Irminger Sea 6 Cruise Report

R/V *Neil Armstrong*, AR 35-05

2 August – 24 August 2019

Reykjavik, Iceland – Woods Hole, MA

Control Number: 3202-00603

Version: 1-00

Date: 2019-12-03

Authors: Sheri White, Stephanie Petillo, Hilary Palevsky, Allen Smith, James Kuo, Daniel J. Bogorff, Collin Dobson, John Kemp, James Dunn, Chris Basque, David Wellwood

Approver: Derek Buffitt, 2019-12-03

Coastal and Global Scale Nodes

Ocean Observatories Initiative

Woods Hole Oceanographic Institution

Template 3401-00004 Version 2-00

Revision History

Version	Description	Originator	Release Date
0-01	Initial draft	S. White	
0-02	Populated pre-cruise info from Surface & Subsurface Mooring teams	S. Petillo	
0-03	Updates during the cruise	S. White, S. Petillo	
0-04	Review	R. Travis	
0-05	Updates to address review comments	S. White	
0-06	Updated Config Sheet with correct mooring location; added Sec 6.4 by P. Brickley	S. White, P. Brickley	
1-00	Initial release	D. Buffitt	2019-12-03

Abstract

This cruise report documents the sixth infrastructure deployment of the Coastal and Global Scale Nodes (CGSN) Irminger Sea Array of the National Science Foundation's (NSF) Ocean Observatories Initiative (OOI) (http://www.oceanobservatories.org). The Irminger Sea Array includes a Global Surface Mooring, a Global Hybrid Profiler Mooring, two Flanking Moorings, two Open Ocean Gliders, and two Global Profiling Gliders. It is one of as many as four Global Arrays expanding oceanographic capabilities by deploying and maintaining platforms with multidisciplinary sensor suites at high-latitude sites.

The Irminger Sea 6 deployment cruise accomplished all 11 main objectives: 1) Deployed Surface Mooring GI01SUMO-00006, 2) Deployed Hybrid Profiler Mooring GI02HYPM-00006, 3) Deployed Flanking Mooring A GI03FLMA-00006, 4) Deployed Flanking Mooring B GI03FLMB-00006, 5) Recovered Surface Mooring GI01SUMO-00005, 6) Recovered Hybrid Profiler Mooring GI02HYPM-00005, 7) Recovered Flanking Mooring A GI03FLMA-00005, 8) Recovered Flanking Mooring B GI03FLMB-00005, 9) Deployed Open Ocean and Global Profiling Gliders, 10) Conducted CTD casts with water samples at mooring and glider locations, and 11) Carried out shipboard sampling in support of validation of the deployed and recovered platforms. The Global Profiling Glider developed an aft leak shortly after deployment, requiring that it be recovered.

Ancillary activities to support the Biological Carbon Pump (BCP) project included deployment of one Open Ocean Glider with the oxygen optode mounted on top, and shipboard underway sampling.

The cruise was conducted on R/V *Neil Armstrong*, departing Reykjavik, Iceland on 2 August 2019 and returning to Woods Hole, MA, on 24 August 2019 (one day earlier than planned). A fifteen-person science party from Woods Hole Oceanographic Institution (WHOI, 11), Wellesley College (2), Boston College (1) and High Mowing School (1), plus two technicians from WHOI Shipboard Scientific Services Group (SSSG), were on board.

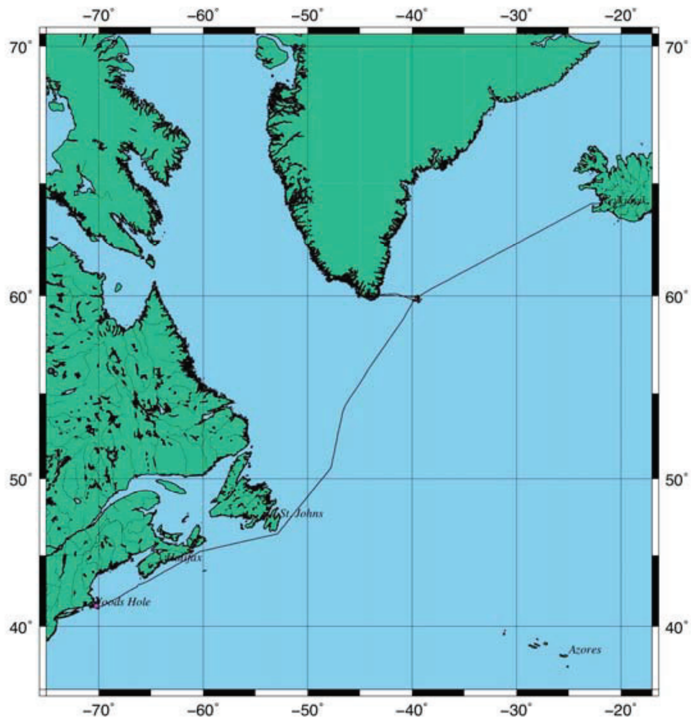


Figure A-1 Cruise Track of AR35-05

Table of Contents

List of Figures

List of Tables

1.0 Introduction

1.1. Background and Purpose

This cruise is the sixth cruise to the Irminger Sea Global Array of the National Science Foundation's Ocean Observatories Initiative (OOI; http://www.oceanobservatories.org). The Irminger Sea Global Array includes four moorings (

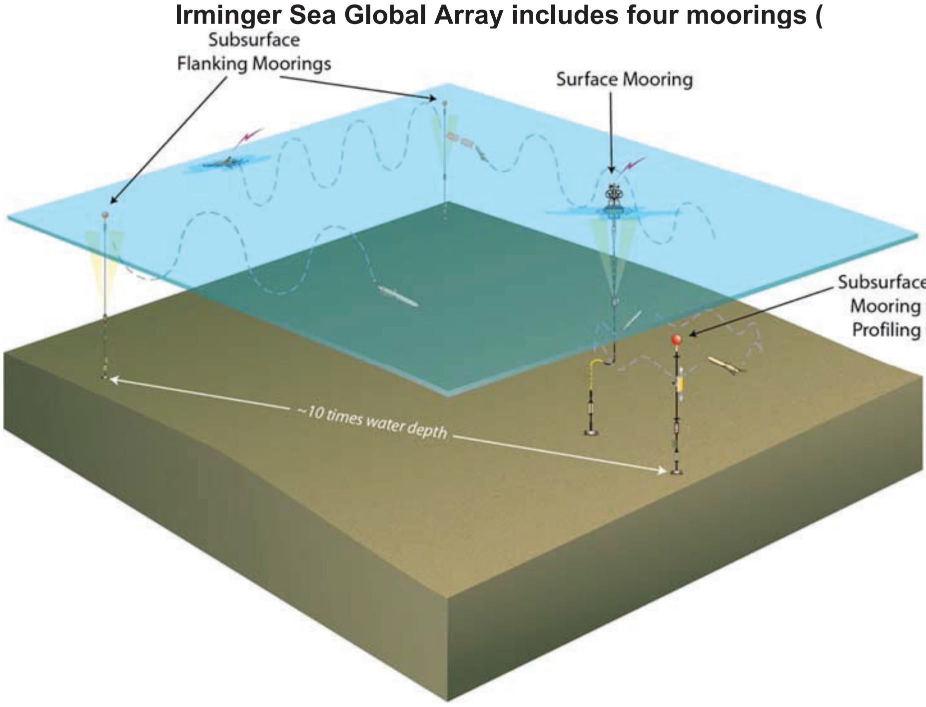


Figure 1-1Figure 1-1) and a combination of Open Ocean and Global Profiling Gliders deployed

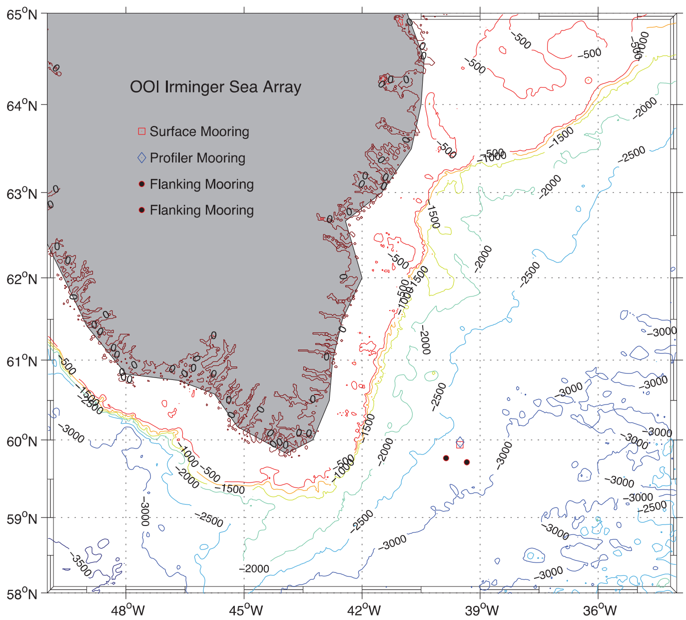


Figure 1-2) wintertime water mass formation that supports the global thermohaline circulation (a.k.a. meridional overturning circulation – MOC), where in recent years a freshening of the water column has been observed. The data from the array contributes to an improved understanding of the impact of both natural and climate variability in the region, as well as how these signals effect changes in ocean physics, chemistry, and biology and vice-versa.

The combination of the moored array and the gliders enables investigation into the role of processes at mesoscale and sub-mesoscale horizontal length scales through observations that sample the full water column, from the sea floor to the sea surface. The Surface Mooring provides a unique time-history of observations of surface meteorology and air-sea fluxes.

This Global Irminger Sea Array deployment cruise (Irminger 6) had the following primary objectives: deployment of new Surface Mooring (GI01SUMO), Hybrid Profiler Mooring (GI02HYPM), and two Flanking Moorings (GI03FLMA, GI03FLMB), and deployment of new Irminger Sea Gliders (GI05MOAS) tasked to patrol around the moored array; recovery of the Surface Mooring, Profiler Mooring, and Flanking Moorings deployed in June 2018; CTD casts with water sampling both for instrument validation and to further characterize the region of the mooring sites; and shipboard underway sampling.

There was one ancillary, NSF-funded program sailing on Irminger 6 – the NSF Project entitled "The Annual Cycle of the Biological Carbon Pump in the Subpolar North Atlantic" (called the BCP Project). There was also a High School teacher from High Mowing School in Wilton, NH, joining the cruise.

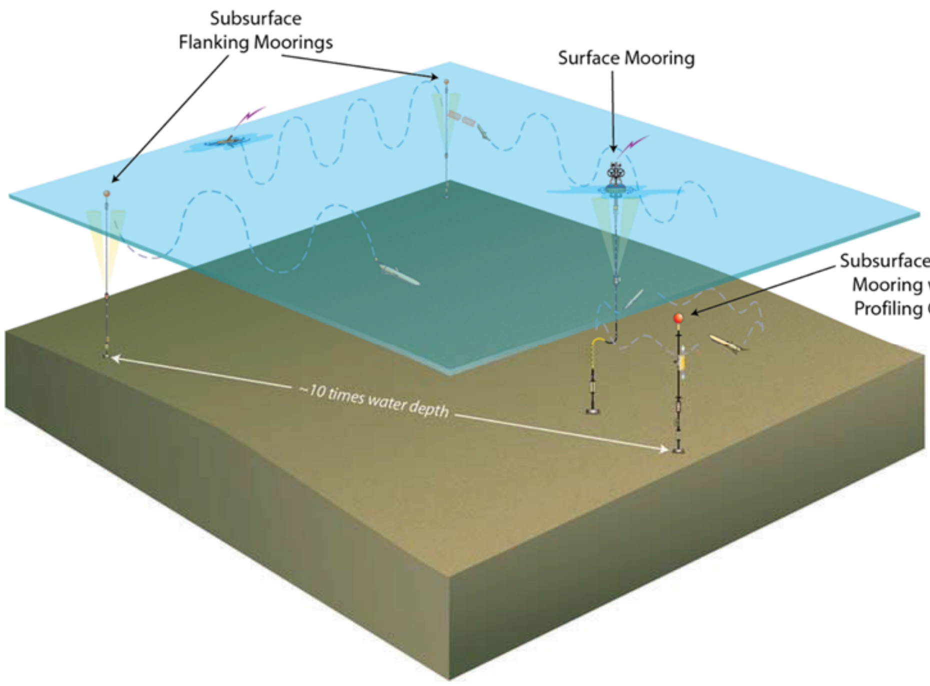
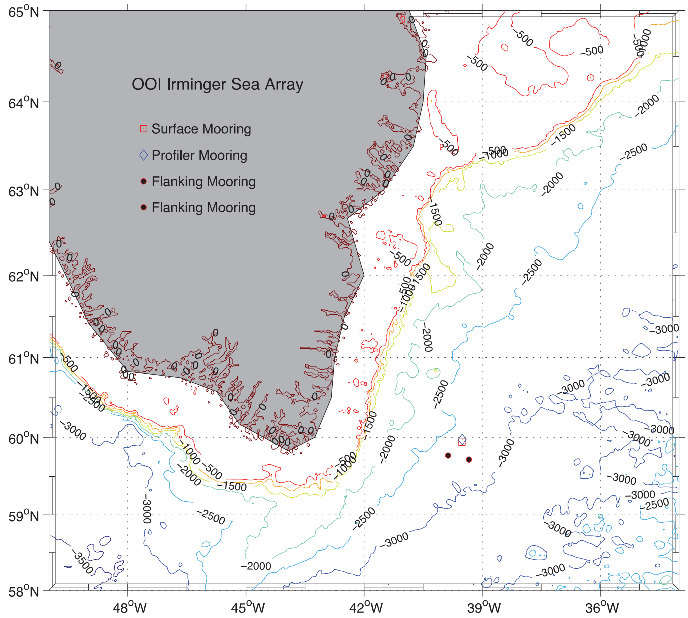


Figure 1-1 – Schematic drawing of the OOI Global Irminger Sea Array.



1.2. Supporting Documents

Table 1-1 – Supporting Documents

Doc Number	Description	Location
1102-00200	Observation and Sampling Approach	Alfresco (Controlled)
3202-00007	Irminger Array Site Characterization	Alfresco (Controlled)
3202-00601	Irminger 6 Deployment Cruise Plan	Alfresco (Controlled)
3202-00602	Irminger 6 Deployment Quick Look Report	Alfresco (Controlled)
3602-40001	GI01SUMO Deck Drawing	Alfresco (Controlled)
3602-40002	GI02HYPM Deck Drawing	Alfresco (Controlled)
3602-40003	GI03FLMA Deck Drawing	Alfresco (Controlled)
3602-40004	GI03FLMB Deck Drawing	Alfresco (Controlled)
3602-40101	GI01SUMO Design Spreadsheet	Alfresco (Controlled)
3602-40102	GI02HYPM Design Spreadsheet	Alfresco (Controlled)
3602-40103	GI03FLMA Design Spreadsheet	Alfresco (Controlled)
3602-40104	GI03FLMB Design Spreadsheet	Alfresco (Controlled)
N/A	CGSN Irminger 6 IRR Checklist	Alfresco (Cruise Data)
3304-00022-00053	Glider 515 Deployment Record	Alfresco (Vehicles)
3304-00022-00054	Glider 525 Deployment Record	Alfresco (Vehicles)
3304-00022-00055	Glider 560 Deployment Record	Alfresco (Vehicles)
N/A	GI01SUMO Configuration Spreadsheet	Alfresco (Asset Information)
N/A	GI02HYPM Configuration Spreadsheet	Alfresco (Asset Information)
N/A	GI03FLMA Configuration Spreadsheet	Alfresco (Asset Information)
N/A	GI03FLMB Configuration Spreadsheet	Alfresco (Asset Information)

1.3. Cruise Chronology

[Note: local Reykjavik time = GMT/UTC]

22-31 July 2019

Mobilization in Reykjavik at the Korngarðar 2 warehouse. All moorings were assembled and tested with no major issues.

The R/V *Neil Armstrong* arrived in port on 29 July, and fueled by barge at the dock (Grandabryggja in the harbor downtown). The ship's underway seawater system was cleaned on 31 July. Loading of most gear took place in the harbor 31 July and 01 August.

1 August 2019

Continued loading at the dock in the harbor downtown.

Allen, Colin and Stephanie removed the PCO2A and NUTNR from the Surface Buoy and brought them to the ship. The PCO2A needed a FW update; the NUTNR needed a pre-deployment cal in the ship's cold room.

2 August 2019

All personnel were aboard by 07:30, and a Science Briefing was held at 08:00.

Allen, Colin and Stephanie went to the warehouse around 09:00 to re-install the PCO2A instrument, and re-board the ship from there.

R/V *Neil Armstrong* shifted from the harbor to a dock near the Korngarðar warehouse at 09:45. The buoy, EM Chain and WFP were loaded.

The ship sailed from Reykjavik at 14:00 underway to the Irminger Sea Array.

3 August 2019

Underway to the Irminger Sea Array. At 09:00 we stopped to conduct CTD casts to test the acoustic releases. We were ~175 NM from Iceland (still in Icelandic water). During CTD Cast #001 to 1000 m (with 3 acoustic releases: 48501, 50453, 50779), the CTD shut off at the bottom when attempting to fire a bottle. The rosette was brought back up without upcast data or water collection. Acoustic release 50779 indicated release, but did not release. A second rosette cast was done to 1000 m with 3 more acoustic releases (50686, 50466, 50684, all successfully released), but without a functioning CTD. The plan was to do 4 casts to test all acoustic releases. Instead we resumed transiting after 2 casts to troubleshoot the CTD issues. We left Icelandic waters around 17:00.

4 August 2019

Transit continued, making around 11 kts. Entered Greenlandic waters around 08:00. Troubleshooting of CTD issues continued with support from WHOI Marine Operations and Sea-Bird personnel on shore. At 19:25 the root cause of the CTD issue was identified. Approximately 2-3 inches of water had leaked into the Pylon housing and corroded the boards at the top of the housing. The Pylon is responsible for tripping the Niskin bottles, so CTD casts could be done with data collection, but without water sampling.

We arrived at the Irminger Array at 21:00 and set up just off the SUMO-5 buoy for overnight meteorological (MET) comparison beginning at 21:34.

5 August 2019

At 06:00 we stopped the MET comparison and set up for the SUMO-6 deployment.

Started SUMO-6 deployment at 08:34, and anchor drop was at 15:29 at 59° 56.6072' N, 39° 34.1905' W, 2688 m depth (corrected to 2664 m with Carter tables). No issues on deployment.

CTD Cast #002 – GI01SUMO site center to 1500 m with 3 acoustic releases for testing (50779, 50457, 48492). Release 50779 was a successful re-test. No water samples collected.

Anchor survey for GI01SUMO-00006. Used Sounds Speed Velocity (SSV) of 1487. Surveyed position was ~27 m from target location.

Acoustically downloaded ~20 kB of data from HYPM-5 mooring. The mooring is functioning and recent data includes CTDMO and ZPLSG. The WFP was later verified to have a dead battery after 14 months of deployment.

Overnight MET comparison at SUMO-6 buoy, beginning at 21:16.

Back on shore, the WHOI Marine Operations team began looking into options of getting a replacement CTD pylon shipped to a nearby port for transfer to the ship. There was not sufficient time to return to Reykjavik, so options in Greenland were investigated.

6 August 2019

At 06:47 we stopped the MET comparison and set up for the HYPM-6 deployment.

Started HYPM-6 deployment at 08:15, and anchor drop was at 12:37 at 59° 58.2686' N, 39° 31.7813' W, 2688 m depth (corrected to 2664 m with Carter tables). No issues on deployment.

CTD Cast #003 – GI02HYPM site center to 2650 m with 3 acoustic releases for testing (45269, 45599, 50681). All releases passed. An OOI DOSTA (S/N 502) was added to the CTD rosette and remained on for the rest of the cruise. No water samples collected.

Moved to position ~1 NM into Glider Box (NW corner) and deployed 3 gliders: 515 (GPG) at 17:20, 525 (BCP OOG) at 17:23, and 560 (OOG) at 18:05.

CTD Cast #004 – Glider deployment location to 1000 m. No water samples collected.

In transit to HYPM to start EK80 survey when Glider 515 aborted due to a leak. We returned to the Glider Box and recovered 515 (GPG) at 21:28.

Overnight EK80 survey – 3 km transit over HYPM-5 and HYPM-6 at 2 kts (1 kt when over the moorings).

7 August 2019

Started FLMA-6 deployment at 08:21, and anchor drop was at 13:34 at 59° 46.1752' N, 39° 53.1695' W, 2716 m depth (corrected to 2692 m with Carter tables). No issues on deployment.

CTD Cast #005 – GI03FLMA site center to 2600 m with 1 acoustic release for testing (48595). Release passed. No water samples collected.

Anchor survey for GI03FLMA-00006. Used SSV of 1487.

Acoustically downloaded ~20 kB of data from FLMA-5 mooring. There were no communications above the EM Chain since deployment. The MSIOC, ADCP and deepest 4 CTDMOs are good.

Transited to FLMB-5 to acoustically download data (~20 kB). The MSIOC, ADCP and all CTDMOs are good; no data from the Biopackage (presumed to be a Persistor issue; the PHSEN is not connected to the SSIOC).

Back on shore arrangements were finalized for Ellen Roosen to hand carry the CTD pylon to Nanortalik, Greenland for a small boat transfer in Prince Christian Sound on or about 13 August.

8 August 2019

Started FLMB-6 deployment at 08:09, and anchor drop was at 13:20 at 59° 43.2980' N, 39° 21.2008' W, 2842 m depth (corrected to 2819 m with Carter tables). No issues on deployment.

CTD Cast #006 – GI03FLMB site center to 2750 m w/ Styrofoam cups. No water samples collected.

Anchor survey for GI03FLMB-00006. Used SSV of 1487.

Deployed USBL Test Mooring (CASIUS) at 18:35 at center of Array (surveyed position 59° 50.0431' N, 39° 31.0032' W).

SSSG techs conducted USBL calibration overnight including non-OOI CTD Cast #007.

9 August 2019

Recovered SUMO-5 mooring – anchor release fired at 08:04; glass balls on the surface at 08:26. Mooring recovered bottom up. Small boat was used to hook the trawl wire to the buoy for recovery. On recovery, the port METBK SWND lightly hit the A-frame; no other issues. Recovery was completed at 13:27.

Anchor survey for GI02HYPM-00006. Used SSV of 1487.

Updated the VICS software on the SUMO-6 mooring – changed the boot delay from 10 secs to 1 sec.

SSSG techs attempted further USBL calibration, but the beacon would not respond.

10 August 2019

Recovered the HYPM-5 mooring – anchor release fired at 06:34; top sphere on the surface at 06:35, glass balls on the surface at 06:59. Top sphere hooked before glass balls surfaced; mooring recovered bottom up. Recovery was completed at 09:25.

Recovered the FLMB-5 mooring – mid-water release fired at 12:09; top sphere on the surface immediately. Top half of recovery completed at 13:27. Anchor release fired at 14:15; mid-water sphere on the surface at 14:22; glass balls on the surface at 14:43. Recovery completed at 17:43. No major issues.

Transited to Glider box to re-ballast both gliders – 525 and 560. Used small boat ops to add wing rail weights to both gliders while in the water. 6 weights added – 4 to port wing rail, 2 to starboard wing rail. In the vicinity of the gliders at ~19:00, small boat ops completed ~20:15.

CTD Cast #008 – near the center of the Glider Box in the vicinity of the re-ballasted gliders, cast to 1000 m depth. 3 acoustic releases rigged to trip 3 bottles (7, 11, 19) at depths of 850 m, 650 m, 300 m. On upcast, the rosette was stopped for 5 min. every 100 m and at water sampling depths to allow the OOI DOSTA to equilibrate.

SSSG techs attempted further USBL calibration, but the beacon would not respond.

11 August 2019

Recovered the FLMA-5 mooring – mid-water release fired at 08:25; top sphere on the surface immediately. Top half of recovery completed at 09:35. Anchor release fired at 10:12; mid-water sphere on the surface at 10:18; glass balls on the surface at 10:39. Mid-water sphere hooked at 10:25 before glass balls surfaced; mooring recovered bottom up. Recovery completed at 13:02. No major issues.

Recovered the USBL Test mooring – anchor release fired at 14:32; glass balls on the surface at 14:58; recovery completed at 15:17.

CTD Cast #009 – In between the SUMO-6 and HYPM-6 moorings to 2500 m depth. 4 acoustic releases rigged to trip 2 bottles each (7 & 8, 11 & 12, 19 & 20, 23 & 24) for water samples at depths of 2500 m, 500 m, 80 m and 12 m.

Acoustically downloaded data from HYPM-6 mooring. All instruments and profiler working and reporting data. The CTDMO reported pressures of 153 to 172 dbar.

Used the EK80 to image the HYPM-6 mooring. Sphere was identified at a location ~80 m south of the anchor position. The sphere was at 145 m, the EM Chain termination at 152 m, the CTDMO at 155 m, and the Bumper Stop at 156 m.

12 August 2019

CTD Cast #010 – At the FLMB-6 mooring to 2500 m depth. 4 acoustic releases rigged to trip 2 bottles each (7 & 8, 11 & 12, 19 & 20, 23 & 24) for water samples at depths of 2500 m, 500 m, 90 m and 30 m.

Acoustically downloaded ~32 kB data from FLMB-6 mooring. All instruments working and reporting data; but gaps in the ADCP data. The 30 m CTDMO reported pressure of 37 dbar.

Departed the Array for Greenland at 10:18. Entered Prince Christian Sound around 21:20, and took shelter for the night in a small cove just inside the mouth of the Sound.

Clocks turned back 1 hour overnight (to local shiptime = UTC - 1 hr)

13 August 2019

Weather conditions on the west side of Greenland were too rough for the small boat conducting the CTD pylon transfer, so the rendezvous was postponed one day. The *Armstrong* transited farther up the Sound to try to find more sheltered waters, and make the trip for the small boat shorter the next day. Winds were extremely strong within the Sound (30-40+ kts with higher gusts). We found a good spot about 3/4 through.

We received a request to recover a drifting float from an OSNAP mooring in the Labrador Sea on our transit home (Johannes Karstensen from GEOMAR).

14 August 2019

The small boat departed Nanortalik at 08:00 Greenland time (10:00 UTC) and arrived at the ship at 11:15 UTC. The CTD pylon was transferred to the ship, and R/V *Neil Armstrong* souvenirs, cookies and fruit were transferred to the small boat as thanks.

We got underway at 11:30 and exited the east side of the Sound at ~15:00. At ~18:00, once we were 12 miles from shore, we conducted a test CTD cast and confirmed the new pylon worked (all bottles were successfully fired).

15 August 2019

CTD Cast #011 – in between the SUMO-6 and HYPM-6 moorings, with Gliders 525 and 560 just to the east of HYPM-6; cast to 2500 m depth. All 24 bottles were fired collecting both OOI and BCP water samples from 2500 m to the surface.

Once the CTD was on deck, the ship transited to FLMB-6. Water sampling of the CTD rosette occurred throughout the transit.

Used the EK80 to try to image the FLMB-6 mooring. A hint of what was assumed to be the top sphere was imaged at ~35 m. This corresponds to the CTDMO pressure of ~37-38 dbar from the acoustic data download on 12 August.

Had to wait for water sampling from the first CTD cast of the day to be completed before the next cast could begin.

CTD Cast #012 – At the FLMB-6 mooring to 2700 m depth. 15 bottles were fired collecting both OOI and BCP water samples from 2700 to the surface.

Once the CTD was on deck, the ship transited to FLMA-6. Water sampling of the CTD rosette occurred throughout the transit.

Acoustically downloaded ~59 kB data from FLMA-6 mooring. All instruments working and reporting data; but gaps in the ADCP data. The 30 m CTDMO reported pressure of ~36-37 dbar.

CTD Cast #013 – At the FLMA-6 mooring to 2600 m depth. All 24 bottles were fired collecting both OOI and BCP water samples from 2600 to the surface.

Once the CTD was on deck, the ship departed the Array at ~22:30 for Woods Hole. We departed earlier than originally planned due to weather forecasts suggesting headwinds on our transit home, which could add an additional day to the transit.

Clocks turned back 1 hour overnight (to local shiptime = UTC - 2 hr)

16 August 2019

Continued transiting (~10-11 kts SOG) – winds 17-19 kts out of the NW

Contacted Johannes Karstensen and Christian Begler (GEOMAR) for position updates of the ONSNAP K1 upper float. Automated Sable beacon position emails sent to bridge@armstrong.whoi.edu.

17 August 2019

Continued transiting (~10-11 kts SOG) – winds ~17 kts out of the SW

Arrived at the last known position of the OSNAP K1 float around 11:45 UTC. New positions were supposed to be sent every 30 minutes, but were still coming in only every 2 hours. After a new position arrived at 12:12, the ship was able to located the float. It was hooked and recovered on deck in 4 minutes. The recovered portion consisted of 2 glass balls and a Sable beacon attached to a metal frame, with 1.2 m of chain beneath it, and ~8 m of nylon rope with one SBE MicroCAT CTD attached. The Nylon rope was severed ~1 ft below the MicroCAT.

Resumed transit home (~10 kts SOG) – winds ~20 kts out of the SW

18 August 2019

Continued transiting (~8-10 kts SOG) – winds out of the SW decreasing from ~25 to 15 kts throughout the day.

Entered Canadian waters at 16:05 – last water sample taken, and ADCPs and pCO_2 systems turned off.

19 August 2019

Continued transiting (~8.5-10 kts SOG) – winds out of the SW ~6 to 17 kts.

20 August 2019

Continued transiting (~8-10 kts SOG) – winds out of the SW to W ~4 to 23 kts.

Began making plans for a Saturday morning arrival (customs can come on Saturday, morning tide is ~10:00 local).

21 August 2019

Continued transiting (~9-10 kts SOG) – winds out of the NW coming around to the S ~2-7 kts.

Clocks turned back 1 hour overnight (to local shiptime = UTC - 3 hr)

22 August 2019

Continued transiting (~8-10 kts SOG) – winds out of the S, SW ~4-10 kts.

23 August 2019

Continued transiting (~8-9 kts SOG) – winds moving from the SW to N and dropping from ~6-8 kts to ~3 kts.

Overnighted off-shore of Oak Bluff, Martha's Vineyard.

24 August 2019

Arrive at WHOI at 14:25.

Off-load gear onto dock and to LOSOS building.

Some personnel remained on ship overnight due to early arrival.

1.4. Weather and Operating Conditions

Weather conditions during the first part of the Irminger 6 cruise were extremely favorable due to high pressure over the area (Figure 1-3). From 5 to 11 August winds were between 1 and 10 kts (Figure 1-4) with only light swell and negligible waves. These conditions enabled the completion of all 4 mooring deployments and 4 mooring recoveries within 7 days.

Conditions began to worsen on 12 August with decreasing pressure and increasing wind. The ship departed to Greenland (Prince Christian Sound) both to avoid the weather and to obtain a replacement CTD pylon. Even within the relatively sheltered Sound, winds were strong (30-40 kts in places) with gusts up to 70 kts. Measurements from the GI01SUMO-00006 mooring show that weather conditions at the Array during this time (Figure 1-5) were similar, with winds increasing from less than 10 kts to 30 kts, and seas building from 1-3 ft to 9 ft.

We returned to the Array the morning of 15 August. Winds were ~20 kts out of the north, with increased waves and swell compared to our previous time at the Array. But conditions were sufficient to conduct CTD casts.

We departed the Array to transit back to Woods Hole the evening of 15 August. Over the next 2 days, winds moved around from north to west to south. We were able to maintain a speed of ~10 kts through 17 August. Winds were primarily out the SW during our transit, but we were able to maintain a speed of about 8-10 kts, enabling an early arrival into port.

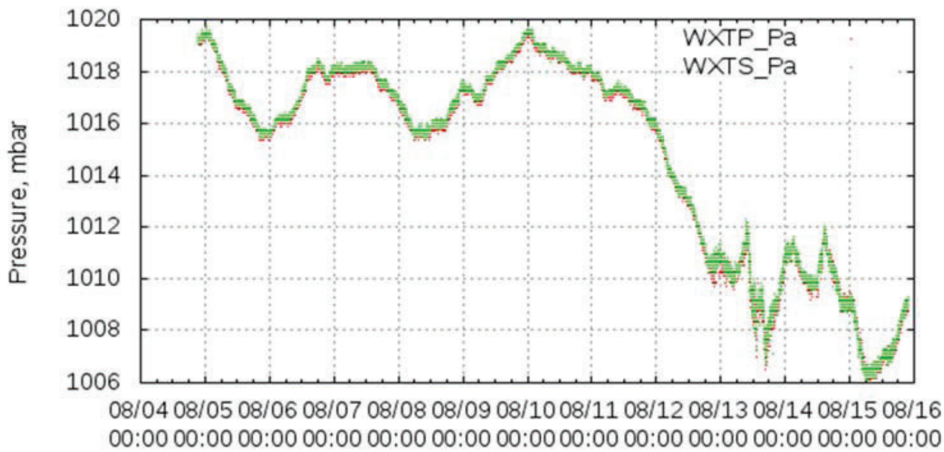


Figure 1-3 – Irminger Array weather
Barometric Pressure from the bow mast of the R/V *Armstrong*. Times are UTC.

