



OSNAP GDWBC Cruise Report

R/V Neil Armstrong, AR30-03

05 June – 24 June 2018

Reykjavik to Reykjavik

Authors: Heather Furey, Amy Bower, and Andy Davies
Woods Hole Oceanographic Institution
Woods Hole, MA 02536 USA

Abstract

This cruise report documents the fourth deployment of the Deep Western Boundary Current array off the east coast of Greenland as part of the Overturning in the Subpolar North Atlantic Program (OSNAP). This marks the first time this array has been overseen by A. Bower at the Woods Hole Oceanographic Institution. In previous years (2014, 2015, 2016), the array has been deployed by P. Holliday at the National Oceanography Center in Southampton, UK.

In addition to the four 'GDWBC' mooring deployments, we completed a section of CTD casts both to calibrate the mooring instruments and to measure water properties during the deployment time period. We also recovered two of the thirteen moored sound sources, marking the end of the RAFOS program. This report will also include a summary of sound source recoveries completed by the R/V MSMerian during the same time period.

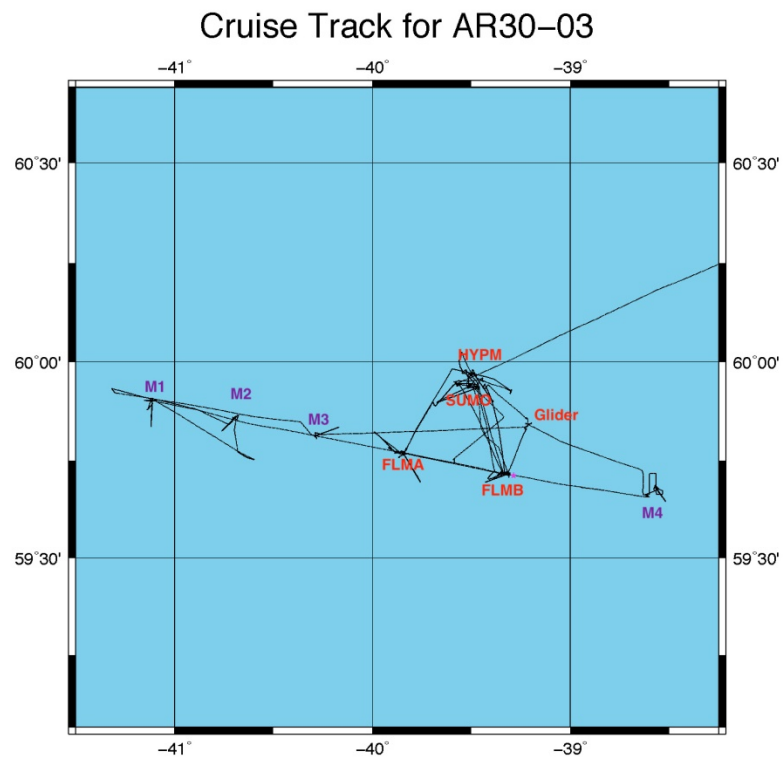


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1 Science Personnel

Alison MacDonald, WHOI, Chief Scientist
Amy S. Bower, WHOI, Lead OSNAP Scientist
John Kemp, WHOI, Lead mooring technician
Meaghan Donohue, WHOI, Mooring technician
Jim Dunn, WHOI, Mooring technician
Sheri White, WHOI, Lead OOI Scientist
David Wellwood, WHOI, Water sampling and CTD
Stephanie Petillo, WHOI, OOI technician
Andrew Davies, WHOI, OSNAP instrumentation and mooring operations
Daniel Bogorff, WHOI, OOI technician
James Kuo, WHOI, OOI technician
Collin Dobson, WHOI, OOI technician
Heather Furey, WHOI, OSNAP technician
Hilary Pavlesky, WHOI, Water sampling
Lucy Wanzer, Wellesley College, Student, Water sampling
Emma Jackman, Wellesley College, Student, Water sampling
Glen (Allen) Smith, WHOI, OOI technician
Henry Holm, WHOI, Water sampling
Julian Race, WHOI, SSSG
Chris Seaton, WHOI, SSSG

2. Overview of OOI and OSNAP work

The ship left Reykjavik, Iceland on 05 June, 2018, and steamed to the OOI Irminger Sea area, where we worked on OSNAP instrument preparation, including microcat calibration dips and acoustic release tests while the OOI mooring work was being done. We deployed M4, at the eastern end of the work study area and then proceeded westerly towards Greenland. We had to coordinate the GDWBC mooring deployments with the GDWBC mooring recoveries being completed by Johannes Karstensen and Penny

Holiday on the R/V MSMerian during a short window from 13-19 June. For this reason, we deployed M4 2 nm to the north of the existing 2016-2018 M4, which was still in the water at the time of the 2018-2020 M4 deployment. We performed a multibeam survey of the area to make sure the bathymetric conditions were favorable. The R/V MSMerian were able to recover M1-M3 on June 16th, and we proceeded to deploy M1 on June 17th, M2 on June 18th, and M3 on June 19th. The calibration CTDs near each mooring site were performed within a couple hours of the anchor drop. The CTDs were not performed sequentially across the OSNAP line. We performed CTDs at different locations hopscotching around the line during and after OOI operations. Figure 1 shows the overall station locations and cruise track.

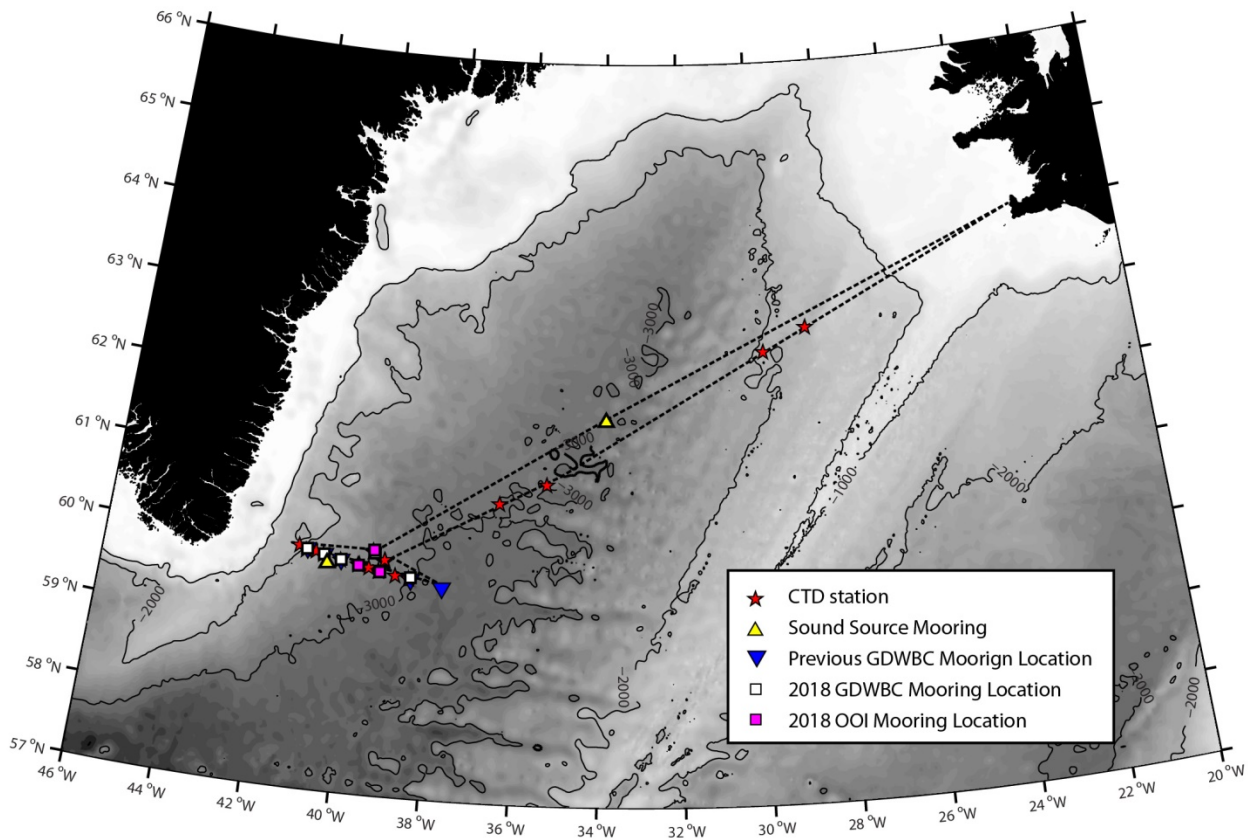
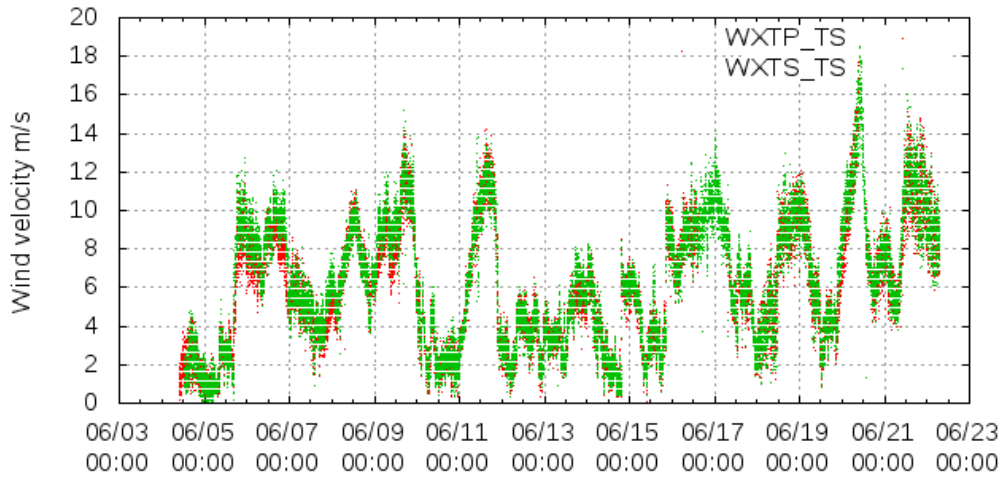


