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Woods Hole Oceanographic Institution

WHOI Hawaii Ocean Timeseries Station (WHOTS):

WHOTS-14 2017 Mooring Turnaround Cruise Report

by

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Technical Report

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Abstract

The Woods Hole Oceanographic Institution (WHOI) Hawaii Ocean Time-series Station (WHOTS), located approximately 100 km north of Oahu, Hawaii, is intended to provide long-term, high-quality air-sea fluxes as a part of the NOAA Climate Observation Program. The WHOTS mooring also serves as a coordinated part of the Hawaii Ocean Time-series (HOT) program, contributing to the goals of observing heat, fresh water and chemical fluxes at a site representative of the oligotrophic North Pacific Ocean. The approach is to maintain a surface mooring instrumented for meteorological and oceanographic measurements at a site near 22.75°N, 158°W by successive mooring turnarounds. These observations are used to investigate air–sea interaction processes related to climate variability.

This report documents recovery of the thirteenth WHOTS mooring (WHOTS-13) and deployment of the fourteenth mooring (WHOTS-14). Both moorings used Surlyn foam buoys as the surface element and were outfitted with two Air–Sea Interaction Meteorology (ASIMET) systems. Each ASIMET system measures, records, and transmits via Argos and Iridium satellite the surface meteorological variables necessary to compute air–sea fluxes of heat, moisture and momentum. The upper 155 m of the moorings were outfitted with oceanographic sensors for the measurement of temperature, conductivity and velocity in a cooperative effort with Dr. Roger Lukas of the University of Hawaii. A pCO_2 system and ancillary sensors were installed on the buoys in cooperation with Adrienne J. Sutton at the Pacific Marine Environmental Laboratory.

The WHOTS mooring turnaround was conducted on the NOAA ship *Hi'ialakai* (R/V HA). Operations were a joint effort undertaken by the Upper Ocean Processes group (UOP) of the Woods Hole Oceanographic Institution (WHOI), the University of Hawaii's (UH) Hawaii Ocean Time-series group (HOT), and the able-bodied crew of R/V HA. The cruise took place between 25 July and August 3 2017. Operations began with deployment of the WHOTS-14 mooring on 27 July. This was followed by a period of intercomparison, where meteorological measurements and CTDs were collected at both the W13 and W14 stations. Recovery of the WHOTS-13 mooring took place on 31 July. This report details the in-port operations, pre-cruise buoy preparations, cruise operations and data collected.

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1. Introduction

Station ALOHA (A Long Term Oligotrophic Habitat Assessment), located approximately 100 km north of Oahu, Hawaii, was established in 1988 as a part of the World Ocean Circulation Experiment (WOCE) and the Joint Global Ocean Flux Study (JGOFS). Station ALOHA is the focal point of numerous oceanographic studies of varying spatial and temporal scales. The Hawaii Ocean Timeseries (HOT) site within Station Aloha includes comprehensive, interdisciplinary upper ocean observations, but does not include continuous surface forcing measurements. In 2004, collaboration with the Woods Hole Oceanographic Institution (WHOI) Upper Ocean Processes (UOP) group was established to provide long-term, high-quality air-sea fluxes as a coordinated part of the HOT observation program. The WHOI HOT Station (WHOTS) compliments the ongoing time-series by contributing to the program goals of observing heat, fresh water and chemical fluxes at a site representative of the oligotrophic North Pacific Ocean. The WHOTS mooring also serves as an Ocean Reference Station – a part of NOAA's Global Ocean Monitoring and Observing Program – providing time-series of accurate surface meteorology, air-sea fluxes, and upper ocean variability to quantify air-sea exchanges of heat, freshwater, and momentum, to describe the local oceanic response to atmospheric forcing, to motivate and guide improvement to atmospheric, oceanic, and coupled models, to calibrate and guide improvement to remote sensing products, and to provide anchor point for the development of new, basin scale air-sea flux fields.

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 22° 45′N, 158° 00′W by means of annual "turnarounds" (recovery of one mooring and deployment of a new mooring near the same site). The moorings use Surlyn foam buoys as the surface element, outfitted with two complete Air–Sea Interaction Meteorology (ASIMET) systems. Each system measures, records, and transmits via Iridium satellite the surface meteorological variables necessary to compute air–sea fluxes of heat, moisture and momentum.

Subsurface observations are made on the WHOTS mooring in cooperation the University of Hawaii (UH) HOT project. The upper 155 m of the mooring line is outfitted with oceanographic sensors for the measurement of temperature, conductivity and velocity. A pCO_2 system for investigation of the air-sea exchange of CO2 at the ocean surface was mounted in the buoy well in cooperation with Adrienne Sutton at the Pacific Marine Environmental Laboratory (PMEL). The pCO_2 system was augmented with conductivity, temperature, chlorophyll fluorescence, turbidity, dissolved oxygen and pH measurements utilizing instruments mounted on the buoy base.

The mooring turnaround was done on the NOAA Ship *Hi'ialakai* (R/V HA), by the Upper Ocean Processes Group (UOP) of the Woods Hole Oceanographic Institution (WHOI) with assistance from UH participants. The cruise originated from, and returned to, Honolulu, HI (Fig. 1). The facilities of the NOAA operations center at Ford Island were used for pre-cruise staging.

The HA departed Ford Island at 1000 local on 25 July. A gyro compass calibration was performed in the harbor prior transiting to WHOTS station. The cruise was completed in 9 days, between 25 July and 3 August, 2017. The WHOTS 14 cruise track projected onto a bathymetric map of the off-shore area surrounding Oahu is shown in Figure 1.

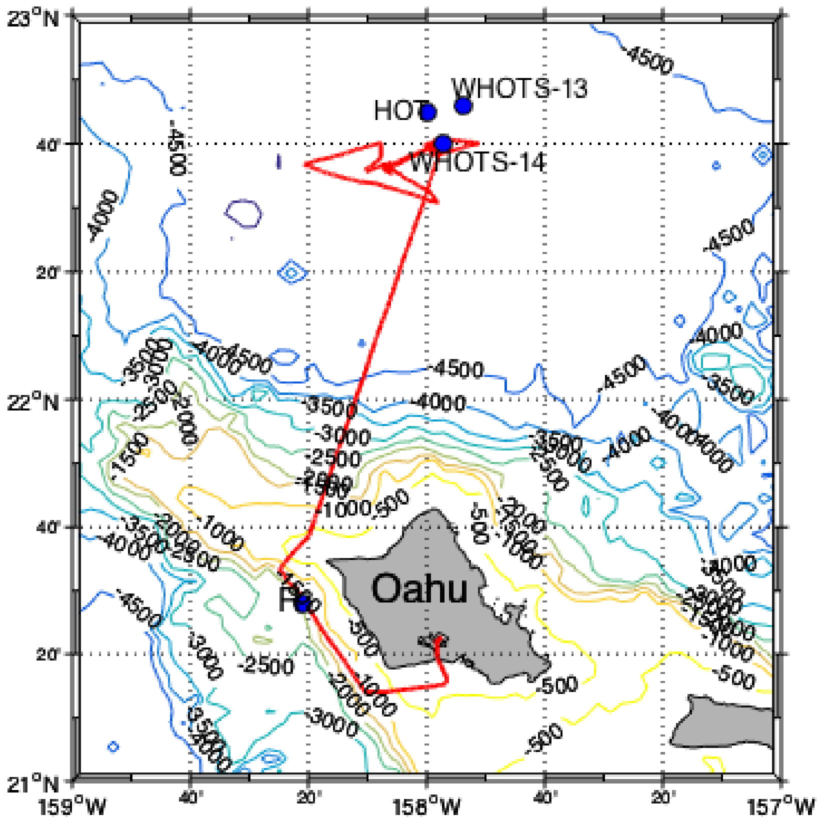


Figure 1. WHOTS-14 cruise track showing location of WHOTS-13 and WHOTS-14 mooring locations, and the HOT Station.

This report consists of six main sections, describing pre-cruise operations (Sec. 2), the WHOTS-14 mooring design (Sec. 3), the WHOTS-14 mooring deployment (Sec. 4), the WHOTS-13 mooring recovery (Sec. 5), and meteorological intercomparison made on-site by WHOI and ESRL (Sec. 6). Nine appendices contain ancillary information.

2. Pre-Cruise Operations

a. Staging and Loading

Pre-cruise operations were conducted at the NOAA port facility on Ford Island, Oahu, Hawaii. A shipment consisting of two 40' containers left Woods Hole for Hawaii on 01 July 2017. Major items in the containers were the tower top and base, winding and tension carts, anchor, mooring instrumentation and miscellaneous deck and lab equipment, wire baskets with synthetic line, dragging gear, and a Tension Stringing Equipment (TSE) winch. Several pieces of mooring equipment, including the buoy hull, glass balls, spare anchor and anchor tip plate, were stored at the University of Hawaii Marine Center facility at Pier 35. The UH group moved this equipment from Pier 35 to Ford Island prior to arrival of the UOP Group.

Dr. Bob Weller, Emerson Hasbrouck and Ben Pietro traveled to Hawaii on 17 July, unloaded the containers, and set up an operation area on the port grounds. Pre-cruise operations took place from 18 July to 24 July; the *Hi'ialakai* was in port for the duration of the WHOTS mobilization. Pre-cruise operations included assembly of the buoy tower top and well, painting the foam hull, evaluation of ASIMET data, instillation of PCO2 system, a buoy compass evaluation, insertion of the tower assembly into the hull, loading, deck arrangement, and lab setup. During the set-up and evaluation of the ASIMET system the real-time telemetered data was accessed via the UOP web-site.

b. Sensor Evaluation

The UOP science party started work at Ford Island on 18 July 2017. The buoy well and tower top were unpacked from the container and assembled (modules were shipped still attached to the tower top). By the end of the day on 19 July the buoy was operating and transmitting meteorological data. Evaluation of ASIMET Argos and Iridium data showed all variables looking reasonable and comparisons within expected tolerances. Internally recorded 1-minute ASIMET data was downloaded for evaluation on 23 July.

A wind module compass/vane evaluation was performed prior to the 1-minute data download. Due to the variability associated with measuring the wind components prior to deployment, a wind module evaluation is performed to ensure that both system's compass and directional vane encoder on the System 2 RM Young wind module are functioning properly. The evaluation is initiated by orienting the wind modules, mounted to the tower top and assembled buoy well (without the foam hull attached), towards a distant point with a known magnetic heading. The entire well assembly is then rotated through the cardinal positions in approximate 45-degree increments. At each position, the vane of the RM Young wind sensors is oriented parallel with the sight line (vane towards the sighting point and propeller away) and held for several sample intervals. If the compass and vane are working properly, they should co-vary such that their sum (the wind direction) is equal to the sighting direction at each position (expected variability is plus or minus a few degrees). The WHOTS-15 buoy had one RM Young wind sensor and one Gill sonic anemometer. Since the Gill has no vane, the buoy spin serves as a compass performance check.

The first wind module evaluation was completed in the parking lot outside of WHOI's Clark South Laboratory high bay, with care taken to reduce the magnetic deviation associated with structures, equipment and vehicles. The sighting azimuth was 0°.

The second buoy spin was done in Hawaii, on an open area of pavement at the Ford Island facility on July 21st. A sighting direction of 300° was established with a distant object as a reference point. All three wind modules (RM Young, Gill sonic and WXT) contain a compass. Fig. 2 shows the wind module compass error relative to the buoy orientation for the Ford Island

and WHOTS spin. The RM Young module has both compass and vane, so the apparent wind direction can be determined for each buoy orientation (Figure 2). An azimuth of 330° for the WHOTS 14 compass evaluation was sighted with a Viton Mini2000 marine grade hand-bearing compass.

The vane direction, compass heading and calculated wind direction error for each of the two separate wind modules must average to below 5 degrees for the module to be acceptable for deployment.

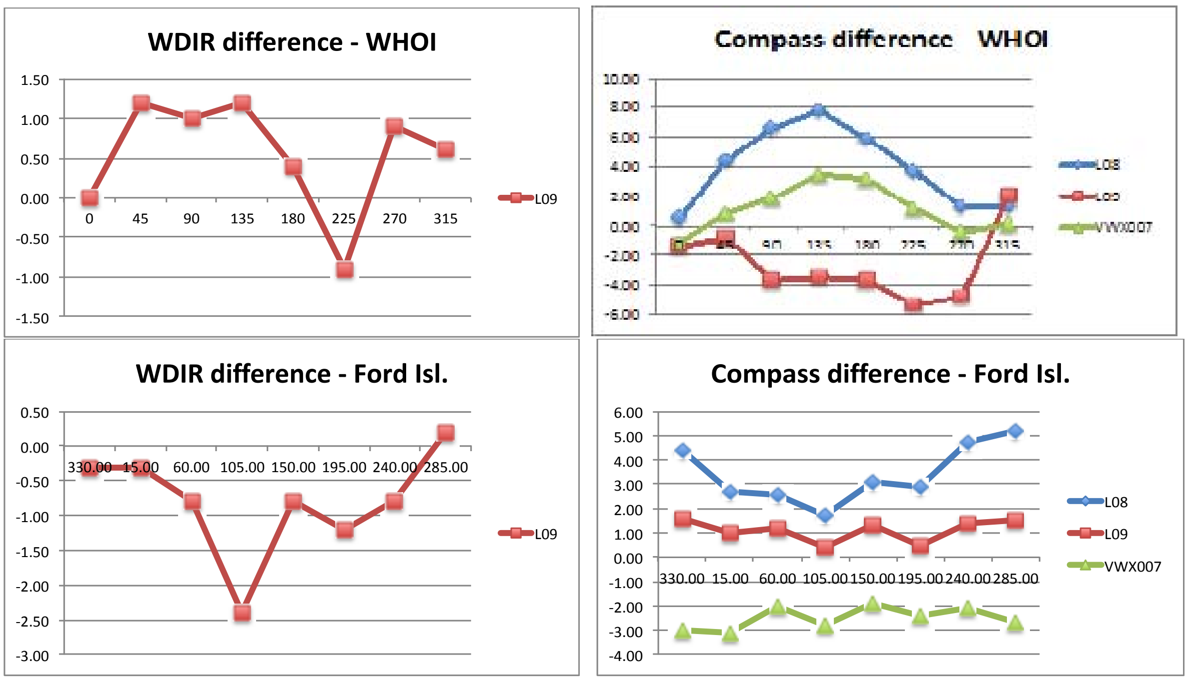


Figure 2. Results of wind module evaluation at both WHOI, MA and Ford Island, HI

Once the compass evaluation was completed all of the one minute meteorological data was recovered directly from the internally recording compact flash cards. All buoy sensor pairs agreed well. At night, the two buoy HRH modules air temperature measurements (AT) agreed to about 0.1°C and compared well with the SBE-39 AT (Fig 2). The Vaisala WXT AT was low by about 0.2°C compared to the SBE-39 AT. The HRH module AT differences were only slightly larger during the day (~0.15°C), while the Vaisala AT was ~0.4°C lower at midday.

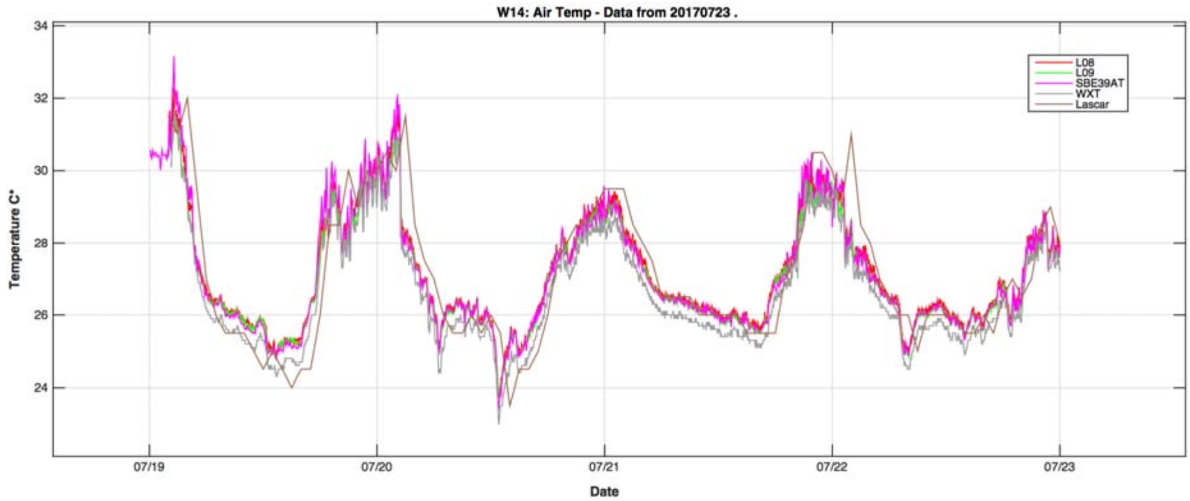


Figure 3. Air temperature sensor check at Ford Island on 23 July.
The buoy tower was in open air on the pier prior to arrival of the Hi'ialakai.

The observed wind speeds for the two ASIMet systems compared well (within 0.2 m/s) during an overnight test on the pier prior to arrival of the HA. The Vaisala wind speed was typically 0.5 m/s lower than the buoy pair. The buoy wind directions agreed to within about 5°.

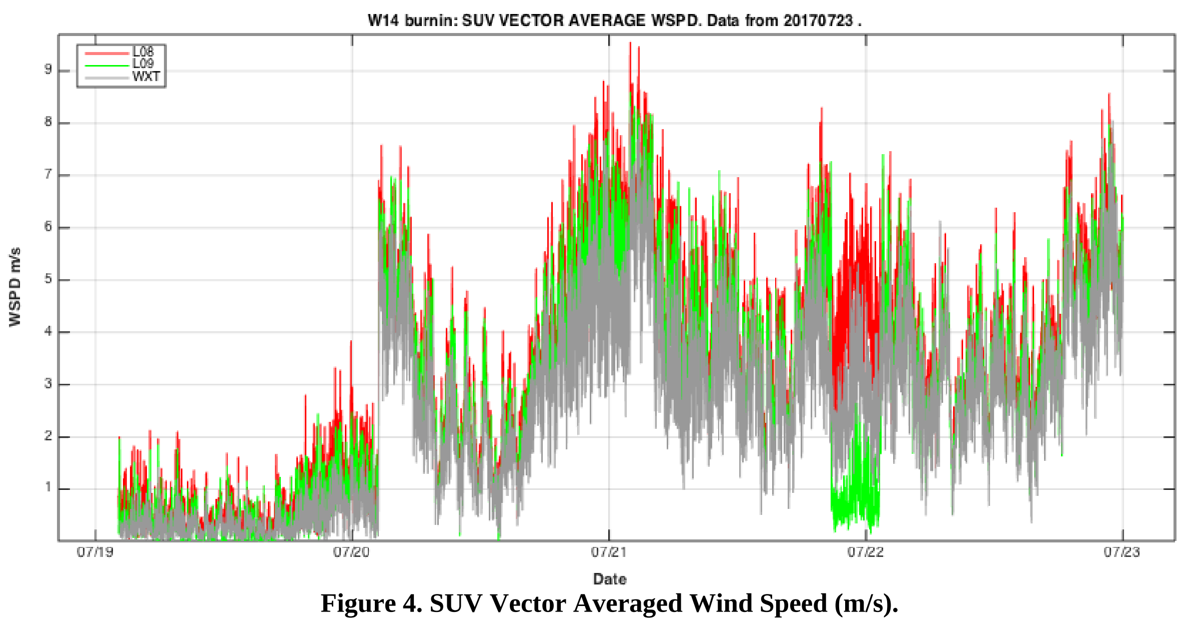


Figure 4. SUV Vector Averaged Wind Speed (m/s).
The buoy was in open air on the pier prior to arrival of Hi'ialakai

A series of “sensor function checks”, including filling and draining the PRC modules, covering and uncovering the solar modules, and dunking the sea temperature and conductivity sensors (SeaBird 37SM) in a salt-water bucket, were completed on Ford Island prior to the cruise departure. The function checks showed proper operation. The buoy tower was loaded into the foam buoy hull on 23 July and loaded onto the vessel.

3. WHOTS-14 Mooring, Systems, and Sensors

a. Mooring Design

The mooring is an inverse-catenary design of compound construction (Fig. 5), utilizing chain, wire rope, nylon and Colmega (buoyant synthetic line). The mooring scope (ratio of total mooring length to water depth) is about 1.25. The watch circle has a radius of approximately 2.2 nm (4.1 km). The surface element is a 2.7-meter diameter Surlyn foam buoy with a watertight electronics well and aluminum instrument tower. The two-layer foam buoy is “sandwiched” between aluminum top and bottom plates, and held together with eight 3/4" tie rods. The total buoy displacement is 15,000 pounds, with reserve buoyancy of approximately 12,000 lb when deployed in a typical configuration. A fully assembled buoy weighs about 4500 lb. The modular buoy design can be disassembled into components that will fit into a standard ISO container for shipment. A subassembly comprising the electronics well and meteorological instrument tower can be removed from the foam hull for ease of outfitting and testing of instrumentation. Data loggers, electronics for satellite telemetry, and batteries fit into the instrument well.
Instruments were attached along the mooring line using a combination of load cages (attached in-line between chain sections), load bars and clamps (Fig. 6). The design was consistent with that of WHOTS-12, with the transition from chain to jacketed wire at 47.5 m and MicroCATs clamped to the wire from 50 m to 155 m.

The wire to synthetic transition was a urethane-encapsulated termination with 100 m of 3/8” wire and 200 m of 7/8” nylon. The termination was stored in a box large enough for the urethane section to lay flat. Split plastic tubing was used to cover the urethane coated 8-strand nylon line immediately below the wire to nylon junction during storage and while on the winch drum. The tubing was removed as the termination was spooled off the winch during deployment.
Dual acoustic releases, attached to a central load-bar, were placed approximately 30 m above the anchor. Above the release were 68 17” glass balls meant to keep the release upright and ensure separation from the anchor after the release is fired. This flotation is sufficient for backup recovery, raising the lower end of the mooring to the surface in the event that surface buoyancy is lost.

For WHOTS-10 to 13, the mooring design depth alternated between 4670 m (for the NE site, e.g. WHOTS-11) and 4756 m (for the SW site, e.g. WHOTS-12). Starting with WHOTS-14 it was determined that both depths could be accommodated within the mooring scope using a design depth of 4720 m.

WHOTS-15 incorporated two different types of spiked strips for bird deterrence (Fig. 6). Four-foot metal strips were used around the crash bar and tower top aft of the front face. Plastic strips were used along the front face of the tower top (to avoid possible magnetic effect on the wind module compasses). The spiked strips were secured to the tower crash bar with cable ties and hose clamps. Short strips were also placed around the solar radiometers and other potential roosting sites. As a deterrent to birds settling on the buoy hatch, transparent monofilament fishing line was installed along the tower faces and inside the tower.

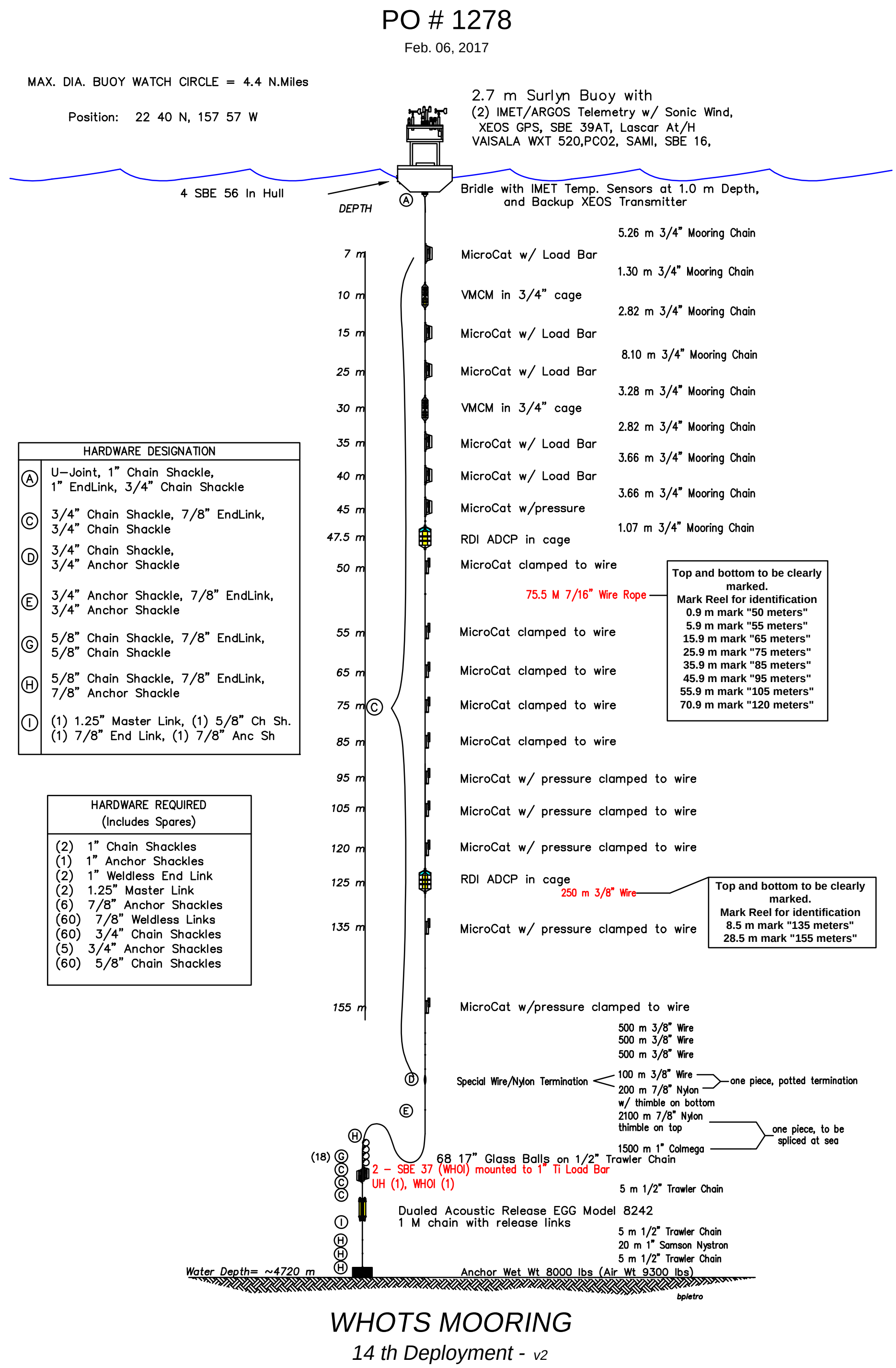


Figure 5. WHOTS-14 mooring diagram.

The WHOTS-14 buoy incorporated a remote line deployment system (Fig. 6) to enable a hauling line to be deployed from the buoy rather than attaching it by hand using a snap hook from the deck or a small boat. The system consists of two cylinders and an actuating device. The first cylinder contains 1 small float attached to 50 feet of 3/8” Amsteel Blue buoyant synthetic line that serves as a “leader” for the hauling line. The actuator is connected to this cylinder. Upon receiving a radio signal, the actuator opens a hinged door allowing the leader line to drop into the sea where it will trail behind the buoy. The second cylinder contains 50 feet of 5/8” Amsteel Blue (53,000 lb break strength) hauling line. When the leader is grappled form the ship and hauled in, sufficient tension is generated to pull open the door of the second cylinder and release the hauling line, which is connected to the lifting bale of the buoy. Note that the foam hull is notched at the location of the line deployment system in order to accommodate the two cylinders at an angle that will allow the line to readily fall into the water.

The line launcher on WHOTS-13 was remotely deployed from the bow deck of the R/H HA on 29 July. The leader line canister fouled against the foam hull (Fig. 8) preventing the successful release of the Amsteel Blue recovery line.

Figure 6. Remote line deployment system fouled on the WHOTS-13 buoy.

b. Buoy Instrumentation

Two independent sets of ASIMET sensor modules were attached to the upper section of the two-part aluminum tower at a height of about 3 m above the water line. Two ASIMET data loggers and two isolated battery banks, sufficient to power the loggers and tower sensors for about 18 months, were mounted in the buoy well. The two independent systems provide redundancy in the event of component failures. The ASIMET system is the second-generation of the Improved Meteorological (IMET) system described by Hosom et al. (1995). Performance of the second-generation sensors is described by Colbo and Weller (2009). Sensor modules are connected to a central data logger and addressed serially using the RS485 communication protocol. Modules also log internally using compact flash (CF) card memory.

As configured for WHOTS-14, each system included six ASIMET modules mounted to the tower top (Fig. 6), one Sea-Bird SBE-37SM "MicroCAT" mounted beneath the buoy hull, a data logger mounted in the buoy well, and an Iridium modem (System 1) or a Argos Platform Transmit Terminal (PTT – System 2) mounted inside the logger electronics housing. The seven-module set measures ten meteorological and oceanographic variables: tower-top ASIMET modules measure wind speed and direction (WND), barometric pressure (BPR), relative humidity and air temperature (HRH), shortwave radiation (SWR), longwave radiation (LWR), and precipitation (PRC). The hull-mounted MicroCAT measures sea temperature and conductivity (STC). The MicroCATs were specified with an RS485 interface option, and thus could be addressed by the ASIMET logger in the same manner as the meteorological modules.

Figure 7. WHOTS-14 tower top, showing the location of ASIMET modules and a variety of auxiliary sensors.

Serial numbers of the sensors and loggers comprising the two ASIMET systems are given in Table 1, along with the various stand-alone sensors and telemetry system components. The sensor heights relative to the buoy deck, and relative to the water line, are given in Table 2.

Table 1. WHOTS - 14 ASIMET System					
System	**Module**	**Type**	**Serial Number**	**Firmware Version** [1]	**Sample Rate** [2]
ASIMET-1	HRH	ASIMET-Rotronic	257	VOSHRH53 v4.29cf	1 minute
	BPR	ASIMET-Heise	240	VOSBPR53 v4.03cf (Heise)	1 minute
	SWND	ASIMET-Gill	268	SONICWND53 v4.11cf	1 minute
	PRC	ASIMET-RM Young	215	VOSPRC53 v4.03cf	1 minute
	LWR	ASIMET-Eppley	224	VOSLWR53 v4.02cf	1 minute
	SWR	ASIMET-Eppley	502	VOSSWR53 v4.01cf	1 minute
	SST	Sea-Bird 37SM	1834	SBE V 2.3b	1 minute
	Logger	C530	L08	LOGR53 v4.38-1spurs2	1 minute
	Iridium	JouBeh HECTO	J104NF	300234063345500	60 minutes
ASIMET-2	HRH	ASIMET-Rotronic	247	VOSHRH53 v4.29cf	1 minute
	BPR	ASIMET-Heise	502	VOSBPR53 v4.03cf (Heise)	1 minute
	WND	ASIMET-RM Young	219	VOSWND53 v4.02cf	1 minute
	PRC	ASIMET-RM Young	501	VOSPRC53 v4.03cf	1 minute
	LWR	ASIMET-Eppley	205	VOSLWR53 v4.02cf	1 minute
	SWR	ASIMET-Eppley	351	VOSSWR53 v4.01cf	1 minute
	SST	Sea-Bird 37SM	5994	SBE V 2.3b	1 minute
	Logger	C530	L42	LOGR53 v4.38-1spurs2	1 minute
	PTT	WildCAT	63879	07561, 27415, 27416	240 min.
Stand- Alone	Air Temp	SBE39	1446	SBE 39 V 3.1b	5 minutes
Stand- Alone	VWX	Vaisala WXT-536	7	VAISALA24 v5.65	1 minute
Stand- Alone	AT/RH	Lascar	10032208	v0.1	60 minutes
Stand- Alone	GPS	Xeos Mello	N/A	300034012709960	240 minutes
Stand- Alone	GPS	Xeos Sable	N/A	300034012194230	180 minutes

[1] For Iridium and Argos Transceivers IMEI is given rather then Firmware

[2] For Iridium and ArgosTransceivers transmit interval is given rather then sample rate

The water line was determined to be approximately 60 cm below the buoy deck by visual inspection after launch.

Each tower-top module records one-minute data internally to a CF memory card at one-hour intervals. The STC module records internally at five-minute intervals. The logger polls each module during the first few seconds of each minute, and then goes into low-power mode for the rest of the minute. The logger writes one-minute data to the CF memory card once every 10 minutes, and also assembles hourly averaged data for transmission through Argos PTTs and Iridium modems at one-hour intervals. The Argos transmitter utilizes three PTT IDs to transmit the most recent six hours of one-hour averaged data. The Argos and Iridium transmissions also include location data that can be used to monitor buoy position.

Table 2. WHOTS-14 ASIMET Sensor Height			
Module	Relative [1] Height cm	Absolute [2] Height cm	Measurement Location
HRH	240	310	sensor
BPR	237	307	sensor
WND	270	340	prop axis
SWND	279	349	transducer
PRC	256	326	top of cup
LWR	286	356	top of dome
SWR	286	356	top of dome
STC	-157	-87	center of port
SBE39AT	223	293	sensor
VWX	271	341	top of plate
Lascar	229	299	sensor
[1] Relative to buoy deck - negative is below deck			
[2] As measured to the water line - negative values are below water			
W14 WL = -60cm from deck			

A wind vane on the tower top keeps the "bow" of the buoy oriented towards the wind. For WHOTS-14, a bolt-on vane extension, as used for WHOTS-11 through 13, was added to the standard vane to improve performance. Flat-plate Argos PTT antennas are mounted on either side of the lower vane. A radar reflector was mounted in at cut-out in the upper portion of vane. Wind modules were mounted in locations that minimize obstructions along the downwind path. Radiation sensors, mounted at the stern of the buoy, are at the highest elevation to eliminate shadowing. Two marine lanterns were mounted on either side of the tower, just outboard of the PRC modules. The two HRH modules were mounted on 18" extension arms off the port and starboard sides of the buoy to maximize aspiration and minimize self-heating.

Three additional sensors serve as back-ups to the ASIMET modules: a SBE-39 temperature sensor, a Lascar temperature/humidity sensor and a Vaisala WXT 520 multi-parameter instrument. The SBE-39 was configured with a radiation shield to serve as a backup air temperature sensor and mounted inboard of the ASIMET HRH module on the port side (Fig. 8). The Lascar was mounted behind the SBE-39. The Vaisala WXT 520 was configured as a stand-alone ASIMET module and deployed on the forward rail of the tower between the two RM Young wind modules (Fig. 7). The WXT measures pressure, temperature, relative humidity, wind speed and direction and precipitation. The WXT is powered by an independently wired set of batteries in the buoy well and serves as a backup for the ASIMET BPR, HRH, WND and PRC modules.

A stand-alone Xeos GPS module mounted to the tower, forward of the port side BPR, (Fig. 6) to record buoy position while anchored and provide real-time positions in the event that the buoy breaks free from the anchor. For internal recording, a 5-minute burst of 20 second samples, repeated every 30 minutes, was specified. The real-time telemetry interval was set to 4 h. In addition to an internal battery, the GPS module was connected to batteries in the buoy well to provide power for approximately 700 days of operation. A second positioning system (Xeos Sable) was mounted beneath the hull. This is a backup system, and would only be activated if the buoy capsized.

A pCO_2 system was added to the WHOTS buoy by Chris Sabine of the Pacific Marine Environmental Laboratory (PMEL) starting in 2007. The research partnership has continued with the PMEL Ocean Carbon Project under the guidance of Adrienne Sutton. The electronics, batteries and gas cylinder are mounted in the buoy well, with sensors in the air and in the water. The WHOTS pCO_2 system provides measurements every three hours of CO_2 in marine boundary layer air and in air equilibrated with surface seawater using an infra-red detector. The detector is calibrated prior to each reading using a zero gas derived by chemically stripping CO_2 from a closed loop of air and a span gas produced and calibrated by NOAA's Earth System Research Laboratory (ESRL). Starting 2011 PMEL added a pH sensor and a SBE16 package with dissolved oxygen, chlorophyll and turbidity instruments. For this deployment, the SBE-16 package and SAMI-2 pH sensor were mounted on the base of the buoy hull and wired to the controller through pass-through tubes in the foam hull. These measurements were added to upgrade WHOTS from a carbon flux monitoring site to a full ocean acidification (OA) site as part of the growing OA network. For an overview of the PMEL carbon network visit: http://www.pmel.noaa.gov/co2/story/Buoys+and+Autonomous+Systems.

The pCO_2 system configuration for WHOTS-15 is shown in Table 3. To view the daily data from WHOTS, visit the NOAA PMEL Moored CO_2 Website: http://www.pmel.noaa.gov/co2/story/WHOTS.

Table 3. WHOTS-14 pCO2 System

Serial Number	Make / Model	Measurement / Use
0179	Battelle & PMEL	pCO2 in Air and Seawater
JB03371	ESRL	Calibration Span Gas @ 455.02 ppm
P059	Sunburst SAMI2	pH
7412	Seabird SBE16V2	Temperature & Conductivity
1950	Wetlabs ECOFLNTUS	Chlorophyll and Turbidity
515	Seabird SBE63	Dissolved Oxygen

c. Subsurface Instrumentation

Four Sea-Bird SBE-56 temperature sensors were installed in the buoy hull to provide a SST measurement within about 10 cm of the mean water line. These small (0.83 cm diameter x 30 cm long) sensors are recessed directly into the buoy hull by drilling a hole in the foam and inserting the sensor. For WHOTS-14, three sensors were inserted at the "bow" of the buoy (180^0 from the vane) at depths of about 80, and 90 cm below the buoy deck. Two more were inserted at approximately 120^0 and 240^0 at about 80 cm below the deck. The protruding ends were coated with anti-seize lubricant just prior to deployment as an antifouling measure. The buoy hull SST configuration is summarized in Table 4.

Table 4. WHOTS-14 Buoy Hull SST Configuration					
	Serial	Sample	Relative	Absolute	
Instrument	Number	Rate	Depth [1]	Depth [2]	Orientation [3]
SBE 56	7212	60	-80	-20	120
SBE 56	7213	60	-80	-20	180
SBE 56	7214	60	-90	-30	180
SBE 56	7215	60	-80	-20	240
[1] Relative to buoy deck - negative is below deck					
[2] As measured to the waterline - negative values are below water					
[3] wind vane is 0 value - clockwise from vane is positive angle value					
W14 WL - 60cm from deck					

Along the mooring line, WHOI provided 2 Vector Measuring Current Meters (VMCMs), configured as shown in Table 5.

Table 5. WHOTS-14 VMCM Configuration					
	Serial		Sample	Start	Start
Instrument	Number	Depth (m)	Interval (s)	Date	Time (z)
VMCM	2042	10	60	20170726	1955
VMCM	2068	30	60	20170727	0017

Deep temperature/conductivity (T/C) sensors, introduced on WHOTS-9, were also deployed on WHOTS-14. A pair of SBE-37 MicroCAT sensors were placed just below the glass balls at about 36 m above the bottom. The SBE-37s were configured as shown in Table 6.

Table 6. WHOTS-14 Deep SBE 37SMP Configuration					
	Serial		Sample	Start	Start
Instrument	Number	Depth (m)	Interval (s)	Date	Time (z)
SBE 37SM	9988	4850	60	20170724	0000
SBE 37SMP	10602	4850	300	20170720	0100

The University of Hawaii provided 17 SBE-37 MicroCATs and one RDI Workhorse ADCP (300 kHz). In addition to the instrumentation on the buoy, WHOI provided two Vector Measuring Current Meters (VMCM), one deep MircoCAT (SBE-37), and one RDI Workhorse ADCP (600 kHz), and all required subsurface mooring hardware. The MicroCATs all measure temperature and conductivity, with 7 also measuring pressure. All MicroCATs were deployed with antifoulant capsules. Information about these instruments, including location on the mooring, is given in Table 8.

The ADCPs were deployed with transducers facing upward. The ACDPs were programmed as described in Table 9. Each instrument was rubbed gently by hand for 20 seconds to produce a spike in the data as a reference point to check the instrument's clock.

