WHOI-2017-01

Woods Hole Oceanographic Institution

NTAS 16

Sixteenth Setting of the NTAS Ocean Reference Station
Cruise On Board RV *Endeavor*
January 21 - February 8, 2017
Narragansett, Rhode Island - San Juan, Puerto Rico

by

Sebastien Bigorre[1], Benjamin Pietro[1], Emerson Hasbrouck[1]

Woods Hole Oceanographic Institution
Woods Hole, MA 02543

July 2017

Technical Report

Funding was provided by the National Oceanic and Atmospheric Administration under Grant No. NA14OAR4320158.

Upper Ocean Processes Group
Woods Hole Oceanographic Institution
Woods Hole, MA 02543
UOP Technical Report 2017-01

1 Woods Hole Oceanographic Institution, Woods Hole, MA

WHOI-2017-01

NTAS 16
Sixteenth Setting of the NTAS Ocean Reference Station
Cruise on Board RV *Endeavor*
January 21 - February 8, 2017
Narragansett, Rhode Island - San Juan, Puerto Rico

by

Sebastien Bigorre, Benjamin Pietro, Emerson Hasbrouck

Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

July 2017

Technical Report

Funding was provided by the National Oceanic and Atmospheric Administration
under Grant No. NA14OAR4320158

Approved for public release; distribution unlimited.

Approved for Distribution:

Albert J. Plueddemann, 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 inter-annual 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-15 mooring and deployment of the NTAS-16 mooring. 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 R/V *Endeavor* (cruise EN590). The cruise took place between January 21 and February 8 2017. The NTAS-16 mooring was deployed on January 30, and the NTAS-15 mooring was recovered on January 31. A 24-hour inter-comparison period was conducted on January 29 in front of the NTAS 15 buoy, and again on February 1 in front of the NTAS 16 buoy. During the inter-comparisons, data from instrumentation on the buoys, telemetered through Argos satellite system, and the ship's meteorological and oceanographic measurements were monitored while the ship was stationed 0.2 nm downwind of the buoys. 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 EN590 consisted in the recovery and deployment of the Meridional Overturning Variability Experiment (MOVE) Pressure Inverted Echo Sounders (PIES) at two MOVE arrays (MOVE 1 in the east, and MOVE 3 in the west near Guadeloupe). Acoustic downloads of data from (PIES) and subsurface mooring (MOVE1, 3 and 4) were also conducted. MOVE is designed to monitor the integrated deep meridional flow in the tropical North Atlantic.

Table Of Contents

List of Figures

Fig No. **Page**

List of Tables

Table No. **Page**

I. Introduction

A. Timeline

The NTAS 16 cruise originated in Narragansett, Rhode Island on Monday January 21, 2017 and ended in San Juan, Puerto Rico on February 8, 2017. Planning waypoints for the cruise are shown in Table I-1. The track (Figure I-1) was set to first deploy the NTAS 16 mooring and then recover the NTAS 15 mooring. Comparison between the two buoys and ship's measurements was also planned. Next were PIES recovery and deployment, as well as acoustic downloads at MOVE 1. After transiting to the west towards Guadeloupe, we recovered and re-deployed a PIES at MOVE 3 and did acoustic downloads at MOVE 3 and 4. WHOI Upper Ocean Processes Group staff left Cape Cod and arrived in Narragansett on January 13, in preparation of the cruise. Departure for cruise EN590 had previously been planned for January 13th but there were delays at the dry dock where R/V *Endeavor* was being maintained. A change in the UNOLS policy also created further cost for the funding agency and the cruise was shortened one day, so departure ultimately occurred on January 21st. An overview of the chronology of the cruise is provided below. Local time on the ship during EN590 cruise started as UTC-5 and was changed to UTC-4 during the transit southeast until the end of the cruise. Science party is shown in Table I-2.

January 13-16, Friday-Monday: WHOI personnel arrive in Narragansett, RI to unload equipment, stage warehouse, assemble buoy, spin buoy, download and evaluate burn-in data. Buoy put into foam (Monday).

January 17, Tuesday: Ship arrives at the dock in the evening.

January 18, Wednesday: Ship loading starts. ASIMET standalones installed on ship. Argos telemetry running.

January 19, Thursday: Buoy brought down from warehouse to dock next to ship. Lab and deck lashing.

January 20, Friday: Rewind wire rope onto TSE winch. Benthos reps visit Jessica Durette (Scripps personnel for MOVE) onboard to improve connection between deck (add narrowband filter to remove noise from bubbles and ship engine) and a balance (ground wire) between Jessica's deck box and the ship's transducer.

January 21, Saturday: Depart Narragansett 15:00 UTC. SOG 12 knots; captain pushes engine to 170 rpm (usually 160 rpm) to make way ahead of storm forecast for Monday. Safety and orientation meetings.

January 22, Sunday: Crossed Gulf Stream in the late morning. SOG 11.5 kts to the SE; crabbing due to current to the left. Acoustic releases tested in air. Unbag PRCs, connect SSTs and put in bucket with seawater. 18:00 to 20:45 UTC CTD#1 with three acoustic releases; stop 500 m then at 2,000 m. One acoustic release did not talk. Back on deck, all releases have functioned.

January 23, Monday: Wooden box containing rope are broken due to green water on starboard rail. Rope rubbed on deck floor during the night and caused chafing; line will need to be cut in damaged areas and spliced back together. Rope is moved into nylon bag secured on centerline on back deck, behind TSE winch. Bucket with SSTs toppled; SSTs brought back inside. Second wooden box gets broken in afternoon; it is also moved behind TSE winch. Ship deviates from SE course to offer protection during deck work. Hasbrouck downloads data from two loggers and WXT in the meantime.

January 24, Tuesday: ASIMET data evaluation is good. WXT data record stops on 1/23 00:30 so will need to be checked in a few days with another data download. In late afternoon, turn starboard for quick work on deck to remove buoy vane to avoid potential damage during transit. SOG 8-9 kts, seas 10-13 ft with swell from SSE, winds ~25 kts from South then shift West. Squall with winds above 50 kts in morning; gale force winds again in evening.

January 25, Wednesday: Continue transit to NTAS site. SOG 9.5 kts, COG145°, wind 20-25 kts.

January 26, Thursday: In the morning, advance clocks one hour, to UTC-4. SOG 12 kts, wind 12 kts. Cascading connection of subsurface inductive sensors. Pietro cuts rope and starts re-splicing. First day with sun, so plan a data download in late day to evaluate SWR sensors. In evening, reinstalled buoy wind vane and removed SIM sensors from inductive line for the night.

January 27, Friday: Fire drill. SOG 11 kts. Move wooden boxes back to starboard rail, rearrange deck. Splicing continues. Bird wire on buoy tower. Spike ASIMET sensors and initialize cards.

January 28, Saturday: Transit continues. SOG 11.3 kts, winds 17 kts. Pietro turns on subsurface beacon for testing. Clamps and tape on instruments. Some clamps for SBE39s are missing so will use single clamps instead of double. Connect bellmouth to EM chain and ground to TSE winch, with one IM instrument on line. Pre-deployment walk through on fantail.

January 29, Sunday: Arrive near NTAS 16 target, but winds 25-30 kts with waves up to 10 ft. Cancel deployment. Move to NTAS 15 and drive by buoy for pictures (small bump on buoy vane with ship's stern). Stand by NTAS 15 for inter-comparison. CTD #2 around 14:00 UTC. Hasbrouck and Bigorre remove radiometers from 01 deck to check proper functioning and data, then re-install. CTD #3 at 18:12 UTC.

January 30, Monday: CTD #4 at 00:04 UTC. CTD #5 (250 m) at 09:00 UTC. Move to NTAS 16 target site for set and drift test. Prepare deck for deployment, install instruments on wire line, remove bulwarks. Track start will be 7.5 nm to WSW of target (75° course). Wind 25 kts, from 94°, but may drop as they did day prior. Currents ¼ - ½ kt to the east. Ship starts 8.5 nm from target as we slowly proceeds along track during preps. 14:14 UTC buoy in water, smooth launch. 14:40 UTC, last instrument (160 m) deployed. At 15:22 UTC still 6.6 nm from target. SOG 1.25 – 1.5 kts, COG 67°. Winds 15 kts, 103°. 17:25 UTC start Colmega. 20:13 UTC releases go over. 20:31 UTC anchor dropped at 14° 45.256', 50° 56.946' W.

January 31, Tuesday: Hove to overnight near NTAS 15 buoy. 11:00 UTC move near NTAS 15 anchor; winds 20-25 kts, 90°. NTAS 15 anchor released at 11:41 UTC. Buoy back onboard at 19:20 UTC. Clean deck, move back to NTAS 16. 23:12 UTC, CTD #6, 500 m near NTAS 16.

February 1, Wednesday: Hove to overnight near NTAS 16 buoy. 07:00 UTC, CTD #7 near NTAS 16, down to 500 m. 12:30 UTC drive by NTAS 16 for pictures and waterline (75 cm), followed by anchor survey. 16:00 UTC, CTD #8 to 500 m. Winds 22 kts, 71°, broken clouds. 22:00 UTC, CTD #9 to 500 m (prior to cast, marine tech Bill Faning inspected secondary CTD sensor which had wrong O2 and conductivity data on previous cast; back to normal on this cast). Last drive by NTAS 16, get telemetry data through Alpha Omega. 23:15 UTC leave NTAS site, transit towards MOVE 1.

February 2, Thursday: PIES 237 released at 07:20 UTC, spotted at surface at 09:20 UTC thanks to RF and flasher light. 09:45 UTC PIES 237 on deck. PIES 180 deployed at 11:24 UTC. NTAS 15 buoy tipped upright on fantail. 13:30 – 16:00 UTC anchor survey for PIES. A-coms at MOVE-1 but almost no data to download. A-coms at PIES 299 but no answer (same as last year). Around 21:00 UTC, Durette receive news from Scripps team to return to PIES 180 site as the data we downloaded indicates it was coming back up. When we are on site, RF signal from PIES is picked up and strobe light is visible in the dark. PIES 180 recovered, but floatation sphere is imploded, rubber gasket on transducer head is loose and PIES is not chirping.

February 3, Friday: Deployed PIES 198 at 13:06 UTC to replace failed PIES 180. 15:00 UTC anchor survey. A-coms with PIES 198. 19:30 UTC leave MOVE 1 site and start transit west towards MOVE 3.

February 4, Saturday: Transit to MOVE 3, SOG 11.1 kts, winds 14 kts, 103°. Downloading data from NTAS 15 instrumentation.

February 5, Sunday: Arrive at MOVE 3 around 22:00 UTC. A-coms start.

February 6, Monday: A-coms at MOVE 3 continue. By 08:00 UTC, half of subsurface mooring data has been downloaded. PIES 238 recovered and back onboard at 10:34 UTC. PIES 334 deployed at 11:13 UTC. At 12:46 UTC range on PIES is constant which means it reached the seafloor. Start downloading data from PIES 300. Anchor survey for PIES 334. Remove UOP standalone met sensors on ship. Arrive at MOVE 4 around 22:30 UTC; all mooring data quickly downloaded through A-coms. Leave MOVE site at 23:16 UTC and start transit towards San Juan.

February 7, Tuesday: Transit to San Juan, SOG 11 kts. Remove GPS antenna from 01 deck. Pass Anegada passage and turn towards Puerto Rico at 23:07 UTC.

February 8, Wednesday: Arrive San Juan, Puerto Rico at 10:00 UTC. Pick up pilot at 10:30 UTC. At 12:00 UTC docking at Miramar, gangway installed ½ hour later. Unloading starts.

Figure I-1. NTAS 15 cruise itinerary Narragansett – NTAS 15 and 16 – MOVE 1, 3 and 4 – SanJuan, Puerto Rico.

Table I-1. Waypoints used for planning of NTAS 16 cruise.