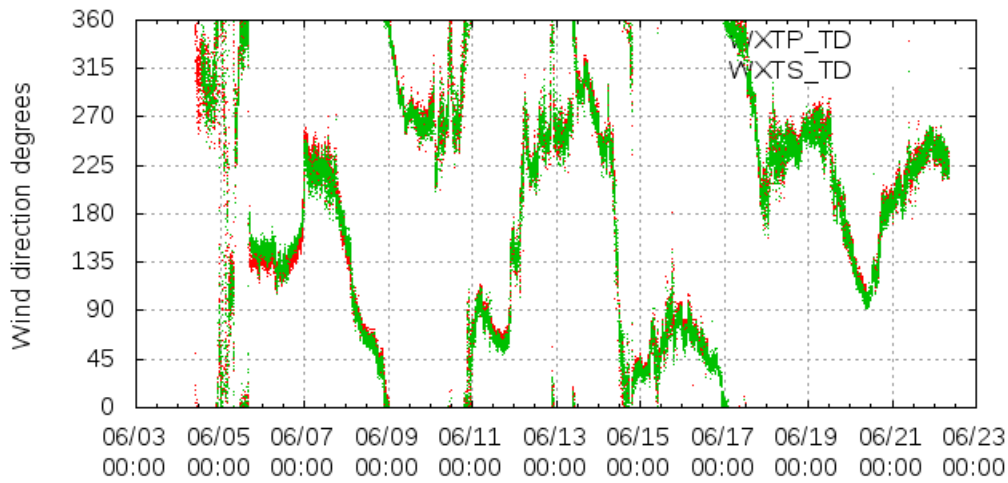
Figure 1. Cruise track with station locations coded by activity.

The weather during this cruise was favorable to mooring deployments, with generally low winds (less than 10 knots), and low sea state. A blow on ~20 June kicked up the seas for the last sound source mooring recovery. Figure 2 shows wind speed, wind direction, and air temperature during the cruise time period. Air temperatures during mooring deployments were generally 3-5°C except when near to Iceland, where temperatures warmed to 7-9°C.

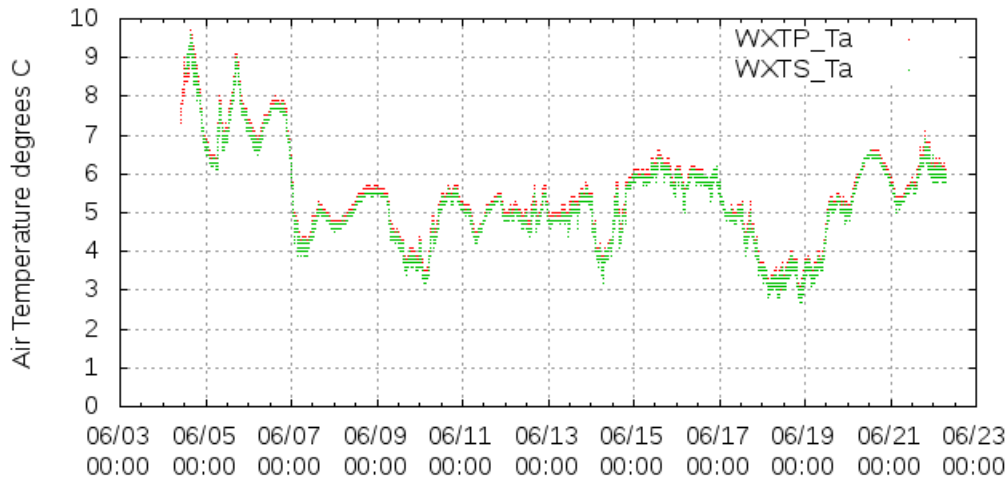
Wind speed: Friday, June 22, 2018



Wind direction: Friday, June 22, 2018



Last Air Temperature: Friday, June 22, 2018



Rain Intensity: Friday, June 22, 2018

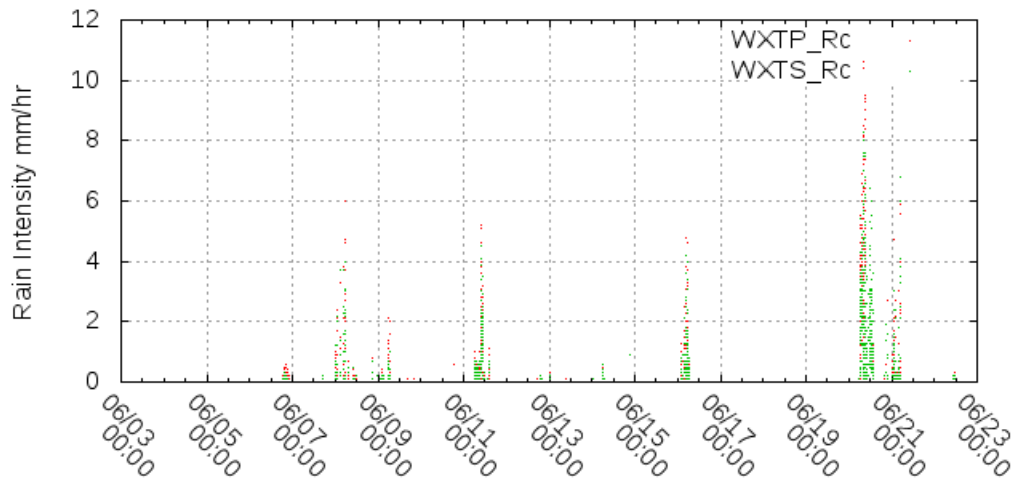


Figure 2. Weather conditions from the bow mast of the R/V *Armstrong* during AR30-03. Times are UTC.

3. Cruise Narrative relevant to OSNAP Operations

Date	Summary	Details
05 June 2018	-	Departed Reykjavik after refueling, ~1100.
06 June 2018	-	Transit to OOI work site, two CTD test casts performed, OOI release testing.
07 June 2018	CTD003 - caldip CTD004 - caldip	Ventured in to water deeper than 3000 m, two calibration dip CTD casts preformed with all OSNAP microcats, 15 instruments per cast. Microcats programmed for a 10 second rep rate during caldips and sat for five minutes at each depth. NOTE: Use CTD Temperature sensor #2, sensor #1 data has drift. CTD sensor #2 swapped to sensor #1 pot for remainder of cruise.
08 June 2018	-	OOI work, OSNAP instrument prep. {Deploy OOI SUMO5 mooring.}
09 June 2018	-	OOI work, OSNAP instrument prep. {Deploy OOI HYPM5 mooring and OOI gliders.}
10 June 2018	CTD007	OOI work, CTD 'FLMA' #007; OSNAP instrument prep. {Deploy OOI FLMA5 mooring.}
11 June 2018	CTD008 – release test - abort	OOI work, OSNAP instrument prep. {Deploy OOI FLMB5 mooring. CTD #008 midway between FLMB4 and FLMB5 with 3 OSNAP releases aborted. Ship drifted into FLMB4 watch circle, and CTD cable and rosette entangled in FLMB mooring line. Amazing, lucky, cool under pressure, graceful recovery of all instrumentation. CTD cable was cut, minor damage to rosette, all mooring recovered. Julian, Chris, and Dave made CTD functional by next day.}
12 June 2018	CTD010 – release test, multibeam	OOI work; multibeam survey for new GDWBC M4 site. Site needed to be moved because 2016-2018 M4 not yet recovered. New position 2 nm north of old position. Three acoustic releases re-tested on CTD 'Glider CTD' #010 to make sure not damaged in aborted CTD008.

	survey of M4 site	
13 June 2018	Deploy M4, CTD011, Anchor survey, CTD012	Deploy M4 as designed; CTD 'CM4' #011 at M4; survey of M4 mooring location. OSNAP CTD 'CB4' #012 mid-way between FLMB and M4.
14 June 2018	-	OOI work, OSNAP instrument prep. {Recovery of SUMO4, the surface mooring with missing top flotation. After 12 hours of very stressful recovery – high tension in lines, wuzzles, imploded flotation and instruments – the last remnant came on deck, with one bolt still dangling in place. Most likely cause of failure was improperly tightened bolts. }
15 June 2018	CTD014 – release test	OSNAP CTD 'CAB' #014 mid-way between FLMA and FLMB, 3 releases tested.
16 June 2018	CTD015 – release test	CTD #015 at FLMB center site with 3 OSNAP releases tested. R/V MSMerian in area at same time, and recovered M1, M2, M3 on this date, so we were free to redeploy the remaining moorings in the 2016 locations. Passed the R/V MSMerian, us travelling westward and they travelling eastward on OSNAP line, and waved / radioed / took photographs.
17 June 2018	Deploy M1, CTD016, Anchor survey, EK80 survey, Recover SS4, M2 multibeam survey	Deploy M1 as designed; CTD 'CM1' #016 at M1 with remainder releases; survey of M1 mooring location; EK80 survey of M1 - were able to 'see' instruments between 300 and 1750; recover SS4. NOTE: Top sphere does not contain a XEOS Iridium tracking beacon – “backordered”. Multibeam survey of M2 region to check bathymetry for gradient. After looking at transport data of previous GDWBC arrays provided by P Holliday, and survey, we decided to deploy in 2016 location. Keeping data set consistent trumped moving mooring site to possible better location. Checked multibeam against Knudsen to see if Knudsen (with local sound speed correction) would give accurate depth.
18 June 2018	Deploy M2, Anchor survey, CTD017, CTD018, CTD019	Careful check of depth at mooring location, confirmation of depth, and decided to deploy mooring as designed. Deploy M2 as designed; immediate survey of M2 mooring location; CTD 'CM2' #017. Transit to CLT 'C12' #018, halfway between M1 and M2. Transit to CTD 'C01' – to the east of M1.
19 June 2018	Deploy M3, CTD020, Anchor survey	Deploy M3 as designed; CTD 'CM3' #020; survey of M3 mooring location.
20 June 2018	-	Weather day; OOI work, specifically data download at SUMO5 and met instrument comparison during strong wind event. {R/V MSMerian reports that needs to cut CTD section short and return to port early due to equipment failure. Johns reports that he was planning to do most of the remaining CTD stations on the next OSNAP cruise.}
21 June 2018	-	Remaining OOI work; Transit towards Reykjavik, arrive at SS11 site.
22 June 2018	Recover	Recover SS11.

