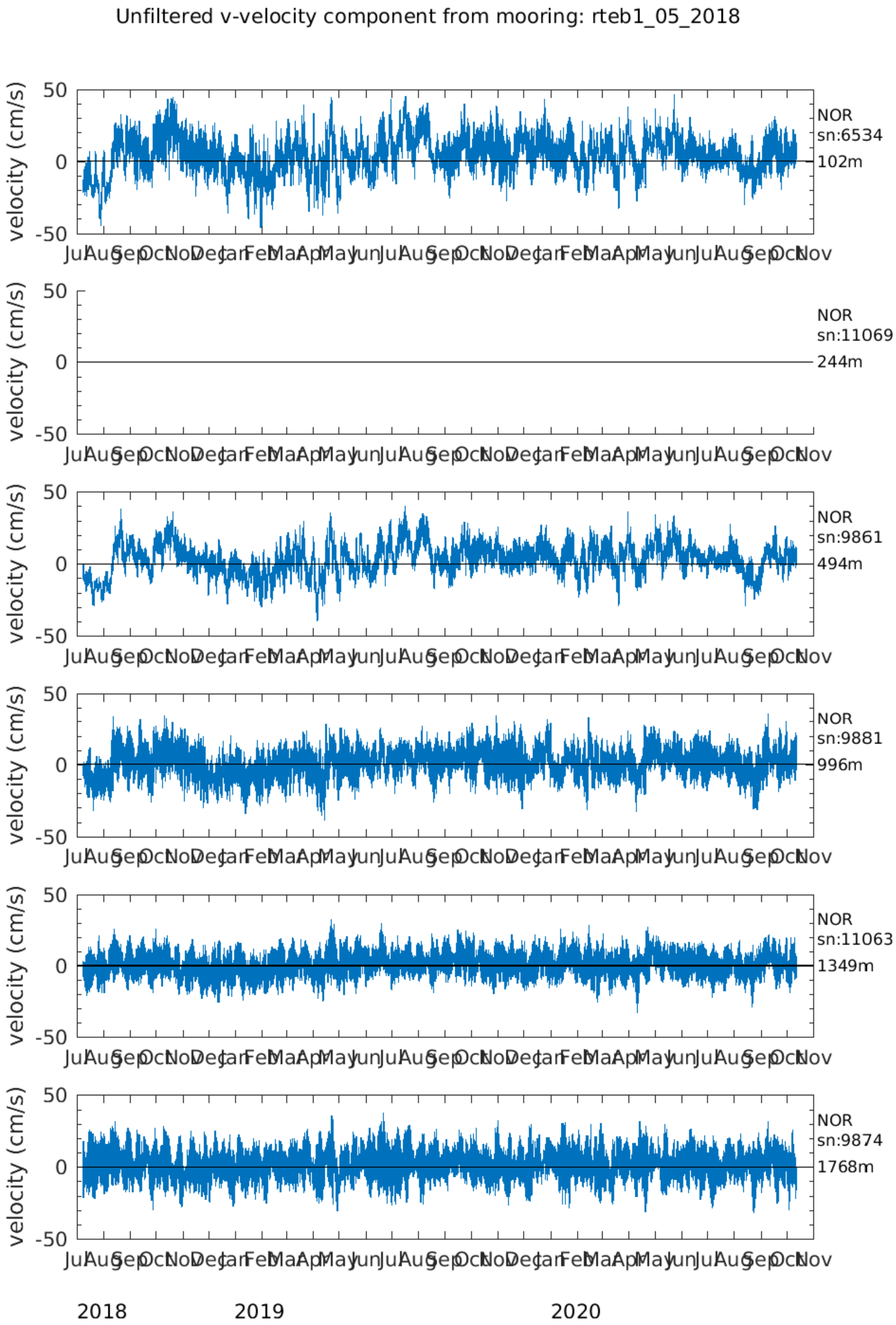


Figure 26.6: Figure of the meridional velocity at RTEB1 generated by the script *batch_all.m.*

```
rtwb2_05_2018_stats.asc — /Volumes/pstar/osnap/Documents/datareports/stats

rtwb2_05_2018_stats.asc

OSNAP Mooring Array.
Simple Statisctics for Mooring:-   rtwb2_05_2018
Mooring deployment - start:  09/07/2018 22:30
                      end:  14/10/2020 07:00

--------------------------------------------------------------------------------------------
      SN  var        first             last         valid     mean    stdev      min      max
                    record           record       records
--------------------------------------------------------------------------------------------
    9377    p   09/07/18 22:30  14/10/20 06:30     39713   1018.2      5.5   1013.5   1127.3
            t   09/07/18 22:30  14/10/20 06:30     39713      6.6      0.4      5.5      8.0
            c   09/07/18 22:30  14/10/20 06:30     39713     35.5      0.4     34.5     36.9
--------------------------------------------------------------------------------------------
   11064    p   09/07/18 23:00  14/10/20 07:00     19857   1019.4      5.5   1014.3   1127.1
            t   09/07/18 23:00  14/10/20 07:00     19857      6.5      0.4      5.5      8.0
            u   09/07/18 23:00  14/10/20 07:00     19857      0.7      8.5    -33.6     33.3
            v   09/07/18 23:00  14/10/20 07:00     19857      1.4      9.9    -38.3     35.0
          spd   09/07/18 23:00  14/10/20 07:00     19857      1.6      6.1      0.0     41.7
          dir   09/07/18 23:00  14/10/20 07:00     19854     27.4     99.0      0.0    359.7
--------------------------------------------------------------------------------------------
   11067    p   09/07/18 23:00  14/10/20 07:00     19857   1370.5      4.0   1366.6   1444.6
            t   09/07/18 23:00  14/10/20 07:00     19857      4.7      0.2      4.1      5.3
            u   09/07/18 23:00  14/10/20 07:00     19857      0.2     10.3    -34.5     35.8
            v   09/07/18 23:00  14/10/20 07:00     19857      0.6     11.7    -39.3     42.8
          spd   09/07/18 23:00  14/10/20 07:00     19857      0.6      6.3      0.1     46.6
          dir   09/07/18 23:00  14/10/20 07:00     19857     17.7    104.1      0.0    359.8
--------------------------------------------------------------------------------------------
    3218    p   09/07/18 22:30  14/10/20 06:30     39713   1598.2      2.8   1595.1   1645.7
            t   09/07/18 22:30  14/10/20 06:30     39713      4.1      0.1      3.8      4.7
            c   09/07/18 22:30  14/10/20 06:30     39713     33.3      0.1     33.0     33.8
--------------------------------------------------------------------------------------------
    9885    p   09/07/18 23:00  14/10/20 07:00     19857   1810.5      0.9   1808.5   1816.8
            t   09/07/18 23:00  14/10/20 07:00     19857      3.6      0.1      3.1      4.0
            u   09/07/18 23:00  14/10/20 07:00     19857     -0.5     12.3    -35.4     45.2
            v   09/07/18 23:00  14/10/20 07:00     19857     -0.5     13.7    -48.3     41.8
          spd   09/07/18 23:00  14/10/20 07:00     19857      0.7      7.3      0.2     48.4
          dir   09/07/18 23:00  14/10/20 07:00     19857    227.7    104.0      0.0    359.8
--------------------------------------------------------------------------------------------
    9372    p   09/07/18 22:30  14/10/20 06:30     39713   1798.9      0.8   1796.9   1804.3
            t   09/07/18 22:30  14/10/20 06:30     39713      3.6      0.1      3.1      4.1
            c   09/07/18 22:30  14/10/20 06:30     39713     33.0      0.1     28.2     33.4
--------------------------------------------------------------------------------------------

/Volumes/pstar/osnap/Documents/datareports/stats/rtwb2_05_2018_stats.asc   1:1   LF   UTF-8   AsciiDoc   GitHub   Git (0)
```

Figure 26.7: Example of summary statistics file generated by the wrapper script *batch_all.m.*

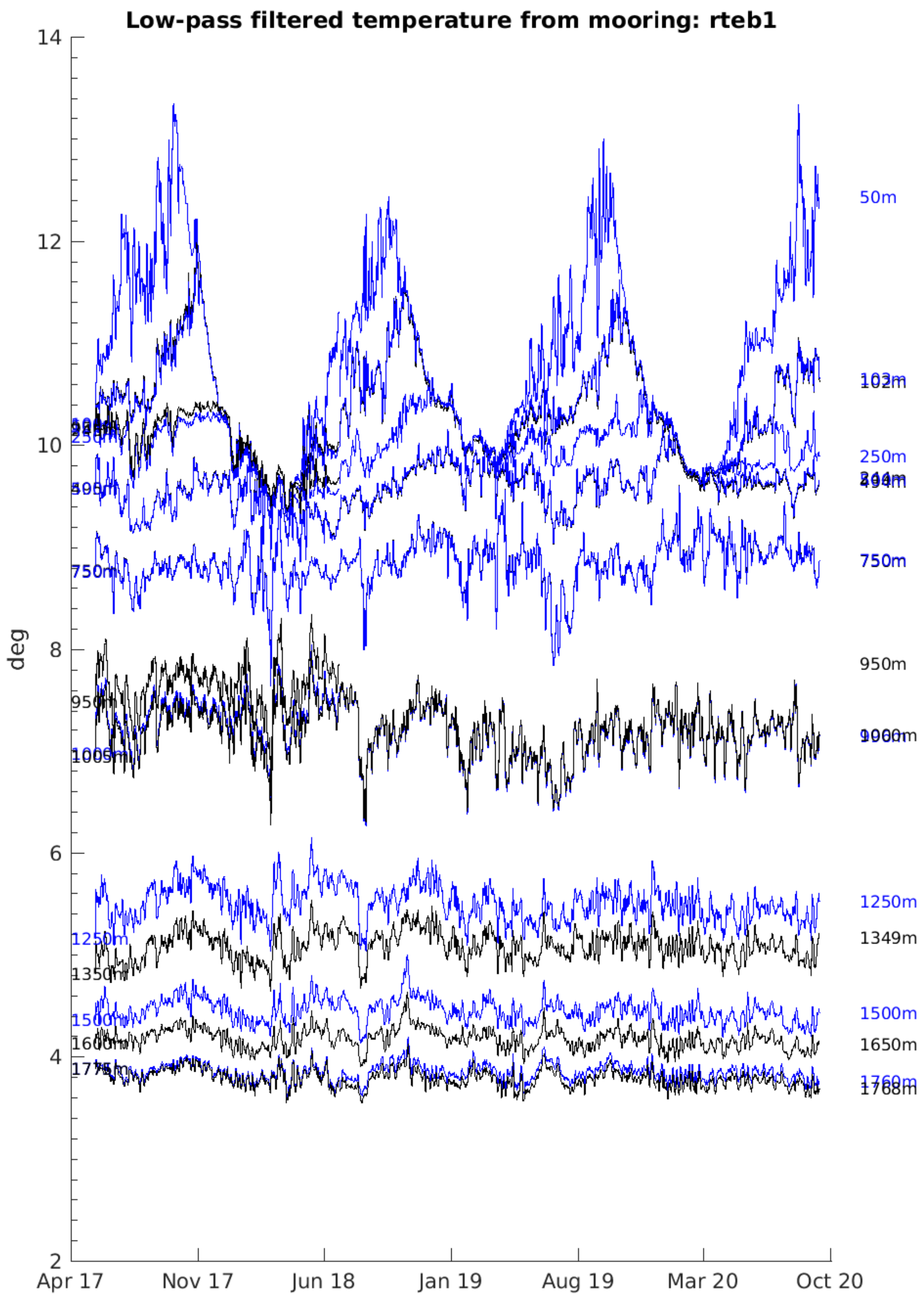


Figure 26.8: Temperature time-series at RTEB1 generated by the script *batch_all_severalyr.m*. Figures are saved under *osnap/Documents/datareports/figs/rteb1_04_2017_05_2018/.*

26.6 Spurious and missing data, and instrument failures

- MicroCAT s/n 13021 recovered from IB3 at a target depth of 350 m returned only 528 samples. After sample number 510 the date output became extremely erratic and recorded seemingly random dates and data. The erroneous data was removed from the converted .cnv file but not from the .hex and .xml files. The .cap files were compared against similarly deployed instruments and no peculiarities were found.

- MicroCAT ODO s/n 15254 recovered from RTEB1 was affected by water ingress and therefore no data was returned.
- MicroCAT ODO s/n 15298 had unreliable conductivity (and oxygen) data for the approximate period between early February to mid-March 2020.
- MicroCAT s/n 9372 recovered from RTWB2 had a conductivity spike from approximately 33 to 28
- MicroCAT s/n 14355 recovered from 100 m depth at RTWB1 had a period of extrememly unreliable conductivity data from day 400 to the end of deployment. The data was removed from the .cnv file in the *osnap/data/moor/raw/microcat* directory, but the .xml and .hex files remain intact.
- Nortek s/n 11069 recovered from RTEB1 was redeployed on ar30 with previous data, no re-battery, and no re-deployment file. No data between 2018-2020 was returned.
- DeepSeaPhOx (comprising seaFET s/n 117 and microCAT ODO s/n 15476) recovered from RETB1 had data from previous deployments and calibrations. Data recording for the 2018 deployment had stopped in September 2019.

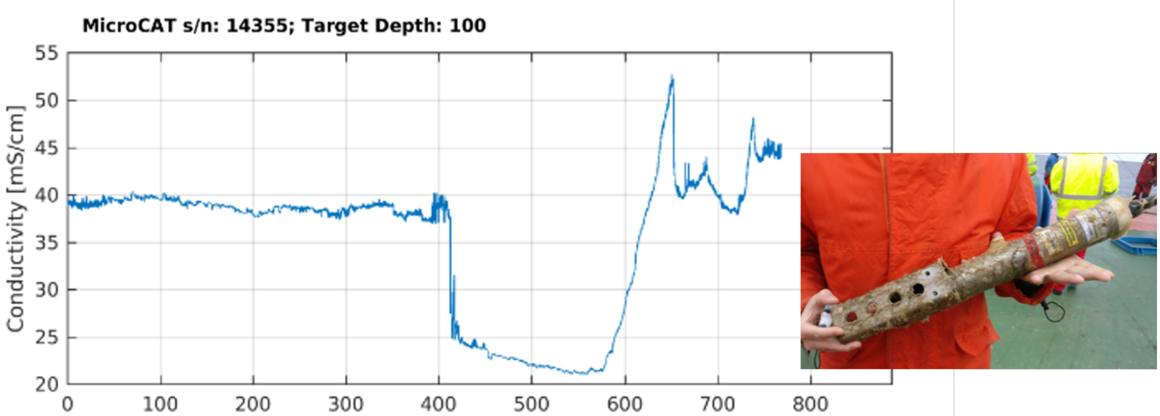


Figure 26.9: Conductivity plot showing corruption of data from MicroCAT presumably as a result of bio-fouling. Inset photo of instrument with serial number 14355 post-recovery shows extensive fouling.

27 Calibration Dips & Tables of instruments recovered and deployed

Sam Jones

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

27.1 Microcat CTD

Before the caldip scripts can be run, we create a new *info.dat* file in */local/users/pstar/osnap/data/moor/proc_calib/dy120/cal_dip/,* using a previous *info.dat* file as a template. This contains some basic information on the time and location of the CTD cast, and then a list of microcat IDs and their intended depth when mounted on the mooring (the cal dips take place before and after a mooring deployment, so microcats on the CTD can be pre or post-deployment, or a mix of both). We then run:

mc_call_caldip_dy120.m

Reads raw data (located in */local/users/pstar/osnap/data/moor/dy120/microcat_cal_dip/cast#*), converts to RODB format and compares to the CTD profile. Produces timeseries plots for C,T,P which can be used to quickly assess instrument function and accuracy. Plots of CTP differences at bottle stops are written to */local/users/pstar/osnap/data/moor/proc_calib/dy120/cal_dip/microcat/cast#/cast#_serialnum_bottle_stops.jpg*.

mc_cal_caldip_check_dy120.m

Reads data from raw RODB files and compares to the CTD profile. Produces plots showing mean and standard deviation of SBE-CTD parameters from the deepest bottle stop and also at the nominal instrument deployment depth (read from the info.dat file). Tables of statistics are recorded in file */local/users/pstar/osnap/data/moor/proc_calib/dy120/cal_dip/microcat/cast#/microcat_check_cast#.log.*

27.2 DeepSeapHOx

1. Process CTD station data and create the 1s average up and down profile (file: ctd_dy120_###_psal.nc).

2. Download DeepSeapHOx, transfer to the processing computer: */local/users/pstar/osnap/data/moor/proc_calib/dy120/cal_dip/seaphox/cast3.* Then a cast3_filenames.txt file needs to be created. Similar to the nortek filenames.txt files, the first column of each line contains the serial number of each SeapHOx instrument (e.g. 117) and the name of the data file (e.g. C0000001.CSV)

3. Make sure that the info.dat file contains the serial number of the DeepseapHOx (e.g. /local/users/pstar/osnap/data/moor/proc_calib/dy120/cal_dip/cast#info.dat).

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

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

28 Appendix A: RSYNC Scripts for Backups of Linux Workstation to a Mac-Mini

```
Back_dy120_v2_mac.csh
#!/bin/csh -f
# Script to run on a Mac (or other remote computer on the same LAN as the workstations)
# for the backup of linux workstation. Data is copied to an external
# drive mounted in /Volumes on the Mac
#
# This version by DAS Updated 17 Oct 2015
# 1) syncs data from "cruise" directory, and creates a bakup of all changed files
# 2) syncs data from "rapid" directory, and creates a bakup of all changed files
# 3) syncs data from "users" directory, and creates a bakup of all changed files
# When change for a new cruise need to change
# - drive names
# - $root_fs
# - $cru
# This version by SCU 14 OCT 2020
# The rsync is to the hard drive. Then just use the Time Machine to provide the additional
external copy
# Make check that the volume to be synced is mounted
#
# Is the samba mount to Koaekea established
echo ' '
set mount_name = 'pstar'
#
if (-e /Volumes/${mount_name}) then
 echo '/Volumes/'${mount_name} ' connected'
else
 echo '/Volumes/'${mount_name} ' Does not seem to be there. Run smb mount first.'
 exit
endif
# Is the samba mount to the Public/DY120 drive established
echo ' '
set mount_name2 = 'public'
#
if (-e /Volumes/${mount_name2}) then
 echo '/Volumes/'${mount_name2} ' connected'
else
 echo '/Volumes/'${mount_name2} ' Does not seem to be there. Run smb mount first.'
 exit
endif
# Insert a link to the current_cruise volume
# Drives connected start backup
echo ' Volumes to be archived are mounted '
# Check that the backup directory exists on local machine.
# On DY120 this is on the internal disk so should always be connected
set drive_name = '/Users/pstar/Documents/DY120_BACKUP/dy120_pstar'
#
if (-e ${drive_name}) then
 echo ${drive_name} ' connected'
```

```
else
 echo ${drive_name} ' Does not seem to be there'
 exit
endif
#
echo ' Backup directory on local machine exists '
echo `date` ' Starting backup'
#
# Setup pathnames for use on remote computer
set root = '/Volumes/pstar/'
set root_public = '/Volumes/public/'
#set root = /Volumes/${mount_name}/
#set root_public = /Volumes/${mount_name2}/
#
# Create a logfile for the backup
set now = `date +%Y%m%d%H%M%S`
set backuplog = ${drive_name}/backup_logs/backup_log_${now}
if (-e $backuplog) then
 echo $backuplog exists
 exit
else
 touch $backuplog
endif
#
#
# ---------------------------------------------------------------
# First backup the cruise directory
set cru = dy120
set root_path_cru = $root$cru
set sync_cru = ${drive_name}/cruise_sync
set back_cru = ${drive_name}/cruise_back
#/backup_${now}
#
# Call the main routine
# ---------------------------------------------------
backup_core_local $root_path_cru $sync_cru $back_cru $backuplog
# ---------------------------------------------------
#
#
# ---------------------------------------------------------------
# Backup the OSNAP directory
set now = `date +%Y%m%d%H%M%S`
set osnap_dir = osnap
set root_path_osnap = $root$osnap_dir
set sync_osnap = ${drive_name}/osnap_sync
set back_osnap = ${drive_name}/osnap_back/backup_${now}
#
# Call the main routine
# ---------------------------------------------------
backup_core_local $root_path_osnap $sync_osnap $back_osnap $backuplog
# ---------------------------------------------------
```

```
#
#
#-----------------------------------------------------------------
# Sync all of the user directory
set now = `date +%Y%m%d%H%M%S`
set usersdir = users
set root_path_use = $root$usersdir
set sync_use = ${drive_name}/users_sync
set back_use = ${drive_name}/users_back/backup_${now}
#
# Call the main routine
# ---------------------------------------------------
backup_core_local $root_path_use $sync_use $back_use $backuplog
# ---------------------------------------------------
#
# ---------------------------------------------------------------
# Sync all of the program directory
set now = `date +%Y%m%d%H%M%S`
set progdir = programs
set root_path_prog = $root$progdir
set sync_prog = ${drive_name}/programs_sync
set back_prog = ${drive_name}/programs_back/backup_${now}
#
# Call the main routine
# ---------------------------------------------------
backup_core_local $root_path_prog $sync_prog $back_prog $backuplog
# ---------------------------------------------------
#
# ---------------------------------------------------------------
# Sync all of the DY120/public directory
set now = `date +%Y%m%d%H%M%S`
set pubdir = DY120
#set root_public = '/Volumes/public/'
set root_path_public = $root_public$pubdir
set sync_public = ${drive_name}/public_sync
set back_public = ${drive_name}/public_back/backup_${now}
#
# Call the main routine
# ---------------------------------------------------
backup_core_local $root_path_public $sync_public $back_public $backuplog
# ---------------------------------------------------
echo `date` - Backup finished
```

