WHOI-2018-02

Woods Hole Oceanographic Institution

The Northwest Tropical Atlantic Station (NTAS):

NTAS-17 Mooring Turnaround Cruise Report
Cruise On Board FV Pisces
May 30 – June 21, 2018
Mayport, FL, USA – Morehead City, NC, USA

by

Sebastien Bigorre[1], Benjamin Pietro[1], Jason Smith[1], Matthias Lankhorst[2], Jannes Koelling[2]

Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

September 2018

Technical Report

Funding was provided by the National Oceanic and Atmospheric Administration
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Upper Ocean Processes Group
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543
UOP Technical Report 2018-01

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Approved for Distribution:

Amy Bower, Chair

Department of Physical Oceanography

Abstract

The Northwest Tropical Atlantic Station (NTAS) was established to address the need for accurate air-sea flux estimates and upper ocean measurements in a region with strong sea surface temperature anomalies and the likelihood of significant local air–sea interaction on interannual to decadal timescales. The approach is to maintain a surface mooring outfitted for meteorological and oceanographic measurements at a site near 15°N, 51°W by successive mooring turnarounds. These observations are used to investigate air–sea interaction processes related to climate variability. The NTAS Ocean Reference Station (ORS NTAS) is supported by the National Oceanic and Atmospheric Administration's (NOAA) Ocean Observing and Monitoring Division.

This report documents recovery of the NTAS-16 mooring and deployment of the NTAS-17 mooring at the same site. Both moorings used Surlyn foam buoys as the surface element. These buoys were outfitted with two Air–Sea Interaction Meteorology (ASIMET) systems. Each system measures, records, and transmits via Argos satellite the surface meteorological variables necessary to compute air–sea fluxes of heat, moisture and momentum. The upper 160 m of the mooring line were outfitted with oceanographic sensors for the measurement of temperature, salinity and velocity.

The mooring turnaround was done by the Upper Ocean Processes Group of the Woods Hole Oceanographic Institution (WHOI), onboard F/V *Pisces*, Cruise PC-18-03. The cruise took place between May 30 and June 21 2018. The NTAS-17 mooring was deployed on June 10, and the NTAS-16 mooring was recovered on June 12. No inter-comparison between ship and buoys was performed on this cruise. This report describes these operations, as well as other work done on the cruise and some of the pre-cruise buoy preparations.

Other operations during PC-18-03 consisted in the recovery and deployment of the Meridional Overturning Variability Experiment (MOVE) subsurface moorings array (MOVE 1 in the east, and MOVE 3 and 4 in the west near Guadeloupe). Acoustic download of data from Pressure Inverted Echo Sounders (PIES) was also conducted. MOVE is designed to monitor the integrated deep meridional flow in the tropical North Atlantic.

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I. INTRODUCTION

I. A. Timeline

The NTAS 17 cruise departed from the naval base in Mayport, FL on Wednesday May 30, 2018 and ended in Morehead City, NC on June 21, 2018. The planned track (Figure I-2) was set to first deploy the NTAS 17 mooring, recover and deploy MOVE 1, recover the NTAS 16 mooring, then sail west for the mooring turnarounds at the MOVE 3 and 4 sites. However, multiple changes (detours to Puerto Rico and Barbados) modified this plan and led to a different track. At the MOVE sites, data downloads from and turnarounds of Pressure Inverted Echo Sounders (PIES) were also done. An overview of the chronology of the cruise is provided below. Local time on the ship during PC-18-03 cruise remained EST (UTC-4).

May 19-24, *Wednesday*: WHOI personnel arrive in Mayport, FL: paperwork for access to naval base, delivery of trucks, unloading equipment from trucks, staging on the pier for buoy assembly and testing. ASIMET logger cards erased and buoy spin (5/22), data download and evaluation (5/23), buoy married to foam (5/24). Ship docks on May 24 and unloads departing science team. Ship loading starts. Scripps logistics team arrives.

May 25, *Friday*: Ship loading continues, install beams on 01 deck for securing of storage baskets, setting up labs. SIO's first truck equipment arrives.

May 26-28: finish setting up labs. Ship's crew on leave during Memorial Day weekend.

May 29, Tuesday: ship's refueling, oil and sewage waste offload, stores delivery.

May 30, *Wednesday*: Orientation meeting at 1030 EST. Ship departure at 1230 EST. Install ASIMET standalones on ship. SIO start their PIES. Steam SE towards Puerto Rico to pick up medical officer and additional engineer.

May 31, Thursday: Steaming towards PR. Get out of Gulf Stream in early morning. Fire and ship drills. CTD test to 200 m and no data collection (inside Bahamas waters). ASIMET data dump, clear cards and restart. Logger 6 (system 2) does not restart, replace with spare (logger 3). Check Xeos beacons.

June 1, *Friday*: Buoy dressing, wire spooling on split net drum.

June 2, *Saturday*: Buoy tipped on port side. SSTs mounted on bridle. Spiking subsurface instruments.

June 3, *Sunday*: 1030 EST, enter US waters around Puerto Rico. Deck folks switch to CTD winch#2 which has more wire and will ensure CTD cast to 3,000 m for SIO team. 1205 EST, CTD#1 with 3 acoustic releases (WHOI) to 1,500 for releases test. Problem with oil that gets out of winch#2 (aft) into winch#1 (forward), as ship pitches down while on station (all fuel tanks are forward and full, which balances weight on fantail during transit). CTD cast stops while engineers add 10 gallons oil inside the winch. CTD#1 ends at 1410. 15:05 EST, CTD#2 for SIO team to 3000m, water depth near 8000 m (Puerto Rico trench, position 19 29.374 N, 067 18.317 W). Bottles (12), 2 releases and 16 Seabird microcats. Back onboard at 18:27 EST. Spike ASIMETs in afternoon (cover radiations, fill PRCs, remove nose cone from wind sensors).

June 4, Monday: Pickup medical officer at 0500 EST about 5 nm off of PR. Steam away at 0530. Ship goes north around Antilles islands and rides coastal current, SOG 11+ kts. Test inductive line with subsurface instruments. Check ids on each instrument using plastic bag filled with ice for temperature drop in data stream.

June 5, Tuesday: Leave Antilles behind and enter open Atlantic ocean. Crew sets up wire protection on outboard edge of crate above fish chute.

June 6, Wednesday: Steaming at 10.5 to 11 kts, heading 115-120. Swell picks up a bit. Wind 15-20 kts out of ENE. 0800: mtg on bridge, review schedule for NTAS/MOVE1 ops. Late afternoon, captain diverts ship to Barbados for a medical evacuation of one of the crew members.

June 7, Thursday: Steaming towards Barbados at about 11 kts. Arrive before midnight. Crew member evacuated on land.

June 8, Friday: ~0700 ship finally departs Barbados and start steaming towards NTAS (delay caused by repair on rescue boat (water pump) and mandatory test before going offshore). 1900: science presentations of NTAS and MOVE.

June 9, Saturday: steaming towards NTAS17 target site. 0830: rearrange deck. Leave Barbados EEZ in early morning and resume data collection from ADCP and TSG around 0900. Start event on SCS. TSG salinity drops from 35.8 to ~34 for about 6 hours around 1200 UTC. Ship steams into waves and swell and reduces speed a bit in afternoon. Picks up speed again in later part of day. Wind around 20 kts from ENE.

June 10, Sunday

11:35 UTC, wind 18 kts, (from) 55 degree true. SOG ~10 kts, COG ~80 degrees.

Arrive at NTAS site for drift test around 1300. Set and drift indicates track to the northeast as predicted. Current to northeast <0.5 kt. Wind 15-20 kts from ENE, same with waves (swell slightly NE, wind wave ENE). Safety meeting at 1200 UTC. Prepare deck, remove bulwarks. Buoy in water at 1440 UTC. Anchor drop at 2053 UTC. Move about 5 nm to SE, 1 nm north of N16 buoy, for CTD#3 (with samples and releases), to 1000m, from 2158 to 2348 UTC. Transit back near NTAS 17 anchor drop location for triangulation from 0027 to 0126 UTC next day.

June 11, Monday

After triangulation of NTAS 17, ship steams towards MOVE1, but some green water comes on starboard side by CTD deck. Ships adjusts course more to the west. Then at 0400 next day they tack, with sharp turn right due east towards MOVE1. 0600 local, arrive at MOVE 1 site. Ship heaves to 6/10 nm to NW of MOVE1. Mooring released at 0615 and rising. Northward current >0.5 kt in upper ocean <200m (near surface is actually current to the east). Wind 20-25 kts from 070 T. 8 sets of glass balls eventually at surface around 0700, out of 9. They are in a C shape in front of the ship, so plan is to grab set closest on the right so ship does not have to turn to make approach (would make for a big roll with sea state). It seems like missing set is the one with the controller (it has only a few glass balls next to it so controller's weight takes the balls down). Grappling hook connects from CTD deck on starboard side, and then hauled in with outhaul winch on A-frame. It is connected to 2 cables since it is a middle set. One cable goes up on mooring; other one goes down towards bottom set with acoustic releases. ~0750, one set of balls back on deck. We pull 2 wires and wind them up on split net drum (starboard) together. Around 0930 local, start talking about PIES recovery. It is at this time about 2 nm behind us, to the west. We think we could release from where we are, then be done with mooring recovery and accounting for transit back to PIES, be on site when PIES surfaces, about 1.5 to 2 hours after release. Just to be sure we wait until mooring recovery is well advanced and there is better understanding of which line goes where and what tension there is. At 11:11 local, PIES 299 is released, about 2.5 nm away from its anchor site. 1212 local, all MOVE-1 is back on deck,

recovery ends and ship steams towards PIES 299 location. Radio on bridge hears a signal, almost right away flag is spotted on the bow about ½ nm away (0.2 nm NNW of its anchor). Matthias radio finder also picks it up. 13:31 local, PIES is recovered using CTD A-frame on starboard side. Modem is missing top cap. Modem is unscrewed while held in mid-air against rail on starboard side, and then jettisoned. PIES brought onboard, and its hard hat is opened for visual inspection. No indication of any leak and PIES is functioning so we can keep it onboard. SIO gears up for deployment of new PIES. 14:16 local PIES deployed.
15:32 local, start MOVE1 deployment, 8.1 nm from target. Initially going at ~1.3 kt, then quickly down to 0.5 kt. 22:26 local, deployment ends.

June 12, Tuesday
Overnight and in the morning, transit from MOVE1 to NTAS16. First part of transit is bumpy as we sail with sea incoming a few points on our port bow. Transit is more East than straight route, then turn west to N16. After turn, ride is much smoother. Arrive at buoy at 0700 local. At 0730, chief scientist goes to bridge and realize ship is at buoy; ship then start moving towards anchor. ~0800, at N16 anchor site, 0.5 nm NNW of anchor. Winds are 20-25 kts, upper ocean current to the north, but seas have built up since yesterday. 0827, mooring is released. Glass balls spotted at surface at 0927 EST on our starboard beam about 0.5 nm. Recovery NTAS16 starts. Ship does nice manoeuver, falling back on them without turning to avoid big roll due to seas. Grappling hook into balls from CTD launch station and then Ben uses extended pole to hook into chain. Line is then pulled with glass balls back through A-frame using split net drum on port side. 15:02 local buoy back on deck. After recovery, disconnect EM chain and instruments from buoy. Put bulwarks on port side back. Move buoy from fantail center to port side. Depart to N17 for pictures at 16:59 EST. Sail about 40 mn and pass by N17 buoy on our starboard; everything looks good, pictures taken. 18:00 local, end of NTAS ops, steam towards Guadeloupe for MOVE 3 and 4 operations.

June 13, Wednesday
Transit west towards Guadeloupe. Around 0900 EST, slight turn north around Dominica EEZ.
14:11 to 16:47 local, CTD#4 to 2,300 m with microcats, bottles and acoustic releases. SIO folks rewind wire on split net drum. Instrument cleanup. Off spool wire from split net drum.

June 14, Thursday
Overnight, steam between eastward current to the north, and westward current to the south (northern branch of a cyclonic eddy). SIO folks spool wire on split net drum. 1000 debrief meeting in mess for past mooring ops. 23:00 local, arrive at MOVE 4 site (on the way, surveyed bathymetry around alternate MOVE 4 site, about 2 nm north of current MOVE 4-12 site). 23:28 local, transducer in the water for A-coms at MOVE 4. Trouble with A-coms, but managed to grab 2/3 of the data (up to December 2017), then latest block of data. The latter shows inductive sensors do not report data, except one whose pressure is deeper than its nominal depth (by about 500 dbars, but sensor is not at bottom). One theory is that fishing gear got entangled with mooring, and brought part of it deeper, while chaffing inductive line and corrupting data transmission.

June 15, Friday

03:04 local, transducer back on deck, start transit to MOVE 3 for A-coms. 03:44 to 04:34 local, A-coms at MOVE-3 and PIES. 07:04 to 11:42 local, recovery MOVE3-12. 13:46 to 17:02 local, deployment MOVE4-13. Anchor survey and A-coms for MOVE 4-13 (17:28 to 20:34 local), followed by transit back to MOVE 3. A-coms near MOVE 3 start at 21:25 local.

June 16, Saturday
A-coms near MOVE 3 end; 01:06 to 03:45 local, CTD#5 to 2,300m near MOVE 3. 06:46 to 13:06 local, deployment of MOVE 3-13. Anchor triangulation for MOVE 3 and nearby PIES (previous year's triangulation was incomplete). 15:55 local, depart work area and start transit back towards Morehead City, NC.

June 17-20
Transit towards Morehead City, NC. SOG around 12 knots. Weak winds and seas. Data download and packing. Fire and abandon ship drills on June 18. Standalones ASIMET on 02 deck forward removed on June 19. Cruise debrief on bridge on June 20.

June 21, Thursday
Enter Gulf Stream. 14:10 docking at Morehead City pier.

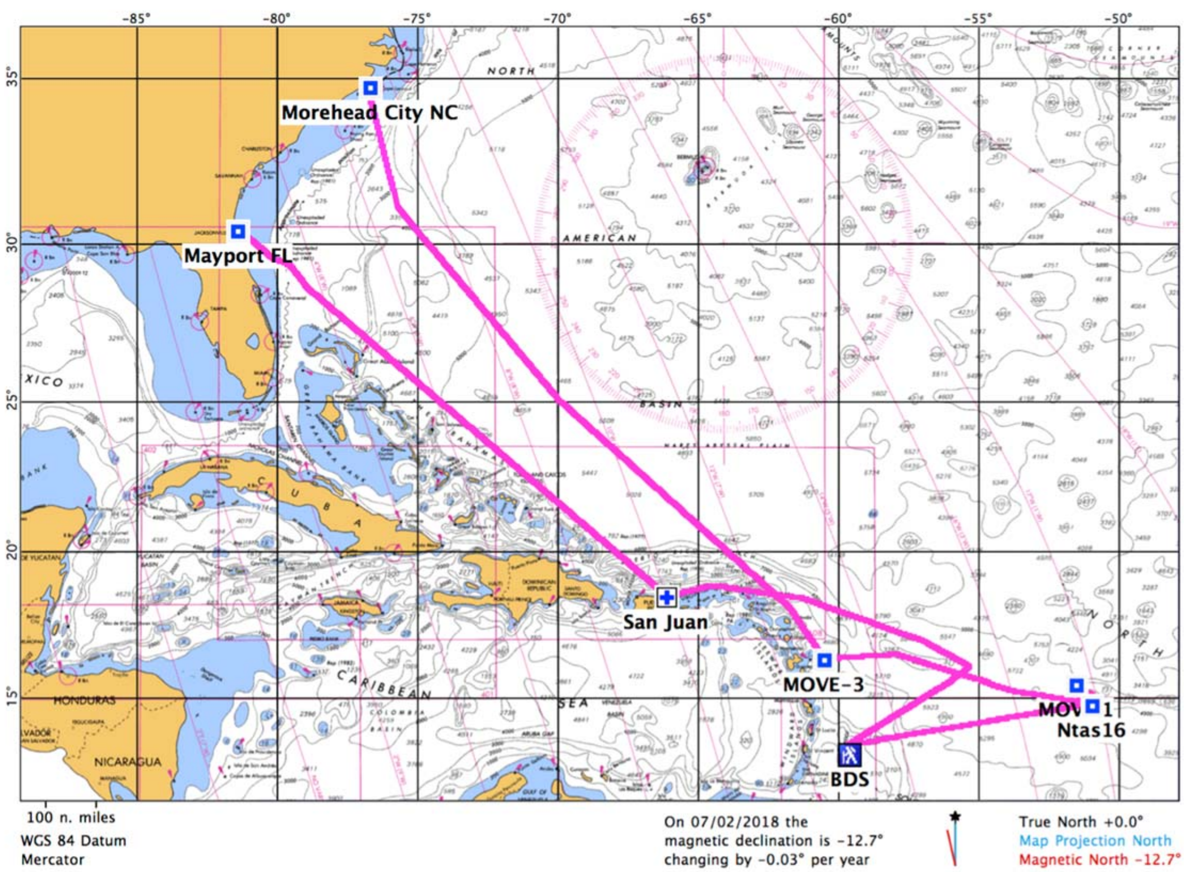


Figure I-1. NTAS 17 cruise track onboard R/V *Pisces* (cruise PC1803).

I. B. Background and Purpose

The Northwest Tropical Atlantic Station (NTAS) project for air–sea flux measurement was conceived in order to investigate surface forcing and oceanographic response in a region of the tropical Atlantic with strong sea surface temperature (SST) anomalies and the likelihood of significant local air–sea interaction on inter-annual to decadal timescales. Two intrinsic modes of variability have been identified in the ocean–atmosphere system of the tropical Atlantic, a dynamic mode similar to the Pacific El Niño–Southern Oscillation (ENSO) and a thermodynamic mode characterized by changes in the cross-equatorial SST gradient. Forcing is presumed to be due to at least three factors: synoptic atmospheric variability, remote forcing from Pacific ENSO, and extra-tropical forcing from the North Atlantic Oscillation (NAO). Links among tropical SST variability, the NAO, and the meridional overturning circulation, as well as links between the two tropical modes, have been proposed. At present neither the forcing mechanisms nor links between modes of variability are well understood.

The primary scientific objectives of the NTAS project are to determine the in-situ fluxes of heat, moisture and momentum, to use these fluxes to make a regional assessment of flux components from numerical weather prediction models and satellites, and to determine the degree to which the oceanic budgets of heat and momentum are locally balanced. To accomplish these objectives, a surface mooring with sensors suitable for the determination of air–sea fluxes and upper ocean properties is being maintained at a site near 15° N, 51° W by means of annual "turnarounds" (recovery of one mooring and deployment of a new mooring near the same site).

The surface elements of the moorings are Surlyn foam discus buoys outfitted with two complete Air–Sea Interaction Meteorology (ASIMET) systems. Each system measures, records, and transmits via Argos satellite the surface meteorological variables necessary to compute air–sea fluxes of heat, moisture and momentum. The upper 160 m of the mooring line is outfitted with oceanographic sensors for the measurement of temperature, salinity and velocity. The upper 80 m also contain inductive instruments that transmit their data to a logger inside the surface buoy; this data is then telemetered to a satellite.

The NTAS 17 mooring turnaround was achieved on the research vessel R/V *Pisces*, cruise PC1803, by the Upper Ocean Processes Group (UOP) of the Woods Hole Oceanographic Institution (WHOI). Seven personnel from Scripps Institution of Oceanography (SIO) were also aboard to service the MOVE array, recover and deploy three subsurface moorings and download data from Pressure and Inverted Echo Sounder (PIES) devices through acoustic telemetry.

The cruise was completed in 23 days, from May 30 to June 21 2018. It originated from Mayport, Florida and terminated in Morehead City, North Carolina. Two unplanned detours were made during this cruise, the first one to Puerto Rico to pick up a medical officer and the second one to Barbados for a medical evacuation. The planned cruise track and waypoints are shown in Table I-1 and Figure I-2. The actual track is shown in Figure I-1.
The primary objectives were:

- To deploy the NTAS-17 mooring.

- To log data from the NTAS-17 buoy and *Pisces* shipboard meteorological sensors during an inter-comparison period during which a sequence of CTD casts would also be made.
- To recover the NTAS-16 mooring.
- To do an inter-comparison between the NTAS-16 buoy and *Pisces* shipboard data (meteorological sensors and CTD cast).
- To recover MOVE 1-12 and deploy MOVE 1-13 at the same site and with calibrated instruments.
- To retrieve data via acoustic link from PIES near the MOVE-1 site.
- To recover MOVE 3-12 and deploy MOVE 3-13 at the same site and with calibrated instruments.
- To retrieve data via acoustic link from PIES near the MOVE-3 site.
- To recover MOVE 4-12 and deploy MOVE 4-13 at the same site and with calibrated instruments.
- To retrieve data via acoustic link from PIES near the MOVE-4 site.

Table I-2. List of waypoints used for planning of NTAS 17 cruise.