	SS11.	
23 June 2018	-	Transit to Reykjavik.
24 June 2018	-	Temporary dock and unload to warehouse, move to permanent dock in town.

SSSG Notes:	
-20180605 1610 UTC:	underway system was chlorine shocked on arrival for ar30-02 and on departure for ar30-03. System was turned on at 1355 and tablets were left in for approximately 2 hours, removed at 1610.
-20180605 1610 UTC:	underway system was chlorine shocked on arrival for ar30-02 and on departure for ar30-03. System was turned on at 1355 and tablets were left in for approximately 2 hours, removed at 1610.
-20180607 1900 UTC:	primary temp. sensor on CTD swapped out following cast 004 due to drifting temp at depth. New primary sensor serial # 4312
-20180611 approx 1445 UTC:	average sound speed on Knudsen for 3.5 kHz and 12 kHz changed to 1488 m/s from 1500 m/s for more accurate depth
-20180611 approx 1650 UTC:	CTD became entangled in mooring, spiking wire tension to 6105 lbs at 1518.6 m wire out. Eventually, mooring was released from bottom and CTD and mooring were recovered. CTD wire was cut near the rosette during recovery. Minor damage to CTD, included damaged lanyards.
-20180614 1400 UTC:	replaced primary pump on CTD package in response to strange behaviour in the oxygen sensor, the conductivity sensor and the temperature sensor (both primary) observed during cast 011 and 012.
-20180617 0700 UTC:	met station power cycled, power lost to port vaisala sensors around 1440 on 20180616. accumulated rain data for both port and stbd sensors was reset.

4. GDWBC Mooring Deployments

Four GDWBC moorings were deployed, one less than the NOC mooring array it was replacing. After exhaustive analysis, we determined that the instruments at NOC M5 were usually beyond the eastern boundary of the GDWBC, and better used to increase sampling in the water column in other locations. M5 did not contribute to the transport of the GDWBC and was removed from the array completely in 2018. Figure 3 shows the locations of the newly deployed as well as previous GDWBC moorings, with the OOI mooring sites, CTD locations and one of the sound source mooring locations.

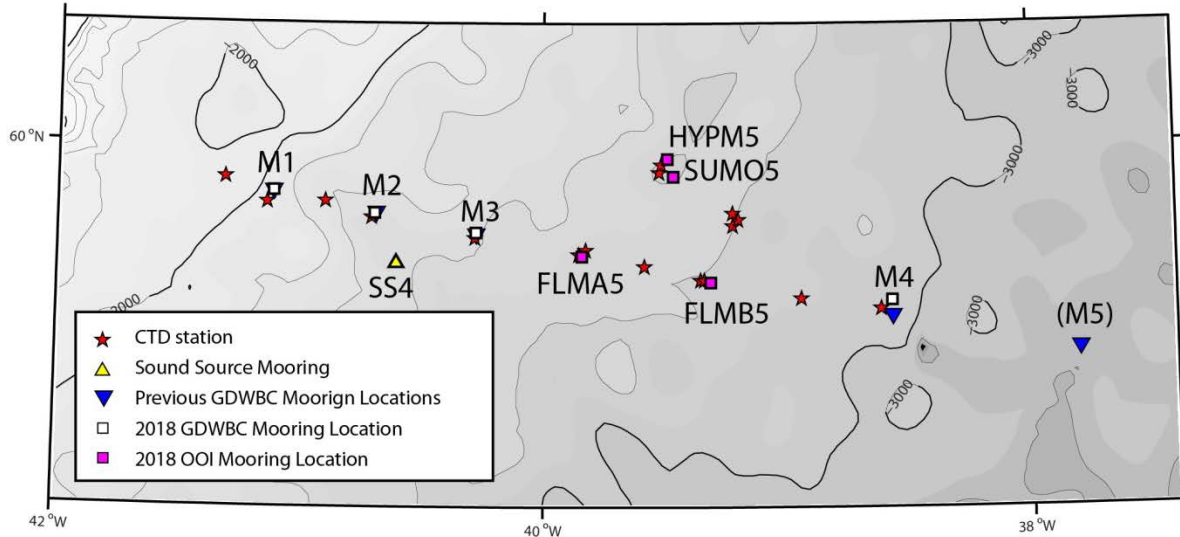


Figure 3. Enlargement of work area. Legend identifies activities. OSNAP GDWBC moorings M1-M4 were deployed on the same line as two of the OOI moorings, FLMA5 and FLMB5.

Table 1. GDWBC mooring deployment information.

Mooring	Anchor Drop		Surveyed Anchor Position			Mooring deploy duration	
	Date	Position	Corrected Depth (m)	Triangulated position	Distance from target position (m)	First flotation over side	Anchor drop
M1	17 June 2018	59° 54.268'N 41° 06.708'W	2086	59° 54.154'N 41° 06.762'W	69	0808	1125
M2	18 June 2018	59° 51.638'N 40° 41.312'W	2436	59° 51.417'N 40° 41.741'W	713	0804	1051
M3	19 June 2018	59° 48.817'N 40° 16.933'W	2557	59° 49.021'N 40° 16.710'W	289	0803	1112
M4	13 June 2018	59° 40.819'N 38° 34.080'W	2984	59° 40.637'N 38° 34.121'W	258	0811	1057

All moorings were instrumented with Aquadopp current meters, Seabird SBE37 microcats and Edgetech acoustic releases. The schematic in Figure 4 shows the general configuration of the mooring array. The total instrument count was: 8 releases, 19 aquadopp current meters, and 30 microcats. Instruments were placed at nominal depths of [50 300 500 750 1000 1250 1500 1750 2000 2250 2500 2750 3000], except near the bottom, where instruments were located 40 meters above bottom depth, and at M2, where the second instrument from bottom, was located mid-way between the bottom instrument pair and the one at 2000 m. Details on all instrumentation may be found in Appendix C.

Mooring Name	M1	M2	M3			M4	M5
2016 Surveyed Location	59.9030N 41.1118W	59.8597N 40.6905W	59.8145N 40.2772W			59.6460N 38.5665W	59.5788N 37.7995W
Bottom Depth (m)	2086	2423	2557	OOI FLMA	OOI FLMB	2985	3121
Instrument Depths (m)							
50	aquadopp/ microcat						ELIMINATED
300	microcat						
500	aquadopp/ microcat						
750	microcat						
1000	aquadopp/ microcat	aquadopp/ microcat	aquadopp/ microcat				
1250	microcat	microcat	microcat				
1500	aquadopp/ microcat	aquadopp/ microcat	aquadopp/ microcat			aquadopp/ microcat	
1750	aquadopp/ microcat	microcat	microcat			microcat	
2000		aquadopp/ microcat	aquadopp/ microcat			microcat	
2046	aquadopp / microcat / two release						
2191		aquadopp / microcat					
2250			aquadopp/ microcat			aquadopp/ microcat	
2383		aquadopp / microcat / two release					
2500						microcat	
2517			aquadopp / microcat / two release				
2750						microcat	
2945						aquadopp / microcat / two release	

Figure 4. Schematic of the 2018 GDWBC array. Mooring trilaterated locations and corrected depths from P Holliday 2016 cruise report 'OSNAPY3L2report_NOC_CR_40.pdf', Table 6.4.

4. CTD Casts

CTDs were completed non-sequentially due to extensive OOI operations. CTD locations relevant to the OSNAP line are presented in Figure 5. Table 1 lists all CTDs along the OSNAP line and those used to calibrate the microcat data. We have not included the CTDs taken at OOI sites off the line, and details of other CTD activity may be found in the [Irminger Sea 5 Cruise Report](#) (OOI document 3202-00503). Each 'OSNAP' cast sampled water at depths in a manner designated by past OSNAP cruises: at nominal [surface 100 200 300 400 600 800 1000 1300 1600 2000 2250 2500 2750 3000] meters depth. If sampling deviated from this nominal set, this information may be found in the OOI digital excel CTD worksheet 'Irminger-5_CTD_sampling_log.xlsx'.

