Southern Ocean 6 Cruise Report

RRS *Discovery*, DY112

January 16-26, 2020

Punta Arenas, Chile – Punta Arenas, Chile

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Revision History

Version	Description	Originator	Date
0-01	Initial Draft	S. N. White	2020-02-06
0-02	Edits, comments	R. Travis	2020-02-25
0-03	Updates to address comments	S. N. White	2020-03-01
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Abstract

This report documents the sixth cruise to the Southern Ocean Array of the National Science Foundation's (NSF) Ocean Observatories Initiative (OOI). This cruise was supported by both NSF's OOI program and the UK's Natural Environment Research Council's (NERC). The cruise took place on the RRS *Discovery* (DY112), departing Punta Arenas, Chile on 16 January 2020 and returning to Punta Arenas, Chile on 25 January 2020. The science party consisted of a five-person OOI team from the Woods Hole Oceanographic Institution (WHOI), a three-person team from the National Oceanography Centre (NOC), and three technicians from the UK's National Marine Facilities (NMF).

The previous cruise, DY111, was a NERC funded CUSTARD Program (Carbon Uptake and Seasonal Traits of Antarctic Remineralisation Depth, PI Adrian Martin, NOC) cruise. During that cruise water sampling was conducted in the vicinity of the OOI Surface Mooring for data validation.

The primary objective of recovering the GS01SUMO-00004 Surface Mooring was accomplished. We were unable to collected shipboard meteorological data for validation of the Surface Mooring due to time and weather constraints. CUSTARD activities included underway and Go-flo water sampling.

This report includes brief descriptions of pre-cruise preparation activities; a chronology of the cruise, including details about weather conditions; a description of the mooring recovery, with analysis of platform functionality; a description of shipboard data collection; and a discussion of selected issues which arose during the cruise. Appendices and other program documents provide supporting information.

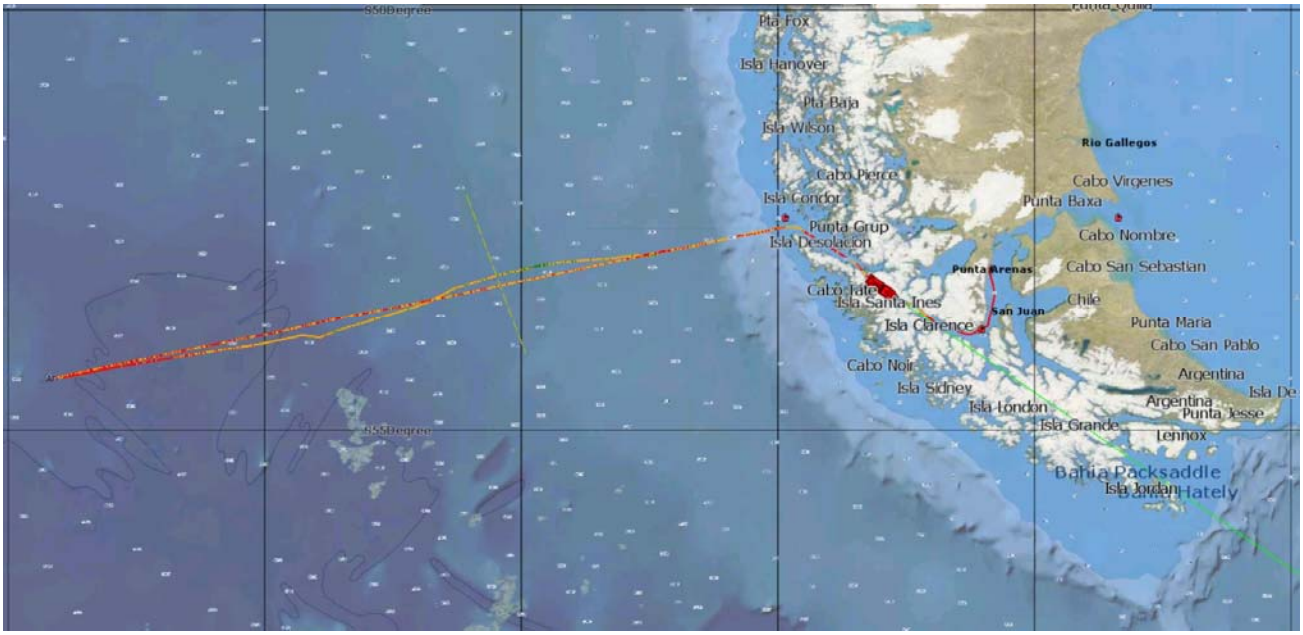

Figure A-1 Cruise Track of DY112

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1.0 Introduction

1.1. Background and Purpose

Located southwest of Chile near 55° S, 90° W, the OOI Global Southern Ocean Array was comprised of four moorings set in water depths of approximately 4800 m, and a combination of Open Ocean and Profiling Gliders. The array was first deployed in March 2015 aboard R/V *Atlantis* (AT 26-30), and then replaced with new moorings and gliders in December 2015 and November-December 2016 on the R/V *Nathaniel B. Palmer* (NPB15-11 and NBP 16-10, respectively).

In 2017, guided by the National Academy of Sciences' 2015 report "Sea Change: Decadal Survey of Ocean Sciences 2015-2025", the NSF elected to discontinue the Operations and Management of the OOI Southern Ocean Array due to budget reductions. The November-December 2017 cruise on the R/V *Nathaniel B. Palmer* (NPB17-09) was supposed to recover all assets. However, due to difficult weather conditions, the Surface Mooring and bottom halves of both Flanking Moorings could not be recovered in 2017 and remained in place collecting data for an additional year.

The Southern Ocean 5 cruise in November-December 2018 was a collaboration between NSF/OOI and the Natural Environment Research Council (NERC), the United Kingdom's (UK) science funding agency. The cruise took place on the RRS *Discovery* (DY096), supporting the CUSTARD program (Carbon Uptake and Seasonal Traits of Antarctic Remineralisation Depth, PI Adrian Martin, National Oceanography Centre – NOC) funded by NERC. The remaining OOI moorings were recovered, and a new OOI Surface Mooring outfitted with 2 NOC sensors and an additional PCO2A instrument was deployed. That surface mooring (GS01SUMO-00004) was recovered on the present cruise, DY112, and shipboard measurements were acquired for validation of the existing moorings on the preceding CUSTARD cruise, DY111.

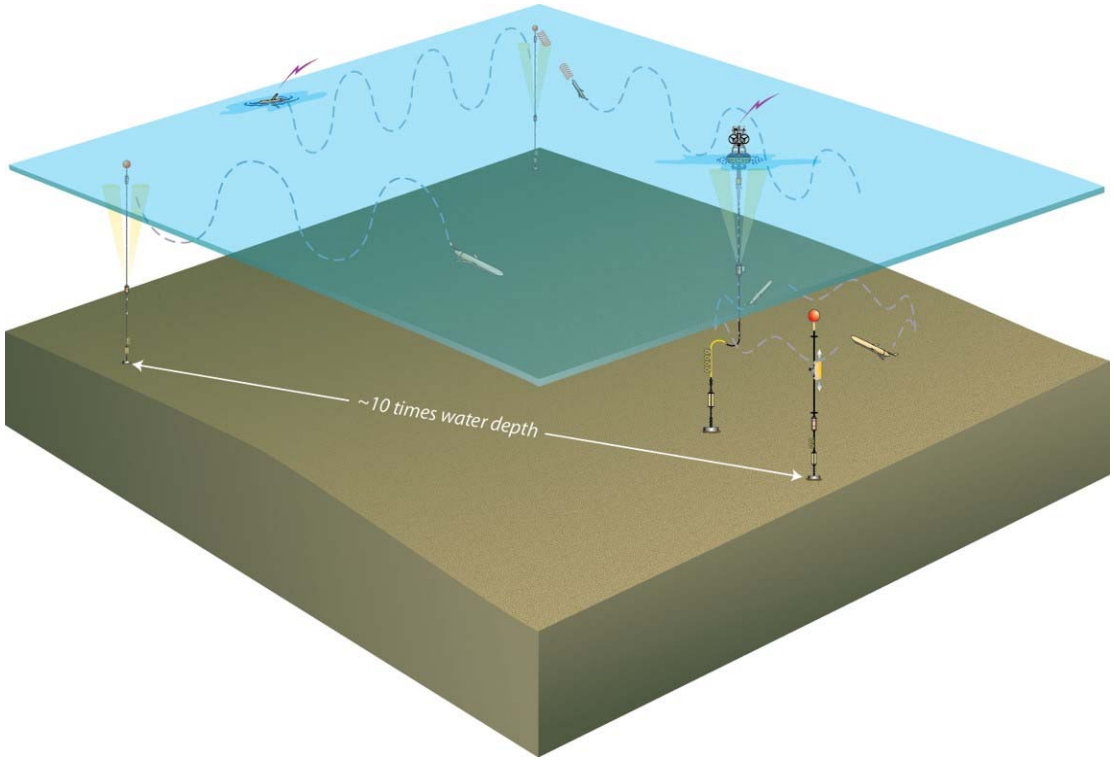

Figure 1-1 – Schematic drawing of the OOI Southern Ocean Array.