Table 7. WHOTS-14 mooring subsurface instrument deployment information

SN	Instrument	Depth (m)	Pressure SN	Sample Interval (sec)	Start Logging Data		Cold Spike Begin		Cold Spike End		Time in Water	
3617	MicroCAT	7	N/A	180	7/24/17	00:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/27/17	18:29:00
042	VMCM	10	N/A	60	7/27/17	00:00:17	7/27/17	18:25:00*	N/A	N/A	7/27/17	18:26:00
6893	MicroCAT	15	N/A	60	7/24/17	0:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/27/17	18:19:00
6894	MicroCAT	25	N/A	60	7/24/17	0:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/27/17	18:15:00
068	VMCM	30	N/A	60	7/26/17	19:54:00	7/27/17	18:10:00*	N/A	N/A	7/27/17	18:10:00
6895	MicroCAT	35	N/A	60	7/24/17	0:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/27/17	18:07:00
6896	MicroCAT	40	N/A	60	7/24/17	0:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/27/17	18:04:00
6887	MicroCAT	45	2651319	75	7/24/17	0:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/27/17	18:02:00
1825	600 kHz ADCP	47.5	N/A	600	7/26/17	00:00:00	N/A	See Table 8	N/A	See Table 8	7/27/17	19:30:00
6897	MicroCAT	50	N/A	60	7/24/17	0:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/27/17	19:31:00
6898	MicroCAT	55	N/A	60	7/24/17	0:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/27/17	19:33:00
6899	MicroCAT	65	N/A	60	7/24/17	0:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/27/17	19:35:00
3618	MicroCAT	75	N/A	180	7/24/17	0:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/27/17	19:36:00
3634	MicroCAT	85	N/A	180	7/24/17	0:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/27/17	19:38:00
3670	MicroCAT	95	5701	240	7/24/17	0:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/27/17	19:40:00
6889	MicroCAT	105	2651321	75	7/24/17	0:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/27/17	19:42:00
6890	MicroCAT	120	2651322	75	7/24/17	0:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/27/17	19:54:00
4891	300 kHz ADCP	125	N/A	600	7/24/17	0:00:00	N/A	See Table 8	N/A	See Table 8	7/27/17	19:55:00
6888	MicroCAT	135	3418742	75	7/24/17	0:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/27/17	19:57:00
6891	MicroCAT	155	2651323	75	7/24/17	0:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/27/17	19:59:00
9988	MicroCAT	36m off bottom	N/A	60	7/24/17	0:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/28/17	02:02:00
10602	MicroCAT	36m off bottom	10602	60	7/20/17	1:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/28/17	02:02:00

Table 8. WHOTS-14 ADCP Deployment and Configuration information		
	ADCP S/N 4891	ADCP S/N 1825
Frequency (kHz)	300	600
Number of Depth Cells	30	25
Depth Cell Size (m)	4 m	2 m
Pings per Ensemble	40	80
Time between Ensembles	10 min	10 min
Ping interval	4 sec	2 sec
Time of First Ping	07/24/17, 00:00:00	07/26/17, 00:00:00
Transducer 1 Spike Time	07/26/17, 00:30:00	07/26/17, 00:30:00
Transducer 2 Spike Time	07/26/17, 00:30:15	07/26/17, 00:30:15
Transducer 3 Spike Time	07/26/17, 00:30:30	07/26/17, 00:30:30
Transducer 4 Spike Time	07/26/17, 00:30:45	07/26/17, 00:30:45
Time in Water	07/27/17, 19:55:00	07/27/17, 19:30:00
Depth (m)	125 m	47.5 m

4. WHOTS-14 Mooring Deployment

a. Deployment Approach

Mooring deployment operations were conducted on the *Hi'ialakai* using techniques developed from previous cruises. Starting with WHOTS-4, a southern site was used alternately so that both the newly deployed mooring and the mooring to be recovered were in the water during the intercomparison period. Thus, the WHOTS-14 mooring was slated for the southern site at a nominal location of 22° 46'N, 157°54'W, about 6 nm east of the HOT central site at 22° 45'N, 158°00'W.

The day before deploying WHOTS 14, the ship assessed the winds and currents in the area near the WHOTS 14 anchor target. Trade winds from just north of east prevailed, but currents up to 0.7 kts were observed on the ship's ADCP. On the 26th, the currents were flowing to the south, and the intent was to start the deployment from a position out of the northwest relative to the anchor target. At ~0500 local on July 27 it was noted that the currents had reversed and were flowing to the north, so the start point was chosen 10 nm away from the anchor target to the west southwest of that target:

	latitude	longitude
WHOTS 14 anchor target	22° 40.12'N	157° 57.01'W
WHOTS 14 deploy start	22° 36.685'N	158° 07.280'W

Table 9. WHOTS 14 deployment start and target

Thus, the desired track would be 10.09 nm along 110° towards 70°. The actual track achieved up to and including the three point acoustic survey is shown in Figure 1. The black line is the planned track, while the red is the ship's track.

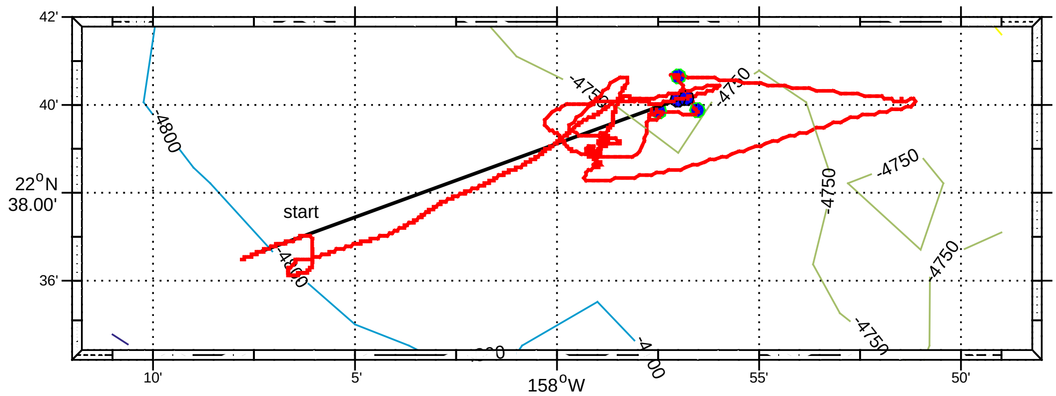


Figure 8. Ship's track (red) and planned track (black) during deployment of WHOTS 14. Blue dot is the target for the anchor and green dots show three points of the acoustic anchor survey.

Initial ship handling at the start point was done to facilitate the deployment of the upper 40 m of mooring and instrumentation and the surface buoy. During this time the ship fell off to the south. As more gear went into the water the ship began to steam towards the target and moved back to the north towards the line. A change in currents brought the ship across the track and to the north towards the end of the deployment. This required a final approach from west to east across the anchor track, with course and heading corrections done while towing on the chain prior to attaching the acoustic releases. With the releases attached, the ship was taken over the anchor target passing east by about 300 m to allow fallback, at which time the anchor was dropped. Once the anchor was dropped, the ships continued ahead and off to the side, then swung in behind the buoy as it moved towards the drop site. After about 90 minutes, three points about 0.5 nm from the anchor target were passed to the bridge and the ship stopped briefly at each of these three points to collect ranges to the anchor using the release deck gear, which was using 1500 m s^{-1} for sound speed:

	Latitude	Longitude	Range (m)	Time (ms)
1	22° 39.797'N	157° 57.431'W	5467.5	3.645
2	22° 39.844'N	157° 57.0456'W	5518.5	3.679
3	22° 40.621'N	157° 57.046'W	5536.5	3.691

Table 10. WHOTS 14 anchor triangulation position, slant range and two way travel time

b. Deployment Operations

The mooring was deployed in multiple stages. The first stage was the lowering of the upper 45 meters of the mooring over the starboard side of the ship. Instruments and the chain sections immediately above them had been assembled and laid out on deck prior to the start of operations (Fig. 10). The 45 m Microcat was selected as the first instrument to be deployed. Instruments up to the 7 m Microcat were deployed from deepest to shallowest, using the crane to lift them into the water over the starboard rail.

Figure 9. Subsurface instrumentation assembled and laid out in sequence on deck prior to deployment. The deepest instrument is at the far left.

A ½ inch spectra hauling line was payed out from the mooring winch and passed through the UOP block. The block was hauled up by using the large air tugger. The spectra line was passed around the A-frame, around the starboard quarter, and shackled to the chain below the first instrument to be deployed. Instruments and chain were lifted over the side with the crane. A stopper line was then hooked into a chain link and made fast to the deck cleat. The crane was removed and the next instrument was shackled to the stopped-off chain. Once connected, the crane lifted the chain and instrument off the deck. After the crane had the load, the stopper line was eased off and cleared. As each instrument was added and lowered into the water, the hauling line was payed out to follow the mooring down. Once the upper 45 m of the mooring was in the water, the upper chain section was connected to the buoy universal and then slipped out using a slip line attached to the cleat on the rail.

The next stage of the operation was the launching of the surface buoy. Slip lines were rigged on the buoy tower D-ring, the port-side deck D-ring and the buoy base to maintain control during the lift. The ship's crane was attached to the Peck and Hale release hook on the buoy lifting bale and a tag line was attached just above the crane hook. The buoy was lifted off the deck and the slip line holding the 45 meters of instrumented mooring was eased off to transfer the load to the buoy. The buoy was then swung outboard and lowered to the water as the tag lines were slipped out (Fig. 11). Once the buoy settled into the water, and the crane wire went slack, the release hook was tripped. The ship then maneuvered slowly ahead to allow the buoy to pass around the stern. The 45-meter length of mooring, along with the ½” spectra hauling line, provided adequate scope for the buoy to clear the stern.

Figure 10. WHOTS-14 buoy deployment. The buoy is lifted over the (non-removable) gunwales with the ship’s crane. Tag lines for the crane whip, quick release, buoy deck, and buoy tower can be seen.

The remainder of the mooring was deployed over the stern. Once the buoy was behind the ship, speed moved ahead slowly (~0.5 kt) and the spectra leader was hauled in on the winch bringing the chain below the 45 meter Microcat over the stern. The mooring was stopped off using the cleated stopper lines and the 47.5 m ADCP was shackled into the chain. The ½” spectra leader was off-spooled from the winch, exposing the 75.5 m section of wire rope. The 75.5 m section of wire rope was attached to the lower end of the ADCP cage. Tension was taken up by the winch and the ADCP was eased over the transom. The Microcats from 50 m to 120 m were clamped to the 7/16” wire as it was spooled off the winch drum. As the wire was payed out, the ship’s speed was increased to about 1.25 kt. The mooring was stopped off at the end of the 75.5 m wire section using the cleated stopper lines. The 125 m ADCP was shackled into the 75.5 m wire section above and the 250 m wire section below. The final two Microcats were clamped to the 250 m 3/8” wire as it was spooled off the winch.

When all the instruments were deployed, the remaining 1600 meters of wire and 200 meters of nylon (previously wound on the winch drum) were payed out. When the winch drum was empty, the end of the nylon was stopped off to a deck cleat and connected to the first length of nylon in the wire baskets. An H-bit, positioned in front of the winch was used to slip out the 2050 m of nylon and 1500 m of Colmega line stowed in three wire baskets. The entire 3550 m of synthetic line had been previously spliced into a continuous piece. While the synthetic line was being payed out, the 68 glass balls were staged on the main deck for deployment.

With approximately 20 m of Colmega line remaining, payout was stopped and the shackle-link termination was connected to the winch leader. The mooring was stopped off using a Yale Grip. The slack line was removed from the H-bit and wound onto the winch, taking tension off the Yale Grip. The Yale grip was removed and the remaining line was payed out from the winch until it was at the transom. The glass balls were then shackled into the mooring line and eased over the transom using the winch and stopper lines. The distance from winch drum to transom was just enough to allow two four-ball strings to be deployed at once.

Part way through the glass ball deployment, approximately 1.4 nm away from the drop point, the ship fell off course and was losing ground relative to the drop site (see Fig. 9). Deployment operations were paused with a set of glass balls at the transom and a stopper line shackled to the 7/8 end link below the glass balls. The ship then maneuvered for approximately 25 min to re-acquire the desired course towards the drop point. Glass ball deployment commenced when the ship was back on course.

With the last glass ball at the transom, two stopper lines were shackled to the chain and to the 7/8 end link below the glass balls. Two SBE 37s on a 1" load bar were shackled into the mooring. The tandem-mounted acoustic releases were shackled into the mooring chain at the transom. Another 5-meter section of chain was attached to the bottom link of the release chain. The 20 meter of Nystron line was wound on the winch and the 5 m chain section at the bottom of the releases was shackled to the Nystron. A ½" chain hook was shackled into the spectra working line hanging from the A-frame and hooked into the chain just below the acoustic releases. The working line was pulled up with the air tugger, lifting the releases off the deck. The tugger payed out and the A-frame was boomed out until the releases were clear of the transom. The working line was lowered and the chain hook removed from the mooring. The winch continued to pay out until the end of the 20-meter Nystron line was near the transom. The load was then transferred from the winch to a stopper line.

The anchor, positioned on the starboard side inboard of the A-frame, was rigged with a 5-meter section of ½" chain. The 5 meter chain section was shackled to the 20 meter Nystron line. An expendable back stay was rigged from the eye of the anchor to a deck eye to secure it. With approximately 1/2 h still to go until the anchor drop, a screw pin shackle and pear link were connected to the middle of the 5 m 1⁄2" chain from the anchor. A 3⁄4" nylon line was attached to the winch leader using a bowline and fed through the pearl link on the 5m chain and brought back to the winch leader and tied off with a bowline.

With about 10 minutes to the drop site, the chain binders holding the anchor in place were removed and the 3⁄4" slip line took the load from the stopper line. The crane was positioned over the forward end of the tip plate and hooked into the tip plate bridle. As the ship approached the launch site, the winch payed out slowly and put the load to the anchor and the nylon backstay. The backstay was removed in the last minute, the crane hook was raised, and the tip plate raised enough to let the anchor slip into the water. The anchor was dropped at 0219 UTC on 28 July at 22° 40.158′ N, 157° 56.803′ W.

An anchor survey was done to determine the exact anchor position and allow estimation of the anchor fall-back from the drop site. Three positions about 1.5 nm away from the drop site were occupied in a triangular pattern (Fig. 9). WHOI's Edgetech 8011M deck gear was used to range on the release. The anchor survey began at about 1830 local on 16 July and took about 1.5 hours to complete. Triangulation using the horizontal range to the anchor from the three sites gave an anchor position of 20° 40.0154′ N, 157° 57.0915′ W (Fig. 11). Fallback from the drop site was about 589 m.

Buoy over	19:11 UTC 7/27/17			
Anchor over	02:19 UTC 7/28/17	20° 40.158'N	157° 56.803'W	
Anchor target		20° 40.12'N	157° 57.01'W	
Anchor position		22° 40.0154'N	157° 57.0915'W	
Distance from target				238 m

Table 11 – WHOTS 14 deployment information

Matlab code from R. Weller was run to solve for the intersection of the ranges and yielded the following location and depth solution (Figure 11). During the WHOTS 14 cruise the depth sounder on the R/V HA was not functioning. The solution from R. Weller has a high degree of accuracy in the x and y planes, while the z solution can be inaccurate. Actual depth of the W14 anchors will be determined using the data from the deep SBE 37s.

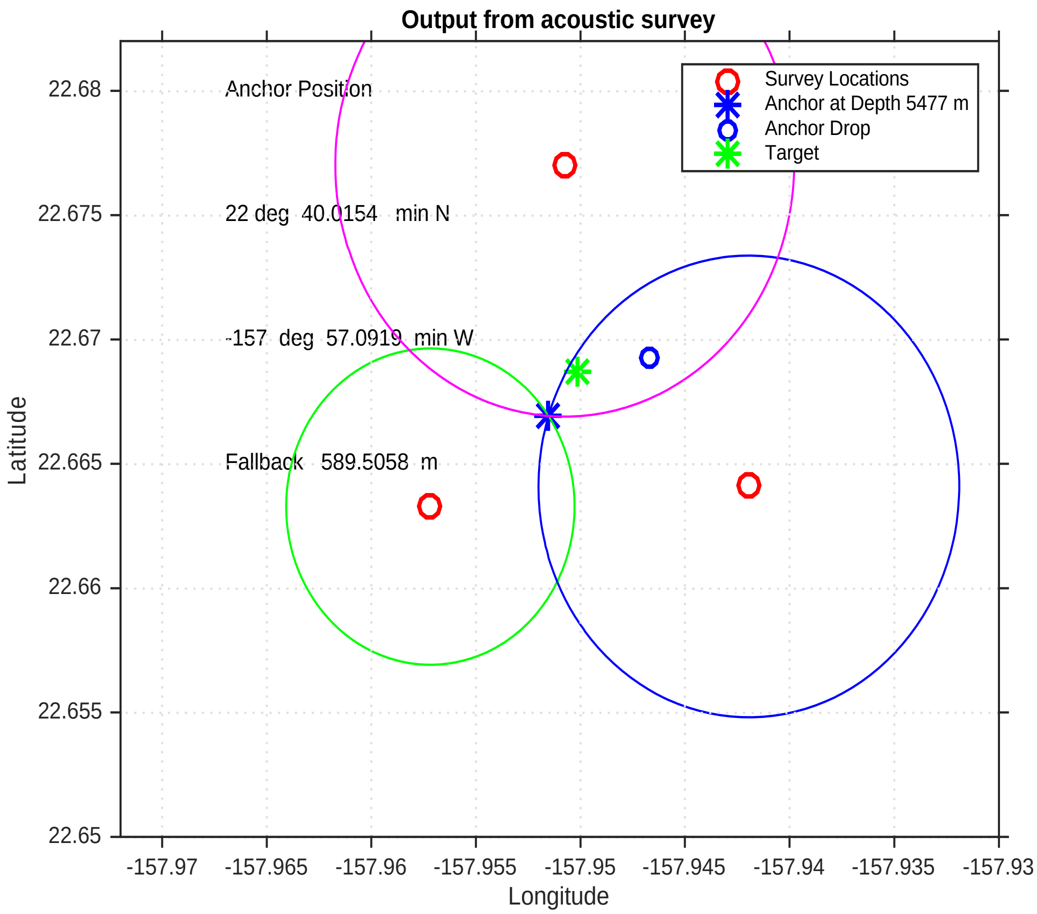


Figure 11. WHOTS-14 post-deployment anchor position survey. Arcs from the three survey sites are shown along with the anchor drop location (o) and surveyed anchor position (blue *).

Visual observations from the bridge the day after deployment showed the tower top instrumentation intact and the buoy riding smoothly with a nominal waterline about 60 cm below the buoy deck.

5. WHOTS-13 Mooring Recovery

On July 30, 2017 the day before planned recovery, we made a close approach to the surface buoy with the ship and tried to release the trailing line. The line did not trail, and after recovery we found the white plastic canister jammed by the foam of the hull. There was insufficient clearance for the release of the line. We did talk to the WHOST 13 releases to verify functionality, and did both a walk through on deck and a meeting with OODs on the bridge.

On July 31, 2017, we had a safety assessment (GAR) on the bridge at 0600 local. The go ahead was given and at 16:38 UTC July 31, 2017 the release was triggered. After approximately 45 minutes the balls were spotted, and the small boat was launched. The boat went first to the buoy to attach a trailing line and floats to the pickup bail. The boat then went to the balls and hooked in securely. The boat approached the stern and a heaving line to the boat was used to connect the balls to a double long leader on the TSE winch. The boat was recovered. Glass balls were brought aboard using the TSE and the two tuggers. Balls came aboard at 18:58 UTC and the deep SBE 36s at 19:14 UTC and the releases at 19:18 UTC.

After the balls were stored, the recovery of the synthetic was carried out by using the capstan to pull line, which was passed into bags inside three wire baskets. At the end of the synthetic line, the nylon to wire transition was wound onto the TSE, and recovery was carried on using the TSE to wind up first the transition piece and then the wire rope. SBE 37s and an RDI were removed up until 45 m was reached at 00:51 UTC August 1, 2017. The buoy and the hanging 45 m were cast loose. The ship then made an approach taking the buoy down the starboard side. The crane was attached and three tending lines. The buoy was lifted and brought aboard at 01:55 UTC and secured to the deck. Then the last remaining instruments and chain were recovered with successive crane picks.

6. Meteorological Intercomparison

a. Shipboard Instruments

The R/V Hi'ialakai (HA) is outfitted with sensors for air temperature (Ta), relative humidity (RH), barometric pressure (P), sea surface temperature (SST), wind speed (U), and wind direction (DIR).

Ta and RH is from an RM Young 41372 VC in an RM Young 43502 aspirated radiation shield mounted along the ship centerline on a short mast at the front edge of the pilot house roof, at an estimated height of 13.4 m.

Pressure is a Vaisala PTB 330 SPH10 mounted in the aft section of the bridge on the 03 deck at a height of 12 m. SAMOS metadata indicate the pressure is specified at measurement height, but based on a comparison with PSD pressure data it appears to be corrected to sea level.

Wind speed and direction are from an RM Young 85000 Ultrasonic anemometer, also mounted to the short mast on the forward edge of the pilot house roof. The SAMOS archive gives the wind measurement height at 15.88 m, but this cannot be correct as it is on the same mast with the T/RH sensor and only ~50 cm higher. We estimate the anemometer height at 14 m. This is not a desirable location for accurate wind measurements, and flow distortion may contribute to bias compared to wind measured from the bow tower. There is an RM Young prop-vane anemometer mounted to the top of ship's bow jack staff, but this is not being logged. The SAMOS dataset provides relative and true wind speed and direction; the latter is computed by the ship's SCS system.

Ship SST measurements are from an SBE-38 digital thermometer, TS2, at the 4 m seawater intake and the SBE-21 thermosalinograph, TS (SAMOS metadata indicates, incorrectly, that both TS2 and TS are the SBE-21). The SBE-21 receives water pumped from the forward intake to the wet lab, which may lead to temperature bias due to the length of the plumbing.

All ship data used in this report are from the 1-minute SAMOS archive: (http://samos.coaps.fsu.edu/html/data_availability.php).

b. ESRL/PSD flux system

The ESRL/PSD/BLO air-sea flux group collected surface meteorology and sea surface temperature data during the cruise. The PSD met system deployed on WHOTS 2017 consists of five components:

1. Vaisala WXT520 weather station for U, Ta, RH, P and rain rate @ 17.15 m ASL on a PSD-supplied 10 m met tower, installed on the bow immediately behind the ship's (shorter) bow jackstaff.
2. Eppley PSP and PIR solar and infrared radiometers (2 each) located on the aft the pilot house roof.
3. Differential GPS unit measuring 2 Hz SOG, COG, heading and roll angle.
4. Floating thermistor sea surface temperature measurement (YSI 46040 thermistor, sea snake) deployed from a davit off the port bow
5. Vaisala PTB220 digital barometer @ 13.3 m ASL on the aft pilot house roof.

These were all logged on a NOAA/PSD acquisition system. Measurements were continuous through the duration of the cruise. Raw motion and GPS data are 2 Hz. WXT data are 1 Hz. Others are averaged to 1 min.

The location for the sea snake was 2-3 m forward of an above-waterline water discharge on the ship's hull. The snake was adjusted as far forward as possible, and at most times on station the ship maintains at least 0.5 knots of forward way, which should keep the seasnake clear of temperature contamination from the discharge, but we cannot completely rule out the possibility. The starboard side has a similar discharge, with the addition of the ship's black-water discharge, and therefore provides no advantage. In general, the HA does not have an ideal configuration for deployment of the seasnake.
Additional details on PSD instruments are given in Table 1.

c. Additional notes on PSD and ship variables

Air Temperature: As has been the case for many years, HA air temperature is biased high by more than a degree compared to PSD and WHOI sensors. The sensor was recently calibrated, so the offset is likely due to a heat source near the measurement location.

Pressure: As mentioned above, the ship's pressure seems to be corrected to sea level, despite the information given in SAMOS metadata. As provided, the pressure is within 0.1 mb of the sea level-corrected PSD pressures. Pressure measured with the PSD digital barometer on the pilot house roof agrees with the WXT to within 0.1 mb, but shows greater variability at 1-min resolution from dynamic pressure effects of airflow over the bridge. WXT pressure is preferred.
Sea Surface Temperature: The ship's SBE-38 SST tracks the PSD sea snake measurements, with a mean offset of +0.1 °C. The seasnake sees a slightly larger diurnal warm layer signature (i.e. it cools off more at night), which seems reasonable given the difference in measurement depth. The seasnake temperatures exhibit a tendency to flat- line for many hours during the night, with hour-to-hour mean temperature variability less than 0.01 C. This is in the raw data and I'm not sure why we don't see more signal noise or variability in the SST at night. Interestingly, WHOTS-13

SST also flat-lines for a period of time at night on DOY 211 and 212, so the phenomenon may be real.

Radiation Measurements: Prior to the cruise, a month-long intercomparison and calibration was performed on the PSD radiometers at the NOAA/GMD roof-top radiation calibration facility. Solar radiometers (Eppley PSP S/N 28110F3 and S/N 34290F3) were calibrated against the sum of two GMD reference standards: a sun-tracking pyroheliometer for direct flux and a shaded Eppley model 848 pyranometer for the diffuse component. A direct comparison was also made to a secondary reference PSP maintained by GMD (S/N 73-36). The direct comparison before recalibration is illustrated by the time-series plots. The recalibration yields coefficients that are 4.6% and 3.7% smaller than the most recent Eppley coefficients for the two PSP instruments shown in Table 12. The mean measurement from the two PSD PSPs is used in this report for the reference solar flux. The updated calibration curve versus the reference, standard is shown in the lower plot of Figure 12. The 95th-percentile of the difference between PSD and reference solar flux for 5-min measurements is ~20 W/m^2 for both instruments.

The IR radiometers (S/N 30558F3 and S/N 30433F3) were compared to an unshaded, unventilated GMD PIR maintained by as a secondary standard, referenced to BSRN instruments as the primary standard. Following the recommendation of GMD, the PSD recalibration was determined from a 3-coefficient form of the Albrecht-Cox equation. Figure 13 shows the calibration curve and derived coefficients. The 95th-percentile of the difference between PSD and reference IR flux for 5-min measurements is ~2.5 W/m^2 for both instruments. Of the two PSD PIRs, S/N 30558F3 (PIR1) shows less measurement variability and is used as the reference IR flux measurement in this report.

d. Comparisons with WHOTS-13 and -14

Tables 13 show the mean, median and standard deviation in measurement bias for ship and buoy systems relative to the PSD measurements. Pressures are adjusted to sea level (z = 0) for all systems. For the PSD-ship comparison, U, T and RH variables are unadjusted for measurement height. PSD wind speed is adjusted for mean flow distortion effects at the ship's bow: U is increased by 5% and V decreased by 15%. For the comparison with buoy systems, PSD data (U, Ta, RH) are adjusted to z = 3 m with the COARE bulk flux model (v.3.5). Comparison statistics for U, Ta and RH are restricted to hours when the relative wind direction at the ship is within +/-60° from the bow and the hourly standard deviation in relative wind direction at the bow tower is less than 30°.

WHOTS-13 (W13) data are 1-hr averages from data logger 2. Logger 1 had failed prior to the cruise. Additionally, the wind measurement on logger 2 was not operating, so wind comparisons are not possible with WHOTS-13.

WHOTS-14 (W14) data are 1-hr averages transmitted from loggers 1 and 2 following deployment.

Table 12 shows a comparison over the entire period at station ALOHA (DOY 208.0– 215.125).

Table 13 limits the comparison with each buoy to periods when the ship was near the mooring. Valid comparison data are selected by proximity to the mooring anchor, with additional relative wind direction restrictions mentioned above for U, Ta and RH comparisons. Position tolerance was set to +/- 0.03° of latitude and longitude from the anchor location (+/- 3.33 km). The map plots show hourly positions near each mooring corresponding to valid comparison data (red markers).

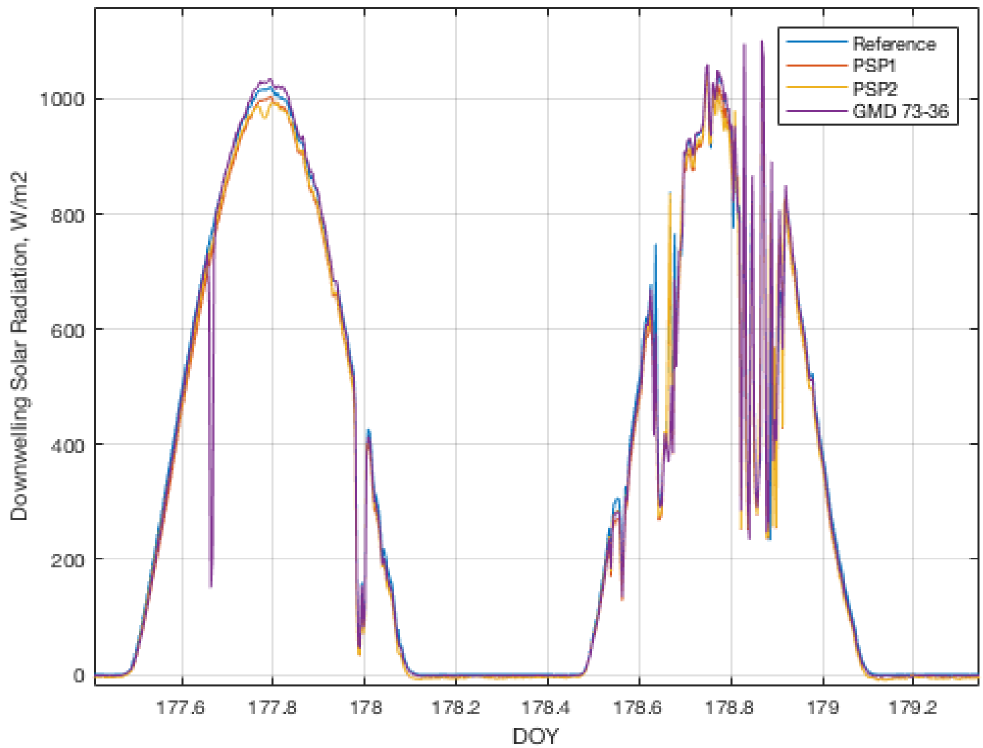
Time series and correlation plots for each variable are shown on following pages and available as separate files in .png format. Time series plots show all measurements, unfiltered for relative wind direction or location. Correlation plots show only valid intercomparison measurements.

Table 12: PSD instrument details

Sensor	Calibration coefficient	Make / Model	Serial Number	Date of calibration
Precision Spectral Pyranometer	0.00835	Eppley / PSP 1	28110F3	June 08, 2017
Precision Spectral Pyranometer	0.00839	Eppley / PSP 2	34290F3	June 08, 2017
Precision Infrared Radiometer	0.00416	Eppley / PIR 1	30558F3	June 06, 2017
Precision Infrared Radiometer	0.00325	Eppley / PIR 2	30433F3	June 06, 2017
Sea Snake thermistor 0C to 40C	C4=0.001399937 C5=0.00237854	YSI 46040 series	n/a	
Class A Barometer	n/a	Vaisala/ PTB330	L2820128	Jun 07, 2017
Vaisala Weather Transmitter		WXT-520	E2850022	Jun 09, 2017

Table 13: Bulk met measurement bias relative to NOAA/PSD measurements for the entire period of time at Station ALOHA.								
Bias psd – ship	Ta C	RH %	SST C	U m/s	dir deg	Rs W/m2	Rl W/m2	P mb
mean	-1.58	-1.94	-0.11	1.37	-5.12	-	-	0.10
median	-1.49	-1.94	-0.11	1.36	-5.81	-	-	0.10
std	0.25	0.87	0.05	0.33	4.27	-	-	0.04
psd – W13-1								
mean	-	-	-	-	-	-	-	-
median	-	-	-	-	-	-	-	-
std	-	-	-	-	-	-	-	-
psd – W13-2								
mean	-0.04	0.71	0.08	-	-	6.44	-2.71	0.30
median	-0.04	0.62	0.08	-	-	-5.05	-0.92	0.30
std	0.15	0.77	0.03	-	-	32.02	5.68	0.07
psd – W14-1								
mean	-0.51	-1.74	0.16	0.87	10.03	2.24	8.02	-0.01
median	-0.50	-1.93	0.14	0.84	9.94	-2.95	6.70	-0.02
std	0.13	1.72	0.09	0.30	3.98	36.22	6.75	0.06
psd – W14-2								
mean	-0.42	-2.82	0.16	1.06	8.01	2.90	10.87	0.63
median	-0.42	-2.89	0.14	1.05	7.74	-6.23	9.86	0.65
std	0.13	1.64	0.09	0.32	3.92	33.97	6.91	0.30

Table 14: Bulk met measurement bias relative to NOAA/PSD measurements for the entire period of time at Station ALOHA.								
Bias	Ta C	RH %	SST C	U m/s	dir deg	Rs W/m2	Rl W/m2	P mb
psd – W13-1								
mean	-	-	-	-	-	-	-	-
median	-	-	-	-	-	-	-	-
std	-	-	-	-	-	-	-	-
psd – W13-2								
mean	-0.35	-1.43	0.15	-	-	20.22	-5.13	0.70
median	-0.32	-1.60	0.12	-	-	-1.92	-5.08	0.72
std	0.08	1.00	0.07	-	-	41.25	1.83	0.27
psd – W14-1								
mean	-0.53	-0.98	0.19	0.91	9.96	4.91	9.44	0.03
median	-0.53	-1.24	0.18	0.88	10.32	-3.00	8.51	0.02
std	0.12	1.17	0.08	0.26	2.16	39.96	8.90	0.05
psd – W14-2								
mean	-0.43	-2.31	0.19	1.13	7.62	5.41	12.45	0.66
median	-0.42	-2.68	0.18	1.06	7.94	-6.46	12.18	0.70
std	0.11	1.12	0.07	0.27	1.53	40.66	8.61	0.27



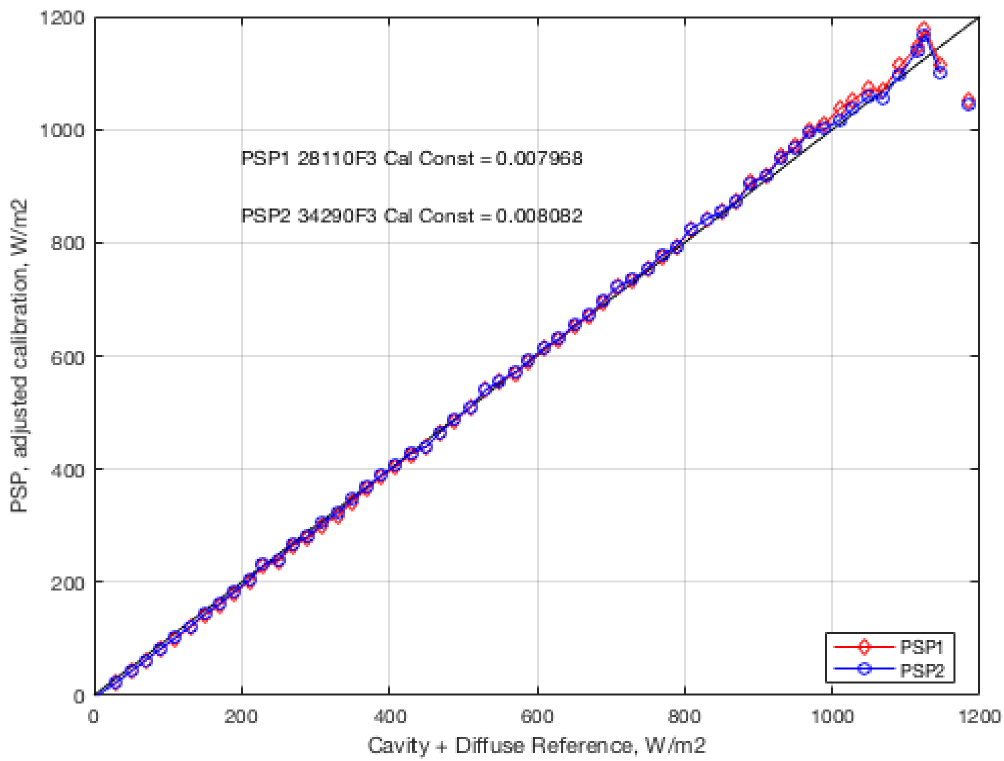


Figure 12. PSD radiometers month-long intercomparison and calibration

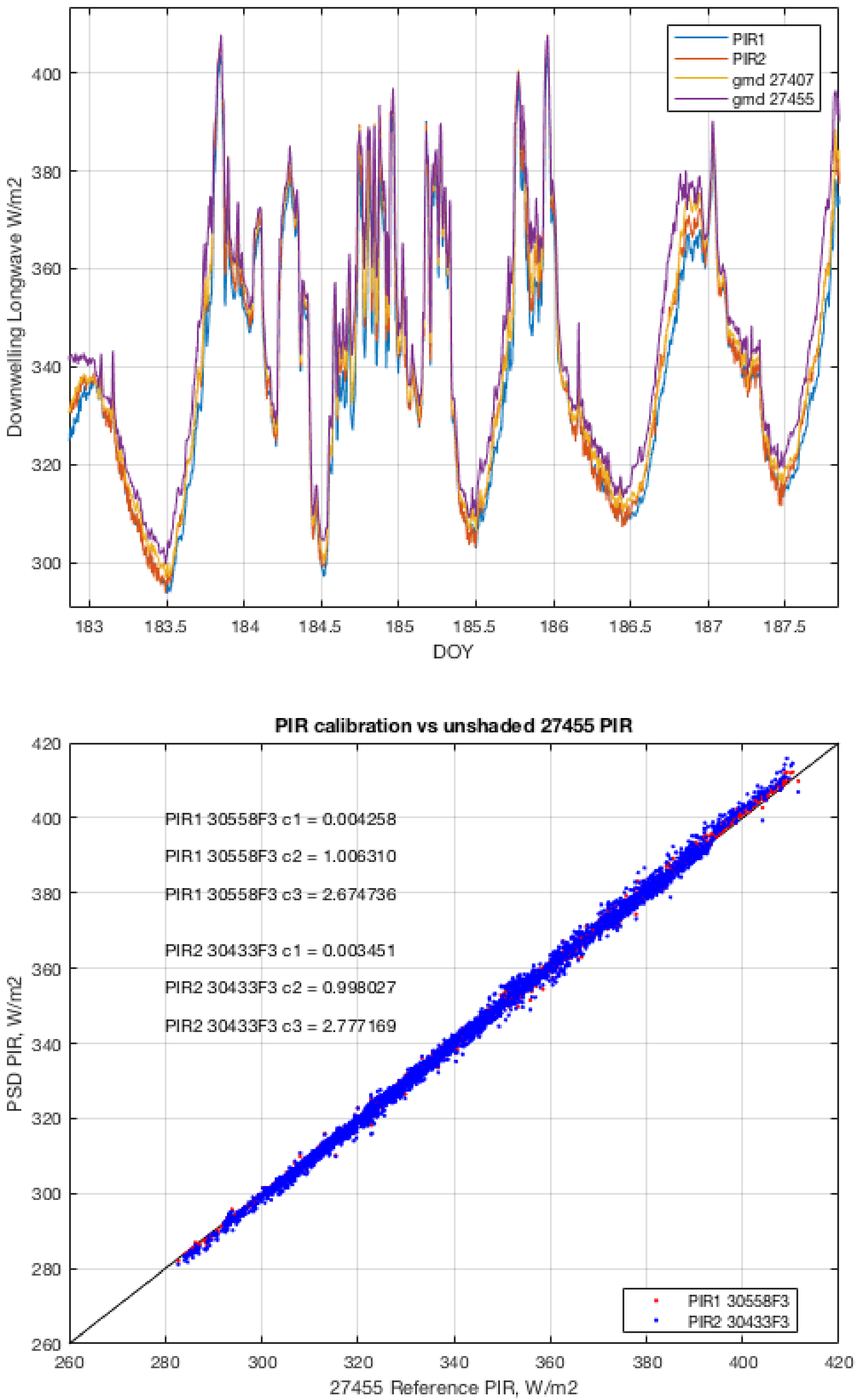


Figure 13. PSD calibration curve and derived coefficients

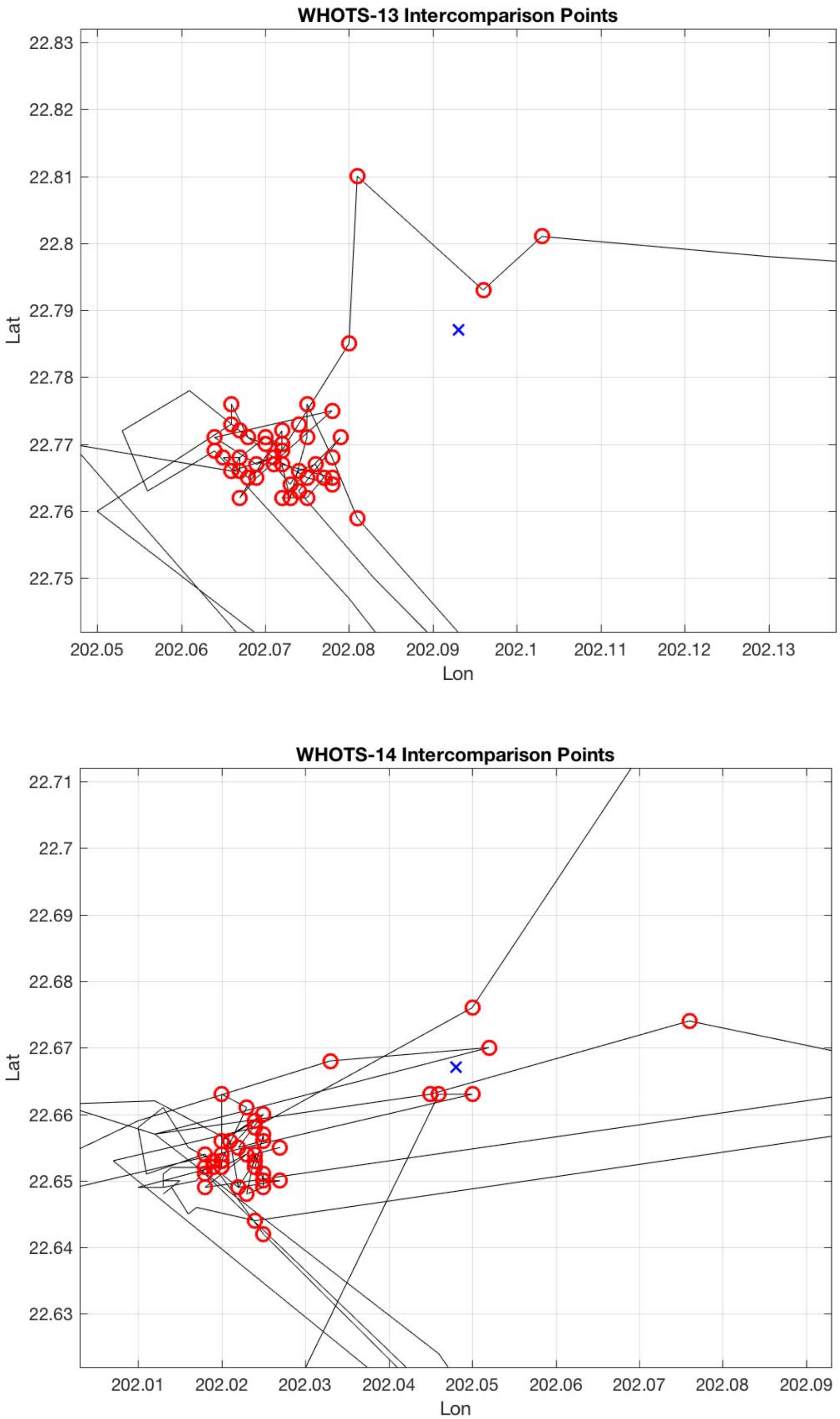
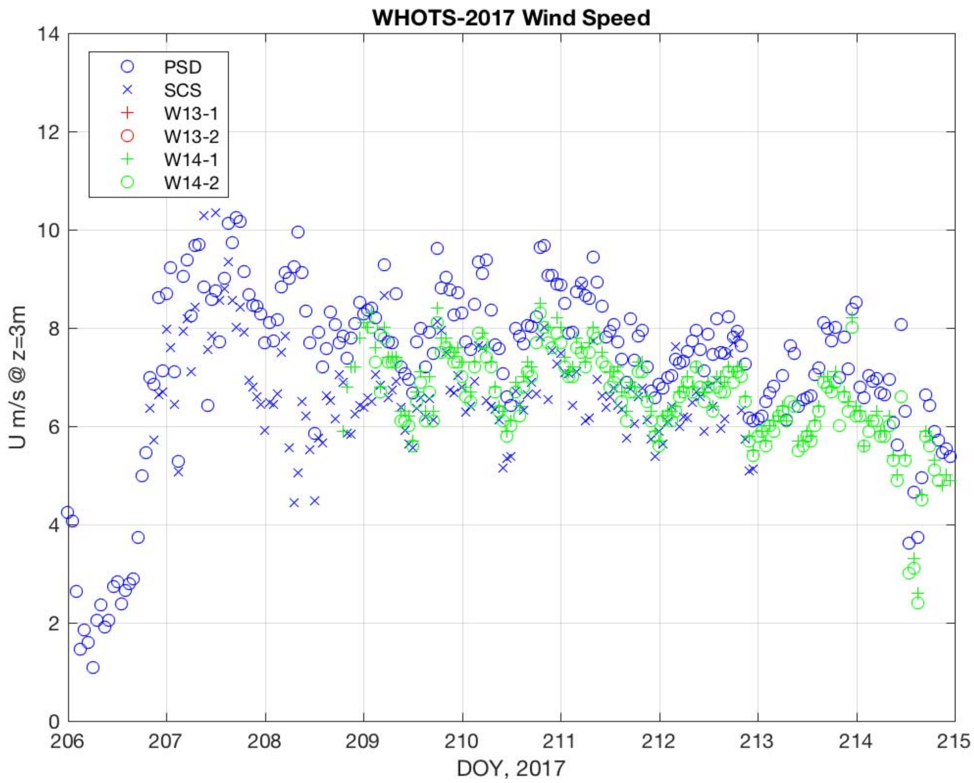