Way-point	Latitude (dd mm.mm N)	Longitude (dd mm.mm W)	Expected Date, Time (local)	Description
1	41 29.53	71 25.12	1/21/17 10:00	Narragansett (departure)
2	TBD	TBD	1/22/17 16:00	Release test and CTD test cast
3	TBD	TBD	1/29/17 8:00	NTAS 16 deployment start site
4	14 45.00	50 57.00		NTAS 16 anchor target
5	15 27.11	51 30.00	1/31/17 11:00	MOVE 1 mooring acoustic data offload
6	15 27.93	51 30.83		MOVE 1 PIES#299
7	15 27.00	51 31.65		MOVE 1 PIES#237
8	14 49.50	51 00.978	2/3/17 8:00	NTAS 15 anchor
			2/3/17 16:00	Leave NTAS site
9	16 33.00	57 54.00		Dominica EEZ jog
10	16 21.34	60 29.78	2/5/17 22:00	MOVE 3 PIES#300
11	16 20.30	60 29.33		MOVE 3 PIES#238
12	16 20.14	60 30.36		MOVE 3 mooring acoustic data offload
13	16 19.85	60 36.45	2/6/17 19:30	MOVE 4 mooring acoustic data offload
			2/7/17 0:00	End science ops, depart to San Juan
14	17 55.50	64 56.00		between US and British Virgin islands
15	18 24.00	65 33.00		between PR and isla Culebra
16	18 30.00	66 08.00	2/8/17 10:00	in front of San Juan
17	18 27.63	66 05.44	2/8/17 11:00	Navy Frontier Pier, San Juan, PR (arrival)

Table I-2. Scientific personnel during EN590 cruise.

Name	Function	Affiliation
Bigorre, Sebastien	Chief Scientist	WHOI
Durette, Jessica	Technician	SIO
Graham, Raymond	Technician	WHOI
Hasbrouck, Emerson	Instrument Lead	WHOI
Pietro, Benjamin	Deck and Logistics Lead	WHOI

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 16 mooring turnaround was achieved on the research vessel R/V *Endeavor*, Cruise EN590, by the Upper Ocean Processes Group (UOP) of the Woods Hole Oceanographic Institution (WHOI). One person from Scripps Institution of Oceanography (SIO) was also aboard to partially service the MOVE array (recover and deploy two Pressure and Inverted Echo Sounder (PIES) devices and download data from subsurface moorings and PIES through acoustic telemetry).

The cruise was completed in 18 days, between January 21 and February 8 2017. It originated from Narragansett, Rhode Island and terminated in San Juan, Puerto Rico. The planned cruise waypoints are shown in Table I-1. The primary objectives were:

- To deploy the NTAS-16 mooring.
- To log data from the NTAS-15 buoy and R/V *Endeavor* shipboard meteorological sensors during an inter-comparison period during which a sequence of CTD casts would also be made.
- To recover the NTAS-15 mooring.
- To do an inter-comparison between the NTAS-16 buoy and R/V *Endeavor* shipboard data (meteorological sensors and CTD cast).
- To recover a PIES and deploy a new PIES at the MOVE 1 site.
- To retrieve data via acoustic link from PIES and subsurface mooring at the MOVE-1 site.
- To recover a PIES and deploy a new PIES at the MOVE 3 site.
- To retrieve data via acoustic link from PIES and subsurface mooring at the MOVE-3 site.
- To retrieve data via acoustic link from subsurface mooring at the MOVE-4 site.

II. Cruise and Instrument Preparations

A. Staging and Loading

Pre-cruise operations were conducted at WHOI and at the pier in Narragansett, Rhode Island. Instrumentation (sensor, telemetry) was tested at WHOI during burn-in from November to December 2016. Buoy and instrumentation were then shipped from Woods Hole, Massachusetts, to Narragansett on January 12 2017. The WHOI equipment, including NTAS 16 buoy, were delivered by a 5302 box truck and WHOI's Ford flatbed truck at a warehouse near the pier in Narragansett the next day. Three WHOI personnel unloaded and staged the equipment in the warehouse to begin assembly of the buoy (hardware, electronics) with some protection from wind and low temperatures. Buoy was turned on the same day and stored inside the non-heated warehouse at night. Buoy spin occurred on Sunday January 15. Data was downloaded and evaluated the next day. Some of the data did not look promising but it was suspected that local near freezing temperatures were the cause. The WHOI team returned to Woods Hole on Tuesday for other projects that needed attention, and R/V *Endeavor* moored at the pier late that day after sea trial following a maintenance period at the yard and refueling. On Wednesday January 18, WHOI standalone instruments (HRH on bow mast, SWR and LWR on rail of 01 deck crane) were mounted on ship. Argplot system was installed on the ship and communications with NTAS 16 buoy started while ship's loading continued. The buoy was brought on the pier next to the ship and a SBE 37 was connected to the inductive line to check the telemetry messages. On Thursday, no subsurface inductive telemetry messages had come through so the buoy was placed upright and the buoy well was opened to power cycle the inductive modem; throughput then resumed normally. Buoy was loaded on starboard side of ship fantail and tilted back. Ship was loaded with equipment for the cruise (spare wires, glass balls, tension carts, capstan, anchor, rope baskets, lab gear). Standalone HRH was mounted on ship's bow mast. Equipment in the science laboratories was lashed on January 19. Friday January 20, the TSE winch was winded with wire. Ship departed for cruise EN590 on January 21 2017 at 10:08 EST.

B. Buoy Spin

The buoy spin was conducted in Narragansett on January 15 2017. 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 eight different angles with respect to the reference and the vanes of the anemometers are visually oriented and blocked towards the reference direction. Data from the wind sensor 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 or the environment. Buoy spin results are shown in Figure II-1, where wind direction and compass errors are plotted as a function of buoy orientation. The compass error recorded in this manner during past buoy spin procedures, have usually exhibited a sinusoidal curve, which is the case here for wind sensor on logger 12. Note that values when buoy was oriented at 270° were not recorded and are missing in the plots. Compass errors from ASIMET wind sensors and Vaisala WXT are for the

most part within or close to the +/- 5° quality threshold used by the Upper Ocean Group. For details of the buoy spin, see Appendix 1: NTAS 16 Buoy Spin.

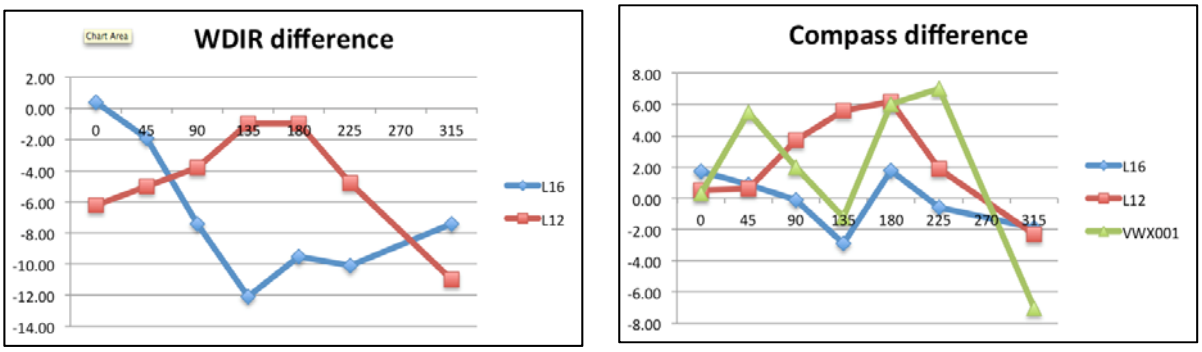


Figure II-1. NTAS 16 buoy spin on January 15 2017 in Narragansett, RI. Left: difference (in degrees) between wind direction from wind sensors on loggers L16 and L12, and line-of-sight reference. Right: difference between wind sensors (including VWX001) compasses and reference. X-axis: angle (in degrees) between buoy and line-of-sight reference.

C. Antifouling

E-Paint's products have been refined to best suit WHOI's wishes for effective products that remain relatively safe to apply. Treatment of the NTAS 16 mooring was as follows:
One gallon of grey E-Primer 1000 provided two coats on the Surlyn foam buoy hull, and aluminum bottom plate. One gallon of blue E-Paint Ecominder was applied in the same areas. Pasco PVC tape was wrapped around the housing of the SSTs mounted to the bottom base plate of the buoy and every instrument down to 80 meters. Copper guards were used on the SBE 37 instruments starting at the SST and going down to 70 meters. Desitin was also used on the cells, avoiding the entrance of the conductivity cells. Sea surface temperature probes were inserted into the hull and Green Aqua Lube was applied to the heads of the probes. Both Norteks and the Workhorse ADCP had Desitin applied to the transducers heads. Details are in Appendix 4: Antifouling on NTAS 16.

On the buoy tower, bird wire was applied to the tower perimeter, precipitation sensors including the Vaisala WXT and in the middle of the radiometers cluster.

NTAS 15 showed no significant signs of bio fouling. Recommendations for the following years will be to use just Desitin on the heads of the ADCP and other transducer heads. No tape is necessary on any of the instruments on the wire. Tape is still required on the SST. For further recommendations, see section "Notes" section at the end of this cruise report.

III. NTAS 16 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 16 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 16 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.

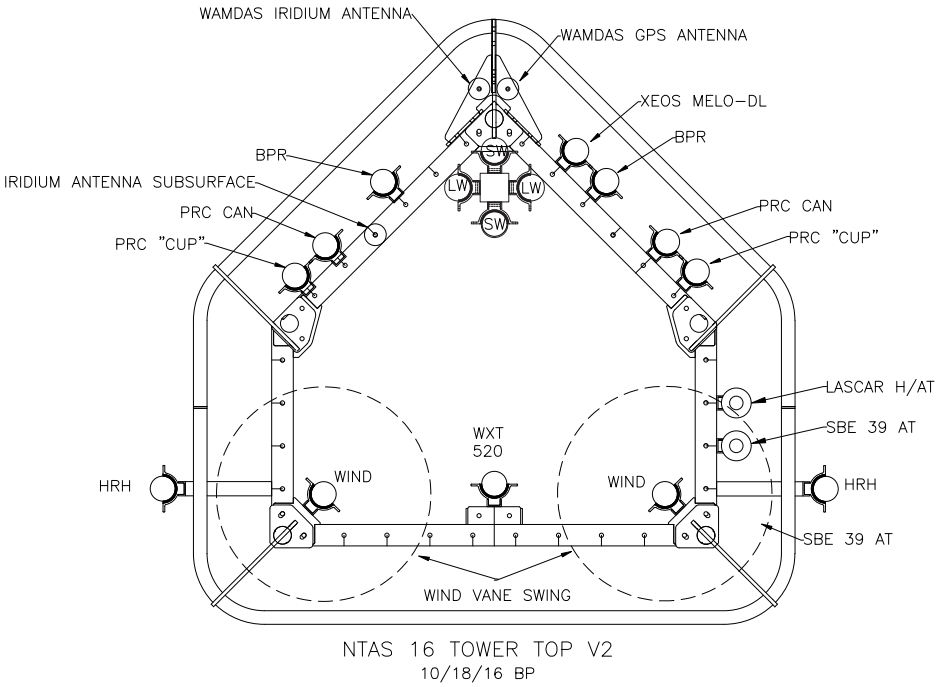


Figure III-1. Top view schematic of the meteorological tower on the NTAS 16 buoy with the location of the ASIMET and other instruments.