1.2. Supporting Documents

Table 1-1 – Supporting Documents

Doc Number	Description	Location
1102-00200	Observation and Sampling Approach	Alfresco, CONTROLLED
3103-00022	Global Surface Mooring Sampling Plan	Alfresco, CONTROLLED
3201-00007	Southern Ocean Array Site Characterization	Alfresco, CONTROLLED
3201-00501	Southern Ocean 5 Cruise Plan	Alfresco, CONTROLLED
3201-00502	Southern Ocean 5 Quick Look Report	Alfresco, CONTROLLED
3201-00503	Southern Ocean 5 Cruise Report	Alfresco, CONTROLLED
3201-00601	Southern Ocean 6 Deployment Cruise Plan	Alfresco, CONTROLLED
3201-00602	Southern Ocean 6 Deployment Quick Look Report	Alfresco, CONTROLLED
3601-40001	GI01SUMO Deck Drawing	Alfresco, CONTROLLED
3601-40101	GI01SUMO Design Spreadsheet	Alfresco, CONTROLLED
N/A	CGSN Southern Ocean 6 IRR Checklist	Alfresco, ARCHIVE

1.3. Cruise Chronology

All times in local, Punta Arenas, time (UTC - 3 hours) unless otherwise indicated. Punta Arenas is 2 hours ahead of Woods Hole.

12 January 2020 (Sunday)

Deck team (Jim Ryder, Kris Newhall, Nico Llanos) arrived in Punta Arenas.

13 January 2020 (Monday)

Deck team arrived begin unpacking, and staging gear for loading.

Remainder of team (Sheri White, Jennifer Batryn) arrived in Punta Arenas.

14 January 2020 (Tuesday)

Loading of the RRS *Discovery*. The Rigging van, generator, TSE winch, air tuggers, wire baskets of instrument cases and cruise kits, and empty Ropak containers and wire baskets for recovered mooring components were loaded in the morning and early afternoon.

15 January 2020 (Wednesday)

Continued to set up deck gear.

13:00 The ship's safety briefing for the OOI Team and other onboarding personnel.

16 January 2020 (Thursday)

06:10 Departed Punta Arenas through the western passage of the Strait of Magellan. Light winds (~15 kts from the WSW, calm seas, and partly cloudy skies).

10:30 Emergency muster drill

Started off making 10-12 kts , but had to slow down a bit approaching the narrows to allow other ships to pass, and then because of wind conditions.

17 January 2020 (Friday)

~02:00 Departed the Strait. Had to slow down to ~6.5 kts in the open ocean. Wind around 25-30 kts from the West.

08:30 Daily cruise planning meeting with the Captain in the Main Lab. Despite having to slow down more than expected, the weather looks promising to make up time on Sunday. Still hope to arrive at the Array by Monday morning for recovery (wind and seas look most favorable on Monday for mooring operations).

18 January 2020 (Saturday)

Continued transit to the Array.

08:30 Daily cruise planning meeting with the Captain in the Main Lab. Still making slow progress, but the weather is supposed to improve this evening and into tomorrow. So we hope to make up time then. Probably will arrive at the Array around breakfast-time on Monday.

09:00 Toolbox Talk on Surface Mooring Deployment in the Conference Room/Library.

12:43 Exited the Chilean EEZ and the acoustic and underway systems were turned on (at approximately 53° 13.9' S, 80° 30.3' W).

18:40 Able to pick up speed a bit to 7-8 kts; winds 25-30 out of the WNW.

19 January 2020 (Sunday)

Continued transiting to the Array. Winds 20-35 out of the W; gray and overcast.

08:30 Daily cruise planning meeting with the Captain in the Main Lab. Had to slow down a bit overnight, but still hoping to pick up speed over the course of the day and make up time. Stuart still thinks we can make it there by first light. The plan would be to start with a drive-by of the buoy for a quick inspection and for Jennifer to shut down the NSIF over WiFi. Then move into position for recovery.

12:30 Wind and seas coming down a bit. The CGSN Shore Team turned on the buoy FW and WiFi. Making about 7 kts SOG; winds down to 20-25 kts out of the W.

14:00 Winds down to 15-25 kts out of the WNW; making ~7-8 kts SOG.

15:44 Wind and seas coming down more (15-20 kts out of the WNW); making 9 kts.

16:30 CGSN Shore Team sent a command via SBD to shut down charging on the buoy.

18:25 Held a Touch-Base Meeting in the Main Lab with the Captain. We are making ~10 kts now (winds 10-20 kts from the NW) and expect to be at the Array site by around 05:00. Sunrise is at 07:00 but lightening before then. The plan is to do a drive-by of the buoy at 06:00 to see what we can and shut down the NSIF over WiFi. Then move into position ~1NM upwind of the buoy for recovery.

20 January 2020 (Monday)

~06:00 Driving by the GS01SUMO-00004 buoy. Connected via WiFi to check mooring status and shut down the NSIF. Skies are hazy, but the seas are flat and winds are 10-20 kts out of the NE.

06:55 In position ~1 NM upwind of the anchor position. Winds shifted to the NW ~20 kts. The ship is NW of the anchor position and the buoy is SE of the anchor position. Conditions are foggy, with light seas and little current (<0.5 kt).

07:01 GS01SUMO-00004 recovery began – acoustic release fired (shipboard ADCPs and echosounder shut down to reduce acoustic noise).

Details of the mooring recovery are in Section 3.1.2. Recovery was completed at 16:05 local.

21 January 2020 (Tuesday)

Remained on station overnight to conduct CUSTARD Go-Flo sampling.

14:40 Completed Go-Flo sampling (2 profiles of 4 depths each) and departed the Array for Punta Arenas. Transitting at ~10 kts SOG.

22 January 2020 (Wednesday)

Continued transit to Punta Arenas.

23 January 2020 (Thursday)

Continued transit to Punta Arenas. Entered the Strait of Magellan around 20:30, then took up a position in sheltered waters to wait until morning.

24 January 2020 (Friday)

Continued transit to Punta Arenas. Transited the Strait in the morning at ~13 kts SOG, but slowed for passage through the narrows. Paused at ~13:00 for ship's crew training, then proceeded to Punta Arenas; arrived at ~020:00 to anchor for the night.

25 January 2020 (Saturday)

06:30 Pilot boarded and we shifted to Mardones Pier.

07:35 Docked at Punta Arenas Mardones Pier.

Off-loaded all OOI gear in the morning and had it trucked to Pratt Pier to Bond and the Warehouse.

OOI Team departed the RRS *Discovery*.

26 January 2020 (Sunday)

Too windy for crane operations, and no fork trucks available. All OOI gear remained at Pratt Pier on 4 flatbed trucks.

27 January 2020 (Monday)

Winds were suitable for crane work. All OOI gear was off-loaded by crane and fork truck. All items went into bond except for the Rigging Van & generator, surface buoy, and 3 instrument wire baskets. The buoy was broken down, and the batteries in the well were disconnected for shipping. All halo instruments were removed (METBK, FDCHP, SPKIR) and data was down-loaded.

28 January 2020 (Tuesday)

Did some final clean-up and packing. No shipping containers have arrived, and no fork trucks available to start loading. One air shipment prepared.

29 January 2020 (Wednesday)

Still awaiting 40' shipping container, and 40' flat rack.

30 January 2020 (Thursday)

Sheri White and Jennifer Batryn departed Punta Arenas.

31 January 2020 (Thursday)

Containers arrived for loading at 11:30.

Deck team (Jim Ryder, Kris Newhall, Nico Llanos) departed in Punta Arenas.

1.4. Weather and Operating Conditions

All loading occurred at Pratt Pier on 14 January when winds were light. Winds significantly increased on 15 January, and crane operations would not have been allowed.

During the transit out from Punta Arenas to the Southern Ocean Array, we faced headwinds of 25-35 kts and rough seas and swell. While the ship's top speed is 10-12 kts and we were able to maintain that through much of the Strait, we were reduced to ~4-6 kts the first 2 days in the open ocean. By the afternoon of 19 January we were able to pick up speed.

Weather died down on the 20th enabling recovery of the Surface Mooring. Seas were calm with very light swell, but increased slightly over the course of the day as winds increased from the W. Following Go-flow water sampling on the 21st, we departed for Punta Arenas. Winds continued to come predominantly from the W-NW during the transit back to shore.