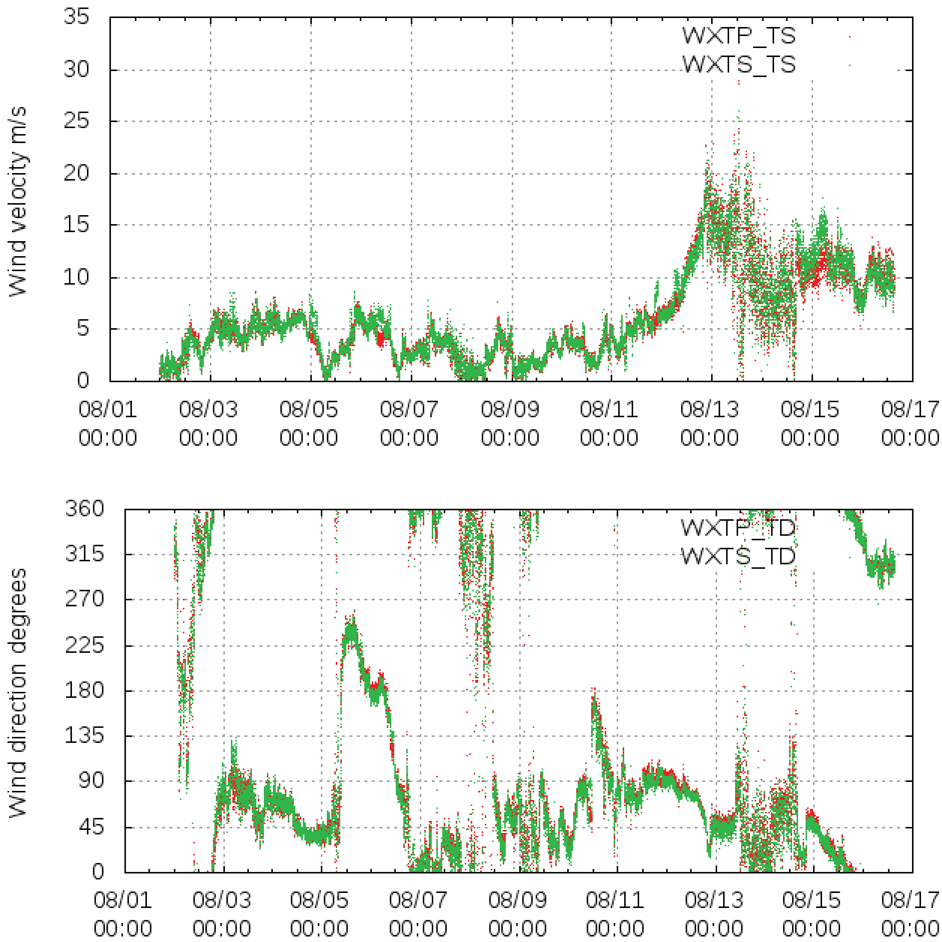


Figure 1-4 – Irminger Array weather
Wind speed and direction from the bow mast of the R/V *Armstrong*. Times are UTC.

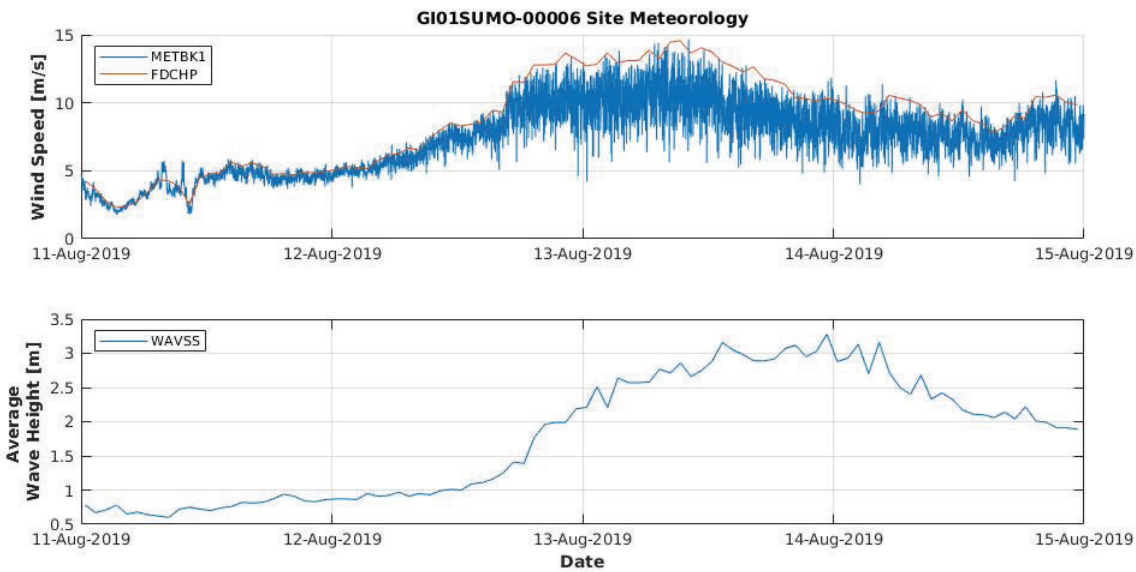


Figure 1-5 – GI01SUMO-00006 measured meteorology during weather event

2.0 Pre-Cruise Operations

Principal pre-cruise operations included integration and testing of the Surface Moorings at the WHOI LOSOS building, and integration and testing of the Subsurface Moorings at the WHOI LoNo building. These operations are described briefly below. Note that standard preparation fabrication, integration and testing according to Technical Data Package and verification procedures are not described. Instead, this section provides a general overview of integration and testing operations and notes any anomalies and how they were addressed.

An Installation Readiness Review (IRR) was held Tuesday, 16 July 2019 at 13:00 EDT at the WHOI LOSOS Building. The IRR checklist was signed off by CGSN Project Manager (PM) Derek Buffitt and approved by OOI PM Paul Matthias prior to departure.

Remote integration and build were completed in a warehouse at Korngarðar 2 in Reykjavik. Gear was loaded onto the ship at the fishing dock in Reykjavik harbor and at the container ship dock at Korngarðar.

2.1. Global Surface Mooring Preparation

The Surface Mooring build process began with bench-top testing of the Platform Controller (PlatCon), cables and instrument components in the lab at LOSOS. The Buoy well was subsequently populated and tested in the high bay integration area; the masthead was populated with telemetry and METBK instruments. The masthead was then dressed with previously tested cables and the cables were dressed with Tygon tubing. The Near Surface Instrument Frame (NSIF) was populated with all instruments and platform control components. The sub-surface instrument frames were populated with all instruments.

On 10 May 2019 the well, NSIF, masthead, ADCP and inductive instruments were relocated to the burn-in area where the subsurface buoy instrument panels and NSIF were placed in a saltwater tank to check for proper operation. The inductive instruments were also connected and were placed near the test tank on a cart.

Each checklist shown below was completed to verify the complete functionality of the entire platform:

- 3403-50212 – Surface Mooring Initial Communication Checklist
- 3403-50215 – Surface Mooring Initial Instrument Checklist
- 3403-50217 – Surface Mooring Well Leak

The platform was kept in the burn-in area until 17 June 2019 when the shipment preparation began. All equipment was shut down and packed for shipment in shipping containers. The containers left WHOI on 24 June 2019 for ocean shipment to Reykjavik, Iceland.

The Surface Mooring mobilization team began the mobilization process on 23 July 2019 at the Korngarðar warehouse in Reykjavik, Iceland. By the end of the first day the buoy well was hooked up to all telemetry and instrumentation (with the exception of the inductive instruments), and all were tested with both the primary and backup Communications and Power Mangers (CPMs).

On the second day of the mobilization, all power sources (photovoltaic – PV – panels and wind turbines) were tested and working. The masthead was mounted onto the tower and then attached to the well. Inductive instrument communications were verified by hooking up the CTDMOs.

The buoy well/tower insert was installed into the foam on the third day. Additionally, the buoy camera was installed and adjusted to find the correct orientation, and the ventilation hoses and PV panels were installed. The compass characterization was also completed on this day.

On the fourth day, the subsurface instrument panels were attached to the buoy and laced. This was the first year that the subsurface panel instrument cables were pre-laced with Tygon tubing. It was slightly more difficult to run the cables up the buoy's tubing to the J-boxes, but still manageable. The rest of the buoy's lacing was also completed on this day. The inductive CTDMOs and CTDBPs were launched via the buoy, and code version 1.3 was installed on the Visual Inspection Camera System (VICS), which included updates to keep high-res photos on the camera and not transfer them to Data Concentrator Logger (DCL). Lastly, the Electro-Mechanical (EM) chain was connected between the buoy and riser electronics.

The Surface Mooring was then allowed to operate in a steady-state and burn-in for a few days. Every computer board, instrument, and communication pathway operated as expected and no issues were noted during the burn-in phase.

On the seventh day of the mobilization, the buoy was turned off and broken down to prepare for staging and shipment to the dock.

On 31 July 2019 it was noted by a member of the instrument team that the PCO2A firmware would need to be updated before deployment. In order to properly update the firmware, the instrument had to be removed from the subsurface panel on the buoy. Doing so required removing the air intake and exhaust lines that travel from the instrument, up the corner tube of the buoy frame to the air intake box mounted on the forward tower leg. In order to ensure the air lines could fit back up the through the buoy corner tube when the instrument was reinstalled, a snake-line was tied to each air line before it was pulled down the tube. The software was successfully updated by the instrument team and it was reinstalled to the subsurface panel on 1 August 2019.

2.2. Global Subsurface Mooring Preparation

Many of the components/instruments recovered during Irminger 5 were refurbished, recalibrated, and tested for the Irminger 6 deployment. The bio-package and controller cage assemblies were integrated, and connected via inductive test cables to the rest of the instrumentation (ADCPs, CTDMOs, ZPLSGs, and Wire Following Profiler – WFP) (Figure 2-1 and Figure 2-2) and to the Raspberry Pi test computer for burn-in testing. The moorings were burned-in for several weeks.

While starting the Irminger burn-in, it was noted that there was an issue with the HYPM ACOMMs not responding. A factory reset was done and it was put into Data Logger Mode, but ultimately it was determined that it should be swapped out with another more functional unit.

During the burn in operations data were checked periodically. It was noted that some of the CTDMOs were out of calibration, and any that were two or more years old were put back into storage and swapped for different CTDMOs. The FLMA PHSEN was also found to be faulty and was replaced. The faulty unit was inspected by a Sunburst technician, who found that an optic fiber inside the housing was pinched. It was suspected that the optic fiber was pinched when the housing was removed to reconnect the battery at Sunburst prior to shipment to WHOI.

After the burn-in was completed all instruments and controllers were shut down and put into hibernate mode for shipping. ZPLCG batteries were unplugged to avoid an auto-deployment in the shipping case. Mooring components and cruise kits were packed and prepared for shipment.

Figure 2-1 – GI03FLMA-00006 Lab Burn-in

Figure 2-2 – GI03FLMB-00006 and GI02HYPM-00006 Lab Burn-in

The integration and testing in Reykjavik began on 24 July 2019. The gear was unpacked and organized at the warehouse, and the mooring components were assembled (Figure 2-3). All reassembly and testing went smoothly. No issues were found with the moorings. The only issues were with Wi-Fi connection to the remote Raspberry Pi setup that was used monitor the burn-in progress, which would not affect mooring performance.

The glider team tested the acoustic modem download using a simulated ACOMM mission. Glider data were compared to the serial downloaded data from the acoustic modem to verify similarity.

Figure 2-3 – Subsurface Mobilization Burn-in Set-up
GI02HYPM-00006 (left), GI03FLMA-00006 (center), GI03FLMB-00006 (right)

Prior to transporting the moorings to the ship on 2 August 2019, all data were downloaded and the moorings were disconnected from the inductive and serial monitoring, controllers and CTDMOs were palletized, cables were broken down, and any boxes required for burn-in were consolidated. All connections were dummied off, and instruments and controllers were left running and deployed, except for the WFP.

On 2 August 2019, Subsurface moorings were brought to the dock from the warehouse. Mooring components were staged and secured on deck, in the hanger, and in the main lab for burn-in during transit.

2.3. Glider Preparation

Two OOI Open Ocean Gliders (gi_525 and gi_560) and one OOI Global Profiling Glider (gi_515) were assembled, integrated and tested at WHOI. These gliders were assembled from various sub-assemblies, all of which were carefully selected from the OOI inventory after returning from the vendor post-refurb and calibration, per the OOI Glider Refurb and Integration Procedure (3407-30045).

Once the gliders were assembled the ballast phase of integration began, per the OOI Ballasting Procedure (3407-30037). All three gliders were ballasted in the lab's freshwater tank to a target density of 1024.5 kg/m^3 at 6°C, which is the same ballast point that was used for Irminger 4 and 5. All three gliders were successfully ballasted to this target density (+/- 1 g) with even trim.

After the gliders were ballasted, they each were sealed per the OOI Final Seal Procedure (3407-30037). The final seal procedure begins with a deep cleaning and close inspection of the hulls using a Dino Lite Microscope Camera Imaging system. This process is used to look for scratches and imperfections on the hull sealing surfaces. While inspecting gi_525's hulls, a scratch was detected on the energy bay hull and it was rejected. The hull was sent to the vendor for a repair/buff job and returned to WHOI where it passed inspection. All other hulls were deemed deployment-worthy.

Once the gliders were sealed, they entered the Functional Checkout Procedure (FCP) phase, per 3407-00100. While each glider ultimately passed each section of the FCP, there were a few issues that required intervention. First, it was noted during gi_515's FCP that the glider was reporting a time of 1 November 1999. This issue was immediately recognized as the week rollover issue that many Garmin GPS units experienced worldwide in April 2019. The GPS unit was swapped with another unit that was known to be working the last time it was deployed. However, that did not fix the issue as the glider was still reporting the incorrect timestamp. After much troubleshooting in the lab and with the vendor's assistance, a fix was implemented. By replacing the GPS unit, as well as the coin cell battery that operates the real time clock board, a correct timestamp was maintained by the glider. Unfortunately, this issue was caught at this stage of integration and the final seal had to be completed again before it received another functional checkout.

During gi_560's FCP it was determined that the glider's acoustic transducer was not functioning. While communications to the acoustic modem could be achieved through the glider, the transducer would exhibit no response when given commands. After troubleshooting it was determined that the transducer was not plugged in during the glider's final seal process. This connection was likely missed because one side of the connector was zip-tied back in the same fashion it is on other gliders that do not have a transducer. After the transducer connection was established, it worked as expected. Unfortunately, this glider also had to be opened for this troubleshooting to occur, so the final seal procedure had to be completed again.

Having to open both gi_515 and gi_560 after the final seals were completed resulted in the integration phase taking longer than expected. In the future, it would be wise to quickly test the gliders' integral systems after they are assembled and before the final seal procedure is completed. Doing so could help prevent the discovery of failures and allow troubleshooting to occur without undoing the glider's seal.

Outdoor compass calibrations were completed on gliders using the TNT Revolution Software, per the OOI Compass Check and Calibration Procedure (3407-30038). After calibration, each compass was checked at 30 degree intervals while level, pitched up and pitched down. Compass readings were generally less than 5 degrees of variation from the values observed with the hand-held compass and often less than 3 degrees. All three gliders passed the compass check and did not require compass re-calibration. Iridium communications to both the primary and backup dockserver were tested, as well as the ARGOS position transmissions.

Glider gi_525 was allocated to the ancillary BCP project as noted in the Irminger 6 Cruise Plan (3202-00601). Also per the BCP project, the oxygen optodes (DOSTA) on both gi_525 and gi_560 were relocated from the side of the tail section to just above the strobe so that they protrude into the air when the gliders are at the surface (Figure 4-1).

2.4. Loading and Deck Layout

The R/V *Neil Armstrong* arrived in Reykjavik on 29 July, and refueled by barge at the Grandabryggja fishing dock in the harbor on 30 July.

Loading of the ship began at the dock on 31 July. The storage van filled with lab gear (instruments, cruise kits, etc.), the Rigging Van, and other equipment from the warehouse were trucked to the dock in town for loading. Winches, anchors, and the ball van were delivered directly to the dock for loading. On 2 August, prior to departing Reykjavik, the ship moved to a dock near the Korngarðar warehouse for loading of the Surface Mooring buoy, EM chain and Wire Following Profiler (WFP).

The Surface Buoy and NSIF were positioned under the A-frame and staged for deployment (Figure 2-5). Anchors were positioned along both the port side of the fan tail. The subsurface spheres were positioned along the starboard rail. The Lebus winch was mounted along the centerline, with the TSE winch just to starboard. The Lebus power pack was located in the hangar along with the acoustic releases, Subsurface Mooring controller cages, and Surface Mooring ADCP and Instrument Frames.

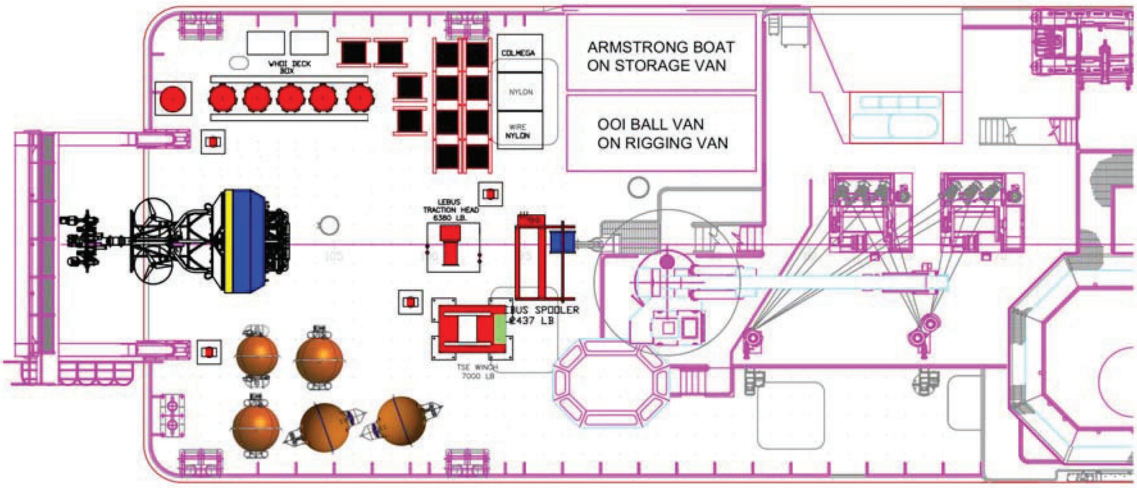


Figure 2-4 – Planned Deck Layout

Figure 2-5 – Actual Deck Layout

The forward center and portside benches in the Main Lab were used for OOI personnel and equipment, with the 3 gliders on the starboard side of the center bench. OOI inductive instruments and the WFP were set up at the aft end of the Main Lab. The rest of the aft bench was used for ancillary chemistry activities (BCP). The walk-in freezer in the Main Lab was set at 10° C and used for storage of spare instruments, and some small water samples for the ancillary work. The Wet Lab was primarily used for OOI Water Sampling, and the walk-in freezer in the Wet Lab was set to -10° C. The Wet Lab walk-in was changed to 4° C during the transits to support pre- and post-deployment calibration of the NUTNR instruments.

3.0 Platform Deployments/Recoveries

3.1. Preparation during transit

3.1.1. Global Surface Mooring

The Surface Buoy, EM Chain, NSIF and first 26.9 m shot of inductive wire rope were staged on deck and connected prior to departure. For the Irminger 6 deployment, a new, larger 30-degree U-Joint was deployed (Figure 3-1). The U-Joint was connected to the EM Chain with 1/2 Inconel hardware, which was torqued to spec and marked. Gaskets between the EM Chain, adapter plate, U-Joint, and Surface Buoy were nylon reinforced. The changes above were all implemented to prevent a re-occurrence the failure that occurred on the GI01SUMO-00004 mooring that caused the buoy to go adrift.

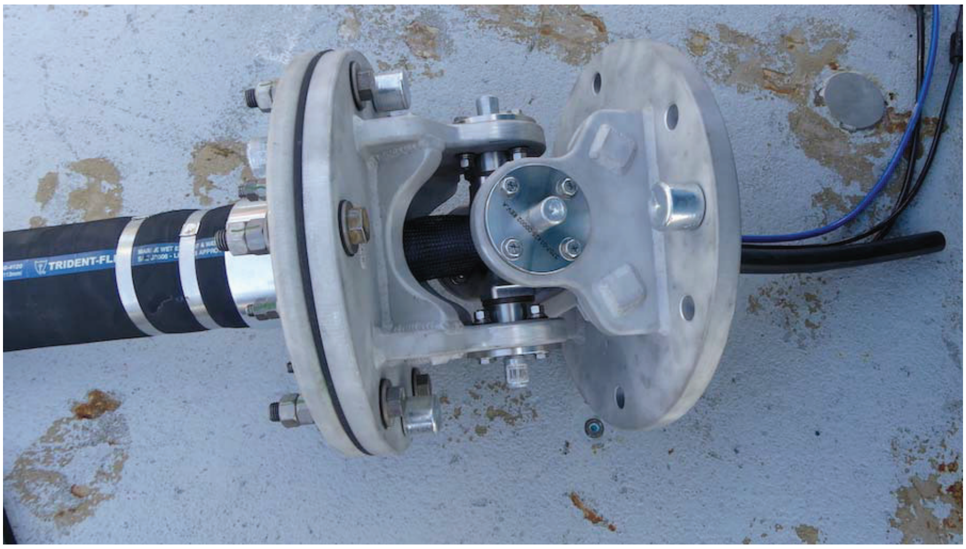


Figure 3-1 – Global 30-degree U-Joint

The EM chain was connected such that the orientation of the NSIF would put the SPKIR instrument upwind of the buoy, minimizing shadowing of the SPKIR as the buoy is blown downwind (see Section 6.3). This alignment assumed that the EM chain twists only minimally, keeping the buoy and NSIF in a fixed orientation relative to each other.

During the transit, test cables were used to run the inductive line from bottom end of the first shot of inductive wire rope to the ADCP and instrument cages in the hangar, and into the Main Lab through the remaining inductive riser instruments (CTDMOs and PHSEN-Es). The Surface Buoy and NSIF were powered on and tested during the transit to confirm functionality of the Surface Buoy, NSIF, and inductive instruments. A power supply/battery charger was installed on the ship and connected to the buoy to maintain a full charge on the batteries prior to deployment. The charger was disconnected the evening prior to deployment. The battery was at 100% charge when deployed.

During transit all instruments were tested and monitored. Pumps were disconnected from the instruments to avoid damaging the pumps by running them dry. There were some initial difficulties with configuring and grounding the inductive test line. These issues were resolved by making sure the ground pins/wires and cables were properly grounded, while the signal pins/wired were routed through the instruments to complete the inductive loop.

3.1.2. Global Subsurface Moorings

The Subsurface Mooring spheres were clustered together on the starboard side of the deck, so that the spheres (with bio-packages and ADCPs) could be connected to the controller cages in the hanger and the CTDMOs and profiler in the Main Lab using the inductive test cables (Figure 3-2). Testing was conducted during the transit to confirm functionality of all mooring components.

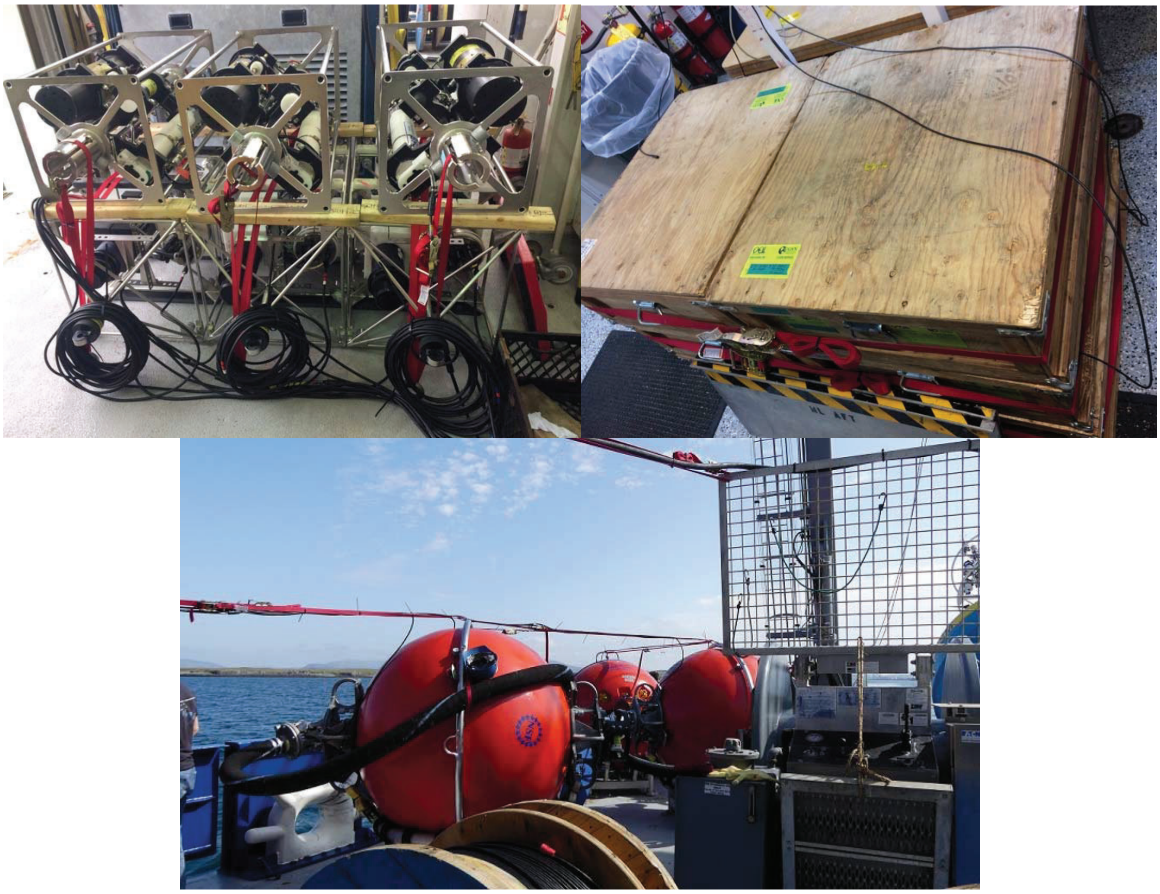


Figure 3-2 – Subsurface Mooring Deck and Lab Set-up

Some issues were found with the FLMA SSIOC (Secondary SIO Controller) getting hung up and automatically resetting upon disconnecting and reconnecting the COM line. The watchdog had been flashed with a new Basic Stamp program with the wake pin (Input 2) disabled. The new code should allow the watchdog to reset the Persistor while the COM line is connected, as tested on the bench test setup in the lab. After waiting for longer than the prescribed six hours, analyzing the data showed an almost 1-day gap in the SSIOC controller data, showing that the code fix for the watchdog did not work when the controller was hung in this particular configuration. Rebooting the Persistor made the issue go away, and the controller remained stable without further errors through the remainder of testing and initial deployment.

In addition, we noticed one of the acoustic prongs on the VEL3D stinger on the WFP was not aligned perpendicular to the central post (Figure 3-3). The vendor, Falmouth Scientific, Inc. (FSI), was contacted and confirmed that the stinger did pass all of their testing and is okay to deploy.

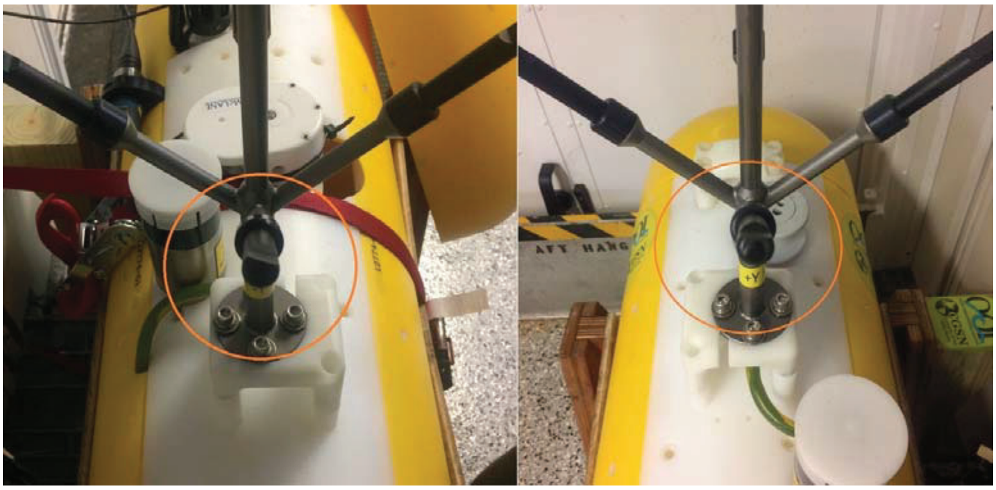


Figure 3-3 – GI02HYPM-00006 VEL3D stinger comparison between the skewed -Y (left) and normal +Y (right)

The FLMA ADCP (S/N 21450) was having communication issues that caused disconnections and hanging of the serial line when connecting with a test cable from the ADCP to a laptop without externally powering the ADCP. This suggested that the ADCP batteries were suspect, and there was no record we could find of the ADCP unit going through refurbishment and Quality Conformance Testing (QCT) after its last recovery. However, the ADCP had been running normally and collecting data as expected until attempting to connect to it directly on the ship, and when external power was applied through the ADCP test cable, this issue was resolved and we were able to confirm that the ADCP was properly programmed and ready for deployment. This led us do decide to deploy with this unit as-is instead of incurring additional risk from swapping ADCP units or opening the ADCP to replace some of the batteries (we did not have enough spare batteries to give it a full fresh set).

3.2. GI01SUMO-00006 Deployment

3.2.1. Deployment

The GI01SUMO-00006 Surface Mooring was deployed on 5 August 2019. The deployment start location was 6.5 nautical miles (NM) NW of the nominal anchor target site. There was negligible wind and current, and only light swell. The ship's 9/16” trawl wire was reeved through the center block on the A-frame, then connected to the 5-ton Peck and Hale quick release hook. The NSIF was positioned near the starboard side of the A-frame. A 40-foot orange slip line was rigged through the NSIF frame, then hooked into a spectra leader on an air tugger. Prior to the start of the mooring operation, the NSIF was lowered over the transom into the water using the air tugger and A-frame, the slip line was removed transferring the load of the NSIF and EM chain to the surface buoy.

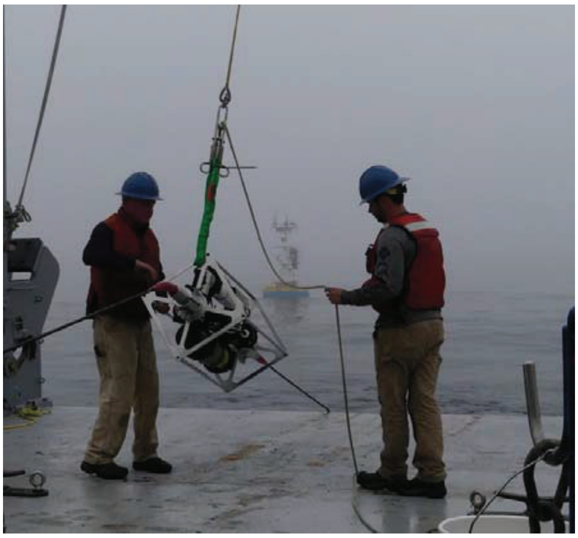
A four foot red liftall sling was barreled through the lifting bail of the buoy and hooked into to the Peck & Hale release. Four slip lines (2 blue@ 80’ and 2 yellow@ 65’) were used to control the buoy during the deployment. The first 26.9-m wire shot was connected to the 40-m Instrument Cage, and the CTDMO and PHSEN were attached to the wire at the 20-m depth mark prior to the deployment.

The trawl wire was hauled in lifting the buoy off the deck, the A-frame was boomed out while the winch paid out keeping the load level (Figure 3-4). The blue slip lines were cleared first. As the buoy settled in the water the Peck & Hale was released and the yellow slip lines were cleared.

Figure 3-4 – Deployment of the GI01SUMO-00006 Surface Buoy

The wire rope was deployed hand over hand and the 40-m Instrument Cage was moved to the aft of the fantail and stopped off. The CTDMO was attached to the wire at the 60-m depth mark. The port tugger line was reeved through the center A-frame block and connected to the Instrument Cage with the Peck & Hale release. The 40-m Instrument Cage was lifted off the deck and the A-Frame boomed out. The Cage was released into the water and the slip line paid out as the 38.9-m wire shot was deployed hand over hand. At the termination, a Yale grip was attached, and the 80-m Instrument Cage connected. This Cage was once again deployed using the port tugger and a slip line. At the 100-m depth mark on the 48.9-m wire shot, the CTDMO and PHSEN were attached. At the termination, a Yale grip was attached, and the 130-m Instrument Cage connected (Figure 3-5, left). The 368.4-m wire shot was on the Lebus and connected to the Instrument Cage. This Cage was once again deployed using the port tugger, but because the following wire shot was on the Lebus, no slip line was needed.

Once the 130-m Instrument Cage was in the water and clear of the ship, the wire rope was placed into the traveling snatch block. At designated depths, the winch was stopped so instrumentation could be clamped onto the wire (Figure 3-6). With 8 wraps remaining on the 368.4-meter reel the Lebus was stopped and a Yale grip was place on the high tension side of the winch and then stopped off to a deck cleat. The remaining wire rope was spooled off the reel and flaked on deck. The empty reel was removed from the spooler and the reel with the ½-inch Amsteel blue winch leader was installed. A Yale grip was attached about 1 meter from the end of the bottom IM termination. The Yale grip was then shackled to the winch leader and remaining wire rope was wound onto winch leader reel. Once tension was applied to the spooler, the stopper line on the high tension side was eased off and cleared from the Yale grip. The Yale grip was then removed and payout continued. When the lower termination passed through the low tension gate, it was passed around the heads of the winch with assistance of 2 deck personnel.