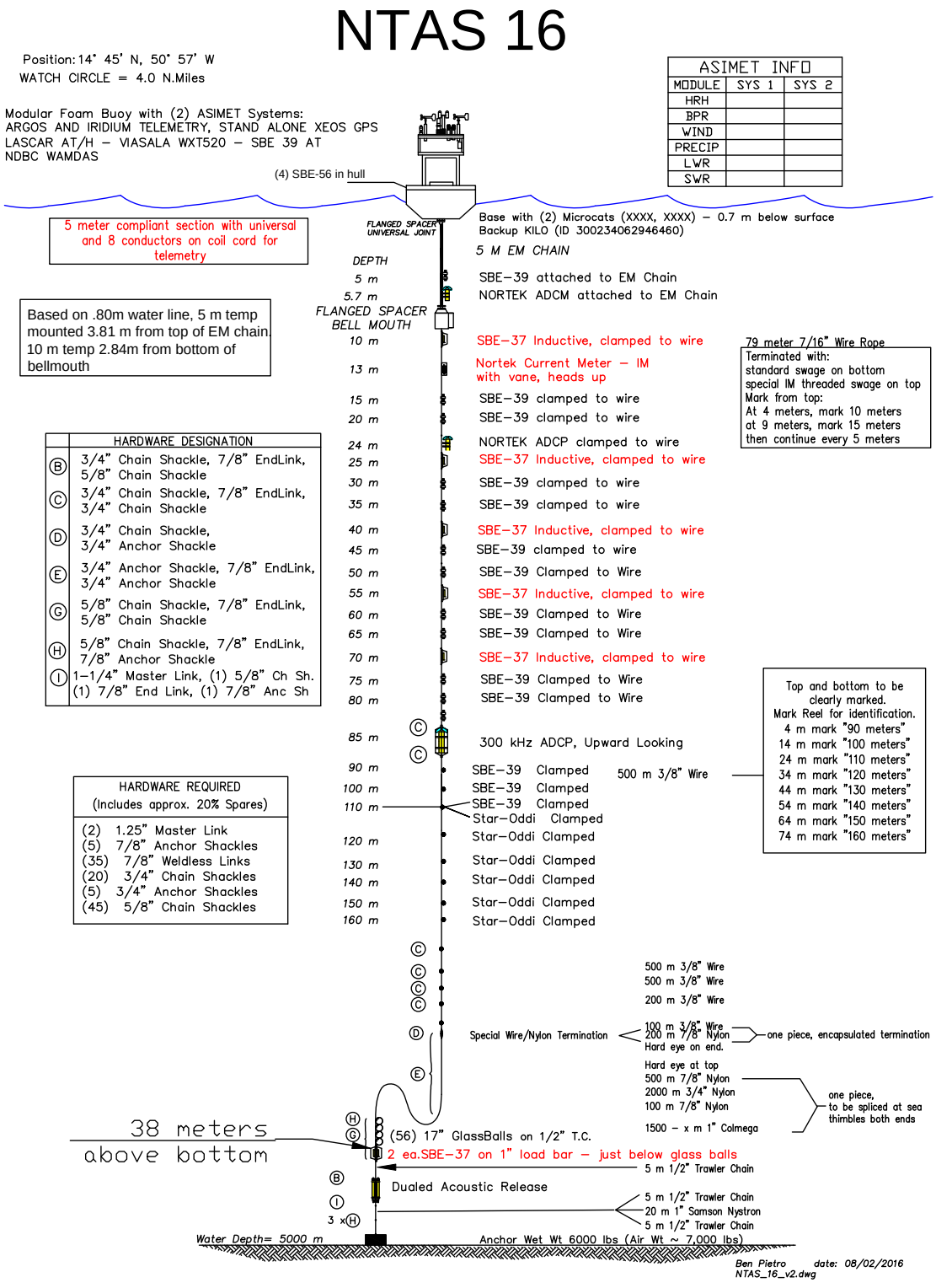


Figure III-2. NTAS 16 mooring diagram.

B. Deployment

In preparation for the deployment of NTAS 16, the ship ran a set and drift test. The winds were 25 kts from the east and the ship ADCP showed a current of ¼ to ½ knot current to the east. Due to the current and wind the ship needed to keep a speed of 1.25kt over the water to keep its course (~ 75° T). We therefore started ~8 nautical miles downwind of the target site (in the past 2 years, the deployment track was 6 nm). During the set and drift and repositioning at the track start, the last preparations on the fantail were done, including applying Desitin to the instruments.

Deployment started with the buoy pick up after breakfast and the buoy was in the water at 14:14 UTC (10:15 local time). Around 10:45 local the wire-nylon termination was deployed. Glass balls were over at 14:05 local. The anchor was deployed at 16:31 local (20:31 UTC) at 14° 45. 256' N, 50° 56.946' W.

Prior to deployment, three sections of bulwark were removed as well as a vent pipe. The 79 m 7/16'' wire rope was payed out through the center of the A-frame, around the starboard quarter and down the rail. The wire rope was fair lead under the 5 meter EM chain. The top of the 7/16'' IM wire rope was bolted to the bell mouth frame.

Roughly 45 meters were payed out from the TSE winch and faked out on deck. The upper 45 meters of instrumentation were attached to the wire rope as designated per the mooring design. The 01 crane was used for the deployment of the surface buoy. Roughly 50 feet of boom was needed. The crane's headache ball was attached to the Peck & Hale release and then attached to the lifting bail of the buoy. Three slip lines were used to control the buoy while deploying. One reeved around the buoy base leg, which was slipped first. Second to be slipped was the tower top, which was reeved around a D-handle. Last to be slipped was the mid section tag line that was reeved through a D-handle on the buoy well.

The bell mouth and EM chain were eased into the water using a slip line and the knuckle boom crane. The EM chain settled aft to the buoy. The crane took up the slack and the remaining aircraft straps securing the buoy were cleared. The crane lifted the buoy roughly one foot off the deck and swung to outboard. When the buoy was clear of the ship, the crane boomed down lowering the buoy to the water. Once the buoy settled in the water, the Peck & Hale was released. As the buoy came astern, personnel that were positioned along the starboard rail and starboard quarter slipped the wire rope to the buoy. When the 45 meters of line faked on the deck was deployed, the wire rope was placed in the red Gifford snatch block.

As the winch payed out the wire, instrumentation was clamped onto the wire at designated depths. At the end of the 79-meter shot, the mooring was stopped off and the ADCP cage was shackled to the wire. The winch hauled in taking the load from the stopper line. The stopper was eased off and cleared. The remaining instruments were clamped onto the upper 500-meter shot of wire rope. The winch continued to pay out the remaining 1,700 meters of wire rope. The wire to nylon boot and remaining nylon was payed out.

The stopper line was hooked into the link at the end of the nylon and made fast to the deck cleat. The H-bit was bolted into position and the upper nylon shot from the wire basket was shackled to the link from the 200-meter nylon shot. The H-bit was dressed with 4 turns initially and the stopper line was eased off and cleared. All the nylon and Colmega was payed out using the H-bit. With roughly 10 meters of Colmega remaining in the box, a Yale grip was placed onto the Colmega and the stopper line was attached to the Yale grip and made fast to the deck cleat. The remaining Colmega was removed from the H-bit and wound onto the TSE winch. The stopper line was removed and the remaining line was payed out. At the end of the Colmega the mooring was stopped off and the first section of the 56 glass balls were shackled into place. A stopper line and TSE winch leader were used together to purse out the glass balls. At the end of the glass balls, a load bar with two dual SBE 37's was shackled to the end of the chain. A 5-meter shot of chain was shackled to the load bar. The end of the chain shot was shackled to the winch leader, as the winch took up slack; the stopper line was eased off and cleared. The large air tugger line was reeved through the center block on the A-frame and a chain hook was shackled into place. The chain hook was dipped into a link roughly a meter below the load bar. The tugger hauled in, lifting the load bar and cage off the deck. The A-frame boomed out while the winch payed out keeping the load level. Once the frame was cleared off the stern, the tugger payed out lowering the frame. The hook was removed and the winch payed out the 5-meter shot of chain. The dual Edge Tech releases were shackled to the bottom of the 5-meter shot. A 5-meter shot of chain was shackled to the master link. The winch tag line was shackled into a link near the bottom of the shot. The tugger line with the hook was now placed on the 5-meter shot below the releases. The tugger hauled in, lifting the releases off the deck. The A-frame was boomed out while the tugger payed out lowering the releases over the stern. The stopper line was shackled into the 5-meter shot and made fast and the winch leader was removed.

A 50-foot ¾" nylon slip line reeved through the 7/8" link, which was shackled to the 20-meter shot of 1" Samson Nystron. The two ends of the slip line were tied with a bowline knot to the winch leader. The slip line and the 20-meter shot of Nystron were wound on the winch. The 5-meter ½" chain from the releases was shackled to the 20-meter shot of Nystron. The 5-meter shot was shackled to the 7,000 lbs. anchor. The chain lashings on the anchor were removed, and an expendable backstay was rigged on the anchor to secure it. When the end of the 20-meter shot of 1" Nystron was near the ½" chain from the anchor, the winch stopped so the connection could be made between the two. Payout continued until anchor had the load. The 3/4" slip line was removed from the winch leader and was slowly slipped out through the 7/8" link. The TSE winch leader was reeved through the block and shackled into the tip plate bridle. As the ship approached the launch site, the backstay was cut, the winch hauled in and the tip plate raised enough to let the anchor slip into the water.

C. Anchor Survey

NTAS 16 anchor was dropped at 14 45.256' N, 50 56.946' W on January 30 2017 at 20:31 UTC. An acoustic survey of the anchor position of NTAS 16 was carried out on February 1 2017. The three triangulating positions were occupied in a triangular pattern (see Table III-1) around the drop site. WHOI's Edgetech 8011M deck gear was used with the ship's transducer (5 m below the waterline) to range on one of the mooring releases. The releases are about 31 meters above

the anchor, which rests on the seafloor. The ship's 12 kHz echo-sounder measured the water depth as 5002 m in the area of the anchor. Correcting for local speed of sound (1511 m s^{-1}), the water depth is 5040 m. Triangulation using the horizontal range to the release from the three sites, gave an anchor position of 14□ 45.211' N, 50□ 57.052' W (in decimal convention 14.7535 N, 50.9509 W). Fallback from the drop site was 208 m or 4.1% of the water depth (Table III-2).

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

Waypoint	Latitude	Longitude	Travel time (s)
1	14° 45.546' N	50° 58.503' W	7.511
2	14° 46.429' N	50° 55.923' W	7.752
3	14° 43.819 N	50° 56.463 W	7.586

Table III-2. NTAS 16 anchor coordinates based on acoustic survey.

Anchor Drop	14 45.256' N	50 56.946' W
Anchor position, Newhall's code	14° 45.211' N	50° 57.052' W
Depth at anchor position	5002 m (12 kHz)	5040 m (corrected)
Fallback	208m	4.1% water depth

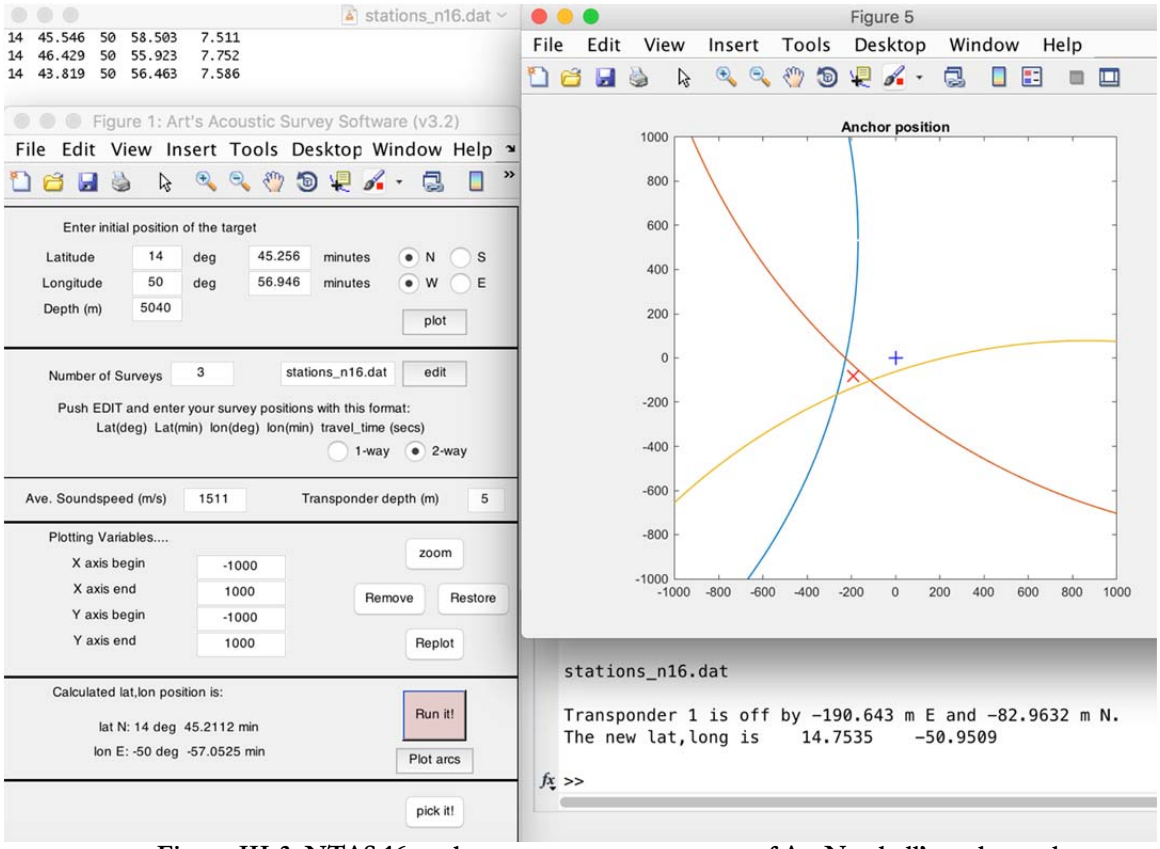


Figure III-3. NTAS 16 anchor survey: screen capture of Art Newhall's code results.

D. NTAS 15 and NTAS 16 Inter-comparisons

Details of the inter-comparison between the two buoys NTAS 15 and 16 and the ship's measurements are presented in detail in a separate report (NTAS15_Intercomparison.docx). The results of the intercomparison analysis from that document are repeated below.