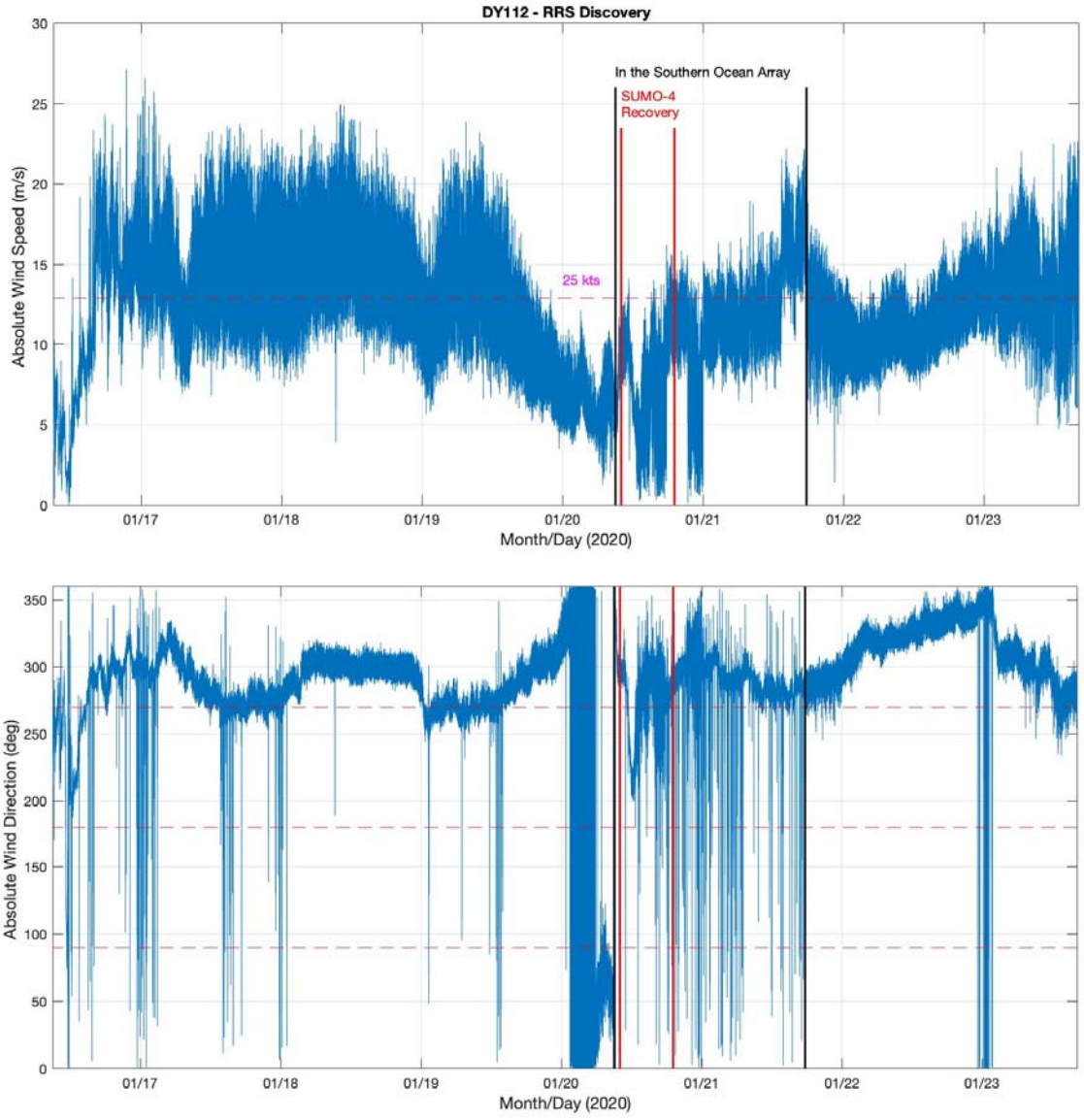

Figure 1-2 – Weather during the DY112 Cruise.
Absolute Wind speed (top) & direction (bottom) from the bow mast of the RRS *Discovery*. Times are UTC. The magenta dashed line in the wind speed plot is 25 kts. The solid black lines in both plots indicate the time *Discovery* was in the vicinity of the Array; red lines indicate the time period during which the mooring was recovered.

The ship docked at the Mardones Pier on the NE side of town on the morning of 25 January and all gear was off-loaded there. Winds picked up over the course of the morning, but crane operations were not halted due to high winds until all OOI gear was offloaded. Four flatbed trucks with all of the OOI gear were moved to Pratt Pier, but could not be offloaded due to high winds on both the 25th and 26th of January. Crane operations were allowed on 27 January and the trucks were off-loaded, and the Surface Buoy was broken down for shipment.

2.0 Pre-Cruise Operations

Due to being a recovery-only cruise, there were very little pre-cruise operations aside from shipping. Much of the gear needed for recovery remained in Punta Arenas following the December 2018 DY096 cruise – empty instrument and mooring component cases, and support equipment such as the halo stand and lifting bridle.

Shipment of the remaining gear needed for recovery left WHOI on 8 November. This included the 20' Rigging van, and a 40' container with the TSE winch, generator, and wire baskets full of deck and lab gear.

An Installation Readiness Review (IRR) was held Monday, 6 January 2020 at 4:00 pm EST 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 the cruise.

2.1. Loading and Deck Layout

Loading of the RRS *Discovery* at Pratt Pier occurred on 14 January 2020. The Rigging Van was positioned on the starboard side of the main deck, just forward of the A-frame, with the generator just inboard of the Rigging Van. The TSE winch was positioned on the centerline just aft of the hangar. Wire baskets for the recovered glass balls were just forward of the Rigging Van. Empty Ropak boxes and wire rope spools were on the port side just inboard of gear from previous cruises. Additional components (e.g., instrument cases) were located in wire baskets in the hangar.

Adapter plates were required to mount the TSE winch and the air tuggers to the deck. US ships have a 1 ft x 1 ft bolt pattern, whereas the UK ships have a 1 m x 1 m bolt pattern.

The main OOI team occupied the Deck Lab just port of the hangar.