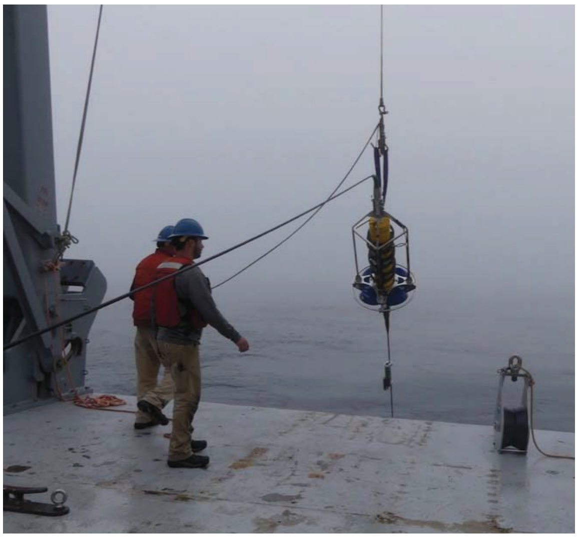


Figure 3-5 – Deployment of GI01SUMO-00006 130 m Instrument Cage and ADCP

Prior to the lower IM termination passing through the traveling snatch block, the Nystron stopper line was snapped into the Yale grip and made fast to a deck cleat. The Lebus winch was slacked and cleared from the Yale grip. The wire rope shot was removed from the snatched block. The ADCP cage was moved in to position and bolted to the lower termination of the 368.4-m shot. The winch leader spool was replaced with the 1000-meter IM shot. The 1000-meter shot was passed through both gates of the capstan and bolted to the bottom of the ADCP cage. The spooler operator paid out the wire slowly so a deck tech could wind the capstan heads with six wraps. The trawl wire, reeved through the center A-frame block, hauled in raising the ADCP of the deck. The A-frame boomed out while the Lebus paid out keeping the ADCP level off the deck (Figure 3-5, right). Once the ADCP cage was in the water and clear of the ship, the wire rope was placed into the traveling snatch block. The wire continued to pay out while stopping at designated depths to attach instruments.

Figure 3-6 – Installing the 1500 m CTDMO on the GI01SUMO-00006 mooring

With roughly 8 wraps remaining on the reel, the Lebus was stopped and the Yale grip was placed on the high tension side of the winch. A stopper line was then connected into the eye of the Yale grip, then made fast by a Nystron stopper line made fast to a deck cleat. (**Note:** This process of stopping off the mooring cables with a Yale grip on the high tension side of the winch is repeated at every wire rope connection. The installation of the Yale grip prevents slippage of the wire on the low tension side of the traction heads if the wire was to go slack for some unforeseen reason.)

The 300-meter reel of 3/8" wire rope was installed on the spooler. The terminations ends of the 3/8" and 7/16" wire ropes were shackled together with a 7/8" link between them. A canvas wrap was placed around the terminations prior to spooling the slack wire on top of the 3/8" wire rope. The winch took the load and the stopper line was slacked and removed. The winch then continued to pay out wire. At the end of the 300 meters with 8 wraps remaining on the drum, the cable was stopped off.

The remaining 300-meter shot was removed from the wooden reel, then shackled into the top of 100-meter shot of 3/8" wire to nylon special termination. This wire/nylon section had previously been flaked on deck. An additional five wraps were added to the capstan heads in order to prevent the wire from slipping on the heads as this section of the mooring would be tensioned by hand. The stopper line was slacked, allowing form the removal of the Yale grip. The winch slowly paid out the 100 meters of wire until the wire/nylon boot was close to the gates on the low tension side of the Lebus. At this point a Yale grip was permanently installed on the high tension side and stopped off using a 150' 3/8" Yalex slip line that was made fast to a deck cleat. Once the mooring was stopped off, both upper fairlead rollers on the gates were removed to allow the wire/nylon boot to slip pass the winch. When the boot was clear of the winch, the 90 meters of Plymkraft over braid nylon was wrapped around the capstan heads with six turns, the rollers were reinstalled. The yellow slip line was then slacked transferring the mooring load back on the Lebus winch. Payout of the synthetics resumed (Figure 3-7).

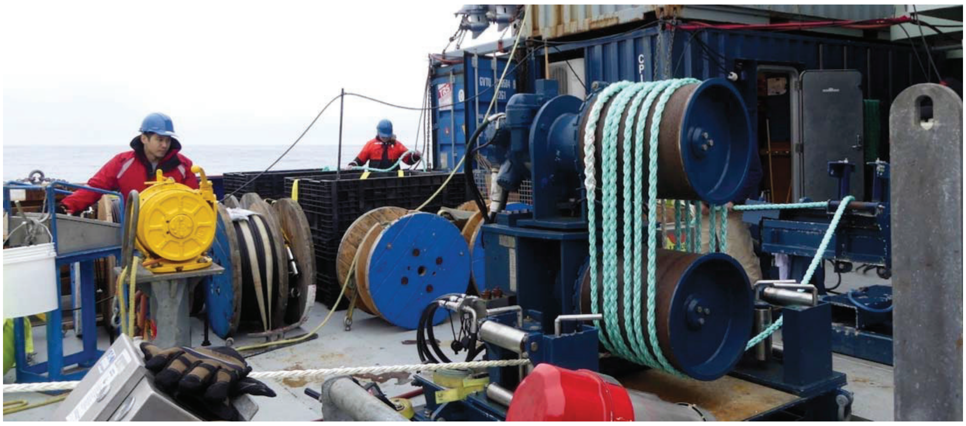


Figure 3-7 – Deploying synthetic section of GI01SUMO-00006

With roughly 20 meters of Colmega to be paid out of the Ropack containers, a Yale grip was installed on the high tension side and stopped off. The winch tag line reel was installed on the spooler, then connected to the termination on the end of the Colmega. The remaining slack of the Colmega was wound on top of the winch tag line reel. The stopper line was slacked, cleared and the Yale grip was removed. The winch paid out until there was approximately two meters of Colmega on deck by the stern. The stopper line was attached to the 7/8" end link of the Colmega and stopped off. The traveling block was lowered and removed. Once the traveling block was lowered and removed, the first two set of balls was moved to the stern and shackled to the Colmega termination hardware. The Lebus winch leader was then shackled to the 7/8" end link on the forward sting of glass balls. The Lebus took tension, the stopper line was eased and cleared. The Lebus paid out the string of glass balls until there were two balls left on deck. The stopper was snapped into the aft 7/8" end link and made fast. This process for deploying the string of glass balls was repeated until all 16 sets of glass balls were deployed.

A 5-meter shot of trawler chain was shackled into the chain on the last set of balls, then stopped off so the anchor tip plate and mooring anchor could be moved into the launch position. The dueled Edgetech releases were moved into position under the A-frame. The releases were shackled to the 5-m shot of chain below the glass balls, the 5-m shot of chain and 20-m shot of Nystron rope were shackled into the master link below the release. Once all the connections had been made, a slip line was reeved through the 7/8" end link at the lower end of the 1” Nystron, the bitter ends were made fast to the Lebus winch line using bowline knots. Once all the connections were made, the slip line and 20-m shot of 7/8” Nystron were wound on the Lebus winch. With 400 meters to go to the anchor drop position, the releases were lifted over the stern using a chain hook that was connected to the 01 winch. Once the releases were deployed, the ship's crane wire was attached to the chain bridle on the tip plate, slack was removed. The Lebus winch slowly paid out the 20-m shot of 1” Nystron until the lower hardware connection was close enough to the anchor to attach the 1/2” chain to the lower 7/8” end link. Once this connection was made, the Lebus winch paid out the slip line transferring the mooring load to the anchor. The slip line was removed by untying one of the bowlines. As the ship passed over the anchor drop site, the back stay was removed; the crane wire was hauled in raising the tip plate off the deck just enough allowing the anchor to free-fall into the water.

The anchor was dropped at 15:29 on 5 August 2019, 260 m past the target location (based on last year's fall back distance).

3.2.2. Anchor Survey

Three locations were selected as survey points for ranging on the acoustic releases. At each survey point, three acoustic ranges were obtained using the release deck box with the ship's in-hull micromodem Gavial ITC-3013 12 kHz transducer. Water depth recorded at the drop location (59° 56.6072’ N, 39° 34.1905’ W) was 2688 m measured with the Knudsen (1500 SSV). The Carter-corrected depth is 2664 m. The depth of the releases is 2632, and the transducer depth is 5 meters. The sound speed velocity used was 1487 m/s.

Table 3-1 – GI01SUMO-00006 Anchor Survey Data

Survey Pt Latitude	Survey Pt Longitude	Slant Range (sec)
59° 56.2086’ N	39° 35.0081’ W	3.812
59° 56.6161’ N	39° 33.3507’ W	3.793
59° 57.1791’ N	39° 34.8480’ W	3.759

The anchor location was calculated using Art Newhall's Anchor Survey Software Matlab program. The solution (Figure 3-8) yielded an anchor position of **59° 56.7071' N, 39° 34.4403' W**. The fallback was 296 m. The distance from the target position was 27 m.

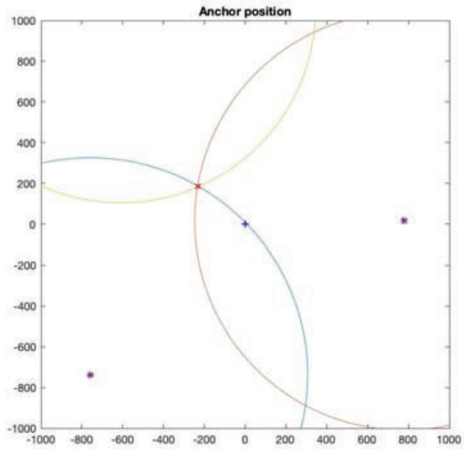


Figure 3-8 – Anchor Survey of GI01SUMO-00006

3.2.3. Validation

The GI01SUMO-00006 mooring functionality (instruments, telemetry, and power systems) was continuously monitored during transit, pre-deployment, deployment, and post-deployment. All telemetry and power systems were verified as functional. The mooring was successfully charging during periods of wind and sun. All instruments were verified as producing data pre-deployment. Post-deployment issues were noted with the following instruments:

- **PHSEN1 (20 m)** – invalid characters received from inductive modem immediately after deployment; no response from the modem since deployment; no telemetered data expected
- **PCO2W1 (40 m)** – invalid characters received from inductive modem immediately after deployment; no response from modem since 8 August; no telemetered data expected
- **PCO2W2 (80 m)** – modem responds but no valid data has been received since 8 August; no telemetered data expected
- **PHSEN2 (100 m)** – invalid characters received from inductive modem immediately after deployment; modem still responds but sends no valid data; no telemetered data expected
- **PCO2W3 (130 m)** – invalid characters received from inductive modem immediately after deployment; no response from the modem since; no telemetered data expected

These issues are noted in the 16 August 2019 Stoplight Chart (Table 3-2). There have previously been issues with PCO2W and PHSEN instruments failing or failing to communicate after deployment. It is unlikely that the cause of these issues can be determined prior to recovery next year.

Table 3-2 – GI01SUMO-00006 Stoplight Chart

System Status for	GI01SUMO-00006			
DCL	Pressure (psi)		% Operational Sensors	89%
DCL 16	9.7		% Operational Telemetry	100%
			% Operational Power	100%

	Sensor	Port	Deployed	Eng Check	Sci Check	Comments
DCL11	MOPAK	1	1	1	1	
DCL11	IMM	2	1	1	1	
DCL11	HYD1	3	1	1	1	
DCL11	DOSTA1	4	1	1	1	
DCL11	SPKIR1	5	1	1	1	
DCL11	METBK1	6	1	1	1	
DCL11	MET-HTR1	7	1	1	1	
DCL11	NUTNR1	8	1	1	1	
DCL12	OPTAA1	1	1	1	1	
DCL12	FLORT1	2	1	1	1	
DCL12	HYD2	3	1	1	1	
DCL12	PCO2A	4	1	1	1	
DCL12	WAVSS	5	1	1	1	
DCL12	METBK2	6	1	1	1	
DCL12	MET-HTR2	7	1	1	1	
DCL12	FDCHP	8	1	1	1	
DCL13	VICS-HTR	1	1	1	1	
DCL13	VICS	3	1	1	1	
DCL13	UV-LIGHT	5	1	1	1	
DCL13	VICS-LIGHT	7	1	1	1	
DCL16	OPTAA2	1	1	1	1	
DCL16	FLORT2	2	1	1	1	
DCL16	CTDBP	3	1	1	1	
DCL16	VELPT	4	1	1	1	
DCL16	PCO2W	5	1	1	1	
DCL16	DOSTA2	6	1	1	1	
DCL16	NUTNR2	7	1	1	1	
DCL16	SPKIR2	8	1	1	1	
INDUCTIVE	ADCP	ID 10	1	1	1	
INDUCTIVE	CTDMO01	ID 11	1	1	1	
INDUCTIVE	CTDMO02	ID 12	1	1	1	
INDUCTIVE	CTDMO03	ID 13	1	1	1	
INDUCTIVE	CTDMO04	ID 14	1	1	1	
INDUCTIVE	CTDMO05	ID 15	1	1	1	
INDUCTIVE	CTDMO06	ID 16	1	1	1	
INDUCTIVE	CTDMO07	ID 17	1	1	1	
INDUCTIVE	CTDMO08	ID 18	1	1	1	
INDUCTIVE	CTDMO09	ID 19	1	1	1	
INDUCTIVE	CTDMO10	ID 20	1	1	1	
INDUCTIVE	CTDBP01	ID 31	1	1	1	
INDUCTIVE	CTDBP02	ID 32	1	1	1	
INDUCTIVE	CTDBP03	ID 33	1	1	1	
INDUCTIVE	pHSEN1	ID 41	1	0	0	invalid chars received from modem; no response since deployed
INDUCTIVE	pHSEN2	ID 42	1	0	0	invalid chars received from modem; no valid data
INDUCTIVE	pCO2W1	ID 51	1	0	0	invalid chars received from modem; no response since 8/8
INDUCTIVE	pCO2W2	ID 52	1	0	0	some valid data right after deployment; no valid data since 8/8
INDUCTIVE	pCO2W3	ID 53	1	0	0	invalid chars received from modem; no response since deployed
			100%	89%	89%	

Telemetry	Deployed	Eng Check	Comments
FBB1	1	1	
FBB2	1	1	
WiFi	1	1	
ISU1	1	1	
SBD1	1	1	
GPS 1	1	1	
FW 1	1	1	
ISU2	1	1	
SBD2	1	1	
GPS 2	1	1	
FW 2	1	1	
XEOS 1	1	1	
XEOS 2	1	1	
XEOS 3	1	1	
XEOS 4	1	1	
	100%	100%	

Power	Deployed	Eng Check	Comments
BT1	1	1	
BT2	1	1	
BT3	1	1	
BT4	1	1	
PV1	1	1	
PV2	1	1	
PV3	1	1	
PV4	1	1	
WT1	1	1	
WT2	1	1	
	100%	100%	

After the deployment of GI01SUMO-00006 on 5 August, the ship was positioned in the vicinity of the surface buoy overnight to collect meteorological comparison data. Due to unusually good weather during our time at the Irminger Sea Array, we only have comparison data for wind speeds below ~13 kts (~7 m/s). Measurements of wind speed were in close agreement between the buoy and ship once the ship data were adjusted to account for differences in the height of the measurements above sea level (Figure 3-9). Wind direction, however, showed an offset of ~30-40 degrees between the buoy and the ship; but both METBK units on the buoy were in agreement

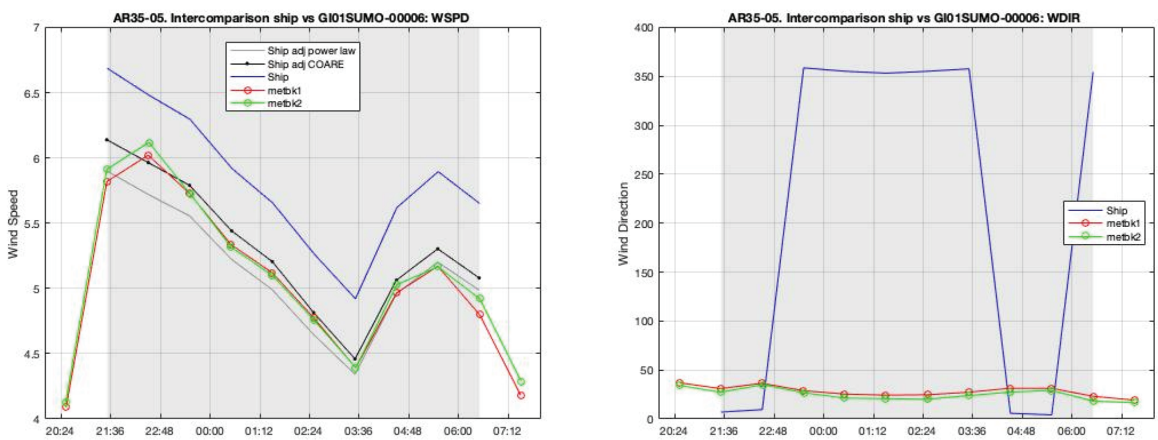


Figure 3-9 – METBK Comparison: Wind Speed (m/s; left) and Direction (right)

Both METBK units showed close agreement in air temperature and barometric pressure, with only slight offsets between the buoy and ship measurements (Figure 3-10).

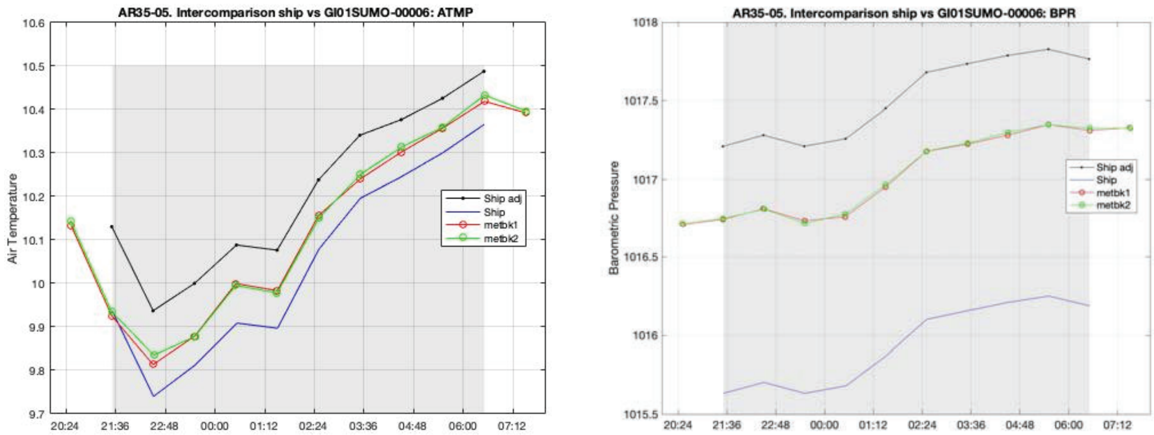


Figure 3-10 – METBK Comparison: Air Temp (°C; left); Barometric Pressure (right)

Buoy measurements of humidity were higher than those of the ship, and there was a discrepancy observed between the buoy METBK units (Figure 3-11). At the start of the MET comparison period, both METBK units measured a relative humidity of ~94%. However, the METBK1 unit showed a drop in humidity of about 3% over the first 2 hours, and an offset of 2-3% remained over the comparison period.

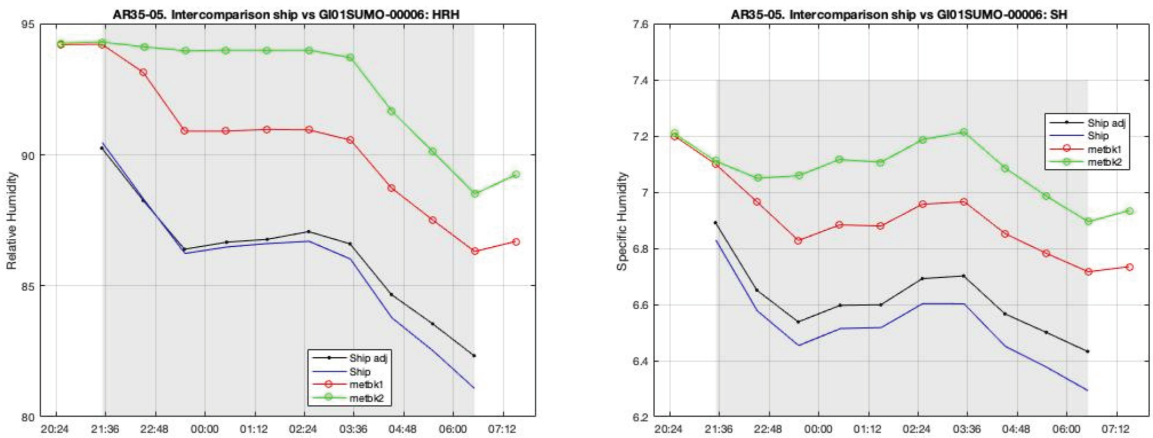


Figure 3-11 – METBK Comparison: Relative Humidity (left) and Specific Humidity(right)

Comparison of shortwave and longwave radiation measurements on the buoy and ship is shown in Figure 3-12. Shortwave measurements between METBK1 and METBK2 are in agreement, but are about 10 W/m2 higher than the ship measurements. For Longwave radiation, the ship and buoy METBK units are all close agreement (within 1 W/m2 of each other).

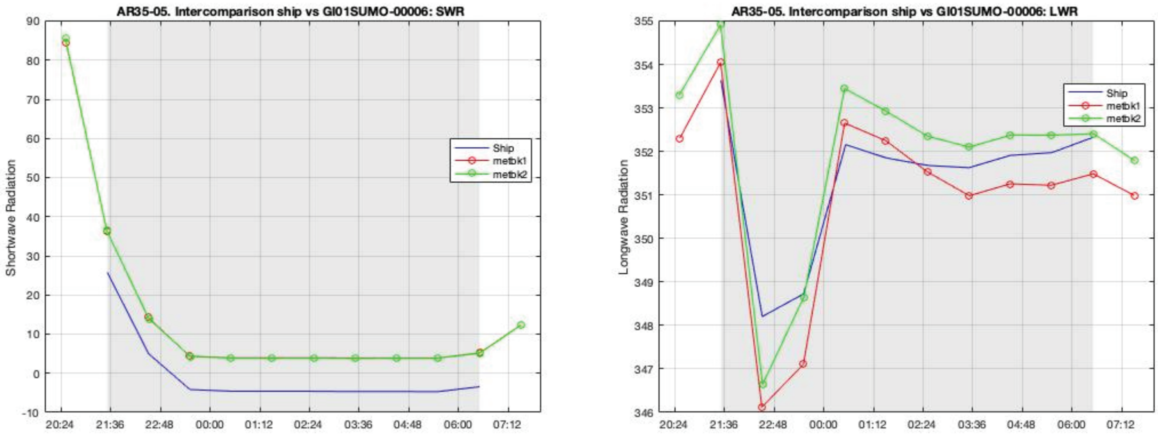


Figure 3-12 – METBK Comparison: Shortwave Radiation (left) and Longwave Radiation (right)

Measurements of sea surface temperature and salinity are also in close agreement (Figure 3-13). The buoy METBK units are almost identical, and are within 0.05°C and 0.1 PSU of the ship measurements.

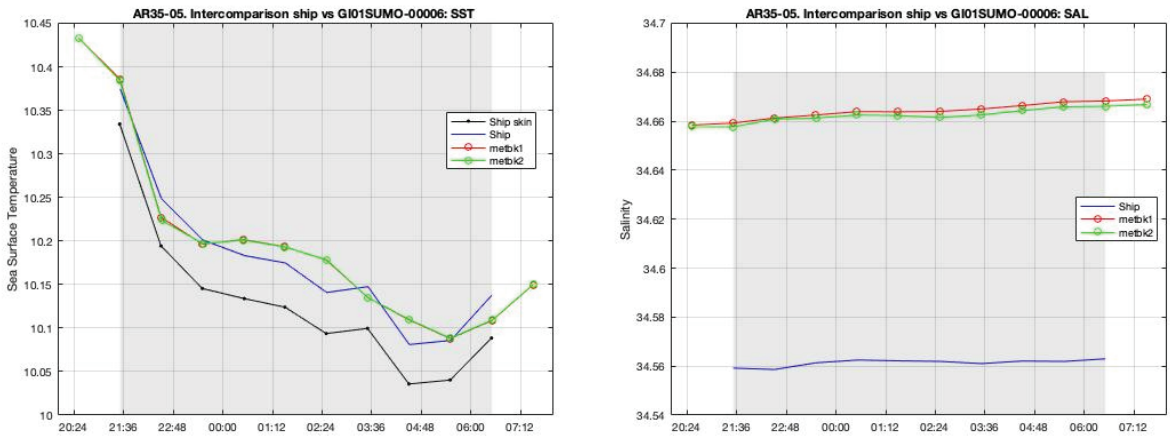


Figure 3-13 – METBK Comparison: Sea Surface Temp (left) and Salinity (right)

3.3. GI02HYPM-00006 Deployment

3.3.1. Deployment

The GI02HYPM-00006 mooring was deployed on 6 August 2019. The deployment start location was 4.5 nautical miles (NM) NNE of the nominal anchor target site. The current was 0.5 kts from the south, the wind ~10 kts from the SSE, and only light swell. The winds decreased and the seas flattened as the deployment progressed.

Prior to the start of mooring operations, the top sphere was positioned on the center line between the A-frame legs, and the mooring anchor was moved on to the tip plate using the ship's crane. The 2440-meter shot was paid out from the winch and the IM connection made to EM chain. An additional 10-20 meters of wire rope was faked out on deck to allow mounting of the CTDMO and upper bumper stop. The trawl winch was reeved through a block on the A-frame then attached to the quick release. Two (2) ten foot green slings were reeved through the lifting bails of the sphere and attached to the quick release. Two blue slip lines were used to control the sphere while being deployed.

The trawl winch wire lifted the sphere from the stand while the A-frame boomed out (Figure 3-14). The EM chain was slipped into the water. When the sphere was clear of the stern, the winch lowered the sphere into the water. The release was tripped and the wire rope that had been faked out on deck was paid out by hand. The wire was then placed into the traveling snatch block which was then raised off the deck using the 01 winch leader.

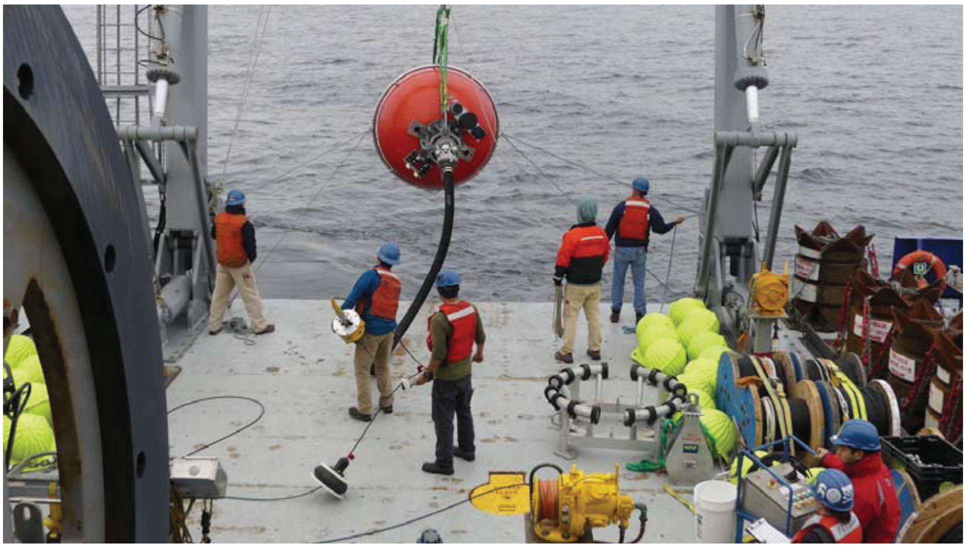


Figure 3-14 – Deployment of the GI02HYPM-00006 top sphere

With approximately 1000 meters of wire paid out, the winch was stopped so the wire following profiler (WFP) could be installed on the wire rope. The A-frame was boomed in and the traveling block lowered to allow the wire to pass through the WFP motor and clamps. A 3/8" Dacron slip line was reeved through the rope handle on the WFP, then tied to the traveling block with a bowline. The A-frame was then boomed out enough so the WFP could be slipped slowly into the water (Figure 3-15, left).

Figure 3-15 – Deployment of the GI02HYPM-00006 WFP (left) and glass balls (right)

At the end of the 2440-m IM shot, the winch was stopped with 8-10 wraps remaining on the wooden reel, the Lebus was stopped and a Yale grip installed on the high tension side of the winch. A stopper line was then connected into the eye of the Yale grip and made fast with a

Nystron stopper to a deck cleat. The remaining wraps of wire were removed from the drum prior to installing a new reel with the spectra winch leader onto the spool.

The lower end of the 2440-m IM cable was connected to the controller cage and a 5-meter shot of chain was installed on the lower end of the cage and temporally connected to the Lebus winch leader. The controller cage was deployed using the trawl winch, A-frame and chain hook in the same manner as the upper float package. When the connection between the 5-m chain and winch leader reached the transom, it was stopped off with a Nystron rope stopper made fast to a deck cleat. Two sets of four (4) glass balls were installed between this connection. Once connected, tension was taken with the Lebus winch, the deck stopper was slacked, then removed allowing this section of glass balls to be paid out until the lower connection to be stopped off again using the Nystron deck stopper. This process was repeated for the deployment of the remaining ten (10) strings of glass balls (Figure 3-15, right).

Once the mooring was stopped off, the dualed Edgetech releases were moved into position under the A-frame. The releases were shackled to the 5-m shot of chain below the glass balls, the 5-m shot of chain and 20-m shot of Nystron rope were shackled into the master link below the release. Once all the connections had been made, a slip line was reeved through the 7/8" end link at the lower end of the 1” Nystron, the bitter ends were made fast to the Lebus winch line using bowline knots. Once all the connections were made, the slip line and 20-m shot of 7/8” Nystron were wound on the Lebus winch. With 400 meters to go to the anchor drop position, the releases were lifted over the stern using a chain hook that was connected to the 01 winch. The ship's crane wire was attached to the chain bridle on the tip plate, and the slack was removed. The Lebus winch slowly paid out the 20-m shot of 7/8” Nystron until the lower hardware connection was close enough to the anchor to attach the 3/4” chain to the lower 7/8” end link. Once this connection was made, the winch paid out the slip line transferring the load to the anchor. The slip line was removed by untying one of the bowlines (Figure 3-16, left). As the ship passed over the anchor drop site, the back stay was removed (cut); the crane wire was hauled in raising the tip plate off the deck just enough allowing the anchor to free-fall into the water (Figure 3-16, right).

Figure 3-16 – Shifting the load to, and deploying the GI02HYPM-00006 anchor

The anchor was dropped at 12:37 on 6 August 2019, 330 m past the target location (based on last year's fall back distance).

3.3.2. Anchor Survey

Three locations were selected as survey points for ranging on the acoustic releases. At each survey point, three acoustic ranges were obtained using the release deck box with the ship's in-hull micromodem Gavial ITC-3013 12 kHz transducer. Water depth recorded at the drop location (59° 58.2686' N, 39° 31.7813' W) was 2688 m measured with the Knudsen (1500 SSV). The Carter-corrected depth is 2664 m. The depth of the releases is 2632, and the transducer depth is 5 meters. The sound speed velocity used was 1487 m/s.

Table 3-3 – GI02HYPM-00006 Anchor Survey Data

Survey Pt Latitude	Survey Pt Longitude	Slant Range (sec)
59° 58.9153' N	39° 31.4134' W	3.820
59° 57.9612' N	39° 31.2736' W	3.745
59° 58.3991' N	39° 32.8505' W	3.745

The anchor location was calculated using Art Newhall's Anchor Survey Software Matlab program. The solution (Figure 3-17) yielded an anchor position of **59° 58.3719' N, 39° 31.8491' W**. The fallback was 201 m. The distance from the target position was 223 m.

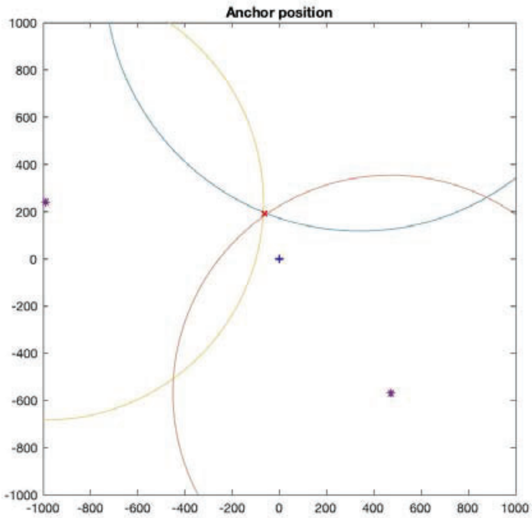


Figure 3-17 – Anchor Survey of GI02HYPM-00006

3.3.3. Validation

A total of 67 kilobytes of data were downloaded from the mooring using the ship's transducer on 11 August 2019. The downloaded data contain 5 days of samples. All instruments on the mooring are working as expected. The data shows that the WFP started pattern zero at 04:00:00 on 7 August 2019 and had 6 profiles so far (Figure 3-18). The CTDMO measures a pressure of ~153-172 dbar (Figure 3-19).

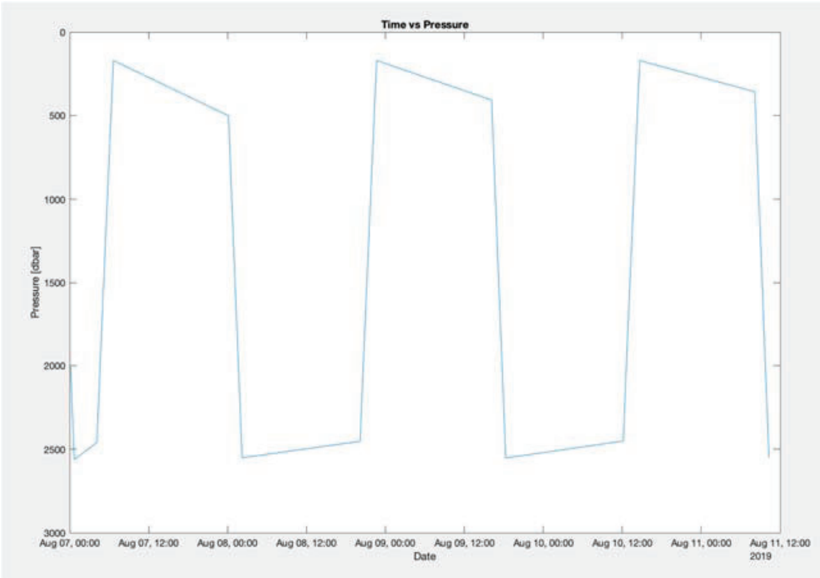


Figure 3-18 – GI02HYPM-00006 WFP data

Figure 3-19 – GI02HYPM-00006 CTD data

On 11 August, the EK80 was used to image the GI02HYPM-00006 mooring. The upper sphere of the mooring was detected at a position ~80 m south of the anchor position. The sphere was at 145 m depth, the EM Chain termination at 152 m, the CTDMO at 155 m, and the Bumper Stop at 156 m (Figure 3-20). This suggests that the mooring is slightly shallower than expected. The design depth is 2668 m, and GI02HYPM-00006 was deployed at 2664 m which accounts for the slight difference. And the CTDMO depth is consistent with the measured pressure noted above.