Name	Comment	Latitude	Longitude
Mayport FL	Departure	30° 23.738'	-81° 24.916'
NTAS17	Mooring deployment, intercomparison, CTDs	14° 49.500'	-51° 00.978'
MOVE 1	Mooring recovery/deployment, PIES, CTDs, A-coms	15° 27.110'	-51° 30.000'
NTAS16	Mooring recovery, intercomparison, CTDs	14° 45.211'	-50° 57.052'
MOVE-3	Mooring recovery/deployment, PIES, CTDs, A-coms	16° 20.140'	-60° 30.360'
MOVE-4	Mooring recovery/deployment, CTDs, A-coms	16° 19.850'	-60° 36.450'
Morehead City NC	End	34° 43.062'	-76° 42.184'

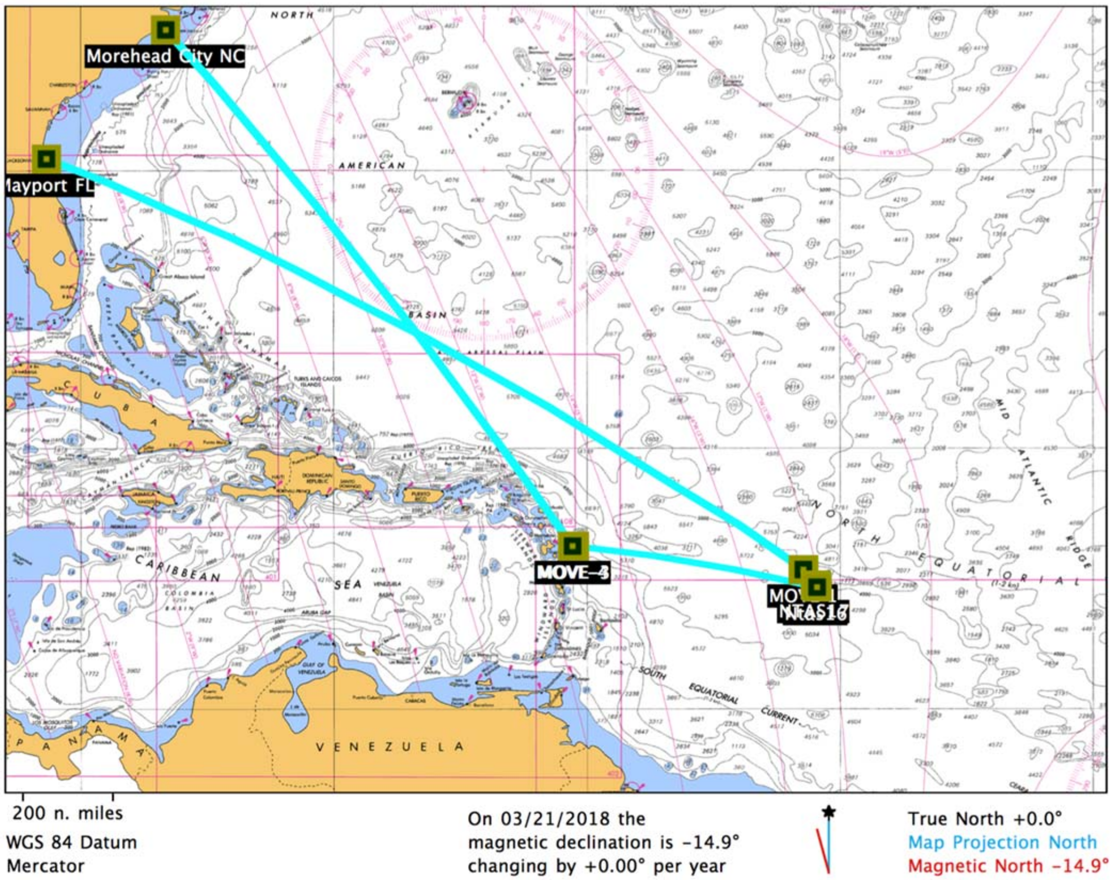


Figure I-2. Planned track for NTAS 17 (PC1803) cruise according to waypoints in Table I-2.

II. Cruise Preparations

II. A. Staging and Loading

Pre-cruise operations were conducted at WHOI and at the pier in Mayport, FL. Instrumentation (sensor, telemetry) were tested at WHOI during burn-in then shipped to Florida. On May 20, the WHOI equipment, including NTAS 17 buoy were delivered by two trucks at the Navy base in Mayport. Two WHOI personnel unloaded and staged the equipment on the pier to begin assembly of the buoy (hardware, electronics). Buoy was turned on the next day. R/V *Pisces* moored at the pier on May 24. That afternoon, loading of the NTAS equipment on board started. On Friday May 25, all the loading was completed, including equipment for the Scripps group. On the ship, laboratories, sensors and communications systems were also setup. Due to the following Memorial Day weekend, there were minimal personnel on board the ship and no crane activities. On Tuesday May 29, the ship was refueled and stores were delivered. The captain announced that due to the length and distance away from shore during the cruise, the ship was required to have a medical officer onboard. Despite the last minute notice, a medical officer was found but would have to be flown from Hawaii and picked up in San Juan, Puerto Rico (a detour of approximately 90 nm to our planned track). Last personnel from Scripps arrived. Ship departed Mayport, FL, on Wednesday May 30th at 12:30 EST, starting cruise PC1803.

II. B. Buoy Spin

The NTAS 17 buoy spin was conducted in Woods Hole on September 27 2017 and again on May 7 2018. The buoy spin is a procedure to check the compasses in the wind sensors mounted on the buoy. A visual reference direction is first set using an external compass. The buoy is then oriented successively at 8 different angles with respect to the reference and the vanes of the anemometers are visually oriented towards the reference direction, and blocked. Wind is recorded for 15 minutes at the end of which the average compass and wind direction is read. Their sum should correspond to the reference heading, within errors due to approximations in orientation, compass precision, and any deformation of the magnetic field due to the buoy metallic structure that may affect the compass reading. Buoy spin results from May 7 are shown in Figure II-1 and Figure II-2, where compass error is plotted as a function of buoy orientation. Note that for this second buoy spin, only 6 rotations, instead of the usual 8, were done with the buoy. Compasses on ASIMET wind sensors are slightly outside of the 5° expected accuracy. For this buoy spin, the reference direction was oriented towards 0°. A third buoy spin was conducted in port prior to the cruise, on the pier in Mayport, to confirm that wind sensors were still operational after shipment. The magnetic disturbance from the reinforced concrete on the pier prevented a very accurate spin, but it confirmed that compasses and wind vanes were intact.

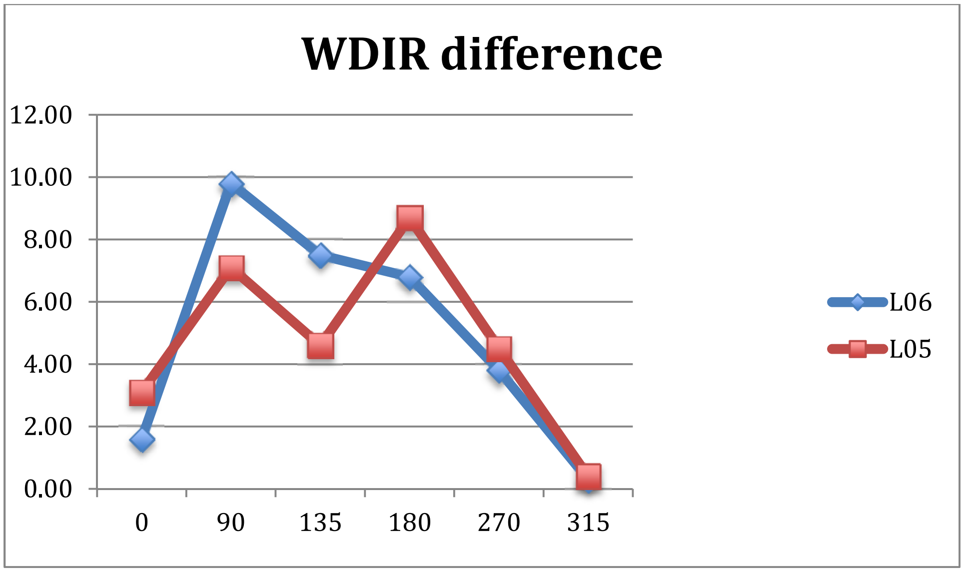


Figure II-1. NTAS 17 buoy spin on May 7 2018 in Woods Hole. Y-axis: difference between wind direction (WND221 on L05 and WND210 on L06) and line-of-sight reference (in degrees). X-axis: angle between buoy and line-of-sight reference (in degrees).

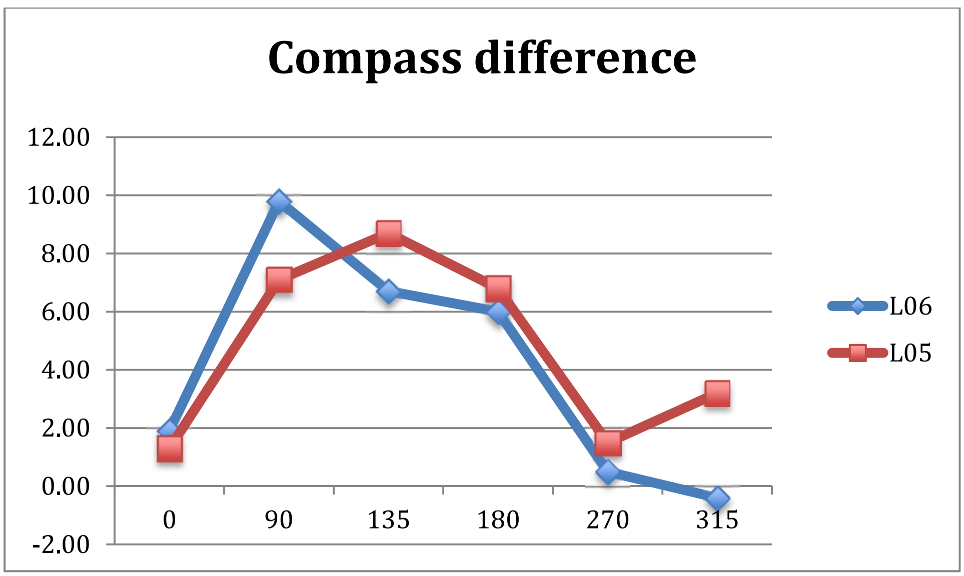


Figure II-2. NTAS 17 buoy spin on May 7 2018 in Woods Hole. Y-axis: difference between wind compass (WND221 on L05 and WND210 on L06) and reference compass (in degrees). X-axis: angle between buoy and line-of-sight reference (in degrees).

II.C. Sensor Evaluation and Burn-in

For burn-in, the buoy was mounted with ASIMET (two primary systems) and other instrumentation in the same configuration as the one planned for deployment, and placed in a clear outdoor area at WHOI. Systems were running, collecting data and telemetry transmitted hourly data. Spare instruments were also mounted on a similar buoy next to NTAS 17. Every two week or so, the data was downloaded and processed to ensure all instrument was functioning properly and that their measurements were accurate. Burn-in started in October 2017, was interrupted during the winter due to low temperatures and resumed in May 2018.

After the buoy and instrumentation were shipped to Florida prior to the cruise, more burn-in was done. One data download during the burn-in on the dock established that the shortwave radiation (SWR) sensors were slightly off level, which was then adjusted, and that one primary precipitation (PRC) did not perform well (large amplitudes slow variations, maybe due to temperature changes); the latter was swapped with the spare PRC. A final data download and evaluation was done on board during transit towards Puerto Rico on May 31. This data download included burn-in in port, while the buoy was upright on the dock, a few meters from the water. Some rain events occurred during this period, including a large storm that travelled along the Florida peninsula on May 27. Apart from that, conditions were warm, humid with sunny or partly cloudy skies. Final data evaluation concluded that all data looked good, and HRH from WXT was 6%RH low (typical). Figures below present data from the May 31st data download.

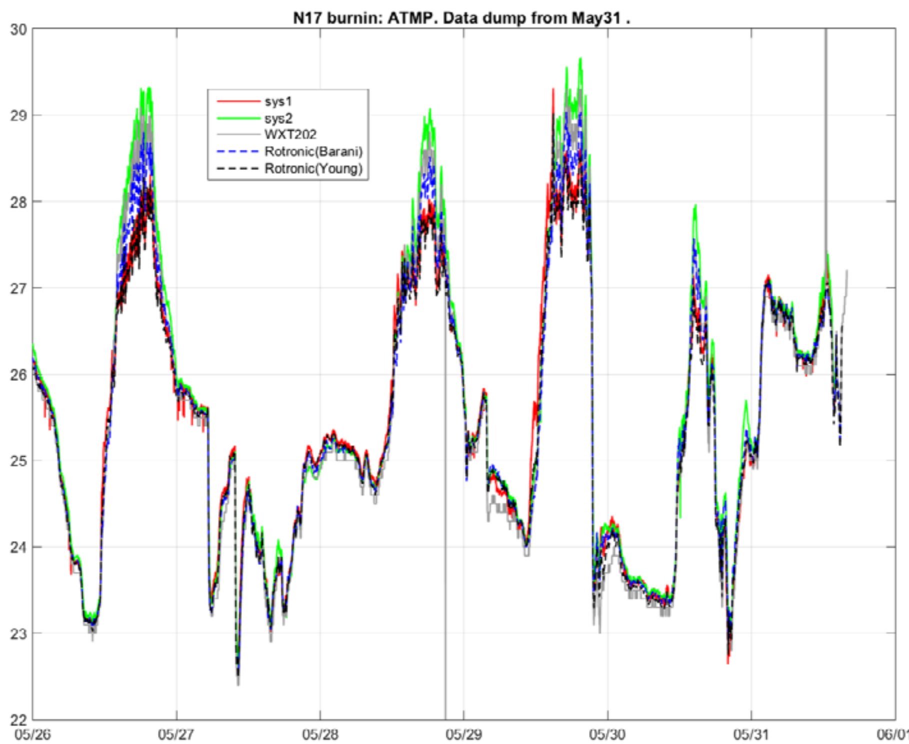


Figure II-3. NTAS 17 burn-in downloaded May 31 2018: air temperature (ATMP) from ASIMET primary system 1 (red) and 2 (green), standalones Rotronic with Barani ventilating shield (dash blue) and no shield (dask black), as well as standalone WXT (solid grey).

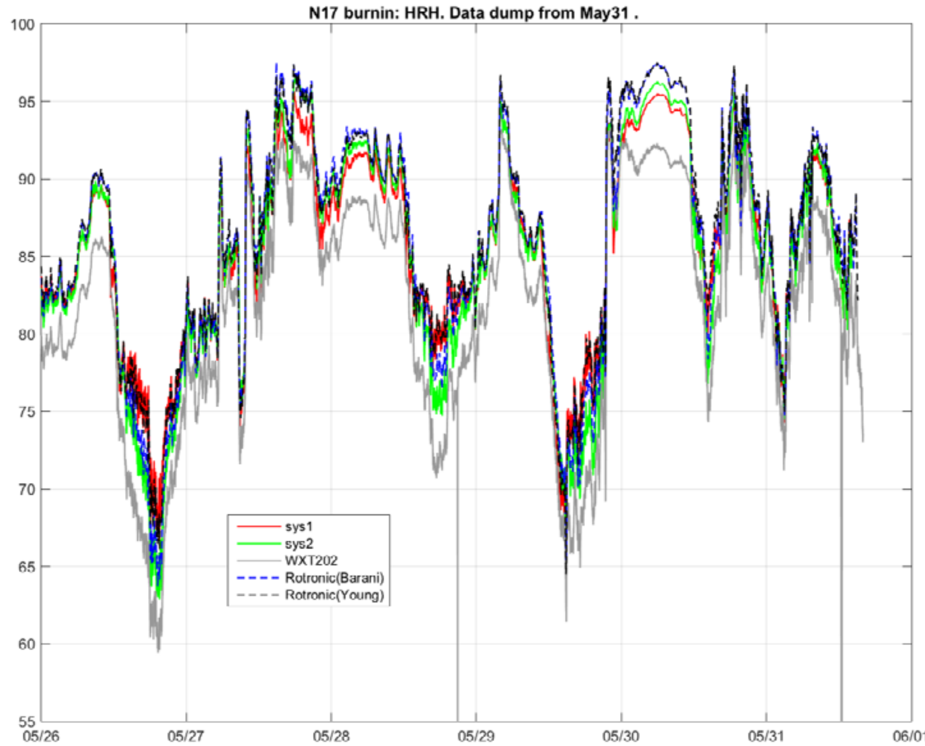


Figure II-4. Same as Figure II-3, but for air relative humidity (HRH).

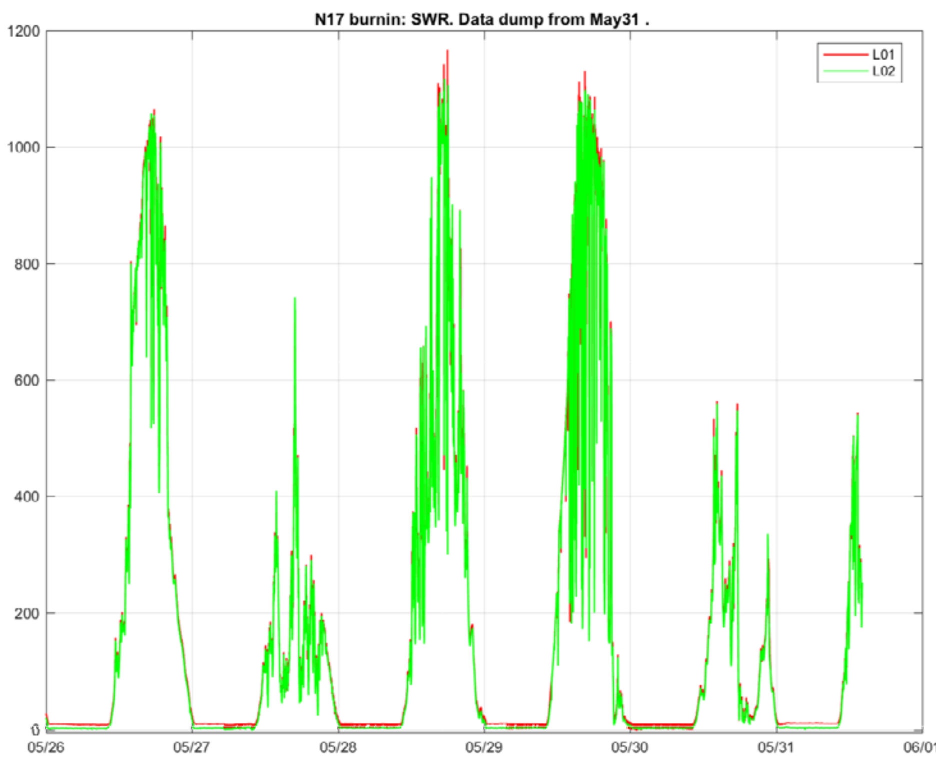


Figure II-5. Same as Figure II-3, but without standalone sensors, for shortwave radiation (SWR).

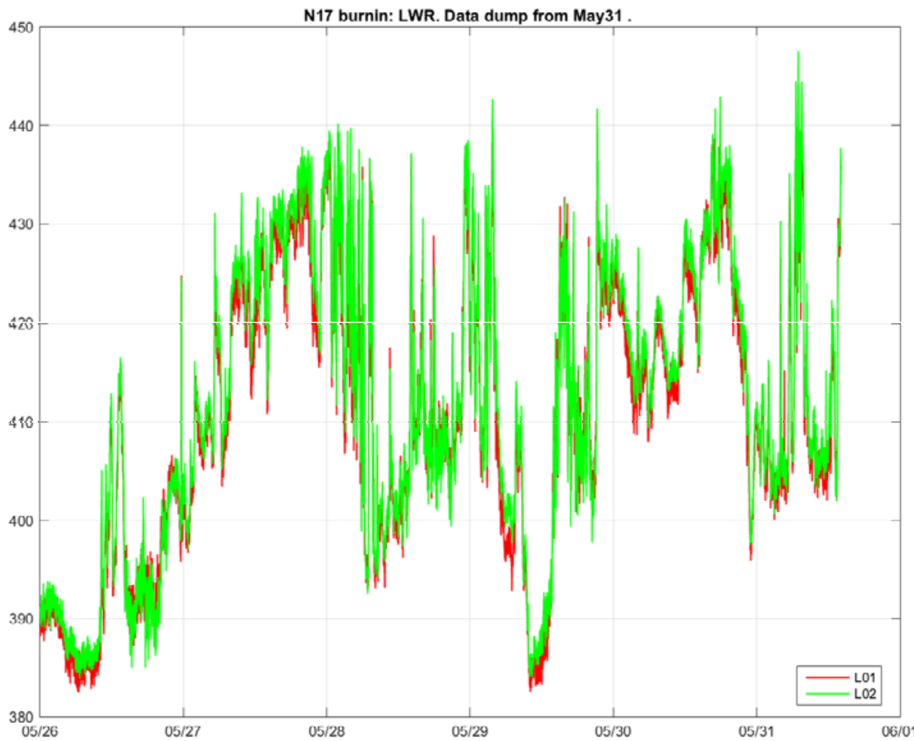


Figure II-6. Same as Figure II-3, for longwave radiation (LWR).