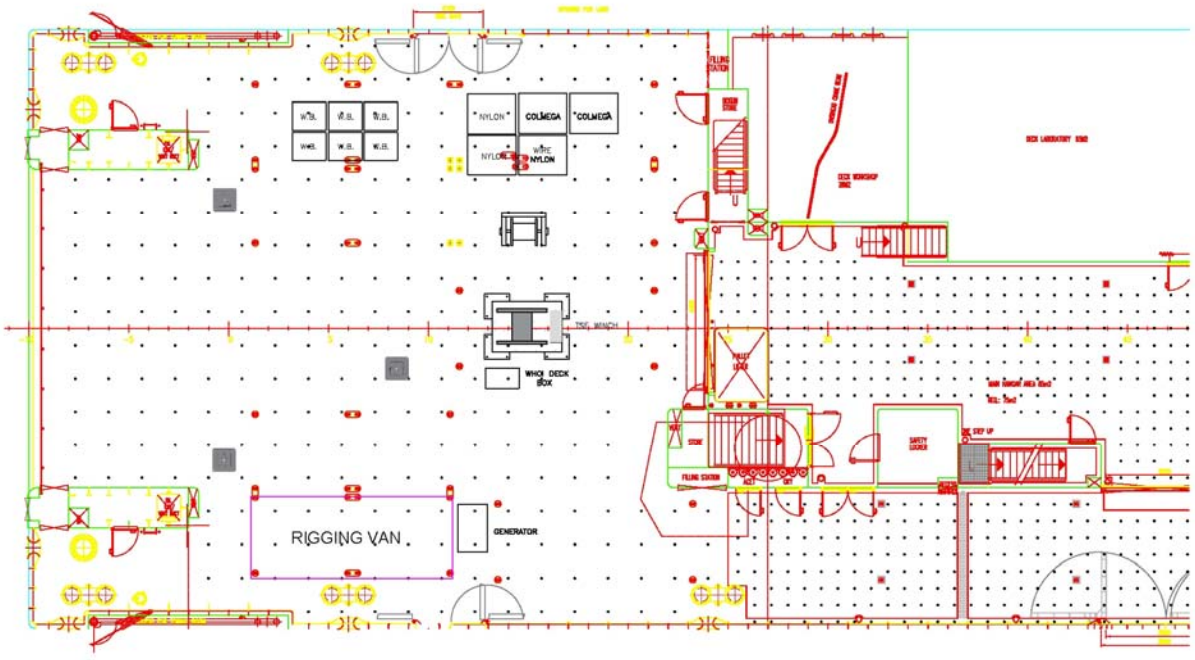

Figure 2-1 – Planned Deck Layout

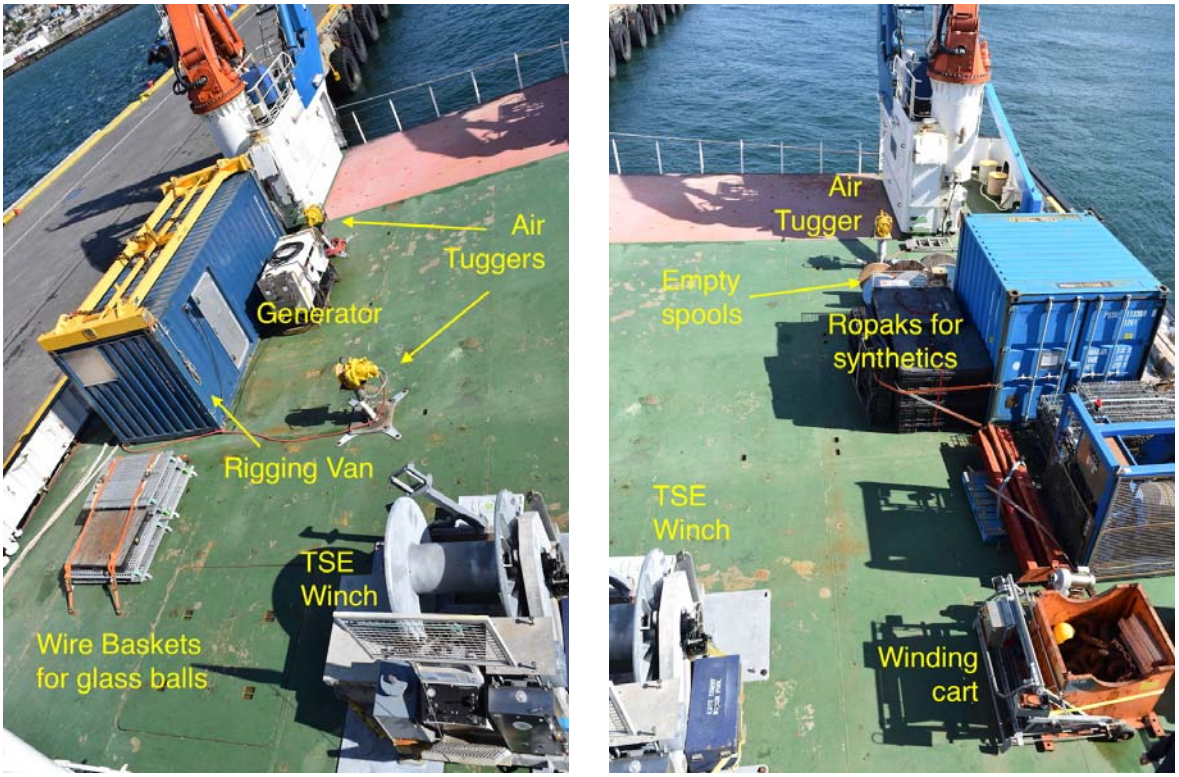

Figure 2-2 – Actual Deck Layout looking aft

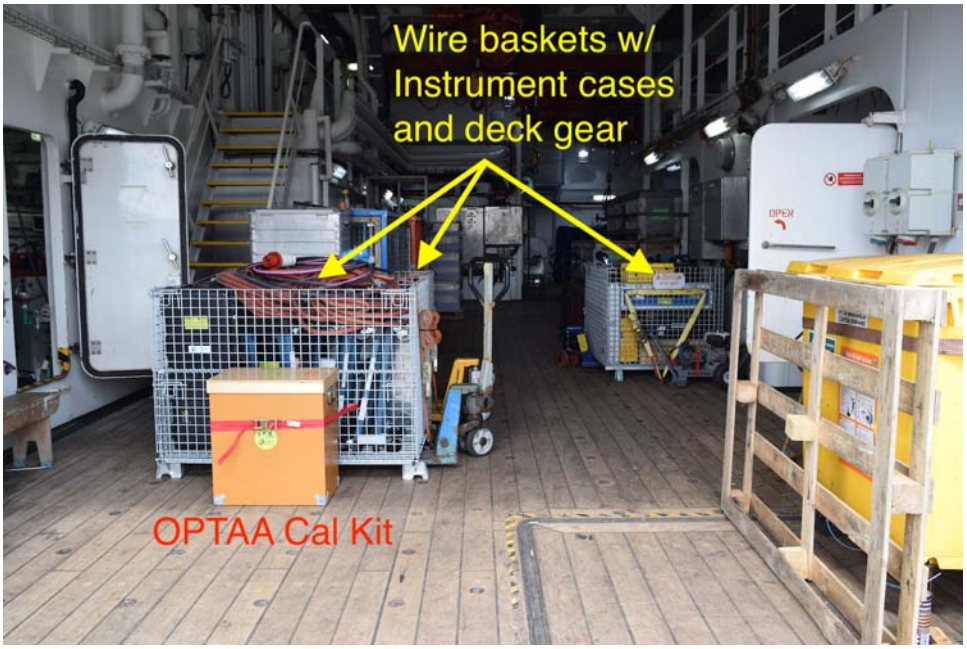

Figure 2-3 – Actual Hangar Layout

3.0 Platform Deployments/Recoveries

3.1. GS01SUMO-00004 Recovery

3.1.1. Deployed Status

The GS01SUMO-00004 Mooring was deployed 4 December 2018 at 17:10 UTC. The surveyed anchor position was 54° 24.4301' S, 89° 12.3622' W in a water depth of 4589 m. The OPTAA on the buoy was removed prior to deployment because it was not functioning properly. The FDCHP stopped reporting at 13:00 UTC on 5 December 2018. The inductive PCO2W, PHSEN and CTDBP1 instruments also stopped reporting a couple of days after deployment. Wind Turbine 2 (starboard side) failed one day after deployment, due to what is believed to be a PSC 2.0 issue.

On 3 February 2019 a failure occurred which shut down the Near Surface Instrument Frame (NSIF). No data was collected from 4-10 February. The issue was an i2c error. An override command was sent which enabled the NSIF to remain powered when the i2c error occurred. On 18 February the NSIF began having power issues again. This was resolved by turning off GPS on the mooring, which was causing communications issues.

Issues with data from the POC2A instruments began occurring on 31 December 2018 for PCO2A2 and 11 April 2019 for PCO2A1. Based on discussions with the vendor, it was determined that both lamps probably failed. These instruments were disabled on 14 May 2019.

The PCO2W instrument on the NSIF stopped sending data on 11 March 2019. Attempts were made to resolve the issue by changing the current limit and opening up the listening window of the DCL (in case clock drift was causing the instrument to report data at a later time). On 17 May 2019, the mooring software was updated to operate the PCO2W in polled mode.

By the time of recovery (January 2020), all telemetry and power (except for WT2) were functional. All instruments on the buoy and NSIF were operating except for the instruments discussed above, and the buoy FLORT (which stopped on 18 December 2019). Some of the individual METBK modules were having issues. The status of the inductive instruments was unknown – it was not clear if the instruments themselves failed, or the inductive line failed.

3.1.2. Recovery

The GS01SUMO-00004 mooring was recovered during the day on 20 January 2020. Winds were ~20 kts from the NW with light seas and little current (<0.5 kts). Conditions were overcast and foggy at the start which limited visibility.

Before recovery operations began, the RRS *Discovery* was positioned roughly 1 NM upwind of the surveyed anchor position. The TSE winch leader was reeved through the port quarter crane 2.5-ton block, around the starboard quarter then walked forward along the starboard bulwark and secured. The portable transducer was lowered into the water on the starboard side and one of the dualed acoustic releases was enabled, ranged to confirm, then released at 10:01 UTC (07:01 local). The backup floatation (glass balls) surfaced in a large cluster within one hour after being released. Due to the limited visibility the ship had to close to ~0.5 NM before the balls were visible on the surface.

The ship had to readjust its approach with the wind to keep the cluster on the starboard side with the Colmega line trailing away from the ship (Figure 3-1). The cluster eventually was hooked on the starboard side by a 5-ton Titanium pickup hook after the balls were held by grapnel to keep them close. The ship made forward headway letting the balls drift aft and away from the stern. The TSE winch hauled in, while adjusting the crane block height, until the cluster was on deck.

Figure 3-1 – Glass balls hooked with Colmega line leading away from the ship

The starboard crane moved the cluster of balls further forward until a Yale grip could be applied to the 1” Colmega that was leading off the ship’s stern. The Samson stopper line was attached to the Yale grip, stopping off the mooring. Once tension was transferred from the winch leader to the stopper line, the Colmega line was cut and the balls moved further forward and out of the way of operations (Figure 3-2).

Figure 3-2 – Glass balls secured on deck and Colmega line being hauled in onto the TSE winch

The winch leader reeved through the hanging block was shackled into the 5-meter shot of ½" trawler chain above the releases, which were still hanging from the stern. The winch paid in, pulling the releases onto the stern. The leader was removed from the chain and shackled to the Yale grip on the Colmega. The winch leader hauled in and the stopper line removed from the Yale grip. The TSE then paid in all of the Colmega and a small amount of transitioned Nylon, completely filling up the winch drum. A Yale grip was applied to the Nylon and attached to a deck stopper line. For added safety as well as the need for sufficient length of line to re-attach to the TSE winch leader, ~5 m of Nylon was stripped off the winch above the Yale grip and tied off to a deck cleat. Once secured, the Nylon was cut. All of the Colmega was removed from the TSE winch and put into a Ropak box on deck.

Once the Colmega was fully removed from the winch, the Nylon was removed from the deck cleat and a bowline was tied to the bitter end through the winch leader thimble. Once attached and tension applied, the stopper line and Yale grip were removed from the Nylon. The winch paid in the Nylon until the drum was fully loaded. Citing the same procedure above, the Nylon was fully removed from the winch into Ropaks (Figure 3-3) and then the recovery continued.

Figure 3-3 – Synthetics being off-spooled from the TSE into Ropaks

After all of the synthetics were recovered there was a mechanical boot transition to 3/8" wire rope. The urethane boot and the remaining 3/8" and 7/16" wire rope as well as clamped inductive instrumentation (CTDMOs) were recovered.

At the top of this shot, the Acoustic Doppler Current Profiler (ADCP) was recovered by continuing to haul in with the TSE as well as extending the height of the port quarter crane/block (Figure 3-4, left). Once the ADCP was on deck, a Yale grip was secured above the lower termination of the 485.5 m shot of 7/16" wire and secured with the deck stopper line. The ADCP was disconnected from both sides of the mooring wire rope. Once removed, a second Yale grip was added below the upper termination of the 1,000 m shot of 7/16" wire rope. The two Yale grips were secured with a 4' sling and hardware.

Figure 3-4 – Recovery of the ADCP (left) and instrumentation from the wire rope (right)

The TSE then recovered approximately half of the 485.5 m shot of wire rope along with clamped instrumentation (Figure 3-4, right). Once the wire became relatively slack, a line was secured to the wire aft of the hanging Gifford block to control any recoil once the wire rope was cut with the hydraulic cutters. The wire rope section leading to the buoy was cut at the 180 m depth mark, thus releasing the surface buoy and allowing the remaining section of mooring riser free, setting up for a buoy-last recovery. Due to the top-heaviness of the buoy, having a portion of the mooring riser hanging below the buoy is suggested to keep it upright and stable.

The deck was prepared for the buoy recovery. The TSE winch leader was reeved through the 2.5-ton block secured to the port quarter crane and brought around to the starboard bulwark then shackled to a long 5-ton recovery hook pennant (Note: a specialized pennant length of approximately 12 meters was made and used for the buoy recovery to make it easier to connect to the ship's core wire at the transom). The ship repositioned allowing the buoy to come along the starboard side. When the buoy was hooked, the ship moved slow ahead allowing the buoy to come astern (Figure 3-5). When the buoy was center line, the TSE winch hauled in bringing the buoy closer to the ship's stern. Once the end of the 5-ton pennant was on deck it was disconnected then shackled into the ship's core (trawl) wire which was reeved through the A-frame center line block.