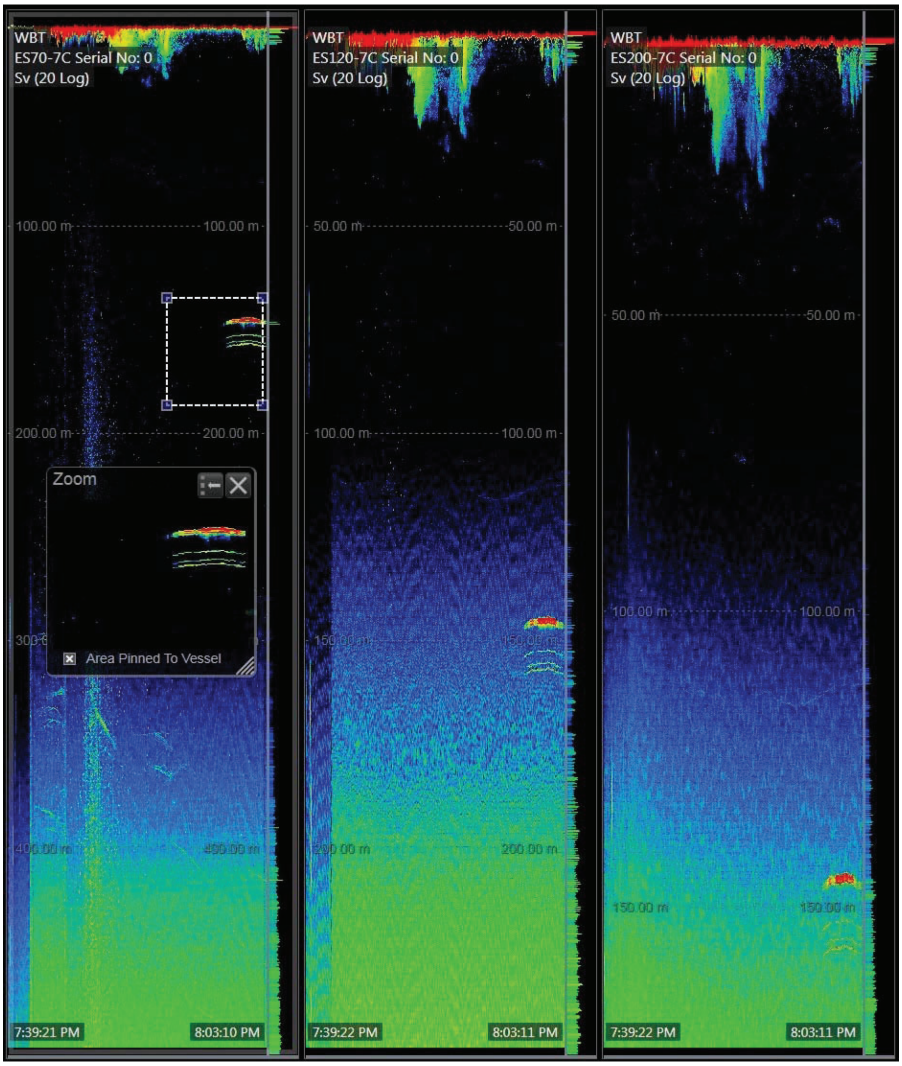


Figure 3-20 – GI02HYPM-00006 upper components imaged by EK80

3.4. GI03FLMA-00006 Deployment

3.4.1. Deployment

The GI03FLMA-00006 mooring was deployed on 7 August 2019. The deployment start location was 4 nautical miles (NM) NE of the nominal anchor target site. There was minimal wind and slight current, but they were at different angles.

Prior to the start of mooring operations, the mooring anchor was craned on to the anchor tip plate which was positioned outside the A-frame on the stern. The 440-meter shot was paid out from the Lebus winch and the IM connection made to EM chain. An additional 10-20 meters of wire rope was faked out on deck to allow mounting of upper instruments. The trawl winch wire was reeved through a block on the A-frame then attached to the quick release, two (2) ten foot green slings were reeved through the lifting bails of the sphere and attached to the quick release. Two blue slip lines were attached to the sphere; these lines were used to control the sphere while being deployed.

The trawl winch lifted the sphere from the stand while the A-frame boomed out. The EM chain was slipped into the water. When the sphere was clear of the stern, the winch lowered the sphere into the water (Figure 3-21). The release was tripped and the wire rope that had been faked out on deck was paid out by hand. The wire was then placed into the traveling snatch block which was then raised off the deck using the trawl winch. Once the traveling block was secured, we slowing eased out two blue slip lines to prevent snap loading on the wire rope. Payout of the wire resumed. The winch was stopped at depth location marks on the wire rope to attach instrumentation.

Figure 3-21 – Deployment of the GI03FLMA-00006 top sphere

At the end of the 440-m IM shot, the winch was stopped with 8-10 wraps remaining on the wooden reel, a Yale grip was installed on the high tension side of the winch. A stopper line was then connected into the eye of the Yale grip and made fast by a Nystron stopper line made fast to a deck cleat. The remaining wraps of wire were removed from the drum prior to installing a new reel with a 1000-meter shot of IM cable onto the spooler.

The upper syntactic release float was moved in position under the A-frame, the lower end of the 440-meter shot was connected. The 20-meter IM cable was connected on the lower end of the Edgetech acoustic release. A Yale grip was attached 2 meters up from the lower termination, then shackled to the Lebus winch leader. Once all the connections were made, slack in the 20-meter shot was taken up by the Lebus winch. A West coast quick release was attached to the end of the trawl wire, then hooked into the lifting bail on the float. The float was then lifted off the deck, kept level as the A-frame boomed out. Once clear of the transom, the float was lowered in to water (Figure 3-22, left), the load was transferred to the Lebus winch prior to pulling the quick release. The 20-m IM shot was paid out until the lower Yale grip could be stopped off with the Nystrom deck stopper.

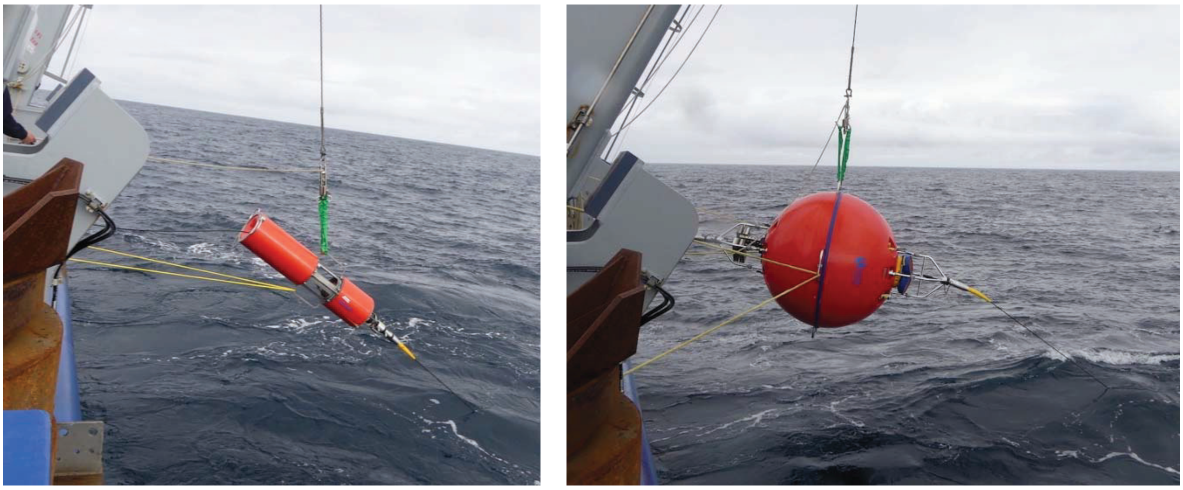


Figure 3-22 – Deployment of the GI03FLMA-00006 mid-water release and sphere

The lower 62" syntactic sphere was moved into launch position using a pallet jack. The A-frame was boomed back inboard over the lower 62" syntactic sphere. One 4' green sling was reeved through the lifting bail of the sphere and attached to the quick release. Two blue slip lines were used to control the sphere while being deployed. The lower end of the 20-m IM cable was connected to the top of the sphere; the upper end of the lower 1000-m IM cable was connected to the bottom of the sphere. Prior to deploying the sphere, the deck stopper holding the lower end of the 20-m IM shot was slacked, transferring the mooring load to the 62" sphere. The trawl winch then lifted the sphere from the stand while the A-frame boomed out. When the sphere was clear of the stern, the trawl winch lowered the sphere into the water (Figure 3-22, right). The quick release was tripped and the wire rope that had been faked out on deck was paid out by hand. The 1000-m wire was then placed into the traveling snatch block which was then raised off the deck using the 01 winch. Once the traveling block was secured, we slowly eased out two blue slip lines to prevent snap loading on the wire rope. Payout of the wire resumed. The winch was stopped at depth location marks on the wire rope to attach instrumentation.

At the lower end of the 1000-meter IM shot, the wire was stopped off with a Yale grip prior to changing reels on the spooler. The lower end of the 1000-m IM cable was connected to the controller cage and a 5-meter shot of chain was installed on the lower end of the cage. The 78.3-m wire rope shot was temporarily connected to the 5-m chain below the controller cage. The controller cage was deployed using the trawl winch, a-frame and chain hook in the same manner as the upper float package. When the connection between the 5-m chain and 78.3-m shot reached the transom, the connection was stopped off using the Nystron deck stopper made fast to a deck cleat. Two sets of four (4) glass balls were installed between these components. Once connected, tension was taken with the Lebus winch, the deck stopper was slacked, then removed allowing this section of glass balls to be paid out. After the balls were deployed, the traveling block was lowered to deck so the mooring wire could be lifted into the block. Once the block was lifted off the deck, payout of the wire could resume.

At the end of the 78.3-m IM shot, the wire was stopped off using a Yale grip so the 1000-m reel of wire could be loaded onto the spooler. The 1000-m wire was then placed into the traveling snatch block which was then raised off the deck using the 01 winch. Payout of the wire resumed. The winch was stopped at depth location marks on the wire rope to attach OSNAP instrumentation. Once all the wire had been deployed, the mooring was stopped off with the Nystrom deck stopper.

A 5-m shot of 1/2" chain was shackled into last wire rope termination, and tension was taken up by the Lebus winch. The deck stopper was slacked then removed allowing the winch to pay out 5-m shot. The hardware connection at the end of the 5-meter shot was stopped off near the transom. Two sets of glass balls were connected to the 5-meter chain shot, the Lebus winch leader was connected to the forward end of the string of glass balls. One connected, tension was taken up by the winch, and the deck stopper was slacked and removed allowing the winch to pay out. Once the connection between the upper string of balls and the winch leader reached the transom, it was stopped off using the Nystron deck stopper. This process was repeated for the deployment of the remaining nine (9) strings of glass balls.

Once all the glass ball flotation was deployed, the mooring was stopped off. The dualed Edgetech releases were moved into position under the a-frame. The releases were shackled to the 5-m shot of chain below the glass balls, the 5-m shot of chain and 20-m shot of Nystron rope were shackled into the master link below the release. Once all the connections had been made, a slip line was reeved through the 7/8" end link at the lower end of the 1" Nystron, the bitter ends were made fast to the Lebus winch line using bowline knots. Once all the connections were made, the slip line and 20-m shot of 7/8" Nystron were wound on the Lebus winch. With 400 meters to go to the anchor drop position, the releases were lifted over the stern using a chain hook that was connected to the trawl winch. Once the releases were deployed, the ship's crane was positioned was boom over the mooring anchor. The crane wire was attached to the chain bridle on the tip plate, slack was removed. The Lebus winch slowly paid out the 20-m shot of 7/8" Nystron until the lower hardware connection was close enough to the anchor to attach the 3/4" chain to the lower 7/8" end link. Once this connection was made, the winch paid out the slip line transferring the mooring load to the anchor. The slip line was removed by untying one of the bowlines. As the ship passed over the anchor drop site, the back stay was removed; the crane wire was hauled in raising the tip plate off the deck just enough allowing the anchor to free-fall into the water (Figure 3-23).

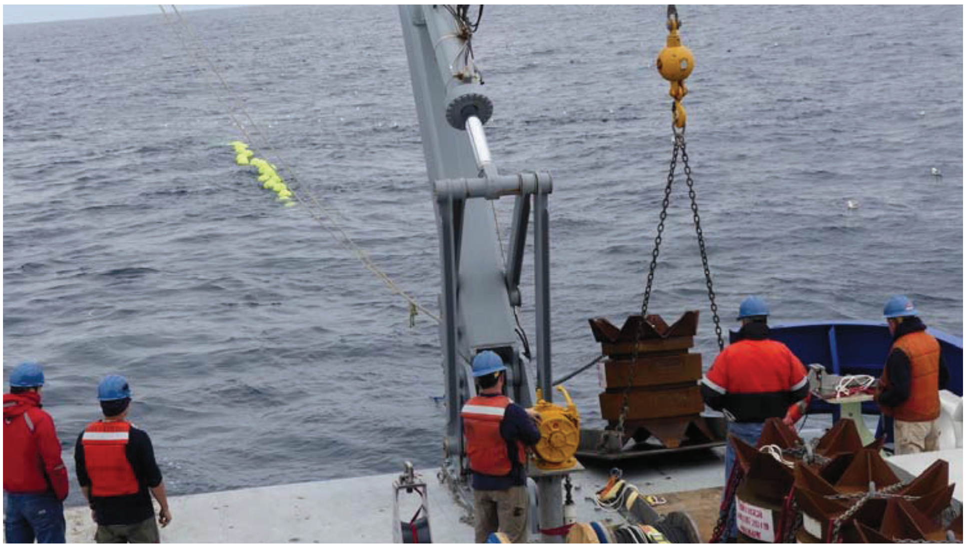


Figure 3-23 – GI03FLMA anchor deployment

The anchor was dropped at 13:34 on 7 August 2019, 280 m past the target location (based on last year's fall back distance).

3.4.2. Anchor Survey

Three locations were selected as survey points for ranging on the acoustic releases. At each survey point, three acoustic ranges were obtained using the release deck box with the ship's in-hull micromodem Gavial ITC-3013 12 kHz transducer. Water depth recorded at the drop location (59° 46.1752’ N, 39° 53.1695’ W) was 2716 m measured with the Knudsen (1500 SSV). The Carter-corrected depth is 2692 m. The depth of the releases is 2660, and the transducer depth is 5 meters. The sound speed velocity used was 1487 m/s.

Table 3-4 – GI03FLMA-00006 Anchor Survey Data

Survey Pt Latitude	Survey Pt Longitude	Slant Range (sec)
59° 46.1675’ N	39° 51.7343’ W	3.932
59° 46.7852’ N	39° 53.4264’ W	3.877
59° 45.9602’ N	39° 53.7320’ W	3.719

The anchor location was calculated using Art Newhall's Anchor Survey Software Matlab program. The solution (Figure 3-24) yielded an anchor position of **59° 46.2058' N, 39° 53.0511' W**. The fallback was 124 m. The distance from the target position was 204 m.

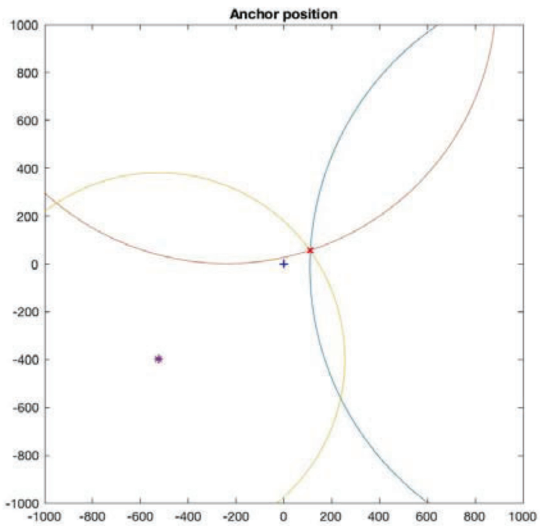


Figure 3-24 – Anchor Survey of GI03FLMA-00006

3.4.3. Validation

A total of 59 kilobytes of data were downloaded from the mooring using the ship’s transducer on 15 August 2019. The downloaded data contain 8 days of samples (Figure 3-25). All instruments on the mooring are working as expected except the ADCP. The controller started receiving “No samples in memory” message from the ADCP’s IMM on 15 August 2019. It is believed that the ADCP is still sampling and logging internally, but the data failed to be stored inside the ADCP’s IMM occasionally.

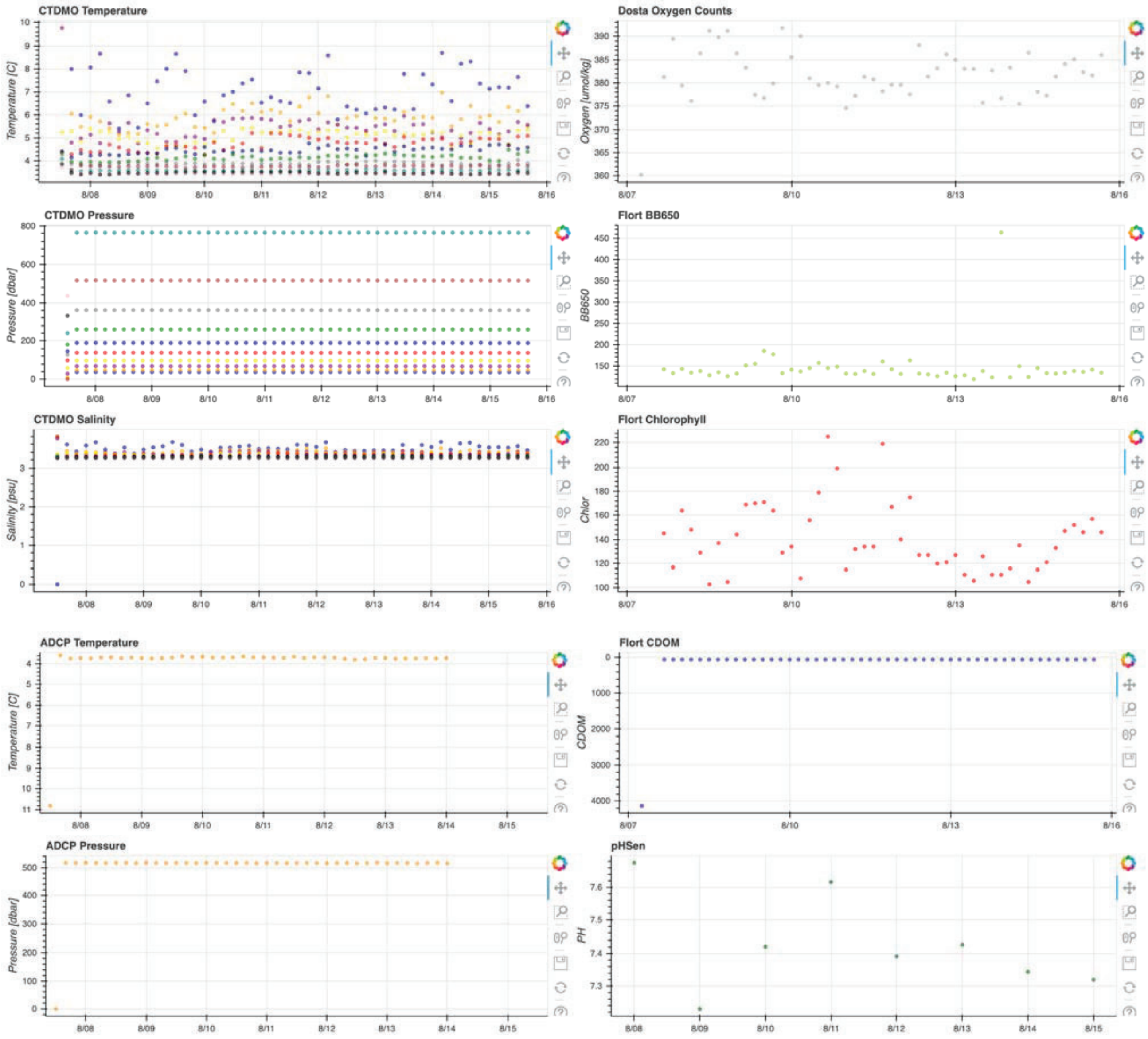


Figure 3-25 – GI03FLMA-00006 Main (left) and Secondary (right) controller and instrument data

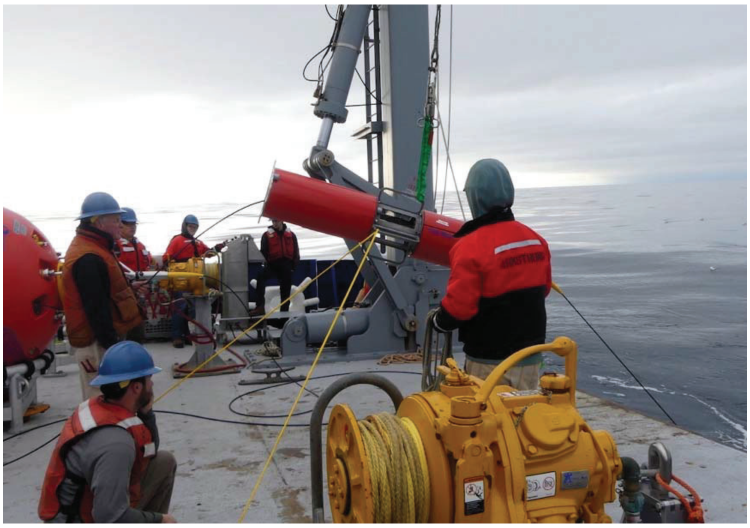
3.5. GI03FLMB-00006 Deployment

3.5.1. Deployment

The GI03FLMB-00006 mooring was deployed on 8 August 2019. The deployment start location for Flanking Mooring GI03FLMB-00006 was 5.0 nautical miles (NM) SSW nominal anchor target site. Course during deployment was to the north-northeast. The deployment of this mooring was identical to that of GI03FLMA-00006 described in Section 3.4.1 above.

The deployment of key components are shown below in Figure 3-26, Figure 3-27, and Figure 3-28.

Figure 3-26 – GI03FLMB-00006 top sphere and ADCP sphere prior to deployment



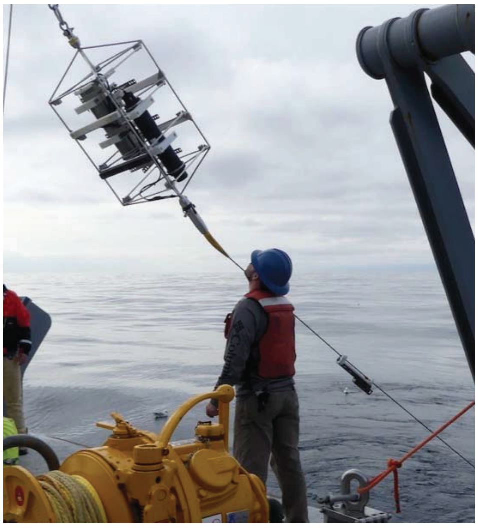


Figure 3-27 – GI03FLMB-00006 mid-water release float and controller cage deployment

Figure 3-28 – Deployment of GI03FLMB-00006 OSNAP instruments and acoustic releases

The anchor was dropped at 13:20 on 8 August 2019, 280 m past the target location (based on last year's fall back distance).

3.5.2. Anchor Survey

Three locations were selected as survey points for ranging on the acoustic releases. At each survey point, three acoustic ranges were obtained using the release deck box with the ship's in-hull micromodem Gavial ITC-3013 12 kHz transducer. Water depth recorded at the drop location (59° 43.2980' N, 39° 21.2008' W) was 2842 m measured with the Knudsen (1500 SSV). The Carter-corrected depth is 2819 m. The depth of the releases is 2787, and the transducer depth is 5 meters. The sound speed velocity used was 1487 m/s.

Table 3-5 – GI03FLMB-00006 Anchor Survey Data

Survey Pt Latitude	Survey Pt Longitude	Slant Range (sec)
59° 42.8835' N	39° 20.3919' W	3.999
59° 42.8151' N	39° 22.0606' W	4.002
59° 43.6066' N	39° 21.6431' W	3.881

The anchor location was calculated using Art Newhall's Anchor Survey Software Matlab program. The solution (Figure 3-29) yielded an anchor position of **59° 43.2309' N, 39° 21.2843' W**. The fallback was 147 m. The distance from the target position was 225 m.

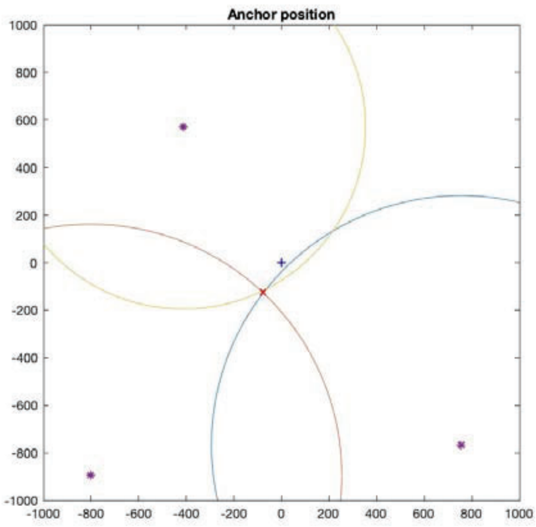


Figure 3-29 – Anchor Survey of GI03FLMB-00006

3.5.3. Validation

A total of 33 kilobytes of data were downloaded from the mooring using the ship's transducer on 12 August 2019. The downloaded data contain 4 days of samples (Figure 3-30). All instruments on the mooring are working as expected. The controller started receiving "No samples in memory" message from the ADCP's IMM from 10-11 August 2019, but the data came back on 12 August 2019.

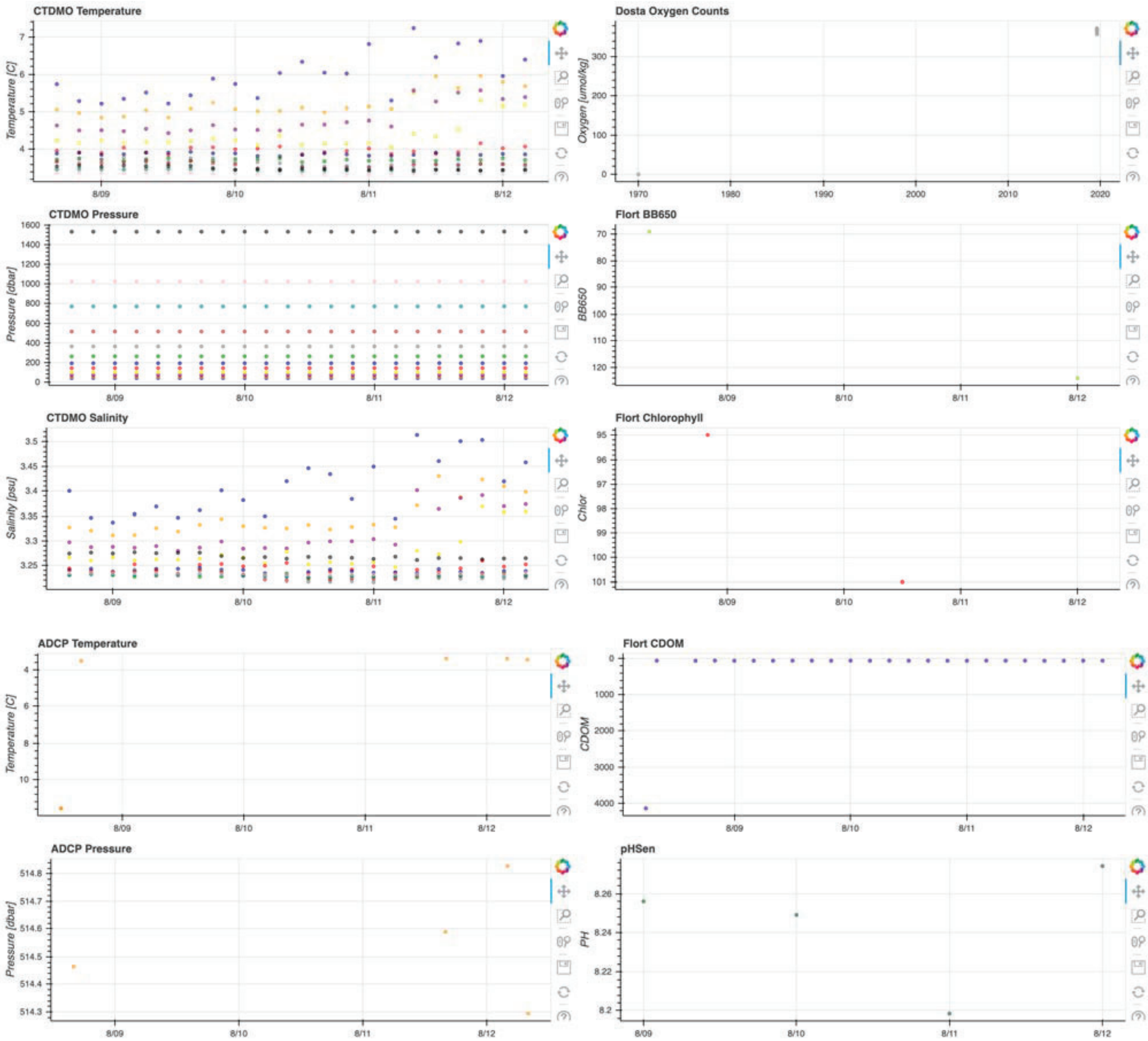


Figure 3-30 – GI03FLMB-00006 Main (left) and Secondary (right) controller and instrument data

3.6. GI01SUMO Recovery

3.6.1. Deployed Status

GI01SUMO-00005 was deployed on 8 June 2018. The FDCHP was damaged on deployment; over the course of the deployment the FDCHP slowly fell back until it was resting on the starboard METBK BPR. Additionally, communications from inductive PHSEN1 and PCO2W3 became spotty shortly after deployment. Around 27-28 January 2019 a storm hit the Irminger Sea Array which resulted in icing conditions on the halo, and bent the buoy vane (as determined from images from the buoy camera). Prior to recovery the mooring was functioning nominally:

- Power system believed to be functioning normally, though direct communications with this system were lost on 24 June 2018. Though power system logs were no longer available after this day, the buoy was believed to be charging due to the main voltage rebounding and other indications from the SBD messages.

- All telemetry systems (both fleet broadband units, primary/secondary SBD messages, and primary Iridium) were functioning.
- All DCLs, with the exception of DCL13 which was turned off on June 20 2019 to conserve power, were turned on and functioning normally.

There were a few known instrument issues:

- All PHSEN/PCO2W and CTDBPs are off due to dead batteries
- The NSIF CTDBP batteries died, but the PCO2W was successfully being polled
- The Buoy FLORT was failing.

3.6.2. Recovery

The GI01SUMO-00005 mooring was recovered on 9 August 2019. The seas were calm with the slightest swell, and wind was 2-3 kts. The acoustic release was enabled, then released (with approval from the bridge) at 08:03. The glass balls were sighted on the surface at 08:26. A cluster of balls was closest to the ship, with the rest of the balls strung out towards the buoy.

Figure 3-31 – Hooking into the glass balls from the GI01SUMO-00005 mooring

The balls were brought down the starboard side of the ship, and grappled. They were hooked with the spectra line from the Lebus winch (Figure 3-31) reeved through the center A-frame block with a recovery hook attached to the end of the line. The glass balls were lifted on board the ship using the Lebus winch. Once on deck, the cluster of balls was stopped off using a Nystron stopper. The remaining strings of balls along with the acoustic releases were lifted on board using the A-frame and trawl winch. Once the fifteen (15) sets of glass balls were untangled and disconnected they were craned in the open rag top container. The Lebus winch leader was then shackled to the link above the Colmega. The winch hauled in the Colmega taking the load from the stopper line, allowing it to be removed. Once the Colmega was placed in the traveling block, the recovery of the Colmega and Nylon commenced. The remaining 1440 meters of the mooring synthetics were hauled in using only the Lebus traction heads, then hand packed into 2 plastic Ropack containers (Figure 3-32). Near the end of the Nylon, a Yale grip was put on and the Nylon was cut. The remaining Nylon, Nylon-to-wire transition, and 100 m and 300 m shots were wound onto the TSE winch. An empty spool was put on the Lebus, and the 1000m IM wire was recovered next stopping to remove instruments along the way. Once the ADCP was on deck, a Yale grip was placed above the lower termination of the 486 meter shot and connected to the 300 m shot on the TSE. The ADCP was disconnected, then removed from the work area. The 486 m wire shot was spooled in on the TSE until the 20 m was recovered, at this point the deck was rigged to recover the surface buoy.

Figure 3-32 – Recovery of the GI01SUMO-00005 synthetic rope section

The 9/16" trawl wire was reeved through the center block on the A-frame, where approximately 60 meters was flaked out on the deck. The ship's zodiac was launched and took up position just off the ships stern. The recovery hook was passed to the small boat via messenger line, then attached to the recovery bail on the buoy with a red lifting strap (Figure 3-33, left). Once hooked, the trawl wire was hauled in lifting the buoy out of the water. As expected, the buoy turned with the halo facing forward (the port METBK WND lightly tapped the sided of the A-frame). The first air tugger was attached to the halo, preventing the halo from swinging. The other two tuggers were then attached to the side bails to control the swing of the buoy. The A-framed boomed the buoy inboard (Figure 3-33, right) placing it in the proper position for transport. Once on deck, 8 aircraft straps were used to secure the buoy. Once the buoy was secured, the NSIF was lifted on deck using the TSE winch, then pulled forward with an air tugger until the EM chain was fully on deck.