Figure 14. Intercomparison positions



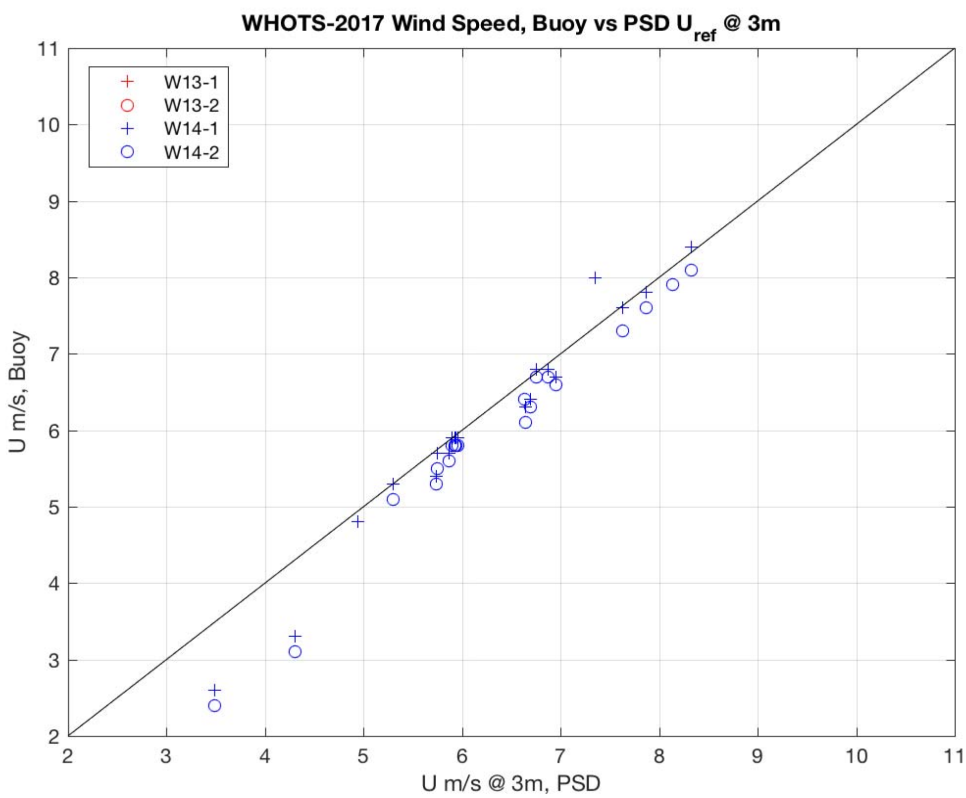
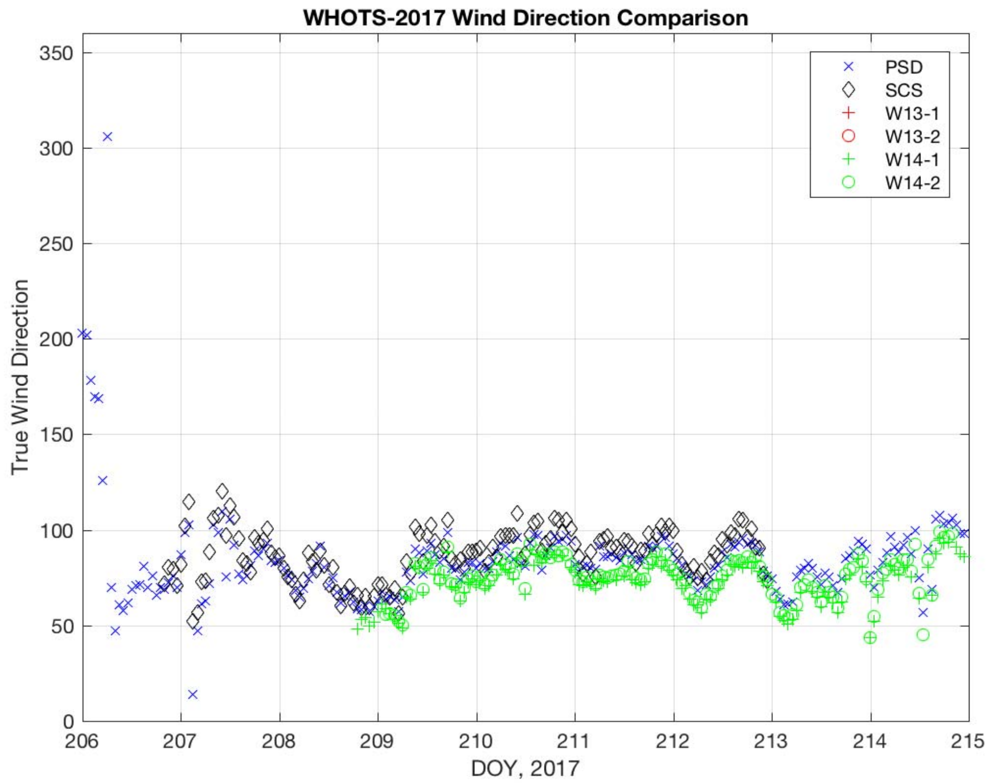


Figure 15. Time series and correlation plot Wind Speed



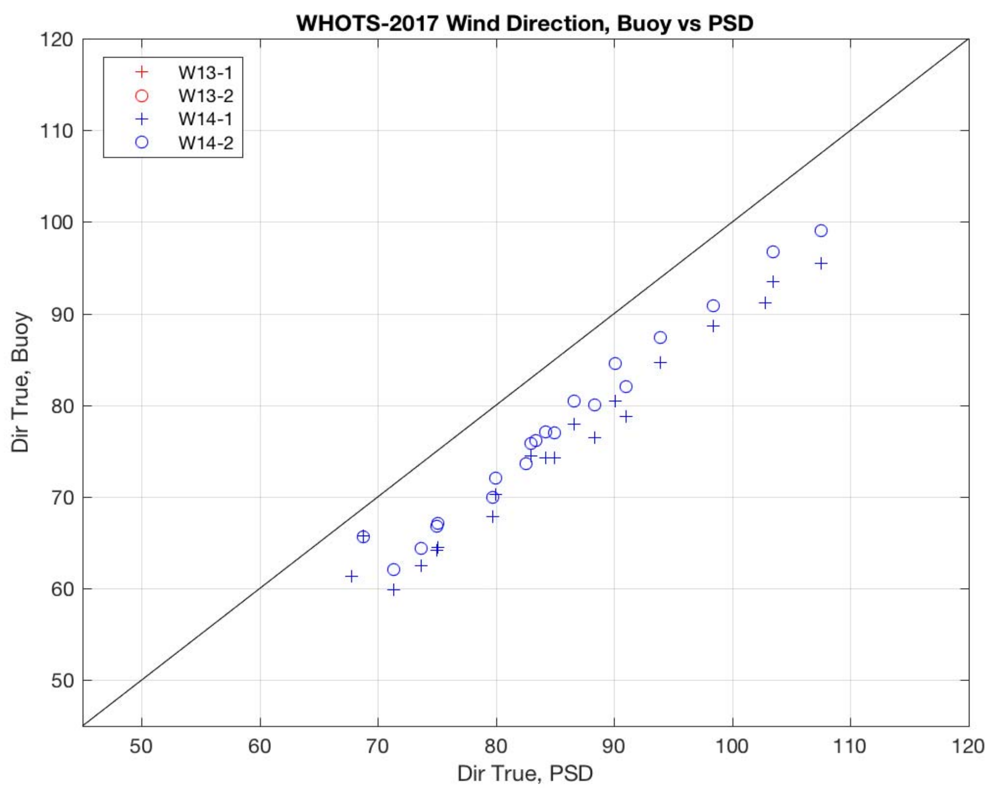
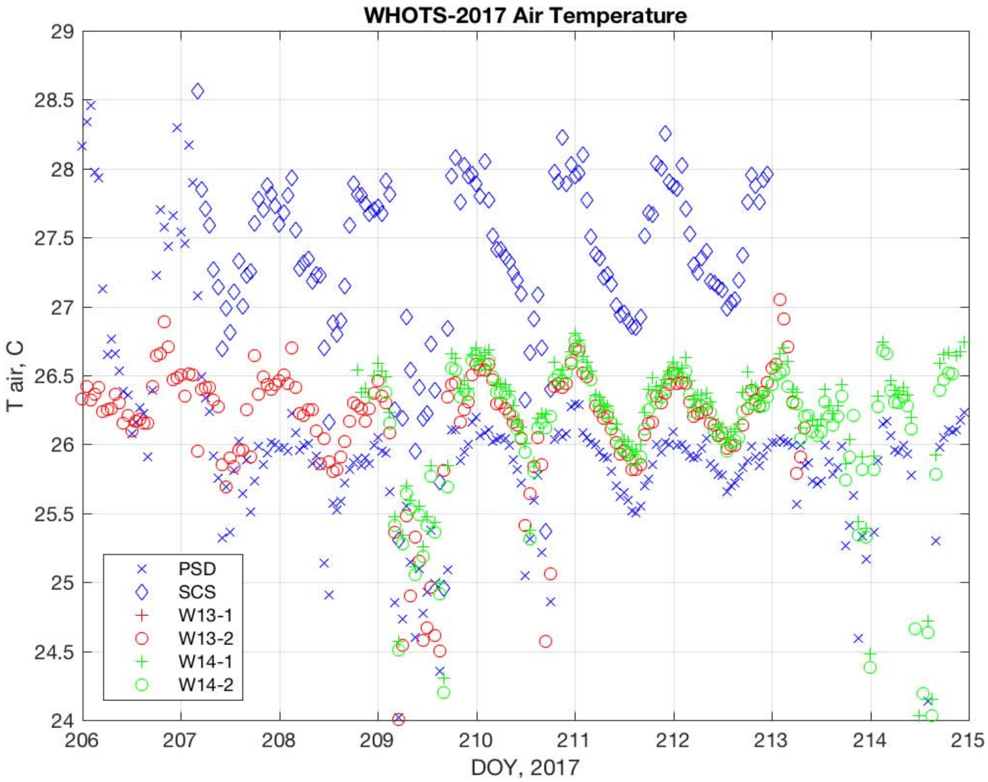


Figure 16. Time series and correlation plot Wind Direction



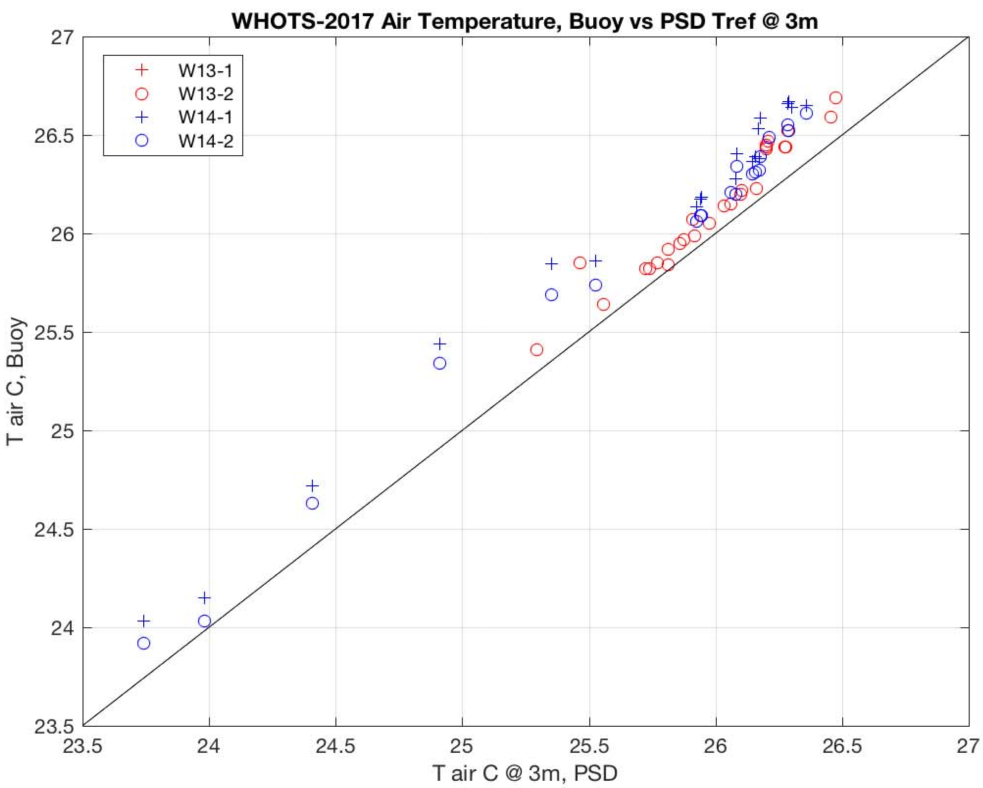


Figure 17. Time series and correlation plot Air Temperature

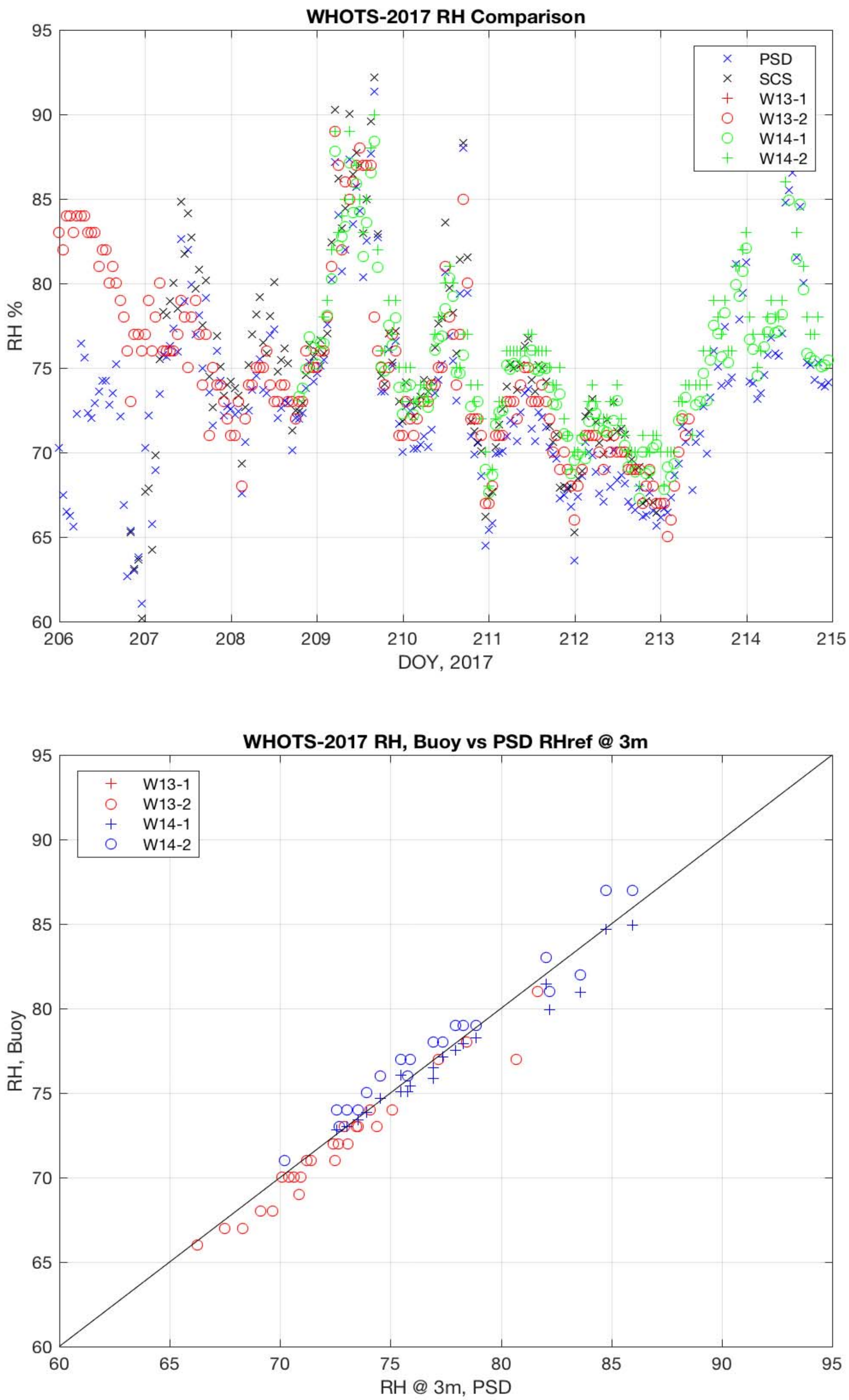
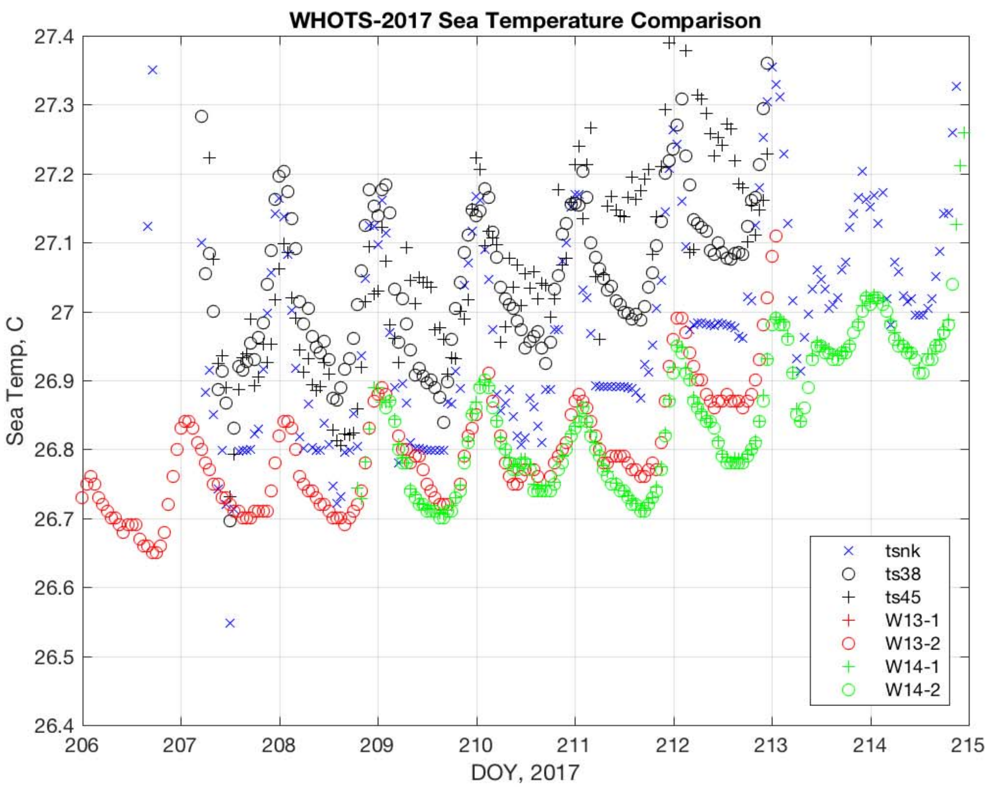


Figure 18. Time series and correlation plot Relative Humidity



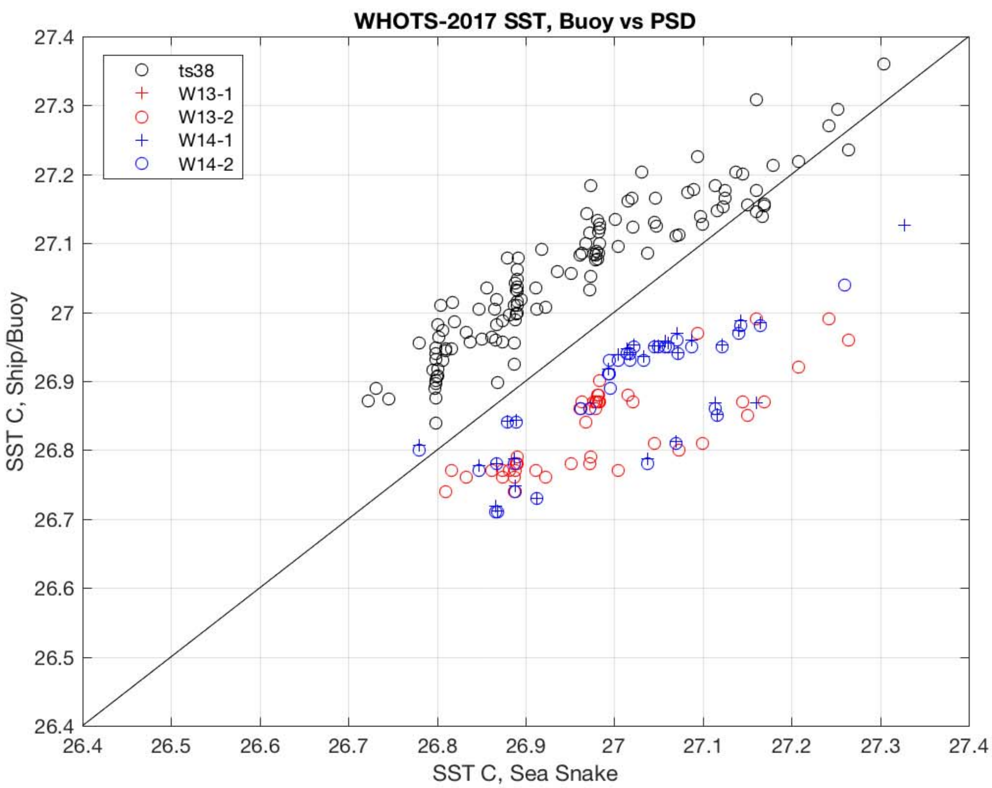
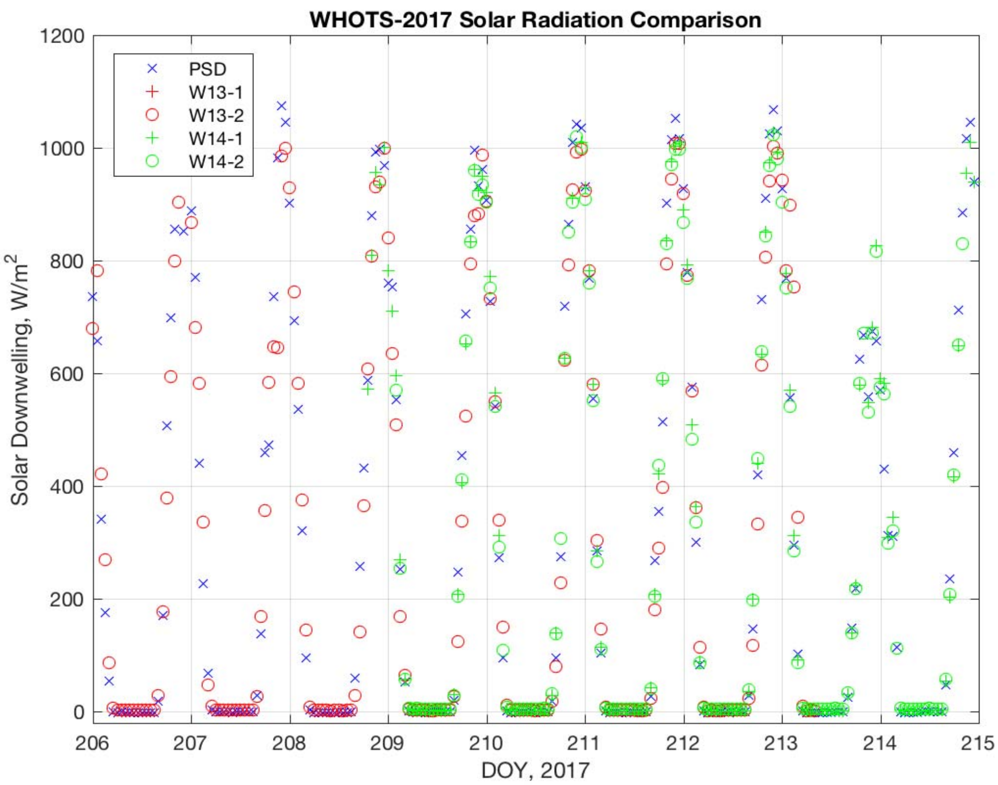


Figure 19. Time series and correlation plot Sea Surface Temperature



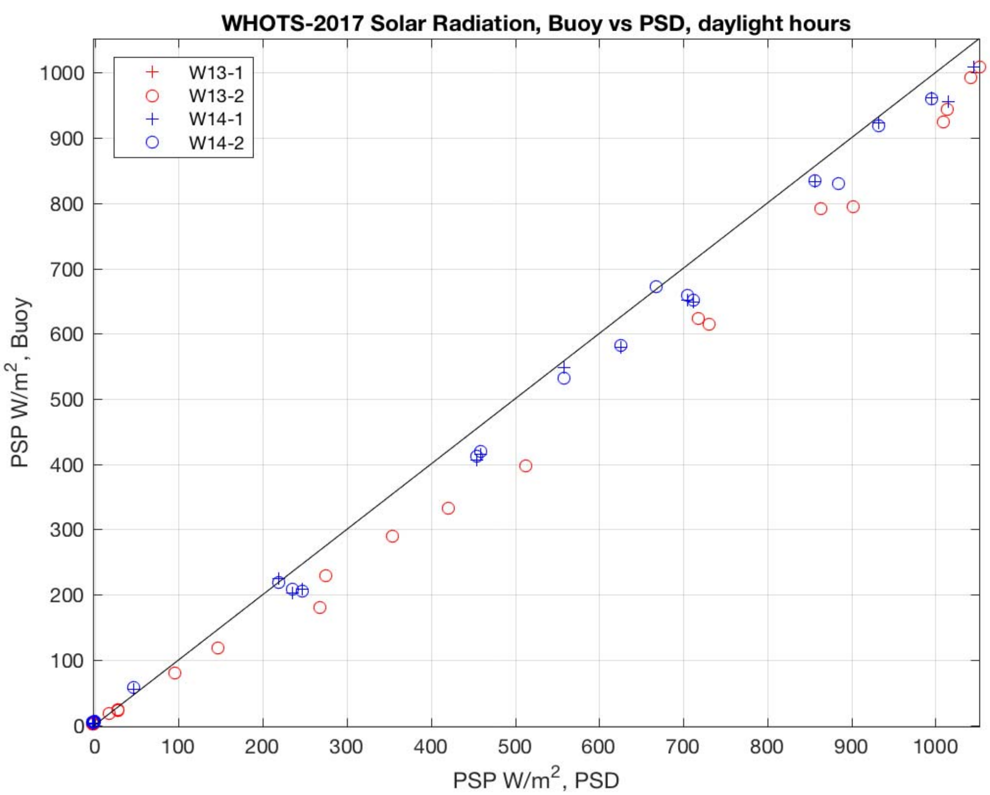
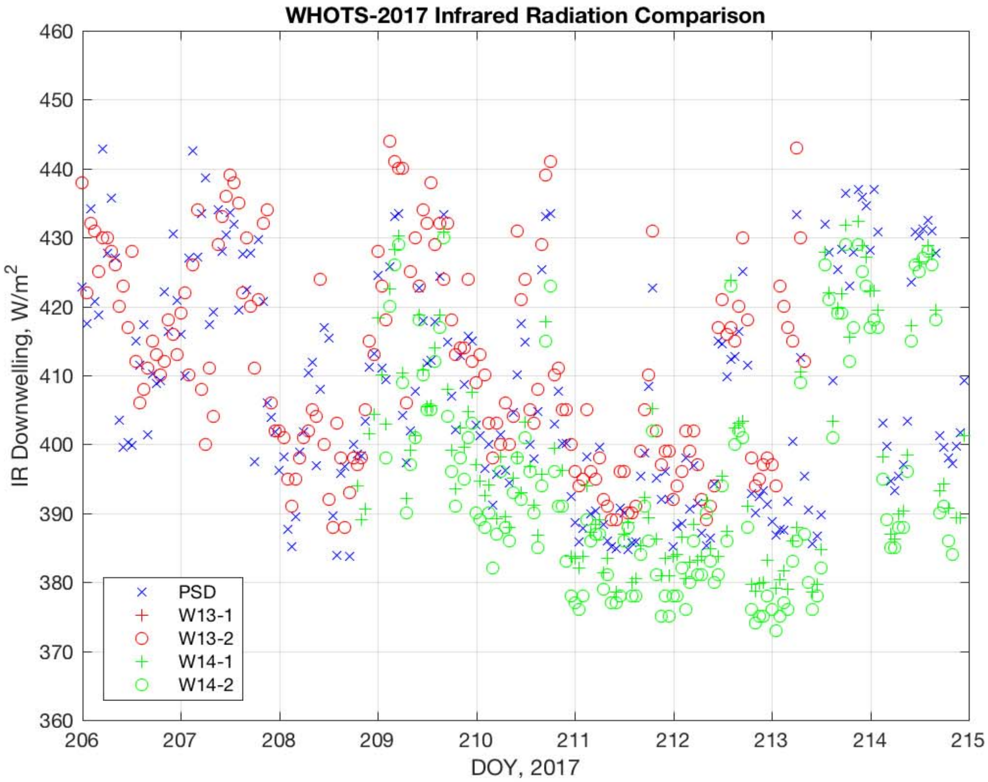


Figure 20. Time series and correlation plot Solar Radiation



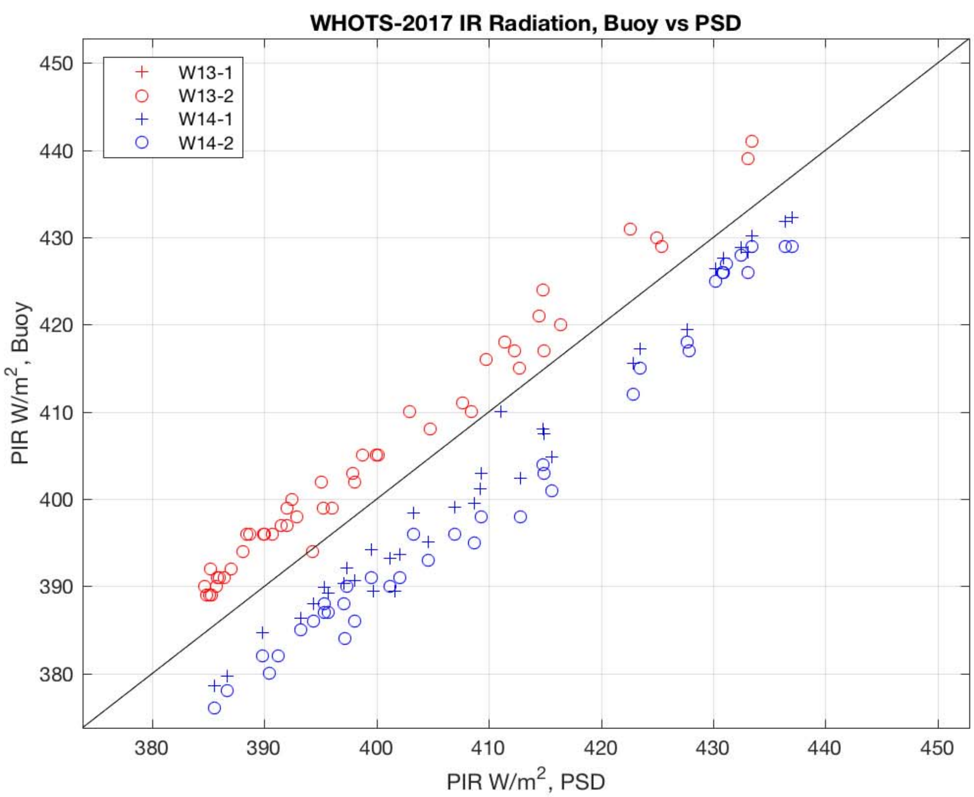
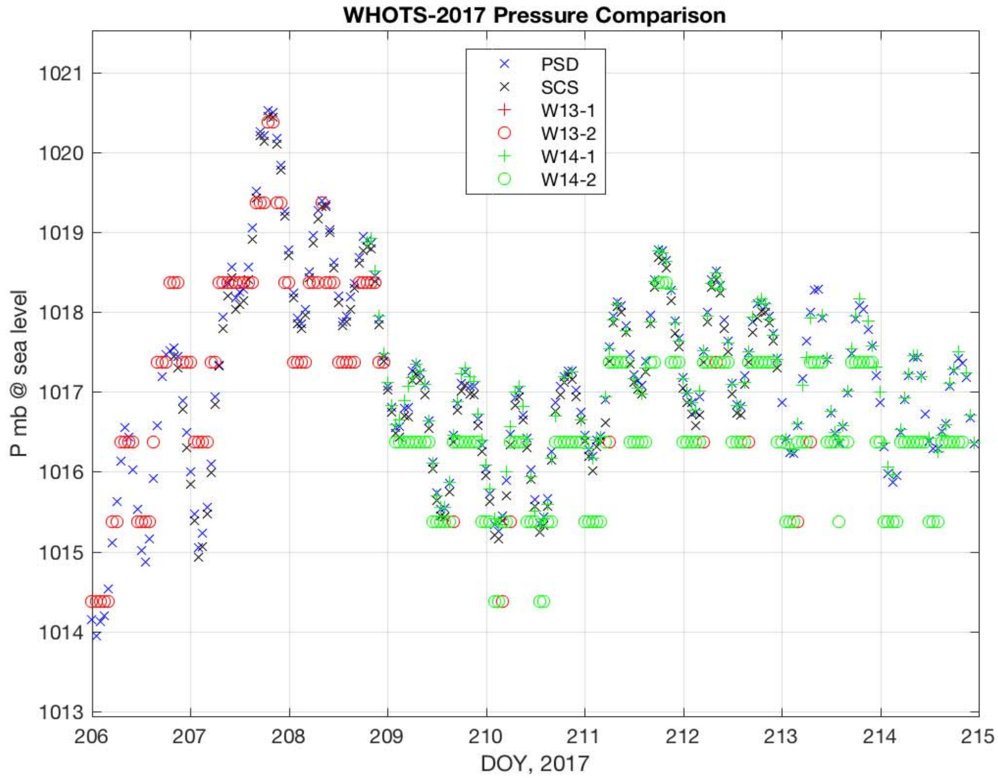


Figure 21. Time series and correlation plot Infrared Radiation



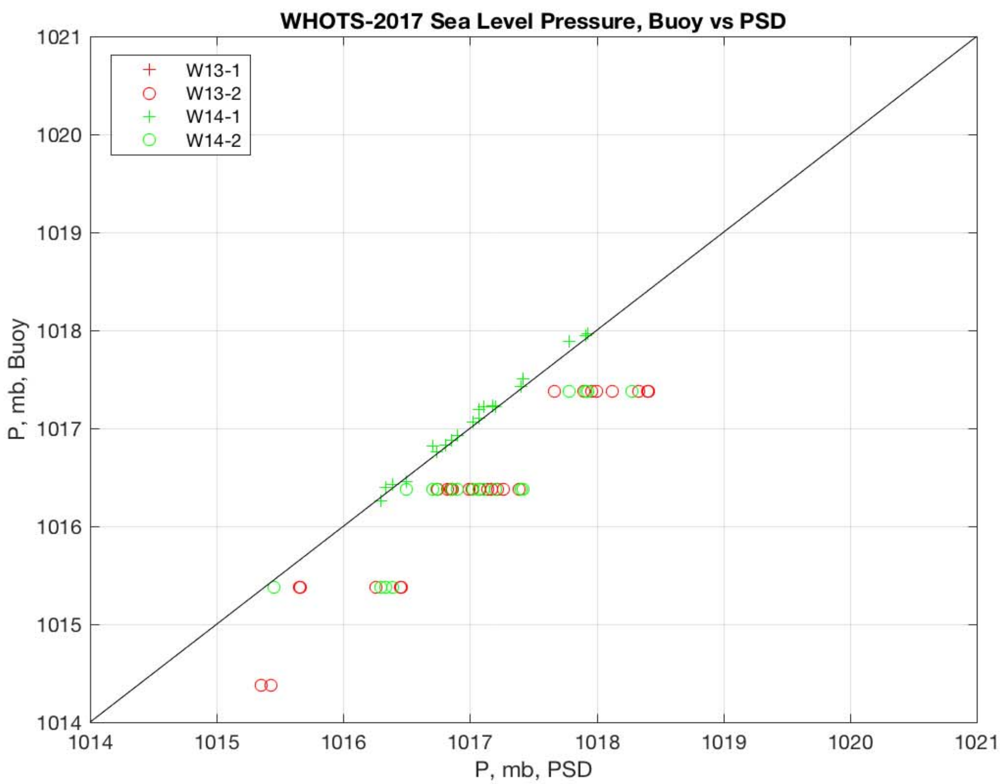


Figure 22. Time series and correlation plot Atmospheric Pressure

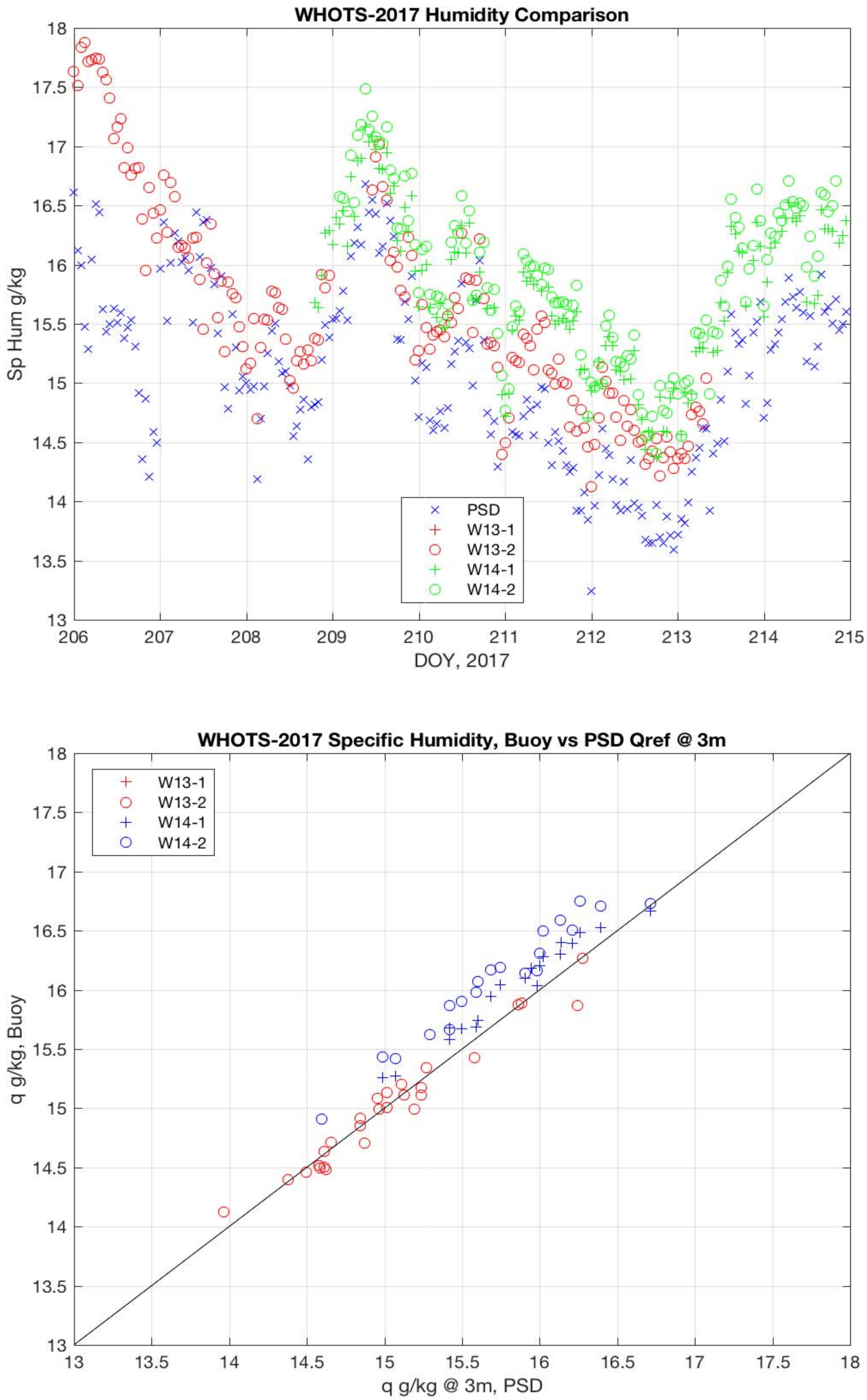


Figure 23. Time series and correlation plot Humidity

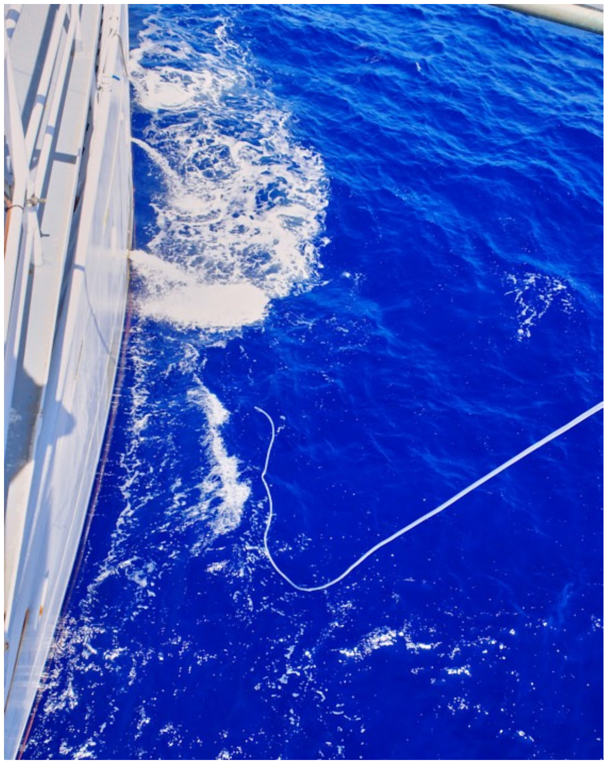


Figure 24. PSD seasnake and port-side overboard discharge.

