The University of Hawaiʻi at Mānoa

Hydrographic Observations At the Woods Hole Oceanographic Institution Hawaii Ocean Time-series Site: 2021 - 2022

by

Fernando Carvalho Pacheco[1], Fernando Santiago-Mandujano[1], James Potemra[1], Albert Plueddemann[2], Robert Weller[2], Daniel Fitzgerald[1], and Nan Galbraith[2]

Tuesday 13th February, 2024

Data Report - 17

Approved for public release; distribution unlimited.

The University of Hawaiʻi at Mānoa
School of Ocean and Earth Science and Technology
1000 Pope Road, Honolulu, Hawaii 96822

SOEST Publication no. 11768

[1]The University of Hawaii at Manoa
[2]Woods Hole Oceanographic Institution (WHOI)

Hydrographic Observations At the Woods Hole Oceanographic Institution Hawaii Ocean Time-series Site: 2021 - 2022

by

Fernando Carvalho Pacheco[1], Fernando Santiago-Mandujano[1], James Potemra[1], Albert Plueddemann[2], Robert Weller[2], Daniel Fitzgerald[1], and Nan Galbraith[2]

The University of Hawaiʻi at Mānoa
School of Ocean and Earth Science and Technology
1000 Pope Road
Honolulu, Hawaii 96822
U.S.A

Tuesday 13th February, 2024

Data Report - 17

This report should be cited as Carvalho Pacheco, F., Santiago-Mandujano, F., Potemra, J. T., Plueddemann, A. J., Weller, R. A., Fitzgerald, D., & Galbraith, N. R. (2024). Hydrographic Observations at the Woods Hole Oceanographic Institution Hawaii Ocean Time-Series Site: 2021 - 2022, Data Report 17, School of Ocean and Earth Science and Technology (SOEST), Department of Oceanography, University of Hawaiʻi at Mānoa, Honolulu, HI. DOI: https://doi.org/10.5281/zenodo.10652516 URL: http://whots17-data-report.readthedocs.io/.

Acknowledgments

Many people participated in the WHOTS mooring deployment/recovery cruises. They are listed in Table 1 and Table 4. We gratefully acknowledge their contributions and support. Thanks are due to all the personnel of the Upper Ocean Processes Group (UOP) at WHOI who prepared the WHOTS buoy's instrumentation and mooring; to Kelsey Maloney, Tully Rohrer, Noah Howins, Ryan Tabata, and James Harris, for their technical assistance with the moored and shipboard instrumentation; We gratefully acknowledge the support from the colleagues at Sea-Bird to maintain the quality of the CTD data. We would also like to thank the captains and crew of the Ship Oscar Sette, and the University of Hawai'i Marine Center staff for their efforts. This publication is based upon observations from the WHOI-Hawaii Ocean Time-series Site (WHOTS) mooring, which is supported in part by the National Oceanic and Atmospheric Administration (NOAA) Global Ocean Monitoring and Observing (GOMO) Program through the Cooperative Institute for the North Atlantic Region (CINAR) under Cooperative Agreement NA14OAR4320158. NOAA CPO FundRef number 100007298 to the Woods Hole Oceanographic Institution, and by National Science Foundation grants OCE-0327513, OCE-0752606, OCE-0926766, OCE-1260164 and OCE-1756517 to the University of Hawaii for the Hawaii Ocean Time-series. This is SOEST contribution number 11768

Table of contents

List of figures

List of tables

1 Introduction

In 2003, Robert Weller (Woods Hole Oceanographic Institution [WHOI]) , Albert Plueddemann (WHOI), and Roger Lukas (The University of Hawaii [UH]) proposed to establish a long-term surface mooring at the Hawaii Ocean Time-series (HOT) Station ALOHA (22°45'N, 158°W) to provide sustained, high-quality air-sea fluxes and the associated upper ocean response as a coordinated part of the HOT program, and as an element of the global array of ocean reference stations supported by the National Oceanic and Atmospheric Administration's (NOAA) Office of Climate Observation.

With support from the NOAA and the National Science Foundation (NSF), the WHOI HOT Site (WHOTS) surface mooring has been maintained at Station ALOHA since August 2004. This project aims to record long-term, high-quality air-sea fluxes as a coordinated part of the HOT program and contribute to the goals of observing heat, freshwater, and chemical fluxes at a site representative of the oligotrophic North Pacific Ocean. The approach is to maintain a surface mooring outfitted for meteorological and oceanographic measurements at a site near Station ALOHA by successive mooring turnarounds. These observations will be used to investigate air-sea interaction processes related to climate variability

The original mooring system is described in the mooring deployment/recovery cruise reports [Plueddemann *et al.*, 2006, Whelan *et al.*, 2007, Whelan *et al.*, 2008, Whelan *et al.*, 2010, Santiago-Mandujano *et al.*, 2019, Hasbrouck *et al.*, 2019, Santiago-Mandujano *et al.*, 2021, Santiago-Mandujano *et al.*, 2022, Santiago-Mandujano *et al.*, 2022]. Briefly, a Surlyn foam surface buoy is equipped with meteorological instrumentation, including two complete Air-Sea Interaction Meteorological (ASIMET) systems, measuring air and sea surface temperatures, relative humidity, barometric pressure, wind speed and direction, incoming shortwave and longwave radiation, and precipitation [Hosom *et al.*, 1995, Colbo and Weller, 2009]. Complete surface meteorological measurements are recorded every minute, as required to compute air-sea fluxes of heat, freshwater, and momentum. Each ASIMET system also transmits hourly averages of the surface meteorological variables via the Argos satellite system. The mooring line is instrumented to collect time series of upper ocean temperatures, velocities, and salinities coincident with the surface forcing record. This mooring includes conductivity, salinity and temperature recorders, two Vector Measuring Current Meters (VMCMs), and two Acoustic Doppler current profilers (ADCPs). See the WHOTS-17 mooring diagram in the Fig. 1.1.

The subsurface instrumentation is located to resolve the temporal variations of shear and stratification in the upper pycnocline to support the study of mixed layer entrainment. Experience with moored profiler measurements near Hawaii suggests that Richardson number estimates over 10 m scales are adequate. Salinity is essential to the stratification, as salt-stratified barrier layers are observed at HOT and in the region [Kara *et al.*, 2000]. Hence, we use Sea-Bird SeaCATs and MicroCATs with vertical separation ranging from 5 to 20 m to measure temperature and salinity. We use two ADCPs made by Teledyne RD Instruments to obtain current profiles across the entrainment zone and in the mixed layer zone. Both ADCPs are in an upward-looking configuration, one is at 125 m, using 4 m bins, and the other is at 47.5 m using 2 m bins. To provide near-surface velocity (where ADCP estimates are less reliable), we deploy two Vector Measuring Current Meters (VMCMs). The nominal mooring design is a balance between resolving extremes versus the typical annual cycling of the mixed layer [Plueddemann *et al.*, 2006, Santiago-Mandujano *et al.*, 2007]. A pair of Sea-Bird SeaCATs (SBE-16) or MicroCATs (SBE-37) have been included since the WHOTS-9 deployment (June 2012) to measure near-bottom temperature and salinity.

The WHOTS-17 mooring was deployed on August 26, 2021 (WHOTS-17 cruise) and was recovered on July 25, 2022

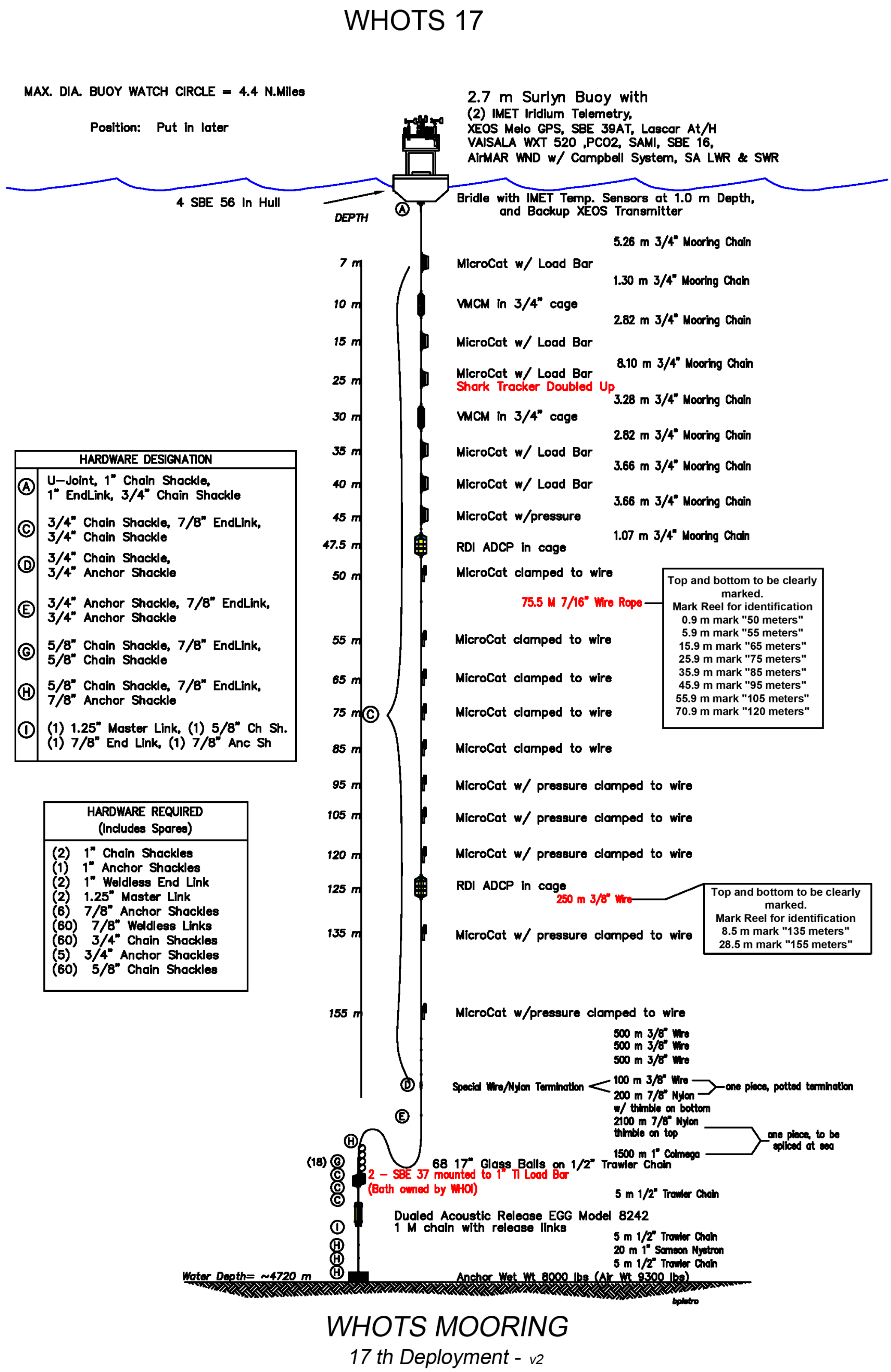


Fig. 1.1: WHOTS-17 mooring design

(WHOTS-18 cruise). The cruises were aboard the R/V Oscar Elton Settle. The WHOTS-18 mooring was deployed on July 24, 2022, during the WHOTS-18 cruise and was recovered on June 19, 2023, during the WHOTS-19 cruise

This report documents and describes the oceanographic observations made on the WHOTS-17 mooring for nearly eleven months and from shipboard measurements during the two cruises when the mooring was deployed and recovered. Sections *II* and *III* include a detailed description of the cruises and the mooring, respectively. Sampling and processing procedures of the hydrographic casts, thermosalinograph, and shipboard ADCP data collected during these cruises are described in Section *IV*. Section *V* includes the processing procedures for the data collected by the moored instruments: *SeaCATs, MicroCATs*, *Moored ADCPs* and *VMCM*. Plots of the resulting data and preliminary analysis are presented in Section *VI*.

2

Description of the WHOTS-17 Mooring Cruises

2.1 WHOTS-17 Cruise: WHOTS-17 Mooring Deployment

The Woods Hole Oceanographic Institution Upper Ocean Processes Group (WHOI/UOP) , with assistance from the UH group, successfully carried out the 17th deployment of the WHOTS mooring during the WHOTS-17 cruise. This operation took place on board the Oscar Elton Settle between August 24 and September 1, 2021. The WHOTS-17 mooring was deployed at Station 50 on August 26, 2021, at 03:13 UTC, at 22°46.042'N, 157°53.795'W. Additionally, the WHOTS-16 mooring was recovered on August 28, 2021.

The scientific personnel that participated during the cruise are listed in Table 2.1.

Table 2.1: Scientific personnel on Ship Oscar Sette during the WHOTS-17 deployment cruise.

Name	Title or function	Affiliation
Plueddeman, Albert	Chief Scientist	WHOI
Hasbrouck, Emerson	Senior Engineering Assistant II	WHOI
Fitzgerald, Dan	Marine Electronics Technician	UH
Santiago-Mandujano, Fernando	Research Associate	UH
Maloney, Kelsey	Student Assistant	UH
Harris, James	Student Assistant	UH
Jackson, Caroline	Student Assistant	UH

The UH group conducted the shipboard oceanographic observations during the cruise. A complete description of these operations is available in the [Santiago-Mandujano *et al.*, 2022]

A Sea-Bird CTD (conductivity, temperature, and depth) system was used measure T, S, and O2 profiles during CTD casts. The time, location, and maximum CTD pressure for each profile are listed in Table 2.2. Ten CTD casts were conducted during the WHOTS-17 cruise, from August 24 through September 1. CTD profile data were collected at Station 20 (in transit to the WHOTS mooring), Station 50 (near the WHOTS-17 buoy), Station 52 (near the WHOTS-16 buoy), and at Station 2 at the ALOHA site. The cast at Station 20 was 1508 m deep, and three acoustic releases (two to be used in the WHOTS-17 mooring and one backup) were attached to the rosette frame for function testing. Five CTD yo-yo casts and one near-bottom CTD cast were conducted to obtain profiles for comparison with subsurface instruments on the WHOTS-17 mooring after deployment, and two yo-yo casts were conducted for comparison with the WHOTS-16 mooring before recovery. The yo-yo casts were started about 0.25 nm from the buoys with varying drift during each cast, and consisted of 5 up-down cycles between near the surface and 202 to 204 m. One additional near-bottom CTD cast was conducted at Station ALOHA. The CTD had modulo errors during some of the casts, displaying some glitches.

Water samples were taken from all casts; 3 to 4 samples for each of them. These samples were to be analyzed for salinity at UH and used to calibrate the CTD conductivity sensors.

Table 2.2: CTD stations occupied during the WHOTS-17 cruise (Datetime is in mm/dd/yyyy hh:mm)

Station/cast	Date	In-water Time	Location	Maximum pressure (dbar)
2 / 1	8/31/2021	18:29	22° 45.12´ N, 157° 59.98´ W	4796
20 / 1	8/24/2021	23:03	21° 28.03´ N, 158° 20.83´ W	1508
50 / 1	8/29/2021	15:59	22° 45.73´ N, 157° 55.25´ W	202
50 / 2	8/29/2021	21:55	22° 46.17´ N, 157° 54.85´ W	202
50 / 3	8/29/2021	23:52	22° 46.19´ N, 157° 54.72´ W	204
50 / 4	8/30/2021	4:02	22° 45.89´ N, 157° 54.65´ W	202
50 / 5	8/30/2021	7:57	22° 44.79´ N, 157° 54.53´ W	202
50 / 6	9/1/2021	1:36	22° 44.28´ N, 157° 54.14´ W	4754
52 / 1	8/27/2021	19:58	22° 40.69´ N, 157° 58.38´ W	202
52 / 2	8/28/2021	4:00	22° 40.67´ N, 157° 58.73´ W	202

Also, continuous ADCP and near-surface thermosalinograph data were obtained while underway.

The R/V Oscar Elton Settle was equipped with a TRDI Ocean Surveyor 75 kHz ADCP, set to function in broadband and narrowband configurations. The configuration information is shown in Table 2.3. The ADCP utilized primary heading measurements from a SAMOS gyrometer, with additional heading corrections obtained from Trimble ABX-Two gyrocompass. GPS positions were derived from Furuno GP-170 GNSS (Global Navigation Satellite System).

Table 2.3: Configuration of the Ocean Surveyor 75kHz ADCP on board the Ship Oscar Sette during the WHOTS-17 cruise

Parameters	OS75BB	OS75NB
Sample interval (s)	300	300
Number of bins	80	55
Bin Length (m)	8	16
Transducer depth (m)	5	5
Blanking length (m)	8	8

Near-surface temperature and salinity data during the WHOTS-17 cruise were acquired from the thermosalinograph (TSG) system installed on the NOAA Ship Oscar Sette. The sensors were sampling water from the continuous seawater system running through the ship, and were comprised of one thermosalinograph model SBE-21 (SN 3168) and a micro-thermosalinograph model SBE-45 (SN 0290), both with (internal) temperature and conductivity sensors located in the ship's chemistry lab, about 70 m from the hull intake; and an SBE-38 (SN 266) external temperature sensor located at the entrance of the water intake. All instruments recorded data every second. The water intake was located at the bow of the ship, forward from the starboard side bow thruster at a depth of 3 m. The system had a flow meter in the chemistry lab, showing a flow rate of about 1.1 liter/minute during the cruise. Only the SBE-45 had a debubbler. Salinity water samples were taken every 8 hours from the exhaust in the Chemistry lab using 0.25 litter glass bottles, to be measured in the UH lab to correct for any drift in the thermosalinograph conductivities.

Both thermosalinographs exhibited a number of conductivity and temperature glitches due to air going into the plumbing. In addition, the system had a drainage problem according to the ship's technician. The data between August 26 at 13:30 and 27 at 07:00 are particularly bad because it was during transit back to Oahu to disembark a crew member with medical problems, and the flow through the system was stopped during that time. The temperature differences between the internal SBE-45 and SBE-21 were between -0.5 and 0.5°, and the conductivity differences were ±0.007 S/m resulting in a salinity difference of about ±0.05 g/kg. These conductivities were calibrated against the bottle samples collected during the cruise, and the bad data was be flagged. A diurnal cycle was apparent in the temperature and conductivity.

2.2 WHOTS-18 Cruise: WHOTS-17 Mooring Recovery

The WHOI/UOP Group conducted the mooring turnaround operations during the WHOTS-18 cruise between July 23, and July 27, 2022. The WHOTS-18 mooring was deployed at Station 52 on July 24, 2022, 02:17 UTC at 22 40.002'N, 157 56.793'W, and the WHOTS-17 mooring was recovered on July 25, 2022, 18:03 UTC. The scientific personnel that participated during the cruise are listed in Table 2.4.

Table 2.4: Scientific personnel on Ship Oscar Sette during the WHOTS-18 deployment cruise.

Name	Title or function	Affiliation
Plueddeman, Albert	Chief Scientist	WHOI
Graham, Raymond	Senior Engineering Assistant II	WHOI
Llanos, Nico	Senior Engineering Assistant I	WHOI
Fitzgerald, Dan	Marine Electronics Technician	UH
Harris, James	Student Assistant	UH
Maloney, Kelsey	Visiting Researcher Program Coordinator	UH/HIMB
Howins, Noah	Undergraduate Volunteer	UH
Penunuri, Alexander	Graduate Student	University of Colorado Boulder
Conner, Kyle	Graduate Student	UH
Rohrer, Tully	Research Associate	UH

The UH group conducted the shipboard oceanographic observations during the cruise. A complete description of these operations is available in the WHOTS-18 cruise report [Santiago-Mandujano *et al.*, 2022].

A Sea-Bird CTD system was used to measure T, S, and O2 profiles during CTD casts. The time, location, and maximum CTD pressure for each profile are listed in Table 2.5. Nine CTD casts were conducted during the WHOTS-18 cruise from July 23 through July 27. CTD profile data were collected at Station 20 (in transit to the WHOTS mooring), Station 50 (near the WHOTS-17 buoy), and Station 52 (near the WHOTS-18 buoy). The cast at Station 20 was 1501 m deep, and three acoustic releases (two to be used in the WHOTS-18 mooring and one backup) were attached to the rosette frame for function testing. Four CTD yo-yo casts were conducted to obtain profiles for comparison with subsurface instruments on the WHOTS-18 mooring after deployment, and four yo-yo casts were conducted for comparison with the WHOTS-17 mooring before recovery. The yo-yo casts were started about 0.25 nm from the buoys with varying drift during each cast and consisted of 5 up-down cycles between near the surface and 203 to 210 m. The first set of T, C, and O2 sensors displayed bad data during various casts, apparently due to problems with the cable termination, but the second sensor set displayed good data.

Between 3 and 4 water samples were taken from all casts, except from Station 52 casts 2, 3 and 4, in which the pylon failed to communicate with the CTD. These samples were to be analyzed for salinity at UH and used to calibrate the CTD conductivity sensors. Station numbers were assigned following the convention used during HOT cruises.

Table 2.5: CTD stations during the WHOTS-18 cruise (WHOTS-17 mooring recovery). Datetime is in UTC (mm/dd/yy hh:mm).

Station/cast	Date	In-water Time	Location	Maximum pressure (dbar)
20/1	7/23/22	04:30	21° 28.286´ N, 158° 21.342´ W	1501
50 / 1	7/24/22	16:04	22° 46.021´ N, 157° 56.186´ W	208
50 / 2	7/24/22	20:14	22° 46.224´ N, 157° 56.091´ W	208
50 / 3	7/24/22	23:57	22° 46.606´ N, 157° 56.014´ W	204
50 / 4	7/25/22	04:06	22° 46.068 ´ N, 157° 56.001´W	210
52 / 1	7/26/22	16:13	22° 39.682´ N, 157° 59.152´ W	203
52 / 2	7/26/22	20:06	22° 39.836´ N, 157° 59.066´ W	203
52 / 3	7/27/22	00:10	22° 40.087´ N, 157° 59.123´ W	206
52 / 4	7/27/22	04:13	22° 40.192´ N, 157° 59.041´ W	203

Also, continuous ADCP and near-surface thermosalinograph data were obtained while underway.

The R/V Oscar Elton Settle was equipped with a TRDI Ocean Surveyor 75 kHz ADCP, set to function in broadband and narrowband configurations. The configuration information is shown in Table 2.6. The ADCP utilized primary heading measurements from a SAMOS gyrometer, with additional heading corrections obtained from Trimble ABX-Two gyrocompass. GPS positions were derived from Furuno GP-170 GNSS (Global Navigation Satellite System).

Table 2.6: Configuration of the Ocean Surveyor 75kHz ADCP on board the Ship Oscar Sette during the WHOTS-18 cruise

Parameters	OS75BB	OS75NB
Sample interval (s)	300	300
Number of bins	80	55
Bin Length (m)	8	16
Transducer depth (m)	5	5
Blanking length (m)	8	8

Near-surface temperature and salinity data during the WHOTS-18 cruise were acquired from the thermosalinograph (TSG) system installed on the NOAA Ship Oscar Sette. The sensors were sampling water from the continuous seawater system running through the ship, and were comprised of one thermosalinograph model SBE-21 (SN 3168) and a micro-thermosalinograph model SBE-45 (SN 0290), both with (internal) temperature and conductivity sensors located in the ship's chemistry lab , about 70 m from the hull intake; and an SBE-38 (SN 266) external temperature sensor located at the entrance of the water intake. All instruments recorded data every second. The water intake was located at the bow of the ship, forward from the starboard side bow thruster at a depth of 3 m. The system had a flow meter in the chemistry lab, showing a flow rate of about 1.1 liter/minute during the cruise. Only the SBE-45 had a debubbler. Salinity water samples were taken every 8 hours from the exhaust in the Chemistry lab using 0.25 litter glass bottles, to be measured in the UH lab to correct for any drift in the thermosalinograph conductivities.

3 Description of WHOTS-17 Mooring

The WHOTS-17 mooring, deployed on August 26, 2021, from R/V Oscar Elton Settle, was outfitted with two complete sets of Air-Sea Interaction Meteorological (ASIMET) sensors on the buoy and underneath subsurface instruments from 7 to 155 m depth, and near the bottom. See [Santiago-Mandujano *et al.*, 2022, Santiago-Mandujano *et al.*, 2022] for a complete description of the buoy. The WHOTS-17 was recovered on July 25, 2022.

The buoy is equipped with meteorological instrumentation, including two complete Air-Sea Interaction Meteorological (ASIMET) systems on the buoy and underneath subsurface instruments from 7 to 155 m depth and near the bottom. The buoy tower contains standalone sensors: Vaisala WXT-520 multi-variable (temperature, humidity, pressure, wind, and precipitation), an SBE-39 temperature sensor adapted to measure air temperature, and Lascar RH/ATMP. The ASIMET sensors include air temperature and relative humidity (ATMP/HRH), barometric pressure (BPR), wind speed and direction (WSPD) and (WDIR), precipitation (PRC), longwave (LWR) and shortwave (SWR) radiations, and seas surface temperature (SST) and salinity (SSS). The buoy tower also contains a radar reflector, two marine lanterns, and two Iridium satellite transmission systems that provide continuous buoy position monitoring. Two Rover and one Melo sensor from Xeos Melo Global Positioning System (GPS) receiver recorded the buoy's positions. A fourth positioning system (Xeos Kilo transmitter) was mounted beneath the hull. A Battelle pCO2 system, a pumped SBE-16 CTD, and a SAMI-2 pH sensor were mounted to the buoy's underside. A Sea-Bird SBE-63 hosted a dissolved oxygen sensor. A Wetlabs ECOFLNTUS chlorophyll fluorometer was also mounted on the buoy hull.

Five internally logging Sea-Bird SBE-56 temperature sensors were bolted to the buoy hull's underside, measuring sea surface temperature (SST) and salinity. The SBE-56s measured SST once every 60 sec between 80-110 cm below the surface. Two SBE-37 MicroCATs were at 1.55m, measuring at every 300s (See Table 3.1).

Table 3.1: WHOTS-17 MicroCAT and SBE-56 Temperature Sensor Information.

Instrument	SN	Depth (m)	Sample Interval (sec)
SBE-56	6150	0.80	60
SBE-56	6239	0.80	60
SBE-56	6410	0.95	60
SBE-56	6412	1.10	60
SBE-56	7211	0.80	60
MicroCAT	5996	1.55	300
MicroCAT	1727	1.55	300

Underwater instrumentation included 18 MicroCATs (SeaBird SBE-37) deployed to record temperature and conductivity (C-T) at 7, 15, 25, 35, 40, 45, 50, 55, 65, 75, 85, 95, 105, 120, 135, 155, and two at about 40 m off the bottom. The MicroCATs at 7, 45, 85, 105, 120, 135, 155, and the two near the bottom included a pressure sensor. Two upward-looking RDI ADCPs were deployed at 47.5 m (600 kHz) and 125 m (300 kHz), respectively, and two Next Generation Vector Measurement Current Meters (VMCMs) were deployed at 10 and 30 m, respectively, to measure current speed and direction.

The Table 3.2 provides a listing of the WHOTS-17 subsurface instrumentation at their nominal depths on the mooring, along with serial numbers, sampling rates, and other pertinent information. A cold water spike was induced to the UH MicroCATs before deployment (Table 3.2) and after recovery Table 3.3 by placing an ice pack in contact with their temperature sensor to check for any drift in their internal clock. To produce a spike in the ADCP data, each instrument's transducer was rubbed gently by hand for 20 seconds (Table 3.4 , and Table 3.5).

Table 3.2: WHOTS-17 mooring subsurface instrument deployment information. SN=Serial Number; I=Instrument; D=Depth(m); PSN=Pressure Serial Number; SI=Sample Interval(s); SL=Starting Logging ; CSB=Cold Spike Begin; CSE= Cold Spike End; TIW= Time in Water. All times are in UTC (mm/dd/yy hh:mm:ss). * VMCM Spin start times, ** AC=Acoustic Receiver (Vemco VR2W Acoustic Receiver 69 kHz attached to 25 m MicroCAT loadbar).

SN	I	D	PSN	SI	SL	CSB	CSE	TIW
6892	MicroCAT	7	2651324	75	8/25/21 0:00:00	8/25/21 0:03:00	8/25/21 1:06:00	8/25/21 20:20:00
35	VMCM	10	N/A	60	8/7/21 2:01:00	08/25/21 19:08:00*	N/A	8/25/21 19:57:00
3382	MicroCAT	15	N/A	180	8/25/21 0:00:00	8/25/21 0:03:00	8/25/21 1:06:00	8/25/21 19:42:00
4663	MicroCAT	25	N/A	180	8/25/21 0:00:00	8/25/21 0:03:00	8/25/21 1:06:00	8/25/21 19:37:00
135934	AC **	25	N/A	N/A	8/12/21 19:00:00	N/A	N/A	8/25/21 19:37:00
58	VMCM	30	N/A	60	8/7/21 2:40:00	8/25/21 19:22:00*	N/A	8/25/21 19:32:00
3633	MicroCAT	35	N/A	180	8/25/21 0:00:00	8/25/21 0:03:00	8/25/21 1:06:00	8/25/21 19:24:00
3381	MicroCAT	40	N/A	180	8/25/21 0:00:00	8/25/21 0:03:00	8/25/21 1:06:00	8/25/21 19:20:00
3668	MicroCAT	45	5579	240	8/25/21 0:00:00	8/25/21 0:03:00	8/25/21 1:06:00	8/25/21 19:15:00
13917	600kHz ADCP	47.5	N/A	600	8/25/21 5:50:00	Table 3.4	Table 3.5	8/25/21 20:39:00
3619	MicroCAT	50	N/A	180	8/25/21 0:00:00	8/25/21 0:03:00	8/25/21 1:06:00	8/25/21 20:41:00
3620	MicroCAT	55	N/A	180	8/25/21 0:00:00	8/25/21 0:03:00	8/25/21 1:06:00	8/25/21 20:41:00
3621	MicroCAT	65	N/A	180	8/25/21 0:00:00	8/25/21 0:03:00	8/25/21 1:06:00	8/25/21 20:44:00
3632	MicroCAT	75	N/A	180	8/25/21 0:00:00	8/25/21 0:03:00	8/25/21 1:06:00	8/25/21 20:46:00
4699	MicroCAT	85	10209	240	8/25/21 0:00:00	8/25/21 0:03:00	8/25/21 1:06:00	8/25/21 20:47:00
3791	MicroCAT	95	N/A	180	8/25/21 0:00:00	8/25/21 0:03:00	8/25/21 1:06:00	8/25/21 20:49:00
2769	MicroCAT	105	2949	240	8/25/21 0:00:00	8/25/21 0:03:00	8/25/21 1:06:00	8/25/21 20:52:00
4700	MicroCAT	120	2479944	240	8/25/21 0:00:00	8/25/21 0:03:00	8/25/21 1:06:00	8/25/21 21:00:00
7637	300kHz ADCP	125	N/A	600	8/25/21 6:07:00	Table 3.4	Table 3.5	8/25/21 21:00:00
2451	MicroCAT	135	1556	240	8/25/21 0:00:00	8/25/21 0:03:00	8/25/21 1:06:00	8/25/21 21:01:00
4701	MicroCAT	155	10211	240	8/25/21 0:00:00	8/25/21 0:03:00	8/25/21 1:06:00	8/25/21 21:04:00
11380	MicroCAT	39m off Anchor	2146835	300	8/25/21 0:00:00	8/25/21 0:03:00	8/25/21 1:06:00	8/26/21 0:36:00
11381	MicroCAT	39m off Anchor	2146836	300	8/25/21 0:00:00	8/25/21 0:03:00	8/25/21 1:06:00	8/26/21 0:36:00

Table 3.3: WHOTS-17 mooring C-T and ADCP Instruments recovery information. D=Depth(m); Sea-Bird 37 Serial Number (SN). TOW=Time out of water; TOS=Time of Spike; TOES=Time of End Spike; TLS=Time Logging Stopped; ITS=Instrument Time when Stopped; SL=Samples Logged; DQ=Data Quality; FN=File Name(all file names start with whots17_.). All times are in UTC (mm/dd/yy hh:mm:ss).

D	SN	TOW	TOS	TOES	TLS	ITS	SL	DQ	FN
7	6892	7/26/22 5:05	7/26/22 18:26	7/26/22 19:04	7/27/22 3:05	7/27/22 3:05	387221	C failed-2/2022	7m_6892.XML
15	3382	7/26/22 5:09	7/26/22 18:26	7/26/22 19:04	7/27/22 3:11	7/27/22 3:11	161343	Good	15m_3382.asc
25	4663	7/26/22 5:09	7/26/22 18:26	7/26/22 19:04	7/27/22 2:58	7/27/22 2:58	161340	Good	25m_4663.XML
35	3633	7/26/22 3:57	7/26/22 18:26	7/26/22 19:04	7/27/22 2:52	7/27/22 2:51	161337	Good	35m_3633.XML
40	3381	7/26/22 3:54	7/26/22 18:26	7/26/22 19:04	7/27/22 5:47	7/27/22 5:47	161394	Good	40m_3381.asc
45	3668	7/26/22 3:49	7/26/22 18:26	7/26/22 19:04	7/27/22 2:41	7/27/22 2:39	121000	P failed-1/2022	45m_3668.asc
47.5	ADCP 13917	7/26/22 3:45	7/26/22 19:08	7/26/22 19:41	7/27/22 6:53	7/27/22 7:00	48391	Good	000.000
50	3619	7/26/22 3:44	7/26/22 18:26	7/26/22 19:04	7/27/22 2:47	7/27/22 2:46	161334	Good	50m_3619.asc
55	3620	7/26/22 3:43	7/26/22 18:26	7/26/22 19:04	7/27/22 6:10	7/27/22 6:10	161404	Good	55m_3620.asc
65	3621	7/26/22 3:42	7/26/22 18:26	7/26/22 19:04	7/27/22 3:38	7/27/22 3:38	161353	Good	60m_3621.asc
75	3632	7/26/22 3:41	7/26/22 18:26	7/26/22 19:04	7/27/22 6:06	7/27/22 6:05	161402	Good	75m_3632.asc
85	4699	7/26/22 3:39	7/26/22 18:26	7/26/22 19:04	7/27/22 6:01	7/27/22 6:01	121051	Good	85m_4699.XML
95	3791	7/26/22 3:38	7/26/22 18:26	7/26/22 19:04	7/27/22 5:56	7/27/22 5:56	161399	Good	95m_3791.asc
105	2769	7/26/22 3:37	7/26/22 18:26	7/26/22 19:04	7/27/22 3:32	7/27/22 3:33	65459	Failed-11/2021	105m_2769.asc
120	4700	7/26/22 3:36	7/26/22 18:26	7/26/22 19:04	7/27/22 3:43	7/27/22 3:43	121016	Good	120m_4700.XML
125	ADCP 7637	7/26/22 3:32	7/26/22 19:08	7/26/22 19:41	7/27/22 6:43	7/27/22 6:42	48387	Good	1000.000
135	2451	7/26/22 3:31	7/26/22 18:26	7/26/22 19:04	7/27/22 5:43	7/27/22 5:41	121046	Bad Pressure	135m_2451.asc
155	4701	7/26/22 3:30	7/26/22 18:26	7/26/22 19:04	7/27/22 5:51	7/27/22 5:51	121048	Good	155m_4701.XML
38 mab	11380	7/25/22 21:47	7/26/22 18:26	7/26/22 19:04	7/27/2022 n/a	7/27/22 16:45	96970	Good	4661m_11380.asc
38 mab	11381	7/25/22 21:47	7/26/22 18:26	7/26/22 19:04	7/27/2022 n/a	7/27/22 17:05	96974	Good	4661m_11381.asc

Table 3.4: WHOTS-17 mooring ADCP deployment and configuration information. All times are in UTC (mm/dd/yy hh:mm:ss).

-	ADCP S/N 13917	ADCP S/N 7637
Frequency (kHz)	600	300
Number of Depth Cells	25	30
Depth Cell Size (m)	2 m	4 m
Pings per Ensemble	80	40
Time per Ensemble (min)	10 min	10 min
Time per Ping (sec)	2 sec	4 sec
Time of First Ping	08/25/21, 05:50:00	08/25/21, 06:07:00
Transducer 1 Spike Time	08/25/21, 06:10:00	08/25/21, 06:17:00
Transducer 2 Spike Time	08/25/21, 06:10:15	08/25/21, 06:17:15
Transducer 3 Spike Time	08/25/21, 06:10:30	08/25/21, 06:17:30
Transducer 4 Spike Time	08/25/21, 06:10:45	08/25/21, 06:17:45
Ice Spike Time Begin	08/25/21, 06:20:00	08/25/21, 06:27:00
Ice Spike Time End	08/25/21, 06:22:00	08/25/21, 06:29:49
Time in Water	08/25/20:39:00	08/25/21, 21:00:00
Depth (m)	47.5 m	125 m

Table 3.5: WHOTS-17 mooring ADCP recovery information. All times are in UTC (mm/dd/yy hh:mm:ss).

-	ADCP S/N 13917	ADCP S/N 7637
Frequency (kHz)	600	300
Number of Depth Cells	25	30
Depth Cell Size (m)	2 m	4 m
Pings per Ensemble	80	40
Time per Ensemble (min)	10 min	10 min
Time per Ping (sec)	2 sec	4 sec
Time of Last Ping	7/27/22, 06:53:00	7/27/22, 06:43:00
Transducer 1 Spike Time	20:13:00	20:10:05
Transducer 2 Spike Time	20:13:15	20:10:20
Transducer 3 Spike Time	20:13:30	20:10:35
Transducer 4 Spike Time	20:13:45	20:10:50
Time in the Water	08/25/21, 20:39:00	08/25/21, 21:00:00
Time out of Water	07/26/22, 03:45:00	07/26/22, 03:32:00
Time of spike	07/26/22, 19:08:00	07/26/22, 19:08:00
Time Logging Stopped	07/27/22, 06:53:00	07/27/22, 06:43:00
Instrument Time when Stopped	07/27/22, 07:00:16	07/27/22, 06:42:45
Depth (m)	47.5 m	125 m

The RDI 300 kHz Workhorse Sentinel ADCP, SN 7637, was deployed at 125 m with transducers facing upwards with an additional external battery pack. This instrument was set to ping at 4-second intervals for 160 seconds every 10 minutes, and the burst sampling was designed to minimize aliasing by occasional large ocean swell orbital motions. The bin size was set for 4 m. The total number of ensemble records was 48,387. The first ensemble was on 08/25/2021 at 06:07:00 and the last was on 07/27/2022 at 06:43 (see Table 3.4, Table 3.5, and *WHOTS-17 300 kHz - Serial 7367* for more configuration). This instrument also measured temperature.

The RDI 600 kHz Workhorse Sentinel ADCP, SN 13917, was deployed at 47.5 m with transducers facing upwards with an additional external battery pack. The instrument was set to ping at 2-second intervals for 160 seconds every 10 minutes, and the burst sampling was designed to minimize aliasing by occasional large ocean swell orbital motions. The bin size was set for 2 m. The total number of ensemble records was 48,391. The first ensemble was on 08/25/2021 at 05:50:00, and the last was on 07/27/2022 at 06:53:00 (see Table 3.4 , Table 3.5, and *WHOTS-17 600 kHz - Serial 13917* for more configuration). This instrument also measured temperature.

The two VMCMs, SN 0035 and 0058, were deployed at 10 m and 30 m depth, respectively. The instruments were prepared for deployment by the WHOI/UOP group and set to sample at 1-minute interval. These instruments also measured temperature.

All WHOTS-17 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 depth.

All MicroCATs except for the one at 155 m were in good condition after recovery. MicroCAT SN 3620 (55 m) had barnacles partially blocking the top of its conductivity cell, and SN 6892 (7 m) was recovered with fishing line wrapped around the instrument and the chain. The MicroCAT SN 4701 at 155 m was recovered missing its sensor guard and with a bent conductivity cell.

After recovery and before stopping recording, 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 the instrument's clock. The data from all instruments were downloaded at the UH lab. Table 3.3 gives the post-deployment information for the C-T instruments; more details are in *MicroCAT Data Processing Procedures*, and *MicroCAT Data*.

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 side-lobe interference. At the time when logging was stopped (Table 3.5), the instrument time was 15 sec behind UTC.

4 WHOTS (17-18) Cruise Shipboard Observations

The hydrographic profile observations made during the WHOTS cruises were obtained with a Sea-Bird CTD package with dual temperature, salinity and oxygen sensors. This CTD was installed on a rosette-sampler with 5 L Niskin sampling bottles for calibration water samples. Furthermore, the ship Oscar Sette came equipped with a thermosalinograph system that provided a continuous depiction of the near-surface layer's temperature and salinity. Horizontal currents over the depth range of 30-650 m were measured from the shipboard 75 kHz Ocean Surveyor (OS75) ADCP (narrowband) with a vertical resolution of 16m for the WHOTS-17 and WHOTS-18 cruises. Broadband mode for the OS75 provided additional current data over the range upper 250 m with a vertical resolution of 8m.

Data gaps occurred when the system was shut down temporarily during communications with the acoustic releases used for the moorings during both cruises. Periods of missing data between 300 and 450 m in the broadband ADCP were apparent due to the lack of scattering material in the water.

4.1 Conductivity, Temperature, and Depth (CTD) Profiling

Continuous measurements of temperature, conductivity, dissolved oxygen, and pressure were made with the UH Sea-Bird SBE-9/11Plus CTD underwater units #850 and #1487 during WHOTS-17 and WHOTS-18 cruises respectively. The CTD was equipped with an internal Digiquartz pressure sensor and pairs of external temperature, conductivity, and oxygen sensors.

Each temperature-conductivity sensor pair used a Sea-Bird TC duct, which circulated seawater through independent pump and plumbing installations. The CTD configuration also included two oxygen sensors, installed in the plumbing for each sensor set. In both cruises, the CTD was mounted in a vertical position in the lower part of a rosette sampler, with the sensors' water intakes located at the bottom of the rosette.

The package was deployed on a conducting cable, which allowed for real-time data acquisition and display. The deployment procedure consisted of lowering the package to approximately 10 dbar and waiting until the CTD pumps started operating. The CTD was then raised until the sensors were close to the surface to begin the CTD cast. The time and position of each cast were obtained via a GPS connection to the CTD deck box. 3-4 salinity samples were taken on each cast for calibration of the conductivity sensors.

4.1.1 Data Acquisition and Processing

CTD data were acquired at the instrument's highest sampling rate of 24 samples per second. Digital data were stored on a laptop computer, and, for redundancy, the analog signal was recorded on a separate computer using a sound card and Audacity (TM) software. Backups of CTD data were made onto USB storage cards.

The raw CTD data were quality controlled and screened for spikes described in the WHOTS Data Report 1 [Santiago-Mandujano *et al.*, 2007]. Data alignment, averaging, correction, and reporting were done as described in [Tupas *et al.*, 1993]. Spikes in the data occur when the CTD samples the disturbed water of its wake. Therefore, the downcast samples were rejected when the CTD was moving upward or when its acceleration exceeded 0.5 ms^{-2} in magnitude. The data were subsequently averaged into 2-dbar pressure bins after calibrating the CTD conductivity with the bottle salinities.

The data were additionally screened by comparing the T-C sensor pairs. These differences permitted the identification of problems with the sensors. The data from only one T-C pair, whichever was deemed most reliable, is reported here. Only data from the downcast are reported, as wake effects from the rosette commonly contaminate upcast data.

Temperature is reported on the ITS-90 scale. Salinity and all derived units were calculated using the UNESCO (1981) routines; salinity is reported in the Practical Salinity(SA) scale (PSS-78). Oxygen is reported in $\mu mol\ kg^{-1}$.

4.1.2 CTD Sensor Calibration and Corrections

4.1.2.1 Pressure

The pressure calibration strategy for CTD pressure transducers #1430 and #53702 used during WHOTS-17 and WHOTS-18 cruises respectively employed a high-quality quartz pressure transducer as a transfer standard. Periodic recalibrations of this lab standard were performed with a primary pressure standard. The only corrections applied to the CTD pressures were a constant offset determined when the CTD first enters the water on each cast. Also, a span correction determined from bench tests on the sensor against the transfer standard was applied. These procedures and corrections are thoroughly documented in the HOT-2020 data report [Fukieki *et al.*, 2023].

4.1.2.2 Temperature/Conductivity

Sea-Bird SBE-3-Plus temperature and SBE 4C conductivity transducers were used during WHOTS-17 and -18 cruises. These sensors' history and performance have been monitored during HOT cruises, and calibrations and drift corrections applied during WHOTS cruises are thoroughly documented in the HOT-2020 data report [Fukieki *et al.*, 2023].

4.1.2.3 Dissolved Oxygen

Sea-Bird SBE-43 oxygen sensors were used during the WHOTS-17 and -18 cruises. The WHOTS-17 oxygen data were calibrated using calibration coefficients obtained during the HOT-327 cruise, which used the same oxygen sensors. The CTD empirical calibration was performed using oxygen water samples and the procedure from [Owens and Millard, 1985]. See [Tupas *et al.*, 1996] for details on these calibrations procedures. The oxygen data from the WHOTS-18 deployment underwent calibration using coefficients obtained during the HOT-305 cruise. This approach was necessary as the oxygen sensors had not been utilized prior to the WHOTS-18 deployment

4.2 Water Sampling and Analysis

4.2.1 Salinity

Salinity samples were collected by a rosette sampler during CTD casts at selected depths during WHOTS-17 and -18, and then sub-sampled in 250 ml glass bottles. The top of each bottle and thimble were thoroughly dried before being tightly capped to prevent water from being trapped between the cap or thimble and the bottle's mouth. It has been observed that residual water trapped in this way increases its salinity due to evaporation, and it can leak into the sample when the bottle is opened for measuring. Samples from each cruise were measured after the cruise in the UH laboratory using a Guildline Autosal 8400B SN 73647 for WHOTS-17 and, WHOTS-18. International Association for Physical Sciences of the Ocean (IAPSO) standard seawater samples were measured to standardize the Autosal, and samples from a large batch of "secondary standard" (substandard) seawater were measured after every 24-48 samples to detect drift in the Autosal. Standard deviations of the secondary standard measurements were less than ± 0.001 for WHOTS-17 and -18 cruises Table 4.1.

The substandard water was collected by a rosette sampler from 1020 m at station ALOHA during HOT cruises and drained into a 50-liter Nalgene plastic carboy. In the laboratory, the water was then thoroughly mixed in a glass carboy for 20 minutes by manually shaking, rolling, and tilting the carboy vigorously, after which a 2-inch protective layer of white oil was added on top to deter evaporation. The substandard water was allowed to stand for approximately three days before it was used and was stored in the same temperature-controlled room as the Autosal, protecting it from the light with black plastic bags to inhibit biological growth. Substandard seawater batch #67 was prepared on August 18, 2019, and it was used for WHOTS-17. The batch #71 was prepared on August 27, 2021, and it was used for WHOTS-18.

Samples from the WHOTS-17 were measured on October 28, 2019 and samples from WHOTS-18 were measured on September 13, 2021. Table 4.1 shows the precision measurements of the secondary sub-standards.

Table 4.1: The precision of salinity measurements of secondary lab standards.

Cruise	Mean Salinity +/- SD	# Samples	Substandard Batch	IAPSO Batch
WHOTS-17	34.5011 ± 0.0004	28	71	P164
WHOTS-18	34.4930 ± 0.0005	3	72	P164

4.3 Thermosalinograph Data Acquisition and Processing

4.3.1 WHOTS-17 Cruise

Near-surface temperature and salinity data during the WHOTS-17 cruise were acquired from the thermosalinograph (TSG) system installed on the NOAA Ship Oscar Sette. The sensors were sampling water from the continuous seawater system running through the ship. They comprised one thermosalinograph model SBE-21 (SN 3168) and a micro-thermosalinograph model SBE-45 (SN 0290), both with (internal) temperature and conductivity sensors located in the ship's chemistry lab, about 70 m from the hull intake; and an SBE-38 (SN 266) external temperature sensor located at the entrance of the water intake. All instruments recorded data every second. The water intake is located at the ship's bow, forward from the starboard side bow thruster at a depth of 3 m. The system has a flow meter in the chemistry lab, showing a flow rate of about 1.1 liters/minute during the cruise. Only the SBE-45 has a debubbler. Salinity water samples were taken every 8 hours from the exhaust in the Chemistry lab using 0.25-liter glass bottles, to be measured in the UH lab to correct any drift in the thermosalinograph conductivities.

4.3.1.1 Temperature Calibration

External temperature data from the SBE-38 sensor (last calibrated at Sea-Bird on November 26, 2020) were used to measure the seawater temperature. These data were compared to the data collected during CTD casts.

4.3.1.2 Nominal Conductivity Calibration

Data from the SBE-45 conductivity and temperature sensors were used to calculate the intake seawater salinity. These sensors were last calibrated at Sea-Bird on November 17, 2020. All conductivity data from the thermosalinograph were nominally calibrated with coefficients from this calibration. However, all the final salinity data reported here were calibrated against bottle data, as explained below.

4.3.1.3 Data Processing

Daily files containing navigation data recorded every second were concatenated with the thermosalinograph data. The thermosalinograph data were then screened for gross errors, with upper and lower bounds of 18°C and 35°C for temperature and 3 and 6 Siemens m^{-1}. for conductivity. There were 488 points outside the valid temperature range and no points outside the valid conductivity range.