Figure 3-5 – The hooked surface buoy moving around the starboard quarter

When the buoy was lifted out of the water it turned, allowing the masthead to face forward; two tugger leaders were attached to the port and starboard buoy tag line bales with a third tugger secured to the masthead, preventing the buoy from swinging further. The A-frame was brought in bringing the buoy on board (Figure 3-6, left) and yellow aircraft straps were used to secure it on deck. Once secured, a 6-foot sling was choked around a cleaned section of the EM chain and secured to the TSE winch leader. As the TSE hauled in, the EM chain was brought forward, adjacent to the buoy foam until the NSIF broke the water's surface. Using the starboard crane winch and 5-ton recovery pennant, the NSIF was brought on deck (Figure 3-6, right). Using the deck mounted port tugger winch, the NSIF was brought as far forward as possible to allow enough room to secure a Yale grip to the remaining 7/16" wire rope still in the water. A deck stopper was secured to the Yale grip and the wire rope was cut, thus freeing the NSIF. The TSE winch leader was secured to the Yale grip and the stopper removed. The remaining wire rope and inductive instrumentation were recovered (many of the instruments from the upper 485 m wire rope shot were damaged or missing – see Section 3.1.3 for details). The recovery was completed at 19:05 UTC (16:05 local) 20 January 2020.

Figure 3-6 – Recovery of the GS01SUMO-00004 surface buoy and NSIF

3.1.3. Inspection and Analysis

The GS01SUMO-00004 mooring was in fairly good shape when it was recovered. The buoy was intact with all instrumentation and telemetry components in place on the halo, and all solar panels and wind turbines intact (Figure 3-7). Both wind turbines were spinning – the port-side WT1 spinning faster than the failed starboard-side WT2. The FDCHP instrument was bent slightly and one of the top sensor tines was missing (Figure 3-7, right). This instrument was not damaged on deployment, but did fail one day after the mooring was deployed.

There was little bio-fouling on the buoy deck and sides of the foam, and some of bottom paint was rubbed off. The bottom of the buoy had a number of goose-neck barnacles attached. All of the subsurface buoy instruments were in place but covered with gooseneck barnacles. The FLORT instrument on the bottom of the buoy failed during deployment. On recovery it was found to have a corroded bulkhead with one pin missing. The METBK-CT 2 sensor had slight corrosion on the bulkhead. Data continued throughout the entire deployment but brief periods of garbage data were observed periodically.

Figure 3-7 – GS01SUMO-00004 Buoy and Halo

Figure 3-8 – Buoy subsurface sensor panels – starboard side (left) and port side (right)

The NSIF was in good condition with little bio-fouling – just a thin slime coating (Figure 3-9). The OPTAA plumbing was securely connected to the exhaust ports, but had had come lose from the pump; the intake plumbing remained intact and secure. The PCO2W copper screen was gone – presumably dissolved away as small bits remained at the tie-wraps used to secure it in place. Bio-fouling components such as the NUTNR brush, SPKIR copper shutter, FLORT copper face and wiper, and DOSTA UV-light all appeared to be have remained functional throughout the deployment. Internal data logged on the PCO2W was found to have stopped 15 March 2019. Battery levels on recovery were low, but sufficiently high to be able to establish communication and download data.

When shutting down the NSIF prior to deployment, it was observed that the DCL clocks were approximately 5 minutes ahead of the computer/shipboard clock. Further checks revealed that all of the clocks were off by 5 minutes. With the GPS turned off (as noted in Section 3.1.1),

there was no NTP on the buoy, so the CPM1 SeaScan clock provided master time. A timekeeping script was run to sync all other components to CPM1 time. So the CPM1 clock drift was the cause of the time offset.

The CUSTARD instruments mounted in the NSIF appeared in good condition (Figure 3-9, right). They were removed from the NISF and cleaned, and data was downloaded from throughout the entire deployment.

Figure 3-9 – GS01SUMO-00004 NSIF – OOI core instruments (left), CUSTARD sensors (right)

In contrast to the good condition of the rest of the mooring, much of the instrumentation clamped directly onto the wire rope was significantly damaged or missing altogether.

Table 3-1 lists the mooring riser instrumentation with an overview of if or where it was recovered, and any damage sustained.

At the time of deployment, the clamps for the PCO2W and PHSEN instruments were the wrong size. These clamps were made for 1/2" wire rope, which is what the newer mooring design with in-line instrument frames use. However, due to the failure of the G01SUMO-00004 mooring in the Irminger Sea which used the new design, it was decided to deploy the old design in the Southern Ocean until the root cause of the failure could be determined. The old design uses 7/16" wire rope, rather than 1/2". Therefore, to mount these instruments to the wire, vulcanizing tape was added to the wire rope and covered with electrical tape before the instruments were clamped on. This appeared to be sufficient to secure the instruments. All 5 PCO2W and PHSEN instruments stopped reporting in the couple of days after the mooring was deployed. It was thought (hoped) that this was just an issue with the inductive communications. However, it may be that all 5 instruments slipped from their locations soon after deployment. The shallowest three sensors were all missing at the time of recovery. The deepest 2 were significantly damaged and found further down the mooring line than where they were deployed (e.g., the remaining portion of the 100 m PHSEN was removed from the wire at 130 m). In addition, it appears that once these instruments become loose on the line and slid down, they impacted other instruments below, causing them to fall off or be damaged.

Table 3-1 – GS01SUMO-00004 Recovered Mooring Riser Instrumentation

Instrument Class-Series	Serial Number	Deployment Depth	Recovery Depth	Notes/Issues
CTDMO-Q	37-12586	20 m	20 m	Conductivity cell guard missing.
PHSEN-E	P0101	20 m	N/A	Instrument missing, only UIMM recovered.
CTDBP-P	16-50137	40 m	N/A	Missing.
DOSTA-D / FLORD-G	508 / 3369	40 m	N/A	Missing.
PCO2W-C	C0137	40 m	N/A	Instrument and UIMM missing.
CTDMO-Q	37-12589	60 m	80 m	Instrument missing conductivity cell guard, damaged temperature probe and conductivity cell. Heavy wear on housing and signs of water ingress. Slid down to 80 m.
CTDBP-P	16-50138	80 M	80 m	Pump missing and damaged cables. Internal lithium clock batteries loose.
DOSTA-D / FLORD-G	512 / 3381	80 m	80 m	Still connected to CTDBP-P but cables damaged.
PCO2W-C	C0138	80 m	N/A	Instrument missing, only UIMM recovered.
CTDMO-Q	37-12940	100 m	100 m	Conductivity cell and temperature probe damaged, conductivity cell guard missing. Signs of battery corrosion. Li clock battery dead.
PHSEN-E	P0179	100 m	130 m	Only top half of the instrument remaining; UIMM still on the wire at 100 m. Housing full of seawater & electronics ruined.
CTDBP-P	16-50139	130 m	N/A	Missing.
DOSTA-D / FLORD-G	514 / 4029	130 m	130 m	Cable to CTDBP-P missing, FLORD connector smashed.
PCO2W-C	C0139	130 m	180 m	Instrument in 2 halves and damaged; UIMM still on the wire at 130 m. Signs of water ingress and heavy corrosion inside.
CTDMO-Q	37-13556	180 m	180 m	Conductivity cell guard missing.
CTDMO-Q	37-13557	250 m	250 m	No issues.
CTDMO-Q	37-13577	350 m	350 m	No issues.
CTDMO-Q	37-13588	500 m	500 m	No issues.
ADCP-N	21639	500 m	500 m	No issues.
CTDMO-R	37-12565	750 m	750 m	Temperature probe damaged, conductivity cell guard missing.
CTDMO-R	37-12567	1000 m	1000 m	No issues.
CTDMO-R	37-13648	1500 m	1500 m	No issues.

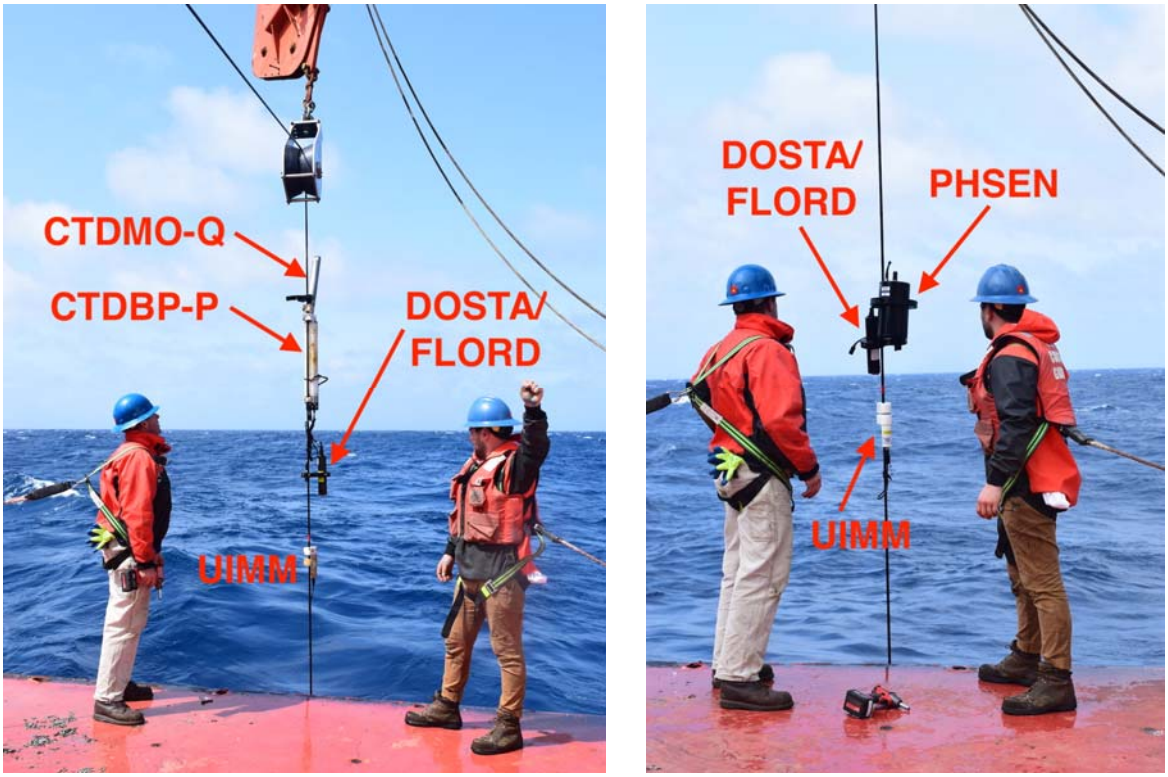

Figure 3-10 – Recovery instruments at 80 and 130 m

Figure 3-10 shows two examples of instruments apparently slipping down the wire rope. On the left are the instruments at the 80 m depth mark. The CTDMO-Q is from 60 m. It was presumably hit by the 40 m PCO2W and knocked down. The 40 m PCO2W is missing, but part of its clamp is with the CTDMO-Q. The CTDBP-P and DOSTA-FLORD pair are still on the wire at 80 m. But the 80 m PCO2W is missing; only its UIMM remains clamped on the wire.

