

UH contributions to WHOTS-6 cruise report

by

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During the WHOTS-6 cruise, Station ALOHA was under the influence of the eastern North Pacific high pressure system, and subject to moderate easterly trade winds (Figure 1). An upper level trough extended from the northeast of ALOHA towards the southwest, slightly destabilizing the lower atmosphere. This resulted in somewhat greater vertical development of trade wind cumulus, and occasional light rainfalls.

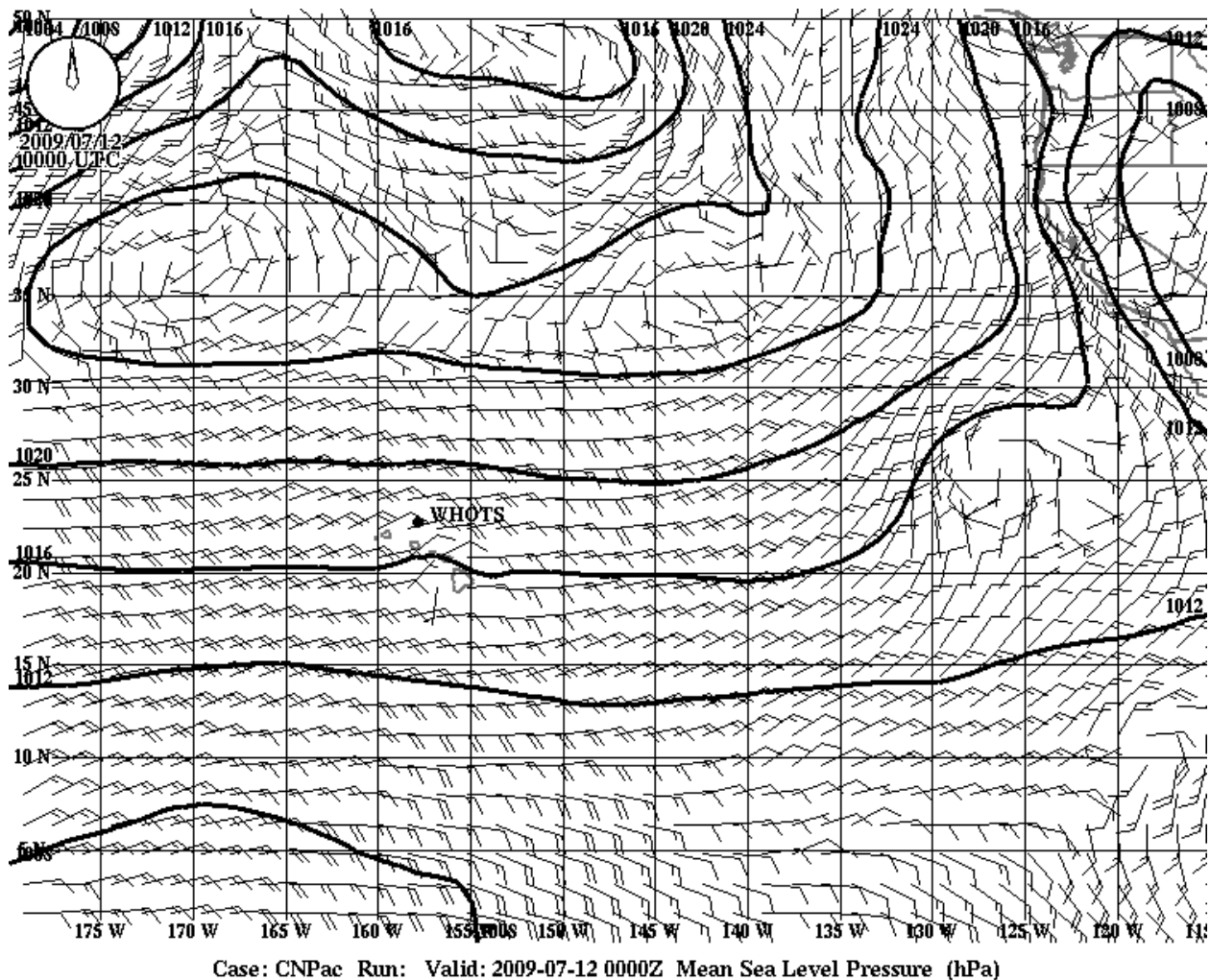


Figure 1. The NOAA/NCEP GFS surface wind and sea level pressure analysis for the central-eastern North Pacific, valid for 0Z on July 12, 2009.

The near surface (27 m) currents were eastward near Oahu (Figure 2). The Hawaiian Ridge Current was evident, with north-northwestward flow between Oahu and ALOHA. At Station ALOHA, the currents veered from northwest to northeast, as an anticyclonic eddy to the east of ALOHA drifted westward (Figure 3). The currents were also influenced by M2 internal tides and by inertial waves (Figure 4).

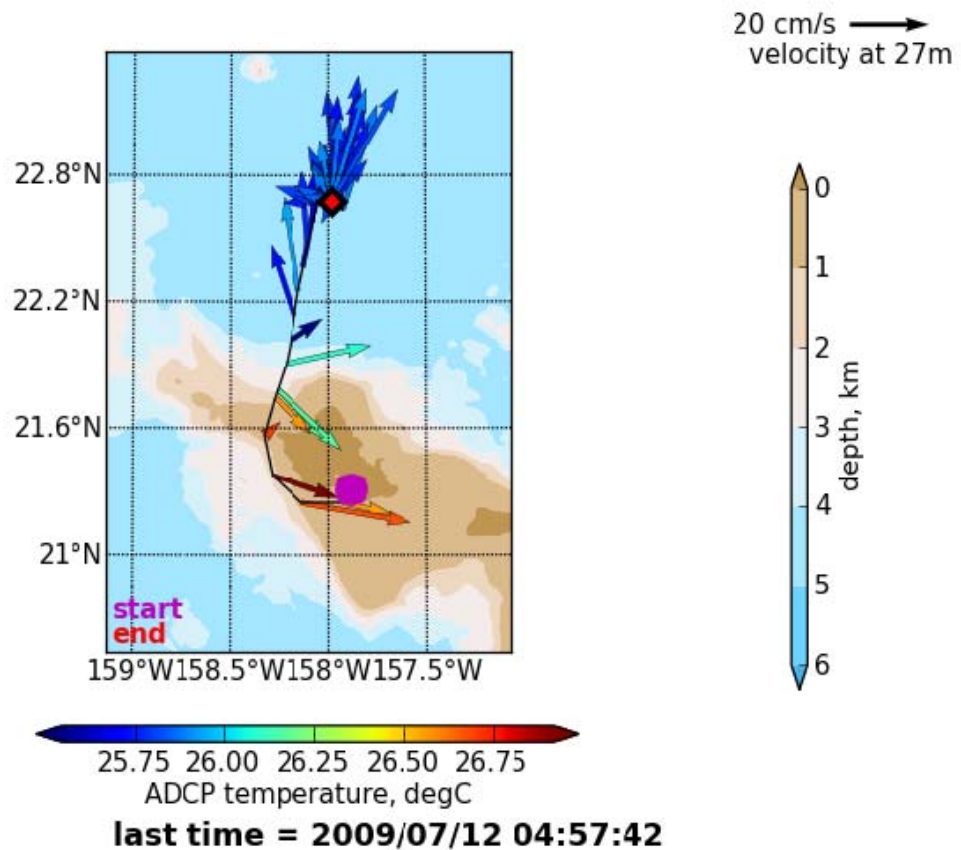


Figure 2. Shipboard 300 kHz ADCP currents from July 9-12, 2009 at a depth of 27 m. The currents at Station ALOHA veered from northwestward to northeastward over the 3 days on station.

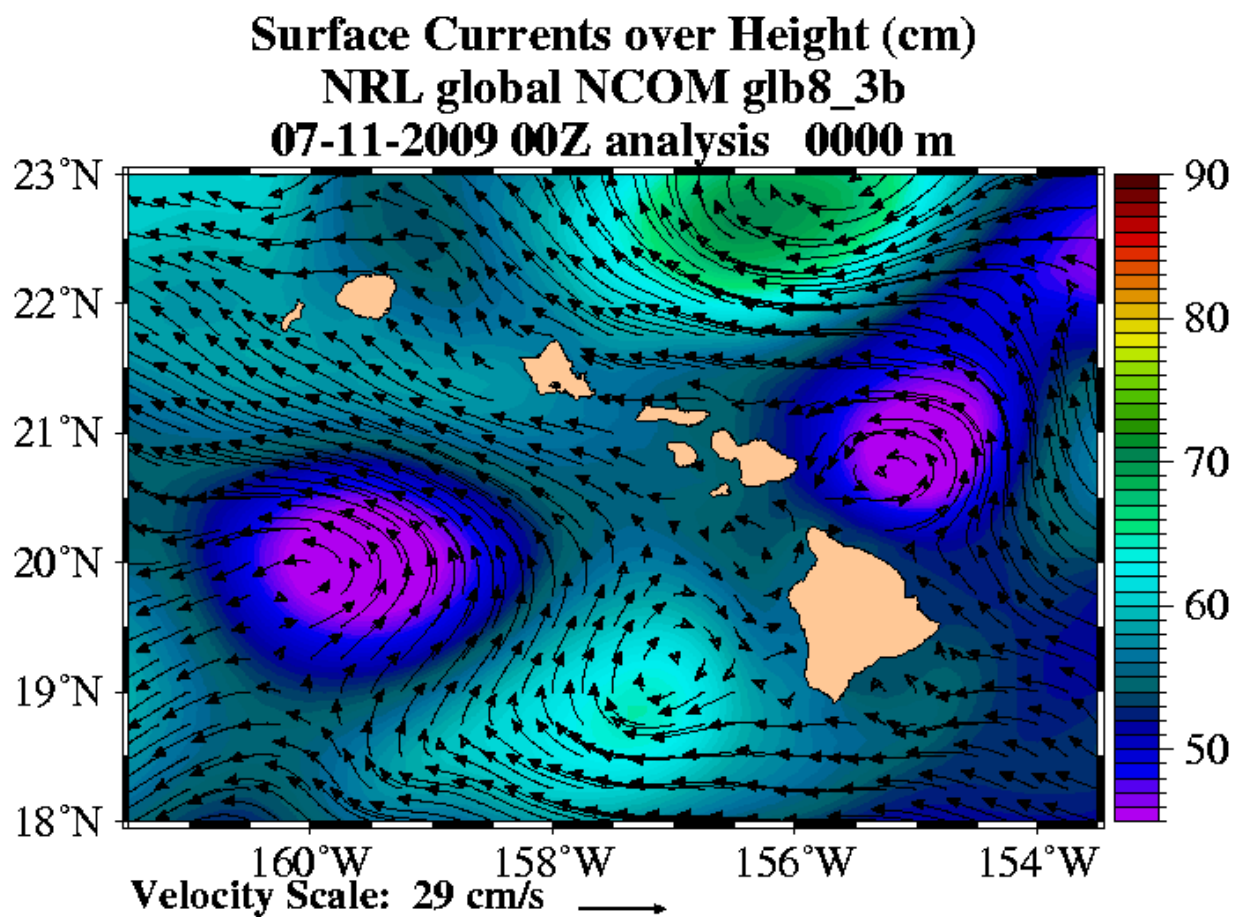


Figure 3. Surface currents (vectors) overlaid on sea surface height anomaly (colors) from the Naval Oceanographic Office NCOM analysis for 0Z on July 11, 2009..

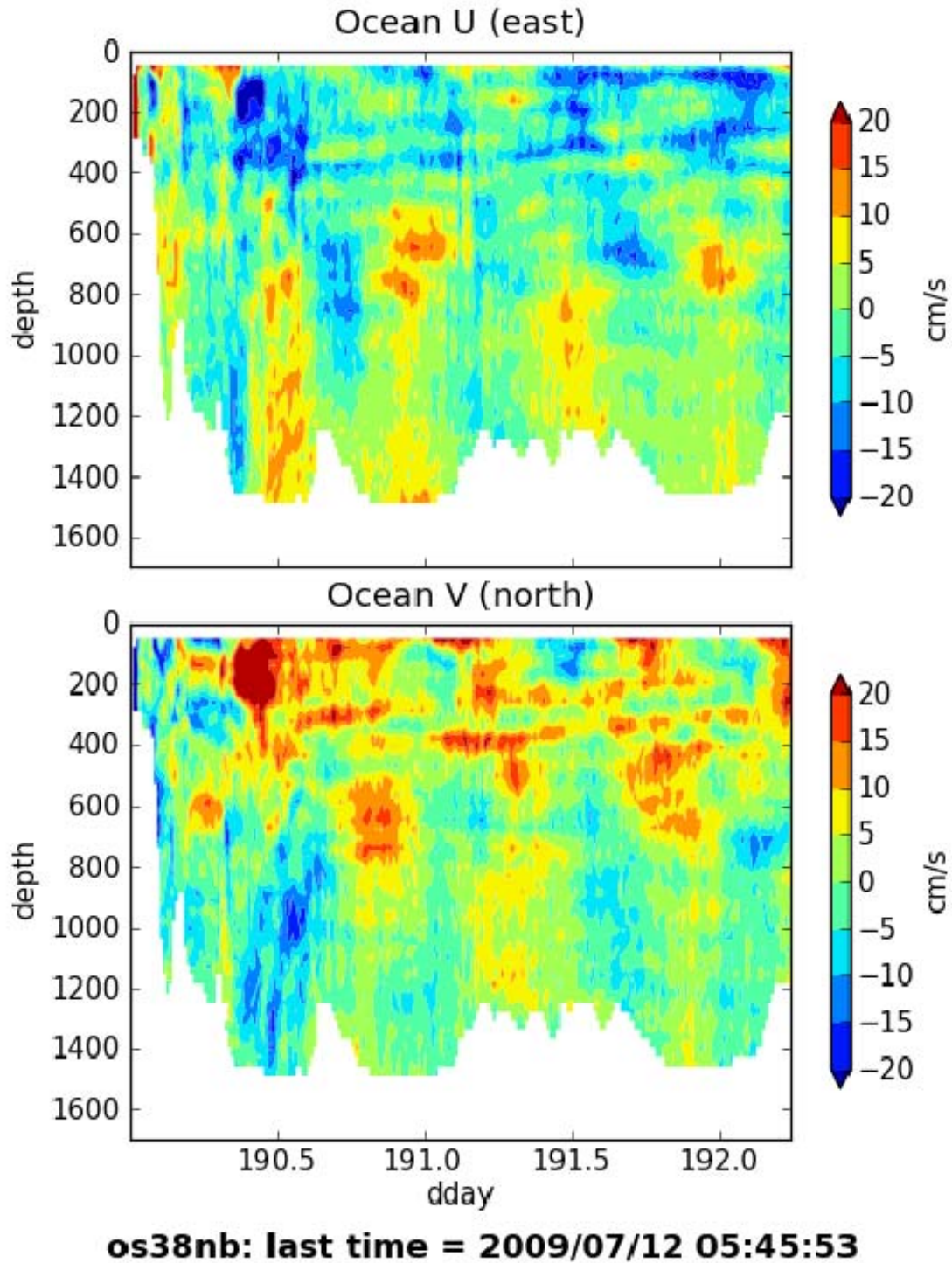


Figure 4. Shipboard 38 kHz ADCP currents from July 9-12, 2009 as a function of depth and time. Inertial waves can be seen as upward trending, but nearly horizontal, maxima and minima in the velocity components. The M2 internal tides can be seen as the nearly vertically aligned maxima and minima in the velocity components.