A 5-point running median filter was used to detect one- or two-point temperature and conductivity glitches in the thermosalinograph data. Glitches in temperature and conductivity detected by the 5-point median filter were immediately replaced by the median. Threshold values of 0.3°C for temperature and 0.1 Siemens m^{-1}. for conductivity were used for the median filter. After running the filter, there were 283 internal temperature, 1998 external temperature, and 341 conductivity points replaced with the median.

A 3-point triangular running mean filter was used to smooth the temperature and conductivity data after passing the glitch detection.The thermosalinograph aboard the Ship Oscar Sette was set to record data every second.

Data were visually scanned to flag spikes likely caused by contamination due to the introduction of bubbles to the flow-through system during transits or rough conditions. Of 649,826 data points, 133,3851 conductivity data points were flagged as bad.

4.3.1.4 Bottle salinity and CTD Salinity Comparisons

The thermosalinograph salinity was calibrated by comparing it to bottle salinity samples drawn from a water intake next to the thermosalinograph every 8 hours throughout the cruise.

Of the sixteen thermosalinograph bottles sampled, bottle #1 was identified as a conductivity outlier and it was discarded from the analysis. Samples were analyzed as described in *Water Sampling and Analysis*. The comparison was made in conductivity to eliminate the effects of temperature. The conductivity of each bottle sample was computed using the salinity of the bottle, thermosalinograph temperature, and a pressure of 10 dbar, which includes the pressure of the flow-through system's pump.

Salinity samples were drawn from the flow-through system, located less than 0.5 m from the SBE-45. Consequently, there should be virtually no delay between when the water passes through the thermosalinograph and sampled. A 90-second average centered on the sample draw time was chosen for processing purposes.

A cubic spline was fit to the time series of the differences between the bottle and TSG conductivity, and a correction was obtained for the TSG conductivities. Salinity was calculated using these corrected conductivities, the thermosalinograph temperatures, and 10 dbar pressure. After applying corrections, the mean difference between the bottle and thermosalinograph salinities was 0 with a standard deviation of 0.00062 psu. The mean CTD - thermosalinograph difference was -0.00018 psu with a standard deviation offshore 0.00124 psu.

4.3.1.5 CTD Temperature Comparisons

In order to make the comparison in conductivity units, the CTD conductivity was calculated using the 3 dbar downcast CTD salinity, the internal thermosalinograph temperature, and a pump pressure of 10 dbar. During WHOTS-17, a total of ten CTD casts were conducted at various stations, including a test cast offshore Honolulu (Station 20), one at Station 2 (ALOHA), two at Station 52 (WHOTS-16), and six at Station 50 (WHOTS-17). To maintain data integrity, Casts #1 and #10 were identified as temperature outliers through a comparison with the thermosalinograph data and subsequently excluded from the analysis. The mean difference between the CTD and the internal temperature sensor was -0.247°C, with a standard deviation of ± 0.067°C.

4.3.2 WHOTS-18 Cruise

Near-surface temperature and salinity data during the WHOTS-18 cruise were acquired from the thermosalinograph (TSG) system installed on the NOAA Ship Oscar Sette. The sensors were sampling water from the continuous seawater system running through the ship, and comprised one thermosalinograph model SBE-21 (SN 3168) and a micro-thermosalinograph model SBE-45 (SN 0290), both with (internal) temperature and conductivity sensors located in the ship's chemistry lab, about 70 m from the hull intake; and an SBE-38 (SN 266) external temperature sensor located at the entrance of the water intake. All instruments recorded data every second. The water intake is located at the bow of the ship, forward from the starboard side bow thruster at a depth of 3 m. The system has a flow meter in the chemistry lab, showing a flow rate of about 1.1 liter/minute during the cruise. Only the SBE-45 has a debubbler. Salinity water samples were taken every 8 hours from the exhaust in the Chemistry lab using 0.25 litter glass bottles, to be measured in the UH lab to correct for any drift in the thermosalinograph conductivities.

4.3.2.1 Temperature Calibration

External temperature data from the SBE-38 sensor (last calibrated at Sea-Bird on December 7, 2020) were used to measure the seawater temperature. These data were compared to the data collected during CTD casts.

4.3.2.2 Nominal Conductivity Calibration

Data from the SBE-45 conductivity and temperature sensors were used to calculate the intake seawater salinity. These sensors were last calibrated at Sea-Bird on December 7, 2020. All conductivity data from the thermosalinograph were nominally calibrated with coefficients from this calibration. However, all the final salinity data reported here were calibrated against bottle data, as explained below.

4.3.2.3 Data Processing

Daily files containing navigation data recorded every second were concatenated with the thermosalinograph data. The thermosalinograph data were then screened for gross errors, with upper and lower bounds of 18°C and 35°C for temperature and 3 and 6 Siemens m^{-1}. for conductivity. There were 28 points outside the valid temperature range and no points outside the valid conductivity range.

A 5-point running median filter was used to detect one- or two-point temperature and conductivity glitches in the thermosalinograph data. Glitches in temperature and conductivity detected by the 5-point median filter were immediately replaced by the median. Threshold values of 0.3°C for temperature and 0.1 Siemens m^{-1}. for conductivity were used for the median filter. After running the filter, there were 332 internal temperature, 391 external temperature, and 40 conductivity points replaced by the median. A 3-point triangular running mean filter was used to smooth the temperature and conductivity data after passing the glitch detection.

The thermosalinograph aboard the Ship Oscar Sette was set to record data every second. Both thermosalinographs exhibited a number of conductivity and temperature glitches due to air going into the plumbing. Data were visually scanned to flag spikes likely caused by contamination due to the introduction of bubbles to the flow-through system during transits or rough conditions. Of 456,895 data points, 86,670 conductivity data points were flagged as bad.

4.3.2.4 Bottle salinity and CTD Salinity Comparisons

The thermosalinograph salinity was calibrated by comparing it to bottle salinity samples drawn from a water intake next to the thermosalinograph every 8 hours throughout the cruise. Of the fifteen thermosalinograph bottles sampled, bottle #2 was identified as a conductivity outlier and were discarded from the analysis. Samples were analyzed as described in *Water Sampling and Analysis*. The comparison was made in conductivity to eliminate the effects of temperature. The conductivity of each bottle sample was computed using the salinity of the bottle, thermosalinograph temperature, and a pressure of 10 dbar, which includes the pressure of the flow-through system's pump.

Salinity samples were drawn from the flow-through system, located less than 0.5 m from the SBE-45. Consequently, there should be virtually no delay between when the water passes through the thermosalinograph and sampled. A 90-second average centered on the sample draw time was chosen for processing purposes.

A cubic spline was fit to the time series of the differences between the bottle and TSG conductivity, and a correction was obtained for the TSG conductivities. Salinity was calculated using these corrected conductivities, the thermosalinograph temperatures, and ten dbar pressure. After applying corrections, the mean difference between the bottle and thermosalinograph salinities was less than -1 mpsu with a standard deviation of 0.00328 psu. The mean CTD - thermosalinograph difference was -0.00110 psu with a standard deviation of 0.00403 psu.

4.3.2.5 CTD Temperature Comparisons

There were 9 CTD casts conducted during WHOTS-18, one of which was a test cast offshore Honolulu (Station 20), four at Station 52 (WHOTS-18), and four at Station 50 (WHOTS-17). The 3 dbar downcast CTD temperature data from those casts were used to compare with the thermosalinograph data at the time of the casts. This comparison gives an estimate of the quality of the thermosalinograph measurements. Of the nine casts, two were identified as temperature outliers (#4 and #8) after comparing it against the thermosalinograph data and removed from the analysis. The mean difference between the CTD and the internal temperature sensor was -0.127°C, with a standard deviation of ± 0.045°C.

4.4 Shipboard ADCP

4.4.1 WHOTS-17 Deployment Cruise

Currents were measured for the cruise duration over the depth range of 30-700 m with a 75 kHz RDI Ocean Surveyor (OS75) ADCP working in narrowband mode with a vertical resolution of 16 m and broadband mode with a vertical resolution of 8 m. The system yielded good data [Santiago-Mandujano *et al.*, 2022] during operations near the WHOTS-16 and WHOTS-17 moorings. The broadband system only recorded good data in the upper 200 m. The times of the datasets from the OS75 kHz are shown in Table 4.2.

Table 4.2: ADCP record times (UTC mm/dd/yy hh:mm:ss) for the Narrow Band 75 kHz ADCP during the WHOTS-17 cruise

WHOTS-17	OS75nb	OS75bb
File starting time	08/20/21 01:22:22	08/20/21 01:22:22
File ending time	09/01/21 19:44:41	09/01/21 19:44:41

4.4.2 WHOTS-18 Deployment Cruise

Currents were measured for the duration of the cruise over the depth range of 30-700 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 (see [Santiago-Mandujano *et al.*, 2022]) during operations near the WHOTS-17 and WHOTS-18 moorings. The broadband system only recorded good data in the upper 200 m. The times of the datasets from the OS75 kHz are shown in Table 4.3.

Table 4.3: ADCP record times (UTC mm/dd/yy hh:mm:ss) for the Narrow Band 75 kHz ADCP during the WHOTS-18 cruise

WHOTS-18	**OS75nb**	**OS75bb**
File starting time	07/22/22 23:24:47	07/22/22 23:24:47
File ending time	07/27/22 20:59:44	07/27/22 20:59:44

5

Moored Instrument Observations

5.1 MicroCAT Data Processing Procedures

Each moored MicroCAT temperature, conductivity, and pressure (when installed) was calibrated at Sea-Bird before their deployment and after their recovery on the dates shown in Table 5.1. The internally-recorded data from each instrument were downloaded onboard the ship after the mooring recovery. The nominally-calibrated data were plotted for a visual assessment of the data quality. The data processing included checking the internal clock data against external event times, pressure sensor drifts correction, temperature sensor stability, and conductivity calibration against CTD data from casts conducted near the mooring during HOT and WHOTS cruises. The detailed processing procedures are described in this section.

Table 5.1: WHOTS-17 MicroCAT temperature sensor calibration dates and sensor drift during deployments; *SN = Sea-Bird Serial Number; PDC = Pre-Deployment Calibration; PRC = Post-Recovery Calibration; TSA = Temperature Sensor Annual Drift during WHOTS-17 ; N. depth = Nominal deployment depth*

N. depth (m)	SN	PDC	PRC	TSA(mili°C)
1.6	5996	1-Aug-20	26-Feb-23	0.19
1.6	1727	31-Jul-20	1-Mar-23	0.4
7	6892	9-Jul-20	30-Sep-22	0.05
15	3382	15-Jul-20	29-Sep-22	0.02
25	4663	13-Dec-18	4-Nov-21	0.61
35	3633	9-Jul-20	29-Sep-22	-0.02
40	3381	10-Jul-20	29-Sep-21	-1.19
45	3668	9-Jul-20	4-Oct-22	-0.13
50	3619	16-Jul-20	1-Oct-22	1.13
55	3620	17-Jul-20	24-Sep-22	-0.08
65	3621	21-Jul-20	29-Sep-22	-0.96
75	3632	15-Jul-20	30-Sep-22	-0.55
85	4699	10-Jul-20	29-Sep-22	-0.11
95	3791	10-Jul-20	29-Sep-22	-0.1
120	4700	23-Jul-20	5-Oct-22	-0.15
135	2451	13-Jun-20	30-Sep-22	-0.84
155	4701	9-Jul-20	30-Sep-22	-0.1
4659	11380	5-Aug-20	15-Feb-23	0.15
4659	11381	4-Aug-20	10-Feb-23	0.43

5.1.1 Internal Clock Check and Missing Samples

Before the WHOTS-17 mooring deployment and after its recovery (before the data logging was stopped), the MicroCATs temperature sensors were placed in contact with an ice pack to create a spike in the data, to check for any problems with their internal clocks, and for possible missing samples (Table 3.3). The cold spike before deployment was detected by a sudden decrease in temperature. For all the instruments, the clock time of this event matched the time of the spike (within the sampling interval of each instrument) correctly. The conductivity sensor from microcat #6892 at 7 m failed on February 2022. The pressure sensor from microcat #3668 at 45 m failed on January 2022. The microcat #2769 at 105 m failed on November 2021. Lastly, the instrument #2451 at 135 m displayed bad pressure data after February 2022.

5.1.2 Pressure Drift Correction and Pressure Variability

Some MicroCATs used in the moorings were outfitted with pressure sensors (Table 3.2). Biases were detected in the pressure sensors by comparing the on-deck pressure readings (which should be zero for standard atmospheric pressure at sea level of 1029 mbar) before deployment and after recovery. Table 5.2 shows the magnitude of the bias for each of the sensors before and after deployment. To correct this offset, a linear fit between the initial and final on-deck pressure offset as a function of time was obtained and subtracted from each sensor. The instruments at 45 and 105 m failed and yielded incorrect pressures before recovery. For these instruments only a before-deployment pressure bias correction was applied, and the data after the failure were flagged bad. The pressure from instrument at 135 m had a large bias and drift, and it failed in February 2022, the before-deployment pressure bias and drift correction were applied, and the data after the failure were flagged bad. Fig. 5.1 shows the linearly corrected pressures measured by the MicroCATs located above 200 m during the WHOTS-17 deployment. For all these sensors, the mean difference from the nominal instrument pressure (based on the deployed depth) was less than 1.4 dbar. The standard deviation of the pressure for the duration of the record was less than 1 dbar for all sensors, with the deeper sensors showing a slightly larger standard deviation. The range of variability for all sensors was about ± 3 dbar.

The causes of pressure variability can be several, including density variations in the water column above the instrument; horizontal dynamic pressure (not only due to the currents but also due to the motion of the mooring); mooring position [Santiago-Mandujano *et al.*, 2007].

Table 5.2: Pressure bias of MicroCATs with pressure sensors for WHOTS-17. The instruments with a NA pressure bias had bad pressures before recovery. SN = Sea-bird Serial Number; BBD = Bias Before Deployment (dbar); BAR = Bias After Recovery (dbar)

Depth (m)	SN	BBD(dbar)	BAR(dbar)
7	6892	-0.17	-0.18
45	3668	-0.02	NA
85	4699	-0.05	-0.03
105	2769	-0.04	NA
120	4700	-0.023	-0.25
135	2451	-5.2	NA
155	4701	-0.075	-0.04
4659	11380	-4.45	-4.45
4659	11381	0.4	1.5

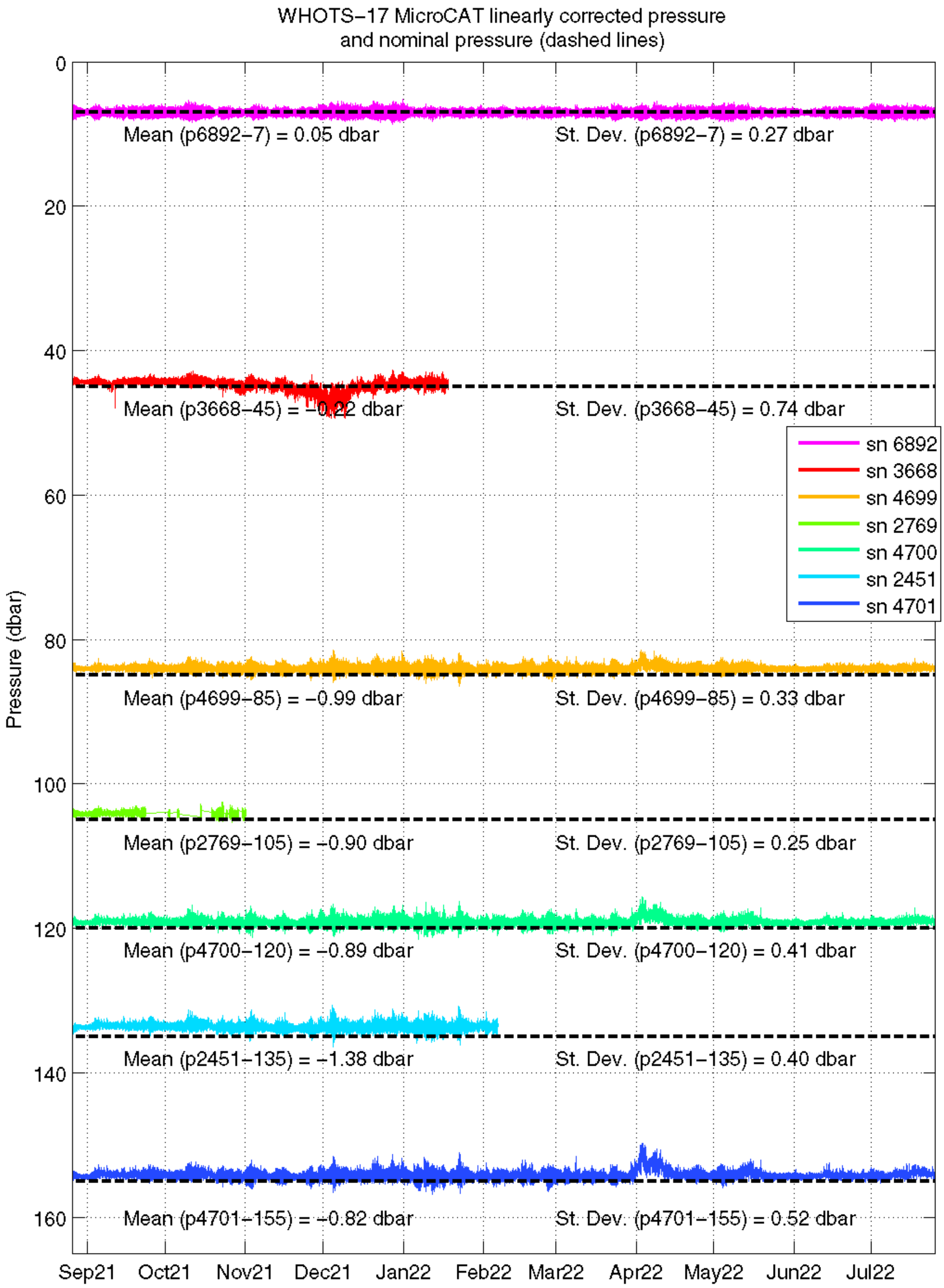


Fig. 5.1: Linearly corrected pressures from MicroCATs between 7 and 155 m during WHOTS-17 deployment. The horizontal dashed line is the sensor's nominal pressure, based on deployed depth. The text on the left (right) side of the figure indicates the mean (standard deviation) of the difference between each instrument's pressure and nominal pressure.

5.1.3 Temperature Sensor Stability

The MicroCAT temperature sensors were calibrated at Sea-Bird before and after each deployment, and their annual drift evaluations based on these calibrations are shown in Table 5.1. These values turned out to be insignificant (not higher than 0.002 °C) for all sensors. Comparisons between the MicroCAT and CTD data from casts conducted near the mooring during HOT cruises confirmed that the rest of the moored instruments temperature drift was insignificant. The two MicroCATs (SN 11380 and SN 11381) deployed near the bottom were drift corrected. Fig. 5.7 (upper panel) shows the temperature differences between both instruments before and after the correction. After the correction, the temperature differences were in the ±0.001 °C range.

Temperature comparisons between one of the WHOTS-17 near-surface MicroCAT (SN 5996) and the five SBE-56 surface temperature sensors in the buoy hull Table 3.1 are shown in Fig. 5.2. All the SBE-56 instruments returned full records, and none of them show any obvious bias compared to the Microcat measurements.

In addition to the Sea-Bird temperature sensors, there were additional temperature sensors in the VMCMs (at 10 and 30 m) and in the ADCPs (at 47.5 m and 125 m). Comparisons with the temperatures from adjacent MicroCATs were conducted to evaluate the temperatures from those sensors.

5.1.3.1 Comparisons with VMCM and ADCP temperature sensors

The upper panel of Fig. 5.3 shows the difference between the 10-m VMCM and the 7-m MicroCAT temperatures during WHOTS-17, after adding a 0.0066°C offset correction to the VMCM. The offset was the mean difference between the uncorrected VMCM and the 7-m MicroCAT data. Also shown for comparison in the middle panel of the figure are the corrected VMCM temperature differences from the 15 m MicroCAT. The lower panel shows the temperature fluctuations in the differences between the 7 and 15-m MicroCATs, which displayed a range between -0.2 and 0.6°C.

Temperature differences between the 30-m VMCM and the temperatures from adjacent MicroCATs at 25 and 35-m during WHOTS-17 are shown in Fig. 5.4 after adding a 0.015772°C offset correction to the VMCM. The offset was the mean difference between the uncorrected VMCM and the 25-m MicroCAT data. For comparison, the differences between the MicroCATs temperatures are also shown in the lower panel.

Temperature differences between the 47.5-m ADCP and the temperatures from adjacent MicroCATs at 45 and 50-m during WHOTS-17 are shown in Fig. 5.5. For comparison, the differences between the MicroCATs temperatures are also shown in the lower panel.

Temperature differences between the 125-m ADCP and the temperatures from adjacent MicroCATs at 120 and 135-m during WHOTS-17 are shown in Fig. 5.6. For comparison, the differences between the MicroCATs temperatures are also shown in the lower panel. It is difficult to assess the quality of the ADCP temperature from these comparisons. These sensors were located at the top of the thermocline, where we expect to find substantial temperature differences between adjacent sensors. However, an indication of the ADCP temperatures quality is given in the upper panel plot, which shows temperatures fluctuating closely around zero.

5.1.4 Conductivity Calibration

The results of the Sea-Bird post-recovery conductivity calibrations indicated that some MicroCAT conductivity sensors experienced relatively large offsets from their pre-deployment calibration. These were qualitatively confirmed by comparing the mooring data against CTD data from casts conducted between 200 m and 5 km from the mooring during HOT cruises. The conductivity offsets are not apparent, and there may have been multiple causes (see [Freitag *et al.*, 1999] for a similar experience with conductivity cells during COARE). For some instruments, the offset was negative, caused perhaps by biofouling of the conductivity cell. In contrast, for others, the offset was positive, for reasons still unknown. A visual inspection of the instruments after recovery did not show any apparent signs of biofouling. There were no cell scourings reported in the post-recovery reviews at Sea-Bird.

Corrections of the MicroCATs conductivity data were conducted by comparing them against CTD data from profiles and yo-yo casts conducted near the mooring during HOT cruises and during deployment/recovery cruises. Casts led between 200 and 1000 m from the mooring were given extra weight in the correction compared to those conducted between 1 and 5 km away. Casts more than 5 km away from the mooring were not used. Given that the CTD casts are conducted at least 200 m from the mooring, CTD and MicroCAT data alignment was done in

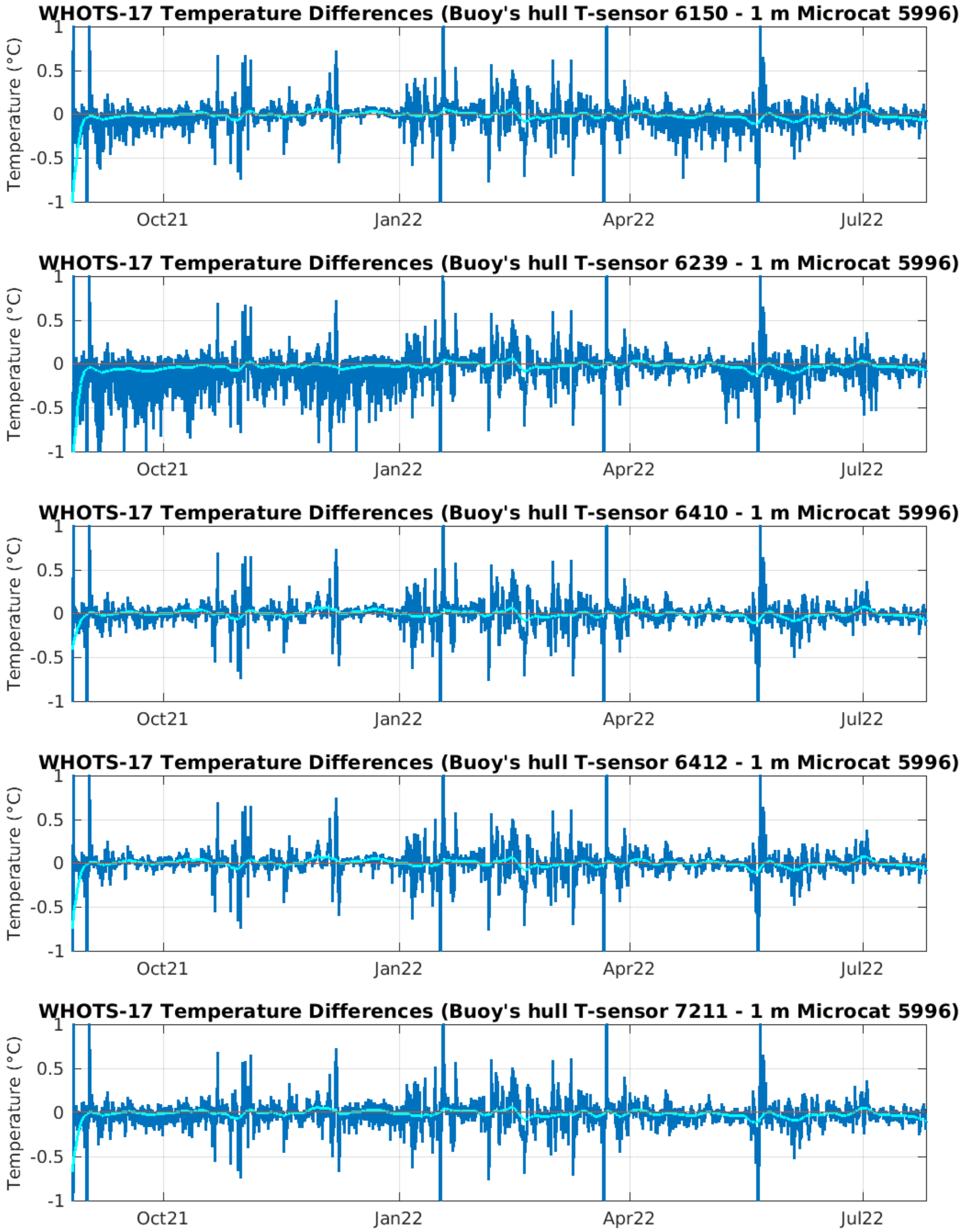


Fig. 5.2: The temperature difference between MicroCAT SN 6150 (top) at 1 m, and near-surface temperature sensors SN 6239 (second panel), 6410 (third panel), 6412 (fourth panel), and 7211 (bottom panel), during the WHOTS-17 deployment. The light blue line is a 24-hour running mean of the differences.

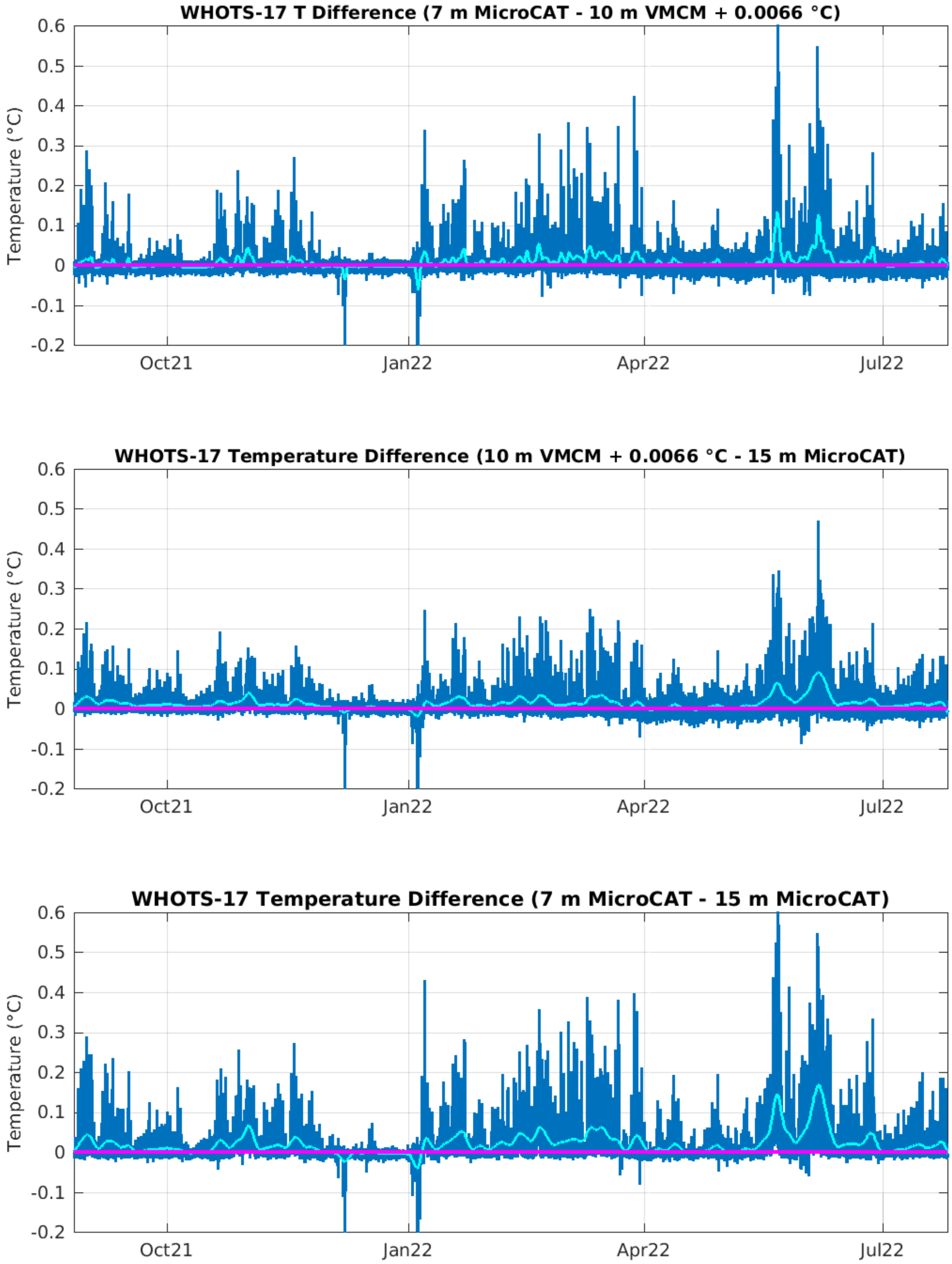


Fig. 5.3: The temperature difference between the 7-m MicroCAT and the 10-m VMCM (upper pane)l; between the 15-m MicroCAT and the 10-m VMCM (middle panel); and between the 7-m and the 15-m MicroCATs (lower panel) during the WHOTS-17 deployment. The light blue line is a 24-hour running mean of the differences.

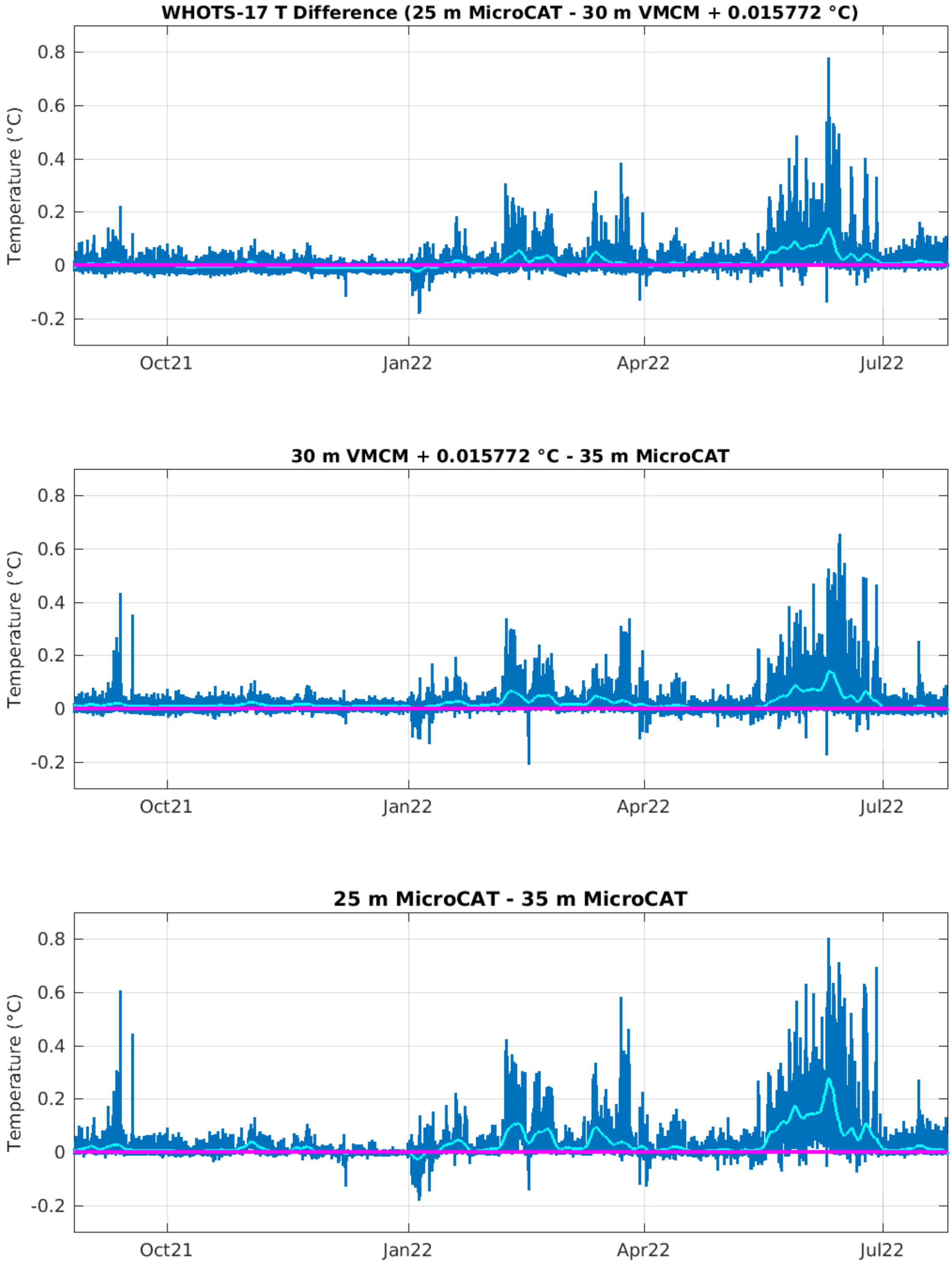


Fig. 5.4: The temperature difference between the 25-m MicroCAT and the 30-m VMCM (upper panel); between the 35-m MicroCAT and the 30-m VMCM (middle panel); and between the 25-m and the 35-m MicroCATs (lower panel) during the WHOTS-17 deployment. The light blue line is a 24-hour running mean of the differences.

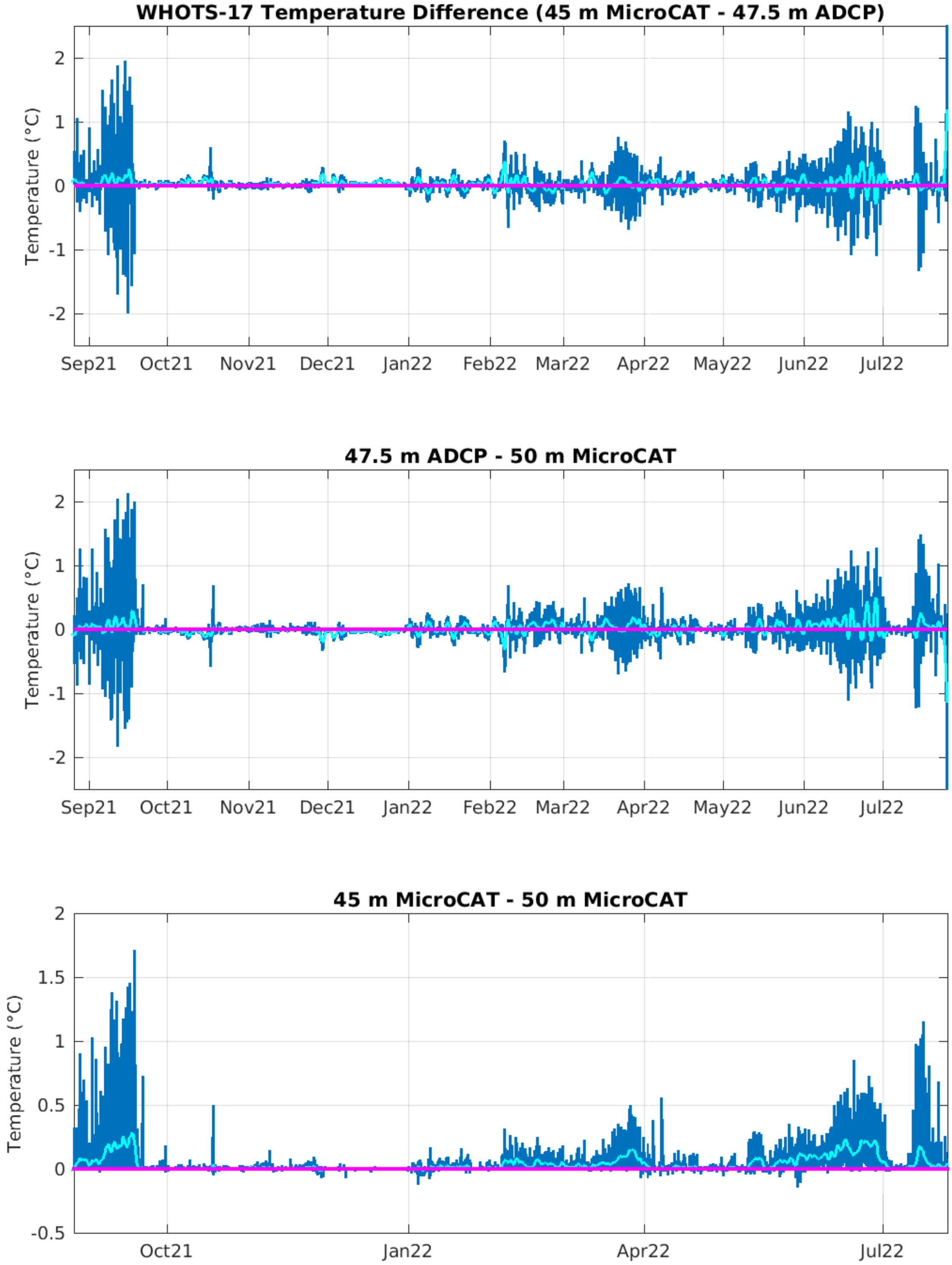


Fig. 5.5: The temperature difference between the 45-m MicroCAT and the 47.5-m ADCP (upper panel); between the 50-m MicroCAT and the 47.5-m ADCP (middle panel); and between the 45-m and the 50-m MicroCATs (lower panel) during the WHOTS-17 deployment. The light blue line is a 24-hour running mean of the differences.

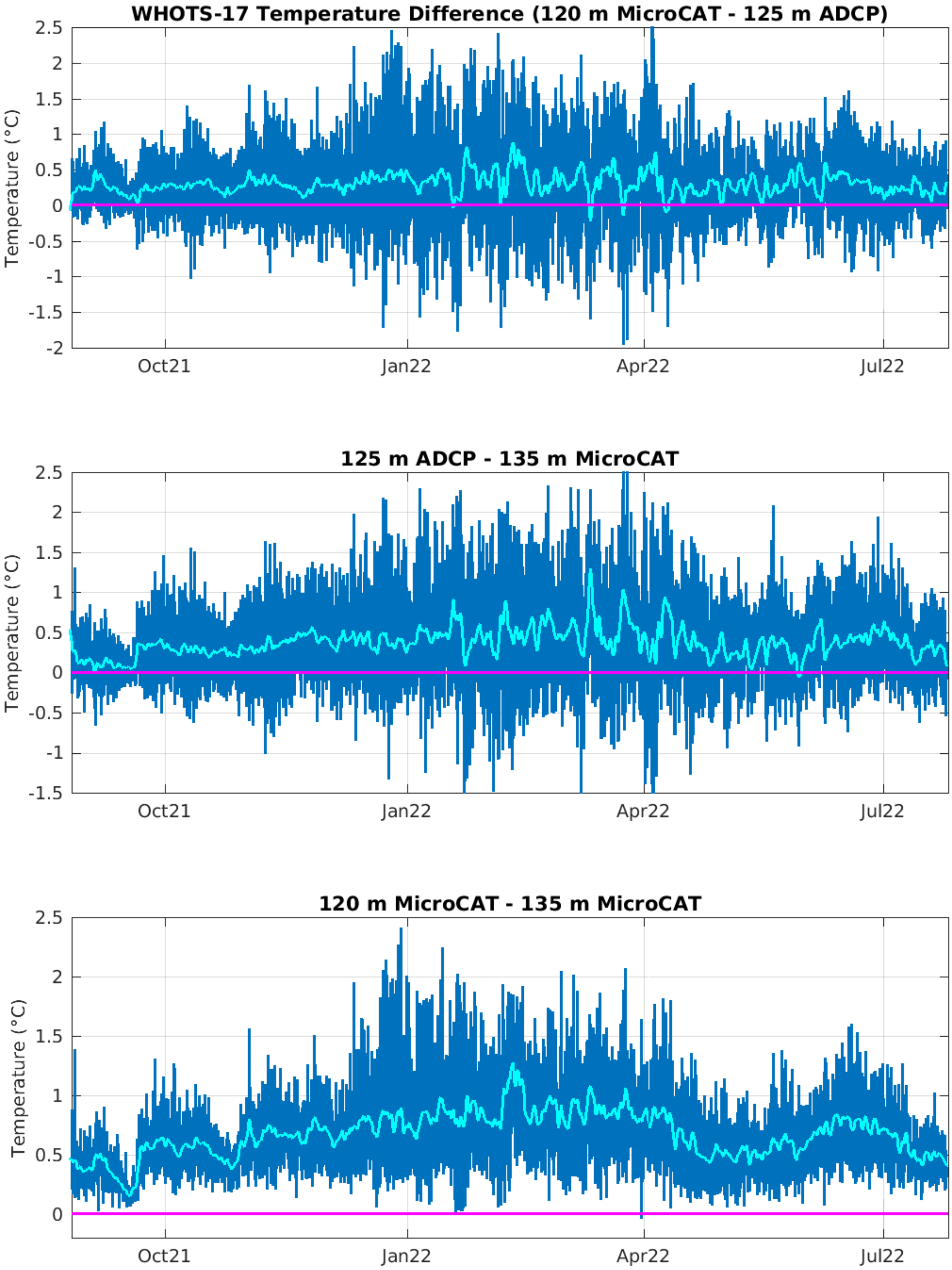


Fig. 5.6: The temperature difference between the 120-m MicroCAT and the 125-m ADCP (upper panel); between the 135-m MicroCAT and the 125-m ADCP (middle panel); and between the 120-m and the 135-m MicroCATs (lower panel) during the WHOTS-17 deployment. The light blue line is a 24-hour running mean of the differences.

density rather than in-depth. For cases where the alignment in density was not possible due to large conductivity offsets (causing unrealistic mooring density values), the alignment was done in temperature space. A cubic least-squares fit (LSF) to the CTD-MicroCAT differences against time was applied as a first approximation, and the corresponding correction was applied.

Some sensors had large offsets and noticeable variability that could not be explained by a cubic LSF (see below). For these sensors, a stepwise correction was applied to match the data to the available CTD cast data and then to use the differences between consecutive sensors to determine when the sensor started to drift. For instance, during periods of weak stratification, the conductivity difference between neighboring sensors A, B, and C could reach near-zero values, in particular for instruments near the surface, which are the ones most prone to suffer conductivity offsets. A sudden conductivity offset observed during this period between sensors A and B, but not between sensors A and C could indicate the beginning of an offset for sensor B.

Given that the most in-depth instruments on the mooring are less likely to be affected by biofouling and consequent sudden conductivity drift, the deep instruments served as an excellent reference to find any possible malfunction in the shallower ones. Therefore, the conductivity from the deepest instruments was corrected first, and the correction was continued sequentially upwards toward the shallower ones.

As a quality control to the conductivity corrections, the buoyancy frequency between neighboring instruments was calculated using finite differences. Over- or under-corrected conductivities yielded instabilities in the water column (negative buoyancy frequency) that were easy to detect and were not real when lasting for several days. Based on this, the conductivity correction of the corresponding sensors was revised.

Correction of the deep and the near-bottom MicroCATs conductivities were done following similar procedures than for the shallow instruments, by comparing them against CTD data from near-bottom profiles conducted during HOT cruises (Fig. 5.7, bottom panel). After correction, the salinity differences between both instruments were in the ± 0.001 range.

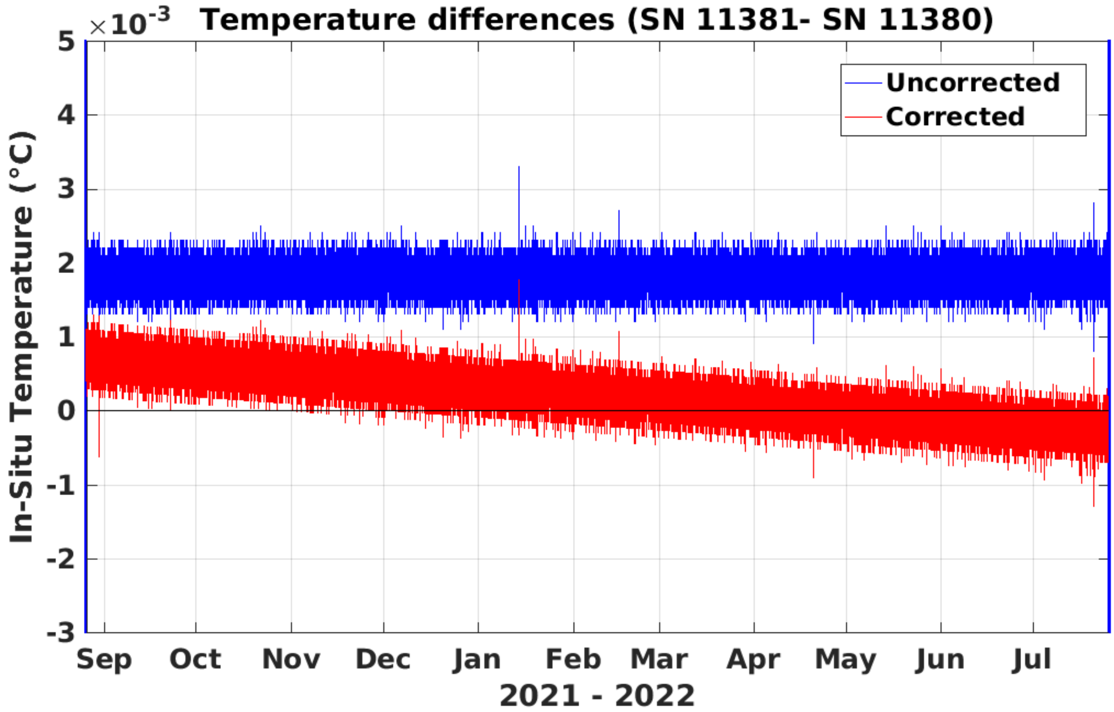
Another characteristic of the offsets in the conductivity sensors is that their development is not always linear in time. Their behavior can be highly variable [Santiago-Mandujano *et al.*, 2007]. The corrections applied to each of the conductivity sensors during WHOTS-17 are shown in Fig. 5.8 through Fig. 5.14. Most of the instruments had a drift of less than 0.02 Siemens/m for the duration of the deployment, and was corrected. Some instruments deployed above 60 m showed a negative drift starting a few months before the end of their record, apparently due to the anti-foulant expiration. The instrument located at 155 m had a large conductivity offset in May 2022 and was corrected.

5.2 Acoustic Doppler Current Profiler

Two TRDI broadband Workhorse Sentinel ADCP's were deployed on the WHOTS-17 mooring. A 600 kHz ADCP was deployed at 47.5 m depth in the upward-looking configuration, and a 300 kHz ADCP was deployed at 125 m, also in the upward-looking configuration. The instruments were installed in aluminum frames,and an external battery module to provide enough power for the intended period of deployment. The four ADCP beams were angled at 20° from the vertical line of the instrument. The 300 kHz ADCP was set to profile across 30 range cells of 4 m with the first bin centered at 6.21m from the transducer. The 600 kHz ADCP was set to profile across 25 range cells of 4 m with the first bin centered at 3.10m from the transducer. The specifications of the instrument are shown in Table 5.3.

Table 5.3: Specifications of the ADCP's used for the WHOTS-17 mooring.