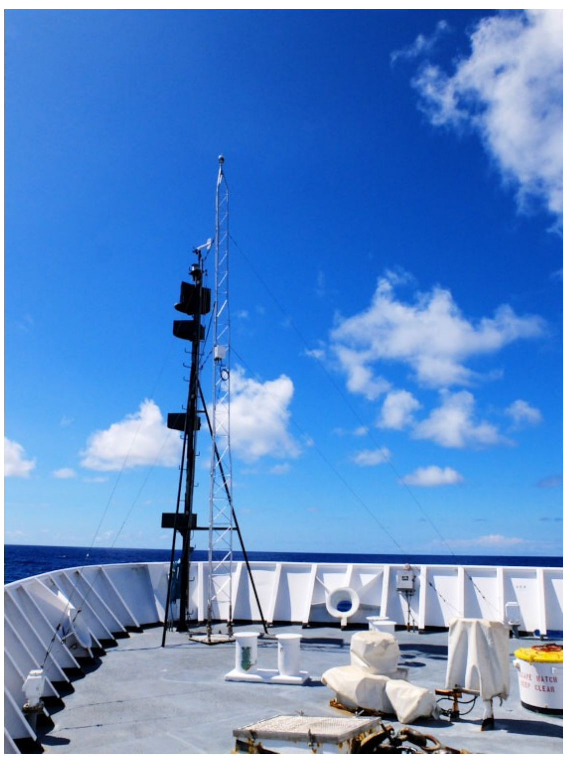


Figure 25. PSD met tower and ship jackstaff.

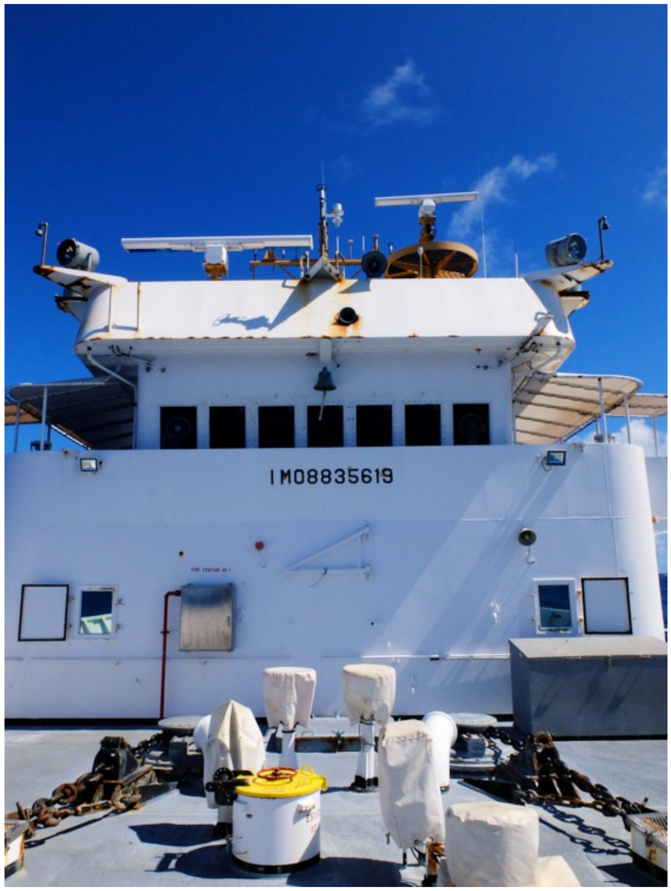


Figure 26. Ship T/RH and sonic anemometer on short mast at bridge roof centerline.

Acknowledgments

The captain, officers and crew of the NOAA Ship *Hi'ialakai* were flexible in accommodating the science mission, and exhibited a high degree of professionalism throughout the cruise. The capabilities of the ship and crew were critical to the success of the mooring operations. WHOTS is funded by the National Oceanic and Atmospheric Administration (NOAA) Climate Observation Division of the Climate Program Office through grant NA09OAR4320129 to the Cooperative Institute for the North Atlantic Region (CINAR) at the Woods Hole Oceanographic Institution.

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Hosom, D.S., R. Weller, R. Payne, K. Prada, 1995. The IMET (Improved Meteorology) Ship and Buoy Systems, *J. Atmosph. Ocean. Technol,* 12 (3), 527-540.

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Plueddemann, A., B. Pietro, S. Whelan, R. Lukas, J. Snyder, C. Fumar, E. Roth, B. Nakahara, D. McCoy, J. George and D. Wolfe, 2014. WHOI Hawaii Ocean Timeseries Station (WHOTS): WHOTS-10 2013 mooring turnaround cruise report, *WHOI Tech. Rept.*, WHOI-2014-02, 115 pp.

Appendix A: Cruise Participants

Science Party
- Robert Weller (Chief Scientist, WHOI)
- Abby Clabaugh (WHOI)
- Emerson Hasbrouck (WHOI)
- Samantha Adams (NOAA)
- Fernando Santiago-Mandujano (UH)
- Jefrey Snyder (UH)
- Andrew King (UH)
- Noah Howins (UH)
- Garrett Herbert (UH)
- Svetlana Natarov (UH)
- Kelsey Maloney (UH)
- Kellen Rosburg (UH)
- Byron Blomquist (NOAA)

Appendix B: WHOTS-14 Weather and Currents

Weather

During the WHOTS-14 cruise, Station ALOHA was under the influence of the eastern North Pacific high pressure system, and the associated east-northeasterly trade winds (Fig. B1). Moisture associated with former Tropical Cyclone Fernanda, which passed north of the islands during the days before the cruise was moving westward away from the state with a drier air-mass gradually filling in from the east at the beginning of the cruise. By July 27th moisture associated with the remnants of former Tropical Cyclone Greg, passing 400 miles SE of Hilo started to bring increased humidity (Fig B2).

Conditions during the WHOTS-14 deployment on July 27th-28th were favorable, with 11-16 kts NE winds and 1.5-2 m waves from E (Fig. B3).

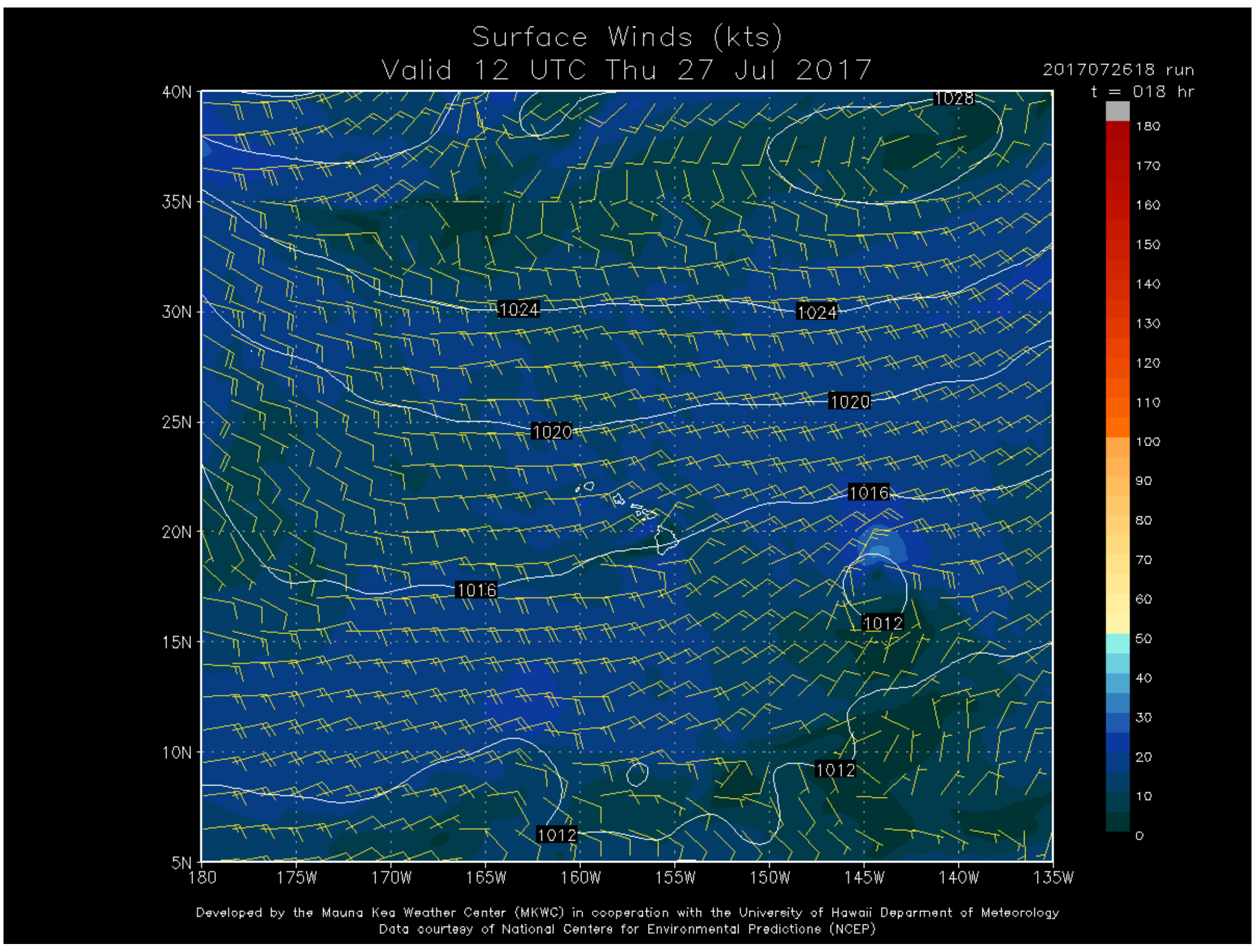


Figure B1. The NOAA/NCEP GFS surface wind and sea level pressure analysis for the central-eastern North Pacific, valid for 12Z on July 27th, 2017.

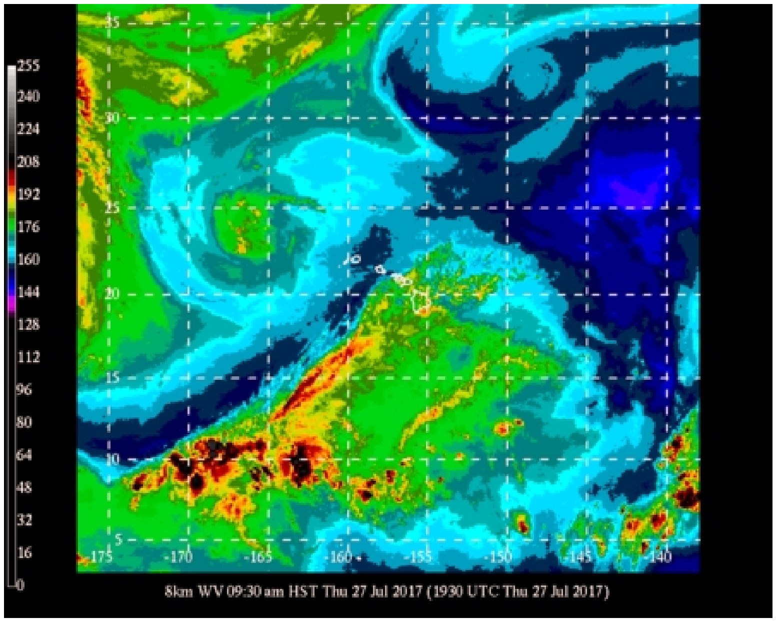


Figure B2. GOES-10 8 km Water Vapor Image for the central-eastern North Pacific at 19:30Z on July 27th, 2017

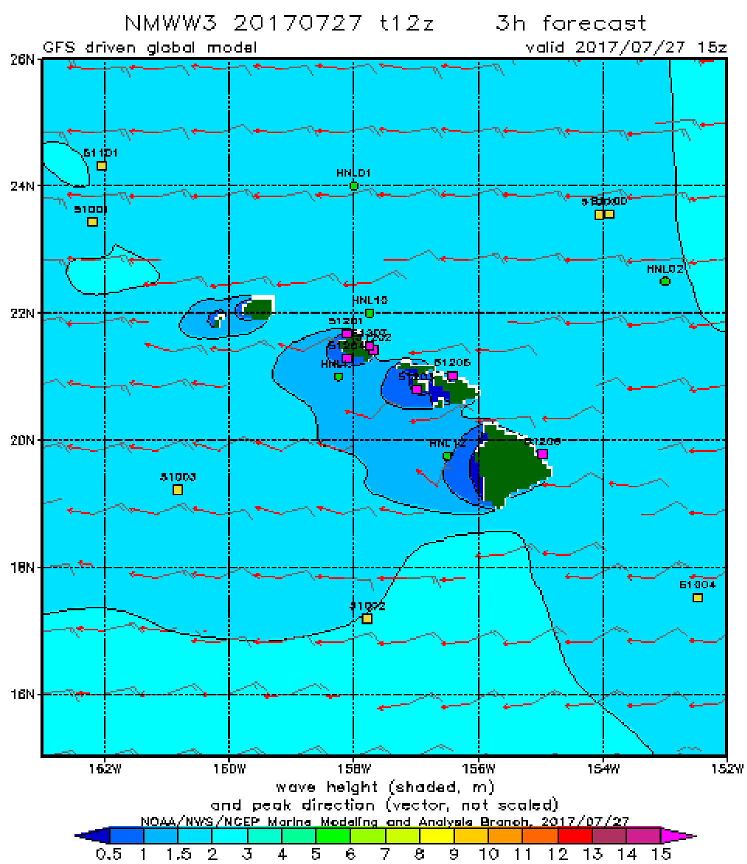


Figure B3. Significant wave height from the NOAA Wave Watch III forecast on July 27th, 2017, 12:00Z.

Weather conditions were favorable during 28th through the 30th, with NE wind speeds of 10-16 kts with occasional higher gusts. Weather conditions were favorable on July 31st - August 1st during the WHOTS-13 recovery, winds were 10-17 kt from the east.

Shipboard ADCP

Currents were measured for the duration of the cruise over the depth range of 30-1000 m with a 75 kHz RDI Ocean Surveyor (OS75) ADCP working in narrowband mode with a vertical resolution of 16 m, and in broadband mode with vertical resolution of 8 m. The system yielded good data, shown in Figures 10 and 11. Periods of missing data between 300 and 450 m in the broadband ADCP are apparently due to the lack of scattering material in the water.

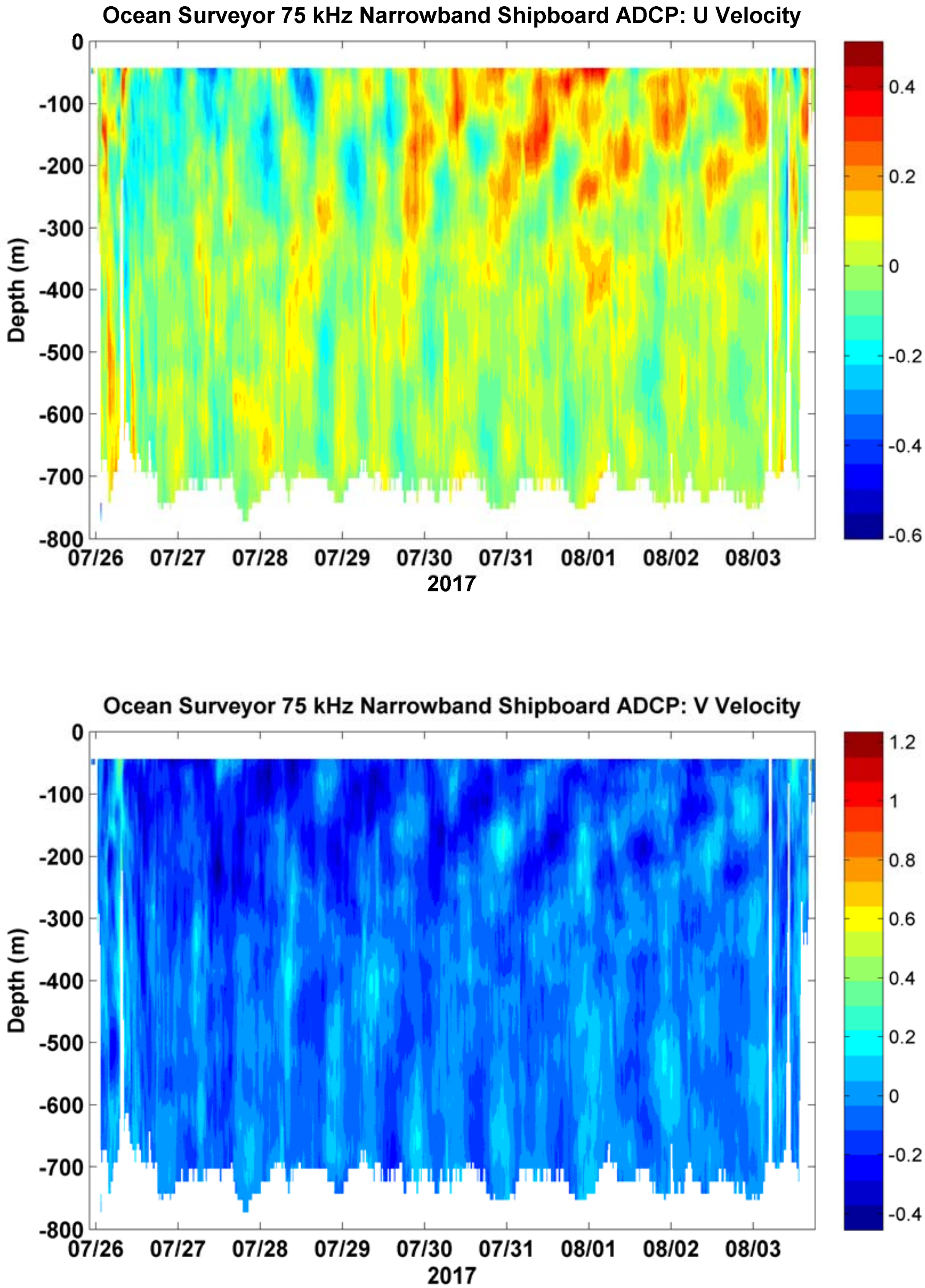


Figure B4. Contours of zonal (upper) and meridional (lower) speeds as a function of depth and time (UTC) from the narrowband ADCP on the NOAA Ship *Hi'ialakai* during the WHOTS-14 cruise. Positive is to the East (North).

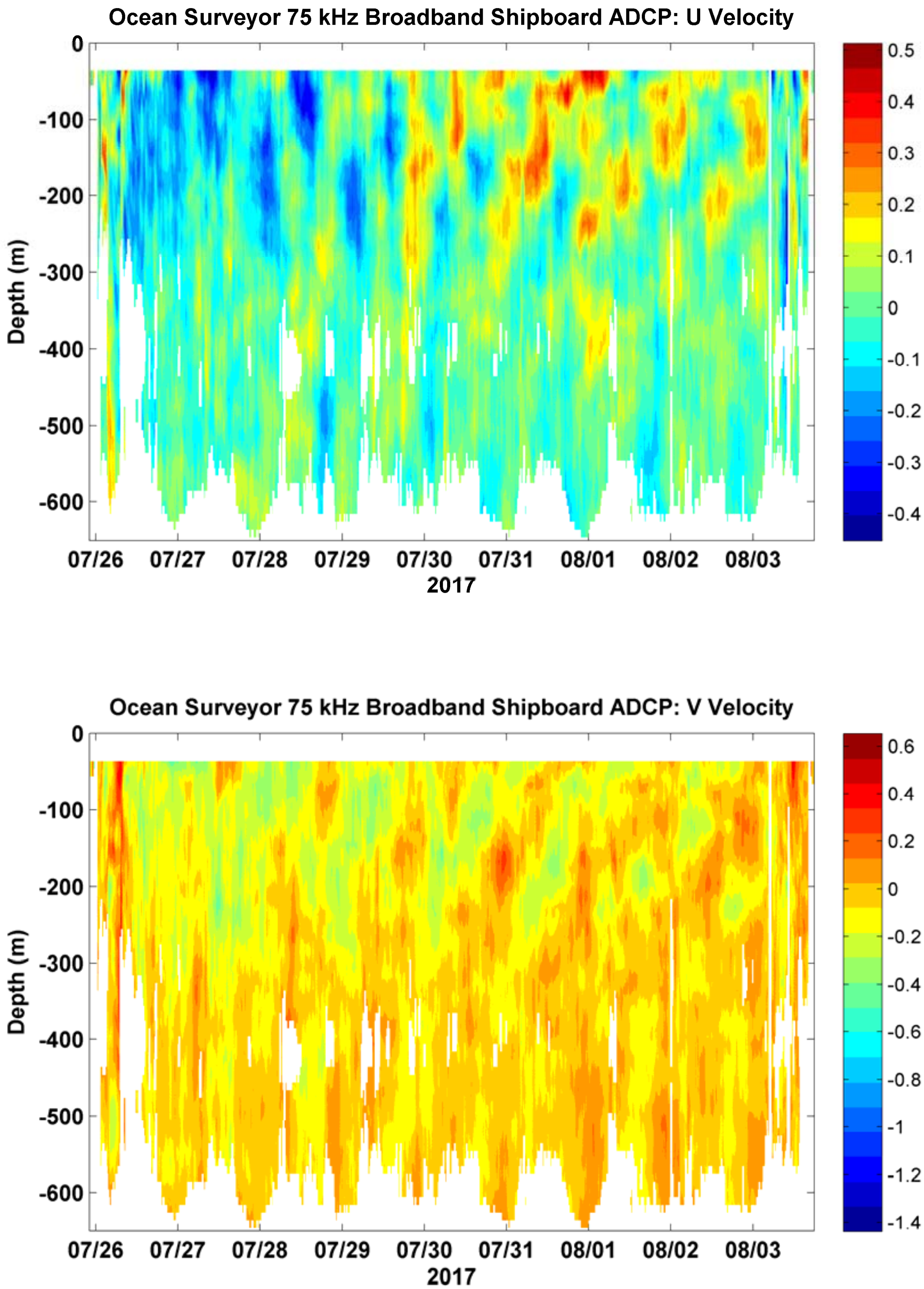


Figure B5. Same as in Figure 10, but for the broadband ADCP.

The shipboard ADCP CODAS real-time data management, processing and display system software was used to monitor the currents during the cruise.

Near-surface currents were nearly 1 kt SSWward during transit to Station ALOHA, turning SWward and Wward upon arrival to Station ALOHA, and remained so for approximately four days, at which point currents swung counter-clockwise to the SE and dropped to an average of ~0.4 m s^{-1} (Fig. B6). There was a nearly stationary cyclonic eddy NW of ALOHA (Fig. B7), suggesting a possible increasing geostrophic flow towards the SW. A combination of internal semidiurnal and diurnal tides, along with near-inertial oscillations, were noticeable especially in vertical shear (Figs. B4, B5 and B8).

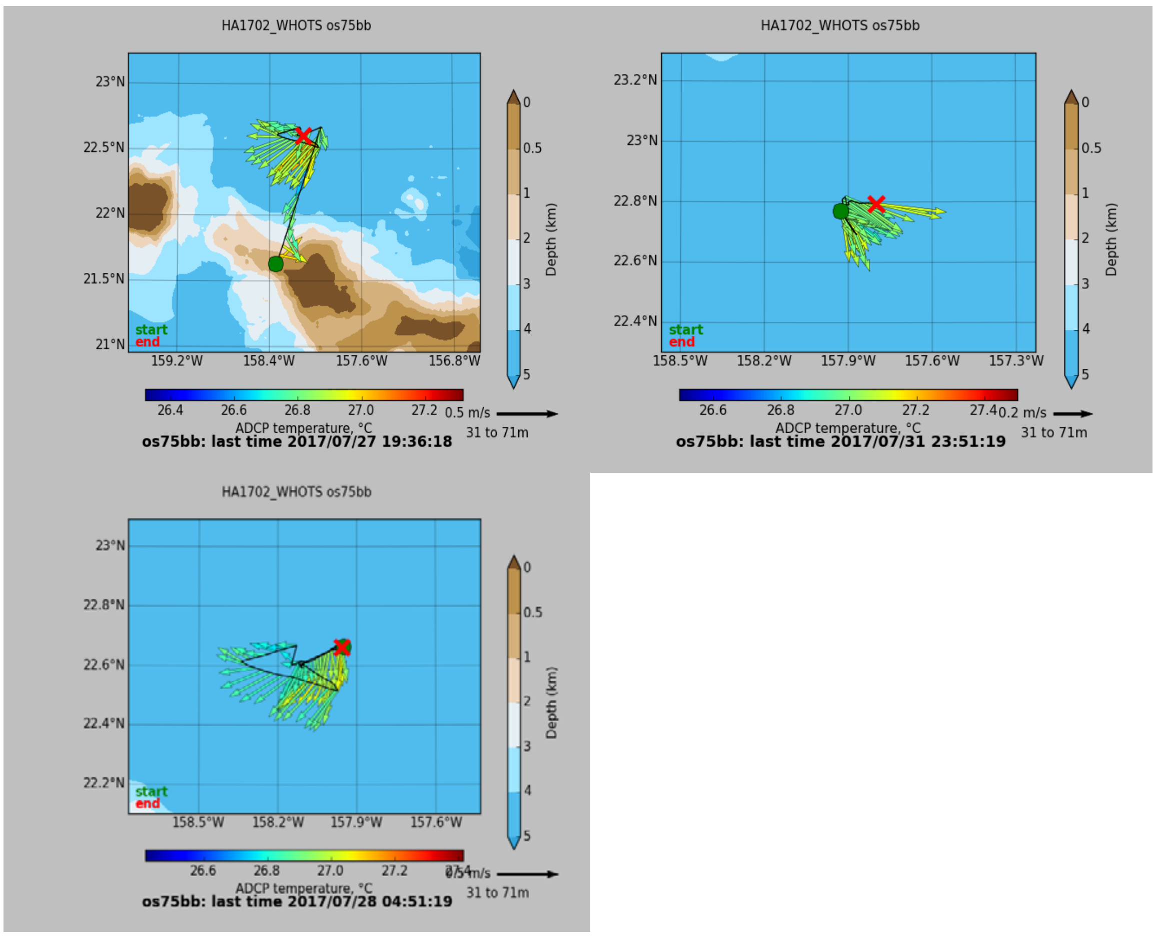


Figure B6. History of shipboard 75 kHz ADCP (OS75bb) current measurements from July 27th, 19:36z (top left), from July 28, 04:51z (top right), and from 31 June 2017 at 23:51z (bottom) averaged over depths from 31 to 71 m. Water temperature at the hull transducer depth is indicated by vector color.

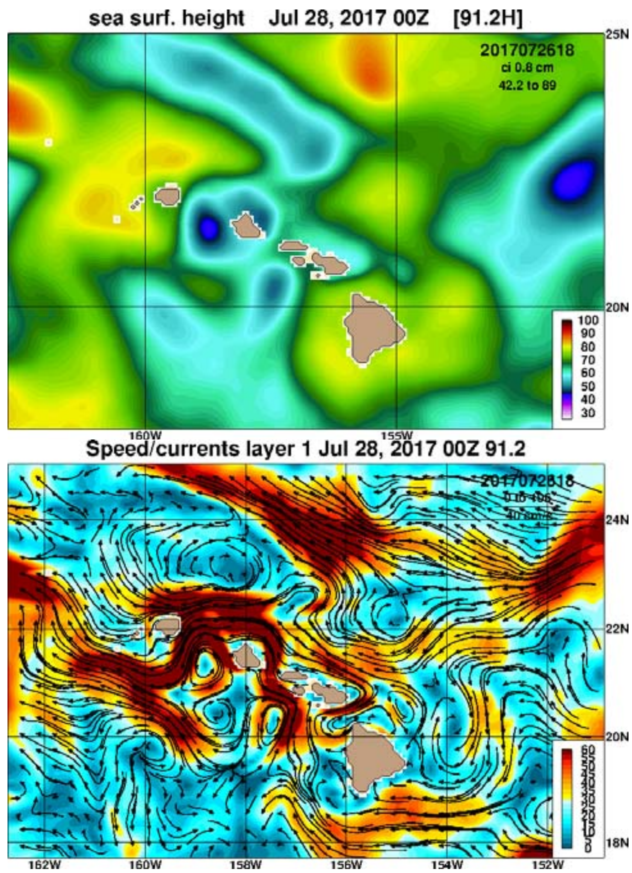


Figure B7. Sea surface height from the NRL 1/12th degree HYCOM analysis for 00Z on July 28th, 2017 (left) and surface currents (right).

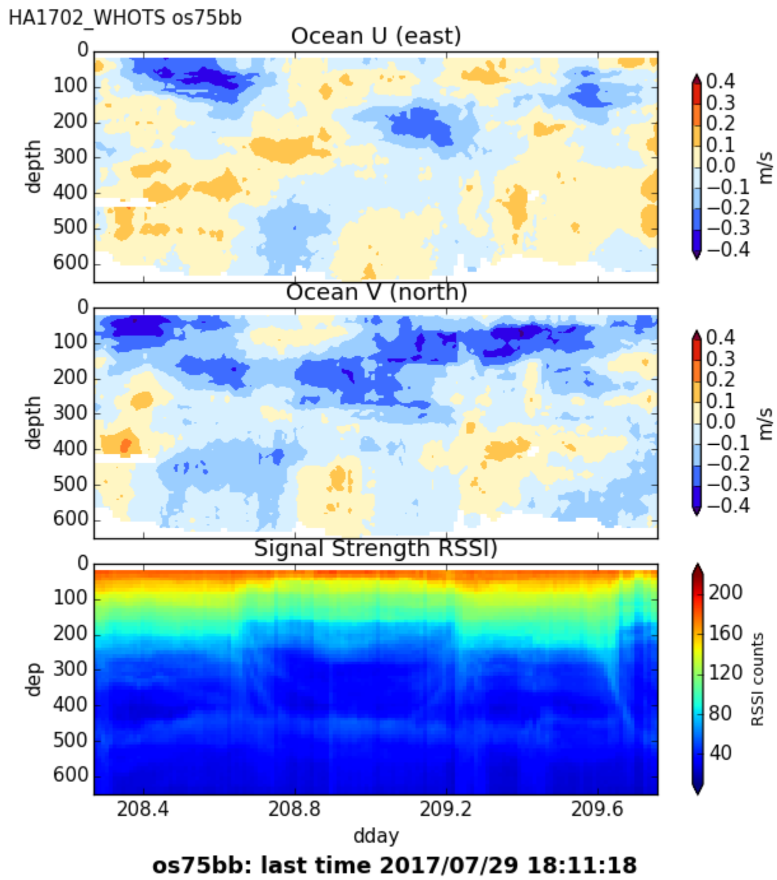


Figure B8. Shipboard 75 kHz ADCP (OS75bb) currents on July 29th as a function of depth and time.

Appendix C: WHOTS-13 Subsurface Instrumentation and Data Return

For the 14th WHOTS mooring deployment that took place on 27 July 2017, UH provided 17 SBE-37 MicroCATs and one RDI Workhorse ADCP (300 kHz). In addition to the instrumentation on the buoy, WHOI provided two Vector Measuring Current Meters (VMCM), one deep MircoCAT (SBE-37), and one RDI Workhorse ADCP (600 kHz), and all required subsurface mooring hardware. The MicroCATs all measure temperature and conductivity, with 7 also measuring pressure. All MicroCATs were deployed with antifoulant capsules. Information about these instruments, including location on the mooring, is given in Table 1C.

Before deployment, a bag of ice was placed in contact with each MicroCAT's temperature sensor to produce a spike in the data as a reference point to check the instrument clocks.

Table 1C. WHOTS-14 mooring subsurface instrument deployment information

SN	Instrument	Depth (m)	Pressure SN	Sample Interval (sec)	Start Logging Data		Cold Spike Begin		Cold Spike End		Time in Water	
3617	MicroCAT	7	N/A	180	7/24/17	00:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/27/17	18:29:00
042	VMCM	10	N/A	60	7/27/17	00:00:17	7/27/17	18:25:00*	N/A	N/A	7/27/17	18:26:00
6893	MicroCAT	15	N/A	60	7/24/17	0:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/27/17	18:19:00
6894	MicroCAT	25	N/A	60	7/24/17	0:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/27/17	18:15:00
068	VMCM	30	N/A	60	7/26/17	19:54:00	7/27/17	18:10:00*	N/A	N/A	7/27/17	18:10:00
6895	MicroCAT	35	N/A	60	7/24/17	0:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/27/17	18:07:00
6896	MicroCAT	40	N/A	60	7/24/17	0:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/27/17	18:04:00
6887	MicroCAT	45	2651319	75	7/24/17	0:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/27/17	18:02:00
1825	600 kHz ADCP	47.5	N/A	600	7/26/17	00:00:00	N/A	See Table 8	N/A	See Table 8	7/27/17	19:30:00
6897	MicroCAT	50	N/A	60	7/24/17	0:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/27/17	19:31:00
6898	MicroCAT	55	N/A	60	7/24/17	0:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/27/17	19:33:00
6899	MicroCAT	65	N/A	60	7/24/17	0:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/27/17	19:35:00
3618	MicroCAT	75	N/A	180	7/24/17	0:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/27/17	19:36:00
3634	MicroCAT	85	N/A	180	7/24/17	0:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/27/17	19:38:00
3670	MicroCAT	95	5701	240	7/24/17	0:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/27/17	19:40:00
6889	MicroCAT	105	2651321	75	7/24/17	0:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/27/17	19:42:00
6890	MicroCAT	120	2651322	75	7/24/17	0:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/27/17	19:54:00
4891	300 kHz ADCP	125	N/A	600	7/24/17	0:00:00	N/A	See Table 8	N/A	See Table 8	7/27/17	19:55:00
6888	MicroCAT	135	3418742	75	7/24/17	0:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/27/17	19:57:00
6891	MicroCAT	155	2651323	75	7/24/17	0:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/27/17	19:59:00
9988	MicroCAT	36m off bottom	N/A	60	7/24/17	0:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/28/17	02:02:00
10602	MicroCAT	36m off bottom	10602	60	7/20/17	1:00:00	7/25/17	02:36:00	7/25/17	03:00:00	7/28/17	02:02:00

* VMCM Spin start times

The ADCPs were deployed in an upward-looking configuration. The instruments were programmed as described in Table 2C. Before deployment, each instrument's transducer was rubbed gently by hand for 10 seconds to produce a spike in the data as a reference point to check the instrument's clock.

Table 2C. WHOTS-14 mooring ADCP deployment and configuration information. All times are in UTC.		
	ADCP S/N 4891	ADCP S/N 1825
Frequency (kHz)	300	600
Number of Depth Cells	30	25
Depth Cell Size (m)	4 m	2 m
Pings per Ensemble	40	80
Time between Ensembles	10 min	10 min
Ping interval	4 sec	2 sec
Time of First Ping	07/24/17, 00:00:00	07/26/17, 00:00:00
Transducer 1 Spike Time	07/26/17, 00:30:00	07/26/17, 00:30:00
Transducer 2 Spike Time	07/26/17, 00:30:15	07/26/17, 00:30:15
Transducer 3 Spike Time	07/26/17, 00:30:30	07/26/17, 00:30:30
Transducer 4 Spike Time	07/26/17, 00:30:45	07/26/17, 00:30:45
Time in Water	07/27/17, 19:55:00	07/27/17, 19:30:00
Depth (m)	125 m	47.5 m

WHOTS-13 Mooring

For the 13th WHOTS mooring deployment that took place on 26 June 2016, UH provided 16 SBE-37 MicroCATs and two RDI Workhorse ADCPs (300 and 600 kHz). In addition to the instrumentation on the buoy, WHOI provided two Vector Measuring Current Meters (VMCM), two deep MicroCATs (SBE-37), and all required subsurface mooring hardware. The MicroCATs all measure temperature and conductivity, with 7 also measuring pressure. All MicroCATs were deployed with antifoulant capsules. Tables 3C and Table 4C provide the deployment information for these instruments on the WHOTS-13 mooring. Before deployment, a bag of ice was placed in contact with each MicroCAT's temperature sensor, except for the WHOI MicroCATs, to produce a spike in the data as a reference point to check the instrument's clock. The WHOI MicroCATs were spiked by submerging them in a cold water bath. To produce a spike in the ADCP data each instrument's transducer was rubbed gently by hand for 20 seconds.