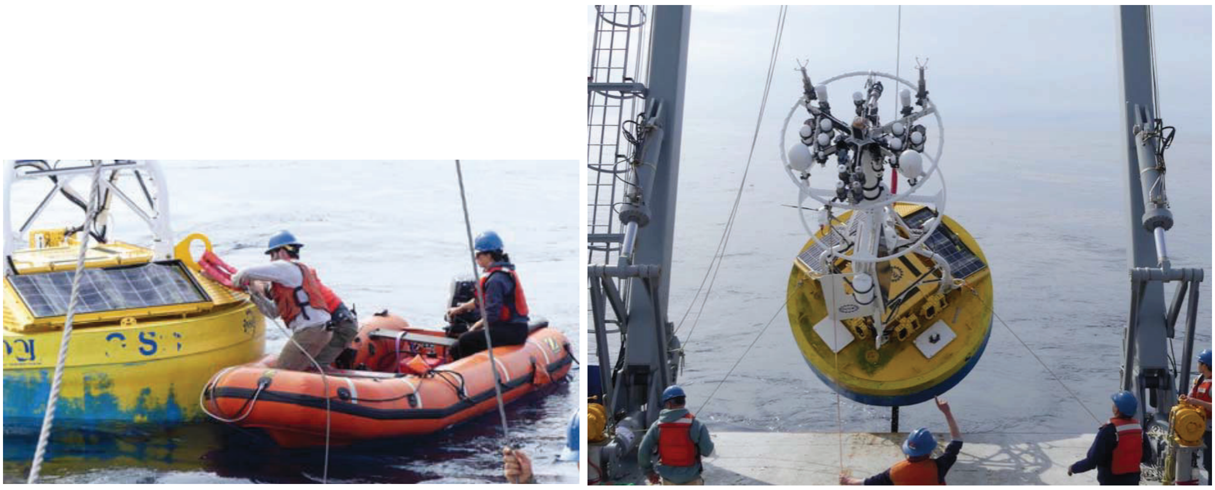


Figure 3-33 – Recovery of the GI01SUMO-00005 surface buoy

The GI01SUMO-00005 mooring recovery was completed at 13:27 when the EM chain was pulled aboard. Because the GI01SUMO-00005 mooring was the first to be recovered, it was positioned further forward and to port to create sufficient room for recovery of the other moorings.

3.6.3. Inspection and Analysis

After the buoy was safety secured on deck, the Chief Scientist, Documentation Lead, Surface Mooring Lead and Instrument Lead conducted a thorough visual inspection of all components. Overall, the surface mooring appeared to be in good shape with no major causes for concern and very minimal biofouling.

The FDCHP was completely bent over and leaning on the starboard METBK BPR, which was chipped (Figure 3-34). This was expected as the Surface Mooring team observed the FDCHP's orientation via the VICS prior to recovery and is inconsequential because the instrument was damaged on deployment in 2018 and power was removed shortly thereafter.

Figure 3-34 – The FDCHP was leaning back on the starboard METBK BPR

The buoy's wind vane was completely bent 90° to port (Figure 3-35). All 3 blade tips of the starboard wind turbine were broken off and the connector was unplugged (Figure 3-36). The starboard PV panel appeared to be smashed and warped, but still present and secured to the frame (Figure 3-37). The damage to the wind turbine and PV panel were unknown to the Surface Mooring team prior to recovery, as they were not observed via the VICS.

Figure 3-35 – The GI01SUMO-00005 wind vane was bent completely 90° to port

Figure 3-36 – The starboard wind turbine was unplugged and all 3 blade tips were broken off

Figure 3-37 – The starboard PV panel was smashed and warped

The NSIF was relatively clean with minimal biofouling. All instruments, wires and locking sleeves were present (Figure 3-38). However, there were a few issues noted by the instrument team. The CTDBP-F was observed to have a corroded power pin rendering it unable to be powered by the mooring. The Instrument Lead was unable to connect to the instrument and download data. However, data should be able to be accessed back at WHOI. The locking sleeve on the OPTAA pump cable was loose and chaffed through the jacket of the cable which could have had an impact on the data collection (Figure 3-39).

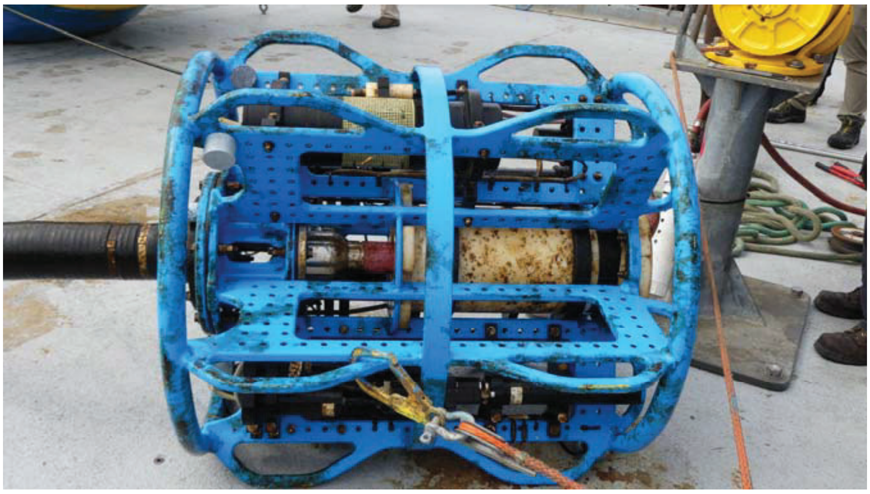


Figure 3-38 – Recovered GI01SUMO-00005 NSIF

Figure 3-39 – Recovered NSIF OPTAA pump cable with jacket tears and loose locking sleeve

The sub-surface panels were also relatively clean with minimal biofouling. All instruments, wires and locking sleeves were present (Figure 3-40). The universal joint at the base of the riser appeared to be in good shape with no obvious signs of wear and tear. All hardware was still present and in place.

Figure 3-40 – Recovered GI01SUMO-00005 subsurface panels

Most instruments on the inductive line were recovered intact with minimal damage, however there were a few issues worth noting:

- **CTDMO1 (20m)** – The cable guide and end cap were abraded and the opening diameter was enlarged by the mooring wire. However, this was existing damage and did not occur on this deployment.
- **PHSEN1 (20m)** – The UIMM cable was severed at the UIMM connector and a length of this cable were missing (up to where it was taped to the instrument housing).
- **CTDBP1 (40m)** – Loose and detached locking sleeves at instrument end cap. Locking sleeve missing from FLORD dummy plug on instrument end cap.
- **PCO2W1 (40m)** – Loose and missing locking sleeves at instrument bulkhead.
- **CTDBP2 (80m)** – There were multiple loose locking sleeves at the instrument end cap. Also, the pump cable severed at the pump connector. Lastly, the DOSTA locking sleeve was loose but still present.
- **PCO2W2 (80m)** – The UIMM cable was severed at the UIMM connector.
- **PHSEN2 (100m)** – The locking sleeve on the main instrument bulkhead connector dummy plug was loose but still present. Also, the locking sleeve at the UIMM was loose but also still present.
- **CTDBP3 (130m)** – Multiple locking sleeves at the instrument end cap were loose. The pump cable was severed at the pump connector. Lastly, the DOSTA locking sleeve was detached, but the cable remained connected.
- **PCO2W3 (130m)** – This instrument appeared to be physically intact, but the pump cable connector was corroded off, rendering pump inoperable. There was also significant corrosion noted at the main instrument bulkhead connector (which was dummied off for deployment).

Figure 3-41 - The 80 m PCO2W and CTDBP upon recovery

3.7. GI02HYPM Recovery

3.7.1. Deployed Status

GI02HYPM-00005 was deployed on 9 June 2018. There were no issues on deployment. The latest data were received on shore from 26 October 2018 – the ZPLSG and WFP were working. The last CTDMO data were from September.

Approximately 20 kB of data were acoustically downloaded on 5 August 2019. Data were recovered from the Main Controller, CTDMO and ZPLSG. Those instruments and the Main Controller were functioning as expected. There were no data from the WFP which was assumed to be due to drained batteries after a 14-month-long deployment.

3.7.2. Recovery

The GI02HYPM-00005 mooring was recovered on 10 August 2019. Currents were mostly to the east and a little south, both light (< 0.5 kts). Winds were light at the beginning of the deployment (1-2 kts) and from the north. The ship was positioned 0.25 nautical miles (NM) south of the mooring anchor position. The anchor release was enabled, ranged on, and then released (with permission from the bridge) at 06:34. The top sphere surfaced just off to starboard within a minute of sending the release command. The trawl winch wire was reeved through the Gifford block on the A-frame, around the starboard quarter to a position just aft of the CTD boom. Deck personnel were positioned along the starboard rail tending the trawl wire. The ship approached the sphere, bringing it down the starboard side. A three (3) ton pickup hook was snapped into a lifting bail. The ship moved ahead allowing the sphere to come astern.

Once the top float was astern of the ship, the recovery commenced. The syntactic sphere was lifted on board using the trawl wire and air tuggers to control the swing of the sphere (Figure 3-42). Once on deck, the trawl winch wire and ship's crane were used together to level the sphere prior to lowering it into its stand. The sphere was secured to the stand with four (4) 2" yellow ratchet straps. The glass balls appeared on the surface aft of the ship at 06:59.

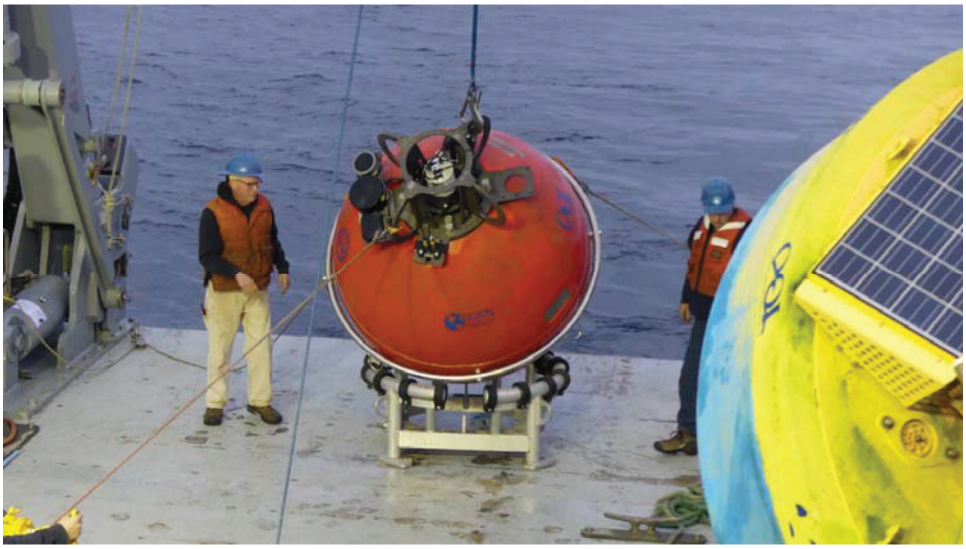


Figure 3-42 – Recovery of the GI02HYPM-00005 sphere

A pallet jack was used to move the sphere forward which allowed the bottom of the 5 meter EM chain and IM wire termination to be recovered using an air tugger. The CTDMO and upper bumper stop was removed (Figure 3-43, left). A Yale grip was placed on the top shot of wire rope and then made fast using the stopper line. The IM termination was unbolted from the bottom of the EM chain; the sphere was moved out of the work area using a pallet jack. The Lebus winch leader was reeved through the travelling snatch block and shackled to the Yale grip. The winch took up the load, the stopper line was cleared. The trawl winch wire was shackled to the block and hauled in raising the block off the deck. Recovery of the 2440 meter shot of IM cable commenced.

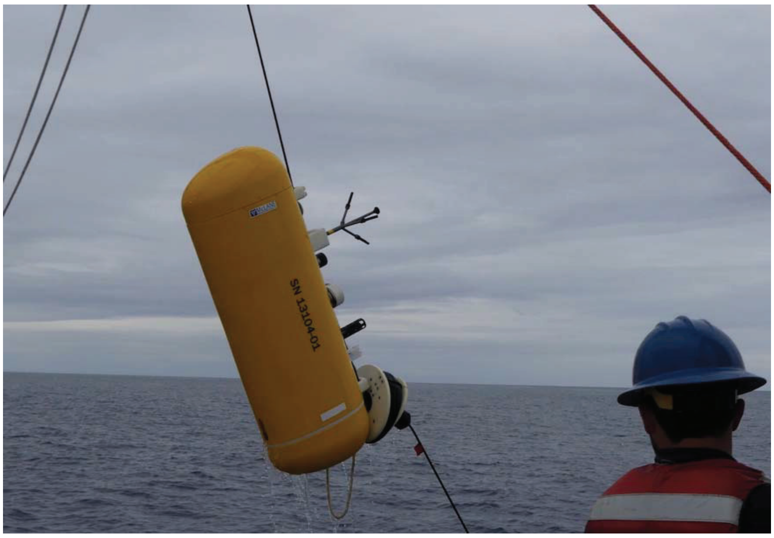



Figure 3-43 – Recovery of the GI02HYPM-00005 CTDMO and WFP

The 2440 meter IM shot was winched in, the WFP was removed from the wire at the lower bumper stop around 08:56 (Figure 3-43, right). The controller cage and two (2) sets of glass balls were recovered using the ships trawl wire and A-frame. The remaining glass balls and acoustic releases were lifted on board the ship using the Lebus winch and trawl wire (Figure 3-44). Once on deck, the cluster of balls was stopped off using a Nystron stopper. The (12) sets of glass balls were untangled and disconnected, then craned in the rag top storage container.

Figure 3-44 – Recovery of the GI02HYPM-00005 glass balls and acoustic releases

The GI02HYPM-00005 mooring recovery was completed at 09:25 when the acoustic releases were brought aboard.

3.7.3. Inspection and Analysis

The WFP stopped sampling on 30 June 2019, which is the one-year mark for the instrument's expected battery life. The figure below shows that the WFP detected a depleted battery and terminated its profile mission on 1 July 2019 (Figure 3-45). The ZPLSG, CTDMO, and controller were still working and sampling upon recovery.

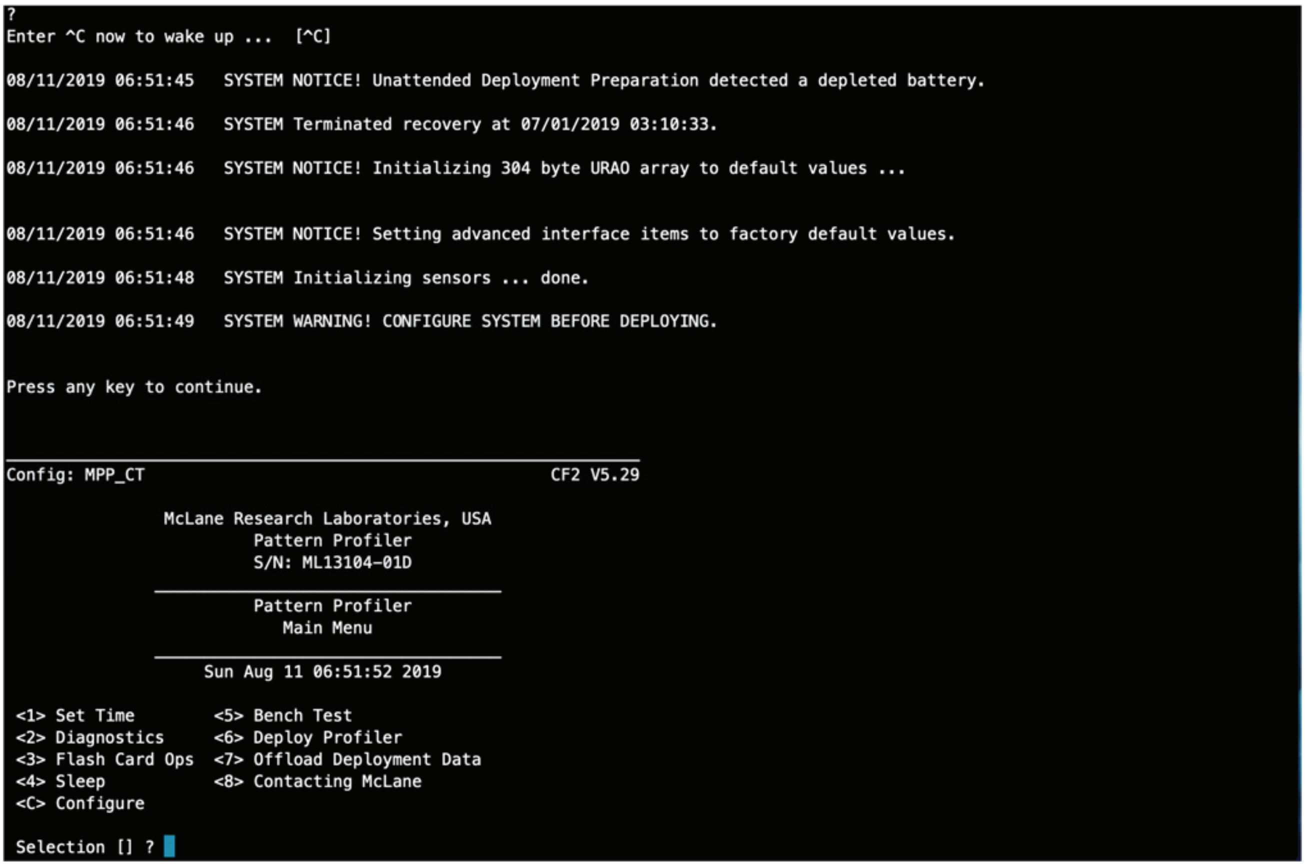


Figure 3-45 – GI02HYPM-00005 WFP deployment terminated due to depleted battery

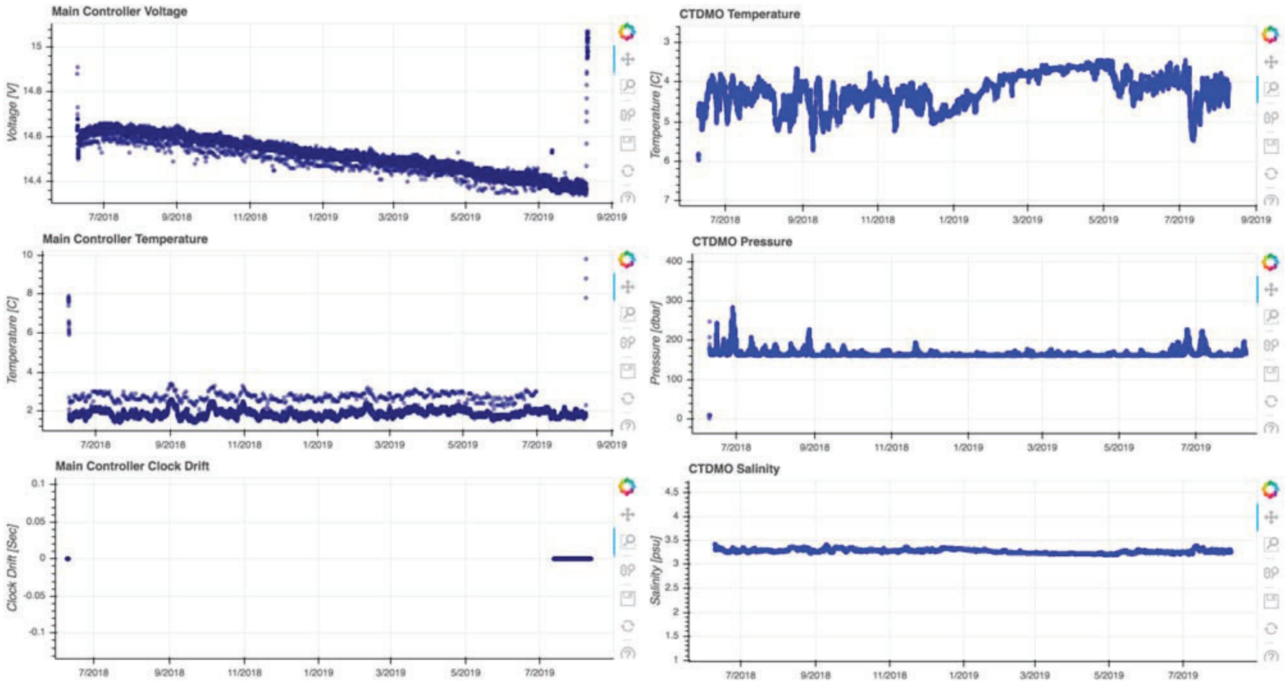


Figure 3-46 – GI02HYPM-00005 Main controller (MSIOC) and CTDMO data

3.8. GI03FLMB Recovery

3.8.1. Deployed Status

GI03FLMB-00005 was deployed on 11 June 2018. There were no issues on deployment

Data were last received on shore from the mooring in December 2018 at which point everything was functional when last heard from. Note that the PHSEN was not connected to the Secondary Controller so its status will not be known until recovery.

Approximately 20 kB of data were acoustically downloaded on 7 August 2019. Data were recovered from the Main Controller, the ADCP and all inductive CTDMOs. Those instruments and the Main Controller were functioning as expected. There was no data from the Secondary Controller, which may have stopped due to a Persistor issue.

3.8.2. Recovery

The GI03FLMB-00005 mooring was recovered on 10 August 2019. The Flanking Moorings were designed to be recovered in two sections. The ship was positioned 200 m south of the mooring anchor position. The mid-water release was enabled, ranged on, and then released (with permission from the bridge) at 12:09. The top sphere surfaced within a minute of sending the release command. The Lebus winch leader was run through the Gifford block on the A-frame, around the starboard quarter to a position just aft of the starboard A-frame. Deck personnel were positioned along the starboard rail tending the winch leader. The ship approached the sphere, bringing it down the starboard side. A three (3) ton pickup hook was snapped into a lifting bail (Figure 3-47, left). The ship moved ahead allowing the sphere to come astern.

Figure 3-47 – Hooking the GI03FLMB-00005 sphere, and recovering the mid-water release

Once the top float was astern of the ship, the recovery commenced. The syntactic sphere was lifted on board using the Lebus winch and air tuggers to control the swing of the sphere. Both the Lebus winch and ship's crane was used together to level the sphere prior to lowering it into its stand. The sphere was secured to the stand with four (4) ratchet straps. A pallet jack was used to move the sphere forward which allowed the bottom of the 5 meter EM chain and IM wire termination to be recovered using the Lebus winch. A Yale grip was placed on the top shot of wire rope and then made fast using the stopper line. The IM termination was unbolted from the bottom of the EM chain; the sphere was moved out of the work area using a pallet jack. The Lebus winch leader was reeved through the travelling snatch block and shackled to the Yale grip. The winch took up the load, the stopper line was cleared. The 01 winch leader was shackled to the block and hauled in raising the block off the deck. Recovery of the 440 m shot of IM cable commenced.

After over spooling 7 wraps of wire on the spectra reel, a Yale grip was installed on the high tension side of the winch. A stopper line was then connected into the eye of the Yale grip and made fast by a Nystron stopper line made fast to a deck cleat.

An empty drum was installed on the spooler replacing the winch leader reel. Hauling resumed, the winch was stopped while the CTDMO instruments were removed from the 440 meter shot and the upper release float was recovered at 13:27 (Figure 3-47, right).

The ship repositioned 500 m NNW of the anchor position. The anchor release was enabled, ranged on, and then released at 14:15. It took 7 minutes for the sphere to surface. The Lebus leader was reeved through the A-frame block, around the starboard quarter, to just aft of the starboard A-frame. Deck personnel were positioned along the starboard rail tending the winch recovery line. The ship slowly approached the sphere brining it down the starboard side. A three (3) ton pickup hook snapped into the sphere as the ship moved ahead to allowing the sphere to come astern. Once the top float was astern of the ship, the recovery commenced. The sphere was recovered using the Lebus winch and air tuggers to control the swing of the buoy. Both the Lebus winch and ships crane was used together to level the sphere. The sphere was secure two with (2) ratchet straps.

Figure 3-48 – Recovering instruments and glass balls from the GI03FLMB-00005 mooring

Once the sphere was secure on deck, a Yale grip was installed on the 1000 m shot of wire rope and then made fast using the stopper line. The IM termination was unbolted from the bottom of the buoy; the sphere was then moved out of the work area using a pallet jack. The Lebus winch leader was reeved through the travelling snatch block and shackled to the Yale grip. The winch took up the load, the stopper line was cleared. The 01 winch leader was shackled to the block and hauled in raising the block off the deck. Recovery of the 1000 meter shot of IM cable commenced. The 1000 meter IM shot was winched in while removing instruments at designated depths (Figure 3-48, left). The controller cage and two (2) sets of glass balls were recovered using the ships trawl wire and Lebus winch.

At the junction of each section of wire rope, the mooring was stopped off using a Yale grip on the high tension side of the Lebus winch. This allowed deck personnel to change reels on the take-up spooler. This process was repeated for the recovery of all the shots of wire rope. The glass balls were lifted on board the ship using the Lebus winch (Figure 3-48, right). Once on deck, the cluster of balls was stopped off using a Nystron stopper. The remaining strings of balls along with the acoustic releases were lifted on board using the A-frame and trawl winch. The eight (8) sets of glass balls were untangled and disconnected, then craned in the rag top storage container.

The GI03FLMB-00005 mooring recovery was completed at 17:43 when the acoustic releases were brought aboard.

3.8.3. Inspection and Analysis

The main controller clock was compared to the actual time (on the ship) and showed accuracy within a minute. However, clock drift of the controller clock compared to the atomic clock was at -1565542914 sec (~49 years), which suggested the Atomic clock was reset at some point with a power cycle. Despite being able to communicate with the main controller and having 25 inHg of vacuum, there were signs of a leak inside the pressure housing (Figure 3-50 and Figure 3-51). The batteries were slightly swollen and there was minimal corrosion present.

The secondary controller stopped working on 10 January 2019. There is a data gap between 15 September 2018 and 21 November 2018. The PHSEN was kept disconnected from the controller to test whether the PHSEN being connected was a possible cause of SSIOC failure during deployment. Apparently, it is not the culprit, as the SSIOC failed anyway.

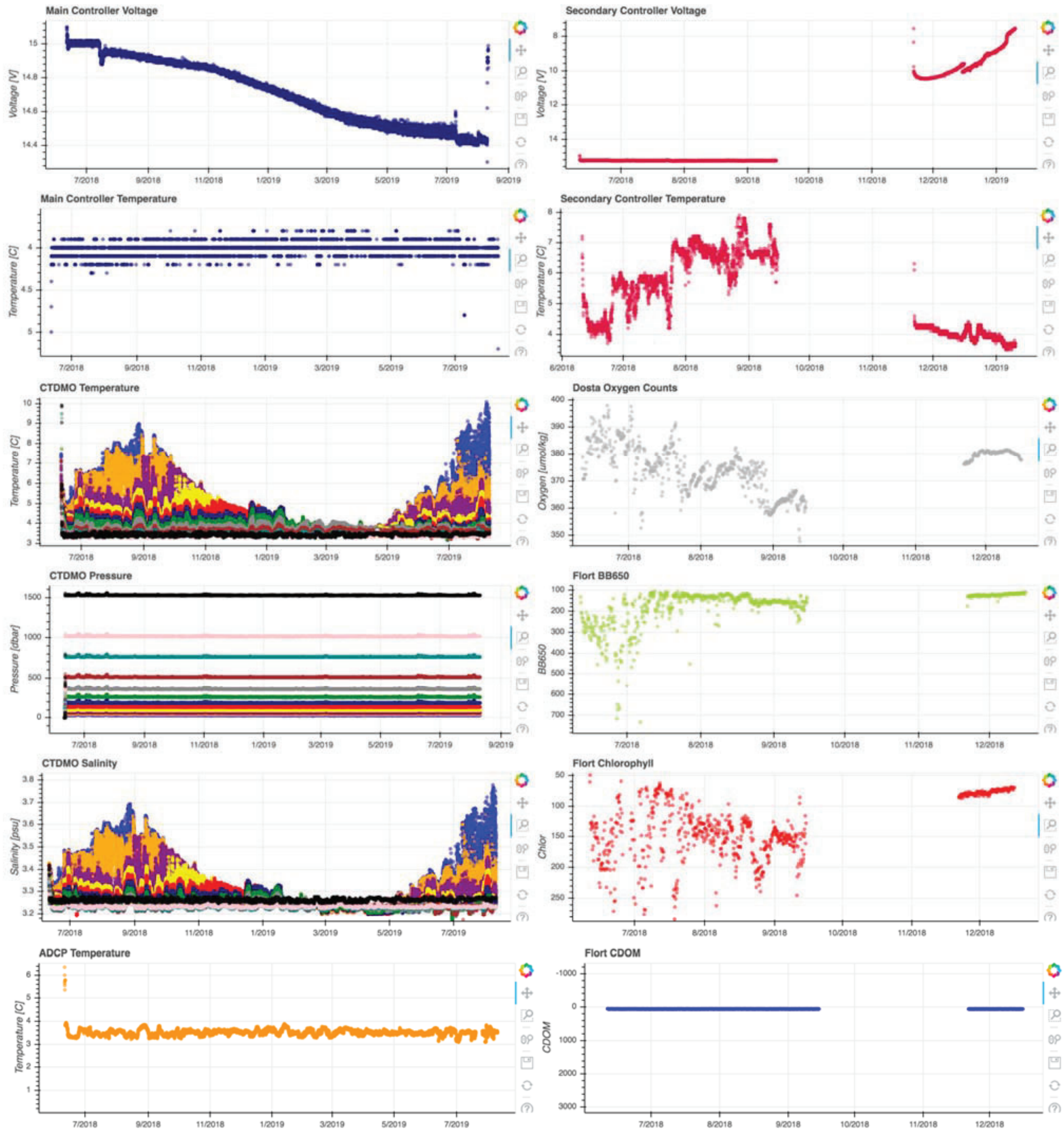


Figure 3-49 – GI03FLMB-00005 recovered data

Figure 3-50 – GI03FLMB-00005 Main controller housing leak and corrosion

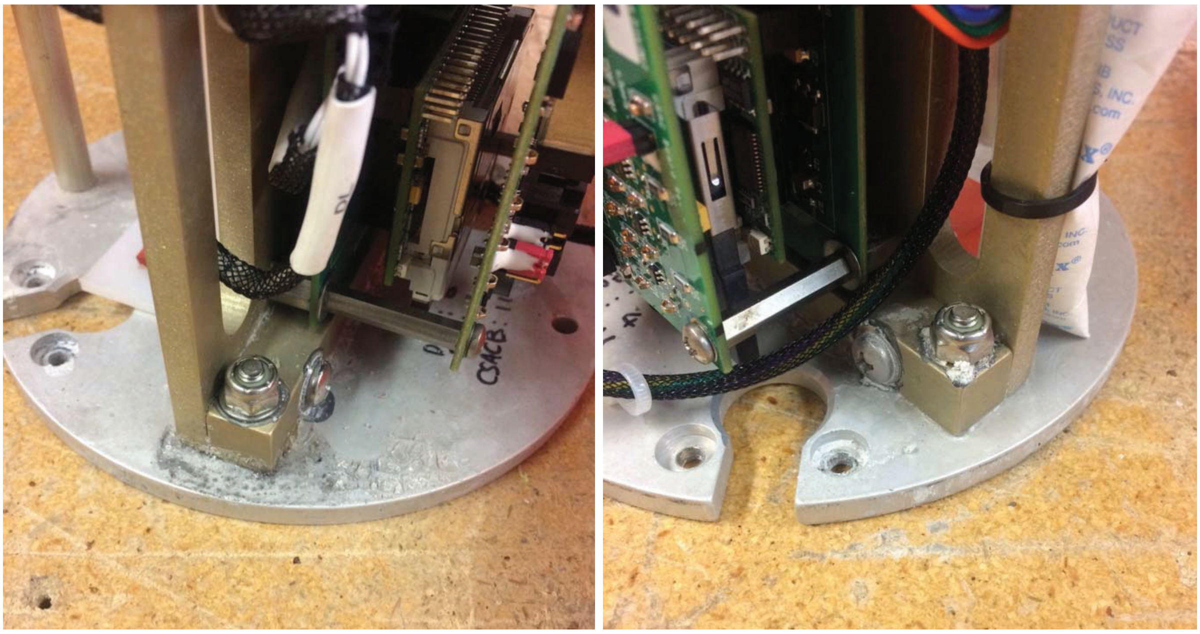


Figure 3-51 – GI03FLMB-00005 Main controller corrosion

3.9. GI03FLMA Recovery

3.9.1. Deployed Status

GI03FLMA-00005 was deployed on 10 June 2018. After deployment there were no inductive communications above the EM Chain. Last data from CTDMOs was received from 26 December 2018, and from the ADCP on 5 February 2019.

Approximately 20 kB of data were acoustically downloaded on 7 August 2019. Only data from the ADCP and the lowest 4 CTDMOs (below the ADCP cage) was obtained. Those instruments and the Main Controller were functioning as expected.

3.9.2. Recovery

The GI03FLMA-00005 mooring was recovered on 11 August 2019. The recovery of this mooring was identical to that of GI03FLMB-00005 described in Section 3.8.2 above.

The mid-water release was fired at 08:25, and the top half recovery was completed at 09:35. The anchor release was fired at 10:12, and the bottom half mooring recovery was completed at 13:02 when the acoustic releases were brought aboard.