Frequency (kHz)	Instrument	Model	Serial Number
300	TRDI Workhorse Sentinel	WHS300-I-UG129	7637
600	TRDI Workhorse Sentinel	WHS600-I	13917



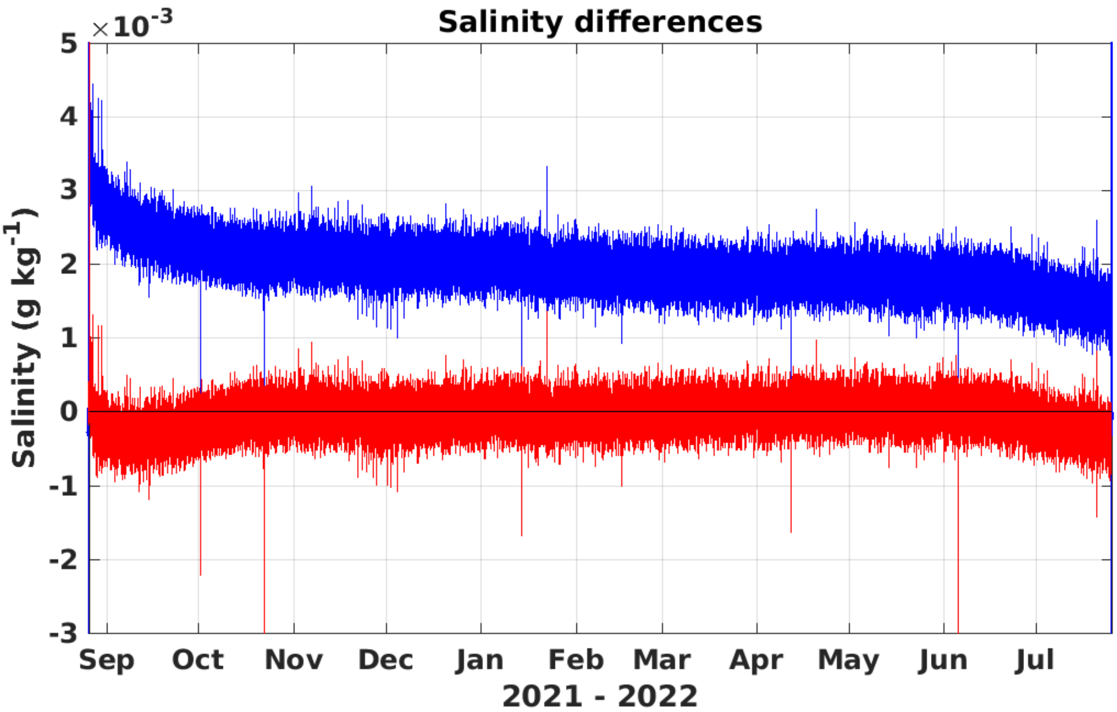


Fig. 5.7: Temperature differences (top panel) and salinity differences (bottom panel) between MicroCATs #11381 and #11380 during WHOTS-17. The blue (red) lines are the differences before (after) correcting the data following the text procedures.

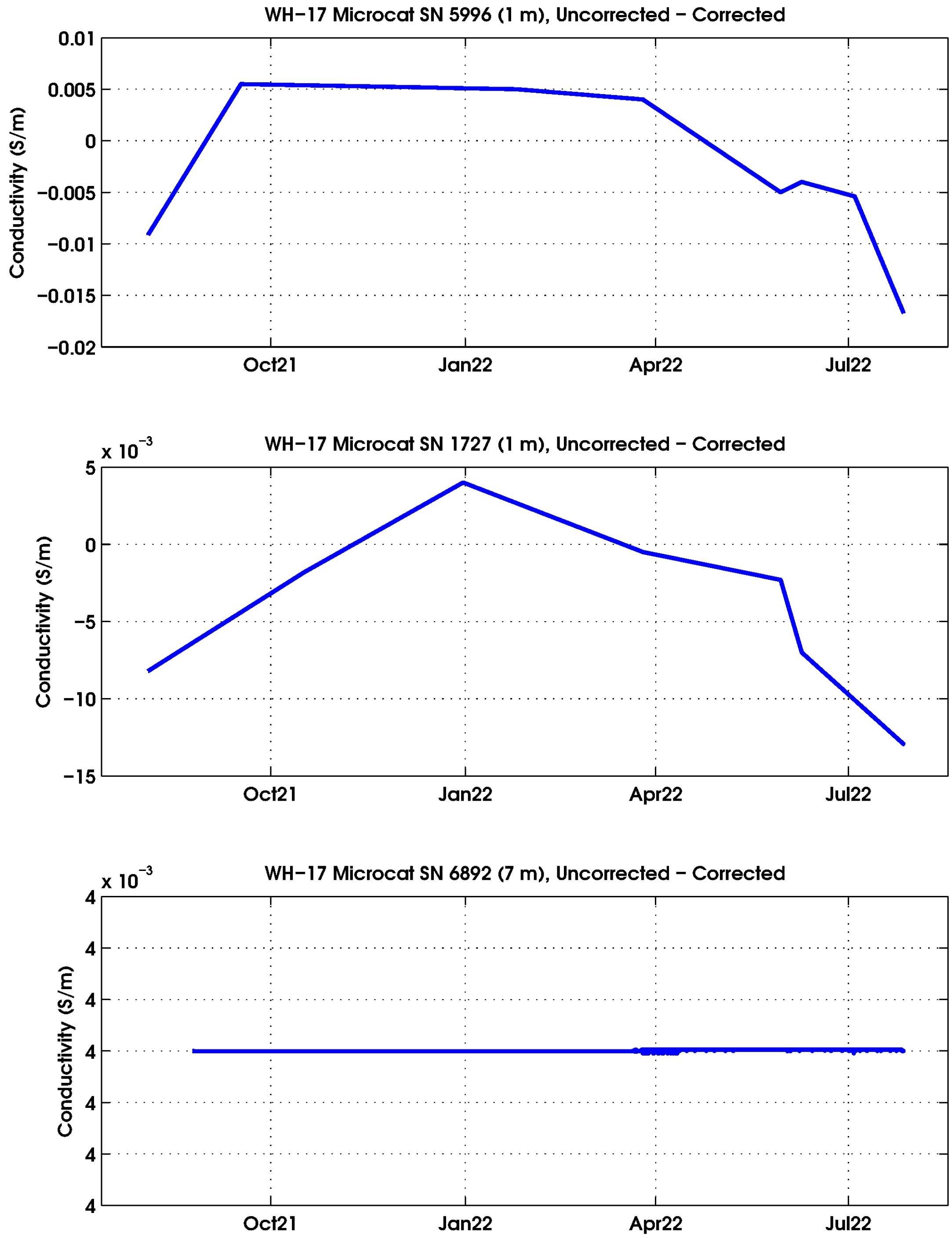


Fig. 5.8: Conductivity sensor corrections for MicroCATs from 1 to 7 meters during WHOTS-17.

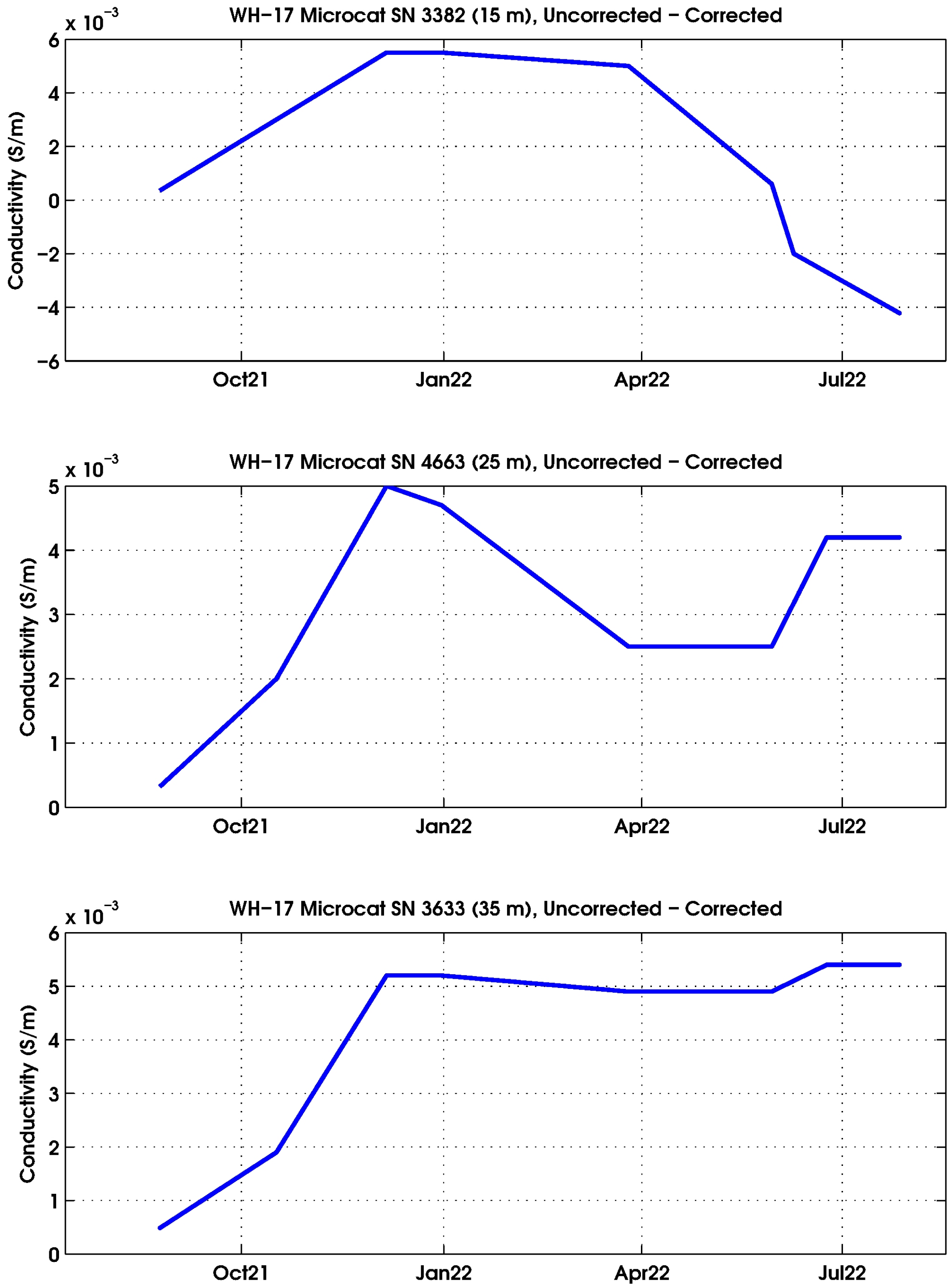


Fig. 5.9: Conductivity sensor corrections for MicroCATs from 15 to 35 meters during WHOTS-17.

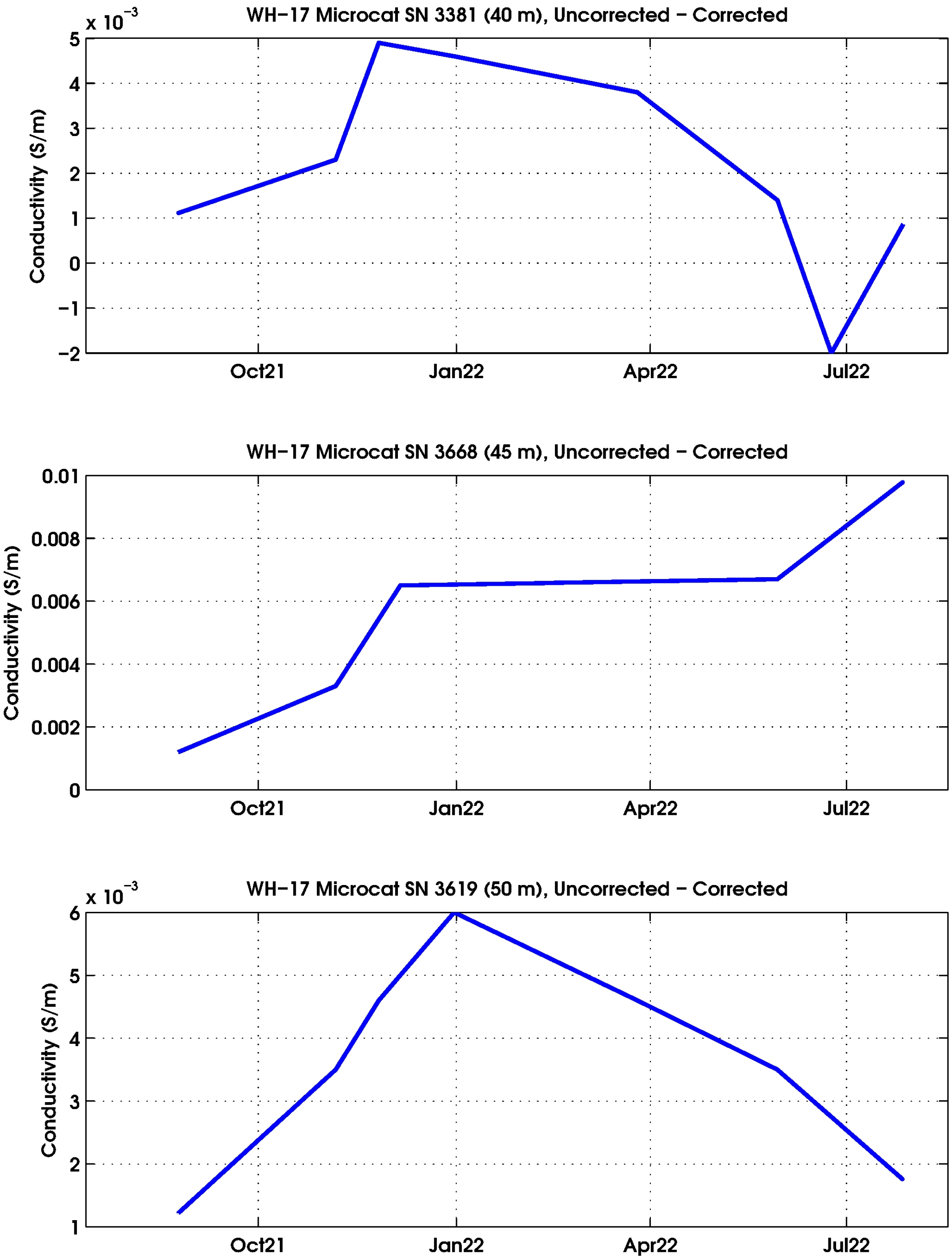


Fig. 5.10: Conductivity sensor corrections for MicroCATs from 40 to 50 meters during WHOTS-17.

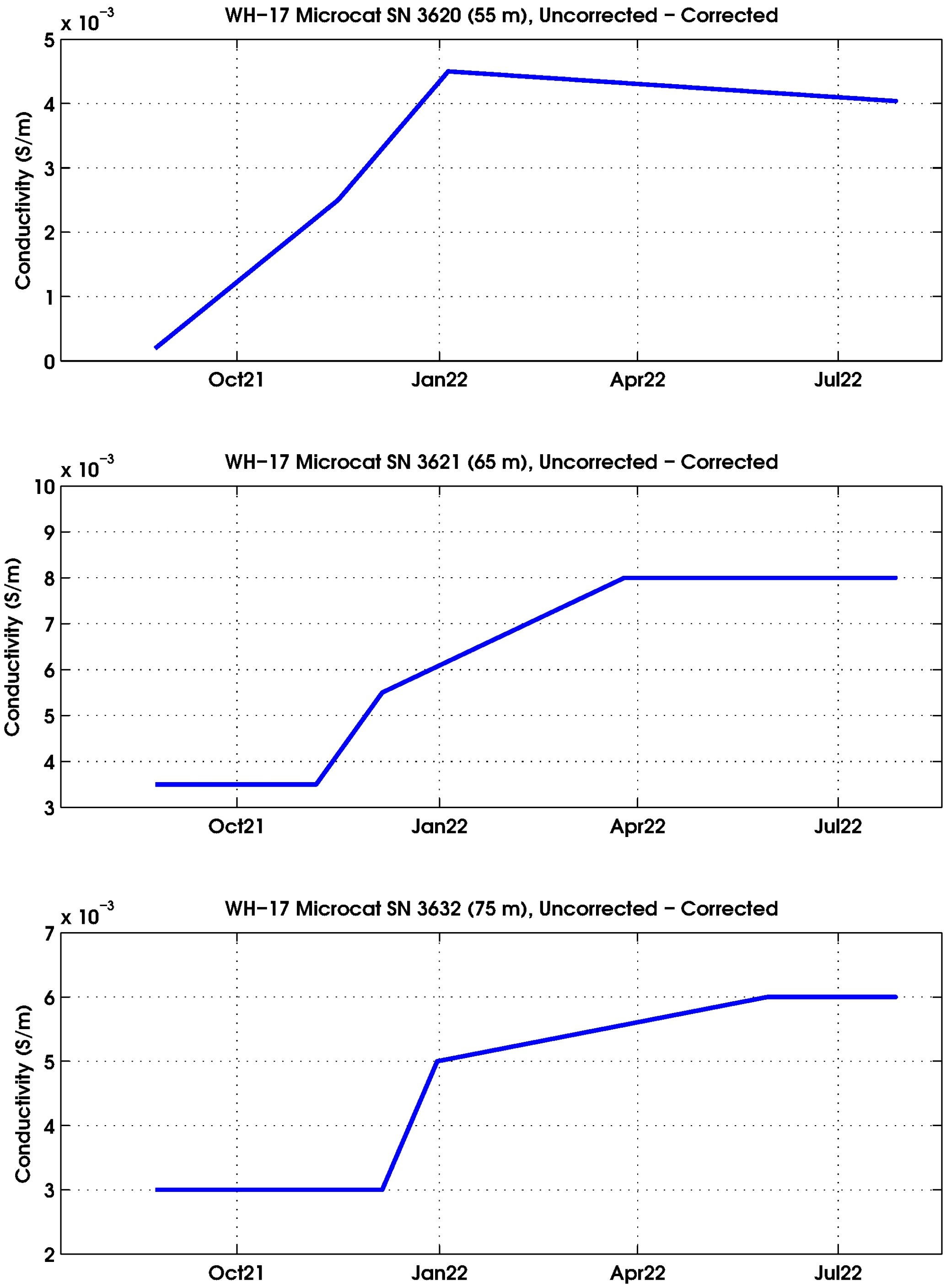


Fig. 5.11: Conductivity sensor corrections for MicroCATs from 55 to 75 meters during WHOTS-17.

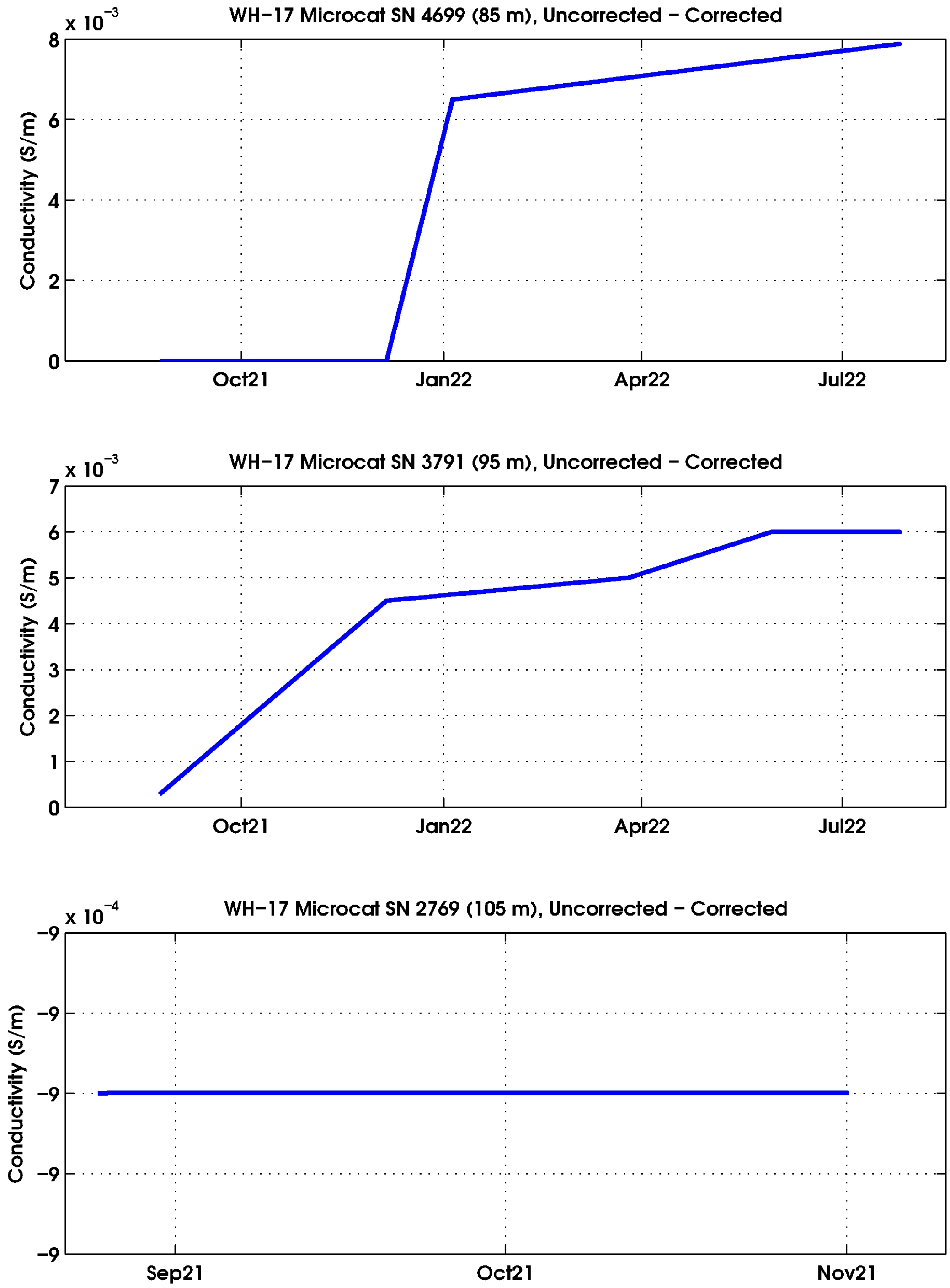


Fig. 5.12: Conductivity sensor corrections for MicroCATs from 85 to 105 meters during WHOTS-17.

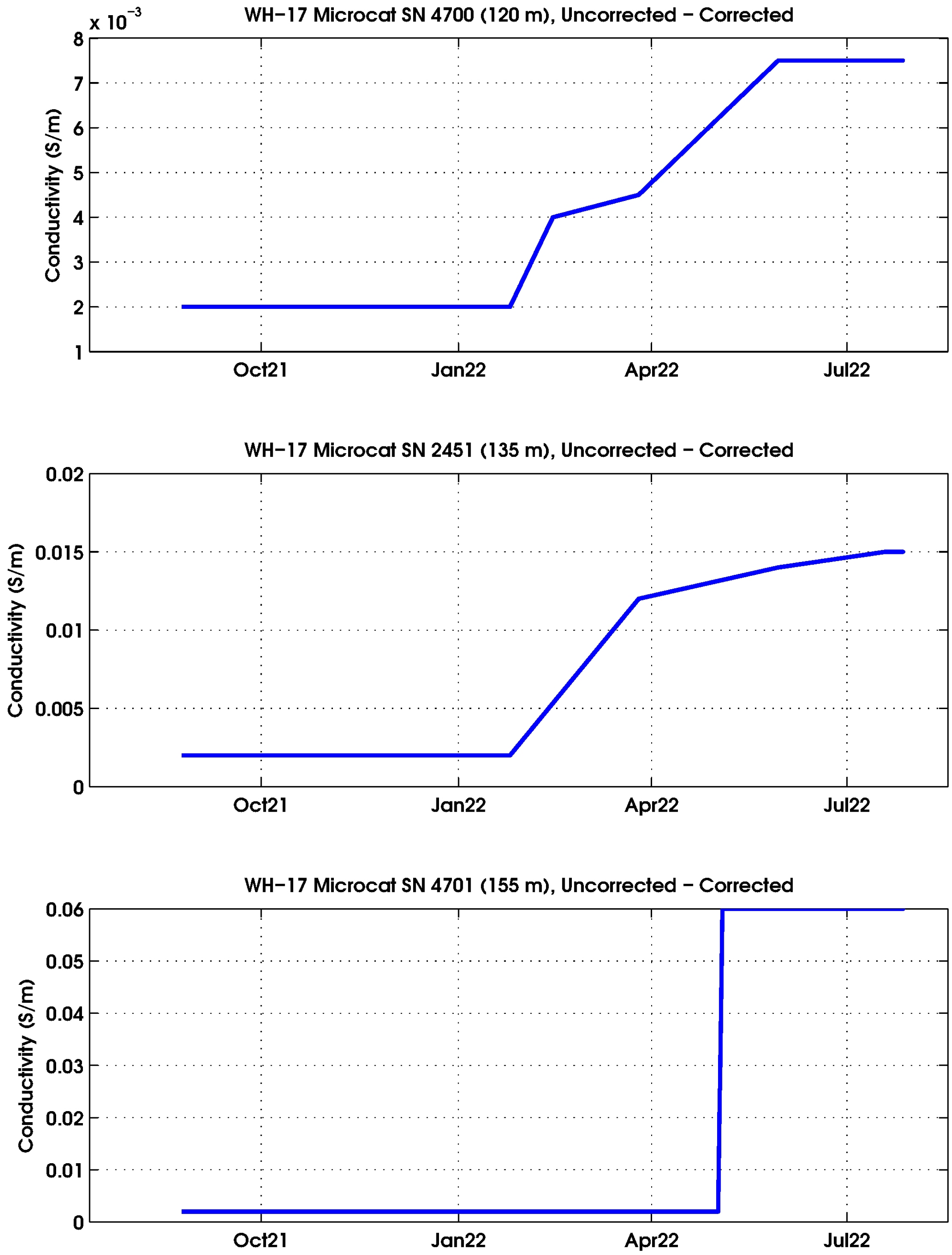


Fig. 5.13: Conductivity sensor corrections for MicroCATs from 120 to 155 meters during WHOTS-17.

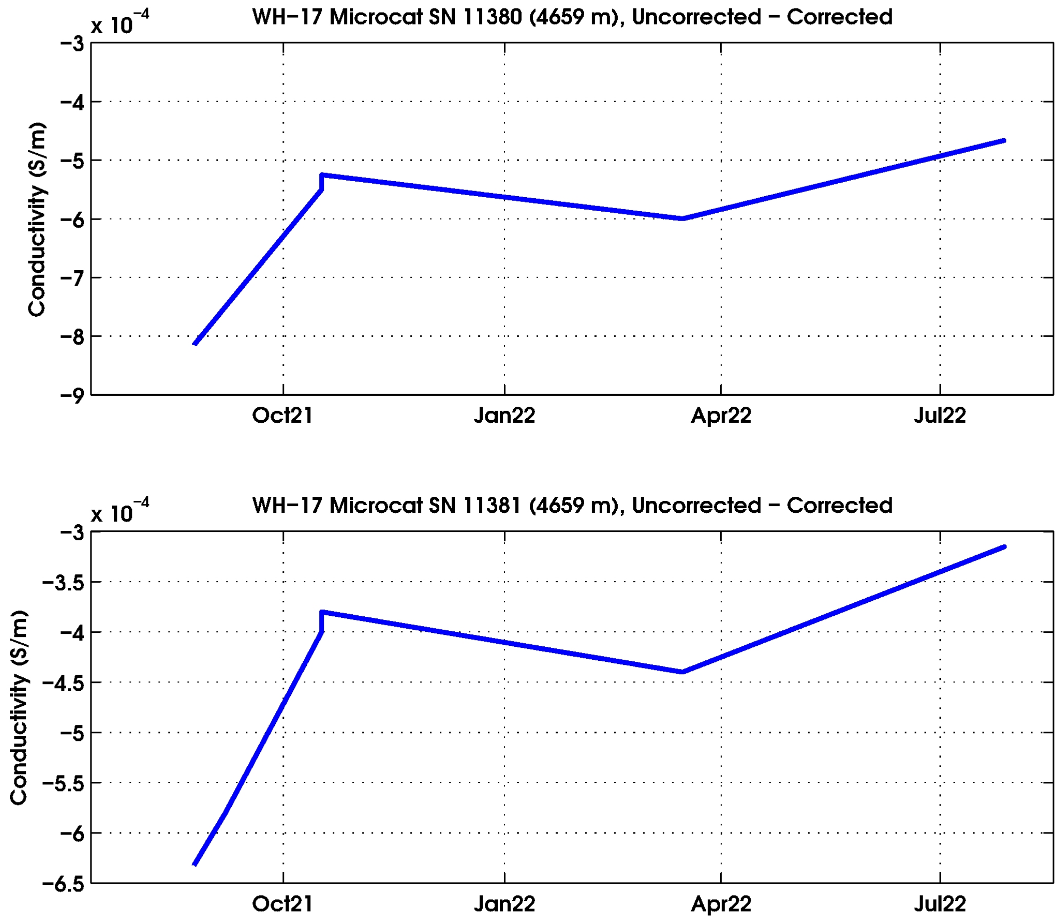


Fig. 5.14: Conductivity sensor corrections for MicroCATs at 4659 meters during WHOTS-17.

5.2.1 Compass Calibrations

5.2.1.1 Pre-Deployment

Before the WHOTS-17 deployment, field calibration of the internal ADCP compass was performed at the University of Hawaiʻi at Mānoa on August 3, 2021 for 300 kHz and the 600 kHz instruments. Each instrument was mounted in the deployment cage with the external battery module and was located away from potential sources of magnetic field disturbances. The ADCP was mounted to a turntable, aligned with the magnetic north using a surveyor's compass. Using the built-in RDI calibration procedure, the instrument was tilted in one direction between 10 and 20 degrees and then rotated through 360 degrees at less than 5° per second. The ADCP was then tilted in a different direction, and a second rotation was made. Based on the results from the first two rotations, calibration parameters are temporarily loaded, and the instrument, tilted in a third direction, is rotated once more to check the calibration. Results from each pre-deployment field calibration are shown in Table 5.4 and Table 5.5 (Fig. 5.15 and Fig. 5.16).

Table 5.4: Results from the WHOTS-17 pre-deployment 300 kHz ADCP compass field calibration procedure. *SCE = Single Cycle Error (°); DCE = Double Cycle Error (°); LD_SCE = Largest Double + Single Cycle Error (°); RMS_RE = RMS of 3rd Order and Higher + Random Error (°); OE = Overall Error (°); PM_STD = Pitch, Mean and St. Deviation (°); RM_STD = Roll, Mean and St. Dev. (°)*

(SN 7367)	SCE	DCE	LD_SCE	RMS_RE	OE	PM_STD	RM_STD
Before	5.10	0.28	5.37	0.14	5.11	0.34 ± 0.38	11.88 ± 0.40
After	0.50	0.26	0.77	0.18	0.61	-15.36 ± 0.51	0.19 ± 0.50

Table 5.5: Results from the WHOTS-17 pre-deployment 600 kHz ADCP compass field calibration procedure. See acronyms on Table 5.4

(SN 13917)	SCE	DCE	LD_SCE	RMS_RE	OE	PM_STD	RM_STD
Before	3.42	0.19	3.61	0.09	3.44	13.68 ± 0.42	-0.02 ± 0.39
After	0.18	0.01	0.19	0.16	0.18	-14.50 ± 0.45	-0.02 ± 0.41

5.2.1.2 Post-Deployment

After the WHOTS-17 mooring was recovered, the ADCP compass performance was tested at the University of Hawaiʻi at Mānoa on August 9, 2022, with an identical compass calibration procedure as during the pre-deployment calibration. Results from the WHOTS-17 post-deployment ADCP compass field calibration procedure are listed in Table 5.6 and Table 5.7 (Fig. 5.15 and Fig. 5.16).

Table 5.6: Results from the WHOTS-17 post-deployment 300kHz ADCP compass field calibration procedure. See acronyms on Table 5.4

(SN 7367)	SCE	DCE	LD_SCE	RMS_RE	OE	PM_STD	RM_STD
After	1.82	0.14	1.97	0.10	1.82	-0.68 ±0.52	-0.22±0.48

Table 5.7: Results from the WHOTS-17 post-deployment 600kHz ADCP compass field calibration procedure. See acronyms on Table 5.4

(SN 13917)	SCE	DCE	LD_SCE	RMS_RE	OE	PM_STD	RM_STD
After	1.72	0.09	1.81	0.08	1.73	-0.40 ±0.48	-1.09±0.52

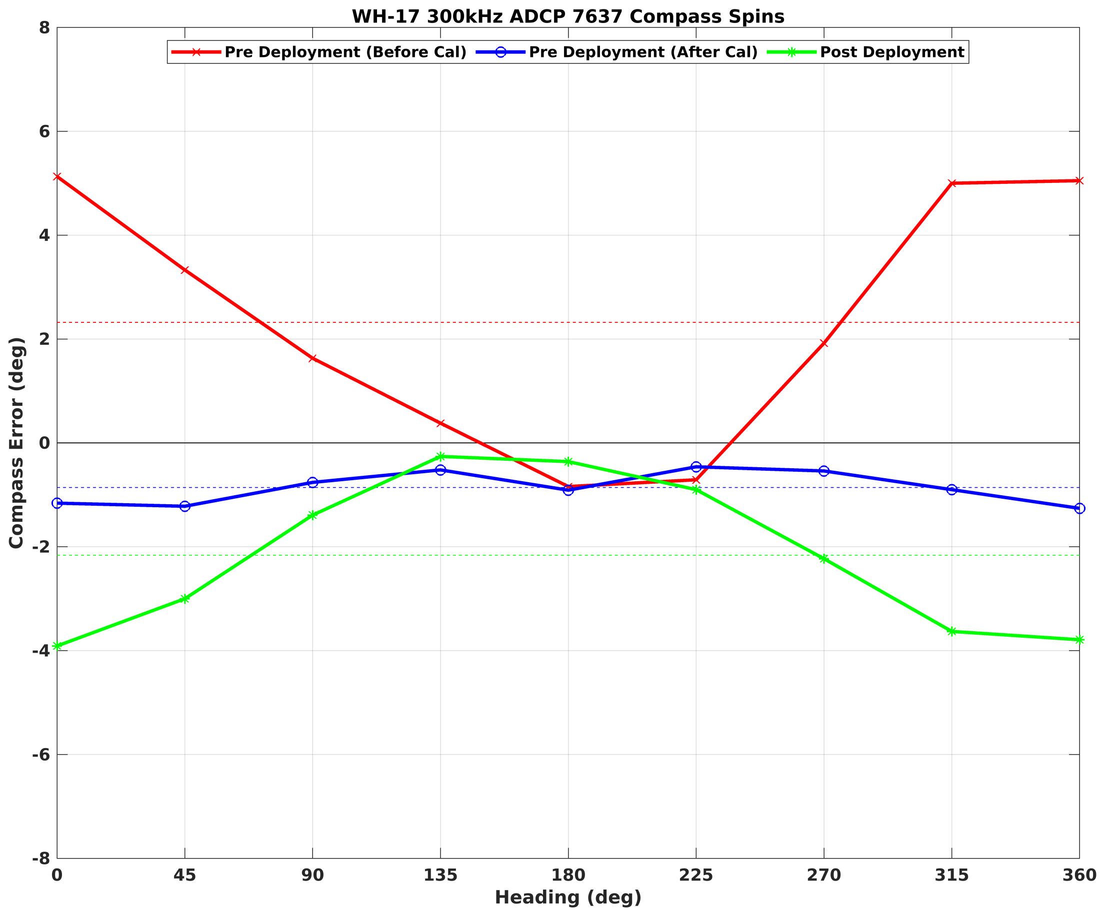


Fig. 5.15: Results of the post-cruise compass calibration, conducted August 9, 2022, on ADCP SN 7637 at the University of Hawaiʻi at Mānoa.

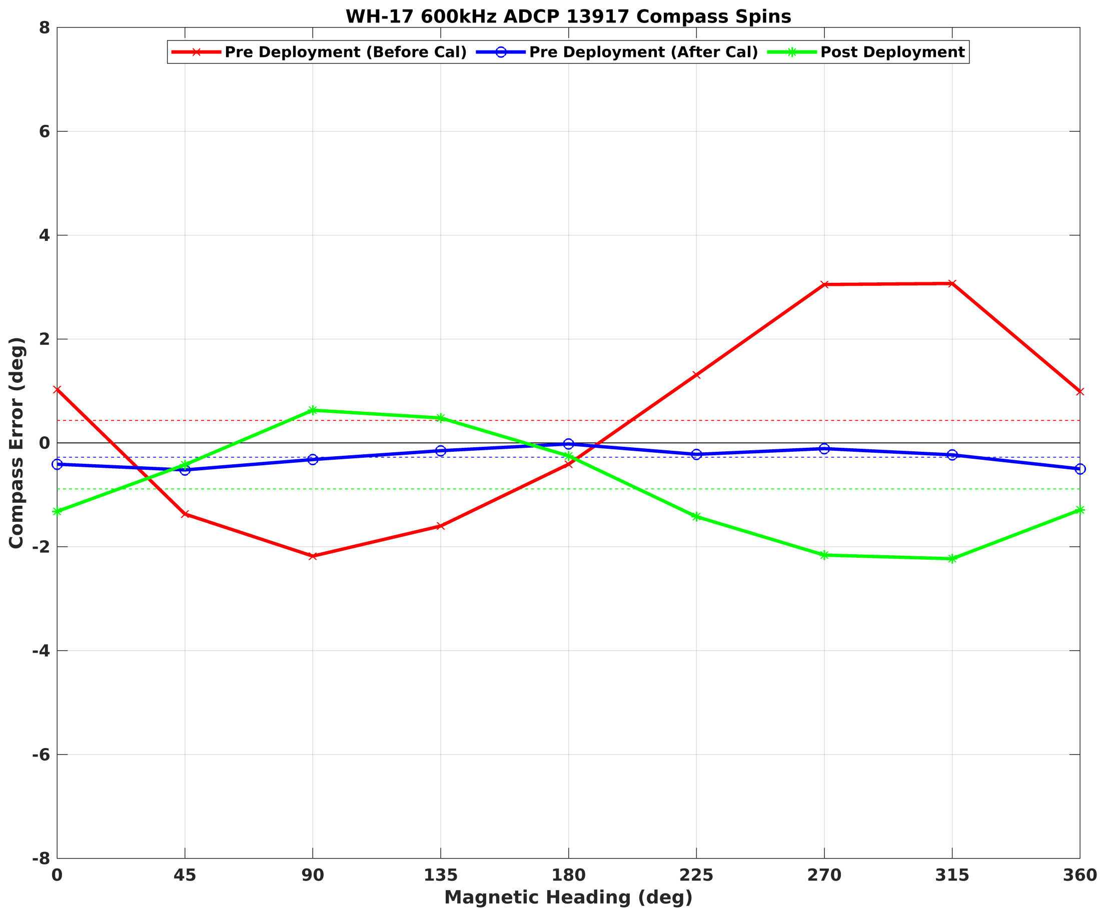


Fig. 5.16: Results of the post-cruise compass calibration, conducted August 9, 2022, on ADCP SN 13917 at the University of Hawaiʻi at Mānoa.

5.2.2 ADCP Configurations

Individual configurations for the two ADCP's on the WHOTS-17 mooring are detailed in *WHOTS-17 300 kHz - Serial 7367*, and *WHOTS-17 600 kHz - Serial 13917*. The salient differences for each of the ADCP's are summarized below.

5.2.2.1 300 kHz (SN/7367- 125m)

The ADCP, set to a beam frequency of 300 kHz, was configured in a burst sampling mode consisting of 40 pings per ensemble to resolve low-frequency wave orbital motions. The interval between each ping was 4 seconds, so the ensemble length was 160 seconds. The interval between ensembles was 10 minutes. Data were recorded in earth coordinates, with a heading bias of 9.48° E due to magnetic declination. False targets, usually fish, were screened by setting the threshold maximum to 70 counts. Velocity data were rejected if the difference in echo intensity among the four beams exceeded this threshold.

5.2.2.2 600 kHz (SN/13917- 47.5m)

The ADCP, set to a beam frequency of 600 kHz, was configured in a burst sampling mode consisting of 80 pings per ensemble. The interval between each ping was 2 seconds, so the ensemble length was also 160 seconds. The interval between ensembles was 10 minutes. Data were recorded in earth coordinates with a heading bias of 9.48° E. The threshold maximum was also set to 70 counts. Velocity data were rejected if the difference in echo intensity among the four beams exceeded this threshold.

5.2.3 ADCP data processing procedures

Binary files output from the ADCP were read and converted to MATLAB™ binary files using scripts developed by Eric Firing's ADCP lab. The beginning of the raw data files was truncated to a time after the mooring anchor was released to allow time for the anchor to reach the seabed and for the mooring motions that follow the anchor's impact on the seafloor to dissipate. The pitch, roll, and ADCP temperature were examined to pick reasonable times that ensured good data quality without unnecessarily discarding too much data (Fig. 5.17, Fig. 5.18). Truncation at the end of the data files was chosen to be the ensemble before the acoustic release signal was sent to avoid contamination due to the instrument's ascent. The times of the first ensemble from the raw data, deployments and recovery time, along with the truncated records of both deployments, are shown in Table 5.8.

Table 5.8: ADCP record times (UTC mm/dd/yyyy, hh:mm:ss) during WHOTS-17 deployment

Activities	300 kHz	600 kHz
Raw file start	08/25/2021, 06:07:00	08/25/2021, 05:50:00
Raw file end	07/27/2022, 06:16:59	07/27/2022, 06:39:59
ADCP In water	08/25/2021, 21:00:00	08/25/2021, 20:39:00
Anchor over	08/26/2021, 03:13:00	08/26/2021, 03:13:00
Anchor release fired	07/25/2022, 18:03:00	07/25/2022, 18:03:00
ADCP on deck	07/26/2022, 03:32:00	07/26/2022, 03:45:00

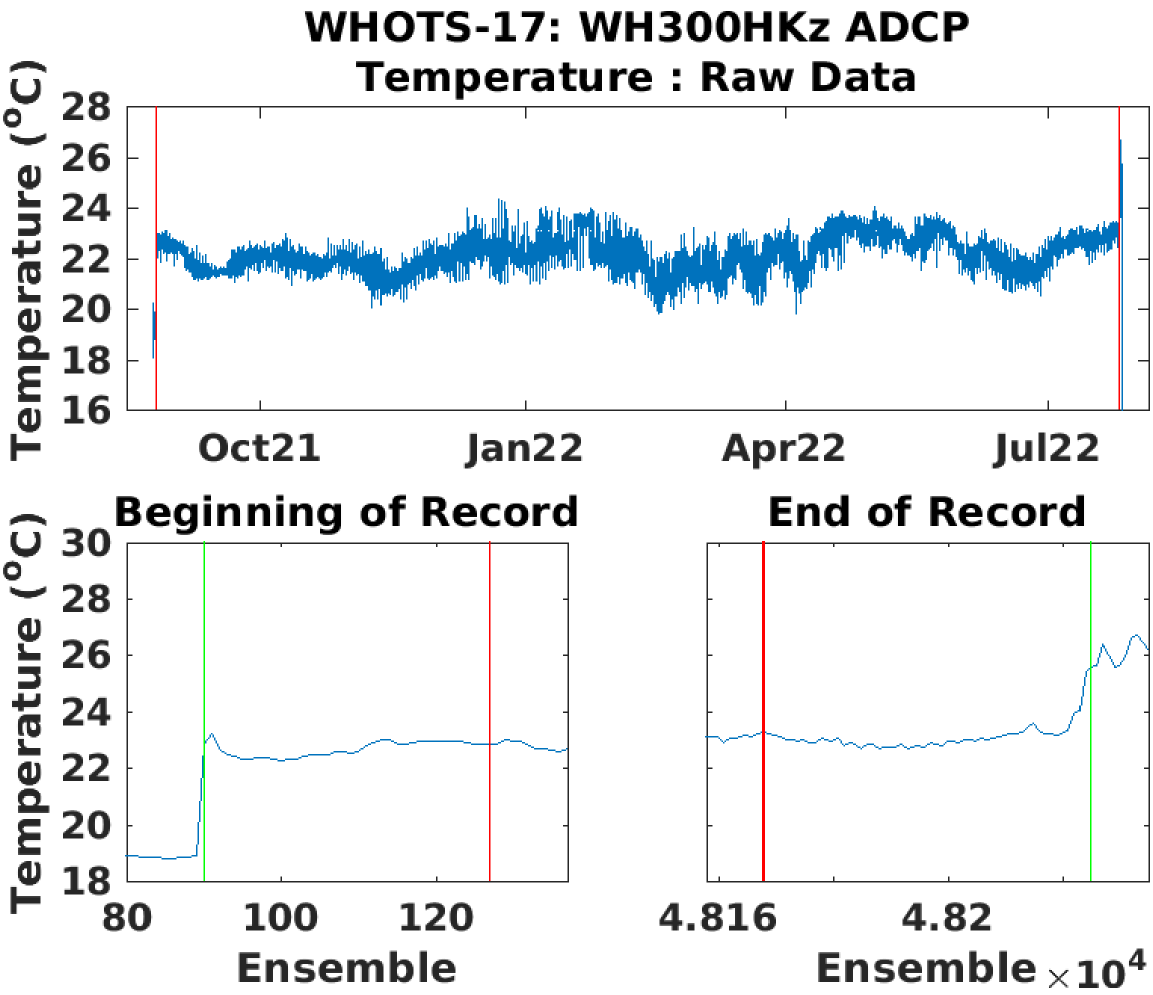


Fig. 5.17: Temperature record from the 300 kHz ADCP during WHOTS-17 mooring (top panel). The bottom panel shows the beginning and end of the record, with the green vertical line representing the in-water time during deployment and out-of-water recovery time. The red line represents the anchor release and acoustic release trigger for deployment and recovery, respectively.

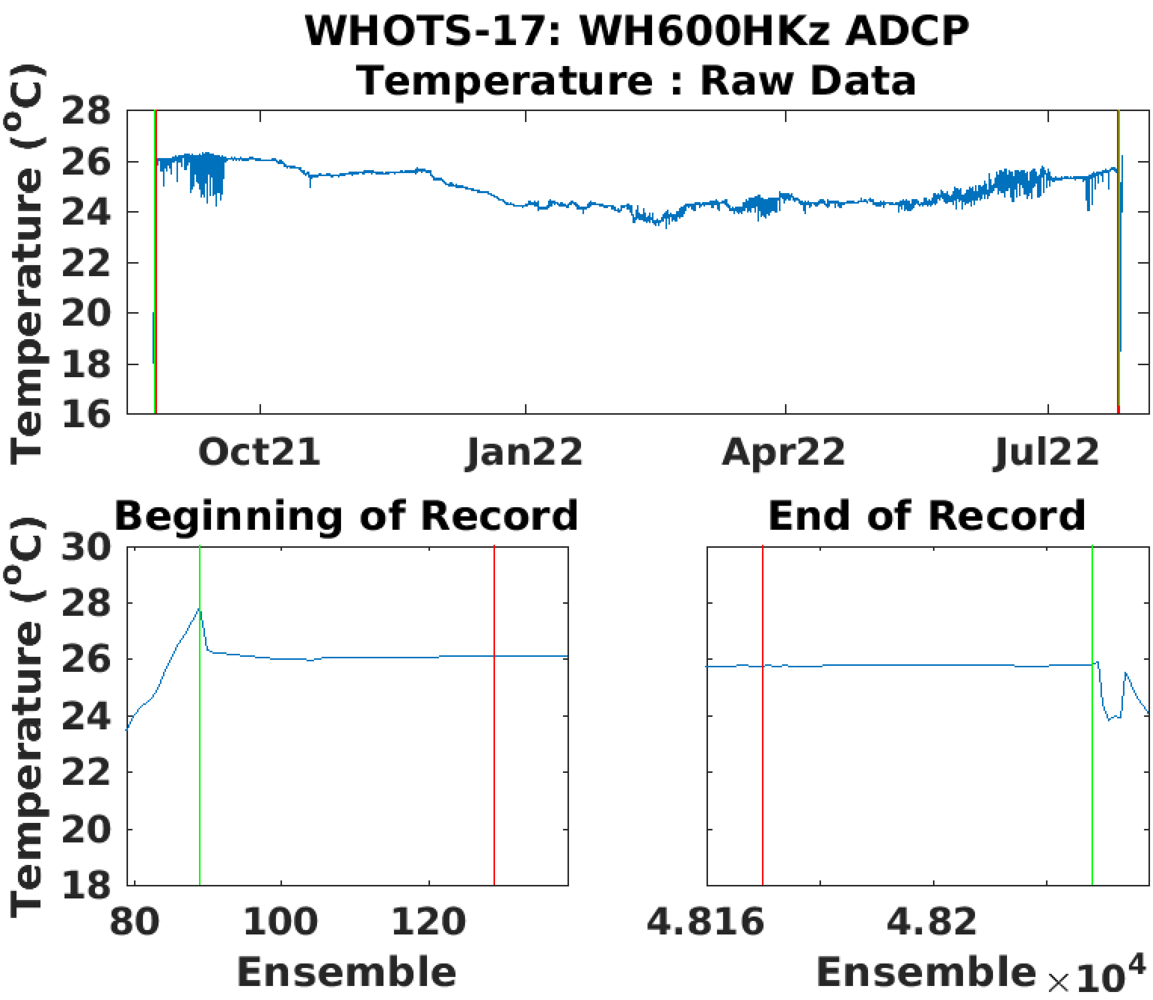


Fig. 5.18: Same as Fig. 5.17, but for the 600 kHz ADCP.

5.2.3.1 ADCP Clock Drift

Upon recovery, a spike is normally produced in the ADCP data by applying an ice pack next to the temperature sensor (see Table 3.5) to compare the ADCP clocks with the ship's time server. The ice-spike time matched the time of the 300 kHz ADCP temperature sensor spike within the corresponding 600 sec sample interval, however for the 600 kHz ADCP the temperature sensor spike was off by one sample. At the time when logging was stopped, the 300 kHz instrument time was 15 sec behind UTC and the 600 kHz was 7 min 16 sec ahead of UTC. No drift corrections were made. However, this drift may be significant if the data are used for time-dependent analysis, such as tidal or spectrum analysis. A drift correction needs to be applied in those cases.

