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# The Northwest Tropical Atlantic Station (NTAS):
## NTAS-20 Mooring Turnaround Cruise Report
## Cruise on Board RV Pisces
## November 4-28, 2021
## Newport, RI - Pascagoula, MS

**by**

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Woods Hole, MA 02543

November 2021

**Technical Report**

Funding was provided by the National Oceanic and Atmospheric Administration under Grant No. NA19OAR4320074.

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Upper Ocean Processes Group
Woods Hole Oceanographic Institution
Woods Hole, MA 02543
UOP Technical Report 2023-01

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**Young-Oh Kwon, 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) Global Ocean Monitoring and Observing (GOMO) Program (formerly Ocean Observing and Monitoring Division).

This report documents recovery of the NTAS-19 mooring and deployment of the NTAS-20 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 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 *Pisces*, Cruise PC-21-07. The cruise took place from November 4 to 28, 2021. The NTAS-20 mooring was deployed on November 12, and the NTAS-19 mooring was recovered on November 13. Limited inter-comparison between ship and buoys were performed on this cruise. This report describes these operations and the pre-cruise buoy preparations.

Other operations during PC-21-07 consisted of one CTD cast near the Meridional Overturning Variability Experiment (MOVE) subsurface mooring array MOVE 1-14. 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 20 cruise departed from Newport, Rhode Island on Thursday November 4, 2021 and returned to Pascagoula, Mississippi on November 26, 2021. The NTAS 20 mooring was deployed on November 12, 2021, inter-comparison at NTAS 19 was done the previous day on November 11 and the NTAS 19 mooring was recovered the next day on November 13. The ship docked in Pascagoula on November 26, 2021, at 10:00 UTC-4, and offloading of NTAS equipment proceeded.

A detailed chronology of the cruise is provided below. Local time on the ship during PC-21-07 cruise was EST (UTC-4).

*October 22*, *Friday*: Loading of equipment on two trucks at WHOI: one flatbed truck with buoy foam and anchors, and one trailer truck with buoy well, halo and remaining equipment. At 2 pm, WHOI personnel (Graham, Keane, Bigorre) arrive at Navy base in Newport, RI, get entrance passes, and start offloading trucks on pier 2, using NOAA forklift truck. Buoy assembled in early evening. Bigorre return to MA at end of day.

*October 23*, *Saturday*: Buoy spin on the pier (Ray notices errors in wind compasses, probably due to disturbance from reinforced concrete) followed by data download. Brizo wave sensor installed and running. Buoy brackets, bird wire, front crash bar installed, decals and water marks applied on buoy foam. Drew Cole arrives in RI, starts isolation at same hotel as ship's crew.

*October 24*, *Sunday:* Replaced SST cable on ASIMET Logger 16 with spare cable and SST data now coming through (new spare cable will be brought from WHOI for the cruise). WAMDAS powered on and spun at 45 degrees intervals for 10 minutes each. Measured heights, mounted bird spikes (PRCs, WXT, radiometers, front crash bar for winds), dressed tower and well cables and started the SS telemetry system with 1 Microcat on the jumper wire. Secured buoy and equipment for hurricane forecast. Graham and Keane return to MA next day.

*October 26 – November 1:* WHOI team in isolation. PCR testing in RI on October 30. Ship crew loads non-sensitive equipment (steel beams, glass balls, wood line wire baskets, deck boxes) onboard.

*November 2, Tuesday:* Science party receives rapid test for Covid on dock, then boards. Load ship using NOAA forklift and ship's starboard crane. 15:30 EST, buoy loaded on port side and tilted. Issues with adapter plates for securing H-bit and capstan on deck: spacing between plates holes is 1/16" short and spacing between Baxter plug holes on deck is not uniform.

*November 3, Wednesday:* Chief engineer widen adapter plates holes using torch. 10:00 orientation meeting. 11:00 abandon ship drill. Connect lab to GPS antennae on 01 deck starboard side. Data dump from 2 ASIMET systems and Campbell system (not WXT due to difficult access caused by

Brizo). Check WXT in test mode. Data ok, except SST on Logger 12 (flat for half day on 11/2 and for shorter duration on 8/28–29). Replace with spare SST.

*November 4, Thursday:* 0800 gangway removed and stored on 01 deck, along with other equipment including capstan. 09:54 EST ship departs. Afternoon: rewind wire on starboard net drum, on top of some ship's rope and a tarp that act as padding on sharp edges from separating disk in the middle of the drum.

*November 5, Friday:* transit SE, 11-13 kts to avoid storm on US east coast. 13:00 safety meeting.

*November 6, Saturday*: 9:20 EST one Microcat installed on inductive line inside bucket, data looks good. Review telemetry data on inductive line from October 12–20 test at WHOI: data is good and no need to retest on deck (same configuration). Splices nylon rope.

*November 7, Sunday*: Spike subsurface instruments. Splice Colmega and Nylon.

*November 8, Monday*: Air test three acoustic releases in morning. 10:00 meeting with bridge and bosun regarding deployment. 13:12 CTD#1 with 3 acoustic releases on Rosette (24° 38.488' N, 059° 21.557' W).

*November 9–10*: mount universal section to buoy, EM chain, SSTs. Clear and format instruments cards.

*November 11, Thursday*: Mock run for deployment. 07:30 EST arrive at NTAS20 target, wind 15 kts, 070° true, current 1 kt to 132°. 07:45 set and drift. 08:40 start mock run, course 075°. 08:00 XBT launched, new sound velocity profile updates bathymetry reading at target (7 m reduction), new depth is 5044 m. 11:00 mock run satisfactory (kept constant course 075° at 1 kt) and allowed for a couple of test maneuvers. After mock run, check bathymetry in zone beyond target. 11:45 departs to NTAS19. 12:50-13:10 CTD#2 to 250 m (14° 48.35' N, 051° 02.07' W) near NTAS19 buoy. Bullwarks removed on port side to prepare for deployment. 14:15 ship repositions near NTAS19 buoy for drive by: propellers on one wind anemometer are gone, and do not move on the other wind sensor. 18:00 (UTC-4) CTD#3 to 250 m (14° 48.69' N, 051° 02.09' W) near NTAS19 buoy, intercomparison at NTAS19 buoy starts.

*November 12, Friday*: 04:30 (UTC-4) departs NTAS19 towards NTAS20 deployment site. 05:30 (UTC-4) set and drift test at target site (14° 45' N, 050° 56' W); drift to the west at less than 1 kt. Wind from ENE (070° and 10 kts), small current from ESE. Start track 6.5 nm from target. 07:30 (UTC-4) safety brief on deck, install IM sensors on mooring line up to 55 m mark. 08:30 (UTC-4) buoy in the water. Nortek ADCP intended for deployment at 24 m is inadvertently overlooked, so line is brought back, and it is deployed instead at 54 m. 10:10 (UTC-4) last instrument deployed. 13:00 (UTC-4) start deploying glass balls. 14:20 (UTC-4) bathymetry is confirmed satisfactory for deployment. 14:57 (UTC-4) anchor drop at (14° 44.958' N, 050° 56.170' W), water depth is 5044 m. 16:50 – 18:50 (UTC-4) anchor survey. 18:00 (UTC-4) CTD#4 to 250 m (14° 44.34' N, 050° 57.73' W, 250 m downwind of NTAS20 buoy) at same site as anchor survey point #2. Ship heaves to overnight 600 yards downwind of NTAS20 buoy for inter-comparison. Bridge is

concerned about distance from shore with increasing weather to the north and some suspicious noise from a backup engine and prefers to advance return to Pascagoula to tomorrow.

*November 13, Saturday*: 08:00 (UTC-4) CTD#5 to 250 m (14° 43.73' N, 050° 57.62' W, 250 m downwind of NTAS20 buoy). 08:30 safety meeting for mooring recovery. 09:00 drive by NTAS20 buoy for pictures and waterline. 10:22 (UTC-4) release NTAS19 mooring, ship is 0.5 nm west of anchor, buoy is southwest of anchor. Wind 15 kts, 080° true. Ping on releases to check ascent. 11:15 (UTC-4) glass balls at surface 500 yards ahead of ship. 11:45 ship power shuts down as we are about to grab onto glass balls, mooring line drifts under the ship. Power shuts down again on next approach but this time, line is entangled under the hull. Once line is secured on two points (one towards the buoy, one towards the glass balls) on starboard rail, the part that is entangled is cut off. Ship used one big and one small engine and should use two big engines for future recovery maneuvers. After NTAS19 recovery ends and deck secured, ship departs towards MOVE1. 22:30 (UTC-4) CTD#6 to 2,300 m, (15° 26.36' N, 051° 32.25' W), 1.8 nm from MOVE1-14 mooring. After CTD, start return transit to Pascagoula.

*November 14, Sunday*: 07:00 (UTC-4) CTD#7 to 250 m at (15° 22' N, 052° 39' W). 13:00 (UTC-4) CTD#8 to 250 m at (15° 20.275' N, 053° 38.148' W). 19:00 (UTC-4) CTD#9 to 250 m at (15° 19' N, 054° 38.01' W). Clean up subsurface instruments. Data download

*November 15, Monday*: 01:00 (UTC-4) CTD#10 at (15° 15' N, 055° 38' W) aborted due to problem with CTD electronics. 07:00 (UTC-4) CTD#10 to 250 m at (15° 13.81' N, 056° 35.8' W), problem with electronics occurs again and survey technician fixes problem by drying connecting pins.

*November 16, Tuesday*: subsurface data downloaded. Safety meeting at 12:30. 14:00 buoy tipped upright. Offspooled wire from net drum onto wooden reels. Remove ASIMET instruments from buoy.

*November 17, Wednesday*: surface data downloaded, except Lascar (battery depleted). Offspooled rope from net drum into bags.

*November 18, Thursday*: Pack instruments and lab equipment into baskets. Drills at 12:30. Melo battery depleted, but data downloaded by applying external power.

*November 19, Friday*: lunar eclipse around 04:00 (UTC-4). Convert and pre-process data files to Matlab. Some SBE39 data files seem short and are later redownloaded completely. Compare NTAS19 subsurface data to CTDs 2,3.

*November 20–25:* transit to Pascagoula continues. Review meeting between science team, bridge, deck, and engineering crew on 11/23.

*November 26, Friday:* 10:00 ship docks at Halter shipyard in Pascagoula. Offload NTAS equipment, and load onto two trucks (one semi, one low-boy flatbed). NTAS20 cruise ends.

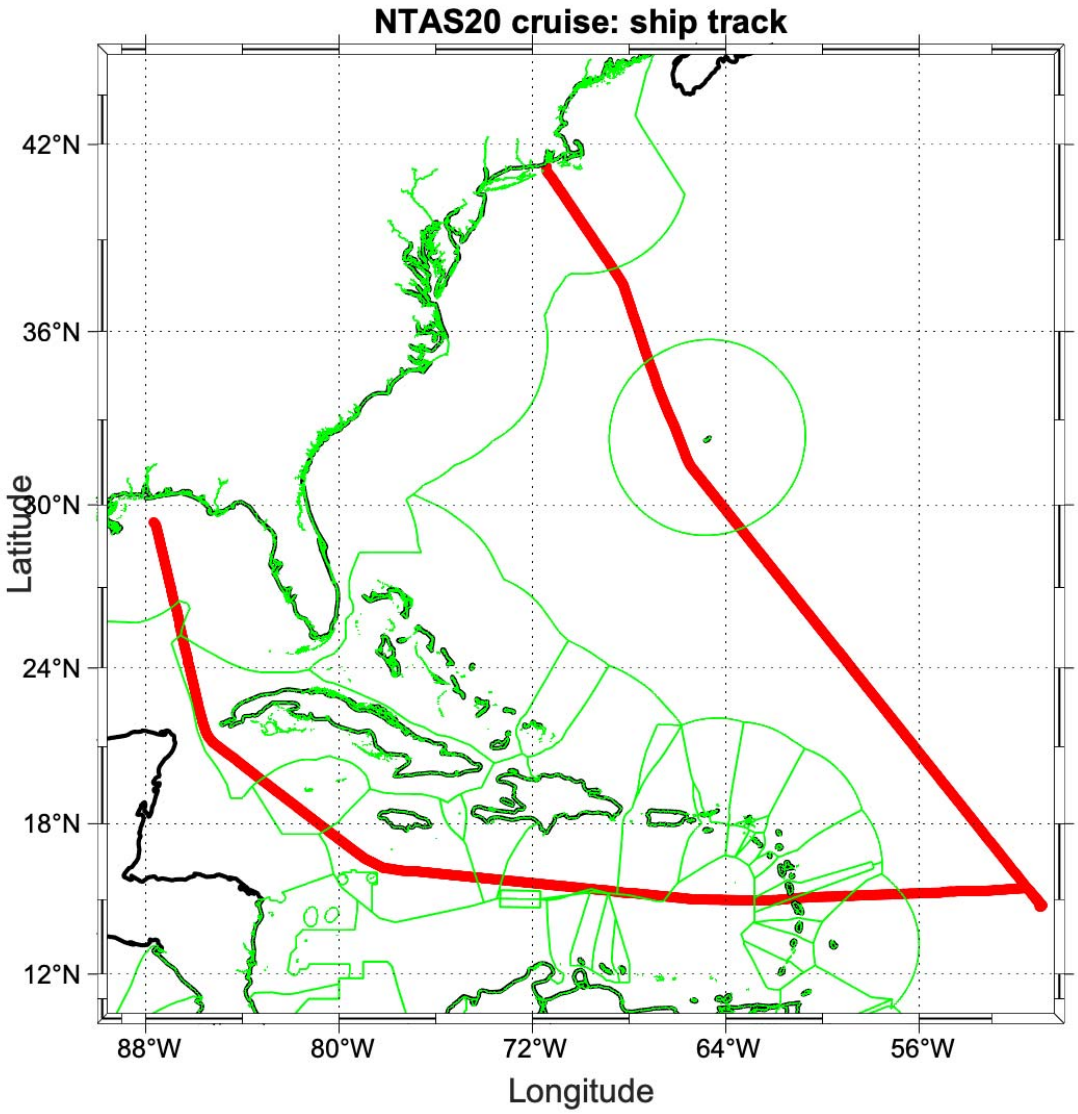


**Figure I-1. NTAS 20 cruise track onboard FSV *Pisces* (cruise PC21-07).**

## 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 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 20 mooring turnaround was achieved on the research vessel FSV *Pisces*, cruise PC 21-07, by the Upper Ocean Processes Group (UOP) of the Woods Hole Oceanographic Institution (WHOI).

The cruise was completed in 23 days, during November 4–26, 2021. It originated from Newport RI, and returned to Pascagoula, MS. The cruise track is shown in Figure I-1. The NTAS primary objectives were:

- To deploy the NTAS-20 mooring.
- To log data from the NTAS-20 buoy and *FSV Pisces* shipboard meteorological sensors during an inter-comparison period during which a sequence of CTD casts would also be made.
- To recover the NTAS-19 mooring.
- To do an inter-comparison between the NTAS-19 buoy and *FSV Pisces* shipboard data (meteorological sensors and CTD cast).

# II. Cruise Preparations

## II. A. Staging and Loading

The buoy systems were tested at WHOI during burn-in before being shipped to Rhode Island. On October 22, 2021, the NTAS 20 buoy and all supporting gear was loaded onto 2 trucks, a 48 ft low-boy flatbed and a 53 ft box truck. The gear was loaded at WHOI in Woods Hole, MA, in the morning and offloaded at Pier 17 at the Newport Naval Station in Newport, RI, by 3 WHOI personnel (Graham, Bigorre, Keane) later that same day. Once offloaded, the buoy well, mid-section and tower were reconstructed, and the primary meteorological systems were turned on. Over the next several days, in-port cruise preparations continued including: mounting all accessory brackets on the buoy, buoy spin, surface instrumentation, data evaluation, and testing of the subsurface telemetry system. On October 24, in-port cruise preparations were complete, and the buoy was left to run on the pier while WHOI personnel were in quarantine. Quarantine for WHOI personnel was from 10/25–11/2, with a PCR Covid test in West Greenwich, RI on 10/30. WHOI personnel joined the Pisces at pier 17 on November 2 and prior to loading operations were required to pass a rapid PCR Covid test on the pier. Once all personnel were confirmed negative, loading operations began. All equipment was loaded by the end of the day on 11/3 and equipment was either stored in the lab or set up on deck and secured for transit. Custom butterfly plates were used to mount the air-tugger and H-bit and custom bars for standard deck cleats. The Pisces deck pattern was found to be inconsistent such that the holes on the butterfly plates did not line up with the deck pattern. An acetylene torch was used by one of the ships engineers to further slot the butterfly plate holes. With all equipment secured, the ship departed Newport, RI on Thursday, November 4 at 10:00 EST, starting cruise PC-2107

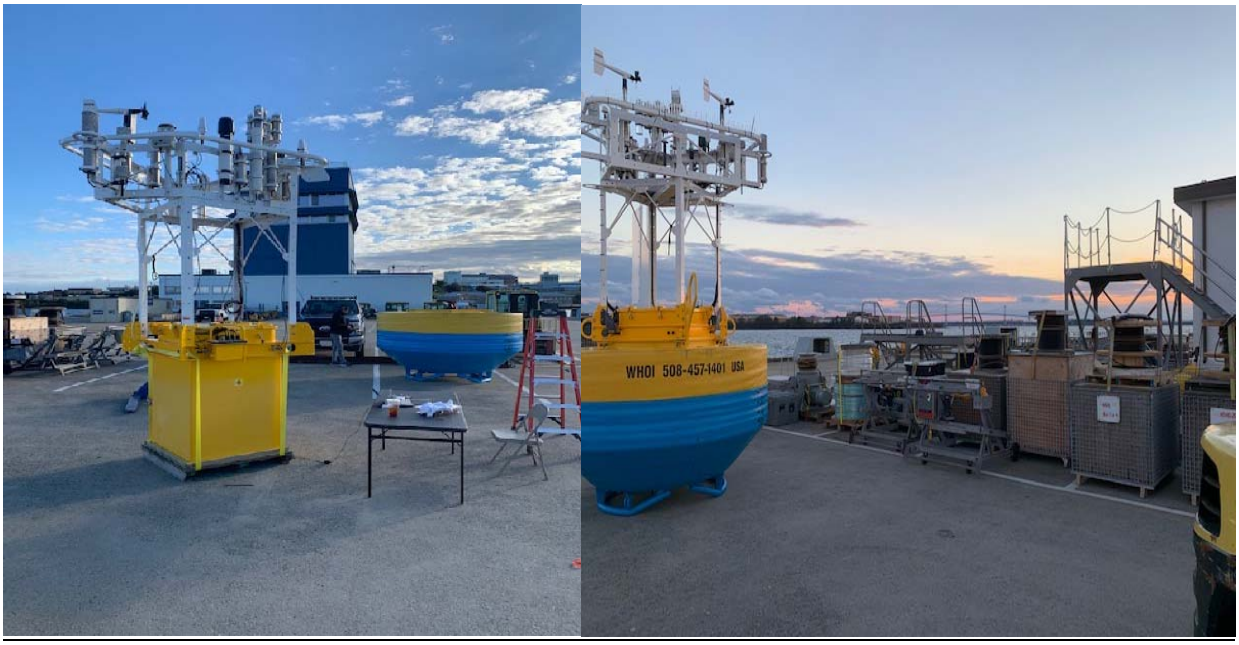


**Figure II-1. NTAS 20 surface buoy and mooring equipment staged on Pier 17 at the Newport Naval Station in Newport, RI.**

## II.C. Sensor Evaluation and Burn-in

The NTAS meteorological instrumentation consists of two Air-Sea Interaction Meteorology (ASIMET) primary systems, which are connected to loggers and battery packs in the buoy well, and standalone instrumentation, which are not connected to loggers and have independent batteries. For burn-in, the buoy was mounted with ASIMET and standalone sensors in the same configuration as the one planned for deployment and placed for almost two months 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 20. Every two week or so, the data was downloaded and processed to ensure all instruments were functioning properly and that their measurements were accurate. Burn-in occurred in summer 2021, and a short burn-in was done in port in Bridgetown and again onboard *FSV Pisces* during the transit between Rhode Island and the NTAS site.

# III. NTAS 20 Deployment

## A. Mooring Design

The buoys used in the NTAS project are equipped with surface meteorological instrumentation, including two ASIMET systems and standalone sensors (Vaisala WXT, SBE39 temperature, Lascar RH/ATMP), see Figure III-1. The ASIMET sensors include air temperature and humidity (ATMP/HRH), barometric pressure (BPR), wind speed and direction (WSPD and WDIR), precipitation (PRC), longwave (LWR) and shortwave (SWR) radiations, and seas surface temperature (SST) and salinity (SSS). Since NTAS 18, an additional data collection system was also implemented which included some of the same measurements (precipitation, air humidity and temperature, barometric pressure, longwave and shortwave radiations, and a GPS) that were recorded to a Campbell data logger. NTAS 20 also included two wave measurement systems, a WAMDAS system provided by NDBC, which recorded data internally, and a Brizo system from the XEOS company which recorded internally and telemetered data as well. Positions of the buoy were recorded by several two Rover and one Melo sensors from XEOS. The NTAS surface buoys have 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. On NTAS 13, NTAS 15 and subsequent deployment (including NTAS 20), the original metal wind vane (used up to NTAS 12) received a Delrin extension. This made for a lightweight addition and easier maneuverability of the buoy on deck. The wind vane on NTAS 14 was made of a single metal piece and larger than the original wind vanes.

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.