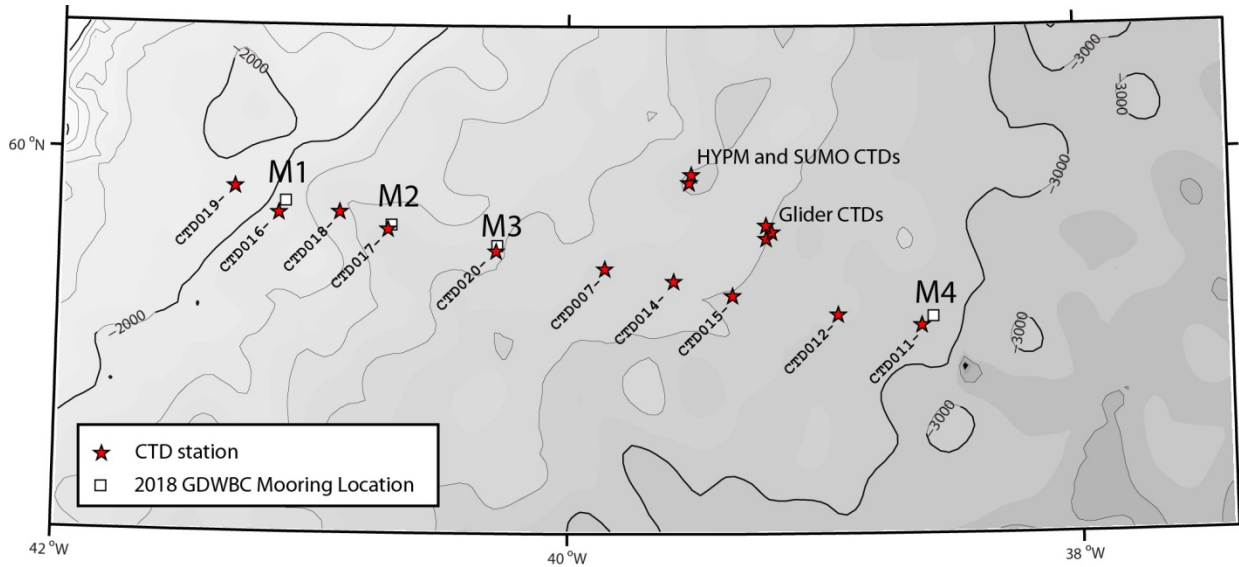


Figure 5. Map showing CTD station numbers relevant to OSNAP line and GDWBC moorings.

Table 2. Table of CTDs taken during AR30-03.

Cast #	Date	Time (UTC)	Site	Water Depth	Cast Depth	Water Samples
001	06/06/2018	08:10-09:45	62° 46.314' N 28° 39.368' W (at max depth)	1858 m	1000 m	Test acoustic releases 46257, 50124, 50672. Non-OOI water samples (Lipids)
002	06/06/2018	13:14-14:40	62° 29.867' N 29° 47.898' W (at max depth)	1956 m	1000 m	Test acoustic releases 34817, 45608, 46367. Non-OOI water samples (Lipids & BCP)
003	06/07/2018	18:15-11:33	60° 53.390' N 35° 21.369' W (at max depth)	3003 m	2950 m	OSNAP cal-dip 15 MicroCATs
004	06/07/2018	15:09-17:57	60° 38.250' N 36° 30.848' W (at max depth)	2997 m	2500 m	OSNAP cal-dip 15 MicroCATs

Cast #	Date	Time (UTC)	Site	Water Depth	Cast Depth	Water Samples
005	06/08/2018	18:10-20:30	GI01SUMO site center	2701 m	2500 m	OOI water samples: Salt, O ₂ , pH, DIC/TA, Nutrient, Chl
006	06/09/2018	13:34-16:10	GI02HYPM site center	2695 m	2650 m	Test OOI acoustic releases. OOI water samples: Salt, O ₂
007	06/10/2018	14:33-16:52	GI03FLMA site center	2720 m	2650 m	Test OOI acoustic releases. OOI water samples: Salt, O ₂ , pH, DIC/TA, Chl
008	6/11/2018	15:10-aborted at 16:50	GI03FLMB site center	2820 m (corrected)	2793 m	No water samples analyzed due to aborted cast. Three OSNAP releases [54683 32480 28289] were on cast.
009	6/12/2018	17:58 to 18:24	Test cast	2802 m	133 m	No water samples
010	6/12/2018	19:47-21:37	Gliders	2799 m	998 m	OOI water samples: O ₂ and nitrate; Three OSNAP releases [54683 32480 28289] re-tested.
011	6/13/2018	13:07-15:32	OSNAP M4	2974 m	2946 m	OSNAP water samples: salts.
012	6/13/2018	16:56-19:08	OSNAP CB4	2915 m	2897 m	OSNAP water samples: salts.
013	6/14/2018	20:15-20:37	Test cast	N/A	130 m	No water samples
014	6/15/2018	15:50-18:27	OSNAP CAB	2761 m	2750 m	OSNAP water samples: salts. Three OSNAP releases [51917 54685 54684] tested.
015	6/16/2018	13:49-16:20	GI03FLMB site center	2824 m	2800 m	Test OSNAP acoustic releases. OOI water samples: Salt, O ₂ , pH, DIC/TA, Chl
016	6/17/2018	11:56-13:46	OSNAP M1	2055 m	2043 m	OSNAP water samples: salts.
017	6/18/2018	12:59-15:08	OSNAP M2	2488 m	2452 m	OSNAP water samples: salts.
018	6/18/2018	16:01-18:02	OSNAP C12	2296 m	2286 m	OSNAP water samples: salts.
019	6/18/2018	20:01-21:39	OSNAP C01	1945 m	1930 m	OSNAP water samples: salts.

Cast #	Date	Time (UTC)	Site	Water Depth	Cast Depth	Water Samples
020	6/19/2018	11:45-13:53	OSNAP M3	2565 m	2542 m	OSNAP water samples: salts.
021	6/18/2018	18:17-19:31	Glider 363	2788 m	1000 m	OSNAP water samples: salts.

5. Sound Source Mooring Recoveries

Two sound source moorings were recovered as part of eight sound source moorings which will be recovered over the course of the OSNAP 2018 deployments and recoveries across the OSNAP line. This signals the end of the RAFOS portion of OSNAP. The sound source array is being pulled now, and 2016 floats will begin surfacing in July 2018. We have included in this section information on the two sound source moorings recovered earlier this month by the R/V MSMerian. Table 3 lists general details for each source mooring recovered. Appendix D includes log files from each recovery.

Table 3. Sound source mooring recovery information.

Sound source mooring number	Serial number	Recovery date	Sound source clock offset	Notes.
OSNAP SS1	81	01-June-2018	Clock check: 19 seconds fast (-19s) Clock Module: 16 seconds fast (-16s)	Recovered by C. Begler on RV MSMerian MSM74
OSNAP SS2	24	03-June-2018	77 seconds fast (-77s)	Recovered by C. Begler on RV MSMerian MSM74
OSNAP SS4	84	17 June 2018	7 seconds fast (-7s)	Resonator tube has significant corrosion after four years, preventable by more anodes?
OSNAP SS11	50	22 June 2018	0 (zero) seconds	TWR style source. Mooring diagram did not match actual mooring configuration: source on strongback rather than in two pieces, section of mooring cable missing near release. Source came up with deployment rope still attached to it. Pins on comm port completely bent and two near broken. We were lucky to get comms to be able to check clock status. Instructions for shut down (and clock check) did not match screen output, and we decided to disconnect electronics from battery. Sound source was sealed properly using vacuum of -5, and left with screws in place to 'catch' endcap in case of explosion. The instructions sent were not sufficient to yield positive outcome on recovery. We were lucky to have J. Kemp on board to help. Let's not do that again.

Appendix A: Mooring diagrams for GDWBC moorings M1-M4 shown as deployed mooring information.

Target Position 59 54.18'N 41 06.71'W
 Anchor drop: 59 54.271'N 41 06.708'W

Surveyed Position:
 59° 54.154'N
 41° 06.762'W
 Depth (corrected): 2086 m
 AR30-03 17-June-2018

42 m Depth

Hardware Required (per mooring without spares)	
(33)	5/8" Anchor Shackle
(3)	3/4" Anchor Shackle
(2)	7/8" Anchor Shackle
(25)	5/8" Sling Link (SL)
(1)	1-1/4" Master Link
(1)	3 ton Swivel with Anode

Hardware Designation	
(B)	(1) 1/2" SH, (1) 5/8" SL, (1) 5/8" SH
(F)	(1) 5/8" SH, (1) 5/8" SL, (1) 3/4" SH
(H)	(2) 5/8" SH, (1) 5/8" SL
(J)	(1) 5/8" SH, (1) 5/8" SL, (1) 7/8" SH
(M)	Master Link
(S)	Swivel

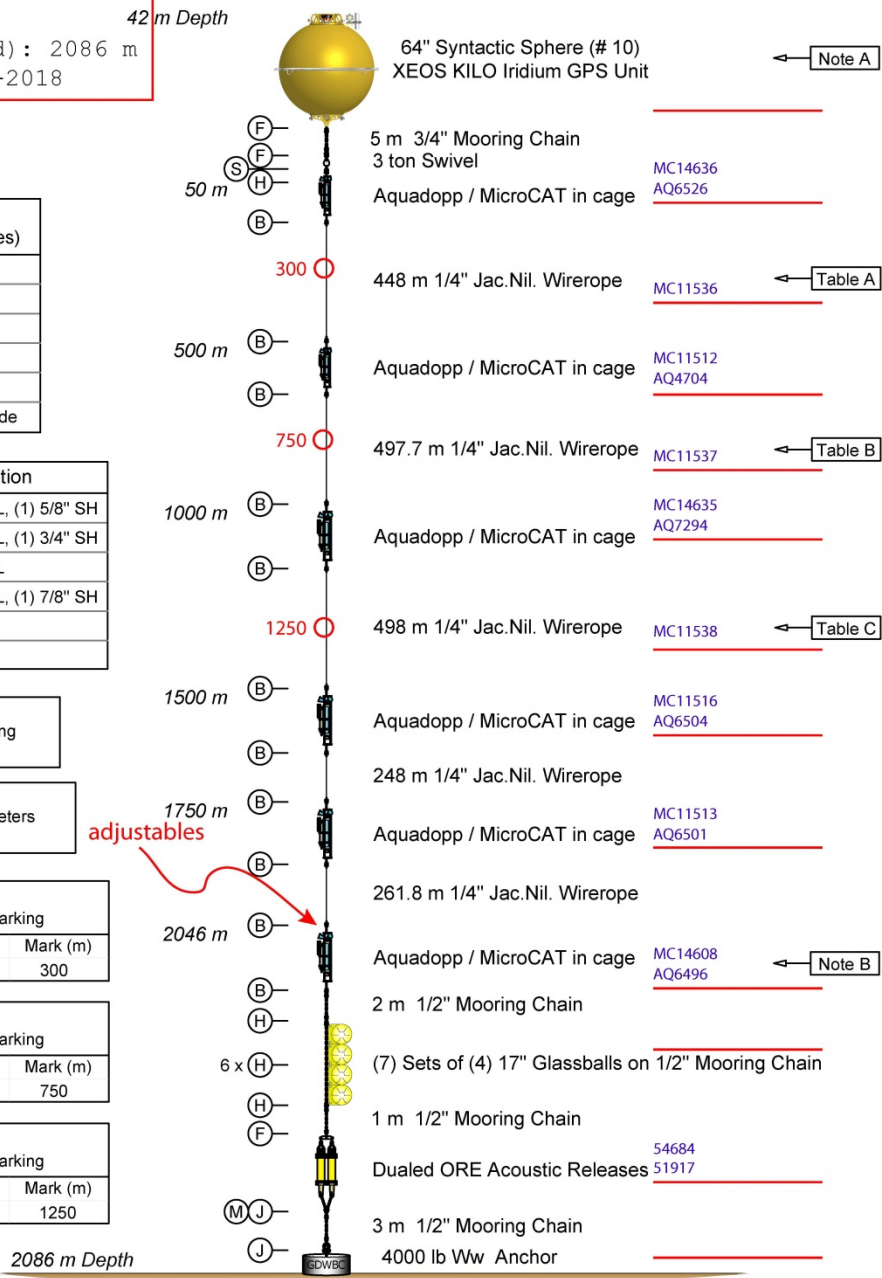
Note A
 Mooring to be deployed using
 Lebus Winch