At the 130 m depth mark (Figure 3-10, right), we recovered the top half of the PHSEN from 100 m. The CTDBP-P was missing altogether. The DOSTA-FLORD pair were still attached to the wire, but the FLORD connector was smashed. The 130 m PCO2W was recovered at 180 m. Only its UIMM remained at the 130 m location.

Due to our late arrival at the mooring site and a limited operational weather window, we were not able to collected shipboard MET data for comparison with the buoy.

4.0 Ancillary Data Collection

4.1. Bathymetry and Water Column Echosounders

The RRS *Discovery* is equipped with Kongsberg EA640 10 & 12 kHz and EK60 echosounders as well as a Kongsberg EM122 multi-beam swath bathymetry system. Both the 10 kHz and 12 kHz echosounders were used. The 12kHz echo sounder was used on passive mode and the 10 kHz was used in active move for determination of water depth; with a sound speed of 1500 m/s. The EK60 was used in international waters with the 70 kHz and 120 kHz in passive mode, and the 200 kHz and 333 kHz in active mode.

Multi-beam swath bathymetry was collected during the Southern Ocean 6 cruise while in international waters (using the mammal protection soft-start 15 min ramp-up). But no detailed surveys were conducted.

4.2. CTD Casts and Water Sampling

No CTD casts were conducted during the Southern Ocean 6 cruise (DY112). But the CUSTARD team did conduct CTDs in the vicinity of the GS01SUMO-00004 mooring during the previous CUSTARD cruise (DY111). The RRS *Discovery* was outfitted with both Stainless Steel (SS) and Titanium (Ti) CTD rosettes. Both rosettes were used during the CUSTARD (DY111) cruise.

The SS rosette held instrumentation to measure the following parameters:

- Conductivity, Temperature and Pressure – Sea-Bird SBE 9p, S/N 09P-77801-1182
  Dual sensors for temperature and conductivity measurements (secondary sensors were mounted to the rosette vane).
  - Temperature – SBE 3p, S/N 3P-4383 (primary) and 3P-4381 (secondary) (calibration dates: 11 Jul 2018 and 25 Jul 2018)
  - Conductivity – SBE 4C, S/N 4C-2580 (primary) and 4C-2450 (secondary) (calibration dates: 11 Jul 2018 and 14 Jun 2018)
  - Pump – SBE 5T, S/N 05T-3085 (primary) and 05T-3090 (secondary)

  Pressure – Paroscientific Digiquartz, S/N 129735 (calibration date: 03 Nov 2017)
- Dissolved Oxygen – Sea-Bird SBE 43, S/N 43-1940 (calibration date: 21 Jul 2018)
- Backscatter – WET Labs BB-RTD, S/N BBRTD-5466 (calibration date: 4 Feb 2019)
- Transmissometer – WET Labs C-Star, S/N CST-1654DR (calibration date: 07 Apr 2017)
- Fluorescence – CTD Aquatracka III, S/N 88-2615-126 (calibration date: 16 Aug 2018)
- DWIRR PAR – Biospherical QCP02350-HP, S/N 70510 (calibration date: 27 Jun 2019)
- UWIRR PAR – Biospherical QCP02350-HP, S/N 70520 (calibration date: 27 Jun 2019)

The Ti rosette held instrumentation to measure the following parameters:

- Conductivity, Temperature and Pressure – Sea-Bird SBE 9p, S/N 09P-34173-0758
  Dual sensors for temperature and conductivity measurements (secondary sensors were mounted to the rosette vane).
  - Temperature – SBE 3p, S/N 3P-2729 (primary) and 3P-5495 (secondary) (calibration dates: 11 Jul 2019 for both)
  - Conductivity – SBE 4C, S/N 4C-3567 (primary) and 4C-2571(secondary) (calibration dates: 27 Jun 2019 and 11 Jul 2018)
  - Pump – SBE 5T, S/N 05T-7371 (primary), 05T-7515 (secondary Casts 1-7) and 05T-6320 (secondary, Casts 8-22)

  Pressure – Paroscientific Digiquartz, S/N 90074 (calibration date: 19 Jul 2019)
- Dissolved Oxygen – Sea-Bird SBE 43, S/N 43-2831 (calibration date: 20 Aug 2019)

- Backscatter – WET Labs BB-RTD, S/N 758R (calibration date: 30 Aug 2019)
- Transmissometer – WET Labs C-Star, S/N CST-1718TR (calibration date: 22 Mar 2018)
- Fluorescence – CTD Aquatracka III, S/N 88-2050-095 (calibration date: 4 Jun 2018)

CTD casts and water sampling were conducted to provide ancillary data for evaluation of instrumentation on the deployed moorings, and for the CUSTARD Project. Water samples were collected for measuring oxygen, salts, chlorophyll, nutrients and carbon (dissolved inorganic carbon, total alkalinity and pH). A summary of CTD casts from DY111 is listed in Table 4-1.

Table 4-1 – CTD Casts

Cast #	Date	Time (UTC)	Location	Cast Depth	Water Samples
CTD002SS	12/6/2019	06:06	54° 25.28' S 89° 07.72' W	2000 m	O2, DIC/TA, nutrients, Cl, Salts
CTD002T	12/6/2019	15:42	54° 25.28' S 89° 07.72' W	1000 m	Nutrients, Salts
CTD003SS	12/6/2019	22:10	54° 25.28' S 89° 07.72' W	1000 m	O2, DIC/TA, nutrients, Cl, Salts
CTD013SS	12/14/2019	04:08	54° 25.48' S 89° 06.38' W	1000 m	O2, DIC/TA, nutrients, Cl, Salts
CTD009T	12/14/2019	11:15	54° 25.64' S 89° 06.37' W	1000 m	Nutrients, Salts
CTD014SS	12/14/2019	18:39	54° 25.01' S 89° 08.10' W	1000 m	O2, DIC/TA, nutrients, Cl, Salts
CTD010T	12/15/2019	05:55	54° 24.98' S 89° 08.09' W	4500 m	Nutrients, Salts
CTD015SS	12/15/2019	10:12	54° 24.98' S 89° 08.09' W	4600 m	O2, DIC/TA, nutrients, Cl, Salts
CTD024SS	12/22/2019	04:08	54° 24.99' S 89° 07.94' W	1000 m	O2, DIC/TA, nutrients, Cl, Salts
CTD016T	12/22/2019	10:04	54° 24.97' S 89° 07.97' W	1000 m	Nutrients, Salts
CTD025SS	12/22/2019	16:10	54° 25.14' S 89° 08.77' W	500 m	No bottle samples
CTD026SS	12/22/2019	16:55	54° 25.14' S 89° 08.77' W	1000 m	O2, DIC/TA, nutrients, Cl, Salts
CTD021T	1/2/2020	19:15	54° 24.92' S 89° 07.56' W	4335 m	Nutrients, Salts
CTD037SS	1/3/2020	06:35	54° 24.68' S 89° 07.69' W	1000 m	O2, DIC/TA, nutrients, Cl, Salts
CTD022T	1/3/2020	14:16	54° 24.90' S 89° 07.57' W	750 m	Nutrients, Salts
CTD038SS	1/3/2020	17:46	54° 24.91' S 89° 07.57' W	1000 m	O2, DIC/TA, nutrients, Cl, Salts

On DY112, Go-Flo samples were collected in the vicinity of the recovered mooring on 21 January 2020. Two profiles of 4 depths each were collected (10, 50, 100 and 150 m). Water samples were collected for oxygen, salts, DIC/TA, Chlorophyll a, and nutrients by the CUSTARD team (see Appendix C for more details of CUSTARD sampling during DY112).

4.3. Meteorological Data

The RRS *Discovery* meteorological platform on the foremast is outfitted with the following sensors:

- Air temperature and humidity (1869 cm above the waterline) – Vaisala HMP155A, S/N K0950057 (calibration date: 15 Aug 2019)
- Barometric pressure (1806 cm above the waterline; on top of wheel house) – Vaisala PTB210C, S/N P1640265 (calibration date: 14 Aug 2019)
- Sonic anemometer (1970 cm above the waterline on the starboard side) – Gill Windsonic Option 3, S/N 10280018 (test date: 29 Sep 2015)
- Port and starboard TIR and PAR sensors (1869 cm above the waterline)
  - Port TIR – Kipp & Zonen TIR CM 6B, S/N 973134 (calibration date: 6 Jun 2019)
  - Stbd TIR – Kipp & Zonen TIR CM 6B, S/N 994132 (calibration date: 18 Oct 2018)
  - Port PAR – Skye PAR SKE510, S/N 48927 (calibration date: 30 Jan 2018)
  - Stbd PAR – Skye PAR SKE510, S/N 28563 (calibration date: 3 Sep 2019)

4.4. Near-Surface Parameters

The RRS *Discovery* is outfitted with system and sensors to measure the following near-surface parameters (seawater intake is 5.5 m below the waterline):

- Surface Sound Velocity – AML Micro-X / SV•Xchange, S/N 10377 / 203551 (calibration date: 3 Apr 2019)
- Near-Surface Temperature – Sea-Bird SBE38, S/N 3854115-0487 (calibration date: 26 Jul 2019)
- Near-Surface Temperature and Salinity – Sea-Bird SBE45 TSG, S/N 4548881-0230 (calibration date: 27 Jun 2019)
- Near-Surface Fluorescence – WET Labs WS3S, S/N WS3S-351P (calibration date: 5 Aug 2019)
- WET Labs CST Transmissometer, S/N CST-1852PR (calibration date: 19 Mar 2018)

4.5. Acoustic Doppler Velocity Profilers

The RRS *Discovery* was outfitted with two ADCP data streams to provide water-column velocity estimates of varying vertical extent and depth resolution.