Only one ASIMET HRH (system 2, logger 6, HRH#257) was still working normally on NTAS 15 at recovery. This sensor was low compared to all other measurements (ship sensor, SA UOP sensor on bow mast on ship, both ASIMET sensors on NTAS 16). During intercomparison, the humidity values were in the 60-70 %RH range. The SA UOP humidity sensor on the ship may have been biased a bit high. Compared to other sensors, the observed low bias on HRH#257 was roughly -4%RH. Since it is the only ASIMET sensor that performed through the whole duration of NTAS 15 deployment, the HRH dataset will need to be looked at carefully. Post-calibration for HRH#257 is highly recommended.

Air temperature (ATMP) was gathered from same sensors as HRH. ATMP from HRH#257 on NTAS 15 (system 2, logger 6) compared well with ship's measurements during intercomparison with ship on 1/29/2017. The next day when both buoys were in the water, there was indication that ATMP from HRH#257 was low by about 0.1 Celsius, which is within the tolerance usually used by UOP. However, some of this apparent bias may have been caused by physical separation when ship and NTAS 16 were far from NTAS 15.

Sea surface conductivity (SSC) was still recorded by both ASIMET systems on NTAS 15. System 2 (logger 6, port side, SST#3604) had large low bias compared to all measurements (system1 on NTAS15, systems 1 and 2 on NTAS16 and ship). Compared to other sensors, the observed low conductivity bias on SST#3604 was roughly -0.06 S m^{-1}. Sea surface temperature (SST) showed no bias during intercomparison.

Wind speed (WSPD) measurements all agreed within tolerance. System 1 (logger 5, WSPD#241) on NTAS 15 was about 0.16 m s^{-1} low compared to system 2 (logger 6, WSPD#239) on NTAS 15; it also tended to be lower than both systems on NTAS 16 although there was more variability there to extract a clear bias. Some of the bias may be due to flow distortion, and does not necessarily represent a problem with the instrument per se.

Longwave radiation (LWR) ASIMET sensors agree with each other on each buoy. The ship's sensor has higher values than other measurements. The UOP SA mounted on the ship agrees well with system 2 (logger 6, LWR#208) on NTAS 15. System 1 (logger5, LWR#205) on NTAS 15 is lower than system 2, with a consistent bias -4 W m^{-2}, but on the other hand agrees slightly better with sensors on NTAS 16. Both systems on NTAS 15 are about 7 to 10 W m^{-2} higher than systems on NTAS 16 when the two buoys were in the water. But this may be caused by real environmental differences. The small bias between the two ASIMET on NTAS 15 is close to the UOP tolerance.

Short wave radiation (SWR) ASIMET sensors agree with each other on each buoy. The two ASIMET SWR on NTAS 15 agree within 15 W m^{-2}. Difference with values from NTAS 16 are

within 22 W m^{-2}. The UOP SA mounted on the ship tends to be higher than other measurements. The ship's sensor tends to be a bit low compared to ASIMET SWRs.

Wind direction (WDIR) measurements agree well between all platforms. On NTAS 15, system 1 was about 8 degrees lower than system 2. This may be the effect of flow distortion on the buoy. The local magnetic deviation being -17.1 degrees, it explains the difference seen between buoy measurements, which are referenced to magnetic North, and the ship's one, which are relative to true North.

Barometric pressure (BPR) values are all very close to each other. The telemetry data from NTAS 16 has low resolution due to limited bandwidth. The ship's values are low but this may be because they were already adjusted to a standard height by the ship's processing.

Precipitation measurements from two ASIMET systems on NTAS 15 agreed prior to recovery and captured rain event on 1/30/2017. Logger 5 (system 1) on NTAS 15 precipitation was in good agreement with the WXT, although strong evaporation lowered its level during dry periods. Logger 6 has some trouble capturing a few rain events (1/17, 1/18), over-estimated some events (1/19, 1/23) and collected bad data (1/7 through 1/12).

Telemetry data from subsurface instruments was compared to CTD casts near NTAS 15 and NTAS 16. Salinity at 25 m (SBE37#13410) on NTAS 15 was higher than CTD casts. Salinity values at 10 m and 40 m tended to be higher as well, although not as much. Similar comparison with NTAS 16 showed better agreement with CTD casts. Subsurface temperature telemetry data on NTAS 15 agreed well with CTD casts (see figures Figure V-1 to Figure V-4).

IV. NTAS 15 Recovery

A. Mooring Recovery

The NTAS 15 mooring was recovered on January 31, 2017. Winds were 20-25 kts and from the East. Currents were weak near the surface and to the Southeast. Deeper currents (below 200 m) were about ¼ kt to the North, according to ship's ADCP. Recovery was initiated with R/V *Endeavor* positioned approximately ¼ mile upwind (North Northeast) of the anchor position while the acoustic release was fired (at 11:41 UTC) to separate the anchor from the mooring line. At 12:35 UTC the glass balls were spotted at the surface, 300 to 400 yards dead astern of the ship. At 12:55 UTC, the ship maneuvered to the cluster of balls. The TSE winch leader was reeved through the center block and passed forward along the starboard rails. The 5-ton titanium hook pendent was shackled to the leader. With the cluster of balls along the starboard side, the titanium hook snapped into a section of chain at 13:10 UTC. The ship moved ahead slowly allowing the cluster to come astern. When the cluster was centered behind the ship, hauling began (13:15 UTC).

As the balls came on board, stopper and air tugger lines were attached to the chain. The TSE lowered the balls on deck. The clusters of balls were disconnected and placed into the wire baskets. Of the 56 glass balls recovered, only one was broken. The TSE was used to recover the pair of Microcats deep sensors on the load bar and the dual releases. The large snatch block was raised off the deck using the large air tugger. A ¾" nylon line was tied with a bowline to the thimble on the Colmega and fed around the capstan head six times. The capstan picked up the load from the stopper line and approximately 4,100 meters of Colmega and Nylon were recovered from the capstan. The recovered synthetic was fed into a composite nylon bag that was inserted into wood lined baskets. The TSE winch leader was used to take the load from the capstan when the special wire to nylon termination came up threw the block (17:10 UTC). After the nylon was cleared off the capstan the TSE recovered the majority of the remaining wire, stopping periodically to remove instruments that were clamped onto the mooring wire.

At the RDI ADCP section of the mooring (85 m depth), the ADCP was stopped off using a stopper line and removed (18:09 UTC). The tension or the mooring was passed back to the TSE and recovery of the mooring resumed. After the 45-meter SBE39 was recovered (18:22 UTC), wire cutters were used to cut the 7/16 wire to set the buoy adrift.

It took approximately 30 minutes to rearrange the deck and get the ship into position to recover the buoy. The ship re-positioned to have the buoy come along the starboard side. The crane had roughly 20 feet of boom extension out. The 5-ton hook snapped into the lifting bail of the buoy (19:15 UTC) and the soft eye of the pendent was hooked to the crane. The crane hauled in lifting the buoy out of the water. Air tuggers were attached to tagline bails to reduce rotational movement while recovering. The crane swung the buoy inboard and once on deck (19:20 UTC), the capstan was used to pull the bottom half of the buoy and EM chain inboard (Figure IV-1). Once the buoy was safely on deck it was secured using eyebolts and ratchet straps. The knuckle boom crane was then used to recover the 5-meter EM chain and bell mouth. After the bell mouth was on board, the remaining portion of the wire rope and instrumentation was recovered by hand. Last instrument (SBE 37 IM at 40 m depth) was recovered at 19:36 UTC.

Figure IV-1. NTAS 15 buoy recovery.

B. Instrument Performance

The data return from instrumentation recovered on NTAS 15 is detailed in the initial data processing report (NTAS15InitialDataProcessing.docx). A brief overview is given here and some pictures are shown of the condition of instruments at recovery.

- Nortek current meters collected data for the whole duration (364 days) of NTAS 15:
  - Aquadopp #12309 (13 m) instrument's heading and current direction were well correlated. This is surprising as they should be 180° if the instrument was truly heading
  - based on pressure data they collected, Aquadopp current meter SN 12309 (13 m) and Aquadopp profiler SN12393 (24 m), these two instrument were 1 m deeper than target depths.
- Conductivity from SST sensor SBE37#3604 (logger 6) seemed to have a low drift.
- SOLO SN 100036 (in buoy hull's foam) has a RMSE about 10 times higher and biases low; this may be due to the fact that this sensor was located in the buoy hull and may have been in the air during parts of the deployment.
- On logger 6, precipitation PRC had downward spikes towards the end of the deployment but seemed to match PRC from logger 5 otherwise. Salinity SAL has downward spikes mid-deployment. Salinity comparison between the two loggers shows an increasing offset.
- On logger 5, LWR had a gap in data during the summer 2016. ATMP and HRH exhibit numerous spikes after October 2016.
- Data in logger 5 (system 1) has many spikes in ATMP and HRH, but the data in the corresponding module (HRH/ATMP232) is present and looks good during the logger spikes.
- Data in logger 5 (system 1) has many spikes in LWR and periods with constant values. Corresponding data in modules (LWR 205) is missing during these periods.
- Lascar data record ends prematurely, on July 30 2016.
- Multiple spikes are present in the WXT data for all variables. These spikes are concomitant across variables (power outages? card writing failures?).

Figure IV-2. NTAS 15 recovered RDI ADCP (SN 23281, 85 m).

Figure IV-3. NTAS 15 recovered SBE 37 instruments: top left and right (SN 13413, depth 70 m), center left (SN 13411, 40 m), bottom left (SN 13410, 25 m), bottom right (SN 13409, 10 m).

Figure IV-4. NTAS 15 recovered Nortek instruments. Top, SN 12393 (ADCP at 24 m); Middle, SN 12309 (ADCM at 13 m); Bottom, SN 12688 (ADCM at 5.7 m).

Figure IV-5. NTAS 15 SOLO T recovered. From top to bottom: SN 10036 (forward, up), SN 10037 (forward, low), SN 10038 (starboard), SN 10035 (port).

V. Ancillary Work

A. CTDs

During the NTAS 16 cruise, nine CTD casts were operated. The first one was located just after crossing the Gulf Stream as R/V *Endeavor* was transiting from its homeport in Narragansett to the work site at NTAS. This first cast served as a test for the acoustic releases that were to be deployed on the NTAS 16 mooring. Four CTDs were done near the NTAS 16 and 15 buoys each (Figure V-1 through Figure V-4). Locations and times of the CTD casts are summarized in Table V-1.

Table V-1. Time and locations of the CTD casts made during the NTAS 16 cruise.

CTD #	Event or Site	Date and Time (UTC)	Latitude	Longitude	Depth (m)
1	Release test	1/22/17 18:18	37° 00.46'N	67° 43.34' W	2,000
2	N15	1/29/17 13:46	14° 49.62' N	51° 03.16' W	511
3	N15	1/29/17 18:13	14° 49.57 N	51° 03.25' W	501
4	N15	1/30/17 00:04	14° 49.67' N	51° 03.40' W	501
5	N15	1/30/17 09:06	14° 49.49' N	51° 03.10' W	251
6	N16	1/31/17 23:11	14° 45.11' N	50° 59.31' W	505
7	N16	2/1/17 11:11	14° 45.34' N	50° 59.08' W	501
8	N16	2/1/17 16:08	14° 45.54' N	50° 59.21' W	500
9	N16	2/1/17 22:04	14° 45.80' N	50° 59.12' W	501

The ship's CTD sensor used during the cruise was a SBE911plus instrument connected to a SBE11plus deck unit. The SBE911plus was outfitted with dual temperature and conductivity sensors that were calibrated between December 13 and 15 2016. Additional sensors included the pressure (cal. in November 2016), dual oxygen sensors (cal. December 2016). Primary conductivity sensor was advanced by 0.073 second in the ship's suite of Seabird's processing codes.