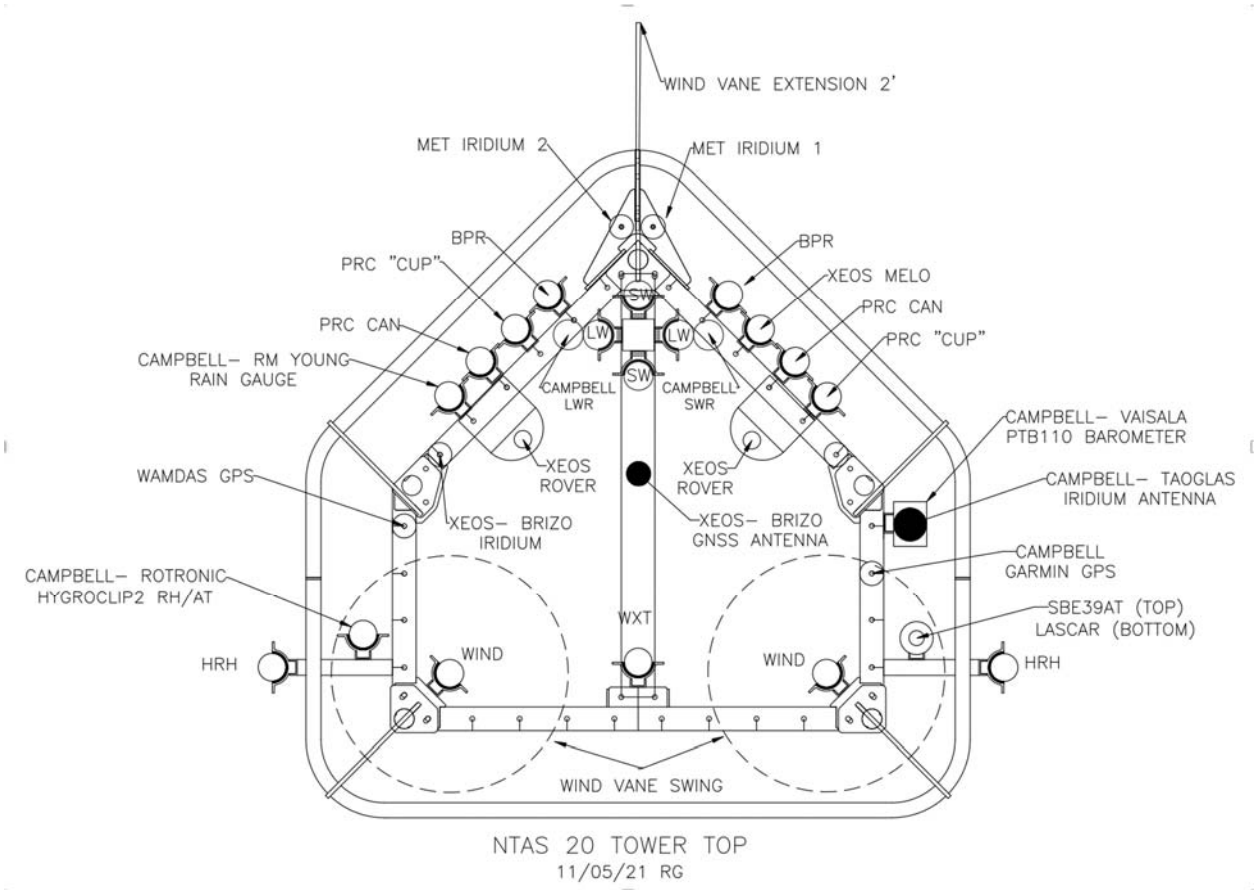


**Figure III-1. Top view schematic of the meteorological tower on the NTAS 20 buoy with the location of the ASIMET and other instruments.**

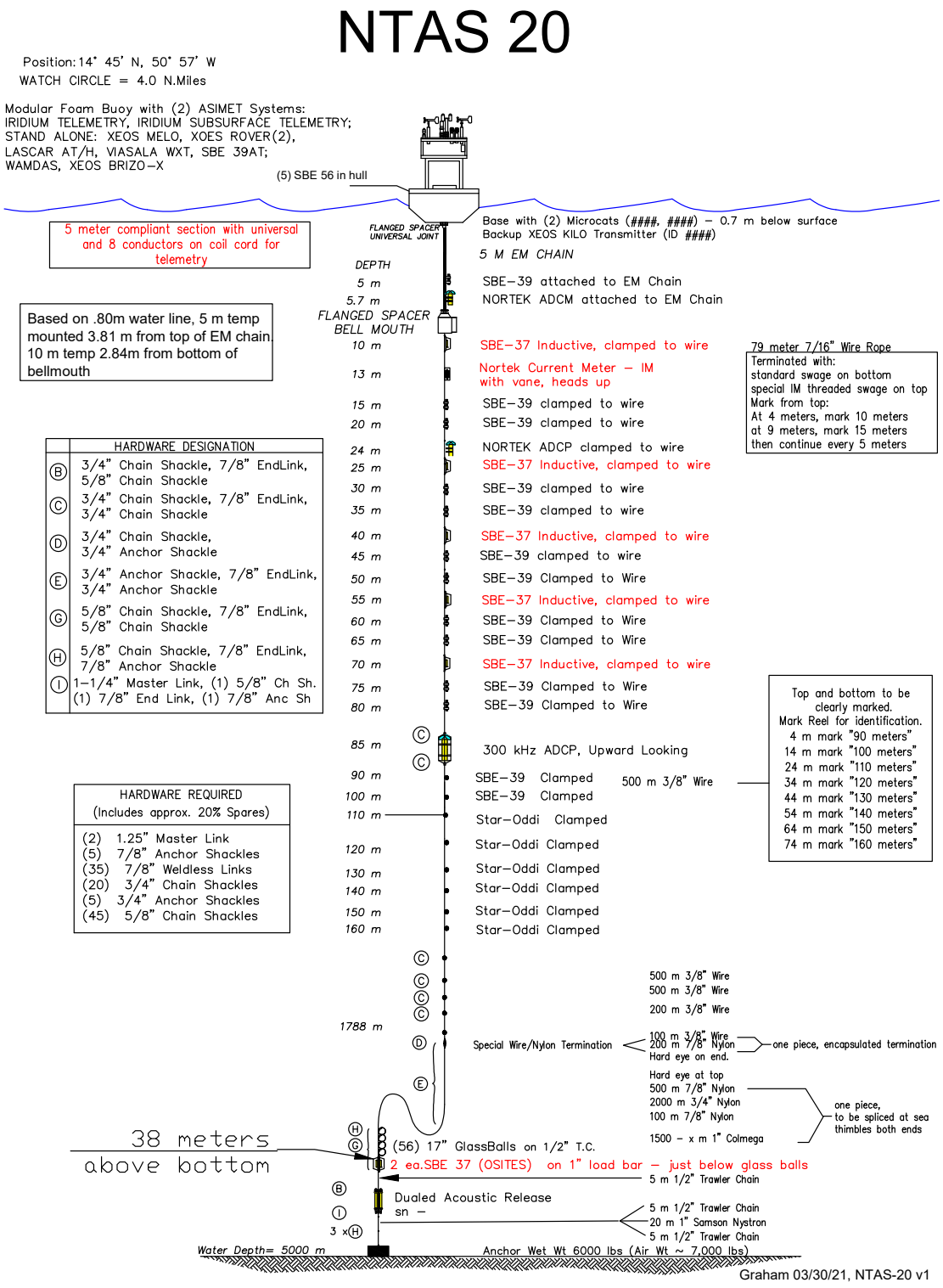


**Figure III-2. NTAS 20 mooring diagram.**


**Figure III-3. NTAS 20 buoy and meteorological instrumentation on deployment day.**

## B. Deployment

The deployment of NTAS 20 surface mooring occurred on November 12, 2021. Preparation for the deployment began at approximately 0530 (UTC-4) with the *Pisces* conducting a set and drift test at the target site. The ship drifted to the west at less than 1 kt. Wind was from ENE (070° and 10 kts), and there was a small current from ESE. Thus, it was determined that the *Pisces* would set up 6.5 nm, down-wind from the anchor drop site.

On deck, preparation for deployment involved mounting the upper 79 m section of 7/16" mooring wire to the subsurface telemetry interface section. In the days prior to deployment, the universal joint, flanged spacers, compliant section and coupling assembly were mounted to the buoy. On the morning of deployment, the 79 m section of mooring wire was led through a travelling block, around the port quarter and forward to the wire coupling assembly. A SeaBird 39 and Nortek current meter were clamped to the compliant section and all other instruments down to 55m were clamped to the mooring wire as well. Once the instruments were connected, a large loop of mooring wire with instruments was lowered along the port side and secured in the port corner with a slip line. Deployment operations began at approximately 0800 (UTC-4) with the ship's knuckle (Appleton) crane lowering the assembled telemetry interface section over the port side of the ship. The crane was connected to the outboard portion of the bottom coupling assembly using a 6' sling and a Peck and Hale release. Once connected the crane lifted the assembly and moved outboard until the full telemetry interface section was leading off the port side of the ship, at that time the crane lowered the bottom coupling assembly to the water and the release was triggered.


**Figure III-4. Subsurface telemetry system being deployed over the port side of the NOAA F/V *Pisces*.**

**Figure III-5. Preparing the NTAS 20 surface buoy for deployment with EM chain deployed over the port side.**

The next phase of the operation was to deploy the surface buoy. Slip lines were rigged on the buoy base, tower D-handle, and mid-section D-handle to maintain control during the buoy deployment. There were two tag-lines rigged to the buoy base, one leading to the H-bit that would be cleared first because of the distance between the H-bit and the buoy once outboard of the ship, and a second leading to a cleat on the port rail to be cleared last. Two parallel 12' slings were used to connect the ship's starboard crane to the Peck and Hale release. The release was then connected to the buoy using a 6' sling basketed through the pick-up bale. This was rigged in order to raise the crane's headache ball above the buoy tower to help avoid a collision with the instrumentation on the tower top during deployment. Once connected, the ship was instructed to increase speed from 0 kn to between 0.5-0.75 kn through the water. Once the bridge confirmed 0.5 to 0.75 kn through the water, the last two straps lashing the buoy to the deck were removed. The buoy was raised slightly off the deck and swung outboard at approximately 45º, with the tower leading slightly outboard. The slip lines were cleared in the following order: buoy base to H-bit, mid-section D-handle, tower-top and buoy base to port rail, with the final two cleared as the buoy reached the water. Once the buoy settled into the water, approximately 15 ft from the side of the ship, the quick-release was triggered and pulled away from the buoy at 08:30 (UTC-4). With the ship already moving slowly ahead, the approximately 50 m of mooring wire with instrumentation was lead over the rail until the buoy was clear of the stern and wire was paying out straight aft. The remainder of the 79 m section of wire was payed out the stern stopping to put instrumentation on along the way.

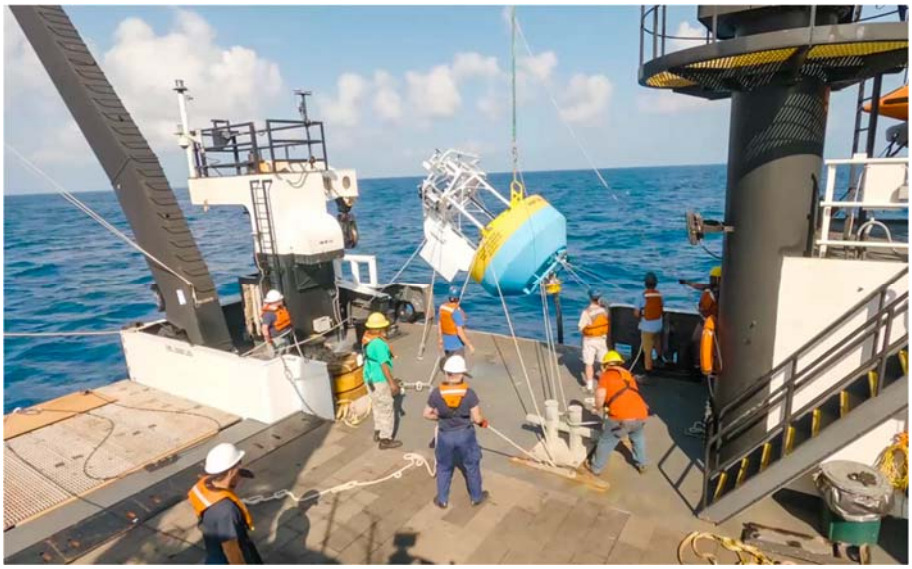

**Figure III-6. NTAS 20 Surface buoy deployment over the port side of the NOAA F/V Pisces**

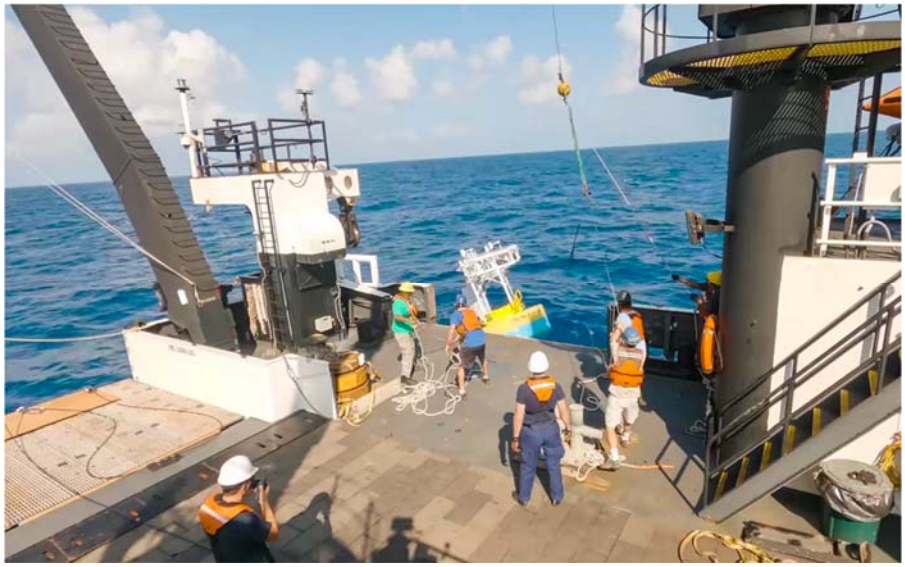

**Figure III-7. NTAS 20 surface buoy just after release with top section of mooring wire set-up on deck.**

Once at the bottom of the 79 m section of mooring wire, two stopper lines were connected to the end link on the leading end of the mooring wire and the wire termination was disconnected. The stopper lines were run through the travelling block with the wire to keep a good wire angle and prevent chaffing on the deck. The RDI ADCP cage was then shackled into the mooring between the two wire sections. With the wire from the ship's split net drum winch connected to the bottom of the ADCP cage, tension was taken back onto the winch and stopper lines were removed. Wire continued being payed out the stern with instruments being clamped on periodically. At approximately 100 m it was noted that an instrument (Nortek ADCP) set to be deployed at 24m had been missed. At that time the mooring was hauled back in, removing instruments, stopping off and removing the ADCP cage and the instrument was mounted at 54 m due to concerns of pulling the buoy in too far and risking flipping it over. The same method described previously for

deploying the rest of the 79 m section and ADCP cage termination were used going back out. At 10:10 (UTC-4), all instrumentation was deployed, at 160 m depth, and the ship was instructed to increase speed to 1 kn and again instructed at the end of the first 500 m wire section to increase speed to 1.25 kn. The remaining 700 m of mooring wire was deployed at this speed while monitoring winch pay-out speed to ensure proper tension throughout deployment.

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 200 meters of 7/8" Nylon 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 7/8" nylon off the H-bit.

The H-bit cleat was positioned approximately 20 feet from the transom and secured to the deck using custom butterfly plates to match the ships 47–48" x 47–48" center on center, deck pattern. The free end of the 4100 m section of nylon and Colmega line, stowed in three wood-lined wire baskets, was wrapped onto the H-bit and passed to the hard eye at the end of the 200-meter section from the wire to nylon termination. The two nylon sections were shackled together and wrapped with canvas to provide rigidity and protection for the nylon from the shackles. The line handler took tension onto the H-bit as the winch slowly payed out and was disconnected. A few wraps were removed from the H-bit to allow for slow but smooth deployment of the line. With moderate back tension, the H-bit line handler and one assistant eased the mooring line out of wooden boxes with another person spraying water on the H-bit to keep the line from overheating. A large stopper line was attached to the hard thimble at the end of the Colmega to assist with load transfers at the end of the line.

The hard thimble at the end of the Colmega line was slowly payed out through the H-bit using the stopper line until the thimble was approximately 10 ft from the end of the transom. At that point the stopper line was secured around the H-bit and the glass floats were dragged into position. At 13:00 (UTC-4), the first set of glass floats were shackled to the thimble on the end of the Colmega line and connected to the winch leader on the other end. Once connected the winch took up tension as the stopper line was slipped out of the H-bit and cleared. After the line was cleared, the winch payed out until only one ball remained on the deck. Stopper lines were then attached, the winch leader was removed, and two more strings of glass floats were inserted into the mooring line, with the end of the second string connected back to the winch leader. This process was repeated until all 56 floats were deployed.

A 1" titanium load bar with two SBE 37 was shackled to the last glass float segment. After that, a 5 m section of ½" chain was connected to the mooring on one end and the ship's winch on the other. The winch took up tension, 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. During this time the dual acoustic releases were rigged with the release chain and master link. The master link was then connected to a 5 m section of ½" trawler chain, followed by a 20 m section of 1" Samson Nystron line. The Nystron line was then wound onto the winch and the dual acoustic releases were shackled to the 5 m section of chain. The anchor was then moved into position ~10 ft from the transom on center using the ship's crane and a 5 m section of ½" trawler

chain was shackled to the anchor. The Nystron line was payed out until the connection could be made between the Nystron and the 5 m anchor chain. At this time, a large slip line was doubled back through the hard eye on the end of the Nystron and used to transfer the load to the anchor.

At 14:20 (UTC-4), the bathymetry was confirmed satisfactory for deployment and preparations for anchor drop started. The ship's Gilson winch with 1" spectra was fed through a block on the A-frame and connected to the anchor using the Peck and Hale release rigged with a 12-foot sling basketed through the anchor eye bolt. Two slip lines were rigged through the eye on the anchor to assist in stability during the deployment. The final step required the A-frame and Gilson winch operator to work together to lift and lead the anchor over the stern. Once clear of the stern, the Gilson winch lowered the anchor to the water and lines were cleared. At 14:57 (UTC-4) on November 12, 2021, the anchor was released at 14º44.958 N, 050º56.170 W in water depth of 5044 m.

**Figure III-8. NTAS 20 surface mooring anchor just before release**

Following the deployment, the ship positioned away from moving buoy and set in position for anchor survey, which occurred from 16:50 to 18:50 (UTC-4). At 18:00 (UTC-4), CTD#4 to 250 m (14° 44.34' N, 050° 57.73' W, 250 m downwind of NTAS 20 buoy) at same site as anchor survey point #2. After anchor survey, FSV *Pisces* remained 600 yards downwind of NTAS 20 buoy for inter-comparison overnight. At 08:00 (UTC-4) the next morning, November 13 2021, CTD#5 to 250 m was cast 250 m downwind of NTAS 20 buoy. At 09:00 (UTC-4), the ship slowly drove by NTAS 20 buoy. Visual observations showed the no damage to the tower top instrumentation during deployment and the buoy riding smoothly with a nominal waterline about 70 cm below the buoy deck.

## C. Anchor Survey

NTAS 20 anchor was dropped at 14:57 (UTC-4) on November 12, 2021, at 14º 44.958' N, 050º 56.170' W (measured on fantail using handheld GPS) in water depth of 5044 m. The acoustic survey of the anchor position was carried out the same day. 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 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 Multibeam measured the water depth in the area of the anchor drop as 5044 m, using local speed of sound from an XBT profile. Triangulation using the horizontal range to the release from the three sites, gave an anchor position of 14º 44.897' N, 050º 56.332' W (in decimal convention 14.7483° N, 50.9389° W). Fallback from the drop site was 290 m or 5.7 % of the water depth (Table III-2).

**Table III-1. Acoustic ranges for NTAS 20 anchor survey.**

| Waypoint | Latitude (dd mm.mmm N) | Longitude (dd mm.mmm W) | Travel time (s) |
|---|---|---|---|
| 1 | 14 45.456 | 50 54.810 | 7.656 |
| 2 | 14 44.490 | 50 57.873 | 7.620 |
| 3 | 14 43.483 | 50 56.048 | 7.501 |

**Table III-2. NTAS 20 anchor coordinates based on acoustic survey.**

| | | |
|---|---|---|
| Anchor Drop | 14 44.958 N | 50 56.170 W |
| Anchor position, Newhall's code | 14 44.897 N | 50 56.332 W |
| Depth at anchor position | 5044 m | |
| Fallback | 290 m | 5.7% water depth |

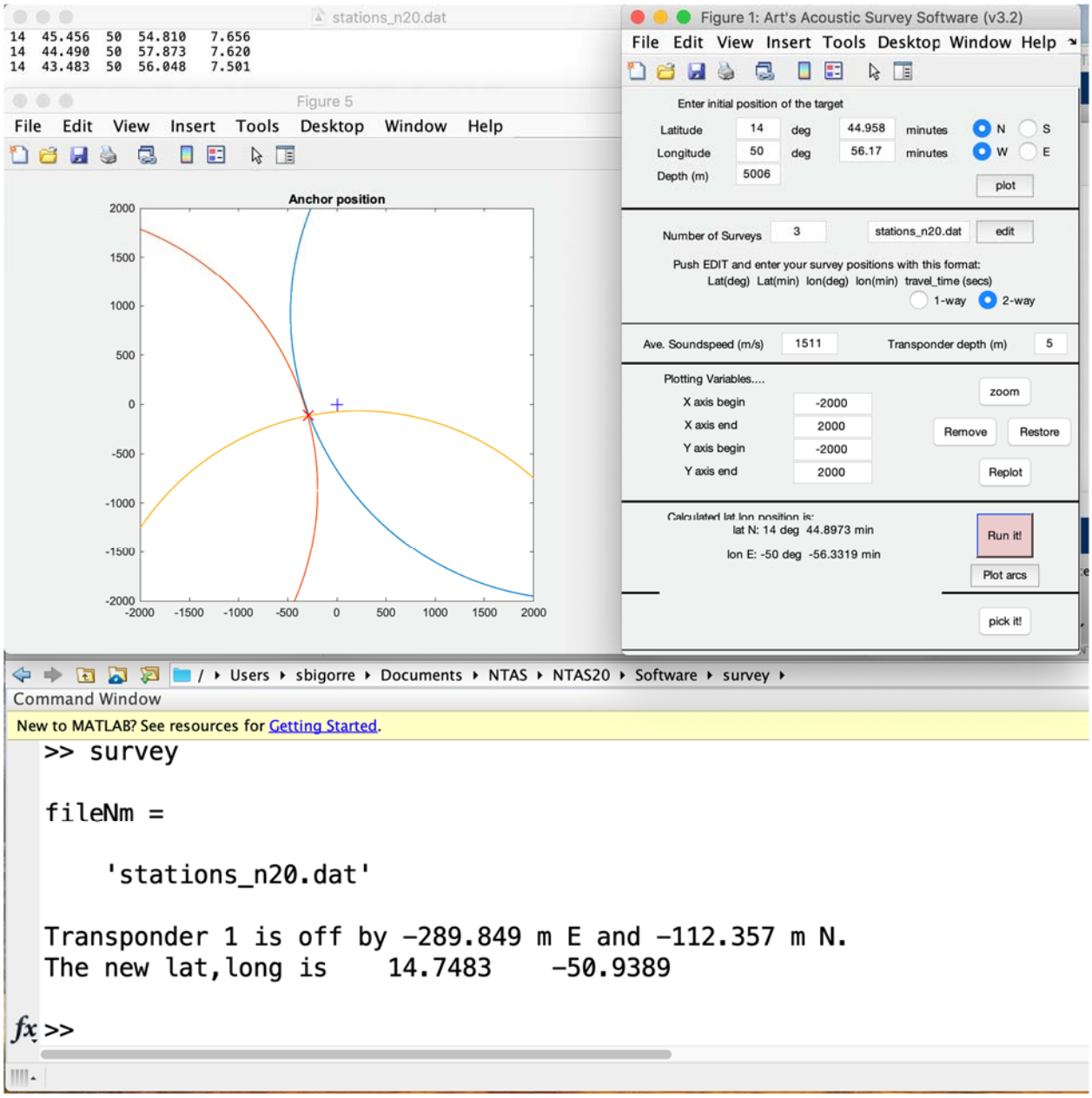


**Figure III-9. NTAS 20 anchor survey: screen capture of Newhall's Matlab code (survey.m) results.**

# IV. NTAS 19 Recovery

## A. Mooring Recovery

Recovery of the NTAS 19 mooring occurred on November 13, 2021. At 10:22 (UTC-4) the ship *FSV Pisces* was positioned roughly 0.5 nm downwind of NTAS 19 anchor and 260° from it. Wind was 15 kts, 80° True. NTAS 19 buoy was southwest of its anchor. upwind from the anchor position and the release command was sent to the acoustic release to separate the anchor from the mooring line. At 11:15 (UTC-4), the glass balls surfaced 500 yards and one starboard point on the ship's bow (Figure IV-1).