The primary contributions by the UH group to the WHOTS-6 cruise were preparing, handling, and managing data from most of the subsurface instrumentation on the WHOTS moorings, and conducting CTD profiling and water sampling, including salinity sampling for thermosalinograph calibration. UH personnel also participated in the mooring recovery and deployment deck operations.

A. WHOTS mooring subsurface instrumentation

1. WHOTS-6 deployment

UH provided 15 SBE-37 Microcats, an RDI 300 kHz Workhorse acoustic Doppler current profiler (ADCP), and a Nobska MAVS acoustic velocity sensor. The Microcats all measure temperature and conductivity, with 5 also measuring pressure. WHOI provided 2 Vector Measuring Current Meters (VMCM), an RDI 600 kHz Workhorse ADCP, and all required subsurface mooring hardware. Table 1 provides deployment information for the C-T instrumentation on the WHOTS-6 mooring.

Table 1. WHOTS-6 mooring subsurface instrument deployment information. All times are in GMT.

Depth (meters)	Seabird Model/Serial #	Variables	Sample Interval (seconds)	Navg	Time Logging Started	Cold Spike Time	Time in the water
15	37SM31486-6893	C, T	90	1	07/6/09 00:00:00	07/06/09 00:51:00	07/10/09 18:35
25	37SM31486-6894	C, T	90	1	07/6/09 00:00:00	07/06/09 00:51:00	07/10/09 18:30
35	37SM31486-6895	C, T	90	1	07/6/09 00:00:00	07/06/09 00:51:00	07/10/09 18:24
40	37SM31486-6896	C, T	90	1	07/6/09 00:00:00	07/06/09 00:51:00	07/10/09 18:19
45	37SM31486-6887	C, T, P	90	1	07/6/09 00:00:00	07/06/09 01:41:00	07/10/09 18:17
50	37SM31486-6897	C, T	90	1	07/6/09 00:00:00	07/06/09 00:51:00	07/10/09 19:49
55	37SM31486-6898	C, T	90	1	07/6/09 00:00:00	07/06/09 00:51:00	07/10/09 19:53
65	37SM31486-6899	C, T	90	1	07/6/09 00:00:00	07/06/09 00:51:00	07/10/09 19:59
75	37SM31486-3618	C, T	150	2	07/6/09 00:00:00	07/06/09 00:51:00	07/10/09 20:03
85	37SM31486-6888	C, T, P	90	1	07/6/09 00:00:00	07/06/09 01:41:00	07/10/09 20:06
95	37SM31486-3617	C, T	150	2	07/6/09 00:00:00	07/06/09 00:51:00	07/10/09 20:09
105	37SM31486-6889	C, T, P	90	1	07/6/09 00:00:00	07/06/09 00:51:00	07/10/09 20:12
120	37SM31486-6890	C, T, P	90	1	07/6/09 00:00:00	07/06/09 00:51:00	07/10/09 20:16
135	37SM31486-3634	C, T	150	2	07/6/09 00:00:00	07/06/09 00:51:00	07/10/09 20:23
155	37SM31486-	C, T, P	90	1	07/6/09	07/06/09	07/10/09

6891				00:00:00	00:51:00	20:27
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The WHOTS-6 VMCM configuration and deployment information is provided in Table XXX [Sean]?

The ADCPs were deployed in the upward-looking configuration. The instruments were programmed as described in Table 2. The configuration of the MAVS is also included in Table 2.

Table 2. WHOTS-6 mooring ADCP and MAVS deployment information.

	ADCP S/N 4891	ADCP S/N 1825	MAVS S/N 10260
Frequency (kHz)	300	600	NA
Number of Depth Cells	30	25	1
Pings per Ensemble	40	80	80
Depth Cell Size	4 m	2 m	NA
Time per Ensemble	10 min	10 min	30 min
Time per Ping	4 sec	2 sec	2 sec
Time of First Ping	07/08/09, 00:00	07/10/09, 00:00	07/09/09, 00:00
Time in water	07/10/09, 20:19	07/10/09, 19:48	07/10/09, 18:31
Depth (meters)	125	47.5	20

2. WHOTS-5 recovery

For the fifth WHOTS mooring deployment that took place on 4 June 2008, UH provided 6 SBE-37 Microcats, 9 SBE-16 Seacats, an RDI 300 kHz Workhorse ADCP, and a 1.2 MHz RDI Workhorse ADCP. WHOI provided 2 VMCMs, and all required subsurface mooring hardware via a subcontract with UH. The Microcats and Seacats measured temperature and conductivity; four Microcats also measured pressure.

Table 3 provides the deployment information for each C-T instrument on the WHOTS-5 mooring.

Table 3. WHOTS-5 mooring Microcat deployment information. All times are GMT.

SN:	Instrument	Depth	Pressure SN	Sample Interval (sec)	Start Logging Data(GMT)	Ice Bath In (GMT)	Ice Bath Out (GMT)	Time in Water (GMT)
1099	Seacat	15	N/A	600	05/19/08 0:00:00	05/19/08 23:59:00	05/20/08 0:34:00	06/04/08 19:02:00
1085	Seacat	25	N/A	600	05/19/08 0:00:00	05/19/08 23:59:00	05/20/08 0:34:00	06/04/08 18:58:00
1087	Seacat	35	N/A	600	05/19/08 0:00:00	05/19/08 23:59:00	05/20/08 0:34:00	06/04/08 18:49:00
3381	Microcat	40	N/A	150	05/19/08 0:00:00	05/20/08 0:39:00	05/20/08 1:19:00	06/04/08 18:45:00
4663	Microcat	45	N/A	150	05/19/08 0:00:00	05/20/08 0:39:00	05/20/08 1:19:00	06/04/08 18:41:00
2530	1200 kHz ADCP	47.5	N/A	600	5/31/2008 0:00:00	N/A	N/A	06/04/08 18:41:00
1088	Seacat	50	N/A	600	05/19/08 0:00:00	05/19/08 23:59:00	05/20/08 0:34:00	06/04/08 18:36:00
1090	Seacat	55	N/A	600	05/19/08 0:00:00	05/19/08 23:59:00	05/20/08 0:34:00	06/04/08 20:04:00
1092	Seacat	65	N/A	600	05/19/08 0:00:00	05/20/08 0:39:00	05/20/08 1:19:00	06/04/08 20:09:00
1095	Seacat	75	N/A	600	05/19/08 0:00:00	05/19/08 23:59:00	05/20/08 0:34:00	06/04/08 20:13:00
4699	Microcat	85	10209	180	05/19/08 0:00:00	05/20/08 0:39:00	05/20/08 1:19:00	06/04/08 20:16:00
1097	Seacat	95	N/A	600	05/19/08 0:00:00	05/19/08 23:59:00	05/20/08 0:34:00	06/04/08 20:19:00
2769	Microcat	105	2949	180	05/19/08 0:00:00	05/20/08 0:39:00	05/20/08 1:19:00	06/04/08 20:24:00
4701	Microcat	120	10211	180	05/19/08 0:00:00	05/20/08 0:39:00	05/20/08 1:19:00	06/04/08 20:27:00
7637	300 kHz ADCP	125	N/A	600	5/31/2008 0:00:00	N/A	N/A	06/04/08 20:31:00
1100	Seacat	135	N/A	600	05/19/08 0:00:00	05/19/08 23:59:00	05/20/08 0:34:00	06/04/08 20:35:00
4700	Microcat	155	2479944	180	05/19/08 0:00:00	05/20/08 0:39:00	05/20/08 1:19:00	06/04/08 20:38:00

see Table 4 for details of sampling programs for these instruments

The WHOTS-5 VMCM configuration and deployment information is provided in Table YYY [Sean]?

Table 4 provides the ADCP deployment and recovery information.

Table 4. WHOTS-5 mooring ADCP deployment and recovery information.

	S/N 7637 300 kHz	S/N 2530 1200 kHz
Number of Depth Cells	30	17
Pings per Ensemble	40	120
Depth Cell Size	4 m	1 m
Time per Ensemble	10 min	10 min
Time per Ping	4 sec	2 sec
Time of First Ping	05/31/08, 00:00	05/31/08, 00:00
Time in water	06/04/08, 20:31	06/04/08, 18:41
Time out of water	07/15/09, 23:58	07/16/09, 00:36
Time of last ensemble	06/22/08, 07:50	07/16/09, 21:34
Number of ensembles	3,216	59,309
Depth (meters)	125 m	47.5 m

All instruments on the mooring were successfully recovered. Most of the instruments had some degree of biofouling, with the heaviest fouling near the surface (e.g. Fig. 6). Fouling extended down to the ADCP at 125 m, although it was minor at that level (Fig. 5).

Table 5 gives the post-deployment information for the C-T instruments. All instruments except Seacat SN 1097 returned full data records. The Seacat SN 1097 data record was almost

empty. The Seacat SN 1087 conductivity sensor suffered an offset in late November 2008, and the Seacat SN 1095 temperature sensor failed soon after deployment.

With the exceptions noted above, the data recovered from the C-T instruments appear to be of high quality, although post-deployment calibrations are required. Figures A1-A14 show the nominally calibrated temperature, conductivity and salinity records from each instrument, and pressure for those instruments that were equipped with pressure sensors.

Table 5. WHOTS-5 mooring Seacat and Microcat recovery information. All times are GMT.

Depth (meters)	Seabird Serial #	Time out of water	Time of Spike	Time Logging Stopped	Samples Logged	Data Quality	File Name raw data
15	Seacat 1099	7/16/2009 01:30	07/16/2009 05:08:00	07/16/2009 22:56:00	61,050	good	whots5_s_1099.hex
25	Seacat 1085	7/16/2009 01:39	07/16/2009 05:08:00	07/16/2009 09:43:00	60,971	good	whots5_s_1085.hex
35	Seacat 1087	7/16/2009 01:44	07/16/2009 05:08:00	07/16/2009 17:51:00	61,020	C offset in Nov '08	whots5_s_1087.hex
40	Microcat 3381	7/16/2009 01:47	07/16/2009 06:06:00	07/16/2009 09:46:00	233,016	good	whots5_m_3381.asc
45	Microcat 4663	7/16/2009 01:50	07/16/2009 06:06:00	07/16/09 23:07:00	233,016	good	whots5_m_4663.asc
50	Seacat 1088	7/16/2009 00:32	07/16/2009 05:08:00	07/16/2009 06:18:00	60,950	good	whots5_s_1088.hex
55	Seacat 1090	7/16/2009 00:28	07/16/2009 05:08:00	07/16/2009 09:52:00	60,972	good	whots5_s_1090.hex
65	Seacat 1092	7/16/2009 00:23	07/16/2009 06:06:00	07/16/2009 23:02:00	61,051	good	whots5_s_1092.hex
75	Seacat 1095	7/16/2009 00:20	07/16/2009 05:08:00	07/16/2009 06:12:00	60,950	Bad T	whots5_s_1095.hex
85	Microcat 4699	7/16/2009 00:13	07/16/2009 06:06:00	07/16/2009 09:20:00	190,650	good	whots5_p_4699.asc
95	Seacat 1097	7/16/2009 00:08	07/16/2009 05:08:00	07/16/2009 09:41:00	211	No in-water data	whots5_s_1097.hex
105	Microcat 2769	7/16/2009 00:05	07/16/2009 06:06:00	07/16/2009 09:15:00	190,650	good	whots5_p_2769.asc
120	Microcat 4701	7/16/2009 00:01	07/16/2009 06:06:00	07/16/2009 09:23:00	190,650	good	whots5_p_4701.asc
135	Seacat 1100	7/15/2009 23:53	07/16/2009 05:08:00	07/16/2009 17:56:00	61,020	good	whots5_s_1100.hex
155	Microcat 4700	7/15/2009 23:47	07/16/2009 06:06:00	07/16/2009 18:12:00	190,650	good	whots5_p_4700.asc

The WHOTS-5 VMCM recovery information is provided in Table ZZZ [Sean]?

Table 4 gives the post-deployment information for the ADCPs. The 300 kHz ADCP failed soon after deployment and returned a short data record. The 1200 kHz ADCP returned a full data record. The fouling on the 300 kHz ADCP transducer head at 125 m (Fig. 5) was minimal. The transducer faces for the 1200 kHz ADCP at 47.5 m were treated with an antifouling compound and consequently did not show any significant fouling (Fig. 6).