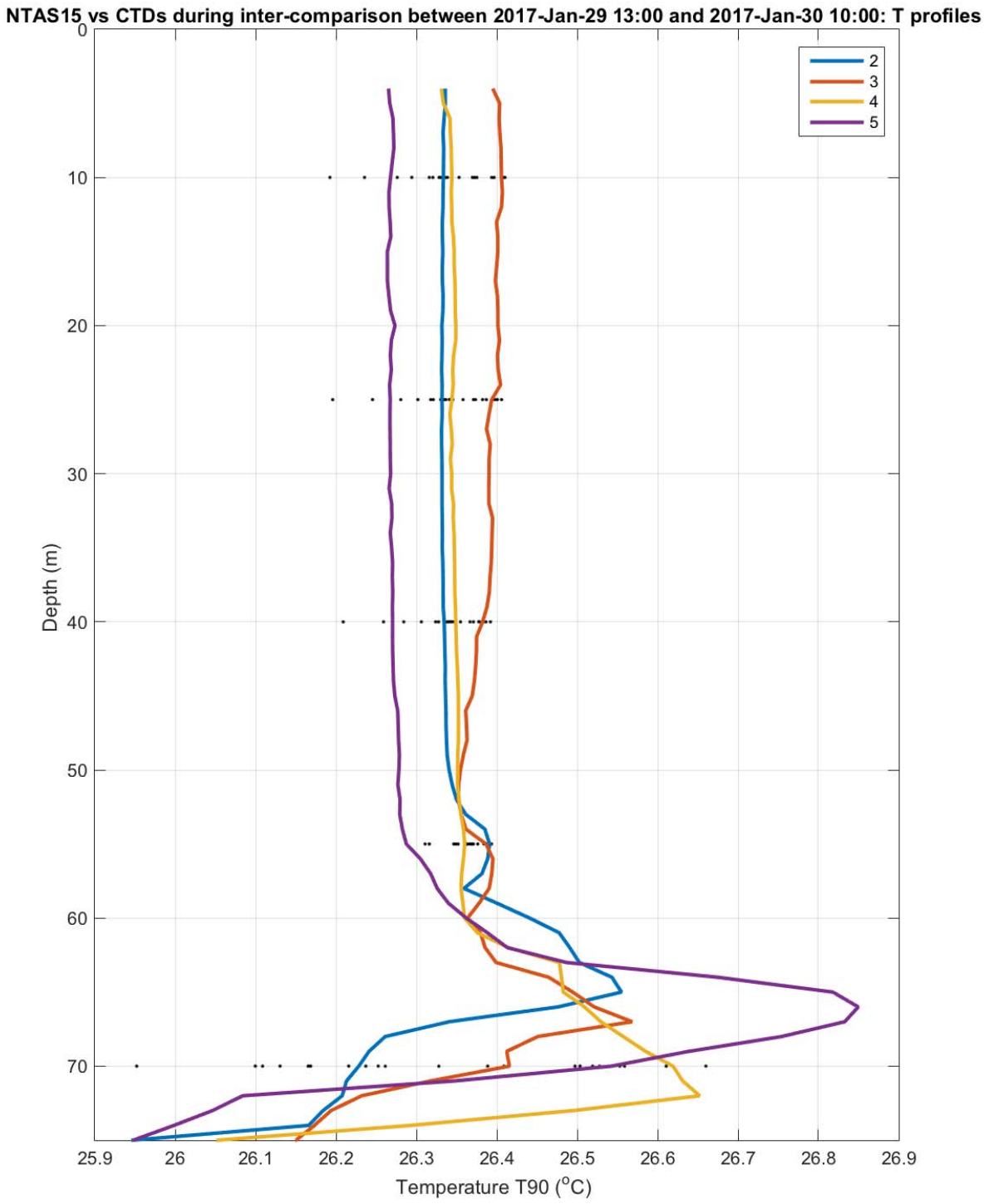


Figure V-1. In-situ temperature profiles from CTD casts (colored lines) made near NTAS 15 buoy during cruise EN 590. Black dots represent measurements from instruments on NTAS 15 mooring line at the depth shown on the y-axis.

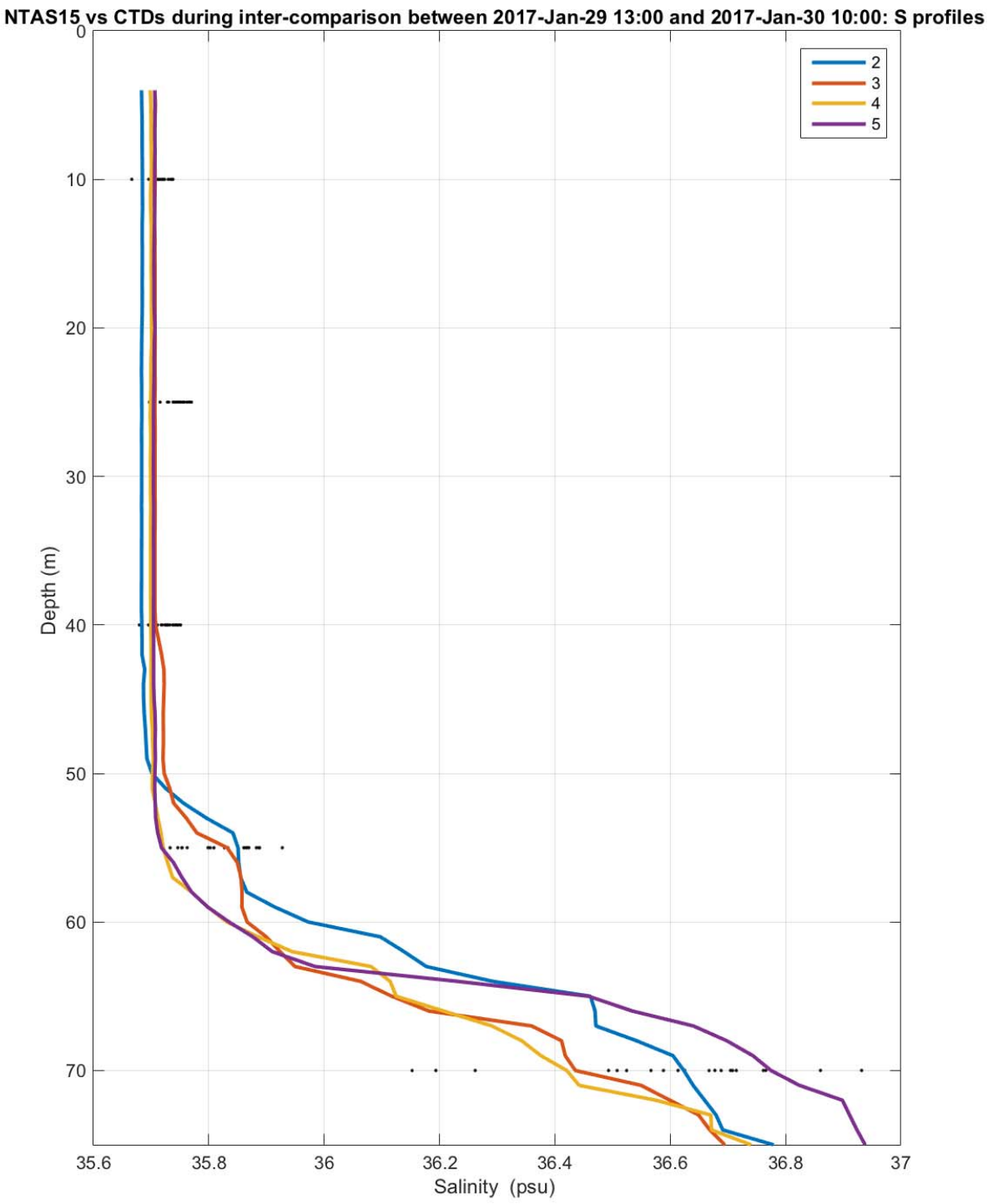


Figure V-2. Same as Figure V-1 but for salinity.

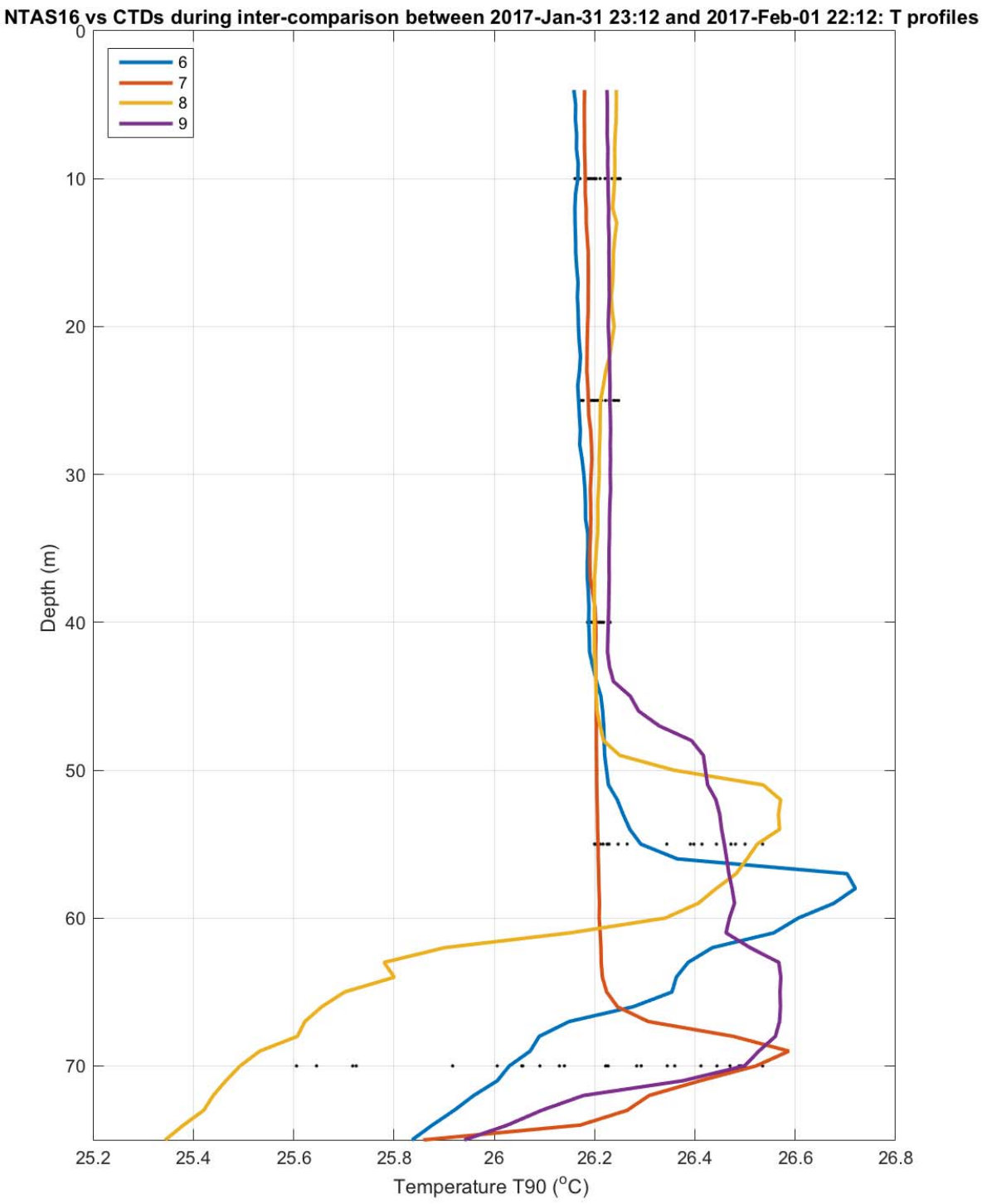


Figure V-3. Same as Figure V-1 but for casts and measurements at NTAS 16; data from the mooring is from telemetry.