5.2.3.2 Heading Bias

As mentioned in the ADCP configuration section, the data were recorded in the earth coordinates. A heading bias, the angle between magnetic north and true north, can be included in the setup to obtain output data in true-earth coordinates. Magnetic variation was obtained from the National Geophysical Data Center 'Geomag' calculator . A constant value is acceptable for a yearlong deployment because the change in declination is small, approximately -0.02° $year^{-1}$ at the WHOTS location. A heading bias of 9.48° was entered in the setup of the WHOTS-17 ADCP's.

5.2.3.3 Speed of sound

Due to the constant proportionality between the Doppler shift and water speed, the speed of sound needs only be measured at the transducer head [Firing, 1991]. The sound speed used by the ADCP is calculated using a constant value of salinity (35), and the temperature recorded by the transducer temperature sensor of the ADCP. Using CTD profiles close to the mooring during HOT cruises, HOT-333 to 337, and from the WHOTS deployment/recovery cruises, the mean salinity at 125 dbar was 35.17 while the mean salinity at 47.5 dbar was 35.11 . The mean ADCP temperature at 125 dbar was 22.64 °C and 25.49 °C at 47.5 dbar (Fig. 5.17, Fig. 5.18, and Fig. 5.19).The mean sound velocity at 47.5 and 125 dbar was 1536.47ms^{-1} and 1530.77ms^{-1}, respectively.

5.2.3.4 Quality Control

Quality control of the ADCP data involved the thorough examination of the velocity, instrument orientation, and diagnostic fields to develop the basis of the QC flagging procedures. Details of the methods used can be found in the WHOTS Data Report 1 [Santiago-Mandujano *et al.*, 2007]. The following QC procedures were applied to the WHOTS-17 deployment of ADCP data.

1. The first bin (closest to the transducer) is sometimes corrupted due to what is known as ringing. A period of time is needed for the sound energy produced during a transducer's transmit pulse to dissipate before the ADCP can adequately receive the returned echoes. This "blanking interval" is used to prevent useless data from being recorded. If it is too short, signal returns can be contaminated by the lingering noise from the transducer. The blanking interval is expressed as a distance. The default value of 1.76 m was used for the 300 kHz ADCP, whereas an interval of 0.88 m was used for the 600 kHz ADCP. As a result, bin one was flagged and replaced with `Not a Number (NaN)` in the quality-controlled dataset (Fig. 5.20).
2. For an upward-looking ADCP with a beam angle of 20° within range of the sea surface, the upper 6% of the depth range is contaminated with sidelobe interference [Teledyne RD Instruments, 2011]. This contamination results from the much stronger signal reflection from the sea surface than from scatters, overwhelming the sidelobe suppression of the transducer. Data quality is quantified using echo intensity, a measure of the backscattered echo`s strength for each depth cell. With distance from the transducer sensor, echo intensity is expected to decrease. Sharp increases in echo intensity indicate contamination from surface reflection. Most of the data within the upper four bins were flagged. These top four bins range from about 15 m up to the sea surface.
3. The Janus configuration of four beams (along with instrument orientation) is used to resolve currents into their component earth-referenced velocities, providing a second estimate of the vertical velocity. The scaled difference between these estimates is defined as the error velocity, and it is useful for assessing data quality. Error velocities with an absolute magnitude more significant than 0.15ms^{-1} (value comparable to the standard deviation of observed horizontal velocities) were flagged and removed.

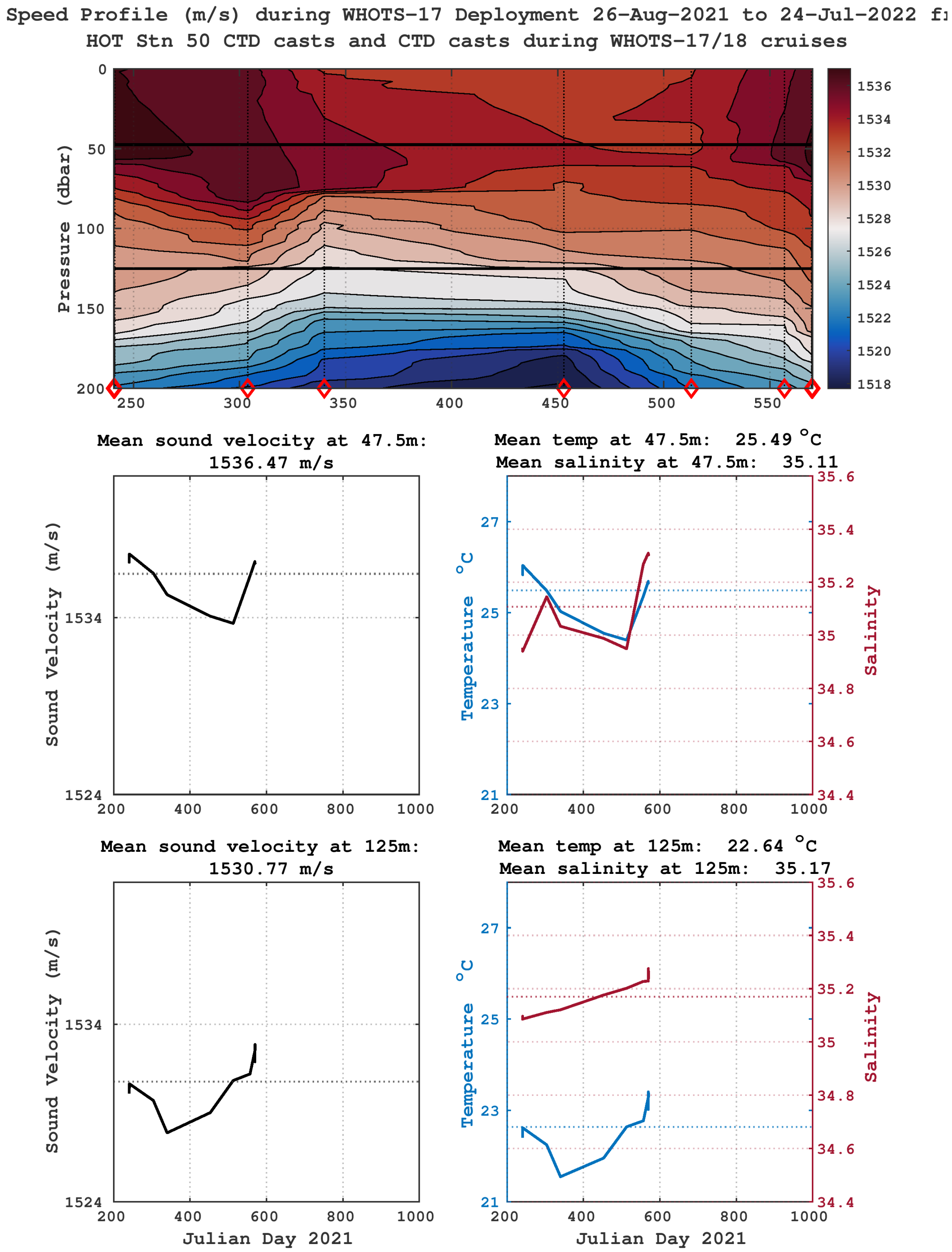


Fig. 5.19: Sound speed profile (top panel) during the deployment of the WHOTS-17 mooring from 2 dbar CTD data taken during regular HOT cruises and CTD profiles taken during the WHOTS-17 and -18) deployment cruises (individual casts marked with a red diamond). The bottom left panels show the sound velocity at a depth of the ADCP's (47.5 m and 125 m), with the mean sound velocity indicated with a dashed black line. The lower right panels show the temperature and salinity at each ADCP depth for the time series, with the mean temperatures indicated with blue lines and mean salinity indicated with red lines.

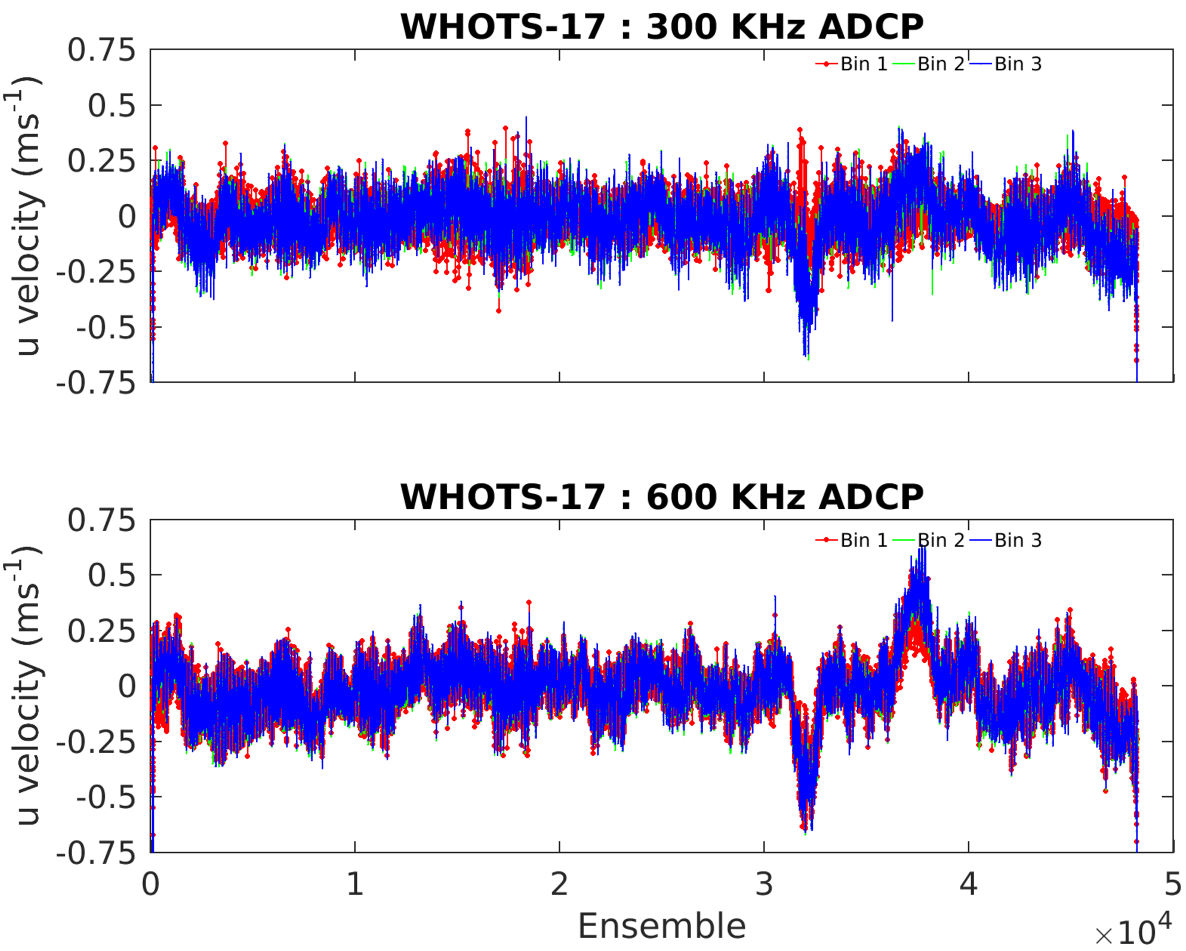


Fig. 5.20: Eastward velocity component for the 300 kHz (top panel) and the 600 kHz (bottom panel) ADCPs are showing the incoherence between depth bins 1 (red), 2 (green), and 3 (blue).

4. An indication of data quality for each ensemble is given by the "percent good" data indicator, which accompanies each beam for each bin. The use of the percent good indicator is determined by the coordinate transformation mode used during the data collection. For profiles transformed into earth coordinates, the percent good field shows the percentage of pings that could be used to create the earth coordinate velocities. The percent good fields show the percentage of data made using 4 and 3 beam solutions in each depth cell within an ensemble, and the percentage that was rejected due to failing one of the criteria set during the instrument setup (see *WHOTS-17 300 kHz - Serial 7367*). Data were flagged when data in each depth cell within an ensemble made from 3 or 4 beam solutions was 20% or less.
5. Data were rejected using correlation magnitude, which is the pulse-to-pulse correlation (in ping returns) for each depth cell. Correlation magnitude represents how the shape of the received signal corresponds to the outgoing signal for each ping. If at least three of the beams exhibited a correlation magnitude more significant than 64 counts for a given bin, the profile could be transformed into earth coordinates. Low correlation magnitudes may indicate sudden changes in particle density or sudden changes in ADCP tilt. More research is needed at this time into relationships between ADCP tilt and correlation magnitude. If any beam had a correlation magnitude of 20 counts or fewer, that data point was flagged.
6. Histograms of raw vertical velocity data and partially cleaned data from the ADCP (Fig. 5.21 and Fig. 5.22) and the WHOTS Data Report 1 [Santiago-Mandujano *et al.*, 2007] showed vertical velocities larger than expected, some exceeding $1ms^{-1}$. Recall that the instruments' burst sampling (4-second intervals for the 300 kHz and 2-second intervals for the 600 kHz, for 160 seconds every 10 minutes) was designed to minimize aliasing by occasional large ocean swell orbital motions *Description of WHOTS-17 Mooring* , and therefore are not the source of these speeds in the data. These significant vertical speeds are possibly fish swimming in the beams based on the histograms of the partially cleaned data; depth cells with an absolute value of vertical velocity greater than $0.3ms^{-1}$ were flagged.

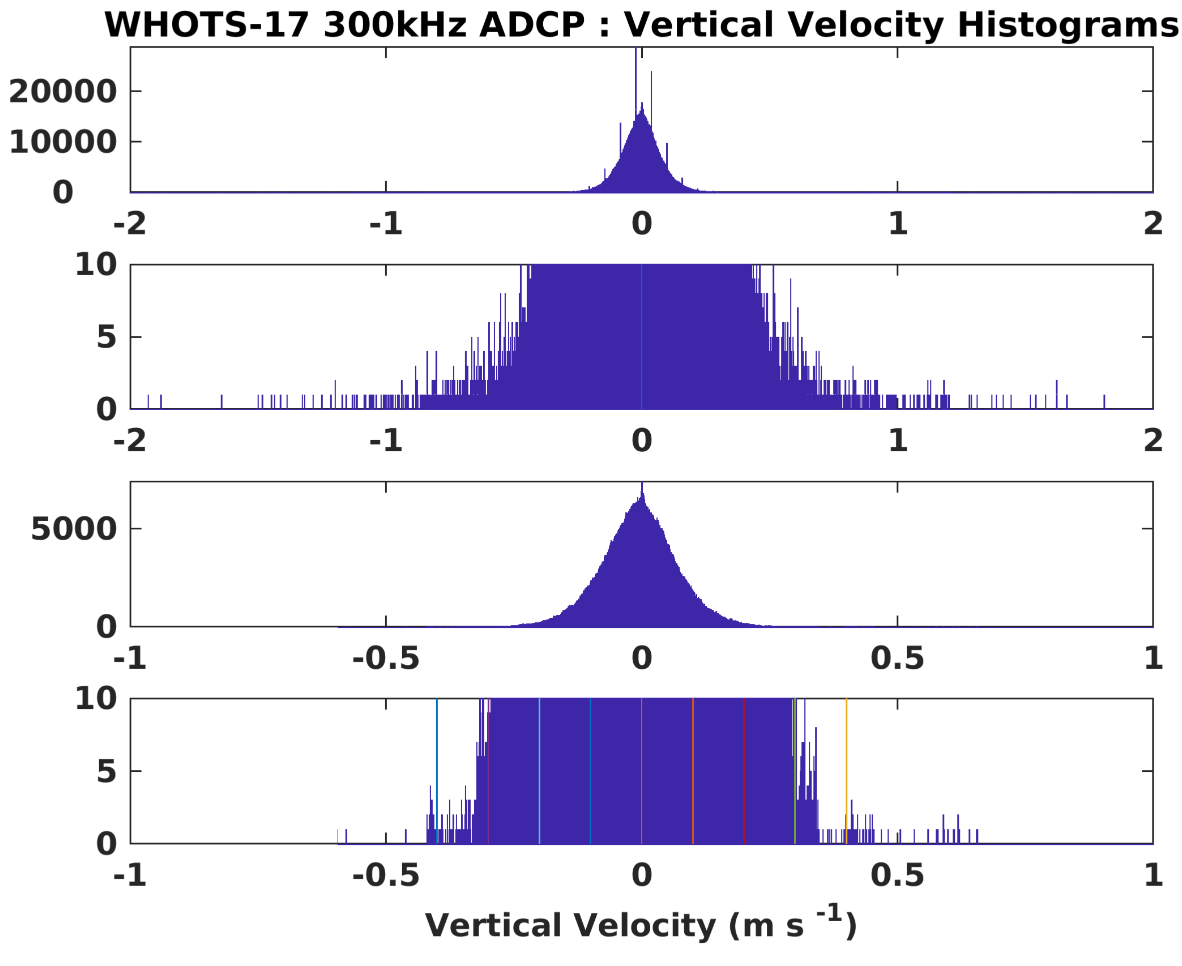


Fig. 5.21: Histogram of the vertical velocity of the 300 kHz ADCP for raw data (top panel) and enlarged for clarity (upper middle panel), and partial quality controlled data (lower middle panel) and enlarged for clarity (bottom).

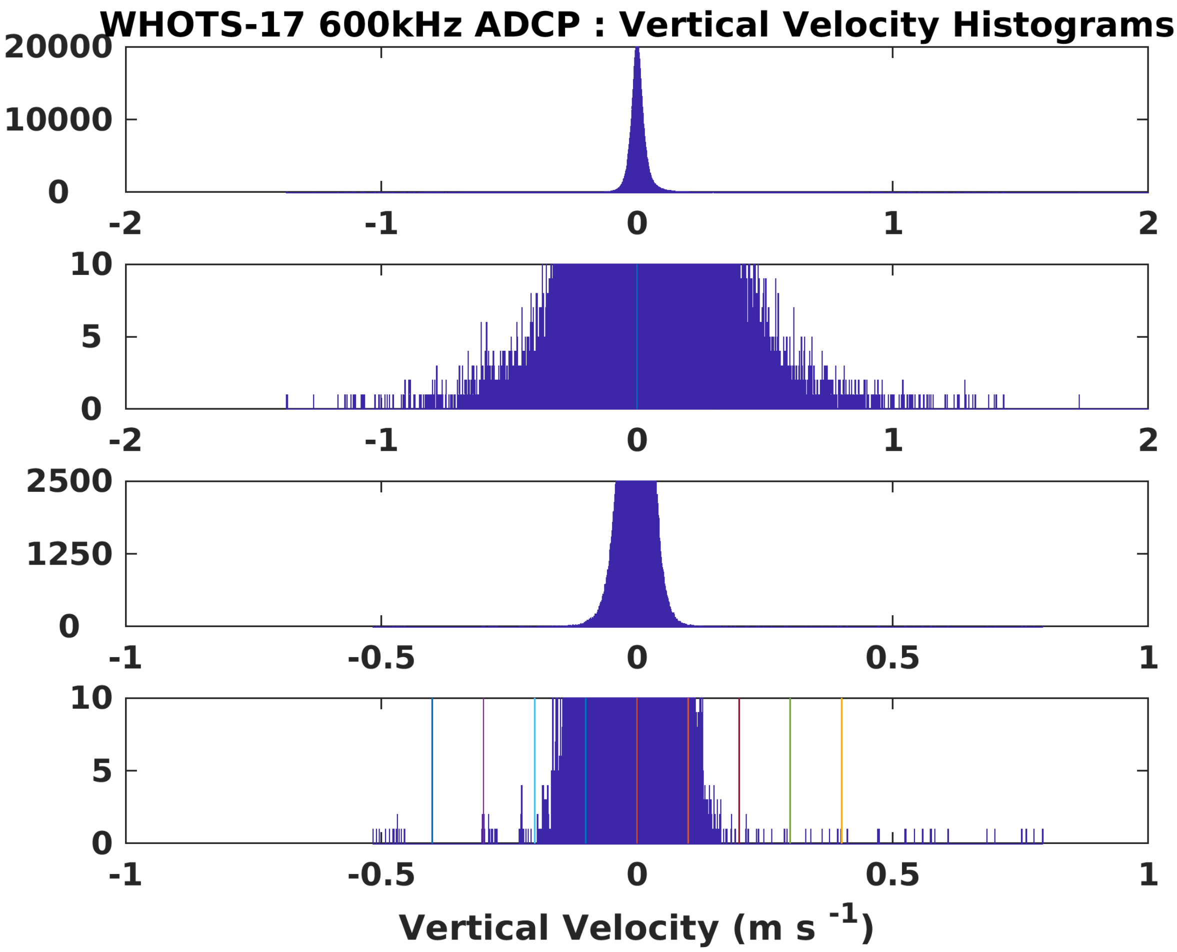


Fig. 5.22: Same as Fig. 5.21, but for 600kHz ADCP.

7. A quality control routine known as 'edgers' identifies outliers in surface bins using a five-point median differencing method. The median velocity from surface bins was calculated for each ensemble, and then a five-point running median of the surface bin median was calculated. This last median was then compared to individual velocity observations in the surface bins, and those differing by greater than $0.48ms^{-1}$ were flagged.
8. A 5-pole low pass Butterworth filter with a cutoff frequency of $0.25\frac{cycles}{hour}$ was used upon the time-series` length to isolate low-frequency flow for each bin independently. The low-frequency flow is then subtracted, giving a time series of high-frequency velocity component fluctuations for each bin. Data points were considered outliers when their values exceeded four standard deviations from the mean (for each bin) and were removed.
9. A median residual filter used a 7-point (70 minutes) median differencing method to define velocity fluctuations. A 7-point running median is calculated for each bin independently, and the result is subtracted out, giving time series of variations relative to the running median. Outliers higher than four standard deviations from the mean of the 7 points are flagged and removed for each bin.
10. Meticulous verification of all the quality control routines was performed through visual inspections of the quality-controlled velocity data. Two methods were utilized; time-series of u and v components for multiple bins were evaluated, and individual vertical profiles. The time-series methodology involved inspecting u and v components separately, five bins at a time, over 600 ensembles (100 hours). Any instance showing one bin behaving erratically from the other four bins was investigated further. If it seemed that there could be no reasonable rationale for the erratic points from the identified bin, the points were flagged. The intent of the inspection of vertical profiles of u and v components was to find entire profiles that were not aligned with neighboring profiles. Thirty u and v profiles were stacked at a time and were visually inspected for any anomalous data.

5.3 Vector Measuring Current Meter (VMCM)

Vector measuring current meters (VMCM) were deployed on the WHOTS-17 mooring at depths of 10 m and 30 m, serial numbers SN 0035 and 0058, respectively. VMCM data were processed by the WHOI/UOP group, and the record times are shown in Table 5.9.

Table 5.9: Record times (UTC mm/dd/yy hh:mm) for the VMCMs at 10 m and 30 m during the WHOTS-17 deployment

Time Over	VMCM (SN 0035)	VMCM (SN 0058)
Deployment	08/25/21 19:57	08/25/21 19:32
Recovery	07/26/22 05:05	07/26/22 05:12

Daily (24 hours) moving averages of quality controlled 600 kHz ADCP data are compared to VMCM data interpolated to the ADCP ensemble times in the top panels of Fig. 5.23 through Fig. 5.26, and the difference is shown in the middle panels. The absolute value of the mean difference plus or minus one standard deviation is shown at the top of the middle panel. Velocities are not compared if greater than 80% of the ADCP data within a 24-hour average was flagged. The absolute value of mean differences for all deployments and both velocity components varied between 1.5 and 3 cms^{-1}, with standard deviations between 1.3 and 2.4 cms^{-1}. The VMCM data does not appear to degrade over time for any deployment. Propeller fouling would dampen measured VMCM velocity magnitudes, but a decrease in VMCM velocity magnitude than ADCP velocity magnitude with time is not observed.

5.4 Global Positioning System Receiver

Xeos Global Positioning System receiver Melo(“IMEI:300034013707580”) and Rover(low central tower:”IMEI:300434064530400”; high tower top: “IMEI:300434063547190”) were attached to the buoys tower top during the WHOTS-17 deployment (*Description of WHOTS-17 Mooring*). Data returns from the receiver were high (Table 5.10).

Table 5.10: GPS record times (UTC mm/dd/yy hh:mm) during WHOTS-17.

Raw file	Xeos GPS (Melo)	Xeos GPS (Rover)
Start Time	08/04/21 02:11:00	08/04/21 02:10:00
End Time	07/26/22 18:53:00	07/26/22 12:02:01

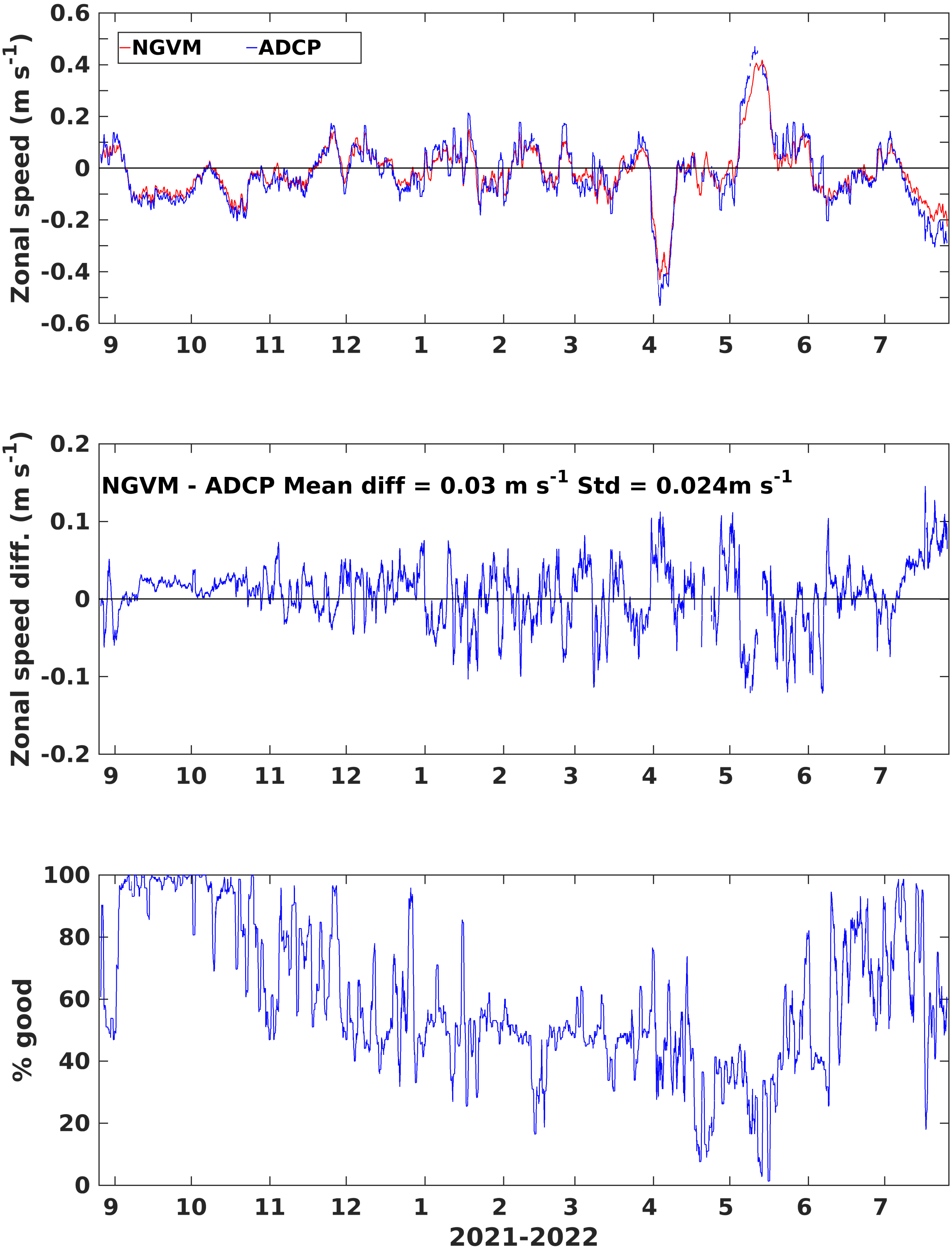


Fig. 5.23: A comparison of 30 m VMCM and ADCP U velocity for WHOTS-17. The top panel shows 24-hour moving averages of VMCM zonal (U) velocity at 30 m depth (red) and ADCP U velocity from the nearest depth bin to 30 m (30.22 m). The middle panel shows the U velocity difference, and the bottom panel shows the percentage of ADCP data within the moving average not flagged by quality control methods.

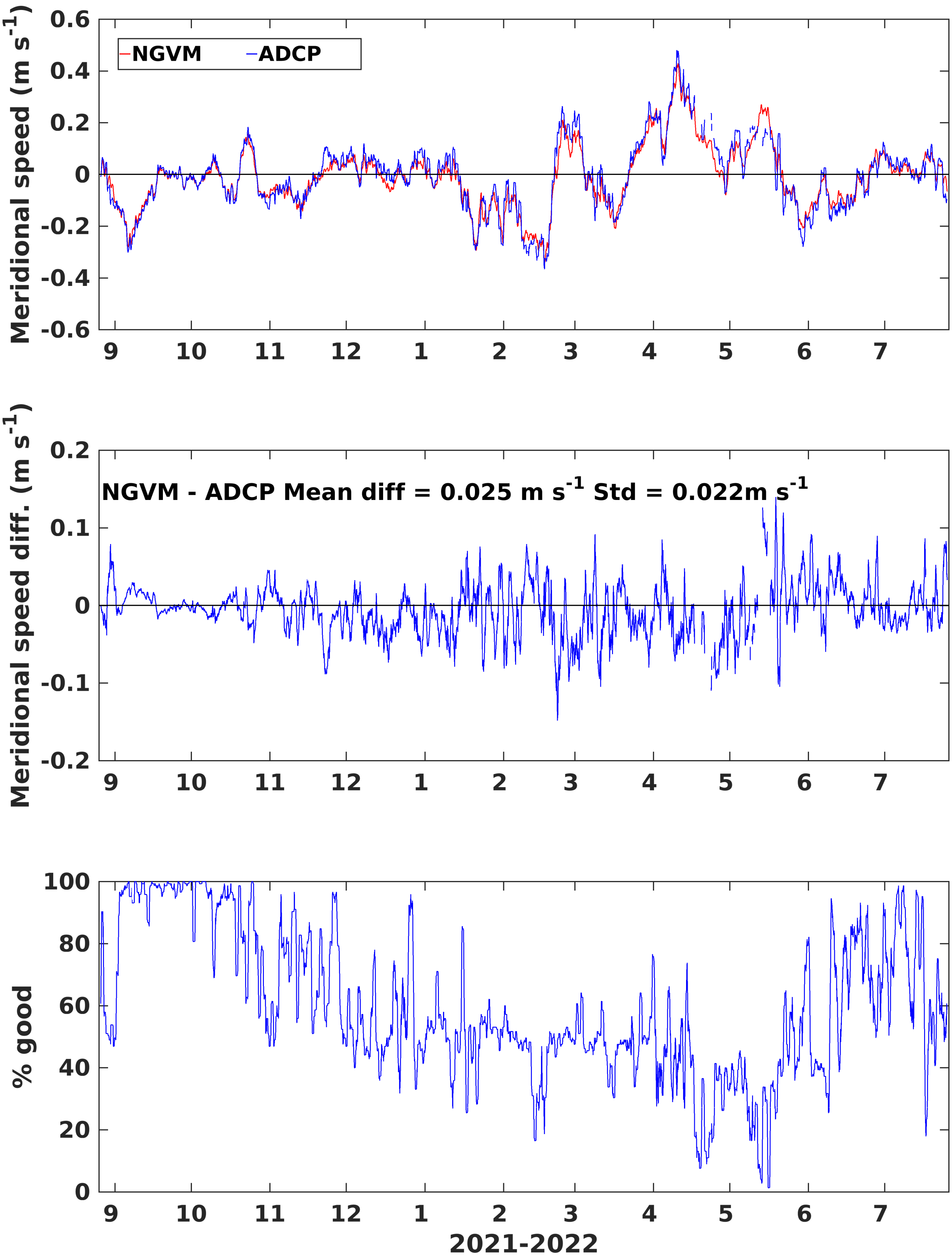


Fig. 5.24: Same as in Fig. 5.23 but for the meridional (V) velocity component.

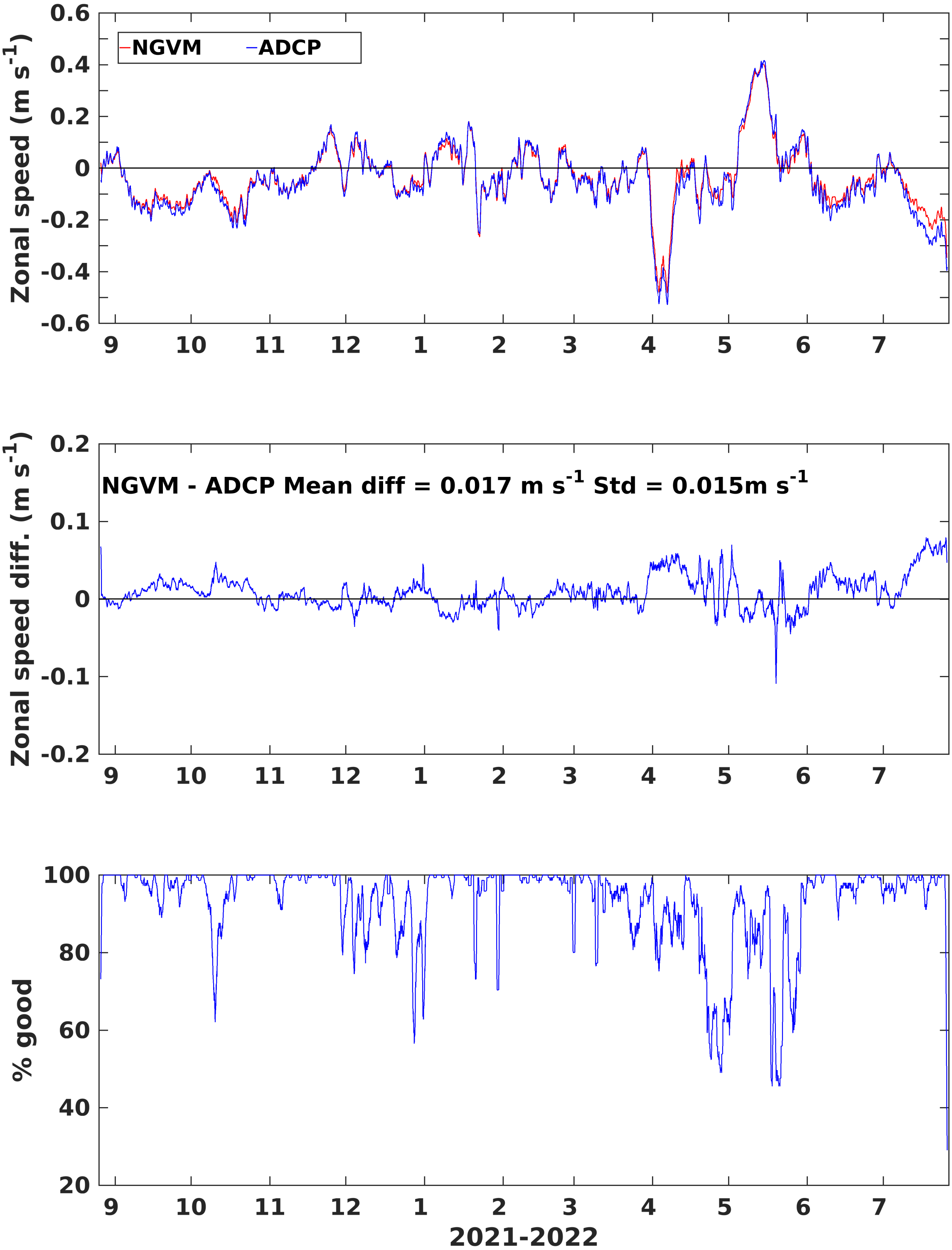


Fig. 5.25: Same as in Fig. 5.23 but for the 10 m VMCM.

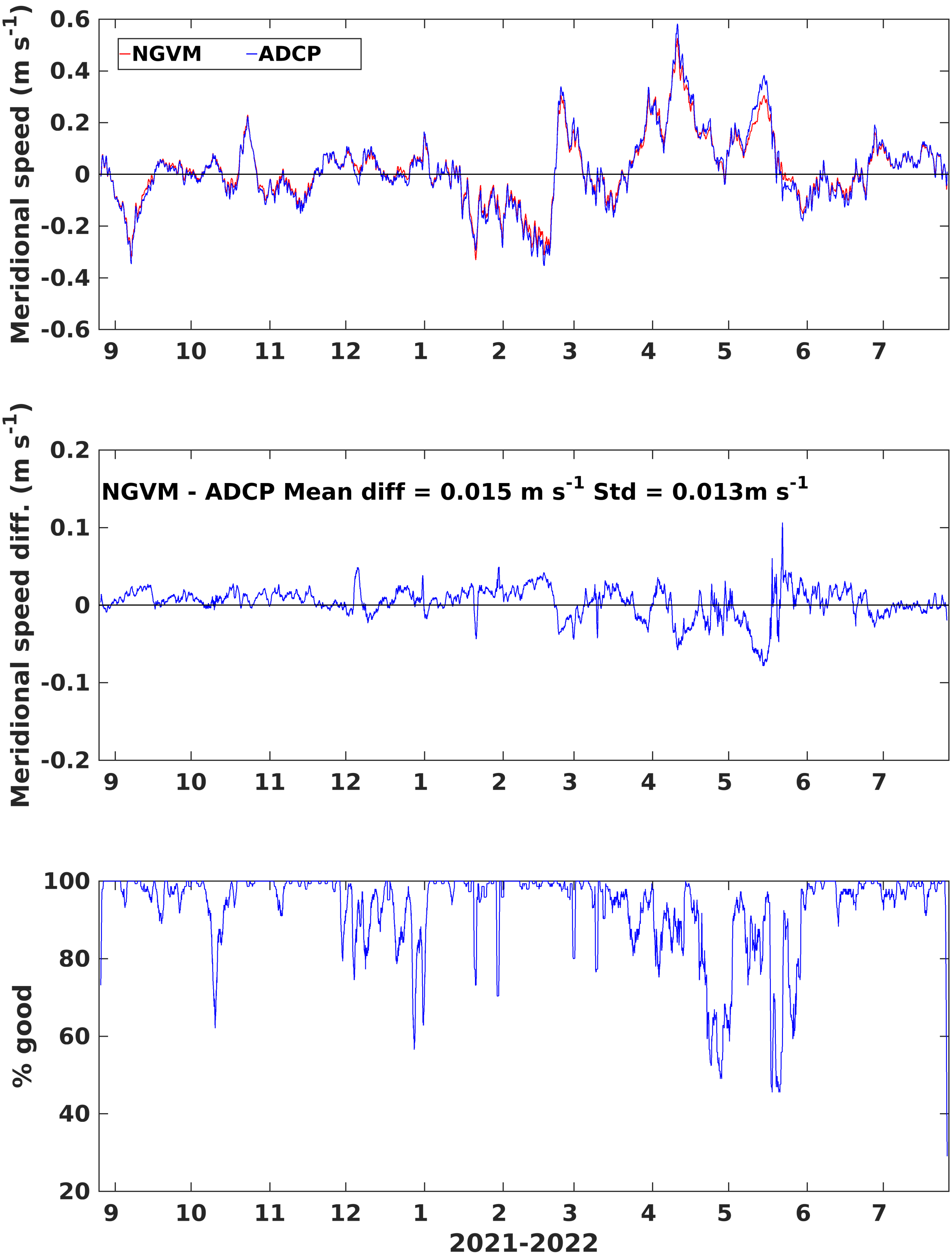


Fig. 5.26: Same as Fig. 5.25, but for the meridional (V) velocity component.

6 Results

During the WHOTS-17 cruise (WHOTS-17 mooring deployment, August 24 - September 1, 2021), a high-pressure ridge far north of the Hawaiian Islands maintained a tight enough pressure gradient down across the region to produce moderate to locally strong trades. As this high slowly moved northeast away from the area and subtly weakened the gradient, trades gradually weakened. There was no measurable precipitation during the deployment or recovery times.

Near-surface currents were nearly 1 kt west-northeastward between Oahu and Station ALOHA, and was seen in the shipboard ADCP record during the transit from ALOHA to Oahu on August 26 to disembark an injured crew member, and during the transit back to Oahu at the end of the cruise on September 1. This WNWward flow seemed to be associated with a high sea level just east of Station ALOHA . Surface currents during the WHOTS-16 mooring recovery were less than 1 kt. A combination of internal 53 semidiurnal and diurnal tides, along with near-inertial oscillations, were noticeable especially in vertical shear.

Conditions during the WHOTS-17 deployment on August 26 were favorable, with light ENE winds of ~ 10 kt by the end of the deployment. There were clear skies and no precipitation in the region, and small short- period wind waves. CTD casts conducted near the WHOTS-17 buoy (Station 50) (Fig. 6.2, Fig. 6.3, Fig. 6.4), after recovering WHOTS-16 mooring, displayed a subsurface salinity maximum between 140 and 160 dbar and a mixed layer 40 to 80 dbar deep.

During the WHOTS-18 cruise (WHOTS-17 mooring recovery, July 22-27, 2022), a high-pressure ridge far north of the Hawaiian Islands maintained a tight enough pressure gradient down across the region to produce moderate local trades, increasing by the end of the cruise. There was no measurable precipitation during the deployment or recovery times. CTD casts conducted near the WHOTS-17 buoy (Station 50)(Fig. 6.6,Fig. 6.7,Fig. 6.8), after deploying the WHOTS-18 mooring, displayed a subsurface salinity maximum between 100 and 160 dbar and a mixed layer of 60 dbar deep.

The temperature MicroCAT records during the WHOTS-17 deployment (Fig. 6.15 through Fig. 6.19) show noticeable seasonal variability in the upper 100 m. The salinity records (Fig. 6.20 through Fig. 6.24) do not show an apparent seasonal cycle, but a salinity decrease was recorded from mid April through June 2022 in the upper 65 m. This decrease was followed by a period with high salinity.

Fig. 6.30 through Fig. 6.32 show contours of the WHOTS-17 MicroCAT data in context with data from the previous 16 deployments. The seasonal cycle is evident in the temperature record, with record temperatures (higher than 26°C) in the summer of 2004, and again in 2014, 2015, 2017, 2019, and 2020. Salinities in the subsurface salinity maximum were relatively low during the first 6 years of the record, only to increase drastically after 2008 through 2015, with some lower salinity episodes in mid-2011 and early 2012. The salinity maximum extended to near the surface in early 2010, 2011, late2012-early 2013, and February-March 2013. Salinities in the salinity minimum decreased after 2015, showing low salinities above 100 m in 2016, 2017, 2018, and reaching record low values (34.4) in July-August 2019 and July-September 2020 and increasing in 2021. When plotted in $\sigma\theta$ coordinates (Fig. 6.32), the salinity maximum seems to be centered roughly between 24 and 24.5 $\sigma\theta$.

Records from the WHOTS-17 MicroCATs (Fig. 6.33) deployed near the bottom of the mooring (4659 m) detected temperature and salinity changes related to episodic 'cold events' apparently caused by bottom water moving between abyssal basins [Lukas *et al.*, 2001]. These events are being monitored by instruments at the ALOHA

Cabled Observatory (ACO) [Howe *et al.*, 2011] , a deep water observatory located at the bottom of Station ALOHA (about 6 nautical miles north from the WHOTS-17 anchor), since June 2011. Fig. 6.33 shows temperature and salinity records from the WHOTS-17 MicroCATs superimposed on the ACO data. The MicroCAT data agreed with the temperature decrease and the salinity increase registered by ACO instruments during cold events in September 2021 and July 2022. Minor events in January and February 2022 were registered by the MicroCATs, but not by the ACO instruments.

Fig. 6.36 through Fig. 6.38 shows the time series of the zonal, meridional, and vertical currents recorded with the moored ADCPs during the WHOTS-17 deployment. Fig. 6.34, through Fig. 6.35, shows the ADCP current components' contours in context with data from the previous deployments. Despite the gaps in the data, an apparent variability is seen in the zonal and meridional currents, apparently caused by passing eddies. There have been periods of intermittent positive or negative zonal currents on top of this variability, for instance, during 2007-2008. The contours of the vertical current component Fig. 6.35 show a transition in the magnitude of the contours near 47 m, indicating that the 300 kHz ADCP located at 126 m moves more vertically than the 600 kHz ADCP located at 47.5 m.

A comparison between the moored ADCP data and the shipboard ADCP data obtained during the WHOTS-17 cruise is shown in Fig. 6.39, and Fig. 6.40, and a similar comparison during the WHOTS-18 cruise is shown in Fig. 6.41 and Fig. 6.42. Some differences were seen, especially in the zonal component, maybe due to the mooring motion, which was not removed from the data. Comparisons between the available shipboard ADCP from HOT-333 to -336 cruises and the mooring data are shown in Fig. 6.43 through Fig. 6.44.

The Xeos-GPS receiver registered the WHOTS-17 buoy motion, and its positions are plotted in Fig. 6.46. The buoy was located west of the anchor for most of the deployment. The power spectrum of these data (Fig. 6.47) shows extra energy at the inertial period (~31 hr). Combining the buoy motion with the tilt (a combination of pitch and roll) from the ADCP data (Fig. 6.48) showed that the tilt increased as the buoy distance from the anchor WHOTS-17 increased. This was expected since the inclination of the cable increases as the buoy moves away from the anchor.

6.1 CTD Profiling Data

Profiles of temperature, salinity, and potential density ($\sigma\theta$) from the casts obtained during the WHOTS-17 deployment cruise are presented in Fig. 6.1 through Fig. 6.5, together with the results of bottle determination of salinity. Fig. 6.6 through Fig. 6.10 shows the results of the CTD profiles during the WHOTS-18 cruise.

6.2 Thermosalinograph Data

Underway measurements of near-surface temperature and salinity from the thermosalinograph (TSG) system onboard the R/V Oscar Sette cruise are presented in Fig. 6.11 and navigational data is shown in Fig. 6.12 for the WHOTS-17 cruise. The data between August 25 and 27, 2021 are particularly bad because it was during transit back to Oahu to disembark a crew member with medical problems, and the flow through the system was stopped during that time. TSG and navigational data during the WHOTS-18 cruise, onboard the R/V Oscar Sette, are presented in Fig. 6.13 and Fig. 6.14, respectively.

6.3 MicroCAT Data

The temperatures measured by MicroCATs during the mooring deployment for WHOTS-17 are presented in Fig. 6.15 through Fig. 6.19 for each of the depths where the instruments were located. The salinities are plotted in Fig. 6.20 through Fig. 6.24. The potential densities ($\sigma\theta$) are plotted in Fig. 6.25 through Fig. 6.29.

Contoured plots of temperature and salinity as a function of depth for the deployments WHOTS-1 through -16 are presented in Fig. 6.30, and contoured plots of potential density ($\sigma\theta$) as a function of depth are in Fig. 6.31, and of salinity as a function of $\sigma\theta$ are in Fig. 6.32.