Table 3C. WHOTS-13 mooring subsurface instrument deployment information. All times are in UTC (MM/DD/YY hh:mm:ss).												
SN:	Instrument	Depth (m)	Pressure SN	Sample Interval (sec)	Start Logging Data		Cold Spike Begin		Cold Spike End		Time in Water	
6892	MicroCAT	7	51324	75	6/23/16	0:00:00	6/24/16	22:16:00	6/24/16	22:46:00	6/26/16	18:33:00
2016	VMCM	10	N/A	60	6/19/16	20:58:00	N/A	N/A	N/A	N/A	6/26/16	18:33:00
3382	MicroCAT	15	N/A	180	6/23/16	0:00:00	6/24/16	22:16:00	6/24/16	22:46:00	6/26/16	18:29:00
4663	MicroCAT	25	N/A	180	6/23/16	0:00:00	6/24/16	22:16:00	6/24/16	22:46:00	6/26/16	18:20:00
2075	VMCM	30	N/A	60	6/19/16	22:05:00	N/A	N/A	N/A	N/A	6/26/16	18:19:00
3633	MicroCAT	35	N/A	180	6/23/16	0:00:00	6/24/16	22:16:00	6/24/16	22:46:00	6/26/16	18:15:00
3381	MicroCAT	40	N/A	180	6/23/16	0:00:00	6/24/16	22:16:00	6/24/16	22:46:00	6/26/16	18:10:00
3668	MicroCAT	45	5579	240	6/23/16	0:00:00	6/24/16	22:16:00	6/24/16	22:46:00	6/26/16	18:05:00
13917	600 kHz ADCP	47.5	N/A	600	6/23/16	0:00:00	N/A	See Table 2	N/A	See Table 2	6/26/16	19:37:00
3619	MicroCAT	50	N/A	180	6/23/16	0:00:00	6/24/16	22:16:00	6/24/16	22:46:00	6/26/16	19:37:00
3620	MicroCAT	55	N/A	180	6/23/16	0:00:00	6/24/16	22:16:00	6/24/16	22:46:00	6/26/16	19:39:00
3621	MicroCAT	65	N/A	180	6/23/16	0:00:00	6/24/16	22:16:00	6/24/16	22:46:00	6/26/16	19:40:00
3632	MicroCAT	75	N/A	180	6/23/16	0:00:00	6/24/16	22:16:00	6/24/16	22:46:00	6/26/16	19:42:00
4699	MicroCAT	85	10209	240	6/23/16	0:00:00	6/24/16	22:16:00	6/24/16	22:46:00	6/26/16	19:43:00
3791	MicroCAT	95	N/A	180	6/23/16	0:00:00	6/24/16	22:16:00	6/24/16	22:46:00	6/26/16	19:44:00
2769	MicroCAT	105	2949	240	6/23/16	0:00:00	6/24/16	22:16:00	6/24/16	22:46:00	6/26/16	19:45:00
4700	MicroCAT	120	9944	240	6/23/16	0:00:00	6/24/16	22:16:00	6/24/16	22:46:00	6/26/16	19:53:00
7637	300 kHz ADCP	125	N/A	600	6/23/16	0:00:00	N/A	See Table 2	N/A	See Table 2	6/26/16	19:54:00
2965	MicroCAT	135	3021	240	6/23/16	0:00:00	6/24/16	22:16:00	6/24/16	22:46:00	6/26/16	19:55:00
4701	MicroCAT	155	10211	240	6/23/16	0:00:00	6/24/16	22:16:00	6/24/16	22:46:00	6/26/16	19:57:00
12246	MicroCAT	36m off bottom	N/A	300	6/15/16	1:00:00	6/23/16	20:11:00	6/23/16	21:46:00	6/27/16	8:13:00
12247	MicroCAT	36m off bottom	N/A	300	6/15/16	1:00:00	6/23/16	20:11:00	6/23/16	21:46:00	6/27/16	8:13:00

Table 4C. WHOTS-13 mooring ADCP deployment and configuration information. All times are in UTC.		
	ADCP S/N 7637	ADCP S/N 13917
Frequency (kHz)	300	600
Number of Depth Cells	30	25
Depth Cell Size	4 m	2 m
Pings per Ensemble	40	80
Time between Ensembles	10 min	10 min
Ping interval	4 sec	2 sec
Time of First Ping	06/25/16, 00:10:05	06/25/16, 00:49:54
Transducer 1 Spike Time	06/25/16, 01:00:10	06/25/16, 00:50:30
Transducer 2 Spike Time	06/25/16, 01:00:20	06/25/16, 00:50:40
Transducer 3 Spike Time	06/25/16, 01:00:30	06/25/16, 00:50:50
Transducer 4 Spike Time	06/25/16, 01:00:40	06/25/16, 00:51:00
Time in Water	06/26/16, 19:54:00	06/26/16, 19:37:00
Depth (m)	125 m	47.5 m

WHOTS-13 Recovery

The WHOTS-13 mooring was recovered on July 31st - August 1st 2017 (UTC). All instruments on the mooring were successfully recovered. Most of the instruments had some degree of biofouling, with the heaviest fouling near the surface. Fouling extended down to the ADCP at 125 m, although it was minor at that level.

MicroCATs

All MicroCATs were in good condition after recovery. MicroCAT 3633 (35 m) had barnacles attached at the top end of its conductivity cell, possibly partially blocking the flow (Fig. 1C). After recovery and before recording was stopped, a bag of ice was placed in contact with each MicroCAT temperature sensor, to produce a spike in the data as a reference point to check each instrument’s clock. To produce a spike in the ADCP data, each instrument’s transducer was rubbed gently by hand for 20 seconds. The data from all instruments were downloaded on board the ship, and all instruments returned full data records. A post-cruise evaluation showed no missing samples in all the MicroCATs and both ADCPs. Table 4 gives the post-deployment information for the MicroCATs and ADCP instruments.

Figure 1C. WHOTS-13, MicroCAT SN 3633 at 35 m, recovered with barnacles partially blocking the top end of its conductivity cell.

Table 5C. WHOTS-13 mooring C-T and ADCP Instruments recovery information. All times are in UTC.								
Depth (m)	Sea-Bird Serial #	Time out of water	Time of Spike	Time of End Spike	Time Logging Stopped	Samples Logged	Data Quality	File Name
7	SBE 37-6892	8/01/17 02:13:00	8/01/17 05:15:00	8/01/17 5:55:00	8/01/17 06:12:30	465706	Good	w13_6892.cap
15	SBE 37-3382	8/01/17 02:20:00	8/01/17 05:15:00	8/01/17 5:55:00	8/01/17 06:37:45	194052	Good	w13_3382.cap
25	SBE 37-4663	8/01/17 02:25:00	8/01/17 05:15:00	8/01/17 5:55:00	8/02/17 03:15:00	194465	Good	w13_4663.cap
35	SBE 37-3633	8/01/17 02:29:00	8/01/17 05:15:00	8/01/17 5:55:00	8/01/17 18:29:00	194289	Good	w13_3633.cap
40	SBE 37-3381	8/01/17 02:30:00	8/01/17 05:15:00	8/01/17 5:55:00	8/01/17 06:31:00	194050	Good	w13_3381.cap
45	SBE 37-3668	8/01/17 02:35:00	8/01/17 05:15:00	8/01/17 5:55:00	8/01/17 06:23:30	145535	Good	w13_3668.cap
47.5	ADCP 13917	8/01/17 00:51:00	N/A	See Table 5	8/02/17 02:39:00	58336	Good	wh13_600.000
50	SBE 37-3619	8/01/17 00:51:00	8/01/17 05:15:00	8/01/17 5:55:00	8/01/17 06:50:15	194056	Good	w13_3619.cap
55	SBE 37-3620	8/01/17 00:50:00	8/01/17 05:15:00	8/01/17 5:55:00	8/01/17 07:01:00	194060	Good	w13_3620.cap
65	SBE 37-3621	8/01/17 00:49:00	8/01/17 05:15:00	8/01/17 5:55:00	8/01/17 07:06:00	194062	Good	w13_3621.cap
75	SBE 37-3632	8/01/17 00:47:00	8/01/17 05:15:00	8/01/17 5:55:00	8/01/17 07:10:45	194064	Good	w13_3632.cap
85	SBE 37-4699	8/01/17 00:46:00	8/01/17 05:15:00	8/01/17 5:55:00	8/1/17 18:01:15	145710	Good	w13_4699.cap
95	SBE 37-3791	8/01/17 00:46:00	8/01/17 05:15:00	8/01/17 5:55:00	8/1/17 20:56:00	194338	Good	w13_3791.cap
105	SBE 37-2769	8/01/17 00:45:00	8/01/17 05:15:00	8/01/17 5:55:00	8/01/17 18:31:30	145718	Good	w13_2769.cap
120	SBE 37-4700	8/01/17 00:43:00	8/01/17 05:15:00	8/01/17 5:55:00	8/01/17 18:26:30	145717	Good	w13_4700.cap
125	ADCP 7637	8/01/17 00:39:00	N/A	See Table 5	8/02/17 02:30:30	58334	Good	w13_300.000
135	SBE 37-2965	8/01/17 00:38:00	8/01/17 05:15:00	8/01/17 5:55:00	8/01/17 18:09:30	145712	Good	w13_2965.cap
155	SBE 37-4701	8/01/17 00:37:00	8/01/17 05:15:00	8/01/17 5:55:00	8/01/17 18:05:45	145711	Good	w13_4701.cap
36 mab	SBE 37-12246	7/31/17 19:14:00	8/01/17 05:15:00	8/01/17 5:55:00	8/02/17 05:52:30	119003	Drift?	w13_12246.cap
36 mab	SBE 37-12247	7/31/17 19:14:00	8/01/17 05:15:00	8/01/17 5:55:00	8/02/17 03:58:30	118981	Drift?	w13_12247.cap

The data recovered from the MicroCATs appear to be mostly of high quality, although post-deployment calibrations are required. All instruments' records were complete according to a post-cruise evaluation. Figures A1-A18 show the nominally calibrated temperature, conductivity and salinity records from each instrument, and pressure for those instruments that were equipped with pressure sensors. Pressure variability of up to 4 dbar was registered in some instances (e.g. in October 2016 and July 2017, Figs. 16C and 17C). The deep MicroCATs SN 12246 and 12247 appeared to have a salinity drift at the beginning of the deployment.

Moored C-T Time Series Figures

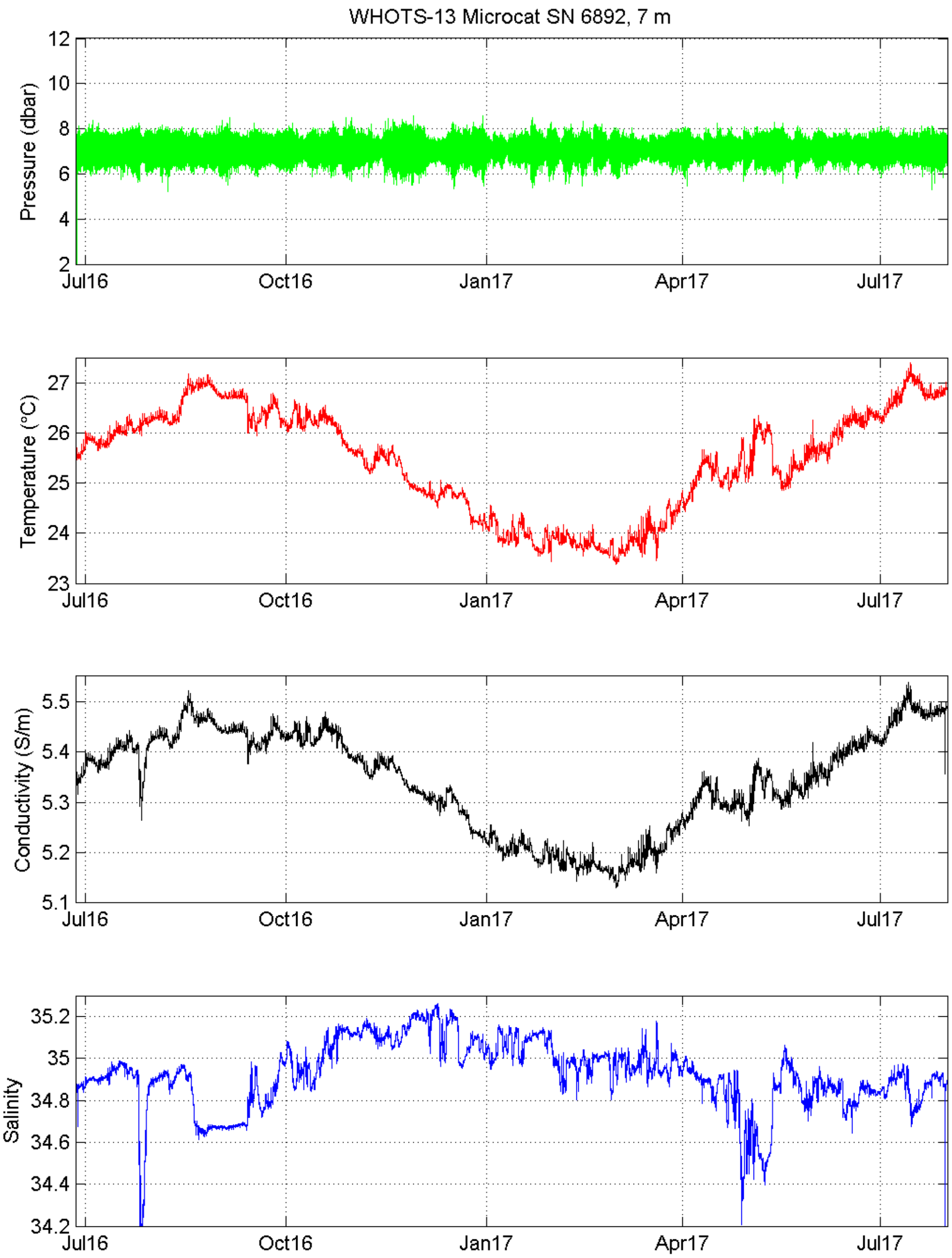


Figure 2C. Pressure, temperature, conductivity and salinity time-series from MicroCAT SBE-37 SN 6892 deployed at 7 m on the WHOTS-13 mooring. Pre-deployment calibration information was used.

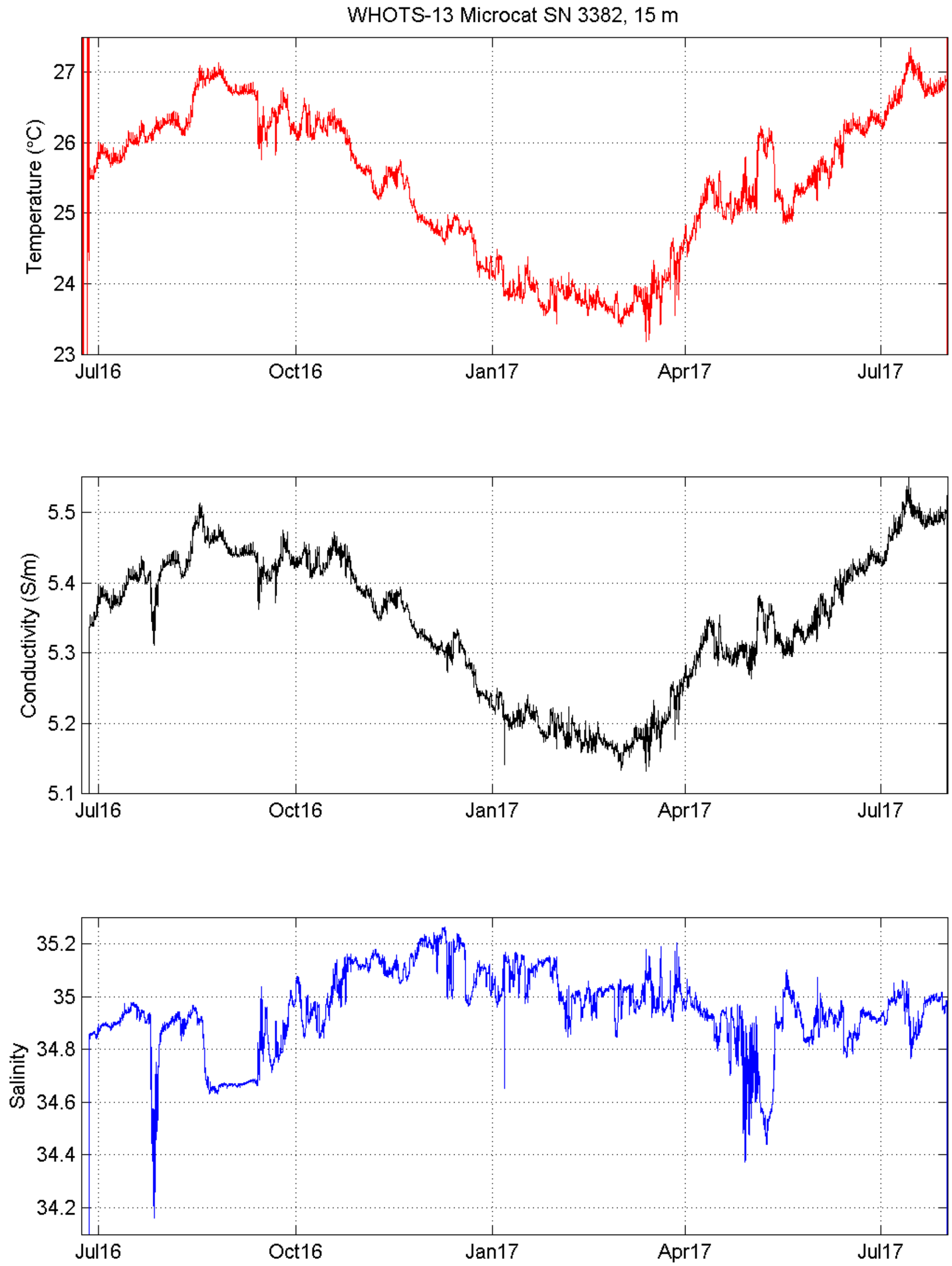


Figure 3C. Temperature, conductivity and salinity time-series from MicroCAT SBE-37 SN 3382 deployed at 15 m on the WHOTS-13 mooring. Pre-deployment calibration information was used. Nominal pressure to calculate salinity.

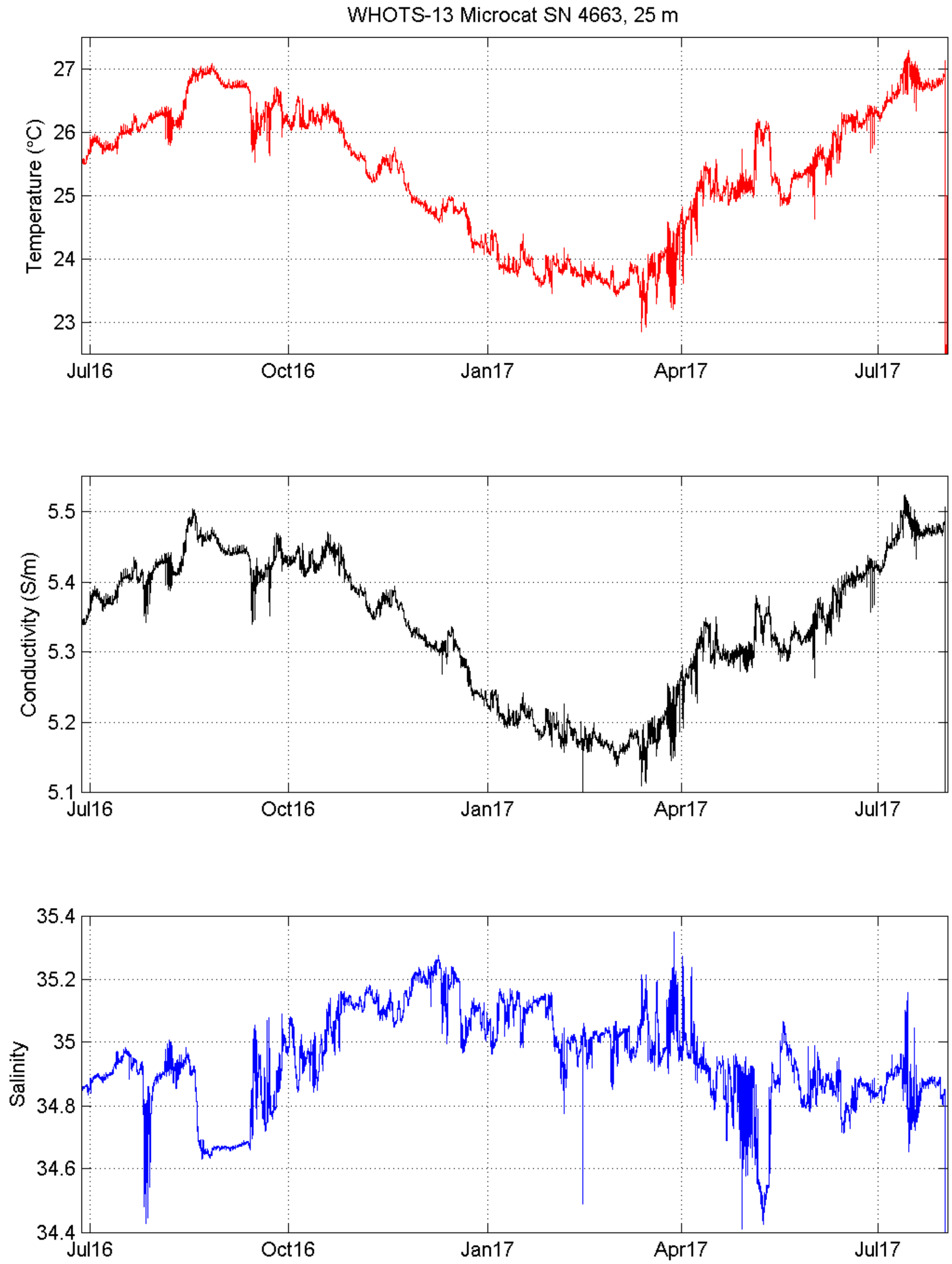


Figure 4C. Temperature, conductivity and salinity time-series from MicroCAT SBE-37 SN 4663 deployed at 25 m on the WHOTS-13 mooring. Pre-deployment calibration information was used. Nominal pressure to calculate salinity.

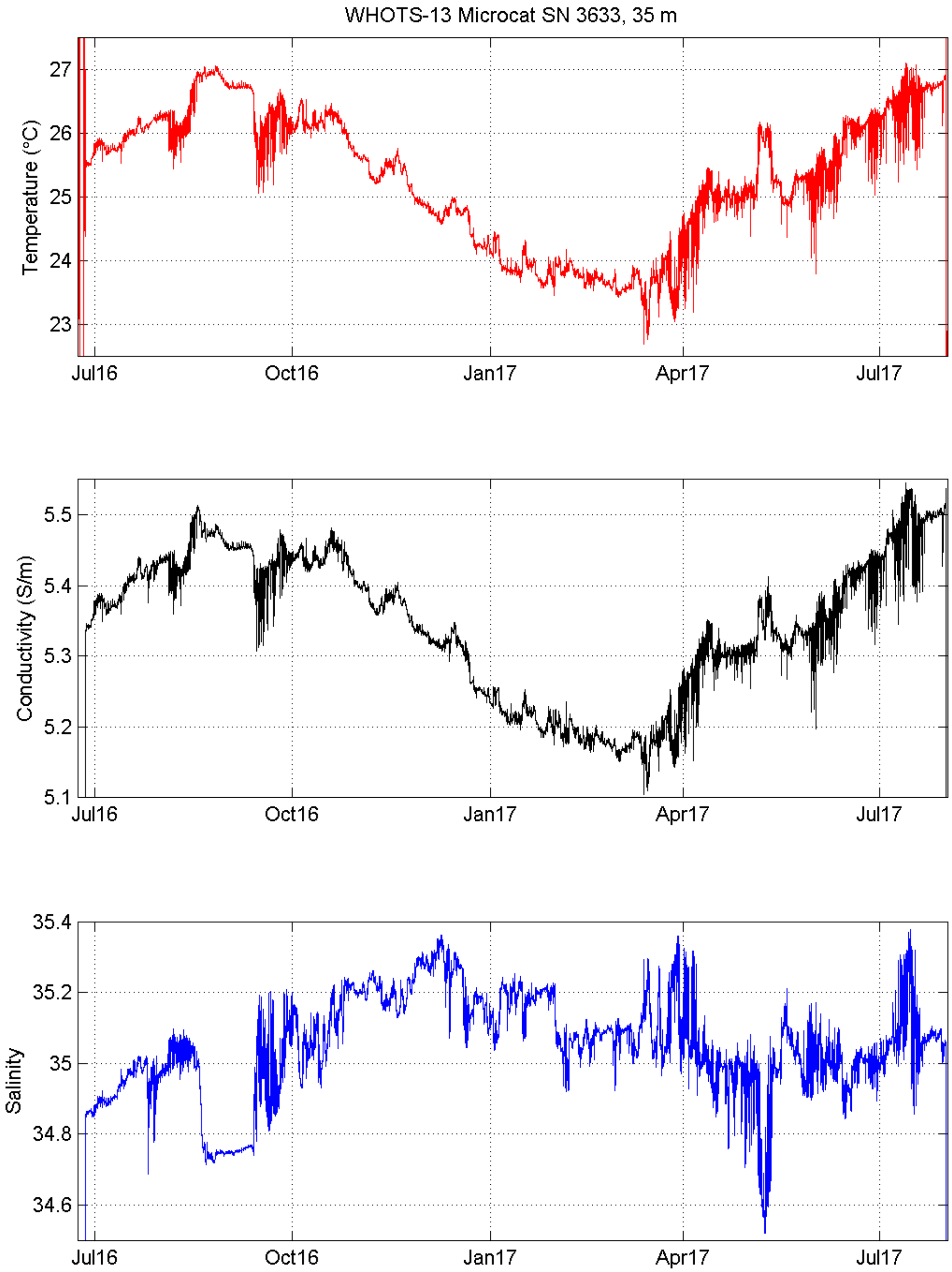


Figure 5C. Temperature, conductivity and salinity time-series from MicroCAT SBE-37 SN 3633 deployed at 35 m on the WHOTS-13 mooring. Pre-deployment calibration information was used. Nominal pressure to calculate salinity.

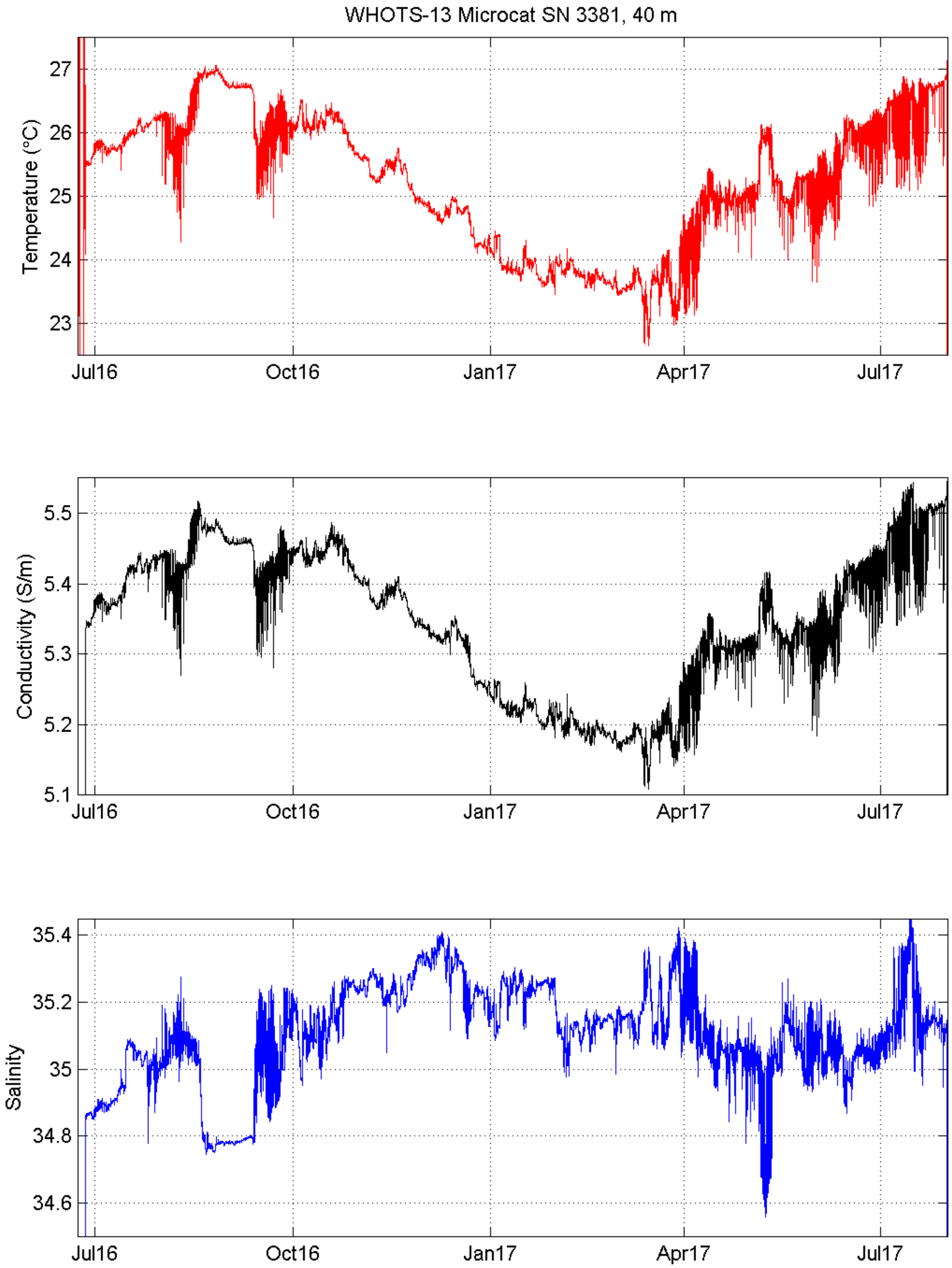


Figure 6C. Temperature, conductivity and salinity time-series from MicroCAT SBE-37 SN 3381 deployed at 40 m on the WHOTS-13 mooring. Pre-deployment calibration information was used. Nominal pressure to calculate salinity.

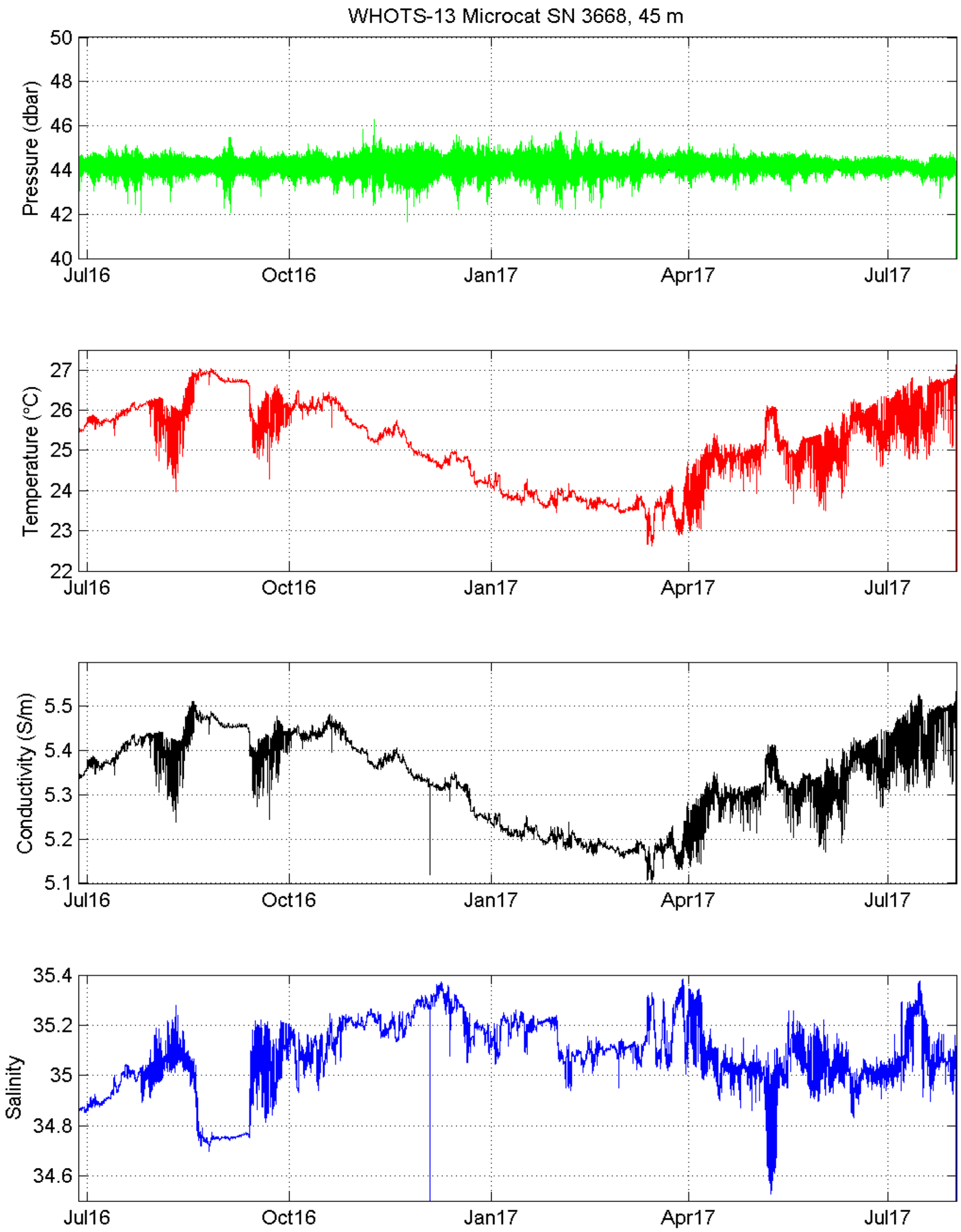


Figure 7C. Pressure, temperature, conductivity and salinity time-series from MicroCAT SBE-37 SN 3668 deployed at 45 m on the WHOTS-13 mooring. Pre-deployment calibration information was used.

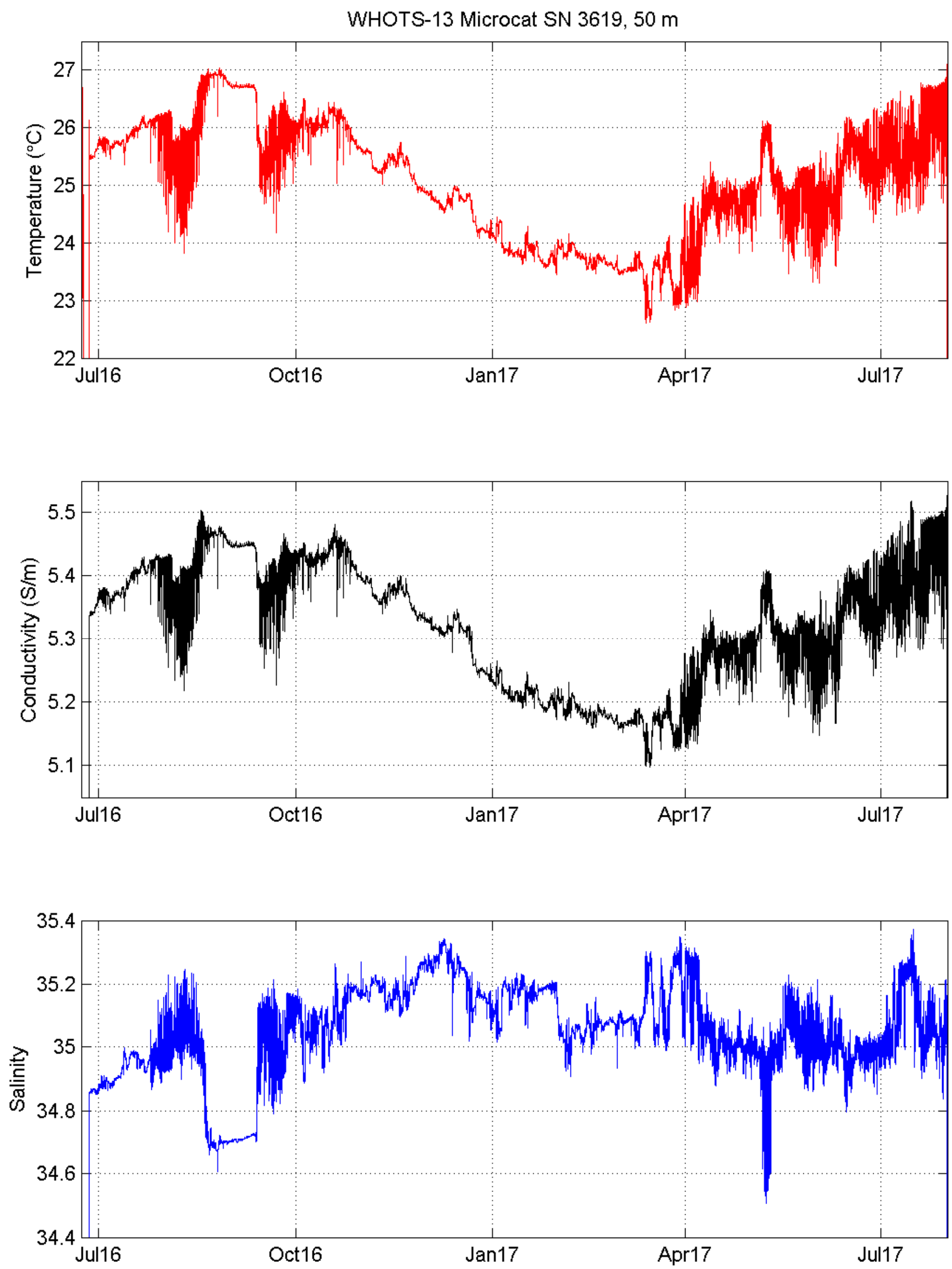


Figure 8C. Temperature, conductivity and salinity time-series from MicroCAT SBE-37 SN 3619 deployed at 50 m on the WHOTS-13 mooring. Pre-deployment calibration information was used. Nominal pressure to calculate salinity.

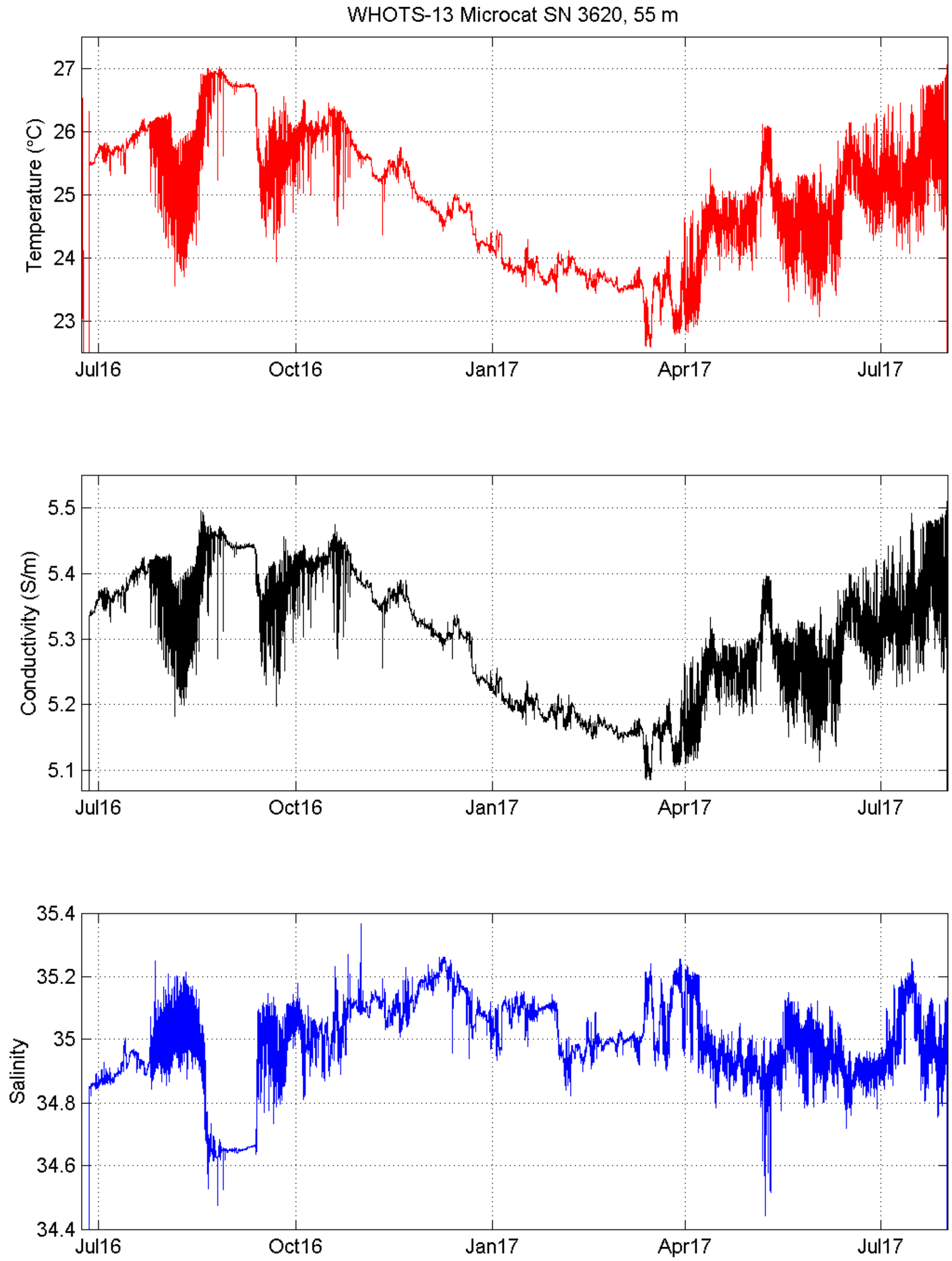


Figure 9C. Temperature, conductivity and salinity time-series from MicroCAT SBE-37 SN 3620 deployed at 55 m on the WHOTS-13 mooring. Pre-deployment calibration information was used. Nominal pressure to calculate salinity.