backup_core_local

```
#!/bin/csh
# For backing up using rsync
# Intended to be called y other scripts e.g. 'rapid_backup'
if ($#argv != 4) then
 echo Wrong number of arguements
else
 echo ' '
```

```
 echo '------------------'
 echo - root_path = $1
 echo - sync_dir = $2
 echo - back_dir = $3
 echo - backuplog = $4
endif
set root_path = $1
set sync_dir = $2
set back_dir = $3
set backuplog = $4
if (-e $back_dir) then
 echo ' '
else
 echo $back_dir does not exist and will be created
 mkdir $back_dir
endif
if (-e $sync_dir) then
 echo ' '
else
 echo $sync_dir does not exist and will be created
 mkdir $sync_dir
endif
# Sync all of the cruise directory
echo Going to sync: $root_path
echo to: $sync_dir,
echo backup changed files to $back_dir
echo and record in logfile $backuplog,
echo ' '
echo ------------- >> $backuplog
echo Syncing $root_path to $sync_dir >> $backuplog
echo Start `date` >> $backuplog
# rsync -v -a --delete --exclude '._*' --exclude '.DS_Store' -b --backup-dir=$back_dir
$root_path $sync_dir
set now = `date +%Y%m%d%H%M%S`
set backupdir = $back_dir/backup_${now}
rsync -v -ab --backup-dir=$backupdir --delete --exclude '._*' --exclude '.DS_Store' $root_path
$sync_dir
set how_much1 = `du -sm $sync_dir`
set how_much2 = `du -sm $back_dir`
echo done copying
echo Finish `date` >> $backuplog
echo Total size '(Mb)': $how_much1 >> $backuplog
echo Total size '(Mb)': $how_much2 >> $backuplog
echo ------------- >> $backuplog
```

rsync_koaekea.csh

```
#
rsync -avzul --rsh='ssh' pstar@192.168.62.110:/local/users/pstar/dy120 /Users/pstar/
rsync -avzul --rsh='ssh' pstar@192.168.62.110:/local/users/pstar/osnap /Users/pstar/
rsync -avzul --rsh='ssh' pstar@192.168.62.110:/local/users/pstar/programs /Users/pstar/
```

```
rsync -avzul --rsh='ssh' pstar@192.168.62.110:/local/users/pstar/Documents/ /Users/pstar/DY120_Documents
rsync -avzul --rsh='ssh' pstar@192.168.62.110:/mnt/techsas/DY120/NetCDF /Users/pstar/techsas/
# remove symbolic links that work on the ship
rm netcdf_files_rawdir*
# make symbolic link to the NetCDF data which is in techsas/NetCDF
ln -s /Users/pstar/techsas/NetCDF /Users/pstar/cruise/data/techsas/netcdf_files_rawdir
rm /Users/pstar/cruise/sw/MEXEC
ln -s /Users/pstar/programs/MEXEC_v3 /Users/pstar/cruise/sw/MEXEC
```

29 Appendix B: Serial Numbers of CTD Underwater Sensors and Hardware

Hardware / Sensor	Manufacturer & Model	s/n	Channel	Casts Used
Stainless steel 24-way frame	NOCS	SBE CTD 6	N/A	
Titanium EM CTD Swivel	Machinery Development Services	1246-2	N/A	All casts
Carousel	SBE 32	32-31240-0423	N/A	All casts
10 l Water Samplers	OTE BES-110	Set A	N/A	All casts
Primary CTD deck unit	SBE 11plus	11P-24680-0589	N/A	All casts
CTD Underwater Unit	SBE 9plus	09P-54047-0943	N/A	All casts
Primary Temperature Sensor (Vane)	SBE 3P	03P-4380	F0	All casts
Primary Conductivity Sensor (Vane)	SBE 4C	04C-4065	F1	All casts
Digiquartz Pressure sensor	Paroscientific	110557	F2	All casts
Secondary Temperature Sensor	SBE 3P	03P-4728	F3	All casts
Secondary Conductivity Sensor	SBE 4C	04C-4138	F4	All casts
Primary Pump	SBE 5T	05T-6916	N/A	All casts
Secondary Pump	SBE 5T	05T-6320	N/A	All casts
Secondary Dissolved Oxygen Sensor (Vane)	SBE 43	43-1624	V0	All casts
Primary Dissolved Oxygen Sensor	SBE 43	43-0862	V1	All casts
Backscatter (Vane)	WETLabs BBRTD	BBRTD-5466	V2	All casts
Altimeter	Tri Tech	6196,112522	V3	All casts
CO2 Sensor	Hydros CO2	CO2T-1019-006	V4	1,2,
CO2 Battery	Hydros 20C	20C-003	N/A	1-2
CO2 Pump	SBE 5T	05T-10112	N/A	1-2
CO2 Sensor	Hydros CO2	CO2T-1019-005	V4	4
CO2 Battery	Hydros 20C	20C-004	N/A	4
CO2 Pump	SBE 5T	05T-10116	N/A	4
pH Sensor	AMT Deep pH	347	V7	1-3
pH Sensor	AMT Deep pH	346	V7	4-10
Deep Ocean Temperature Sensor	SBE 35	35-34173-0048	N/A	All casts

30 Appendix C: Sea-Bird 9*plus* Configuration File

DY120_0943_SS_nmea.ps
Date: 10/07/2020
Instrument configuration file:
DY120_0943_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-4380
Calibrated on: 14 June 2018
G: 4.37208689e-003
H: 6.54988408e-004
I: 2.37424960e-005
J: 1.86148776e-006
F0: 1000.000
Slope: 1.00000000
Offset: 0.0000
2) Frequency 1, Conductivity
Serial number: 04C-4065
Calibrated on: 14 Mar 2018
G: -9.85576737e+000
H: 1.48758413e+000
I: -2.41871604e-003
J: 2.63830958e-004
CTcor: 3.2500e-006
CPcor: -9.57000000e-008
Slope: 1.00000000
Offset: 0.00000
3) Frequency 2, Pressure, Digiquartz with TC
Serial number: 110557
Calibrated on: 21 September 2018
C1: -6.010548e+004
C2: -1.565601e+000
C3: 1.823090e-002
D1: 2.668300e-002
D2: 0.000000e+000
T1: 3.020528e+001
T2: -6.718318e-004
T3: 4.457980e-006
T4: 1.203850e-009
T5: 0.000000e+000
Slope: 1.00002000
Offset: 2.14950
AD590M: 1.280700e-002
AD590B: -9.299640e+000
4) Frequency 3, Temperature, 2
Serial number: 03P-4782
Calibrated on: 13 March 2018
G: 4.34998383e-003
H: 6.36619788e-004
I: 2.09700604e-005
J: 1.78036895e-006
F0: 1000.000
Slope: 1.00000000
Offset: 0.0000
5) Frequency 4, Conductivity, 2
Serial number: 04C-4318
Calibrated on: 14 March 2018
G: -9.84094910e+000
H: 1.45317113e+000
I: -2.13516384e-003
J: 2.55747427e-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: 43-0862
Calibrated on: 13 March 2019
Equation: Sea-Bird
Soc: 5.47800e-001
Offset: -5.02600e-001
A: -4.97970e-003
B: 1.74410e-004
C: -3.03980e-006
E: 3.60000e-002
Tau20: 1.50000e+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, Oxygen, SBE 43, 2
Serial number: 43-1624
Calibrated on: 14 March 2019
Equation: Sea-Bird
Soc: 3.60000e-001
Offset: -7.18500e-001
A: -4.45230e-003
B: 1.50280e-004
C: -2.32780e-006
E: 3.60000e-002
Tau20: 2.08000e+000
D1: 1.92634e-004
D2: -4.64803e-002
H1: -3.30000e-002
H2: 5.00000e+003
H3: 1.45000e+003
8) A/D voltage 2, OBS, WET Labs, ECO-BB
Serial number: 758
Calibrated on:
ScaleFactor: 1.000000
Dark output: 0.000000
9) A/D voltage 3, Altimeter
Serial number: 6196.112522
Calibrated on: 11 July 2013
Scale factor: 15.000
Offset: 0.000
10) A/D voltage 4, User Exponential
Serial number:
Calibrated on:
Sensor name:
Sensor units:
ScaleFactor: 1.00000000
ExponentFactor: 1.00000000
11) A/D voltage 5, Free
12) A/D voltage 6, Free
13) A/D voltage 7, pH
Serial number: 347
Calibrated on: 23 Jan 2020
pH slope: 4.3754
pH offset: 2.9164
Scan length: 45
Pump Control
This setting is only applicable to a custom build of the SBE 9plus.
Enable pump on / pump off commands: NO
Data Acquisition:
Archive data: NO
Delay archiving: NO
Data archive:
C:\Users\sandm\Documents\Cruises\DY120\Data\Raw CTD data\DY120 test data.hex
Timeout (seconds) at startup: 60
Timeout (seconds) between scans: 20
Instrument port configuration:
Port = COM4
Baud rate = 19200
Parity = N
Data bits = 8
Stop bits = 1

Water Sampler Data:
Water Sampler Type: SBE Carousel
Number of bottles: 36
Port: COM5
Enable remote firing: NO
Firing sequence: User input
Tone for bottle fire confirmation uses PC sound card.
Header information:
Header Choice = Prompt for Header Information
prompt 0 = Ship: RRS Discovery
prompt 1 = Cruise: DY120
prompt 2 = Cast:
prompt 3 = Station:
prompt 4 = Julian Day:
prompt 5 = Date:
prompt 6 = Time (GMT):
prompt 7 = Latitude:
prompt 8 = Longitude:
prompt 9 = Depth (uncorrected m):
prompt 10 = Principal Scientist: Stuart Cunningham
prompt 11 = Operator:
TCP/IP - port numbers:
Data acquisition:
Data port: 49163
Status port: 49165
Command port: 49164
Remote bottle firing:
Command port: 49167
Status port: 49168
Remote data publishing:
Converted data port: 49161
Raw data port: 49160
Miscellaneous data for calculations
Depth, Average Sound Velocity, and TEOS-10
Latitude when NMEA is not available: 55.0000
Longitude when NMEA is not available: 0.0000
Average Sound Velocity
Minimum pressure [db]: 20.0000
Minimum salinity [psu]: 20.0000
Pressure window size [db]: 20.0000
Time window size [s]: 60.0000
Descent and Acceleration
Window size [s]: 2.0000
Plume Anomaly
Theta-B: 0.0000
Salinity-B 0.0000
Theta-Z / Salinity-Z 0.0000
Reference pressure [db] 0.0000
Oxygen
Window size [s]: 2.0000
Apply hysteresis correction: 1
Apply Tau correction: 1
Potential Temperature Anomaly
A0: 0.0000
A1: 0.0000
A1 Multiplier: Salinity
Serial Data Output:
Output data to serial port: NO
Mark Variables:
No variables are selected.
Shared File Output:
Output data to shared file: NO
TCP/IP Output:
Raw data:
Output raw data to socket: NO
XML wrapper and settings: NO
Seconds between raw data updates: 0.0000
Converted data:
Output converted data to socket: NO
XML format: NO
SBE 11plus Deck Unit Alarms
Enable minimum pressure alarm: NO
Enable maximum pressure alarm: NO
Enable altimeter alarm: NO
SBE 14 Remote Display
Enable SBE 14 Remote Display: NO
PC Alarms
Enable minimum pressure alarm: NO
Enable maximum pressure alarm: NO
Enable altimeter alarm: NO
Enable bottom contact alarm: NO
Alarm uses PC sound card.
Options:
Prompt to save program setup changes: YES
Automatically save program setup changes on exit: NO
Confirm instrument configuration change: YES
Confirm display setup changes: YES
Confirm output file overwrite: YES
Check scan length: YES
Compare serial numbers: YES
Maximized plot may cover Seasave: NO

31 Appendix D: Summary of CTD Station numbers, dates, positions, depth.

Table 31.1: Summary of CTD Station numbers, dates, positions, depth and caldip number (CD).

Num	Date	Time (UTC)	Lat (°W)	Long (°E)	Lat°	Lat'	Lon°	Lon'	Depth (m)	CD
001	09/10	08:41	50.069742	-4.858194	50	04.18	4	51.49	76	
002	11/10	19:39	57.297819	-10.385839	57	17.87	10	23.15	2208	
003	12/10	06:59	57.087548	-9.542647	57	05.25	9	32.56	1787	1
004	13/10	09:57	57.481144	-11.535490	57	28.87	11	32.13	2014	2
005	13/10	14:20	57.482795	-11.533351	57	28.97	11	32.00	2015	3
006	15/10	20:45	57.608969	-15.427572	57	36.54	15	25.65	1069	
007	16/10	13:22	57.790724	-19.162868	57	47.44	19	09.77	925	
008	17/10	08:02	57.983317	-21.158411	57	59.00	21	09.50	2929	4
009	17/10	16:39	57.989690	-21.146456	57	59.38	21	08.79	2920	
010	20/10	14:23	57.992834	-24.387171	57	59.57	24	23.23	2841	5

32 Appendix E: Microcat CTDs. Deployed, Recovered, Calibration Dips

MCAT s/n	Recovered DY120	Post-rec CALDIP	Deploy D120	Pre-dep CALDIP	Owner	Notes
3218	WB2	4	IB4	4		
3276	EB1	3	IB4	3		
3276	EB1	5	IB4	3		
3481	WB1	4	IB3	4		
4608	spare		spare			
4609	spare		spare			
4610	spare		spare			
7923		2	WB1	2		
7924		2	WB1	2	SAMS	
8077	IB4	6		6		
8078	IB4	6		6		
8079	IB4	6		6		
8080	IB3	6		6		
8081	IB3	6		6		
8082	IB5	4	IB4	4		
8443	IB5	4	IB4	4		
9113	EB1	3	ADCP	3		
9140	WB1	4		4		
9141	spare	1	spare	1		
9253		2	WB1	2	SAMS	
9371	IB4	5		5		
9372	WB2	4	IB4	4		
9373	IB4	5		5		
9374	IB4	5		5		
9375	EB1	3	IB5	3		
9376	IB5	5	IB3	5		
9377	WB2	4	IB4	4		
9378	IB3	6		6		
9381		6	DMLTM	6		DMLTM - Veerla
9384		6	DMLTM	6		DMLTM - Veerla
9390		1	EB1	1		
9391				4		no data on caldip
9395		1	EB1	1		$\Delta C=0.07$
9396		1	EB1	1		
10559	WB1	4	IB3	4		

10560	EB1	3	IB5	3		
10561	IB3	6		6		Dipped twice; Good shallow
10562	EB1	3	IB4	3		
10575		2	IB5	2	SAMS (1000m rated)	Dipped to 1900dbar, worked fine.
10576		2	WB1	2		
10577	EB1	3	IB4	3		
10578	IB3	6		6		
10579	IB3	6		6		
11107		4		4		
11108		5	IB3	5		
11109		4		4		
11110		2	IB5	2		
11111		4		4		Flooded on CALDIP
11115		3		1	SAMS	ΔC=-0.05
11115		3		1	SAMS	ΔC=-0.05
11137		4	WB1	2		
11139		2	WB1	2		
11140		4		4		
11287	EB1	3	IB4	3		
11288	EB1	3	IB5	3		
11289	EB1	3	IB5	3		
11290	EB1	2	IB5	3		
11320		2	IB5	2		
11321	IB3	6		6		
11322		5	EB1	1	SAMS	
11323	IB4	5		5		
11324	IB3	6		6		
11326	IB4	5		5		
11327		1	EB1	1	SAMS	
11328	IB4	5		5		
11329	WB1	4	IB3	4		
11330		1	EB1	1	SAMS	
11331	IB4	6		6		
11332	IB4	5		5		
11333	IB5	4	IB4	4		
11334		1	EB1	1		

11335		1	EB1	1		
11336	IB3	6		6		
11337	WB1	4	IB3	4		
11338		1	EB1	1		
11339	IB5	5	IB3	5		
11340	IB3	6		6		
11341		1	WB2	1		
11342		3	WB2	1		
11343		2	WB1	2		
11465		2	WB1	2		
13019	IB3	6		6		
13020		2	WB1	2		
13021	IB3	6		6		Worked for 2-weeks on mooring then stopped
14353	WB1	4	IB4	4		
14354	WB1	4	IB4	4		
14355	WB1	4	IB3	4		ΔC=-3.3. Heavily fouled or failed after 1yr.
14356	IB5	4	IB4	4		ΔC=0.14
14364		2	IB5	2		
14365		2	IB5	2		
14366	IB4	6		6		
14367	IB5	5	IB3	5		
14368	WB1	4	IB3	4		ΔC=-0.019

33 Appendix F: Microcat ODOs & seaFETs. Deployed, Recovered, Calibration Dips.

ODO s/n	Recovered DY120	Post-rec CALDIP	Deploy D120	Pre-dep CALDIP	OWNER ODO	s/n seaFET	OWNER SeaFET	Notes
14987			EB1	1	SAMS			ODO refurb unit
15254	EB1	3	IB4	4	SAMS			leaked; needs checked
15298	EB1	4	IB4	4	SAMS			ΔC=2.1
15476	EB1	4			SAMS	117	SAMS	ΔC=-7.9
21317			IB4	1	CLASS	117	SAMS	
21318			EB1	1	CLASS			
21319			EB1	1	CLASS			
21320			EB1	1	CLASS			
21560			EB1	1	iAtlantic	004	Darren	