Note B
 Instrument Depth is 40 meters
 off Bottom

Table A MicroCat Depth and Marking		
Instrument	Measure (m)	Mark (m)
SBE 37 SMP	249.9	300

Table B MicroCat Depth and Marking		
Instrument	Measure (m)	Mark (m)
SBE 37 SMP	248.7	750

Table C MicroCat Depth and Marking		
Instrument	Measure (m)	Mark (m)
SBE 37 SMP	248.8	1250



2086 m Depth

Greenland Deep Western
 Boundary Current
 As Deployed - HFurey 17JUN2018

Woods Hole Oceanographic Institution
 designed by John Kemp, drawn by Jim Ryder
 file: OSNAP Bower date: 02/20/2018

GDWBC-M1

Surveyed Position:
 59° 51.417'N
 40° 41.741'W
 Depth (corrected): 2436 m
 AR30-03

950 m Depth

Hardware Required (per mooring without spares)	
(35)	1/2" Anchor Shackle (SH)
(12)	5/8" Anchor Shackle
(1)	3/4" Anchor Shackle
(2)	7/8" Anchor Shackle
(25)	5/8" Sling Link (SL)
(1)	1-1/4" Master Link
(1)	3 ton Swivel with Anode

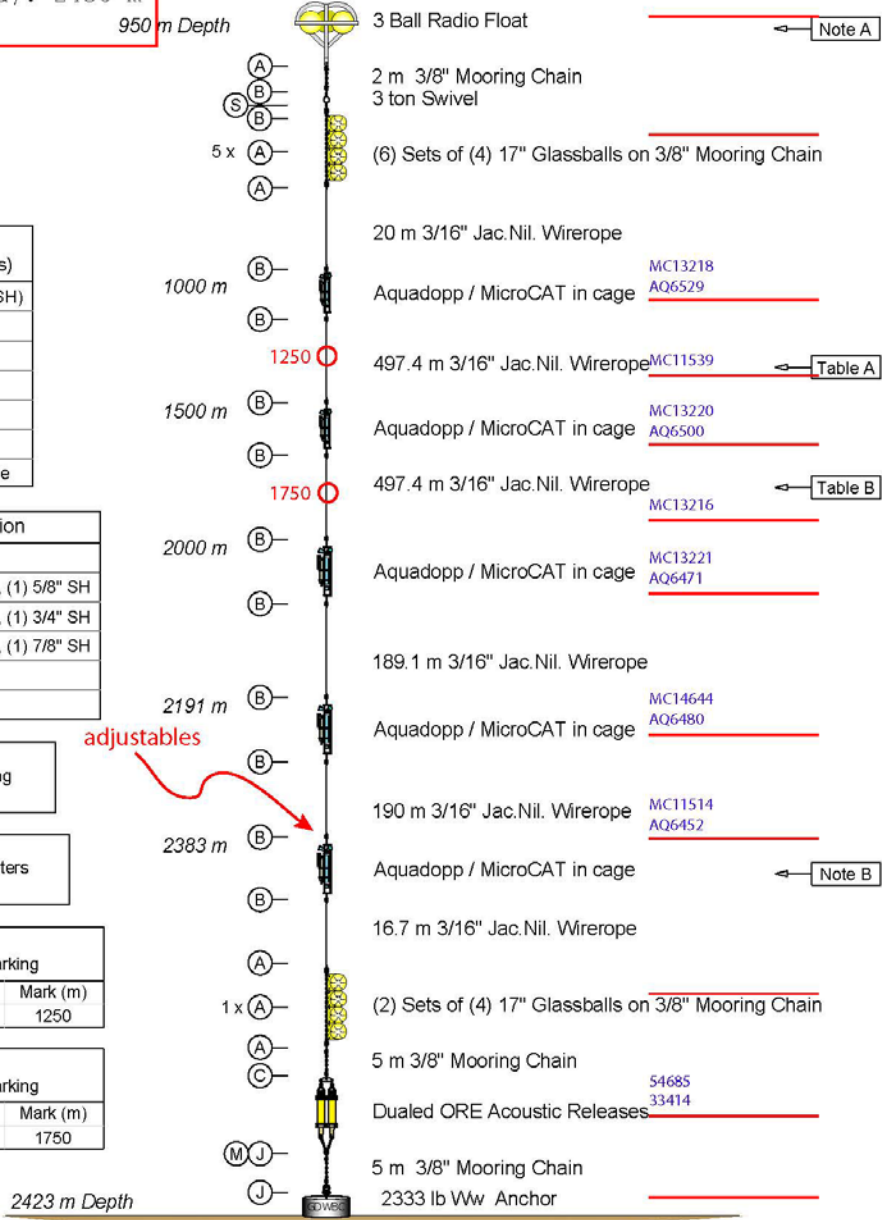
Hardware Designation	
(A)	(2) 1/2" SH, (1) 5/8" SL
(B)	(1) 1/2" SH, (1) 5/8" SL, (1) 5/8" SH
(C)	(1) 1/2" SH, (1) 5/8" SL, (1) 3/4" SH
(J)	(1) 1/2" SH, (1) 5/8" SL, (1) 7/8" SH
(M)	Master Link
(S)	Swivel

Note A
 Mooring to be deployed using
 Lebus Winch

Note B
 Instrument Depth is 40 meters
 off Bottom

Table A MicroCat Depth and Marking		
Instrument	Measure (m)	Mark (m)
SBE 37 SMP	248.8	1250

Table B MicroCat Depth and Marking		
Instrument	Measure (m)	Mark (m)
SBE 37 SMP	248.7	1750



2423 m Depth

Greenland Deep Western
 Boundary Current
 As Deployed - hfurey 18Jun2018

Woods Hole Oceanographic Institution
 designed by John Kemp, drawn by Jim Ryder
 file: OSNAP Bow or date: 02/20/2018

GDWBC-M2

Surveyed Position:
 59° 49.021'N
 40° 16.710'W
 Depth (corrected): 2557 m
 AR30-03

Hardware Required (per mooring without spares)	
(35)	1/2" Anchor Shackle (SH)
(12)	5/8" Anchor Shackle
(1)	3/4" Anchor Shackle
(2)	7/8" Anchor Shackle
(25)	5/8" Sling Link (SL)
(1)	1-1/4" Master Link
(1)	3 ton Swivel with Anode