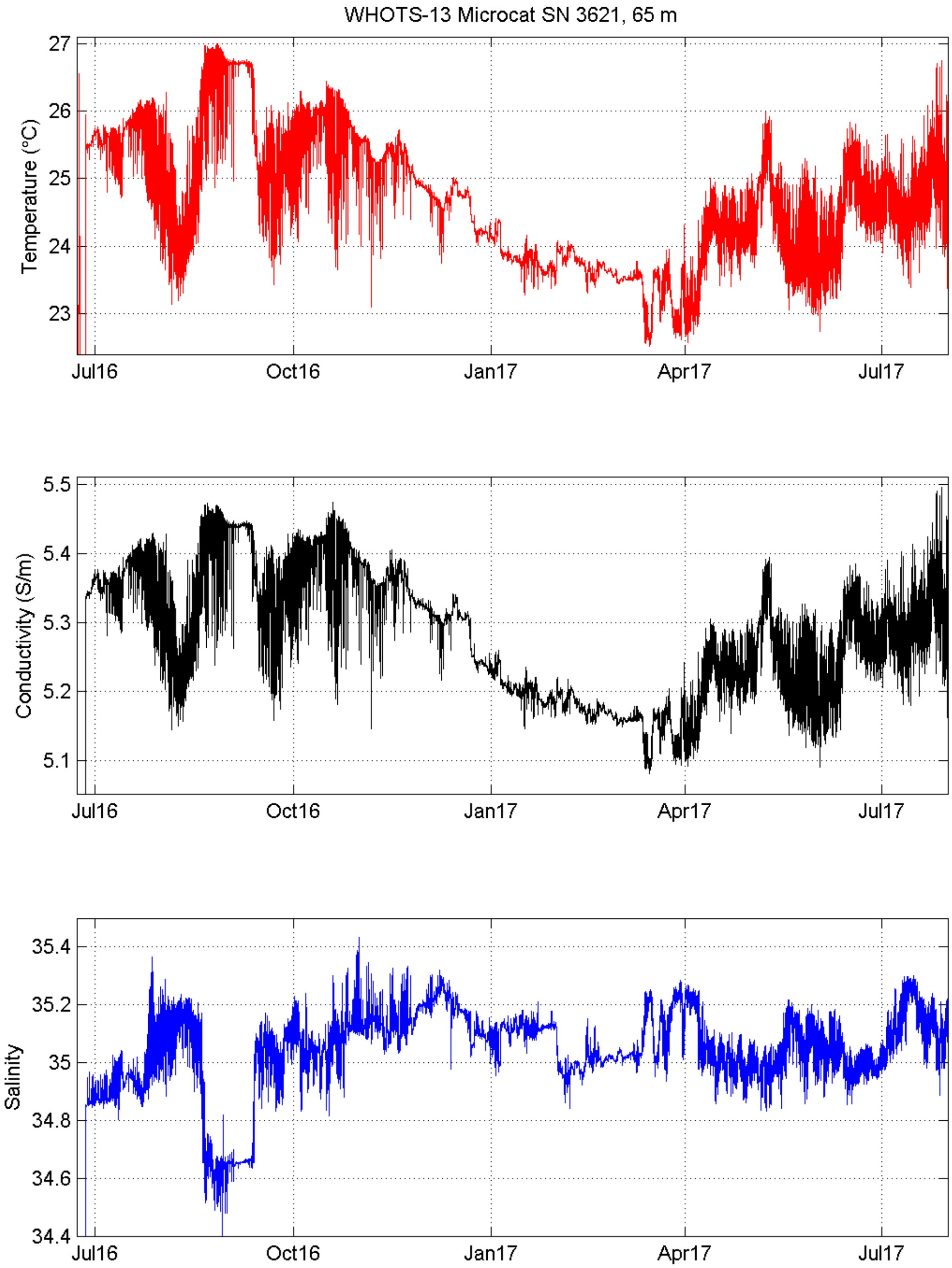


Figure 10C. Temperature, conductivity and salinity time-series from MicroCAT SBE-37 SN 3621 deployed at 65 m on the WHOTS-13 mooring. Pre-deployment calibration information was used. Nominal pressure to calculate salinity.

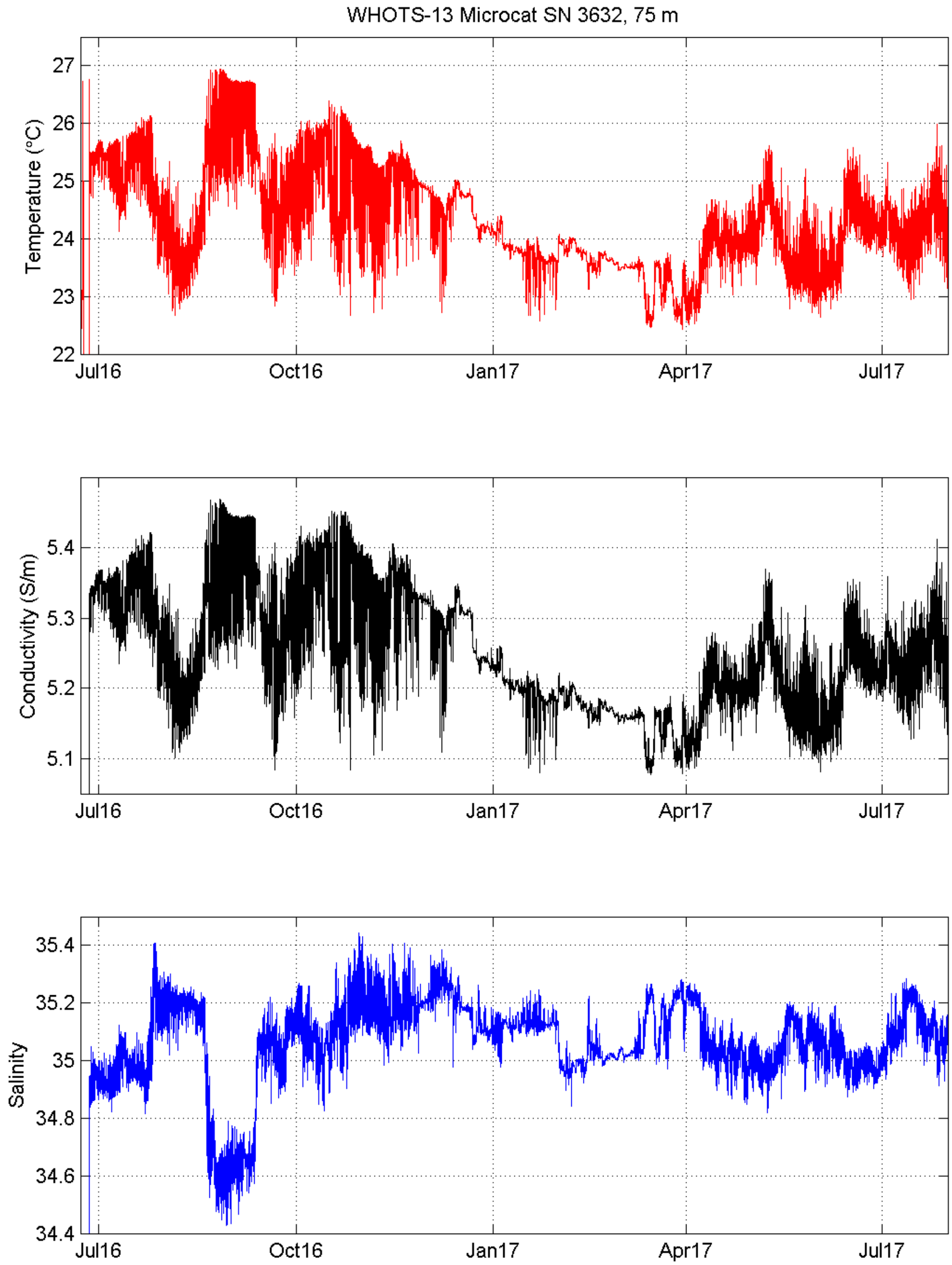


Figure 11C. Temperature, conductivity and salinity time-series from MicroCAT SBE-37 SN 3632 deployed at 75 m on the WHOTS-13 mooring. Pre-deployment calibration information was used. Nominal pressure to calculate salinity.

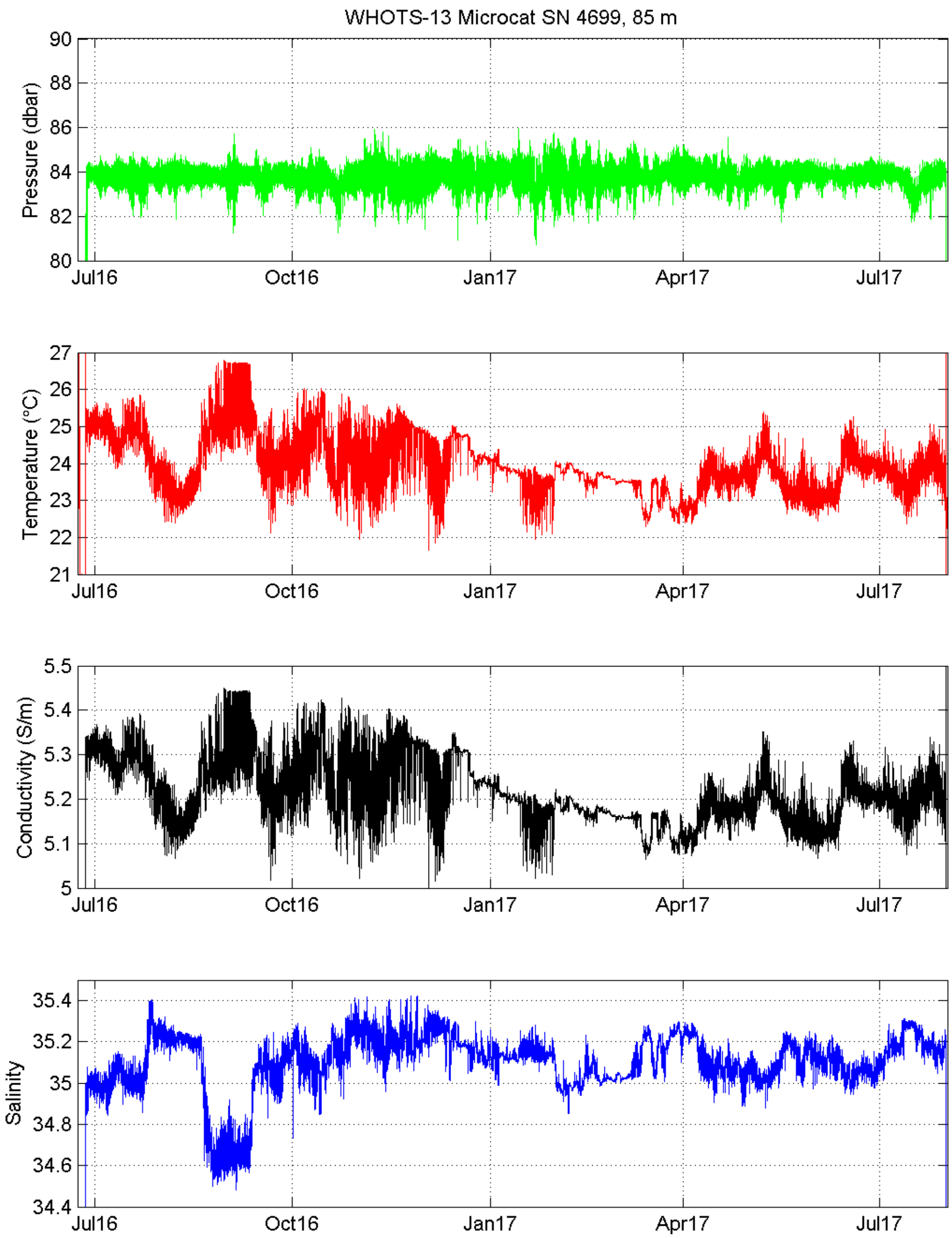


Figure A12C. Pressure, temperature, conductivity and salinity time-series from MicroCAT SBE-37 SN 4699 deployed at 85 m on the WHOTS-13 mooring. Pre-deployment calibration information was used.

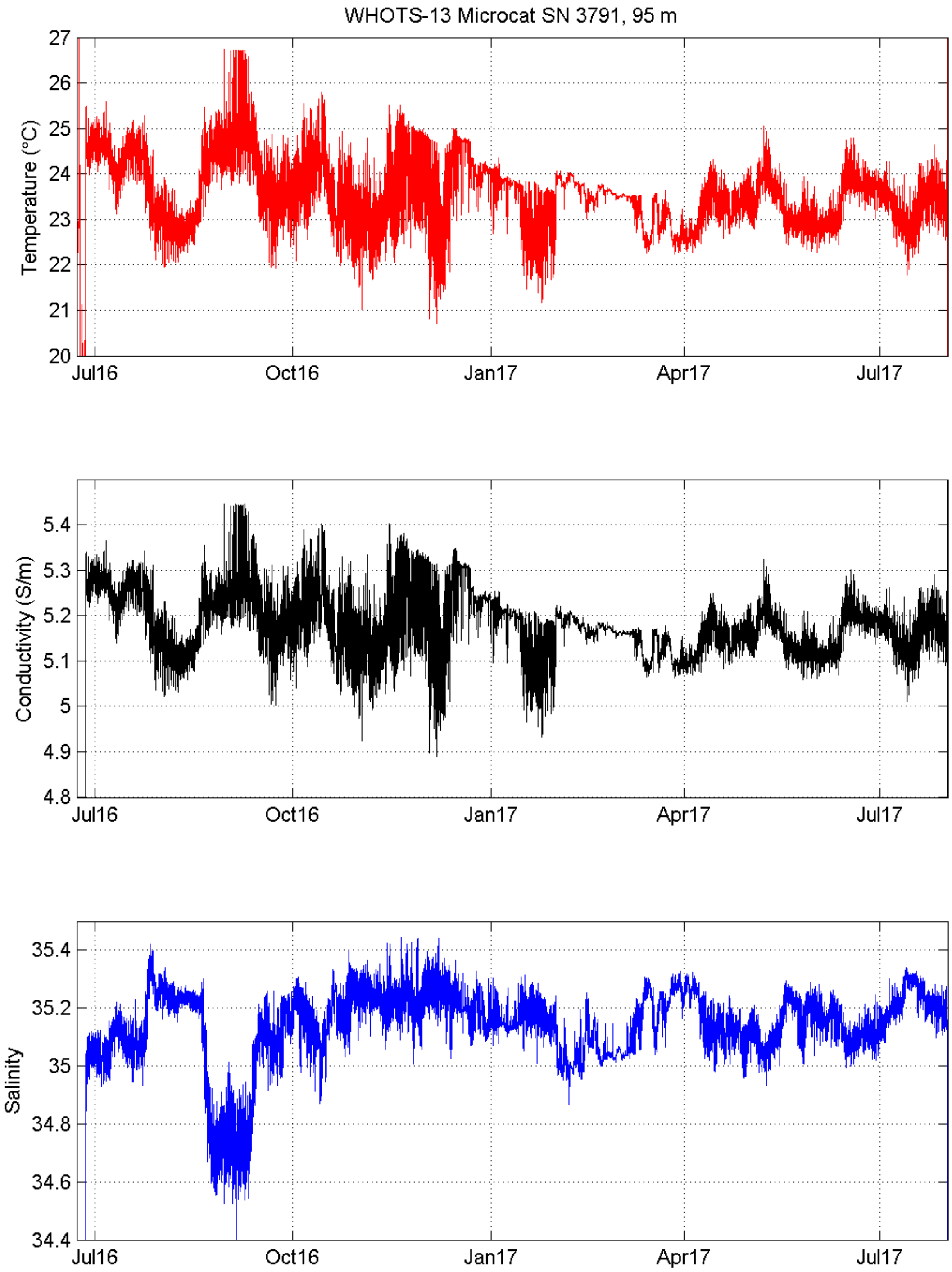


Figure 13C. Temperature, conductivity and salinity time-series from MicroCAT SBE-37 SN 3791 deployed at 95 m on the WHOTS-13 mooring. Pre-deployment calibration information was used. Nominal pressure to calculate salinity.

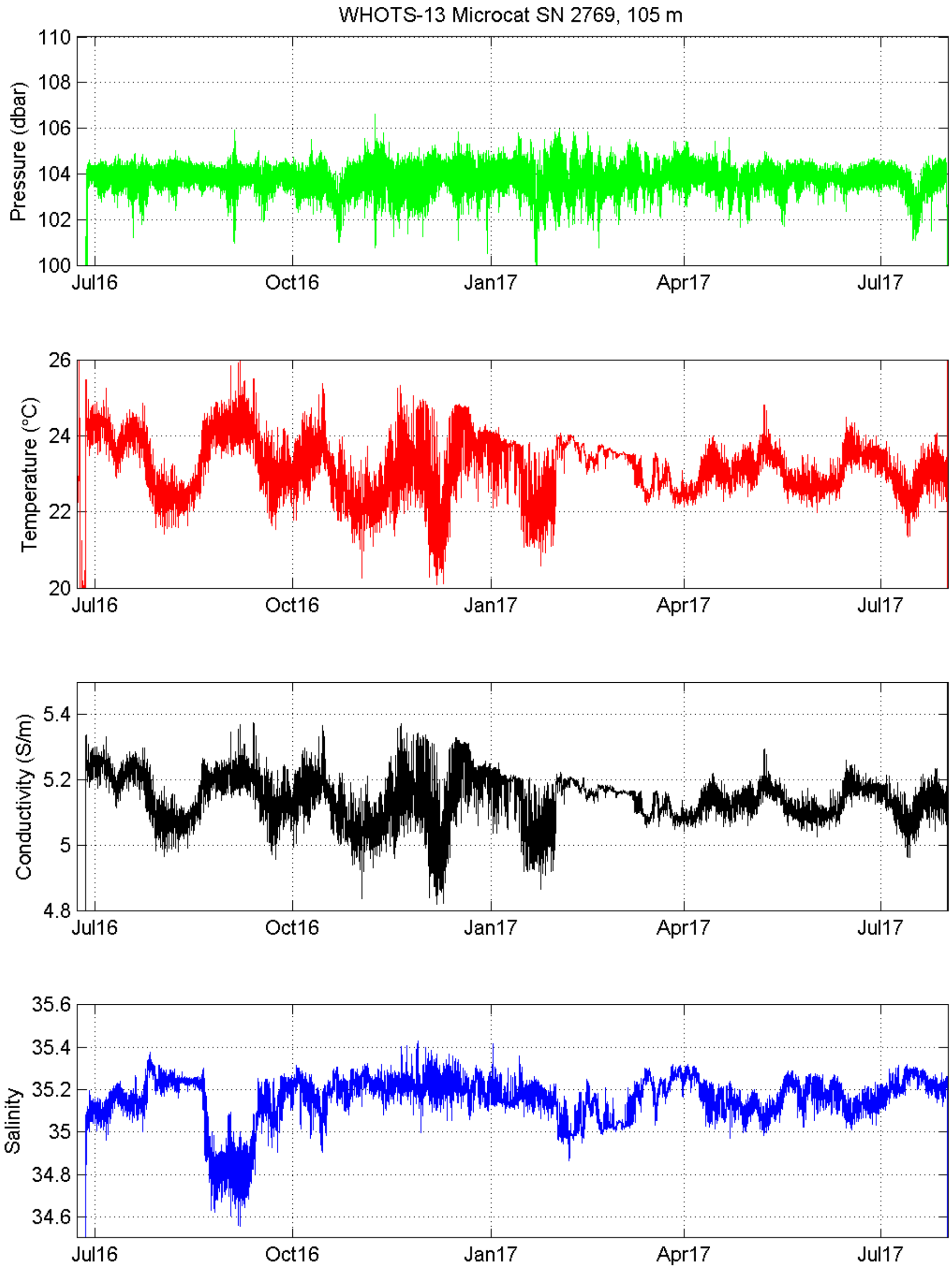


Figure 14C. Pressure, temperature, conductivity and salinity time-series from MicroCAT SBE-37 SN 2769 deployed at 105 m on the WHOTS-13 mooring. Pre-deployment calibration information was used. The pressure plot shows instances in which the instrument moved up to 4 dbar vertically (e.g. in January and July 2017).

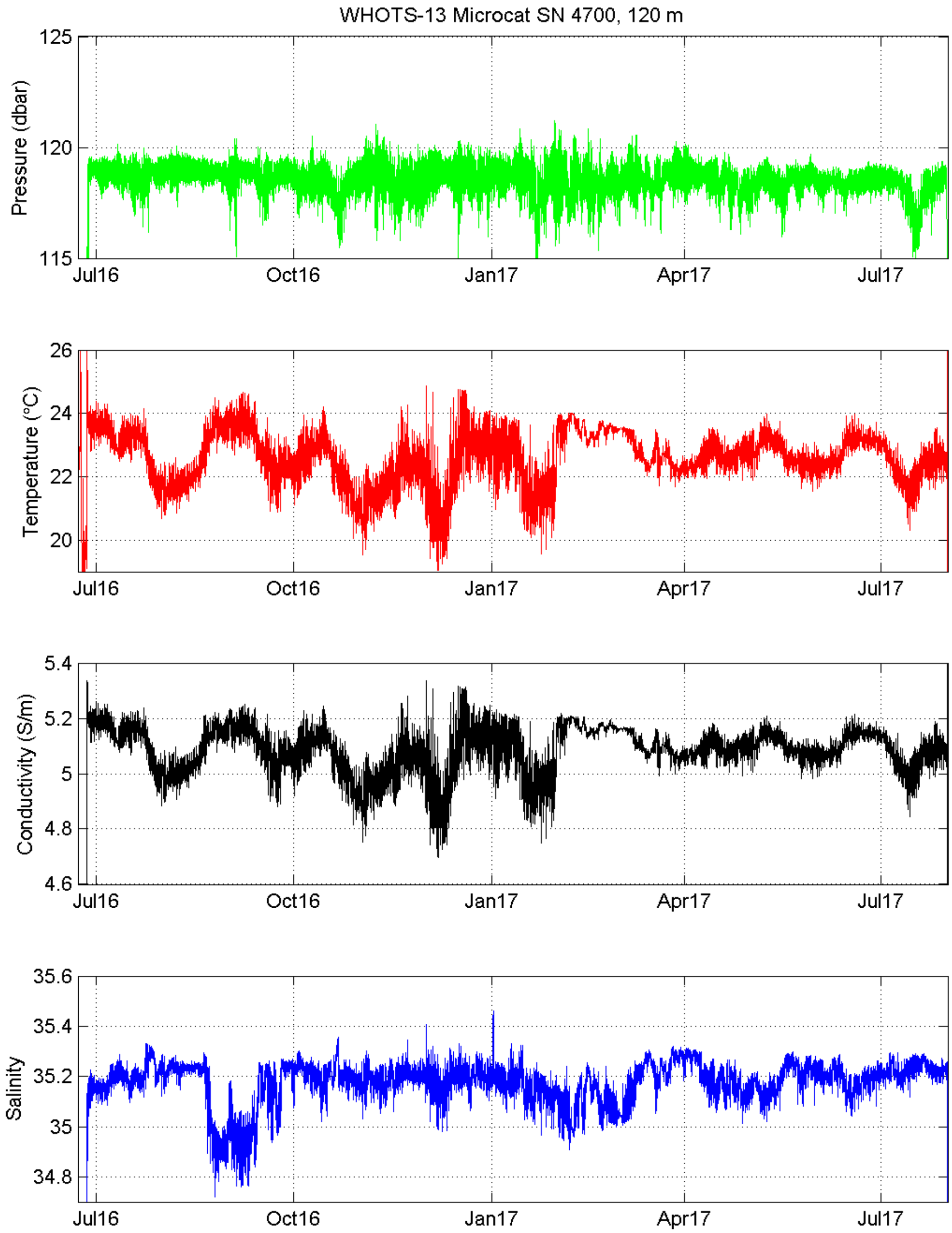


Figure 15C. Pressure, temperature, conductivity and salinity time-series from MicroCAT SBE-37 SN 4700 deployed at 120 m on the WHOTS-13 mooring. Pre-deployment calibration information was used. The pressure plot shows instances in which the instrument moved up to 4 dbar vertically (e.g. in January and July 2017).

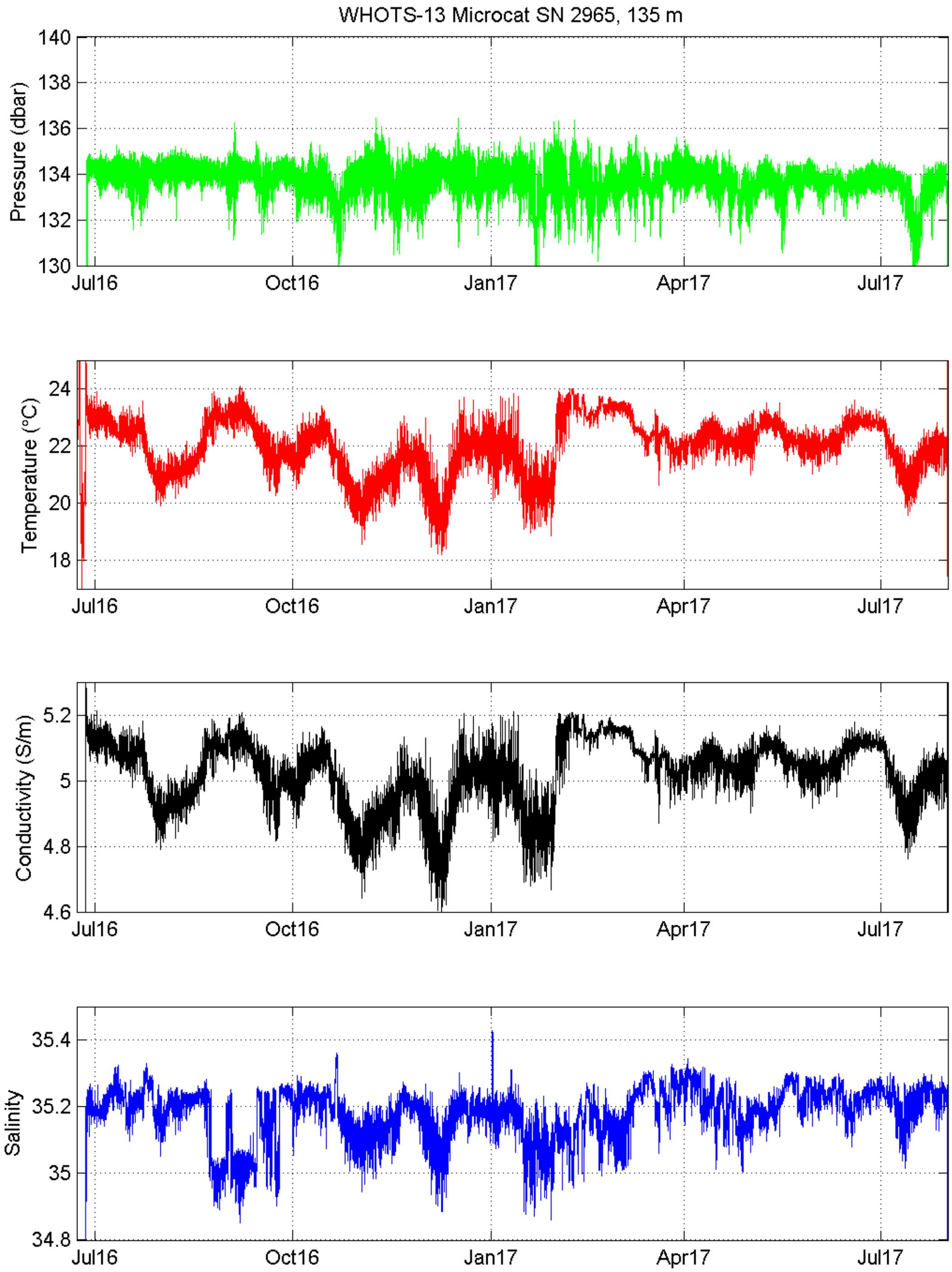


Figure 16C. Pressure, temperature, conductivity and salinity time-series from MicroCAT SBE-37 SN 2965 deployed at 135 m on the WHOTS-13 mooring. Pre-deployment calibration information was used. The pressure plot shows instances in which the instrument moved up to 4 dbar vertically (e.g. in October 2016 and January and July 2017).

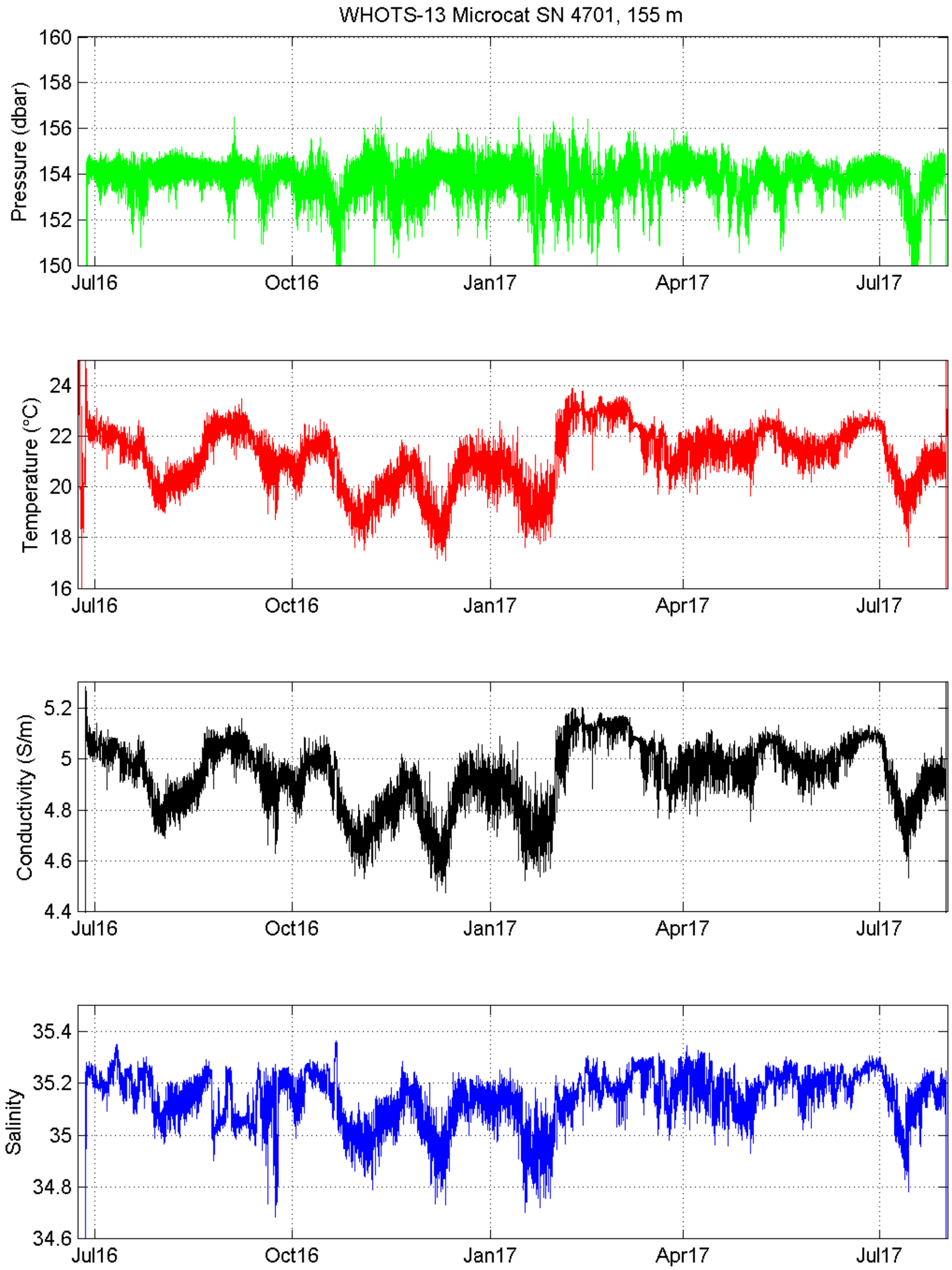


Figure 17C. Pressure, temperature, conductivity and salinity time-series from MicroCAT SBE-37 SN 4701 deployed at 155 m on the WHOTS-13 mooring. Pre-deployment calibration information was used. The pressure plot shows instances in which the instrument moved up to 4 dbar vertically (e.g. in October 2016 and January and July 2017).

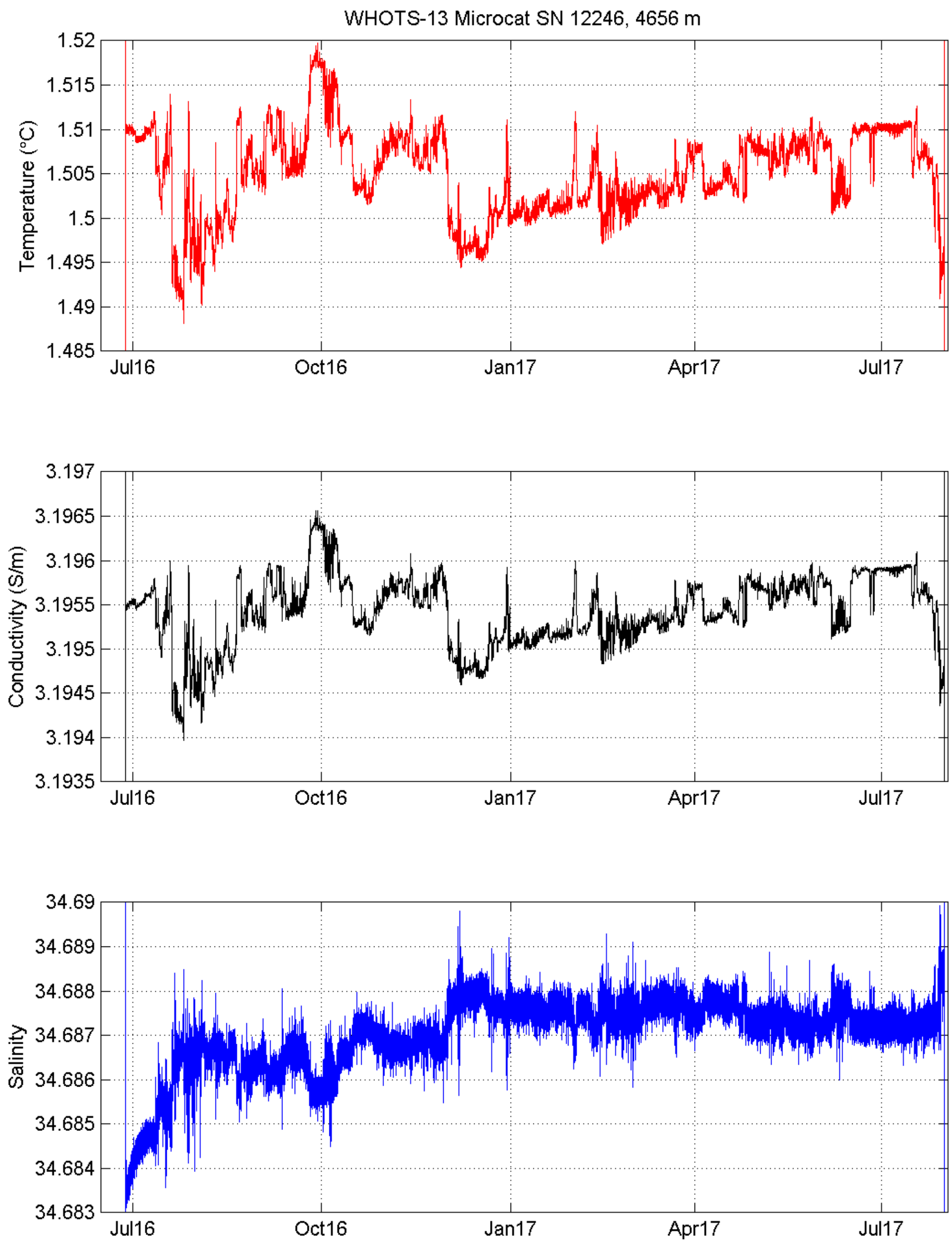


Figure 18C. Temperature, conductivity and salinity time-series **from MicroCAT SBE-37 SN 12246 deployed at 35 m above the bottom on the WHOTS-13 mooring. Pre-deployment calibration information was used. Nominal pressure to calculate salinity.**

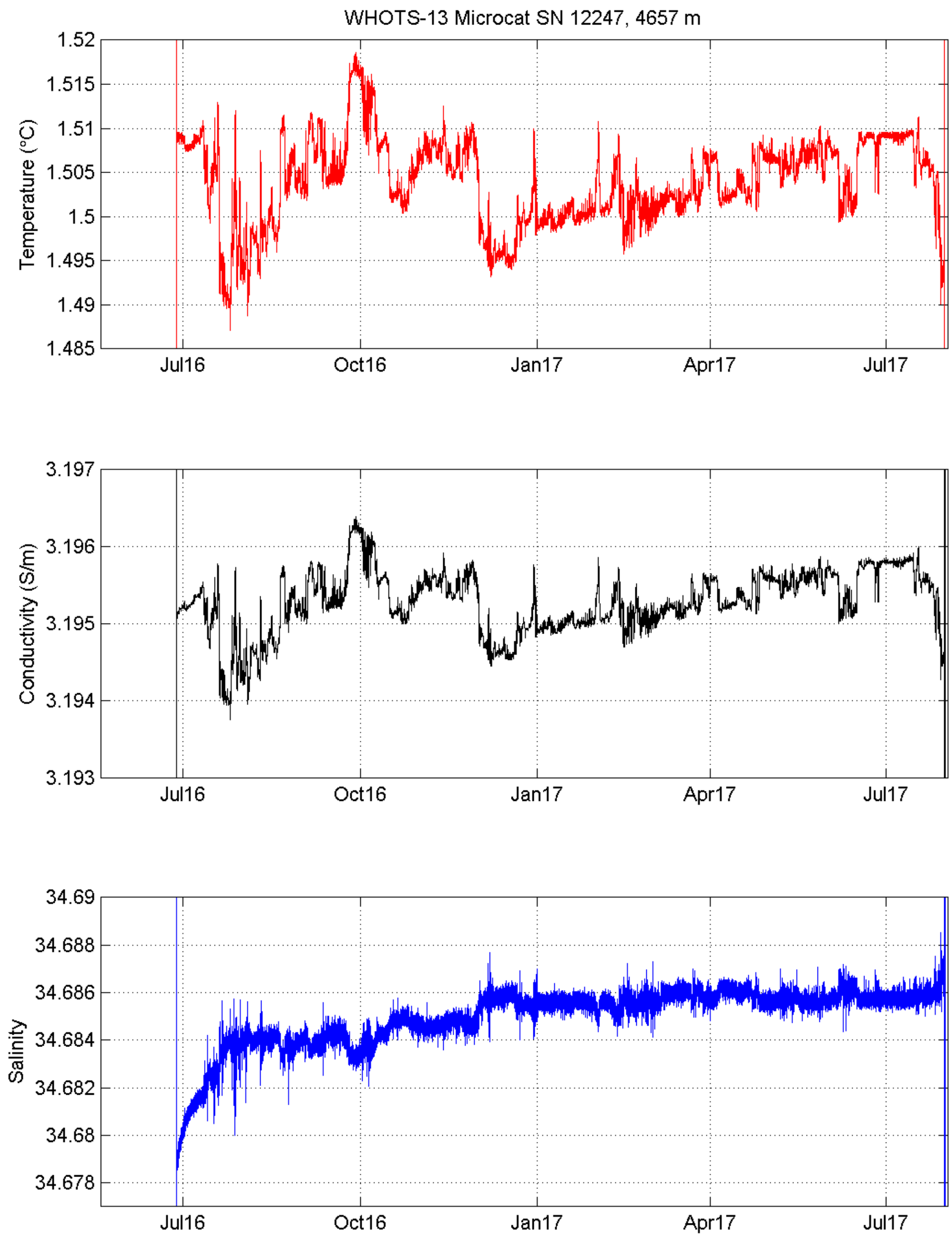


Figure 19C. Temperature, conductivity and salinity time-series **from SeaCAT SBE-16 SN 12247 deployed at 35 m above the bottom on the WHOTS-13 mooring. Pre-deployment calibration information was used. Nominal pressure to calculate salinity.**

ADCP

Table 6C provides the WHOTS-13 ADCP deployment configuration and recovery information.