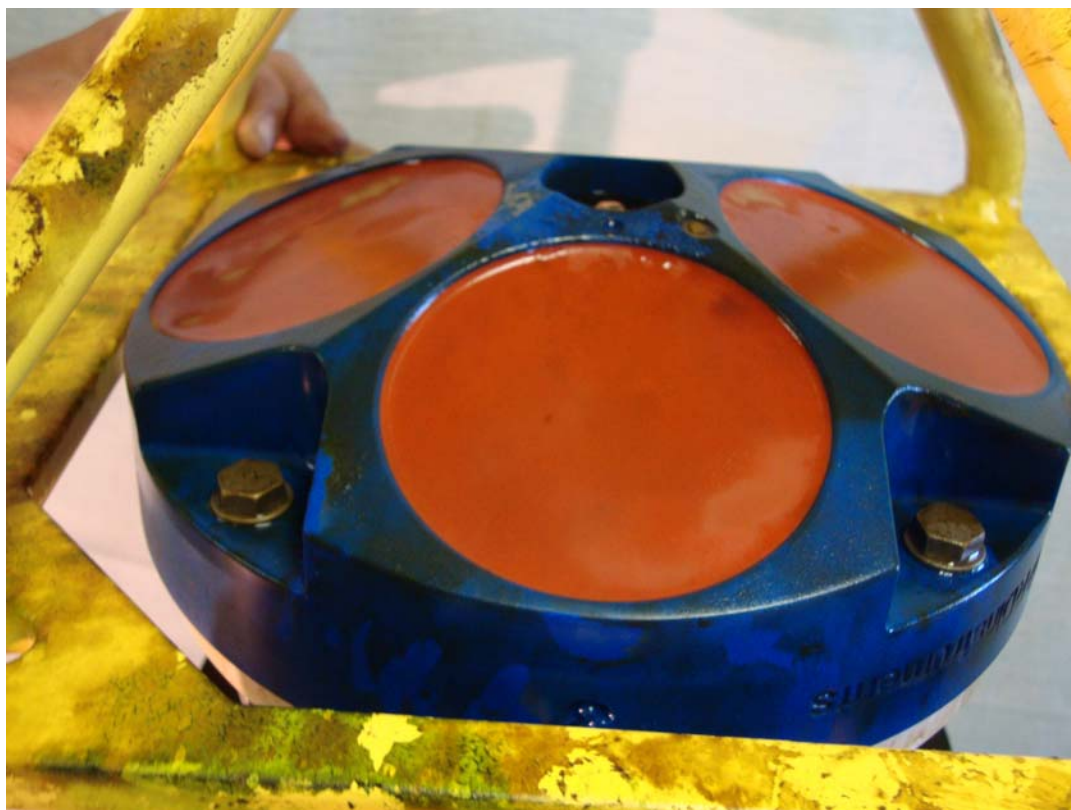


Figure 5. WHOTS-5 300 kHz ADCP deployed at 125 m, after recovery showing only minor fouling

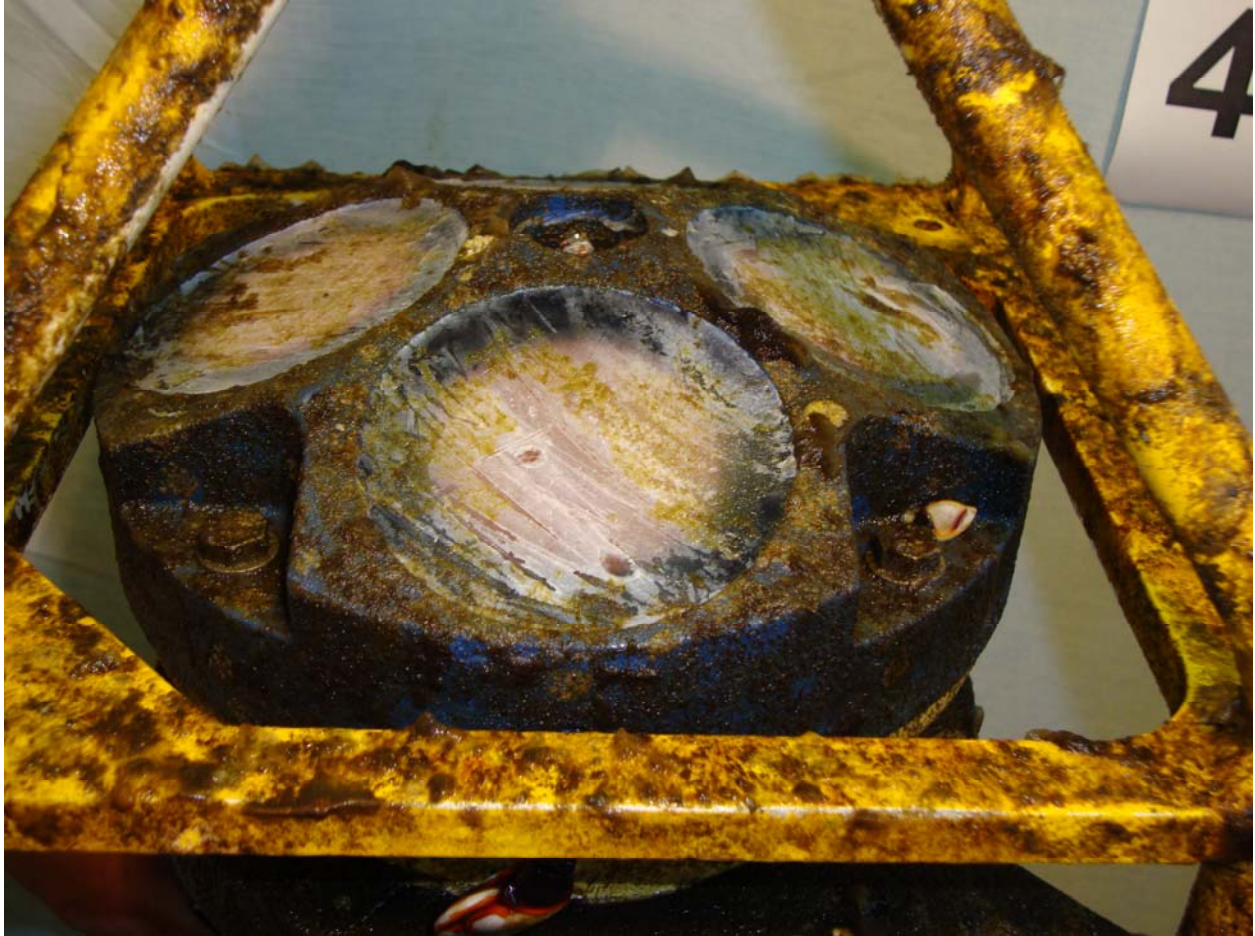


Figure 6. WHOTS-5 1200 kHz ADCP deployed at 47.5 m, after recovery.

The 300 kHz ADCP was not pinging when recovered. The external battery pressure case was disconnected and its voltage was found to measure zero. The external battery underwater housing end-cap was removed carefully and high internal pressure was evident as the housing released a large amount of gas when the O-ring seal was opened. There was no indication of water inside the pressure housing, and there were no dry salt crystals present. Both battery packs were severely corroded with brown liquid trails observed on the upper battery pack plastic wrapping. This brown liquid is most likely the electrolyte from the batteries cells, which consists of a concentrated aqueous solution of potassium hydroxide. The electrolyte eventually dripped down to the lower battery pack, shorting it where the power wire is connected to the battery pack. High temperatures were certainly experienced on both battery packs as severe charring was present. It is hypothesized that one or more cells in the upper battery pack failed, venting hydrogen gas which caused the leakage of electrolyte. This leakage started a chain event, destroying both batteries. It is uncertain why one or more of the cells failed, possibly from a poorly constructed cell, or a cell which started to discharge more rapidly than the others. A cell that is discharged below a safe cutoff voltage will also vent, resulting in electrolyte leakage. The University of Hawaii is working closely with RDI to try and determine the cause of the battery pack failure. The ADCP pressure case was subsequently opened and after finding no problems,

communication was established with the instrument. The internal clock was offset by 1 minute 4 seconds ahead of GMT. It appears that the ADCP functioned for approximately 22 days although it was actually deployed 6 days after logging was initiated. Data collected during this brief time indicate that there may be some other problems, as it appears that there are gaps in the data resulting from rejection by the ADCPs internal diagnostics in greater amounts than seen in previous deployments using the same instrument. Where data exists, the range of the ADCP is approximately 90 m from the transducer head which is normal for this instrument.

Figure 7 shows the heading, pitch and roll from the short record from this instrument. Pitch and roll are generally less than 5 degrees from the vertical, but there are some periods with deviations from the vertical of as much as 10 degrees. Figure 8 shows the variations of the horizontal and vertical components of velocity in depth and time. The acoustic returns from the upper 40 m of the water column are intermittent, due to very low levels of scattering material near the surface. Diurnal migration of plankton often allowed good data returns from near the surface at night, however. The high spurious speeds due to sideband reflections near the surface are apparent.

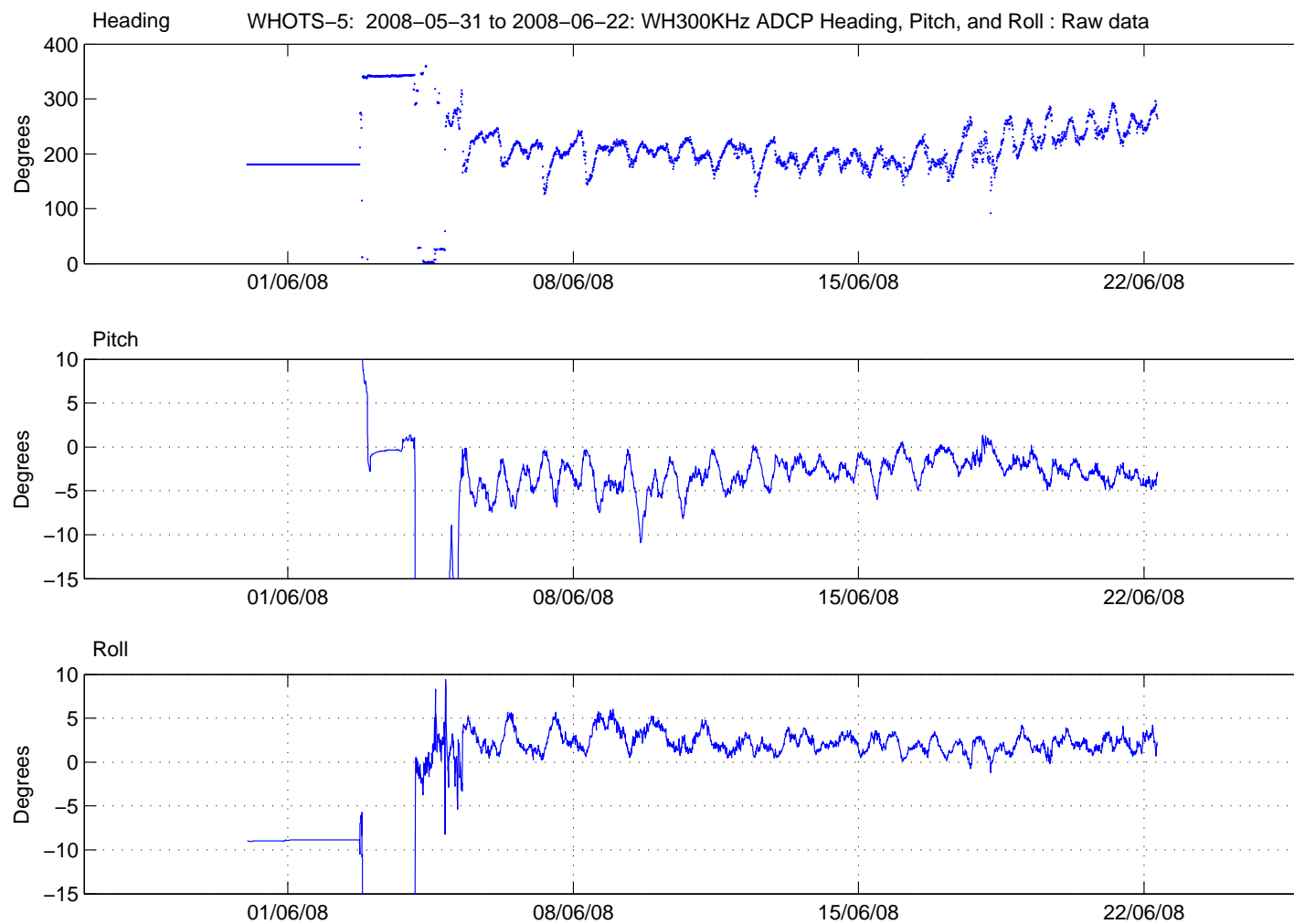


Figure 7. Heading, pitch and roll variations measured by the ADCP at 125 m depth on the WHOTS-5 mooring.

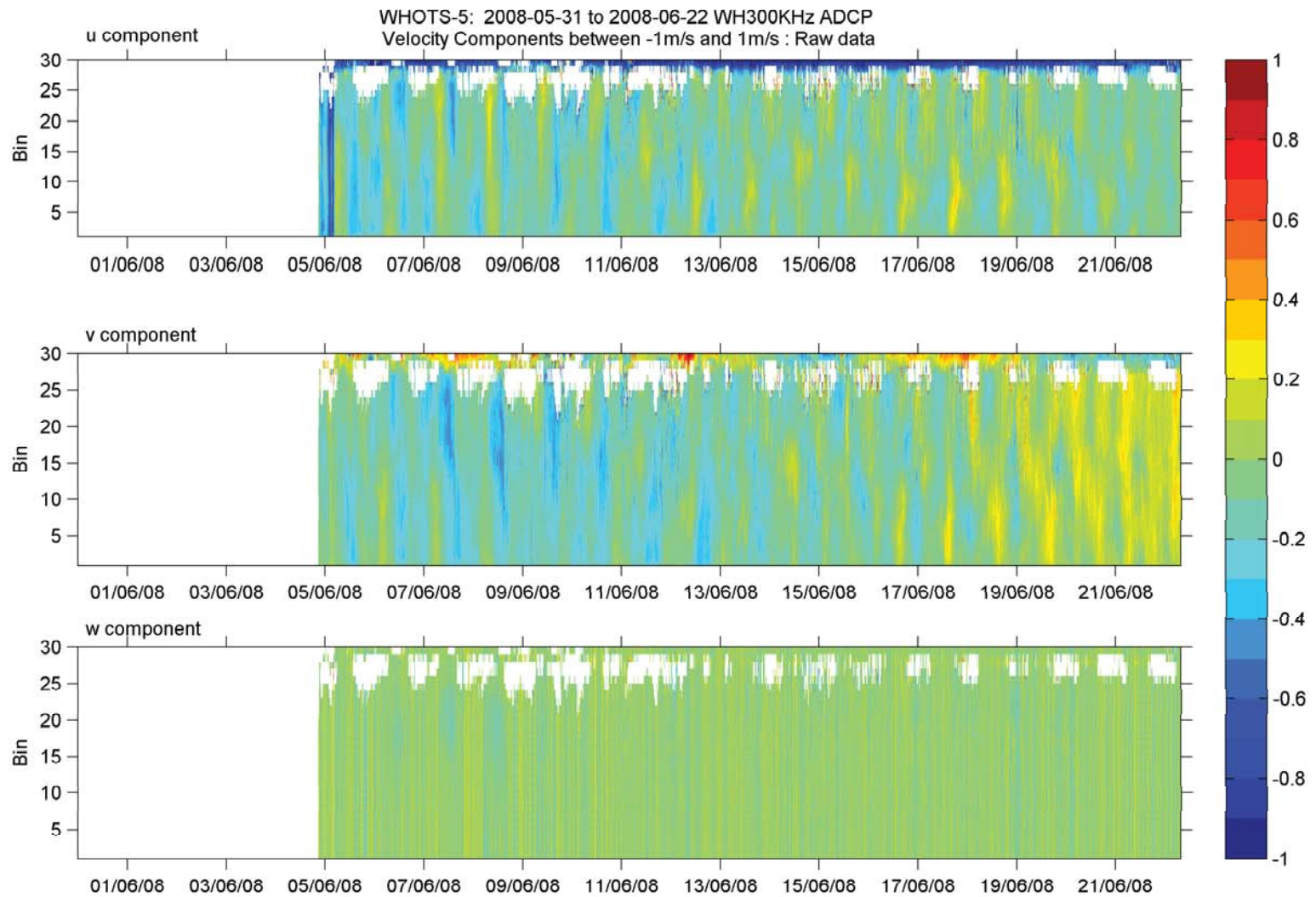


Figure 8. Time-series of eastward, northward and upward velocity components versus bin number measured by the ADCP at 125 m depth on the WHOTS-5 mooring. Height in meters above the transducer is approximately 4 times the bin number

The data from the upward-looking 1200 kHz ADCP at 47.5 m appears to be of high quality. The internal clock was offset by 1 hour 13 minutes 34 seconds ahead of UTC, which seems abnormally high. Further examination of the record revealed that the ensemble time jumped from 09:30:00.00 to 10:33:59.59 between ensembles 5818 and 5819 (see Table 6). This offset in clock time seems to have propagated from this point forward to the end of the record. Prior to cancelling data acquisition the timing of the pings were checked against UTC. Pings were recorded to commence at 20:10:26 and end at 20:14:24. This leads us to suspect that the time stamp has somehow been corrupted and not the timing of the instrument.