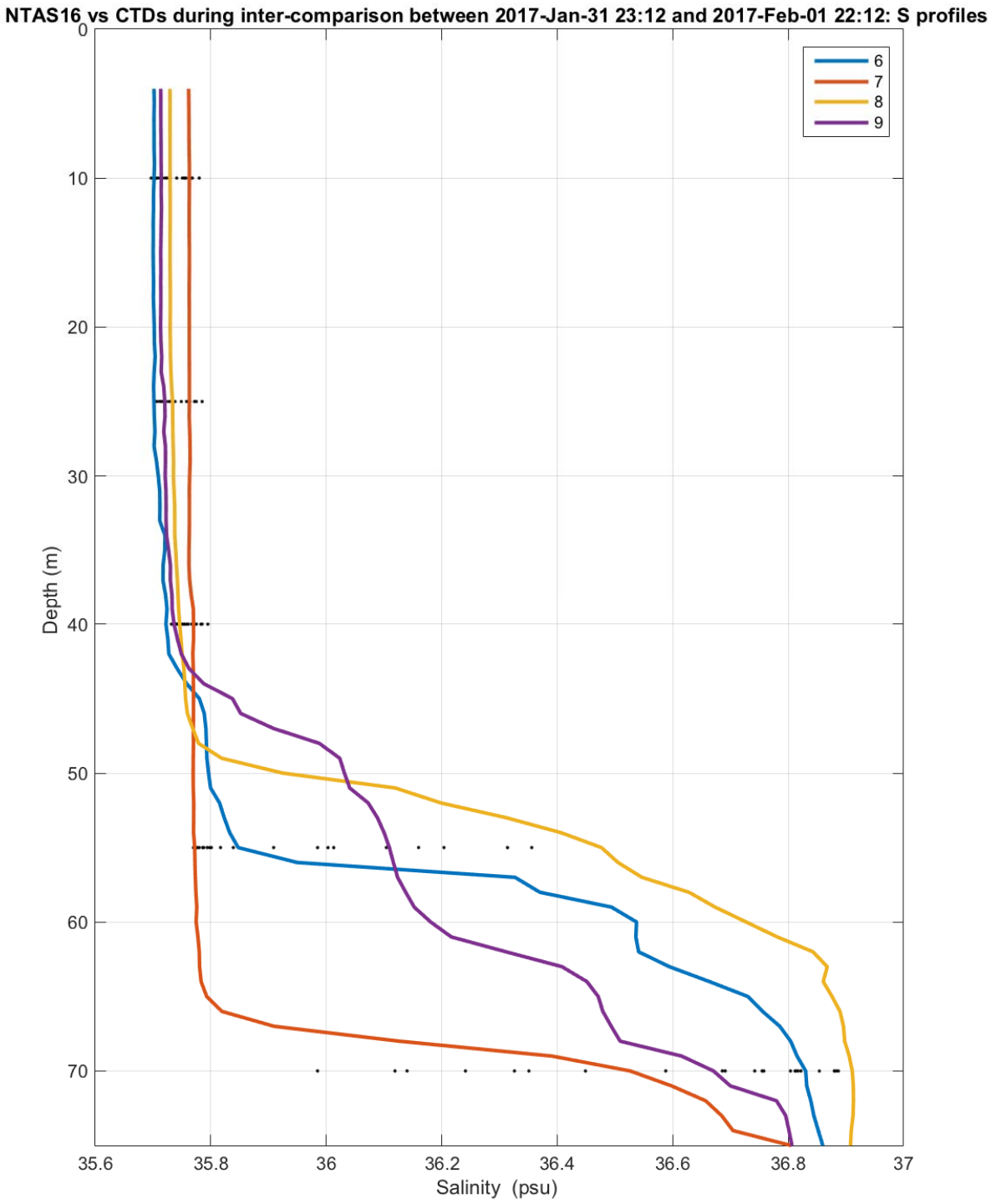


Figure V-4. Same as Figure V-3 but for salinity.

B. MOVE Operations

The Meridional Overturning Variability Experiment (MOVE) program is ran by a team from Scripps Institution of Oceanography. Three MOVE moorings (MOVE-1, MOVE-3 and MOVE-4) were turned around in 2016 (cruise EN573), and the following turn around will be two years after that. So, this year, MOVE operations consisted only of the recovery and deployment of two PIES and the downloading of data using acoustic communications.

After completing operations at the NTAS work site, we arrived at MOVE 1 near 15.5 N, 51.5 W on February 2 2017. PIES 237 was released at 07:20 UTC and spotted at the sea surface at 09:20 UTC about 400 yards southwest of its anchor position, thanks to the radio-frequency (RF) signal and flashing lights. Local currents at 800 m depth were about 10 cm s^{-1} to the South-Southwest and winds were 20 kts and from 66°. PIES 237 was back on board at 09:45 UTC. We then deployed its replacement, PIES 180 at 11:24 UTC, which reached the bottom around 12:55 UTC. During the day, Jessica Durette, who was in charge of the PIES work during this cruise, sent data collected from the PIES and modem using acoustic communications to her colleagues at Scripps. An anchor survey was done followed by acoustic communications near MOVE 1 mooring (within one nautical mile). Acoustic communications at nearby PIES 299 were also attempted but there was no answer (same behavior as in 2016).

At about 21:00 UTC, Jessica received text messages from her colleagues asking to go back to the deployment site and see if PIES#180 was at the surface. Indeed as we approached the site where we had deployed it in the morning, the PIES was detected on the RF receiver on the bridge and the flashing light was also seen. The PIES was floating less than expected and was recovered on the starboard rail. Once on deck it was apparent that the yellow hard hat was damaged and that the glass float sphere inside had imploded. The PIES looked fine but did not chirp.

The next day, February 3 2017, PIES 198 was deployed to replace the faulty PIES 180. Drop location was 15° 27.113' N, 51° 31.552' W. Survey resulted in anchor position at 15° 27.206' N, 51° 31.572' W and water depth 4978 m. Acoustic communications then resumed to ensure proper behavior of PIES 198. Communications with over the side transducer were poor so we returned to setup in the lab using the ship's transducer, which worked great. After troubleshooting a software upgrade, the Scripps team confirmed that PIES 198 was healthy. We left MOVE 1 area at 19:30 UTC and started transit towards MOVE 3.

We arrived at MOVE 3 on February 5 at 22:00 UTC and started acoustic communications with mooring, with good results using ship's transducer. Initially, ship would start at the mooring site and sail upwind to the Northwest for 1 nm, then come back slowly towards MOVE 3 downwind at 1 to 2 kts. At 03:00 UTC we changed this pattern and stayed at the "sweet spot" where communications were consistently good and which was 400 to 500 yards to the Northwest of the mooring. The ship would then hove to at this spot, spending most of its time with the wind on its port bow, but slowly falling back due to the push from the wind and then sail back to the same start position. With this strategy, downloads were very successful with a block size of 512 bytes. By 08:00 UTC about half of the data had been downloaded (about 850 blocks out of 1754).

At 10:34 UTC on February 6, PIES 238 was recovered and back on board. At 11:13 UTC, PIES 334 was deployed; its range stopped increasing around 12:45 UTC indicating it had settled on the ocean floor. An anchor survey was conducted and acoustic downloads from PIES 300 started. We then transited to nearby MOVE 4 mooring where we arrived at 22:30 UTC. All its data was quickly downloaded (only twelve blocks; this mooring instrumentation consisting only of a current meter). At 23:16 UTC all scientific operations stopped and we started our transit towards San Juan, Puerto Rico.

Notes

NTAS 15 showed no significant signs of bio fouling. Recommendations for the following years will be to use just Desitin on the heads of the ADCP and other transducer heads. No tape is necessary on any of the instruments on the wire. Tape is still required on the SST.

The RDI on NTAS 15 was put in a "sleep mode" just before deployment. It didn't record any data for the year. It is recommended that instrument technicians and field personnel work together and confirm all instrumentation to be set up and running in the proper manner prior to deploying.

During the transit from RI to the NTAS 16 site, R/V *Endeavor* took heavy seas over the starboard rail where the three boxes of synthetics were lashed down. The most forward box (nylon) took heavy damage. The box stove in under the pressure of water as waves passed above the rail. The line then got loose out of the box. Large sections of line were damaged from rubbing on the non-skid deck and the course edges from the plywood. In total seven extra splices had to be done as well as replacing the damages pieces with approximately 140 meters of nylon from the spare reel. It is recommended that the line not be stored on the starboard rail during long transits or heavy seas.

Acknowledgements

The Upper Ocean Processes group at WHOI is very thankful for the crew of the research vessel *Endeavor*. The Marine Operations office at the University of Rhode Island was also instrumental in the logistics pre and post-cruise. Thanks to the National Ocean and Atmospheric Administration (NOAA) for its continuing support of the NTAS and MOVE projects. The NTAS project is funded by the Ocean Observing and Monitoring Division, Climate Program Office (FundRef number 100007298), National Oceanic and Atmospheric Administration, U.S. Department of Commerce, under grant NA14OAR4320158.

Appendix 1: NTAS 16 Buoy Spin

URI-GSO Buoy Spin

Heading	**0**
Turn	**0**

	Time	**Date**
Vanes Secured UTC	17:00:00	15-Jan-17

System 1		**VANE**	**Compass**	**Direction**	**Sample Time**
Logger	**L16**				
WND	**205**	358.70	1.70	0.40	18:38:00
System 2		**Vane**	**Compass**	**Direction**	**Sample Time**
Logger	**L12**				
WND	**207**	353.30	0.50	353.80	18:35:00
		VANE	**Compass**	**Direction**	**Sample Time**
VWX001		N/A	0.30	N/A	18:33:00

Heading	**0**
Turn	**45**

	Time	**Date**
Vanes Secured UTC	18:50:00	15-Jan-17

System 1		**VANE**	**Compass**	**Direction**	**Sample Time**
Logger	**L16**				
WND	**205**	312.20	45.90	358.10	19:11:00
System 2		**Vane**	**Compass**	**Direction**	**Sample Time**
Logger	**L12**				
WND	**207**	309.40	45.60	355.00	19:09:00
		VANE	**Compass**	**Direction**	**Sample Time**
VWX001	Stand Alone	N/A	50.50	N/A	19:07:00

Heading	**5**
Turn	**90**

	Time	**Date**

Vanes Secured UTC	19:17:00	15-Jan-17			
System 1		**VANE**	**Compass**	**Direction**	**Sample Time**
Logger	**L16**				
WND	**205**	267.5	89.9	357.40	19:34:00
System 2		**Vane**	**Compass**	**Direction**	**Sample Time**
Logger	**L12**				
WND	**207**	267.70	93.70	1.40	19:32:00
		VANE	**Compass**	**Direction**	**Sample Time**
VWX001	Stand Alone	N/A	92.00	N/A	19:31:00

Heading	**5**				
Turn	**135**				
	Time	**Date**			
Vanes Secured UTC	19:40:00	15-Jan-17			
System 1		**VANE**	**Compass**	**Direction**	**Sample Time**
Logger	**L16**				
WND	**205**	220.80	132.10	352.90	19:59:00
System 2		**Vane**	**Compass**	**Direction**	**Sample Time**
Logger	**L12**				
WND	**207**	223.40	140.60	4.00	20:03:00
		VANE	**Compass**	**Direction**	**Sample Time**
VWX001	Stand Alone	N/A	133.80	N/A	20:05:00

Heading	**5**				
Turn	**180**				
	Time	**Date**			
Vanes Secured UTC	20:13:00	15-Jan-17			
System 1		**VANE**	**Compass**	**Direction**	**Sample Time**
Logger	**L16**				
WND	**205**	173.7	181.8	355.50	20:35
System 2		**Vane**	**Compass**	**Direction**	**Sample Time**
Logger	**L12**				
WND	**207**	177.80	186.20	4.00	20:36:00

		VANE	Compass	Direction	Sample Time
VWX001	Stand Alone	N/A	186.00	N/A	20:31:00

Heading	**5**
Turn	**225**
	Time	**Date**
Vanes Secured UTC	20:44:00	15-Jan-17

System 1		**VANE**	**Compass**	**Direction**	**Sample Time**
Logger	**L16**				
WND	**205**	130.50	224.40	354.90	21:02:00
System 2		**Vane**	**Compass**	**Direction**	**Sample Time**
Logger	**L12**				
WND	**207**	133.30	226.90	0.20	21:01

		VANE	Compass	Direction	Sample Time
VWX001	Stand Alone	N/A	232.00	N/A	21:00:00

Heading	**5**
Turn	**270**
	Time	**Date**
Vanes Secured UTC	21:05:00	15-Jan-17

System 1		**VANE**	**Compass**	**Direction**	**Sample Time**
Logger	**L16**				
WND	**205**	NaN	NaN	#VALUE!	
System 2		**Vane**	**Compass**	**Direction**	**Sample Time**
Logger	**L12**				
WND	**207**	NaN	NaN	#VALUE!	