- RD Instruments Ocean Surveyor 150 kHz (NarrowBand Modes) – configured with bottom track off, ping interval of 1.10 sec, and 40 depth bins of 8 m each.
- RD Instruments Ocean Surveyor 75 kHz (NarrowBand Mode) – configured with a ping interval of 1.8 s, and 60 bins of 16 m each.

5.0 Issues and Recommendations

5.1. Damage to instrumentation on the mooring riser

Significant damage to and loss of instrumentation occurred on the GS01SUMO-00004 mooring riser. As noted in Section 3.1.3, one of the causes is thought to be the fact that the PCO2W and PHSEN clamps were sized for 1/2" rather than 7/16" wire rope, and vulcanizing tape had to be added to the wire rope to increase the thickness for suitable clamping. In the end, the use of vulcanizing was not sufficient for this purpose.

Once the root cause of the GI01SUMO-00004 failure was determined not to be the in-line frame design, we will and should go back to that design for all future Global Surface Mooring deployments. The use of the in-line frame allows for more secure clamping of the clusters of instrumentation at 40, 80 and 130 m (CTDBP-P, DOSTA, FLORD, PCO2W and UIMM. With the new design, only the two PHSEN instruments at 20 and 100 m and all of the CTDMOs would be clamped directly to the wire.

Due to the fragility of the PHSEN instruments, the existing clamps (3707-01101-00001) have been modified such that the top and bottom clamps are joined by 2 strengthening rods along the sides (assembly 3707-01162-00001). This design reduces torsion and stresses on the instrument.

Both of the above design changes that have already been implemented should help to improve survivability of instrumentation on the mooring riser.

5.2. CTDBP-P battery issues

Only one CTDBP-P was recovered from the mooring riser. The standard D cell batteries that power the instrument were depleted and had to be replaced to establish communication and download data. This is despite the fact that the sample interval was reduced to every other hour (7200 sec) from the previous 1-hour sampling interval (3600 sec) in order to conserve battery life such that the sensor would be operational throughout the entire year-long deployment. Further efforts are needed to better understand the battery draw of this instrument and the DOSTA and FLORD instruments which are connected to it for communications and power.

In addition, the lithium clock batteries that are soldered onto the internal circuit board were found to be loose on recovery (soldered tabs had broken and batteries were not attached). As a result, the instrument did not know the correct time (the instrument reset to Jan 1, 2000 at 00:00:00 upon repowering) or the where it was in the sample sequence (samples = -420892820, free = 423753608). Reasonable samples exist on the instrument through 22 February 2019, before turning to garbage (535.6826, 1359.63708, 53419.175, 5.0000, 5.0000, 5.0000, 5.0000, 06 Feb 2136 06:28:15). This has been observed on other CTDBPs in the past and the soldered tabs and security of the lithium battery mounting should be checked on future instruments.

Appendix A – Cruise Participants

Table A-1 – DY112 OOI Science Party List

Name	Affiliation	Email	Responsibility
Sheri N. White	WHOI	swhite@whoi.edu	Chief Scientist, Documentation
James Ryder	WHOI	jryder@whoi.edu	Deck Lead
Kris Newhall	WHOI	knewhall@whoi.edu	Deck Ops
Nico Llanos	WHOI	nllanos@whoi.edu	Deck Ops
Jennifer Batryn	WHOI	jbatryn@whoi.edu	Instrumentation, Surface Mooring

Table A-2 – DY112 CUSTARD/NMF Science Party List

Name	Affiliation	Email	Role
Adrian Martin	National Oceanography Centre	adrian.martin@noc.ac.uk	CUSTARD Lead
Chelsey Baker	National Oceanography Centre		CUSTARD
Katsia Pabortsava	National Oceanography Centre	katsia@noc.ac.uk	CUSTARD
Andy Leadbeater	National Marine Facility	andrew.leadbeater@noc.ac.uk	Mooring Tech
Steve Whittle	National Marine Facility	spwh@noc.ac.uk	Mooring Tech
Jennifer Ward-Neale	National Marine Facility		Computer Tech
Andrew Cottmore	National Marine Facility		Trainee

Global Surface Mooring Station Log

ARRAY & DEPLOYMENT: Southern 5 **MOORING S/N:** GS01SUMO-00004

Launch (Anchor Over)

Date (Day-Month-Year): 4 Dec 2018 Time: 17:10:40 UTC

Latitude (N/S, Deg-Min): 54° 24.286' S Longitude (E/W, Deg-Min): 89° 12.501' W

Deployed By: Jim Ryder Recorder(s): Sheri N. White

Ship and Cruise Number: DY096 RRS *Discovery*

Depth Recorder Reading: 4589 m EM122 Multi Beam SSV = 1474.30 Intended Duration: 1 year

Corrected Water Depth: m Correction Source:

Surveyed Anchor Position

Lat (N/S): 54° 24.4301' S Long (E/W): 89° 12.3622' W

Acoustic Releases

Model: 8242 Tested To: 1500m m

Release No. 1 (S/N): 48512 Release No. 2 (S/N): 52869

FOR REFERENCE ONLY – Use Acoustic Release command codes in blue books or scanned sheet in Vault

Interrogate Frequency: 11 kHz	Interrogate Frequency: 11 kHz
Reply Frequency: 12 kHz	Reply Frequency: 12 kHz
Enable Command: 575375	Enable Command: 373675
Disable Command: 575412	Disable Command: 373704
Release Command: 554372	Release Command: 352306

Recovery (Released Fired)

Date (Day-Month-Year): 20-Jan-2020 Time: 10:01 UTC

Latitiude (N/S, Deg-Min): 54° 23.698' S Long. (E/W, Deg-Min): 89° 13.364' W

Recovered By: Jim Ryder Recorder(s): Sheri N. White

Ship / Cruise No.: DY112

Distance of waterline from buoy deck: m Actual Duration: 412 days

Template 3401-20011 Ver 2-00 Page 1 of 3

ARRAY & DEPLOYMENT: Southern 5 **MOORING S/N:** GS01SUMO-00004

Deployment and Recovery Log

Item #	Item	[Length] / Depth (m)	Serial No.	Time Over	Time Back	Notes
1	Buoy			09:52	18:17	FDCHP BENT, TIME MISSING
2	EM Chain	[10]	0039			
3	NSIF	1			18:40	
4	7/16" wire rope	[486.3]	18120-1 ✓			
5	CTDMO-Q	20	37-12586 ✓		19:48	
6	PHSEN-E	20	P0101 ✓		JIMM	Remove bag ☑
7	**CTDBP-P**	**40**	**16-50137** ✓			Plug in Pump ☑
8	**DOSTA-D**	**40**	**508**			Remove cover ☑
9	**FLORD-G**	**40**	**3369** ✓			Remove cover ☑
10	**PCO2W-C**	**40**	**C0137** ✓		JIMM	Plug in Pump ☑
11	CTDMO-Q	60	37-12589 ✓		18:57	@ 80m
12	**CTDBP-P**	**80**	**16-50138** ✓		18:57	Plug in Pump ☑
13	**DOSTA-D**	**80**	**512**		"	Remove cover ☑
14	**FLORD-G**	**80**	**3381** ✓		18:57	Remove cover ☑
15	**PCO2W-C**	**80**	**C0138** ✓		JIMM	Plug in Pump ☑
16	CTDMO-Q	100	37-12940 ✓	10:04	19:00	
17	PHSEN-E	100	P0179 ✓	"	19:02	HALF @ 130m Remove bag ☑
18	**CTDBP-P**	**130**	**16-50139** ✓	10:13		Plug in Pump ☑
19	**DOSTA-D**	**130**	**514**	"	19:03	Remove cover ☑
20	**FLORD-G**	**130**	~~3382~~ 4029 ✓	"	"	Remove cover ☑
21	**PCO2W-C**	**130**	**C0139** ✓	"	17:27	Plug in Pump ☑
22	CTDMO-Q	180	37-13556 ✓	10:17	17:27	1/2" ROPE CUT @ 180m
23	CTDMO-Q	250	37-13557 ✓	10:20	17:24	
24	CTDMO-Q	350	37-13577 ✓	10:24	17:21	
25	CTDMO-Q	500	37-13588 ✓	" 12	17:02	
26	ADCP-N in Frame	500	21639 ✓	"	17:03	
27	7/16" wire rope	[1000]	17060-6 ✓	"		
28	CTDMO-R	750	37-12565 ✓	11:22	16:54	
29	CTDMO-R	1000	37-12567 ✓	11:31	16:47	
30	CTDMO-R	1500	37-13648 ✓	11:59	16:30	
31	3/8" wire rope	[300]	17059-7	"	16:19	
32	3/8" wire rope	[100]	16087-2			
33	Termination			12:56	16:14	Wire to Nylon Termination
34	7/8" Nylon	[200]				Plymkraft overbraid
35	7/8" Nylon plait	[2300]			13:00	
36	1" Colmega	[1725]		14:45	12:19	
37	64-17" GB's*			15:13	12:08 UTC	16 sets x 4 ea
38	1/2" Trawler	[5]				2 BALLS IMPLODED