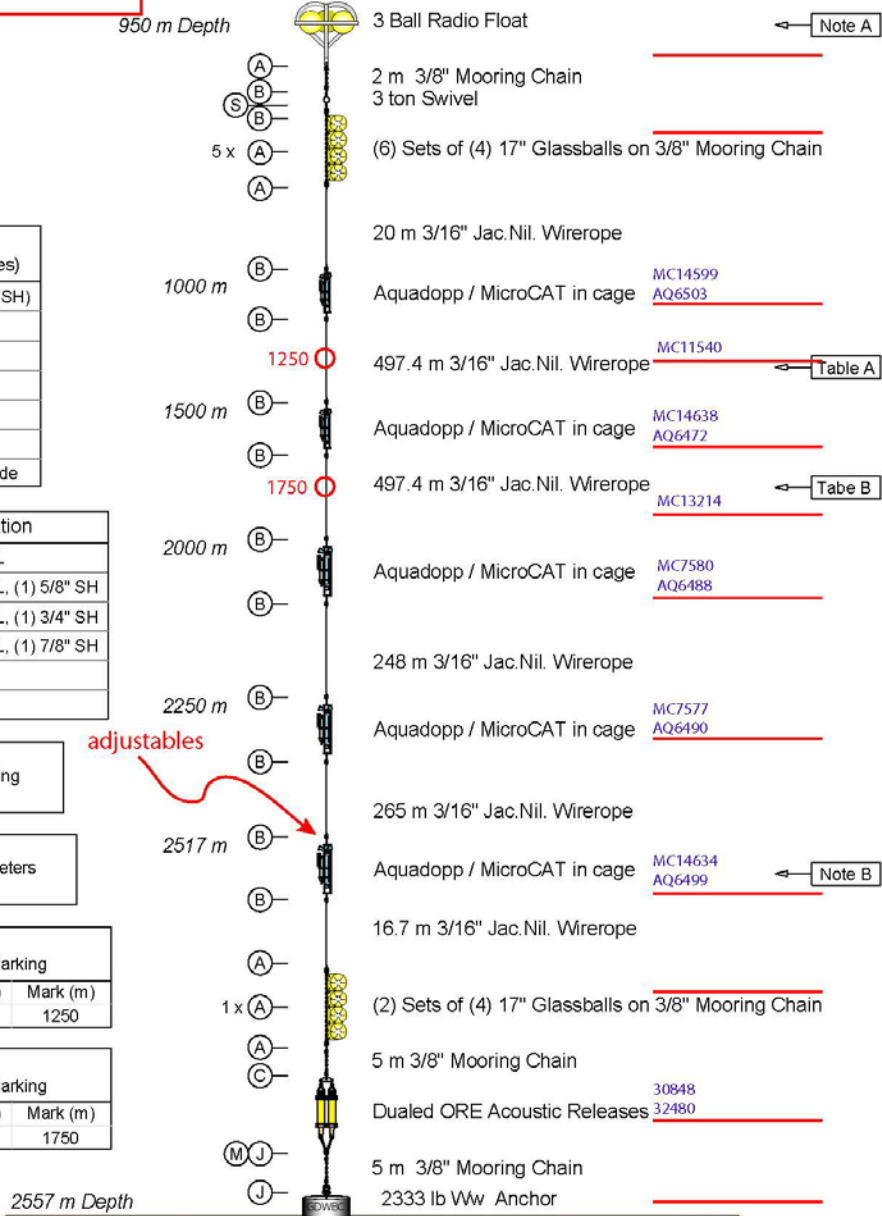
Hardware Designation	
(A)	(2) 1/2" SH, (1) 5/8" SL
(B)	(1) 1/2" SH, (1) 5/8" SL, (1) 5/8" SH
(C)	(1) 1/2" SH, (1) 5/8" SL, (1) 3/4" SH
(J)	(1) 1/2" SH, (1) 5/8" SL, (1) 7/8" SH
(M)	Master Link
(S)	Swivel

Note A
 Mooring to be deployed using
 Lebus Winch

Note B
 Instrument Depth is 40 meters
 off Bottom

Table A MicroCat Depth and Marking		
Instrument	Measure (m)	Mark (m)
SBE 37 SMP	248.8	1250

Table B MicroCat Depth and Marking		
Instrument	Measure (m)	Mark (m)
SBE 37 SMP	248.7	1750



GDWBC-M3

Greenland Deep Western
 Boundary Current
 As Deployed - hfurey 19 June 2018

Woods Hole Oceanographic Institution
 designed by John Kemp, drawn by Jim Ryder
 file: OSNAP Bow or date: 02/20/2018

Surveyed Position:

59° 40.637'N

38° 34.121'W

Depth (corrected): 2984 m

AR30-03

1455 m Depth

Hardware Required (per mooring without spares)	
(37)	1/2" Anchor Shackle (SH)
(8)	5/8" Anchor Shackle
(1)	3/4" Anchor Shackle
(2)	7/8" Anchor Shackle
(24)	5/8" Sling Link (SL)
(1)	1-1/4" Master Link
(1)	3 ton Swivel with Anode

Hardware Designation	
(A)	(2) 1/2" SH, (1) 5/8" SL
(B)	(1) 1/2" SH, (1) 5/8" SL, (1) 5/8" SH
(C)	(1) 1/2" SH, (1) 5/8" SL, (1) 3/4" SH
(J)	(1) 1/2" SH, (1) 5/8" SL, (1) 7/8" SH
(M)	Master Link
(S)	Swivel

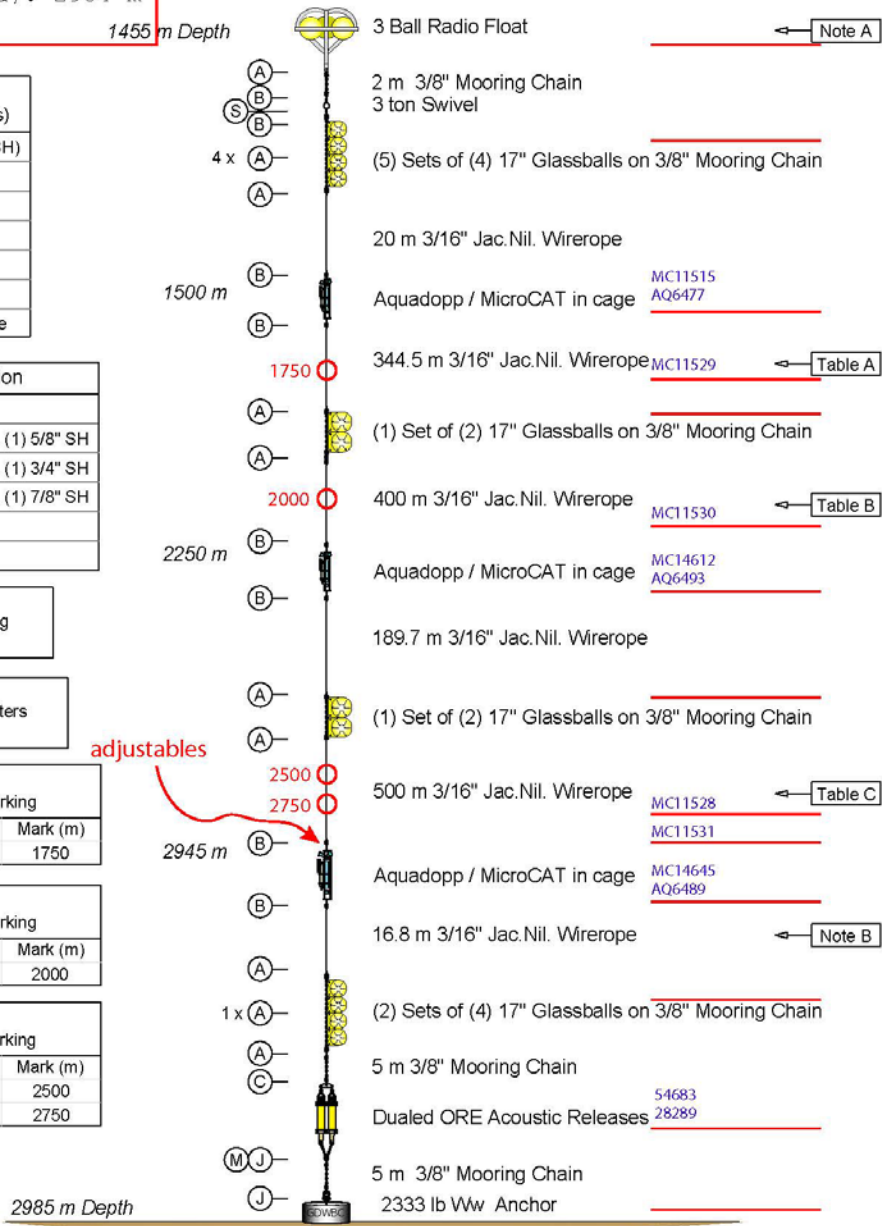
Note A
Mooring to be deployed using Lebus Winch

Note B
Instrument Depth is 40 meters off Bottom

Table A MicroCat Depth and Marking		
Instrument	Measure (m)	Mark (m)
SBE 37 SMP	248.7	1750

Table B MicroCat Depth and Marking		
Instrument	Measure (m)	Mark (m)
SBE 37 SMP	151.2	2000

Table C MicroCat Depth and Marking		
Instrument	Measure (m)	Mark (m)
SBE 37 SMP	56.2	2500
SBE 37 SMP	306.2	2750



2985 m Depth

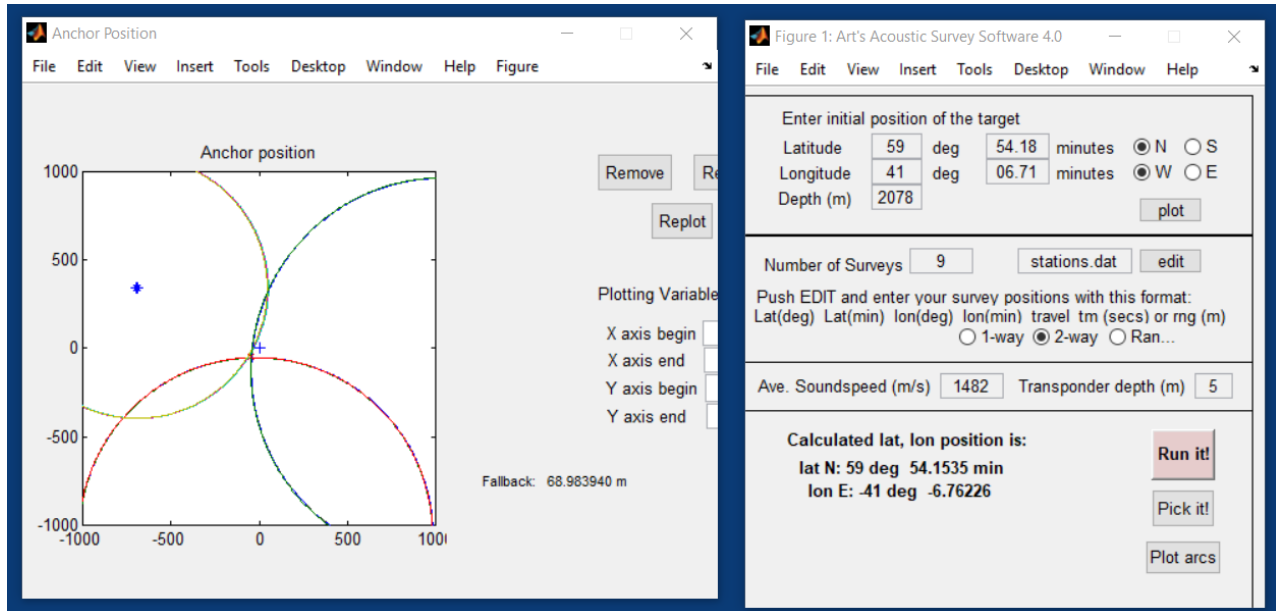
GDWBC-M4

Greenland Deep Western
Boundary Current
As Deployed - HFurey 15JUN2018

Woods Hole Oceanographic Institution
designed by John Kemp, drawn by Jim Ryder
file OSNAP Bow or date 02/20/2018

Appendix B: Anchor survey details for each of the four GDWBC moorings.