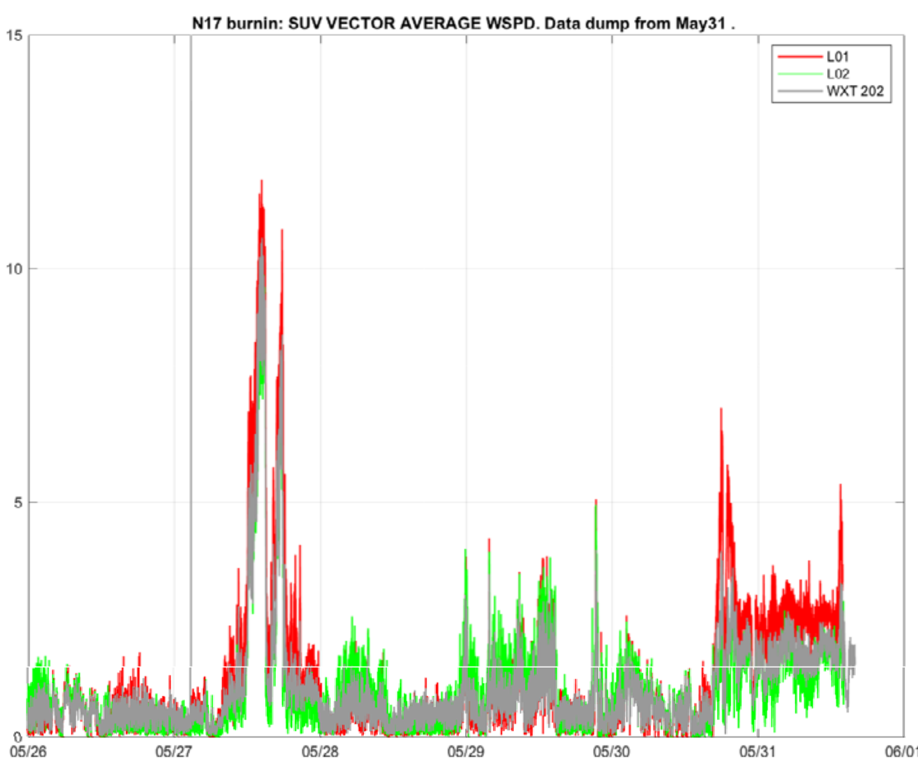


Figure II-7. Same as Figure II-3, but for wind speed (WSPD) and only WXT standalone sensor.

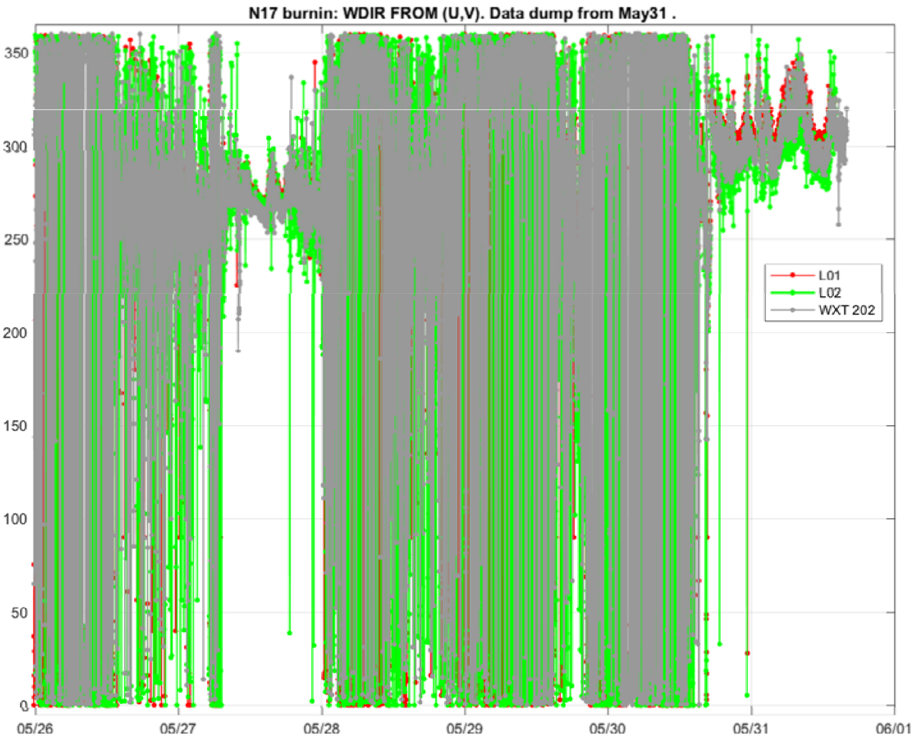


Figure II-8. Same as Figure II-7 **for wind direction (WDIR).**

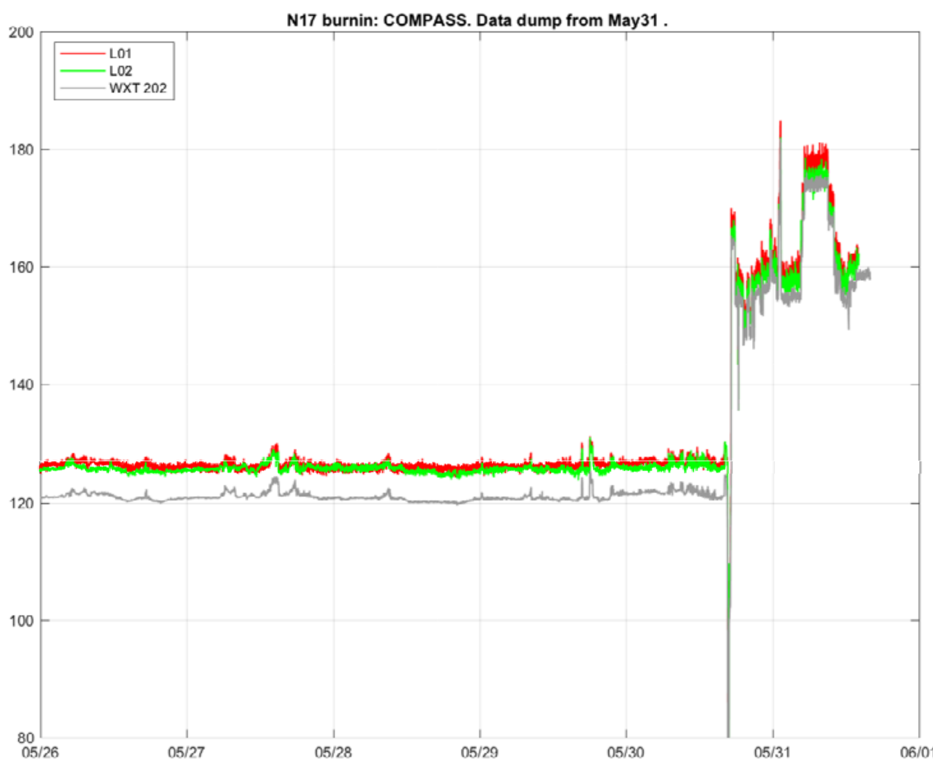


Figure II-9. Same as Figure II-7 but for wind compasses.

Figure II-10. Same as Figure II-7for barometric pressure (BPR).

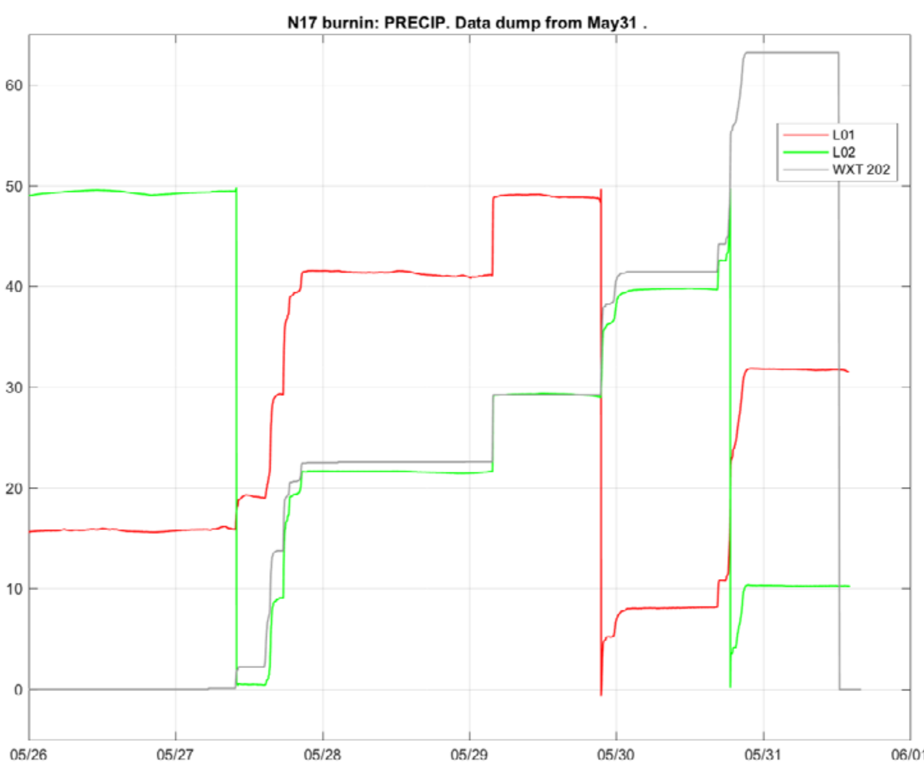


Figure II-11. Same as Figure II-7 but for precipitation (PRECIP).

III. NTAS 17 Deployment

A. Mooring Design

The buoys used in the NTAS project are equipped with surface meteorological instrumentation, including two Improved Meteorological (IMET) systems (see Figure III-1) and standalone sensors. The NTAS 17 surface buoy has a 2.7-meter diameter foam buoy with an aluminum tower and rigid bridle. Starting with NTAS 13, buoys on NTAS received a larger wind vane to improve the alignment into the wind. Wind vane itself was larger on NTAS 14 but thereafter and also for NTAS 13 an extension was added to the regular size vane. NTAS 17 also received the vane extension.

The WHOI mooring is an inverse catenary design utilizing wire rope, chain, nylon and Colmega line. The mooring line also carries subsurface instrumentation down to 160 m that measures temperature and conductivity, two acoustic current meters and two profilers, and two deep SBE 37s near the bottom (Figure III-2). Several instruments transmit their data through the upper 80 m of inductive (IM) wire. The upper 5 m of the mooring includes a compliance section (also called EM chain) through which inductive sensors transmit their data to an Iridium logger in the buoy well.

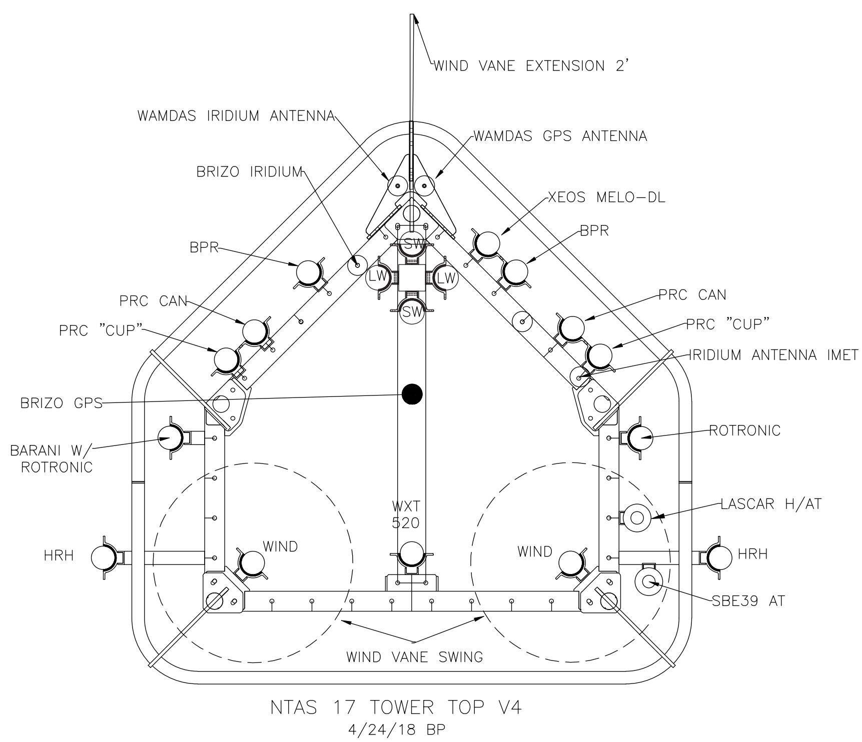


Figure III-1. Top view schematic of the meteorological tower on the NTAS 17 buoy with the location of the ASIMET and other instruments.

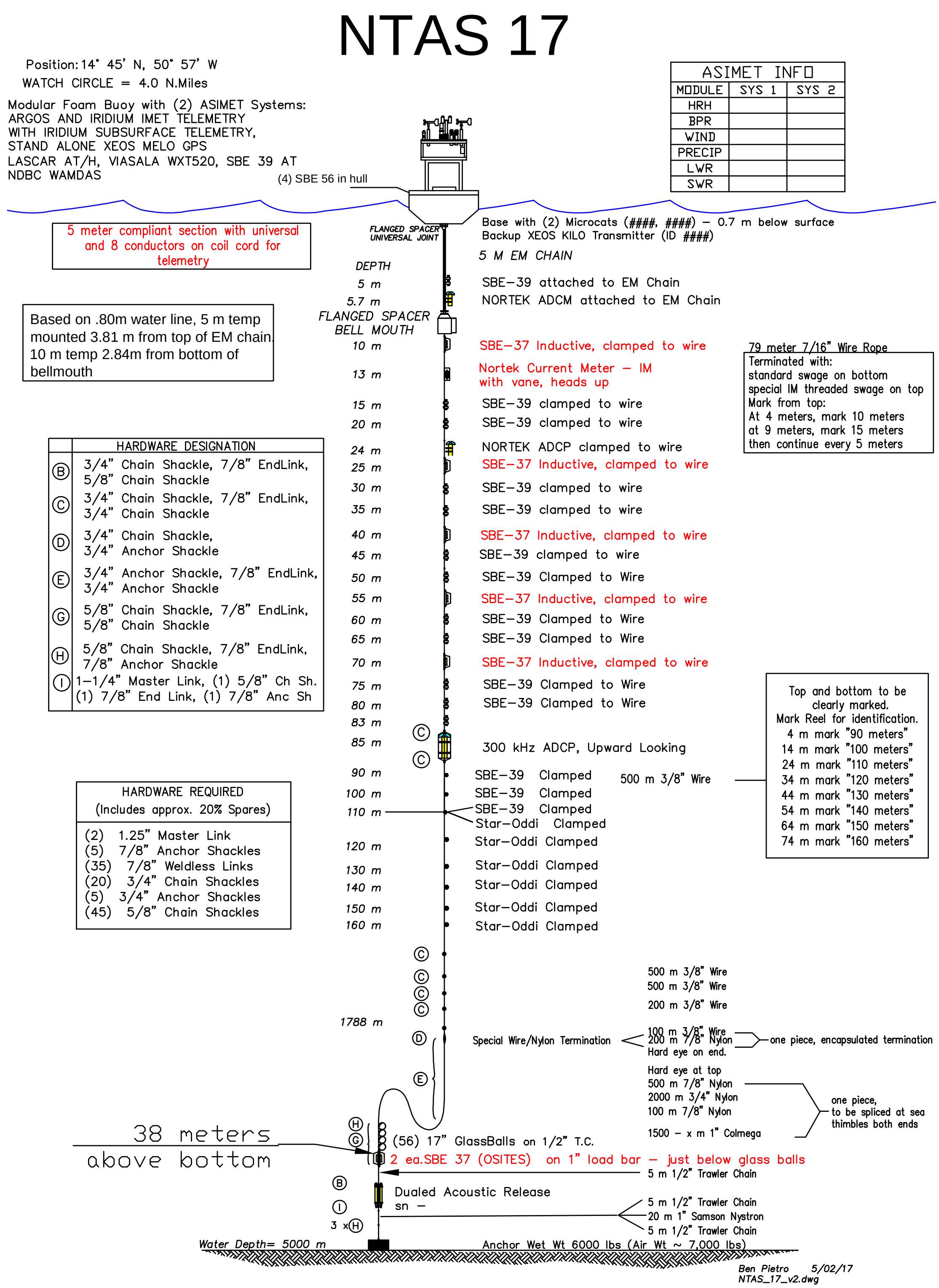


Figure III-2. NTAS 17 mooring diagram.

B. Deployment

Preparation for deployment included mounting the hardware for the telemetry interface section and the upper mooring wire section. The 79-meter section of mooring wire was led around the A-frame, around the port quarter, and forward to the wire coupling assembly. The universal joint, flanged spacers, compliant section, coupling assembly, and the top of the 79-meter mooring wire were assembled and attached to the buoy. A SBE-39 and Nortek current meter were clamped to the compliant section. All other instruments down to 65 meters were clamped to the mooring wire.

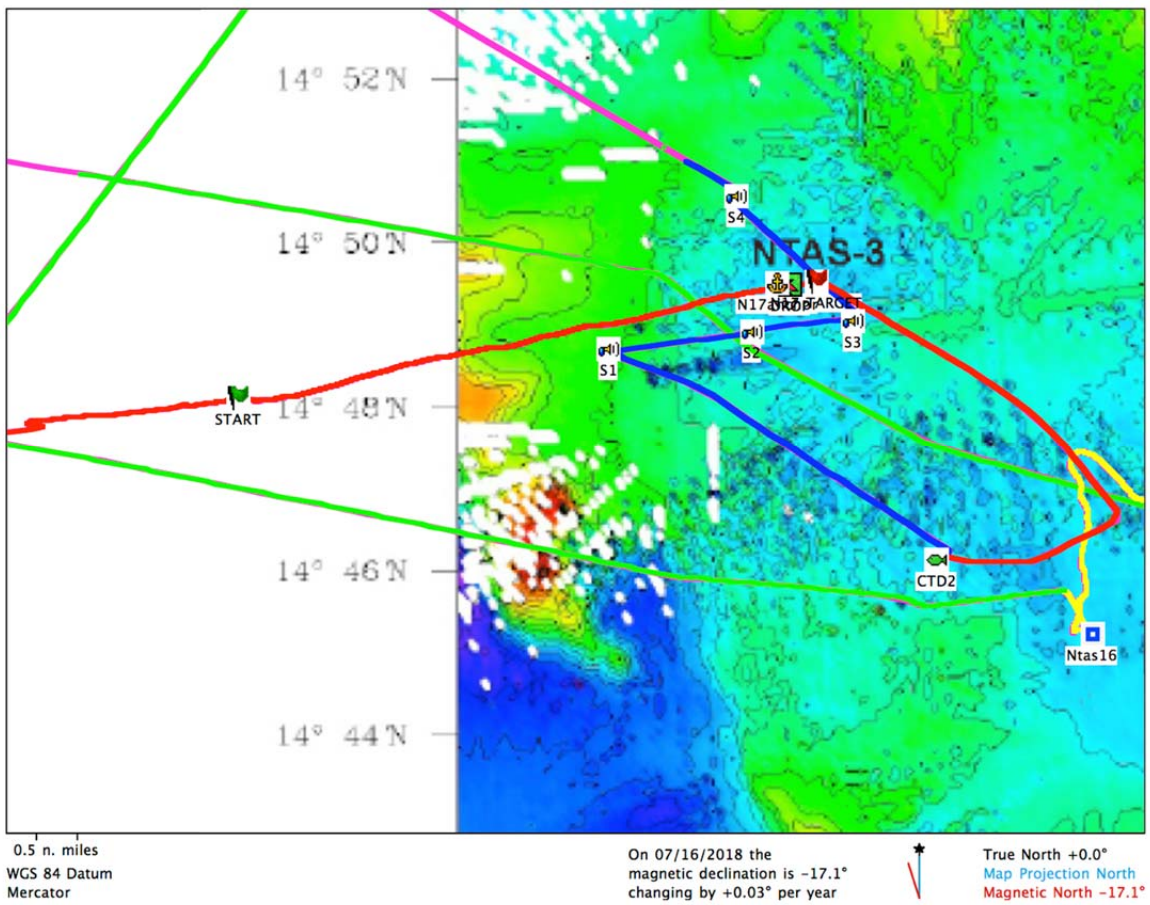


Figure III-3.NTAS 17 deployment track (red line) onboard R/V *Pisces* on June 10 2018. Track started (green flag) about 7 nm West-Southwest of target (red flag). After anchor drop, ship deviated southeast for CTD cast #2.

Deployment operations began approximately 0950h (local) on June 10, 2018 with the Pisces at a distance of 7.0 nm from the drop site. The first step of the deployment procedure was the lowering of the assembled telemetry interface section over the port side of the ship. As the compliant section was lowered, using the knuckle (Appleton) crane and a slip line, mooring wire with instruments clamped to it was fed over the bulwark into the water by wire handlers stationed at the stern and along the port rail. Approximately 50 meters of the mooring wire with instruments attached was lowered in this manner. This formed a loop of wire and instruments hanging from the buoy, and leading back towards the port quarter. The crane was used to lift the EM chain over the rail. The crane hooked up to the outboard portion of the bottom bell mouth. A Nylon stopper line was used to stop off and disconnect the crane. The EM chain was then slipped out.