Template 3401-20011 Ver 2-00

ARRAY & DEPLOYMENT: Southern 5 **MOORING S/N:** GS01SUMO-00004

Deployment and Recovery Log, continued						
Item #	Item	[Length] / Depth (m)	Serial No.	Time Over	Time Back	Notes
39	Dualed Releases	[2]	48512 52867	16:50	12:11 UTC	
40	1/2" Trawler	[5]				
41	1" Nystron	[20]				
42	1/2" Trawler	[5]				
43	Anchor			17:10		

** Be sure to count (use hash marks in Notes column) sets of Glass Balls during deployment*

Appendix C – DY112 CUSTARD Summary Cruise Report

Written by Adrian Martin (CUSTARD, PI)

Personnel

Three of the scientific team from DY111 stayed on for DY112: Adrian Martin, Chelsey Baker and Katsia Pabortsava, all from NOC. The NMF team was replaced by Andy Leadbeater (STO), Steve Whittle, Andrew Cottmore and Jennifer Ward-Neale. They were joined by a mooring team from WHOI led by Sheri White (PSO): Jennifer Batryn, Jim Ryder, Kris Newhall, Nico Llanos. The only crew change from DY111 was that ERPO Brian Conteh was replaced by Neil Glyndor.

Lab-on-a-chip sensors

Adrian Martin, Katsia Pabortsava (NOC)

Following recovery of the buoy, the two NOC Lab-on-a-chip sensors were detached from the NSIF frame that hung 12m below the buoy. Biofouling was apparently light given the 14 months they had been in the water. They were cleaned with fresh water and left to dry for 36 hours. After this the casing was removed. Remaining reagents and waste products were decanted into a carboy. Standards and blanks were split, with one set being run on board and the other stored (nitrate in -20C freezer and silicate in chill room). The analysed set demonstrated that the standards remained very stable throughout giving values apparently identical to the original concentration. The inside was carefully cleaned and then left to dry for another 24 hours. Following this the data cable was attached and data were downloaded. Raw files were numbered sequentially, starting in December 2018 and finishing on the date before the buoy's recovery, suggesting that all files were recovered, though as there are over 400 for each sensor they weren't opened individually to check. The data will be analysed back in NOC.

Figure 1 Lab-on-a-chip sensors within the NSIF on recovery of the buoy.

Underway sampling

Adrian Martin, Chelsey Baker, Katsia Pabortsava (NOC)

Water samples were taken from the non-toxic supply every 6 hours at 0300, 0900, 1500 and 2100 shiptime (0000, 0600, 1200 and 1800 GMT) to be consistent with DY111. Sampling started on 18/1/20 at 1500 (1800 GMT) and continued until 0600 (0300GMT) on 22/1/20. Samples were taken for salinity, nutrients, Chl a, HPLC and DIC/TA. Some lugols were also taken for later analysis of phytoplankton community. At 1500 shiptime each day samples were also taken for size-fractionated Chl a (>0.2, >5, >10/20µm – the 10µm ran out on UW208 so a second sample was run for UW208 using 20µm and all subsequent samples, including all Go-flo samples, used 20µm). All protocols were as DY111

There were considerable problems with bubbles in the non-toxic supply. Jennifer Ward-Neale, the NMF SS tech, adjusted the system but problems persisted. The only time sampling for DIC/TA was possible was when stationary at the OOI site. While the journey out to the site was bumpy, at other times it was no different to DY111 when sampling had been possible.

UW#	Date	JDAY	Lat (S)	Lon (W)	Time (GMT)	S bottle	Time (GMT)	Nuts	Time (GMT)	Inorg C	Time (GMT)	Chl, HPLC	Size-frac Chl	Lugols
200	18/01/2020	18	53 18.29	80 55.07	18:35	200	18:34	UW200	-	Bubbles	18:34	UW200	UW200	-
201	19/01/2020	19	53 32.00	81 49.14	00:01	201	00:00	UW201	-	Bubbles	00:04	UW201	-	-
202	19/01/2020	19	53 45.43	82 57.11	06:00	202	06:03	UW202	-	Bubbles	06:05	UW202	-	-
203	19/01/2020	19	53 56.92	83 57.26	12:04	203	12:06	UW203	-	Bubbles	12:09	UW203	-	-
204	19/01/2020	19	54 1.35	85 2.44	18:03	204	18:06	UW204	-	Bubbles	18:07	UW204	UW204	-
205	20/01/2020	20	54 10.11	86 37.74	00:00	205	00:00	UW205	-	Bubbles	00:04	UW205	-	-
206	20/01/2020	20	54 20.92	88 23.46	05:56	206	05:58	UW206	-	Bubbles	06:00	UW206		
207	20/01/2020	20	54 29.59	89 11.57	12:02	207	12:04	UW207	12:08	96,116	12:06	UW207	-	-
208	20/01/2020	20	54 29.80	89 2.87	18:00	208	18:02	UW208	18:03	45,117	18:08	UW208	UW208	-
209	21/01/2020	21	54 25.29	89 2.32	00:01	209	00:03	UW209	-	Bubbles	00:11	UW209	-	-
210	21/01/2020	21	54 25.11	89 8.35	05:59	210	06:01	UW210	06:05	88,97	06:03	UW210	-	-
211	21/01/2020	21	54 25.11	89 8.31	11:44	211	11:46	UW211	11:50	113,114	11:48	UW211	-	yes
212	21/01/2020	21	54 25.11	89 8.31	-	-	17:37	UW212	-	-	-	-	-	-
213	21/01/2020	21	54 24.22	89 0.53	18:10	220	18:01	UW213	-	Bubbles	18:06	UW213	UW213	yes
214	22/01/2020	22	54 11.92	87 20.32	00:00	221	00:01	UW214	-	Bubbles	00:02	UW214	-	yes
215	22/01/2020	22	53 59.63	85 39.84	05:58	222	05:59	UW215	-	Bubbles	06:01	UW215	-	yes

Figure 2 DY112 underway sampling

Go-flo sampling

Adrian Martin, Chelsey Baker, Katsia Pabortsava (NOC)

The primary aim of DY112 was to recover the mooring so any sampling had to be done on an opportunistic basis. In particular the CTD frame was not available as there was not a CTD technician onboard. Two profiles were nevertheless collected using single Go-flo bottles on a Kevlar rope fired using a messenger. Four depths were sampled: 150m, 100m, 50m, 10m. Each depth was sampled using a single bottle, with water taken before the bottle was sent back over to the next depth. Sampling was as for underway but plus oxygen, POC, PIC and BSi. Once again protocols were as DY111. To obtain depth and higher frequency data, a RBR Concerto was attached to the bottle with sensors for pressure, T, fluorescence, and backscatter.

GoFlo#	Date	JDAY	Lat (fired)	Lon (fired)	Depth (m)	Time (GMT; fired)	Oxygen	S bottle	Nuts	Inorg C	HPLC	Lugols	POC	Bsi	PIC	Chl a	Chl a Size Frac (>20, >5, >0.2)
GF1	21/01/2020	21	-54 25.132	-89 8.274	150	12:22	120	212	GF1	85 & 30	GF1 DY112	GF1 DY112	DY112 POC GF1 150m	DY112 BSi GF1 150m	DY112 BSi GF1 150m	x	x
GF2	21/01/2020	21	-54 25.21	-89 8.19	100	13:05	61 & 90	213	GF2	34 & 60	GF2 DY112	GF2 DY112	DY112 POC GF2 100m	DY112 BSi GF2 100m	DY112 BSi GF2 100m	x	x
GF3	21/01/2020	21	-54 25.22	-89 8.18	50	13:26	106	214	GF3	93 & 31	GF3 DY112	GF3 DY112	DY112 POC GF3 50m	DY112 BSi GF3 50m	DY112 BSi GF3 50m	x	x
GF4	21/01/2020	21	-54 25.24	-89 8.168	10	13:42	80 & 67	215	GF4	57 &35	GF4 DY112	GF4 DY112	DY112 POC GF4 10m	DY112 BSi GF4 10m	DY112 BSi GF4 10m	x	x
GF5	21/01/2020	21	-54 25.28	-89 8.14	150	16:21	92	216	GF5	94 & 32	DY112 HPLC GF5 150m	GF5 DY112	DY112 POC GF5 150m	DY112 BSi GF5 150m	DY112 BSi GF5 150m	x	x
GF6	21/01/2020	21	-54 25.35	-89 8.096	100	16:43	111 & 45	217	GF6	37 & 40	DY112 HPLC GF6 100m	GF6 DY112	DY112 POC GF6 100m	DY112 BSi GF6 100m	DY112 BSi GF6 100m	x	x
GF7	21/01/2020	21	-54 25.41	-89 8.056	50	17:03	94	218	GF7	33 & 41	DY112 HPLC GF7 50m	GF7 DY112	DY112 POC GF7 50m	DY112 BSi GF7 50m	DY112 BSi GF7 50m	x	x
GF8	21/01/2020	21	-54 25.46	-89 8.016	10	17:20	79 & 99	219	GF8	86 & 95	DY112 HPLC GF8 10m	GF8 DY112	DY112 POC GF8 10m	DY112 BSi GF8 10m	DY112 BSi GF8 10m	x	x

Figure 3 DY112 Go-flo sampling