Table 6 Summary of ADCP events during the WHOTS-5 deployment.

Time of first ensemble	31-05-2008 00:00:00.00
ADCP in water time from deck log	04-06-2008 18:41:00.00*
Time of first velocity profile	04-06-2008 18:40:00.00
Time of ensemble 5818	10-07-2008 09:30:00.00
Time of ensemble 5819	10-07-2008 10:33:59.59
ADCP on deck time from deck log	16-07-2009 00:36:00.00*
Time of last velocity profile	16-07-2009 01:43:59.59
Time of last ensemble	16-07-2009 21:33:59.59

* These times are taken from a timeserver or GPS aboard the ship. All other times are taken from the ADCP itself.

Figure 9 shows the heading, pitch and roll information from the ADCP. Pitch and roll are generally less than 5 degrees from the vertical, but there are some periods with deviations from the vertical of as much as 10 degrees. The ADCP can be seen to make one rotation through the months of December 2008 and January 2009.

Figure 10 shows the variations of the horizontal and vertical components of velocity in depth and time. The number and size of the depth cells resulted in a maximum range of less than 20 m from the transducer. With the instrument located at 47.5 m side-lobe interference from the sea-surface was not an issue. Data during the first half of the deployment extend across the full depth range with gradually more gaps appearing in the depth cells furthest from the ADCP during the second half of the deployment. This is most likely due to a combination of bio-fouling on the transducer heads and weaker echo returns as a result of reduced power output due to battery fatigue. Ringing and contamination from reflection from nearby instruments do not seem to be present although this will be examined more thoroughly during data processing.

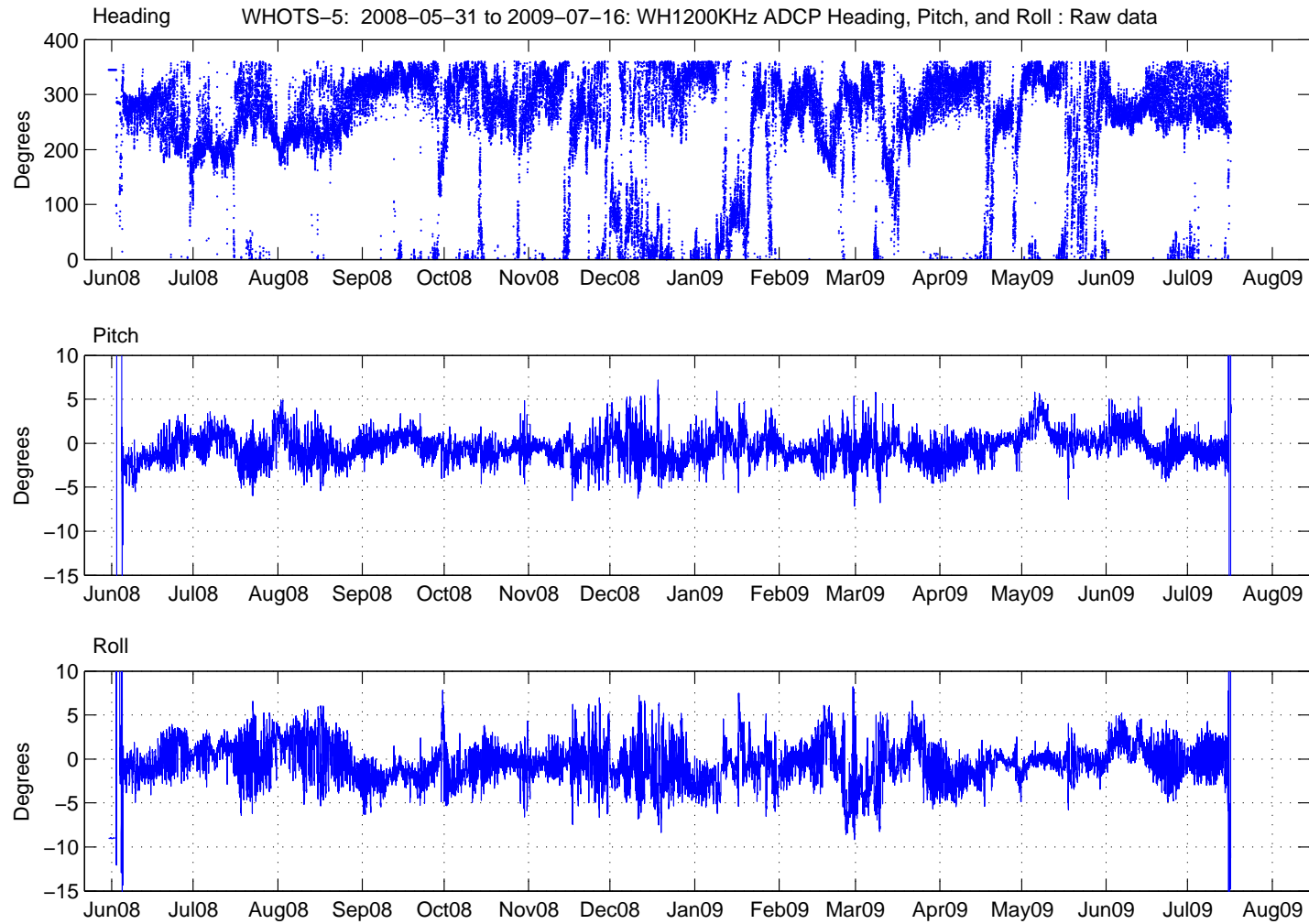


Figure 9. Heading, pitch and roll variations measured by the ADCP at 47.5 m depth on the WHOTS-5 mooring.

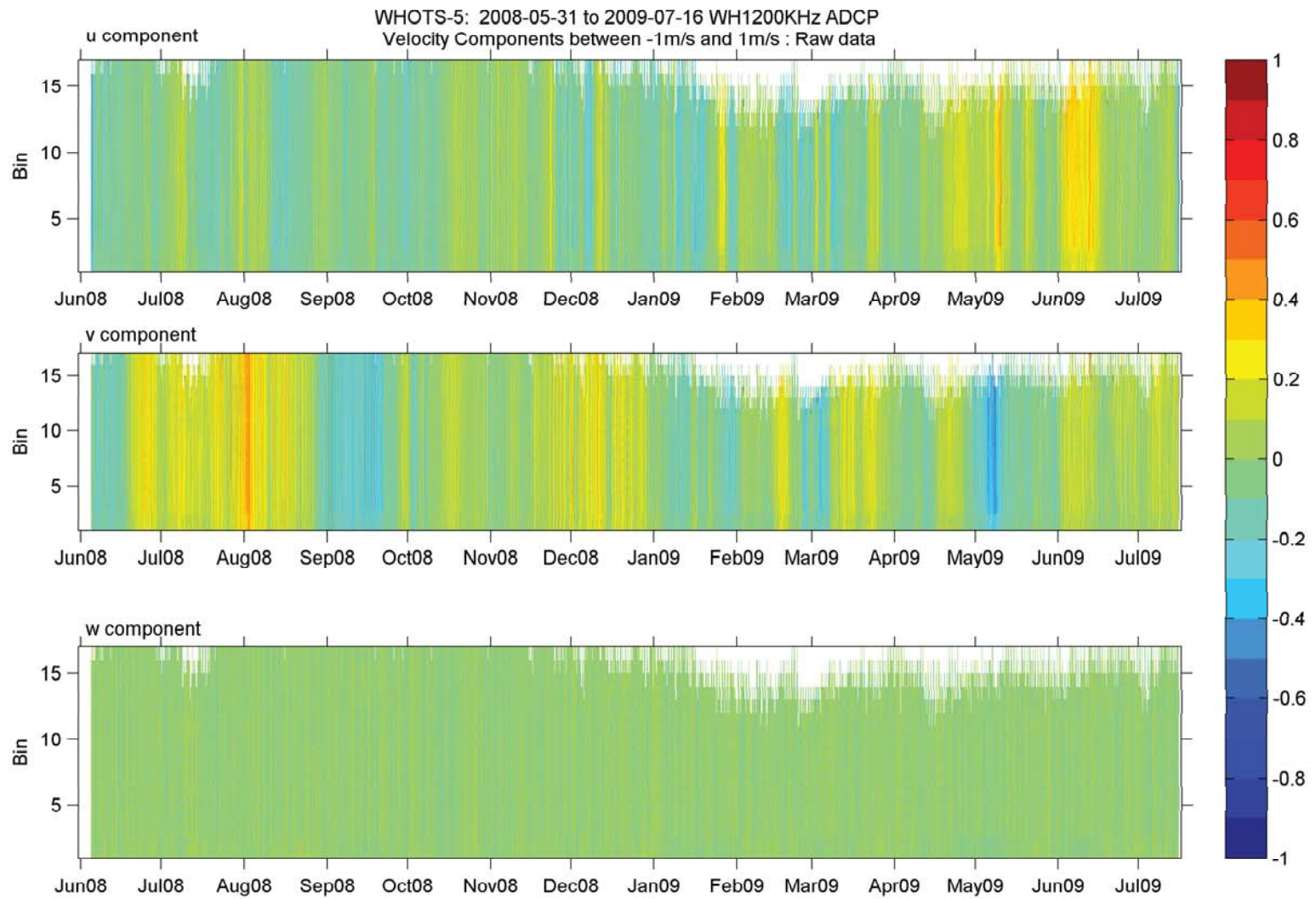


Figure 10. Time-series of eastward, northward and upward velocity components versus bin number measured by the ADCP at 47.5 m depth on the WHOTS-5 mooring. Height in meters above the transducer is approximately the bin number.

B. CTD Stations

UH provided CTD and water sampling equipment, including a Seabird 9/11+ CTD sampling pressure, dual temperature, dual conductivity and dual oxygen sensors at 24 Hz. Seabird sensors used by UH routinely as part of the Hawaii Ocean Time-series were used to more easily tie the WHOTS cruise data into the HOT CTD dataset. The CTD was installed inside a twelve-place General Oceanics rosette with six 5-liter Niskin sampling bottles controlled by a Seabird carousel.

Table 7. CTD stations occupied during the WHOTS-6 cruise.

Station/cast	Date	Time (GMT)	Location	Maximum pressure (dbar)
52 / 1	7/11/09	16:02	22° 40.62' N, 157° 59.32' W	1020
52 / 2	7/11/09	19:55	22° 40.61' N, 157° 58.94' W	500
52 / 3	7/11/09	23:52	22° 40.62' N, 157° 58.97' W	500
52 / 4	7/12/09	03:52	22° 40.63' N, 157° 58.98' W	500
50 / 1	7/13/09	15:55	22° 46.51' N, 157° 55.95' W	500
50 / 2	7/13/09	19:53	22° 46.64' N, 157° 55.94' W	200
50 / 3	7/13/09	20:18	22° 46.65' N, 157° 55.94' W	500
50 / 4	7/13/09	23:53	22° 46.96' N, 157° 55.63' W	500
50 / 5	7/14/09	03:55	22° 46.62' N, 157° 55.78' W	500
2/1	7/16/09	22:03	22° 45.01' N, 158° 00.00' W	4808

A total of 10 CTD yo-yo casts were conducted at stations 52 (near the WHOTS-6 buoy), at station 50 (near the WHOTS-5 buoy), and at station 2 (at the HOT site). The first cast was to a depth of 1000 m for the purpose of calibrating the CTD conductivity cells. Four CTD casts were conducted to obtain profiles for comparison with subsurface instruments on the WHOTS-6 mooring after deployment, and 5 more casts were conducted for comparison with the WHOTS-5 mooring before recovery. These were sited approximately 0.25 to 0.5 nm from the buoys. The comparison casts each consisted of 5 yo-yo cycles between 5 dbar and 200 dbar, with the last cycle up to 200, 500 or 1020 dbar (see Table 6). Station 50 cast 2 had only one yo-yo cycle because the winch operator inadvertently took the CTD out of the water at the end of the first cycle and the cast was terminated. One near-bottom cast was conducted at station 2 for troubleshooting two temperature sensors, and to obtain a full-depth profile. Station numbers were assigned following the convention used during HOT cruises. Station 50 is the nominal site of WHOTS-1, -2, -3, and -5, and station 52 is the nominal site of WHOTS-4, and -6. Table 6 provides summary information for all CTD casts, and figures B1-B19 show the water column profile information that was obtained.

Water samples were taken from all casts except station 50 cast 2; 6 samples for 1020 dbar and 4808 dbar casts, and 2 to 3 samples each for the 500 dbar casts. These samples will be analyzed for salinity and used to calibrate the CTD conductivity sensors.

C. Thermosalinograph

The Kilo Moana has an Uncontaminated Scientific Sea Water (USSW) system that includes an internal Seabird Micro-Thermosalinograph (TSG) model SBE-45, with an SBE-38 digital remote temperature sensor. The seawater intake is located on the starboard hull, 20' 8" from the bow, at a mean depth of 8 m. The remote temperature sensor is installed in the bow thruster chamber approximately 2 – 3 m from the seawater intake. The pump that draws water through the system is situated between the intake and the remote temperature sensor and consequently remote temperature data are affected by warming due to the pump. An offset correction is made to the final data by comparing the remote temperature data with 8 dbar CTD data. The mean temperature difference from the CTD casts conducted during the cruise was 0.25 °C. The internal TSG is located in the IMET lab on the port side of the ship. Sensor information for the TSG system during WHOTS-6 is as follows:

Temperature: SBE-38 Sensor SN 0169 was used to measure temperature near the seawater intake, and was last calibrated on December 12, 2008, and installed on May 20, 2009. The SBE-45 thermosalinograph used temperature sensor SN 0267, which was last calibrated on October 09, 2008, and installed January, 2009.

Conductivity: The SBE-45 thermosalinograph used conductivity sensor SN 0267, which was most recently calibrated on October 09, 2008, and installed January, 2009.

Water samples were drawn from an intake located about 2 m from the thermosalinograph system every 8 hours during the cruise for post-calibration of that dataset. The TSG data are shown in Figures C1-C8.

D. Shipboard ADCPs

The R/V Kilo Moana is equipped with an RD Instruments 300 kHz Workhorse Mariner ADCP and an RD Instruments Ocean Surveyor 38 kHz ADCP. The University of Hawaii ADCP processing system is installed, producing real-time profiles and other products. In addition to providing an intercomparison with the upward-looking ADCPs on the WHOTS moorings, the shipboard ADCP systems revealed interesting regional current features as shown in Figure 2.