As the ship approached the glass balls, slowly steaming east, the green Colmega line was spotted floating behind the glass balls and turning back to the southwest towards the buoy, on the far side relative to the ship. Preparations for a starboard recovery of the glass balls were made, which would avoid crossing over the line between the glass balls and surface buoy.

**Figure IV-1. Cluster of glass ball floats off the starboard bow of the NOAA F/V *Pisces*.**

In preparation for recovery of the glass balls, the Gilson winch was led through the main block on the A-frame 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. When the ship was approximately 100 ft off the glass ball cluster, the ship lost all power. With no propulsion the ship drifted over the floating Colmega until the line was fully out from under the ship. At this time, the ship re-gained power and set up for another approach. Once ready, the ship again slowly brought the cluster of glass balls along the starboard quarter. A grapple hook was used to try and bring the cluster closer to the ship. While a successful grapple was connected to the glass ball cluster, the ship again lost all power. The ship then drifted over the floating Colmega line and the line became caught under the ship. The ship's crew grappled into the Colmega on the port side, pinning the line up under the ship. As the ship

drifted, the line under the ship formed a U-shape around the prop or rudder, so that both ends of the line, one leading to the surface buoy and the other end to glass balls, were coming out from the starboard side. In order to free the line from the ship, two grapples were used to first pull up the line leading to the surface buoy. Once enough slack was pulled up, the Colmega was secured to a cleat using a 6 ft green sling and a Yale grip was installed on the Colmega. Once installed a shackle and stopper line were used to secure the surface buoy side of the mooring line while the glass floats were recovered. Next, the same procedure using grapples, slings and Yale grips was used on the glass float side of the Colmega. Once rigged, and both ends of the Colmega line were secure, the Colmega was cut below the buoy side Yale grip, allowing the line to be pulled out from under the ship. Once the line was out from under the ship the Yale grip on the glass float side of the line was connected to the ship's Gilson winch and began hauling in slowly on the glass float. The winch hauled the cluster of glass floats up and over the stern while tag lines attached with snap hooks were used to control the cluster as it was pulled forward and lowered to the deck. Once the majority of the glass floats were on board, two stopper lines were secured to the chain leading to the acoustic releases on the edge of the transom. Next, the Gilson winch was taken off of the main cluster and attached to the chain leading to the releases. Stopper lines were cleared, and the winch hauled up the remaining chain and acoustic releases and lowered them on the deck. The final step before hauling in the remainder of the mooring was to clear the glass floats using the ship's crane to put the broken-down strings into wire baskets.

**Figure IV-2. Recovery of the NTAS 19 dual acoustic releases with cluster of glass ball floats on deck.**

Once the glass floats were clear, the winch leader from the ship's split net drum winch was lead through a travelling block on the A-frame, around the starboard quarter and up to the Yale grip on the Colmega connected to the rest of the mooring line and surface buoy. Once connected to the split net drum, the Colmega was eased out as the ship came around until the line was leading straight out over the stern. At this time the winch was used to haul in approximately 4000 m of Colmega and Nylon line and 1300 m of 3/8" mooring wire before getting to the heavily

instrumented portion of the mooring wire. As the last 160 m of mooring wire was hauled in by the winch, instruments were removed from the wire, inspected, photographed and recorded on the mooring log. When the 85 m 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 wire were reconnected using the existing mooring hardware and the recovery of the rest of the mooring wire continued, removing instruments as they came in. Instruments were removed up to 55 m before paying the mooring wire back out to the 79 m termination. A slip line was rigged at the end of the termination, winch leader disconnected, and wire slipped out, setting the buoy adrift.

After the buoy was set adrift, the deck was set up for an A-frame recovery. The Gilson winch was run through the main block on the A-frame and around the starboard quarter to where the buoy would be hooked up. A 5-ton titanium hook was connected to the spectra line from the Gilson winch and three tag lines were pre-staged with snap hooks on the stern; one tag line was fair lead through a small block on a shackle to the deck on center and connected to the small air tugger. Once the deck was set up, the ship brought the buoy down the starboard rail and the titanium hook was connected to the buoy pick up bale using a large pick-up pole. The ship continued to slowly move forward until the buoy was straight out off the stern. At this time the ship slowed down to just maintain our heading into the seas. The Gilson began hauling the buoy in until it was directly behind the stern, under the A-frame. The Gilson winch lifted the buoy out of the water, the buoy spun 180 degrees to port and then the three tag lines were connected, two on the mid-section D-handles and the one rigged to the air-tugger to the D-handle on the tower top. The three tag line handlers worked together along with the winch and A-frame operators to stabilize the buoy while it was brought on deck. The air-tugger tag line acted to pull the buoy forward as it was lowered onto the deck. Once the buoy was laid forward of the grated deck and the bottom of the EM chain was above the water line, the buoy was secured to the deck using ratchet straps.

**Figure IV-3. NTAS 19 surface mooring on deck after recovery**

The outhaul winch mounted to the A-frame was rigged with a snap hook and connected to the flanged spacer at the bottom of the EM chain. The outhaul winch then hauled the bottom section of the inductive telemetry assembly until it was clear of the transom, before lowering it to the deck.

Once on board, the bell-mouth was secured with a stopper line, the outhaul winch was disconnected, and a Yale grip was installed at the top of the 79 m section of wire left to recover. The wire from the split net drum was then run through a travelling block and reconnected to the final 79 m section of wire. The travelling block was then lifted the majority of the way up the A-frame using the outhaul winch, so that the wire running through the block could clear the buoy tower as it was hauled in by the split net drum winch. Once rigged, the remaining 79 m of mooring wire were recovered using the split net drum winch, and instruments removed as they came up. The final instrument, marking the end of recovery, was on board at 1640 (UTC-4).

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.

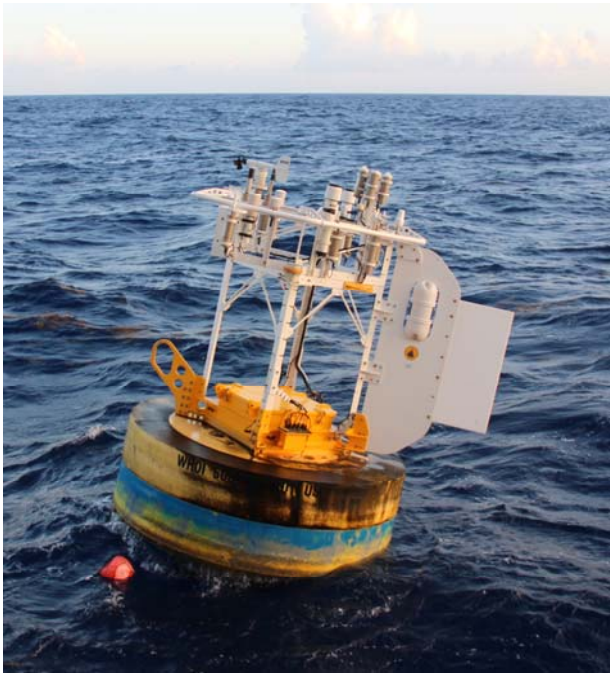

**Figure IV-4. NTAS 19 just before recovery on November 13, 2021.**

## B. Instrument Performance

The NTAS 19 was deployed on 22 October 2020 and recovered on November 13, 2021, thus remaining on station for 287 days. Visual inspection prior to recovery (Figure IV-5) indicated some damaged meteorological instruments (ATMP/HRH on port side missing ventilation plates, wind anemometer on starboard side missing propellers and vanes, propellers from wind sensor on port side not moving). This damage was caused by hurricane Sam on September 27, 2021. Subsurface instrumentation showed little biofouling (Figure IV-66 to Figure IV-10). Fouling with fishing gear was observed in upper section of the mooring (Figure IV-1), which may have been caused by drifting gear than local fishing activity.

A preliminary list of damaged NTAS 19 instruments, many from hurricane follows.
On System 1: Wind (no data starting late October), Air temperature (suspicious data) and humidity, Barometric pressure (data interrupted for several days after hurricane but eventually resumed).

Other instruments damaged by hurricane were System 2 Wind, standalone WXT (no data from any variables after hurricane, and no precipitation for the whole deployment). Air temperature and humidity could not be recovered from Lascar instrument.

Subsurface instruments with suspicious or bad data were SBE37#13413 at 70 m (suspicious data starting early September 2021) and #12247 at 4983 m (bad conductivity starting February 2021, but temperature still good).