		VANE	Compass	Direction	Sample Time
VWX001	Stand Alone	N/A	NaN	N/A	

Heading	**5**
Turn	**315**
	Time	**Date**
Vanes Secured	21:35:00	15-Jan-17

UTC					
System 1		**VANE**	**Compass**	**Direction**	**Sample Time**
Logger	**L16**				
WND	**205**	44.50	313.10	357.60	21:56:00
System 2		**Vane**	**Compass**	**Direction**	**Sample Time**
Logger	**L12**				
WND	**207**	41.30	312.70	354.00	21:53
		VANE	**Compass**	**Direction**	**Sample Time**
VWX001	Stand Alone	N/A	308.00	N/A	21:55:00

Appendix 2: NTAS 16 Surface and Subsurface Instrumentation Configuration

Surface:

NTAS 16 Deployed 1/30/2017 20:31 UTC				
SYSTEM 1				
Module	Serial	Firmware Version	Height Cm	Notes
Logger PORT	L16	v4.11cf		
HRH	226	v4.29cf	233	
BPR	505	v4.03cf	240	
WND	205	v4.02cf	265	
PRC	218	v4.03cf	247	F/D/S-200ml
LWR	212	v4.02cf	282.5	clean - 19:50
SWR	201	v4.01cf	282.5	clean - 19:50
SST	1836		150	first spike is saltwater/second spike ice in bucket
PTT	18128			SST temp spike on 20170127 on:19:40 off:19:51
IDs	20956, 20957, 20959			
SYSTEM 2				
Module	Serial	Firmware Version	Height Cm	Notes
Logger STARBOARD	L12	v4.11cf		
HRH	215	v4.29cf	230	
BPR	503	v4.03cf	243	
WND	207	v4.02cf	265	

PRC	210	v4.03cf	246	F/D/S-300ml
LWR	254	v4.02cf	282.5	clean - 19:50
SWR	209	v4.01cf	282.5	clean - 19:50
SST	2054		150	first spike is saltwater/second spike ice in bucket
PTT	18112			SST temp spike on 20170127 on:19:40 off:19:51
IDs	20741, 20892, 20898			
STAND ALONES MODULES				
Module	Serial	NDBC #	Height Cm	Notes
WAMDAS:	4003	24361		
IMEI #	300124000115920	300124000115920		
SIM #	89881 69312 00205 1336			
3DM-GX1 #	8712	N/A		
IR		24537		
NDBC station #	41060			
SIM				
SIM IR IMEI	300224010043720			
VWX	1		231.5	height is to top of white ring. For actual sensor heights: WXT ATMP/HRH/BPR = 241 cm ; WXT WND = 254 cm ;
Lascar AT/RH	10032233		223cm	
SBE-39-AT	5272		226cm	

Xeao KILO	300234062946460			
XEOS Mello	300034012615100			
Waterline below deck	75 cm			

Subsurface:

SBE 56s in buoy foam hull:

Serial	Below Deck	Below water	Degrees	Position (0=fwd, positive clockwise)
6979	95	20	315	port
6980	85	10	0	forward high
6981	95	20	0	forward low
6982	95	20	45	starboard

NTAS 16 Subsurface									
				SAMPLE START		SPIKE			
INSTRUMENT	SERIAL	DEPTH (m)	SAMPLE RATE (s)	DATE	TIME	DATE	START TIME	STOP TIME	NOTES
SBE 37 IM	669	10	600	20170113	0100	20170126	11:50	~24:00	spike on IM loop
SBE 37 IM	683	25	600	20170113	0100	20170126	13:48	~24:00	spike on IM loop
SBE 37 IM	684	40	600	20170113	0100	20170126	16:10	~24:00	spike on IM loop
SBE 37 IM	685	55	600	20170113	0100	20170126	17:50	~24:00	spike on IM loop
SBE 37 IM	686	70	600	20170113	0100	20170126	19:45	~24:00	spike on IM loop
SBE 37 Deep	11393	4962	300	20170113	0100	20170122	15:30	16:10	*estimated spike stop time
SBE 37 Deep	11392	4962	300	20170113	0100	20170122	15:30	16:10	*estimated spike stop time
SBE 39	7696	5	300	20170113	0100	20170122	15:30	16:10	sbe39+ w/ 4 AA Li
SBE 39	7697	15	300	20170113	0100	20170122	15:30	16:10	sbe39+ w/ 4 AA Li
SBE 39	7695	20	300	20170113	0100	20170122	15:30	16:10	sbe39+ w/ 4 AA Li
SBE 39	684	30	300	20170113	0100	20170122	15:30	16:10	
SBE 39	678	35	300	20170113	0100	20170122	15:30	16:10	
SBE 39	546	45	300	20170113	0100	20170122	15:30	16:10	
SBE 39	545	50	300	20170113	0100	20170122	15:30	16:10	
SBE 39	677	60	300	20170113	0100	20170122	15:30	16:10	
SBE 39	3480	65	300	20170113	0100	20170122	15:30	16:10	
SBE 39	750	75	300	20170113	0100	20170122	15:30	16:10	
SBE 39	631	80	300	20170113	0100	20170122	15:30	16:10	
SBE 39	539	90	300	20170113	0100	20170122	15:30	16:10	
SBE 39	680	100	300	20170113	0100	20170122	15:30	16:10	
SBE 39	681	110	300	20170113	0100	20170122	15:30	16:10	

SBE 56	6979	0.2	60	20170113	0100	20170122	15:30	16:10	
SBE 56	6980	0.1	60	20170113	0100	20170122	15:30	16:10	
SBE 56	6981	0.2	60	20170113	0100	20170122	15:30	16:10	
SBE 56	6982	0.1	60	20170113	0100	20170122	15:30	16:10	
Star-Oddi	5282	110	600	20170113	0100	20170122	15:30	16:10	
Star-Oddi	5283	120	600	20170113	0100	20170122	15:30	16:10	
Star-Oddi	5284	130	600	20170113	0100	20170122	15:30	16:10	
Star-Oddi	5285	140	600	20170113	0100	20170122	15:30	16:10	
Star-Oddi	5286	150	600	20170113	0100	20170122	15:30	16:10	
Star-Oddi	5287	160	600	20170113	0100	20170122	15:30	16:10	
Nortek ADCM	9407	5.7	180/1200	20170120	0100	20170122	16:55	19:15	
Nortek ADCM - IM	5973	13	180/1200	20170120	0100	20170126	20:45	~24:00	spike on IM loop
Nortek ADCP	12391	24	240/3600	20170120	0100	20170122	16:55	19:15	
TRDI 300 kHz	14193	85	180/3600	20170120	0100	20170122	16:55	19:15	

Appendix 3: Setup of current meters and profilers on NTAS 16

Aquadopp 5973:
Deployment : N16
Current time : 12/29/16 6:12:18 PM
Start at : 1/20/17 1:00:00 AM
Comment:
AQD-5973, NTAS 16, 2 Li Batteries, 13m, SIM ID# 041,
Measurement interval (s) : 1200
Average interval (s) : 180
Blanking distance (m) : 0.35
Measurement load (%) : 4
Power level : HIGH-
Diagnostics interval(min) : 1440:00
Diagnostics samples : 50
Compass upd. rate (s) : 1
Coordinate System : ENU
Speed of sound (m/s) : MEASURED
Salinity (ppt) : 36
Analog input 1 : NONE
Analog input 2 : NONE
Analog input power out : DISABLED
File wrapping : OFF
TellTale : OFF
AcousticModem : OFF
Serial output : OFF
Baud rate : 9600
Assumed duration (days) : 540.0
Battery utilization (%) : 85.0
Battery level (V) : 11.1
Recorder size (MB) : 9
Recorder free space (MB) : 8.973
Memory required (MB) : 2.7
Vertical vel. prec (cm/s) : 1.4
Horizon. vel. prec (cm/s) : 0.8
Instrument ID : AQD 5973
Head ID : ALD 3619
Firmware version : 3.36
Inductive modem : ENABLED
Device ID : 41
Transmit power level : HIGH
Data format : ASCII

Aquadopp 12391:
Deployment : N16
Current time : 12/28/16 07:21:50 PM
Start at : 1/20/17 1:00:00 AM
Comment:
600kHz, 24m, N16
Profile interval (s) : 3600
Number of cells : 15
Cell size (m) : 2.00
Blanking distance (m) : 0.50
Measurement load (%) : 25
Average interval (s) : 240
Power level : HIGH
Wave data collection : DISABLED
Compass upd. rate (s) : 1
Coordinate System : ENU
Speed of sound (m/s) : MEASURED
Salinity (ppt) : 36
Analog input 1 : NONE
Analog input 2 : NONE
Analog input power out : DISABLED
File wrapping : OFF
TellTale : OFF
Acoustic modem : OFF
Serial output : OFF
Baud rate : 38400
Assumed duration (days) : 540.0
Battery utilization (%) : 98.0
Battery level (V) : 11.0
Recorder size (MB) : 3773
Recorder free space (MB) : 3772.972
Memory required (MB) : 2.1
Vertical vel. prec (cm/s) : 0.5
Horizon. vel. prec (cm/s) : 1.6
Instrument ID : AQD12391
Head ID : AQP 7427
Firmware version : 3.40
ProLog ID : 1062
ProLog firmware version : 4.22
SD Card Inserted : YES
SD Card Ready : YES
SD Card Write protected : NO
SD Card Type : SDHC
SD Card Supported : YES

Aquadopp 9407:
Deployment : N16
Current time : 12/27/16 7:49:46 PM
Start at : 1/20/17 1:00:00 AM
Comment:
AQD 9407/AQD 4758, 2Mhz CM, 5.7m, 2Li bats, N16
Measurement interval (s) : 1200
Average interval (s) : 180
Blanking distance (m) : 1.01
Measurement load (%) : 4
Power level : HIGH-

Diagnostics interval(min) : 1440:00
Diagnostics samples : 100
Compass upd. rate (s) : 1
Coordinate System : ENU
Speed of sound (m/s) : MEASURED
Salinity (ppt) : 36
Analog input 1 : NONE
Analog input 2 : NONE
Analog input power out : DISABLED
File wrapping : OFF
TellTale : OFF
AcousticModem : OFF
Serial output : OFF
Baud rate : 9600
Assumed duration (days) : 540.0
Battery utilization (%) : 84.0
Battery level (V) : 11.0
Recorder size (MB) : 9
Recorder free space (MB) : 8.973
Memory required (MB) : 3.7
Vertical vel. prec (cm/s) : 1.4
Horizon. vel. prec (cm/s) : 0.8
Instrument ID : AQD 9407
Head ID : AQD 4758
Firmware version : 3.36

;**300 kHz WH SN14193**, 85m depth, 1 Li battery pack
CR1
CF11101
EA0
EB0
ED850
ES36
EX11111
EZ1111101
WA50
WB0
WD111100000
WF300
WN25
WP180
WS400
WV175
TE01:00:00.00
TP00:01.00
TF17/01/20 01:00:00
CK
CS
;

;Instrument = Workhorse Sentinel
;Frequency = 307200
;Water Profile = YES
;Bottom Track = NO
;High Res. Modes = NO
;High Rate Pinging = NO
;Shallow Bottom Mode= NO
;Wave Gauge = NO
;Lowered ADCP = YES
;Ice Track = NO
;Surface Track = NO
;Beam angle = 20
;Temperature = 20.00
;Deployment hours = 12960.00

;Battery packs = 2
;Automatic TP = NO
;Memory size [MB] = 256
;Saved Screen = 3
;
;Consequences generated by PlanADCP version 2.06:
;First cell range = 7.41 m
;Last cell range = 103.41 m
;Max range = 78.36 m
;Standard deviation = 0.26 cm/s
;Ensemble size = 654 bytes
;Storage required = 8.08 MB (8475840 bytes)
;Power usage = 1061.59 Wh
;Battery usage = 2.4

Appendix 4: Antifouling on NTAS 16

Ver. 2, 1-11-2017 (update from NTAS-14 14 Ver. 1, 12-03-2014)

General comments: Experience has shown that the fouling potential at NTAS is low. Instruments below 30 m come up with little more than some sea-slime and are easy to clean up. Shallower sensors show some barnacle growth; but SBE-39s seem to be relatively immune. The 6 m Nortek suffers the most fouling of any sensor on the mooring (barnacles). It is not clear why. The 85 m ADCP comes up pretty clean, except for transducer heads. Copper guards on SBE-37s work best when electrically isolated from the instrument case. A few years ago we started to see evidence of birds on the radiometers, so now include bird wire on the tower.

Note: E-Paint biogrease turns to liquid and runs off in hot conditions. Desitin appears to be a better choice. Transducer heads used to get treated with a mixture of Desitin and biogrease, but only Desitin will be used on NTAS-16.

Tower top: 1) An "X" of bird wire between the radiometers, standard bird spikes used for PRC and WXT. **2)** Additional bird wire along the forward rail as a deterrent. See Fig. 1 for example. Bird wire does not need to be as extensive as on WHOTS.
SBE 56 in buoy hull: 1) Apply Aqualube around and inside the protruding probe covers prior to deployment. **2)** Plug empty holes (e.g. with wooden broom handle sections); touch up with buoy hull paint if available.
SBE-37s on buoy: 1) Tape on body of instrument, no paint. **2)** Copper sensor guard. Desitin on conductivity cell inside guard (but not too much, and not too close to the open cell ends).
SBE-39 on compliant section: Tape on body of instrument, no paint.
Nortek on compliant section: 1) Tape on body of instrument, no paint. **2)** Desitin applied to the transducers just prior to deployment.
SBE-39s clamped to wire: No anti-fouling treatment.
Norteks clamped to wire: 1) 13 m IM and 24 m instruments: tape on body of instrument, no paint. 2) Desitin applied to the transducers just prior to deployment.
SBE-37 IMs clamped to wire: 1) Shallow (10 m and 25m) IM instruments: tape on housing, copper sensor guard, Desitin on conductivity cell inside guard. **2)** Deeper (40 m, 55 m and 70 m) IM instrument: no tape, copper sensor guard, Desitin on cell inside guard.
Workhorse in load cage: 1) No anti-foul paint on the cage or instrument housing. **2)** Desitin applied to the transducers.
Star-Oddi's clamped to wire: No anti-fouling treatment.