The potential temperature (θ) and salinity measured by the deep MicroCATs during the mooring deployment are shown in Fig. 6.33. Also shown in the plot are the θ and salinity data obtained with a MicroCAT (SBE-37)

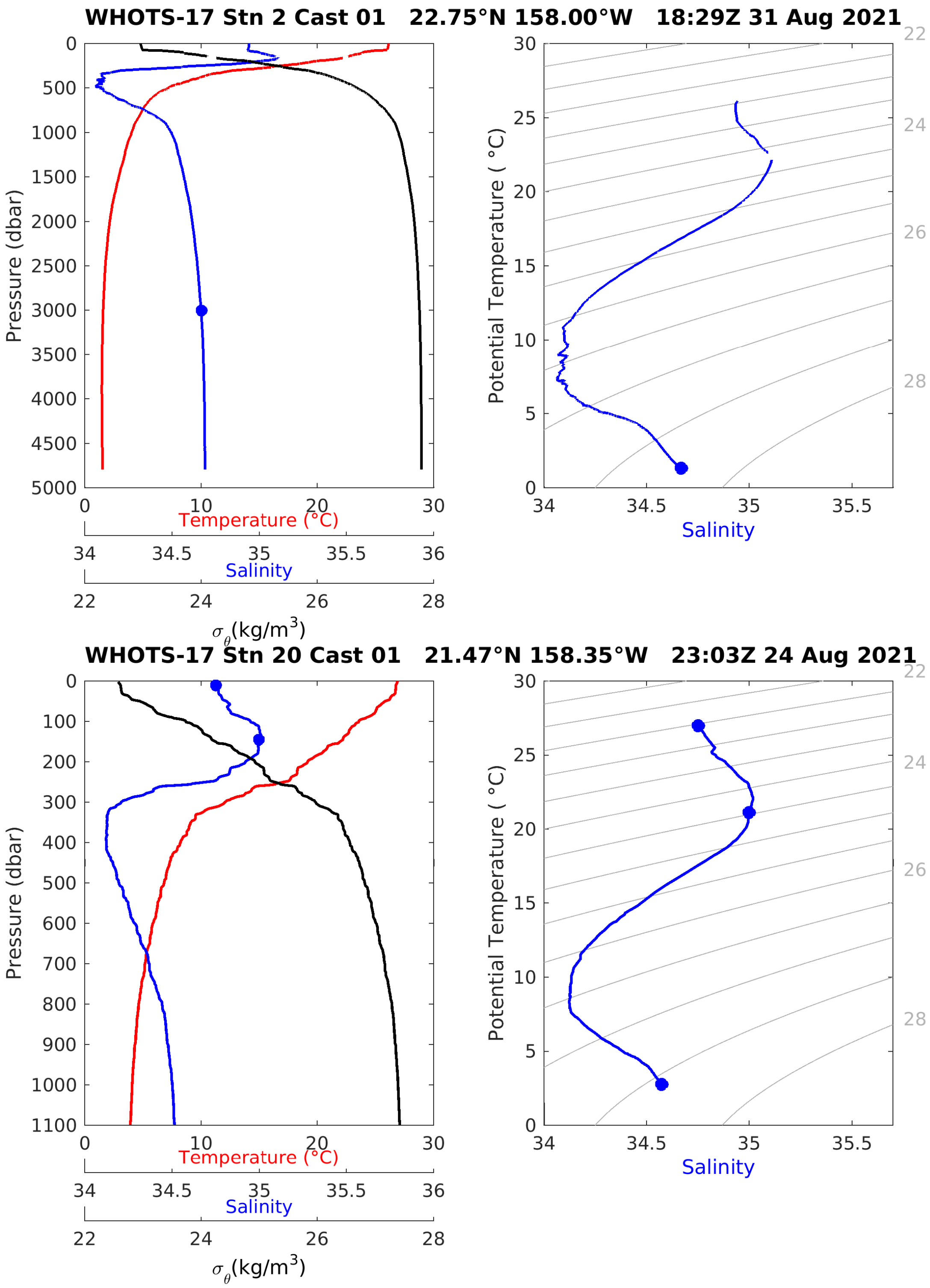


Fig. 6.1: [Upper left panel] Profiles of CTD temperature, salinity, and potential density ($\sigma\theta$) as a function of pressure, including discrete bottle salinity samples (when available) for station 2 cast 1 during the WHOTS-17 cruise. [Upper right panel] Profiles of CTD salinity as a function of potential temperature, including discrete bottle salinity samples (when available) for station 2 cast 1 during the WHOTS-17 cruise. [Lower left panel] Same as in the upper left panel, but for station 20 cast 1. [Lower right panel] Same as in the upper right panel, but station 20 cast 1.

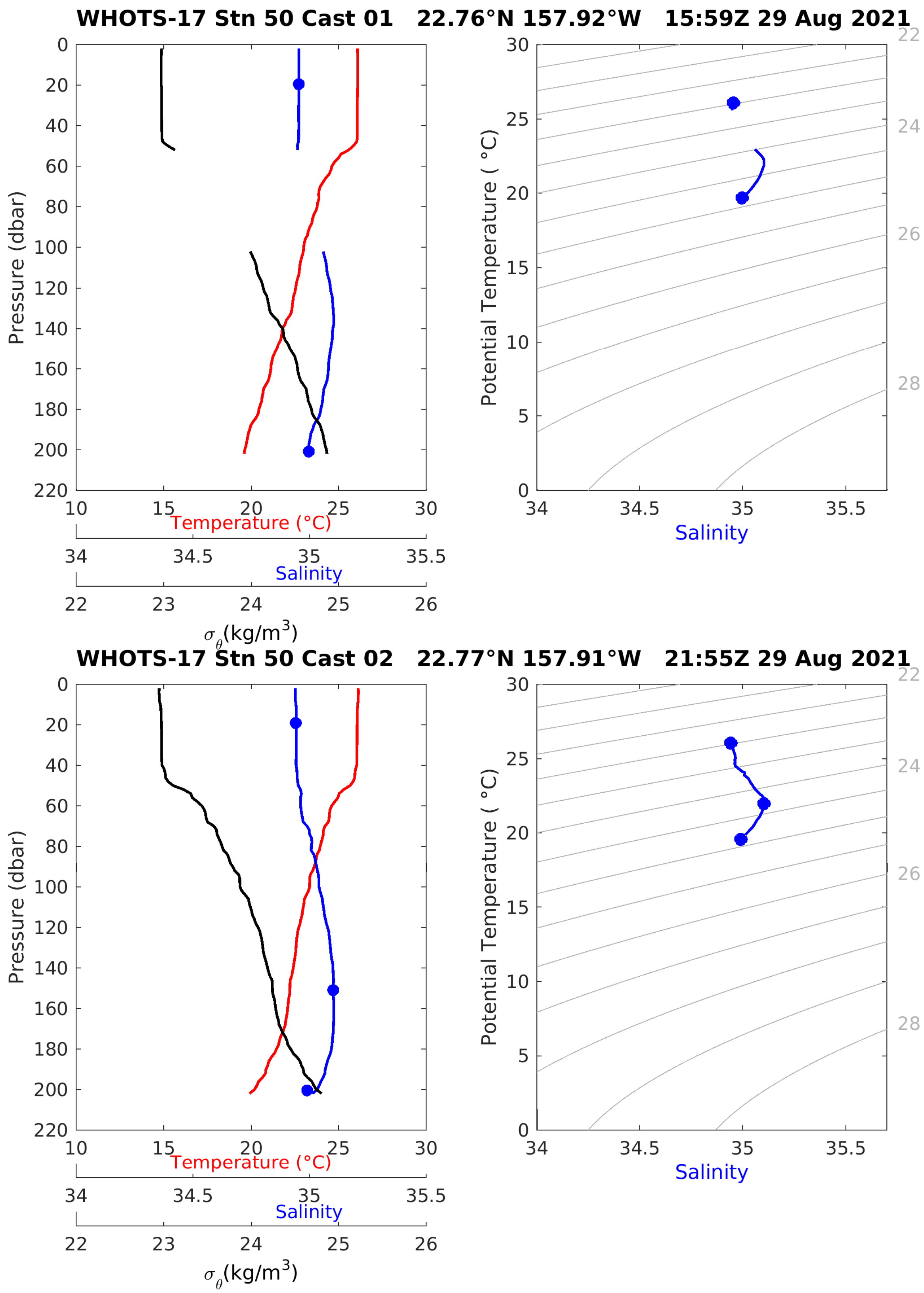


Fig. 6.2: [Upper panels] Same as in Fig. 6.1, but for station 50, cast 1. [Lower panels] Same as Fig. 6.1, but for station 50, cast 2.

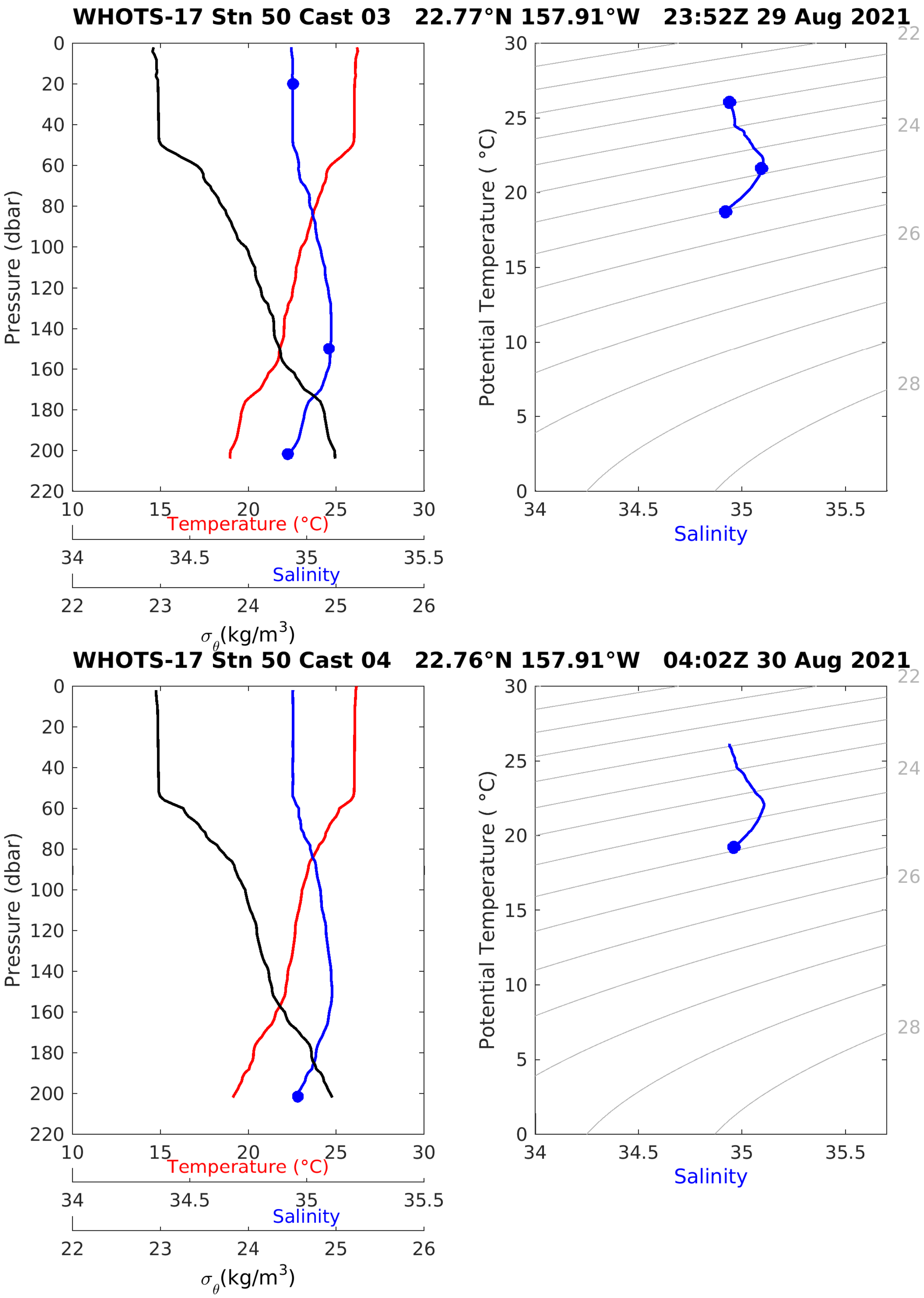


Fig. 6.3: [Upper panels] Same as in Fig. 6.1, but for station 50, cast 3. [Lower panels] Same as in Fig. 6.1, but for station 50 cast 4.

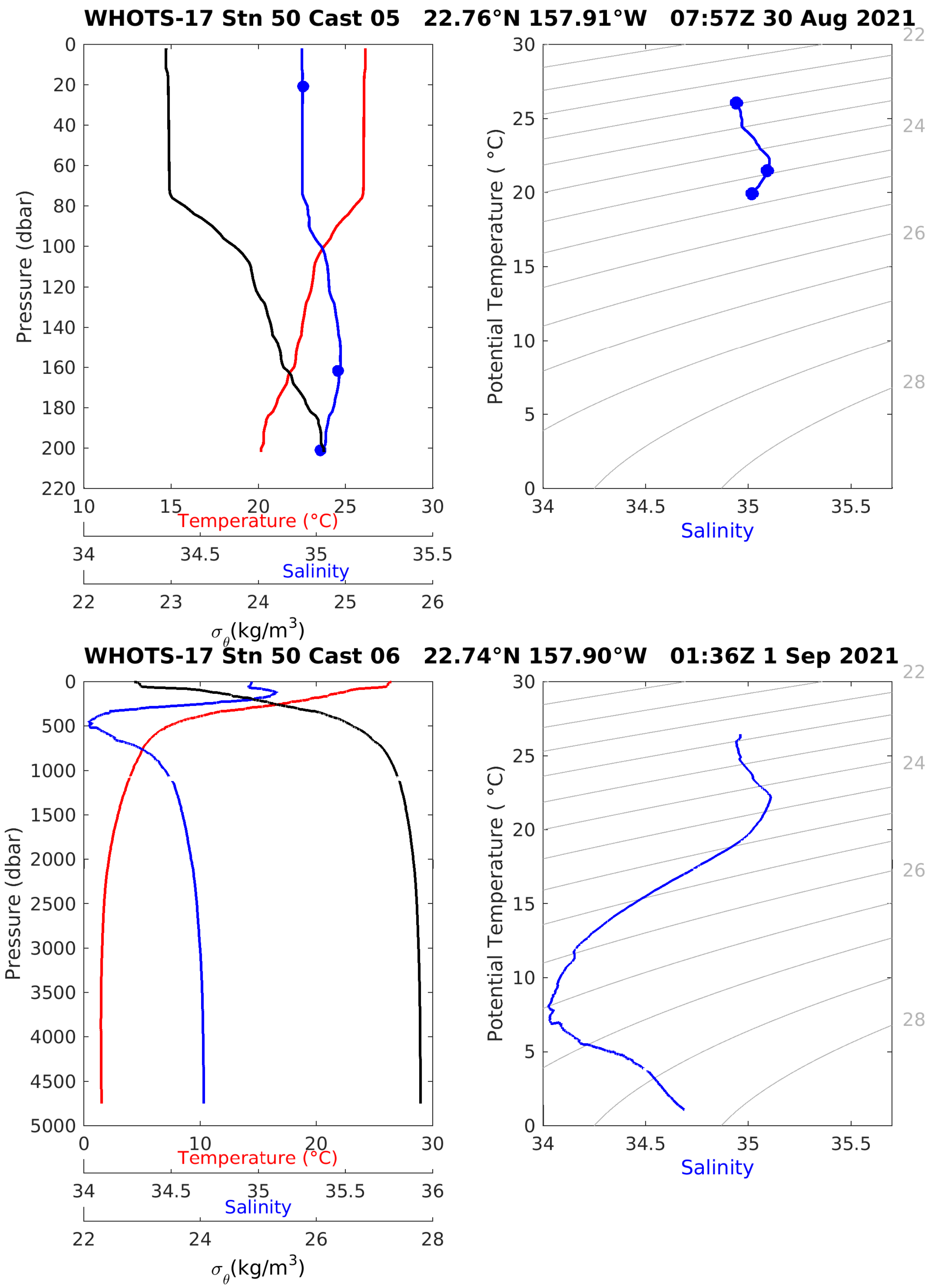


Fig. 6.4: [Upper panels] Same as in Fig. 6.1, but for station 50, cast 5. [Lower panels] Same as in Fig. 6.1, but for station 50, cast 6.

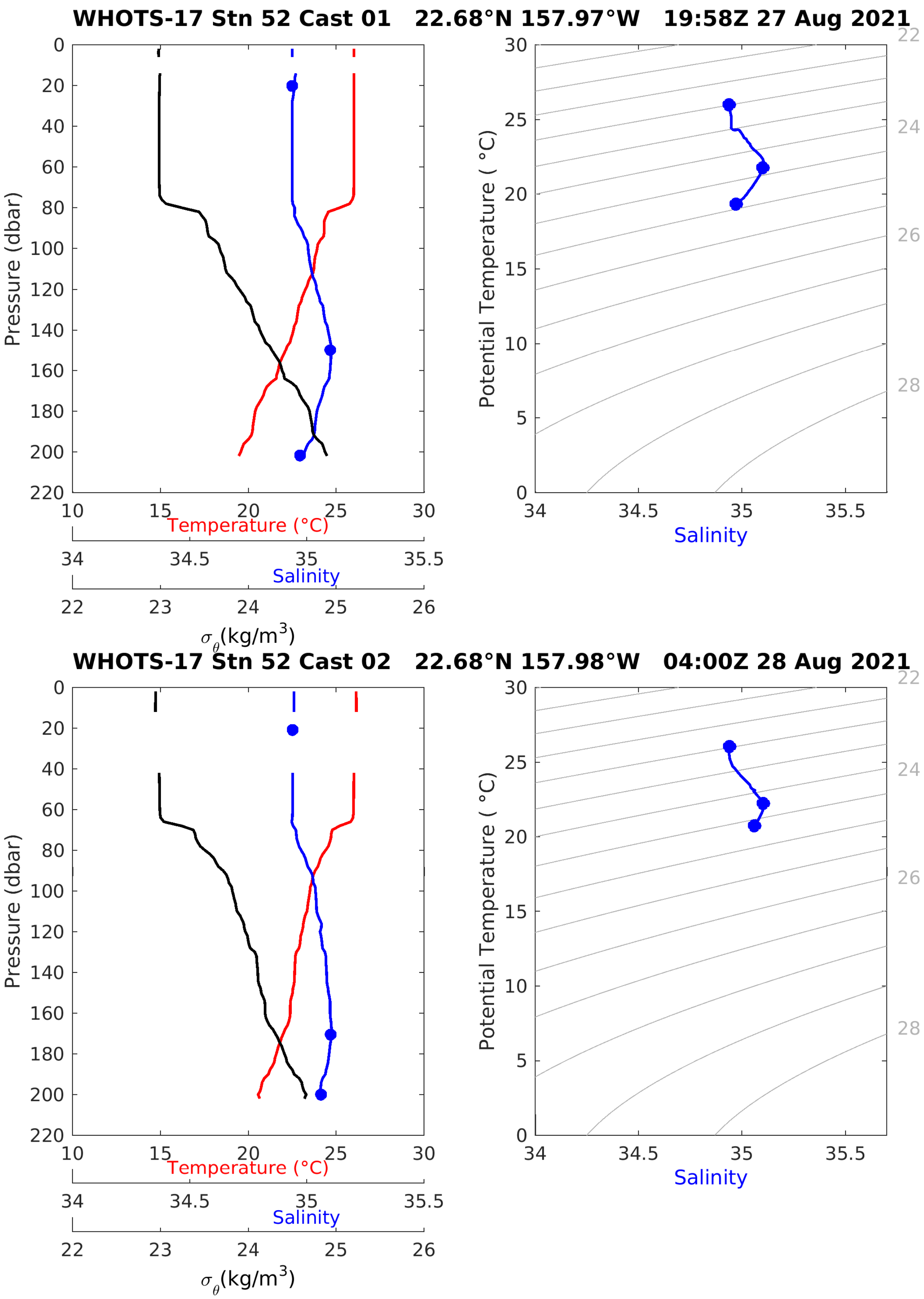


Fig. 6.5: [Upper panels] Same as in Fig. 6.1, but for station 52, cast 1. [Lower panels] Same as in Fig. 6.1, but for station 52, cast 2.

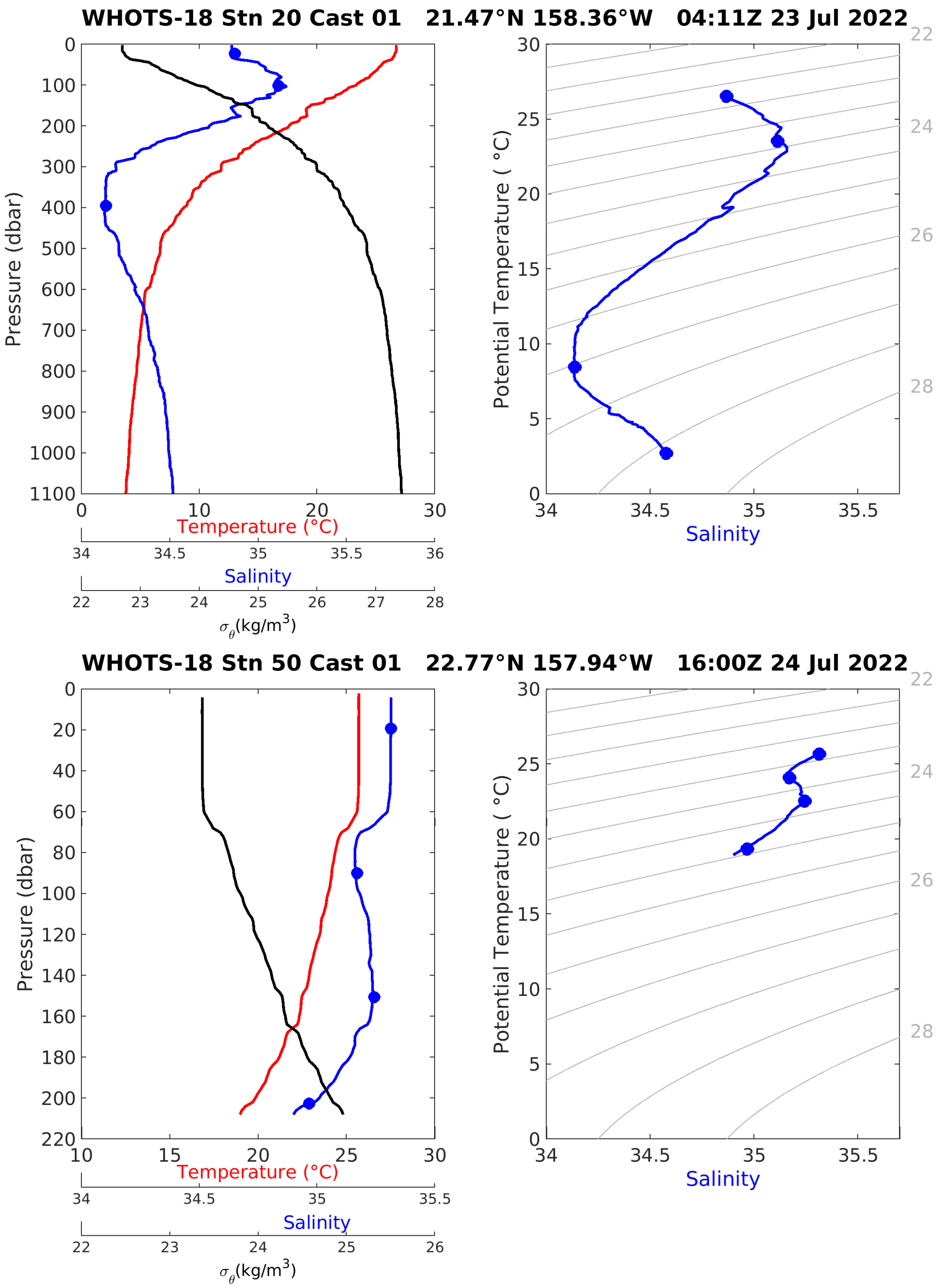


Fig. 6.6: [Upper left panel] Profiles of CTD temperature, salinity, and potential density ($\sigma\theta$) as a function of pressure, including discrete bottle salinity samples (when available) for station 20 cast 1 during the WHOTS-18 cruise. [Upper right panel] Profiles of CTD salinity as a function of potential temperature, including discrete bottle salinity samples (when available) for station 20 cast 1 during the WHOTS-18 cruise. [Lower left panel] Same as in the upper left panel, but for station 50 cast 1. [Lower right panel] Same as in the upper right panel, but station 50 cast 1.

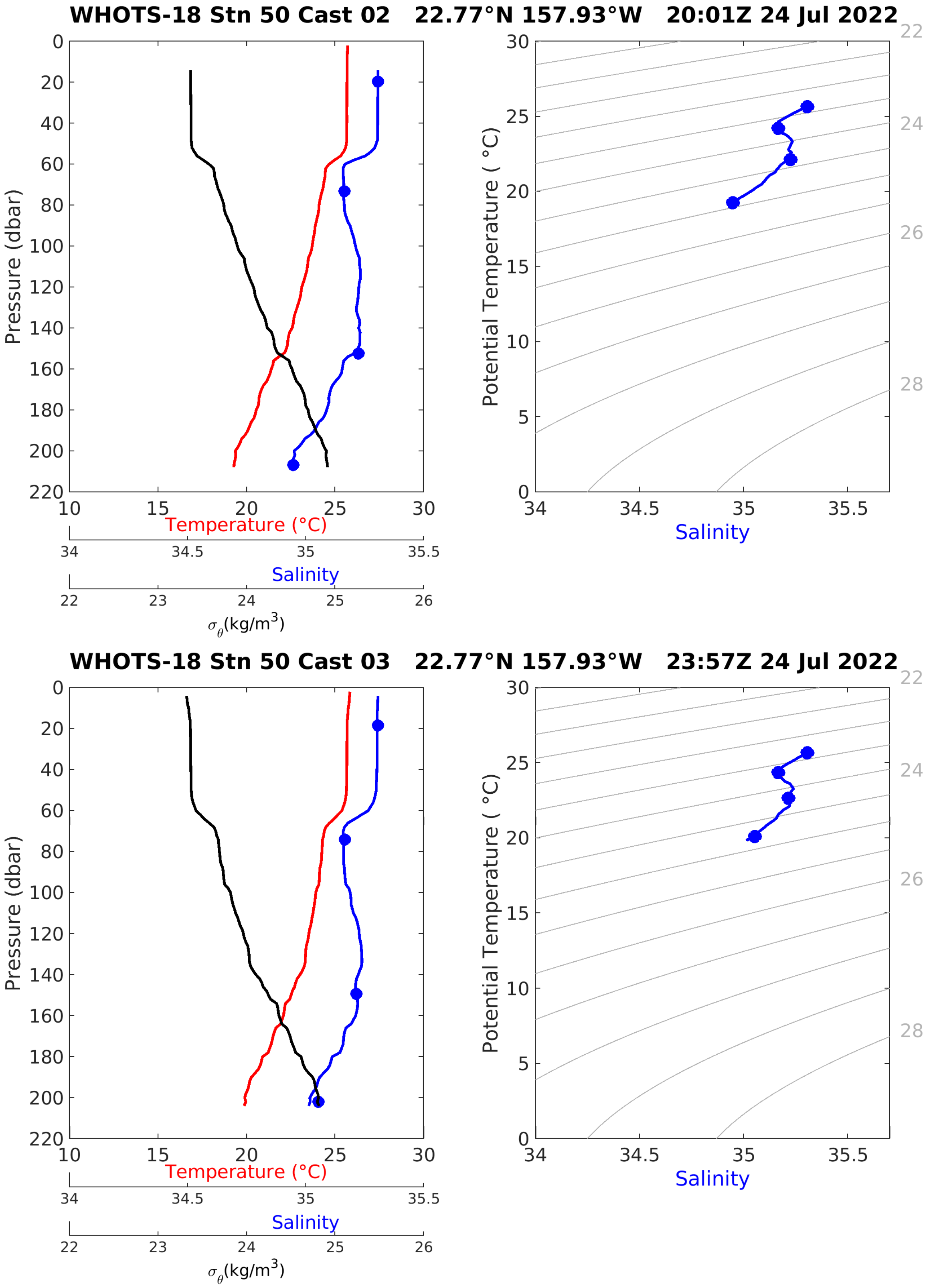


Fig. 6.7: [Upper panels] Same as in Fig. 6.6, but for station 50, cast 2 1.[Lower panels] Same as in Fig. 6.6, but for station 50, cast 3.

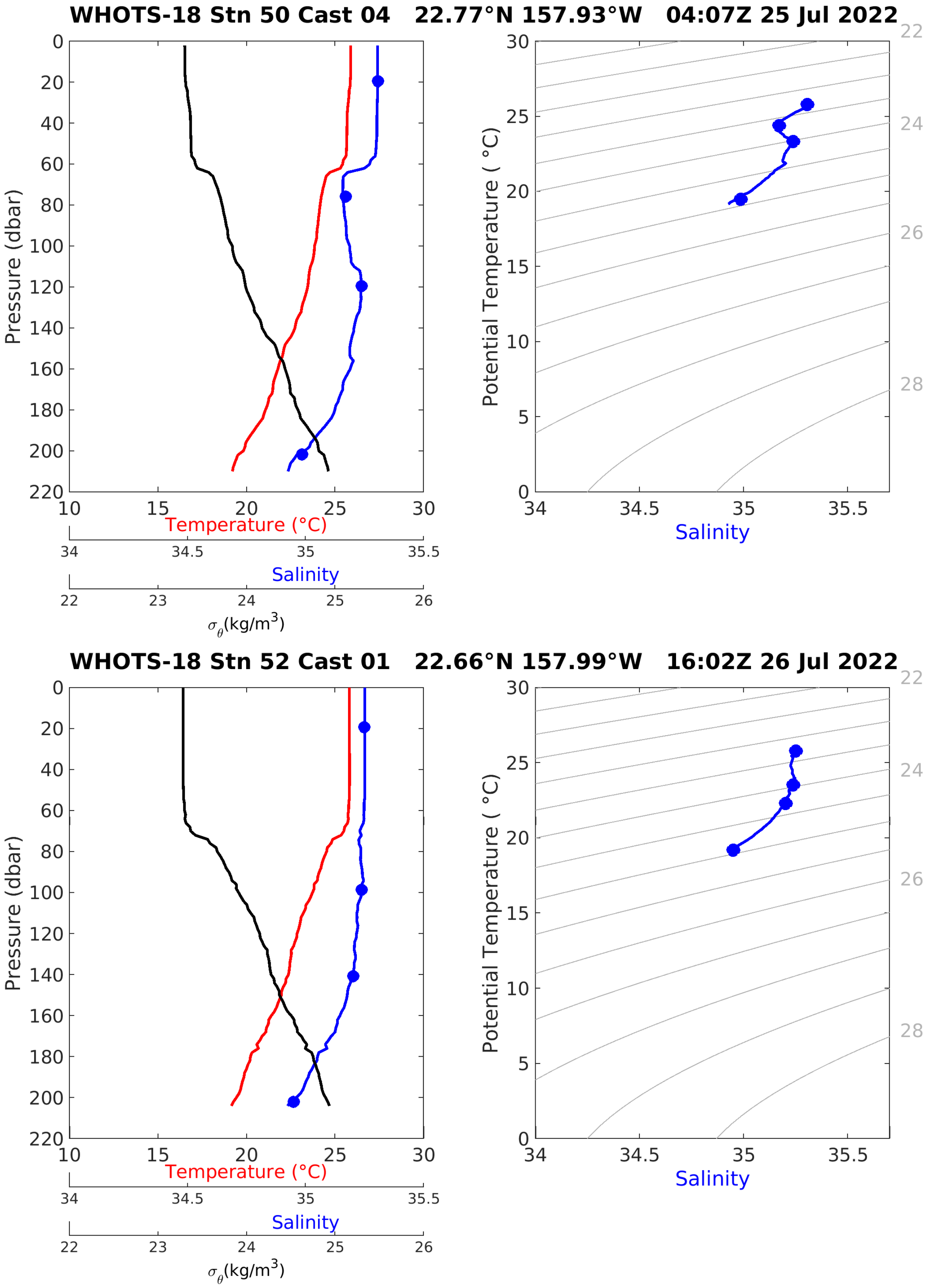


Fig. 6.8: [Upper panels] Same as in Fig. 6.6, but for station 50, cast 4 3.[Lower panels] Same as in Fig. 6.6, but for station 52, cast 1.

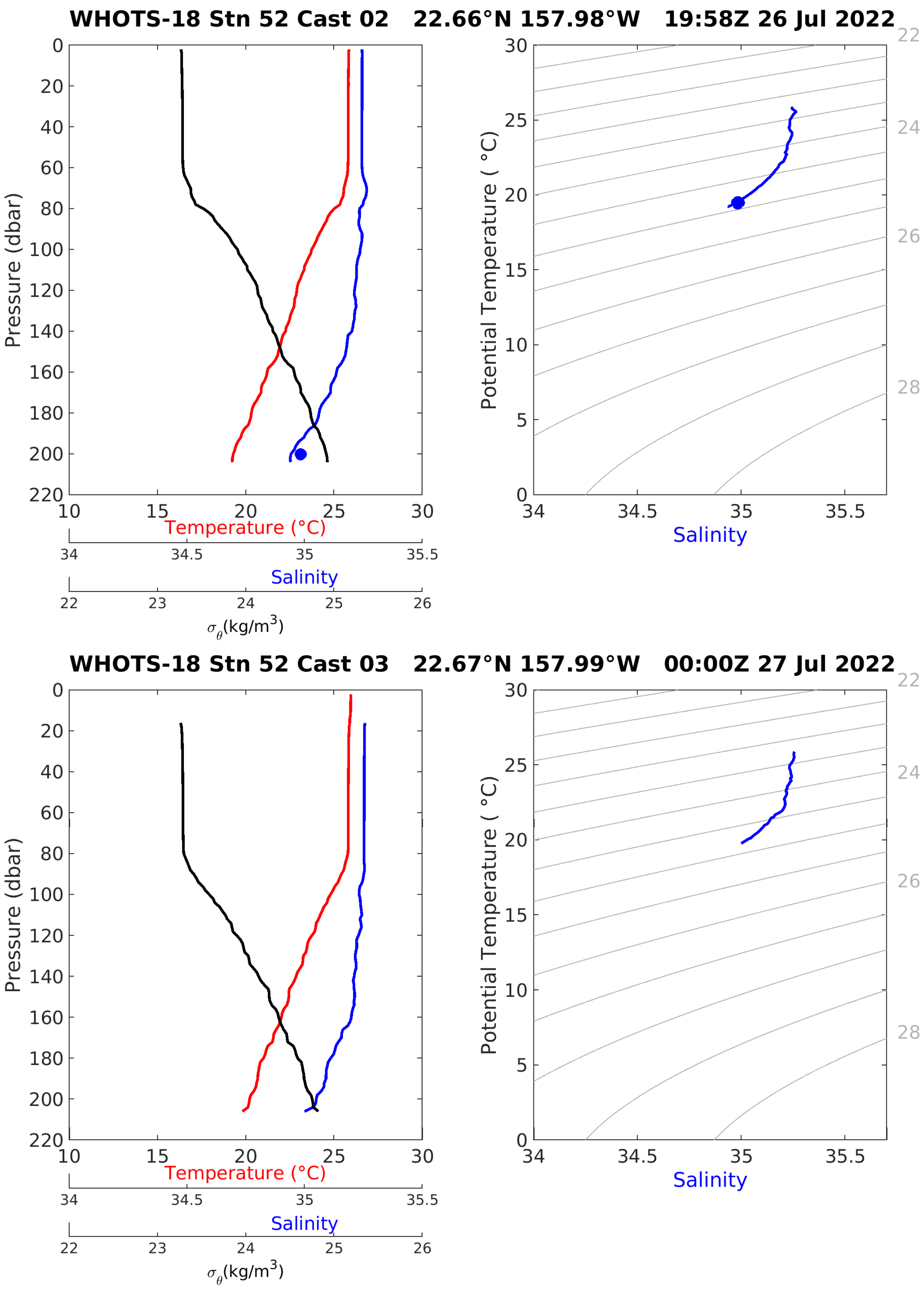


Fig. 6.9: [Upper panels] Same as in Fig. 6.6, but for station 52, cast 2 5.[Lower panels] Same as in Fig. 6.6, but for station 52, cast 3.

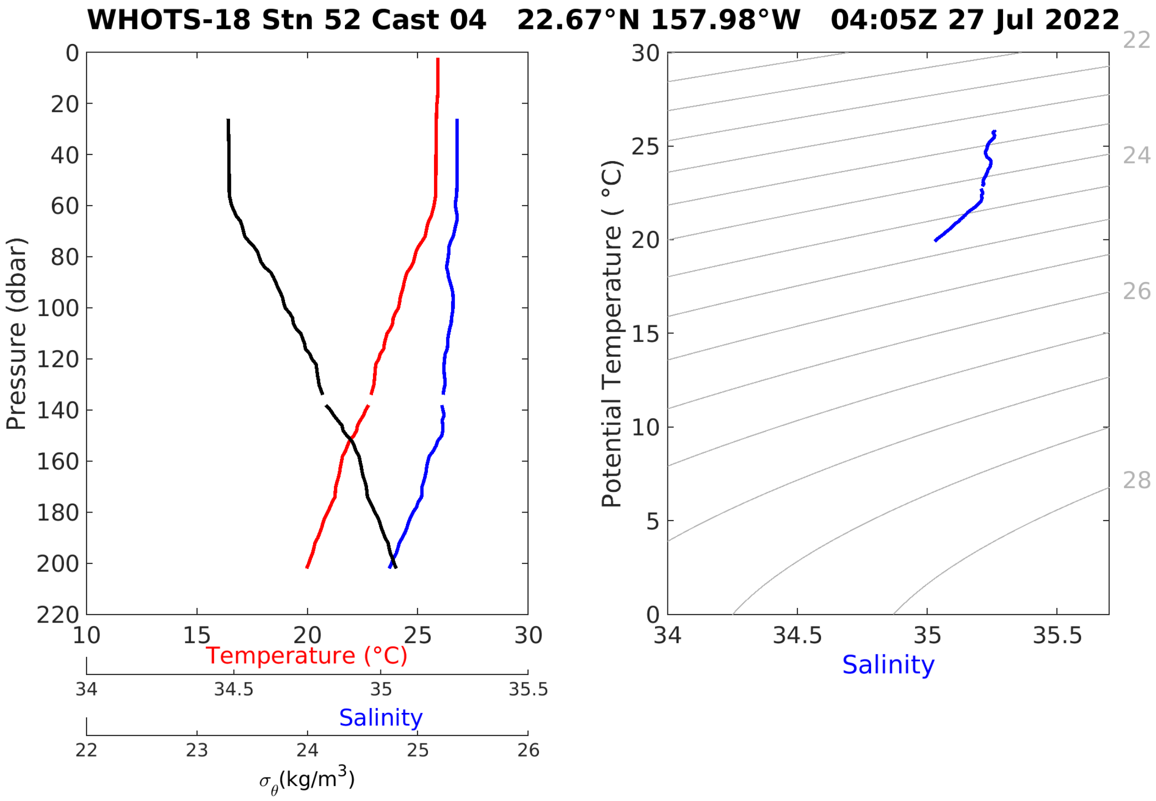


Fig. 6.10: [Upper panels] Same as in Fig. 6.6, but for station 52, cast 4.

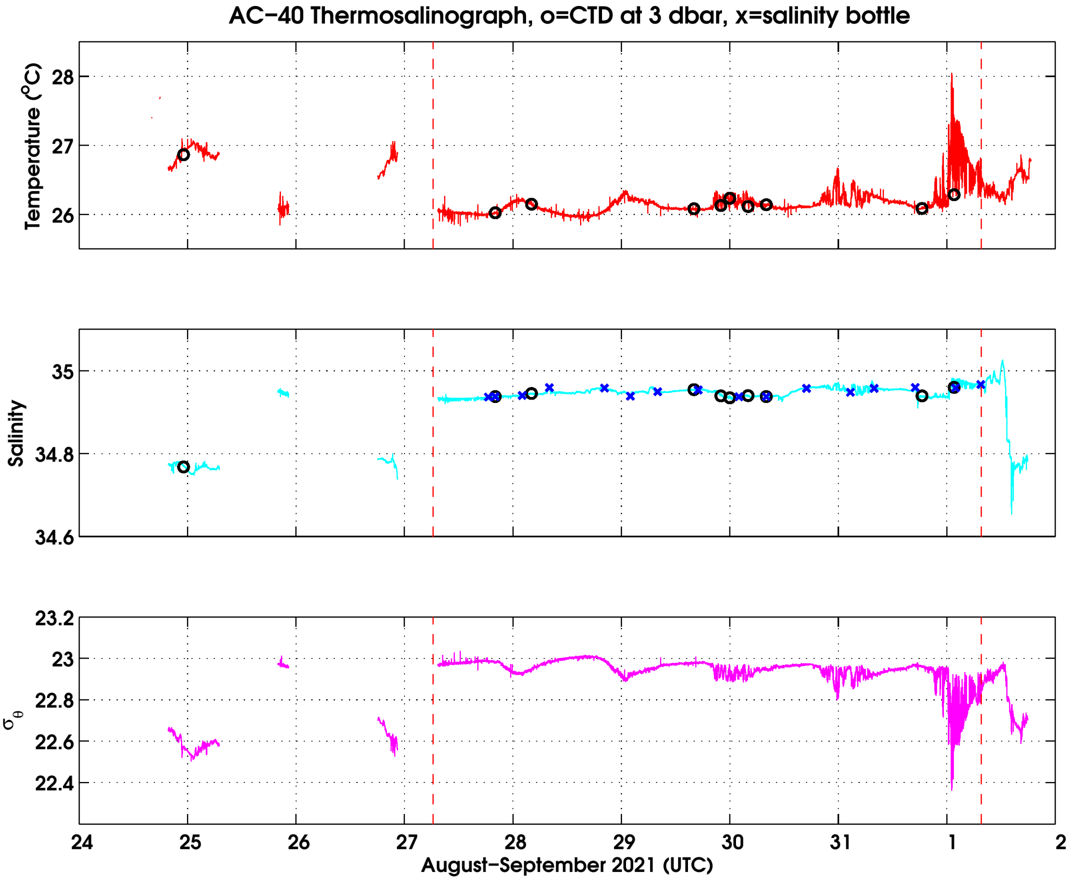


Fig. 6.11: Final processed temperature (upper panel), salinity (middle panel), and potential density ($\sigma\theta$) (lower panel) data from the continuous underway system onboard the R/V Oscar Sette during the WHOTS-17 cruise. Temperature and salinity taken from 6-dbar CTD data (circles) and salinity bottle sample data (crosses) are superimposed. The dashed vertical red line indicates the period of occupation of Station ALOHA and the WHOTS site.

Fig. 6.12: Timeseries of latitude (upper panel), longitude (middle panel), and ship's speed (lower panel) during the WHOTS-17 cruise.

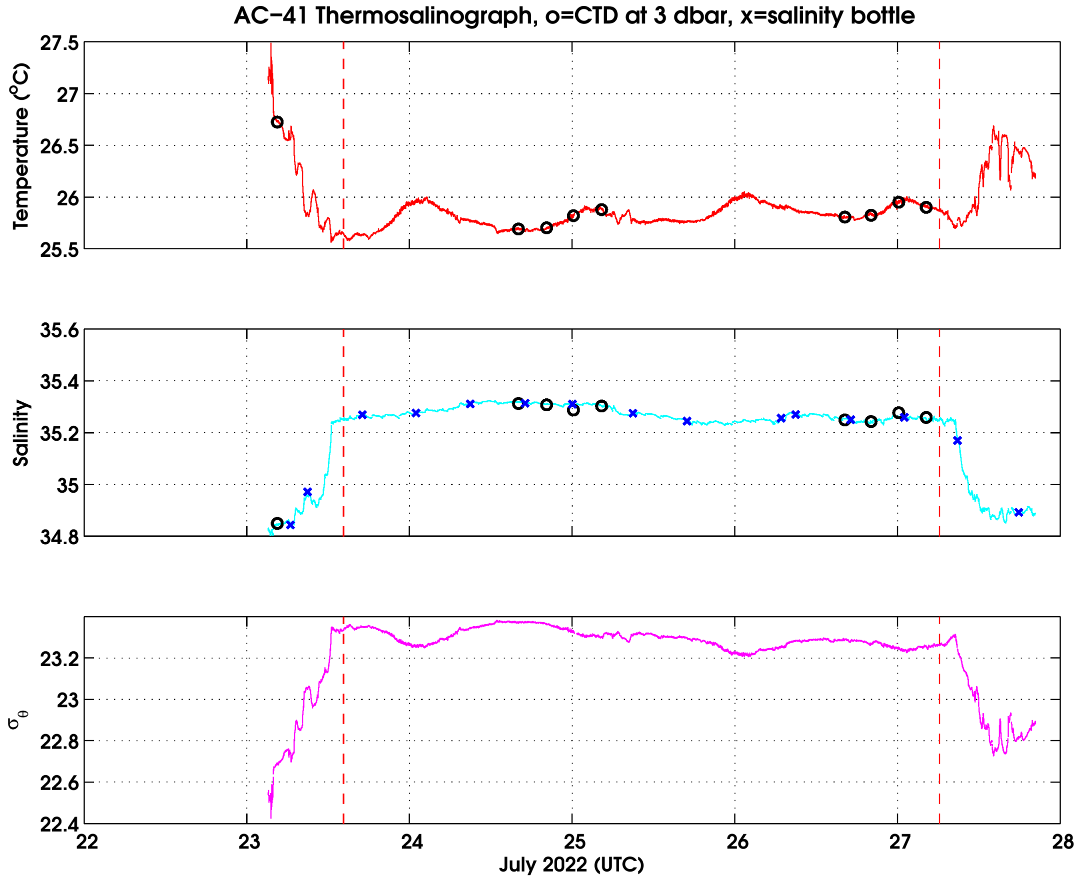


Fig. 6.13: Final processed temperature (upper panel), salinity (middle panel), and potential density ($\sigma\theta$) (lower panel) data from the continuous underway system onboard the R/V Oscar Sette during the WHOTS-18 cruise. Temperature and salinity were taken from 6-dbar CTD data (circles), and salinity bottle sample data (crosses) are superimposed. The dashed vertical red line indicates the period of occupation of Station ALOHA and the WHOTS site.

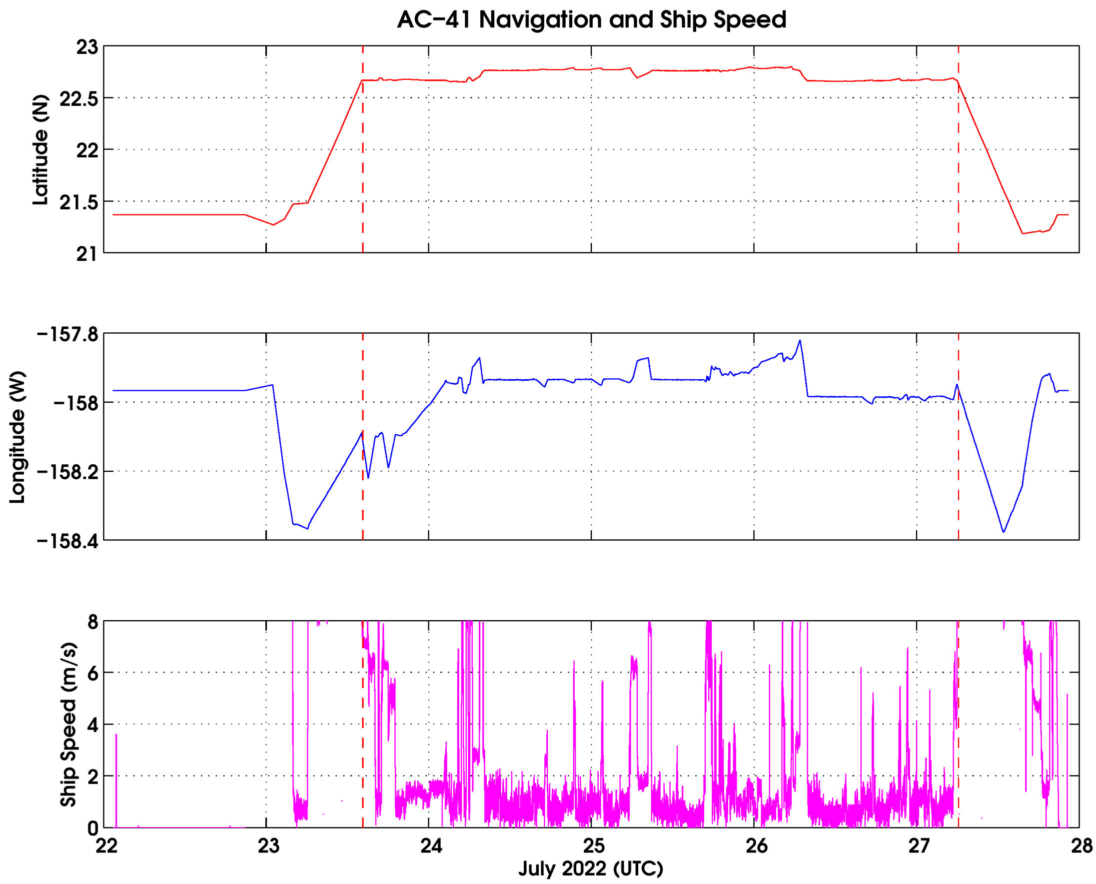


Fig. 6.14: Timeseries of latitude (upper panel), longitude (middle panel), and ship's speed (lower panel) during the WHOTS-18 cruise.

installed in the ALOHA Cabled Observatory, about six nautical miles north from the WHOTS-17 anchor. The instrument is located 2 m above the bottom.

6.4 Moored ADCP Data

Contoured plots of smoothed horizontal (east and north component) and vertical velocity as a function of depth during the mooring deployments 1 through 17 are presented in Fig. 6.34 and Fig. 6.35. A staggered time-series of smoothed horizontal and vertical velocities are shown in Fig. 6.36 through Fig. 6.38. Smoothing was performed by applying a daily running mean to the data and then interpolating it on an hourly grid.

Contours of east and north velocity components from the Ship Oscar Sette Ocean Surveyor broadband 75 kHz shipboard ADCP, and the moored 300 kHz ADCP from the WHOTS-17 deployment as a function of time and depth, during the WHOTS-17 cruise, are shown in Fig. 6.39 and Fig. 6.40.

6.5 Moored and Shipboard ADCP comparisons

Contours of zonal and meridional current components from the Oscar Sette's Ocean Surveyor broadband 75 kHz shipboard ADCP, and the moored 300 kHz ADCP from the WHOTS-17 deployment as a function of time and depth, during the WHOTS-17 cruise, are shown in Fig. 6.39. and Fig. 6.40. Similar comparisons during the WHOTS-18 cruise are in Fig. 6.41. and Fig. 6.42.

Comparisons between quality-controlled moored ADCPs during the WHOTS-17 deployment and available shipboard ADCP obtained during regular HOT cruises 333 to 337, and during the mooring deployment (WHOTS-17) and recovery (WHOTS-18) cruises are shown in Fig. 6.43 for the 300 kHz ADCP. Median and mean velocity profiles were computed when HOT CTD casts were being conducted near the WHOTS mooring specifically intended to calibrate moored instrumentation (see *Conductivity Calibration*). The HOT shipboard profiles were taken when the ship was stationary, within 1 km of the mooring, and within 4 hours before the start and 4 hours after the end of the CTD cast conducted near the WHOTS mooring.