The next phase of the operation was to launch the surface buoy. Slip lines were rigged on the base, tower, and on the mid section D handle to maintain control during the lift. The straps lashing the buoy to the deck were removed. The buoy was then raised up and swung outboard as the slip lines kept the hull stable. The bottom slip line was removed first, followed by the tower slip line. Once the buoy settled into the water (approximately 18 ft. from the side of the ship), the quick-release hook was tripped. The slip line to the buoy deck bale was cleared immediately after the buoy was released. The ship then maneuvered slowly ahead, and the 50-meters of payed out mooring wire and instrumentation provided scope for the buoy to clear the stern.

The remainder of the mooring was deployed over the stern. Once the buoy was behind the ship, ship speed was increased to about 0.5 knots and the remaining portion of the upper top section of instrumented wire rope was slipped off the stern. The bottom of the 79-meter shot of mooring wire was stopped off at the transom and disconnected from the mooring wire on the winch. A snatch block was suspended by the outhaul winch on the A-frame. The mooring wire from the winch drum was passed through this block. The RDI ADCP cage was shackled into the mooring, and the mooring wire from the winch connected to the bottom of the ADCP cage (note that the RDI ADCP was not deployed because batteries were depleted after a few days of sampling and troubleshooting attempts could not resolve the cause of this failure mode). The mooring tension was pulled up on the winch and the stopper lines were removed from the mooring.

The final section of mooring line on the port winch was the wire to nylon transition. This consists of a 100-meter shot of 3/8" mooring wire and 90 meters of 7/8" Nystron line. The termination is encapsulated in urethane providing a transition from the stiff mooring wire to the flexible nylon line. As the end of the nylon came off the winch, it was payed out slowly until the thimble was 10 feet from the transom at which point it was shackled into a thimble on the 7/8th nylon off the H-bit.

The H-bit cleat was positioned approximately 20 feet from the transom, and secured to the deck. The free end of the 4,100 meter shot of nylon/Colmega line, stowed in three wood-lined wire baskets was wrapped onto the H-bit and passed to the stopped off mooring line. The shackle connection between the two nylon shots was made. The line handler at the H-bit pulled in all the residual slack and held the line tight against the H-bit. The stopper lines were then eased off and removed. The person handling the line on the H-Bit kept the mooring line parallel to the H-bit with moderate back tension. The H-bit line handler and one assistant eased the mooring line out of the wire basket and around the H-bit at the appropriate payout speed relative to the ship's speed. Another person sprayed water on the H-bit to keep the line from overheating.

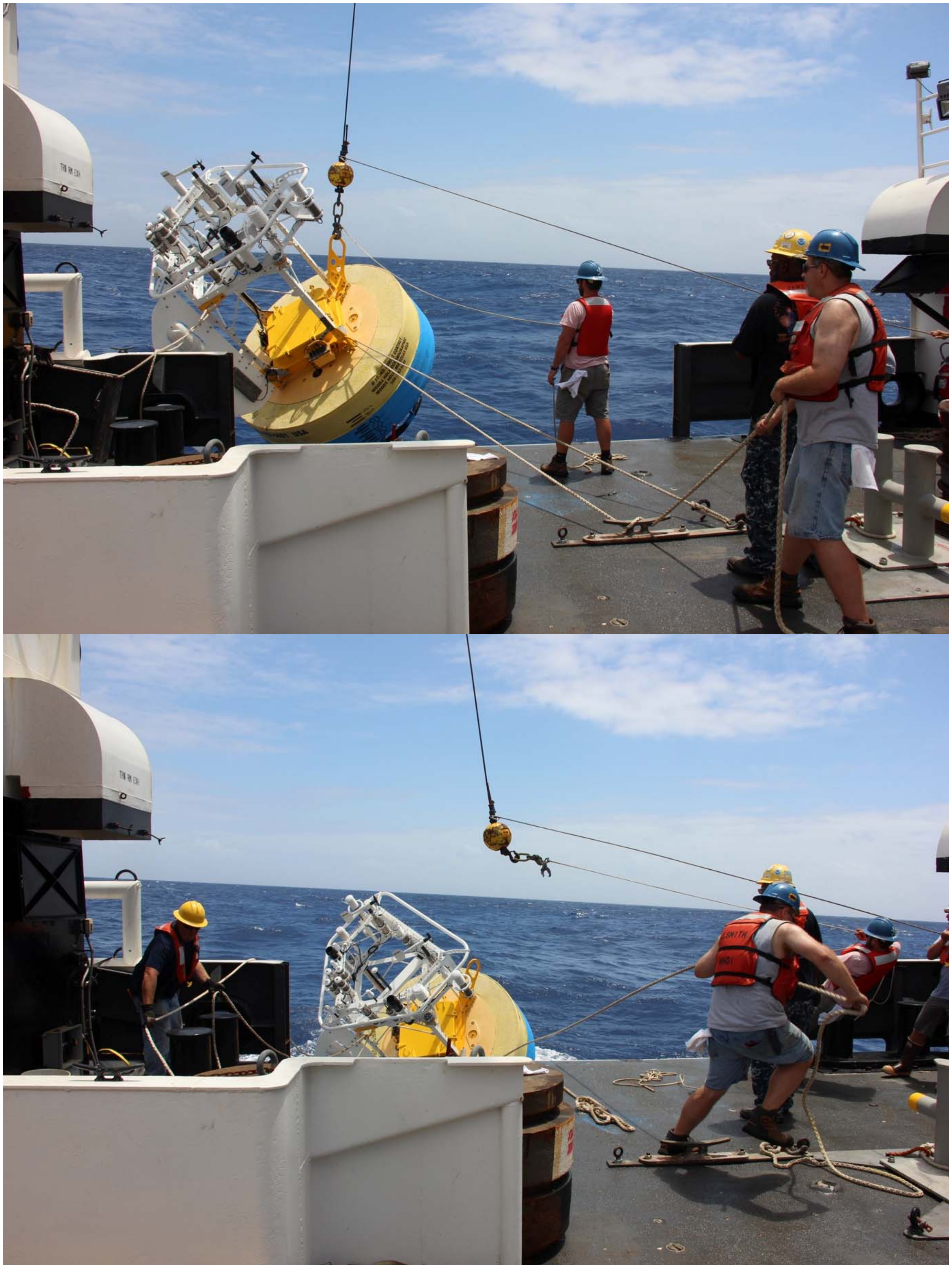


Figure III-4. Deployment of NTAS 17: (top) buoy lifted in the air with crane and tag lines attached to control lateral motion, (bottom) buoy in the water and crane separated from buoy using quick release hook, tag lines loose and slowly removed from buoy.

When the end of the Colmega line was reached, pay out was stopped and a Yale grip was used to take tension off the line. The winch tag leader was shackled to the end of the Colmega line. The line was removed from the H-Bit. The winch line and mooring line were wound up taking the mooring tension away from the stopper lines on the Yale grip. The stopper lines and Yale grip were removed. The winch payed out the mooring line until all but one meter of the Colmega line was over the transom.

The first two sets of glass balls were dragged into position (fore and aft) and shackled together. One end was attached to the mooring at the transom. The other end was shackled to the winch leader. The winch pulled the mooring line tight, stopper lines were removed, and the winch payed out until only one ball remained on the deck. Stopper lines were attached, the winch leader was removed, and two more strings of glass balls were inserted into the mooring line. This process was repeated until all 56 balls were deployed.

A 1" titanium load bar with two SBE 37 was shackled to the last glass ball segment. After that, a five-meter shot of ½" chain was connected to the mooring. The winch took tension on the mooring, stopper lines were removed, and a chain hook connected to the outhaul winch on the A-frame lifted the SBE 37s off the deck. The winch payed out and the instruments were eased over the transom. The outhaul went slack, and the chain hook was removed. The acoustic releases were shackled to the chain. Another 5-meter chain section was shackled to the releases. A 20-meter Nystron anchor pendant was shackled to that chain, and another 5-meter section of ½" chain was shackled to the anchor pendant. The ship's winch wound up these components until it had the tension of the mooring. The acoustic releases were lying flat on the deck. A chain hook connected to the Gilson winch line running through the block on the A-frame lifted the acoustic releases off the deck. The winch payed out with the outhaul, and the instruments were eased over the transom.

The crane was then used to maneuver the anchor into position. The ship's Gilson winch with 1" Spectra line was fed threw a block on the A-frame and connected to the anchor. The mooring was shackled into the anchor and the slip lines were removed. During this time the A-frame and Gilson winch operators worked together to lower the anchor into the water. At 2053 UTC on June 10, 2018 the anchor was released using a Peck and Hale quick release at 14° 49.452' N, 51° 00.823' W in water depth of 5021m.

The buoy waterline was determined from R/V *Pisces'* bridge the morning after deployment. Visual observations showed the tower top instrumentation intact and the buoy riding smoothly with a nominal waterline about 75 cm below the buoy deck. The wind vane appeared to be functioning as intended, with an orientation approximately parallel to the wind direction.

C. Anchor Survey

NTAS 17 anchor was dropped at 14° 49.452’ N, 51° 00.823’ W (measured on fantail using handheld GPS) on June 10 2018 at 20:53 UTC. An acoustic survey of the anchor position of NTAS 17 was carried out on June 10 2018. The three triangulating positions were occupied in a triangular pattern (see Figure III-5 and Table III-1) around the drop site. WHOI’s Edgetech 8011M deck gear was used with the portable transducer lowered (about 5 m below the waterline) over the starboard side by the CTD launch in order to range on one of the mooring releases. The releases are about 38 meters above the anchor, which rests on the seafloor. The ship’s EK-60 echo-sounder measured the water depth as 4985 m in the area of the anchor drop. Correcting for local speed of sound (1511 m s-1), the water depth is 5021 m. Triangulation using the horizontal range to the release from the three sites, gave an anchor position of 14□ 49.4682’ N, 51□ 00.9941’ W (in decimal convention 14.8245° N, 51.0166° W). Fallback from the drop site was 307 m or 6.1% of the water depth (Table III-2).

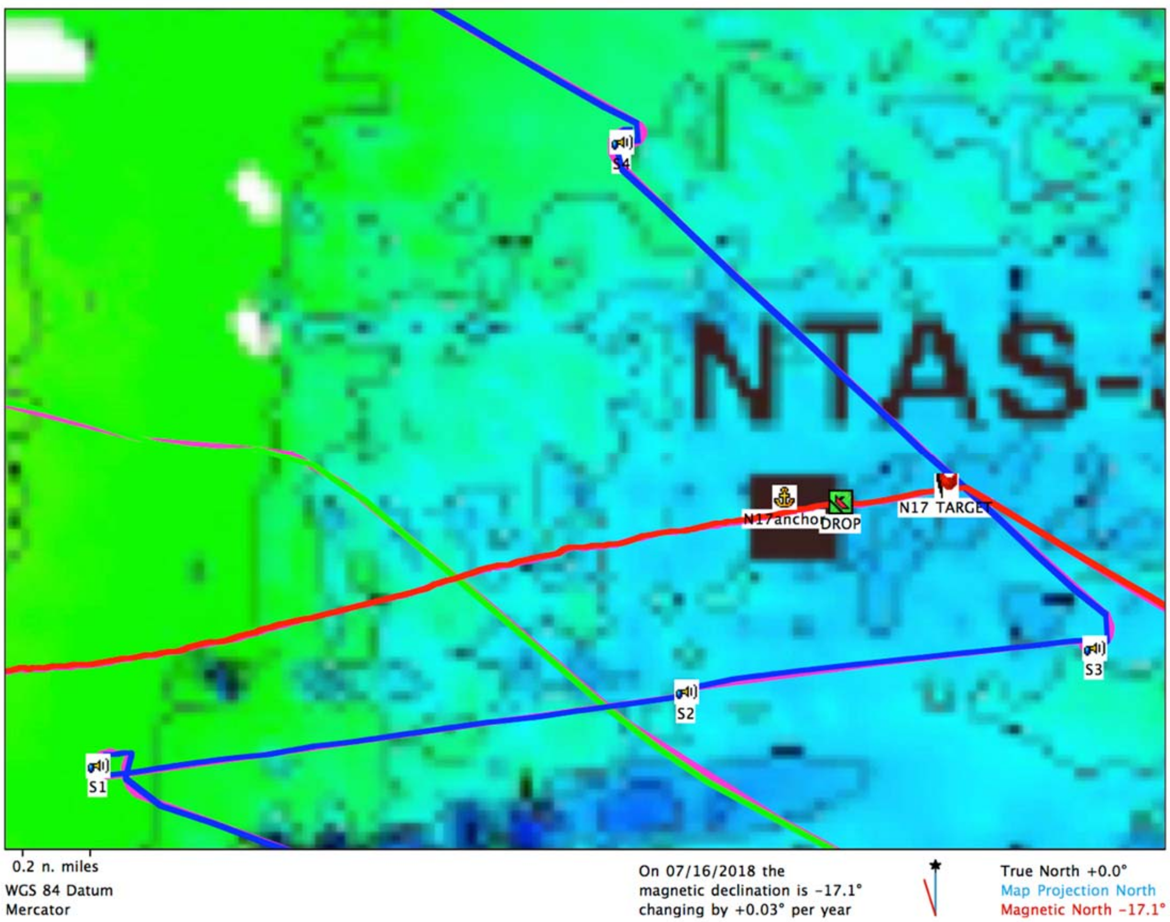


Figure III-5. Zoom on end of NTAS 17 deployment track (red line), with anchor drop location (green square) slightly west of initial target (red flag). Anchor survey track (blue line) and sites (labeled s1 to s4).

Table III-1. Acoustic ranges for NTAS 16 anchor survey.

Waypoint	Latitude (dd mm.mmm N)	Longitude (dd mm.mmm W)	Travel time (s)
1	14 48.690	51 03.086	8.446
2	14 49.040	51 00.066	6.965
3	14 50.566	51 01.467	7.169

Table III-2. NTAS 17 anchor coordinates based on acoustic survey.

Anchor Drop	14 49.452’ N	51 00.823’ W
Anchor position, Newhall’s code	14□ 49.4682’ N	51□ 00.9941’ W
Depth at anchor position	4985 m (EK 60, SoS=1500 m s^{-1})	5021 m (corrected for SoS=1511 m s^{-1})
Fallback	307 m	6.1% water depth

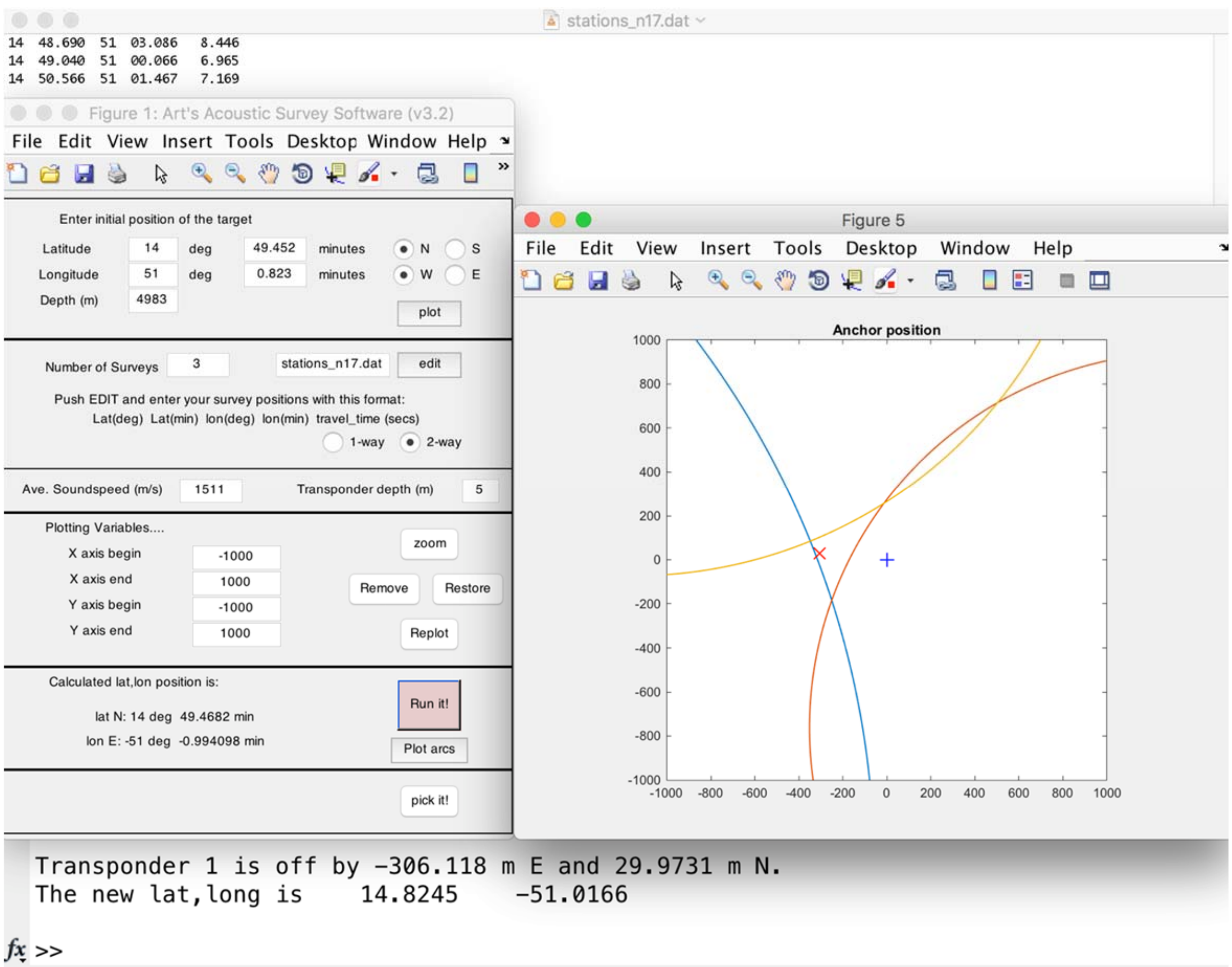


Figure III-6. NTAS 17 anchor survey: screen capture of Art Newhall’s code results.

IV. NTAS 16 Recovery

A. Mooring Recovery

On the morning of June 12 2018, the science team and personnel onboard prepared for recovery of NTAS 16 on board R/V *Pisces*. Winds were 20-25 kts and current was to the north. At 0730 UTC, after completing the overnight transit from MOVE-1, the ship was near the NTAS 16 buoy, to the West of the anchor site. At 0800 the ship was now positioned near the anchor. At 0827 UTC, the mooring was released from its anchor. The release command was sent to the acoustic release to separate the anchor from the mooring line. At 0927 UTC, the glass balls surfaced about 0.5 nm on the starboard beam. Figure IV-1 shows the track of R/V *Pisces* during the recovery. Initially the ship was stationed near the buoy (beginning of green line on the left) and then repositioned ½ nm to the north-northwest of the anchor position (beginning of red track at the bottom left of figure), heaving into the wind while the mooring was released and monitoring for glass balls ascent using acoustic ranging on the releases. The glass balls surfaced on the starboard beam, between the ship and mooring anchor. The ship then slowly approached the glass balls for pick up using an extended pole from the starboard rail.

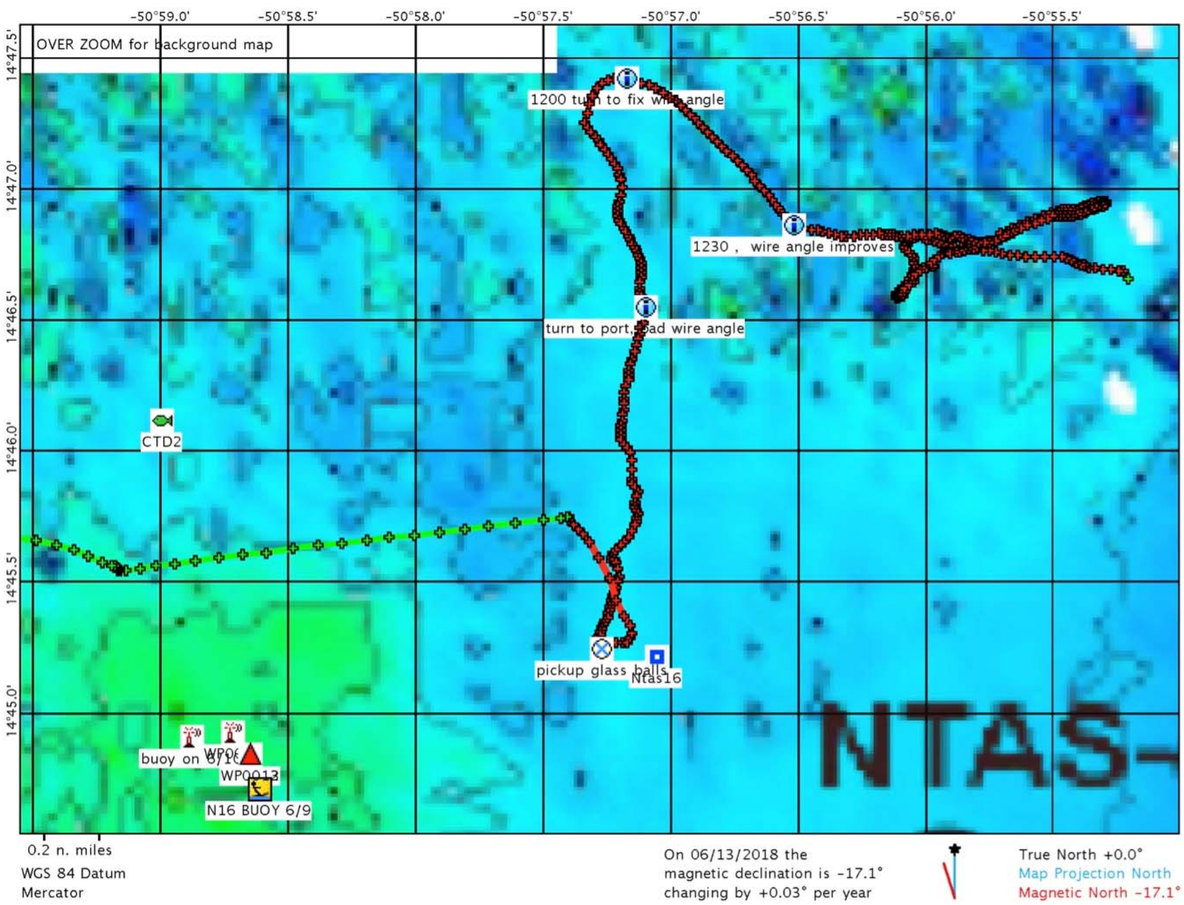


Figure IV-1. Track of R/V Pisces during recovery of NTAS 16 on June 12 2018.