34 Appendix G: Nortek Current Meters. Deployed, Recovered, Calibration Dips.

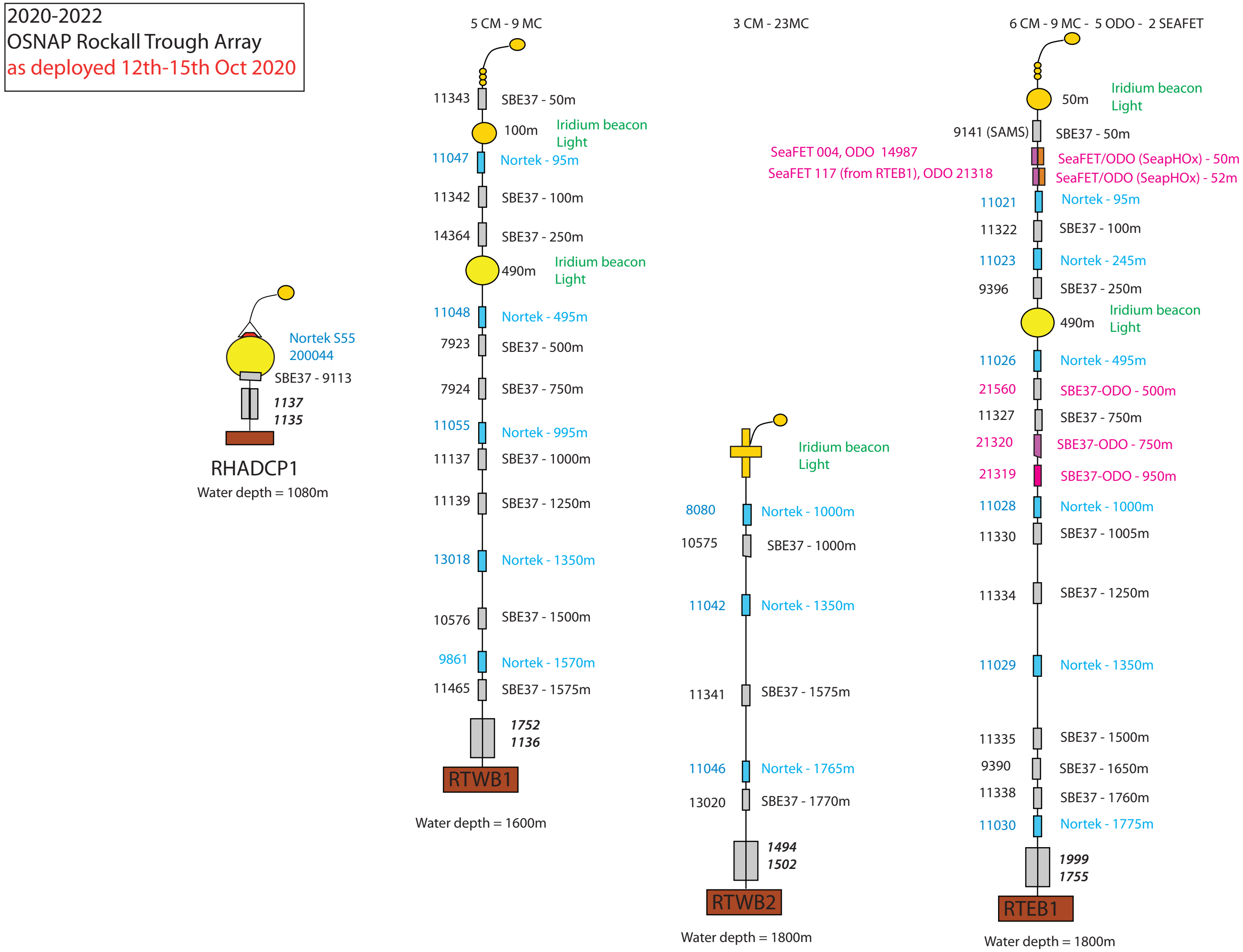
NORTEK s/n	Recovered DY120	Deploy D120	Owner
6534	EB1		
6723	IB3		
8080		WB2	
8120	IB4		
8365	IB5		
9213	WB1		
9822	IB3		
9853	WB1		
9861	EB1	WB1	
9867	IB5		
9874	EB1		
9877	WB1		
9881	EB1		
9885	WB2		
11021		EB1	
11023		EB1	
11026		EB1	
11028		EB1	
11029		EB1	
11030		EB1	
11034	IB3		
11042		WB2	
11046		WB2	
11047		WB1	
11048		WB1	
11051	IB4		

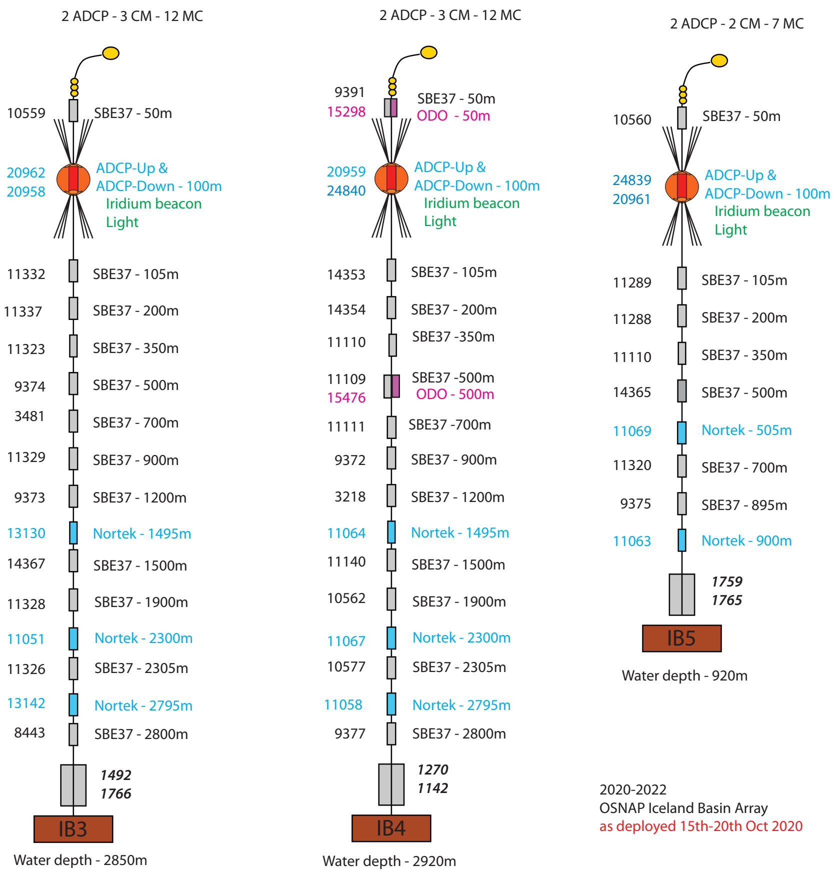
11055		WB1	
11058	WB1		
9867	EB1		
11064	WB2	IB4	
11067	WB2	IB4	
11069	EB1	IB5	
13018		WB1	
13130	WB1	IB3	
13142	IB4	IB3	

35 Appendix H: Work-Horse 300 kHz ADCPs. Deployed, Recovered, Calibration Dips.

s/n (ADCP)	Recovered DY120	Deploy D120
13872	IB5	
20957	IB3	
20958	IB4	IB3
20959	IB5	IB4
20960	IB3	
20961		IB5
20962	IB4	IB3
22790		
24839		IB5
24840		IB4

36 Appendix I: Mooring Instrument Allocation Schematics





2020-2022
OSNAP Iceland Basin Array
as deployed 15th-20th Oct 2020

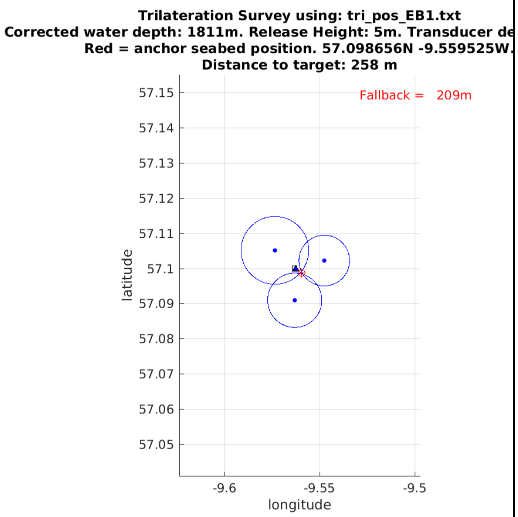
37 Appendix J: Mooring Deployment Summary Table

Moor	Date	Anchor Drop	Anchor Seabed						wd
Name	dd/mm/yy	hh:mm	Lat (°N)	Lon (°W)	Lat °	Lat '	Lon °W	Lon 'W	m
RTEB1	12/10/20	18:07	57.09866	-9.55953	57	05.92	09	33.57	1811
RTWB2	14/10/20	16:55	57.47154	-12.31432	57	28.29	12	18.86	1801
RTWB1	15/10/20	09:34	57.46946	-12.70291	57	28.17	12	42.17	1600
RH ADCP	15/10/20	19:21	57.61482	-15.41099	57	36.89	15	24.66	1083
IB5	16/10/20	17:51	57.80140	-19.17136	57	48.08	19	10.28	945
IB4	18/10/20	12:43	57.98982	-21.14619	57	59.39	21	08.77	2922
IB3	20/10/20	12:16	58.01277	-24.42572	58	00.77	24	25.54	2838
DMLTM	23/10/20	10:25	59.86130	-7.04434	59	51.68	7	02.66	1036

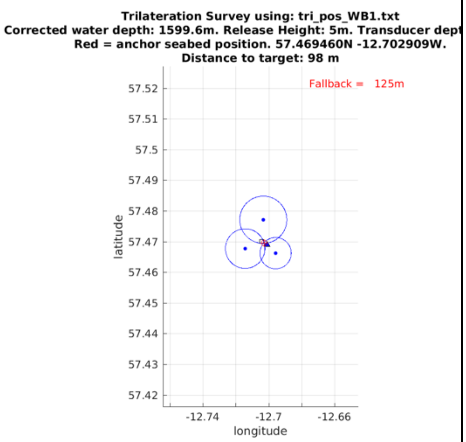
Moor	Date	Start Deploy	Anchor Drop	Tow	Fallback from trilateration	Distance from target	Irridium Beacons		AR 1	AR 2
Name	dd/mm/yyyy	hh:mm	hh:mm	min	m	m	IMEI	IMEI	S/N	S/N
RTEB1	12/10/20	15:17	18:07	57	209	258.0			1999	1755
RTWB2	14/10/20	16:06	16:55	15	231				1494	1502
RTWB1	15/10/20	07:40	09:34	25	125	98.0			1136	1752
RH ADCP	15/10/20	19:08	19:21	6	123	60.0			1137	1135
IB5	16/10/20	15:40	17:51	60	159	60.0	300234060475730	none	1759	1765
IB4	18/10/20	10:26	12:43	30	277	1.0			1270	1142
IB3	20/10/20	09:35	12:16	40	395	177.0			1492	1766
DMLTM	23/10/20	09:54	10:25	0	59	32				

38 Appendix K: Mooring Trilateration Results

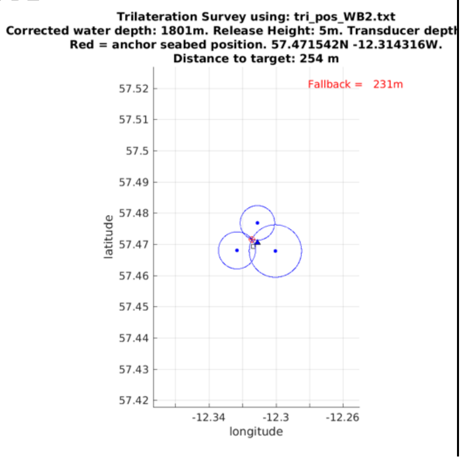
RTEB1



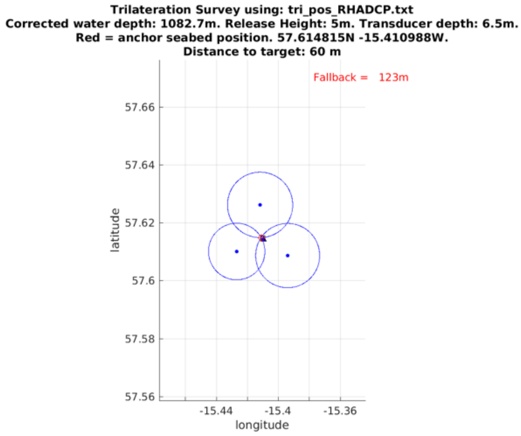
RTWB1



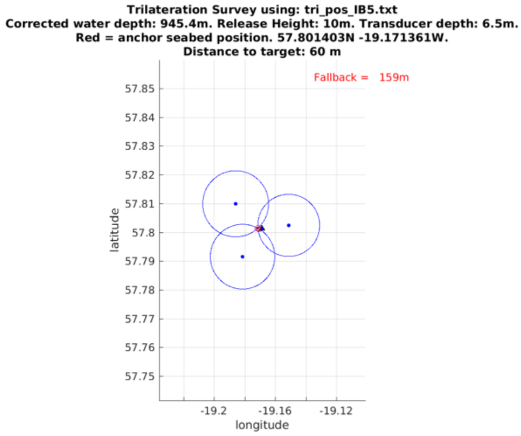
RTWB2



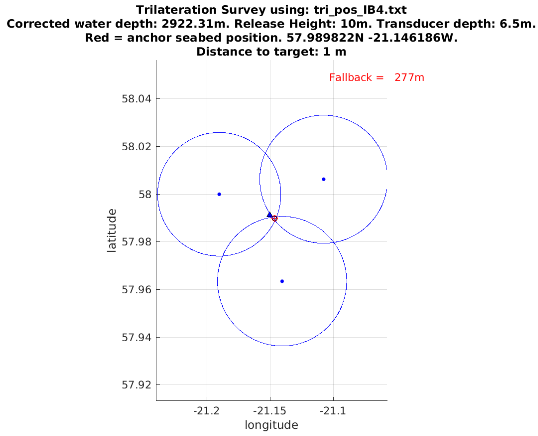
RHADCP



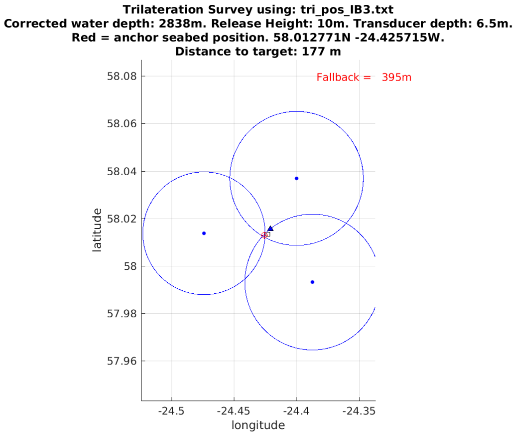
IB5



IB4

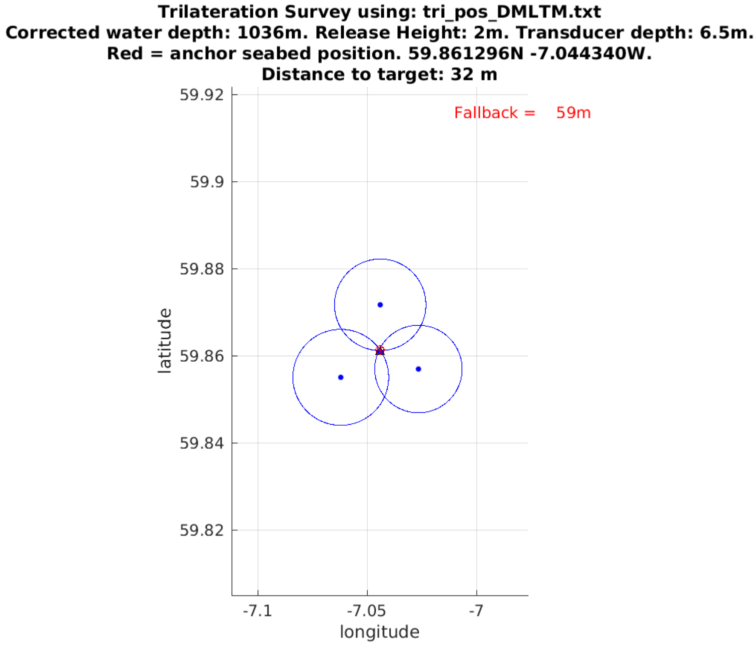


IB3



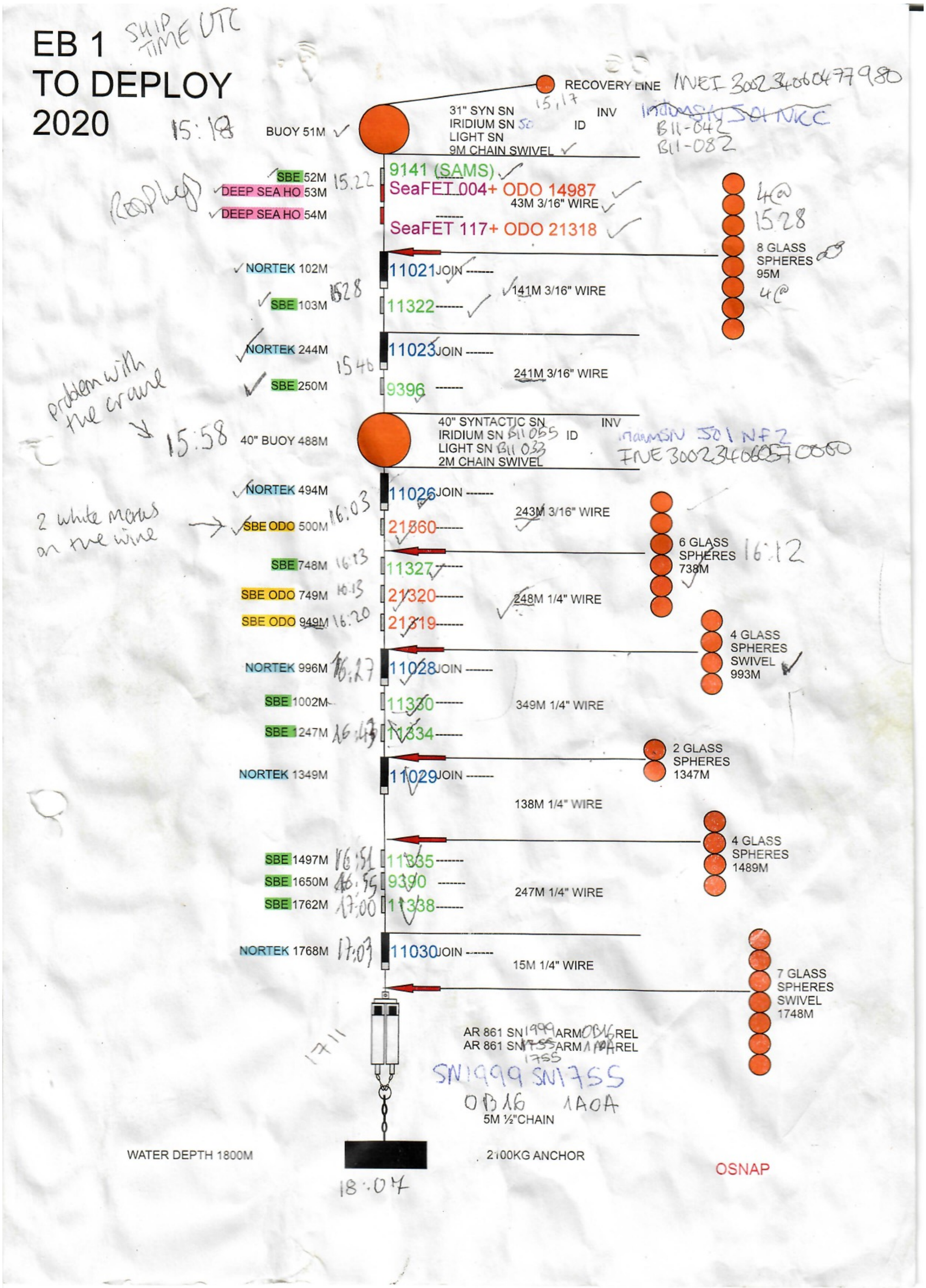
Trilateration Survey using: tri_pos_IB3.txt
Corrected water depth: 2838m. Release Height: 10m. Transducer depth: 6.5m.
Red = anchor seabed position. 58.012771N -24.425715W.
Distance to target: 177 m
Fallback = 395m
latitude
longitude

DMLTM



Trilateration Survey using: tri_pos_DMLTM.txt
Corrected water depth: 1036m. Release Height: 2m. Transducer depth: 6.5m.
Red = anchor seabed position. 59.861296N -7.044340W.
Distance to target: 32 m
Fallback = 59m
latitude
longitude