Appendix A. Moored C-T Time Series Figures

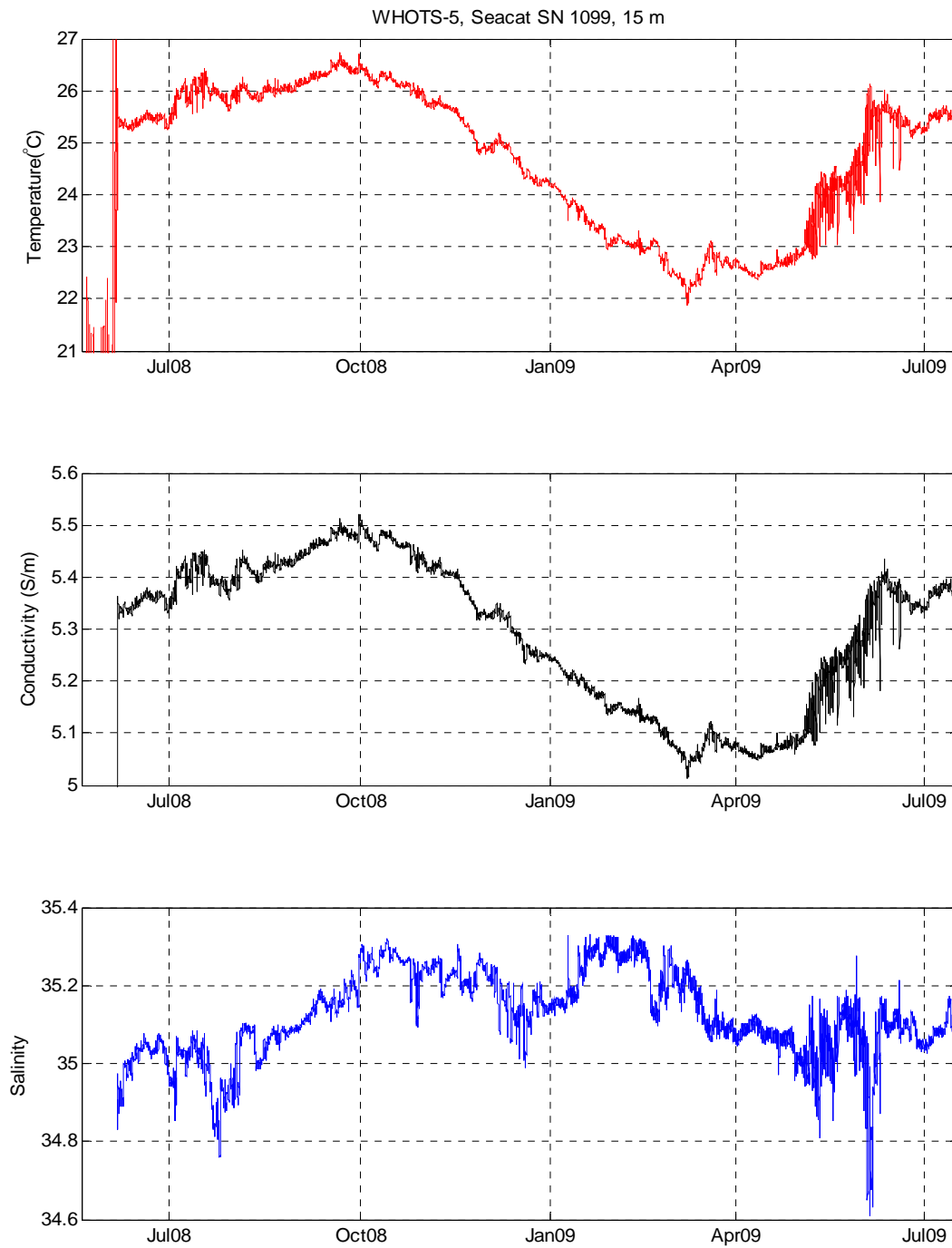


Figure A1. Preliminary temperature, conductivity and salinity from Seacat SBE-16 SN 1099 deployed at 15 m on the WHOTS-5 mooring. Nominal pressure is also included to calculate salinity where pressure data was not available.

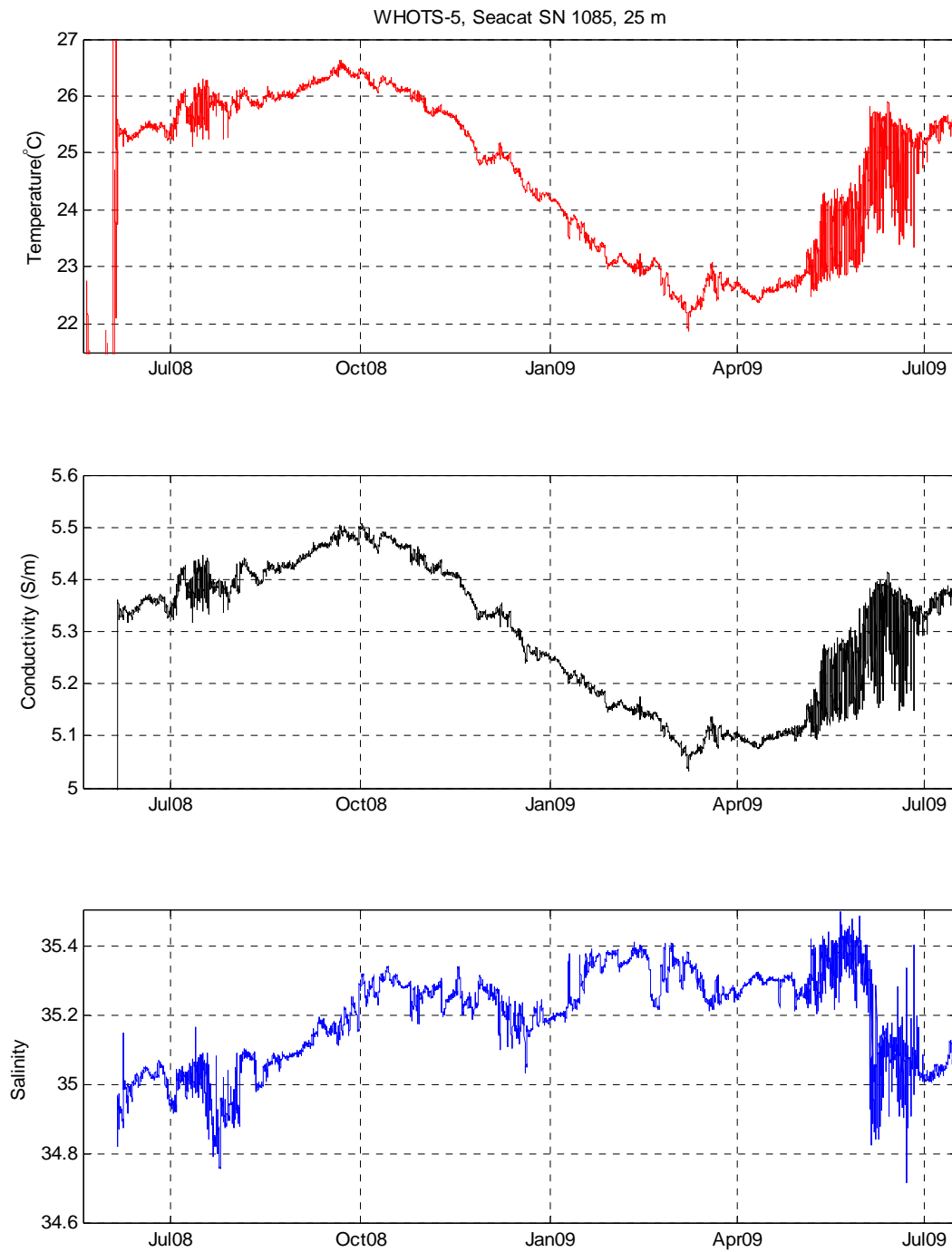


Figure A2. Preliminary temperature, conductivity and salinity from Seacat SBE-16 SN 1085 deployed at 25 m on the WHOTS-5 mooring. Nominal pressure is also included to calculate salinity where pressure data was not available.

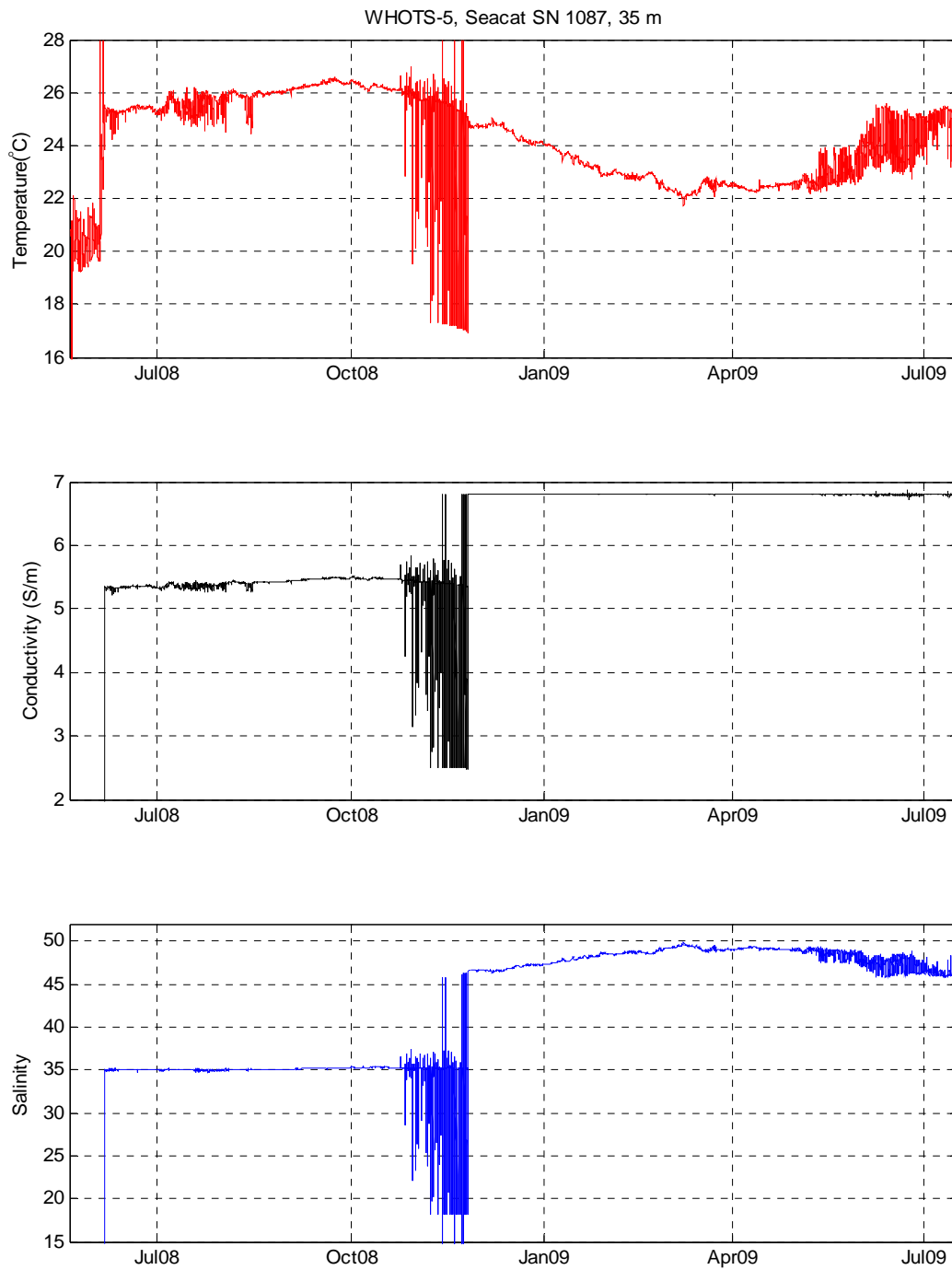


Figure A3. Preliminary temperature, conductivity and salinity from Seacat SBE-16 SN 1087 deployed at 35 m on the WHOTS-5 mooring. Nominal pressure is also included to calculate salinity where pressure data was not available. The sensors recorded noisy data during November, followed by an offset in the conductivity.

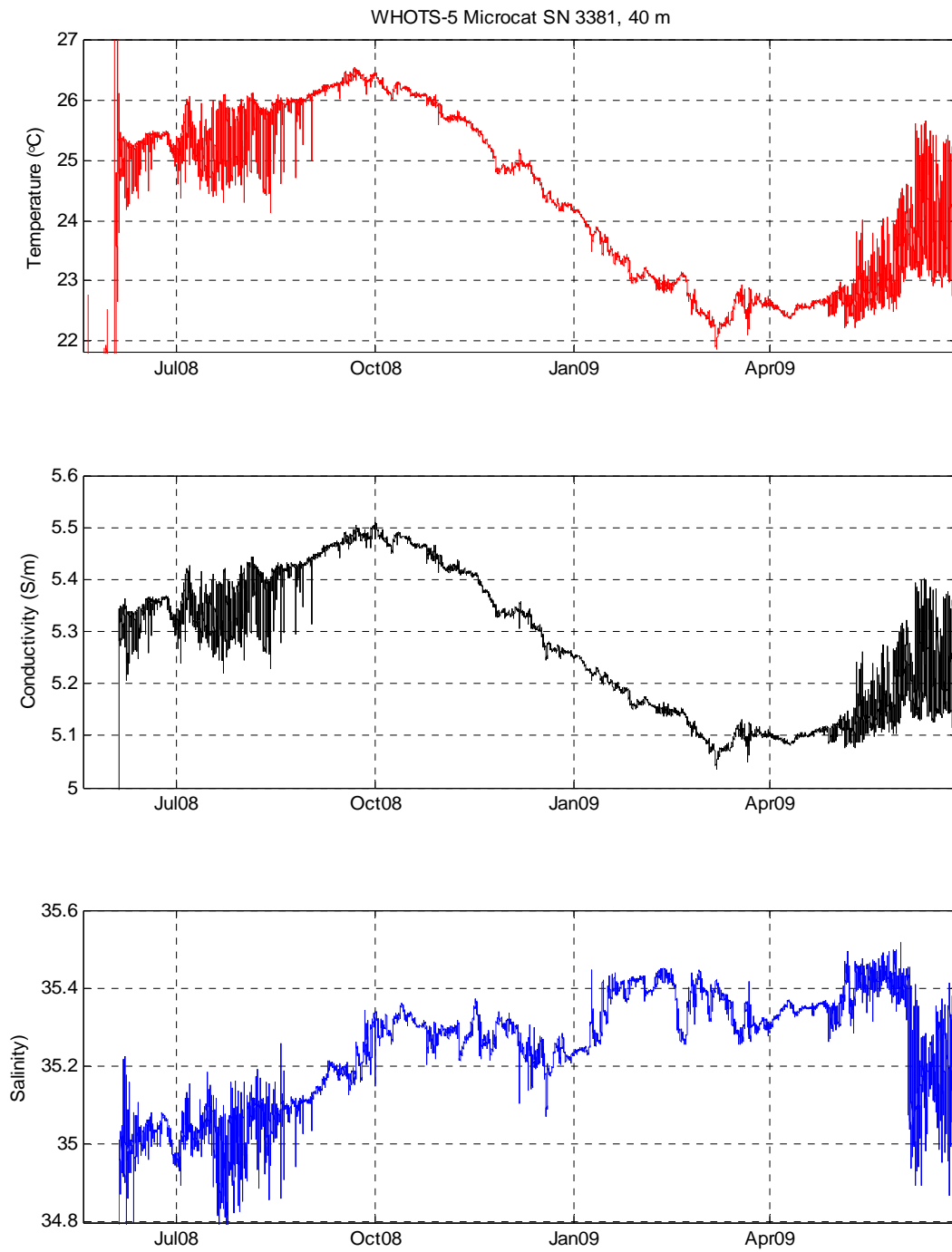


Figure A4. Preliminary temperature, conductivity and salinity from Microcat SBE-37 SN 3381 deployed at 40 m on the WHOTS-5 mooring. Nominal pressure is also included to calculate salinity where pressure data was not available.