In preparation for recovery of the glass balls the Gilson winch was fed through the A-frame block and run around the starboard quarter and up to the side sampling station. Once the glass balls were on the surface, the ship approached slowly and brought the cluster of glass balls along the starboard side of the ship. A grapple hook was used to bring the cluster closer to the ship. A connection was made in a link in between two sets of glass ball strings using a snap hook that was attached to the Gilson's Spectra line. After the connection was made to the glass balls the Gilson started to haul in slow and the ship maneuvered forward stretching out the mooring behind.

Once the mooring was trailing behind the ship, the winch hauled in to bring the cluster of glass balls up and over the stern. Tag lines and an air tugger were used to control the glass balls as they were pulled forward and lowered to the deck. Once all of the glass balls were on board, a stopper line was snapped into a sling link leading to the acoustic releases and then made fast to a deck cleat. Another stopper was attached to the end of the Colmega line leading off the stern. The winch leader was attached to the shot of chain above the releases, and the releases were hauled aboard.

The next step was the disassembly and removal of the glass balls from the working area. Once the glass balls were clear, a winch leader was wrapped around the split net drum and connected to the end of the Colmega line. The winch took the load of the mooring, and the stopper lines were removed. The winch was used to haul in approximately 4100 meters of Colmega and nylon line and approximately 1,800 m of wire on the mooring.

The winch continued to pull in the remaining synthetic line and mooring wire. Several instruments were clamped to the mooring wire above 180 meters. As each instrument was removed from the mooring, it was inspected, photographed, and recorded. When the 85-meter ADCP was pulled over the transom, stopper lines were attached to the termination, and the ADCP was removed from the mooring. The two sections of mooring wire were shackled together, and the recovery continued.

More instruments were removed as the wire was hauled in. When there was 45 meters left between the buoy and the ship, the wire was cut, and the buoy set adrift.

After the buoy was set adrift the deck was set up for an A-frame recovery. This included feeding the Gilson winch through the A-frame block and around the starboard quarter to where the buoy would be hooked up. A 5-ton titanium hook was also attached to the Spectra line on the Gilson winch. Three tag lines were also pre-staged and put in place near the transom. Once the deck was set up the ship made a slow approach to recover the buoy along the starboard quarter. A few attempts were done to hook the Spectra line from the extended pole from the starboard rail and into the lifting bail on the buoy. During this time, the buoy bumped into the ship's hull, damaging the protecting bar of one of the HRH sensors.

After the buoy was hooked up the ship bumped ahead slowly bringing the buoy behind the stern and under the A-frame. The Gilson winch lifted the buoy out of the water and the three tag lines were attached. Two lines were attached to the D-handles and one tag line was on the halo. The three tag line handlers worked together along with the winch and A-frame operators to stabilize the buoy. Once the buoy was stable it was brought in and lowered on deck. The buoy laid forward of the grated deck and was secured using ratchet straps.

The Gilson winch was removed from the buoy and the outhaul winch was inserted into the bell mouth. The crane picked up the EM Chain from the bellmouth until it cleared the transom. After the flange on the EM Chain was clear it was pulled on board and lowered to the grated deck. The remaining wire and instruments were hauled in by hand.

Figure IV-2. Recovery of NTAS 16 buoy through A-frame of R/V Pisces.

Following recovery, instrumentation was removed from the EM chain, which was then disconnected from the buoy. The buoy was then repositioned and secured inboard for transit. The bulwarks were also reinstalled on the port side.

B. Instrument Performance

Pictures of instruments were taken upon recovery (Figure IV-4). SBE 37#684 deployed at 40 m did not record any data internally, although it transmitted data through the subsurface inductive and Iridium telemetry, which was archived. SBE 39 #7696 at 5 m did not start. No communications could be established with SBE 39s #684,677 and 539. SBE 39s #545 and 546 had transmissions errors during data download and data files are corrupted at the time of this writing. SBE 39 #3480 data contains several large gaps. ASIMET record is complete but Melo (GPS) did not record internally. Dust was visually observed on surface instruments and buoy.

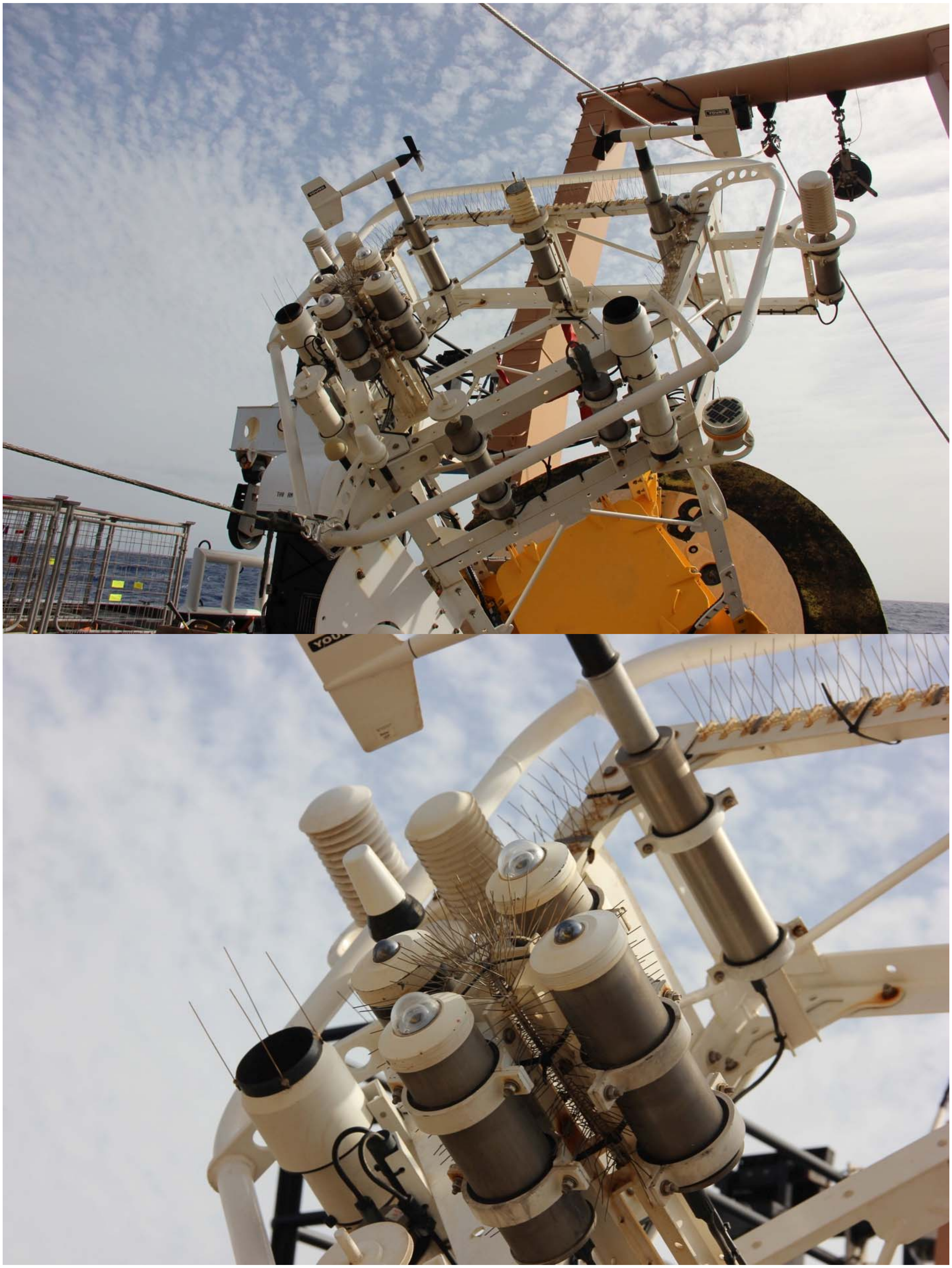


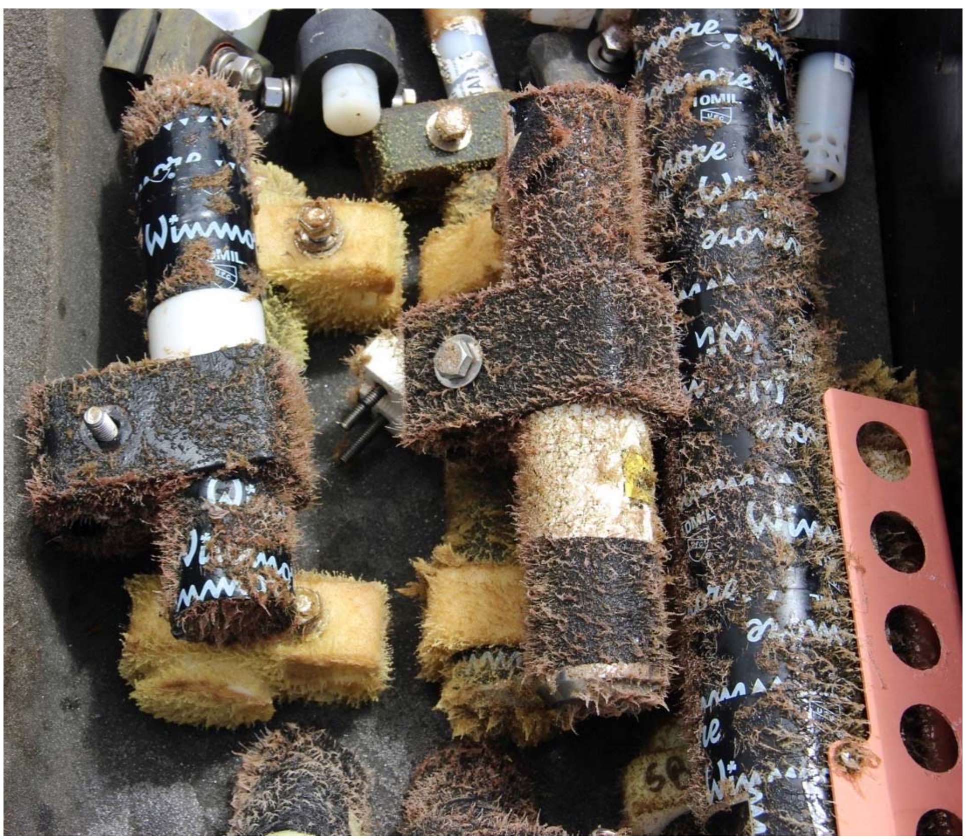
Figure IV-3. ASIMET sensors upon recovery of NTAS16.

Right: from left to right, Starmon Oddi sensors at (top) 160 m, 150m, 140 m, 130 m, 120 m, and (bottom) 110 m.

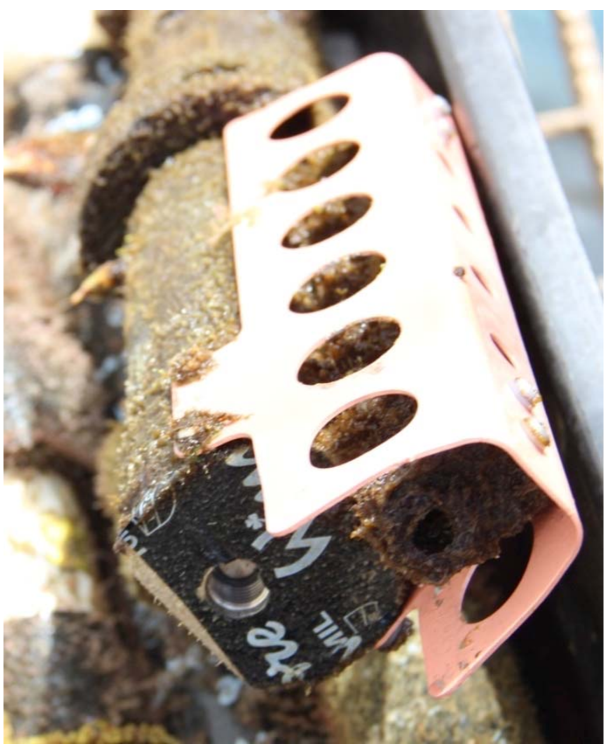
Left: from left to right, Starmon at 110 m, SBE 39 at 110m, SBE 39 at 100m.

Left: from left to right, SBE 39s at 90 m, 80 m and 75 m.

Left: RDI sensor at 85 m.
Above: SBE 37 at 70 m.
Below: from right to left, SBE 37 at 70 m, SBE 39 at 65 m, SBE 39 at 60 m.



Above, left and right: SBE 37 at 55 m.
Right: SBE 39 at 50 m (right).



Above: SBE 39 at 45 m (center).
Left: SBE 37 at 40 m.

Left: SST sensors on bridle.
Below: SBE 37 at 40 m (SN 684) with missing poison plugs.

Figure IV-4. (4 previous pages) Pictures of subsurface instrumentation recovered from NTAS 16 on June 12 2018.

C. NTAS 16 and NTAS 17 Inter-comparisons

Due to time constraints, no ship-buoy intercomparison was done. However, since the two buoys NTAS 16 and 17 were in the water from June 10 to June 12 when NTAS 16 was recovered, we show here some of the measurements from both platforms. These buoys were several miles from each other, so a direct comparison does not serve as a quantitative validation of the data.

In addition to the measurements from the two buoys, we also used data from similar ASIMET instruments that were mounted on the starboard rail on the 02 deck forward of the ship for the cruise. These standalone sensors were shortwave (SWR) and longwave (LWR), air temperature (ATMP) and humidity (HRH). The data used for the comparison were hourly averages (using 1-minute data recovered from NTAS 16 and the ASIMET standalones installed on the ship) or the telemetered data from NTAS 17. The data from all these ASIMET sensors is shown in Figure IV-5 and Figure IV-6.

This comparison indicates that LWR from system 2 on NTAS 16 may have been high by close to 5 W m^{-2}. Similarly, wind speed (WSPD) from system 1 on NTAS 16 may have been low by close to 0.2 m s^{-1}, although this may be due to flow distortion on NTAS 16 due to the comparison period. The wind direction difference for systems 1 and 2 on NTAS 16 was close to 7 degrees, but closer to 10 degrees for systems on NTAS 17, although this may be due to coarser resolution from telemetered data on NTAS 17. Finally, there was a clear offset in conductivity from SST sensors on NTAS 16.

Based on this qualitative evaluation, **special post-cruise assessment, including calibration, should be applied to surface conductivity and longwave sensors recovered from NTAS 16**.

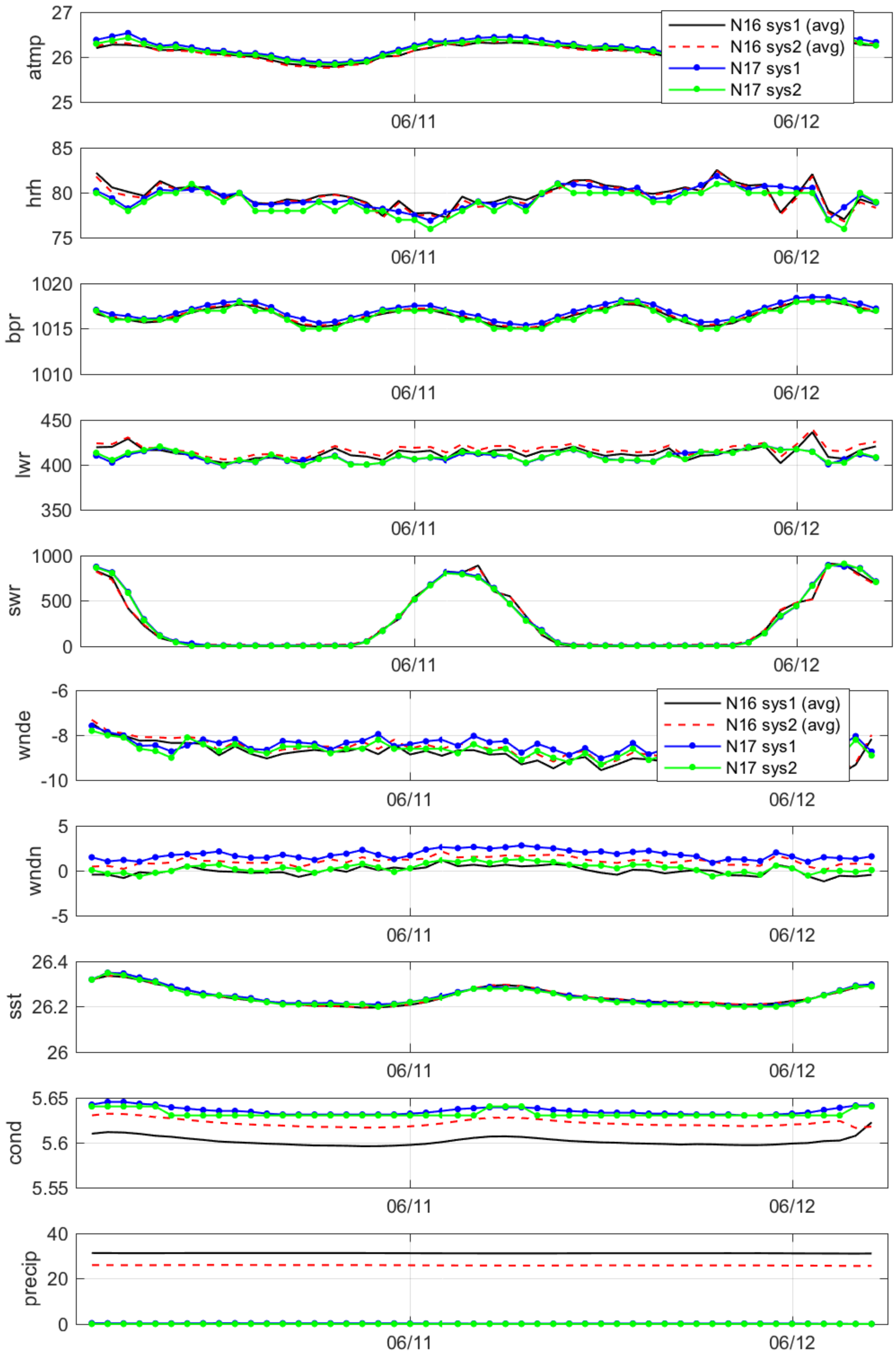
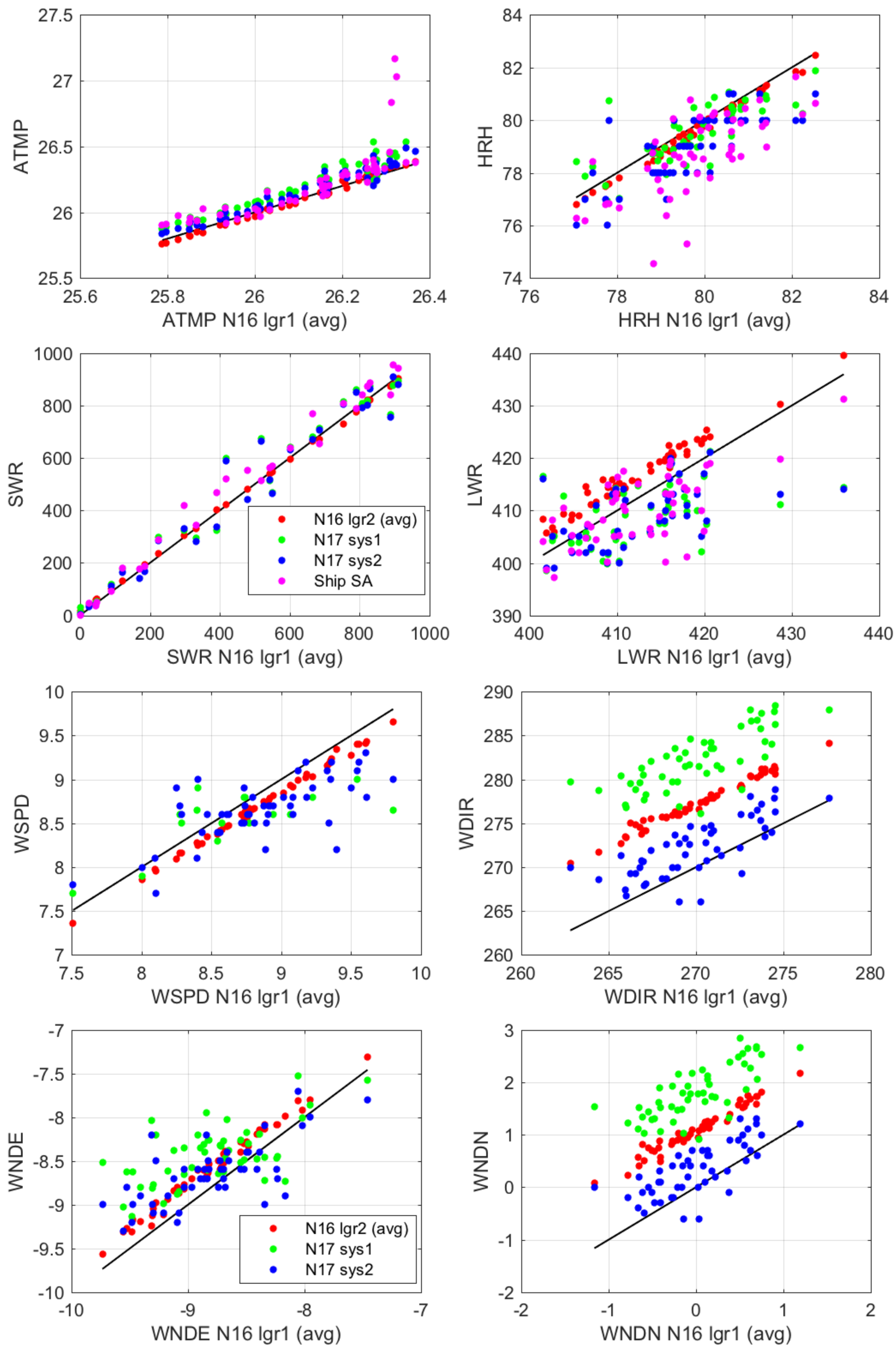


Figure IV-5. Timeseries (hourly averages) of near surface meteorology from ASIMET instrumentation on NTAS 16 and NTAS 17 buoys, while both platforms were deployed from Jun 10-12 2018.