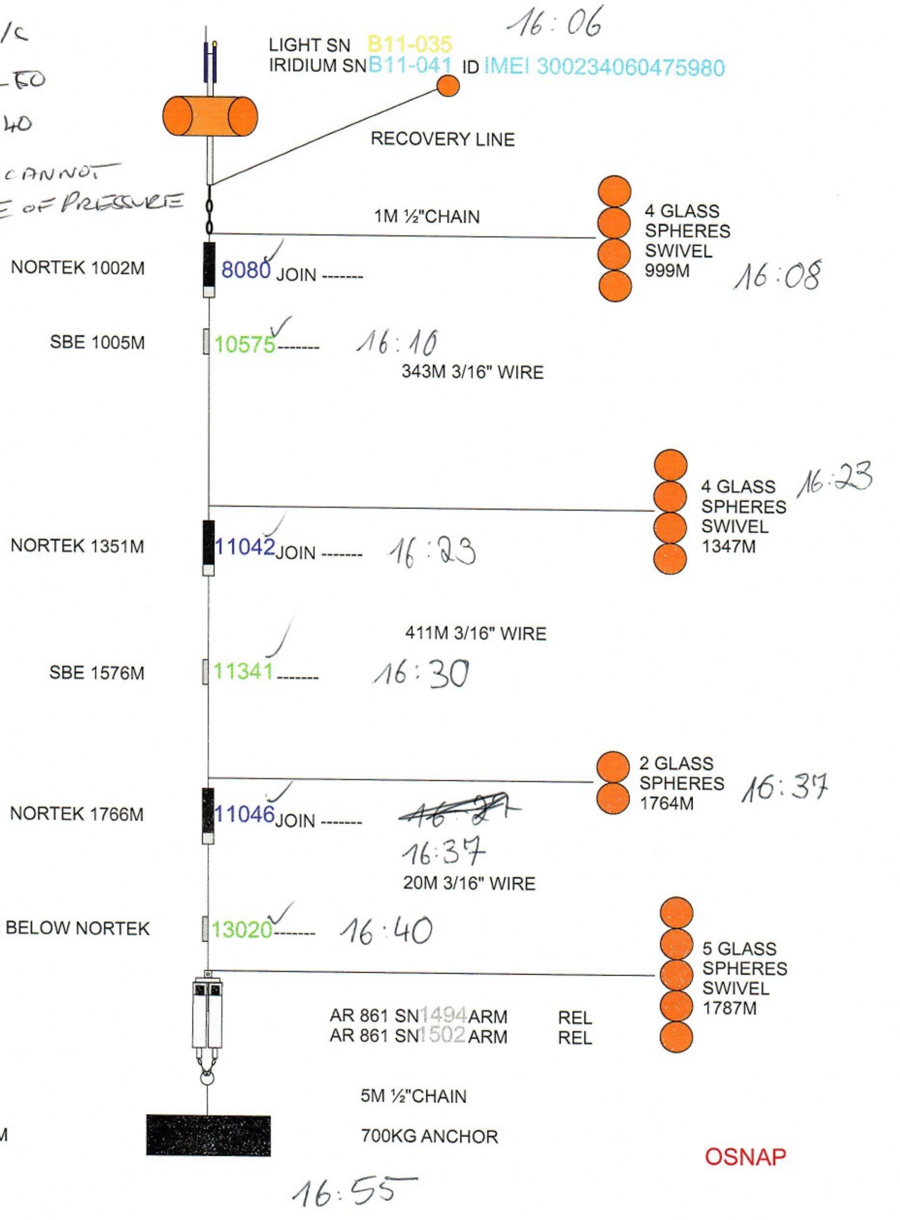
39 Appendix L: Diagrams of Deployed Moorings

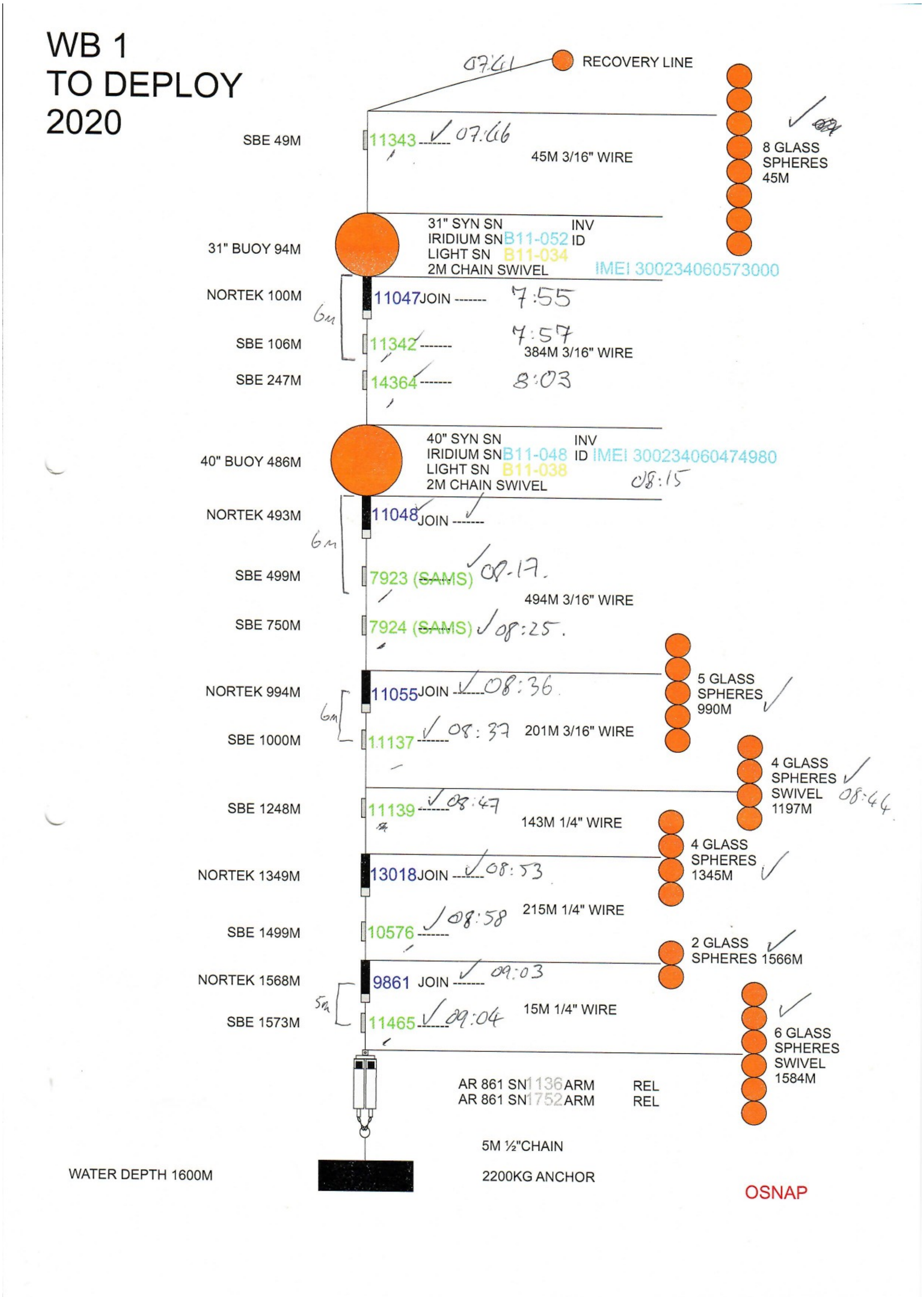


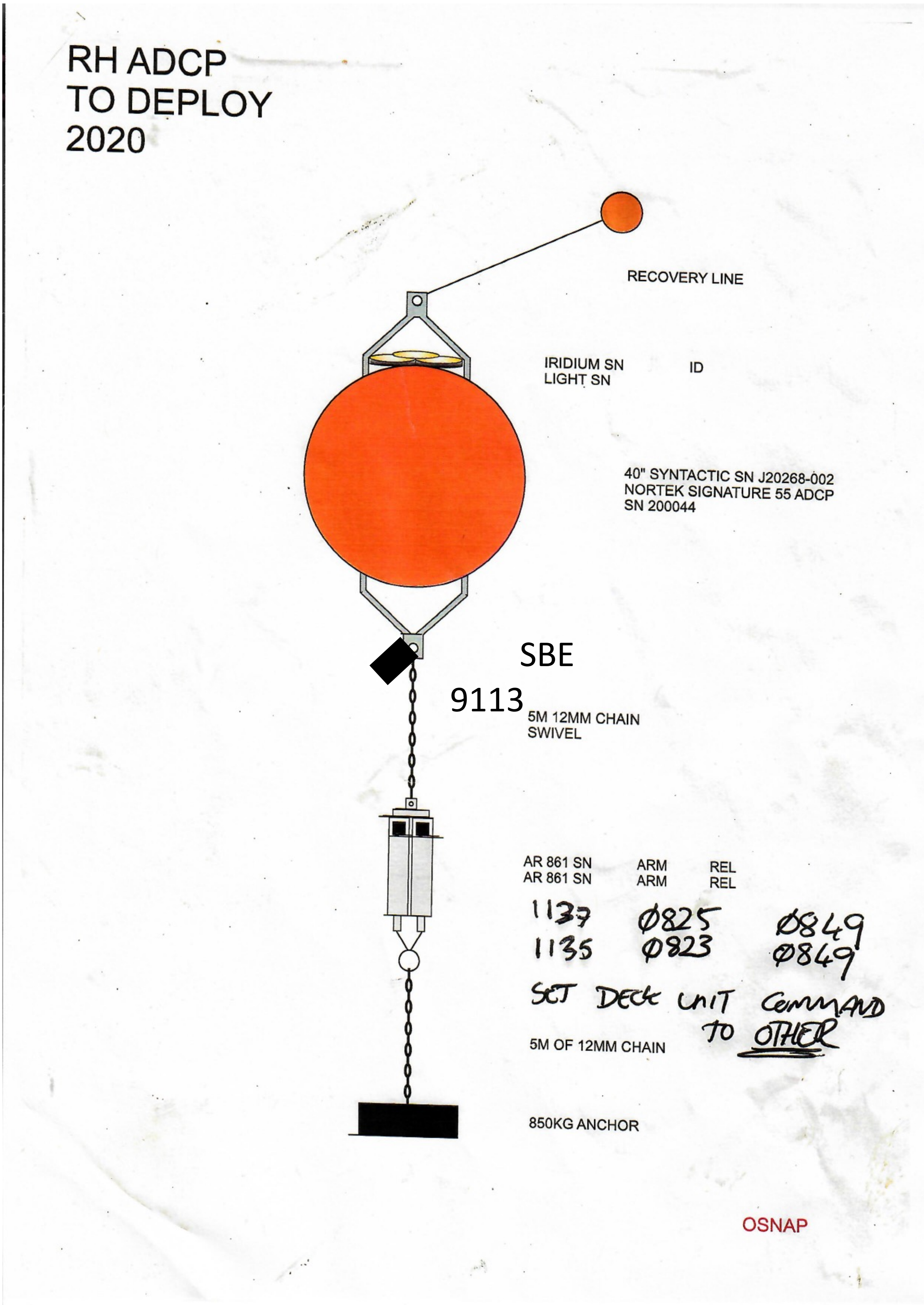
WB 2
TO DEPLOY
2020

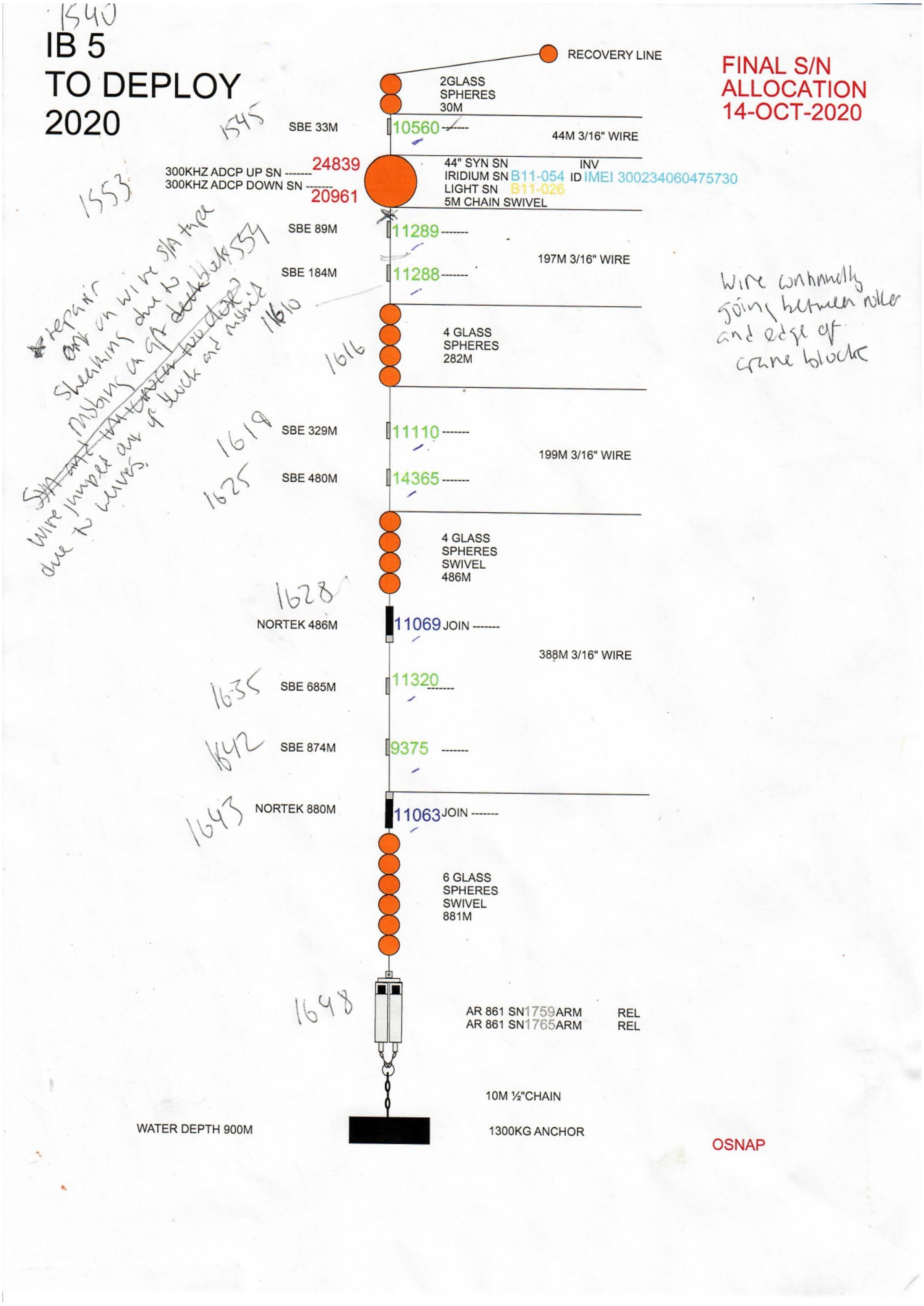
14:05 waiting f. crane to be fixed
14:30 crane working (unclear lift for test), Further delay.

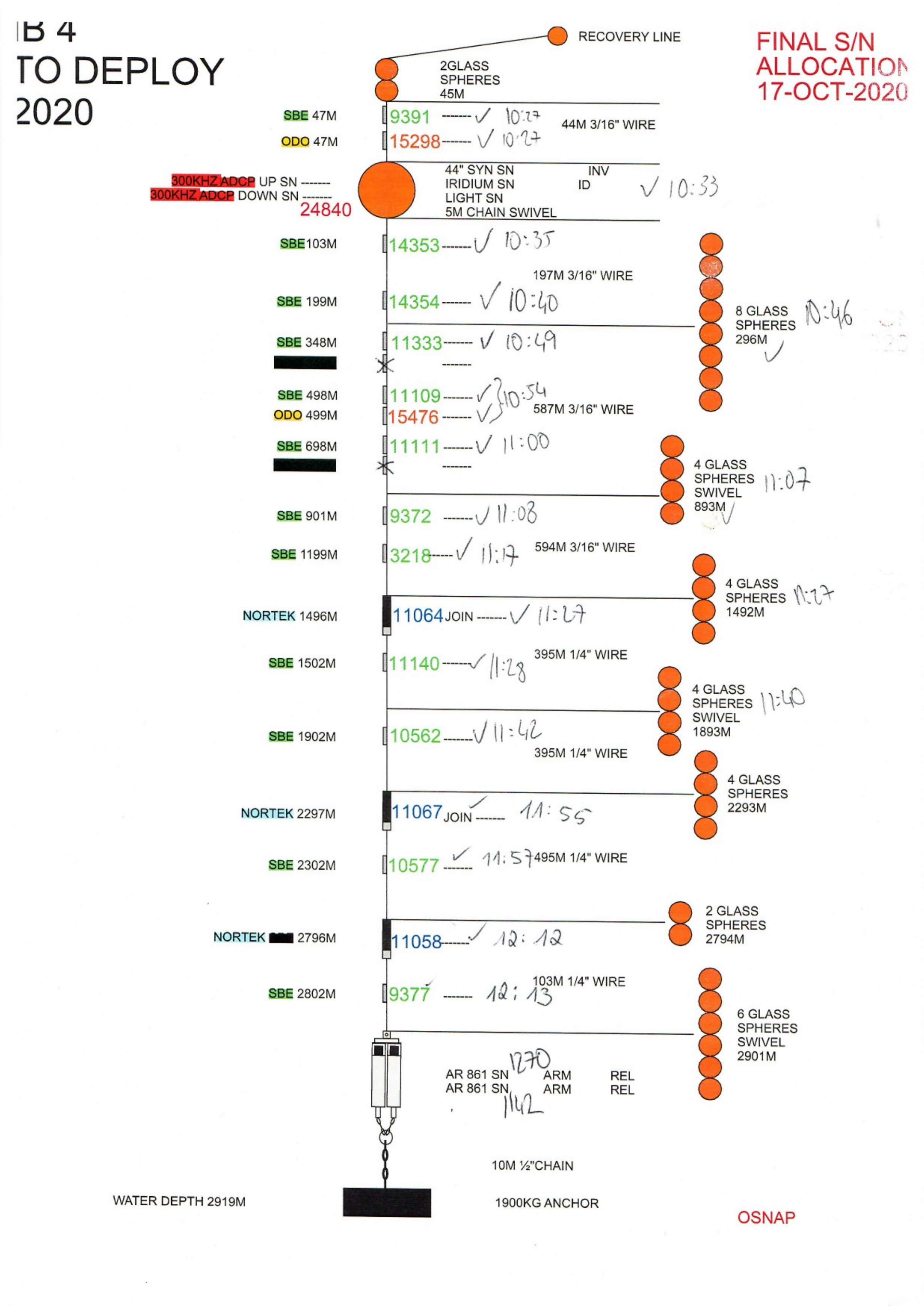
PORT CRANE U/C
CHANGING BLOCK TO
STB CRANE 1440
NO SPARE HOSE & CANNOT
BLANK BECAUSE OF PRESSURE
CRANE (STB) READY
TO USE : 15:50