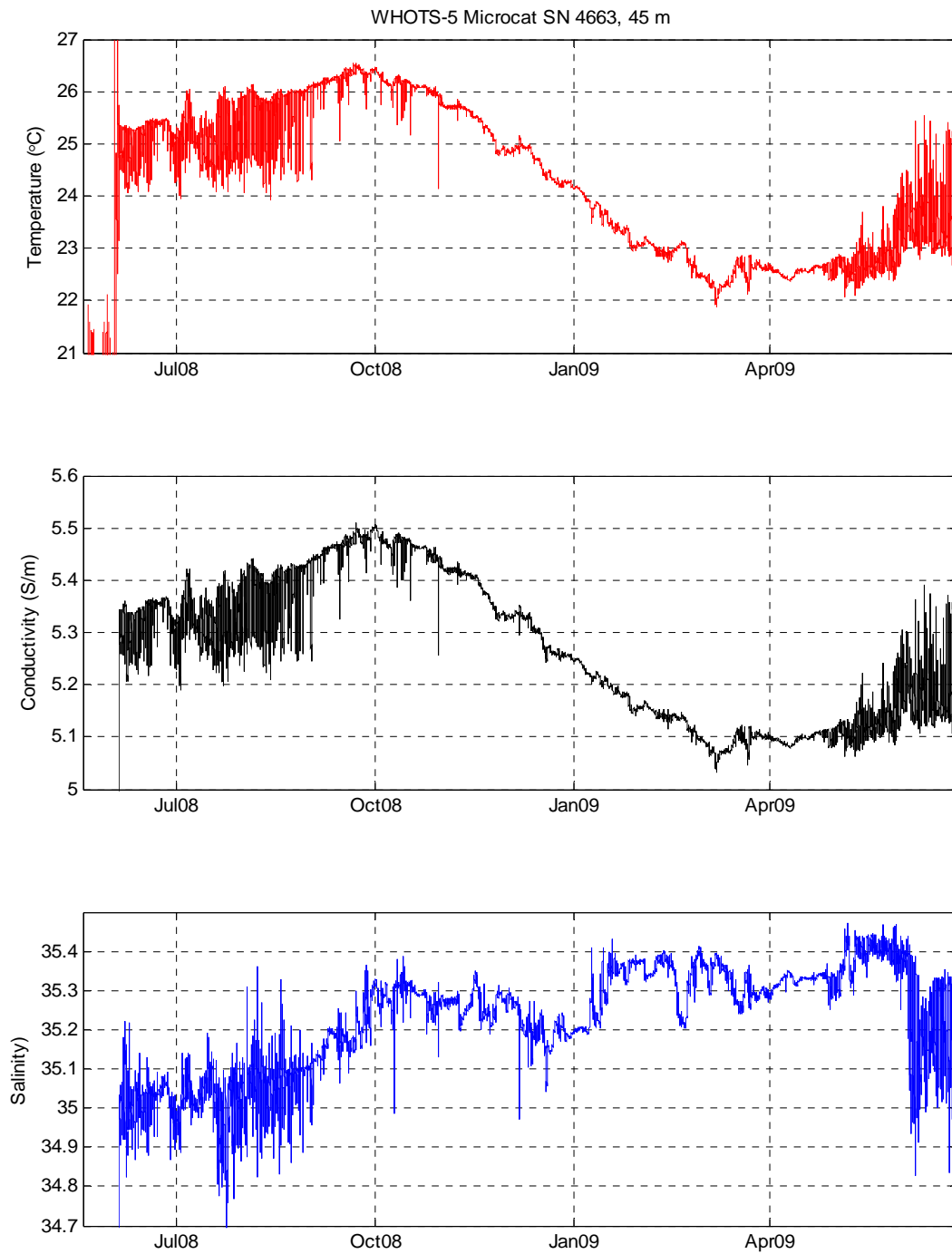


Figure A5. Preliminary temperature, conductivity and salinity from Microcat SBE-37 SN 4663 deployed at 45 m on the WHOTS-5 mooring. Nominal pressure is also included to calculate salinity where pressure data was not available.

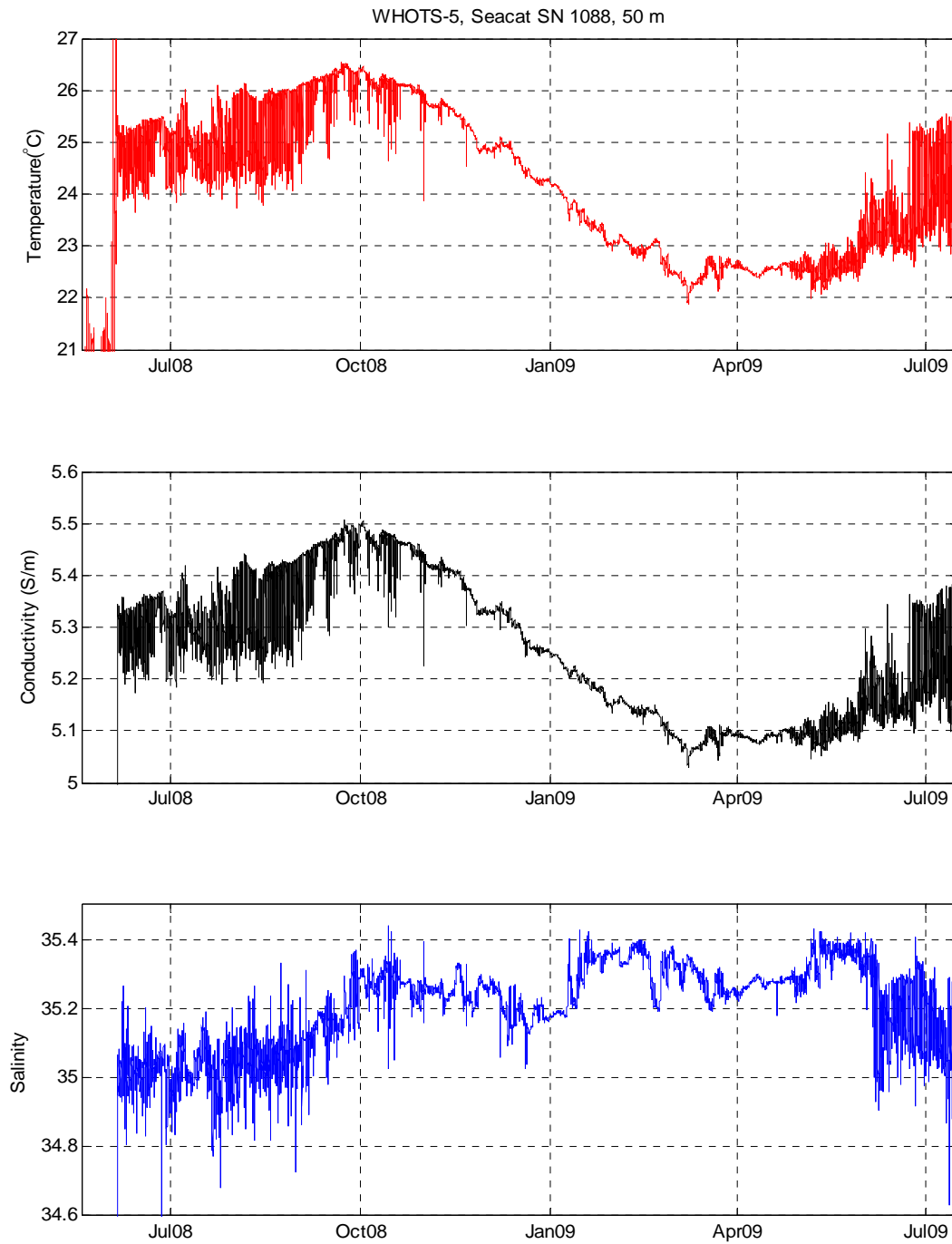


Figure A6. Preliminary temperature, conductivity and salinity from Seacat SBE-16 SN 1088 deployed at 50 m on the WHOTS-5 mooring. Nominal pressure is also included to calculate salinity where pressure data was not available.

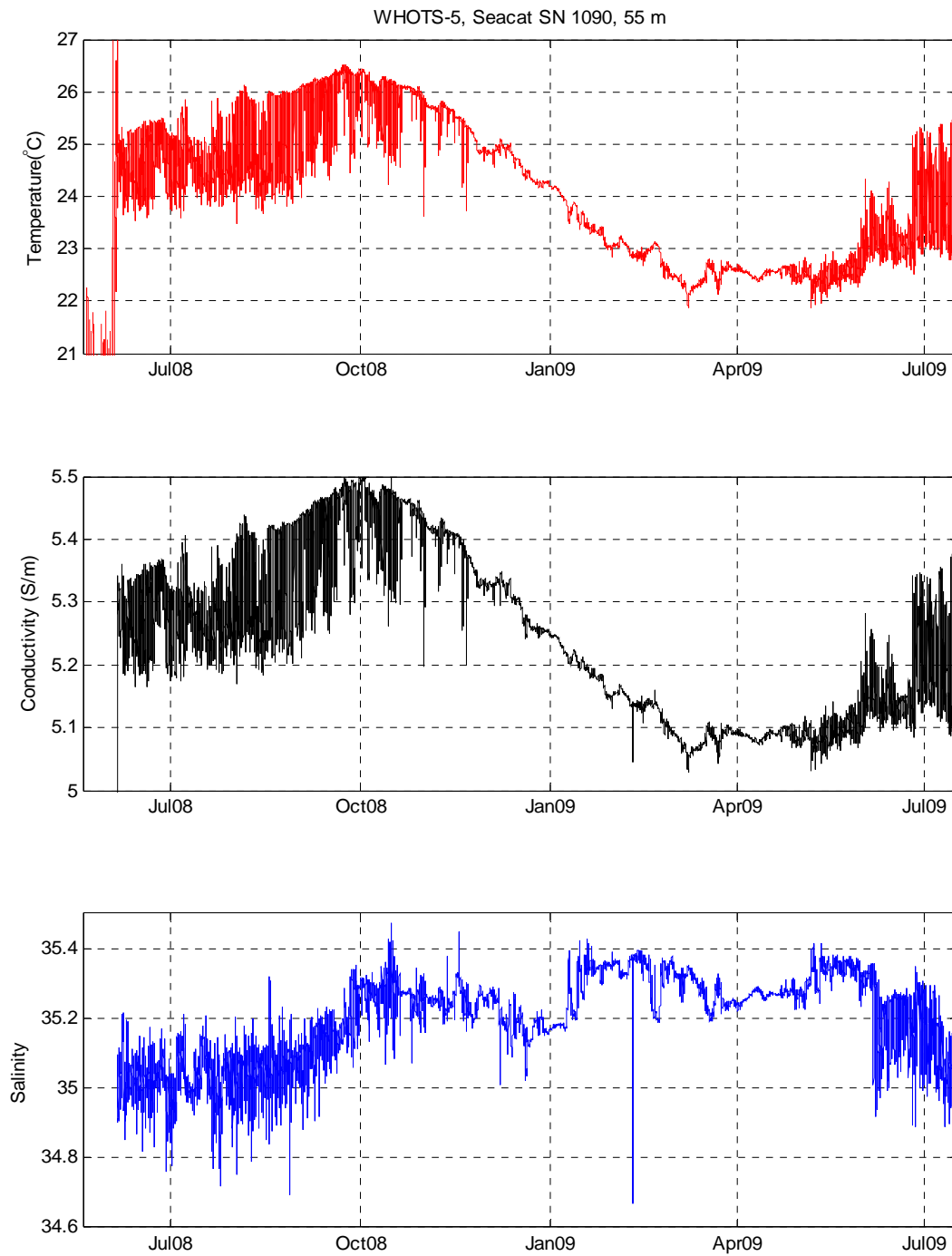


Figure A7. Preliminary temperature, conductivity and salinity from Seacat SBE-16 SN 1090 deployed at 55 m on the WHOTS-5 mooring. Nominal pressure is also included to calculate salinity where pressure data was not available.

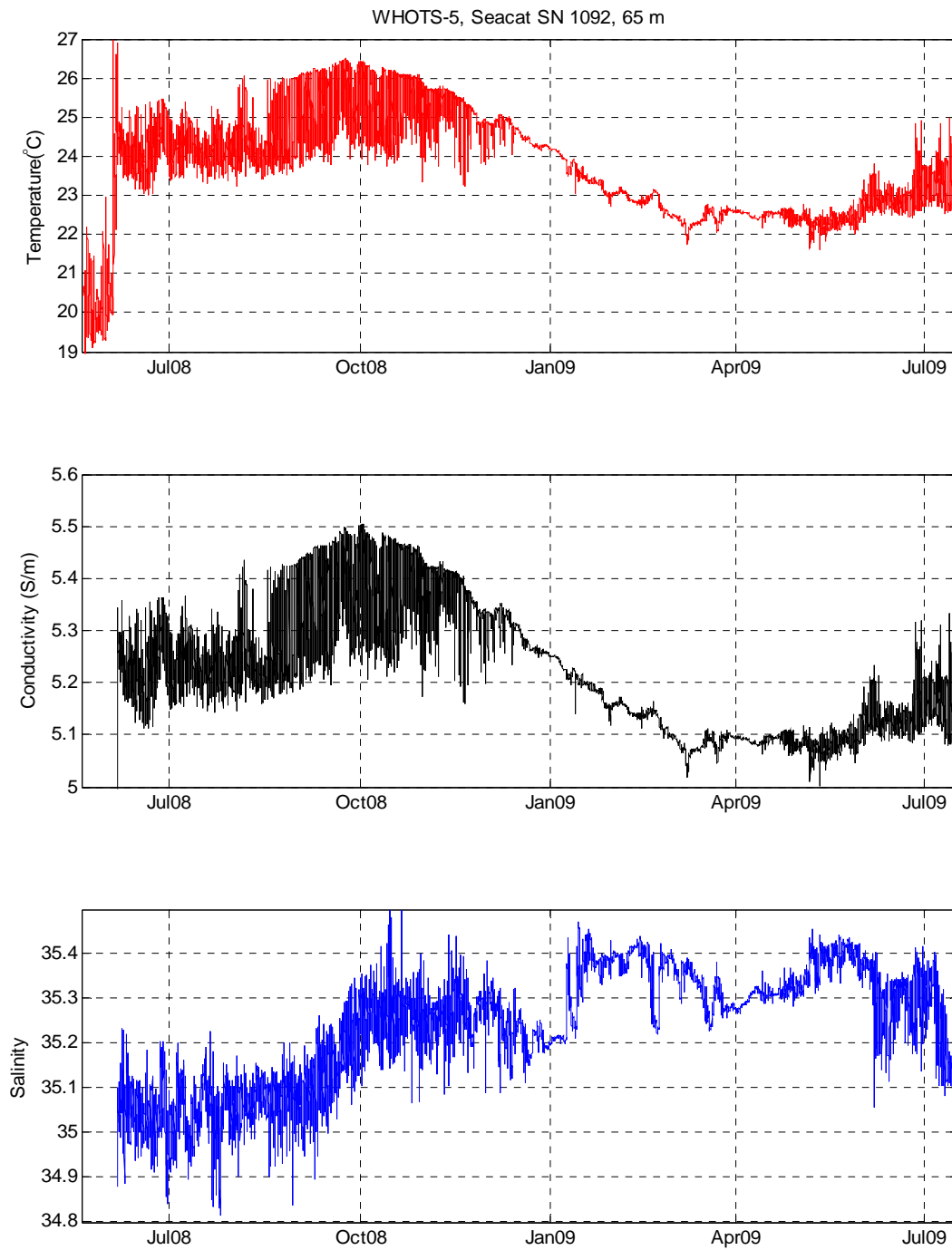


Figure A8. Preliminary temperature, conductivity and salinity from Seacat SBE-16 SN 1092 deployed at 65 m on the WHOTS-5 mooring. Nominal pressure is also included to calculate salinity where pressure data was not available.