The HOT cruises conducted on the R/V Kilo Moana from HOT-333 to -337 utilized data from different types of acoustic instruments. The TRDI Ocean Surveyor 38 kHz operating in broadband mode (OS38BB) with a 12 m bin size and 5-minute ensemble was employed for data collection. However, HOT-335 encountered a failure in obtaining data, and HOT-337 experienced data interruption before completion.

Additionally, the cruises made use of the TRDI Ocean Surveyor 38 kHz operating in narrowband mode (OS38NB) with a 24 m bin size and 5-minute ensemble. Unfortunately, HOT-335 encountered a failure with the OS38NB after approximately 18 hours into the cruise.

Furthermore, the Teledyne Workhorse 300 kHz with a 2 m bin size and 2-minute ensemble was utilized for data acquisition during HOT-333 to HOT-337. HOT-337 experienced data interruption before its scheduled completion.

Comparisons between the 300 kHz and the shipboard ADCP were available for HOT-333 to HOT-336 (Fig. 6.43); data from HOT-337 was excluded due to a lack of comparable data. Comparisons between the moored 600 kHz and the shipboard ADCP were available for HOT-333 to HOT-336 (Fig. 6.44).

6.6 Next Generation Vector Measuring Current Meter Data (VMCM)

Time-series of daily mean horizontal velocity components for the VMCM current meters deployed during WHOTS-17 at 10 m and 30 m are presented in Fig. 6.45.

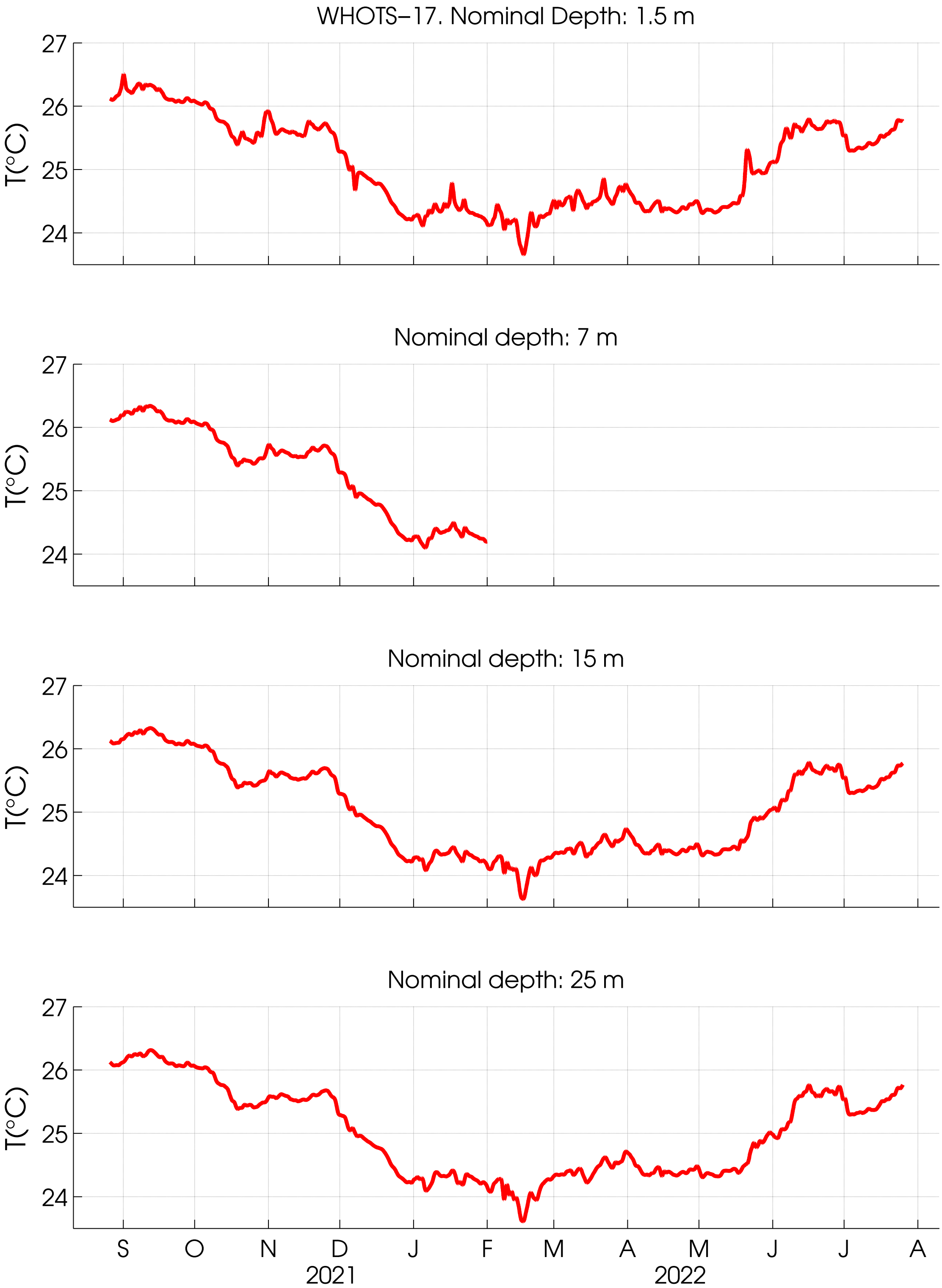


Fig. 6.15: Temperatures from MicroCATs during WHOTS-17 deployment at 1.5, 7, 15, and 25 m.

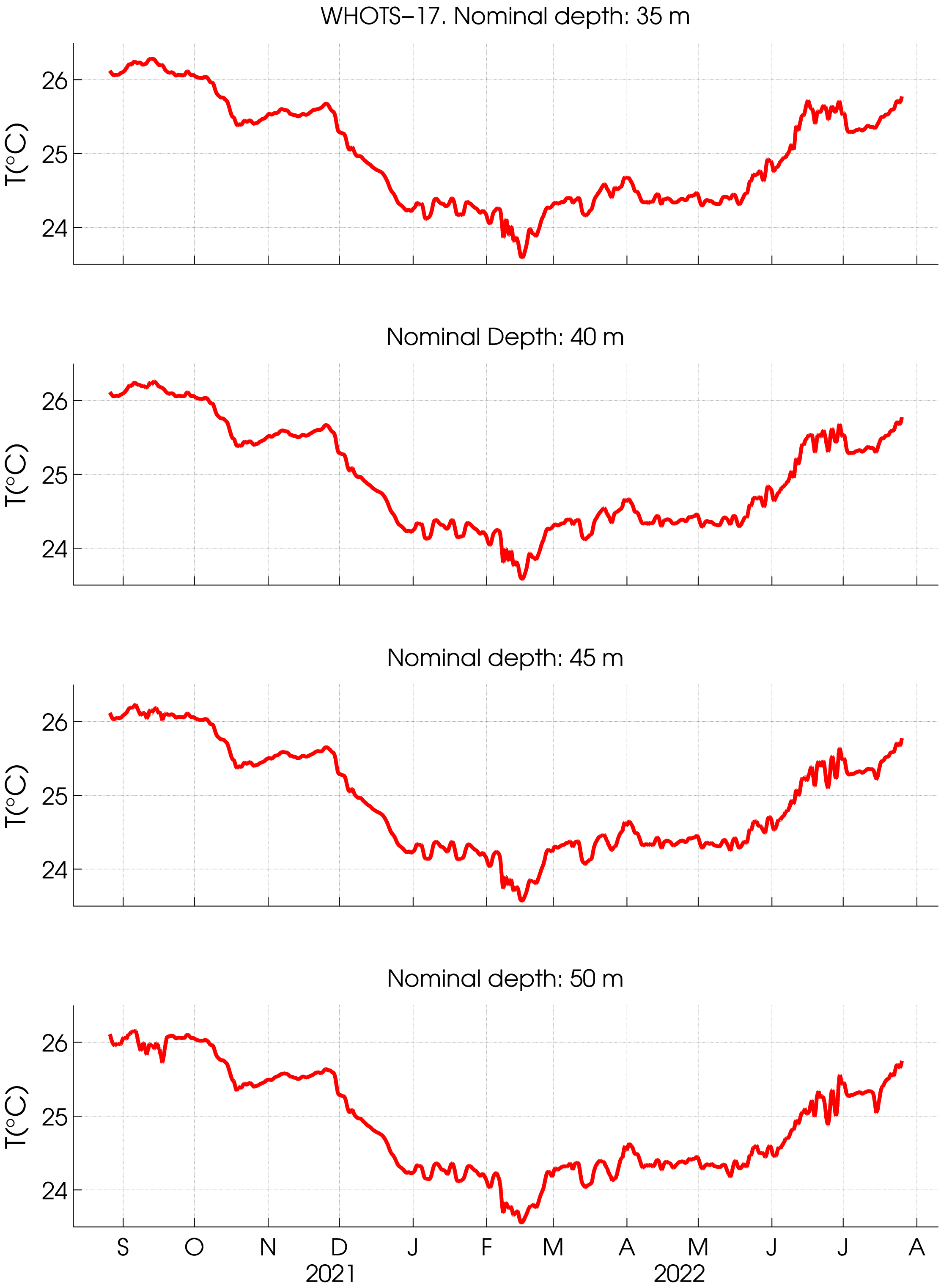


Fig. 6.16: Same as in Fig. 6.15, but at 35, 40, 45, and 50 m.

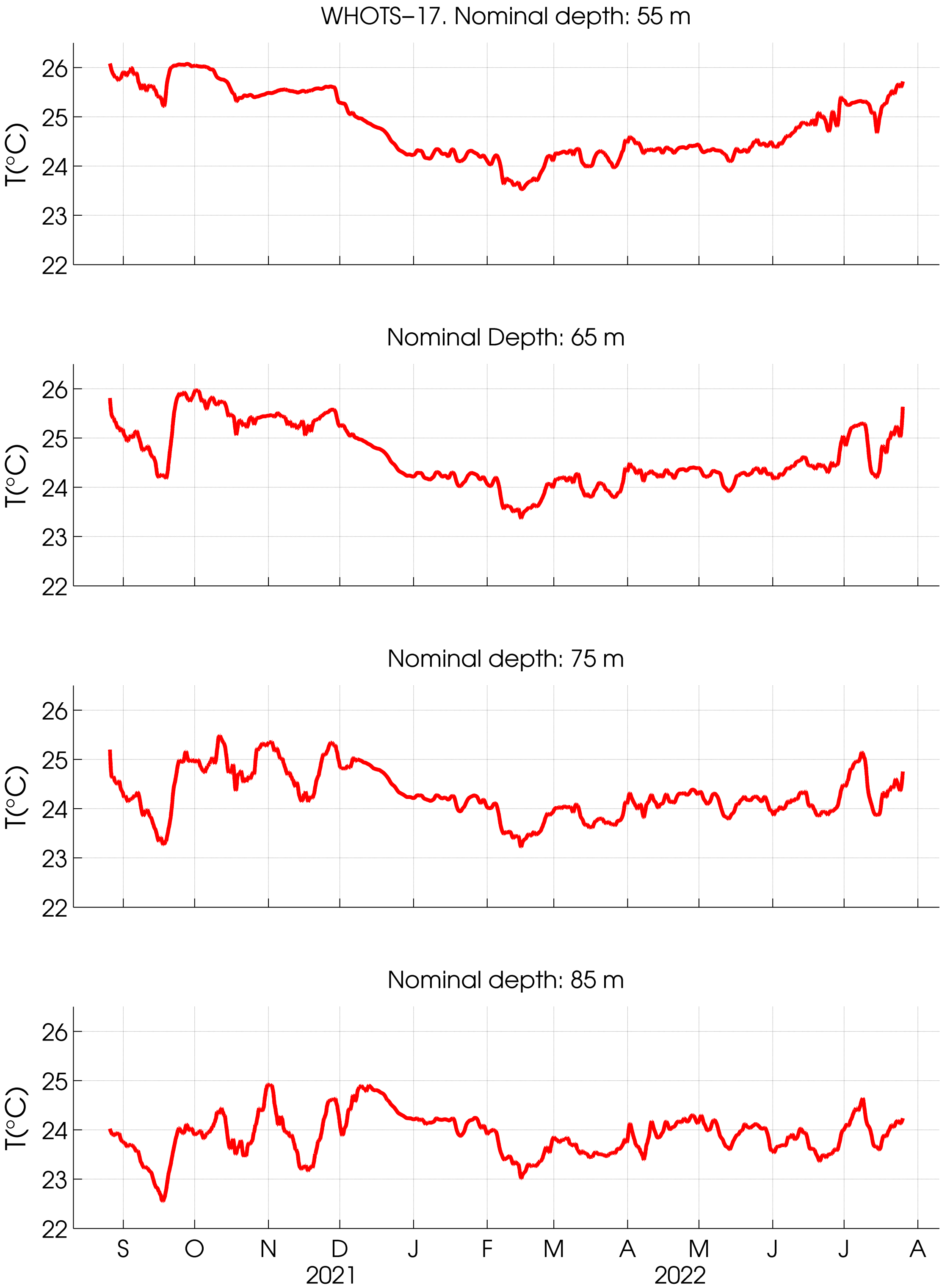


Fig. 6.17: Same as in Fig. 6.15, but at 55, 65, 75, and 85 m.

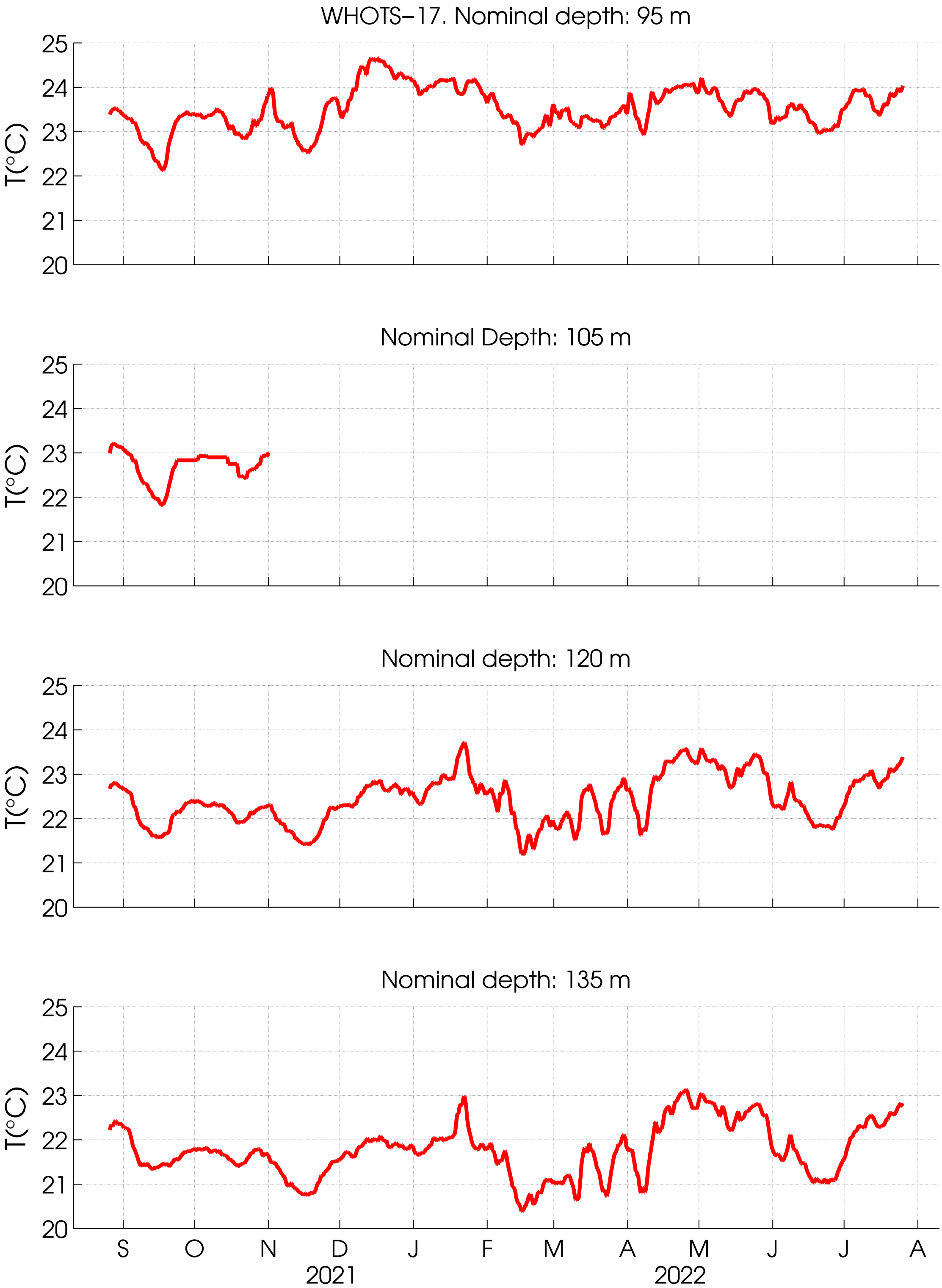


Fig. 6.18: Same as in Fig. 6.15, but at 95, 105, 120, and 135 m.

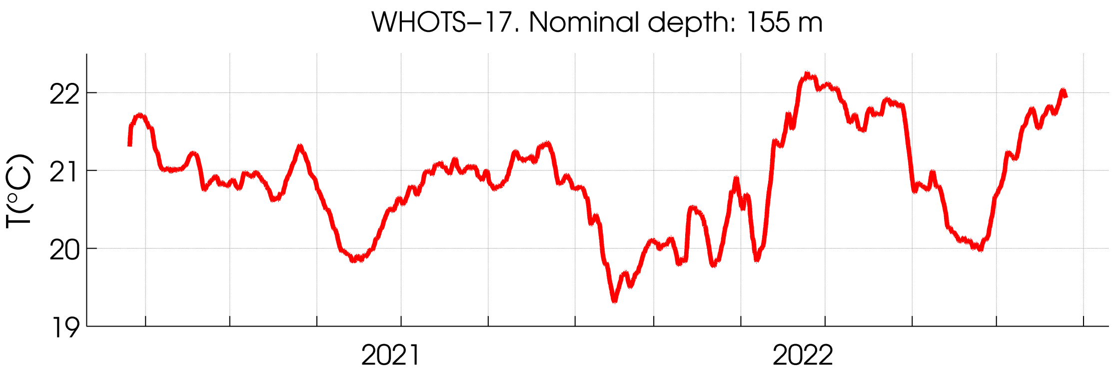


Fig. 6.19: Same as in Fig. 6.15, but at 155 m.

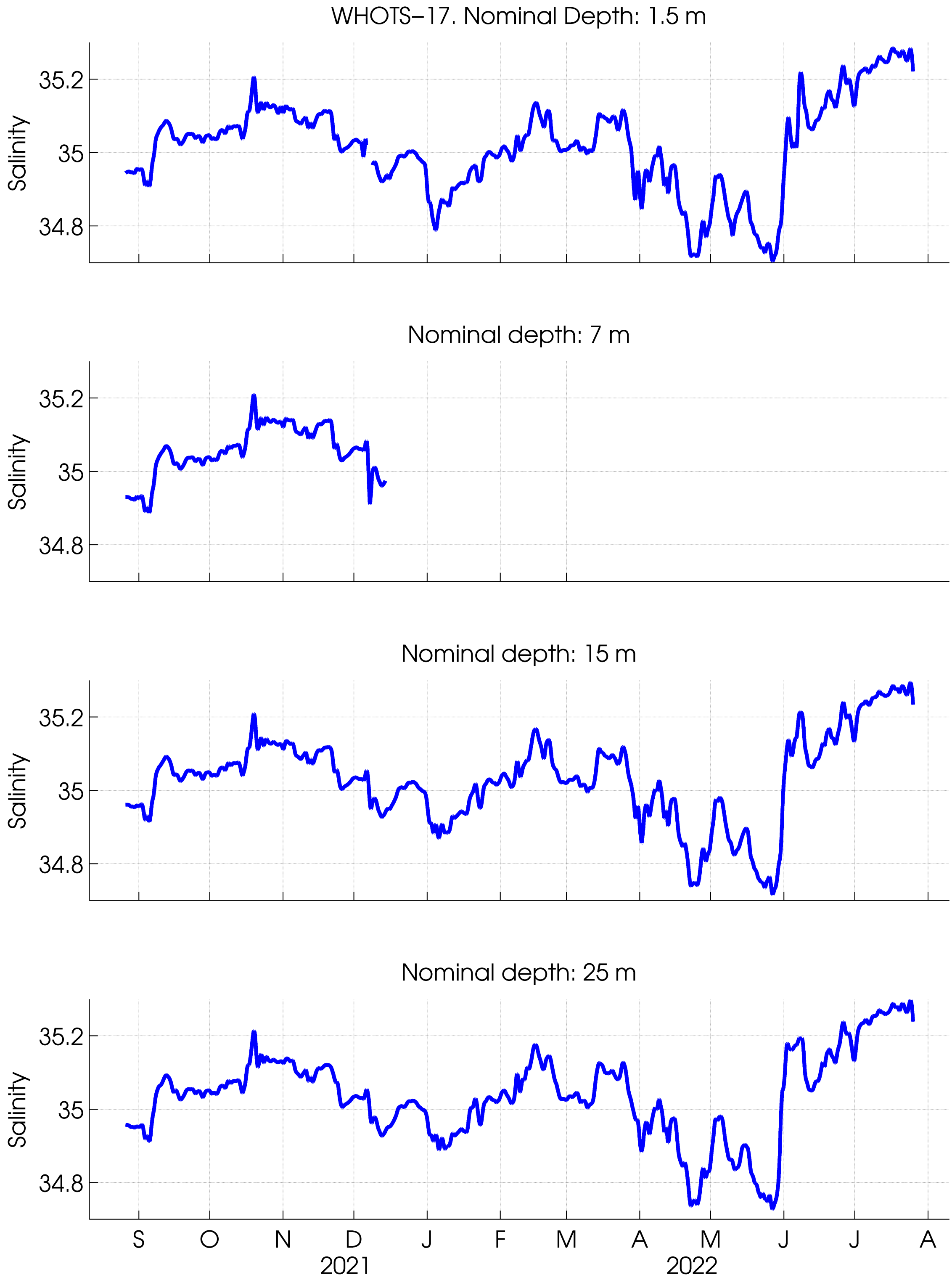


Fig. 6.20: Salinities from MicroCATs during WHOTS-17 deployment at 1.5, 7, 15, and 25 m

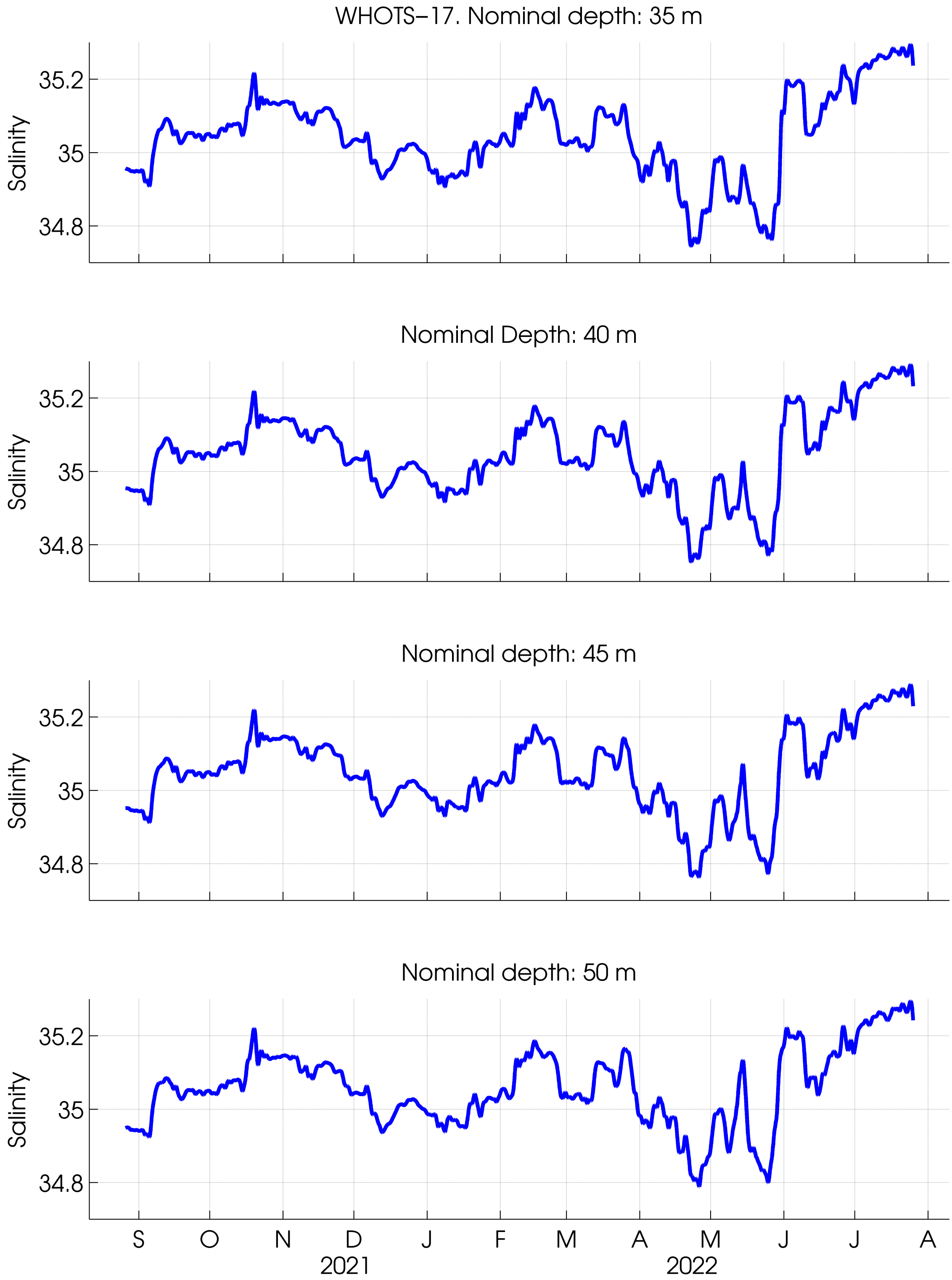


Fig. 6.21: Same as in Fig. 6.20, but at 35, 40, 45, and 50 m.

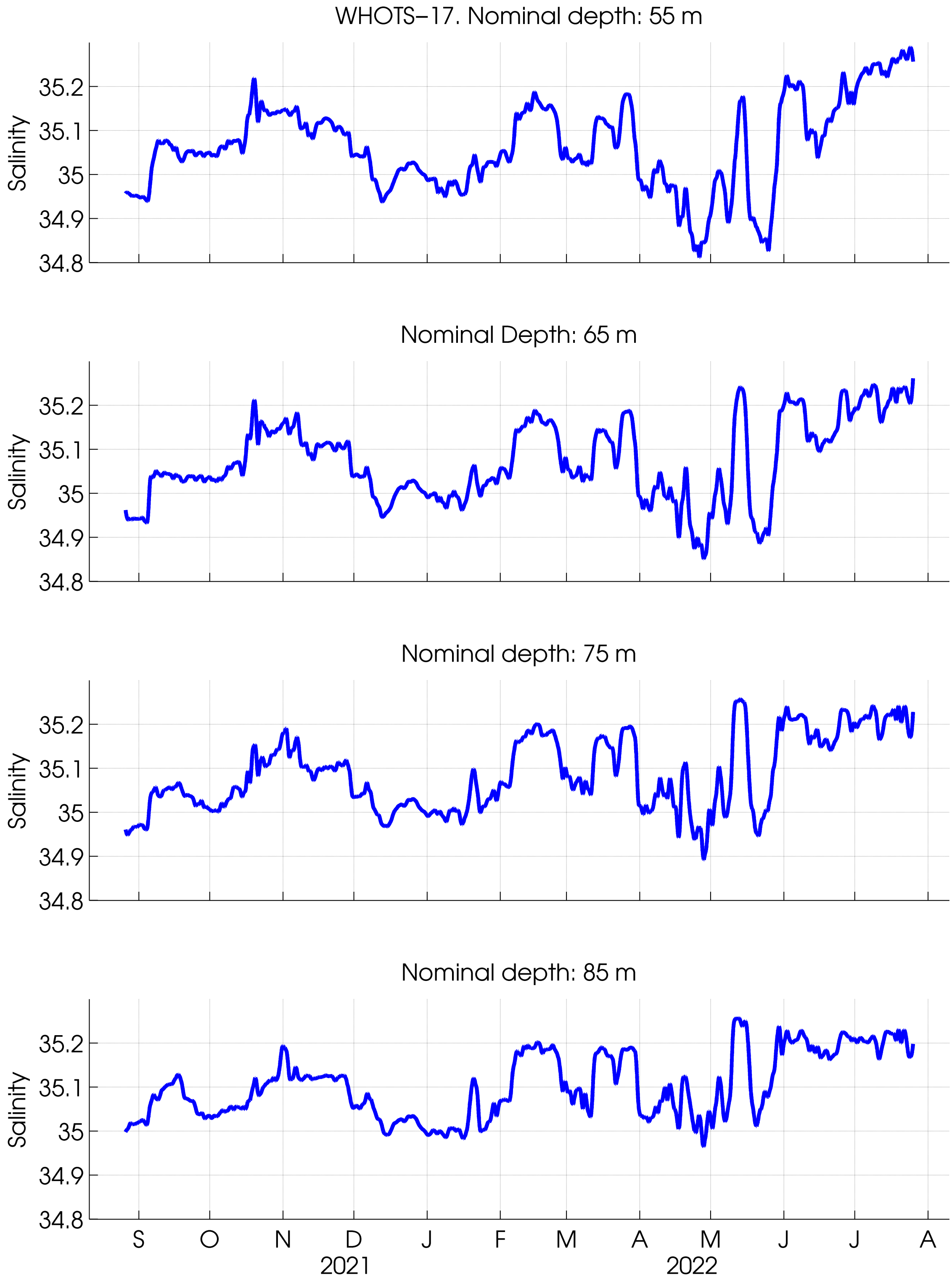


Fig. 6.22: Same as in Fig. 6.20, but at 55, 65, 75, and 85 m

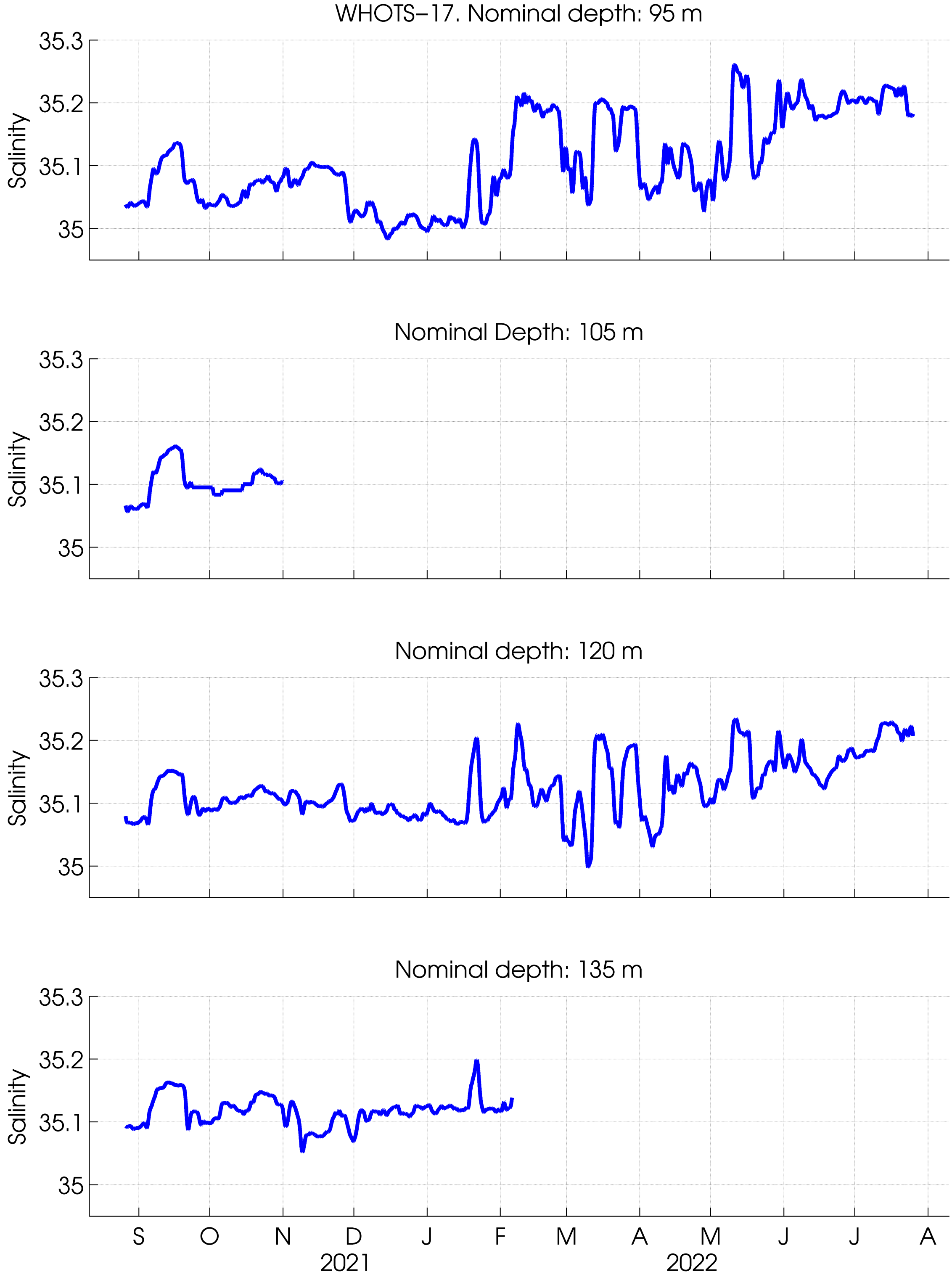


Fig. 6.23: Same as in Fig. 6.20, but at 95, 105, 120, and 135 m.

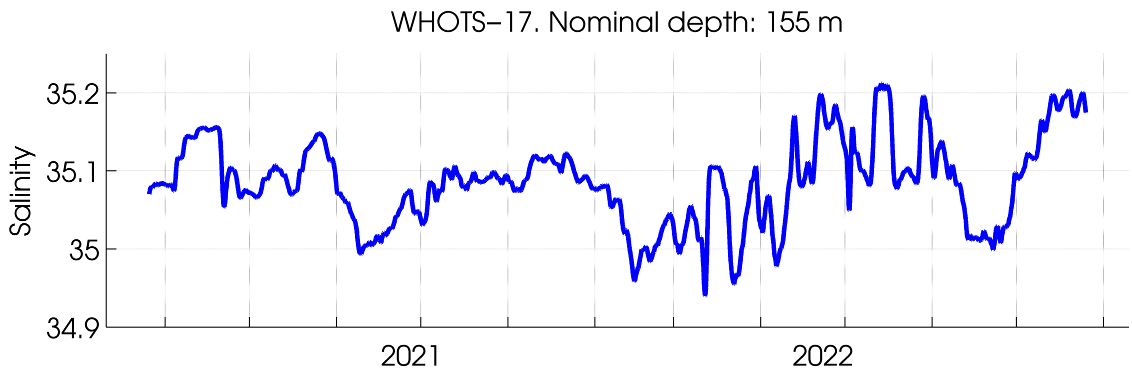


Fig. 6.24: Same as in Fig. 6.20, but at 155 m.

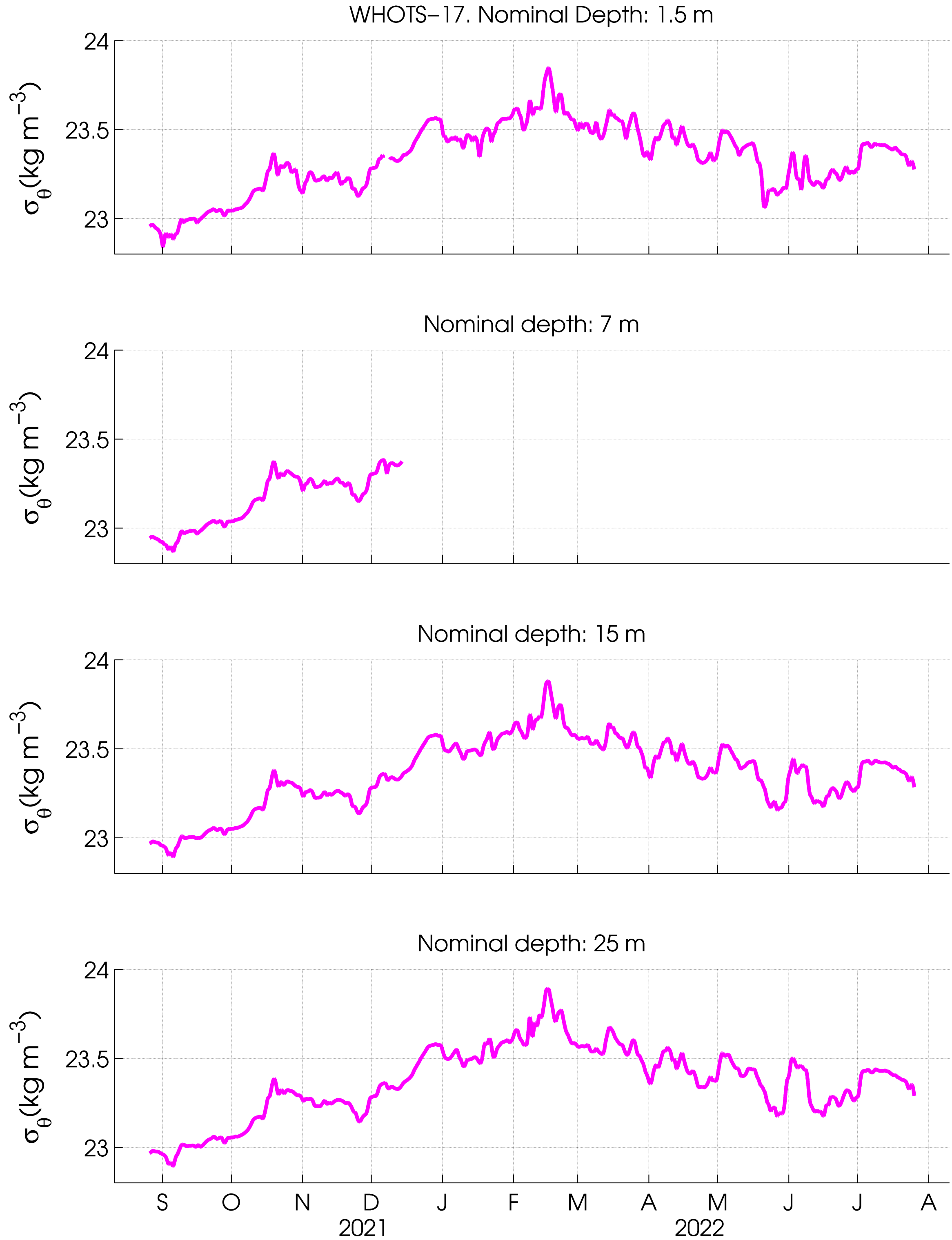


Fig. 6.25: Potential densities ($\sigma\theta$) from MicroCATs during WHOTS-17 deployment at 1.5, 7, 15, and 25 m.

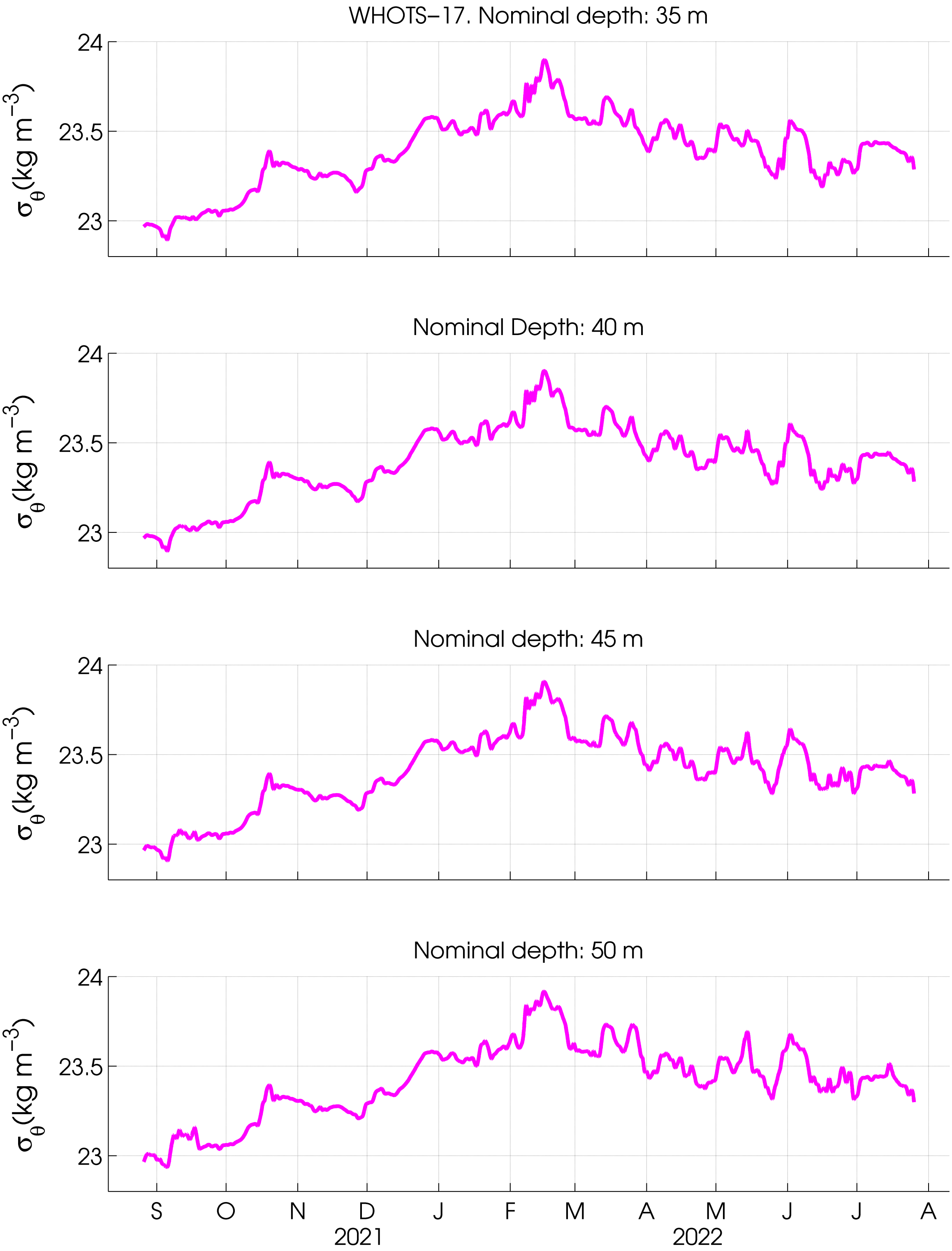


Fig. 6.26: Same as in Fig. 6.25, but at 35, 40, 45, and 50 m.

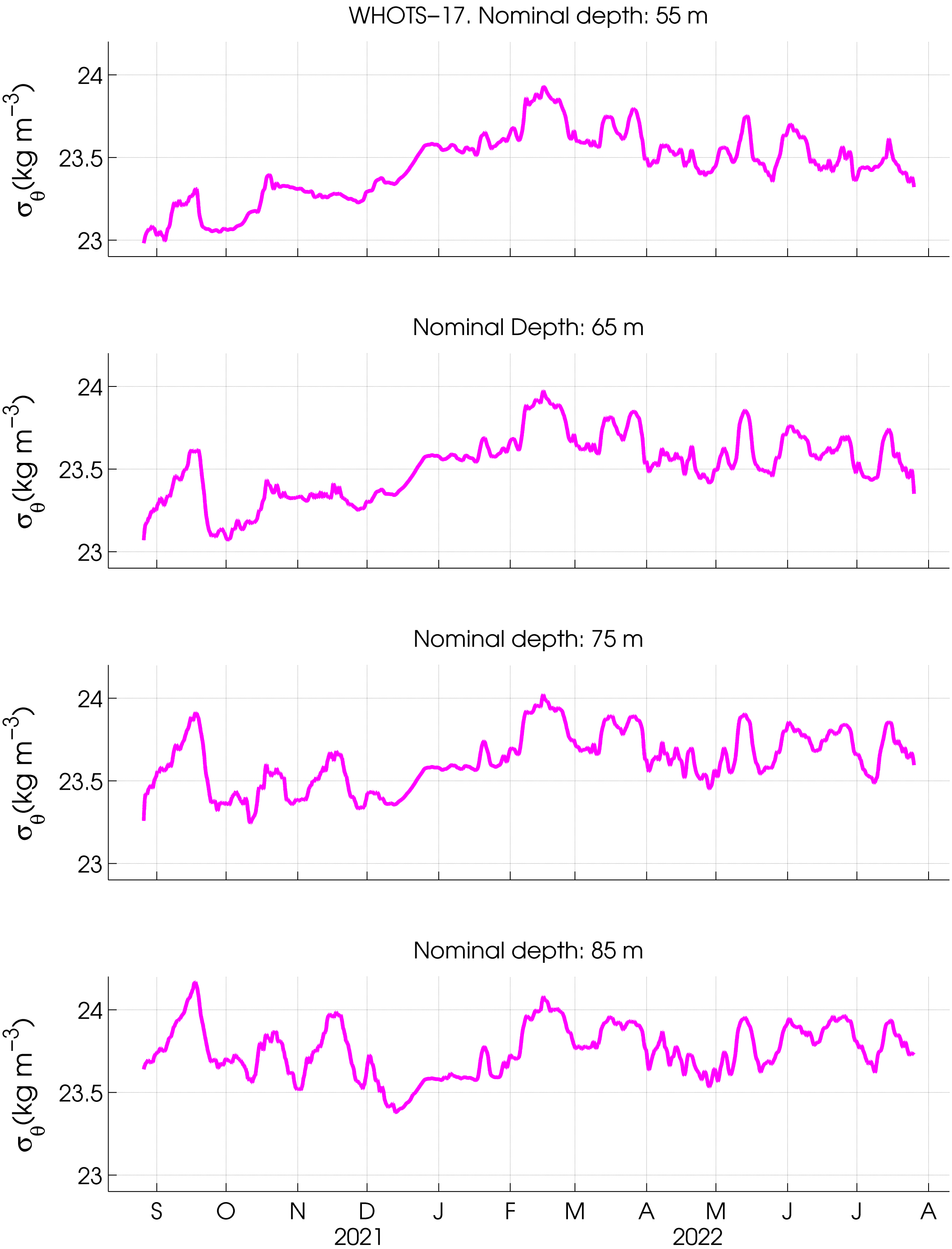


Fig. 6.27: Same as in Fig. 6.25, but at 55, 65, 75, and 85 m.

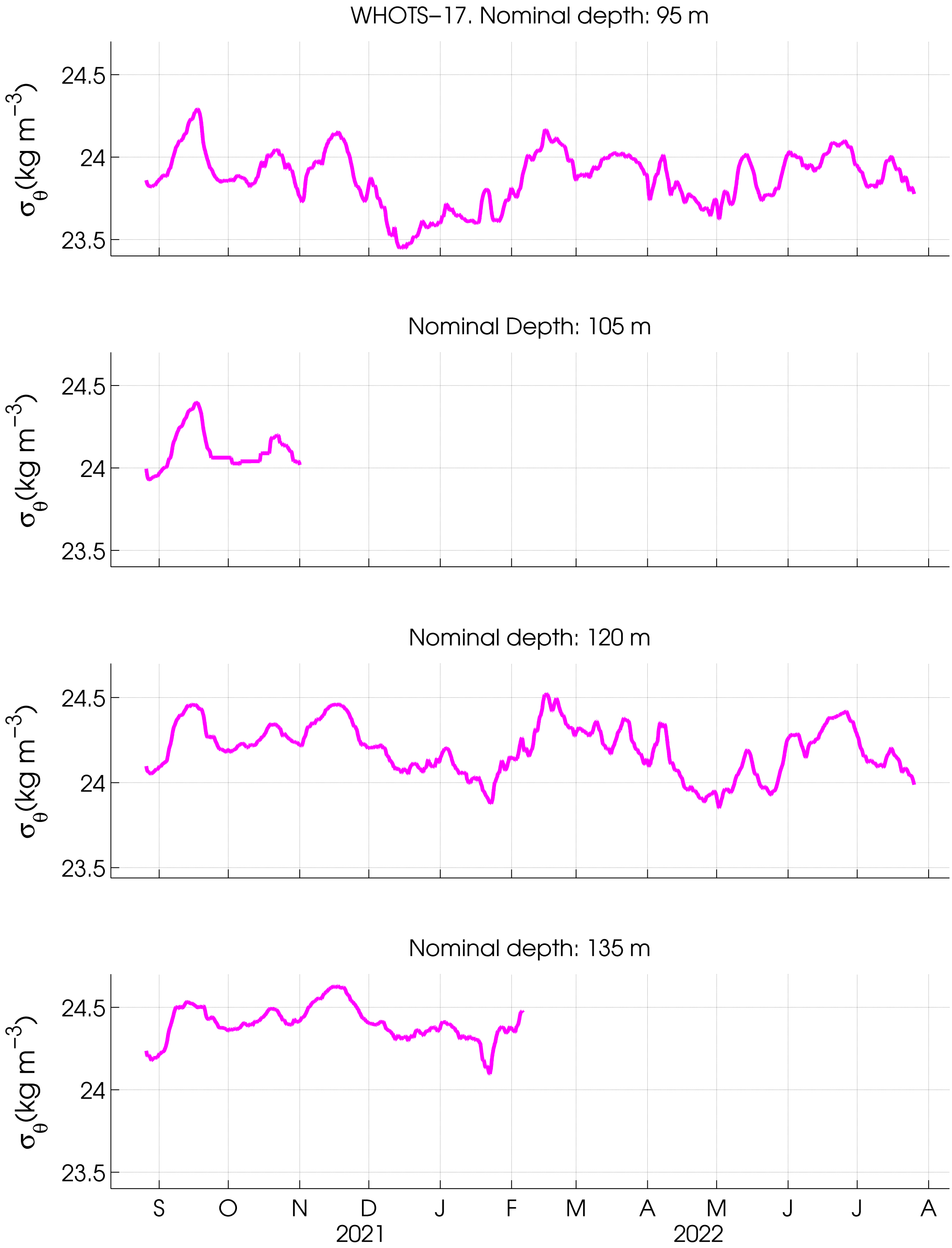


Fig. 6.28: Same as in Fig. 6.25, but at 95, 105, 120, and 135 m.