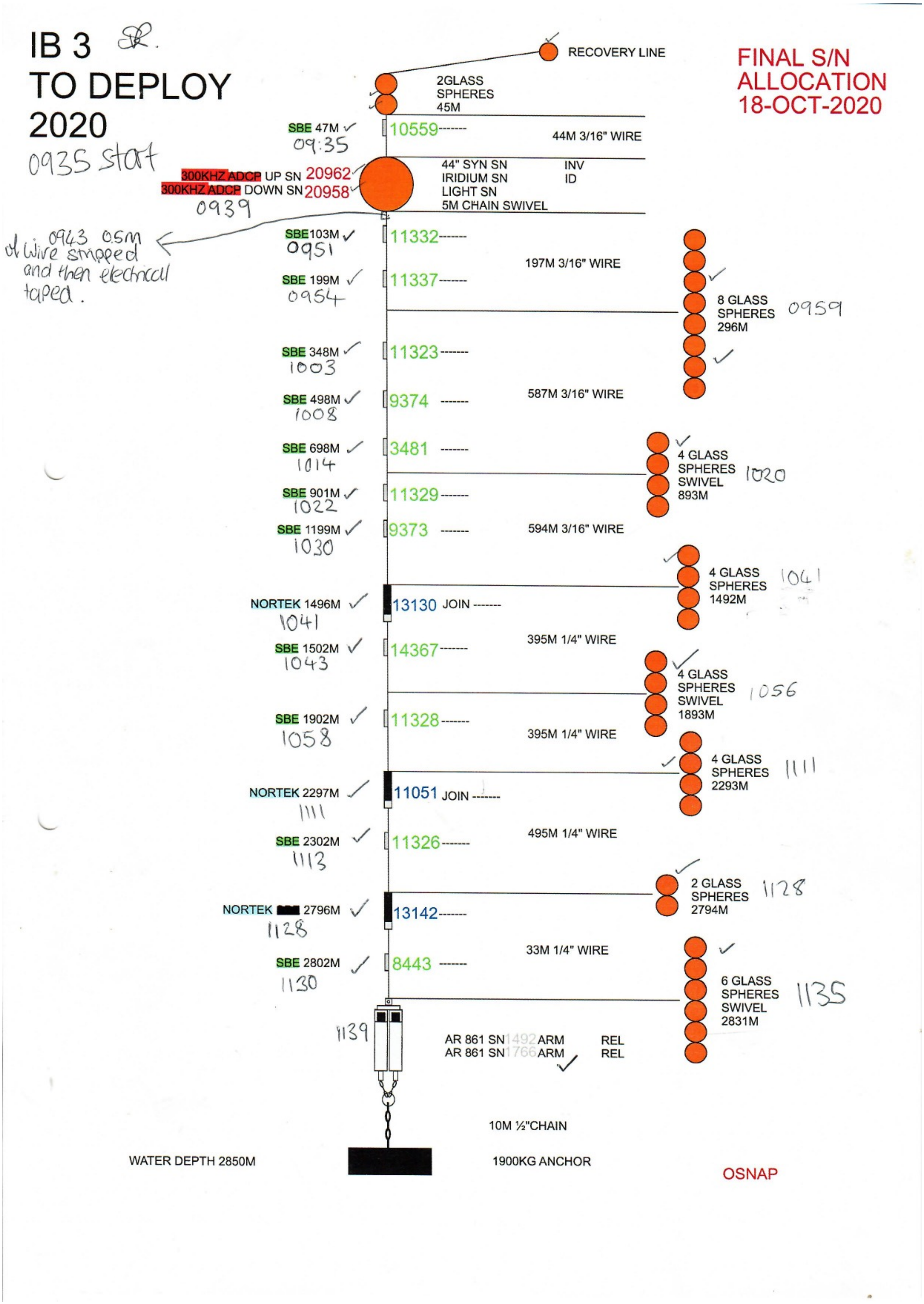



WB 1
TO DEPLOY
2020
07:41
RECOVERY LINE
SBE 49M
11343 07:46
45M 3/16" WIRE
8 GLASS SPHERES 45M
31" BUOY 94M
31" SYN SN INV
IRIDIUM SN B11-052 ID
LIGHT SN B11-034
2M CHAIN SWIVEL
IMEI 300234060573000
NORTEK 100M
11047 JOIN 7:55
6m
SBE 106M
11342 7:57
384M 3/16" WIRE
SBE 247M
14364 8:03
40" BUOY 486M
40" SYN SN INV
IRIDIUM SN B11-048 ID IMEI 300234060474980
LIGHT SN B11-038
2M CHAIN SWIVEL
08:15
NORTEK 493M
11048 JOIN
6m
SBE 499M
7923 (SAMS) 08:17.
494M 3/16" WIRE
SBE 750M
7924 (SAMS) 08:25.
NORTEK 994M
11055 JOIN 08:36
5 GLASS SPHERES 990M
6m
SBE 1000M
11137 08:37
201M 3/16" WIRE
4 GLASS SPHERES SWIVEL 1197M
08:44
SBE 1248M
11139 08:47
143M 1/4" WIRE
NORTEK 1349M
13018 JOIN 08:53
4 GLASS SPHERES 1345M
SBE 1499M
10576 08:58
215M 1/4" WIRE
2 GLASS SPHERES 1566M
NORTEK 1568M
9861 JOIN 09:03
5m
SBE 1573M
11465 09:04
15M 1/4" WIRE
6 GLASS SPHERES SWIVEL 1584M
AR 861 SN 1136 ARM REL
AR 861 SN 1752 ARM REL
5M ½"CHAIN
WATER DEPTH 1600M
2200KG ANCHOR
OSNAP


RH ADCP
TO DEPLOY
2020
RECOVERY LINE
IRIDIUM SN
LIGHT SN
ID
40" SYNTACTIC SN J20268-002
NORTEK SIGNATURE 55 ADCP
SN 200044
SBE
9113
5M 12MM CHAIN
SWIVEL
AR 861 SN
AR 861 SN
ARM
ARM
REL
REL
1137 Ø825 Ø849
1135 Ø823 Ø849
SET DECK UNIT COMMAND
TO OTHER
5M OF 12MM CHAIN
850KG ANCHOR
OSNAP

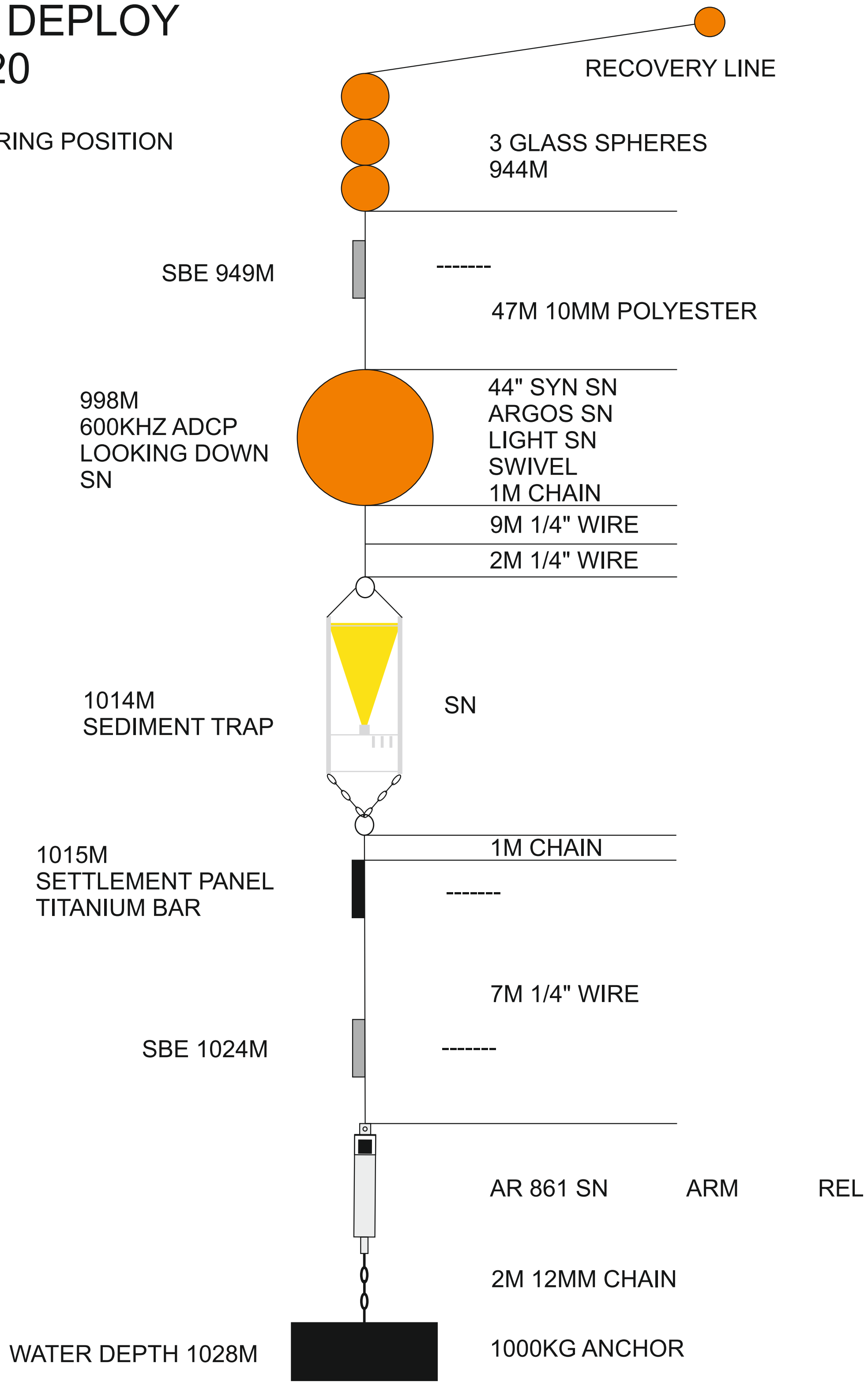

IB 5
TO DEPLOY
2020
1540
FINAL S/N
ALLOCATION
14-OCT-2020
RECOVERY LINE
2GLASS
SPHERES
30M
1545
SBE 33M
10560
44M 3/16" WIRE
300KHZ ADCP UP SN 24839
300KHZ ADCP DOWN SN 20961
1553
44" SYN SN
INV
IRIDIUM SN B11-054 ID IMEI 300234060475730
LIGHT SN B11-026
5M CHAIN SWIVEL
SBE 89M
11289
SBE 184M
11288
197M 3/16" WIRE
Wire continually going between roller and edge of crane block
4 GLASS
SPHERES
282M
1610
1616
SBE 329M
11110
1619
199M 3/16" WIRE
SBE 480M
14365
1625
4 GLASS
SPHERES
SWIVEL
486M
1628
NORTEK 486M
11069 JOIN
388M 3/16" WIRE
SBE 685M
11320
1635
SBE 874M
9375
1642
NORTEK 880M
11063 JOIN
1643
6 GLASS
SPHERES
SWIVEL
881M
1648
AR 861 SN1759ARM REL
AR 861 SN1765ARM REL
10M ½"CHAIN
WATER DEPTH 900M
1300KG ANCHOR
OSNAP


IB 4
TO DEPLOY
2020
RECOVERY LINE
FINAL S/N
ALLOCATION
17-OCT-2020
2GLASS SPHERES 45M
SBE 47M 9391 ------- 10:27
ODO 47M 15298------- 10:27
44M 3/16" WIRE
300KHZ ADCP UP SN -------
300KHZ ADCP DOWN SN -------
24840
44" SYN SN
IRIDIUM SN
LIGHT SN
5M CHAIN SWIVEL
INV ID
10:33
SBE 103M 14353------ 10:35
197M 3/16" WIRE
SBE 199M 14354------ 10:40
8 GLASS SPHERES 296M
10:46
SBE 348M 11333------ 10:49
[redacted] -------
SBE 498M 11109------ 10:54
ODO 499M 15476------
587M 3/16" WIRE
SBE 698M 11111------ 11:00
[redacted] -------
4 GLASS SPHERES SWIVEL 893M
11:07
SBE 901M 9372 ------- 11:08
SBE 1199M 3218----- 11:17
594M 3/16" WIRE
4 GLASS SPHERES 1492M
11:27
NORTEK 1496M 11064 JOIN ------- 11:27
SBE 1502M 11140------ 11:28
395M 1/4" WIRE
4 GLASS SPHERES SWIVEL 1893M
11:40
SBE 1902M 10562------ 11:42
395M 1/4" WIRE
4 GLASS SPHERES 2293M
NORTEK 2297M 11067 JOIN ------- 11:55
SBE 2302M 10577 ------- 11:57
495M 1/4" WIRE
2 GLASS SPHERES 2794M
NORTEK [redacted] 2796M 11058------ 12:12
SBE 2802M 9377 ------- 12:13
103M 1/4" WIRE
6 GLASS SPHERES SWIVEL 2901M
AR 861 SN 1270 ARM REL
AR 861 SN 1142 ARM REL
10M ½"CHAIN
WATER DEPTH 2919M
1900KG ANCHOR
OSNAP


IB 3
TO DEPLOY
2020
0935 start
FINAL S/N
ALLOCATION
18-OCT-2020
RECOVERY LINE
2GLASS
SPHERES
45M
SBE 47M
09:35
10559-------
44M 3/16" WIRE
300KHZ ADCP UP SN 20962
300KHZ ADCP DOWN SN 20958
0939
44" SYN SN
IRIDIUM SN
LIGHT SN
5M CHAIN SWIVEL
INV
ID
0943 0.5m of wire stripped and then electrical taped.
SBE103M
0951
11332-------
197M 3/16" WIRE
SBE 199M
0954
11337-------
8 GLASS
SPHERES
296M
0959
SBE 348M
1003
11323-------
SBE 498M
1008
9374 -------
587M 3/16" WIRE
SBE 698M
1014
3481 -------
4 GLASS
SPHERES
SWIVEL
893M
1020
SBE 901M
1022
11329-------
SBE 1199M
1030
9373 -------
594M 3/16" WIRE
4 GLASS
SPHERES
1492M
1041
NORTEK 1496M
1041
13130 JOIN -------
395M 1/4" WIRE
SBE 1502M
1043
14367-------
4 GLASS
SPHERES
SWIVEL
1893M
1056
SBE 1902M
1058
11328-------
395M 1/4" WIRE
4 GLASS
SPHERES
2293M
1111
NORTEK 2297M
1111
11051 JOIN -------
495M 1/4" WIRE
SBE 2302M
1113
11326-------
2 GLASS
SPHERES
2794M
1128
NORTEK [redacted] 2796M
1128
13142-------
33M 1/4" WIRE
SBE 2802M
1130
8443 -------
6 GLASS
SPHERES
SWIVEL
2831M
1135
1139
AR 861 SN1492 ARM
AR 861 SN1766 ARM
REL
REL
10M ½"CHAIN
WATER DEPTH 2850M
1900KG ANCHOR
OSNAP

DARWIN MOUNDS
TO DEPLOY
2020

MOORING POSITION



40 Appendix M: Meta Data from Deployed Moorings

Cruise DY120

Mooring deployment metadata log

Mooring: EB1

Date: 12/10/20

Arrival on site time: 1340 Setup distance: 2 nm

	Time (UTC)	Latitude	Longitude	Uncorrected depth (m)	Corrected depth (m)
Start deployment	1517	57.0776	-9.5177	1762.4	1757
End deployment (winch)	1711	57.0879	-9.5396	2001.9	19995.9
Anchor drop	180739	57.0997	-9.5624	1808.6	1802.6

Deployment comments: Anchor target: 57°6'N, 9° 33.78'W, wd = 1812 un =1818 c/c
Usual Fallback ~250m.

Deploying @ 0.5kn SOG

Acoustic tracking of descent	
Time (UTC)	Range (m)
6:16:10	1584
6:16:40	1706
6:17:10	1767
6:17:40	1855
6:18:30	1859 } Bottom

Acoustic release S/N: 1755 1999

ARM code: 1AØA ØB16

DIAG code: 1A49 ØB49

Mooring on seabed time: 1819.

Trilaterated latitude: 57.098656

Trilaterated longitude: -9.559525

Corrected depth: 1811 m

Fallback distance: 209 m

Cruise DY120

Mooring deployment metadata log

Mooring: WB2

Date: 14/10/20

Arrival on site time: 13:55 Setup distance: 0.5 nm

	Time (UTC)	Latitude	Longitude	Uncorrected depth (m)	Corrected depth (m)
Start deployment	16:06	57°28.52'N	12°19.32W	1807.8	1801.8
End deployment (winch)	16:40	57°28.29'N	12°18.81'W	1807.4	1801.4
Anchor ~~release~~ drop	16:55	57°28.22N	12°18.67W	1807.6	1801.6

Deployment comments:

254m distance do target

Acoustic tracking of descent	
Time (UTC)	Range (m)
17:00:17	726/738
17:01:04	817/828
17:02:00	923/935
17:03:00	1035/1047
17:04:00	1147/1158
17:05:00	1259/1269
17:06:00	1371/1383
17:07:00	1484/1496
17:08:00	1596/1608
17:09:00	1709/1720
17:10:00	1815/1816
17:11:00	1815/1816
17:12:00	1816/1816

Acoustic release S/N: 1494/1502

ARM code:

DIAG code:

Mooring on seabed time: 17:10

Trilaterated latitude: 57.471542°N

Trilaterated longitude: -12.314316°E

Corrected depth: 1801 m

Fallback distance: 231 m

Cruise DY120

Mooring deployment metadata log

Mooring: WB1

Date: 15/10/2020

Add target posi° on logsheet

Arrival on site time: 07:00 Setup distance: 1 nm

	Time (UTC)	Latitude	Longitude	Uncorrected depth (m)	Corrected depth (m)
Start deployment	07:40	57 28.89	12 44.14W	1545.5	1540.5
End deployment (winch)	09:09	57 28.33 N	12 42.59 W	1588.4	1583.4
Anchor ~~release~~ drop	09:36.	57 28.13N	12 42.07W	1604.6	1599.6

Deployment comments:

Acoustic tracking of descent	
Time (UTC)	Range (m)
09:35	230
09:36	413
09:36	433.
09:37	605/624.
09:38.	786/803
09:39	954/971
09:40	1119/1135.
09:41	1280/1295.
09:42	1426/1441
09:43	1567/1582
09:44	1598/1599
09:44.	1599/1598.

Acoustic release S/N: 1752

ARM code: 1A07

DIAG code: 1A49

Mooring on seabed time: 09:46

Trilaterated latitude: 57.469460

Trilaterated longitude: 12.702909

Corrected depth: 1599.6 m

Fallback distance: 125 m

Cruise DY120

Mooring deployment metadata log

57 36.88 N
15 24.6 W

Mooring: RHADCP

Date: 15/10/20

Arrival on site time: 19:08:20 Setup distance: 0 nm

	Time (UTC)	Latitude	Longitude	Uncorrected depth (m)	Corrected depth (m)
Start deployment	190836	57 36.91N	-15 24.64E	—	1070.3
End deployment (winch)	191418	57 36.88N	-15 24.61E	1084.4	1083.2
Anchor drop	1920:34	57 36.86N	-15 24.58E	1085.7	1082.7

Deployment comments:

Diagnostic: release is vertical

anchor release was early due to large amount of roll on back deck

Acoustic tracking of descent	
Time (UTC)	Range (m)
19:27:14	1079.1
19:27:21	1079
19:27:39	1079.8

Acoustic release S/N: 1137 / 1135

ARM code:

DIAG code:

Mooring on seabed time: 19:28:12

Trilaterated latitude:

Trilaterated longitude:

Corrected depth: m

Fallback distance: m

Cruise DY120

Mooring deployment metadata log

Mooring: IB5

Date: 16/10/2020

Target Position: 57°48.06N 19°10.24W

Arrival on site time: ....

Setup distance: 1.5 nm

	Time (UTC)	Latitude	Longitude	Uncorrected depth (m)	Corrected depth (m)
Start deployment	1540	57°47.86N	19°13.93W	965.1	962.1
End deployment (winch)	1648	57° 47.94N	19° 12.68W	963.3	960.3
Anchor drop	1751	57° 48.07N	19° 10.12W	948.4	945.4

Deployment comments:

50 min steam to anchordrop after winch stop

Acoustic tracking of descent	
Time (UTC)	Range (m)
175200	187
175210	207
175230	286 / 307
1753:00	385 / 405
17:53:30	479 / 497
17:54:00	568 / 587
17:54:30	655 / 674
17:55:00	735 / 752
17:55:30	811 / 828
17:56:00	887 / 902
17:56:30	949 / 952
17:57:00	950 / 950
17:57:10	951 / 951

Acoustic release S/N: 1759 / 1765

ARM code: ....

DIAG code: ....

Mooring on seabed time: 17:57

Trilaterated latitude: 57.801403

Trilaterated longitude: -19.171361

Corrected depth: 945.4 m

Fallback distance: 159 m

Cruise DY120

Mooring deployment metadata log

Target Position: 57°59.39 N 21° 08.77 W

Mooring: IB4

Date: 18/10/2020

Arrival on site time: 0909

Setup distance: ESE 1.6 nm

	Time (UTC)	Latitude	Longitude	Uncorrected depth (m)	Corrected depth (m)
Start deployment	10:26	57°58.89' N	21°06.17' W	2792.3	2782.3
End deployment (winch)	12:18	57°59.31' N	21°08.24' W	2916.6	2907.8
Anchor drop	12:43	57°59.47' N	21° 09.00' W	2931	2923.4

Deployment comments:

13:01:00 2925/2925

Acoustic tracking of descent	
Time (UTC)	Range (m)
12:45:03	–
12:45:41	532.8
12:46:02	–
12:47:00	788/808
48:00	987/1007
:49:00	1177/1197
50:00	1363/1383
51:00	1549/–
52:00	1722/–
53:00	1892/1909
54:00	2057/2074
55:00	2220/2236
56:00	2376/2392
57:00	2527/2542
58:00	2670/2683
59:00	2807/2830
13:00:00	2925/2925

Acoustic release S/N: ....

ARM code: ....

DIAG code: ....