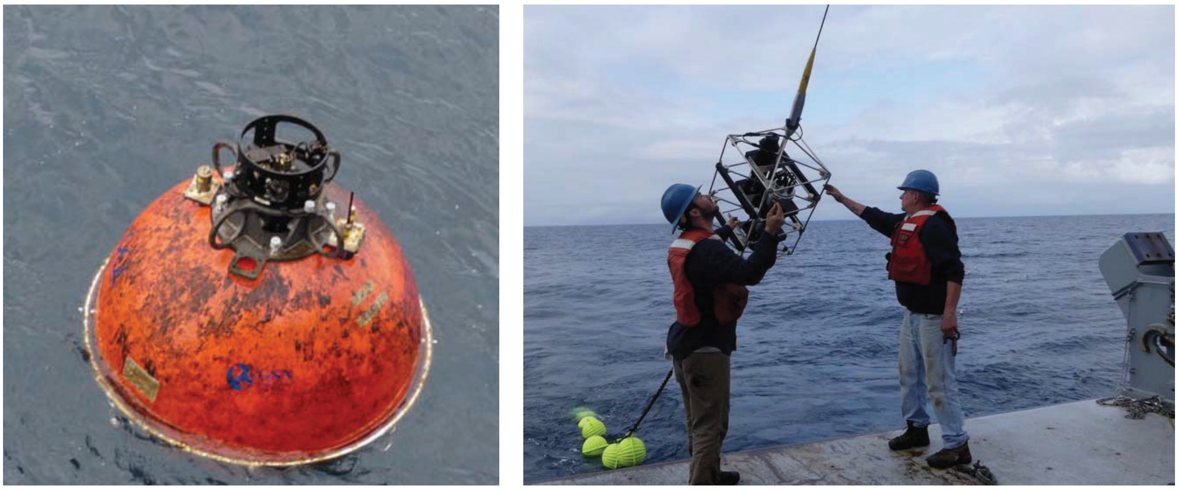


Figure 3-52 – Recovery of the GI03FLMA-00005 top sphere and controller cage

3.9.3. Inspection and Analysis

The main controller clock was compared to the actual time (on the ship) and showed accuracy within a minute. However, clock drift of the controller clock compared to the atomic clock was at -1565539173 sec (~49 years), which suggested the Atomic clock was reset at some point with a power cycle, as was observed on GI03FLMB-00005.

Since deployment, there were no IMM communications with the top sphere through the EM chain, so the MSIOC only had IMM communications up to the ADCP mid-water sphere. This was possible because the inductive wire termination above the ADCP mid-water sphere has a ground that completes the inductive loop. For some reason the MSIOC was able to acquire data from CTDMO (ID:47 at 350 m depth), which is located above the ADCP mid-water sphere, up until 28 October 2018. The EM Chain will undergo further testing back on shore to try to determine the root cause of the inductive communications problem.

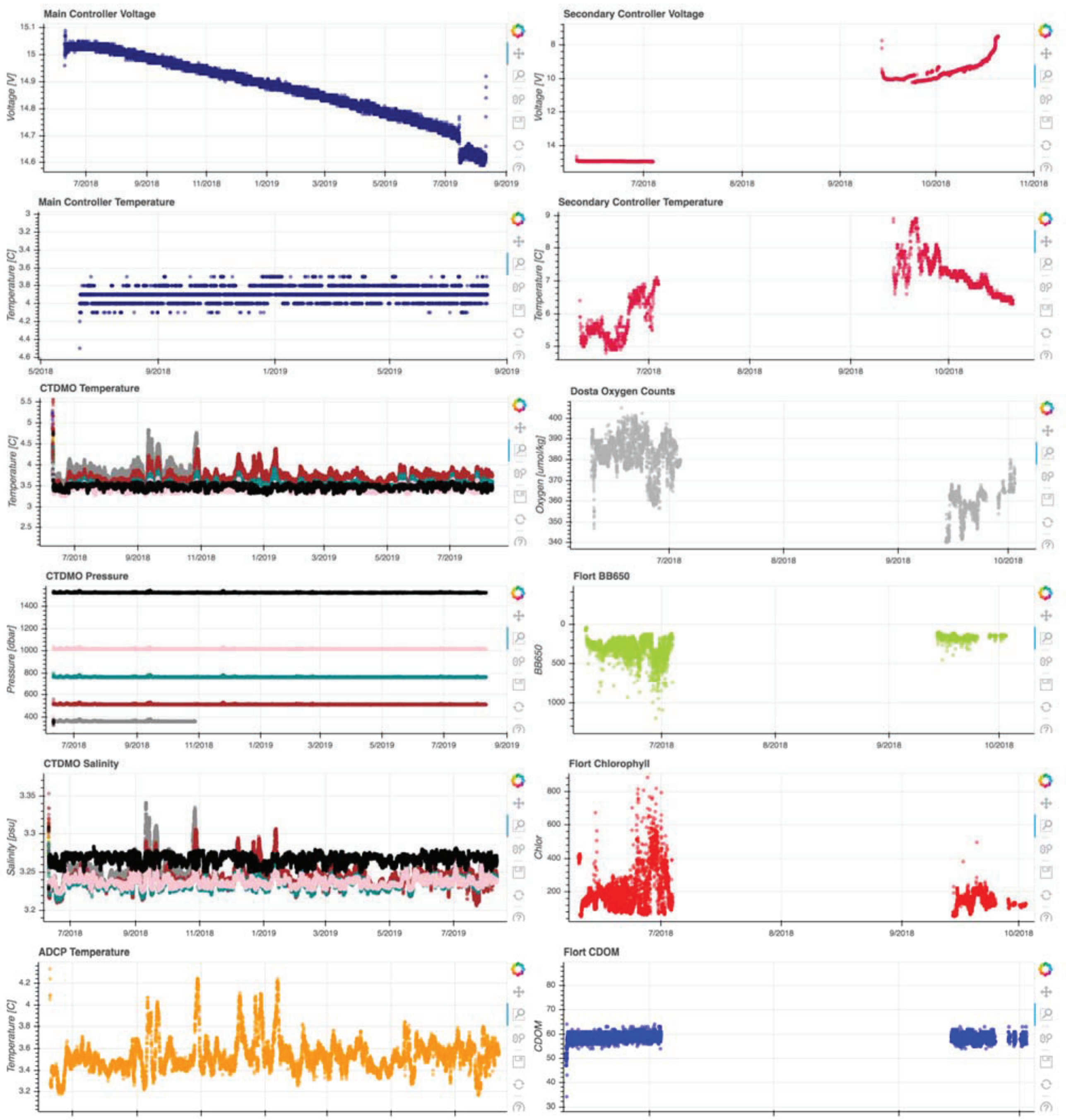


Figure 3-53 – GI03FLMA-00005 recovered data

3.10. Glider Deployments and Recoveries

All three gliders were deployed the evening of 6 August 2019. Gliders were prepared for deployment and moved out on deck. While on deck, the shore-side team ran pre-deployment testing and notified the at-sea team when the gliders were ready to be deployed. Profiling Glider gi_515 was deployed first, followed by Open Ocean Glider gi_525, and lastly Open Ocean Glider gi_560 (Figure 3-54). All deployment locations and times are in Table 3-6.

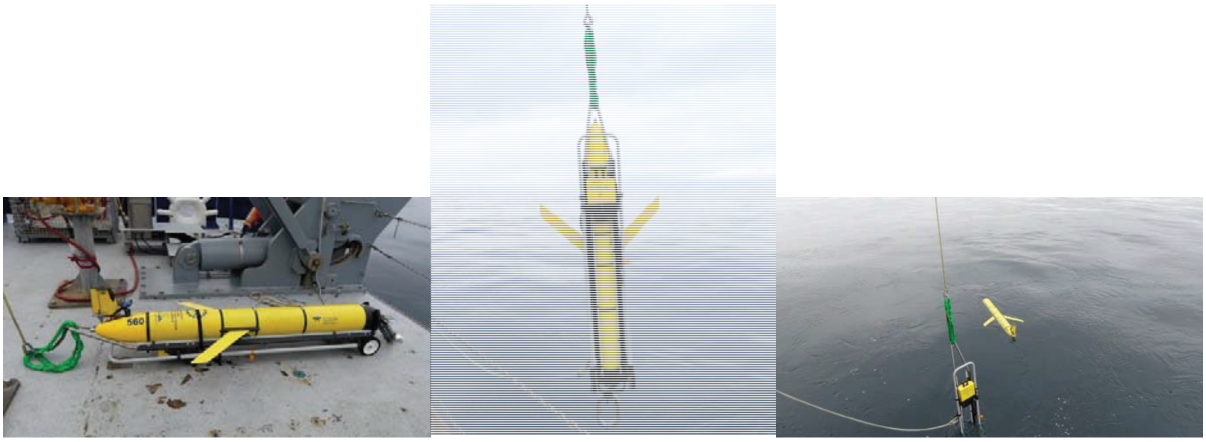


Figure 3-54 – Deployment sequence of Open Ocean Glider gi_560.

Shortly after deployment, glider gi_515 experienced an aft leak at 200 m and needed to be recovered (Figure 3-55, see Section 6.4). This glider has no lifting bale and needed to be recovered via the nose recovery system, which was triggered before the ship arrived. Recovery was as expected with nothing to note, and recovery information is referenced in Table 3-7. No additional gliders were recovered on this cruise.

Figure 3-55 – Recovery sequence of Global Profiling Glider gi_515.

Gliders gi_525 and gi_560 progressed through their check-out dives as expected, but it was noted by the shore team that both gliders appeared to be slightly light and required more pump drive to dive than anticipated. While the gliders would have operated just fine in this state, it was decided to add weight to each glider to reduce the amount of drive needed to dive. Doing so would reduce the amount of energy used by the pump and likely increase the duration of their deployment.

Due to favorable weather conditions and to reduce risk of damaging the gliders, the re-ballast operation was performed via small-boat (Figure 3-56). A total of approximately 100 g was added to both gi_525 and gi_560 by adding 4 wing rail weights to the port wing rail and 2 to the starboard wing rail. Shore pilots noticed a significant improvement in the ballast and dive patterns of both gliders after this weight was added.

Figure 3-56 – Re-ballast operations of glider gi_525.

Table 3-6 – Glider Deployment Locations

Glider S/N	Glider Type	Deployment Date / Time	Latitude	Longitude	Notes
515	1000 m Global Profiling Glider	6 August 2019 17:20 UTC	59° 54.9719' N	39° 15.9473' W	No issues on deployment. Developed a leak and required recovery.
525	1000 m Open Ocean Glider	6 August 2019 17:23 UTC	59° 54.9563' N	39° 15.9403' W	No issues on deployment. BCP Glider with DOSTA on top. Re-ballasted on 10 Aug 2019 – 4 weights add to port, and 2 weights added to stbd wing rails.
560	1000 m Open Ocean Glider	6 August 2019 18:05 UTC	59° 54.8283' N	39° 15.8926' W	No issues on deployment. OOI Glider with DOSTA on top. Re-ballasted on 10 Aug 2019 – 4 weights add to port, and 2 weights added to stbd wing rails.

Table 3-7 – Glider Recovery Locations

Glider S/N	Glider Type	Recovery Date / Time	Notes/Issues
515	1000 m Global Profiling Glider	6 August 2019 21:28 UTC	Aborted due to leak detect. Recovered with nose release recovery system.

4.0 Instrument Configuration and Sampling

The baseline and as-deployed sampling strategies for all OOI platforms are documented in the OOI Observation and Sampling Approach document (1102-00200). The specific configurations for fixed instruments are captured in the platform configuration spreadsheets (e.g., GI01SUMO-00006.xlsx).

4.1. GI01SUMO-00006 Mooring

The Surface Mooring instrument logging is controlled by individual "data logger" routines. These routines are version-controlled in the CGSN BitBucket repository "platcon_sw", and are not repeated here.

The Surface Mooring sampling is controlled by a combination of the power schedule for a given "node" on the mooring (e.g., buoy or NSIF) and the instrument sampling schedule executed by the data logger routines. Instrument sampling schedules are defined in the mooring's configuration files, the baseline of which is version controlled in the CGSN BitBucket repository "platcon_sw", mirroring the baseline defined in the CGSN Global Surface Mooring Sampling Plan (3103-00022) and the OOI Observation and Sampling Approach document (1102-00200), and the as-deployed configuration is captured in Table 4-1 below.

Table 4-1 – Surface Mooring Instrument Power and Communications Schedule

PLATFORM NODE measurement	INSTR Identifier	Power / Comms Schedule		Sampling / Comments
		Interval	Duration	
SURFACE BUOY				
meteorology_bulk (2)	METBK	On continuous		Samples once per minute
flux_direct_covariance	FDCHP	60 min	30 min	Samples for 20 min every hour; Only processed flux data telemetered
wave_spectra_surface	WAVSS	60 min	30 min	Samples for 20 min every hour (at 10 Hz)
nutrient_Nitrate	NUTNR	15 min	3 min	Approximately five (5) 3-sample averages every 15 min
attenuation_absorption_optical	OPTAA	60 min	2 min	4 samples every sec
Fluorometer_three_wavelength	FLORT	15 min	3 min	Samples once per sec
spectral_irradiance	SPKIR	15 min	3 min	Samples once per sec
oxygen_dissolved_stable	DOSTA	15 min	3 min	Samples once per 2 sec
pCO2_air-sea	PCO2A	60 min	55 min	20 min sample time (9 air & 9 water measurements)
Motion Pack	MOPAK	60 min	20 min	Samples at 10 Hz
Hydrogen sensor (2)	HYDGN	60 min	5 min	Samples ever 12 sec; one unit samples on the hour, the other on the half-hour
NSIF				
CTD_bottom_pumped	CTDBP	15 min	3 min	Samples every 10 sec
oxygen_dissolved_stable	DOSTA	15 min	3 min	Samples once per 2 sec
Fluorometer_three_wavelength	FLORT	15 min	3 min	Samples once per sec
spectral_irradiance	SPKIR	15 min	3 min	Samples once per sec
Velocity_point_mean	VELPT	15 min	7 min	
pCO2_water	PCO2W	2 hr	16 min	One sample every 2 hours (on even hours); Reagent-limited
nutrient_Nitrate	NUTNR	15 min	3 min	Approximately five (5) 3-sample averages every 15 min
attenuation_absorption_optical	OPTAA	60 min	2 min	4 samples every sec

PLATFORM NODE measurement	INSTR Identifier	Power / Comms Schedule		Sampling / Comments
		Interval	Duration	
MOORING WIRE (battery powered, inductive comms)				
CTD_Mooring (10)	CTDMO	7.5 min	N/A	@ 20, 60, 100, 180, 250, 350, 500, 750, 1000, 1500 meters
pH_stable (2)	PHSEN	60 min	N/A	@ 20, 100 meters
CTD_bottom_pumped (3)	CTDBP	2 hr	N/A	@ 40, 80, 130 meters Battery-limited
oxygen_dissolved_stable (3)	DOSTA	2 hr	N/A	@ 40, 80, 130 meters Connected to CTD
Fluorometer_two_wavelength (3)	FLORD	2 hr	N/A	@ 40, 80, 130 meters Connected to CTD
PCO2_water (3)	PCO2W	2 hr	N/A	@ 40, 80, 130 meters Reagent-limited Samples on even hours
velocity_profile	ADCPS	3 hr	N/A	@ 500 meters 80 pings, 2.15 sec between pings

4.2. GI02HYPM-00006 Mooring

The Hybrid Profiler Mooring has one CTDMO mounted above the Global Wire Following Profiler (GWFP), and one GWFP that profiles one way every 20 hours between the depths of 161 m and 2560 m. The sampling strategy (consistent with the OOI Observation and Sampling Approach document; 1102-00200) is shown in Table 4-2 below. Due to power and bandwidth constraints, only a subset of the collected data is telemetered to shore via the Open Ocean Glider circling the area.

Table 4-2 – Hybrid Profiler Mooring Sampling Strategy

HYBRID PROFILER MOORING measurement	INSTR Identifier	Sampling Frequency	Telemetered to Shore
CTD_Mooring	CTDMO-G	15 min	4 hr
Wire Following Profiler	GWFP	20 hrs	
CTD_Profiler	CTDPF-L	1 sec	400 sec / 100 m
Oxygen_dissolved_stable	DOSTA-L	10 sec	400 sec / 100 m
Fluorometer_three_wavelength	FLORD-L	10 sec	400 sec / 100 m
Velocity_three_axis	VEL3D-L	0.5 sec	400 sec / 100 m
Acoustic_zoo_plankton	ZPLSG	1 hr	24 hr

4.3. GI03FLMA-00006 and GI03FLMB-00006 Moorings

The Flanking moorings consist of instruments at fixed depths sampling at the frequencies defined in 1102-00200 and shown in Table 4-3.

Table 4-3 – Flanking Mooring Sampling Strategy

FLANKING MOORING measurement	INSTR Identifier	Sampling Frequency	Telemetered to Shore
CTD_Mooring	CTDMO-G, -H	15 min	4 hr
Oxygen_dissolved_stable	DOSTA-D	15 min	4 hr
Fluorometer_three_wavelength	FLORT-D	15 min	4 hr
pH_stable	PHSEN-F	2 hr	24 hr
Velocity_profile	ADCP-L	1 hr	4 hr
Velocity_point_mean (8)	OSNAP VELPT-B	1 hr	
CTD_pumped (8)	OSNAP CTDMO-H	7.5 min	

4.4. GI05MOAS Gliders

4.4.1. Open Ocean Gliders

The Open Ocean Gliders (GI05MOAS-GL) are programmed to fly along the perimeter of the array sampling on every other dive to 1000 m. Only a subset of the data (for a vertical resolution of 5 m) will be telemetered to shore. As noted previously, both gliders have the optode moved from the side of the glider to the top to allow air samples to be taken when the glider is on the surface (Figure 4-1).

The sampling scheme for gi_525 and gi_560 are slightly different from the OOI baseline. Table 4-4 shows the sampling frequency of the instruments, which sample only every other profile. Glider gi_560 will sample on alternating descents (Figure 4-2), and the BCP Glider gi_525 will sample on alternating ascents (Figure 4-3). Both gliders will sample oxygen at the surface.

Table 4-4 – Open Ocean Glider Sampling Frequency

Sensor	Description	OOG Sampling Frequency
CTDGV-M	SBE Glider Payload CTD	0.5 Hz, Every 2nd profile 0-1000 m
DOSTA-M	Aanderaa Optode 4831	0.5 Hz, Every 2nd profile 0-1000 m, and at surface
FLORD-M	WET Labs ECO FLBB	1 Hz, Every 2nd profile 0-1000 m

Figure 4-1 – Glider optode placement

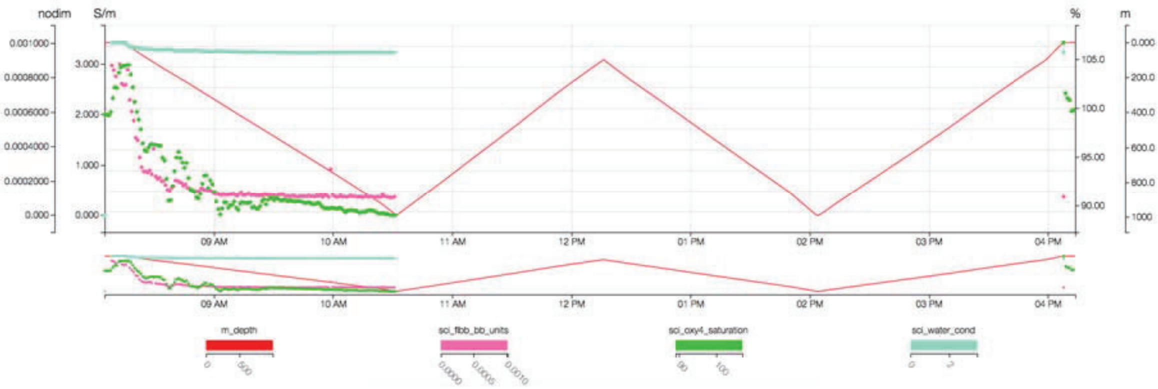


Figure 4-2 – Glider 560 (OOI) Sampling Scheme

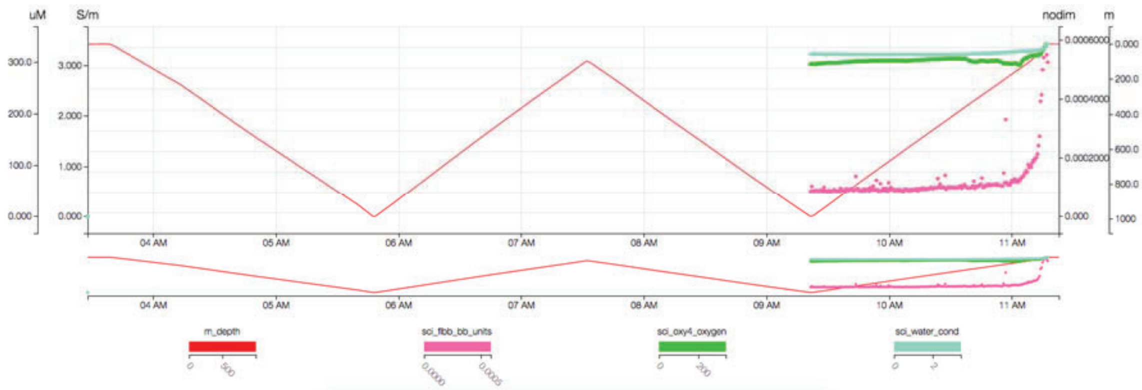


Figure 4-3 – Glider 525 (BCP) Sampling Scheme

4.4.2. Global Profiling Glider

The Global Profiling Gliders (GI05MOAS-PG) are programmed to stay in the vicinity of the GI02HYPM mooring by doing dives to 1000 m. They will only sample the upper 200 m (Table 4-5). Only a subset of the data (for a vertical resolution of 5 m) will be telemetered to shore.

Table 4-5 – Global Profiling Glider Sampling Frequency

Sensor	Description	GPG Sampling Frequency
CTDGV-M	SBE Glider Payload CTD	0.5 Hz, Every profile to 200 m
DOSTA-M	Aanderaa Optode 4831	0.5 Hz, Every profile to 200 m
FLORT-M	WET Labs ECO FLBBCD	1 Hz, Every profile to 200 m
FLORT-O	WET Labs ECO BB3	1 Hz, Every profile to 200 m
PARAD-M	Biospherical QSP-2155	1 Hz, Every profile to 200 m
NUTNR-M	Satlantic SUNA	5 m resolution, Every profile to 200 m

5.0 Ancillary Data Collection

5.1. Bathymetry Surveys

The R/V *Armstrong* is equipped with Knudsen 12 kHz and 3.5 kHz echosounders as well as Kongsberg EM122 and EM710 multi-beam swath bathymetry systems. The 12kHz echo sounder was run as needed for determination of water depth and was shut down during acoustic release testing and ranging. No bathymetry surveys were conducted.

5.2. Water Column Echosounder

The R/V *Armstrong* is equipped with a Simrad EK80 multi-frequency water-column echosounder. This instrument was configured according to the recommendations of the Shipboard Science Services Group (SSSG) technicians (Table 5-1). The frequency options include 18, 38, 70, 120 and 200 kHz. The Global Profiler Mooring has upward- and downward-looking ZPLSG instruments (38, 70, 125 and 200 kHz channels).

To minimize interference, the Knudsen echosounder and all of the shipboard ADCPs were turned off while the EK80 was running, and the bridge fathometer and speed log were turned off when the EK80 was logging. The EK80 was operated to validate the bio-acoustic sonar on the Global Profiler Mooring, and to assess subsurface mooring sphere depths (Table 5-2).

Table 5-1 – EK80 Configuration

Transducer	Pulse Type	Pulse Duration	Power	Depth	Ramping	Frequency Range
18 kHz	CW	1.024 ms	500 W	3.31 m	Fast	n/a
38 kHz	CW	1.024 ms	500 W	3.31 m	Fast	n/a
70 kHz	FM	1.024 ms	500 W	3.35 m	Fast	45 – 90 kHz
120 kHz	FM	1.024 ms	125 W	3.35 m	Fast	95 – 160 kHz
200 kHz	FM	1.024 ms	90 W	3.35 m	Fast	160 – 260 kHz

Table 5-2 – EK80 Surveys

Site	Date	Notes
GI02HYPM	22:15 UTC 8 August to 00:16 UTC 9 August	~3 NM path across both GI02HYPM moorings at ~2 kts (slowing to ~1 kt while over each mooring).

5.3. CTD Casts and Water Sampling

The R/V *Armstrong* is outfitted with a 24-place Niskin bottle rosette and instrumentation to measure the following parameters:

- Conductivity, Temperature and Pressure (Seabird 911) w/ dual sensors for temperature and conductivity measurements:
  - Temperature primary and secondary: S/N 2271 (calibration date: 15 Aug 2018), 4148 (calibration date: 15 Aug 2018).
  - Conductivity primary and secondary: S/N 3093 (calibration date: 29 Jan 2019, S/N 2768 (calibration date: 16 Aug 2018);
  - Digiquartz Pressure: S/N 94763_SBE09785 (calibration date: 23 July 2018).

  Note: The CTD primary pump was swapped out after casts #005 and #011

- Dissolved Oxygen, Seabird SBE 43: S/N 0794 (calibration date: 6 Sep 2018).
- Fluorescence and Turbidity, Wet Labs FLNTU; S/N 149 (calibration date: 28 Nov 2016)
- Transmissometer, Wet Labs C-Star; S/N 1117 (calibration date: Sep 2018).
- No PAR instrument on the CTD rosette due to the water/cast depths at the Irminger Array

CTD casts and water sampling were conducted to provide validation data for evaluation of instrumentation on the deployed moorings, and to characterize the conditions of the Irminger Array (Table 5-3). Water samples were collected for measuring oxygen, salts, chlorophyll, nutrients and carbon (dissolved inorganic carbon, total alkalinity and pH) at all mooring sites. At glider deployment and recovery sites, water samples were collected for measuring oxygen, salts and chlorophyll only.

There were numerous issues affecting CTD data and water collection during the Irminger 6 cruise. They are detailed in Section 6.1.

Table 5-3 – CTD Casts

Cast #	Date	Time (UTC)	Site	Water Depth	Cast Depth	Water Samples
001	8/3/2019	09:15	Acoustic Release Test	1856 m	1000 m	No water samples; acoustic release testing; CTD failed at max depth
002	8/5/2019	16:21	SUMO site center	2702 m	1500 m	No water samples; acoustic release testing
003	8/6/2019	13:20	HYPM site center	2669 m	2650 m	No water samples; acoustic release testing
004	8/6/2019	19:05	Glider Box	2758 m	1000 m	No water samples
005	8/7/2019	14:25	FLMA site center	2694 m	2600 m	No water samples; acoustic release testing
006	8/8/2019	14:24	FLMB site center	2822 m	2750 m	No water samples
007	8/8/2019	23:59	USBL	N/A	N/A	Non-OOI Cast
008	8/10/2019	20:33	Glider Box	2824 m	1000 m	Samples at 850, 650, and 300 m ** (OOI & BCP) OOI samples: Salts
009	8/11/2019	16:43	Between SUMO-6 & HYPM-6	2654 m	2500 m	Samples at 2500, 500, 80, and12 m ** (OOI & BCP) OOI samples: Salt, O_2, pH, DIC/TA, Chl, Nitrate
010	8/12/2019	08:22	FLMB-6	2817 m	2500 m	Samples at 2500, 500, 90, and 30 m ** (OOI & BCP) OOI samples: Salt, O_2, pH, DIC/TA, Chl
011	8/15/2019	09:06	Between SUMO-6 & HYPM-6 w/ Gliders	2648 m	2500 m	24 samples from 2500 to surf (OOI & BCP) OOI samples: Salt, O_2, pH, DIC/TA, Chl, Nitrate

Cast #	Date	Time (UTC)	Site	Water Depth	Cast Depth	Water Samples
012	8/15/2019	15:39	FLMB-6	2816 m	2700 m	15 samples from 2700 to surf (OOI & BCP) OOI samples: Salt, O_2, pH, DIC/TA, Chl
013	8/15/2019	20:04	FLMA-6	2699 m	2600 m	24 samples from 2600 to surf (OOI & BCP) OOI samples: Salt, O_2, pH, DIC/TA, Chl

** Niskins fired using acoustic releases, due to a failed CTD pylon (see Section 6.1)

5.4. Meteorological Data

The R/V *Armstrong* is outfitted to measure the following meteorological parameters:

- Air temperature, Barometric Pressure, Humidity, Wind Speed/Direction and Precipitation (Vaisala WXT520; Port sensor-S/N: C3620001, PTU S/N 5020199 calibration date: 25 Jan 2018, Starboard Sensor-S/N D0220001, PTU S/N N4810059 calibration date: 25 Jan 2018) mounted on the bow mast 17.9 m above the waterline.
- Long Wave and Short Wave Radiation – Radiometer Analog to Digital Interface (S/N RAD_224 calibration date: 13 Nov 2018) with Eppley Standard Precision Pyranometer (SPP; S/N 37501F3, calibrated 12 Nov 2018) and Precision Infrared Radiometer (PIR; S/N 32227F3, calibrated 13 Nov 2018) mounted at the top of the bow mast.
- Photosynthetic Active Radiation (Biospherical Instruments QSR2150A, S/N: 50211, calibrated 27 Apr 2019) installed on the top of the bow mast.

5.5. Near-Surface Parameters

The R/V *Armstrong* is outfitted with system and sensors to measure the following near-surface parameters:

- Surface Sound Velocity (AML hull transducer, S/N 206020, calibration date: 16 Feb 2017) mounted in the transducer room, intake is aft of multibeam transducers, depth approximately the same as the ship's draft (estimated to be 4.5 m).
- Near-Surface Temperature (Sea-Bird Electronics SBE-48, S/N 0040, calibration date: 12 May 2017) magnetic hull-mounted temperature sensor, located in the bow thruster room, on the starboard bulkhead at approximately 2 m depth.
- Near-Surface Temperature (AML hull transducer, S/N 403162, calibration date: 13 Jun 2014) mounted in the transducer room, intake is aft of multibeam transducers, depth approximately the same as the ship's draft (estimated to be 4.5 m).
- Near-Surface Temperature and Salinity (Sea-Bird Electronics SBE-45 MicroTSG, S/N 4554695-0288, calibration date: 18 Mar 2018) located on the wet lab inboard bulkhead. The water is from the starboard sea chest ~8 ft above base line (ABL). Travel distance from intake to sensors: 110 ft. Diaphragm pump.
- Near-Surface Fluorescence (WET Labs WETStar Chlorophyll sensor, S/N WS3S-1032P, calibration date: 14 Feb 2019) located on the wet lab inboard bulkhead. T The water is from the starboard sea chest ~8 ft above base line (ABL). Travel distance from intake to sensors: 110 ft. Diaphragm pump.

5.6. Acoustic Doppler Velocity Profilers

The R/V *Armstrong* was outfitted with three ADCP data streams to provide water-column velocity estimates of varying vertical extent and depth resolution.

- RD Instruments WorkHorse 300 kHz (WH300), configured with bottom track off, ping interval of 0.8 sec, and 50 bins of 2 m each.
- RD Instruments Ocean Surveyor 150 kHz (OS150 NarrowBand and BroadBand Modes). NarrowBand mode was configured with 55 depth bins of 8 m each. BroadBand mode was configured with 55 depth bins of 4 m each. Bottom track off, ping interval of 1.1 sec.
- RD Instruments Ocean Surveyor 38 kHz (OS38 NarrowBand and BroadBand Modes). NarrowBand mode was configured with 75 depth bins of 24 m each. BroadBand mode was configured with 100 depth bins of 12 m each. Bottom track off, ping interval of 3 sec.

6.0 Issues and Recommendations

6.1. CTD issues

6.1.1. Pylon failure

During the first CTD cast (#001) on 3 August to test 3 acoustic releases, a failure occurred when firing a bottle at the bottom of the cast. The CTD rosette was brought to the surface with no upcast data. The connections were checked and a second cast without CTD data was conducted to test 3 more acoustic releases. CTD operations were then stopped so that the issue could be further investigated. The SSSGs (Amy Simoneau and Cris Seaton; with support from shore) thoroughly trouble-shot the full CTD rosette system. The issue seemed to be the connection between the CTD and the rosette. It was at first thought to be a connector on the CTD that needed to be changed out. Then it was thought to be an issue with the CTD deck box. Finally, the root cause was determined on the evening of 4 August. The pylon is the housing that holds the Niskin firing mechanism. This housing was removed and found to have 2-3 inches of water in the bottom. Although the electronics were in the upper portion of the housing, they were found to be corroded. No replacement pylon was on board.

WHOI Marine Operations had a spare pylon on shore and began to investigate ways to ship the pylon to a nearby port where we could pick it up. Reykjavik (at 2 days' steam) was too far away given the number of our contingency days and the weather forecast. Greenland was the best possibility, but due to weather conditions at the southern tip, it was unlikely that the *Armstrong* could get to a west coast port (e.g., Nuuk).

In the meantime, CTD casts were conducted following mooring deployments with the pylon removed and the Niskin bottle vent plugs and petcocks removed to allow water to free-flow through the bottles. During later CTDs, acoustic releases were rigged to fire a few Niskin bottles (see Section 6.1.2).

On 7 August plans were confirmed to have Ellen Roosen hand carry the pylon and associated cables from Woods Hole to Nanortalik (via Reykjavik and Narsarsuaq), and then come by small boat through Prince Christian Sound on 13 August to meet the *Armstrong* on the east side of Greenland. All mooring operations were completed on 11 August, and the morning of 12 August the *Armstrong* steamed to Prince Christian Sound. As noted earlier in the report, the delivery of the pylon was delayed until 14 August due to weather, and the delivery location was shifted further west into the Sound. The pylon was installed and tested on 14 August. On 15 August 3 successful CTD casts with Niskin sampling were conducted.

6.1.2. Tripping Niskin bottles with acoustic releases

During the time that the pylon was removed, we investigated a way to collect at least some water samples (to protect again no samples being collected if the pylon could not be delivered or weather prevented later CTD casts). It was determined that the most likely mechanism to enable sampling of multiple bottles at multiple depths was using acoustic releases. Following all of the deployments and some recoveries, 3 to 4 recovered acoustic releases were mounted to the arms of the CTD rosette. Niskin bottles were cocked outward and connected to a length of twine that was pulled around the bottom of the arm on which the Niskin was mounted, and connected to a mid-water float release pin which was locked into the acoustic release. When the release was fired, the locking bar swung downward dropping the mid-water float release pin and allowing the Niskins to close.

This technique was first used successfully on CTD cast #008 with 3 acoustic releases connected to 3 Niskin bottles (1 each). On CTD casts #009 and #010, 4 acoustic releases were mounted, each connected to 2 Niskin bottles enabling duplicate bottles to be closed at four depths.