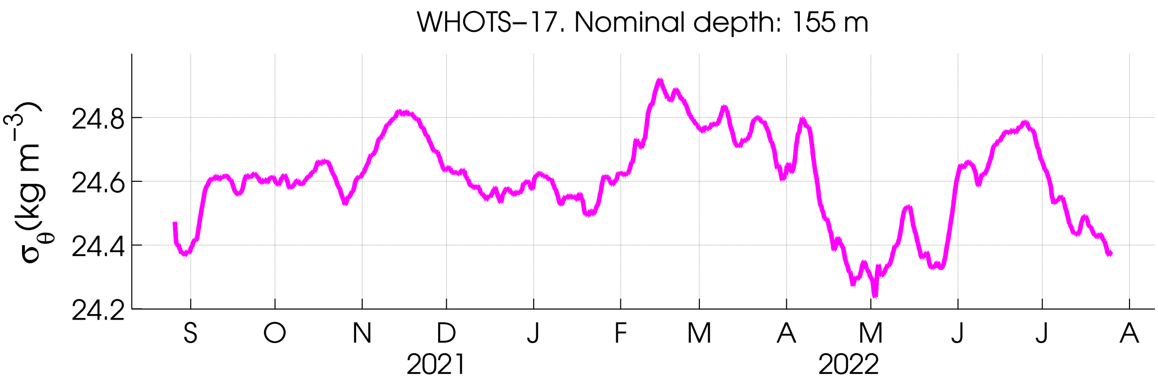


Fig. 6.29: Same as in Fig. 6.25, but at 155 m.

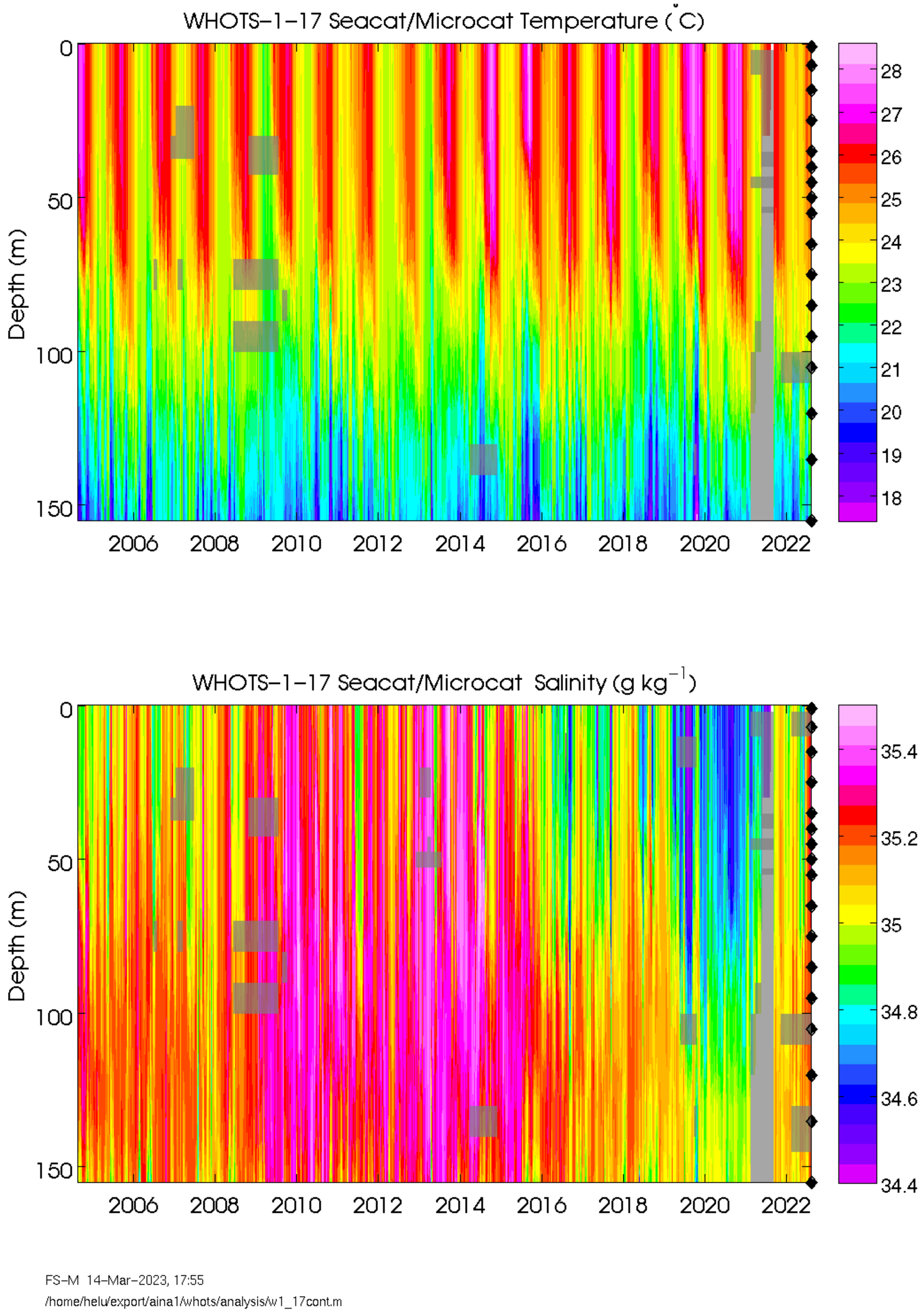


Fig. 6.30: Contour plots of temperature (upper panel) and salinity (lower panel) versus depth from SeaCATs/MicroCATs during WHOTS-1 through WHOTS-17 deployments. The shaded areas indicate missing data. The diamonds along the right axis indicate the depths of the instrument.

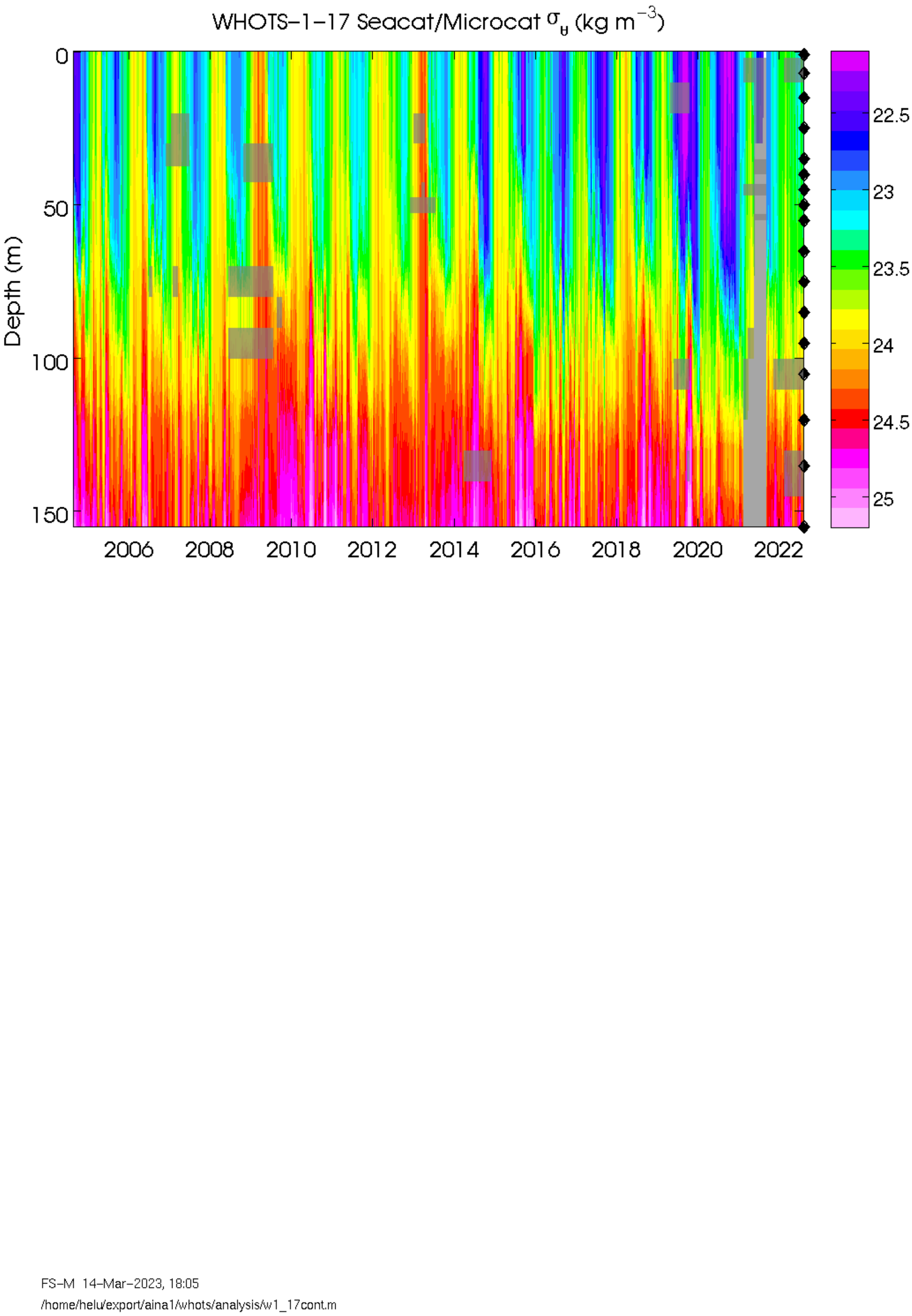


Fig. 6.31: Contour plots of potential density ($\sigma\theta$), versus depth from SeaCATs/MicroCATs during WHOTS-1 through WHOTS-17 deployments. The shaded areas indicate missing data. The diamonds along the right axis in the upper figure indicate the depths of the instrument.

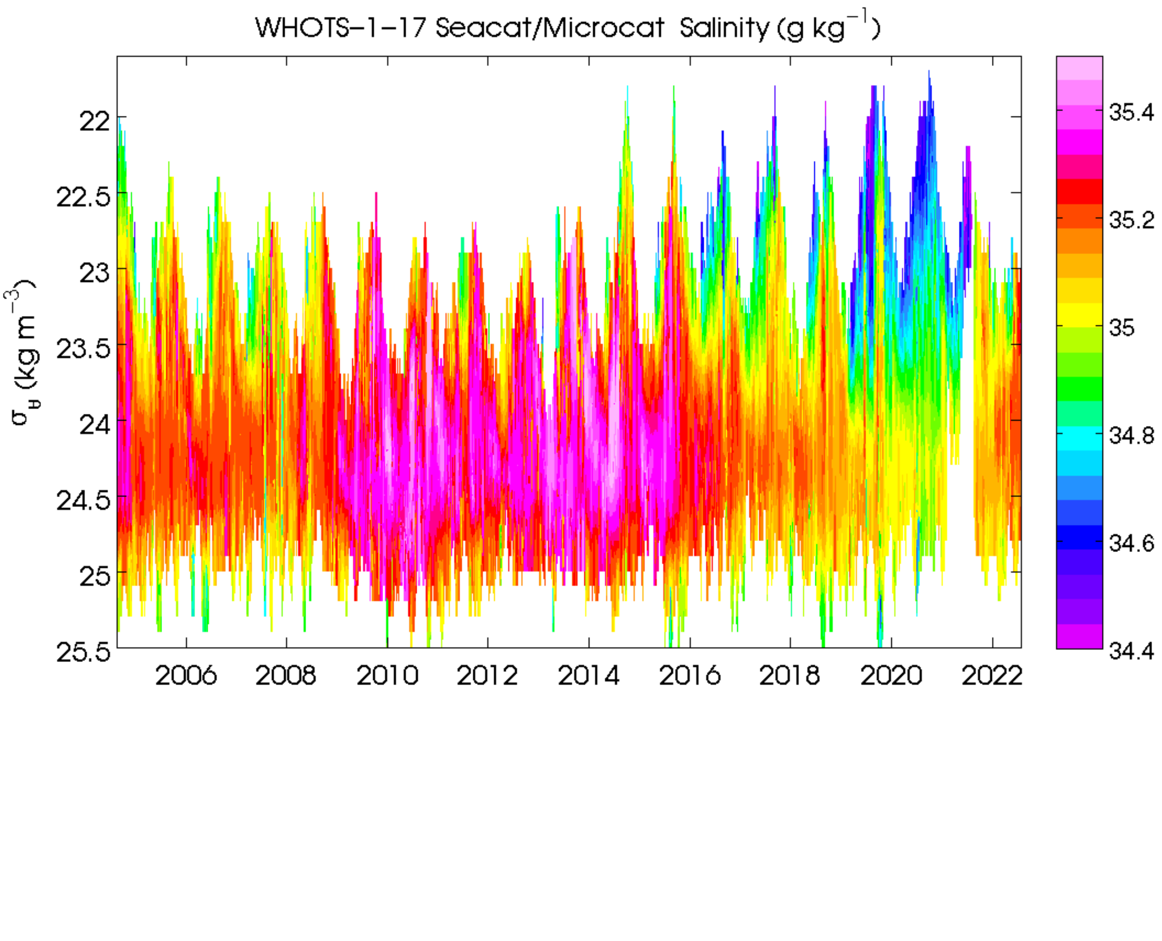


Fig. 6.32: Contour plots of salinity versus $\sigma\theta$ from SeaCATs/MicroCATs during WHOTS-1 through WHOTS-17 deployments.

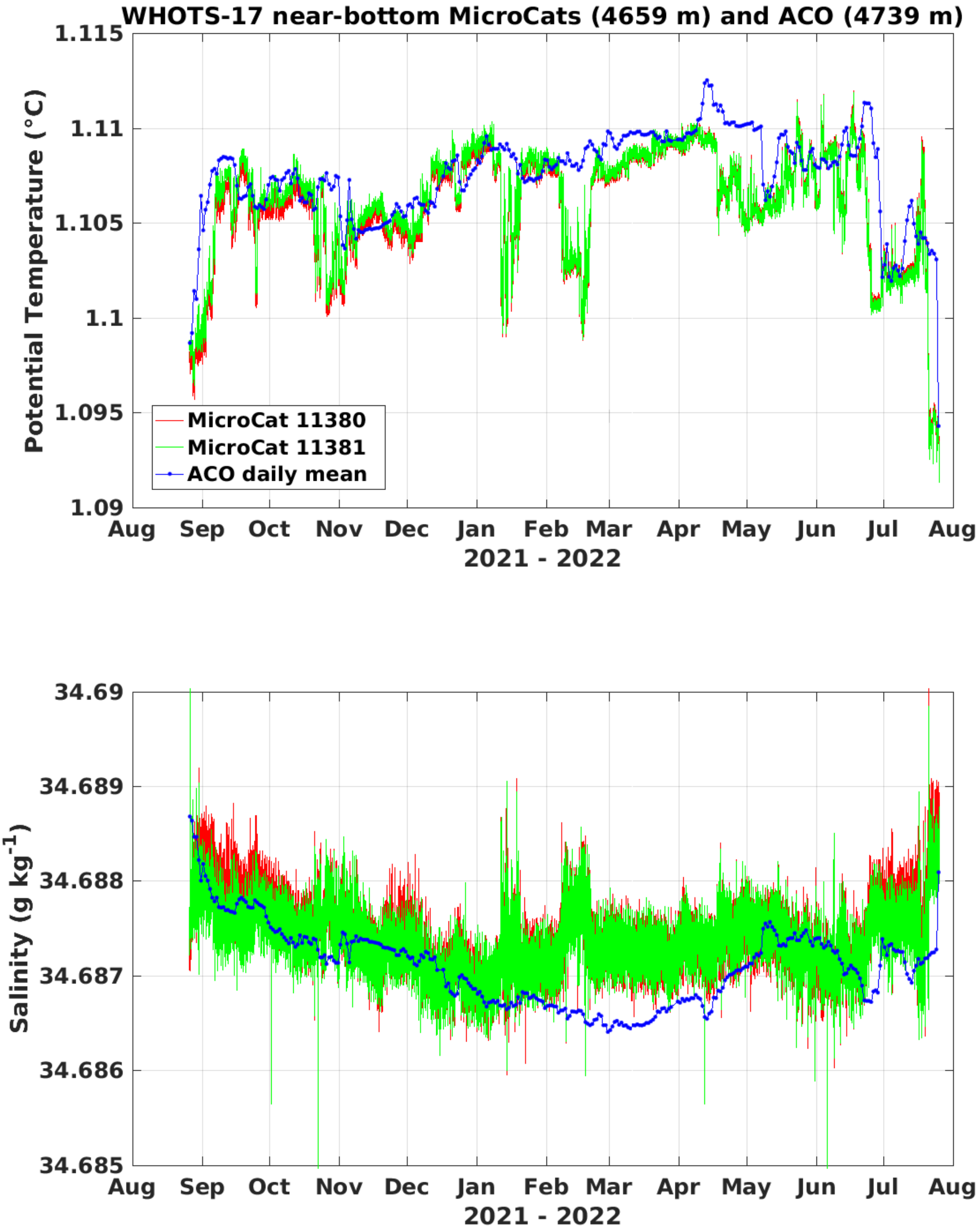
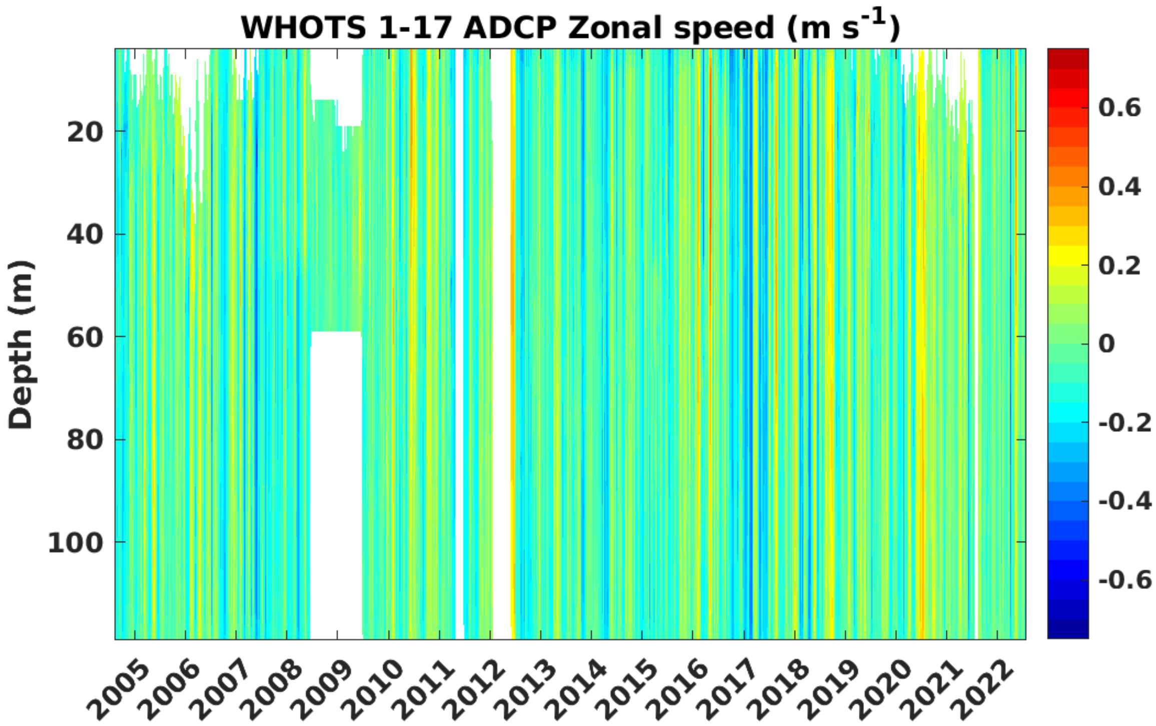


Fig. 6.33: Potential temperature (upper panel) and salinity (lower panel) time-series from the ALOHA Cabled Observatory (ACO) sensors and the WHOTS-17 MicroCATs 11380 and 11381.



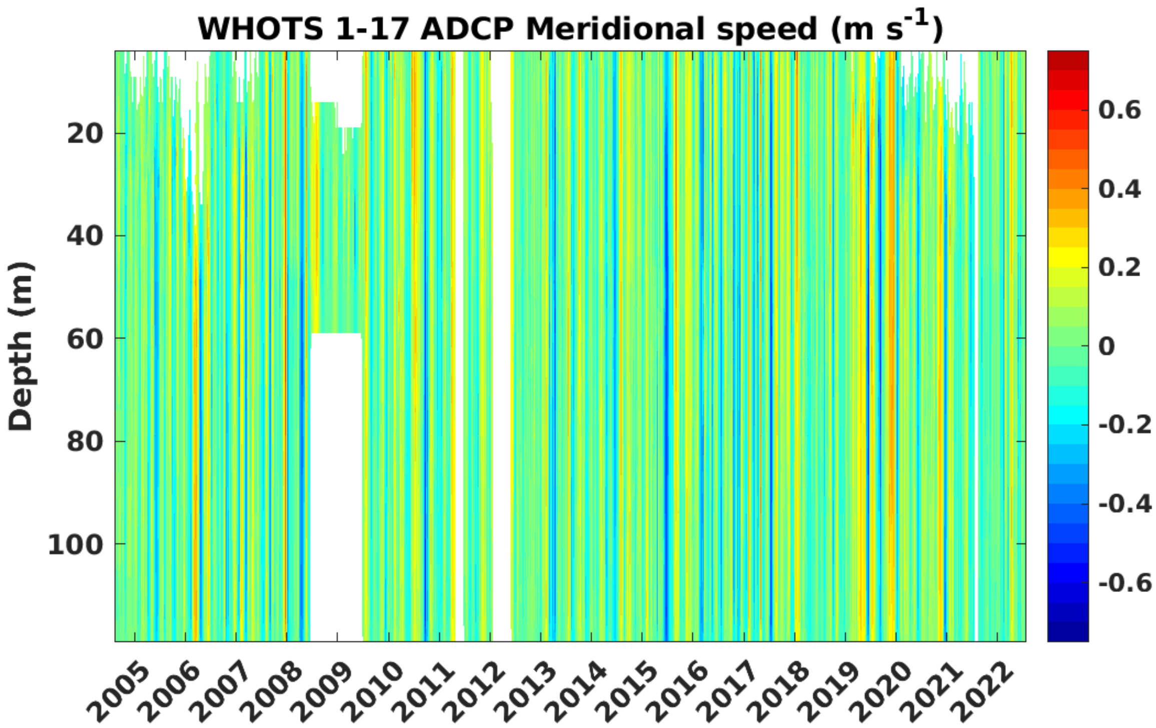


Fig. 6.34: Contour plot of east velocity component (ms^{-1}) versus depth and time from the moored ADCPs from the WHOTS-1 through -17 deployments (upper panel). Contour plot of north velocity component (ms^{-1}) (lower panel).

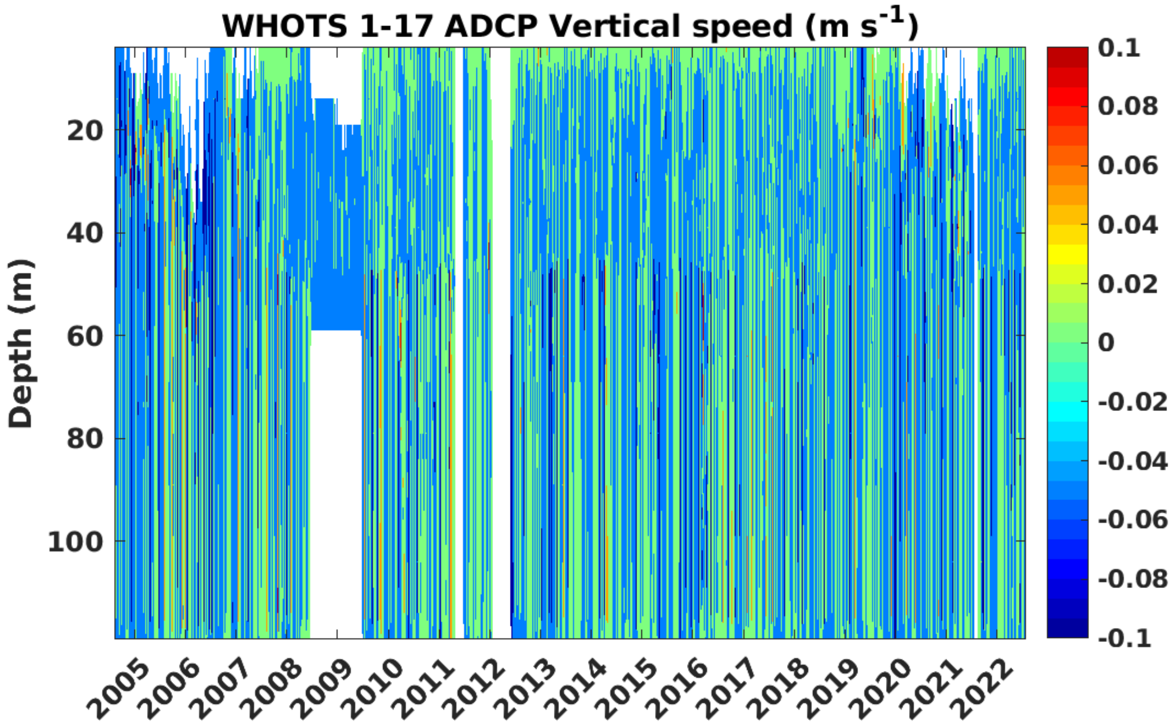


Fig. 6.35: Contour plot of vertical velocity component (ms^{-1}) versus depth and time from the moored ADCPs from the WHOTS-1 through -17 deployments.

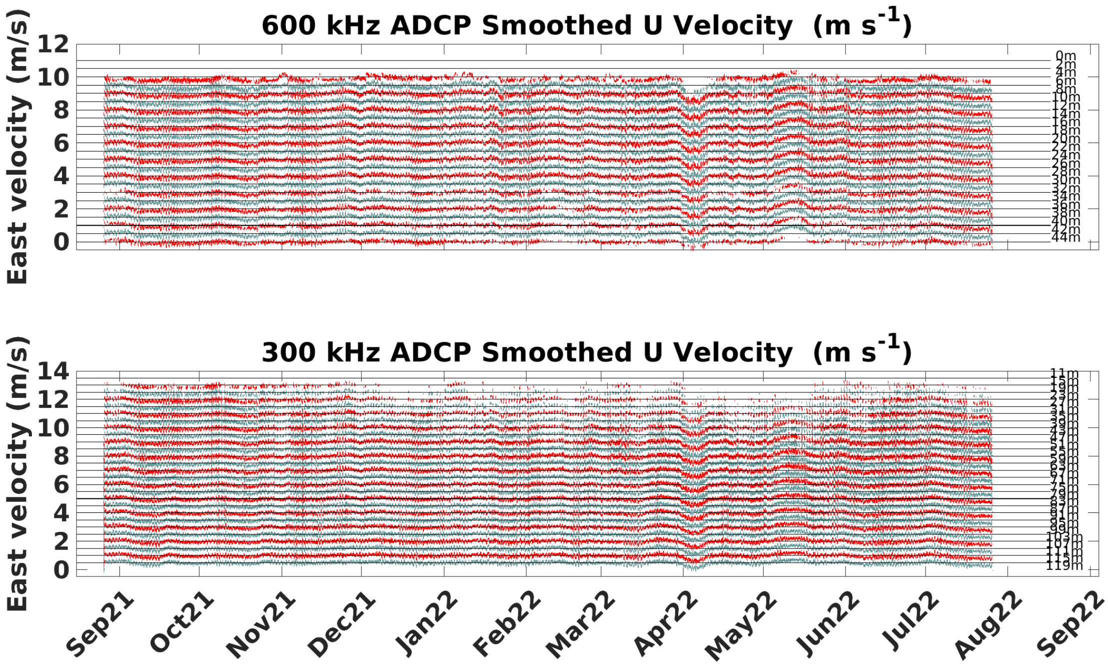


Fig. 6.36: Staggered time-series of east velocity component (ms^{-1}) for each bin of the 600 kHz (upper panel) and 300 kHz (lower panel) moored ADCPs during WHOTS-17. The time-series are offset upwards by 0.5 ms^{-1}; each bin`s depth is on the right.

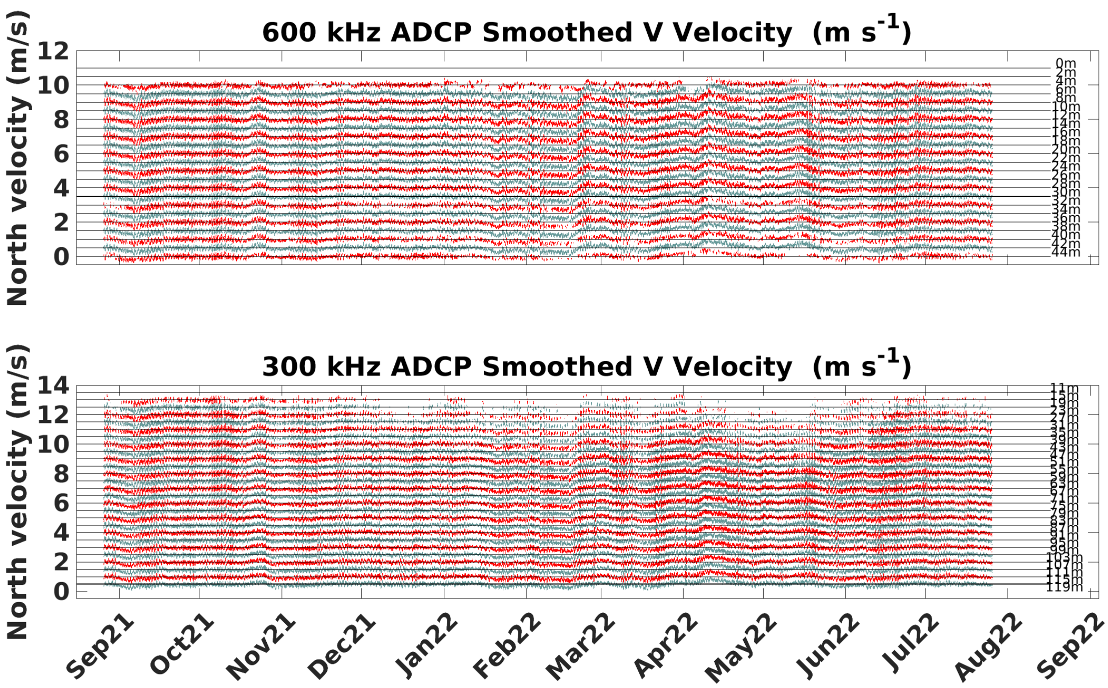


Fig. 6.37: Same as Fig. 6.36 but for north velocity component

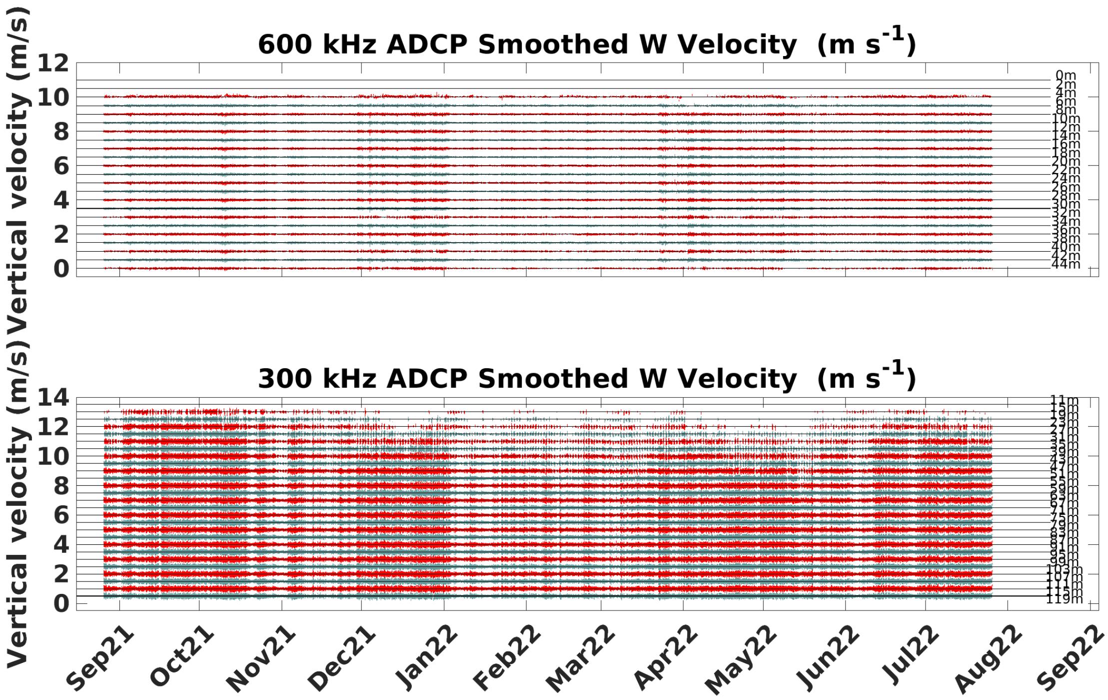


Fig. 6.38: Same as Fig. 6.36 but for north velocity component but for vertical velocity component.

6.7 GPS Data

Time-series of latitude and longitude of the WHOTS-17 buoy from GPS data are presented in Fig. 6.46, and spectra of the time-series are shown in Fig. 6.47.

6.8 Mooring Motion

The position of the mooring with respect to its anchor was determined from the GPS positions. Additional information on the mooring motion was provided by the ADCP data of pitch, roll, and heading, shown in this section.

Fig. 6.48 shows the ADCP data of the instrument's tilt (a combination of the pitch and roll), plotted against the buoy's distance from its anchor (derived from GPS positions), for both WHOTS-17 ADCP's. The plot's red line is a quadratic fit to the median tilt calculated every 0.2 km distance bins. The figure shows that during both deployments, the ADCP tilt increased as the anchor's distance increased. This tilting was caused by the mooring line's deviation from its vertical position as the anchor pulled it. The tilting of the line also caused the rising of the instruments attached to the line.

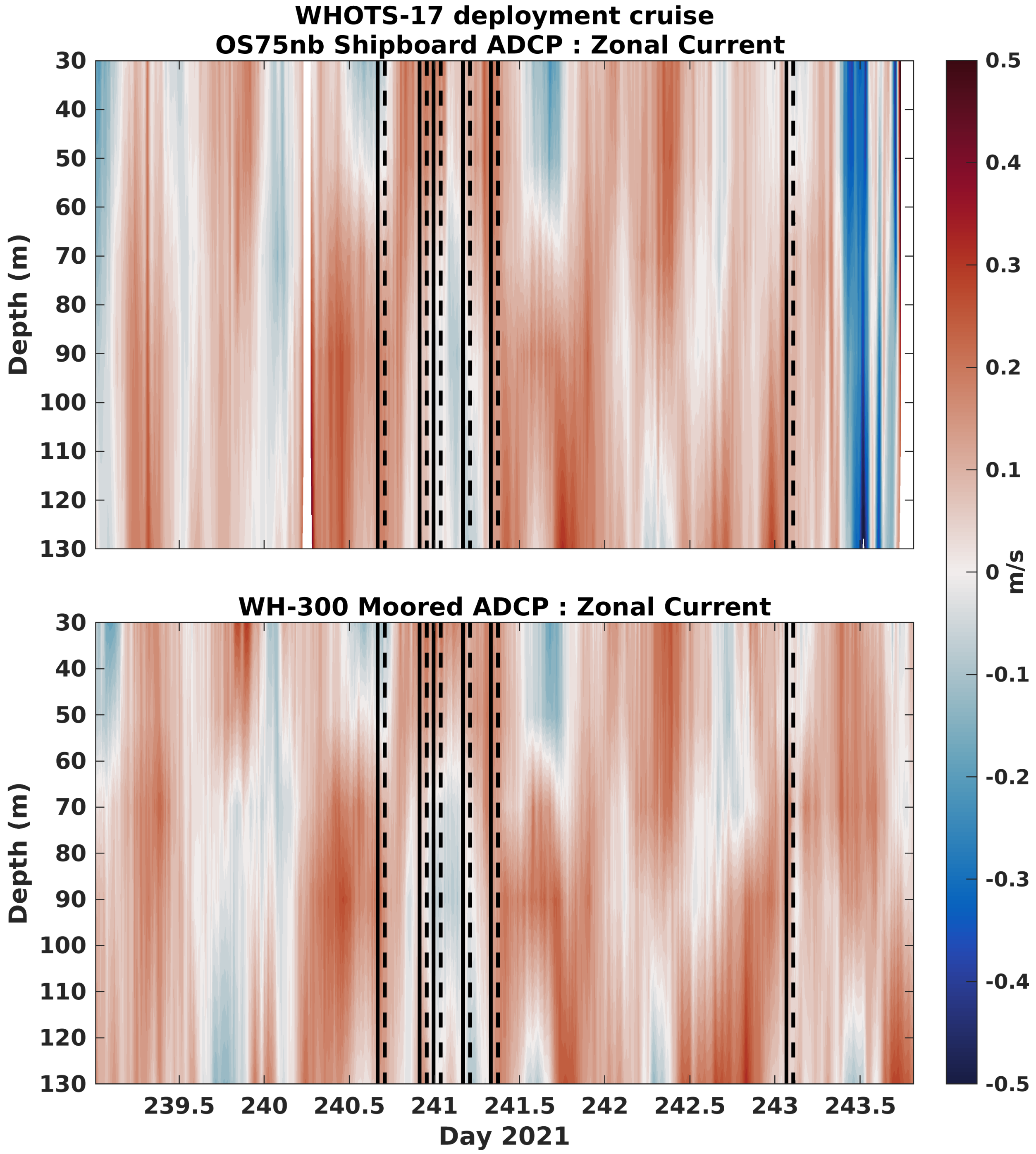


Fig. 6.39: The contour of zonal currents (ms^{-1}) from the Ship Oscar Sette Ocean Surveyor narrowband 75 kHz shipboard ADCP (upper panel), and the moored 300 kHz ADCP from the WHOTS-17 mooring (bottom panel) as a function of time and depth, during the WHOTS-17 cruise. Times when the CTD rosette was in the water are identified between solid and dashed black lines.

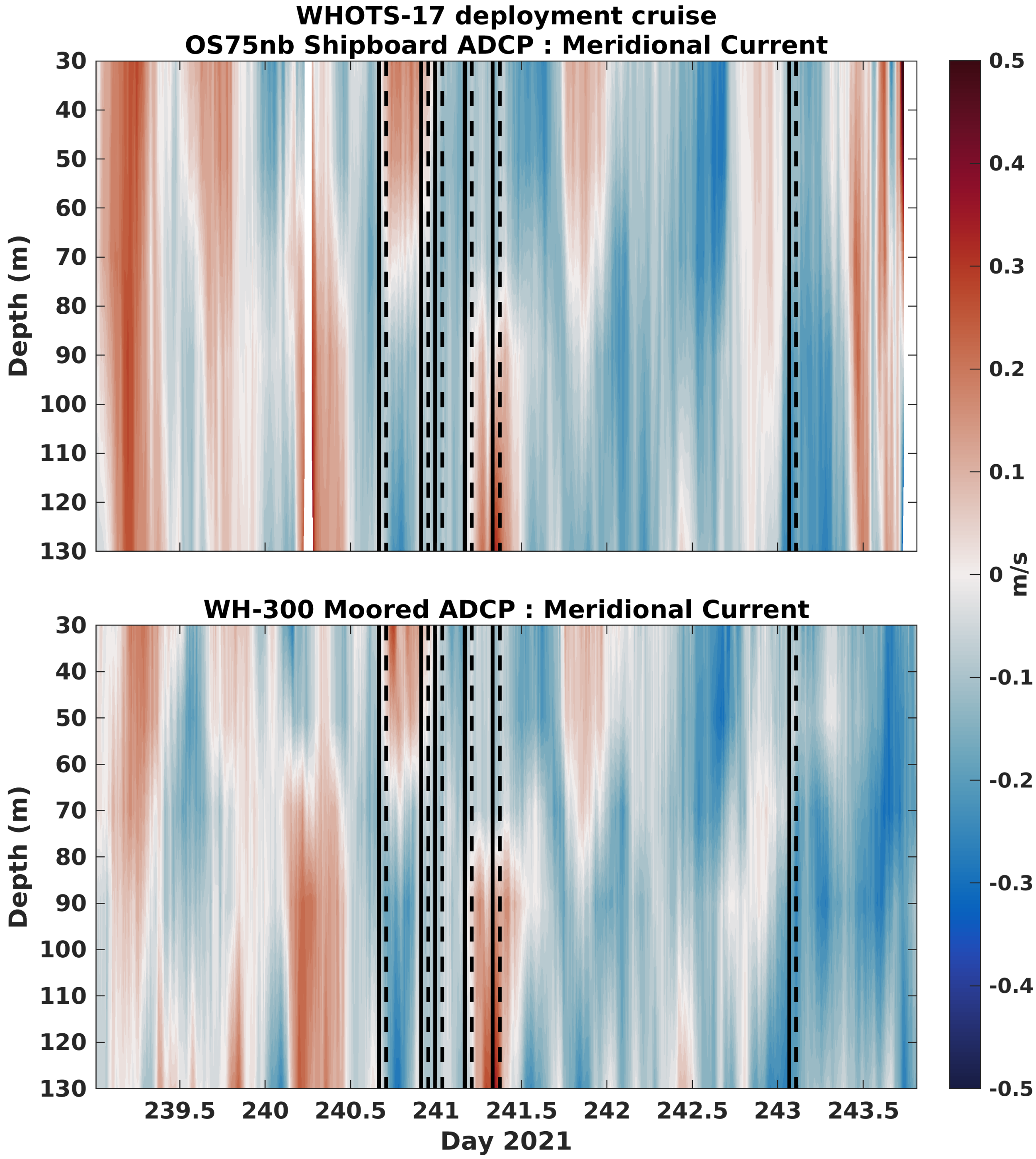


Fig. 6.40: The contour of meridional currents (ms^{-1}) from the Ship Oscar Sette Ocean Surveyor narrowband 75 kHz shipboard ADCP (upper panel), and the moored 300 kHz ADCP from the WHOTS-17 mooring (bottom panel) as a function of time and depth, during the WHOTS-17 cruise. Times when the CTD rosette was in the water are identified between solid and dashed black lines.

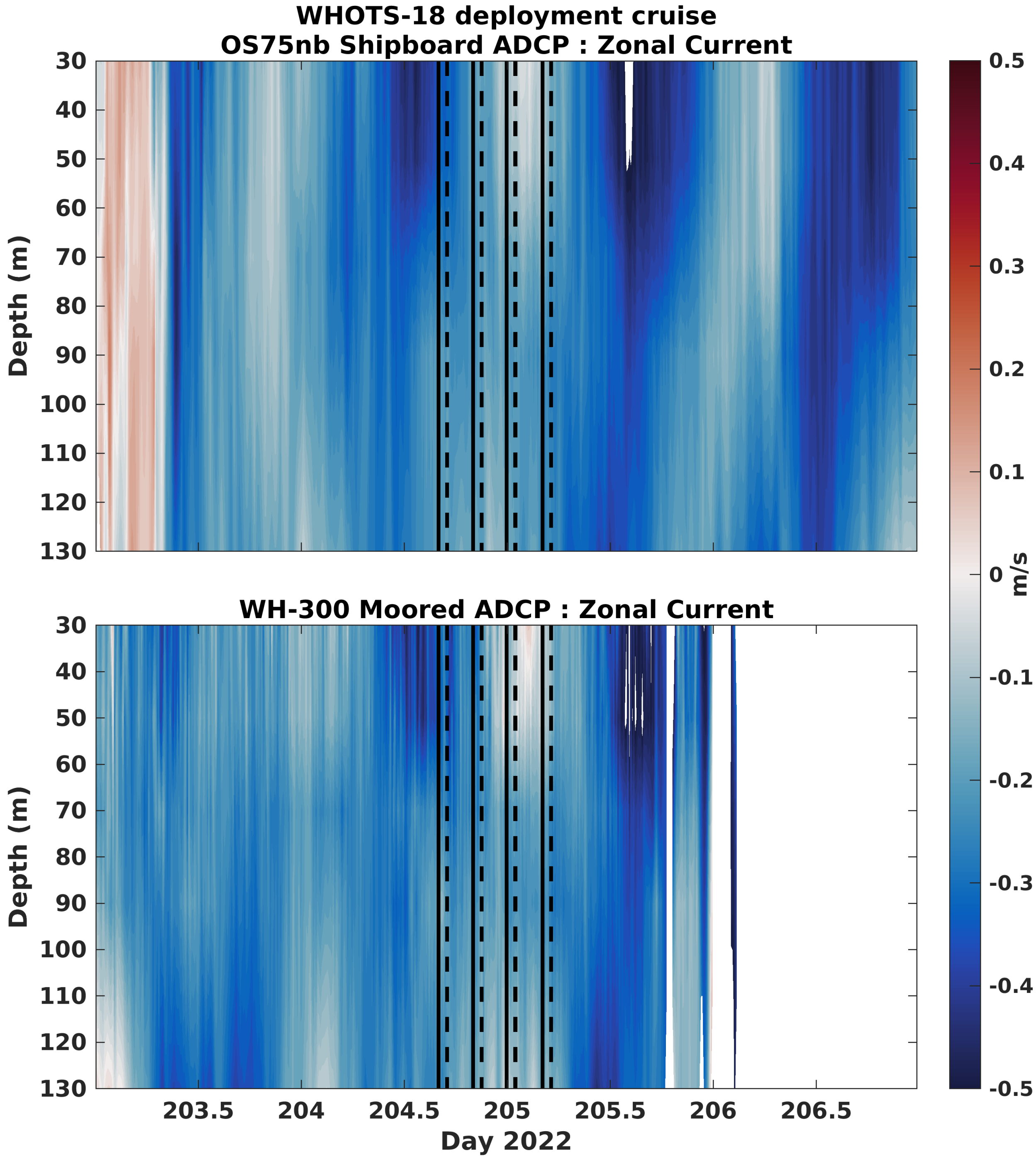


Fig. 6.41: The contour of zonal currents (ms^{-1}) from the Ship Oscar Sette Ocean Surveyor narrowband 75 kHz shipboard ADCP (upper panel), and the moored 300 kHz ADCP from the WHOTS-17 mooring (bottom panel) as a function of time and depth, during the WHOTS-18 cruise. Times when the CTD rosette was in the water are identified between solid and dashed black lines.