Mooring on seabed time: 13:00:00

Trilaterated latitude: 57.98982°N

Trilaterated longitude: 21.14619°W

Corrected depth: 2922.3 m

Fallback distance: 277 m

Cruise DY120

SR

Mooring deployment metadata log

Mooring: IB3

Date: 20.10.20

Target Position: 58°00.799'N 24°25.374'W

Arrival on site time: 19.10.20

Setup distance: 1.6 nm

	Time (UTC)	Latitude	Longitude	Uncorrected depth (m)	Corrected depth (m)
Start deployment	0935	57°59.6214'N	-24°26.63'E	2840	2825
End deployment (winch)	11:35				
Anchor drop	12:16:59	58°00.9168'N	-24°25.2598'E	2853.9	2838.9

Deployment comments:

Acoustic tracking of descent	
Time (UTC)	Range (m)
12:19:00	431/453
20:00	623/642
21:00	807/826
22:00	989/1006
23:00	1164/1183
24:00	1335/1351
25:00	1501/1519
27:00	1825/1843
28:00	1983/1998
29:00	2137/2153
30:00	2286/2301
31:00	2429/2443
32:00	2566/2579
33:00	2697/2709
34:00	2849/2861
35:00	2867/2867
~~36:00~~	

Acoustic release S/N: 1492 1766

ARM code: Ø903 1A15

DIAG code:

Mooring on seabed time: 12:35:00

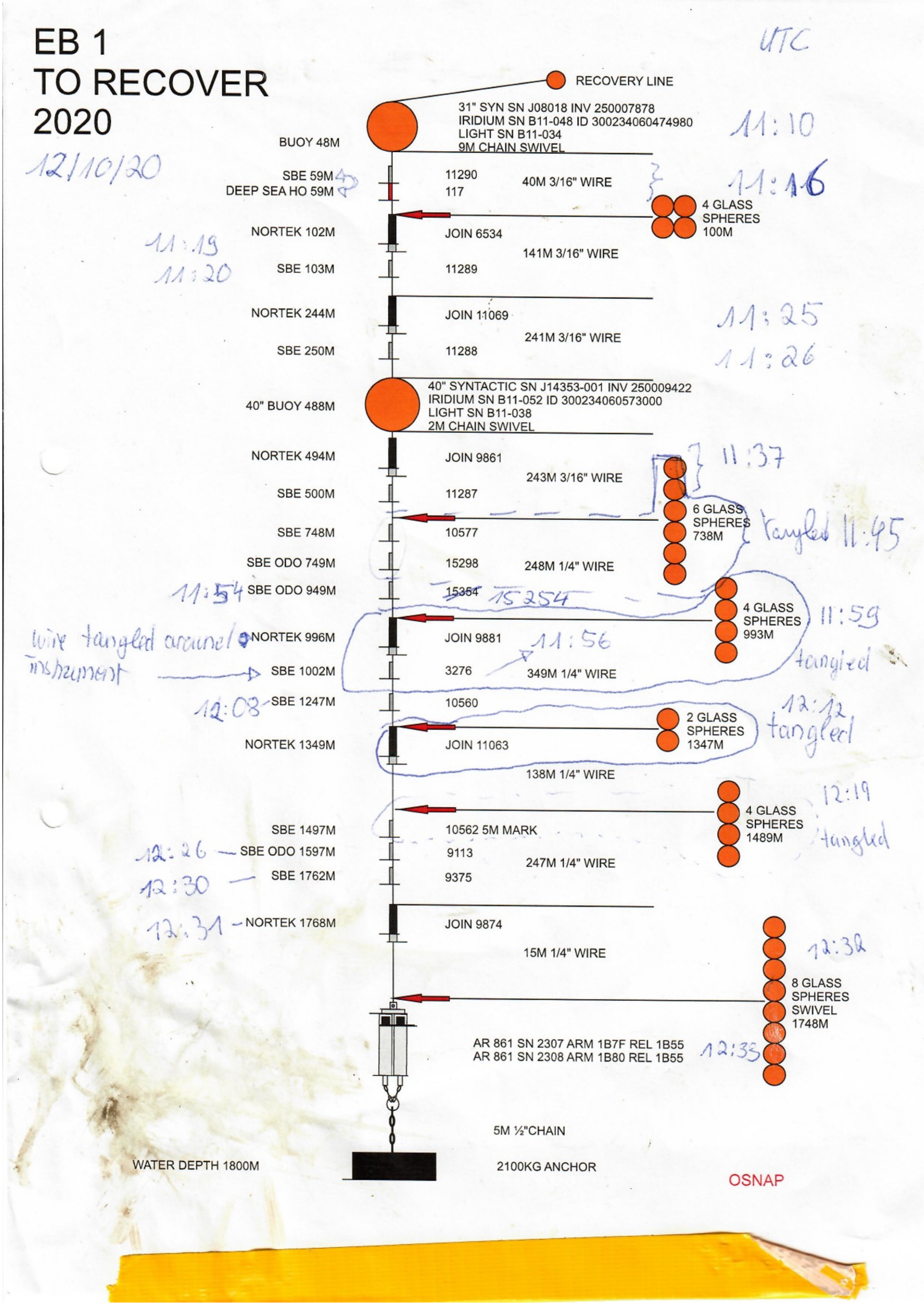
Trilaterated latitude: 58.012771'N

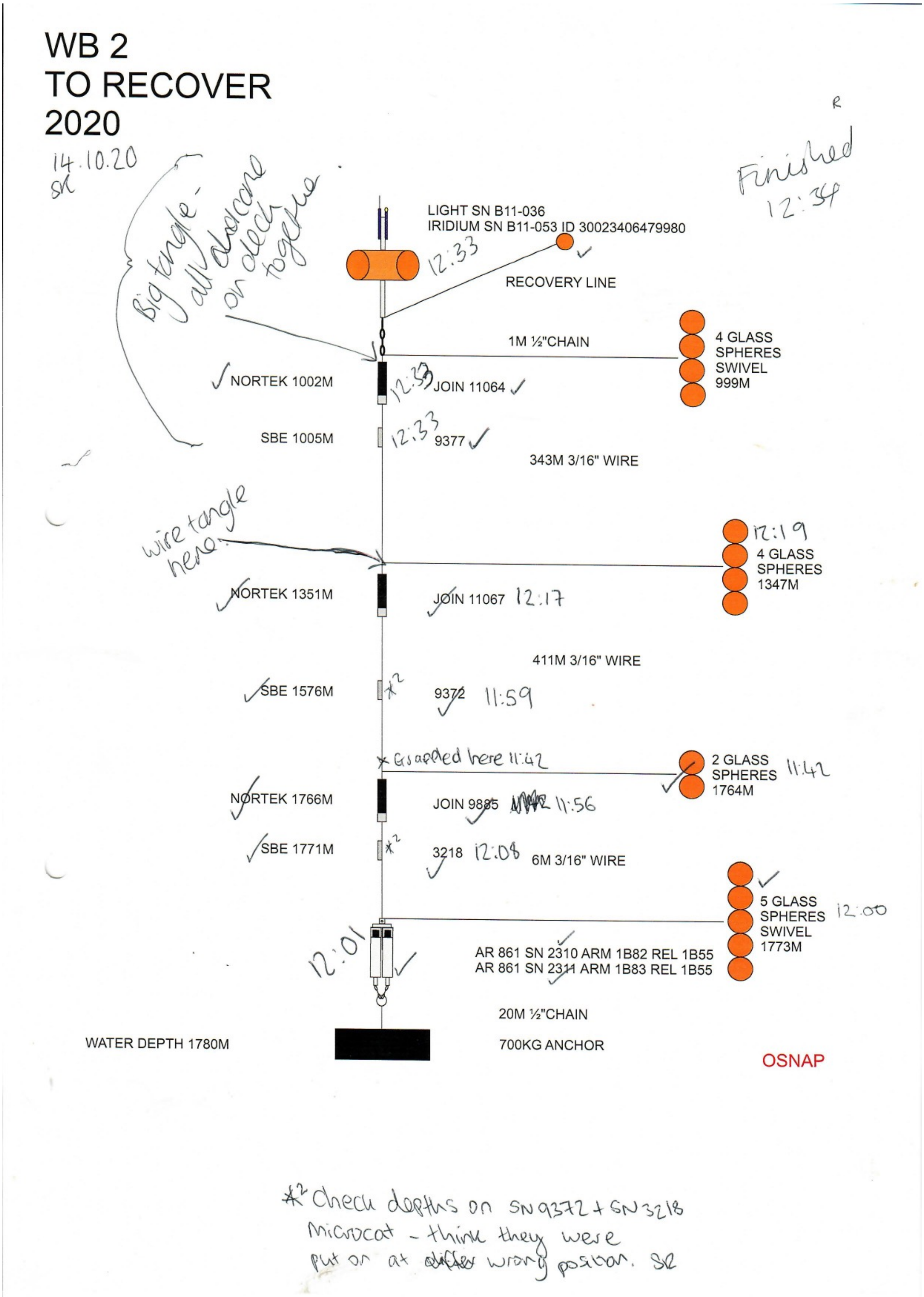
Trilaterated longitude: 24.425715'W

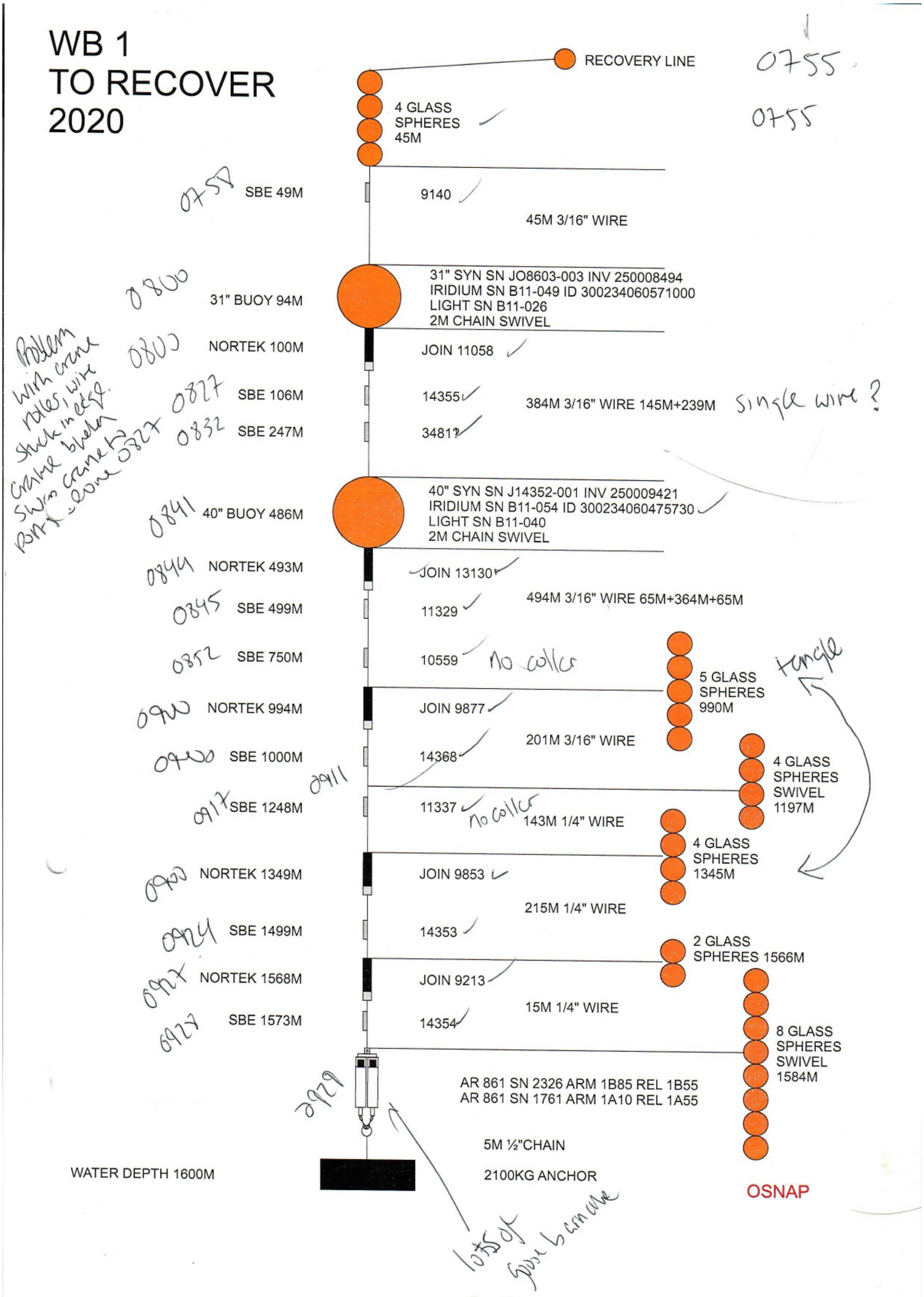
Corrected depth: 2838 m

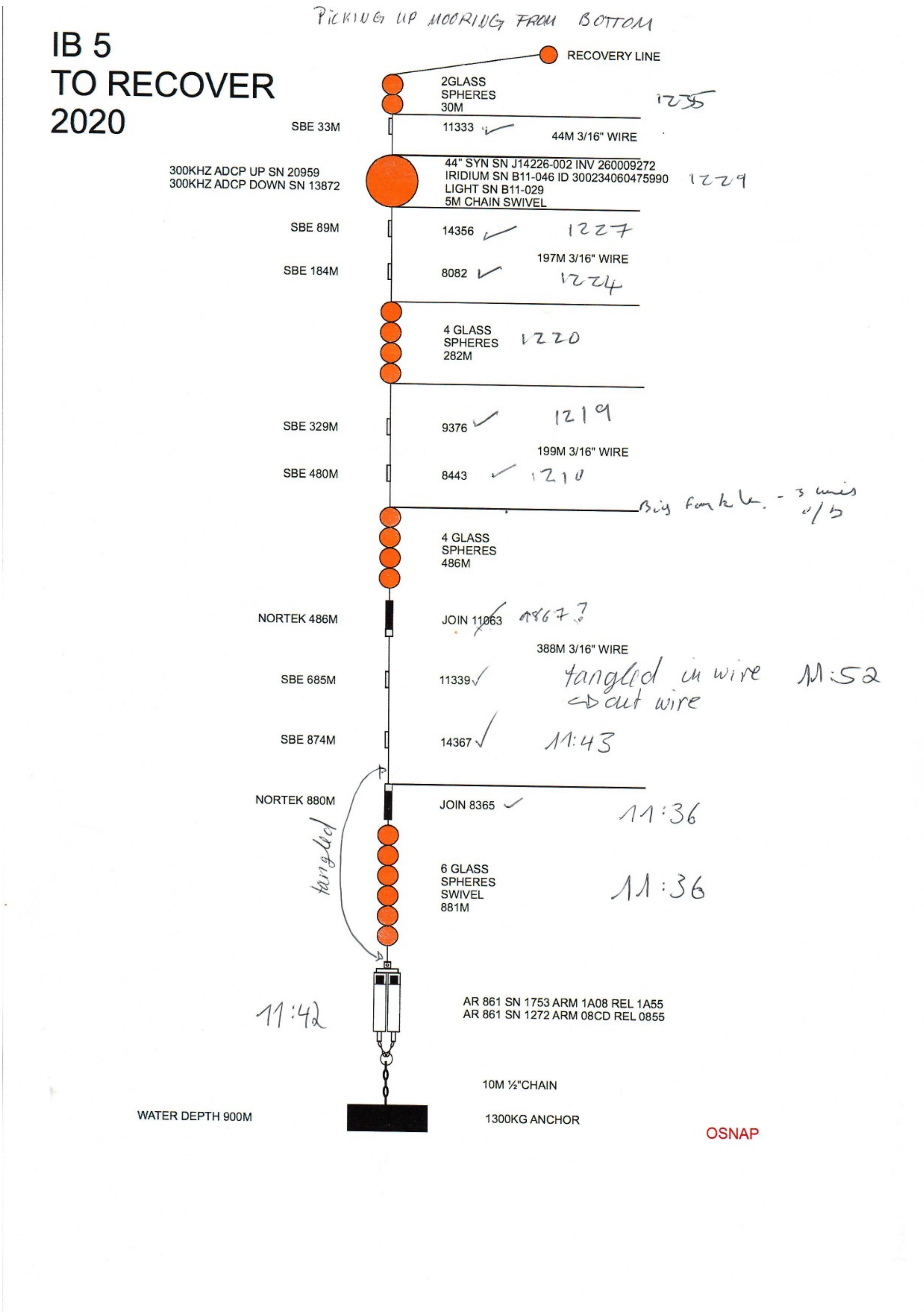
Fallback distance: 395 m

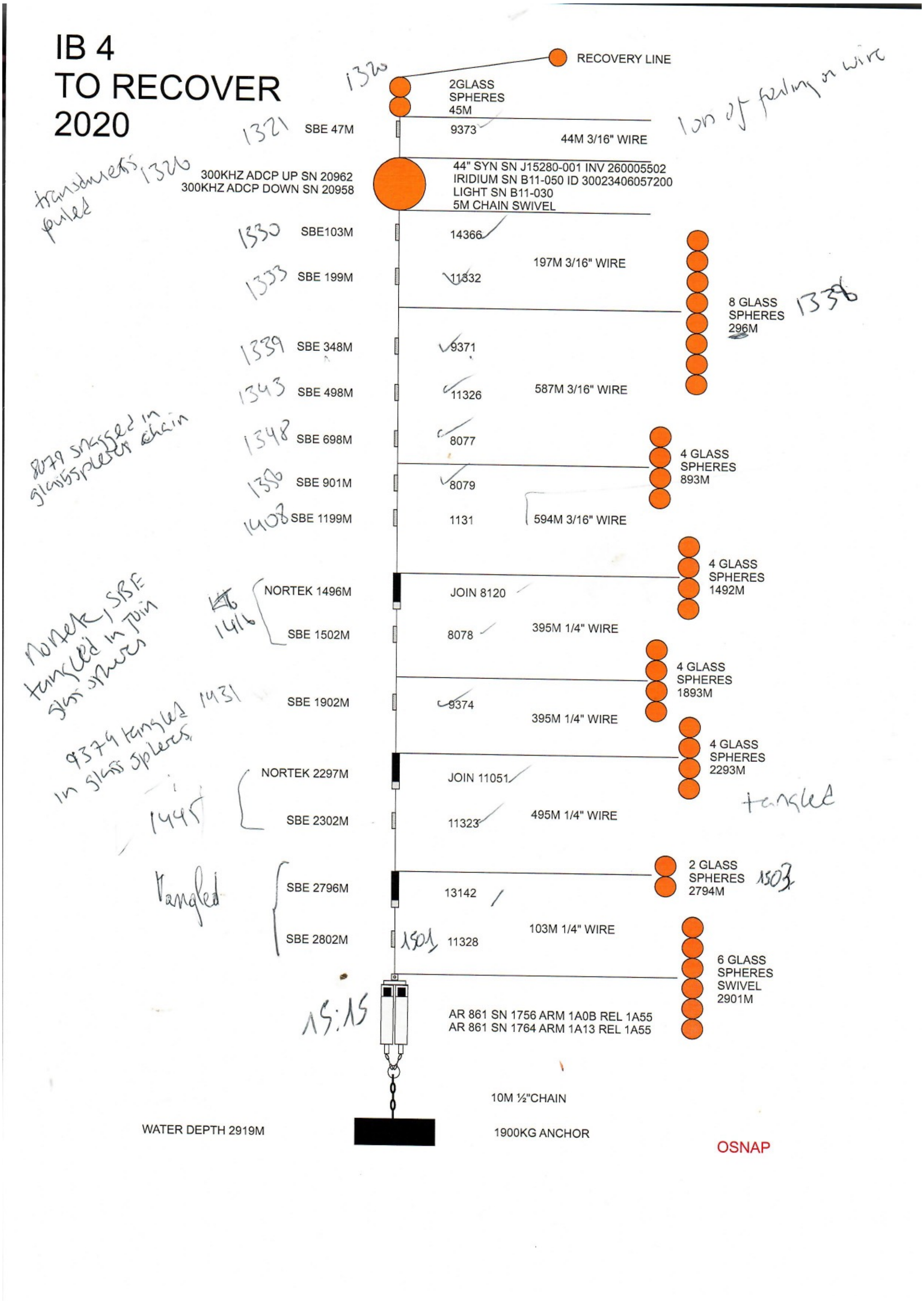
41 Appendix N: Diagrams of Recovered Moorings