ATMP
ATMP N16 lgr1 (avg)
HRH
HRH N16 lgr1 (avg)
SWR
SWR N16 lgr1 (avg)
N16 lgr2 (avg)
N17 sys1
N17 sys2
Ship SA
LWR
LWR N16 lgr1 (avg)
WSPD
WSPD N16 lgr1 (avg)
WDIR
WDIR N16 lgr1 (avg)
WNDE
WNDE N16 lgr1 (avg)
N16 lgr2 (avg)
N17 sys1
N17 sys2
WNDN
WNDN N16 lgr1 (avg)

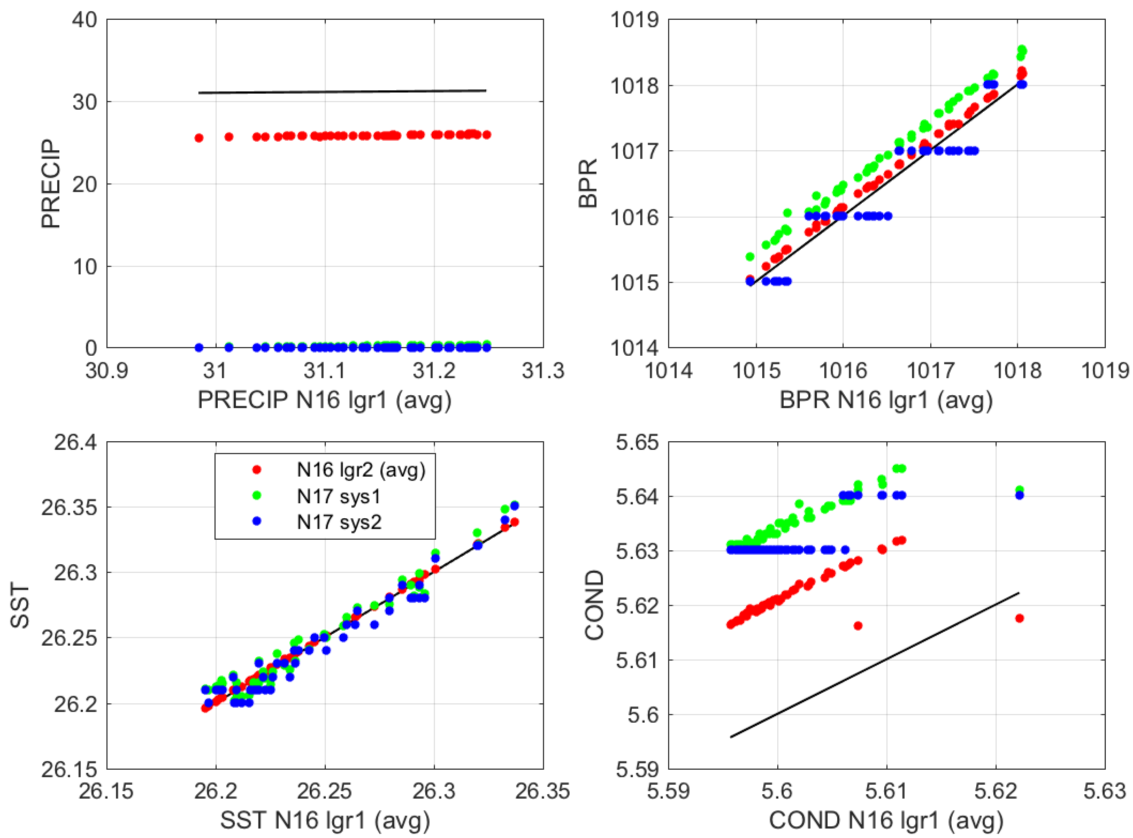


Figure IV-6. Scatter-plots of ASIMET measurements from NTAS 16 and 17 using same data as in Figure IV-5. All measurements plotted versus corresponding variable from system on NTAS 16. Note that data from NTAS 17 are telemetered using Iridium (system 1) or Argos (system 2, which has coarse resolution). Magenta dots in first 4 plots are data from ASIMET standalones installed on R/V Pisces.

V. Ancillary Work

A. CTDs

During the NTAS 17 cruise, several CTD casts were operated. The first two were located just offshore of Puerto Rico as R/V *Pisces* was transiting from its Mayport, FL towards San Juan, PR. The first cast served as a test for the acoustic releases that were to be deployed on the NTAS 17 mooring. The second cast followed immediately and served as a test for SIO's acoustic releases. A third CTD cast was done on June 10 right after the deployment of NTAS 17, about 1 nm north of NTAS 16. A fourth CTD cast was done on June 13 while transiting towards Guadeloupe, for calibration of SIO sensors. The fifth and final CTD was done on June 16 early morning, near MOVE 3 and 4. Table V-1 shows time and location of each CTD cast during PC-18-03.

Table V-1. CTD casts during PC 18-03 cruise.

CTD #	Date and Time (UTC)	Latitude N (dd mm.mm)	Longitude W (dd mm.mm)	Depth (m)	Max Pressure (dbar)
1	6/3/2018 16:05	19 33.20	067 22.99	7750	1516.3
2	6/3/2018 19:06	19 29.38	067 18.32	7750	3119.9
3	6/10/2018 21:59	14 46.12	050 59.00	5021	986.4
4	6/13/2018 18:12	15 36.48	054 51.18	5507	2339.7
5	6/16/2018 05:07	16 21.51	060 28.48	5000	2241.1

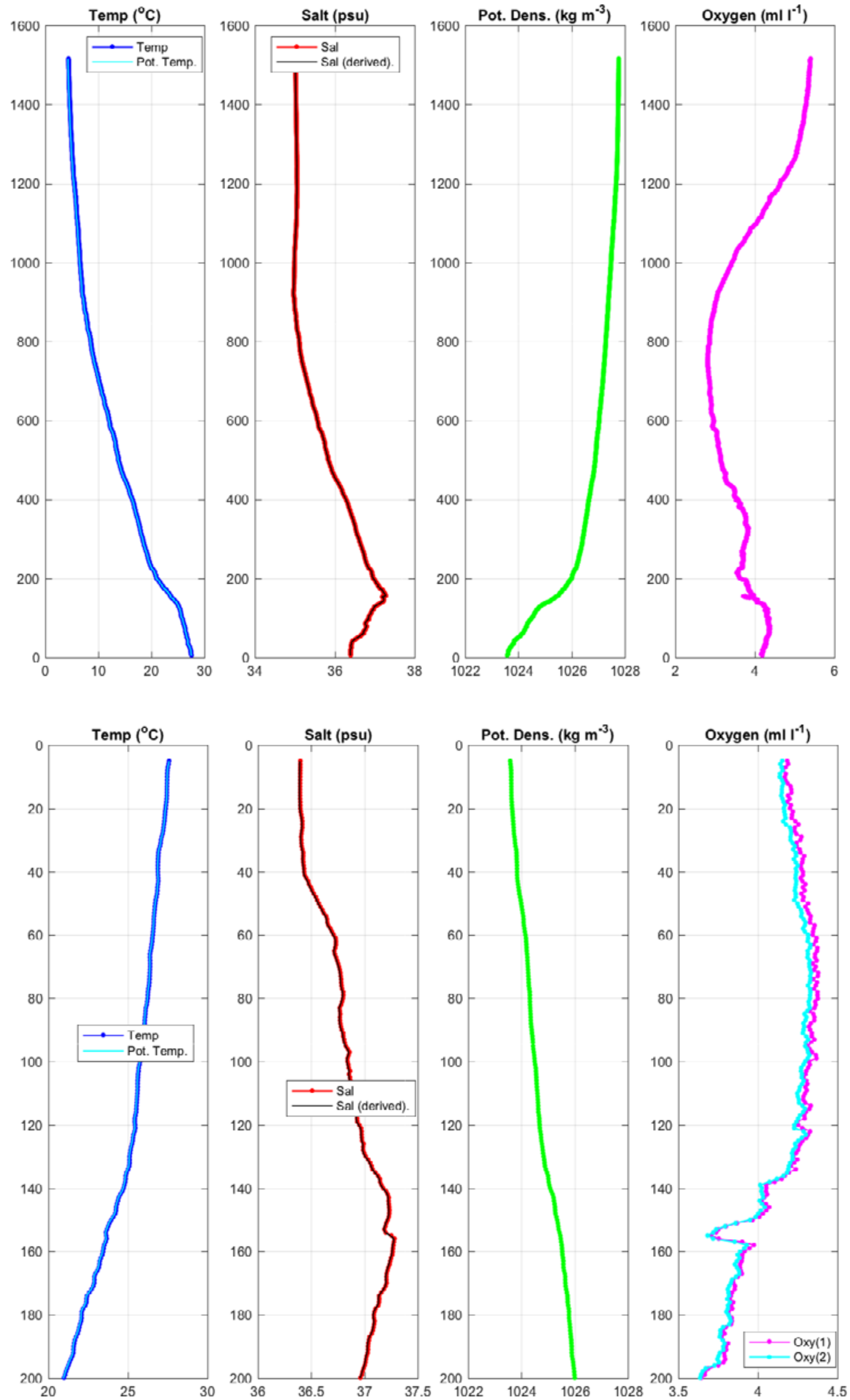


Figure V-1. CTD cast#1. From left to right, profiles of temperature (°C), salinity (psu), potential density (kg m-3), oxygen (ml l-1). Y=axis is pressure (dbars). Whole profile (top) and zoom on upper ocean (bottom).

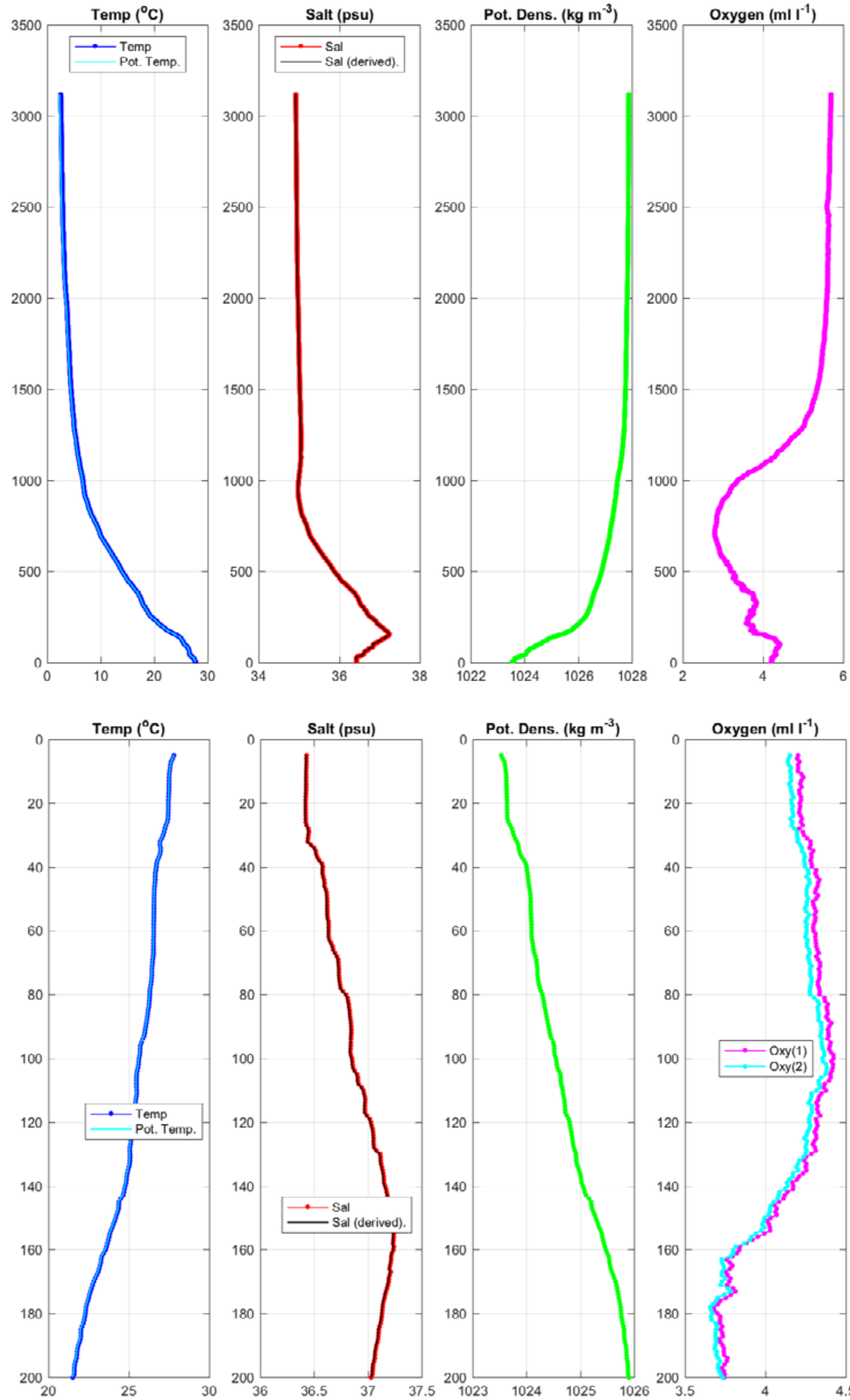


Figure V-2. Same as Figure V-1 but for CTD cast #2.

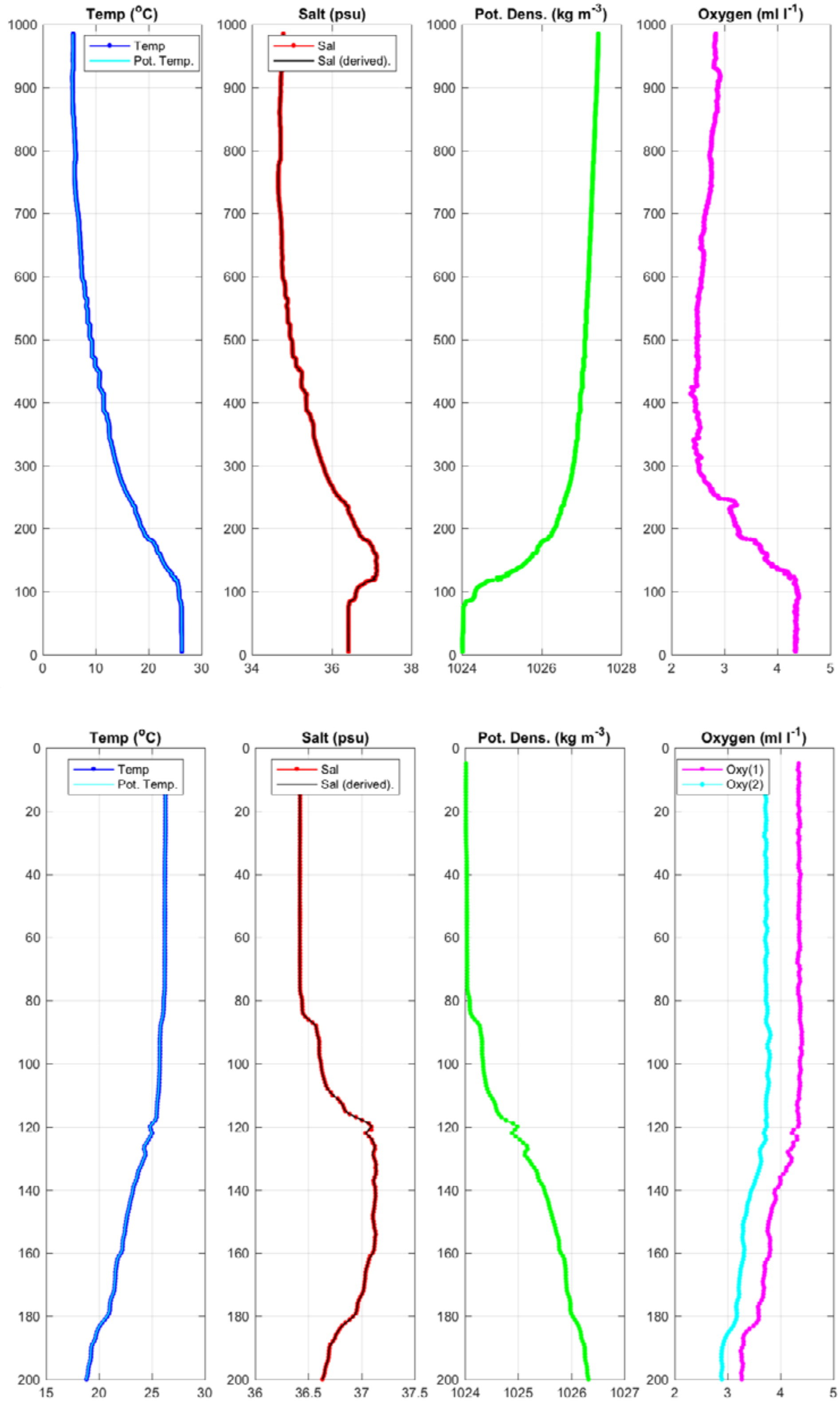


Figure V-3. Same as Figure V-1 but for CTD cast #3.