**Figure IV-5. ASIMET meteorological sensors immediately prior to recovery of NTAS19.**

**Figure IV-6. NTAS 19 buoy bridle immediately following recovery.**


**Figure IV-7. NTAS 19 subsurface instrumentation at recovery: deeper instruments.**


**Figure IV-8. NTAS 19 subsurface instrumentation at recovery: middle instruments.**

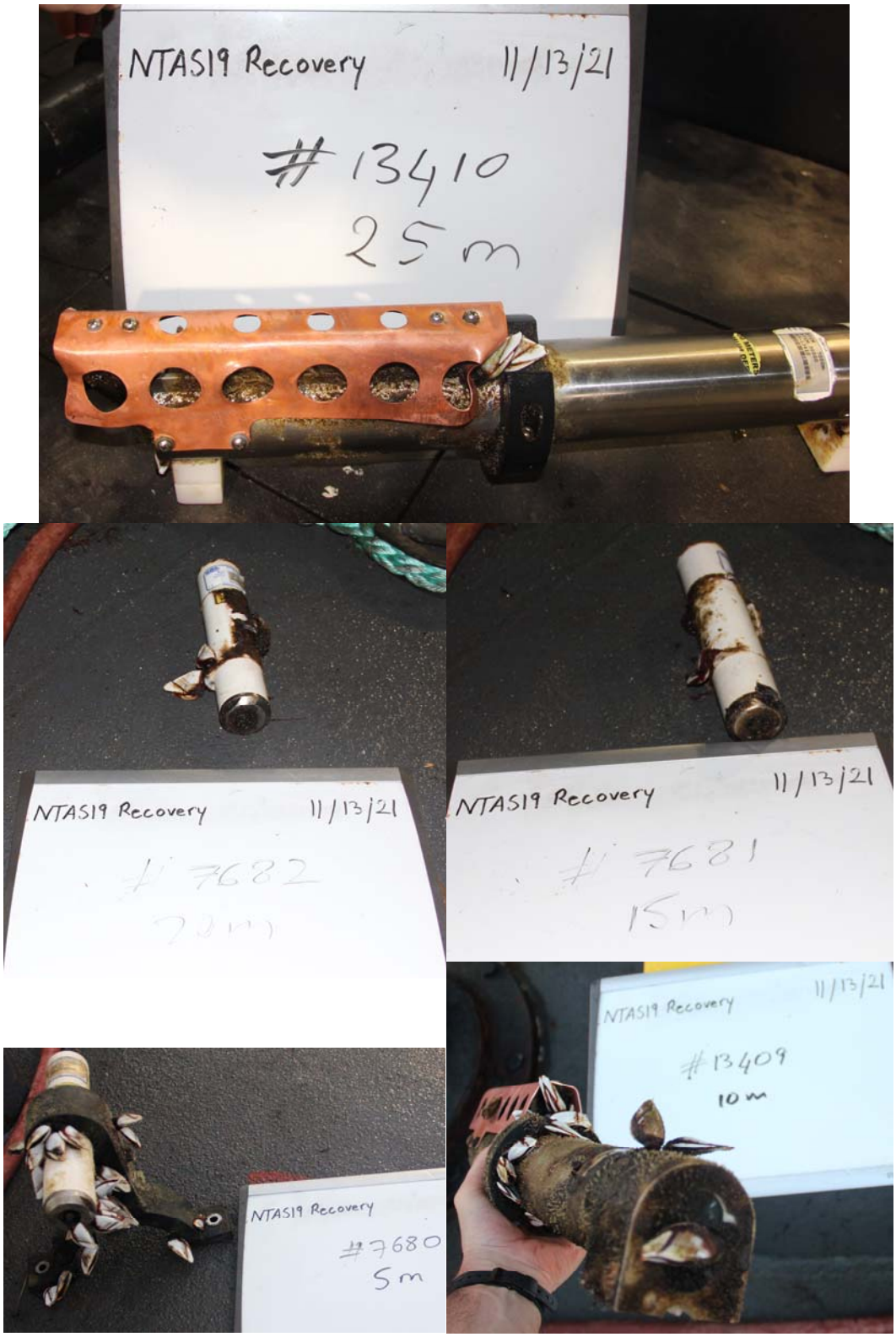


**Figure IV-9. NTAS 19 subsurface instrumentation at recovery: shallower instruments.**

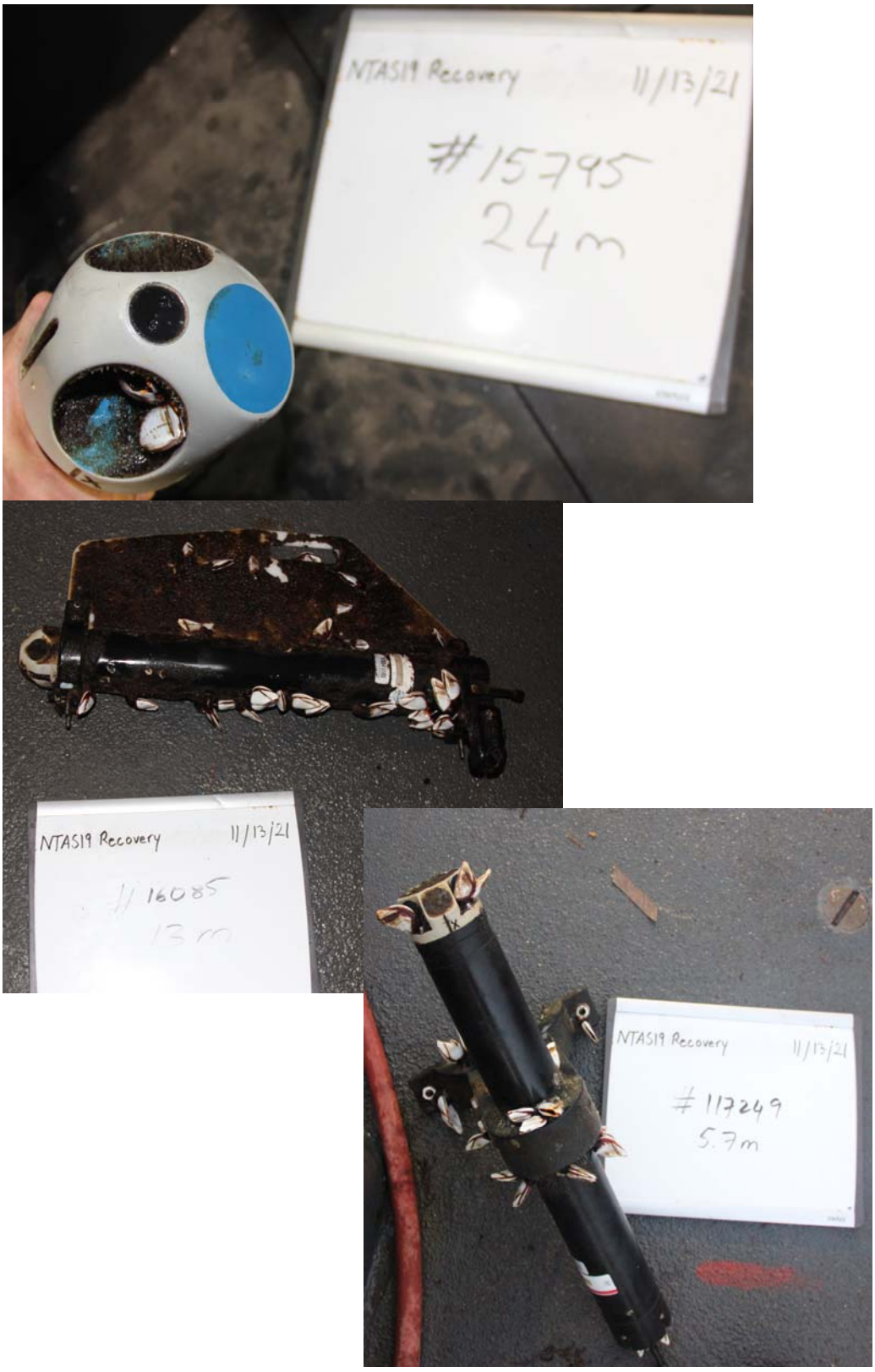


**Figure IV-10. NTAS19: Nortek current meters and profilers.**

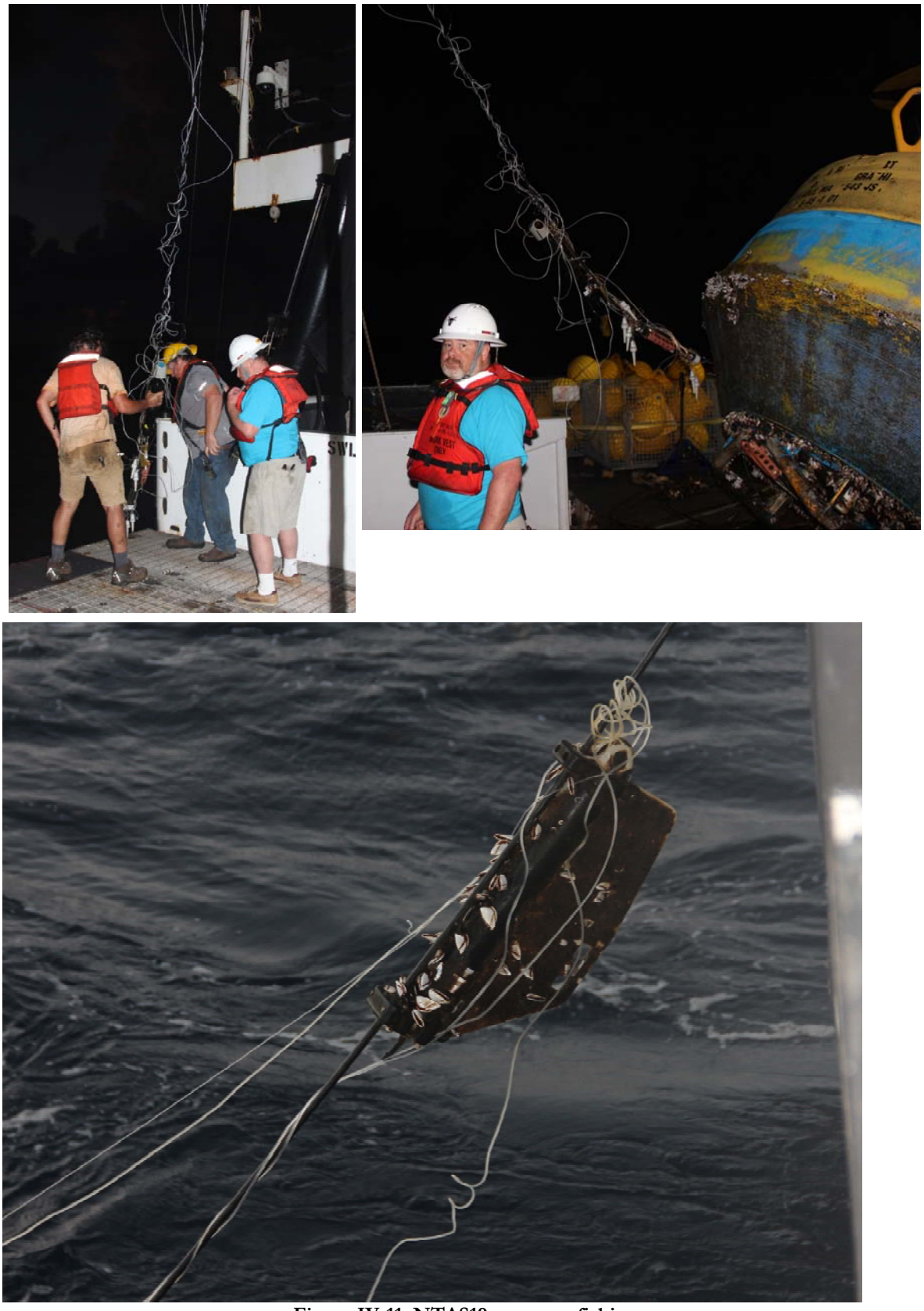

**Figure IV-11. NTAS19 recovery: fishing gear.**

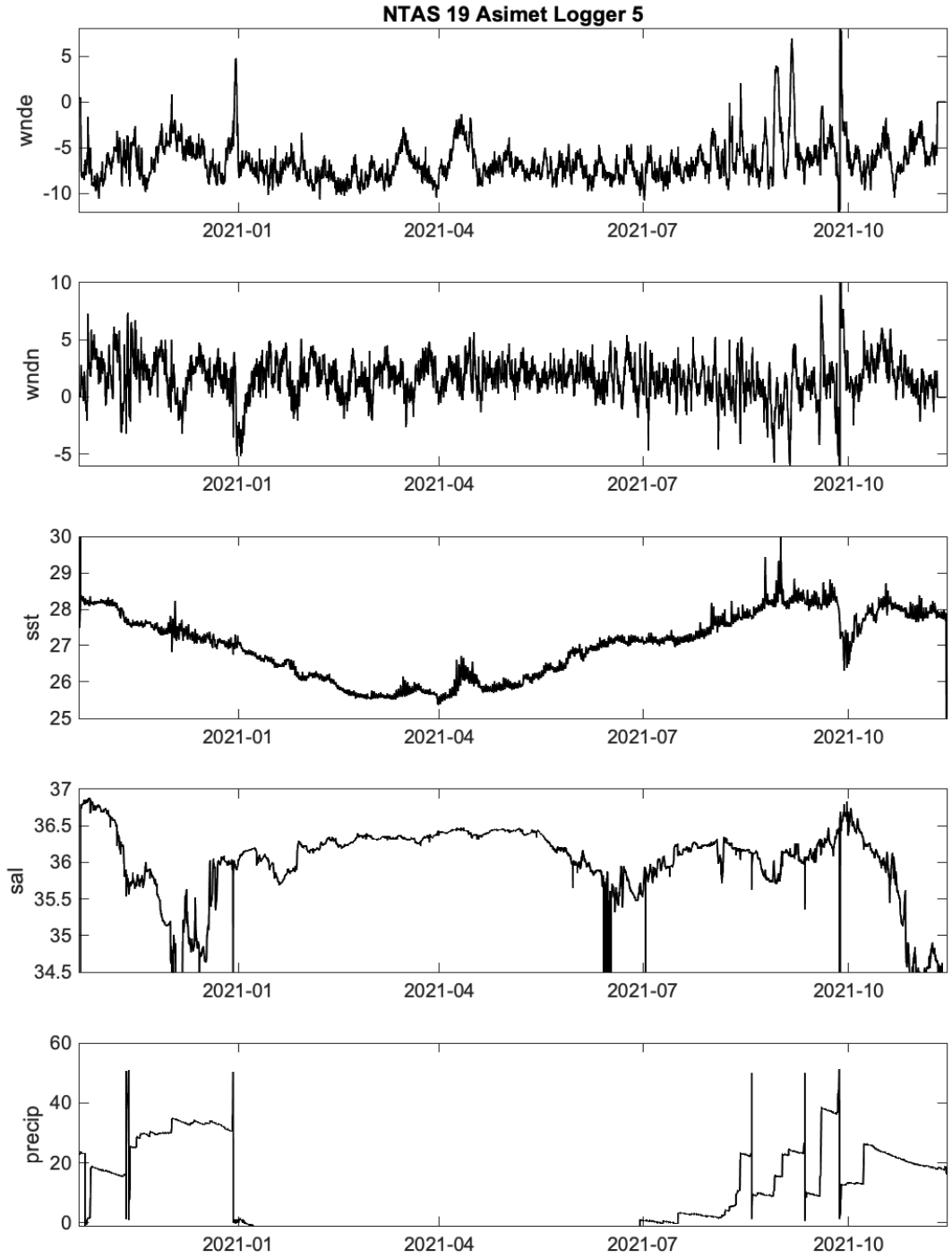


**Figure IV-12. Logger 5 data from NTAS 19: wind U (m/s), wind V (m/s), SST (°C), surface salinity (psu), precipitation (mm).**

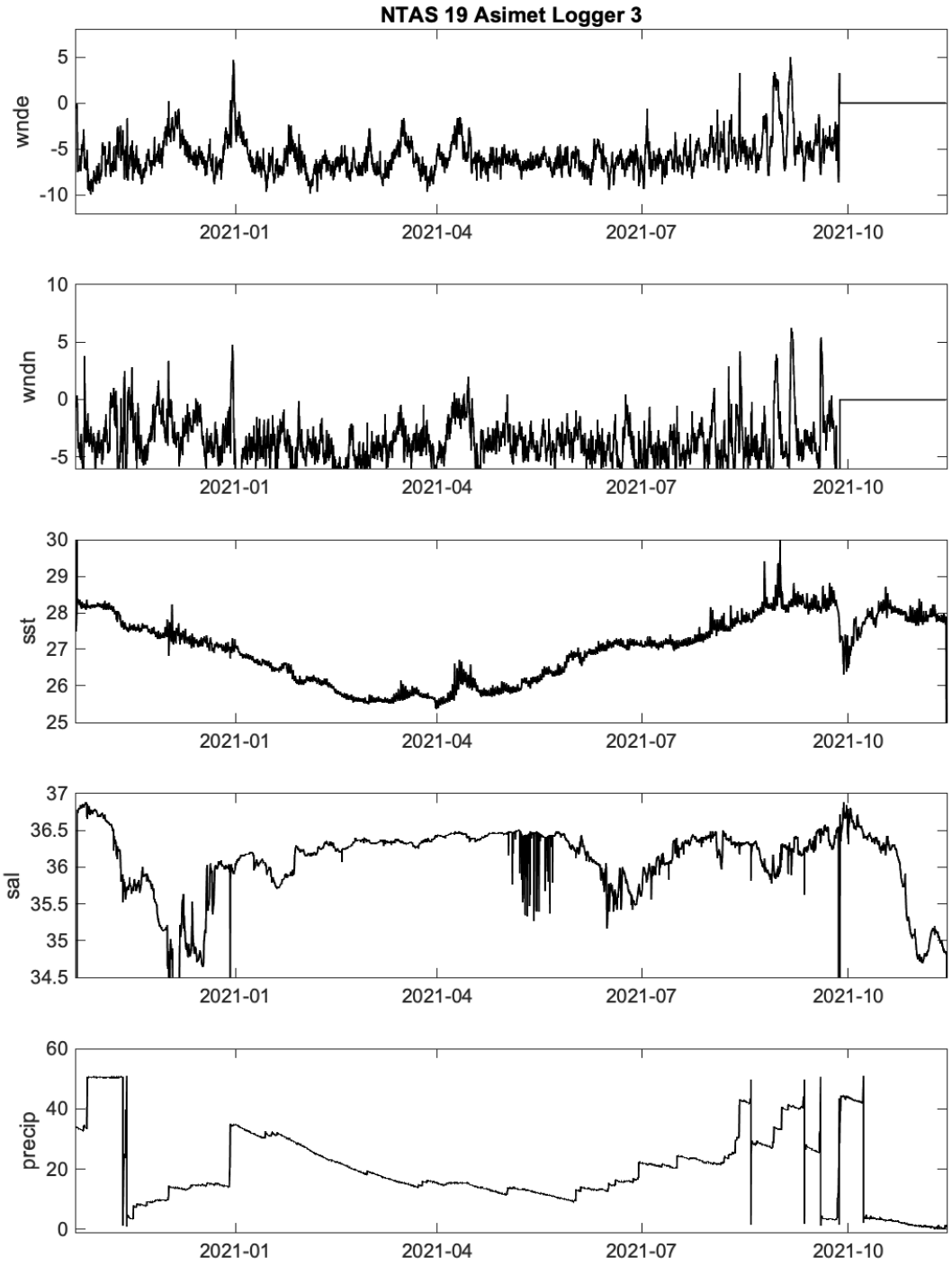


**Figure IV-43. Logger 3 data from NTAS 19: wind U (m/s), wind V (m/s), SST (°C), surface salinity (psu), precipitation (mm).**

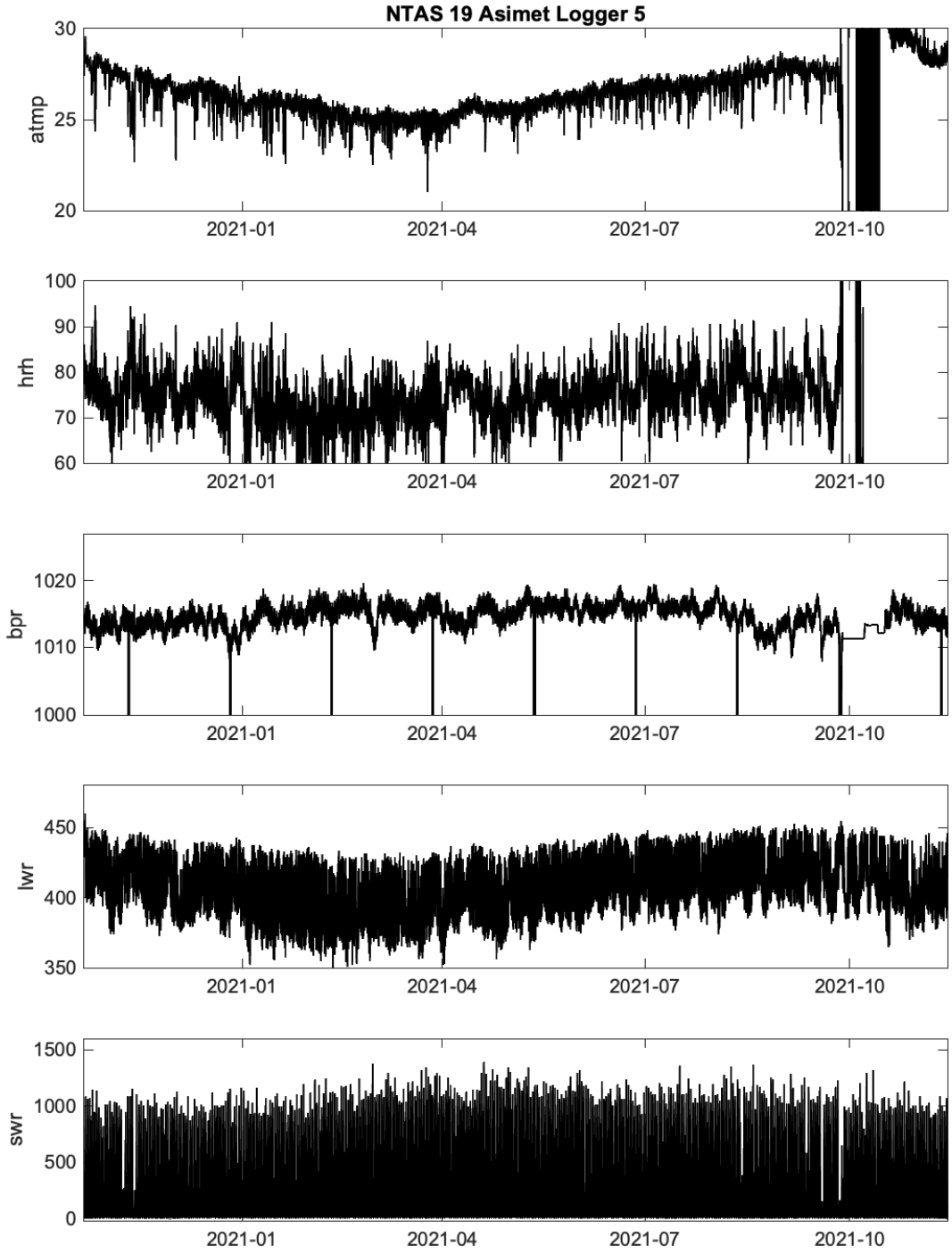


**Figure IV-54. Logger 5 data from NTAS 19: Air temperature (°C), relative humidity (%RH), barometric pressure (mbar), Longwave radiation (W/m$^2$), Shortwave radiation (W/m$^2$).**

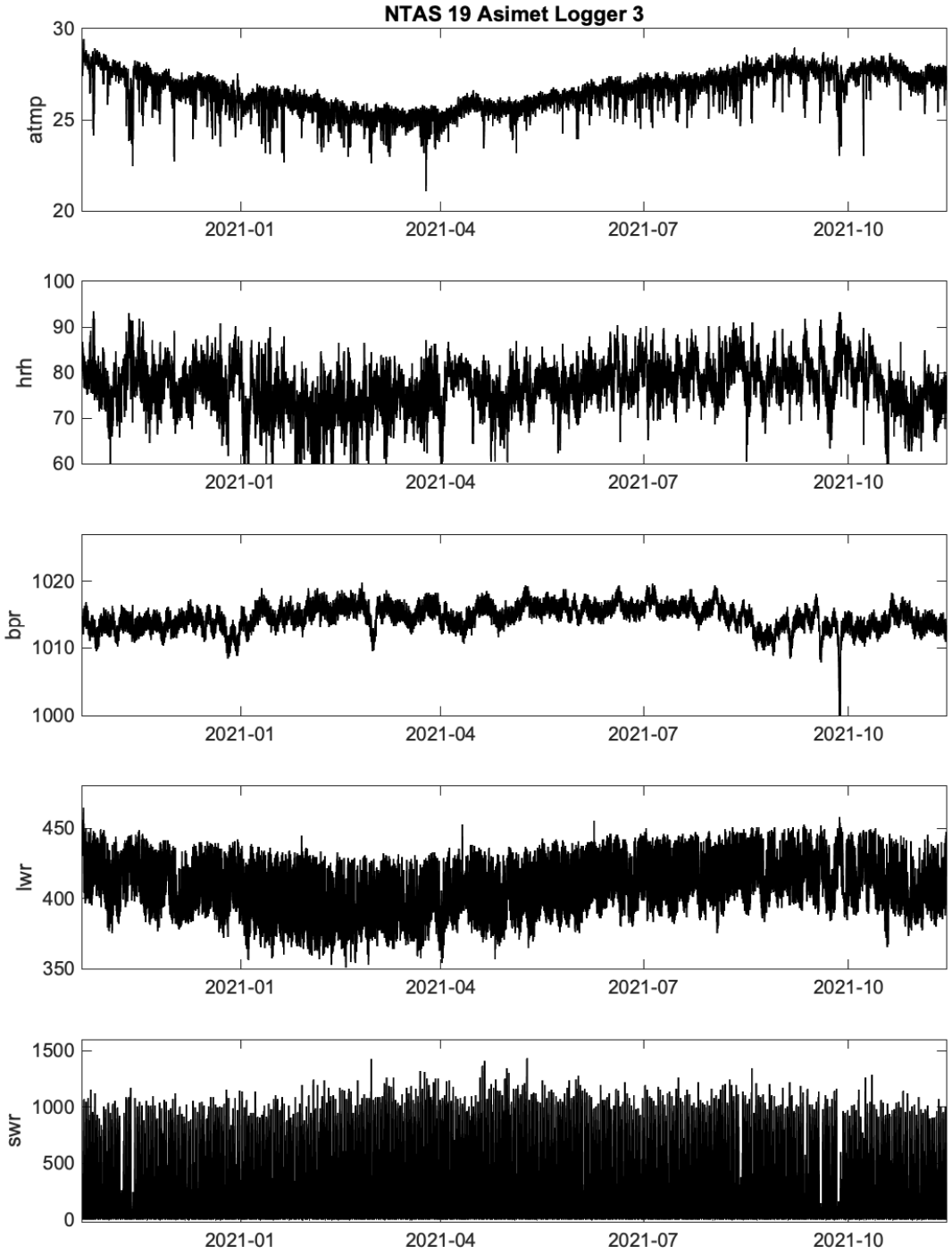


**Figure IV-65. Logger 3 data from NTAS 19: Air temperature (°C), relative humidity (%RH), barometric pressure (mbar), Longwave radiation (W/m$^2$), Shortwave radiation (W/m$^2$).**

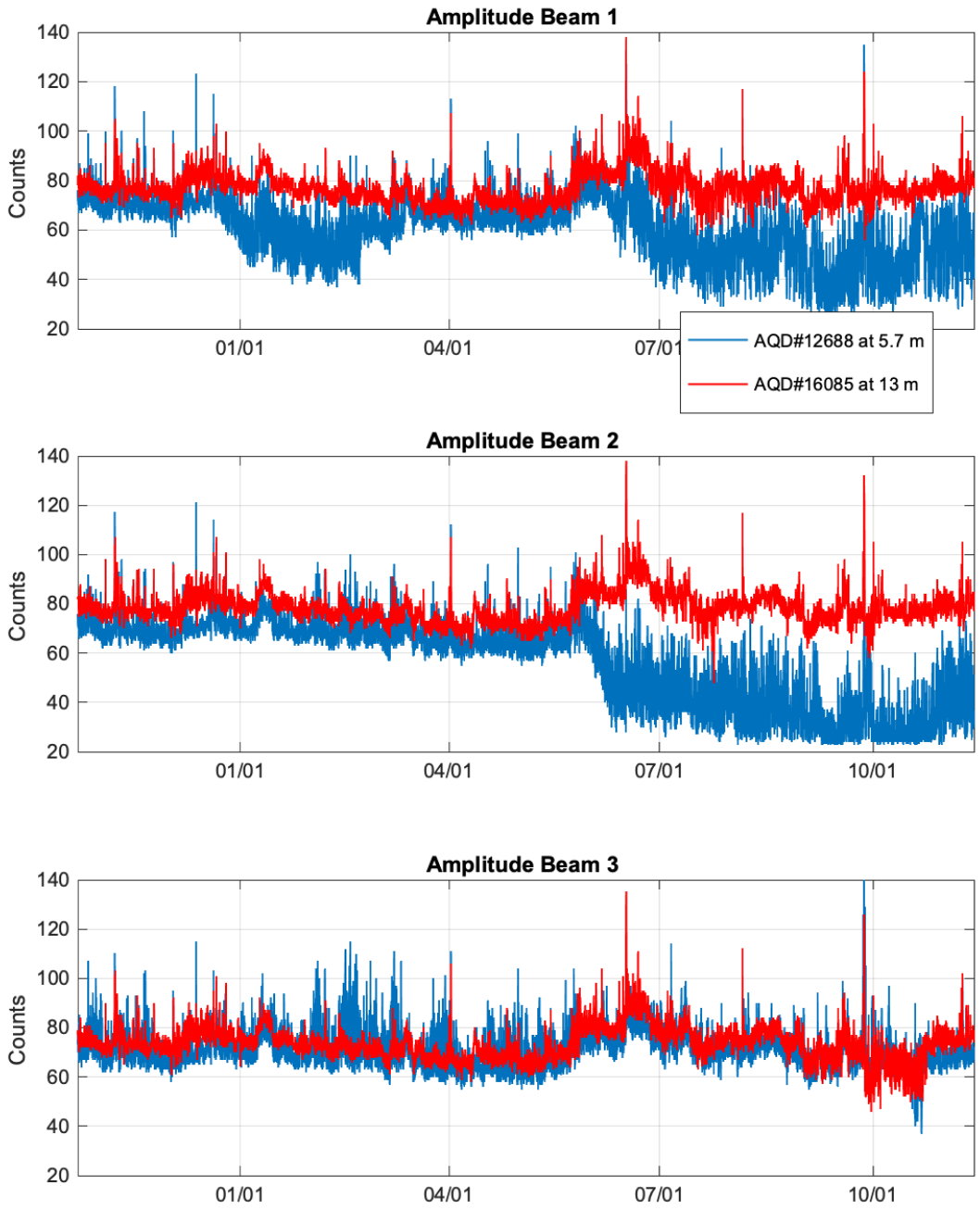


**Figure IV-76. NTAS 19 Aquadopps at 5.7 m and 13 m depths: signal amplitude during all deployment.**

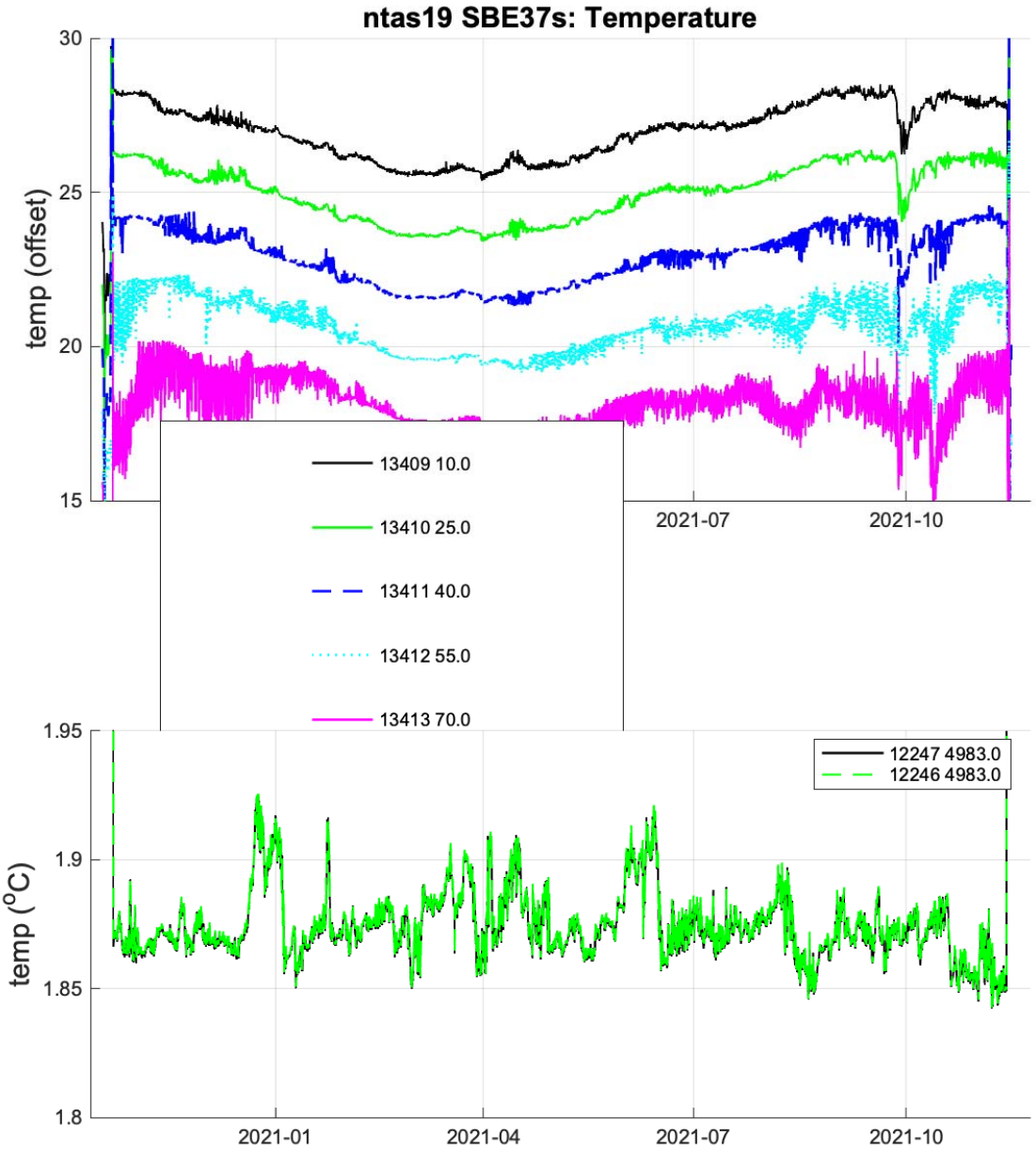


**Figure IV-87. NTAS 19 Seabird SBE37s temperature record. Top: data from upper ocean instruments with added offset for readability. Bottom: two deep instruments near glass balls.**