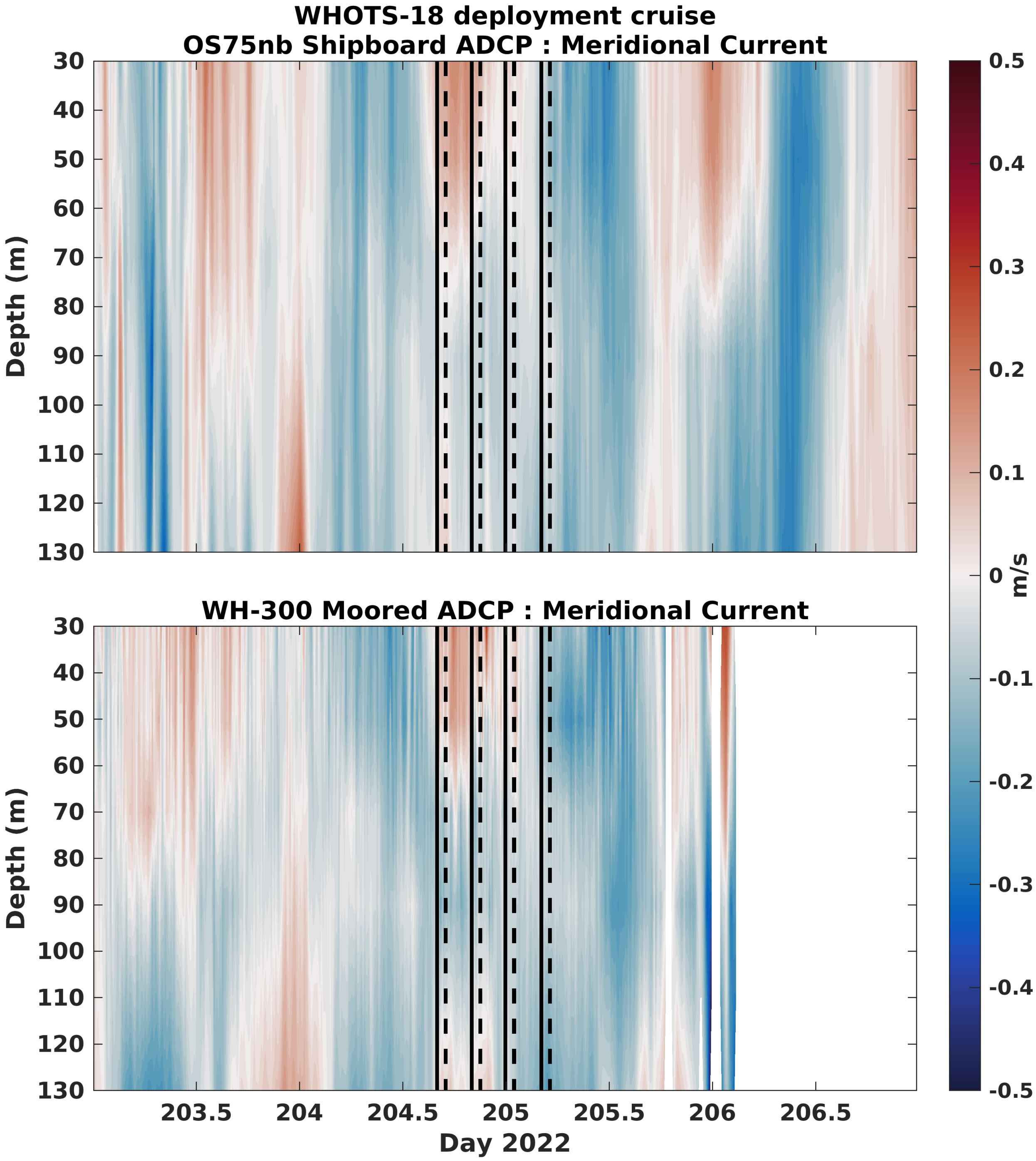


Fig. 6.42: Contours of meridional currents (ms^{-1}) from the Ship Oscar Sette Ocean Surveyor narrowband 75 kHz shipboard ADCP (upper panel), and the moored 300 kHz ADCP from the WHOTS-17 mooring (lower panel) as a function of time and depth, during the WHOTS-18 cruise. Times when the CTD/rosette was in the water are identified between the solid and dashed black lines.

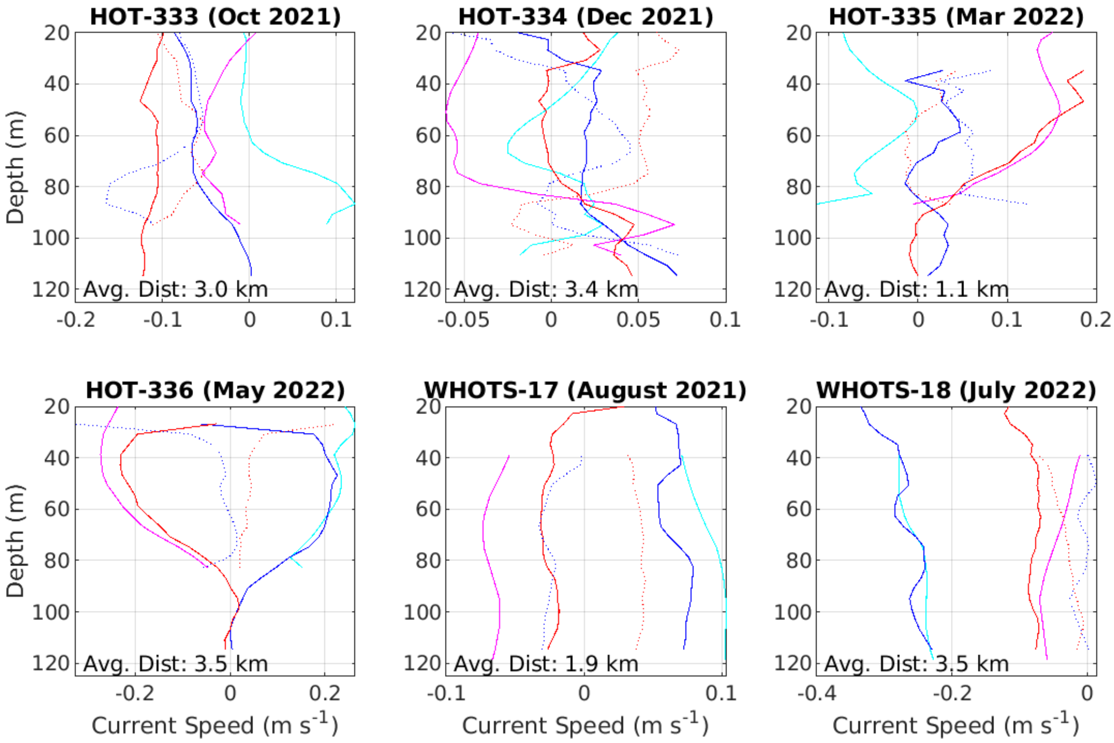


Fig. 6.43: Mean current profiles during shipboard ADCP (cyan: zonal, magenta: meridional) versus moored 300 kHz ADCP (blue: zonal, red: meridional) intercomparisons from HOT-333 through HOT-336. Moored minus shipboard ADCP differences shown in dotted lines (blue: zonal, red: meridional)

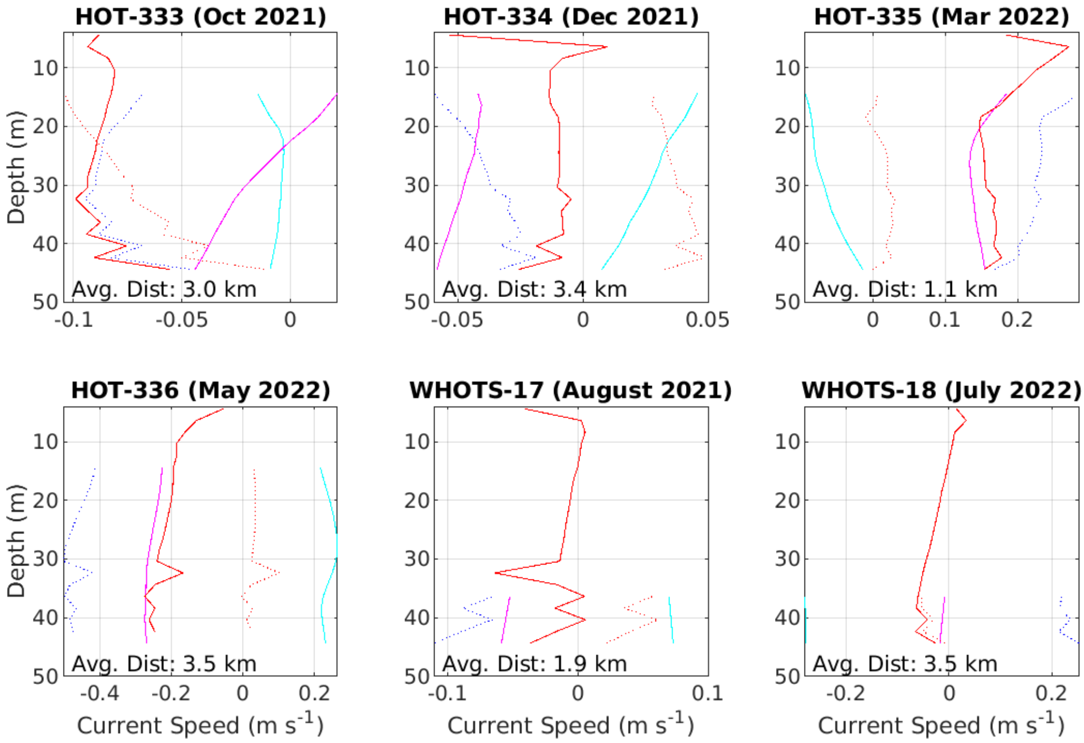


Fig. 6.44: Mean current profiles during shipboard ADCP (cyan: zonal, magenta: meridional) versus moored 600 kHz ADCP (blue: zonal, red: meridional) intercomparisons from HOT-333 through HOT-336. Moored minus shipboard ADCP differences shown in dotted lines (blue: zonal, red: meridional)

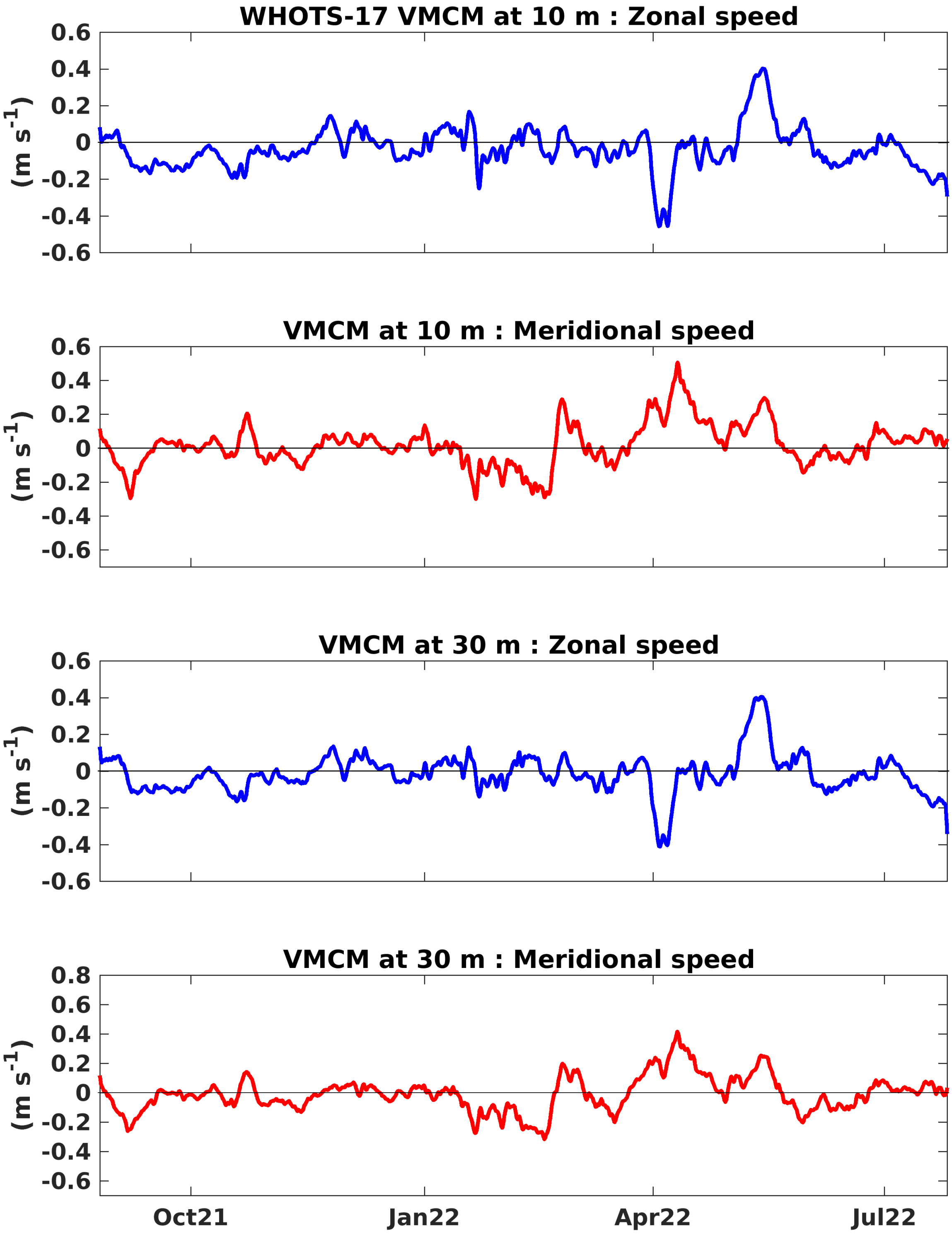


Fig. 6.45: Horizontal velocity data (ms^{-1}) during WHOTS-17 from the VMCMs at 10 m depth (first and second panel) and at 30 m depth (third and fourth panel)

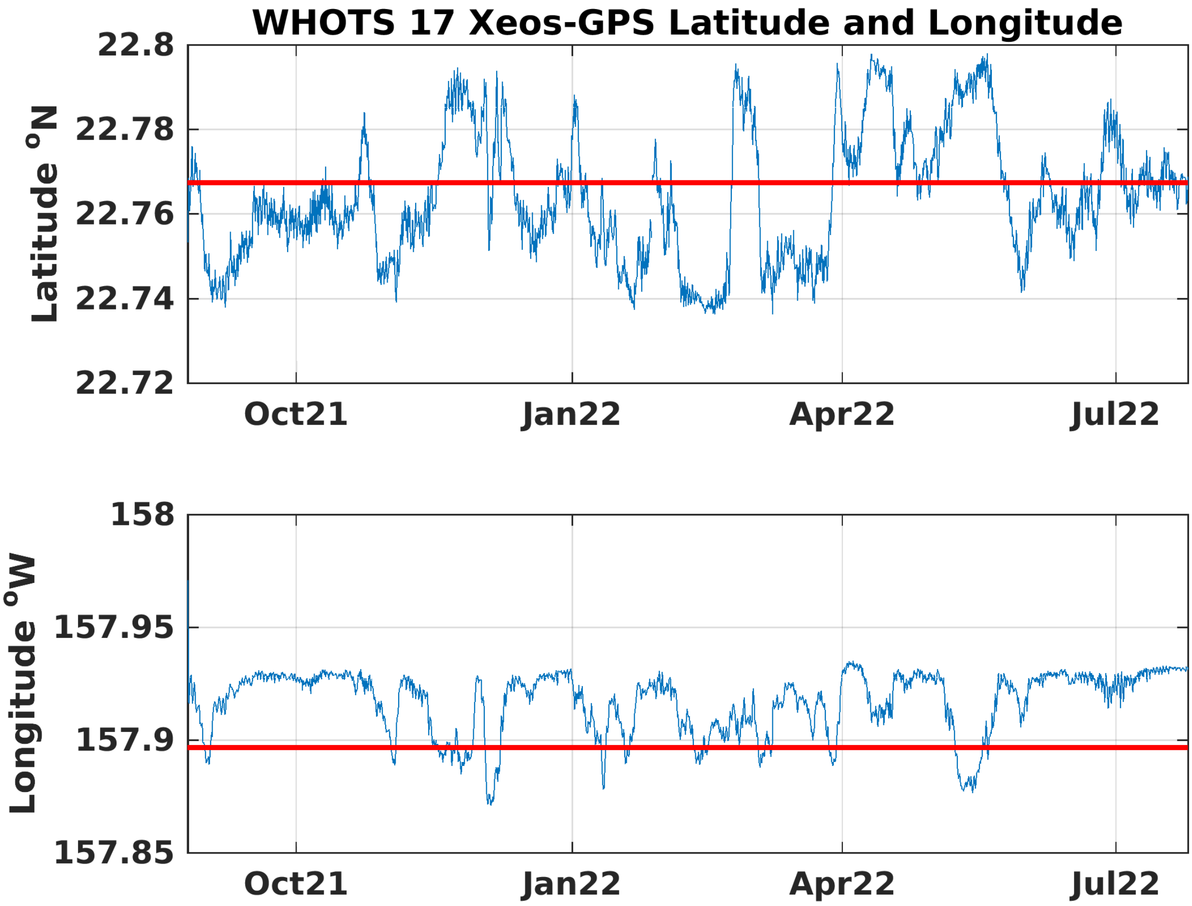


Fig. 6.46: GPS Latitude (upper panel) and longitude (lower panel) time series from the WHOTS-17 deployment.

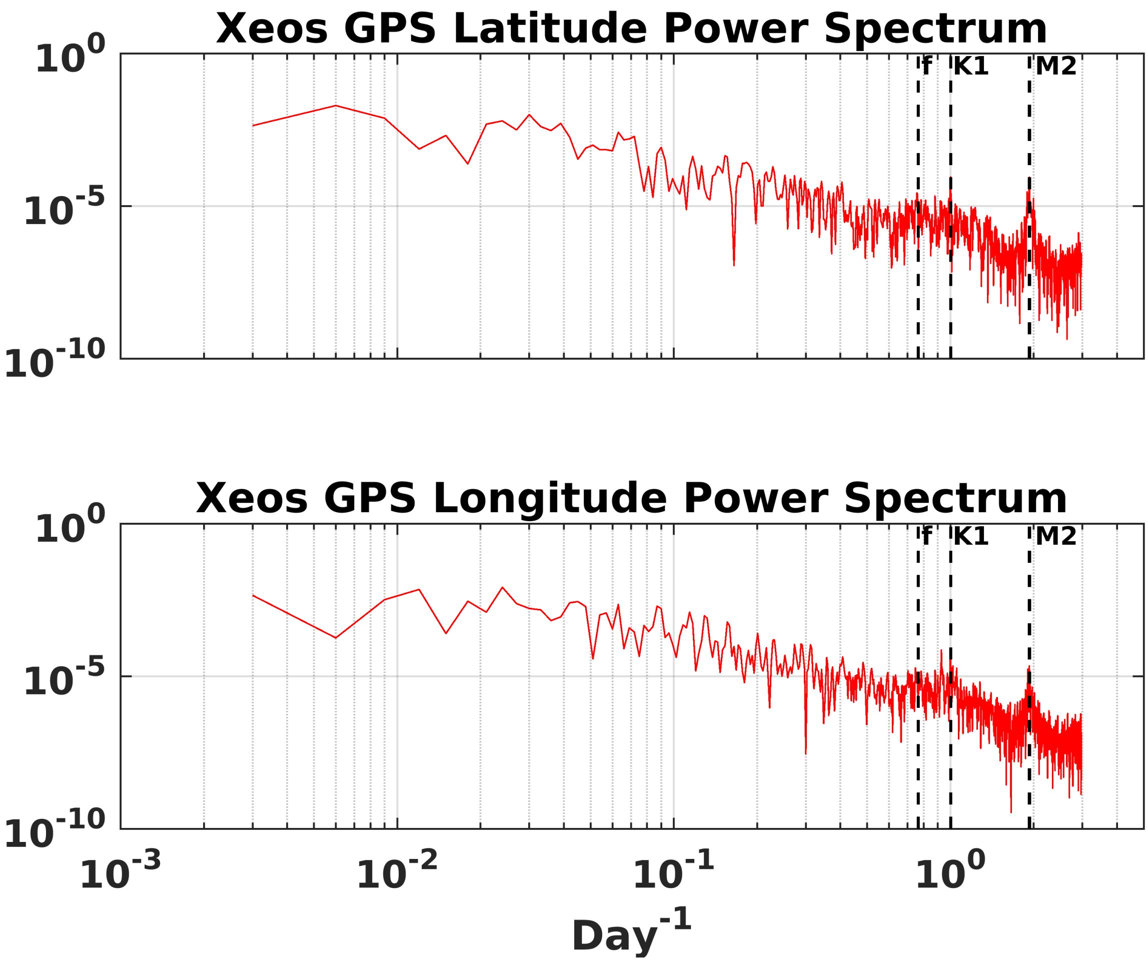


Fig. 6.47: The power spectrum of latitude (upper panel) and longitude (lower panel) for the WHOTS-17.

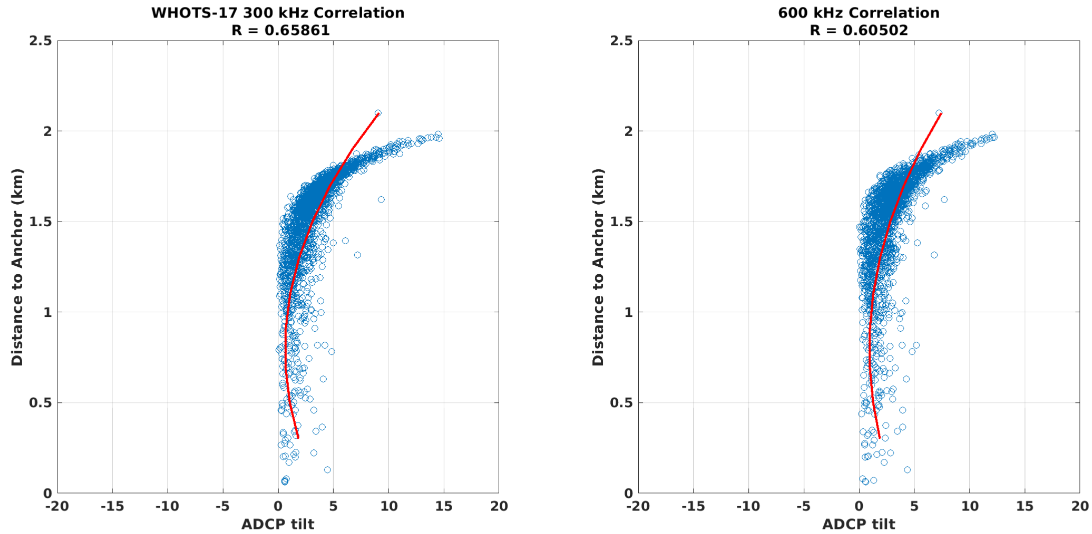


Fig. 6.48: Scatter plots of ADCP tilt and distance of the buoy to its anchor for the 300 kHz (left panel) and the 600 kHz ADCP deployments (right panel, blue circles). The red line is a quadratic fit to the median tilt calculated every 0.2 km distance bins.

7 Appendix

7.1 WHOTS-17 300 kHz - Serial 7367

```
  Instrument S/N:  7637
       Frequency:  307200 HZ
   Configuration:  4 BEAM, JANUS
     Match Layer:  10
      Beam Angle:  20 DEGREES
    Beam Pattern:  CONVEX
     Orientation:  UP
       Sensor(s):  HEADING  TILT 1  TILT 2  TEMPERATURE
Temp Sens Offset:  -0.29 degrees C

    CPU Firmware:  50.40 [0]
   Boot Code Ver:  Required:  1.16   Actual:  1.16
    DEMOD #1 Ver:  ad48, Type:  1f
    DEMOD #2 Ver:  ad48, Type:  1f
    PWRTIMG  Ver:  85d3, Type:   4

Board Serial Number Data:
   97  00 00 00 86 5D 54  09 REC727-1000-04E
   1F  00 00 00 7E 6B FC  09 CPU727-2000-00J
   12  00 00 00 86 BE 49  09 DSP727-2001-04G
   B6  00 00 00 7E 9A 19  09 PIO727-3000-00C
>tt?
TT 2021/08/25,05:50:44 - Time Set (CCYY/MM/DD,hh:mm:ss)
>TT 2021/08/25,07:55:20
>tt?
TT 2021/08/25,07:55:23 - Time Set (CCYY/MM/DD,hh:mm:ss)
>ps3
Beam Width:   3.7 degrees

Beam     Elevation     Azimuth
  1         -70.00      270.00
  2         -70.00       90.00
  3         -70.00        0.01
  4         -70.00      180.00

Beam Directional Matrix (Down):
  0.3420    0.0000    0.9397    0.2419
```

(continues on next page)

(continued from previous page)

```
 -0.3420    0.0000    0.9397    0.2419
  0.0000   -0.3420    0.9397   -0.2419
  0.0000    0.3420    0.9397   -0.2419

Instrument Transformation Matrix (Down):    Q14:
  1.4619   -1.4619    0.0000    0.0000       23952  -23952       0       0
  0.0000    0.0000   -1.4619    1.4619           0       0  -23952   23952
  0.2661    0.2661    0.2661    0.2661        4359    4359    4359    4359
  1.0337    1.0337   -1.0337   -1.0337       16936   16936  -16936  -16936
Beam Angle Corrections Are Loaded.
>pa

PRE-DEPLOYMENT TESTS

CPU TESTS:
  RTC......................................PASS
  RAM......................................PASS
  ROM......................................PASS
RECORDER TESTS:
  PC Card #0...............................DETECTED
    Card Detect............................PASS
    Communication..........................PASS
    DOS Structure..........................PASS
    Sector Test (short)....................PASS
  PC Card #1...............................DETECTED
    Card Detect............................PASS
    Communication..........................PASS
    DOS Structure..........................PASS
    Sector Test (short)....................PASS
DSP TESTS:
  Timing RAM...............................PASS
  Demod  RAM...............................PASS
  Demod  REG...............................PASS
  FIFOs....................................PASS
SYSTEM TESTS:
  XILINX Interrupts... IRQ3  IRQ3  IRQ3 ...PASS
  Wide Bandwidth...........................PASS
  Narrow Bandwidth.........................PASS
  RSSI Filter..............................PASS
  Transmit.................................PASS
SENSOR TESTS:
  H/W Operation.........................***FAIL***
>pc1


BEAM CONTINUITY TEST

When prompted to do so, vigorously rub the selected
beam's face.

If a beam does not PASS the test, send any character to
the ADCP to automatically select the next beam.

Collecting Statistical Data...
  41  44  41  42
  41  43  41  42
```

(continues on next page)

(continued from previous page)

```
 41  43  41  42
 41  43  41  42
 41  43  41  42
 41  43  41  42
 41  43  41  42
 41  43  41  42
 41  43  41  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
 41  43  40  42
```

(continues on next page)

(continued from previous page)

```
  41  43  40  42
  41  43  40  42
  41  43  40  42
  41  43  40  42
  41  43  40  42
  41  43  40  42
  41  43  40  42

Rub Beam 1 = PASS
Rub Beam 2 = PASS
Rub Beam 3 = PASS
Rub Beam 4 = PASS

>ac

              ACTIVE FLUXGATE CALIBRATION MATRICES in NVRAM
               Calibration date and time: 8/3/1921  21:50:35
                             S inverse
     Bx      3.6771e-01  3.6385e-01  2.8706e-02 -3.5228e-02
     By      1.1022e-02 -7.0206e-03 -6.5931e-03 -4.6329e-01
     Bz      1.8963e-01 -1.5037e-01  2.7762e-01 -4.4941e-03
     Err    -4.0055e+01  3.6551e+01  4.7122e+01 -2.1774e+00
                        Coil Offset
                            3.3140e+04
                            3.2124e+04
                            3.4319e+04
                            3.3343e+04

                         Electrical Null
                               33460
                    TILT CALIBRATION MATRICES in NVRAM
                Calibration date and time: 4/14/2006  15:49:48
              Average Temperature During Calibration was   26.3C
                   Up                              Down

 Roll     -6.3199e-08  -1.1565e-05        -3.4249e-09   1.5773e-05
 Pitch    -1.2120e-05   7.1944e-08        -1.5315e-05   3.6304e-08
 Offset    3.1094e+04   2.9535e+04         2.9891e+04   3.1151e+04

                      Null   33097

>rf
RF = 41931448,150034432 --- Rec space used (bytes), free (bytes)

>rs
RS = 040,144 ------------- REC SPACE USED (MB), FREE (MB)

>rr
Recorder Directory:
Volume serial number for device #0 is 1633-17f2

  No files found.

  Bytes used on device #0 = 0
Volume serial number for device #1 is 3357-0de5
```

(continues on next page)

(continued from previous page)

```
  WHOTS000 000          327990 09-21-18   0:22:46a r  a [    2]
  WHOTS001 000        41603458 10-10-19   4:11:08a r  a [  163]

  Bytes used on device #1 = 41931448
Total capacity   =  191969280 bytes
Total bytes used =   41931448 bytes in 2 files
Total bytes free =  150034432 bytes

>RE ErAsE  erasing...
Recorder erased.

>rs
RS = 000,184 ------------- REC SPACE USED (MB), FREE (MB)

>rr
Recorder Directory:
Volume serial number for device #0 is 1633-17f2

  No files found.

  Bytes used on device #0 = 0
Volume serial number for device #1 is 3357-0de5

  No files found.

  Bytes used on device #1 = 0
Total capacity   =  191969280 bytes
Total bytes used =          0 bytes in 0 files
Total bytes free =  191969280 bytes

>rnwhot17
>cf1101  ERR:  Bad command parameters!
>cf1101  ERR:  Bad command parameters!
>cf11101
>eb00934
>ed1250
>es35
>ex11111
>wa70
>wb0
>wd111100000
>wwf176
>wn30
>wp40
>ws0400
>wv175
>te00:10:00.00
>tp00:04:00
>tg2021/08/25,0607:07:00ERR:  TF date/time is in the past!
  ERR:  Bad command parameters!Out of range!
>tt?
TT 2021/08/25,08:03:55 - Time Set (CCYY/MM/DD,hh:mm:ss)
>TT 20241/08/25 06:,06:04:42
>tt?
TT 2021/08/25,06:04:44 - Time Set (CCYY/MM/DD,hh:mm:ss)
>tg2021/08/25,06:07:00
```

(continues on next page)

(continued from previous page)

```
>ck
[Parameters saved as USER defaults]
>deploy
Deployment Commands:
CF = 11101 --------------- Flow Ctrl (EnsCyc;PngCyc;Binry;Set;Rec)
CK ----------------------- Keep Parameters as USER Defaults
CR # --------------------- Retrieve Parameters (0 = USER, 1 = FACTORY)
CS ----------------------- Start Deployment

EA = +00000 -------------- Heading Alignment (1/100 deg)
EB = +00934 -------------- Heading Bias (1/100 deg)
ED = 01250 --------------- Transducer Depth (0 - 65535 dm)
ES = 35 ------------------ Salinity (0-40 pp thousand)
EX = 11111 --------------- Coord Transform (Xform: Type,Tilts,3 Bm,Map)
EZ = 1111101 ------------- Sensor Source (C,D,H,P,R,S,T)

RE ----------------------- Recorder ErAsE
RN ----------------------- Set Deployment Name

TE = 00:10:00.00 --------- Time per Ensemble (hrs:min:sec.sec/100)
TF = 21/08/25,06:07:00 --- Time of First Ping (yr/mon/day,hour:min:sec)
TP = 00:04.00 ------------ Time per Ping (min:sec.sec/100)
TS = 21/08/25,06:05:11 --- Time Set (yr/mon/day,hour:min:sec)

WD = 111 100 000 --------- Data Out (Vel,Cor,Amp; PG,St,P0; P1,P2,P3)
WF = 0176 ---------------- Blank After Transmit (cm)
Press any key to continue

WN = 030 ----------------- Number of depth cells (1-128)
WP = 00040 --------------- Pings per Ensemble (0-16384)
WS = 0400 ---------------- Depth Cell Size (cm)
WV = 175 ----------------- Mode 1 Ambiguity Vel (cm/s radial)

>csd
```

7.2 WHOTS-17 600 kHz - Serial 13917

```
TT 2021/08/25,05:59:17 - Time Set (CCYY/MM/DD,hh:mm:ss)
>TT 2021/08/25,05:37:450
>tt?
TT 2021/08/25,05:37:44 - Time Set (CCYY/MM/DD,hh:mm:ss)
>ps0
  Instrument S/N:  13917
       Frequency:  614400 HZ
   Configuration:  4 BEAM, JANUS
     Match Layer:  10
      Beam Angle:  20 DEGREES
    Beam Pattern:  CONVEX
     Orientation:  UP
       Sensor(s):  HEADING  TILT 1  TILT 2  TEMPERATURE
Temp Sens Offset:  -0.03 degrees C

    CPU Firmware:  50.40 [0]
   Boot Code Ver:  Required:  1.16   Actual:  1.16
```

(continues on next page)

(continued from previous page)

```
    DEMOD #1 Ver:  ad48, Type:  1f
    DEMOD #2 Ver:  ad48, Type:  1f
    PWRTIMG  Ver:  85d3, Type:   6

Board Serial Number Data:
   A7  00 00 06 07 BD C0  09 PIO727-3000-00G
   D3  00 00 06 07 CC 88  09 CPU727-2000-00M
   8A  00 00 05 88 E4 75  09 REC727-1000-03E
   69  00 00 06 07 C9 BF  09 DSP727-2001-03H
>ps3
Beam Width:   3.7 degrees

Beam     Elevation     Azimuth
  1         -70.00      270.00
  2         -70.00       90.00
  3         -70.00        0.01
  4         -70.00      180.00

Beam Directional Matrix (Down):
  0.3420    0.0000    0.9397    0.2419
 -0.3420    0.0000    0.9397    0.2419
  0.0000   -0.3420    0.9397   -0.2419
  0.0000    0.3420    0.9397   -0.2419

Instrument Transformation Matrix (Down):    Q14:
  1.4619   -1.4619    0.0000    0.0000       23952  -23952       0       0
  0.0000    0.0000   -1.4619    1.4619           0       0  -23952   23952
  0.2661    0.2661    0.2661    0.2661        4359    4359    4359    4359
  1.0337    1.0337   -1.0337   -1.0337       16936   16936  -16936  -16936
Beam Angle Corrections Are Loaded.
>pa

PRE-DEPLOYMENT TESTS

CPU TESTS:
  RTC......................................PASS
  RAM......................................PASS
  ROM......................................PASS
RECORDER TESTS:
  PC Card #0...............................DETECTED
    Card Detect............................PASS
    Communication..........................PASS
    DOS Structure..........................PASS
    Sector Test (short)....................PASS
  PC Card #1...............................NOT DETECTED
DSP TESTS:
  Timing RAM...............................PASS
  Demod  RAM...............................PASS
  Demod  REG...............................PASS
  FIFOs....................................PASS
SYSTEM TESTS:
  XILINX Interrupts... IRQ3  IRQ3  IRQ3 ...PASS
  Wide Bandwidth...........................PASS
  Narrow Bandwidth.........................PASS
  RSSI Filter..............................PASS
  Transmit.................................PASS
```

(continues on next page)

(continued from previous page)

```
SENSOR TESTS:
  H/W Operation.........................***FAIL***
>pc1


BEAM CONTINUITY TEST

When prompted to do so, vigorously rub the selected
beam's face.

If a beam does not PASS the test, send any character to
the ADCP to automatically select the next beam.

Collecting Statistical Data...
  50  44  52  46
  50  44  52  46
  50  44  52  46
  50  44  51  46
  49  44  51  46
  49  44  51  46
  49  44  51  46
  49  44  51  46
  49  44  51  46
  49  44  51  46
  49  44  51  46
  49  44  51  46
  49  44  51  46
  49  44  51  46
  49  44  51  46
  49  44  51  46
  49  44  51  46
  49  44  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
```

(continues on next page)

(continued from previous page)

```
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46
  50  43  51  46

Rub Beam 1 = FAIL
Rub Beam 2 = FAIL
Rub Beam 3 = FAIL
Rub Beam 4 = FAIL

>psc1


BEAM CONTINUITY TEST

When prompted to do so, vigorously rub the selected
beam's face.

If a beam does not PASS the test, send any character to
the ADCP to automatically select the next beam.

Collecting Statistical Data...
  50  44  51  46
  50  44  51  46
  50  44  52  46
  50  44  52  46
  50  44  52  46
  50  44  52  46
  50  44  52  46
  50  44  52  46
  50  44  52  45
  50  44  52  45
  50  44  52  45
  50  44  52  45
  50  44  52  45
  50  43  52  45
  50  43  52  45
```

(continues on next page)

(continued from previous page)

```
  50  43  52  45
  50  43  52  45
  50  43  52  45
  50  43  52  45
  50  43  52  45
  50  43  52  45
  50  43  52  45
  50  43  52  45
  50  43  51  45
  50  43  52  46
  50  43  52  46
  50  43  52  46
  50  43  52  46
  50  43  52  46
  50  43  52  46
  50  44  52  46
  50  44  52  46
  50  44  52  46
  50  44  52  46
  50  44  52  46
  50  44  51  46
  50  44  51  46
  50  44  51  46
  50  44  51  46
  50  44  51  46
  50  44  51  46
  50  44  51  46
  50  44  51  46
  50  44  51  46
  50  44  51  46
  50  44  51  46
  50  44  51  46
  50  44  51  46
  50  44  51  46
  50  44  51  46
  50  44  51  46
  50  44  51  46
  50  44  51  46
  50  44  51  46
  50  44  51  46
  50  44  51  46
  50  44  51  46
  50  44  52  46
  50  44  51  46
  50  44  52  46
  50  44  51  46
  50  44  51  46
  50  44  51  46
  50  44  51  46

Rub Beam 1 = PASS
Rub Beam 2 = PASS
Rub Beam 3 = PASS
Rub Beam 4 = PASS
```

(continues on next page)

(continued from previous page)

```
>ac

              ACTIVE FLUXGATE CALIBRATION MATRICES in NVRAM
               Calibration date and time: 8/3/1921  23:24:47
                             S inverse

     Bx      4.5806e-01  4.4931e-01  2.9609e-02 -2.3866e-02
     By     -1.0455e-02 -2.6395e-03 -3.4537e-03 -5.5286e-01
     Bz      2.1380e-01 -2.0241e-01  3.4100e-01 -2.4381e-02
     Err    -4.7694e-01  4.4911e-01  5.6584e-01  3.3404e-03

                             Coil Offset
                            3.3761e+04
                            3.5130e+04
                            3.3647e+04
                            3.4559e+04

                             Electrical Null
                               34227
                    TILT CALIBRATION MATRICES in NVRAM
                Calibration date and time: 2/23/2010  12:26:45
              Average Temperature During Calibration was   24.9C
                   Up                             Down
 Roll      1.0130e-07  -1.5996e-05        -1.6233e-07   1.5691e-05
 Pitch    -1.6182e-05  -2.1434e-07        -1.5455e-05  -3.5425e-07
 Offset    3.1739e+04   3.0585e+04         3.1782e+04   3.2916e+04
                      Null    33506
>rf
RF = 4200920,251363328 ---- Rec space used (bytes), free (bytes)

>rs
RS = 005,239 ------------- REC SPACE USED (MB), FREE (MB)

>rb
RECORDER TESTS:
  PC Card #0..............................DETECTED
    Card Detect...........................PASS
    Communication.........................PASS
    DOS Structure.........................PASS
    Sector Test (Short)...................PASS
  PC Card #1..............................NOT DETECTED

Recorder tests complete.

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

Recorder not erased.

>RE ErAsE  erasing...
Recorder erased.

>rs
RS = 000,244 ------------- REC SPACE USED (MB), FREE (MB)

>rmwhots
```

(continues on next page)

(continued from previous page)

```
>tr
>rnwhots17
>cf11101
>eb934
>ed047
>es35
>ex11111
>ez1111101
>wa70
>wb0
>wf088
>wn25
>wp80
>ws0200
>wv175
>te00:10:00.00
>tp00:02.00
>tg201821/08/25,05:50:-00
>ck
[Parameters saved as USER defaults]
>deploy
Deployment Commands:
CF = 11101 --------------- Flow Ctrl (EnsCyc;PngCyc;Binry;Set;Rec)
CK ----------------------- Keep Parameters as USER Defaults
CR # --------------------- Retrieve Parameters (0 = USER, 1 = FACTORY)
CS ----------------------- Start Deployment

EA = +00000 -------------- Heading Alignment (1/100 deg)
EB = +00934 -------------- Heading Bias (1/100 deg)
ED = 00047 --------------- Transducer Depth (0 - 65535 dm)
ES = 35 ------------------ Salinity (0-40 pp thousand)
EX = 11111 --------------- Coord Transform (Xform: Type,Tilts,3 Bm,Map)
EZ = 1111101 ------------- Sensor Source (C,D,H,P,R,S,T)

RE ----------------------- Recorder ErAsE
RN ----------------------- Set Deployment Name

TE = 00:10:00.00 --------- Time per Ensemble (hrs:min:sec.sec/100)
TF = 21/08/25,05:50:00 --- Time of First Ping (yr/mon/day,hour:min:sec)
TP = 00:02.00 ------------ Time per Ping (min:sec.sec/100)
TS = 21/08/25,05:47:42 --- Time Set (yr/mon/day,hour:min:sec)

WD = 111 100 000 --------- Data Out (Vel,Cor,Amp; PG,St,P0; P1,P2,P3)
WF = 0088 ---------------- Blank After Transmit (cm)
Press any key to continue

WN = 025 ----------------- Number of depth cells (1-128)
WP = 00080 --------------- Pings per Ensemble (0-16384)
WS = 0200 ---------------- Depth Cell Size (cm)
WV = 175 ----------------- Mode 1 Ambiguity Vel (cm/s radial)

>cs
```

References

Albert J. Plueddemann, Robert A. Weller, Roger Lukas, Jeffrey Lord, Paul R. Bouchard, and M. Alexander Walsh. Whoi hawaii ocean timeseries station (whots) : whots-2 mooring turnaround cruise report. Technical Report, Woods Hole Oceanographic Institution, 2006. URL: https://hdl.handle.net/1912/1074, doi:10.1575/1912/1074.

Sean P. Whelan, Robert A. Weller, Roger Lukas, Frank Bradley, Jeffrey Lord, Jason C. Smith, Frank B. Bahr, Paul Lethaby, and Jeffrey Snyder. Whoi hawaii ocean timeseries station (whots) : whots-3 mooring turnaround cruise report. Technical Report, Woods Hole Oceanographic Institution, 2007. URL: https://hdl.handle.net/1912/1825, doi:10.1575/1912/1825.

Sean P. Whelan, Albert J. Plueddemann, Roger Lukas, Jeffrey Lord, Paul Lethaby, Jason C. Smith, Frank B. Bahr, Nancy R. Galbraith, and Christopher L. Sabine. Whoi hawaii ocean timeseries station (whots): whots-4 2007 mooring turnaround cruise report. Technical Report, Woods Hole Oceanographic Institution, 1 2008. doi:https://doi.org/10.1575/1912/2504.

Sean P. Whelan, Fernando Santiago-Mandujano, Frank Bradley, Albert J. Plueddemann, Ludovic Barista, James R. Ryder, Roger Lukas, Paul Lethaby, Jefrey Snyder, Christopher L. Sabine, Diane Stanitski, Anita D. Rapp, Christopher W. Fairall, Sergio Pezoa, Nancy R. Galbraith, Jeffrey Lord, and Frank B. Bahr. Whoi hawaii ocean timeseries station (whots): whots-6 2009 mooring turnaround cruise report. Technical Report, Woods Hole Oceanographic Institution, 2 2010. doi:https://doi.org/10.1575/1912/3458.

Fernando Santiago-Mandujano, Jefrey Snyder, Svetlana Natarov, Kelsey Maloney, Noah Howins, Garrett Hebert, and Roger Lukas. Uh contributions to whots-15 cruise report. Technical Report, School of Ocean and Earth Science and Technology; University of Hawaii, 2019. URL: http://www.soest.hawaii.edu/whots/proc_reports/WHOTS-15_CruiseRpt.pdf.

Emerson Hasbrouck, Robert Weller, Fernando Santiago-Mandujano, Byron Blomquist, Kelsey Maloney, Jefrey Snyder, Abby Clabaugh, Samantha Adams, Kellen Rosburg, Andrew King, Svetlana Natarov, Noah Howins, Garrett Hebert, and Roger Lukas. Whoi hawaii ocean timeseries station (whots) : whots-14 2017 mooring turnaround cruise report. Technical Report, Woods Hole Oceanographic Institution, 1 2019. doi:10.1575/1912/25262.

Fernando Santiago-Mandujano, Dan Fitzgerald, Kelsey Maloney, Tully Rohrer, Noah Howins, Ryan Tabata, and James Potemra. Uh contributions to whots-16 cruise report. Technical Report, School of Ocean and Earth Science and Technology, University of Hawaii, 2021. URL: https://www.soest.hawaii.edu/whots/proc_reports/UH_Contributions_to_WHOTS16_Cruise_Report.pdf.

Fernando Santiago-Mandujano, Dan Fitzgerald, Kelsey Maloney, Tully Rohrer, Noah Howins, Ryan Tabata, and James Potemra. Uh contributions to whots-17 cruise report. Technical Report, School of Ocean and Earth Science and Technology, University of Hawaii, 2022. URL: http://www.soest.hawaii.edu/whots/proc_reports/UH%20Contributions%20to%20WHOTS17_Cruise_Report.pdf.

Fernando Santiago-Mandujano, Fernando Carvalho Pacheco, Dan Fitzgerald, Kelsey Maloney, Tully Rohrer, James Harris III, Noah Howins, and James Potemra. Uh contributions to whots-18 cruise report. Technical Report, School of Ocean and Earth Science and Technology, University of Hawaii, 2022. URL: http://www.soest.hawaii.edu/whots/proc_reports/WHOTS18_Cruise_Report.pdf.

David S. Hosom, Robert A. Weller, Richard E. Payne, and Kenneth E. Prada. The imet (improved meteorology) ship and buoy systems. *Journal of Atmospheric and Oceanic Technology*, 12:527–540, 6 1995. doi:10.1175/1520-0426(1995)012<0527:timsab>2.0.co;2.

Keir Colbo and Robert A. Weller. Accuracy of the imet sensor package in the subtropics. *Journal of Atmospheric and Oceanic Technology*, 26:1867–1890, 9 2009. doi:10.1175/2009JTECHO667.1.

A. Birol Kara, Peter A. Rochford, and Harley E. Hurlburt. Mixed layer depth variability and barrier layer formation over the north pacific ocean. *Journal of Geophysical Research: Oceans*, 105:16783–16801, 7 2000. doi:10.1029/2000jc900071.

Fernando Santiago-Mandujano, Paul Lethaby, Roger Lukas, Jefrey Snyder, Robert A. Weller, Albert J. Plueddemann, Jeffrey Lord, Sean Whelan, Paul Bouchard, and Nan Galbraith. Hydrographic observations at the woods hole oceanographic institution (whoi) hawaii ocean timeseries (hot) site (whots): 2004-2006. Technical Report, School of Ocean and Earth Science and Technology, University of Hawaii, 2007. URL: http://uop.whoi.edu/currentprojects/WHOTS/docs/UH_Whots_data_report_1.pdf.

Luis Tupas, Fernando Santiago-Mandujano, Dale Hebel, Roger Lukas, David Karl, and Eric Firing. Hawaii ocean time-series data report 4, 1992. Technical Report, School of Ocean and Earth Science and Technology, University of Hawaii, 1993. URL: https://hahana.soest.hawaii.edu/hot/reports/rep_y4.pdf.

Lance Fukieki, Fernando Santiago-Mandujano, Fernando Carvalho Pacheco, James Potemra, and Angelicque

White. Hawaii ocean time-series data report 32: 2020. Technical Report, School of Ocean and Earth Science and Technology Publication #11612, 2023. URL: https://hahana.soest.hawaii.edu/hot/reports/rep_y32.pdf.

W. Brechner Owens and Robert C. Millard. A new algorithm for ctd oxygen calibration. *Journal of Physical Oceanography*, 15(5):621 – 631, 1985. URL: https://journals.ametsoc.org/view/journals/phoc/15/5/1520-0485_1985_015_0621_anafco_2_0_co_2.xml, doi:10.1175/1520-0485(1985)015<0621:ANAFCO>2.0.CO;2.

Luis Tupas, Fernando Santiago-Mandujando, Dale Hebel, Craig Nosse, Lance Fujieki, Eric Firing, Roger Lukas, David Karl, Christopher Win, Robert Bidigare, Michael Landry, and Mai Lopez. Hawaii ocean time-series data report 8, 1996. Technical Report, School of Ocean and Earth Science and Technology, University of Hawaii, 1996. URL: https://hahana.soest.hawaii.edu/hot/reports/rep_y8.pdf.

Howard Paul Freitag, M E McCarty, Craig Nosse, Roger Lukas, Michael J. McPhaden, and Meghan F. Cronin. Coare seacat data: calibrations and quality control procedures. *NOAA Technical Memorandum ERL PMEL-115*, pages 1–89, 1999. URL: https://repository.library.noaa.gov/view/noaa/10999.

Eric Firing. Acoustic doppler current profiling measurements and navigation. *WOCE Hydrographic Operations and Methods. WOCE Operations Manual, WHP Office Report WHPO 91-1, WOCE Report No. 68/91*, pages 1–24, 1991. URL: https://www.nodc.noaa.gov/archive/arc0013/0001873/1.1/data/1-data/publications/WOCE/ADCP.pdf.

Teledyne RD Instruments. *Acoustic Doppler Current Profiler Principles of Operation A Practical Primer*. 1 2011. URL: http://www.teledynemarine.com/Documents/Brand%20Support/RD%20INSTRUMENTS/Technical%20Resources/Manuals%20and%20Guides/General%20Interest/BBPRIME.pdf.

Roger Lukas, Fernando Santiago-Mandujano, Frederick Bingham, and Arnold Mantyla. Cold bottom water events observed in the hawaii ocean time-series: implications for vertical mixing. *Deep Sea Research Part I: Oceanographic Research Papers*, 48:995–1021, 2001. URL: https://www.sciencedirect.com/science/article/pii/S0967063700000789, doi:https://doi.org/10.1016/S0967-0637(00)00078-9.

Bruce M Howe, Roger Lukas, Fred Duennebier, and David Karl. Aloha cabled observatory installation. In *OCEANS'11 MTS/IEEE KONA*, 1–11. Waikoloa, HI, USA, 2011. IEEE. doi:10.23919/OCEANS.2011.6107301.