6.1.3. Primary Conductivity and Oxygen measurement

During the Irminger Sea 6 cruise (AR35-05) there was an un-resolved issue with the primary temperature (T) and conductivity (C), and oxygen measurements, making all of that data suspect for the entire cruise. The CTD rosette has two sets of temperature and conductivity sensors each connected to a single pump. The lone oxygen sensor (SBE 43) is connected to the plumbing of the primary T and C sensors. There was a constant offset observed between the primary and secondary conductivity (salinity) data throughout the cruise.

Starting with CTD cast #002 the oxygen and primary T and C data began to show deviations at depth on the downcast, which somewhat resolved on the upcast but was noisy. A summary of the primary C, T and oxygen data issues from each cast is shown in Table 6-1. Data from the secondary C and T appeared to be unaffected, but this should be further investigated to confirm.

Table 6-1 – CTD Primary C & T, and Oxygen Issues

Cast #	Date	Site	Oxygen	Primary Conductivity	Primary Temperature	Notes
001	8/3/2019	AR test	N/A	N/A	N/A	CTD failed at 1000 m
002	8/5/2019	SUMO	Data suspect below ~1060			
003	8/6/2019	HYPM	Data suspect below ~1400			
004	8/6/2019	Gliders	Data suspect	Data potentially okay		
005	8/7/2019	FLMA	Data suspect below ~1500			
006	8/8/2019	FLMB	Data suspect below ~1500			
007		USBL	Data suspect below ~700			
008	8/10/2019	Gliders	Data suspect below ~500			
009	8/11/2019	SUMO/ HYPM	All data suspect			
010	8/12/2019	FLMB	Data suspect	Spike at ~1400 m		
011	8/15/2019	SUMO/ HYPM/ Gliders	All Data suspect			
012	8/15/2019	FLMB	Data suspect	Spike at ~2300 m	Data potentially okay	
013	8/15/2019	FLMA	Data suspect	Data potentially okay	Data potentially okay	Oxygen sensor removed from plumbing

A variety of trouble-shooting steps were taken to try to determine the cause of the issue. No root cause was determined during the cruise.

- Primary pump was swapped between casts #005 and #006 (S/N 052181 in for S/N 055284) – no effect.

- The cables to the pumps were switch between casts #006 and #007 to see if it was a faulty cable issue – no effect.
- The oxygen sensor was flushed between casts #007 and #008 to clear any possible obstructions – no effect.
- The oxygen and primary conductivity sensors were swapped out after cast #008 (oxygen: S/N 0264 in for S/N 0794; conductivity: S/N 3061 in for S/N 3093) – no effect during a test cast after cast #008.
- The oxygen and primary conductivity sensors were swapped back before cast #009
- Primary pump was swapped between casts #011 and #012(S/N 052146 in for S/N 052181) – no effect.
- During cast #013, the oxygen sensor was disconnected from the primary C-T plumbing path – the oxygen data were noisier because the sensor was not pumped, no effect on the C and T data.

6.1.4. Addition of DOSTA to CTD rosette

Due to issues with the CTD rosette oxygen sensor detailed in Section 6.1.3 and the lack of Niskin bottle samples for sensor calibration, Hilary Palevsky requested the addition of an oxygen optode to the CTD rosette. OOI DOSTA (Aanderaa optode 4831) S/N 502 was added to the rosette prior to CTD cast #003.

Aanderaa optodes are not typically used on CTD sensor packages because they have a slower response time than the SBE 43 used as the primary shipboard oxygen sensor. Oxygen profiles from the Aanderaa optode installed on the CTD rosette are therefore expected to be affected by lag. This was evident in comparing the up versus down cast data produced by this sensor during the cruise (Figure 6-1).

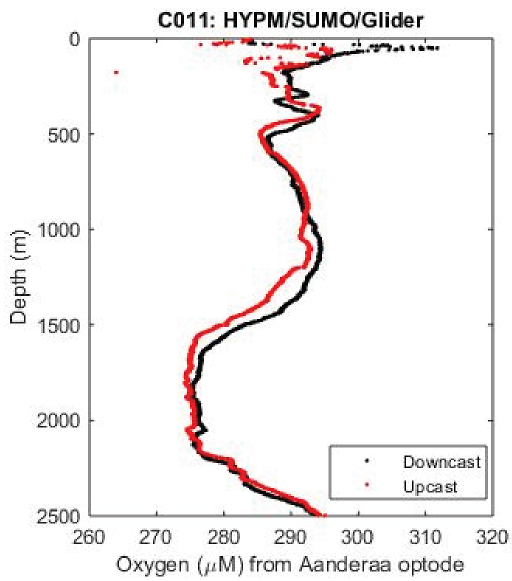


Figure 6-1 – CTD #011 Upcast vs. Downcast Comparison

The potential benefit of using the Aanderaa optode, however, is its greater stability over time. This theoretically provides the opportunity to use the Niskin bottle samples for oxygen collected beginning with Cast #008 to calibrate the optode and apply that calibration to all casts used throughout the cruise.

In using the Aanderaa optode data, note that the CTD package transmitted the Aanderaa data as voltage, rather than as a calculated oxygen value. This can be converted to calphase (a type of raw data typically output by the optode) as: calphase = 10 + 12*volts.

To convert from calphase to oxygen concentration values, use the calibration coefficients for this sensor (S/N 502) provided (see Appendix H). The salinity setting in the optode is 0 salinity, so salinity and pressure corrections will need to be applied.

Note that the Aanderaa optode typically measures temperature as well as oxygen, but this was not logged because there was only a single channel available to transmit data from the optode when attached to the CTD rosette.

6.2. Ship-mounted 12 kHz transducer for acoustic communications and releases

Normally, OOI acoustic communications (both for acoustic releases, and for data download) are done through the ship-mounted Knudsen 12 kHz transducer. This involves during off the Knudsen, and swapping connectors at the Knudsen J-Box in the Main Lab. In an effort to avoid this switching of cables, the Armstrong provided cabling to connect to a different ship-mounted 12 kHz transducer. This one is the micromodem Gavial ITC-3013 transducer.

The micromodem transducer was used successfully to communicate with the acoustic releases using the EdgeTech deck boxes for most of the cruise. However, when connecting to the micromodem transducer with the Teledyne Benthos deck box for acoustic data download, the transducer was found to be too noisy. Thus all of the acoustic data download was done using the Knudsen transducer.

There were some instances during acoustic release testing and recoveries when communications through the micromodem transducer were very spotty. Thus on 11 August during the GI03FLMA-00005 recovery, they switched to using to the Knudsen transducer for the acoustic releases, and communications improved.

Although it is more convenient to use the micromodem transducer (no turning off of the Knudsen and swapping of cable), there did seem to be more noise issues with this one. One difference is that the Knudsen transducer is grounded, and the micromodem transducer is not.

6.3. NSIF Orientation

Jonathan Fram (OSU) recommended orienting the NSIF so that the segment with the SPKIR is furthest from the buoy (so the upwind side) and least likely to be shaded. This was attempted for the first time on the Irminger Sea 6 deployment.

The EM Chain is marked with a tape that runs the length of the chain with manufacturer information. Some years this tape runs straight down one side of the chain, some years it wraps around the chain like a peppermint stick. For the GI01SUMO-00006 deployment, the tape ran straight down the chain. When the buoy was positioned on deck for deployment and the EM Chain was connected, the tape was on the "top" side of the chain (while lying on the deck) and thus pointing toward the upwind side of the buoy. When bent around on deck to connect to the NSIF, the tape was still on the "top" side. Therefore, the NSIF was oriented so that the segment with the SPKIR was on the "top" side of the NSIF as it lay on the deck.

When attempting this orientation on future cruises, one can either use the tape strip down the EM Chain to ensure proper orientation, or create a mark with chalk or such.

Note that the EM Chain when mounting to both the buoy and NSIF has some restrictions due to the bolt hole patterns, so the SPKIR segment may not be exactly aligned, but can be close.

6.4. Glider 515 leak

Glider gi_515 was air-shipped from WHOI and arrived in Reykjavik Iceland with a slight rotation in the aft hull and the SUNA forward mount was loose. Shipping damage was suspected. It was decided to correct these conditions and attempt deployment. The leaking glider gi_515 was later inspected at the WHOI lab after recovery where further internal damage was discovered. The terminal end of the forward tie rod was bent, the forward face-bolt of the SUNA mount was bent, and the aft battery assembly was loose and slightly wracked. Salt trails were found originating at the aft-cap seals. No clear damage to the glider crate was observed; however, it was noted that the orientation labels ("this end up") were faded beyond recognition. It was surmised that the crate orientation was not level during a portion of the journey, which could defeat the function of the crate's internal shock mounts, subjecting the glider to vibration or shock loads and producing the visible damage. Clear labeling would likely eliminate this issue in the future.

Appendix A – Cruise Participants

There were 17 participants in the science party, 10 OOI personnel, 5 ancillary personnel and 2 WHOI Shipboard Scientific Services (SSSG) technicians.

Scientific Party

	Name	Gender	Nationality	Affiliation
1.	Sheri White	F	USA	WHOI/Chief Sci
2.	John Kemp	M	USA	WHOI
3.	Chris Basque	M	USA	WHOI
4.	Jim Dunn	M	USA	WHOI
5.	Collin Dobson	M	USA	WHOI
6.	James Kuo	M	USA	WHOI
7.	Dan Bogorff	M	USA	WHOI
8.	Allen Smith	M	USA	WHOI
9.	Stephanie Petillo	F	USA	WHOI
10.	Dave Wellwood	M	USA	WHOI
11.	Hillary Palevsky	F	USA	Boston College
12.	Shawnee Traylor	F	USA	WHOI
13.	Thanda Newkirk	F	USA	Wellesley
14.	Claire Hayhow	F	USA	Wellesley
15.	Laura Rubiano-Gomez	F	USA	High Mowing School
16.	Amy Simoneau	F	USA	WHOI/SSSG
17.	Cris Seaton	M	Canada	WHOI/SSSG

OOI Roles and responsibilities:

Chief Scientist: S. White

Overall logistics and deck operations lead: J. Kemp

Safety (MSDS) and Shipping Document Coordination: J. Kemp

WHOI Surface Mooring: C. Dobson, S. Petillo

WHOI Subsurface Moorings: J. Kuo, D. Bogorff

WHOI Instrumentation: A. Smith

WHOI Gliders: C. Dobson

CTD/Water Sampling: D. Wellwood

Mooring team (winch, deck): J. Kemp, C. Basque, J. Dunn

Cruise Documentation: S. White, S. Petillo

Appendix B – Cruise E-Log

Message ID	GPS_Time	Instrument	Action	Transect	Station	Cast	Latitude	Longitude	Author	Comment
1	8/2/19 9:46	Ship	other	NaN	NaN	NaN	64.154373	-21.939732	sWhite1	Shifting from harbor to warehouse dock to get Surface Buoy.
2	8/2/19 14:00	Ship	startCruise	NaN	NaN	NaN	64.150144	-21.853395	sWhite1	Departing Reykjavik from warehouse dock
3	8/2/19 14:46	Underway Science seawater	start	NaN	NaN	NaN	64.18191	-22.072657	aSimoneau1	aft diaphragm pump turned on for cruise service
4	8/2/19 14:47	Knudsen 3260	start	NaN	NaN	NaN	64.181522	-22.078387	aSimoneau1	12kHz started for bottom depth
5	8/3/19 9:10	CTD911	deploy	NaN	NaN	1	62.767643	-28.647213	sWhite1	Test cast to 1000 m w/ acoustic releases 48501, 50453, 50779
6	8/3/19 9:36	CTD911	maxDepth	NaN	NaN	1	62.767594	-28.647211	sPetillo	At max depth, 20 min soak
7	8/3/19 10:27	CTD911	recover	NaN	NaN	1	62.76764	-28.647223	sWhite1	CTD on deck
8	8/3/19 10:58	CTD911	deploy	NaN	NaN	NaN	62.767596	-28.647239	sWhite1	Test cast to 1000 m w/ acoustic releases 50686, 50466, 50684 (no CTD data)
9	8/3/19 11:21	CTD911	maxDepth	NaN	NaN	NaN	62.767599	-28.647216	sWhite1	At max depth, 20 min soak
10	8/3/19 12:15	CTD911	recover	NaN	NaN	NaN	62.767609	-28.647263	sWhite1	CTD rosette on deck
11	8/3/19 16:57	UHDAS	start	NaN	NaN	NaN	62.39992	-30.086534	aSimoneau1	cleared iceland eez turned on adcps
12	8/3/19 16:59	PCO2	start	NaN	NaN	NaN	62.397157	-30.097397	sWhite1	Turned on outside of Icelandic waters
13	8/4/19 21:34	SUMO	other	NaN	GI01SUMO-00005	NaN	59.935668	-39.490698	sWhite1	Start MET comparison at SUMO
14	8/5/19 6:00	SUMO	other	NaN	GI01SUMO-00005	NaN	59.944731	-39.495977	sWhite1	End MET comparison at SUMO
16	8/5/19 8:34	SUMO	deploy	NaN	GI01SUMO-00006	NaN	60.006998	-39.752956	sWhite1	Start deployment, 6.5 NM NW of target
15	8/5/19 10:22	Underway Science	service	NaN	NaN	NaN	59.995425	-39.718024	aSimoneau1	brief interruption of diaphragm pump to fix small
17	8/5/19 15:29	SUMO	deploy	NaN	GI01SUMO-00006	NaN	59.94339	-39.569642	sWhite1	Anchor drop
18	8/5/19 16:17	CTD911	deploy	NaN	GI01SUMO	2	59.939829	-39.522176	sWhite1	Cast to 1500 m w/ acoustic releases 50779, 50457, 48492
19	8/5/19 16:49	CTD911	maxDepth	NaN	GI01SUMO	2	59.939767	-39.521473	sWhite1	At max depth, 20 min soak
20	8/5/19 18:23	CTD911	recover	NaN	GI01SUMO	2	59.939767	-39.521457	sWhite1	CTD on deck
21	8/5/19 18:47	SUMO	anchor survey	NaN	GI01SUMO-00006	NaN	59.935327	-39.57721	sWhite1	Starting anchor survey for GI01SUMO-00006 w/ release 50453
22	8/5/19 19:35	SUMO	anchor survey	NaN	GI01SUMO-00006	NaN	59.952979	-39.580586	sWhite1	Survey competed; surveyed position 59 56.7071 N, 39 34.4403 W
23	8/5/19 20:05	UHDAS	stop	NaN	GI02HYPM-00005	NaN	59.96543	-39.495284	sWhite1	ADCPs turned off for acoustic download at GI02HYPM-00005
56	8/5/19 20:15	HYPM	other	NaN	GI02HYPM-00005	NaN	59.967251	-39.495889	sWhite1	Starting acoustic data download
24	8/5/19 20:43	UHDAS	start	NaN	GI02HYPM-00005	NaN	59.972608	-39.498895	sWhite1	ADCPs turned back on after data download
57	8/5/19 20:44	HYPM	other	NaN	GI02HYPM-00005	NaN	59.973379	-39.497086	sWhite1	Data download complete; mooring functioning,
25	8/5/19 21:16	SUMO	other	NaN	GI01SUMO-00006	NaN	59.970275	-39.590593	sWhite1	Start MET comparison at SUMO
26	8/6/19 6:47	SUMO	other	NaN	GI01SUMO-00006	NaN	59.96229	-39.593667	sWhite1	End MET comparison at SUMO
27	8/6/19 8:15	HYPM	deploy	NaN	GI02HYPM-00006	NaN	60.043346	-39.492021	sWhite1	Start deployment ~4.5 NM NNE of target
28	8/6/19 12:37	HYPM	deploy	NaN	GI02HYPM-00006	NaN	59.971124	-39.529696	sWhite1	Anchor drop
29	8/6/19 13:13	CTD911	deploy	NaN	GI02HYPM	3	59.969893	-39.508277	sWhite1	Cast to 2600 m w/ acoustic releases 45599,
30	8/6/19 14:10	CTD911	maxDepth	NaN	GI02HYPM	3	59.969872	-39.508345	sWhite1	At max depth 2650 m, coming up to 2600 m for
31	8/6/19 15:23	CTD911	recover	NaN	GI02HYPM	3	59.969888	-39.508357	sWhite1	CTD on deck
32	8/6/19 17:20	Glider	deploy	NaN	Glider Box	NaN	59.916198	-39.265789	sWhite1	Glider 515 (GPG) deployed
33	8/6/19 17:23	Glider	deploy	NaN	Glider Box	NaN	59.915939	-39.265671	sWhite1	Glider 525 (BCP) deployed
34	8/6/19 18:05	Glider	deploy	NaN	Glider Box	NaN	59.913805	-39.264877	sWhite1	Glider 560 (OOG) deployed
35	8/6/19 19:00	CTD911	deploy	NaN	Glider Box	4	59.913344	-39.264562	sWhite1	Cast to 1000 m in vicinity of Gliders 515, 525, 560
36	8/6/19 19:25	CTD911	maxDepth	NaN	Glider Box	4	59.913353	-39.264539	sWhite1	At 1000 m
37	8/6/19 19:47	CTD911	recover	NaN	Glider Box	4	59.913338	-39.264545	sWhite1	CTD on deck
38	8/6/19 19:59	UHDAS	stop	NaN	NaN	NaN	59.912909	-39.29583	sWhite1	ADCPs turned off for EK80 survery
39	8/6/19 20:00	EK80	start	NaN	GI02HYPM	NaN	59.912956	-39.300775	sWhite1	Starting EK80 in passive mode as we move into position for survey across HYPMs
40	8/6/19 20:34	UHDAS	start	NaN	NaN	NaN	59.961699	-39.446732	sPetillo	ADCPs turned on for transit to glider 515 recovery
41	8/6/19 20:34	EK80	stop	NaN	GI01HYPM	NaN	59.961699	-39.446732	sPetillo	Stopping EK80 for transit to glider 515 recovery location
42	8/6/19 21:28	Glider	recover	NaN	North of Glider Box	NaN	59.930778	-39.232274	sWhite1	Glider 515 recovered due to leak
43	8/6/19 22:07	EK80	start	NaN	GI02HYPM	NaN	59.958634	-39.416976	sWhite1	Starting EK80 in passive mode as we move into
44	8/6/19 22:08	UHDAS	stop	NaN	GI02HYPM	NaN	59.959425	-39.421729	sWhite1	ADCPs turned off for EK80 survery
45	8/6/19 22:15	EK80	start	NaN	GI02HYPM	NaN	59.96446	-39.453726	cSeaton2	all channels switched to active sequential pinging
46	8/7/19 0:16	EK80	stop	NaN	NaN	NaN	59.980142	-39.562611	cSeaton2	end of ek80 survey
47	8/7/19 0:17	Knudsen 3260	start	NaN	NaN	NaN	59.980466	-39.564122	cSeaton2	12kHz bottom sounder On
48	8/7/19 0:17	UHDAS	start	NaN	NaN	NaN	59.980705	-39.565191	cSeaton2	restart after the end of EK80 survey
49	8/7/19 8:21	FLMA	deploy	NaN	GI03FLMA-00006	NaN	59.813271	-39.781591	sWhite1	Start deployment, ~4 NM NE of target
50	8/7/19 13:34	FLMA	deploy	NaN	GI03FLMA-00006	NaN	59.769572	-39.886199	sWhite1	Anchor drop
51	8/7/19 14:17	CTD911	deploy	NaN	GI03FLMA	5	59.770246	-39.863642	sWhite1	Cast to 2600 m w/ acoustic release 48595
52	8/7/19 15:15	CTD911	maxDepth	NaN	GI03FLMA	5	59.769421	-39.862309	hPalevsky1	At max depth (2600 m); water depth ~2694 m (altimeter: 94 m)
53	8/7/19 16:27	CTD911	recover	NaN	GI03FLMA	5	59.769432	-39.861921	sWhite1	CTD on deck
54	8/7/19 16:44	FLMA	anchor survey	NaN	GI03FLMA-00006	NaN	59.769461	-39.862233	sWhite1	Starting anchor survey for GI03FLMA-00006 w/
55	8/7/19 18:10	FLMA	anchor survey	NaN	GI03FLMA-00006	NaN	59.766015	-39.895559	sWhite1	Survey competed; surveyed position 59 46.2058 N, 39 53.0511 W
58	8/7/19 18:41	FLMA	other	NaN	GI03FLMA-00005	NaN	59.774643	-39.853139	sWhite1	Starting acoustic data download
59	8/7/19 18:57	FLMA	other	NaN	GI03FLMA-00005	NaN	59.773382	-39.850977	sWhite1	Data download complete; MSIOC, ADPC, 4 deep CTDMOs good; no comms above ADCP sphere
60	8/7/19 20:41	FLMB	other	NaN	GI03FLMB-00005	NaN	59.718993	-39.326583	sWhite1	Starting acoustic data download
61	8/7/19 20:56	FLMB	other	NaN	GI03FLMB-00005	NaN	59.717738	-39.328422	sWhite1	Data download complete; MSIOC, ADPC, CTDMOs good; no comms from SSIOC
130	8/7/19 22:59	CTD911	other	NaN	NaN	NaN	59.718566	-39.357088	cSeaton2	primary pump swapped out - s/n 052181 in for s/n
62	8/8/19 8:09	FLMB	deploy	NaN	GI03FLMB-00006	NaN	59.644075	-39.426933	sWhite1	Start deployment, ~5 NM SSW of target
63	8/8/19 13:20	FLMB	deploy	NaN	GI03FLMB-00006	NaN	59.721674	-39.353294	sWhite1	Anchor drop
64	8/8/19 14:10	CTD911	deploy	NaN	GI03FLMB	6	59.717241	-39.33563	sWhite1	Cast to 2750 m
65	8/8/19 15:16	CTD911	maxDepth	NaN	GI03FLMB	6	59.714421	-39.339158	sWhite1	At 2750 m
66	8/8/19 16:09	CTD911	recover	NaN	GI03FLMB	6	59.714728	-39.339887	sWhite1	CTD on deck
67	8/8/19 16:10	FLMB	anchor survey	NaN	GI03FLMB-00006	NaN	59.714729	-39.339866	sWhite1	Starting anchor survey for GI03FLMB-00006 w/ release 45269
69	8/8/19 17:15	FLMB	anchor survey	NaN	GI03FLMB-00006	NaN	59.725479	-39.359775	sWhite1	Survey competed; surveyed position 59 43.2309 N, 39 21.2843 W
70	8/8/19 18:16	CTD911	other	NaN	NaN	NaN	59.831411	-39.518072	cSeaton2	switched wiring between primary and second pump to diagnose whether cable is faulty
71	8/8/19 18:35	USBL	deploy	NaN	NaN	NaN	59.833464	-39.516689	sWhite1	Deployment of USBL Test mooring at Irminger
72	8/8/19 20:56	UHDAS	stop	NaN	NaN	NaN	59.836713	-39.50959	cSeaton2	turned off for usbl casius
74	8/8/19 23:23	USBL	service	NaN	NaN	NaN	59.833972	-39.517007	cSeaton2	CASIUS calibration begins
94	8/8/19 23:59	CTD911	deploy	NaN	CASIUS	7	59.838359	-39.517003	cSeaton2	cast for SSV profile for CASIUS
75	8/9/19 3:59	USBL	service	NaN	NaN	NaN	59.833532	-39.526132	cSeaton2	CASIUS calibration completed
73	8/9/19 4:00	UHDAS	start	NaN	NaN	NaN	59.833528	-39.526127	cSeaton2	turned back on after casius

Message ID	GPS_Time	Instrument	Action	Transect	Station	Cast	Latitude	Longitude	Author	Comment
76	8/9/19 8:04	SUMO	recover	NaN	GI01SUMO-00005	NaN	59.92879	-39.458161	sWhite1	Start of recovery; release 34817 fired
95	8/9/19 11:59	CTD911	other	NaN	NaN	NaN	60.001816	-39.420625	aSimoneau1	oxygen sensor was flushed to clear any possible obstructions causing wonky data
77	8/9/19 13:27	SUMO	recover	NaN	GI01SUMO-00005	NaN	60.022887	-39.413458	sWhite1	Recovery complete
78	8/9/19 15:29	HYPM	anchor survey	NaN	GI02HYPM-00006	NaN	59.981697	-39.523563	sWhite1	Starting anchor survey for GI02HYPM-00006 w/
79	8/9/19 16:23	HYPM	anchor survey	NaN	GI02HYPM-00006	NaN	59.973324	-39.547556	sWhite1	Survey competed; surveyed position 59 58.3719
80	8/9/19 20:17	UHDAS	stop	NaN	NaN	NaN	59.83364	-39.516047	cSeaton2	turned off for usbl casius
81	8/9/19 23:25	UHDAS	start	NaN	NaN	NaN	59.838009	-39.5161	cSeaton2	turned back on after casius
82	8/10/19 6:34	HYPM	recover	NaN	GI02HYPM-00005	NaN	59.965899	-39.492111	sPetillo	Start of recovery; release 50672 fired
83	8/10/19 9:25	HYPM	recover	NaN	GI02HYPM-00005	NaN	59.995815	-39.420223	sWhite1	Recovery complete
84	8/10/19 12:09	FLMB	recover	NaN	GI03FLMB-00005	NaN	59.717717	-39.317671	sWhite1	Start of recovery; Mid-water release 46259 fired
85	8/10/19 12:46	PCO2	stop	NaN	NaN	NaN	59.716288	-39.303438	aSimoneau1	initiate stop sequence to clean filter as water flow
86	8/10/19 13:30	PCO2	start	NaN	NaN	NaN	59.7154	-39.281475	aSimoneau1	resumed data collection after filter cleaning
87	8/10/19 14:15	FLMB	recover	NaN	GI03FLMB-00005	NaN	59.717033	-39.316224	sWhite1	Anchor release 50459 fired
88	8/10/19 17:43	FLMB	recover	NaN	GI03FLMB-00005	NaN	59.685206	-39.268221	sWhite1	Recovery complete
89	8/10/19 19:00	Glider	other	NaN	Glider Box	NaN	59.838296	-39.108955	sWhite1	Beginning mission to reballast 525 and 560 by small boat
90	8/10/19 20:07	Glider	other	NaN	Glider Box	NaN	59.849603	-39.08295	sWhite1	Glider reballasting complete
91	8/10/19 20:30	CTD911	deploy	NaN	Glider Box	8	59.844248	-39.093817	sWhite1	CTD cast to 1000 m; Niskin-Release: 7-50672, 11-
92	8/10/19 20:52	CTD911	maxDepth	NaN	Glider Box	8	59.845068	-39.095618	sWhite1	At 1000 m; will pause for 5 min every 100 m on upcast.
93	8/10/19 22:26	CTD911	recover	NaN	Glider Box	8	59.852425	-39.103988	sWhite1	CTD on deck
96	8/11/19 3:34	CTD911	other	NaN	NaN	NaN	59.80233	-39.673183	cSeaton2	sensor swap - oxygen SBE43 s/n 0264 in for 0794
97	8/11/19 4:15	CTD911	deploy	NaN	NaN	953	59.778277	-39.810646	cSeaton2	
98	8/11/19 4:24	CTD911	abort	NaN	NaN	953	59.778272	-39.810619	cSeaton2	bad data - bringing back on deck
99	8/11/19 8:25	FLMA	recover	NaN	GI03FLMA-00005	NaN	59.766175	-39.846552	sWhite1	Start of recovery; Mid-water release 45608 fired
100	8/11/19 10:12	FLMA	recover	NaN	GI03FLMA-00005	NaN	59.765152	-39.847439	sWhite1	Anchor release 50778 fired
101	8/11/19 13:02	FLMA	recover	NaN	GI03FLMA-00005	NaN	59.791471	-39.772307	sWhite1	Recovery complete
102	8/11/19 15:17	USBL	recover	NaN	NaN	NaN	59.834265	-39.506682	sWhite1	USBL Test mooring recovery
104	8/11/19 15:59	CTD911	other	NaN	NaN	NaN	59.895898	-39.492279	cSeaton2	cond & oxygen sensor swaps back to original config
103	8/11/19 16:40	CTD911	deploy	NaN	SUMO/HYPM	9	59.96596	-39.565754	sWhite1	CTD cast to 2500 m; Niskin-Release: 7,8-50672;
105	8/11/19 17:40	CTD911	maxDepth	NaN	SUMO/HYPM	9	59.965723	-39.565846	sWhite1	At max depth, 2500 m
106	8/11/19 18:42	CTD911	recover	NaN	SUMO/HYPM	9	59.965719	-39.565862	sWhite1	CTD on deck
107	8/11/19 18:54	HYPM	other	NaN	GI02HYPM-00006	NaN	59.967628	-39.557587	sWhite1	Starting acoustic data download
108	8/11/19 19:26	HYPM	other	NaN	GI02HYPM-00006	NaN	59.975382	-39.524254	sWhite1	Data download complete; 67 kbytes – CTDMO,
109	8/11/19 19:30	UHDAS	stop	NaN	NaN	NaN	59.975158	-39.526605	sWhite1	ADCPs stopped for EK80 survery
110	8/11/19 19:35	EK80	start	NaN	GI02HYPM-00006	NaN	59.974258	-39.529139	sWhite1	EK80 evaluation of HYPM-6 mooring
111	8/11/19 20:05	EK80	stop	NaN	GI02HYPM-00006	NaN	59.972008	-39.530793	sWhite1	Success seeing HYPM sphere at 145 m.
112	8/11/19 20:05	UHDAS	start	NaN	NaN	NaN	59.972004	-39.530796	sWhite1	ADCPs restarted after EK80 evaluation of HYPM
113	8/12/19 8:15	CTD911	deploy	NaN	GI03FLMB	10	59.718341	-39.336864	sWhite1	CTD cast to 2500 m; Niskin-Release: 7,8-50672;
114	8/12/19 9:10	CTD911	maxDepth	NaN	GI03FLMB	10	59.718321	-39.33682	sWhite1	At max depth
116	8/12/19 10:07	FLMB	other	NaN	GI03FLMB-00006	NaN	59.718279	-39.334407	sWhite1	Starting acoustic data download
115	8/12/19 10:14	CTD911	recover	NaN	GI03FLMB	10	59.718554	-39.334521	sWhite1	CTD on deck
117	8/12/19 10:21	FLMB	other	NaN	GI03FLMB-00006	NaN	59.718165	-39.336921	sWhite1	Data download complete; 32 kbytes – All instruments are working; gap in ADCP data
121	8/12/19 21:20	UHDAS	stop	NaN	NaN	NaN	60.056562	-43.112999	sWhite1	ADCPs turned off as we enter Prince Christian
118	8/14/19 18:07	UHDAS	start	NaN	NaN	NaN	60.01147	-42.602423	sWhite1	ADCPs restarted as we have reached 12 NM from
119	8/14/19 18:10	CTD911	deploy	NaN	NaN	955	60.010888	-42.604174	sWhite1	Test CTD cast w/ new pylon
120	8/14/19 18:36	CTD911	recover	NaN	NaN	955	60.011425	-42.618952	sWhite1	Test cast; all bottles fired
122	8/15/19 9:01	CTD911	deploy	NaN	GI01SUMO/GI02HYPM /Gliders	11	59.968369	-39.578217	sWhite1	CTD cast to 2500 m; near SUMO-6, HYPM-6 and Gliders 525 and 560
123	8/15/19 9:53	CTD911	maxDepth	NaN	GI01SUMO/GI02HYPM /Gliders	11	59.968973	-39.581155	sWhite1	At max depth; 2500 m
124	8/15/19 11:40	CTD911	recover	NaN	GI01SUMO/GI02HYPM	11	59.961598	-39.592092	sWhite1	CTD on deck
125	8/15/19 13:34	UHDAS	stop	NaN	NaN	NaN	59.720983	-39.371099	sWhite1	ADCPs turned off for EK80 imaging
126	8/15/19 13:35	EK80	start	NaN	GI03FLMB-00006	NaN	59.720684	-39.369533	sWhite1	EK80 imaging of FLMB-6 mooring
127	8/15/19 14:00	EK80	stop	NaN	GI03FLMB-00006	NaN	59.723482	-39.349801	sWhite1	EK80 imaging of FLMB-6 done; may have glimpsed top sphere at ~35 m
128	8/15/19 14:05	UHDAS	start	NaN	NaN	NaN	59.723432	-39.352747	sWhite1	ADCPs turned back on after EK80 imaging of GI03FLMB-00006 mooring
129	8/15/19 15:14	CTD911	other	NaN	NaN	NaN	59.712303	-39.360899	sWhite1	Primary pump swap between casts; new pump is S/N 052146 in for s/n 052181
131	8/15/19 15:32	CTD911	deploy	NaN	GI03FLMB-00006	12	59.712265	-39.360782	sWhite1	Cast to 2700
132	8/15/19 16:30	CTD911	maxDepth	NaN	GI03FLMB-00006	12	59.712258	-39.36112	sWhite1	At max depth
133	8/15/19 18:03	CTD911	recover	NaN	GI03FLMB-00006	12	59.711708	-39.357225	sWhite1	CTD on deck
135	8/15/19 19:59	FLMA	other	NaN	GI03FLMA-00006	NaN	59.761368	-39.883389	sWhite1	Starting acoustic data download
134	8/15/19 20:00	CTD911	deploy	NaN	GI03FLMA-00006	13	59.761366	-39.883383	sWhite1	Cast to 2600 m (SBE43 on, but not connected to
136	8/15/19 20:20	FLMA	other	NaN	GI03FLMA-00006	NaN	59.760114	-39.88719	sWhite1	Data download complete; All instruments working and sending data; ADCP may have a data gap.
137	8/15/19 20:51	CTD911	maxDepth	NaN	GI03FLMA-00006	13	59.758895	-39.887396	sWhite1	At max depth
138	8/15/19 22:23	CTD911	recover	NaN	GI03FLMA-00006	13	59.756017	-39.886334	sWhite1	CTD on deck
139	8/15/19 22:32	Ship	other	NaN	NaN	NaN	59.753641	-39.881776	sWhite1	Departing the Irminger Sea 6 Array for home
140	8/17/19 12:30	Mooring	recover	NaN	Labrador Sea	NaN	54.155579	-46.514734	sWhite1	Recovered upper float and MicroCAT from OSNAP K1 mooring
141	8/18/19 16:04	Knudsen 3260	stop	NaN	NaN	NaN	50.398118	-48.103303	aSimoneau1	stopped recording binary files while in canadian eez
142	8/18/19 16:04	UHDAS	stop	NaN	NaN	NaN	50.397103	-48.104565	aSimoneau1	entered Canadian EEZ
143	8/18/19 16:06	PCO2	stop	NaN	NaN	NaN	50.393459	-48.109254	aSimoneau1	shutdown initiated for canadian eez with standards run
144	8/19/19 23:14	PCO2	other	NaN	NaN	NaN	46.509088	-52.81433	cSeaton2	on inspection after cruise - pco2 vent flow sensor was found to be faulty and was replaced - this data cannot be verified
145	8/24/19 12:02	UHDAS	other	NaN	NaN	NaN	41.46416	-70.494354	aSimoneau1	late entry - a bit of ADCP data was collected in US waters. Start: 23 Aug 0843 GMT Stop 24 Aug 0955 GMT
146	8/24/19 14:25	Ship	endCruise	NaN	NaN	NaN	41.523518	-70.67175	sWhite1	Arrival WHOI dock