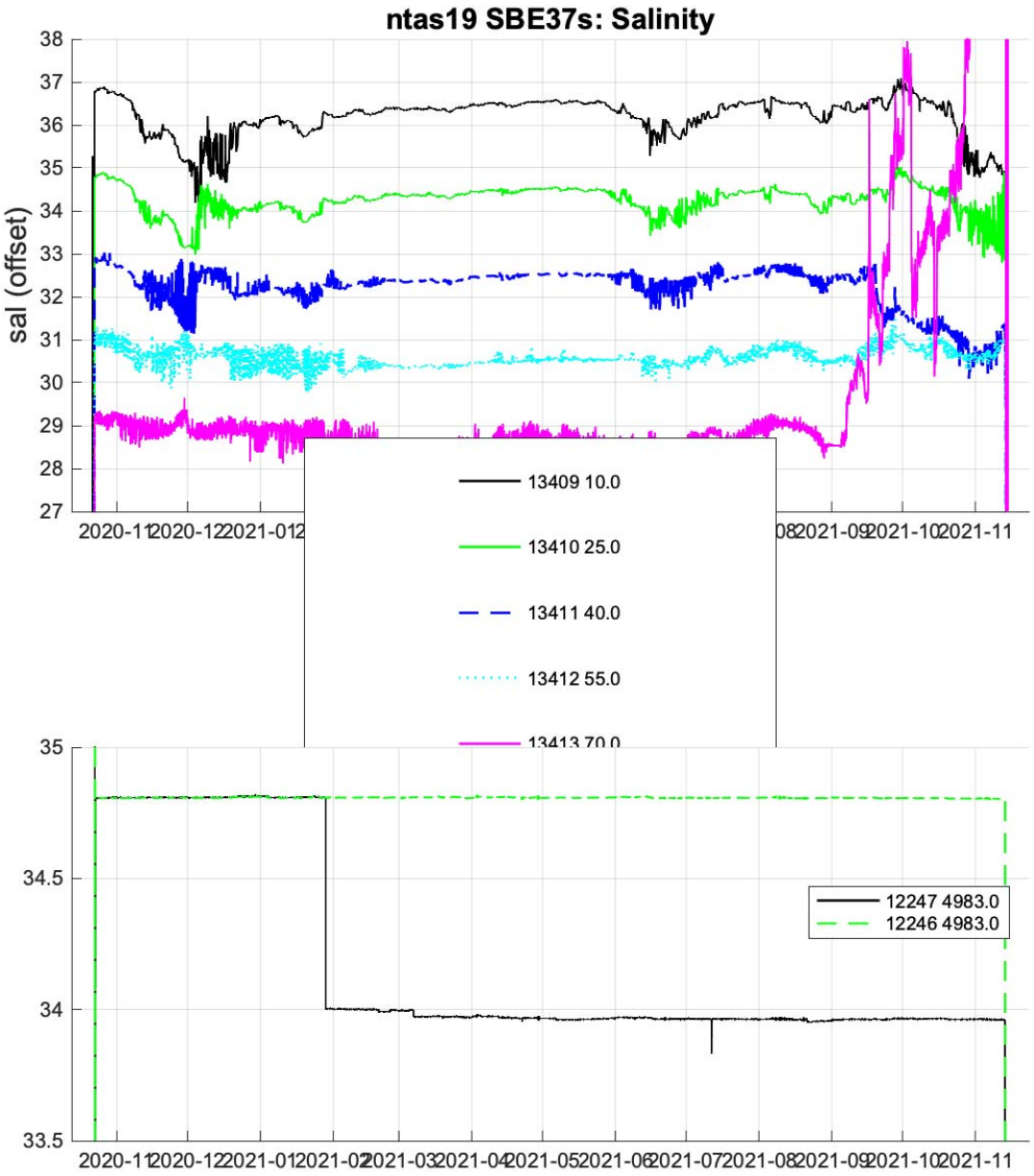


**Figure IV-9. NTAS 18 Seabird SBE37s salinity record. Top: data from upper ocean instruments with added offset for readability. Bottom: two deep instruments near glass balls.**

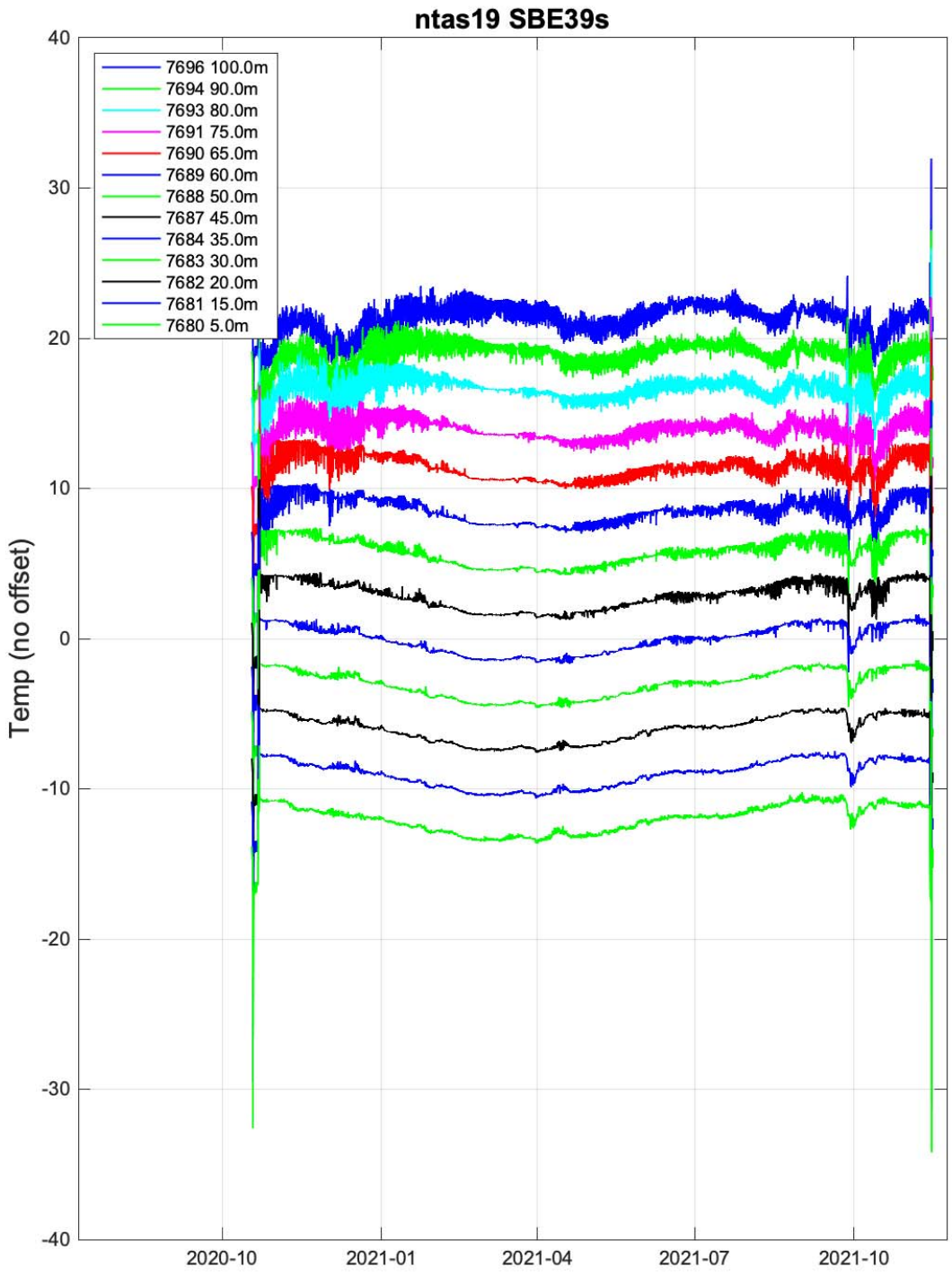


**Figure IV-109. NTAS 19 Seabird SBE39s temperature record, with added offset for readability.**

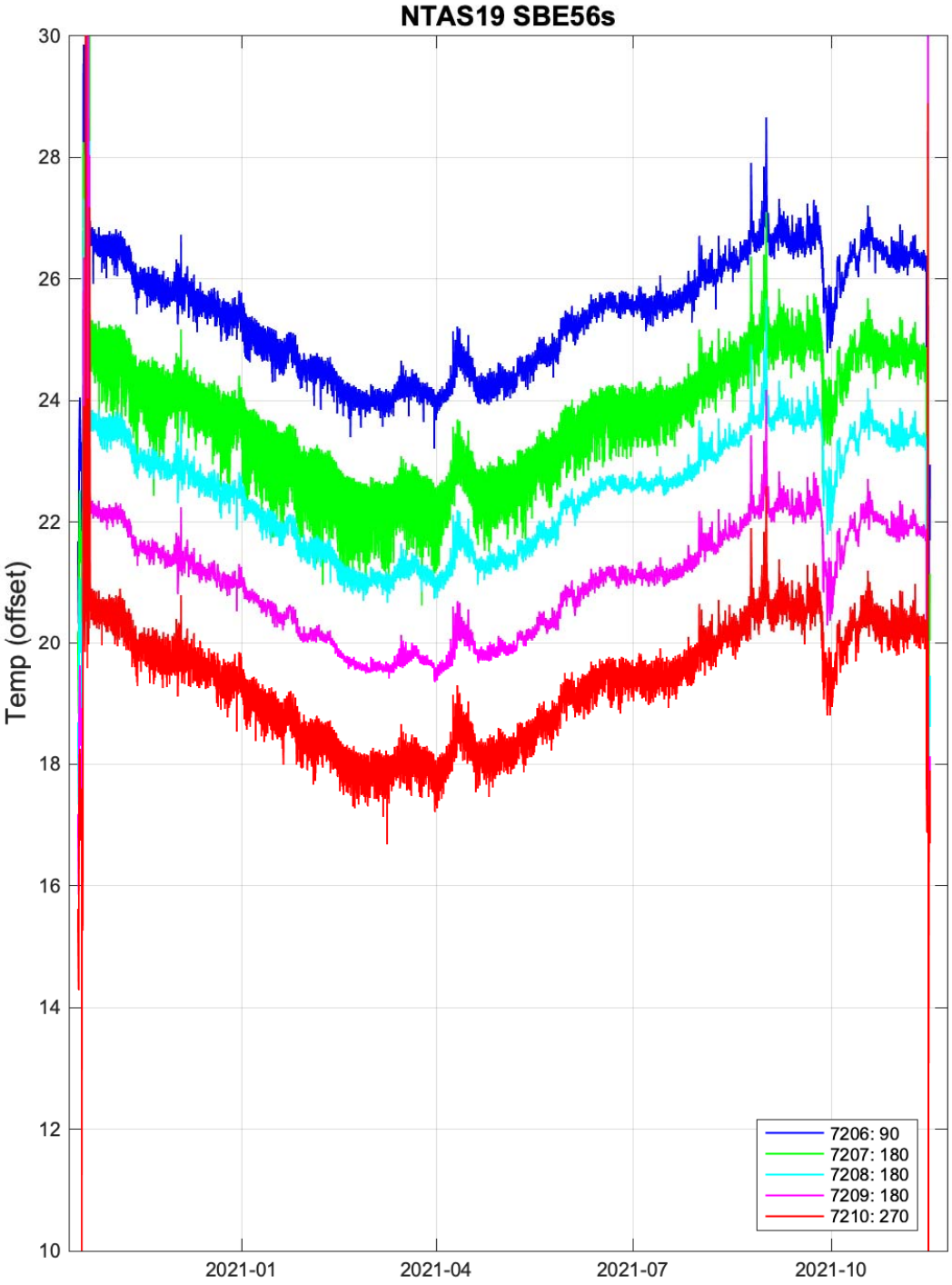


**Figure IV-20. NTAS 19 Seabird SBE56s temperature record.**

## C. NTAS 20 and NTAS 19 Inter-comparisons

The two buoys NTAS 20 and 19 were both in the water from November 12 12:34 UTC when NTAS 20 buoy was deployed, to November 13 20:25 UTC when NTAS 19 was recovered. The anchor drop for NTAS 20 was on November 12 18:57 UTC, and the mooring release for NTAS 19 was November 13 14:22 UTC. The time window between one hour after anchor drop and up to mooring release provide the best data for inter-comparison, as buoy motion decreases when the mooring is secure. However, because of the short overlap when both buoys were in the water, we use the longer time window available for the inter-comparison between the two buoys.

We used hourly averaged data (no quality control) transmitted through telemetry for NTAS 20 and from the recovered loggers for NTAS 19. The plots in Figure IV-111 to Figure IV-122 are time-series for each variable measured from redundant sensors (there are two ASIMET sensors on each buoy, and one Campbell system on NTAS 20). Plots in Figure IV-133 to Figure IV-155 use the same data but present it as scatter plots between similar measurements from redundant sensors. These plots can serve both to identify variations in the surface meteorology in the region, and to evaluate the functionality and accuracy of the measurements. Note that some difference should be expected between similar measurements from redundant sensors on the same buoy and between buoys, due to errors such as flow distortion on the buoy or instrument errors, and also because the two buoys were several miles from each other (NTAS 20 anchor is 7.5 nm to the Southeast of NTAS 19 anchor). However, this comparison is useful as a preliminary evaluation of possible biases, which can be further investigated in the WHOI calibration laboratory.

Comparisons of the time-series and scatter plots indicate that for both NTAS 19 and NTAS 20 air temperature measurements on each buoy were within 0.1 °C for all 3 systems on NTAS 20 and system 2 on NTAS 19. However, system 1 on NTAS 19 had a warm bias. Air relative humidity from ASIMET system 1 and 2 on NTAS 20 agreed very well with each other and well within ASIMET's stated accuracy (less 2 %RH), and the Campbell was about 2 %RH wet. Humidity from system 2 on NTAS 19 was dryer by about 2 %RH, but since system 1 did not provide data at the time, this difference may be from actual differences in conditions between the two buoys.

Downwelling longwave radiation (LWR) on system 1 and 2 on NTAS 20 were within 1-2 W $m^{-2}$, and the Campbell system was almost 5 W $m^{-2}$ higher. System 1 and 2 on NTAS 19 agreed very well with each other and were a bit lower than NTAS 20 measurements, possibly due to the separation between the buoys. was lower than the other three similar measurements (system 1 NTAS 18 and systems 1 and 2 NTAS17); the scatter plot also indicates that this bias (roughly 5 W $m^{-2}$) may increase for low and high values of LWR. For downwelling shortwave radiation (SWR), both primary ASIMET systems on each buoy agree within about 5 W $m^{-2}$ , but the Campbell system on NTAS 20 is lagging in time and will require further investigation using 1-mn data upon recovery. There is some difference between the two buoys and this may be caused, at least in part, by actual different cloud coverage at the two locations.

Barometric pressure from ASIMET primaries on NTAS 20 are within 0.1 mb of each other, and Campbell is 0.15 mb higher, along with system 2 on NTAS 19. System 1 on NTAS 19 is 0.8 mb high.

Sea surface temperature from ASIMET primaries on NTAS 19 agree very well with each other. Good agreement with system 1 on NTAS 20 too, considering spatial separation. There is no SST data reported from system 2 on NTAS 20. The situation is similar for sea surface conductivity, except that conductivity from system 1 on NTAS 19 is biased low (~ 0.06 S $m^{-1}$).

Precipitation gauges on NTAS 19 reported about 1 mm rain on November 13 around 06:00 UTC. No rain was reported at NTAS 20 but there is no indication in the data that instruments are not functioning properly.

Only the two ASIMET wind speed instruments on NTAS 20 provided data for this inter-comparison. Both instruments reported stable eastward wind near – 6 m $s^{-1}$. The northward wind component is much smaller than the eastward component at NTAS which lies in the Trade wind region. System 1(2) reported a small positive (negative) northward wind. System 1 is logger 16 which is located on port side of buoy, and system 2 is logger 12 on starboard side. Since the buoy faces the incoming westward wind, the different signs of northward wind component on each sensor are consistent with the flow distortion previously reported studies (Bigorre et al 2013, Schlundt et al 2020), whereby the impinging wind diverges in front of the buoy and accelerates around the perimeter of the buoy halo.

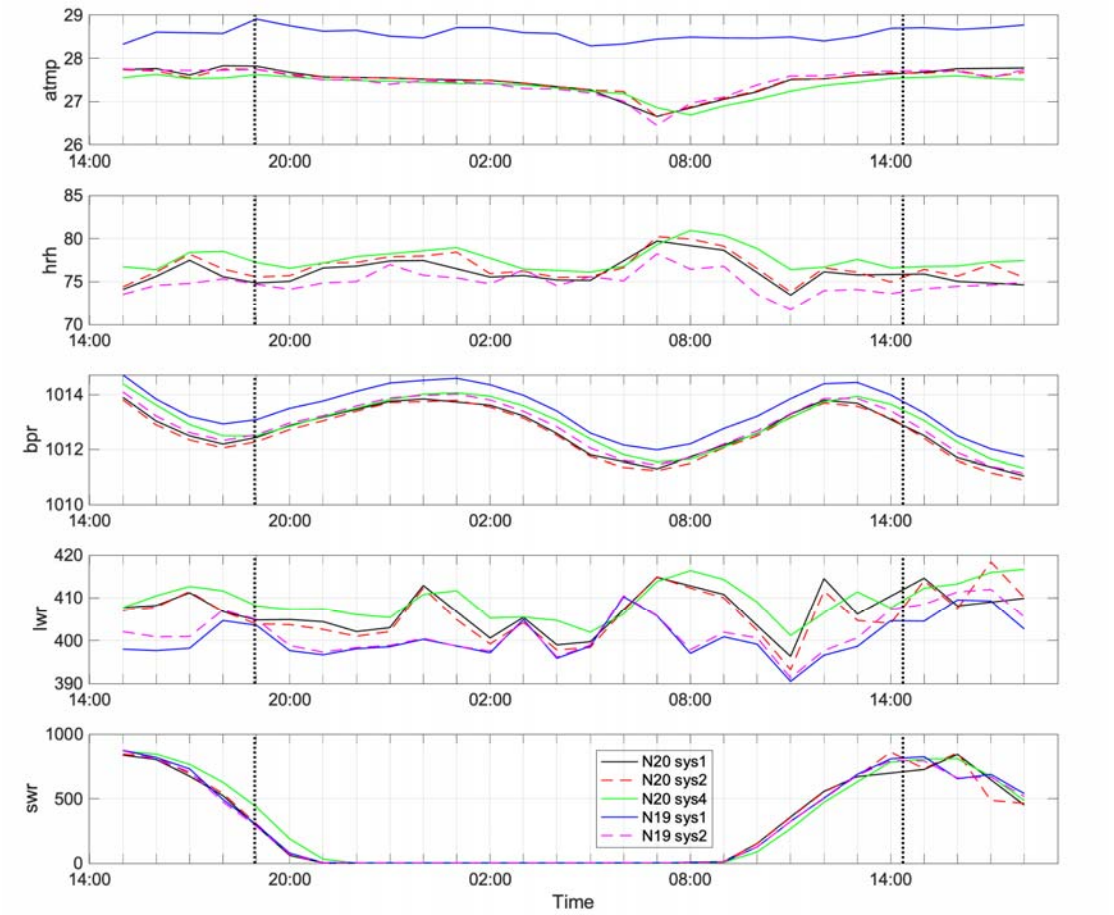


**Figure IV-111. Timeseries of hourly averages of near surface meteorology from NTAS 20 (transmitted through Iridium from ASIMET system1/logger5 and system 2/logger 3 in black, red lines and system4/Campbell in green line) and NTAS 19 (based on recovered 1-mn data in blue, magenta lines), while both platforms were in the water from November 12–13, 2021. From top: air temperature in °C, air relative humidity in %RH , barometric pressure in mbars, downwelling longwave and shortwave radiation in W $m^{-2}$. Black vertical dotted line represents time of NTAS 20 anchor drop (left) and time of NTAS 19 mooring release.**

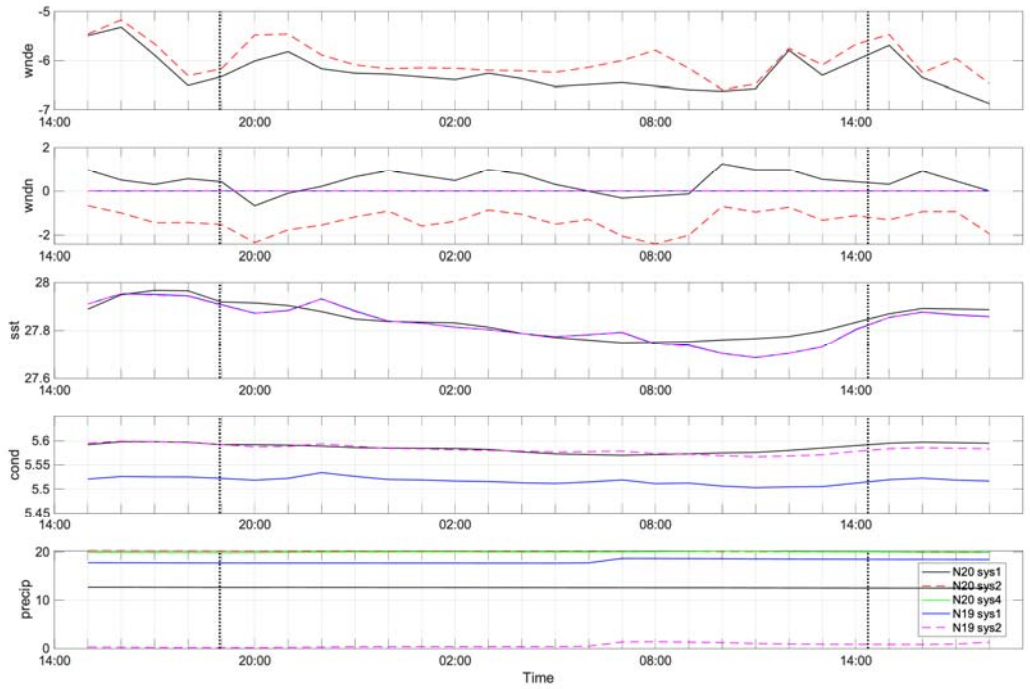


**Figure IV-122. Same as Figure IV-111 but for eastward wind in m $s^{-1}$, northward wind in m $s^{-1}$, sea surface temperature in °C, sea surface conductivity in S $m^{-1}$, and precipitation accumulation in mm (bottom).**