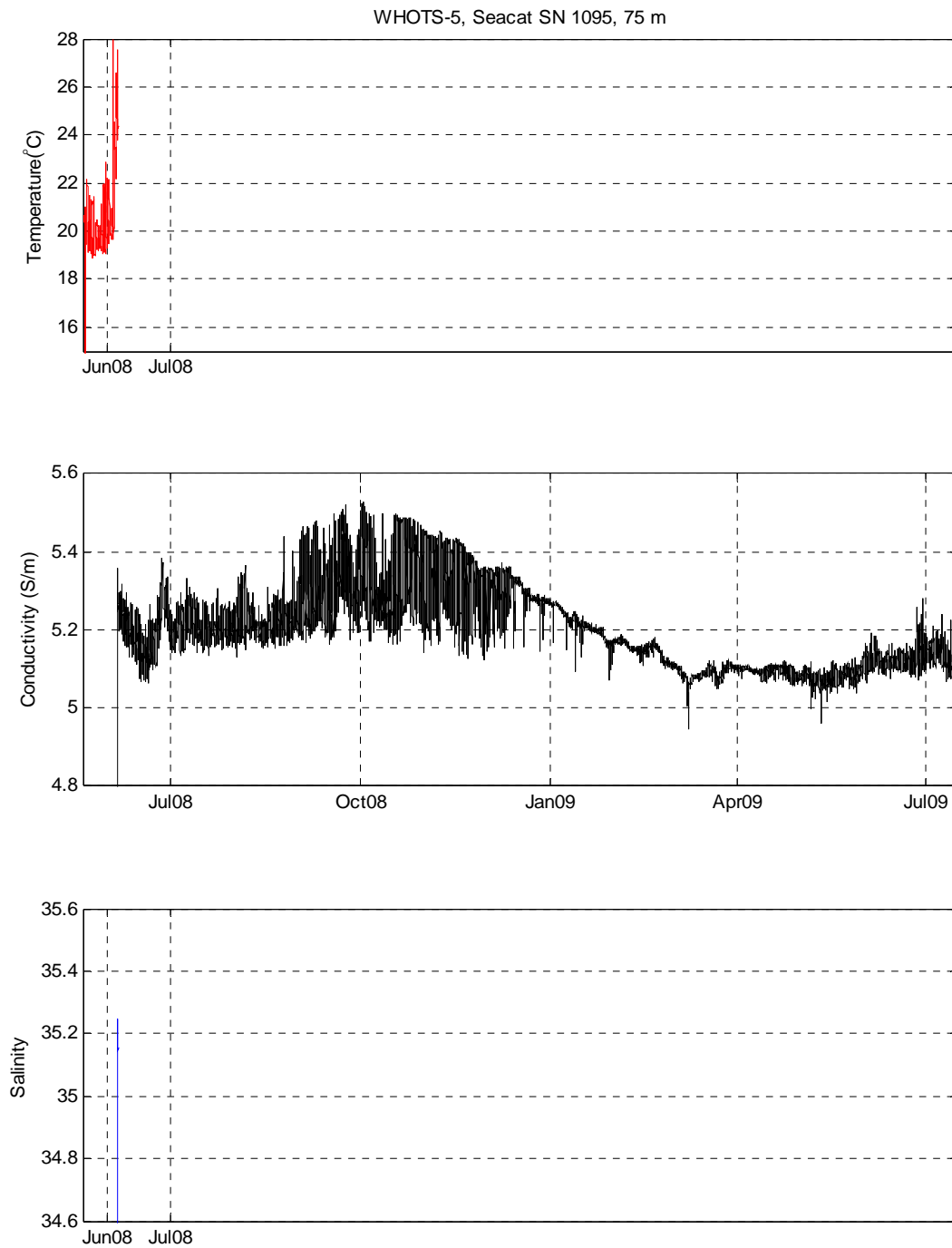


Figure A9. Preliminary temperature, conductivity and salinity from Seacat SBE-16 SN 1095 deployed at 75 m on the WHOTS-5 mooring. Nominal pressure is also included to calculate salinity where pressure data was not available. The temperature sensor failed soon after deployment.

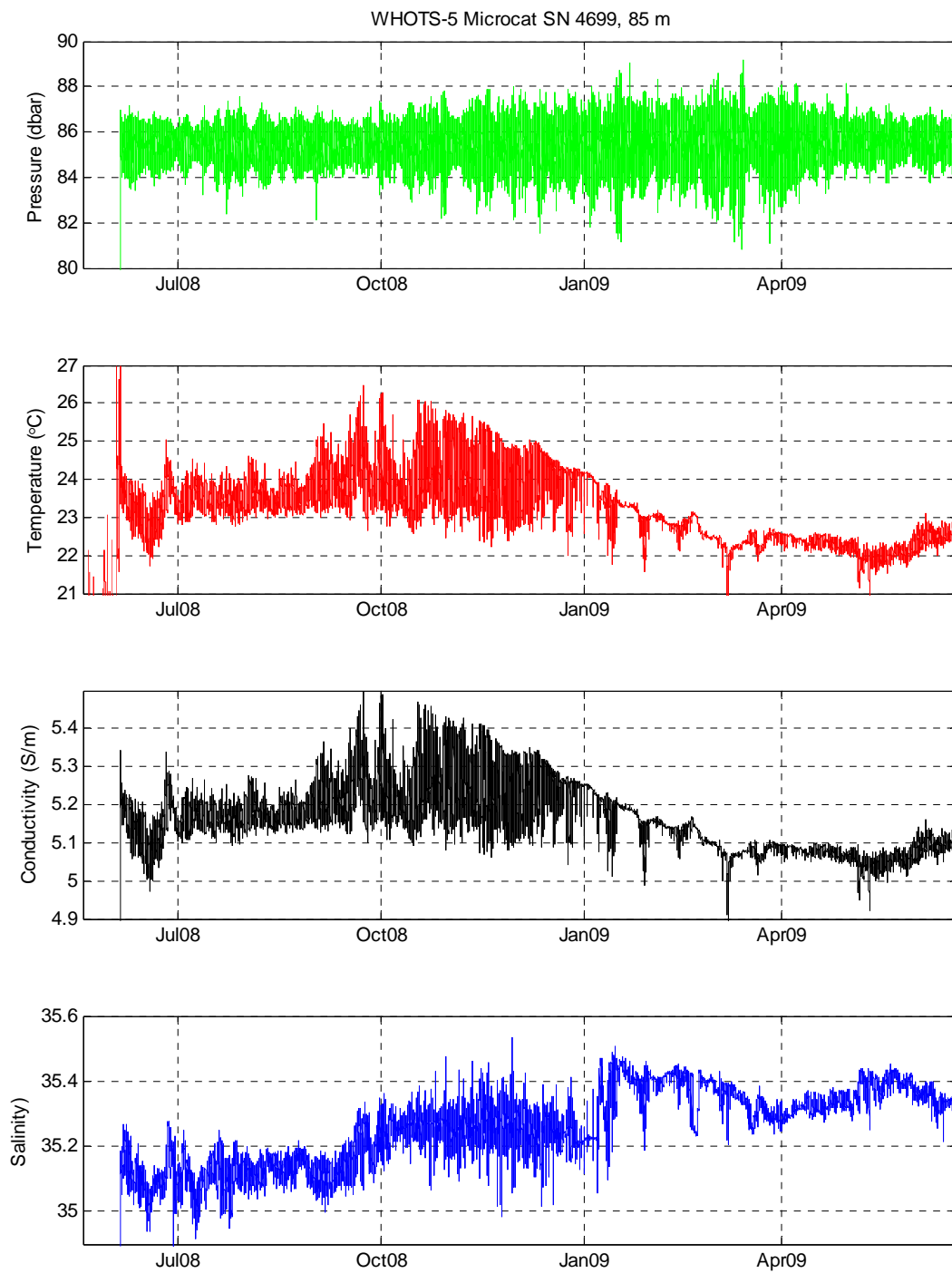


Figure A10. Preliminary pressure, temperature, conductivity and salinity from Microcat SBE-37 SN 4699 deployed at 85 m on the WHOTS-5 mooring.

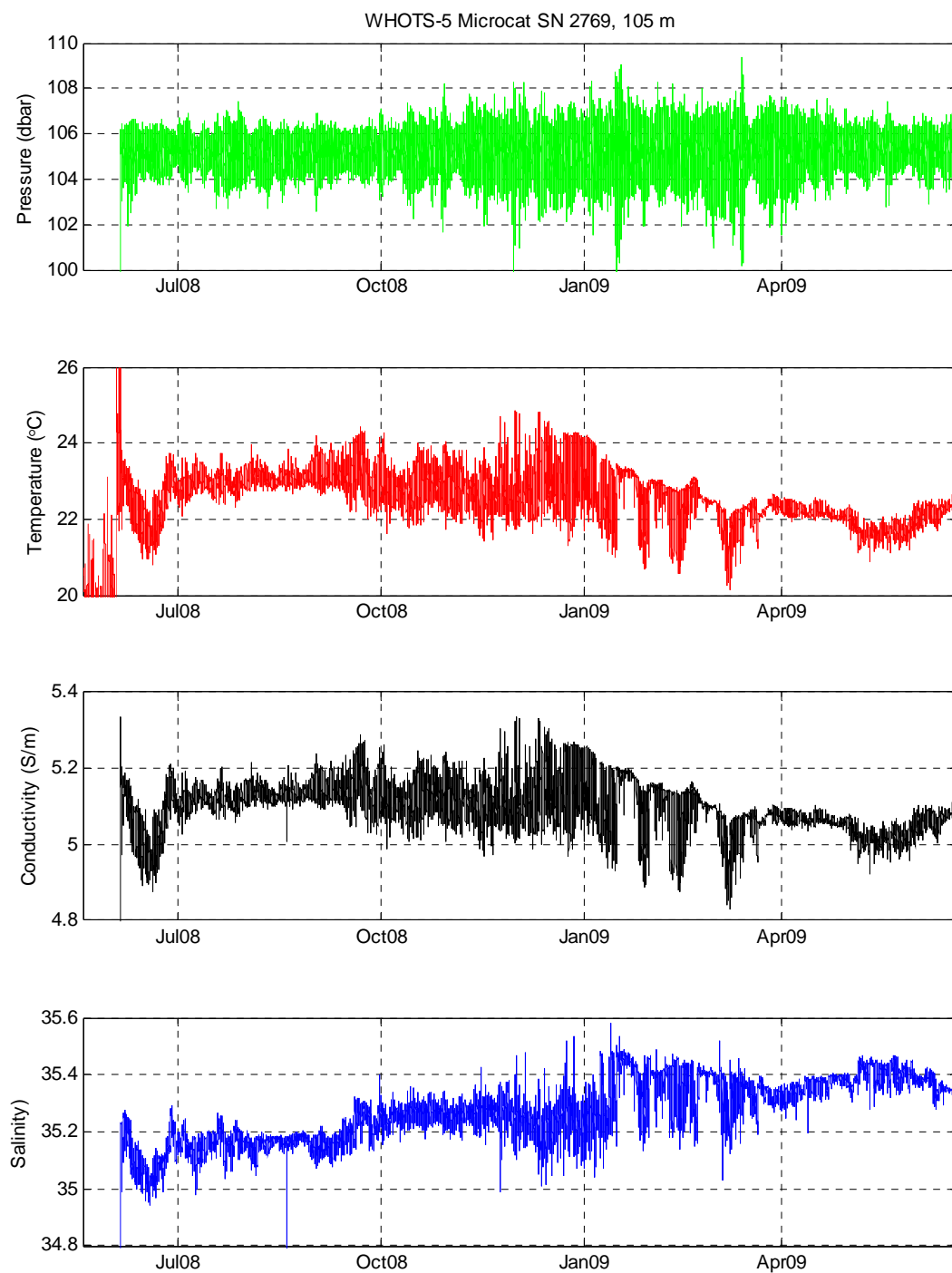


Figure A11. Preliminary pressure, temperature, conductivity and salinity from Microcat SBE-37 SN 2769 deployed at 105 m on the WHOTS-5 mooring.