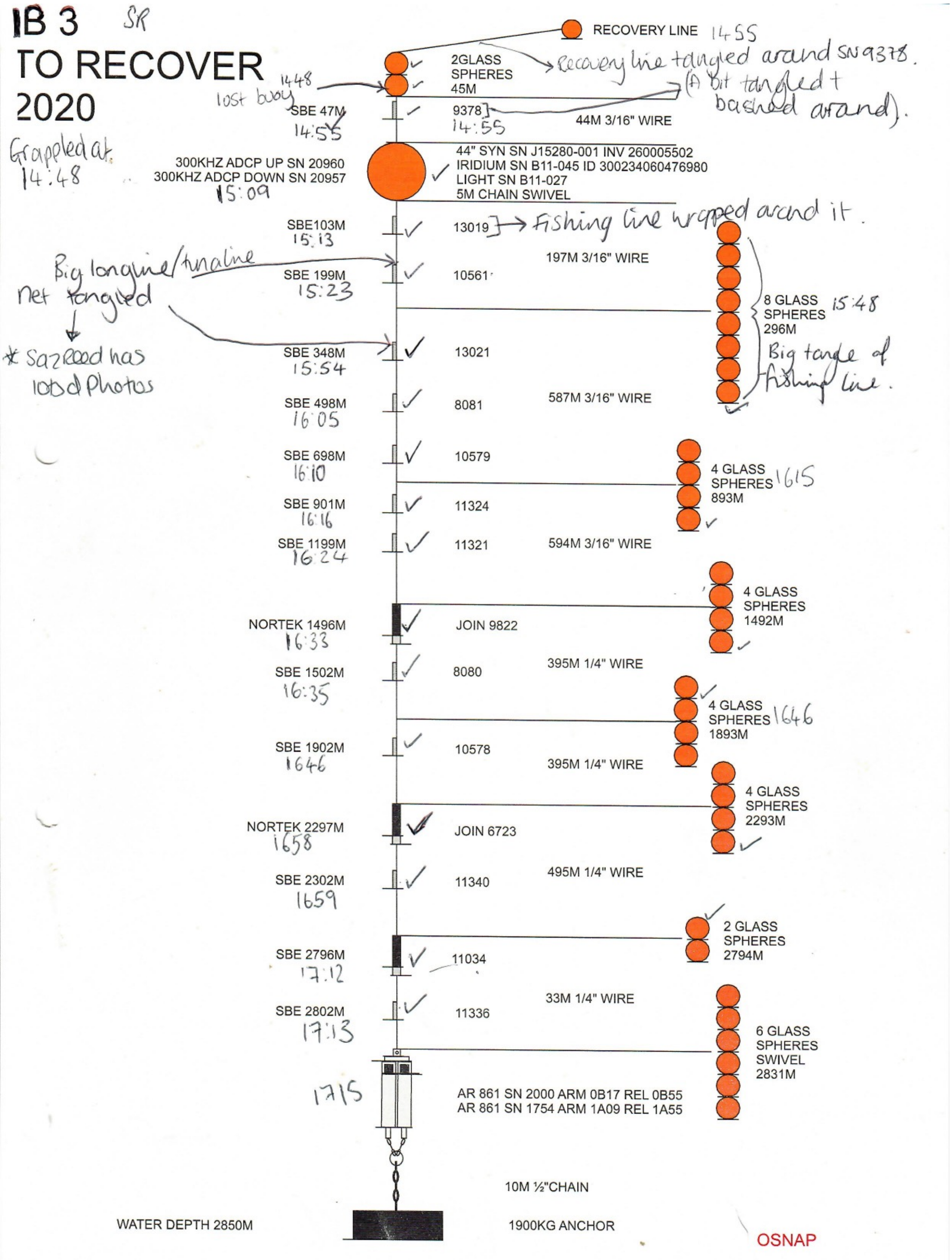

WB 2
TO RECOVER
2020
14.10.20
SR
Finished 12:34
Big tangle - all came on deck together
LIGHT SN B11-036
IRIDIUM SN B11-053 ID 30023406479980
12:33
RECOVERY LINE
1M ½"CHAIN
4 GLASS SPHERES SWIVEL 999M
NORTEK 1002M
JOIN 11064
SBE 1005M
9377
343M 3/16" WIRE
wire tangle here
12:19
4 GLASS SPHERES 1347M
NORTEK 1351M
JOIN 11067 12:17
411M 3/16" WIRE
SBE 1576M
9372 11:59
Grappled here 11:42
2 GLASS SPHERES 1764M 11:42
NORTEK 1766M
JOIN 9885 11:56
SBE 1771M
3218 12:08
6M 3/16" WIRE
5 GLASS SPHERES SWIVEL 1773M 12:00
12:01
AR 861 SN 2310 ARM 1B82 REL 1B55
AR 861 SN 2311 ARM 1B83 REL 1B55
20M ½"CHAIN
WATER DEPTH 1780M
700KG ANCHOR
OSNAP
*2 Check depths on SN 9372 + SN 3218 Microcat - think they were put on at wrong position. SR


WB 1
TO RECOVER
2020
RECOVERY LINE
4 GLASS SPHERES 45M
SBE 49M
9140
45M 3/16" WIRE
31" BUOY 94M
31" SYN SN JO8603-003 INV 250008494
IRIDIUM SN B11-049 ID 300234060571000
LIGHT SN B11-026
2M CHAIN SWIVEL
NORTEK 100M
JOIN 11058
SBE 106M
14355
384M 3/16" WIRE 145M+239M
SBE 247M
3481?
40" BUOY 486M
40" SYN SN J14352-001 INV 250009421
IRIDIUM SN B11-054 ID 300234060475730
LIGHT SN B11-040
2M CHAIN SWIVEL
NORTEK 493M
JOIN 13130
SBE 499M
11329
494M 3/16" WIRE 65M+364M+65M
SBE 750M
10559
5 GLASS SPHERES 990M
NORTEK 994M
JOIN 9877
SBE 1000M
14368
201M 3/16" WIRE
4 GLASS SPHERES SWIVEL 1197M
SBE 1248M
11337
143M 1/4" WIRE
4 GLASS SPHERES 1345M
NORTEK 1349M
JOIN 9853
215M 1/4" WIRE
SBE 1499M
14353
2 GLASS SPHERES 1566M
NORTEK 1568M
JOIN 9213
15M 1/4" WIRE
SBE 1573M
14354
8 GLASS SPHERES SWIVEL 1584M
AR 861 SN 2326 ARM 1B85 REL 1B55
AR 861 SN 1761 ARM 1A10 REL 1A55
5M ½"CHAIN
2100KG ANCHOR
WATER DEPTH 1600M
OSNAP
0755
0755
0758
0800
0803
0827
0832
0827
0841
0844
0845
0852
0900
0900
0911
0917
0920
0924
0927
0928
0929
single wire ?
no collar
no collar
tangle
Problem with crane rollers, wire stuck in edge. Crane broken Swim crane to port - done
lots of goose barnacle

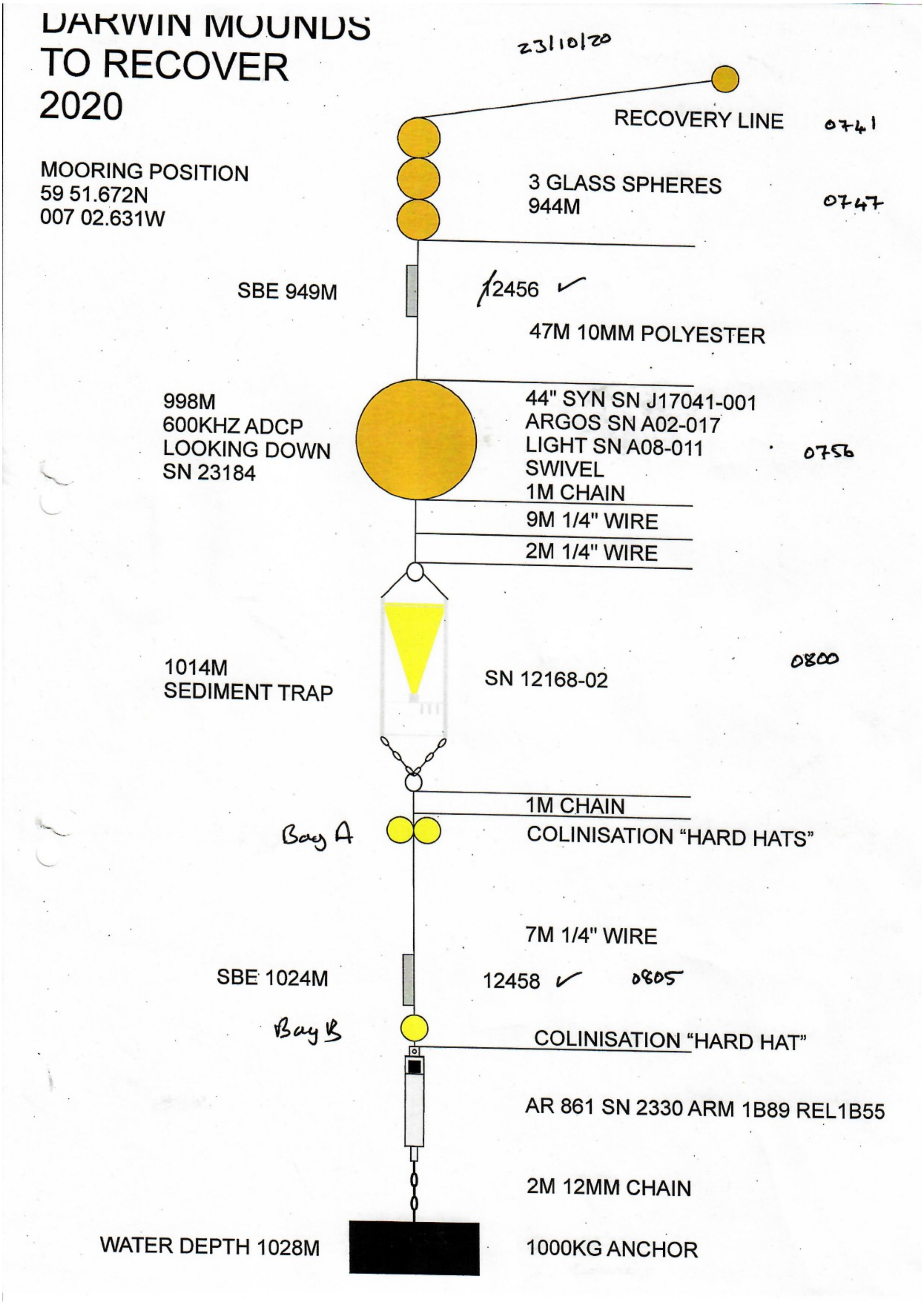

IB 5
TO RECOVER
2020
PICKING UP MOORING FROM BOTTOM
RECOVERY LINE
2GLASS SPHERES 30M
1235
SBE 33M
11333
44M 3/16" WIRE
300KHZ ADCP UP SN 20959
300KHZ ADCP DOWN SN 13872
44" SYN SN J14226-002 INV 260009272
IRIDIUM SN B11-046 ID 300234060475990
LIGHT SN B11-029
5M CHAIN SWIVEL
1229
SBE 89M
14356
1227
197M 3/16" WIRE
SBE 184M
8082
1224
4 GLASS SPHERES 282M
1220
SBE 329M
9376
1219
199M 3/16" WIRE
SBE 480M
8443
1210
4 GLASS SPHERES 486M
NORTEK 486M
JOIN 11063
388M 3/16" WIRE
SBE 685M
11339
tangled in wire
cut wire
11:52
SBE 874M
14367
11:43
NORTEK 880M
JOIN 8365
11:36
tangled
6 GLASS SPHERES SWIVEL 881M
11:36
11:42
AR 861 SN 1753 ARM 1A08 REL 1A55
AR 861 SN 1272 ARM 08CD REL 0855
10M ½"CHAIN
WATER DEPTH 900M
1300KG ANCHOR
OSNAP


IB 4
TO RECOVER
2020
RECOVERY LINE
2GLASS SPHERES 45M
SBE 47M
9373
44M 3/16" WIRE
300KHZ ADCP UP SN 20962
300KHZ ADCP DOWN SN 20958
44" SYN SN J15280-001 INV 260005502
IRIDIUM SN B11-050 ID 30023406057200
LIGHT SN B11-030
5M CHAIN SWIVEL
SBE103M
14366
197M 3/16" WIRE
SBE 199M
11332
8 GLASS SPHERES 296M
SBE 348M
9371
SBE 498M
11326
587M 3/16" WIRE
SBE 698M
8077
4 GLASS SPHERES 893M
SBE 901M
8079
SBE 1199M
1131
594M 3/16" WIRE
4 GLASS SPHERES 1492M
NORTEK 1496M
JOIN 8120
SBE 1502M
8078
395M 1/4" WIRE
4 GLASS SPHERES 1893M
SBE 1902M
9374
395M 1/4" WIRE
4 GLASS SPHERES 2293M
NORTEK 2297M
JOIN 11051
SBE 2302M
11323
495M 1/4" WIRE
2 GLASS SPHERES 2794M
SBE 2796M
13142
103M 1/4" WIRE
SBE 2802M
11328
6 GLASS SPHERES SWIVEL 2901M
AR 861 SN 1756 ARM 1A0B REL 1A55
AR 861 SN 1764 ARM 1A13 REL 1A55
10M ½"CHAIN
WATER DEPTH 2919M
1900KG ANCHOR
OSNAP
tangled
tangled
15:15

IB 3 TO RECOVER 2020



"You never know whats below the surface." KB


DARWIN MOUNDS
TO RECOVER
2020
23/10/20
MOORING POSITION
59 51.672N
007 02.631W
RECOVERY LINE
0741
3 GLASS SPHERES
944M
0747
SBE 949M
12456
47M 10MM POLYESTER
998M
600KHZ ADCP
LOOKING DOWN
SN 23184
44" SYN SN J17041-001
ARGOS SN A02-017
LIGHT SN A08-011
SWIVEL
1M CHAIN
0756
9M 1/4" WIRE
2M 1/4" WIRE
1014M
SEDIMENT TRAP
SN 12168-02
0800
1M CHAIN
Bay A
COLINISATION "HARD HATS"
7M 1/4" WIRE
SBE 1024M
12458
0805
Bay B
COLINISATION "HARD HAT"
AR 861 SN 2330 ARM 1B89 REL1B55
2M 12MM CHAIN
WATER DEPTH 1028M
1000KG ANCHOR

42 Appendix O: Meta Data from Recovered Moorings

Cruise DY120

Mooring recovery metadata log

Mooring: EB1

Date: 12/10/20

Trilaterated latitude: 57.0997 N

Trilaterated longitude: 9.5632 W

Corrected depth: 1801 m

Acoustic release S/N:

ARM code:

DIAG code:

RELEASE code:

Arrival on site time (UTC): 10:23

Ship location relative to mooring (distance + direction): 600m, ship SE from mooring

	Time (UTC)	Latitude	Longitude	Uncorrected depth (m)	Corrected depth (m)
Anchor release	10:25	57.0954N	9.5575 W	1806.3	1800.3
Surface (acoustic tracking)	10:27	---	---	---	---
Surface (spotted)	10:28	---	---	---	---
Start recovery	10:57	57,0981°N	9,5653° W	1813.1	1807.1
End recovery	12:33	57,1181°N	9.5994°W	1838.5	1832.5

Recovery comments:

Tracking up

10:26:30	1733	1722
27:00	1684	1674
27:30	1633	1622
28:00	1581	

Cruise DY120

Mooring recovery metadata log

Mooring: WB2 Recovery

Date: 14.10.20

	1	2
Acoustic release S/N:	2310	2311
ARM code:	1B82	1B83
DIAG code:	~~23~~49	49
RELEASE code:	~~2355~~ 1B55	1B55

Trilaterated latitude: 57°.28.16'N

Trilaterated longitude: 12°18.81'W

Corrected depth: .... m

Arrival on site time (UTC): 11:21

Ship location relative to mooring (distance + direction): 078° 57° 28.17'N 012° 19.27'W

	Time (UTC)	Latitude	Longitude	Uncorrected depth (m)	Corrected depth (m)
Anchor release	10:54	57 28.18296N	12 19.36356W	1805.5m	
Surface (acoustic tracking)	11:04	---	---	---	---
Surface (spotted)	11:14	---	---	---	---
Start recovery	11:37				
End recovery	12:34				

Recovery comments:

1858m range 1054, deployed ok x2
1834m on its way up 1055
1797m ok 1056
1686m 10:57
1586m 10:58

ETA surface 11:05

Discov moving 0.5kts to site 11:21

11:34: grapeled by the 2 glass spheres at 1764 m depth
11:41 grapeled the bottom 5 spheres + attached to capstan

Cruise DY120

Mooring recovery metadata log

Mooring: WB1

Date: 14/10/20

~~Trilaterated~~ latitude: 57.28.30

~~Trilaterated~~ longitude: 12 42.99

Corrected depth: .... m

Acoustic release S/N: 2326|1761

ARM code: 1B85 | 1A10

DIAG code: ....

RELEASE code: ....

Arrival on site time (UTC): 07:01

Ship location relative to mooring (distance + direction): ....

	Time (UTC)	Latitude	Longitude	Uncorrected depth (m)	Corrected depth (m)
Anchor release	0701	57 ~~[illegible]~~ 28.31	-12 42.99E		
Surface (acoustic tracking)		---	---	---	---
Surface (spotted)	0704	---	---	---	---
Start recovery	0755	57 28.45	-12 42.28		
End recovery	0929	57 28.27	-12 39.87 E	1652	

Recovery comments:

1st range	1749 m
07:02	1749m
07:03	1703m
07:04	1640m
07:04	1628m
07:06:52	1371m
07:07:22	1323m

Cruise DY120

Mooring recovery metadata log

Mooring: IB5

Date: 16/10/20

Trilaterated latitude: 57.801° N

Trilaterated longitude: 19.1709 W

Corrected depth: 954 m

Acoustic release S/N: 1753/1272

ARM code:

DIAG code:

RELEASE code:

Arrival on site time (UTC): 10:36

Ship location relative to mooring (distance + direction): 0.5 nm, ship west of mooring

	Time (UTC)	Latitude	Longitude	Uncorrected depth (m)	Corrected depth (m)
Anchor release	10:39	57°48.08' N	19°10.79' ~~E~~ W	2205.3	2199.3
Surface (acoustic tracking)		---	---	---	---
Surface (spotted)	10:39	---	---	---	---
Start recovery	11:36	57° ~~48~~ 47.68' N	19° 10.61' W	949.6 ~~920.3~~	946.6 ~~917.3~~
End recovery	12:35	57°47.14 N	19°09.05' W	920.3	917.3

Recovery comments:

10:37:42 ok
38:28 ok

Cruise DY120

Mooring recovery metadata log

Mooring: 1B4

Date: 17/10/20

Trilaterated latitude: 57 59.39N

Trilaterated longitude: 21 08.77 W

Corrected depth: 2920 m

Acoustic release S/N: 1756 | 1764

ARM code: 1A0B | 1A13

DIAG code:

RELEASE code: 1A55 | 1A55

Arrival on site time (UTC): 1157

Ship location relative to mooring (distance + direction): SW ~ 0.7nm

	Time (UTC)	Latitude	Longitude	Uncorrected depth (m)	Corrected depth (m)
Anchor release	12:03	57 59.17 N	21 9.115W		
Surface (acoustic tracking)	12:03	---	---	---	---
Surface (spotted)	12:04	---	---	---	---
Start recovery	13:15			2923m	
End recovery	15:15	57 56.98	21.12.39		

Recovery comments:

1203 → 2924 m
120310 → 2914 m
12:04:30 2876m
12:09:58 2815m

Grappled at 13:10

Mooring: IB3
Date: 19/10/2020

Trilaterated latitude: 57° 59.41'N
Trilaterated longitude: 24° 21.20'W
Corrected depth: 2854 m

Acoustic release S/N: 2000 / 1754
ARM code: ØB17 / 1AØ9
DIAG code:
RELEASE code: ØB55 / 1A55

Arrival on site time (UTC): early AM
Ship location relative to mooring (distance + direction): 0.4nm to the SSW

	Time (UTC)	Latitude	Longitude	Uncorrected depth (m)	Corrected depth (m)
Anchor release	14:10:25				
Surface (acoustic tracking)	X	---	---	---	---
Surface (spotted)	14:14	---	---	---	---
Start recovery	~~1715~~ 1448				
End recovery	1715				

Recovery comments:
Noisy ranges – drop keel down for release. 1400
Grapple went through the top microcat – but all ok.

Mooring: DMLTM

Date: 23/10/20

Trilateratеd latitude: 59° 51.67' N

Trilaterated longitude: 07° 02.63' W

Corrected depth: 1021 u/c m

Acoustic release S/N: 2330

ARM code: 1889

DIAG code:

RELEASE code: 1855

Arrival on site time (UTC): 2200 22/10

Ship location relative to mooring (distance + direction): 400m to the north

	Time (UTC)	Latitude	Longitude	Uncorrected depth (m)	Corrected depth (m)
Anchor release	0706	59° 51.99' N	7° 2.59' W		
Surface (acoustic tracking)		---	---	---	---
Surface (spotted)	0719	---	---	---	---
Start recovery	0741				
End recovery	0805				

Recovery comments:

Release OK @ 0706 : No ranges after release.