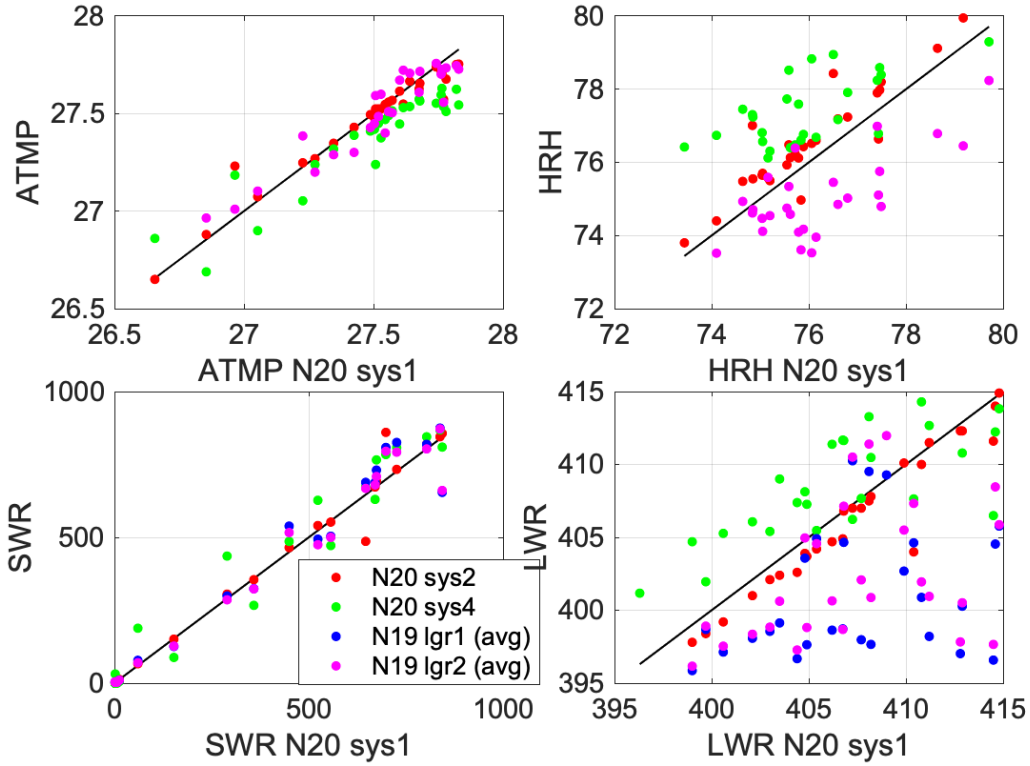


**Figure IV-133. Scatter-plots of measurements in Figure IV-111 and Figure IV-122. collected between November 12–13 2021. From top to bottom, left to right: Air temperature in °C (top), downwelling shortwave radiation in W $m^{-2}$air relative humidity in %RH (center) and downwelling longwave radiation in W $m^{-2}$.**

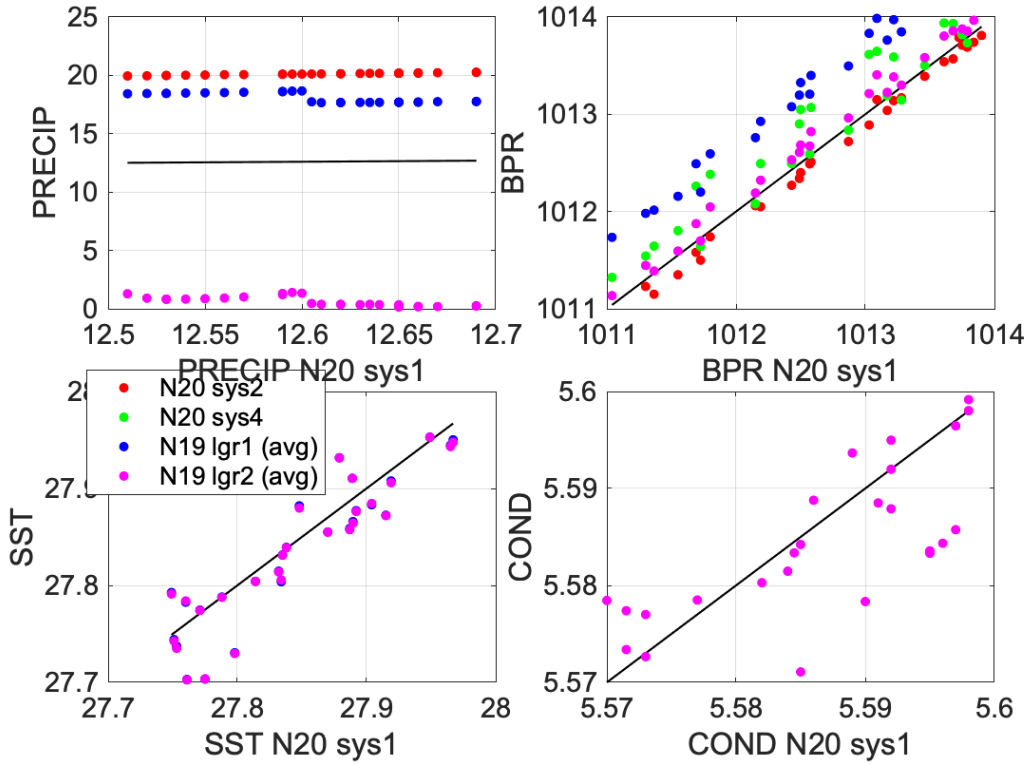


**Figure IV-144. Similar to Figure IV-133. From top to bottom, left to right: precipitation accumulation in mm , sea surface temperature in °C, barometric pressure in mbars, sea surface conductivity in S m$^{-1}$.**

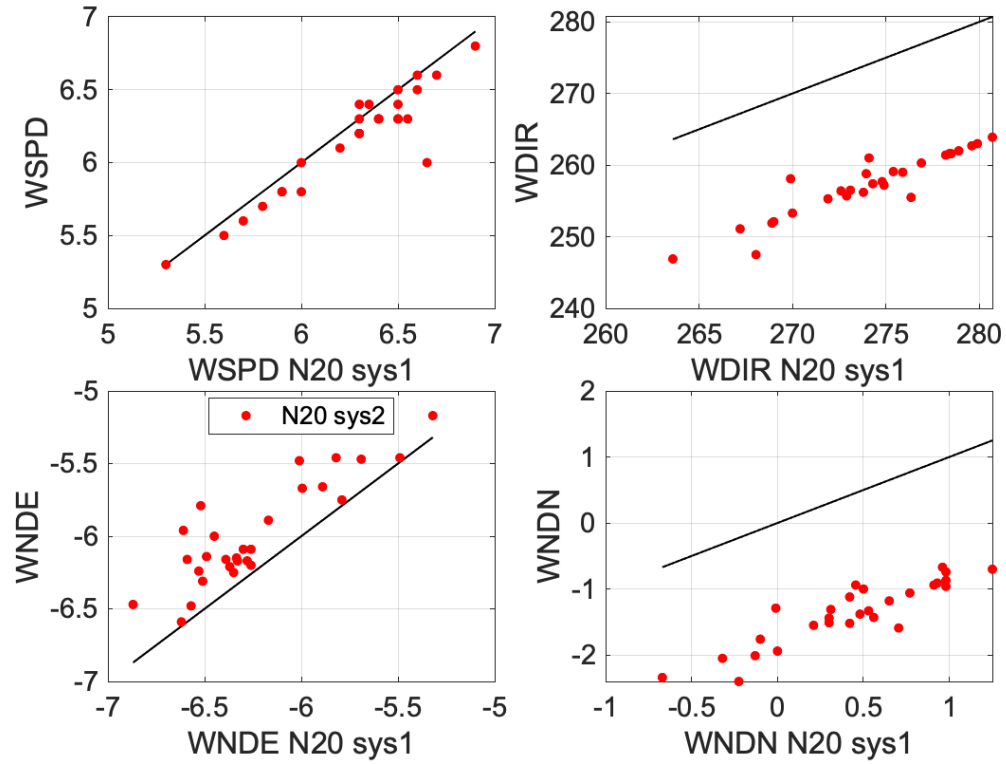


**Figure IV-155. Similar to Figure IV-133. From top to bottom, left to right: Wind speed in m s$^{-1}$, wind speed to the east in m s$^{-1}$, wind heading in degrees and wind speed to the north m s$^{-1}$.**

# V. Ancillary Work

## A. CTDs

During the NTAS 20 cruise, 10 CTD casts were operated. The first cast was done during transit between Rhode Island and the NTAS site and served as a test of the CTD package and acoustic releases prior to their deployment for NTAS 20. Two shallow casts were made each at NTAS 19 and NTAS 20 (within ~ ¼ nm from the buoys) for inter-comparison with the mooring subsurface instruments. The deepest cast (2300 m) was done 1 nm from the subsurface mooring MOVE 1 on behalf of the Scripps Institution of Oceanography. Table V-1 shows the time and location of each CTD cast made during PC-21-07 cruise.

**Table V-1. CTD casts during PC 21-07 cruise.**

| Cast# | Date & Time UTC | Latitude N | Longitude W | Depth (m) | Notes |
|---|---|---|---|---|---|
| 1 | 11/8/2021 17:12 | 24° 38.488’ | 059° 21.557’ | 2020 | Test with acoustic releases |
| 2 | 11/11/2021 16:50 | 14° 48.35’ | 051° 02.07’ | 250 | Intercomparison NTAS19 buoy |
| 3 | 11/11/2021 22:00 | 14° 48.69’ | 051° 02.09’ | 250 | Intercomparison NTAS19 buoy |
| 4 | 11/12/2021 22:00 | 14° 44.34’ | 050° 57.73’ | 250 | Intercomparison NTAS20 buoy |
| 5 | 11/13/2021 12:00 | 14° 43.73’ | 050° 57.62’ | 250 | Intercomparison NTAS20 buoy |
| 6 | 11/14/2021 2:30 | 15° 26.36’ | 051° 32.25’ | 2300 | 1 nm from MOVE 1-14 |
| 7 | 11/14/2021 11:00 | 15° 22’ | 052° 39’ | 250 | |
| 8 | 11/14/2021 17:00 | 15° 20.275’ | 053° 38.148’ | 250 | |
| 9 | 11/14/2021 23:00 | 15° 19’ | 054° 38.01’ | 250 | |
| 10 | 11/15/2021 11:00 | 15° 13.81’ | 056° 35.8’ | 250 | Problem with electronics |

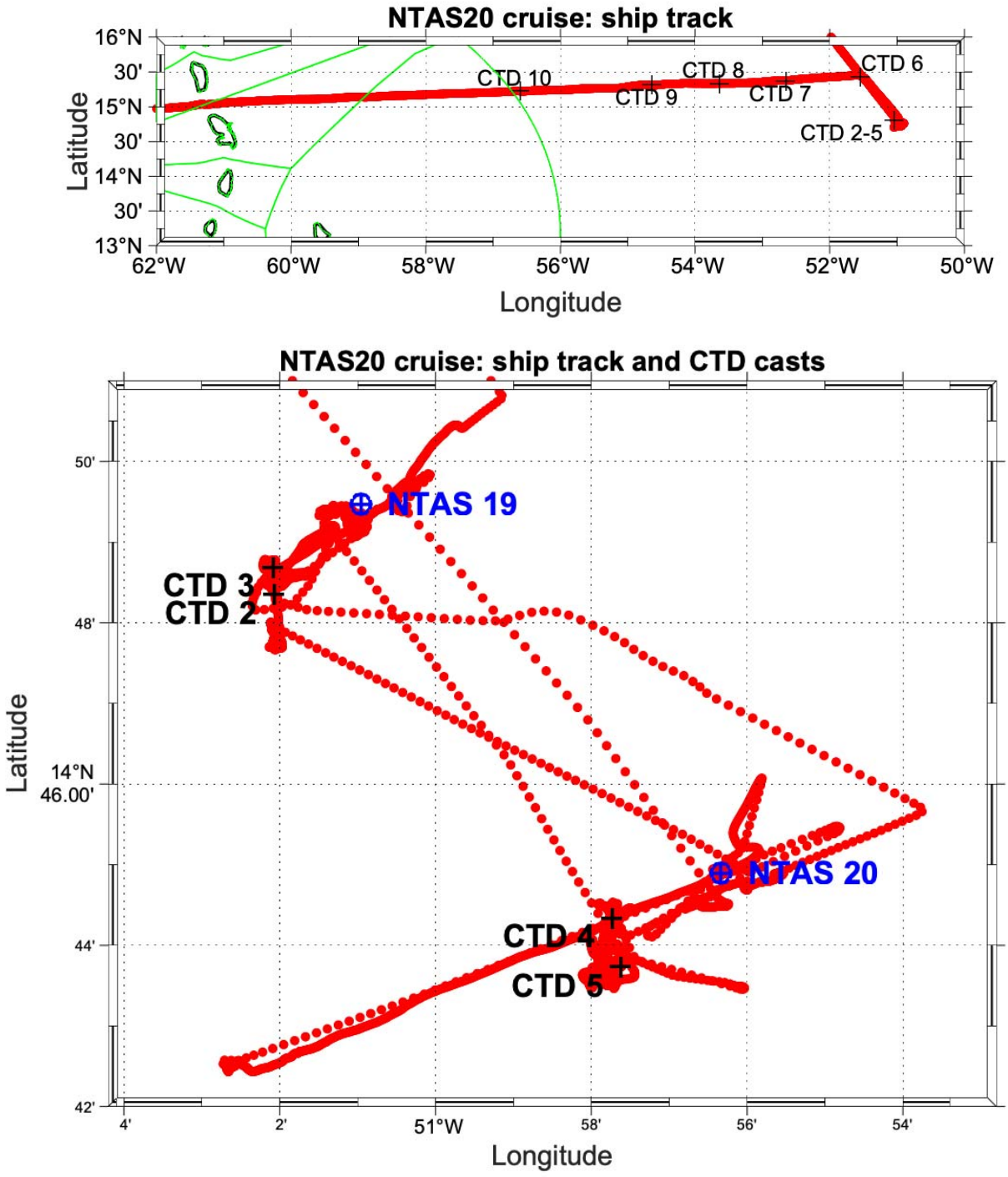


**Figure V-1. Ship track (red), locations of CTD casts (black crosses) during NTAS 20 cruise PC-21-07, and anchors positions for NTAS 19 and 20 moorings (blue crossed circles).**

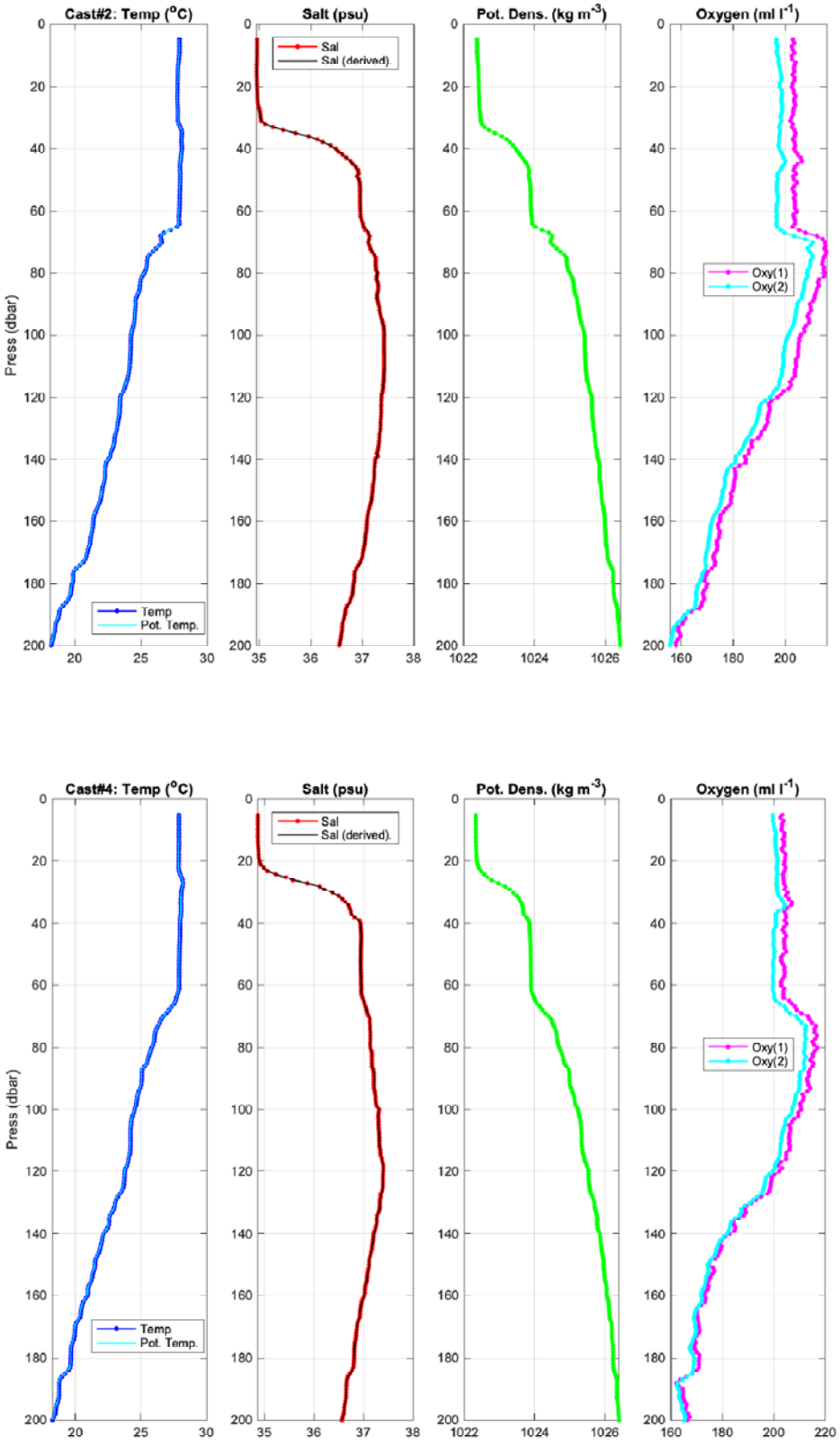


**Figure V-2. Profiles from CTD cast#2 (top) and cast#4 (bottom).**

## References

**Bigorre S**., R. Weller, J. Edson, J. Ware, 2013. A surface mooring for air-sea interaction research in the Gulf Stream. Part 2: Analysis of the observations and their accuracies. *J. Atmos. Ocean. Tech*., v. 30 (3), pp. 450-469. doi: http://dx.doi.org/10.1175/JTECH-D-12-00078.1

**Schlundt, M.**, J.T. Farrar, S.P. Bigorre, A.J. Plueddemann, and R.A. Weller, 2020: Accuracy of Wind Observations from Open-Ocean Buoys: Correction for Flow Distortion. *J. Atmos. Oceanic Technol.,* **37**, 687–703, https://doi.org/10.1175/JTECH-D-19-0132.1

## Acknowledgements

We thank the captain and crew of the NOAA FSV Pisces for accommodating the science mission and providing expertise critical to the success of the mooring operations. Special thanks to Drew Cole for his excellent professionalism in leading and executing mooring operations at sea. The NTAS project is supported by the National Oceanic and Atmospheric Administration (NOAA), Global Ocean Monitoring and Observing (GOMO) Program (formerly Ocean Observing and Monitoring Division), through the Cooperative Institute for the North Atlantic Region (CINAR) under Cooperative Agreement NA19OAR4320074, Fund Ref number (100007298).