GDWBC-M1 / AR30-03 / 17-June-2018



Anchor survey of M1 acoustic release 54684:

Surveyed position is: 59° 54.154'N 41° 06.762'W, corrected depth is 2086 m.

Mooring Depth: 2086 meters.

Acoustic Release depth 2078 m.

Sound Velocity 1482 m/s

Transponder 1 is off by -48.4978 m E and -49.0586 m N.

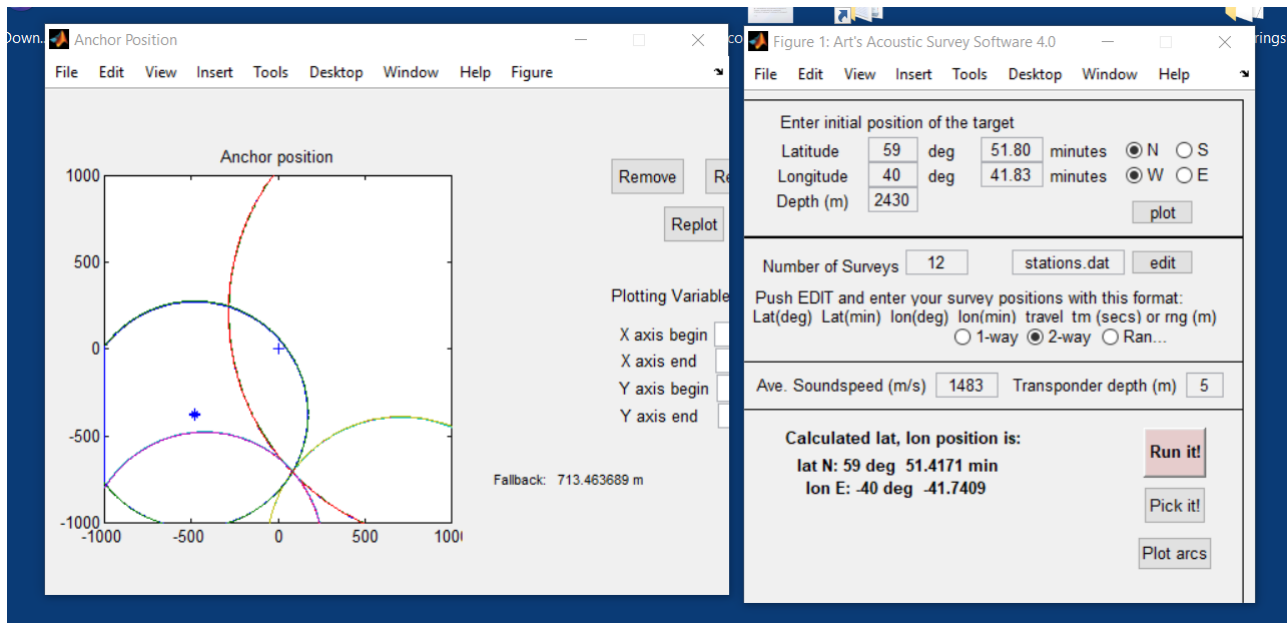
The new lat, long is 59.902558 -41.112704

...

Stations.dat file contents (3 survey locations).

```
Lat_deg lat_min lon_deg lon_min travel_time (twice distance)
59 53.6092 41 06.7280 3.109
59 53.6090 41 06.7300 3.108
59 53.6090 41 06.7309 3.109
59 54.3662 41 07.4520 2.971
59 54.3671 41 07.4596 2.972
59 54.3663 41 07.4596 2.971
59 54.1135 41 05.5817 3.162
59 54.1125 41 05.5810 3.162
59 54.1125 41 05.5812 3.164
```

GDWBC-M2 / AR30-03 / 18-June-2018



Anchor survey of M2 acoustic release 54684:

Surveyed position is: 59° 51.417'N 40° 41.741'W, corrected depth is 2436 m.

Mooring Depth: 2436 meters.

Acoustic Release depth 2430 m.

Sound Velocity 1483 m/s

Transponder 1 is off by 82.767 m E and -708.647 m N.

The new lat, long is 59.856952 -40.695682

...

Stations.dat file contents (4 survey locations).

Lat_deg lat_min lon_deg lon_min travel_time (twice distance)

59 51.9162 40 40.6883 3.741

59 51.9162 40 40.6891 3.739

59 51.9164 40 40.6904 3.740

59 51.1682 40 41.0667 3.434

59 51.1689 40 41.0647 3.435

59 51.1690 40 41.0648 3.435

59 51.5950 40 42.3475 3.387

59 51.5957 40 42.3491 3.387

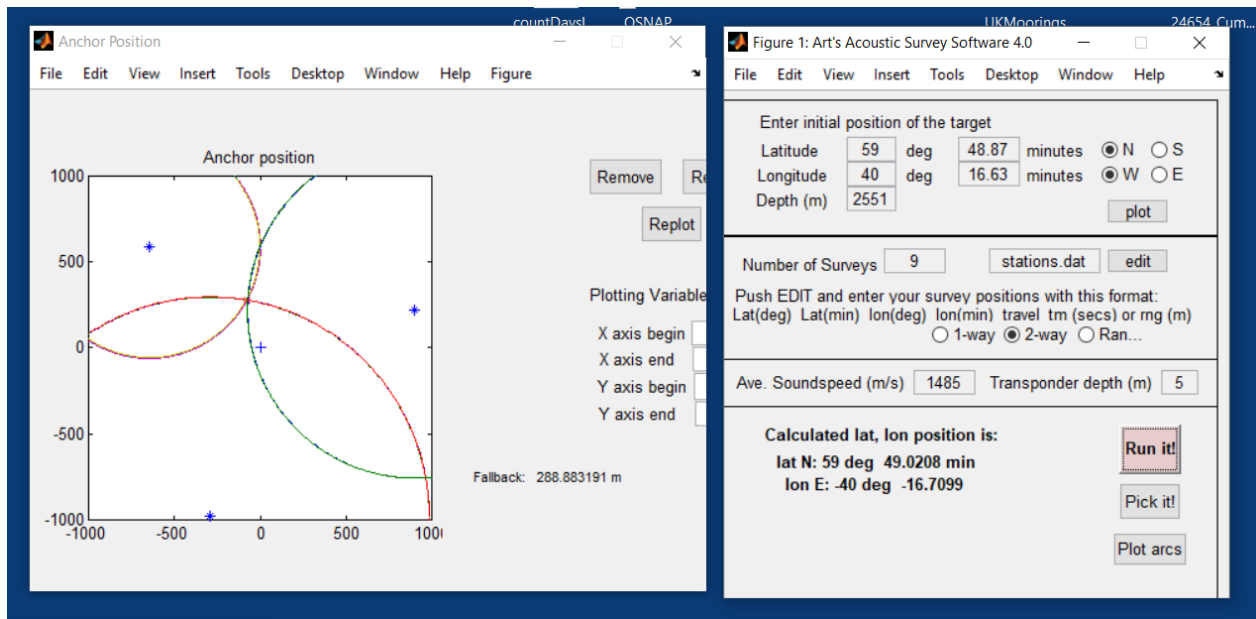
59 51.5967 40 42.3482 3.388

59 51.1734 40 42.2880 3.397

59 51.1727 40 42.2869 3.398

59 51.1724 40 42.2865 3.397

GDWBC-M3 / AR30-03 / 19-June-2018



Anchor survey of M3 acoustic release 30848 or 32480:

Surveyed position is: 59° 49.021'N 40° 16.710'W, corrected depth is 2557 m.

Mooring Depth: 2557 meters.

Acoustic Release depth 2551 m.

Sound Velocity 1485 m/s

Transponder 1 is off by -74.3274 m E and 279.158 m N.