Table 6C. WHOTS-13 mooring ADCP recovery information. All times are in UTC.		
	ADCP S/N 7637	ADCP S/N 13917
Frequency (kHz)	300	600
Number of Depth Cells	30	25
Depth Cell Size	4 m	2 m
Pings per Ensemble	40	80
Time between Ensembles	10 min	10 min
Ping interval	4 sec	2 sec
Time of First Ping	06/23/16, 00:00:00	06/23/16, 00:00:00
Transducer 1 Spike Time	08/02/17, 00:21:00	08/01/17, 00:31:20
Transducer 2 Spike Time	08/02/17, 00:21:20	08/01/17, 00:31:40
Transducer 3 Spike Time	08/02/17, 00:21:40	08/01/17, 00:32:00
Transducer 4 Spike Time	08/02/17, 00:22:00	08/02/17, 00:32:20
Time in Water	06/26/16, 19:54:00	06/26/16, 19:37:00
Time out of Water	08/01/17, 00:37:00	08/01/17 00:51:00
Depth (m)	125 m	47.5 m

The fouling on the 300 kHz ADCP transducer faces (Figure 20C) was minimal, most likely due to the depth of deployment (125 m) as well as Destin rash paste (which contains 40% Zinc oxide) used as anti-foulant on the faces. A barnacle was found attached to the frame above the transducers. The transducer faces for the 47.5 m ADCP (Figure 21C) were also treated with anti-foulant paste, and despite significant algae growth near the faces, the faces themselves did not show the same level of growth.

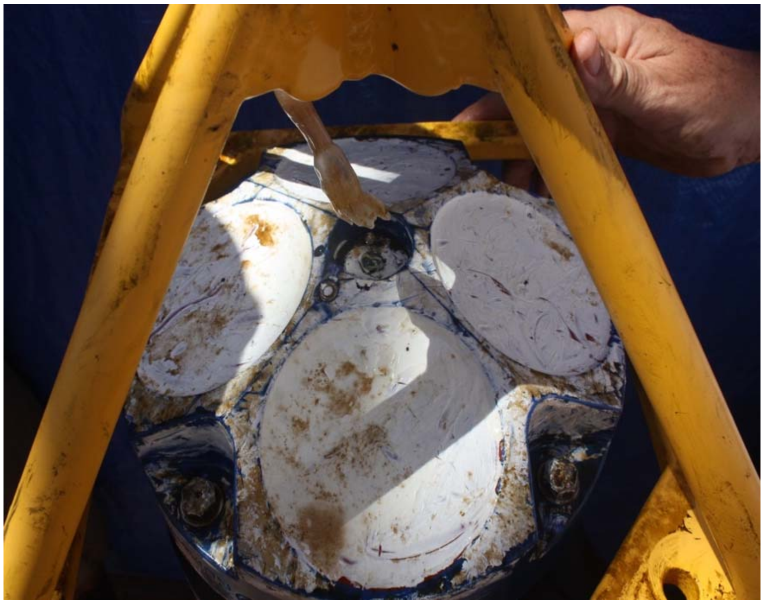


Figure 20C. WHOTS-13 ADCP (300 kHz) deployed at 125 m, after recovery.

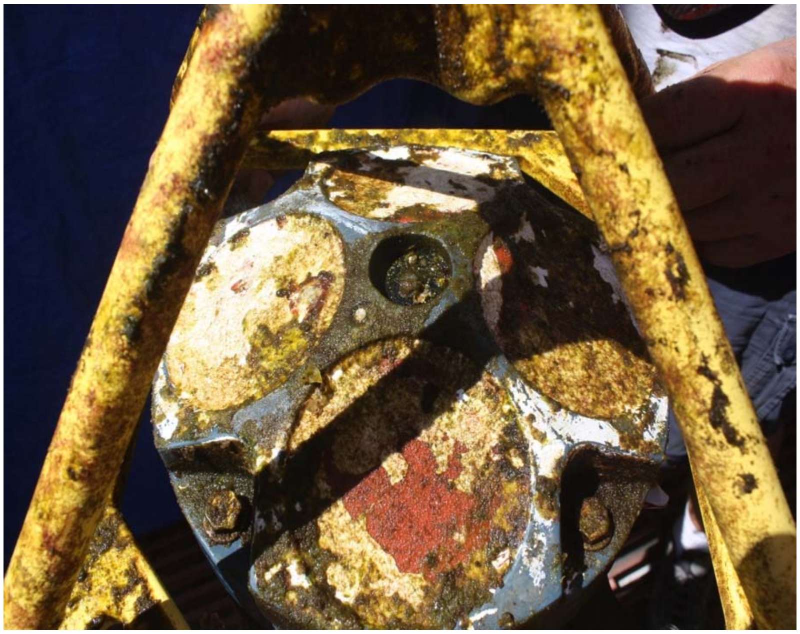


Figure 21C. WHOTS-13 ADCP (600 kHz) deployed at 47.5 m, after recovery.

300 kHz ADCP

The data from the upward-looking 300 kHz ADCP at 125 m were good; the instrument was pinging upon recovery. There appears to be no obviously questionable data from this ADCP at this time, apart from near-surface artifacts.

Figure 22C shows the variations of the horizontal and vertical components of velocity in depth and time.

Figure 23C shows the heading, pitch and roll information from the ADCP.

600 kHz ADCP

The data from the upward-looking 600 kHz ADCP at 47.5 m were good; the instrument was pinging upon recovery. There appears to be no initial questionable data from this ADCP at this time, apart from near-surface artifacts. A low speed bias is observed at certain depths.

Figure 24C shows the variations of the horizontal and vertical components of velocity in depth and time.

Figure 25C shows the heading, pitch and roll information from the ADCP.

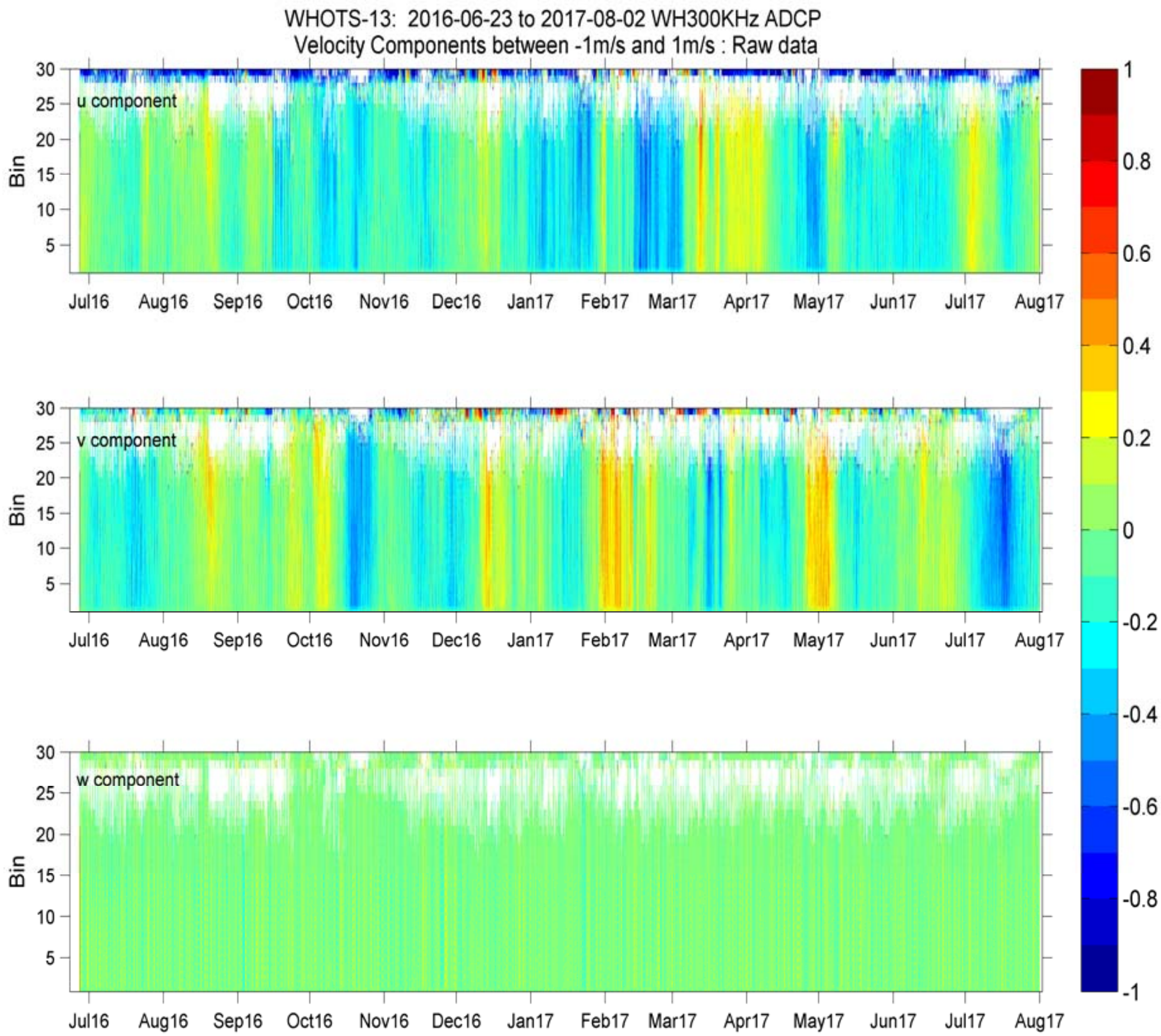


Figure 22C. Time-series of eastward, northward and upward velocity components versus bin number measured by the ADCP at 125 m depth on the WHOTS-13 mooring. Height in meters above the transducer is approximately 4 times the bin number. Current speeds greater than 1 m/s are not included. Color bar gives current speed in m/s.

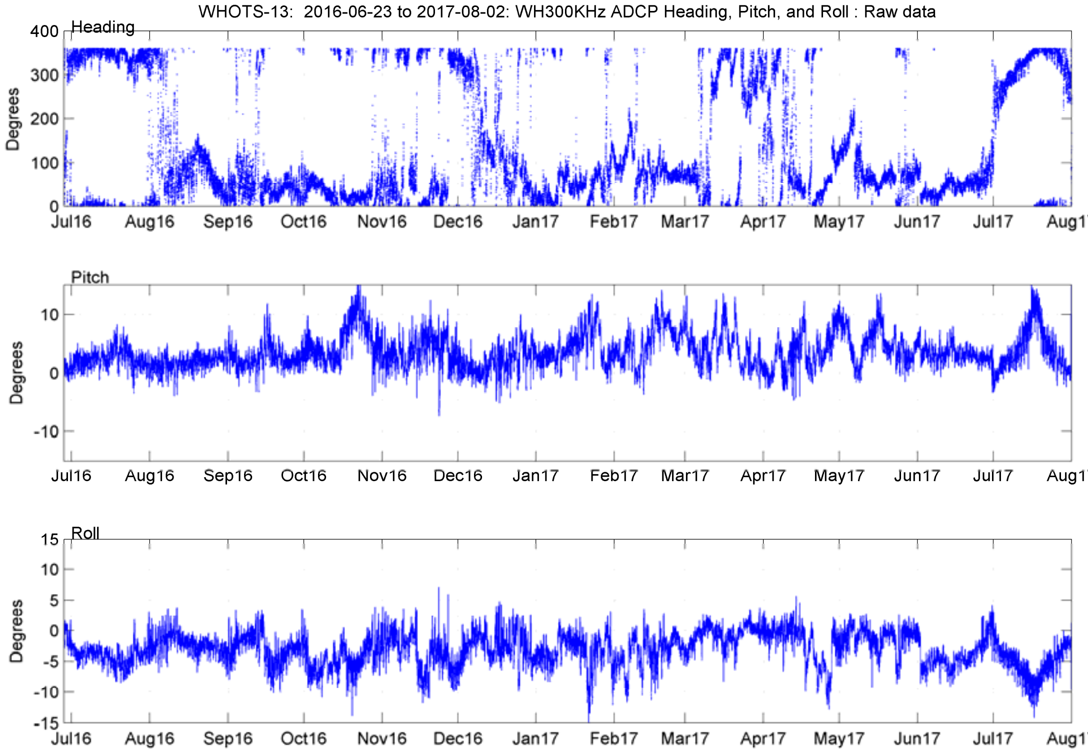


Figure 23C. Heading, pitch and roll variations measured by the ADCP at 125 m depth on the WHOTS-13 mooring.

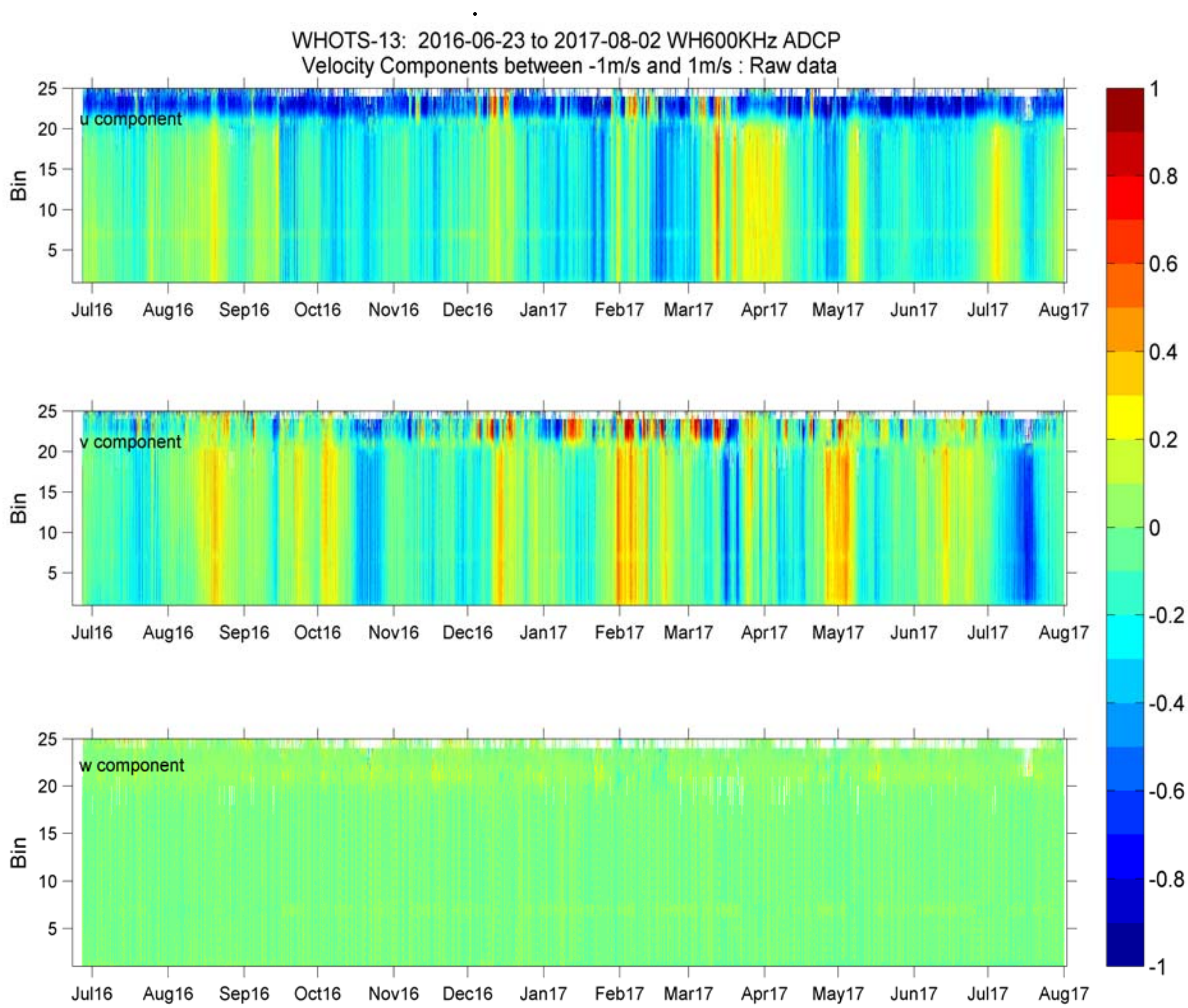


Figure 24C. Time-series of eastward, northward and upward velocity components versus bin number measured by the ADCP at 47.5 m depth on the WHOTS-13 mooring. Height in meters above the transducer is approximately 2 times the bin number. Current speeds greater than 1 m/s are not included. Color bar gives current speed in m/s.

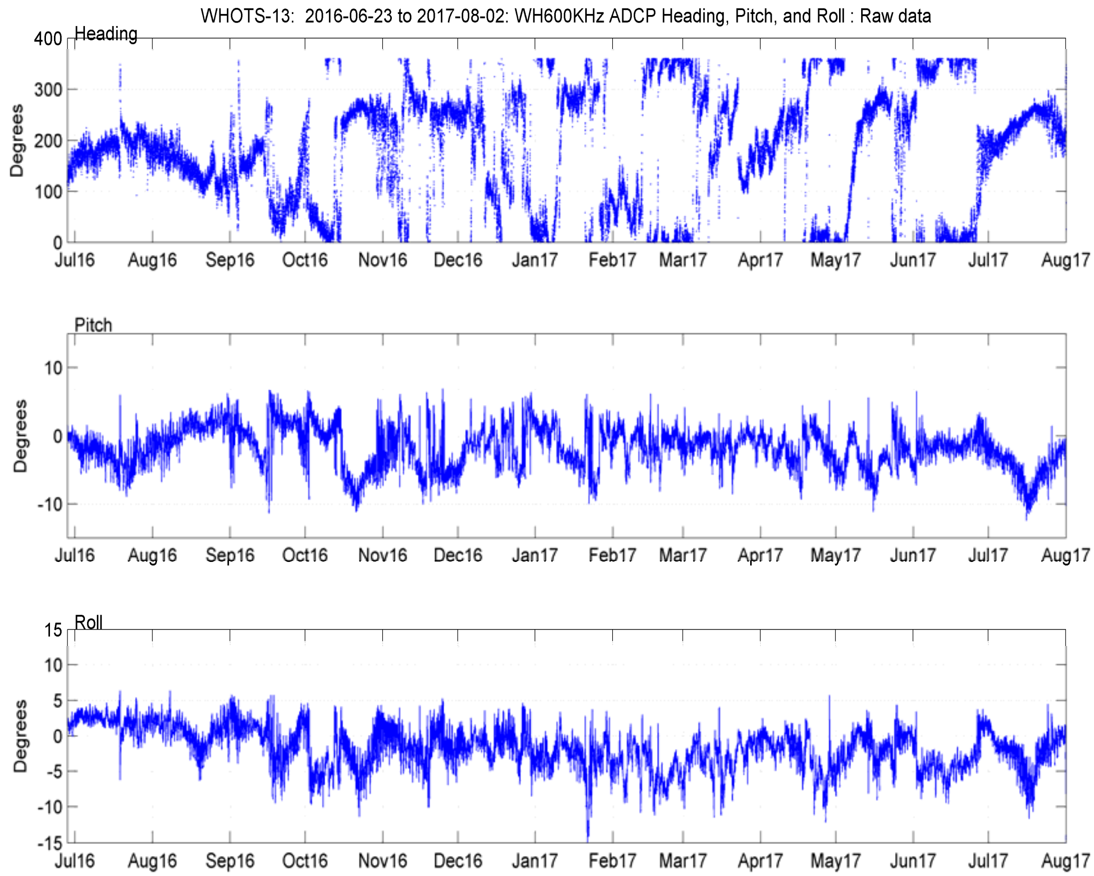


Figure 25C. Heading, pitch and roll variations measured by the ADCP at 47.5 m depth on the WHOTS-13 mooring.

Appendix D: CTD Stations

UH provided CTD and water sampling equipment, including a Sea-Bird 9/11+ CTD with pressure, dual temperature, dual conductivity and dual oxygen sensors sampling at 24 Hz. Sea-Bird sensors used routinely as part of the Hawaii Ocean Time-series were employed to tie the WHOTS cruise data into the HOT CTD dataset. The CTD was installed inside a twelve-place General Oceanics rosette with six 5-liter Niskin sampling bottles controlled by a Sea-Bird carousel. There was no GPS data available to connect to the CTD deck box to provide NMEA position and time, therefore the time and position from the ship's GPS display manually entered in the acquisition program at the beginning of each cast were used. Table 1E provides summary information for all CTD casts, and figures D1-D8 show the water column profile information that was obtained.

Table 1D. CTD stations occupied during the WHOTS-14 cruise.				
Station/cast	Date (MM/DD/YYYY, UTC)	In-water Time (HH:MM,UTC)	Location	Maximum pressure (dbar)
20/1	07/26/2017	04:32	21° 30.761´ N, 158° 22.695´ W	1525
52 / 1	07/28/2017	16:13	22° 38.835´ N, 157° 59.132´ W	215
52 / 2	07/28/2017	20:02	22° 39.229´ N, 157° 58.849´ W	207
52 / 3	07/29/2017	00:07	22° 39.199´ N, 157° 58.856´ W	214
52 / 4	07/29/2017	04:03	22° 39.087´ N, 157° 59.061´ W	490
52 / 5	07/29/2017	08:04	22° 39.328´ N, 157° 58.950´ W	213
50 / 1	07/29/2017	16:04	22° 46.002´ N, 157° 55.804´ W	215
50 / 2	07/29/2017	19:56	22° 46.072´ N, 157° 55.782´ W	215
50 / 3	07/29/2017	23:56	22° 46.048´ N, 157° 56.767´ W	211
50 / 4	07/30/2017	04:02	22° 45.763´ N, 157° 56.389´ W	214
50 / 5	07/30/2017	07:59	22° 45.961´ N, 157° 56.594´ W	215
50 / 6	07/30/2017	23:07	22° 45.608´ N, 157° 55.934´ W	3501
52 / 6	08/01/2017	23:29	22° 39.309´ N, 158° 3.562´ W	3206

Thirteen CTD casts were conducted during the WHOTS-14 cruise, from July 26 through August 1. CTD profile data were collected at Station 20 (in transit to the WHOTS mooring), Station 50 (near the WHOTS-13 buoy), and Station 52 (near the WHOTS-14 buoy). The cast at Station 20 was 1500 m deep, and three acoustic releases (two for the WHOTS-14 mooring and one backup) were attached to the rosette frame for function testing. Five CTD yo-yo casts were conducted to obtain profiles for comparison with subsurface instruments on the WHOTS-14 mooring after deployment, and five yo-yo casts were conducted for comparison with the WHOTS-13 mooring before recovery. These casts were started less than 0.5 nm from the buoys with varying drift during each cast, and consisted of 5 up-down cycles between near the surface and 210 m, except for S52C4 which was to 490 m in its last cycle. S50C1 (Fig. E4) showed conductivity and oxygen glitches at 70 dbar during the downcast of the 4th cycle, probably caused by some biology going through the plumbing. The conductivity and oxygen traces appeared to return to normal values soon after, and the secondary sensors did not show any anomaly during this event. Two 3500 m CTD casts were conducted near the WHOTS-13 and -14 buoys respectively (S50C6 and S52C6), to obtain deep Brunt–Väisälä frequency profiles. The CTD had a modulo error at 1275 dbar during the S50C6 downcast, the pumps went off momentarily, and the primary and secondary conductivity and oxygen traces showed large glitches. There was also one modulo error during S52C6 at 1210 dbar downcast, with glitches in primary and secondary oxygen. It is unknown what caused these errors, though it is suspected that one of the conductors was compromised as the wire was spooled out near this depth.

Water samples were taken from all casts; 4 samples for each of them. These samples were to be analyzed for salinity at UH and used to calibrate the CTD conductivity sensors.

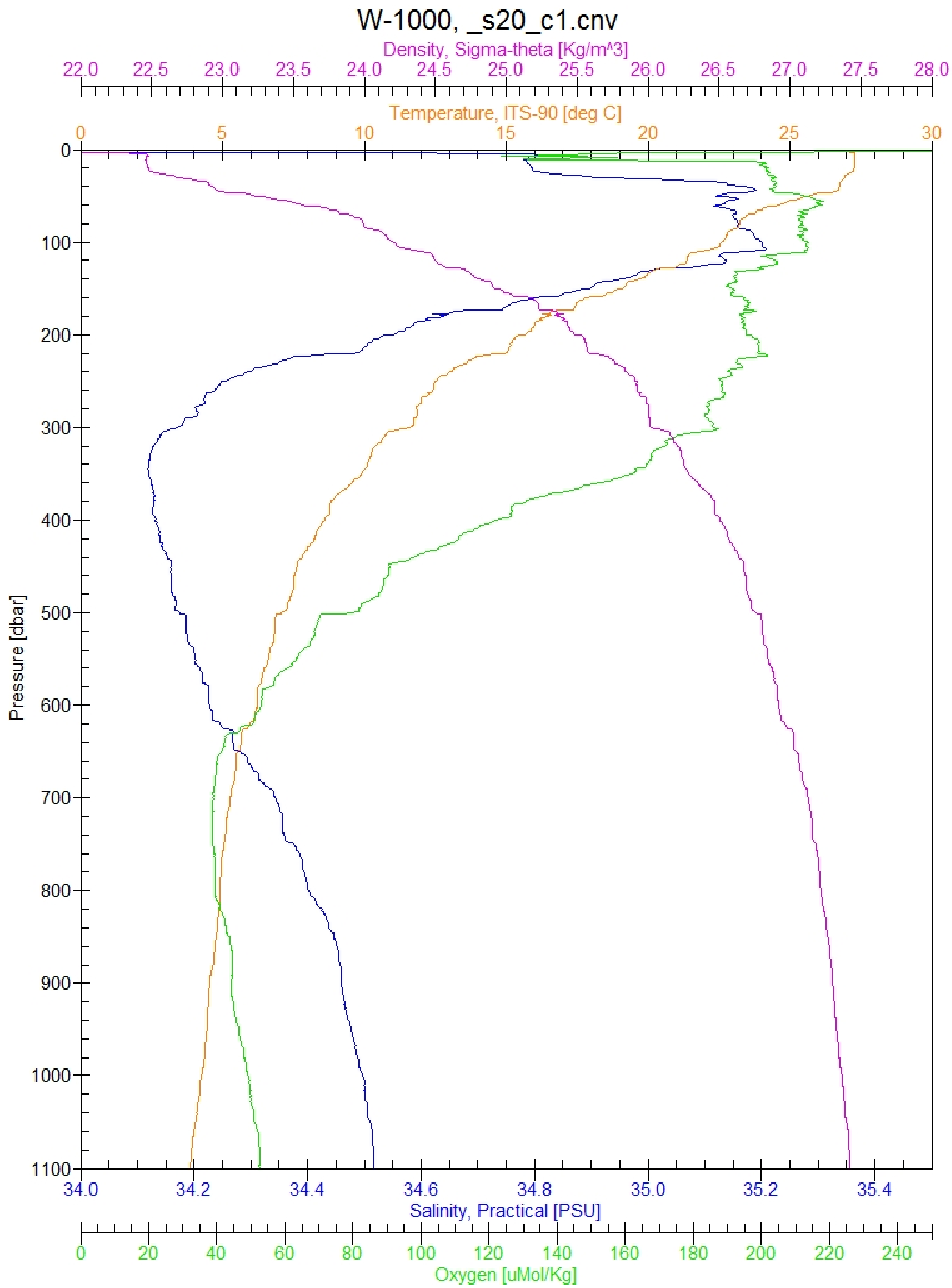


Figure D1. Profiles of 2 Hz temperature, salinity, potential density and oxygen data during the CTD at the test cast near Kaena Point (station 20) on July 26, 2017 at 04:32 Z. The glitches above 5 dbar include data when the CTD pumps were not on, and will be removed during processing.

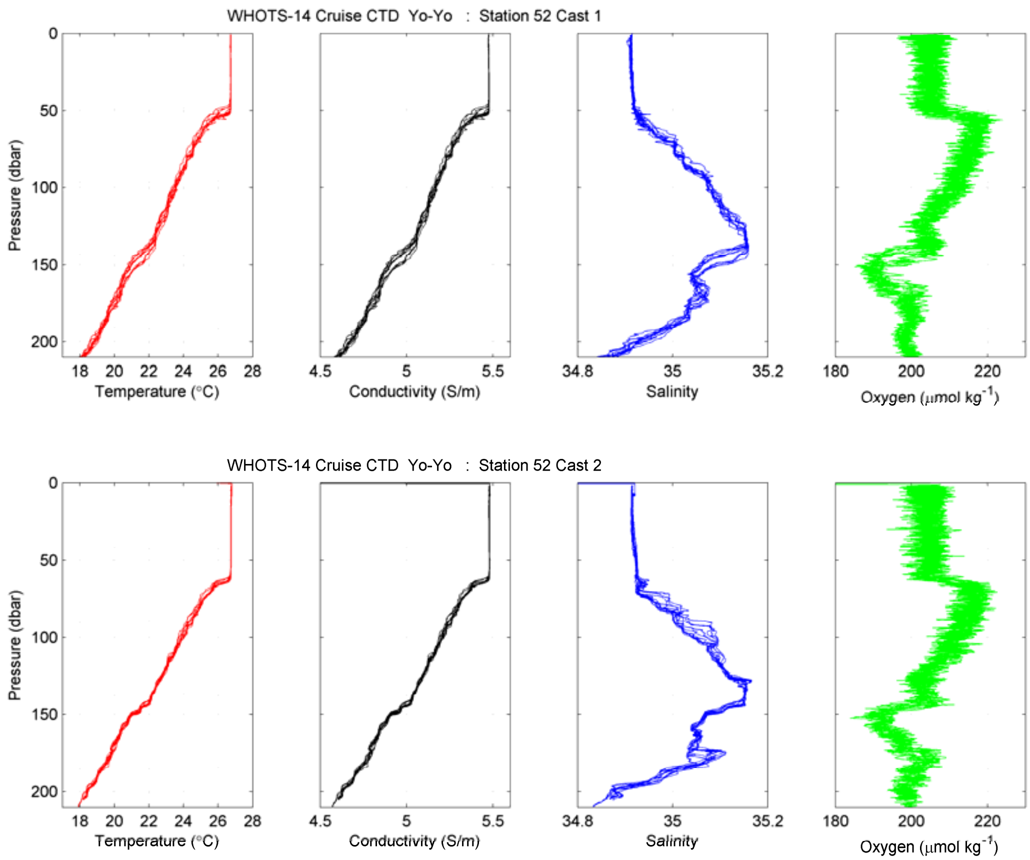


Figure D2. Profiles of 2 Hz temperature, conductivity, salinity, and oxygen data during S52C1 and S52C2 on July 28, 2017 at 16:13 Z and 20:02 Z respectively.

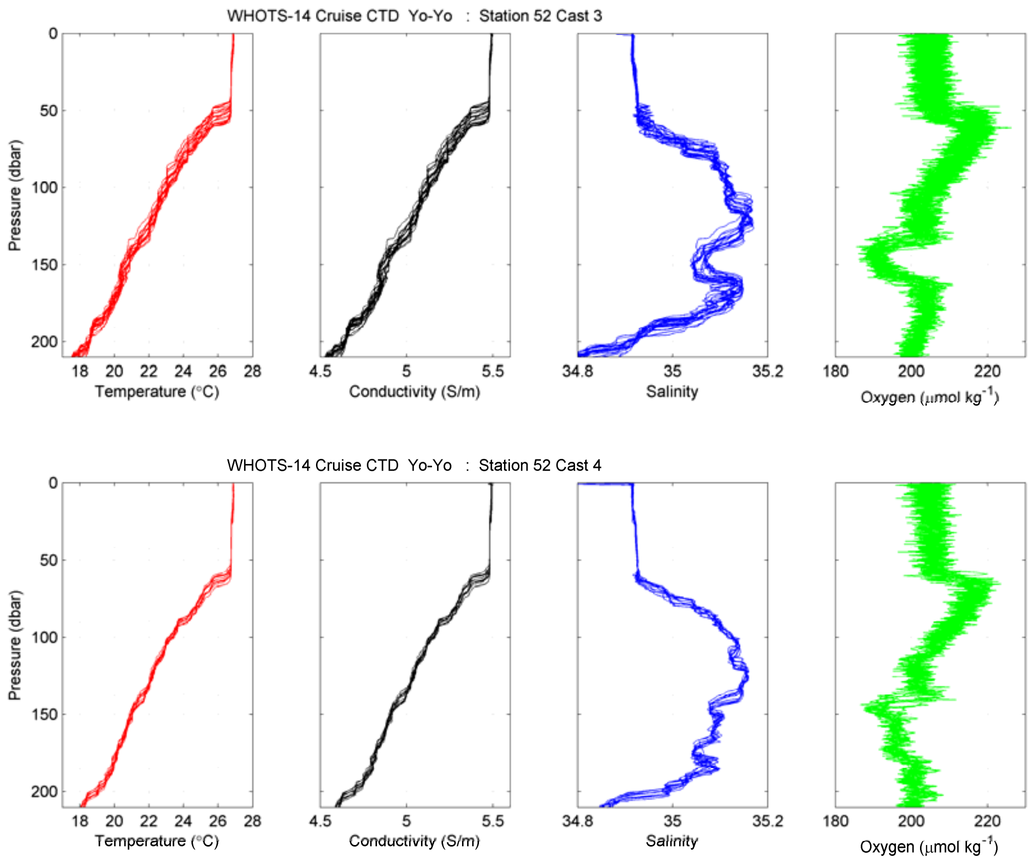


Figure D3. Profiles of 2 Hz temperature, conductivity, salinity, and oxygen data during S52C3 and S52C4 on July 29, 2017 at 00:07 Z and 04:03 Z respectively.

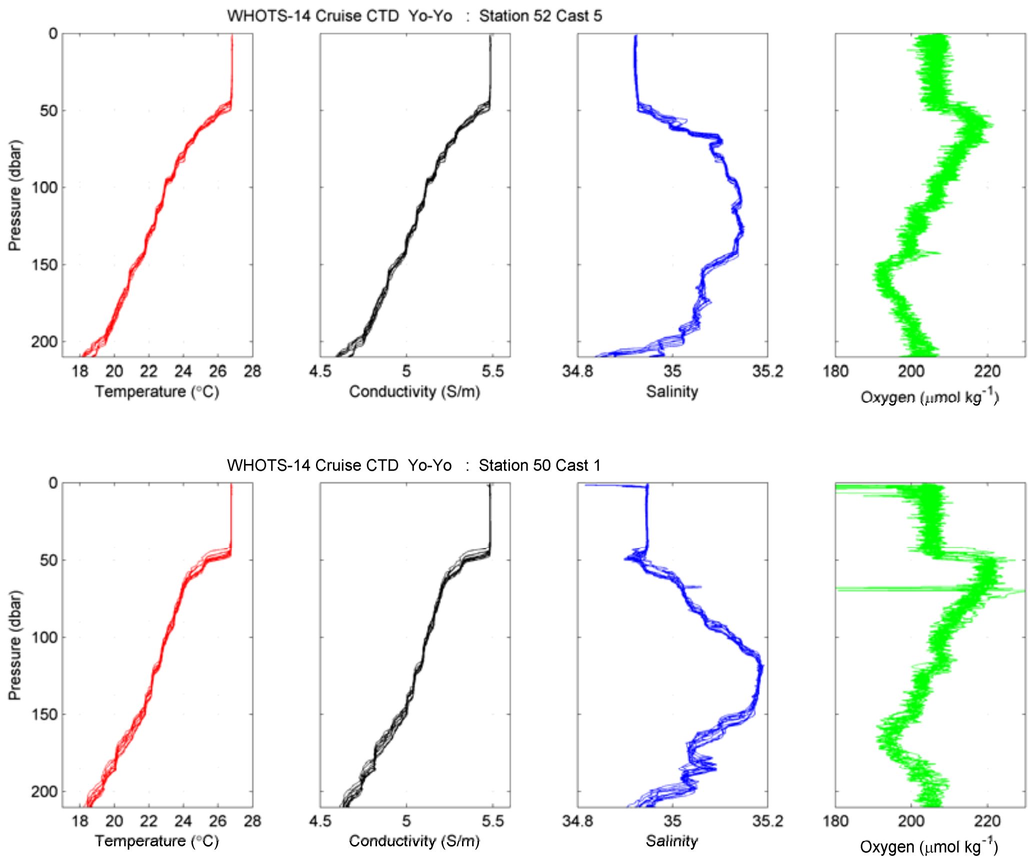
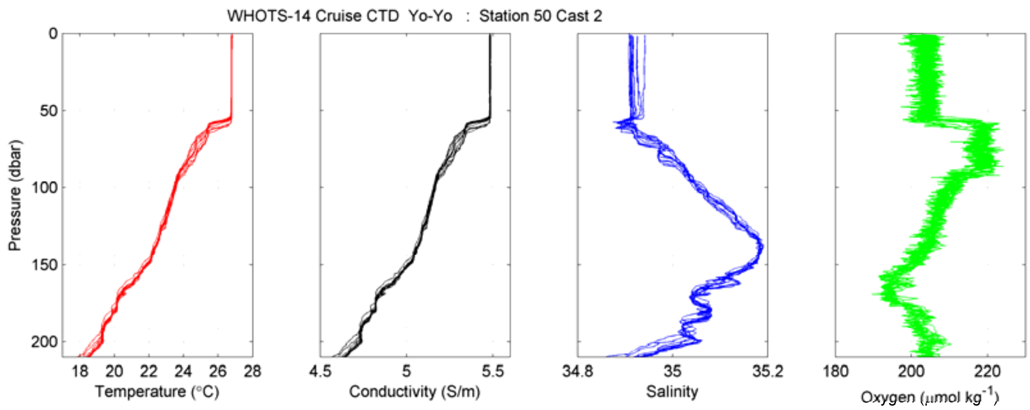


Figure D4. Profiles of 2 Hz temperature, conductivity, salinity, and oxygen data during S52C5 and S50C1 on July 29, 2017 at 08:04 Z and 16:04 Z respectively.



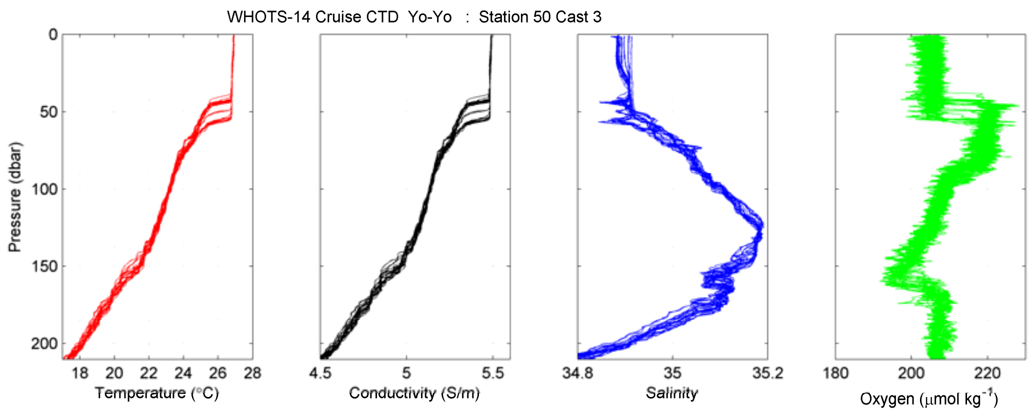


Figure D5. Profiles of 2 Hz temperature, conductivity, salinity, and oxygen data during S50C2 and S50C3 on July 29, 2017 at 19:56 Z and 23:56 Z respectively.

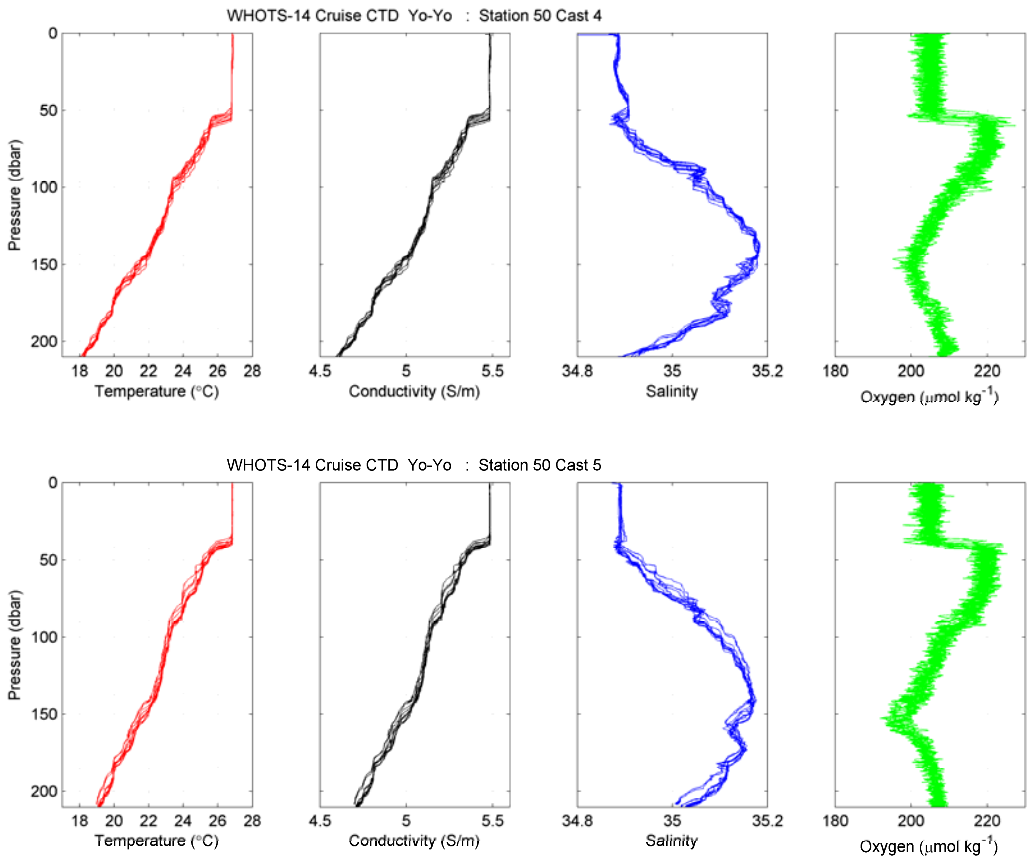


Figure D6. Profiles of 2 Hz temperature, conductivity, salinity, and oxygen data during S50C4 and S50C5 on July 30, 2017 at 04:02 Z and 07:59 Z respectively.