# Appendix 1: NTAS 19 Mooring Log

## Moored Station Log

(fill out log with black ball point pen only)

ARRAY NAME AND NO. NTAS-19 MOORED STATION NO. _____

### Launch (anchor over)

Date (day-mon-yr) 22-Oct-2020 Time 1903 UTC

Deployed by Pietro/Hasbrouck Recorder/Observer Pluddemann

Ship and Cruise No. R. Brown RB-20-06 Intended Duration 365 days

Depth Recorder Reading _____ m Correction Source XBT sound speed profile for multibeam

Depth Correction _____ m

Corrected Water Depth 4985 m Magnetic Variation (E/W) _____

Anchor Drop Lat. (N/S) 14° 49.445 Lon. (E/W) 51° 00.781

Surveyed Pos. Lat. (N/S) 14° 49.475 Lon. (E/W) 51° 00.963

Argos Platform ID No. N/A (Iridium) Additional Argos Info on pages 2 and 3

Acoustic Release Model Edgetech 8242 BACS Tested to 500 m

| | |
|---|---|
| Release No. 1 (sn) 33411 | Release No. 2 (sn) 48282 |
| Interrogate Freq. 11 kHz | Interrogate Freq. 11 kHz |
| Reply Freq. 12 kHz | Reply Freq. 12 kHz |
| Enable 361167 | Enable 570013 |
| Disable 361205 | Disable 570030 |
| Release 346426 | Release 551262 |

### Recovery (release fired)

Date (day-mon-yr) 11.13.2021 Time 14:22 UTC

Latitude (N/S) 14 49.364' Longitude (E/W) 051° 01.362'

Recovered by Cole / Graham Recorder/Observer S. Bigorre

Ship and Cruise No. PC 21-07 Actual duration 387 days

Distance from waterline to buoy deck 70cm

1

ARRAY NAME AND NO. NTAS-19 MOORED STATION NO. _____

| Surface Components | | | |
|---|---|---|---|
| Buoy Type MOB Color(s) Hull Tower | blue hull, yellow deck | | |
| Buoy Markings | If found, call... WHOI 508-457-1401 | | |
| **Surface Instrumentation** | | | |
| **Item** | **ID #** | **Height*** | **Comments** |
| ASIMET LGR | L05 | — | port side |
| HRH | 505 | 230 | PIC-24, SD card |
| BPR | 203 | 240 | PIC-24, SD card |
| WND | ~~346~~ | 260 | replaced w/SN 221 ] damaged on deployment |
| PRC | ~~501~~ | 260 | replaced w/SN 215 ] |
| LWR | 253 | 282 | |
| SWR | 216 | 282 | |
| SST | 1725 | -150 | |
| Iridium | | | IMEI 300234063854580 |
| ASIMET LGR | L03 | — | |
| HRH | 258 | 230 | |
| BPR | 502 | 240 | |
| WND | 210 | 260 | |
| PRC | 218 | 260 | |
| LWR | 214 | 282 | |
| SWR | 253 | 282 | |
| SST | 1305 | -150 | |
| Iridium | | | IMEI 300234063341510 |
| | | | |
| WXT | 202 | 245 | |
| SBE39-AT | 5272 | 230 | |
| Lascar | 1111 | 230 | |
| | | | |
| | | | |
| | | | |
| *Height above buoy deck in centimeters | | | |

ARRAY NAME AND NO. NTAS-19 MOORED STATION NO. _____

| Subsurface Instrumentation on Buoy and Bridle | | | |
|---|---|---|---|
| Item | ID # | Depth† | Comments |
| SBE-56 | 7206 | 80 | 90° CW from vane |
| SBE-56 | 7207 | 80 | 180° |
| SBE-56 | 7208 | 95 | 180° |
| SBE-56 | 7209 | 110 | 180° |
| SBE-56 | 7210 | 80 | 270° |
| | | | |
| WAMDAS | | | not transmitting |
| BIZD-X | 0370 | | IMEI 300125060155490 |
| | | | |
| Xeos Melo | | | IMEI 300034013709580 |
| Rover | | | IMEI 300434064537420 |
| Rover | * | | IMEI 300434063297420 |
| Kilo | | | IMEI 300234067205440 |
| | | | |
| Subsurf. Iridium | * | | IMEI 300224010043720 |
| | | | *transferred from NTAS18 buoy after recovery |
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| | | | |
| †Depth below buoy deck in centimeters | | | |

ARRAY NAME AND NO. NTAS-19 MOORED STATION NO. _____

| Item No. | Length (m) | Item | Depth | Inst No. | Time Over | Time Back | Notes |
|---|---|---|---|---|---|---|---|
| 1 | | buoy | | | 1311 | 2025 | PRC broken on deployment both lights on at recovery |
| 2 | 5 | EM chain | | | | | |
| 3 | | SBE-39 | 5 | 7680 | 1311 | 2040 | |
| 4 | | Nortek CM | 5.7 | 12688 | 1311 | 2040 | or S/N 117249 (recovered)? |
| 5 | 79 | 7/16" wire | | | | | |
| 6 | | SBE-37 | 10 | 13409 | 1312 | 2040 | IM |
| 7 | | Nortek CM | 13 | 16085 | 1312 | 2111 on deck | IM (sailed) |
| 8 | | SBE 39 | 15 | 7681 | 1312 | 2112 deck | |
| 9 | | SBE 39 | 20 | 7682 | 1312 | 2116 deck | |
| 10 | | Nortek ADCP | 24 | 15795 | 1312 | 2118 deck | uplooking ) entangled with several line of fishing gear |
| 11 | | SBE-37 | 25 | 13410 | 1312 | 2118 deck | IM ) |
| 12 | | SBE-39 | 30 | 7683 | 1313 | 2119 | |
| 13 | | SBE-39 | 35 | 7684 | 1313 | 2119 | |
| 14 | | SBE 37 | 40 | 13411 | 1315 | 2119 | IM |
| 15 | | SBE 39 | 45 | 7687 | 1315 | 2119 | |
| 16 | | SBE 39 | 50 | 7688 | 1315 | 2119 | |
| 17 | | SBE 37 | 55 | 13412 | 1319 | 1948 | IM |
| 18 | | SBE 39 | 60 | 7689 | 1323 | 1947 | |
| 19 | | SBE 39 | 65 | 7690 | 1325 | 1946 | |
| 20 | | SBE 37 | 70 | 13413 | 1329 | 1944 | IM |
| 21 | | SBE 39 | 75 | 7691 | 1331 | 1943 | |
| 22 | | SBE 39 | 80 | 7693 | 1333 | 1941 | brought back after inst. 55 m recovered and let free |
| 23 | | RDI ADCP | 85 | ~~23281~~ 2125 | 1338 | 1935 | uplooking |
| 24 | 500 | ~~3/8~~ wire | | | 1338 | | |
| 25 | | SBE 39 | 90 | 7694 | 1340 | 1933 | |

ARRAY NAME AND NO. NTAS-19 MOORED STATION NO. _____

| Item No. | Length (m) | Item | Depth | Inst No. | Time Over | Time Back | Notes |
|---|---|---|---|---|---|---|---|
| 26 | | SBE 39 | 100 | 7696 | 1342 | 1932 | |
| 27 | | star oddi | 110 | 5275 | 1343 | 1931 | Very fuzzy |
| 28 | | star oddi | 120 | 5276 | 1344 | 1930 | |
| 29 | | star oddi | 130 | 5277 | 1346 | 1930 | Fuzz starts here |
| 30 | | star oddi | 140 | 5278 | 1347 | 1929 | |
| 31 | | star oddi | 150 | 5279 | 1348 | 1928 | |
| 32 | | star oddi | 160 | 5280 | 1349 | 1928 | |
| 33 | 500 | 3/8 wire | | 20090-2 | 1408 | 1915 start | buckle in shackle |
| 34 | 500 | 3/8 wire | | 20090-1 | 1426 | 1910 start | |
| 35 | 200 | 3/8 wire | | 19027-5 | 1443 | [illegible] | |
| 36 | 100 | 3/8 wire | | 19027-6 | 1449 | 1905 | special termination encapsulated |
| 37 | 200 | 7/8 nylon | | | 1454 | | |
| 38 | 500 | 7/8 nylon | | | 1511 | | |
| 39 | 2000 | 3/4 nylon | | | | | |
| 40 | 100 | 7/8 nylon | | | | 1830 | |
| 41 | 1500 | 1" colmega | | | 1550 | 1800 → | start hauling in on drum |
| 42 | | glass balls | | | 1634 | 1716 | 44444 44444 4444 = 56 & broken balls |
| 43 | | SBE 37 | | 12246 | 1821 | 1716 | 38m above bottom |
| 44 | | SBE 37 | | 12247 | 1821 | 1716 | |
| 45 | 5 | 1/2 chain | | | | | |
| 46 | | release | | 33411 | 1827 | 1718 | dual releases on load bracket |
| 47 | | release | | 48282 | 1827 | 1718 | |
| 48 | 5 | 1/2 chain | | | | | |
| 49 | 20 5 | 1" nylon 1/2 chain | | | | | |
| 50 | | Anchor | | | 1903 | | |

5

ARRAY NAME AND NO._____ MOORED STATION NO._____

| Date/Time | Comments |
|---|---|
| 11.13.21 15:15 | Glass balls @ site (55 mn after release) |
| | |
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09G0135

# Appendix 2: NTAS 20 Mooring Log

## Moored Station Log

(fill out log with black ball point pen only)

ARRAY NAME AND NO. NTAS - 20 MOORED STATION NO. _____

### Launch (anchor over)

Date (day-mon-yr) 12 - Nov - 2021 Time 18:57 UTC

Deployed by Cole / Graham Recorder/Observer Briguerre

Ship and Cruise No. Pisces PC-21-07 Intended Duration 365 days

Depth Recorder Reading 5044 m Correction Source local speed of

Depth Correction N/A m sound fed into EK60

Corrected Water Depth 5044 m Magnetic Variation (E/W) _____

Anchor Drop Lat. (N/S) 14°44.958' Lon. (E/W) 050° 56.170'

Surveyed Pos. Lat. (N/S) 14° 44.897' Lon. (E/W) 050° 56.332'

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

Acoustic Release Model Edgetech Tested to 2000 m

| | |
|---|---|
| Release No. 1 (sn) 51917 | Release No. 2 (sn) 51915 |
| Interrogate Freq. 11 kHz | Interrogate Freq. 11 kHz |
| Reply Freq. 12 kHz | Reply Freq. 12 kHz |
| Enable 340011 | Enable 337703 |
| Disable 340032 | Disable 337720 |
| Release 335364 | Release 335322 |

### 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 65 cm

1

ARRAY NAME AND NO. NTAS 20 MOORED STATION NO. _____

## Surface Components

Buoy Type NOB Color(s) Hull Tower blue hull, yellow deck

Buoy Markings _____

## Surface Instrumentation

| Item | ID # | Height* | Comments |
|---|---|---|---|
| ASIMET LGR | L16 | | Port side |
| HRH | 256 | 232 | |
| BPR | 205 | 239 | |
| WND | 225 | 267 | |
| PRC | 319 | 253 | |
| LWR | 207 | 283 | |
| SWR | 207 | 283 | |
| SST | 1419 | -150 | |
| Iridium | | | IMEI 3002 3406 3167 170 |
| ASIMET LGR | L12 | | Starboard side |
| HRH | 365 | 230 | |
| BPR | 506 | 237 | |
| WND | 238 | 267 | |
| PRC | 230 | 253 | |
| LWR | 243 | 283 | |
| SWR | 354 | 283 | |
| SST | 1835 | -150 | |
| Iridium | | | IMEI 3002 3406 3346 490 |
| Standalones | | | |
| WXT | 209 | 267 | |
| Lascar | N20 | 193 | |
| SBE39-AT | 5276 | 228 | |
| | | | |
| | | | |
| | | | |

*Height above buoy deck in centimeters

ARRAY NAME AND NO. NTAS 20 MOORED STATION NO. _____

| Subsurface Instrumentation on Buoy and Bridle | | | |
|---|---|---|---|
| Item | ID # | Depth† | Comments |
| SBE56 | 6979 | 90 | 135° clockwise looking at buoy vane |
| SBE56 | 6980 | 80 | 180° |
| SBE56 | 6982 | 90 | 180° |
| SBE56 | 6983 | 90 | 225° |
| | | | |
| WAVDAS | | | INEI 3001 2400 0115 920; NDBC 24361 SIN 8988 1693 1200 205 0000 |
| | | | |
| BRI20 | 116 | 228 | |
| | | | |
| Xeos KILO | 0882 | | 3002 3406 2644 350 |
| Xeos NELO | | | 3003 3401 2615 100 |
| Xeos Rover | 1033 | | 3004 3406 4530 420 |
| Xeos Rover | 590 | | 3004 3406 1508 050 |
| | | | |
| Subsurface Iridium | | | INEI 3002 2401 0043 720 |
| | | | |
| Above Spic | | | |
| Campbell | | | |
| HRH | | 233 | |
| BPR | | 218 | |
| SWR | | 283 | |
| LWR | | 283 | |
| PRC | | 253 | |
| | | | |
| Geoforce | 2-32035588 | | |
| NetOcean | | | INEI 3004 3406 5342 370 |
| | | | |
| | | | |
| | | | |
| | | | |

†Depth below buoy deck in centimeters

**ARRAY NAME AND NO.** NTAS 20 **MOORED STATION NO.** _____

| Item No. | Length (m) | Item | Depth | Inst No. | Time Over | Time Back | Notes |
|---|---|---|---|---|---|---|---|
| 1 | | buoy | | | 1234 | | |
| 2 | 5 | EM chain | | | 1220 | | |
| 3 | | SBE39 | 5 | 8743 | 1220 | | |
| * → 4 | | Nortek ADCP | 5.7 | 9407 | 1220 | | |
| 5 | 79 | 7/16" wire | 21054-2 | | | | |
| 6 | | SBE37 | 10 | 669 | 1220 | | 11 |
| 7 | | Nortek ADCP | 13 | 5973 | 1220 | | 11 |
| 8 | | SBE39 | 15 | 7697 | 1220 | | |
| 9 | | SBE39 | 20 | 7695 | 1220 | | |
| 10 | | Nortek ADCP | ~~24~~ 54 | 12391 | 1220 | | looking up; Forgot to deploy → brought back line, clamped @ 54 m |
| 11 | | SBE37 | 25 | 683 | 1220 | | 11 |
| 12 | | SBE39 | 30 | 8744 | 1220 | | |
| 13 | | SBE39 | 35 | 8745 | 1220 | | |
| 14 | | SBE37 | 40 | 684 | 1220 | | 11 |
| 15 | | SBE39 | 45 | 8746 | 1220 | | |
| 16 | | SBE39 | 50 | 8747 | 1235 | | |
| 17 | | SBE37 | 55 | 685 | ~~1235~~ 1340 | | 11 |
| 18 | | SBE39 | 60 | 8748 | ~~1240~~ 1340 | | |
| 19 | | SBE39 | 65 | 8749 | ~~1244~~ 1347 | | |
| 20 | | SBE37 | 70 | 686 | ~~1246~~ 1347 | | 11 |
| 21 | | SBE39 | 75 | 8750 | ~~1248~~ 1349 | | |
| ** → 22 | | SBE39 | 80 | 8751 | ~~1255~~ 1357 | | |
| 23 | | RDI ADCP | 85 | 23281 | ~~1259~~ 1358 | | uplooking |
| 24 | 500 | 3/8" wire | 21054-4 | | | | |
| 25 | | SBE39 | 90 | 8752 | ~~1305~~ 1400 | | |

ARRAY NAME AND NO._____ MOORED STATION NO._____

| Item No. | Length (m) | Item | Depth | Inst No. | Time Over | Time Back | Notes |
|---|---|---|---|---|---|---|---|
| 26 | | SBE39 | 100 | 8753 | 1403<br>1503 | | |
| 27 | | SBE39 | 110 | 8754 | 1404 | | |
| 28 | | Star oddi | 110 | 5282 | 1404 | | |
| 29 | | Star oddi | 120 | 5283 | 1406 | | |
| 30 | | Star Oddi | 130 | 5284 | 1407 | | |
| 31 | | Star Oddi | 140 | 5285 | 1408 | | |
| 32 | | Star Oddi | 150 | 5286 | 1409 | | |
| 33 | | Star Oddi | 160 | 5287 | 1410 | | |
| 34 | 500 | 3/8" wire | 21054-5 | 21054-5 | start 1419 | | ship speed increases to 1 kt |
| 35 | 500 | 3/8" wire | | 21054-8 | 1432 | | ship speed ↗ 1.25 kt |
| 36 | 200 | 3/8" wire | | 21054-9 | 1445 | | |
| 37 | 100 | 3/8 wire | | 21054-7 | 1452 | | ] encapsulated termination |
| 38 | 200 | 7/8 Nylon | | | 1455 encap. term | | |
| 39 | 500 | 7/8 nylon | | | | | |
| 40 | 2000 | 3/4 nylon | | | | | |
| 41 | 100 | 7/8 nylon | | | | | |
| 42 | 1500 | 1" Co/mega | | | 1545 end 1620 | | |
| 43 | | Glass (56) balls | | | 1700<br>1735 end | | 56 GBs. |
| 44 | | SBE37 | | 11392 | 1844 in water | | |
| 45 | | SBE37 | | 11393 | 1844 | | |
| 46 | 5 | 1/2" chain | | | | | |
| 47 | | release | | 51917 | 1844 | | |
| 48 | | release | | 51915 | 1844 | | |
| 49 | 5 | 1/2" chain | | | | | |
| 50 | 20 | 1" Samson | | | | | |

ARRAY NAME AND NO._____ MOORED STATION NO._____

| | Item No. | Length (m) | Item | Depth | Inst No. | Time Over | Time Back | Notes |
|---|---|---|---|---|---|---|---|---|
| | 51 | 5 | 1/2" chain | | | | | |
| | 52 | | anchor | | | 1857 | | 6000 lbs wet, 7000 lbs air |
| | 53 | | | | | | | |
| | 54 | | Additions: | | | | | |
| | 55 | | | | | | | |
| * | 56 | | RBR SOLO D | 6 | 78198 | | | |
| ** | 57 | | RBR SOLO D | 83 | 78197 | | | |
| | 58 | | | | | | | |
| | 59 | | | | | | | |
| | 60 | | | | | | | |
| | 61 | | | | | | | |
| | 62 | | | | | | | |
| | 63 | | | | | | | |
| | 64 | | | | | | | |
| | 65 | | | | | | | |
| | 66 | | | | | | | |
| | 67 | | | | | | | |
| | 68 | | | | | | | |
| | 69 | | | | | | | |
| | 70 | | | | | | | |
| | 71 | | | | | | | |
| | 72 | | | | | | | |
| | 73 | | | | | | | |
| | 74 | | | | | | | |
| | 75 | | | | | | | |

# Appendix 3: NTAS 20 Instrument Setup

## ASIMET Logger 16:

Model: LOGR53
SerNum: L016
CfgDat: 05FEB02
Firmware: LOGR53 v4.38-1spurs2
RTClock: 2021/11/10 18:12:37
Logging Interval: 60; Current Tick: 48
R-interval: 1
Compact Flash Card present - Compact Flash OK!
Volume in drive is L16
Directory of CF:
2021/11/10 18:12 0 L16.INF
2021/11/10 18:12 0 L16.DAT
2 File(s) 0 bytes
256703488 bytes free
Iridium: MET data enabled
Iridium MET status: SBDI Failed - timeout
Sampling STOPPED
Sampling GO - synchronizing...

## ASIMET Logger 12:

Model: NEWLGR53
SerNum: CA001
CfgDat: 05MAY16
Firmware: LOGR53 v4.38-1spurs2
RTClock: 2021/11/10 18:16:03
Logging Interval: 60; Current Tick: 4
R-interval: 1
Compact Flash Card present - Compact Flash OK!
Volume in drive is L12
Directory of CF:
2021/11/10 18:14 0 L12.INF
2021/11/10 18:14 0 L12.DAT
2 File(s) 0 bytes
256703488 bytes free
Iridium: MET data enabled
Iridium MET status: SBD Message OK
Sampling GO

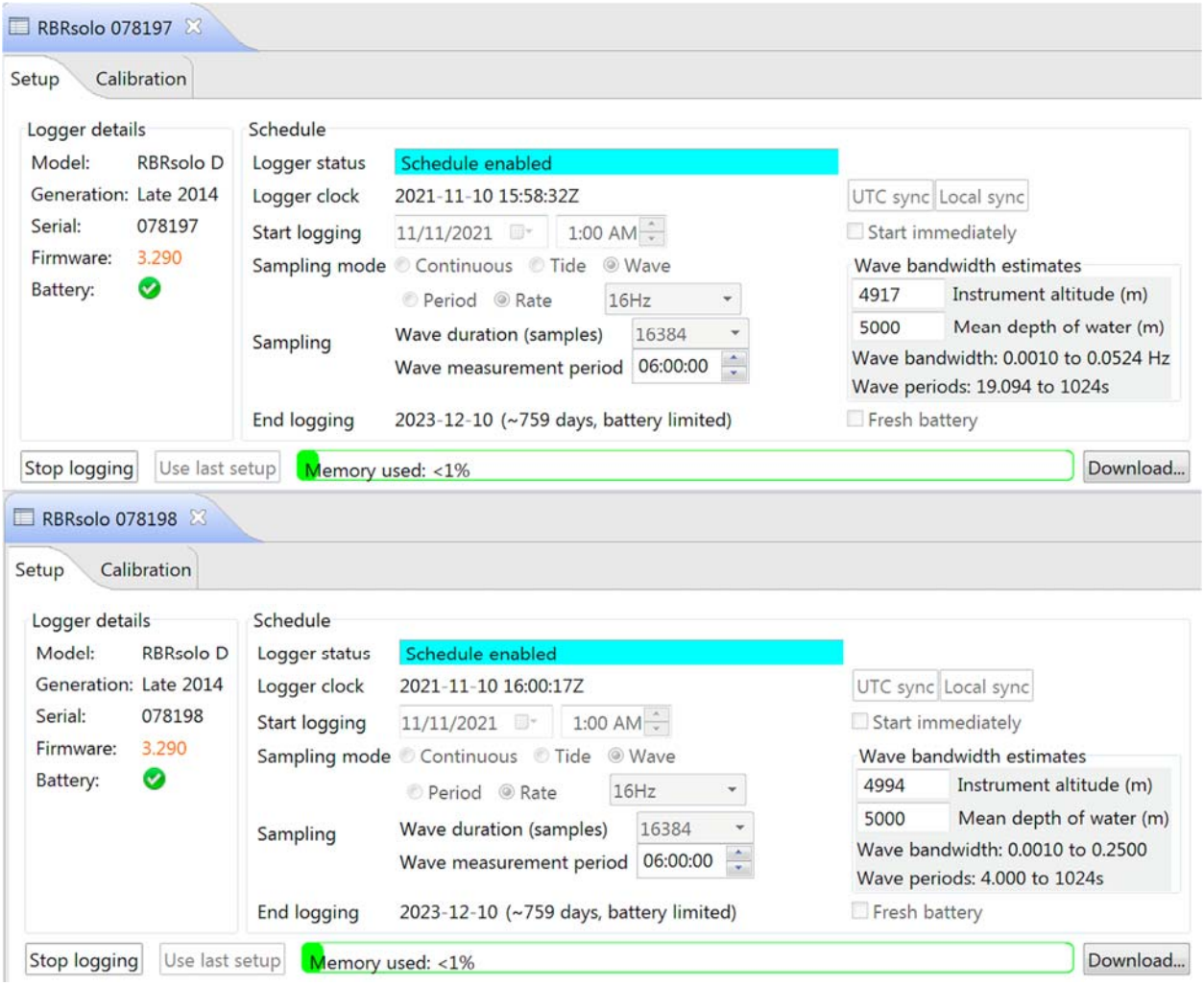
## Vaisala WXT:

WXT01
209
VAISALA24 v5.65
ASIPIC24 RevA
9APR19
RTCC: 2021/11/10 18:18:46
DS3232: 2021/11/10 18:18:46
SD Card found
2021-11-10 18:18:36 240 ASWXT209.ID
2021-11-10 18:18:38 0 ASWXT209.DAT
2021-11-10 18:18:40 0 ASWXT209.INF
SD Card formatted for this ASIMET module!
Sampling STOPPED

---

Sampling GO -
synchronizing.....