The new lat, long is 59.817014 -40.278498

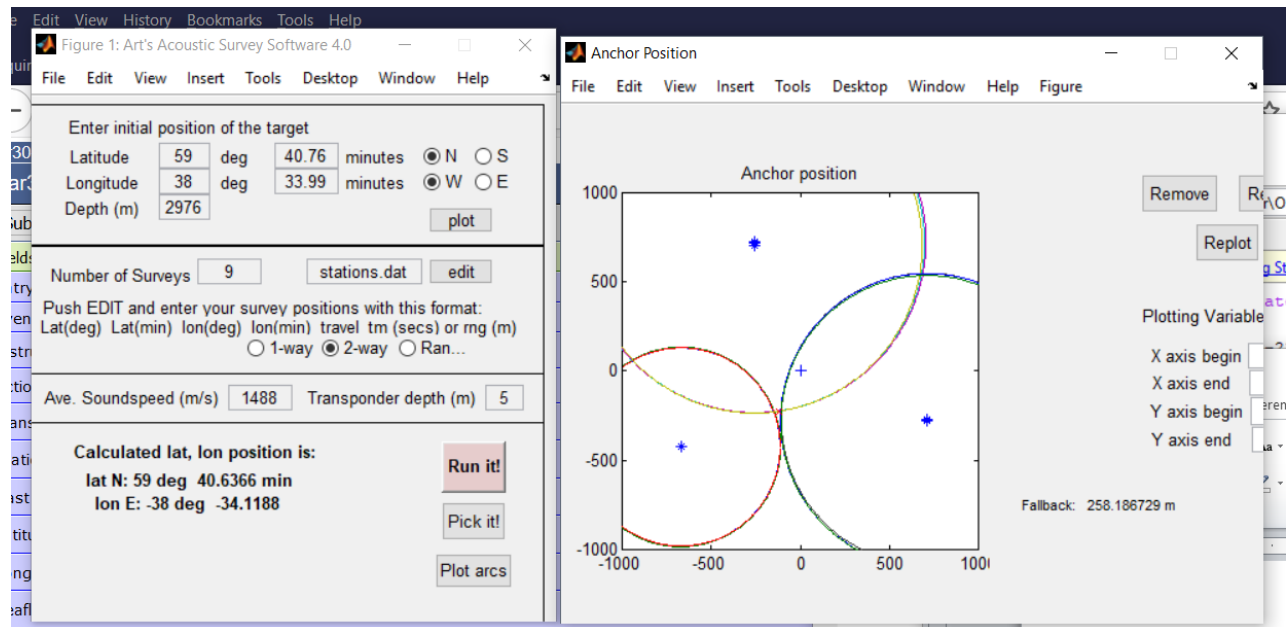
...

Stations.dat file contents:

Lat_deg lat_min lon_deg lon_min travel_time (twice distance)

```
59 48.3397 40 16.9416 3.837
59 48.3388 40 16.9440 3.838
59 48.3383 40 16.9447 3.839
59 49.1883 40 17.3290 3.539
59 49.1881 40 17.3265 3.539
59 49.1882 40 17.3252 3.537
59 48.9884 40 15.6576 3.674
59 48.9877 40 15.6583 3.673
59 48.9877 40 15.6605 3.673
```

GDWBC-M4/ AR30-03 / 13-June-2018



Anchor survey of M4 acoustic release 54683:

Surveyed position is: 59° 40.637'N 38° 34.121'W, corrected depth is 2984 m.

Transponder 1 is off by -120.369 m E and -228.411 m N.

The new lat, long is 59.677276 -38.568647

...

Stations.dat file contents.

Lat_deg	lat_min	lon_deg	lon_min	travel_time (twice distance)
59	40.5296	38	34.7090	4.063
59	40.5297	38	34.7093	4.064
59	40.5299	38	34.7086	4.063
59	41.1504	38	34.2639	4.195
59	41.1545	38	34.2631	4.198
59	41.1428	38	34.2655	4.190
59	40.6138	38	33.2255	4.143
59	40.6102	38	33.2239	4.145
59	40.6074	38	33.2274	4.143

Appendix C: Instrumentation.

The OSNAP GDWBC moorings utilize 3/16" (M2-M4) and 1/4" (M1) 3 x 19 plastic-jacketed galvanized wire rope with swaged sockets to fit 1/2" shackles. These mooring supplies were provided by the WHOI Mooring Lab. The moorings use a combination of instrumentation that are installed on the wire using both in-line rigid aluminum frames and Delrin wire clamps. Prior to deployment all instruments clocks were set to the correct UTC time using the R/V Neil Armstrong's onboard clock. Following this, all of the SBE 37's were to be pre-deployment calibrated by mounting them onto the CTD rosette and running an in-situ calibration at prescribed depths. They were set to a sample rate of ten seconds and mounted on the rosette fifteen at a time for a total of two casts. Once back onboard, they were set to stop sampling and the data was downloaded but left saved on the instruments as well. They were then reset to their deployment rate of 900 seconds. The tables below give an overview of the instrumentation used on the OSNAP GDWBC moorings according to their engineered designs. The columns reflect what type of instrument was used and their deployed depth. Also shown are the sample rates at which measurements were taken, which Parameters were measured, and what time the instruments first entered the water during the deployment.

Mooring M1

Surveyed Position 59° 54.154' N 41° 06.762' W

Depth (corrected) 2086 m

Deploy Date 17 June 2018

Instrument	Serial #	Depth (M)	Sample Rate (s)	Parameters Measured	Time Deployed (UTC)	Inst. Start Time	Inst.Start Date
Aquadopp	6526	50	1800	U,V,W,T,P	0807	00:00:00	18 June 2018
SBE 37	14636	50	900	T,C,P	0807	00:00:00	18 June 2018
SBE 37	11536	300	900	T,C,P	0821	00:00:00	18 June 2018
Aquadopp	4704	500	1800	U,V,W,T,P	0843	00:00:00	18 June 2018
SBE 37	11512	500	900	T,C,P	0843	00:00:00	18 June 2018
SBE 37	11537	750	900	T,C,P	0854	00:00:00	18 June 2018
Aquadopp	7294	1000	1800	U,V,W,T,P	0918	00:00:00	18 June 2018
SBE 37	14635	1000	900	T,C,P	0918	00:00:00	18 June 2018
SBE 37	11538	1250	900	T,C,P	0929	00:00:00	18 June 2018
Aquadopp	6504	1500	1800	U,V,W,T,P	0953	00:00:00	18 June 2018
SBE 37	11516	1500	900	T,C,P	0953	00:00:00	18 June 2018
Aquadopp	6501	1750	1800	U,V,W,T,P	1017	00:00:00	18 June 2018
SBE 37	11513	1750	900	T,C,P	1017	00:00:00	18 June 2018
Aquadopp	6496	2046	1800	U,V,W,T,P	1039	00:00:00	18 June 2018
SBE 37	14608	2046	900	T,C,P	1039	00:00:00	18 June 2018

Mooring M2

Surveyed Position 59° 51.417' N 40° 41.741' W

Depth (corrected) 2436 m

Deploy Date 18 June 2018

Instrument	Serial #	Depth (M)	Sample Rate (s)	Parameters Measured	Time Deployed (UTC)	Inst. Start Time	Inst. Start Date
Aquadopp	6529	1000	1800	U,V,W,T,P	0817	00:00:00	19 June 2018
SBE 37	13218	1000	900	T,C,P	0817	00:00:00	19 June 2018
SBE 37	11539	1250	900	T,C,P	0828	00:00:00	19 June 2018
Aquadopp	6500	1500	1800	U,V,W,T,P	0849	00:00:00	19 June 2018
SBE 37	13220	1500	900	T,C,P	0849	00:00:00	19 June 2018
SBE 37	13216	1750	900	T,C,P	0859	00:00:00	19 June 2018
Aquadopp	6471	2000	1800	U,V,W,T,P	0924	00:00:00	19 June 2018
SBE 37	13221	2000	900	T,C,P	0924	00:00:00	19 June 2018
Aquadopp	6480	2191	1800	U,V,W,T,P	0945	00:00:00	19 June 2018
SBE 37	14644	2191	900	T,C,P	0945	00:00:00	19 June 2018
Aquadopp	6452	2383	1800	U,V,W,T,P	1006	00:00:00	19 June 2018
SBE 37	11514	2383	900	T,C,P	1006	00:00:00	19 June 2018

Mooring M3

Surveyed Position 59° 49.021' N 40° 16.710' W

Depth (corrected) 2557 m

Deploy Date 19 June 2018

Instrument	Serial #	Depth (M)	Sample Rate (s)	Parameters Measured	Time Deployed (UTC)	Inst. Start Time	Inst. Start Date
Aquadop	6503	1000	1800	U,V,W,T,P	0816	00:00:00	20 June 2018
SBE 37	14599	1000	900	T,C,P	0816	00:00:00	20 June 2018
SBE 37	11540	1250	900	T,C,P	0826	00:00:00	20 June 2018
Aquadop	6472	1500	1800	U,V,W,T,P	0848	00:00:00	20 June 2018
SBE 37	14638	1500	900	T,C,P	0848	00:00:00	20 June 2018
SBE 37	13214	1750	900	T,C,P	0859	00:00:00	20 June 2018
Aquadop	6488	2000	1800	U,V,W,T,P	0919	00:00:00	20 June 2018
SBE 37	7580	2000	900	T,C,P	0919	00:00:00	20 June 2018
Aquadop	6490	2250	1800	U,V,W,T,P	0940	00:00:00	20 June 2018
SBE 37	7577	2250	900	T,C,P	0940	00:00:00	20 June 2018
Aquadop	6499	2517	1800	U,V,W,T,P	1001	00:00:00	20 June 2018
SBE 37	14634	2517	900	T,C,P	1001	00:00:00	20 June 2018

Mooring M4

Surveyed Position 59° 40.637' N 38° 34.121' W

Depth (corrected) 2984 m

Deploy Date 13 June 2018

Instrument	Serial #	Depth (M)	Sample Rate (s)	Parameters Measured	Time Deployed (UTC)	Inst. Start Time	Inst. Start Date
Aquadopp	6477	1500	1800	U,V,W,T,P	0827	00:00:00	14 June 2018
SBE 37	11515	1500	900	T,C,P	0827	00:00:00	14 June 2018
SBE 37	11529	1750	900	T,C,P	0842	00:00:00	14 June 2018
SBE 37	11530	2000	900	T,C,P	0908	00:00:00	14 June 2018
Aquadopp	6493	2250	1800	U,V,W,T,P	0929	00:00:00	14 June 2018
SBE 37	14612	2250	900	T,C,P	0929	00:00:00	14 June 2018
SBE 37	11528	2500	900	T,C,P	0952	00:00:00	14 June 2018
SBE 37	11531	2750	900	T,C,P	1005	00:00:00	14 June 2018
Aquadopp	6489	2945	1800	U,V,W,T,P	1020	00:00:00	14 June 2018
SBE 37	14645	2945	900	T,C,P	1020	00:00:00	14 June 2018

Appendix E: Sound source recovery log and information.