Appendix C – GI01SUMO-00006 Mooring Configuration

Global Surface Mooring Configuration

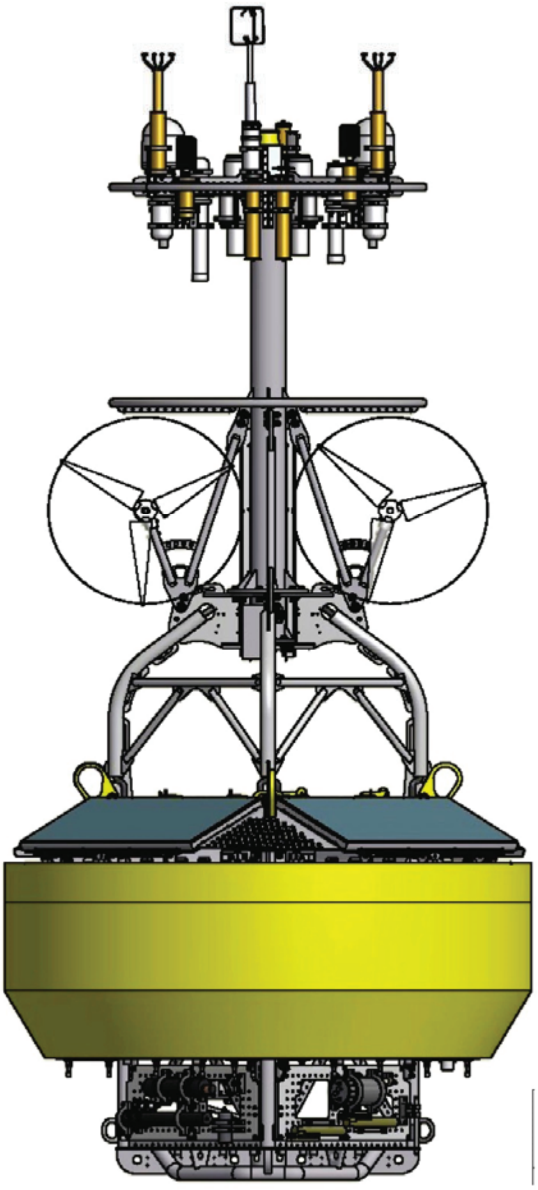
Reference Designator:	GI01SUMO	**Latitude:**	59° 56.7071' N
Mooring S/N:	GI01SUMO-00006	**Longitude:**	39° 34.4403' W
Anchor Launch Date:	5 Aug 2019	**Water Depth:**	2664 m
Anchor Launch Time:	15:29	**Cruise #:**	AR35-05

BUOY TELEMETRY COMPONENTS

	BUILD	DEPLOY
Light S/N	1360024368	
GPS 1 S/N	011	Ck'ed on shore
GPS 2 S/N	037	"
FBB ABU 1 S/N	80989766	"
FBB ABU 2 S/N	81096692	"
ISU 1 S/N	011	"
ISU 2 S/N	037	"
SBD 1 S/N	022	"
SBD 2 S/N	011	"
FreeWave 1 S/N	011	"
FreeWave 2 S/N	058	"
WiFi S/N	010	"
ACOMM S/N	N/A	
XEOS Rover 1 S/N on tower	300434063831760	
(S/N 0691)		
XEOS Rover 2 S/N on tower	300434062571050	
(S/N 0549)		
XEOS Rover S/N on deck	300434063968950	✔
XEOS KILO S/N on buoy	300234062947450	
Flasher S/N on buoy bottom	404	✔

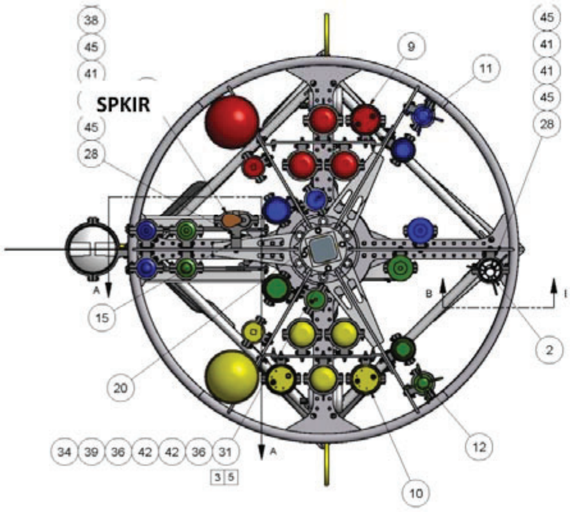
BUOY POWER COMPONENTS

	BUILD	DEPLOY
Wind Turbine 1 S/N – Port	3709-00203-00001-20007	Can't see
Wind Turbine 2 S/N – Stbd	3709-00203-00001-20008	Can't see
PV Panel 1 S/N – Vane-S	1310V04M0002031	✔
PV Panel 2 S/N – Deck-S	1310V04M0002437	Can't see
PV Panel 3 S/N – Deck-P	1310V04M0002439	Can't see
PV Panel 4 S/N – Vane-P	1310V04M0002034	✔

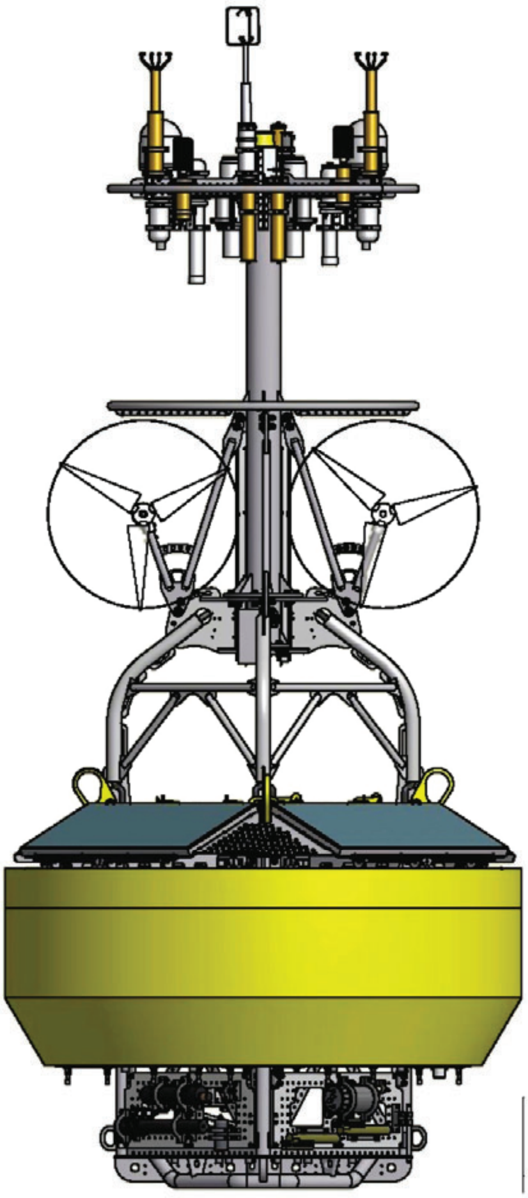


Global Surface Mooring Configuration

Reference Designator:	GI01SUMO



*	INSTRUMENT PACKAGE	CONFIGURATION DRAWING
(red)	TELEMETRY 1	3701-00516
(yellow)	TELEMETRY 2	3701-00517
(blue)	METBK 1	3701-00518
(green)	METBK 2	3701-00519



BUOY HALO INSTRUMENTS

	BUILD	DEPLOY
FDCHP (anemometer) S/N	164403	Ck'ed on shore
FDCHP (housing) S/N	23	"
METBK 1 - WND S/N	SWND265	"
METBK 1 - PRC S/N	PRC248	"
METBK 1 - HRH S/N	HRH275	"
METBK 1 - BPR S/N	BPR247	"
METBK 1 - LWR S/N	LWR267	"
METBK 1 - SWR S/N	SWR292	"
METBK 2 - WND S/N	SWND269	"
METBK 2 - PRC S/N	PRC268	"
METBK 2 - HRH S/N	HRH282	"
METBK 2 - BPR S/N	BPR248	"
METBK 2 - LWR S/N	LWR268	"
METBK 2 - SWR S/N	SWR294	"
SPKIR-B S/N	238	Can't see
SPKIR Bioshutter S/N	184	"

BUOY INSTRUMENTS

	BUILD	DEPLOY
METBK 1 - CT S/N	37-12755	✔
METBK 2 - CT S/N	37-13543	✔
PCO2A-A S/N (box 35-260)	35-262-50A	✔
DOSTA-D S/N	127	✔
UV Light S/N	830151	✔
LED Module S/N	850748	Ck'ed on shore
FLORT-D S/N	1102	✔
OPTAA-D S/N	187	✔
NUTNR-B S/N	NTR-1092	✔
Buoy CAM	0002	Ck'ed on shore

Global Surface Mooring Configuration

Reference Designator:	GI01SUMO

SEGMENT 1 COMPONENTS

	BUILD	DEPLOY
NUTNR-B S/N	NTR-1093	✔
SPKIR-B S/N	275	✔
SPKIR Bioshutter S/N	223	✔

SEGMENT 2 COMPONENTS

	BUILD	DEPLOY
DCL Assm S/N (-00272)	0033	✔

SEGMENT 3 COMPONENTS

	BUILD	DEPLOY
CTDBP-F S/N	16-50143	✔
DOSTA-D S/N	129	✔
UV Light S/N	830108	Ck'ed on shore
LED Module S/N	850851	Ck'ed on shore
DCC S/N	60104	✔
Battery S/N	413	In seg. 1 ✔
VELPT-A S/N	AQD 12230	✔

SEGMENT 4 COMPONENTS

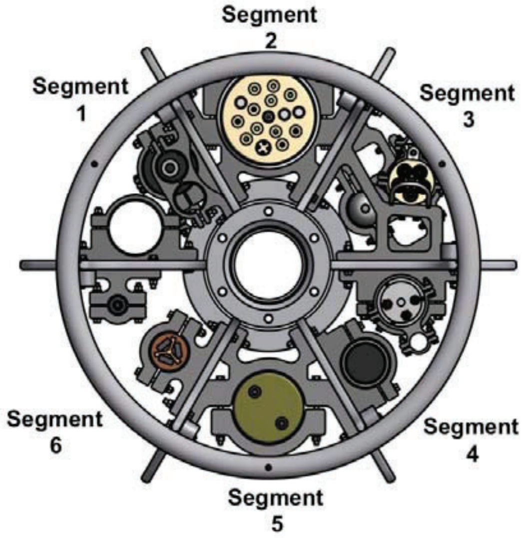
	BUILD	DEPLOY
OPTAA-D S/N	242	✔
FLORT-D S/N	1213	✔

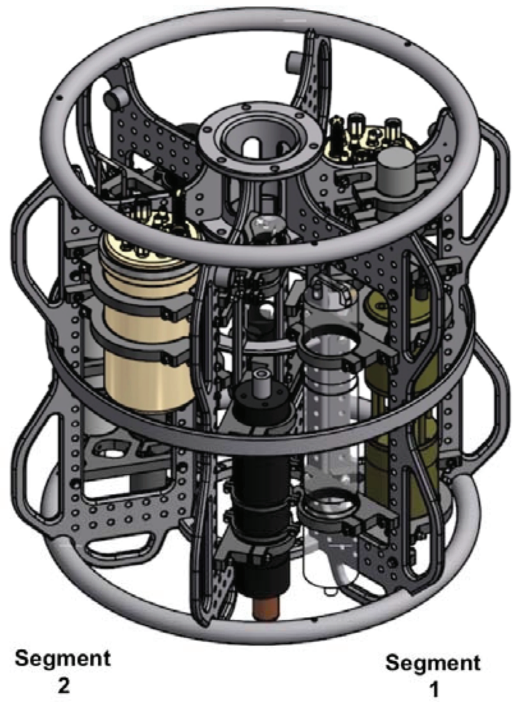
SEGMENT 5 COMPONENTS

	BUILD	DEPLOY
PCO2W-B S/N	C0071	✔

SEGMENT 6 COMPONENTS

	BUILD	DEPLOY
Empty		





Global Surface Mooring Configuration

Reference Designator:	GI01SUMO

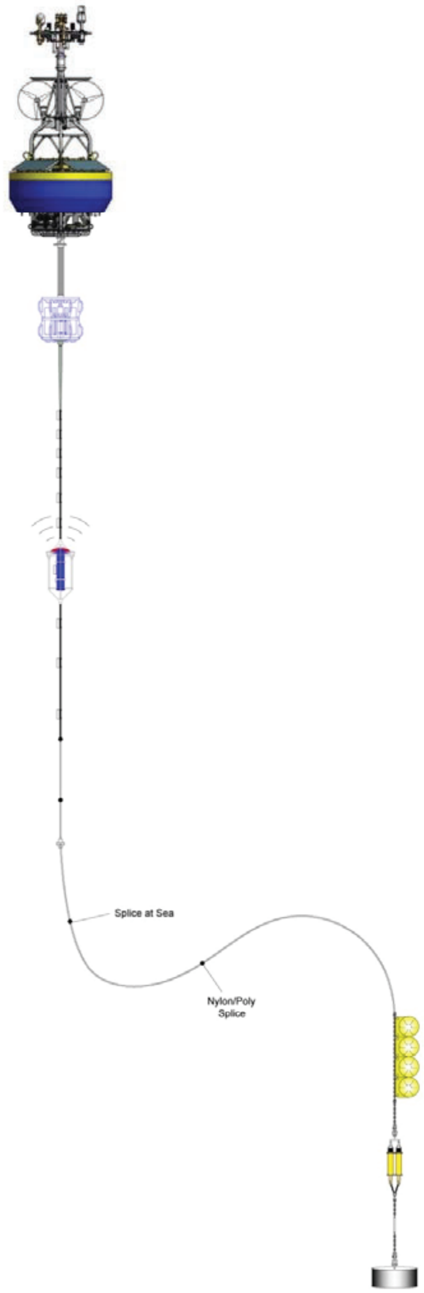
MOORING RISER INSTRUMENTS

	BUILD	DEPLOY
CTDMO-Q (20) S/N	37-12305	
PHSEN-E (20) S/N	P0138	
UIMM (20) S/N	716-3789	
CTDBP-P (40) S/N	16-50124	✔
DOSTA-D (40) S/N	427	✔
FLORD-G (40) S/N	3418	✔
PCO2W-C (40) S/N	C0105	✔ *
UIMM (40) S/N	716-3804	✔
CTDMO-Q (60) S/N	37-12306	
CTDBP-P (80) S/N	16-50125	✔
DOSTA-D (80) S/N	461	✔
FLORD-G (80) S/N	3969	✔
PCO2W-C (80) S/N	C0121	✔
UIMM (80) S/N	716-3805	Can't see
CTDMO-Q (100) S/N	37-12307	
PHSEN-E (100) S/N	P0139	
UIMM (100) S/N	716-3815	
CTDBP-P (130) S/N	16-50126	✔
DOSTA-D (130) S/N	462	Can't see
FLORD-G (130) S/N	3970	✔
PCO2W-C (130) S/N	C0122	✔
UIMM (130) S/N	716-3806	✔
CTDMO-Q (180) S/N	37-12607	
CTDMO-Q (250) S/N	37-13379	
CTDMO-Q (350) S/N	37-13380	
CTDMO-Q (500) S/N	37-13381	
ADCP-N (500) S/N	23579	✔
CTDMO-R (750) S/N	37-13375	
CTDMO-R (1000) S/N	37-13376	
CTDMO-R (1500) S/N	37-13377	

* Power pin broken, deployed as is

RISER COMPONENTS

	BUILD	DEPLOY
EM Chain S/N	0	Can't see/none
Wire Rope S/N (upper)	0	*see Deploy Log*
Wire Rope S/N (lower)	0	*see Deploy Log*
Acoustic Release 1 S/N	48501	✔
Acoustic Release 2 S/N	50453	✔



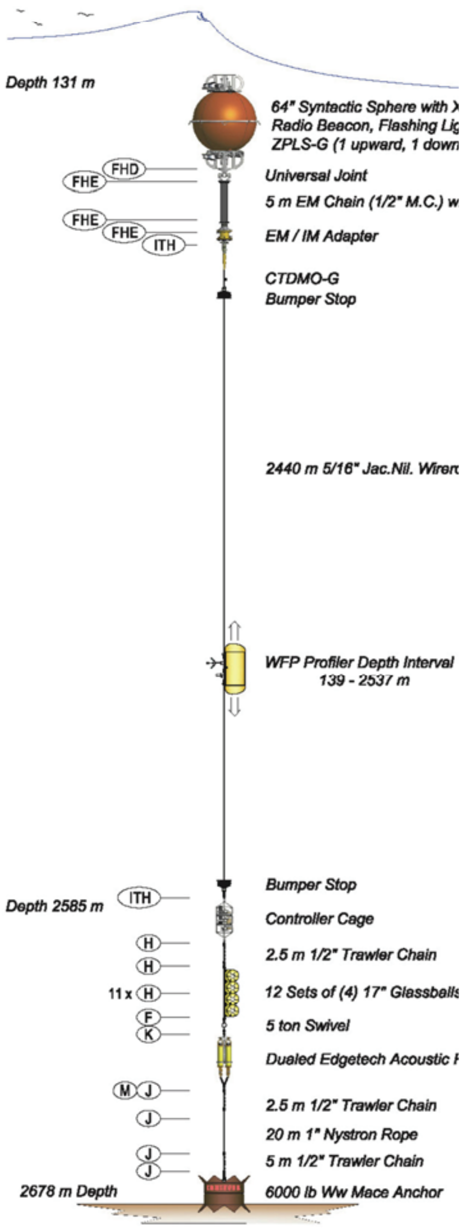
Appendix D – GI02HYPM-00006 Mooring Configuration

Global Hybrid Profiler Mooring Configuration

Reference Designator:	GI02HYPM		**Latitude:**	59° 58.3719' N
Mooring S/N:	GI02HYPM-00006		**Longitude:**	39° 31.8491' W
Anchor Launch Date:	6 Aug 2019		**Water Depth:**	2664 m
Anchor Launch Time:	12:37		**Cruise #:**	AR35-05

64" SPHERE COMPONENTS

	BUILD	DEPLOY
64" Sphere S/N	CG-SIO-0015	✔
Radio S/N (154.585 MHz)	362	✔
XEOS Sable S/N	300234063718500	✔
Flasher S/N	674	✔
ZPLSG (Upward) S/N (ID: 09)	55069	✔
UIMM S/N	716-4350	✔
ZPLSG (Downward) S/N (ID: 10)	55066	✔
UIMM S/N	716-4354	✔



Not present on Irminger, Papa is a 51" Sphere

62" SPHERE COMPONENTS

	BUILD	DEPLOY
62" Sphere S/N	N/A	N/A
Radio S/N (159.480 MHz)	N/A	N/A
XEOS Sable S/N	N/A	N/A
Flasher S/N	N/A	N/A
Pass-though Cable	N/A	N/A

LOAD CAGE COMPONENTS

	BUILD	DEPLOY
Main Controller Bottle S/N	8	✔
Persistor S/N	12368	
ACOMM S/N (ID: 27)	64773	✔
IM Loopback Cable	0016	✔
IM Coupler Cable	0008	✔
J6 ACOMMS Cable	0004	✔

RISER COMPONENTS

	BUILD	DEPLOY
EM Chain S/N	2016 041S	✔
Wire Rope S/N	~~0~~	19042-2
CTDMO-G S/N (ID: 39)	37-11611	✔
GWFP (Upper) S/N (ID: 21)	12774-01	✔
Acoustic Release 1 S/N	N/A	N/A
Wire Rope S/N	N/A	N/A
GWFP (Lower) S/N (ID: 22)	N/A	N/A
Acoustic Release S/N (dualed)	~~0~~	50686
Acoustic Release S/N (dualed)	~~0~~	50466

Appendix E – GI03FLMA-00006 Mooring Configuration

Global Mesoscale Flanking Mooring Configuration

Reference Designator:	GI03FLMA-00006		**Latitude:**	59° 46.2058' N
Mooring S/N:	GI03FLMA-00006		**Longitude:**	39° 53.0511' W
Anchor Launch Date:	7 Aug 2019		**Water Depth:**	2692 m
Anchor Launch Time:	13:34		**Cruise #:**	AR35-05

64" SPHERE COMPONENTS

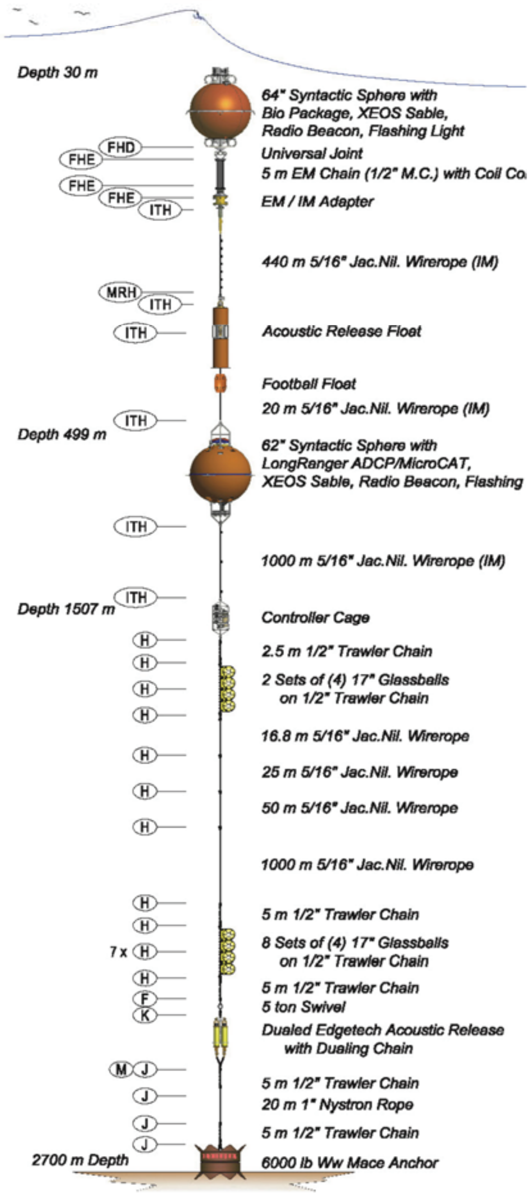
	BUILD	DEPLOY
64" Sphere S/N	CG-SIO-0014	✔
Radio S/N (154.585 MHz)	357	✔
XEOS Sable S/N	300234063712510	✔
Flasher S/N	595	✔
Secondary Controller Btl S/N	24	Can't see
Persistor S/N (ID: 02)	13992	
DOSTA-D S/N	515	Can't see
FLORT-D S/N	1212	✔
PHSEN-F S/N	P0141	Can't see
CTDMO-G (30) S/N (ID: 40)	37-11643	✔

62" SPHERE COMPONENTS

	BUILD	DEPLOY
62" Sphere S/N	J15150-006	✔
Radio S/N (159.480 MHz)	356	✔
XEOS Sable S/N	300234063715480	✔
Flasher S/N	594	✔
ADCPS-L S/N (ID:03)	21450	Can't see
CTDMO-G (500) S/N (ID:48)	37-10256	Can't see (ID 48)
Pass-though Cable	0007	✔

LOAD CAGE COMPONENTS

Main Controller Bottle S/N	25	✔
Persistor S/N (ID: 01)	13994	
ACOMM S/N (ID: 25)	66655	✔
IM Loopback Cable	0011	✔
IM Coupler Cable	0002	✔
J6 ACOMMS Cable	0006	✔



Global Flanking Mooring A Configuration

Reference Designator:	GI03FLMA-00006

RISER COMPONENTS

	BUILD	DEPLOY
EM Chain S/N	0	
Wire Rope S/N	~~0~~	17049-4
CTDMO-G (40) S/N (ID: 41)	37-12401	✔
CTDMO-G (60) S/N (ID: 42)	37-11638	✔
CTDMO-G (90) S/N (ID: 43)	37-10222	✔
CTDMO-G (130) S/N (ID: 44)	37-11595	✔
CTDMO-G (180) S/N (ID: 45)	37-10253	✔
CTDMO-G (250) S/N (ID: 46)	37-10225	✔
CTDMO-G (350) S/N (ID: 47)	37-10223	✔
AcousticRelease 1 S/N	~~0~~	50684
Wire Rope S/N	~~0~~	17067-2
CTDMO-H (750) S/N (ID: 49)	37-10265	✔
CTDMO-H (1000) S/N (ID: 50)	37-10227	✔
CTDMO-H (1500) S/N (ID: 51)	37-11597	✔
AcousticRelease S/N (dualed)	~~0~~	50779
AcousticRelease S/N (dualed)	~~0~~	50457

Irminger Only (OSNAP)	BUILD	DEPLOY
CTDMO S/N (1000 m up)	37-12218	✔
VELPT S/N (1000 m up)	AQD 11970	✔
CTDMO S/N (700 m up)	37-12387	✔
VELPT S/N (700 m up)	AQD 11981	✔
CTDMO S/N (400 m up)	37-12395	✔
VELPT S/N (400 m up)	AQD 12095	✔
CTDMO S/N (100 m up)	37-12619	✔
VELPT S/N (100 m up)	AQD 12197	✔

CTDMOs & VELPTs launched to start at 7 Aug 2019 00:00 UTC

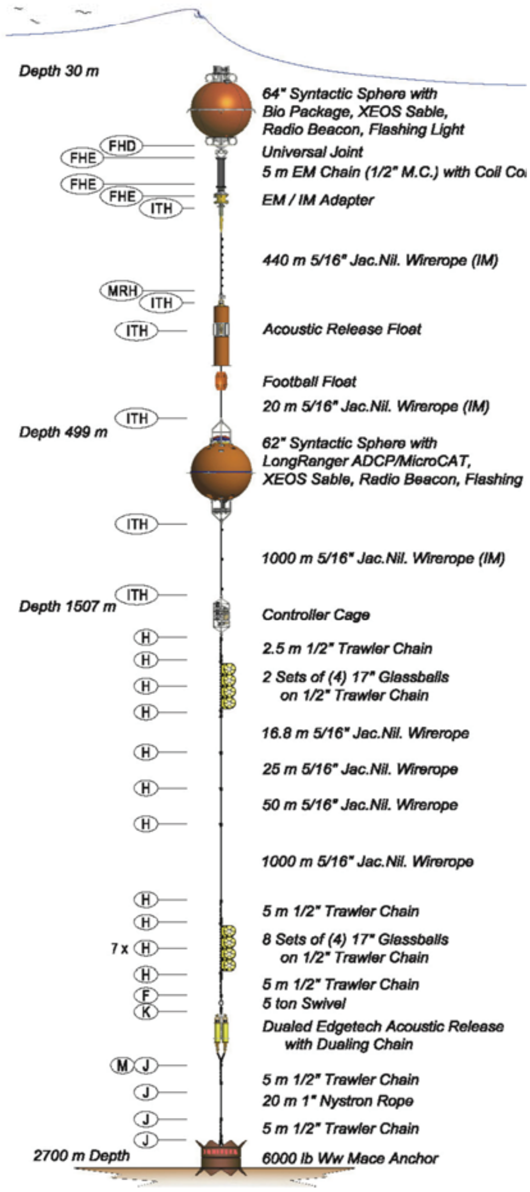
Appendix G – GI03FLMB-00006 Mooring Configuration

Global Mesoscale Flanking Mooring Configuration

Reference Designator:	GI03FLMB-00006		**Latitude:**	59° 43.2309' N
Mooring S/N:	GI03FLMB-00006		**Longitude:**	39° 21.2843' W
Anchor Launch Date:	8 Aug 2019		**Water Depth:**	2819 m
Anchor Launch Time:	13:20		**Cruise #:**	AR35-05

64" SPHERE COMPONENTS

	BUILD	DEPLOY
64" Sphere S/N	CG-SIO-00013	✔
Radio S/N (154.585 MHz)	323	✔
XEOS Sable S/N	300234063119090	✔
Flasher S/N	597	✔
Secondary Controller Btl S/N	15	Can't see
Persistor S/N (ID:06)	12372	
DOSTA-D S/N	224	Can't see
FLORT-D S/N	1221	✔
PHSEN-F S/N	P0183	Can't see
CTDMO-G (30) S/N (ID: 60)	37-11594	✔



62" SPHERE COMPONENTS

	BUILD	DEPLOY
62" Sphere S/N	J14039-003	✔
Radio S/N (159.480 MHz)	324	✔
XEOS Sable S/N	300234063711490	✔
Flasher S/N	675	✔
ADCPS-L S/N (ID: 07)	23381	Can't see
CTDMO-G (500) S/N (ID: 68)	37-12190	Can't see, ID 68
Pass-though Cable	0006	✔

LOAD CAGE COMPONENTS

Main Controller Bottle S/N	20	✔
Persistor S/N (ID: 05)	14874	
ACOMM S/N (ID: 26)	66657	Ck'ed on shore
IM Loopback Cable	0043	"
IM Coupler Cable	no s/n	–
J6 ACOMMS Cable	0002	✔

Global Flanking Mooring B Configuration

Reference Designator:	GI03FLMB-00006

RISER COMPONENTS

	BUILD	DEPLOY
EM Chain S/N	2016055S	✔
Wire Rope S/N	0	19021-2
CTDMO-G (40) S/N (ID: 61)	37-12609	✔
CTDMO-G (60) S/N (ID: 62)	37-11645	✔
CTDMO-G (90) S/N (ID: 63)	37-11604	✔
CTDMO-G (130) S/N (ID: 64)	37-11534	✔
CTDMO-G (180) S/N (ID: 65)	37-11606	✔
CTDMO-G (250) S/N (ID: 66)	37-11608	✔
CTDMO-G (350) S/N (ID: 67)	37-11603	✔
AcousticRelease 1 S/N	0	45599
Wire Rope S/N	0	17048-1
CTDMO-H (750) S/N (ID: 69)	37-12227	✔
CTDMO-H (1000) S/N (ID: 70)	37-11703	✔
CTDMO-H (1500) S/N (ID: 71)	37-12219	✔
AcousticRelease S/N (dualed)	0	45269
AcousticRelease S/N (dualed)	0	50681

Irminger Only (OSNAP)	BUILD	DEPLOY
CTDMO S/N (1000 m up)	37-13454	✔
VELPT S/N (1000 m up)	AQD 12236	✔
CTDMO S/N (700 m up)	37-13455	✔
VELPT S/N (700 m up)	AQD 12459	✔
CTDMO S/N (400 m up)	37-13456	✔
VELPT S/N (400 m up)	AQD 12663	✔
CTDMO S/N (100 m up)	37-13457	✔
VELPT S/N (100 m up)	AQD 12673	✔

Appendix H – Oxygen Optode S/N 502 Calibration Sheet

AANDERAA
a xylem brand

CALIBRATION CERTIFICATE

Form No 854, Dec 16th 2016

Certificate no: Oxygen Optode 4831_502_150686
FoilID: 1206EM

Product: **Oxygen Optode 4831**
Serial no: 502
Calibration date: 17.08.2018

2-POINT RECALIBRATION, MULTIPOINT CALIBRATED OXYGEN OPTODE

This is to certify that this product has been calibrated and verified using the following reference equipment:

Reference Equipment	Serial
Calibration Bath Model Toho TM-005-P-A	12-K
Fluke 5615 PRT	Serial No. 802054 and Serial No. 849155
Fluke CHUB E-4	Serial No. A7C677
Reference sensor 4330	339

Specification

	O2 Concentration	Air Saturation	Temperature
Range	0-500 µM	0 - 120%	-5 to +40°C
Accuracy	< ±3µM or ±2% 1)	±2% 2)	±0.03°C 3)
Resolution	< 1 µM	< 0.4%	0.01°C
Settling Time (63%)	< 25 seconds	< 25 seconds	< 2 seconds

1) Requires salinity compensation for salinity variations > 1mS/cm, and pressure compensation for pressure > 100meter
2) Within calibrated range 0 - 120% / 0 - 30°C
3) Within calibrated range 0 - 36°C for standard version and 0 - 30°C for multipoint version

Calibration points and readings:

	Air Saturated Water	Zero Solution (Na2SO3)
Phase reading (°)	33.01	60.96
Temperature reading (°C)	9.96	22.36
Air Pressure (hPa)	981.50	

Giving these coefficients

Index	0 (Offset)	1 (Slope)
ConcCoef	-1.285961E+00	1.039998E+00

With following settings

Index	0	1	2	3	4	5	6
SVUFoilCoef	2.82567E-03	1.20716E-04	2.45930E-06	2.30757E+02	-3.09502E-01	-5.60627E+01	4.56150E+00
PhaseCoef	0.000000E+00	1.000000E+00	0.000000E+00	0.000000E+00			
TempCoef	2.868794E+01	-3.208739E-02	3.596756E-06	-4.969245E-09	0.000000E+00	0.000000E+00	
Salinity (mS/cm)	0.00						

Date:17.08.2018

Sr. Repair Technician

Page 1