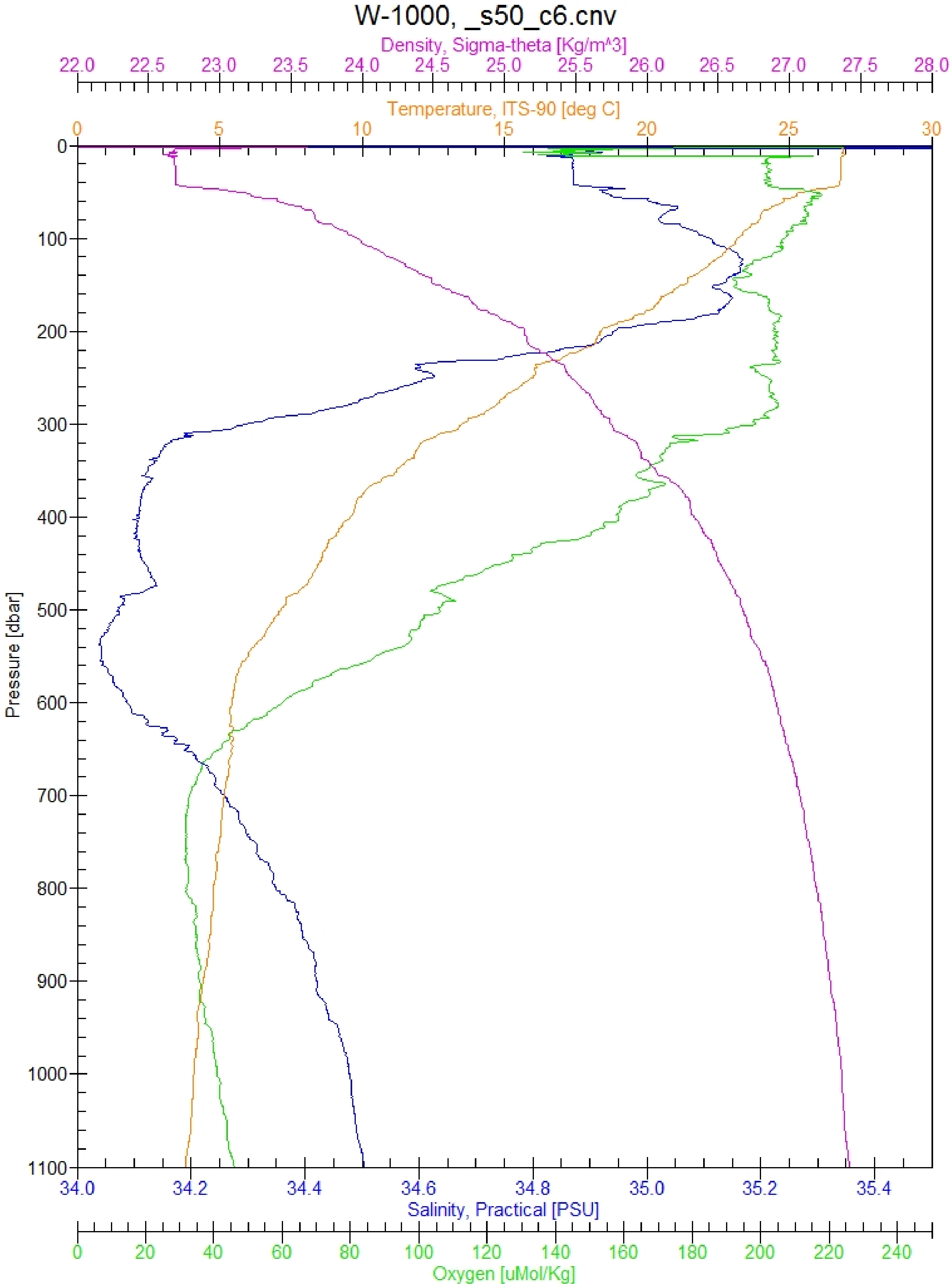


Figure D7. Profiles of 2 Hz temperature, salinity, potential density and oxygen data during the CTD cast 6 at station 50 on July 30, 2017 at 23:07 Z. The glitches above 5 dbar include data when the CTD pumps were not on, and will be removed during processing.

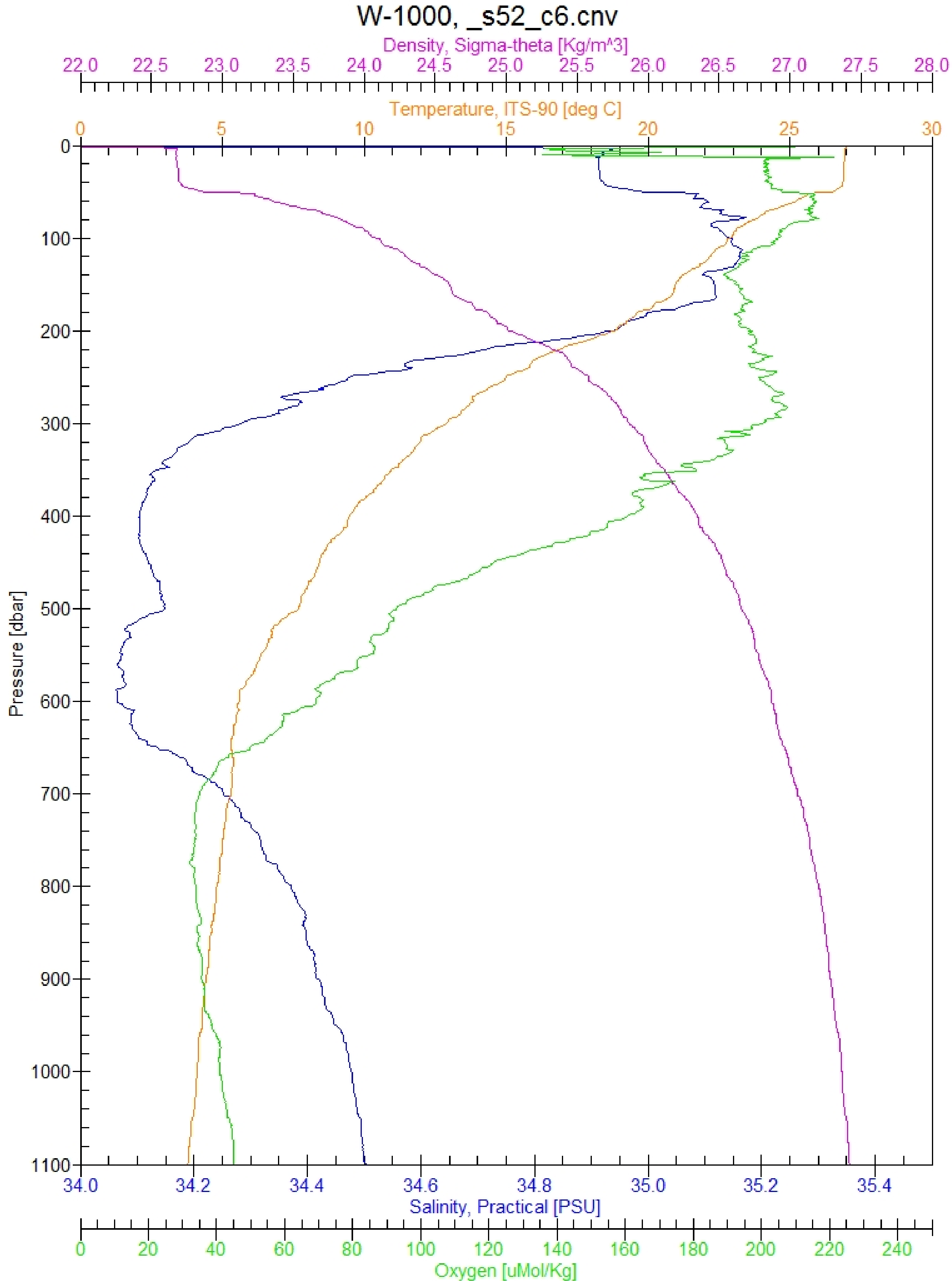


Figure D8. Profiles of 2 Hz temperature, salinity, potential density and oxygen data during the CTD cast 6 at station 52 on August 1, 2017 at 23:29 Z. The glitches above 5 dbar include data when the CTD pumps were not on, and will be removed during processing.

Appendix E: Thermosalinograph Data

Near-surface temperature and salinity data during the WHOTS-14 cruise were acquired from the thermosalinograph (TSG) system installed on the NOAA Ship *Hi'ialakai*. The *Hi'ialaki* has a water intake depth of 2 m located at the bow of the ship, next to the starboard side bow thruster. The sensors were sampling water from the continuous seawater system running through the ship, and were comprised of one thermosalinograph model SBE-21 (SN 3155) and a micro-thermosalinograph model SBE-45 (SN 4540403-0150), both with (internal) temperature and conductivity sensors located in the ship's wet lab, about 67 m from the intake; and an SBE-38 (SN 215) external temperature sensor located at the water intake. The SBE-21 recorded data every 5 seconds, and the other two instruments recorded data every second. The system had a pressure gauge showing a flow pressure of about 20 psi, decreasing to 18 psi when the water intake was open. Both thermosalinograph systems had a debubbler.

The SBE-45 record contains a number of very large conductivity and temperature glitches (Figures E1, E2); however, temperature data comparisons between the SBE-45 and SBE-21 were within ± 0.05 °C outside these glitches (Figure F3). Conductivity and calculated salinity for the SBE-21 seem to be of good quality. The records from the external and internal temperature sensors are also of good quality; however, temperature differences between the SBE-21 and SBE-38 cycle between ± 0.5 °C offset on a diurnal time scale (probably mostly due to ocean, but ship's temperatures also have diurnal cycle). Higher frequency cyclic temperature differences were also noted between the SBE-21 and SBE 38, typically close to 00:00 UTC. The ship's navigation data are also plotted (Figure E4).

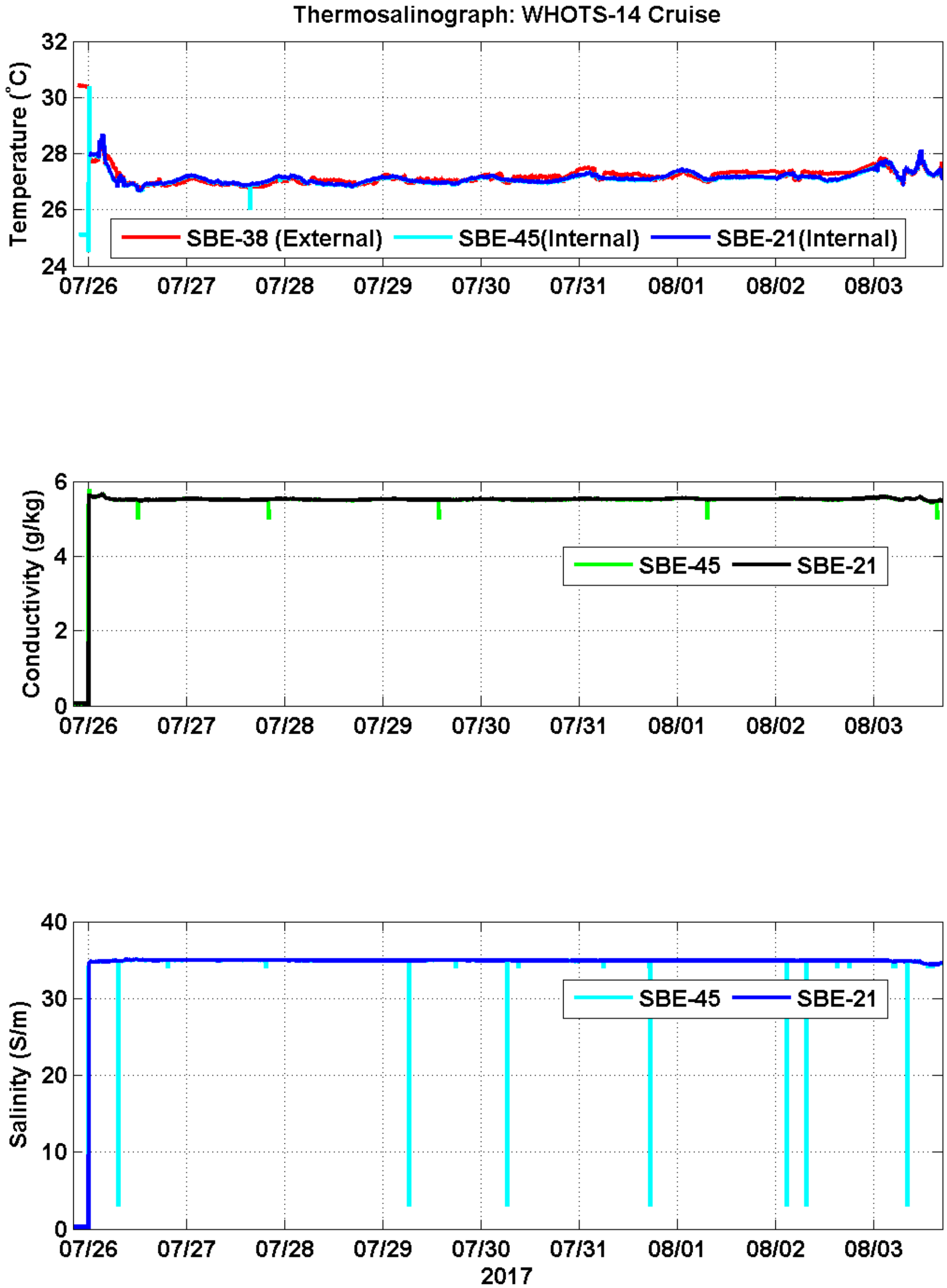


Figure E1. Time-series of Ship Hi'ialakai thermosalinograph data from the WHOTS-14 deployment cruise. Times are UTC.

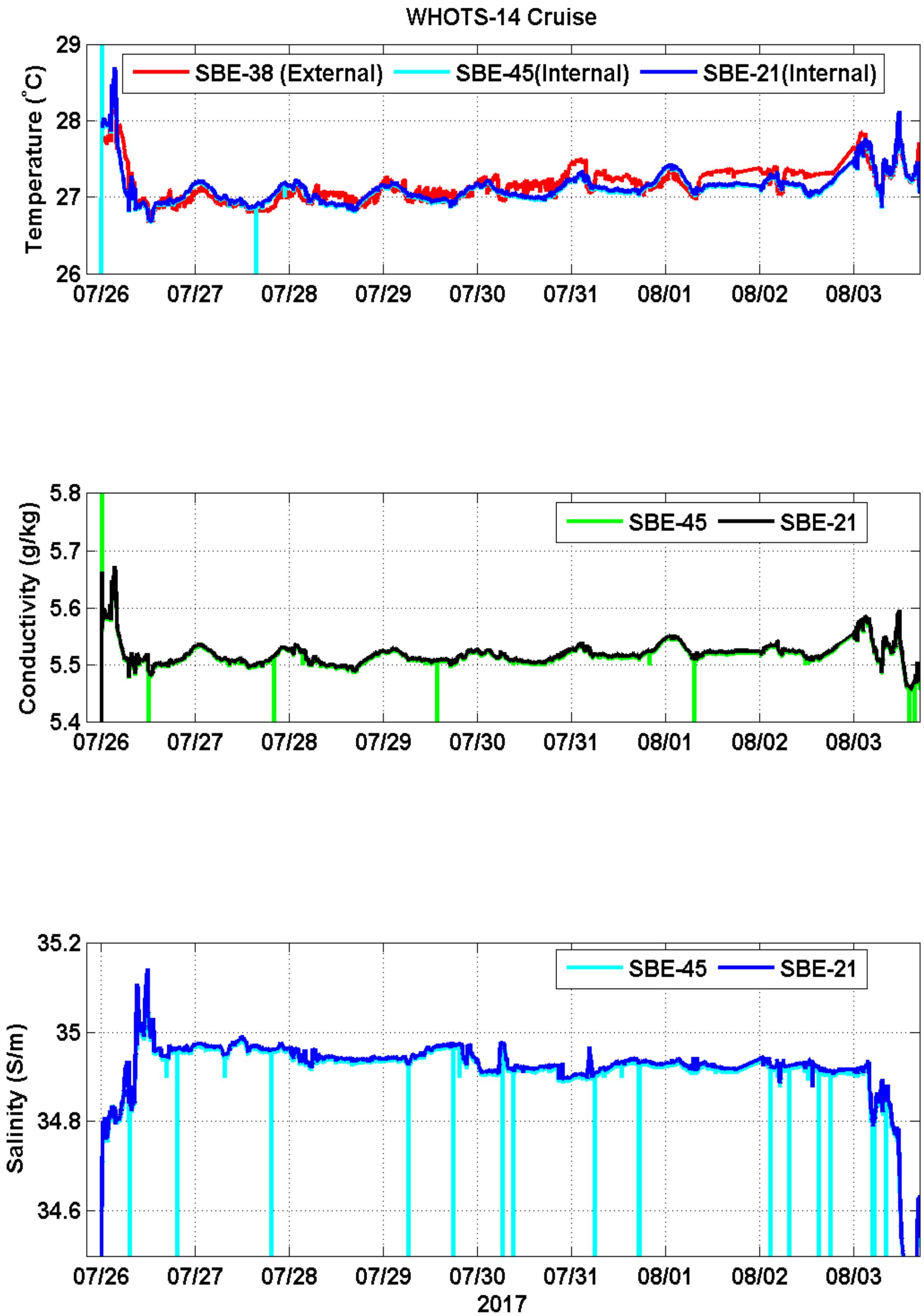


Figure E2. Same as in Figure 8a, but with different scales in the y-axis.

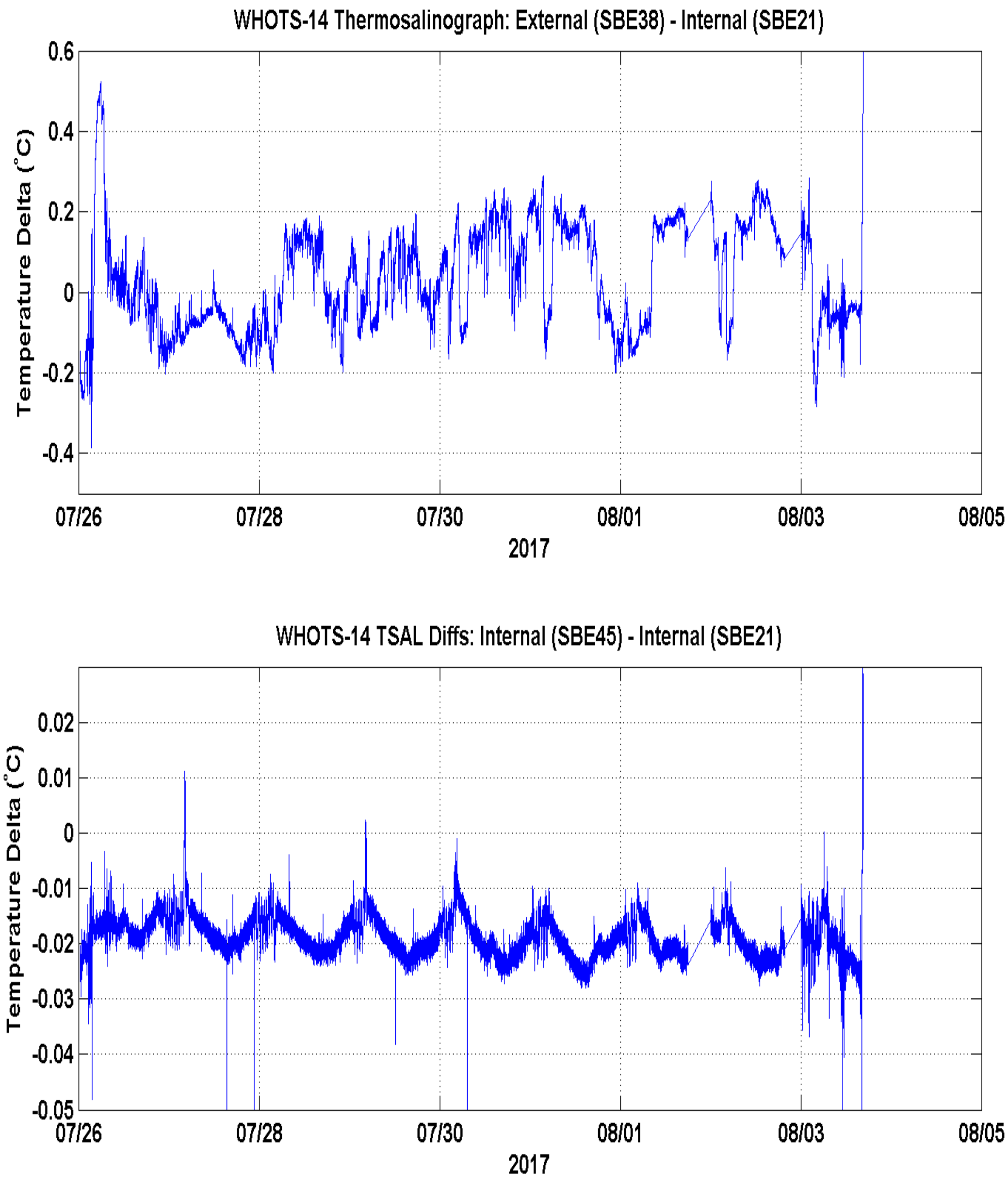


Figure E3. Temperature difference between SBE-38 external and SBE-21 internal thermosalinograph sensors (top), and between internal SBE-21 and SBE-45 sensors (bottom),

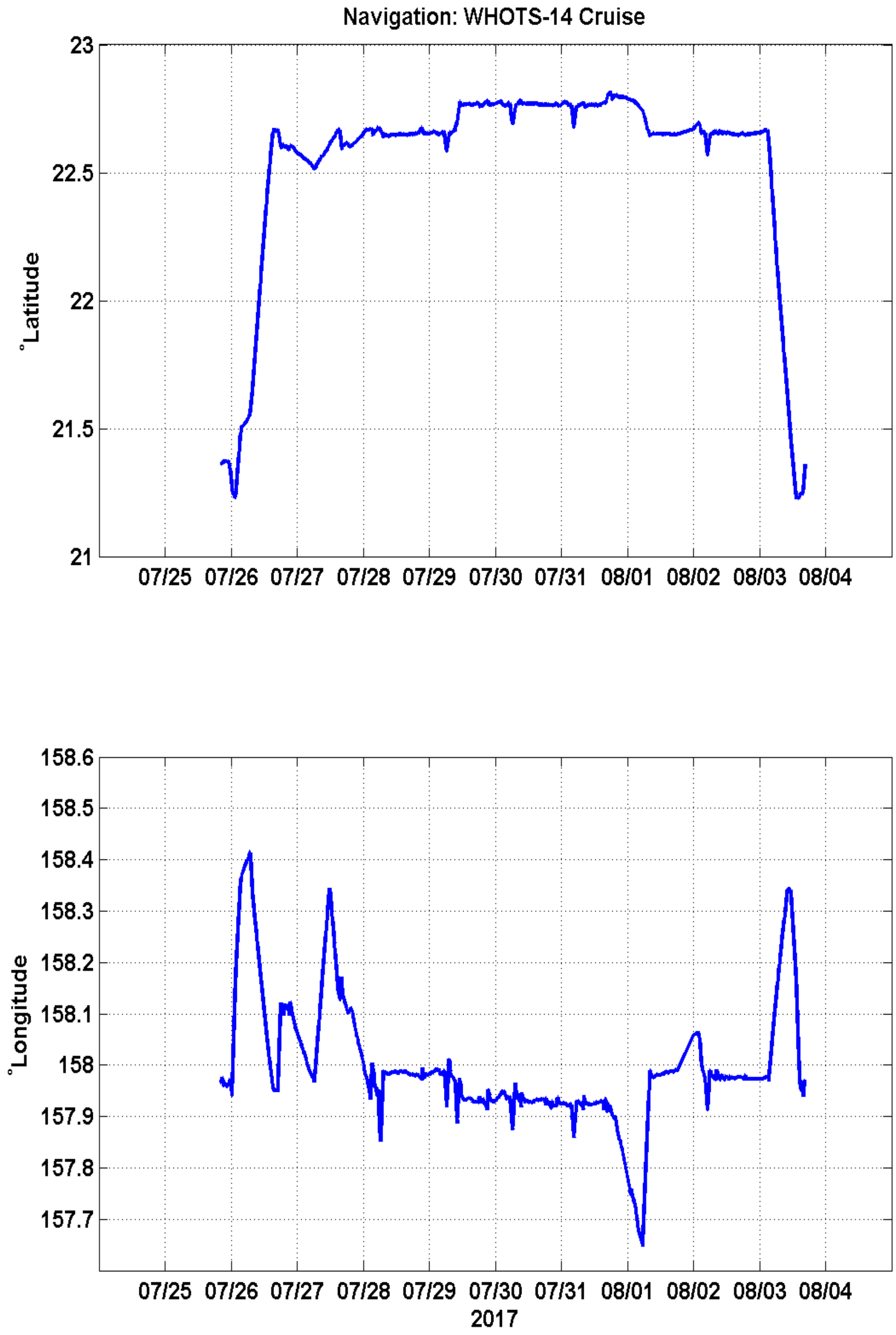


Figure E4. Time-series of Ship *Hi'ialakai* navigation data during the WHOTS-14 cruise.

Appendix F: WHOTS-13 Recovered Buoy Hull Instrumentation

Figure F1. WHOTS-13 buoy hull SST instruments.

Figure F2. WHOTS-13 PMEL SAMI

Figure F3. WHOTS-13 PMEL SBE 16

Appendix G: NOAA teacher-at-Sea

I love using data in my classroom. One of my favorite things to do, when I am introducing a topic to my students, is to give them a data set -- either raw numbers, graphs, or other visualizations -- and have them draw some preliminary conclusions. What is the data doing? Are there trends that you notice? Does anything stand out to you? Look weird? Because I teach Earth Science, there is a wealth of publicly available data, from the USGS, from NASA, from NOAA. For just about anything I choose to teach, from the atmospheres of exoplanets to mass extinction events, a quick Google search almost always yields useful, peer-reviewed, scientific data. However, until I had the opportunity to sail aboard the *Hi'ialakai* and observe the deployment of the WHOTS-14 buoy and the retrieval of the WHOTS-13 buoy, I never quite appreciated just how difficult obtaining all the data I use could be.

Despite my best efforts, I think my students still believe that science is a solitary pursuit -- something done by people in white coats in a lab somewhere. I hope that my experiences aboard the *Hi'ialakai* will help me paint a more realistic picture of what science is all about for my students. It's a highly collaborative profession that needs people with all sorts of skills; not only science, but computer programming, mathematics, technology, logistics, resourcefulness and patience. I also hope be able to impress upon my students just how difficult doing good science can be. I know that I will certainly never look at the data sets I download with just a few clicks of my mouse the same way again.

Samantha Adams
NOAA Teacher at Sea
Pan American International High School at Monroe
Bronx, New York
August 2017

Appendix H: Moored Station Logs

Moored Station Log

(fill out log with black ball point pen only)

ARRAY NAME AND NO. WHOTS-13 MOORED STATION NO. 1280

Launch (anchor over)

Date (day-mon-yr) ~~26~~ 27 Jun 2016 | Time 0847 UTC

Deployed by Cole/Smith | Recorder/Observer Plueddemann

Ship and Cruise No. HA-16-05 | Intended Duration 12 mo

Depth Recorder Reading 4669 m | Correction Source HOT CTD: 1506 m/s =4%, = 19 m, + 5 m 'ducer depth

Depth Correction +24 m

Corrected Water Depth 4693 m | Magnetic Variation (E/W)

Anchor Drop Lat. (N/S) 22° 47.402 | Lon. (E/W) 157° 54.481

Surveyed Pos. Lat. (N/S) 22° 47.240 | Lon. (E/W) 157° 54.450

Argos Platform ID No. see pg 2-3 | Additional Argos Info on pages 2 and 3

Acoustic Release Model Edgetech 8242 | Tested to 1500 m

Release No. 1 (sn) 31269 | Release No. 2 (sn) 48278

Interrogate Freq. 11 kHz | Interrogate Freq. 11 kHz

Reply Freq. 12 kHz | Reply Freq. 12 kHz

Enable 460272 | Enable 567611

Disable 460303 | Disable 567632

Release 444155 | Release 551165

Recovery (release fired)

Date (day-mon-yr) 31 July 2017 | Time 16:38 UTC

Latitude (N/S) 22° 47.464 | Longitude (E/W) 157° 54.654

Recovered by Hasbrouck / Weller | Recorder/Observer Clabaugh

Ship and Cruise No. HA 17-02 | Actual duration days

Distance from waterline to buoy deck 70 cm (visual inspect.)

1

ARRAY NAME AND NO. WH-13 MOORED STATION NO. 1280

Surface Components

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

Buoy Markings 'B', If found adrift: U. Hawaii 808-956-7896

Surface Instrumentation

Item	ID #	Height*	Comments
Logger	L19	—	SYS-1
PTT	99595	—	IDs 14663, 14677, 14697
HRH	249	237 cm	
BPR	224	243	
WND	705	265	
PRC	506	237	
LWR	207	280	
SWR	226	280	
SST	1306	-150	
Logger	L42	—	SYS-2
PTT	14637	—	IDs 07563, 07581, 07582
HRH	211	237	
BPR	502	243	
WND	703	265	
PRC	205	237	
LWR	502	280	
SWR	229	280	
SST	1727	-150	
Xeos Melo		—	IMEI 300034013701980
SBE-39 AT	3795	225	
Vais. WXT	203	251	
Lascar	307	206	
Sonic WND	216	278	
pCO_2	see pg 3	—	

*Height above buoy deck in centimeters

ARRAY NAME AND NO. WH-13 MOORED STATION NO. 1280

Subsurface Instrumentation on Buoy and Bridle			
Item	ID #	Depth†	Comments
SST	6150	80 cm	SBE-56 180° CW from vane
SST	6239	95	" 180
SST	6410	80	" 120
SST	6412	80	" 240
Sable		—	Irid. GPS 3000 340139705090
PMEL	pCO_2	System	
pCO_2	170	84 cm ht	Battelle MAPCO2
CTD	7202	150 cm	SBE-16
fluoro	4132	150	WETlabs ECOFLNTUS
oxy	103/1339	150	Aanderaa optode
pH	P0045	150	SAMI2/ Sunburst

†Depth below buoy deck in centimeters

ARRAY NAME AND NO. WHOTS-13 MOORED STATION NO. 1280

Item No.	Length (m)	Item	Depth	Inst No.	Time Over 6/26/16	Time Back ~~[illegible]~~ 7-1-17	Notes
1		buoy	0	—	1913	1:55	~~[illegible]~~ μCats mounted to buoy have bent cages on recovery
2	5.26	3/4 chain		—		1:55	
3		μCAT	7	6892.	1833	2:13	w/press, pulled back out of water after initial dunk
4	1.3	3/4 chain		—		2:14	
5		VMCM	~~2016~~ 10	2016.	1833	2:17	bands off 1825
6	2.82	3/4 chain		—		2:18	
7		μCAT	15	3382.	1829	2:20	
8	8.1	3/4 chain		—		2:21	
9		μCAT	25	4663.	1820	2:25	
10	3.28	3/4 chain		—		2:25	
11		VMCM	30	2075.	1819	2:25	bands off 1813
12	2.82	3/4 chain		—		2:29	
13		μCAT	35	3633.	1815	2:29	
14	3.66	3/4 chain		—		2:29	
15		μCAT	40	3381.	1810	2:30	
16	3.66	3/4 chain		—		2:34	
17		μCAT	45	3668.	1805	2:35	w/press
18	1.07	3/4 chain		—		~~0:51~~	Time Back: 2:35
19		ADCP	47.5	13917.		0:51	600kHz
20	75.5	7/16 wire		15014-6	~~15014-6~~ 0937	0:39	erroneously used local time for deploy starting here, add 10h for UTC
21		μCAT	50	3619.	0937	0:51	
22		μCAT	55	3620.	0939	0:50	
23		μCAT	65	3621.	0940	0:49	
24		μCAT	75	3632.	0942	0:47	
25		μCAT	85	4699.	0943	0:46	w/press

4

ARRAY NAME AND NO. WHOTS-13 MOORED STATION NO. 1280

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back 8-1-17	Notes
26		µCAT	95	3791	0944	0:46	
27		µCAT	105	2769	0945	0:45	w/press
28		µCAT	120	4700	0953	0:43	w/press
29		ADCP	125	7637	0954	0:39	300kHz
30	250	3/8 wire		15014-4		0:26	nick in wire at 0:34
31		µCAT	135	2965	0955	0:38	w/press
32		µCAT	155	4701	0957	0:37	w/press
33	500	3/8 wire		16007-3	2004	8-1-17 0:12	back to UTC starting here
34	500	3/8 wire		~~16007-2~~	~~2036~~	7-31-17 23:57	damaged, recovered, replaced w/ spare 15007-4
35	500	3/8 wire		15014-2	0433 06/27	23:37	
36	100	3/8 wire		15014-5	0442	23:33	} potted urethane termination
37	200	7/8 nylon		—	0500	23:17	
38	2050	7/8 nylon		—	0520	22:05	All back in at 23:17
39	1500	1" colmega		—	0551	19:04	All back in at 22:05
40		glass balls		—	0645	18:58	
41		SBE37	36m above bottom	12246	0813	~~18:58~~	plugs out Time Back: 19:14
42		SBE37		12247		~~18:58~~	Time Back: 19:14
43	5	1/2" chain		—		~~18:58~~	Time Back: 19:14
44		release		31269	0814	~~18:58~~	Time Back: 19:18
45		release	dual	48278	0814	~~18:58~~	Time Back: 19:18
46	5	1/2" chain		—			
47	20	1" samson		—			
48	5	1/2 chain		—			
49		anchor		—	0847		9300lb (air), 8000 (wet)
50							

5

Moored Station Log

(fill out log with black ball point pen only)

ARRAY NAME AND NO. WHOTS-14 MOORED STATION NO.

Launch (anchor over)

Date (day-mon-yr) 28 July 2017 Time 02:19 UTC UTC

Deployed by Hasbrouck / Weller Recorder/Observer Clabaugh

Ship and Cruise No. HA-17-02 Intended Duration 12m

Depth Recorder Reading NA m Correction Source

Depth Correction m

Corrected Water Depth m Magnetic Variation (E/W)

Anchor Drop Lat. (N/S) 22° 40.158' Lon. (E/W) 157° 56.803'

Surveyed Pos. Lat. (N/S) 22° 40.0358' Lon. (E/W) 157° 57.0703'

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

Acoustic Release Model Edgetech 8242XS Tested to 1500m m

Release No. 1 (sn) 33412	Release No. 2 (sn) 35323
Interrogate Freq. 11 kHz	Interrogate Freq. 11 kHz
Reply Freq. 12 kHz	Reply Freq. 12 kHz
Enable 361226	Enable 111655
Disable 361243	Disable 111676
Release 346443	Release 127562

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 60 cm

1

ARRAY NAME AND NO. WHOTS-14 MOORED STATION NO.

Surface Components

Buoy Type____ Color(s) Hull Tower blue hull, white tower

Buoy Markings If found adrift contact U of Hawaii Honolulu, HI USA 808-956-7896 , 'B'

Surface Instrumentation

Item	ID #	Height*	Comments
Logger	L08		System-1
IR	J104NF		300234063345500
HRH	257	240 cm	
BPR	240	237	
SWND	268	279	
PRC	215	256	
LWR	224	286	
SWR	502	286	
SST	1834	157	
Logger	L09		System-2
PTT	63879		IDS 07561, 27415, 27416
HRH	223	240	
BPR	216	237	
WND	239	270	
PRC	213	256	
LWR	261	286	
SWR	505	286	
SST SBE37	1841	157	
Xeos mello			IMEI 300034013709960
SBE-39-AT	1446	223	
Loscar	1003228	229	
VWX	007	241	
Xeos Sable			IMEI 300034012194230

*Height above buoy deck in centimeters

ARRAY NAME AND NO. WHOTS-14 MOORED STATION NO.

Subsurface Instrumentation on Buoy and Bridle			
Item	**ID #**	**Depth†**	**Comments**
SST	7215	80m	SBE 56 315° Stbd
SST	7214	90	SBE 56 0° bow low
SST	7213	80	SBE 56 0° bow high
SST	7212	80	SBE 56 45° port
PMEL	pCO_2	System	
pCO_2	179	-157	battelle MAPCO2
pH	59	-157	SAMI/Sunburst
CTD	7412	-157	SBE16
oxy	515	-157	SBE 63
fluoro	1950	-157	wet labs

†Depth below buoy deck in centimeters

ARRAY NAME AND NO. WHOTS-14 **MOORED STATION NO.** ________

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
1		buoy	0		19:11		Date: 7-27-17
2	5.26	3/4 chain			18:29		
3		MicroCat	7	3617	18:29		
4	1.30	3/4 chain			18:26		
5		VMCM	10	042	18:25		spin time: 18:25 in water: 18:26
6	2.82	3/4 Chain			18:19		
7		MicroCat	15	6893	18:19		
8	8.10	3/4 chain			18:15		
9		Micro Cat	25	6894	18:15		
10	3.28	3/4 Chain			18:12		
11		VMCM	30	068	18:10		spin time: 18:10 in water: 18:12
12	2.82	3/4 chain			18:07		
13		MicroCat	35	6895	18:07		
14	3.66	3/4 Chain			18:07		
15		MicroCat	40	6896	18:04		
16	3.66	3/4 Chain			18:04		
17		MicroCat	45	6887	18:02		
18	1.07	3/4 chain			19:30		
19		ADCP	47.5	1825	19:30		
20	75.5	7/16 wire		16074	19:30		
21		MicroCat	50	6897	19:31		
22		MicroCat	55	6898	19:33		
23		MicroCat	65	6899	19:35		
24		MicroCat	75	3618	19:36		
25		MicroCat	85	3634	19:38		

4

ARRAY NAME AND NO. WHOTS-14 MOORED STATION NO.________

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
26		MicroCat	95	3670	19:40		
27		MicroCat	105	6889	19:42		
28		MicroCat	120	6890	19:54		
29		ADCP	125	4891	19:55		
30	250	3/8 wire		16007-5	19:55		
31		MicroCat	135	6888	19:57		
32		MicroCat	155	6891	19:59		
33	500	3/8 wire		17044-2	20:15		
34	500	3/8 wire		17044-4	20:44		
35	500	3/8 wire		17044-3	21:00		
36	100	3/8 wire		16007-6	21:16		
37	200	7/8 nylon			21:21		
38	2100	7/8 nylon			21:47		
39	1500	1" colmega			22:18		7-27-17
40		glass balls			23:38		1st ball in at 23:38 last ball in at 0:30 7-28-17 / note: 1 broken ball added spare ½" chain of 4
41		SBE37	36 m off	9988	02:02		Date 7-28-17
42		SBE37	the bottom	10602	02:02		
43	5	½" chain			02:02		
44		release 2	Dualed	35323	02:03		
45		release		33412	02:03		
46	5	½" chain			02:03		
47	20	1" samson			02:10		
48	5	½" chain			02:19		
49		anchor			02:19		22° 40.158 N 157° 56.803
50							

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16. Abstract (Limit: 200 words)
The Woods Hole Oceanographic Institution (WHOI) Hawaii Ocean Time-series Station (WHOTS), located approximately 100 km north of Oahu, Hawaii, is intended to provide long-term, high-quality air-sea fluxes as a part of the NOAA Climate Observation Program. The WHOTS mooring also serves as a coordinated part of the Hawaii Ocean Time-series (HOT) program, contributing to the goals of observing heat, fresh water and chemical fluxes at a site representative of the oligotrophic North Pacific Ocean. The approach is to maintain a surface mooring instrumented for meteorological and oceanographic measurements at a site near 22.75°N, 158°W by successive mooring turnarounds. These observations are used to investigate air–sea interaction processes related to climate variability.

This report documents recovery of the thirteenth WHOTS mooring (WHOTS-13) and deployment of the fourteenth mooring (WHOTS-14). Both moorings used Surlyn foam buoys as the surface element and were outfitted with two Air–Sea Interaction Meteorology (ASIMET) systems. Each ASIMET system measures, records, and transmits via Argos and Iridium satellite the surface meteorological variables necessary to compute air–sea fluxes of heat, moisture and momentum. The upper 155 m of the moorings were outfitted with oceanographic sensors for the measurement of temperature, conductivity and velocity in a cooperative effort with Dr. Roger Lukas of the University of Hawaii.

17. Document Analysis a. Descriptors

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