43 Appendix P: Set-Up Capture Files for Deployed Instruments

43.1 SBE37

```
S>OutputExecutedTag=n
S>Outputformat=3
S>DS
SBE37SM-RS232 v4.1 SERIAL NO. 11322 12 Oct 2020 13:18:26
vMain = 13.55, vLith = 2.92
samplenumber = 804, free = 558436
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 = 3157.9
S>Datetime=10122020131828
S>SAMPLENUMBER=0
this command will modify memory pointers
repeat the command to confirm
SAMPLENUMBER=0
S>OUTPUTSAL=N
S>BAUDRATE=38400
repeat the command at 38400 baud to confirm
S>BAUDRATE=38400
baud rate change is confirmed
S>OUTPUTSV=N
S>SYNCMODE=N
S>TXREALTIME=N
S>SAMPLEINTERVAL=1800
S>STARTDATETIME=10122020150000
<start dateTime = 12 Oct 2020 15:00:00/>
S>STARTLATER
<!--start logging at = 12 Oct 2020 15:00:00, sample interval = 1800 seconds-->
S>DS
SBE37SM-RS232 v4.1 SERIAL NO. 11322 12 Oct 2020 13:19:36
vMain = 13.54, vLith = 2.92
samplenumber = 0, free = 559240
not logging, waiting to start at 12 Oct 2020 15:00:00
sample interval = 1800 seconds
data format = converted engineering alternate
transmit real-time = no
sync mode = no
pump installed = yes, minimum conductivity frequency = 3157.9
S>
```

43.2 SBE37-ODO

```
S>OutputExecutedTag=n
S>OutputFormat=1
S>OutputTemp=1
S>OutputCond=1
S>OutputPress=1
```

```
S>OutputOx=1
S>OutputSal=1
S>AdaptivePumpControl=y
S>OxNTau=7
S>OxTau20=5.5
S>DateTime10122020150000
<dateTime = 12 Oct 2020 13:30:57/>
S>ds
SBE37SMP-ODO-RS232 v6.1.2 SERIAL NO. 21319 12 Oct 2020 13:31:17
vMain = 13.32, vLith = 2.99
samplenumber = 560, free = 398897
not logging, stop command
sample interval = 15 seconds
data format = converted engineering
output temperature, Celsius
output conductivity, S/m
output pressure, Decibar
output oxygen, ml/L
output salinity, PSU
transmit real time data = no
sync mode = no
minimum conductivity frequency = 3121.4
adaptive pump control enabled
nTau = 7.0
S>SampleInterval=4500
S>TxRealTime=n
S>SampleNumber=0
memory pointers will be modified
repeat command to confirm:
SampleNumber=0
S>StartDateTime=10122020150000
<start dateTime = 12 Oct 2020 15:00:00/>
S>StartLater
<!--start logging at = 12 Oct 2020 15:00:00, sample interval = 4500 seconds-->
S>ds
SBE37SMP-ODO-RS232 v6.1.2 SERIAL NO. 21319 12 Oct 2020 13:32:50
vMain = 13.31, vLith = 2.99
samplenumber = 0, free = 399457
not logging, start at 12 Oct 2020 15:00:00
sample interval = 4500 seconds
data format = converted engineering
output temperature, Celsius
output conductivity, S/m
output pressure, Decibar
output oxygen, ml/L
output salinity, PSU
transmit real time data = no
sync mode = no
minimum conductivity frequency = 3121.4
adaptive pump control enabled
nTau = 7.0
```

S>

43.3 DeepSeapHOx

```
SBE37-ODO setup
<Executed/>
DateTime=10122020134100
<Executed/>
ds
SBE37SMP-ODO-RS232 v6.1.2 SERIAL NO. 21318 12 Oct 2020 13:41:05
vMain = 13.38, vLith = 2.95
samplenumber = 563, free = 398894
not logging, stop command
sample interval = 15 seconds
data format = converted engineering
output temperature, Celsius
output conductivity, S/m
output pressure, Decibar
output oxygen, ml/L
output salinity, PSU
transmit real time data = no
sync mode = no
minimum conductivity frequency = 3150.8
adaptive pump control disabled, pump on time 1.0 * 7.0 = 7.0 sec
<Executed/>
SampleInterval=3600
<Executed/>
SampleNumber=0
memory pointers will be modified
repeat command to confirm:
SampleNumber=0
<Executed/>
Baudrate=9600
repeat command at 9600 baud to confirm
Baudrate=9600
baud rate change is confirmed
<Executed/>
OutputFormat=2
<Executed/>
OutputTemp=Y
<Executed/>
SetTempUnits=0
<Executed/>
OutputSal=Y
<Executed/>
OutputOx=Y
<Executed/>
SetOxUnits=1
<Executed/>
OutputPress=1
<Executed/>
OutputPress=Y
```

```
<Executed/>
SetPressUnits=0
<Executed/>
AdaptivepumpControl=N
<Executed/>
OxNTau=7
<Executed/>
OutputExecutedTag=N
S>OxTau20=5.5
S>ds
SBE37SMP-ODO-RS232 v6.1.2 SERIAL NO. 21318 12 Oct 2020 13:46:29
vMain = 13.29, vLith = 2.96
samplenumber = 0, free = 399457
not logging, stop command
sample interval = 3600 seconds
data format = XML
output temperature, Celsius
output conductivity, S/m
output pressure, Decibar
output oxygen, mg/L
output salinity, PSU
transmit real time data = no
sync mode = no
minimum conductivity frequency = 3150.8
adaptive pump control disabled, pump on time 7.0 * 5.5 = 38.5 sec
S>
```

43.4 SeaFET V1 setup

SeaFET Summary Report

Serial Number: 117 Firmware Rev: 3.8.0

Operator: SA01ED

Comment: EB1 deployment 2020

Ancillary	Value
Total Disk Space (byte)	3954802688
Free Disk Space (byte)	3928358912
Main Voltage (V)	13.021
Main Battery Voltage (V)	12.8
Isolated Battery Voltage (V)	6.4
Clock Time	2020/10/12.15:03:05
Supports External Pump	true
Supports Integrated CTD	true

Setting	Value
Serial Baud Rate	57600
Operation Mode	Periodic
Transmitted Frame Format	FULL_ASCII
Logging Frame Format	FULL_ASCII
Periodic Interval	1 hr
Periodic Offset (s)	0
Samples in Average	30
Frames in Burst	1
Sampling Window Enabled	false
Sampling Window Start	2017-05-08
Sampling Window End	2019-05-04
Data Log File Type	By File Size
Data Log File Max Size (KB)	1024
Message Logging Level	INFO
Message Log File Max Size (KB)	1024
Transmit Diagnostic Messages	false
External Pump Enabled	false
External Pump Pumping Time (s)	5
External Pump Flushing Time (s)	5
SBE37-SMP-ODO CTD Enabled	false
SBE37-SMP-ODO Power CTD	true
SBE37-SMP-ODO Output CTD Frames	false
SBE37-SMP-ODO Sampling Timeout (s)	120
ISFET Sample Delay (s)	0
On-Board Salinity (PSU)	35.0
Internal Reference Coefficients (V,V/K)	0.0,-0.0015
External Reference Coefficients (V,V/K)	-1.416523,-9.9E-4
Thermistor Coefficients	340.982,-9.10257E-5, -95.08807,0.9653703

43.5 SeaFET V2 + SBE37-ODO setup

Deep SeapHox2 DeploymentReport

SeaFET 0000004

Operator: SA01ED

Comment:

EB1 2020 deployment

Battery Endurance Inputs

Deployment Sample/Polling Interval: 3600 seconds

Minimum Deployment Temperature: 9.0 Celsius

Battery Capacity = 761270.4 Joules

Battery Endurance is: 5543 days

Ancillary	Value
Recorded Events	0
Stored Samples	0
Free Samples	883011
Power Supply Voltage	12.4
Main Battery Voltage	12.7
Clock Battery Voltage	3.0
Isolated Circuit Voltage	6.4
Clock Time	12 Oct 2020 15:02:17 +0000

Setting	Value
Baud Rate	57600
CTD Power	false
Temperature Units	Celsius
Pressure Units	Decibar
Conductivity Units	S/m
Oxygen Units	ml/L
Transmit Data Realtime	false
Sample Interval (seconds)	3600
Logging Start DateTime	12 Oct 2020 18:00:00 UTC
Pump Time (s)	65

2020/10/12 15:03:09 UTC

Page 1 of 4

Calibration Coefficients

SEA·BIRD SCIENTIFIC

Sensor	Coefficient	Value
pH	F1	-2.162588E-5
pH	F2	1.860449E-8
pH	F3	-8.068283E-12
pH	F4	1.451763E-15
pH	F5	0.0
pH	F6	0.0
pH	K0	-1.372666
pH	K2	-0.001184874
temperature	A0	-1.452622E-4
temperature	A1	3.104889E-4
temperature	A2	-4.487962E-6
temperature	A3	2.011688E-7
conductivity	G	-0.9966855
conductivity	H	0.1337355
conductivity	I	-5.943832E-5
conductivity	J	2.226542E-5
conductivity	PCOR	-9.57E-8
conductivity	TCOR	3.25E-6
conductivity	WBOTC	0.0
conductivity	Z	0.0
pressure	PA0	0.4354999
pressure	PA1	0.008933609
pressure	PA2	-1.581226E-10
pressure	PTCA0	524306.3
pressure	PTCA1	2.063463
pressure	PTCA2	0.001767006
pressure	PTCB0	25.1725
pressure	PTCB1	-5.0E-4

Sensor	Coefficient	Value
pressure	PTCB2	0.0
pressure	PTEMPA0	-64.41306
pressure	PTEMPA1	0.05304942
pressure	PTEMPA2	-5.741488E-7
pressure	POFFSET	0.0
pressure	PRANGE	2900.0
oxygen	TAU20	7.0
oxygen	OXA0	1.0513
oxygen	OXA1	-0.0015
oxygen	OXA2	0.372768
oxygen	OXB0	-0.249691
oxygen	OXB1	1.60682
oxygen	OXC0	0.108314
oxygen	OXC1	0.00461984
oxygen	OXC2	6.445631E-5
oxygen	OXTA0	7.13868E-4
oxygen	OXTA1	2.48279E-4
oxygen	OXTA2	9.452271E-7
oxygen	OXTA3	9.361059E-8
oxygen	OXE	0.011

CTD Settings Report

Setting	Value
Device Type	SBE37SMP-ODO-RS232
Serial Number	03714987
Pressure Installed	true
Output Format	raw decimal
Sample Interval (seconds)	120
Transmit Data Realtime	false
Min Conductivity Frequency (Hz)	3230.1
Adaptive Pump Control	false
Pump Time Multiplier (OxNTau)	5.5
Pump On Time (seconds)	38.5

10/12/20 3:03 PM Page 4 of 4

43.6 Nortek Aquadopp

==

Deployment : 11023

Current time : 11/10/2020 13:34:37

Start at : 12/10/2020 12:00:00

Comment:

EB1 DY120 2020

Measurement interval (s) : 3600
Average interval (s) : 60
Blanking distance (m) : 0.50
Measurement load (%) : 4
Power level : HIGH
Diagnostics interval(min) : 720:00
Diagnostics samples : 20
Compass upd. rate (s) : 1
Coordinate System : ENU
Speed of sound (m/s) : 1500
Salinity (ppt) : N/A
Analog input 1 : NONE
Analog input 2 : NONE
Analog input power out : DISABLED
Raw magnetometer out : OFF
File wrapping : OFF
TellTale : OFF
AcousticModem : OFF
Serial output : OFF
Baud rate : 9600

Assumed duration (days) : 730.0
Battery utilization (%) : 79.0
Battery level (V) : 13.7
Recorder size (MB) : 9
Recorder free space (MB) : 8.973
Memory required (MB) : 1.9
Vertical vel. prec (cm/s) : 1.4
Horizon. vel. prec (cm/s) : 0.9

Instrument ID : AQD11023
Head ID : A6L 6003
Firmware version : 3.37

Aquadopp Deep Water Version 1.40.16
Copyright (C) Nortek AS

43.7 Nortek S55

Deployment file AD2CP_55kHz_900001_RH_ADCP
#$DeployFileVersion,4,aea1ee3a432580b336ab6acf1e946c99
#$SWSource,"Deployment-v3.4.18.1"
#$InstrumentId,{"InstrumentType":"Signature55","HeadFrequency":55,"IsDeepWater":false,"FWVersion":"2211.4"}
#$DeploymentName,"RH_ADCP"
#$Comment,null
#$ApplicationConfig,[{"Enabled":true,"Application":"AvgCoarse","Mounting":"SubsurfaceBuoy","Orientation":"UpLooking","Geography$C
#$":"OpenOcean","SoundVelocity":"Fixed","SoundVelocityValue":1500.0,"Salinity":35.0,"StrongWaves":false,"InstrumentDepth":1000.$C

#$0,"TidalRange":1.0},{"Enabled":false,"Application":"None","Mounting":"SubsurfaceBuoy","Orientation":"UpLooking","Geography":"$C
#$OpenOcean","SoundVelocity":"Fixed","SoundVelocityValue":1500.0,"Salinity":35.0,"StrongWaves":false,"InstrumentDepth":1000.0,"$C
#$TidalRange":1.0}]
#$AlternatingRatio,[3,1]
#$DeploymentConfigExtensions,[{"AvgDesiredRange":1022.0,"BurstDesiredRange":1000.0,"BurstHrDesiredRange":1000.0,"EchoSounderDes$C
#$iredRange":1000.0,"AvgEndProfile":1124.2,"BurstEndProfile":1100.0,"BurstHrEndProfile":1100.0,"EchoSounderEndProfile":1100.0,"$C
#$AIStep":6,"RangeStep":1.0,"BurstMeasurementContinuous":false,"AvgMeasurementLoad":100.0,"MinAvgMeasurementLoad":10.0,"MaxAvgM$C
#$easurementLoad":100.0,"AvgAutoMeasurementLoad":true,"AvgMeasurementLoadTick":10.0,"BurstMeasurementLoad":100.0,"BurstAutoMeas$C
#$urementLoad":true,"BurstMeasurementLoadTick":1.0,"PulseDistanceAutoOption":3,"PulseDistance":3,"DistanceToBottom":2.0,"Distan$C
#$ceToSurface":2.0,"DesiredVelocityRange":0.25,"ValidBurstIntervals":[]},{"AvgDesiredRange":1000.0,"BurstDesiredRange":1000.0,"$C
#$BurstHrDesiredRange":1000.0,"EchoSounderDesiredRange":1000.0,"AvgEndProfile":1100.0,"BurstEndProfile":1100.0,"BurstHrEndProfi$C
#$le":1100.0,"EchoSounderEndProfile":1100.0,"AIStep":1,"RangeStep":0.1,"BurstMeasurementContinuous":false,"AvgMeasurementLoad":$C
#$100.0,"MinAvgMeasurementLoad":0.0,"MaxAvgMeasurementLoad":100.0,"AvgAutoMeasurementLoad":true,"AvgMeasurementLoadTick":1.0,"B$C
#$urstMeasurementLoad":100.0,"BurstAutoMeasurementLoad":true,"BurstMeasurementLoadTick":1.0,"PulseDistanceAutoOption":3,"PulseD$C
#$istance":3,"DistanceToBottom":2.0,"DistanceToSurface":2.0,"DesiredVelocityRange":0.25,"ValidBurstIntervals":[]}]
#$BatteryItem,null
#$BatteryCombo,{"InternalBattery":{"Name":"Lithium 3600 Wh","Volume":3600.0,"Voltage":18.0},"ExternalBattery":{"Name":"None 0 W$C
#$h","Volume":0.0,"Voltage":0.0},"Volume":3600.0,"Voltage":18.0}
#$RecorderItem,{"Name":"16 GB","Capacity":16000000000}
#$AhrsInstalled,false
#$DeploymentDays,730
SETDEFAULT,ALL
SETPLAN,MIAVG=1800,AVG=1,DIAVG=0,VD=0,MV=10,SA=35,BURST=0,MIBURST=120,DIBURST=0,SV=1500,FN="RH_ADCP.ad2cp",SO=0,FREQ=55,NSTT=0
SETAVG,NC=56,CS=20,BD=2,CY="ENU",PL=-2,AI=60,VR=1,DF=3,NPING=10,NB=3,CH=0,MUX=1,BW="NARROW",ALTI=0,BT=0,ICE=0,ALTISTART=0.5,ALTIEND=150,RAWALTI=10
SETTMAVG,EN=1,CD=1,PD=1,AVG=60,TV=1,TA=1,TC=1,CY="ENU",FO=0,SO=1,DF=100
SAVE,ALL

43.8 RDI WH ADCP 300KHz

ts 20/10/18, 09:44:30
>ts?
TS = 20/10/18,09:44:39 --- Time Set (yr/mon/day,hour:min:sec)
>ps0
Instrument S/N: 13872
Frequency: 307200 HZ

Configuration: 4 BEAM, JANUS
Match Layer: 10
Beam Angle: 20 DEGREES
Beam Pattern: CONVEX
Orientation: UP
Sensor(s): HEADING TILT 1 TILT 2 TEMPERATURE
Temp Sens Offset: -0.11 degrees C

CPU Firmware: 50.36 [0]
Boot Code Ver: Required: 1.13 Actual: 1.13
DEMOD #1 Ver: ad48, Type: 1f
DEMOD #2 Ver: ad48, Type: 1f
PWRTIMG Ver: 85d3, Type: 4

Board Serial Number Data:
4C 00 00 06 07 E3 C4 09 DSP727-2001-04H
88 00 00 06 07 BA 5A 09 PIO727-3000-00G
E9 00 00 05 88 EF 7B 09 CPU727-2000-00M
95 00 00 05 89 39 4F 09 REC727-1000-04E
>pa

PRE-DEPLOYMENT TESTS

CPU TESTS:
RTC......................................PASS
RAM......................................PASS
ROM......................................PASS
RECORDER TESTS:
PC Card #0...............................DETECTED
Card Detect............................PASS
Communication..........................PASS
DOS Structure..........................PASS
Sector Test (short)....................PASS
PC Card #1...............................DETECTED
Card Detect............................PASS
Communication..........................PASS
DOS Structure..........................PASS
Sector Test (short)....................PASS
DSP TESTS:
Timing RAM...............................PASS
Demod RAM...............................PASS
Demod REG...............................PASS
FIFOs....................................PASS
SYSTEM TESTS:
XILINX Interrupts... IRQ3 IRQ3 IRQ3 ...PASS
Wide Bandwidth...........................PASS
Narrow Bandwidth.........................PASS
RSSI Filter..............................PASS
Transmit.................................PASS
SENSOR TESTS:
H/W Operation............................PASS

```
>pc2

Press any key to quit sensor display ...

All Sensors are Internal Only.
Heading Pitch Roll Up/Down Attitude Temp Ambient Temp PRESSURE
204.92ø -1.98ø -0.15ø Up 24.71øC 19.78øC 0.0 kPa
204.57ø -2.11ø -0.21ø Up 24.71øC 19.81øC 0.0 kPa
203.99ø -2.74ø 0.03ø Up 24.73øC 19.81øC 0.0 kPa
203.64ø -3.62ø 0.48ø Up 24.71øC 19.78øC 0.0 kPa
203.19ø -4.46ø 1.18ø Up 24.69øC 19.80øC 0.0 kPa

>pc1

BEAM CONTINUITY TEST

When prompted to do so, vigorously rub the selected
beam's face.

If a beam does not PASS the test, send any character to
the ADCP to automatically select the next beam.

Collecting Statistical Data...
 45 45 46 48
45 45 46 48
[...]
 44 44 47 48
44 44 47 48

Rub Beam 1 = PASS
Rub Beam 2 = PASS
Rub Beam 3 = PASS
Rub Beam 4 = PASS

>RE ErAsE erasing...
Recorder erased.

>CR1
[Parameters set to FACTORY defaults]
>CF11111
>EA0
>EB0
>ED19700
>ES35
>EX11111
>EZ1111101
>WA50
>WB0
>WD111100000
>WF176
>WN28
```

>WP42
>WS400
>WV175
>TE01:00:00.00
>TP01:25.71
>TF20/10/18 10:00:00
>CK
[Parameters saved as USER defaults]
>CS

44 REFERENCES

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