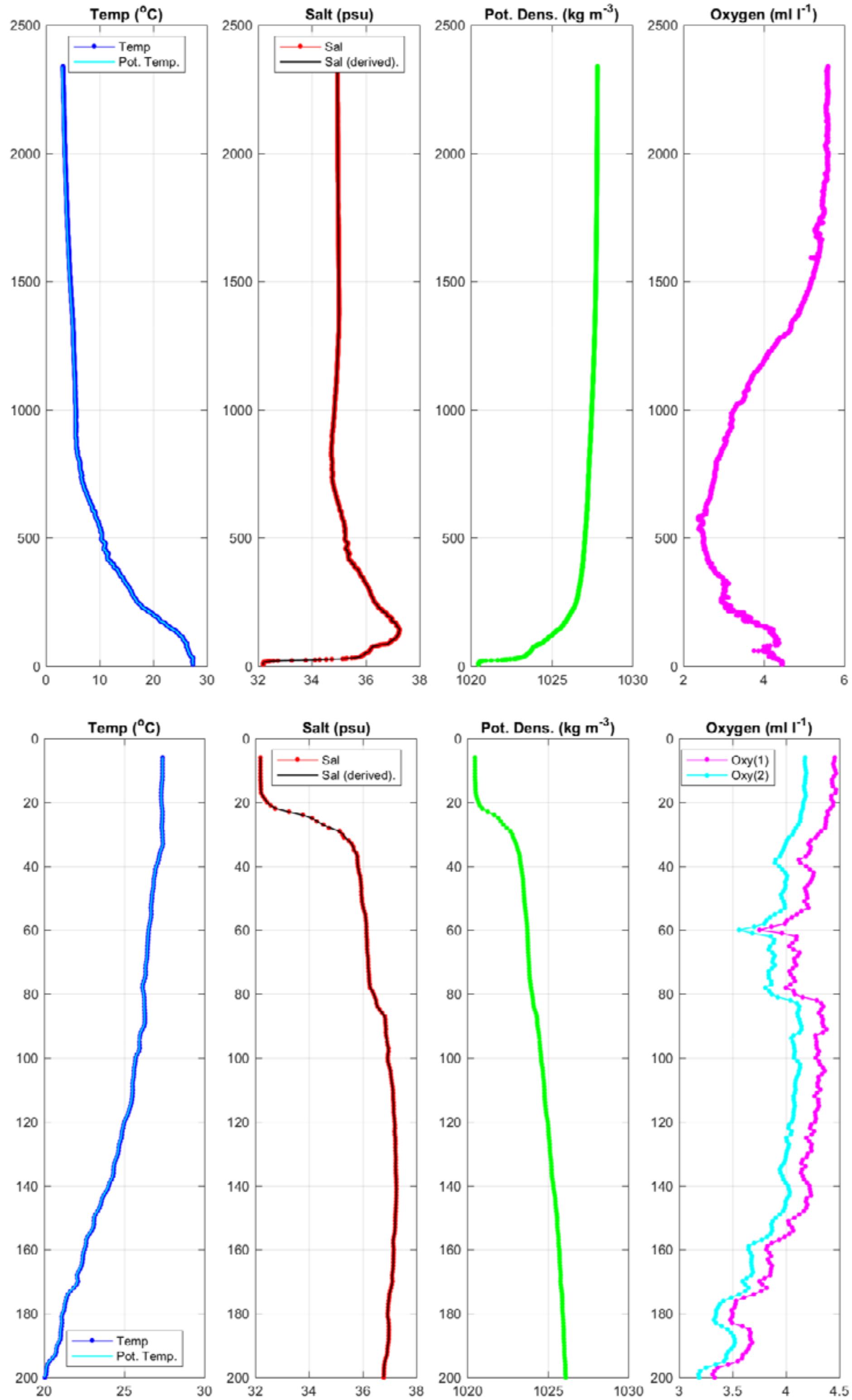


Figure V-4. Same as Figure V-1 but for CTD cast #4.

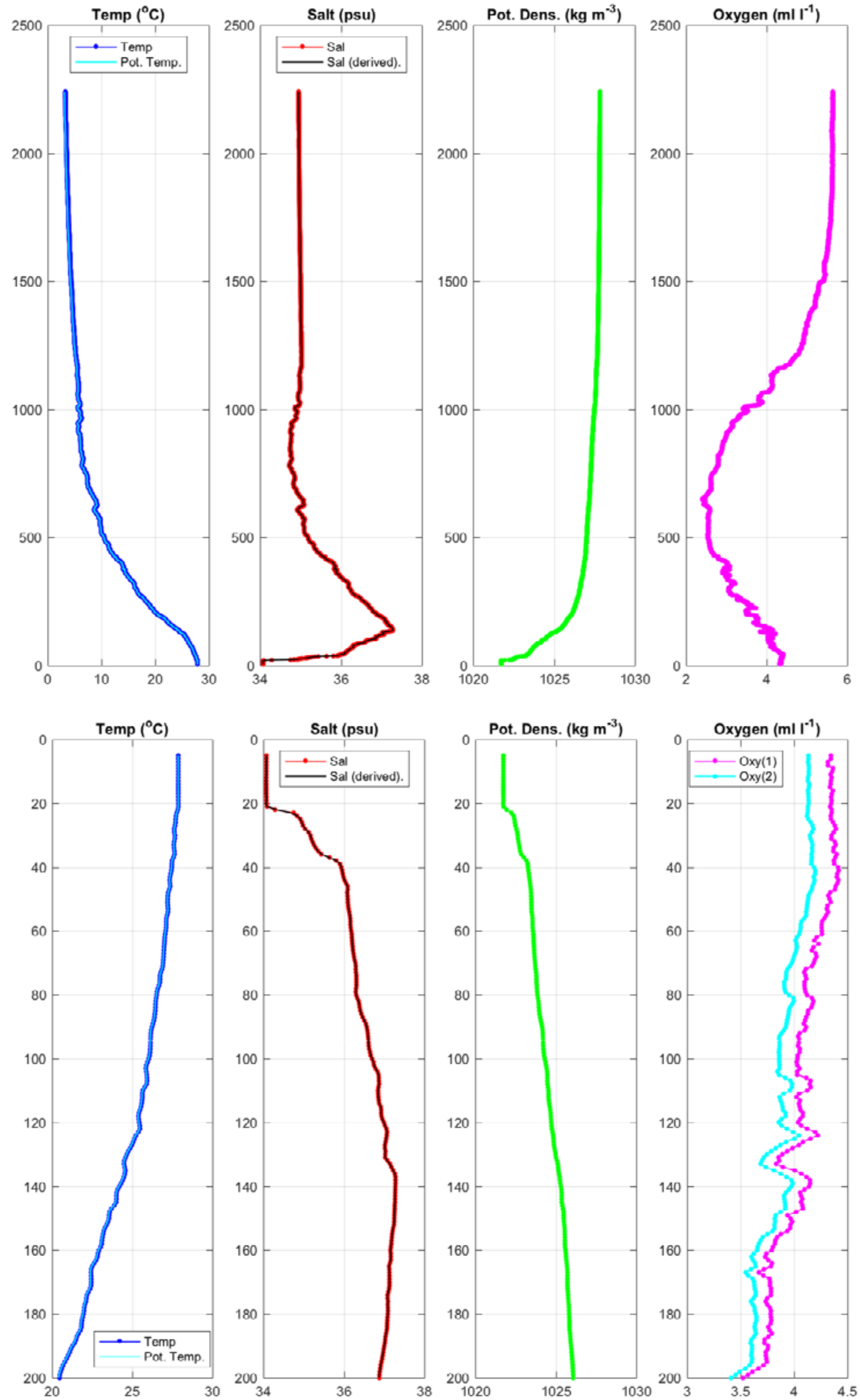


Figure V-5. Same as Figure V-1 but for CTD cast #5.

B. MOVE operations

As quoted from the Meridional Overturning Variability Experiment (MOVE) website (http://mooring.ucsd.edu/index.html?/projects/move/move_results.html):

The meridional overturning circulation in the Atlantic Ocean carries much of the meridional heat flux, and speculations are abundant about variability, slowing, or potential collapse of this system, with the ensuing impacts on northern hemisphere climate. Figure V-6shows the path of the southward branch (or "cold limb") of this regime (i.e. the Deep Western Boundary Current, DWBC, formed by North Atlantic Deep Water, NADW) in the North Atlantic. No monitoring system has existed until recently for the transports of this overturning circulation, thus all evidence of variability came from instantaneous estimates based on hydrography, or from numerical models.

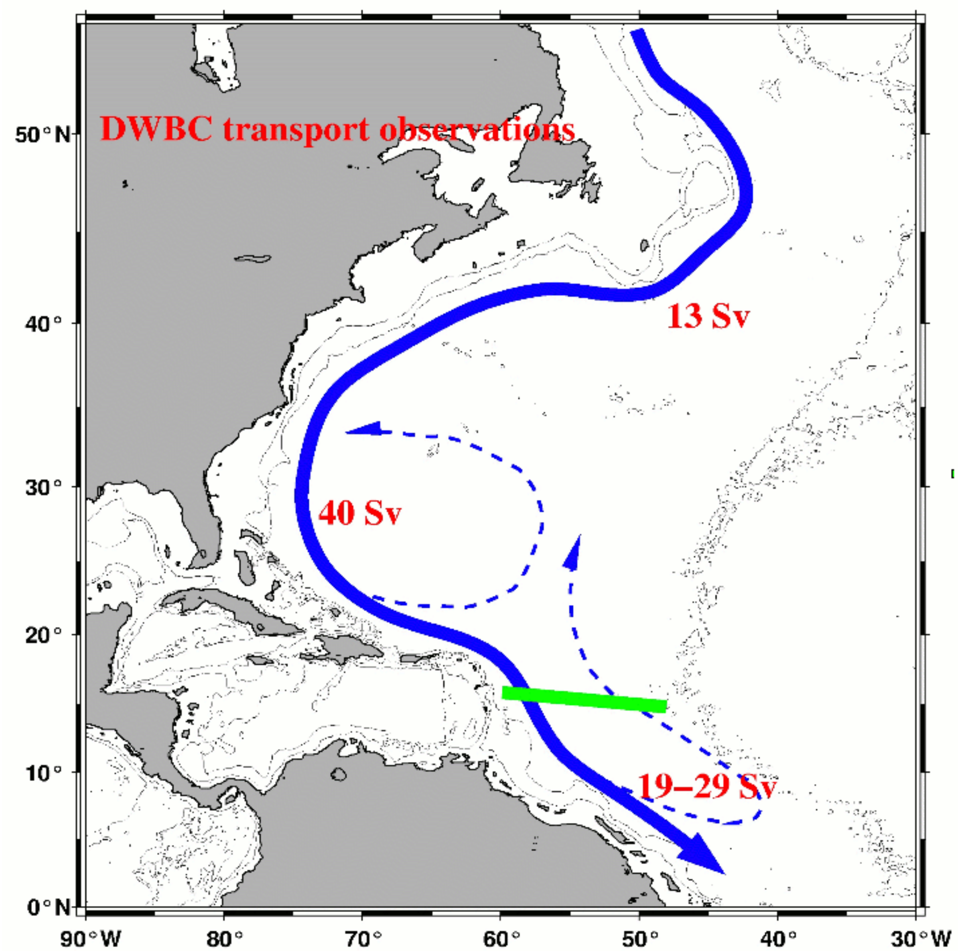


Figure V-6. Path of DWBC and estimated transports of the NADW, including indirectly inferred recirculation. MOVE measures the flow of water in the NADW depth range across the green line.

In the original configuration, three "geostrophic end-point moorings" (MOVE1, MOVE2, MOVE3) plus one traditional current meter mooring on the slope (MOVE4) have been used to cover the section between the Lesser Antilles (Guadeloupe) and the Mid-Atlantic Ridge. The goal is to determine the transport fluctuations across this section, using dynamic height and bottom pressure differences between the moorings for estimates of the geostrophic transport. The core system of moorings has occasionally been augmented with additional measurements, including acoustic thermometry, RAFOS floats, and more bottom pressure sensors for comparison with GRACE satellite data.

The MOVE moorings were first deployed in 2000, and have measured temperature, salinity, and currents ever since. The goal of the project is to observe the volume of water transported across the section covered by the array. There are multiple components to this volume transport, documented by Kanzow et al (2006).

The MOVE program is ran by a team from Scripps Institution of Oceanography. Seven personnel from SIO participated in the PC1803 cruise to support work for MOVE. MOVE 1 and 3 subsurface moorings were turned over during this cruise. MOVE 4-13 was deployed about 1 nm north of its nominal site because MOVE 4-12 could not be recovered due to insufficient time.. Acoustic communications were conducted using over the board transducer to download data from some the PIES near MOVE 1 and 3, as well as data from the MOVE 4-12 mooring. The latter indicated that the top pressure sensor was about 500 m below its nominal target depth. It is therefore possible that MOVE 4-12 is entangled with some nearby fishing gear that is bringing its top part down. Anchor surveys of the PIES that could not be completed the year prior was completed this time. CTD casts with bottled samples were also conducted with MOVE instruments attached to the Rosette for calibration of their conductivity, temperature and oxygen sensors. During these CTD casts, the winch was stopped at a few depths below the main thermocline for a few minutes until the instruments had equilibrated to the environmental temperature and the Rosette motion was minimized. At the end of each stop, a water sample was taken in a Niskin bottle on the Rosette, for calibration of salinity and oxygen (post-cruise).

MOVE 4-13 deployment track was about 9 nm WSW of the target position. MOVE 3 and 4 are in a fishing area and several fishing gear (floats with nets) were spotted during deployment and recovery operations. MOVE 3-13 deployment track was almost 16 nm WSW of target (see Figure V-7 and Figure V-8). These rather long deployment tracks are necessary to take into account the eastward (offshore) current while keeping the ship into the wind and maintaining a speed over water at about 1 knot.

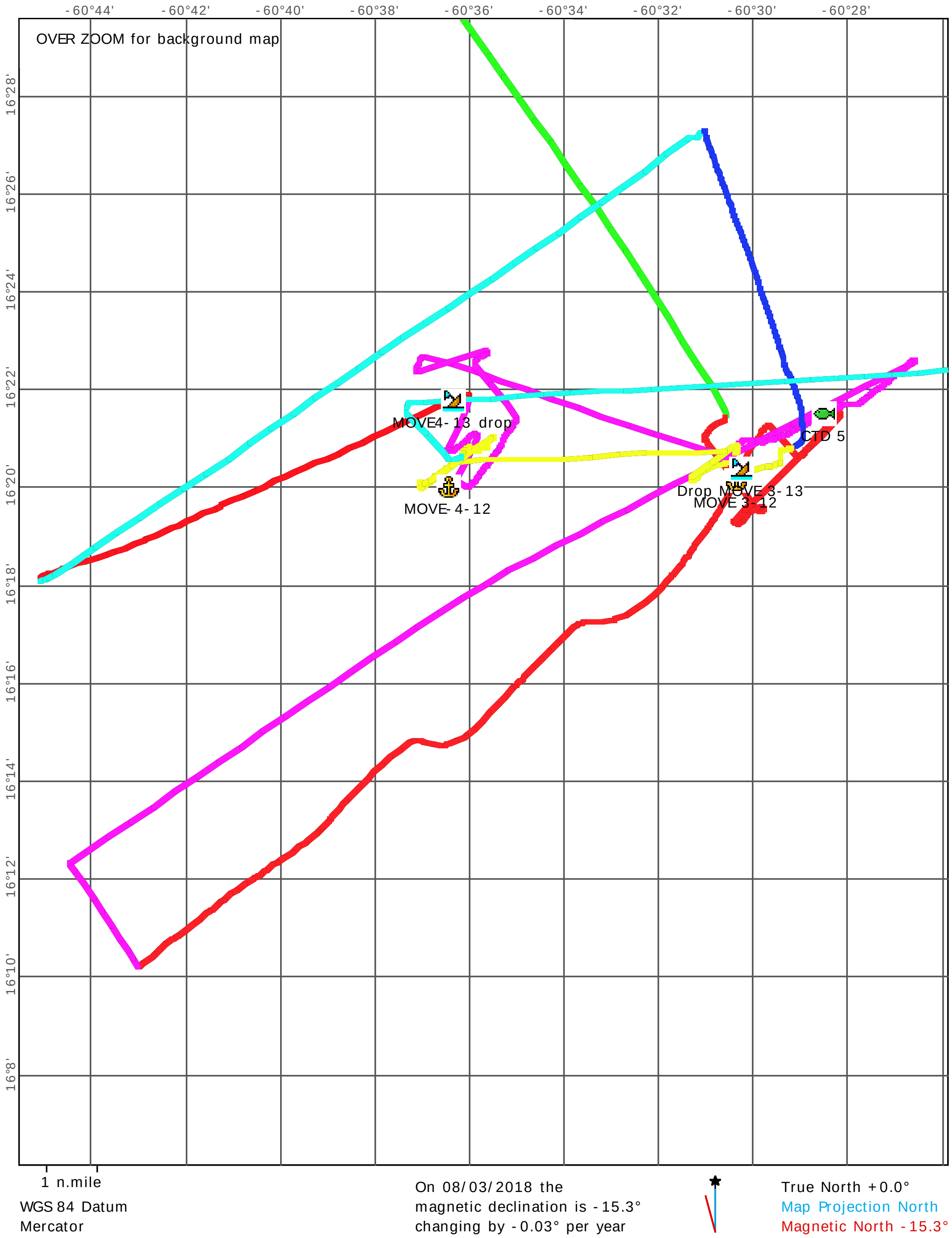


Figure V-7. R/V Pisces track during work at the MOVE 3 and 4 sites. In chronological order: Cyan line on the right is track incoming from NTAS site to the east and arriving at MOVE 4 on evening on June 14, yellow line is track during acoustic communications at MOVE 4 then at MOVE 3 on morning of June 15, blue line is recovery of MOVE 3-12, cyan line (top) is transit to MOVE 4, red line (left) is MOVE 4-13 deployment track, magenta line is anchor survey for MOVE 4-13 followed by A-coms and CTD cast #5 near MOVE 3 and repositioning for deployment, red line (bottom) is MOVE 3-13 deployment track followed by anchor survey on June 16, and green line is start of return track towards Morehead City, NC.

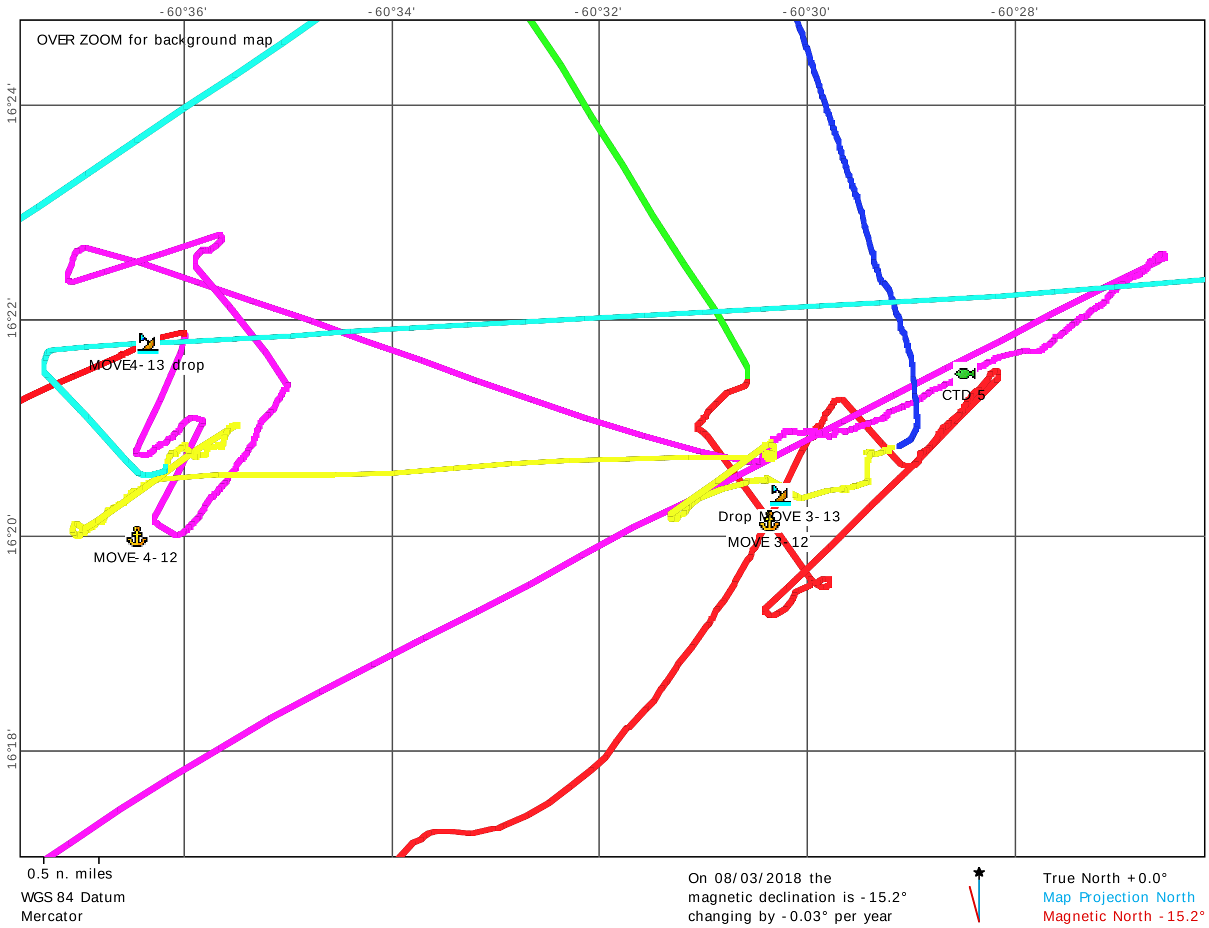


Figure V-8. Zoom from Figure V-7, showing location of MOVE 4-13 drop, about 1.8 nm north of MOVE 4-12 anchor position, CTD cast #5 to the northeast of MOVE 3, location of MOVE 3-12 anchor and drop of MOVE 3-13.

Acknowledgements

We thank the captain and crew of the NOAA R/V Pisces for accommodating the science mission, and providing expertise critical to the success of the mooring operations. We also thank the SIO personnel for assisting with the deck work and CTDs. This research was supported by the National Oceanic and Atmospheric Administration (NOAA), Ocean Observing and Monitoring Division, through the Cooperative Institute for the North Atlantic Region (CINAR) under Cooperative Agreement NA14OAR4320158, FundRef number (100007298).