## RBR Solo D 78198 (6 m, mounted on bellmouth) and 78197 (83 m, mounted on ADCP cage):




## Starmon ODDI:

**Filename: C:\Software\Star-Oddi\SeaStar\Starmon mini\T5282\T5282.RDT**
SeaStar 8.90
---
Recorder type : Starmon mini
Recorder number : T5282
Recorder version : 23 CRC8/38400/HighRes
Recorder measures : Temperature
Recorder memory(Meas/Byte) : 262032 / 524063
Measurement sequence number : 5
Recorder started from PC : 10/19/21 6:12:40 PM
---
Measurement interval def. : Single interval = 00:10:00
Measurement start time : 11/4/21 1:00:00 AM
---
Measurement settings: [dd:hh:mm:ss] x number

---
Start delay : 15:06:47:20
1. interval period : 00:10:00 x 65520
2. interval period : 00:10:00 x 65520

Estimated time duration and battery usage for NMS
---
Battery energy at initiation time(%) : 97,9
Battery energy at measurement start (%): 97,7
---
Cycle 1 Meas.taken

Seq/Inr Date&Time Batt.used(%)
Mem.used(%) Temp
1/1 2/2/23 1:00:00 AM 5 25 65521
2/2 5/2/24 1:00:00 AM 11 50 131041

Cycle 2 Meas.taken
Seq/Inr Date&Time Batt.used(%)
Mem.used(%) Temp
1/1 7/31/25 1:00:00 AM 17 75
196561

Memory full : 10/28/26 4:50:00 PM
After (days:hours) : 1819:15
In Cycle : 2
In sequence : 2
In Interval : 1
In measurement : 65471
Total meas. taken : 262032
Battery used (%) : 23,5
Battery remaining (%) : 74,2

**Filename: C:\Software\Star-Oddi\SeaStar\Starmon mini\T5283\T5283.RDT**
SeaStar 8.90
---
Recorder type : Starmon mini
Recorder number : T5283
Recorder version : 23 CRC8/38400/HighRes
Recorder measures : Temperature
Recorder memory(Meas/Byte) : 262032 / 524063
Measurement sequence number : 4
Recorder started from PC : 10/19/21 6:19:57 PM
---
Measurement interval def. : Single interval = 00:10:00
Measurement start time : 11/4/21 1:00:00 AM
---
Measurement settings: [dd:hh:mm:ss] x number

---
Start delay : 15:06:40:03
1. interval period : 00:10:00 x 65520
2. interval period : 00:10:00 x 65520

Estimated time duration and battery usage for NMS
---
Battery energy at initiation time(%) : 97,9
Battery energy at measurement start (%): 97,7
---
Cycle 1 Meas.taken
Seq/Inr Date&Time Batt.used(%)
Mem.used(%) Temp
1/1 2/2/23 1:00:00 AM 5 25 65521
2/2 5/2/24 1:00:00 AM 11 50 131041

Cycle 2 Meas.taken
Seq/Inr Date&Time Batt.used(%)
Mem.used(%) Temp
1/1 7/31/25 1:00:00 AM 17 75
196561

Memory full : 10/28/26 4:50:00 PM
After (days:hours) : 1819:15
In Cycle : 2
In sequence : 2
In Interval : 1
In measurement : 65471
Total meas. taken : 262032
Battery used (%) : 23,5
Battery remaining (%) : 74,2

**Filename: C:\Software\Star-Oddi\SeaStar\Starmon mini\T5284\T5284.RDT**
SeaStar 8.90
---
Recorder type : Starmon mini
Recorder number : T5284
Recorder version : 23 CRC8/38400/HighRes
Recorder measures : Temperature
Recorder memory(Meas/Byte) : 262032 / 524063
Measurement sequence number : 4
Recorder started from PC : 10/19/21 6:21:44 PM
---
Measurement interval def. : Single interval = 00:10:00

Measurement start time : 11/4/21 1:00:00 AM
---
Measurement settings: [dd:hh:mm:ss] x number

---
Start delay : 15:06:38:16
1. interval period : 00:10:00 x 65520
2. interval period : 00:10:00 x 65520

Estimated time duration and battery usage for NMS
---
Battery energy at initiation time(%) : 97,9
Battery energy at measurement start (%): 97,7
---
Cycle 1 Meas.taken
Seq/Inr Date&Time Batt.used(%)
Mem.used(%) Temp
1/1 2/2/23 1:00:00 AM 5 25 65521
2/2 5/2/24 1:00:00 AM 11 50 131041

Cycle 2 Meas.taken
Seq/Inr Date&Time Batt.used(%)
Mem.used(%) Temp

1/1 7/31/25 1:00:00 AM 17 75
196561

Memory full : 10/28/26 4:50:00 PM
After (days:hours) : 1819:15
In Cycle : 2
In sequence : 2
In Interval : 1
In measurement : 65471
Total meas. taken : 262032
Battery used (%) : 23,5
Battery remaining (%) : 74,2

**Filename: C:\Software\Star-Oddi\SeaStar\Starmon mini\T5285\T5285.RDT**
SeaStar 8.90
---
Recorder type : Starmon mini
Recorder number : T5285
Recorder version : 23 CRC8/38400/HighRes
Recorder measures : Temperature
Recorder memory(Meas/Byte) : 262032 / 524063
Measurement sequence number : 4
Recorder started from PC : 10/19/21 6:24:04 PM
---
Measurement interval def. : Single interval = 00:10:00
Measurement start time : 11/4/21 1:00:00 AM
---
Measurement settings: [dd:hh:mm:ss] x number

---
Start delay : 15:06:35:56
1. interval period : 00:10:00 x 65520
2. interval period : 00:10:00 x 65520

Estimated time duration and battery usage for NMS
---
Battery energy at initiation time(%) : 97,9
Battery energy at measurement start (%): 97,7
---
Cycle 1 Meas.taken
Seq/Inr Date&Time Batt.used(%)
Mem.used(%) Temp
1/1 2/2/23 1:00:00 AM 5 25 65521
2/2 5/2/24 1:00:00 AM 11 50 131041

Cycle 2 Meas.taken
Seq/Inr Date&Time Batt.used(%)
Mem.used(%) Temp
1/1 7/31/25 1:00:00 AM 17 75
196561

Memory full : 10/28/26 4:50:00 PM
After (days:hours) : 1819:15
In Cycle : 2
In sequence : 2
In Interval : 1
In measurement : 65471
Total meas. taken : 262032
Battery used (%) : 23,5
Battery remaining (%) : 74,2

**Filename: C:\Software\Star-Oddi\SeaStar\Starmon mini\T5286\T5286.RDT**
SeaStar 8.90
---
Recorder type : Starmon mini
Recorder number : T5286
Recorder version : 23 CRC8/38400/HighRes
Recorder measures : Temperature
Recorder memory(Meas/Byte) : 262032 / 524063
Measurement sequence number : 4
Recorder started from PC : 10/19/21 6:25:28 PM
---
Measurement interval def. : Single interval = 00:10:00
Measurement start time : 11/4/21 1:00:00 AM
---
Measurement settings: [dd:hh:mm:ss] x number

---
Start delay : 15:06:34:32
1. interval period : 00:10:00 x 65520
2. interval period : 00:10:00 x 65520

Estimated time duration and battery usage for NMS
---
Battery energy at initiation time(%) : 97,9
Battery energy at measurement start (%): 97,7
---
Cycle 1 Meas.taken
Seq/Inr Date&Time Batt.used(%)
Mem.used(%) Temp
1/1 2/2/23 1:00:00 AM 5 25 65521
2/2 5/2/24 1:00:00 AM 11 50 131041

Cycle 2 Meas.taken
Seq/Inr Date&Time Batt.used(%)
Mem.used(%) Temp
1/1 7/31/25 1:00:00 AM 17 75
196561
Memory full : 10/28/26 4:50:00 PM
After (days:hours) : 1819:15
In Cycle : 2
In sequence : 2
In Interval : 1
In measurement : 65471
Total meas. taken : 262032
Battery used (%) : 23,5

Battery remaining (%) : 74,2

**Filename: C:\Software\Star-Oddi\SeaStar\Starmon mini\T5287\T5287.RDT**
SeaStar 8.90
---
Recorder type : Starmon mini
Recorder number : T5287
Recorder version : 23 CRC8/38400/HighRes
Recorder measures : Temperature
Recorder memory(Meas/Byte) : 262032 / 524063
Measurement sequence number : 4
Recorder started from PC : 10/19/21 6:26:43 PM
---
Measurement interval def. : Single interval = 00:10:00
Measurement start time : 11/4/21 1:00:00 AM
---
Measurement settings: [dd:hh:mm:ss] x number

---
Start delay : 15:06:33:17
1. interval period : 00:10:00 x 65520
2. interval period : 00:10:00 x 65520
Estimated time duration and battery usage for NMS
---
Battery energy at initiation time(%) : 97,9
Battery energy at measurement start (%): 97,7
---
Cycle 1 Meas.taken
Seq/Inr Date&Time Batt.used(%) Mem.used(%) Temp
1/1 2/2/23 1:00:00 AM 5 25 65521
2/2 5/2/24 1:00:00 AM 11 50 131041

Cycle 2 Meas.taken
Seq/Inr Date&Time Batt.used(%) Mem.used(%) Temp
1/1 7/31/25 1:00:00 AM 17 75 196561

Memory full : 10/28/26 4:50:00 PM
After (days:hours) : 1819:15
In Cycle : 2
In sequence : 2
In Interval : 1
In measurement : 65471
Total meas. taken : 262032
Battery used (%) : 23,5
Battery remaining (%) : 74,2

## TRDI ADCP 23281 (85 m):

[BREAK Wakeup A]
WorkHorse Broadband ADCP Version 50.41
Teledyne RD Instruments (c) 1996-2014
All Rights Reserved.
>ps0
Instrument S/N: 23281
Frequency: 307200 HZ
Configuration: 4 BEAM, JANUS
Match Layer: 10
Beam Angle: 20 DEGREES
Beam Pattern: CONVEX
Orientation: UP
Sensor(s): HEADING TILT 1 TILT 2 DEPTH TEMPERATURE PRESSURE
Pressure Sens Coefficients:
c3 = -1.522438E-169
c2 = -1.833885E-07
c1 = +3.232684E-01
Offset = -1.122043E+01

Temp Sens Offset: 0.15 degrees C

CPU Firmware: 50.41 [0]
Boot Code Ver: Required: 1.17 Actual: 1.17
DEMOD #1 Ver: ad48, Type: 1f
DEMOD #2 Ver: ad48, Type: 1f
PWRTIMG Ver: 85d3, Type: 6

Board Serial Number Data:
A0 00 00 07 BE DC 30 09 REC727-1000-04E
DF 00 00 07 A6 F1 9E 09 CPU727-2011-00E
0B 00 00 07 A7 02 1D 09 DSP727-2001-04H
FA 00 00 08 8C CF 9F 09 PIO727-3000-00G
>rr
Recorder Directory:
Volume serial number for device #0 is 206f-6241

_RDI_000 000 4676100 10-26-20 10:22:36p r a [ 2]
_RDI_001 000 0 10-19-21 8:30:02p r a [ 0]

Bytes used on device #0 = 4676100
Total capacity = 256352256 bytes
Total bytes used = 4676100 bytes in 2 files
Total bytes free = 251674624 bytes

>re
Must use 'RE ErAsE' or 're ErAsE' to erase recorder!

Recorder not erased.

>r RE ErASe
Must use 'RE ErAsE' or 're ErAsE' to erase recorder!

Recorder not erased.

>RE ErAsE  erasing...
Recorder erased.

>rr
Recorder Directory:
Volume serial number for device #0 is 206f-6241

  No files found.

  Bytes used on device #0 = 0
Total capacity   =  256352256 bytes
Total bytes used =          0 bytes in 0 files
Total bytes free =  256352256 bytes

>CR1
[Parameters set to FACTORY defaults]
>CF11101
>EA0
>EB0
>ED850
>ES35
>EX11111
>EZ1111101
>WA50
>WB0
>WD111100000
>WF300
>WN25
>WP180
>WS400
>WV175
>TE01:00:00.00
>TP00:01.00
>TF21/11/04 01:00:00
>CK
[Parameters saved as USER defaults]
>CS

## Nortek current meter 9407 (5.7 m):

Deployment   : N20
Current time : 10/14/21 12:44:47 PM
Start at     : 11/2/21 1:00:00 AM
Comment:
AQD 9407, 5.7m, N20, 2 Li BATS
---
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
Raw magnetometer out      : OFF
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) : 11.2
Recorder size        (MB) : 9
Recorder free space  (MB) : 6.888
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          : 3.39
---
Aquadopp Version 1.40.14
Copyright (C) Nortek AS
==========

## Nortek current meter 5973 (13 m):

Deployment   : N20
Current time : 11/7/21 3:46:16 PM
Start at     : 11/7/21 4:00:00 PM
Comment:
AQD 5973, NTAS 20, 2 Li Batteries,13m, SIM ID# 041, deploy
---
Measurement interval  (s) : 1200
Average interval      (s) : 180
Blanking distance     (m) : 0.37
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
Raw magnetometer out      : OFF
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

Coupler impedance : Z = 1861

IMM configuration:
<HardwareData
DeviceType='SBE90554 IMM'
SerialNumber='70000899'>
<Manufacturer>Sea-Bird Electronics,
Inc</Manufacturer>
<HardwareVersion>41420H.1</HardwareVersion>
<HardwareVersion>PCB Type 3,
10345B</HardwareVersion>
<MfgDate>2009-11-03</MfgDate>
<FirmwareVersion>IMM Ver
1.12</FirmwareVersion>
<FirmwareDate>Jun 15 2009</FirmwareDate>
<FirmwareLoader>MSP LOADER RS232 57.6K
2007-02-08</FirmwareLoader>
</HardwareData>

<StatusData DeviceType='SBE90554 IMM'
SerialNumber='70000899'>
<HostID>Host ID not set</HostID>
<EventSummary numEvents='316'/>
<Power><TransmitVoltage>8.9</TransmitVoltage><
/Power>
<SampleDataSummary NumSamples='0'
TotalLen='0' FreeMem='16384'/>
<HostFileSummary Len='784'
CRC='0x5BEEFB78'/>
<LineStatus>BUSY</LineStatus>
</StatusData>

<ConfigurationData DeviceType='SBE90554 IMM'
SerialNumber='70000899'>
<Settings ConfigType='2'
DebugLevel='2'
BaudRate='9600'
HostID='Host ID not set'
GdataStr='GDATA'
HostPrompt='x'
ModemPrompt='IMM>'
DeviceID='41'
EnableHostFlagWakeup='0'
EnableHostFlagConfirm='0'
EnableHostFlagTerm='0'
EnableSerialIMMWakeup='1'
EnableHostPromptConfirm='0'
EnableHostServeOnPwrup='0'
EnableAutoIMFlag='1'
EnablePrompt='1'
EnableHostWakeupCR='0'
EnableHostWakeupBreak='0'
EnableEcho='0'
EnableSignalDetector='1'
EnableToneDetect='0'
EnableFullPwrTX='1'
EnableBackSpace='0'
EnableGDataToSample='0'
EnableStripHostEcho='0'
EnableBinaryData='1'
SerialType='0'
TermToHost='254'
TermFromHost='254'
SerialBreakLen='5'
MaxNumSamples='40'
GroupNumber='0'
THOST0='0'
THOST1='5'
THOST2='1000'
THOST3='12000'
THOST4='500'
THOST5='5'
TMODEM2='500'
TMODEM3='18000'
TMODEM4='100'
/>
</ConfigurationData>

---
Aquadopp Version 1.40.14
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## Nortek ADCP 12391 (24 m):

Deployment : N20
Current time : 10/14/21 1:45:55 PM
Start at : 11/2/21 1:00:00 AM

Comment:
600kHz profiler, 24m, AQD 12391, N20, 2 Li BATS
---
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 : 9600
---

Assumed duration (days) : 540.0
Battery utilization (%) : 98.0
Battery level (V) : 11.2
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 : 3.43
ProLog ID : 1062
ProLog firmware version : 4.24
---
SD Card Inserted : YES
SD Card Ready : YES
SD Card Write protected : NO
SD Card Type : SDHC
SD Card Supported : YES
---
AquaPro Version 1.37.08

==========

## NTAS 20
## Subsurface

| | | | | | SAMPLE START | | SPIKE @ ~41-43 degrees C | | |
|---|---|---|---|---|---|---|---|---|---|
| INSTRUMENT | SERIAL | IM ADDRESS | DEPTH (m) | SAMPLE RATE (s) | DATE | TIME | DATE | START TIME | STOP TIME |
| SBE 37 IM | 669 | 3 | 10 | 600 | 20211107 | 010000 | 20211107 | 16:00:00 | 17:00:00 |
| SBE 37 IM | 683 | 4 | 25 | 600 | 20211107 | 010000 | 20211107 | 16:00:00 | 17:00:00 |
| SBE 37 IM | 684 | 5 | 40 | 600 | 20211107 | 010000 | 20211107 | 16:00:00 | 17:00:00 |
| SBE 37 IM | 685 | 7 | 55 | 600 | 20211107 | 010000 | 20211107 | 16:00:00 | 17:00:00 |
| SBE 37 IM | 686 | 8 | 70 | 600 | 20211107 | 010000 | 20211107 | 16:00:00 | 17:00:00 |
| SBE 37 Deep | 11392 | | 4962 | 300 | 20211107 | 010000 | 20211107 | 16:00:00 | 17:00:00 |
| SBE 37 Deep | 11393 | | 4962 | 300 | 20211107 | 010000 | 20211107 | 16:00:00 | 17:00:00 |
| SBE 39 | 8743 | | 5 | 300 | 20211107 | 010000 | 20211107 | 16:00:00 | 17:00:00 |
| SBE 39 | 7697 | | 15 | 300 | 20211107 | 010000 | 20211107 | 16:00:00 | 17:00:00 |
| SBE 39 | 7695 | | 20 | 300 | 20211107 | 010000 | 20211107 | 16:00:00 | 17:00:00 |
| SBE 39 | 8744 | | 30 | 300 | 20211107 | 010000 | 20211107 | 16:00:00 | 17:00:00 |
| SBE 39 | 8745 | | 35 | 300 | 20211107 | 010000 | 20211107 | 16:00:00 | 17:00:00 |
| SBE 39 | 8746 | | 45 | 300 | 20211107 | 010000 | 20211107 | 16:00:00 | 17:00:00 |
| SBE 39 | 8747 | | 50 | 300 | 20211107 | 010000 | 20211107 | 16:00:00 | 17:00:00 |
| SBE 39 | 8748 | | 60 | 300 | 20211107 | 010000 | 20211107 | 16:00:00 | 17:00:00 |
| SBE 39 | 8749 | | 65 | 300 | 20211107 | 010000 | 20211107 | 16:00:00 | 17:00:00 |
| SBE 39 | 8750 | | 75 | 300 | 20211107 | 010000 | 20211107 | 16:00:00 | 17:00:00 |
| SBE 39 | 8751 | | 80 | 300 | 20211107 | 010000 | 20211107 | 16:00:00 | 17:00:00 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| SBE 39 | 8752 | | 90 | 300 | 20211107 | 010000 | 20211107 | 16:00:00 | 17:00:00 |
| SBE 39 | 8753 | | 100 | 300 | 20211107 | 010000 | 20211107 | 16:00:00 | 17:00:00 |
| SBE 39 | 8754 | | 110 | 300 | 20211107 | 010000 | 20211107 | 16:00:00 | 17:00:00 |
| | | | | | | | | | |
| SBE 56 | 6979 | | 0.9 | 60 | 20211107 | 010000 | 20211107 | 16:00:00 | 16:30:00 |
| SBE 56 | 6980 | | 0.8 | 60 | 20211107 | 010000 | 20211107 | 16:00:00 | 16:30:00 |
| SBE 56 | 6982 | | 0.9 | 60 | 20211107 | 010000 | 20211107 | 16:00:00 | 16:30:00 |
| SBE 56 | 6983 | | 0.9 | 60 | 20211107 | 010000 | 20211107 | 16:00:00 | 16:30:00 |
| | | | | | | | | | |
| | | | | | | | | | |
| Star-Oddi | 5282 | | 110 | 600 | 20211104 | 010000 | 20211107 | 16:00:00 | 17:00:00 |
| Star-Oddi | 5283 | | 120 | 600 | 20211104 | 010000 | 20211107 | 16:00:00 | 17:00:00 |
| Star-Oddi | 5284 | | 130 | 600 | 20211104 | 010000 | 20211107 | 16:00:00 | 17:00:00 |
| Star-Oddi | 5285 | | 140 | 600 | 20211104 | 010000 | 20211107 | 16:00:00 | 17:00:00 |
| Star-Oddi | 5286 | | 150 | 600 | 20211104 | 010000 | 20211107 | 16:00:00 | 17:00:00 |
| Star-Oddi | 5287 | | 160 | 600 | 20211104 | 010000 | 20211107 | 16:00:00 | 17:00:00 |
| | | | | | | | | | |
| Nortek ADCM | 9407 | | 5 | 180/1200 | 20211102 | 010000 | 20211107 | 16:00:00 | 20:30:00 |
| Nortek ADCM - IM | 5973 | 41 | 13 | 180/1200 | 20211107 | 160000 | 20211107 | 16:00:00 | 20:30:00 |
| Nortek ADCP | 12391 | | 24 | 240/3600 | 20211102 | 010000 | 20211107 | 16:00:00 | 20:30:00 |
| | | | | | | | | | |
| RBR Solo D | 78198 | | 6 | 21600 | 20211111 | 010000 | | | |
| RBR Solo D | 78197 | | 83 | 21600 | 20211111 | 010000 | | | |
| | | | | | | | | | |
| TRDI 300 kHz | 23281 | | 85 | 180/3600 | 20211104 | 010000 | 20211107 | 16:00:00 | 20:30:00 |

| REPORT DOCUMENTATION PAGE | 1. Report No. WHOI-2023-01 | 2. | 3. Recipient's Accession No. |
|---|---|---|---|

4. Title and Subtitle
The Northwest Tropical Atlantic Station (NTAS):
NTAS-20 Mooring Turnaround Cruise Report Cruise On Board RV Pisces
November 4-28, 2021 Newport, RI - Pascagoula, MS

5. Report Date
November 2021

6.

7. Author(s)

Sebastien Bigorre, Ray Graham

8. Performing Organization Rept. No.

10. Project/Task/Work Unit No.

9. Performing Organization Name and Address

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(C)
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12. Sponsoring Organization Name and Address

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13. Type of Report & Period Covered
Technical Report

14.

15. Supplementary Notes

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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) Global Ocean Monitoring and Observing (GOMO) Program (formerly Ocean Observing and Monitoring Division). This report documents recovery of the NTAS-19 mooring and deployment of the NTAS-20 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 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
Upper Ocean Processes Group
The Northwest Tropical Atlantic Station (NTAS)
NTAS-20 Mooring Turnaround Cruise, Novermber 4-28, 2021

b. Identifiers/
Open-Ended Terms

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