Photo of NTAS-16 tower top prior to deployment, showing bird wire applied to radiometer stalk, PRCs, WXT and inside front rail.

Appendix 5: Mooring Log NTAS 15

Moored Station Log

(fill out log with black ball point pen only)

ARRAY NAME AND NO. NTAS 15 MOORED STATION NO. _____

Launch (anchor over)

Date (day-mon-yr) 2-2-2016 Time 1909 UTC

Deployed by Ryder / Smith Recorder/Observer S. Bigorre

Ship and Cruise No. Endeavor EN573 Intended Duration 365 days

Depth Recorder Reading 4945 (12kHz) m Correction Source Mattews table

Depth Correction +38m m _____

Corrected Water Depth 4983 m Magnetic Variation (E/W) _____

Anchor Drop Lat. (N/S) 14° 49.429' Lon. (E/W) 51° 00.819'

Surveyed Pos. Lat. (N/S) 14° 49.50' Lon. (E/W) 51° 00.978'

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

Acoustic Release Model Edgetech 8242 XS Tested to 1,500 m

Release No. 1 (sn) 35321	Release No. 2 (sn) 35322
Interrogate Freq. 11 kHz	Interrogate Freq. 11 kHz
Reply Freq. 12 kHz	Reply Freq. 12 kHz
Enable 111552	Enable 111613
Disable 111571	Disable 111630
Release 127524	Release 127541

Recovery (release fired)

Date (day-mon-yr) 31 January 2017 Time 1141 UTC

Latitude (N/S) 14 49.715 Longitude (E/W) 51 00.91

Recovered by B. Pietro Recorder/Observer S. Bigorre

Ship and Cruise No. Endeavor, EN590 Actual duration 364 days

Distance from waterline to buoy deck 75 cm

1

=

ARRAY NAME AND NO. NTAS 15 MOORED STATION NO. _____

Surface Components			
Buoy Type MOB Color(s) Hull Tower blue hull, yellow deck, white tower			
Buoy Markings If found adrift contact Woods Hole Oceanographic Woods Hole, MA 02543 USA 508-457-1401			
Surface Instrumentation			
Item	**ID #**	**Height***	**Comments**
ASIMET logger	05		Starboard's J-box
HRH	232	235	
BPR	216	244	
WND	241	270	
PRC	213	235	
LWR	205	280	Only one section of birdwire's "X" remains in middle of radiometers cluster.
SWR	213	280	
SST	3601	-153	forward stbd
PTT	14623		
ASIMET logger	06		Port's J-box
HRH	257	237	
BPR	212	244	
WND	239	270	
PRC	219	235	
LWR	208	280	
SWR	503	280	
SST	3604	-153	forward port
PTT	67720		
SBE 39AT	5270	225	
LASCAR	01002028	208	
VWX	006	258	
XEOS Relo			300034013709960
*Height above buoy deck in centimeters			

ARRAY NAME AND NO. NTAS 15 MOORED STATION NO. _____

Subsurface Instrumentation on Buoy and Bridle			
Item	ID #	Depth†	Comments
SST SOLO-T	10035	~~95~~ 89	60° Port
SST SOLO-T	10036	~~85~~ 82	0° Forward
SST SOLO-T	10037	~~95~~ 89	0° Forward
SST SOLO-T	10038	~~95~~ 89	60° Starboard
WAMDAS	6017	buoy ~~bkll~~ well	300224010103770 IMEI
			8988 1693 1200 2051 229 SIM
			Iridium ID 25719
			NDBC# 28560
XEOS	kilo		300234062643350
Iridium	0432	buoy well	(Logger 05) 300224010237100
			Depths were measured post-recovery and adjusted then on this mooring log. (SB)
†Depth below buoy deck in centimeters			

ARRAY NAME AND NO. NTAS 15 MOORED STATION NO. _____

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
1		buoy	0		1308	1920	buoy bumped ship during approach, near HRH port side.
2	5	EM chain					
3		SBE 39	5	3479	1308	1934	
4		NORTEK ADCM	5.7	12688	1308	1934	
5		RBR SOLO-D	6	78197	1306	1934	
6	79	7/16 wire					15187-7
7		SBE 37 IM	10	13409	1306	1936	No copper guard
8		NORTEK ADCM-IM	13	12309	1306	1936	looks up with vane
9		SBE 39	15	7680	1306	1936	
10		SBE 39	20	7681	1306	1936	
11		NORTEK ADCP	24	12393	1306	1936	
12		SBE 37 IM	25	13410	1306	1936	no copper guard
13		SBE 39	30	7682	1306	1936	
14		SBE 39	35	7683	1306	1936	
15		SBE 37 IM	40	13411	1306	1936	no copper guard
16		SBE 39	45	7684	1306	1822	wire cut for buoy recovery
17		SBE 39	50	7687	1306	1822	
18		SBE 37 IM	55	13412	1306	1821	no copper guard
19		SBE 39	60	7688	1314	1820	
20		SBE 39	65	7689	1315	1819	
21		SBE 37 IM	70	13413	1317	1817	no copper guard
22		SBE 39	75	7690	1318	1817	
23		SBE 39	80	7691	1325	1816	
24		RBR SOLO-D	83	78198	1325	1814	
25		RDI ADCP	85	23281	1328	1809	looks up clamps slided up recently

ARRAY NAME AND NO. NTAS 15 MOORED STATION NO. _____

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
26	500	3/8 wire				start 1743	15187-2
27		SBE 39	90	7692	1329	1807	
28		SBE 39	100	7693	1329	1806	
29		SBE 39	110	7694	1330	1805	paired with Star-Oddi
30		Starmon Oddi	110	5275	1330	1805	
31		Starmon Oddi	120 ~~110~~	5276	1331	1804	
32		Starmon Oddi	130	5277	1331	1803	
33		Starmon Oddi	140	5278	1331	1802	fuzzy growth, but nothing above or below!
34		Starmon Oddi	150	5279	1333	1800	
35		Starmon Oddi	160	5280	1334	1800	
36	500	3/8 wire					14032-2
37	500	3/8 wire				1720 (start)	15187-3
38	200	3/8 wire					14032-4
39	100	3/8 wire			1420	1710	encapsulated termination 14032-6
40	200	7/8 nylon					
41	500	7/8 nylon					
42	2000	3/4 nylon					
43	100	7/8 nylon				1520	
44	1500	1" Colmega				1430	
45		glassballs (56)			1710	1315 1330	~~IIII~~ ~~IIII~~ IIII glass ball broken. In basket at 1415 '14
46		SBE 16	38 m above bottom	2323	1721	1330	paired
47		SBE 16		2324	1721	1330	
48	5	1/2" chain					
49		release		35321		1335	paired
50		release		35322		1335	

ARRAY NAME AND NO. NTAS 15 MOORED STATION NO. _____

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
51	5	½" chain					
52	20	1" nystron					
53	5	½" chain					
54		anchor					
55							
56							
57							
58							
59							
60							
61							
62							
63							
64							
65							
66							
67							
68							
69							
70							
71							
72							
73							
74							
75							

Appendix 6: Mooring Log NTAS 16

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 Tab k

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) _____ 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 (as observed on 2/1/2017 12:30 UTC)

1

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

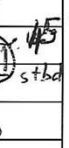
Surface Instrumentation

Item	ID #	Height*	Comments
ASINET logger	L16		Port side
HRH	226	233	
BPR	505	240	
WND	205	265	
PRC	218	247	
LWR	212	282.5	
SWR	201	282.5	
SST	1836	150	
PTT	18128		
ASINET logger	L12		Starboard side
HRH	215	230	
BPR	503	243	
WND	207	265	
PRC	210	246	
LWR	254	282.5	
SWR	209	282.5	
SST	2054	150	
PTT	18112		
SBE39AT	5272	226	
VWX	001	231.5 deck ring	Wind sensor : 250 cm above deck ATMP, HRH, BPR, & 239 cm AD
Lascar	10032233	223	
Xeos Nelo	300034012615100		
WANDAS	4003		

*Height above buoy deck in centimeters

ARRAY NAME AND NO. NTAS16 MOORED STATION NO. _____

Subsurface Instrumentation on Buoy and Bridle			
Item	ID #	Depth†	Comments
SST SBE56	6979	95	port side (-135°) 95cm 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°) 95cm below deck
WAMDAS	4003		NDBC # 24361
			IMEI 300124000115920
			SIM 89881 69312 00205 1336
			3DM-GX1 # 8712
			IR 24537
SIN 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		
2	5	ET chain					
3		SBE39	5	7696			
4		Nortek ADCM	5.7	9407			
5	79	7/16 wire					
6		SBE37 IM	10	669			
7		Nortek ADCM IM	13	5973			with vane; heads up
8		SBE39	15	7697			
9		SBE39	20	7695			
10		Nortek ADCP	24	12391			
11		SBE37 IM	25	683			Endcap replaced with spare
12		SBE39	30	684			
13		SBE39	35	678			
14		SBE37 IM	40	684			
15		SBE39	45	546			
16		SBE39	50	545	~~1415~~ 1414		
17		SBE37 IM	55	685	1415		
18		SBE39	60	677	1417		
19		SBE39	65	3480	1419		
20		SBE37 IM	70	686	1424		
21		SBE39	75	750	1425		
22		SBE39	80	631	1425		
23		RDI ADCP	85	14193	1431		
24	500	3/8 wire					
25		SBE39	90	539	1431		

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		
27		SBE39	110	681	1435		} paired
28		Starmon Oddi	110	5282	1435		
29		Starmon Oddi	120	5283	1436		
30		Starmon Oddi	130	5284	1437		
31		Starmon Oddi	140	5285	1437		
32		Starmon Oddi	150	5286	1438		
33		Starmon Oddi	160	5287	1440		
34	500	3/8 wire			1453		
35	500	3/8 wire			1530		
36	200	3/8 wire			1547		
37	100	3/8 wire			1556		} 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		glassballs (56)			1805		
44		SBE37		11393	2013		
45		SBE37		11392	2013		
46	5	1/2 chain					
47		Acoustic release		33415	2013		
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							

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. WHOI-2017-01	2.	3. Recipient's Accession No.

4. Title and Subtitle
NTAS 16 Sixteenth Setting of the NTAS Ocean Reference Station Cruise on Board RV *Endeavor* January 21 - February 8, 2017 Narragansett, Rhode Island - San Juan, Puerto Rico

5. Report Date
July 2017

6.

7. Author(s)
Sebastien Bigorre, Benjamin Pietro, Emerson Hasbrouck

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C)NA14OAR4320158
(G)

12. Sponsoring Organization Name and Address
NOAA

13. Type of Report & Period Covered
Technical Report

14.

15. Supplementary Notes
This report should be cited as: Woods Hole Oceanographic Institution Technical Report, WHOI-2017-01.

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 inter-annual 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-15 mooring and deployment of the NTAS-16 mooring. 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 R/V Endeavor (cruise EN590). The cruise took place between January 21 and February 8 2017. The NTAS-16 mooring was deployed on January 30, and the NTAS-15 mooring was recovered on January 31. A 24-hour inter-comparison period was conducted on January 29 in front of the NTAS 15 buoy, and again on February 1 in front of the NTAS 16 buoy. During the inter-comparisons, data from instrumentation on the buoys, telemetered through Argos satellite system, and the ship's meteorological and oceanographic measurements were monitored while the ship was stationed 0.2 nm downwind of the buoys. 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 EN590 consisted in the recovery and deployment of the Meridional Overturning Variability Experiment (MOVE) Pressure Inverted Echo Sounders (PIES) at two MOVE arrays (MOVE 1 in the east, and MOVE 3 in the west near Guadeloupe). Acoustic downloads of data from (PIES) and subsurface mooring (MOVE1, 3 and 4) were also conducted. MOVE is designed to monitor the integrated deep meridional flow in the tropical North Atlantic.

17. Document Analysis a. Descriptors

Upper Ocean Processes Group
The Northwest Tropical Atlantic Station (NTAS)
Cruise - San Juan, Puerto Rico

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement
Approved for public release; distribution unlimited.

19. Security Class (This Report)
UNCLASSIFIED

20. Security Class (This Page)

21. No. of Pages
62

22. Price

(See ANSI-Z39.18) *See Instructions on Reverse* OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)
Department of Commerce