Appendix 1: NTAS 16 Mooring Log

Moored Station Log

(fill out log with black ball point pen only)

ARRAY NAME AND NO. NTAS 16 MOORED STATION NO. ________

Launch (anchor over)

Date (day-mon-yr) 30 January 2017	Time 2031 UTC
Deployed by B. Pietro	Recorder/Observer S. Bigorre
Ship and Cruise No. Endeavor EN590	Intended Duration 365 days
Depth Recorder Reading 5002 m	Correction Source Matthews Table
Depth Correction +38 m	
Corrected Water Depth 5040 m	Magnetic Variation (E/W) ________
Anchor Drop Lat. (N/S) 14 45.256	Lon. (E/W) 50 56.946
Surveyed Pos. Lat. (N/S) 14° 45.211'	Lon. (E/W) 50° 57.052
Argos Platform ID No. ________	Additional Argos Info on pages 2 and 3
Acoustic Release Model Edgetech 8011 M	Tested to 2,000 m
Release No. 1 (sn) 33415	Release No. 2 (sn) 31272
Interrogate Freq. 11 kHz	Interrogate Freq. 11 kHz
Reply Freq. 12 kHz	Reply Freq. 12 kHz
Enable 361374	Enable 360422
Disable 361413	Disable 360447
Release 346532	Release 344237

Recovery (release fired)

Date (day-mon-yr) 12-6-18	Time 1227 UTC
Latitude (N/S) 14° 45.749	Longitude (E/W) 050° 57.402
Recovered by B. Pietro	Recorder/Observer S. Bigorre
Ship and Cruise No. Pisces PC1803	Actual duration 498 days

Distance from waterline to buoy deck 75 cm (as observed on 2/1/2017 12:30UTC)

ARRAY NAME AND NO. NTAS 16 MOORED STATION NO.______

Surface Components

Buoy Type MOB Color(s) Hull Tower blue hull, yellow deck, white tower

Buoy Markings WHOI 508-457-1401 USA

Surface Instrumentation

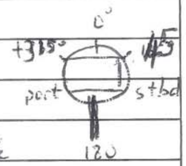
Item	ID #	Height*	Comments
ASIMET logger	L16		Port side
HRH	226	233	All shields covered with dust. See comments at the end. HRH port side: bracket damaged at recovery.
BPR	505	240	
WND	205	265	
PRC	218	247	
LWR	212	282.5	
SWR	201	282.5	
SST	1836	150	* SST copper guard bent
PTT	18128		
ASIMET logger	L12		Starboard side
HRH	215	230	
BPR	503	243	
WND	207	265	
PRC	210	246	3/4 birdwire missing at recovery
LWR	254	282.5	
SWR	209	282.5	
SST	2054	150	* See above . Front plug separated from cell tube
PTT	12112		
SBE 39 AT	5272	226	
VWX	001	231.5 – deck mtg	Wind sensor: 250 cm above deck ATMP, HRH, BPR, 239 cm AD
Lascar	10032233	223	
Xeos Melo	300034012615100		
WAMDAS	4003		

*Height above buoy deck in centimeters

ARRAY NAME AND NO. NTAS 16 MOORED STATION NO.________

Subsurface Instrumentation on Buoy and Bridle

.Item	ID #	Depth†	Comments
SST SBE56	6979	95	port side (−135°) 95 cm below deck
SST SBE56	6980	85	forward upper (0°) 85 cm below deck
SST SBE56	6981	95	forward lower (0°) 95 cm below deck
SST SBE56	6982	95	starboard (135°) 95 cm below deck
WAMDAS	4003		NDBC # 24361
			IMEI 300124000115920
			SIM 29881 69312 00205 1336
			3DM-GX1 # 8712
			IR 24537
SIM IR			Subsurface Iridium
			3002 2401 0043 720
Xeos Kilo	300234062946460		Subsurface beacon



†Depth below buoy deck in centimeters

ARRAY NAME AND NO. NTAS16 MOORED STATION NO.________

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
1		buoy			1414	1850	very little barnacles
2	5	EM chain					
3		SBE39	5	7696		1850	
4		Nortek ADCM	5.7	9407		1857	
5	79	7/16 wire					
6		SBE37 IM	10	669		1859	
7		Nortek ADCM IM	13	5973		1902	with vane; heads up
8		SBE39	15	7697		1902	
9		SBE39	20	7695		1902	
10		Nortek ADCP	24	12391		1902	
11		SBE37 IM	25	683		1902	Endcap replaced with spare
12		SBE39	30	624		1902	
13		SBE39	35	678		1902	
14		SBE37 IM	40	684		1735	Brown dense growth fuzz
15		SBE39	45	546		1734	Fuzz
16		SBE39	50	545	~~1415~~ 1414	1733	fuzz
17		SBE37 IM	55	685	1415	1732	Fuzz. Bent copper guard
18		SBE39	60	677	1417	1732	fuzz
19		SBE39	65	3480	1419	1731	Fuzz
20		SBE37 IM	70	686	1424	1730	Fuzz. Bent copper guard
21		SBE39	75	750	1425	1727	First barnacle, on clamp
22		SBE39	80	631	1425	1726	Fuzzy growth
23		RDI ADCP	85	14193	1431	1723	Fuzz
24	500	3/8 wire					
25		SBE39	90	539	1431	1722	Fuzz

ARRAY NAME AND NO. NTAS 16 MOORED STATION NO.________

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
26		SBE39	100	680	1432	1720	Fuzz
27		SBE39	110	681	1435	1719	} paired Fuzz
28		Starmon Oddi	110	5282	1435	1719	} Fuzz
29		Starmon Oddi	120	5283	1436	1718	clean
30		Starmon Oddi	130	5284	1437	1718	clean
31		Starmon Oddi	140	5285	1437	1717	Fuzzy growth
32		Starmon Oddi	150	5286	1438	1716	clean
33		Starmon Oddi	160	5287	1440	1715	clean
34	500	3/8 wire			1453		
35	500	3/8 wire			1530	1650	|
36	200	3/8 wire			1547		
37	100	3/8 wire			1556	1633	} encapsulated termination (in at 1602 UTC)
38	200	7/8 nylon			1602		}
39	500	7/8 nylon			1626		
40	2000	3/4 nylon					
41	100	7/8 nylon					
42	1500	1" Colmega			1725		
43		glass balls (56)			1805	1410	6 broken glass balls
44		SBE37		11393	2013	1400	
45		SBE37		11392	2013	1400	
46	5	1/2 chain					
47		Acoustic release		33415	2013	1410	
48		Acoustic release		31272	2013		
49	5	1/2 chain			2013		
50	20	1" Samson Nystron			2013		

ARRAY NAME AND NO. NTAS 16 MOORED STATION NO.________

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
51	5	1/2 chain					
52		Anchor			2031		7000 lbs (dry)
53							
54							
55							
56							
57							
58							
59							
60							
61							
62							
63							
64							
65							
66							
67							
68							
69							
70							
71							
72							
73							
74							
75							

ARRAY NAME AND NO.________ MOORED STATION NO.________

Date/Time	Comments
6/12/18	Upon recovery, all ASIMET met sensors had some red dust on them (Sahara dust, maybe), especially HRH/AT. Radiations domes also had fine dust but more white, possibly sea spray.

8

09G0135

Appendix 2: NTAS 17 Mooring Log

Moored Station Log

(fill out log with black ball point pen only)

ARRAY NAME AND NO. NTAS 17 MOORED STATION NO. ____

Launch (anchor over)

Date (day-mon-yr) 10-6-18 Time 20:53 UTC

Deployed by Ben Pietro / Jason Smith Recorder/Observer S. Bigorre

Ship and Cruise No. Pisces PC 18-03 Intended Duration 365 days

Depth Recorder Reading ~~50~~ 4985 m Correction Source average SoS 1511 m/s

Depth Correction +36 m leads to multiplying factor 1511/1500

Corrected Water Depth 5021 m Magnetic Variation (E/W) ____

Anchor Drop Lat. (N/S) 14° 49.452' Lon. (E/W) 051° 00.823'

Surveyed Pos. Lat. (N/S) 14° 49.4682' Lon. (E/W) 051° 00.9941'

Argos Platform ID No. ____ Additional Argos Info on pages 2 and 3

Acoustic Release Model Edgetech Tested to 1,500 m

Release No. 1 (sn) 51915	Release No. 2 (sn) 48277
Interrogate Freq. 11 kHz	Interrogate Freq. 11 kHz
Reply Freq. 12 kHz	Reply Freq. 12 kHz
Enable 337703	Enable 567550
Disable 337720	Disable 567573
Release 335322	Release 551146

Recovery (release fired)

Date (day-mon-yr) ____ Time ____ UTC

Latitude (N/S) ____ Longitude (E/W) ____

Recovered by ____ Recorder/Observer ____

Ship and Cruise No. ____ Actual duration ____ days

Distance from waterline to buoy deck 75 cm

1

ARRAY NAME AND NO. NTAS 17 MOORED STATION NO.________

Surface Components

Buoy Type MOB Color(s) Hull Tower Blue hull, yellow deck, White tower

Buoy Markings________

Surface Instrumentation

Item	ID #	Height*	Comments
ASIMET logger	L05		PORT side : System 1.
HRH	258	238	
BPR	234	242	
WND	221	265	
PRC	235	244	
LWR	253	279.5	
SWR	213	279.5	Forward on center-line.
SST	3601		SBE37.
Iridium	J10F2S		IMEI 300234063854580
ASIMET logger	L03		STBD side . System 3 (spare)
HRH	249	238	
BPR	213	242	
WND	210	265	
PRC	214	244	
LWR	221	279.5	
SWR	208	279.5	Aft on centerline.
SST	3604		SBE37.
Argos PTT	12785		IDs 15448, 15449, 15450.
Standalones:			
VWX	202	254	On centerline, front.
Lascar	10021028	198	PORT and MID buoy.
SBE39 AT	716	220	PORT side and FWD.
Rotronic HRH/AT	~~20202420~~ 12712277	241	Young shield . PORT and AFT.
Rotronic HRH AT	12718282	241	Barani shield. STBD and AFT

*Height above buoy deck in centimeters

2

ARRAY NAME AND NO. NTAS 17 MOORED STATION NO.________

Subsurface Instrumentation on Buoy and Bridle

Item	ID #	Depth†	Comments
SST SBE56	7206	80	FWD
SST SBE56	7207	90	FWD
SST SBE56	7208	90	PORT
SST SBE56	7209	90	STBD
WAMDAS	6014		NDBC # 26829
			IMEI 300224010100810
			SIM 89881 69312 00205 1278
			3DM-GX1 8470
			IR 6004 NDBC 25723
			NDBC Station 41060
			SIM SN 432 SIM IMEI 300224010237100
Xeos KILO			3002 3406 1853 510 (Subsfce)
Xeos MELLO			3000 3401 3707 580 (surface)

†Depth below buoy deck in centimeters

3

ARRAY NAME AND NO. NTAS 17 MOORED STATION NO.________

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
1		buoy			1442		
2	5	EM chain					
3		SBE39	5	3479	1436		
4		Nortek ADCM	5.7	12688	1436		
5	79	7/16" wire					
6		SBE37 IM	10	13409	1430		
7		Nortek ADCM IM	13	12309	1430		w vane, heads up
8		SBE39	15	7680	1430		
9		SBE39	20	7681	1430		
10		Nortek ADCP	24	12393	1430		
11		SBE 37 IM	25	13410	1430		
12		SBE39	30	7682	1430		
13		SBE 39	35	7683	1442		
14		SBE 37 IM	40	13411	1443		
15		SBE 39	45	7684	1443		
16		SBE39	50	7687	1448		
17		SBE37 IM	55	13412	1449		
18		SBE 39	60	7688	1450		
19		SBE 39	65	7689	1452		
20		SBE 37 IM	70	13413	1456		
21		SBE39	75	7690	1458		
22		SBE39	80	7691	1503		
23		RDI ADCP	85	23281	1507		No ADCP in cage (faulty instr/battery)
24	500	3/8" wire					
25		SBE39	90	7692	1508		

4

ARRAY NAME AND NO. NTAS 17 MOORED STATION NO.________

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
26		SBE 39	100	7693	1509		
27		SBE 39	110	7694	1511		
28		Starmon Oddi	110	5275	1511		
29		Starmon Oddi	120	5276	1512		
30		Starmon Oddi	130	5277	1513		
31		Starmon Oddi	140	5278	1514		
32		Starmon Oddi	150	5279	1515		
33		Starmon Oddi	160	5280	1516		
34	500	3/8" wire			1529		
35	500	3/8" wire			1544		
36	200	3/8" wire			1559		
37	100	3/8" wire			1605		} encapsulated termination.
38	200	7/8" nylon			1610		}
39	500	7/8" nylon			1635		
40	2000	3/4" nylon					
41	100	7/8" nylon					
42	1500	1" Colmega			1725		
43		Glass balls (56)			1820		~~||||~~ ~~||||~~ ||||
44		SBE37		11380	2038		} dualed on load bar.
45		SBE37		11381	2038		}
46	5	1/2" chain					
47		acoustic release		51915	2039		} dualed.
48		acoustic release		48277	2039		}
49	5	1/2" chain					
50	20	1" Samson Nystron					

5

ARRAY NAME AND NO. NTAS 17 MOORED STATION NO.________

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
51	5	1/2" chain			2053		
52		anchor			2053		7000 lbs dry (6000 lbs wet)
53							
54							
55							
56							
57							
58							
59							
60							
61							
62							
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72							
73							
74							
75							

Appendix 3: NTAS 17 Instrument Setup

Xeos MELO: (GPS position), setup on October 10 2017
Booting...
Xeos Technologies, Inc
GPS Datalogger, v2.0.0
Total records = 56370
Write address = 49952
Memory usage = 93.58 %
$DLoad -> download
$ERase -> erase all
Flash Bulk Erase...
Leaving download mode in 1 min

WAMDAS: (NDBC wave package)

```
------------------------------------
  Configuration Menu:
------------------------------------
  1  --  Change BuoyID (NTS17)
  2  --  Change Wave Acquisition Period (1hr(s))
  3  --  Change Wave Acquisition Start Time (30)
  4  --  Toggle ADCP (disabled)
  5  --  Toggle MET Acquisition (disabled)
  6  --  Iridium is (ON)
  7  --  Toggle Store Raw Data (enabled)
  8  --  Toggle Store Processed Data (enabled)
  9  --  Toggle DEBUG strings (ON)
 10  --  Change Remote Login Password (00000 )
 11  --  Set Magnetic Variation (-17.010000)
  0  --  Save Settings & Quit
------------------------------------
Enter parameter code:
0
 Out of Configuration mode Menu Mode
 WRITING CONFIGURATION TO EEPROM
Got a $CONFIG*
$CONFIG,  60,30,60,60,60,60,175*
------------------------------------
  Main Menu:
------------------------------------
  0  --  Exit to main program
  1  --  Directory
  2  --  Display Configuration
  3  --  Configuration Menu
  4  --  Test/Calibrate Sensors
  5  --  Quit to TOM-8 monitor
  6  --  Display error log
  7  --  Load Management
------------------------------------
Enter parameter code:
1
Directory of A:
R10_17.RAW       3,097,164 10-18-17 14:50
P10_17.PRO          30,702 10-18-17 14:53
R05_18.RAW       7,226,716 05-15-18 14:50
P05_18.PRO          71,638 05-15-18 14:53
   1,036,386,304 bytes free
------------------------------------
  Main Menu:
------------------------------------
  0  --  Exit to main program
  1  --  Directory
  2  --  Display Configuration
  3  --  Configuration Menu
  4  --  Test/Calibrate Sensors
  5  --  Quit to TOM-8 monitor
  6  --  Display error log
  7  --  Load Management
------------------------------------
Enter parameter code:
2
*******************************************************************
WAMDAS Software Version:      1.40
Parameter Table Byte Count:  40
*******************************************************************
***** System Settings *****
Station ID:           (NTS17)
Store Raw Data:         (Enabled)
```

Store Processed Data: (Enabled)
DEBUG strings: (Enabled)
Wave acquisition mode: (3DM-G)
Wave processing mode: (ARS)
Wave acq. period: (60)
Wave acq. time: (30)
Use ADCP: (No)
Use MET: (No)
Iridium is (ON)
Compact Flash Card Size : 1046855680
Compact Flash Available : 1036386304

Main Menu:
----
0 -- Exit to main program
1 -- Directory
2 -- Display Configuration
3 -- Configuration Menu
4 -- Test/Calibrate Sensors
5 -- Quit to TOM-8 monitor
6 -- Display error log
7 -- Load Management

Enter parameter code:

Subsurface Instrumentation: (next page)

NTAS 17 Subsurface

					SAMPLE START		SPIKE		
INSTRUMENT	SERIAL	IM ADDRESS	DEPTH (m)	SAMPLE RATE (s)	DATE	TIME	DATE	START TIME	STOP TIME
SBE 37 IM	13409	3	10	600	20180520	0100	2-Jun-18	17:27utc	17:42utc
SBE 37 IM	13410	4	25	600	20180520	0100	2-Jun-18	17:27utc	17:42utc
SBE 37 IM	13411	5	40	600	20180520	0100	2-Jun-18	17:27utc	17:42utc
SBE 37 IM	13412	7	55	600	20180520	0100	2-Jun-18	17:27utc	17:42utc
SBE 37 IM	13413	8	70	600	20180520	0100	2-Jun-18	17:27utc	17:42utc
SBE 37 Deep	11380		4962	300	20180520	0100	2-Jun-18	18:29utc	18:43utc
SBE 37 Deep	11381		4962	300	20180520	0100	2-Jun-18	18:29utc	18:43utc
SBE 39	3479		5	300	20180520	0100	2-Jun-18	17:51utc	18:08utc
SBE 39	7680		15	300	20180520	0100	2-Jun-18	17:51utc	18:08utc
SBE 39	7681		20	300	20180520	0100	2-Jun-18	17:51utc	18:08utc
SBE 39	7682		30	300	20180520	0100	2-Jun-18	17:51utc	18:08utc
SBE 39	7683		35	300	20180520	0100	2-Jun-18	17:51utc	18:08utc
SBE 39	7684		45	300	20180520	0100	2-Jun-18	17:51utc	18:08utc
SBE 39	7687		50	300	20180520	0100	2-Jun-18	17:51utc	18:08utc
SBE 39	7688		60	300	20180520	0100	2-Jun-18	17:51utc	18:08utc
SBE 39	7689		65	300	20180520	0100	2-Jun-18	17:51utc	18:08utc
SBE 39	7690		75	300	20180520	0100	2-Jun-18	17:51utc	18:08utc
SBE 39	7691		80	300	20180520	0100	2-Jun-18	17:51utc	18:08utc
SBE 39	7692		90	300	20180520	0100	2-Jun-18	17:51utc	18:08utc
SBE 39	7693		100	300	20180520	0100	2-Jun-18	15:57 utc	16:16 utc
SBE 39	7694		110	300	20180520	0100	2-Jun-18	15:57 utc	16:16 utc
SBE 56	7206		80	60	20180520	0100	2-Jun-18	16:32 utc	16:47 utc
SBE 56	7207		90	60	20180520	0100	2-Jun-18	16:32 utc	16:47 utc
SBE 56	7208		90	60	20180520	0100	2-Jun-18	16:32 utc	16:47 utc
SBE 56	7209		90	60	20180520	0100	2-Jun-18	16:32 utc	16:47 utc
Star-Oddi	5275		110	600	20180520	0100	2-Jun-18	19:24utc	19:46 utc
Star-Oddi	5276		120	600	20180520	0100	2-Jun-18	19:24utc	19:46 utc
Star-Oddi	5277		130	600	20180520	0100	2-Jun-18	19:24utc	19:46 utc
Star-Oddi	5278		140	600	20180520	0100	2-Jun-18	19:24utc	19:46 utc
Star-Oddi	5279		150	600	20180520	0100	2-Jun-18	19:24utc	19:46 utc
Star-Oddi	5280		160	600	20180520	0100	2-Jun-18	19:24utc	19:46 utc
Nortek ADCM	AQD12688		5.7				2-Jun-18	20:46 utc	21:04 utc
Nortek ADCM - IM	AQD12309	41	13				2-Jun-18	20:26 utc	20:42 utc
Nortek ADCP	AQD12393		24				2-Jun-18	21:36 utc	21:55 utc
TRDI 300 kHz	23281		85	180/3600	20180520	0100			

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16. Abstract (Limit: 200 words)

The Northwest Tropical Atlantic Station (NTAS) was established to address the need for accurate air-sea flux estimates and upper ocean measurements in a region with strong sea surface temperature anomalies and the likelihood of significant local air-sea interaction on interannual to decadal timescales. The approach is to maintain a surface mooring outfitted for meteorological and oceanographic measurements at a site near 15°N, 51°W by successive mooring turnarounds. These observations are used to investigate air-sea interaction processes related to climate variability. The NTAS Ocean Reference Station (ORS NTAS) is supported by the National Oceanic and Atmospheric Administration's (NOAA) Ocean Observing and Monitoring Division. This report documents recovery of the NTAS-16 mooring and deployment of the NTAS-17 mooring at the same site. Both moorings used Surlyn foam buoys as the surface element. These buoys were outfitted with two Air-Sea Interaction Meteorology (ASIMET) systems. Each system measures, records, and transmits via Argos satellite the surface meteorological variables necessary to compute air-sea fluxes of heat, moisture and momentum. The upper 160 m of the mooring line were outfitted with oceanographic sensors for the measurement of temperature, salinity and velocity.

17. Document Analysis a. Descriptors

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b. Identifiers/Open-Ended Terms

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