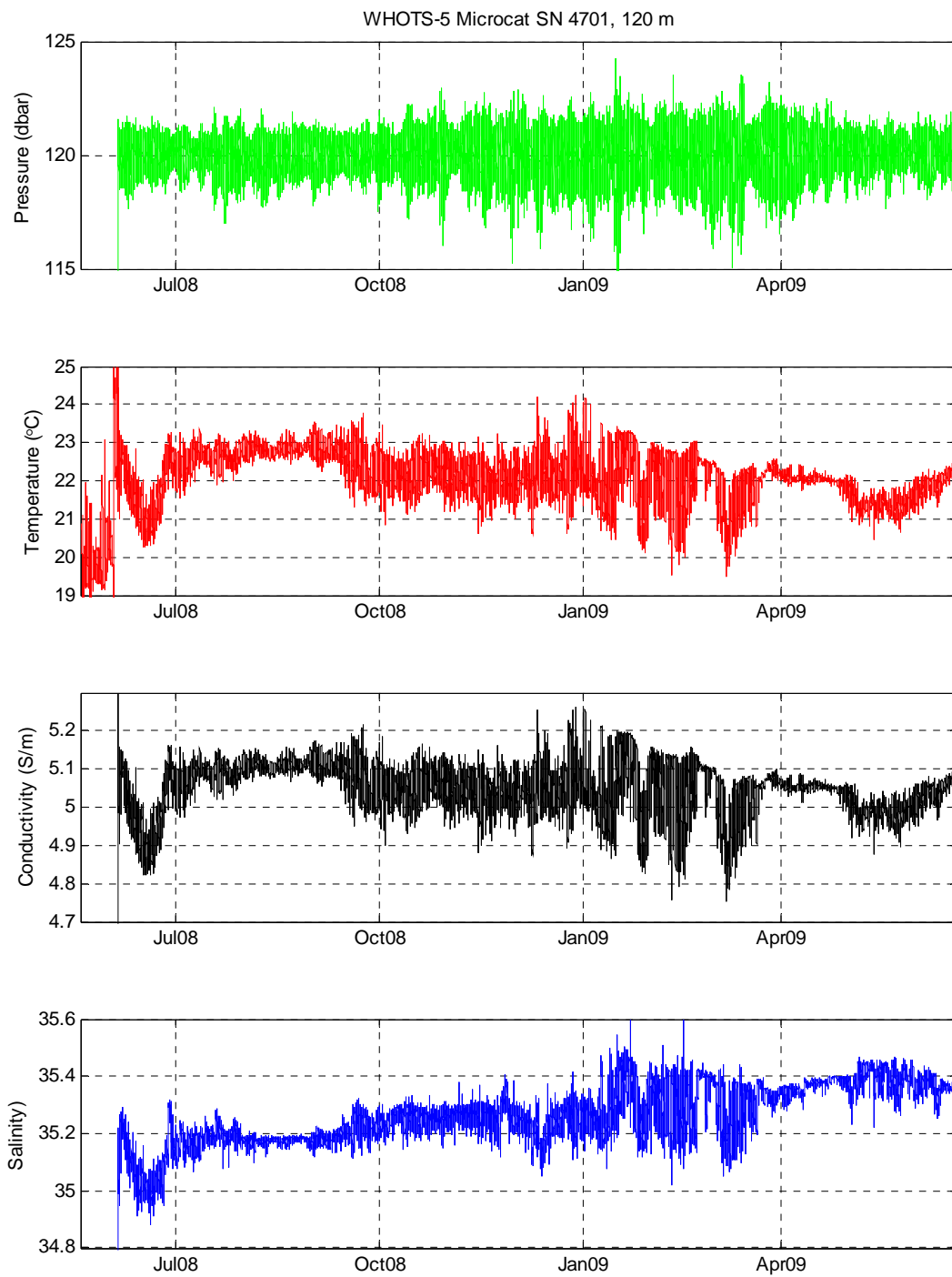


Figure A12. Preliminary pressure, temperature, conductivity and salinity from Microcat SBE-37 SN 4701 deployed at 120 m on the WHOTS-5 mooring.

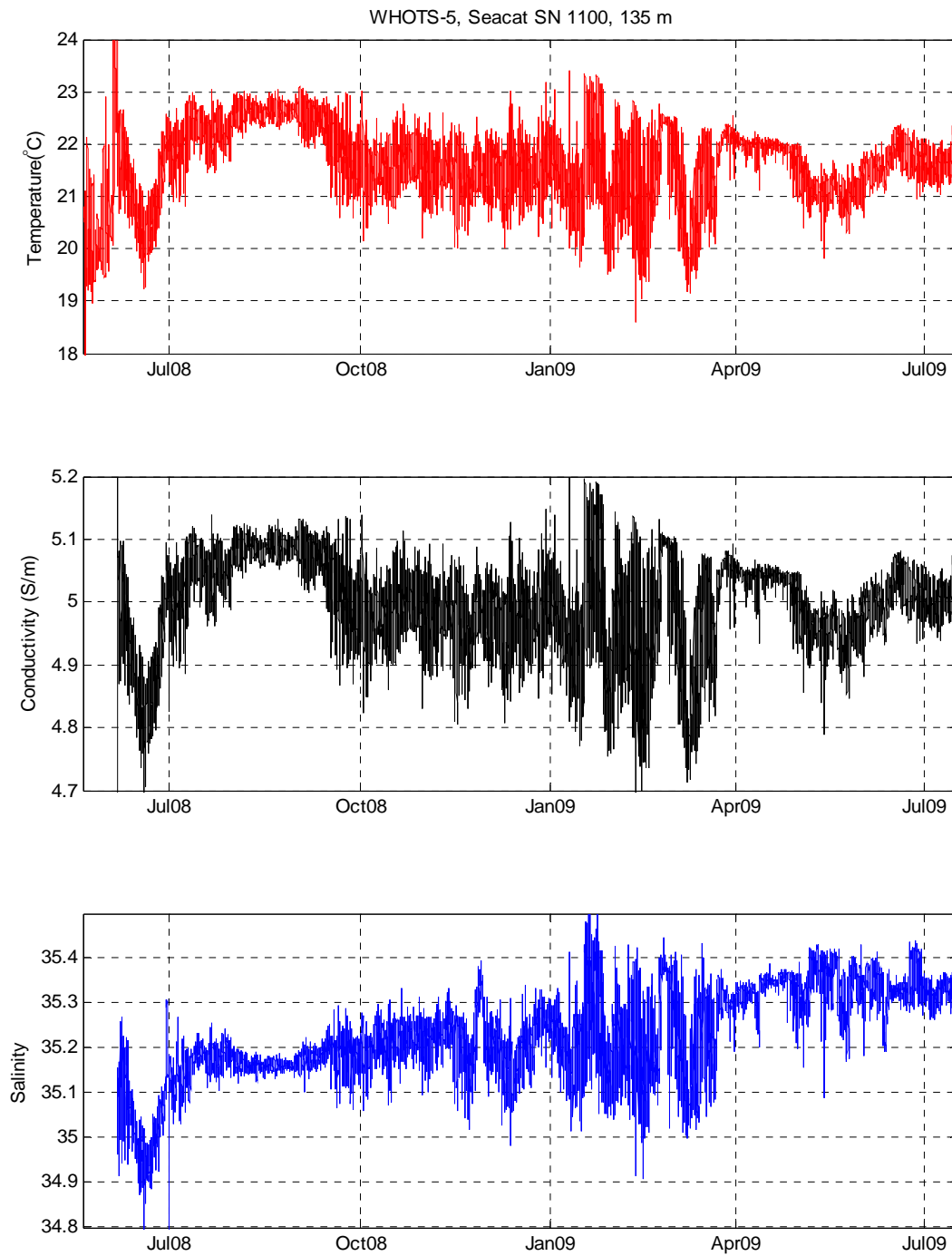


Figure A13. Preliminary temperature, conductivity and salinity from Seacat SBE-16 SN 1100 deployed at 135 m on the WHOTS-5 mooring. Nominal pressure is also included to calculate salinity where pressure data was not available.

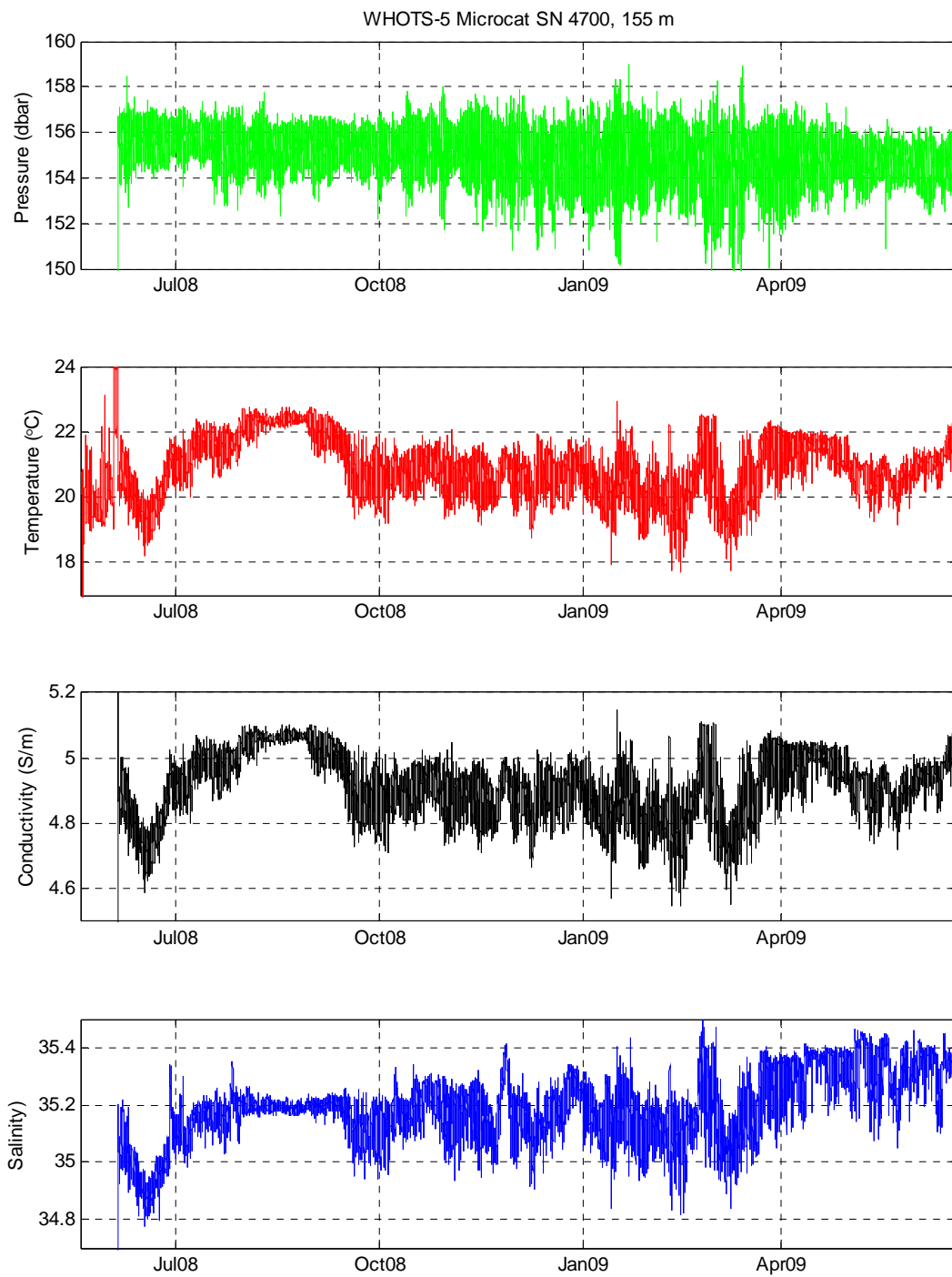


Figure A14. Preliminary pressure, temperature, conductivity and salinity from Microcat SBE-37 SN 4700 deployed at 155 m on the WHOTS-5 mooring.

Appendix B. CTD Casts Figures

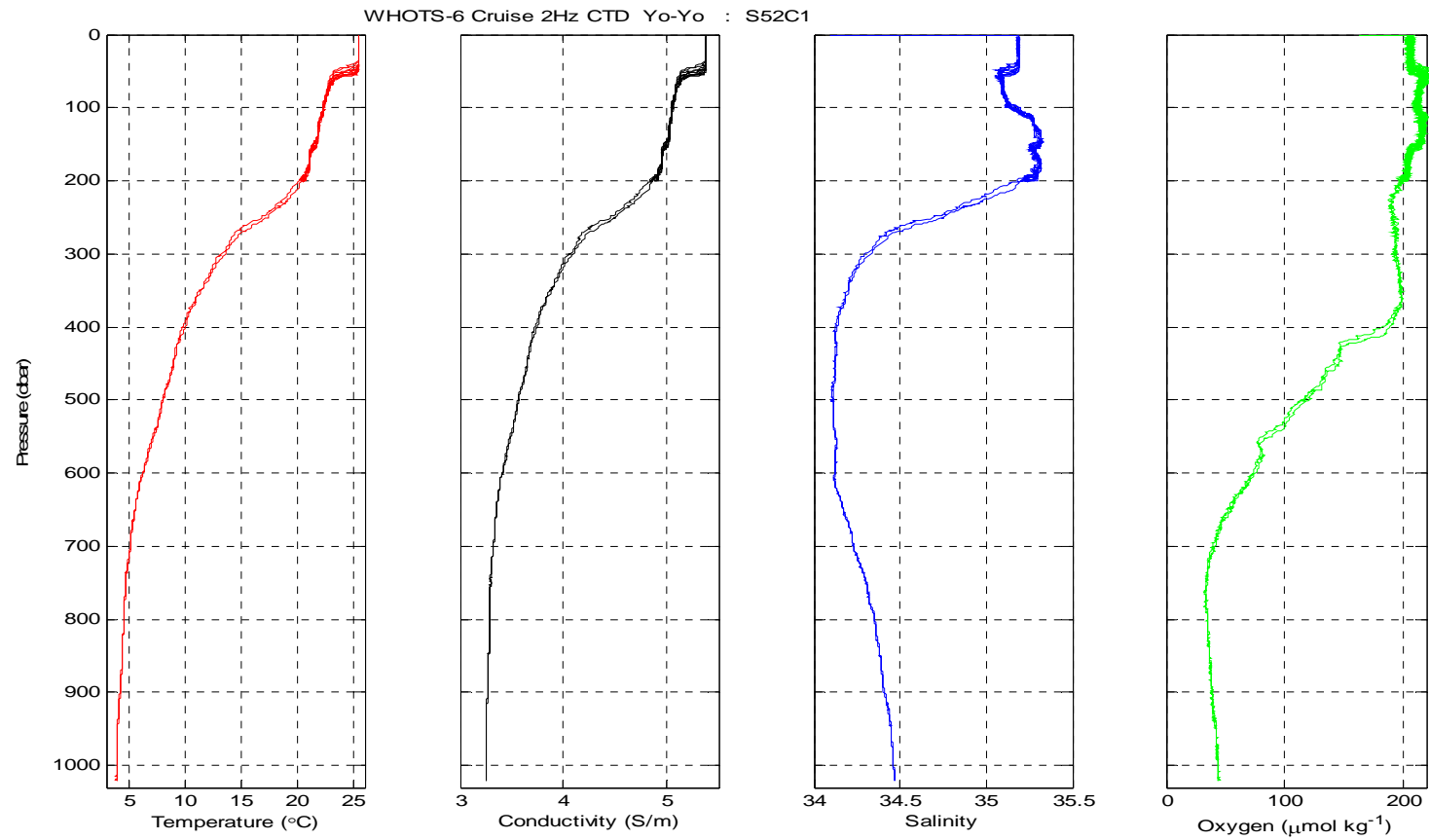


Figure B1. Profiles of 2 Hz temperature, conductivity, salinity, and oxygen data during CTD S52C1.

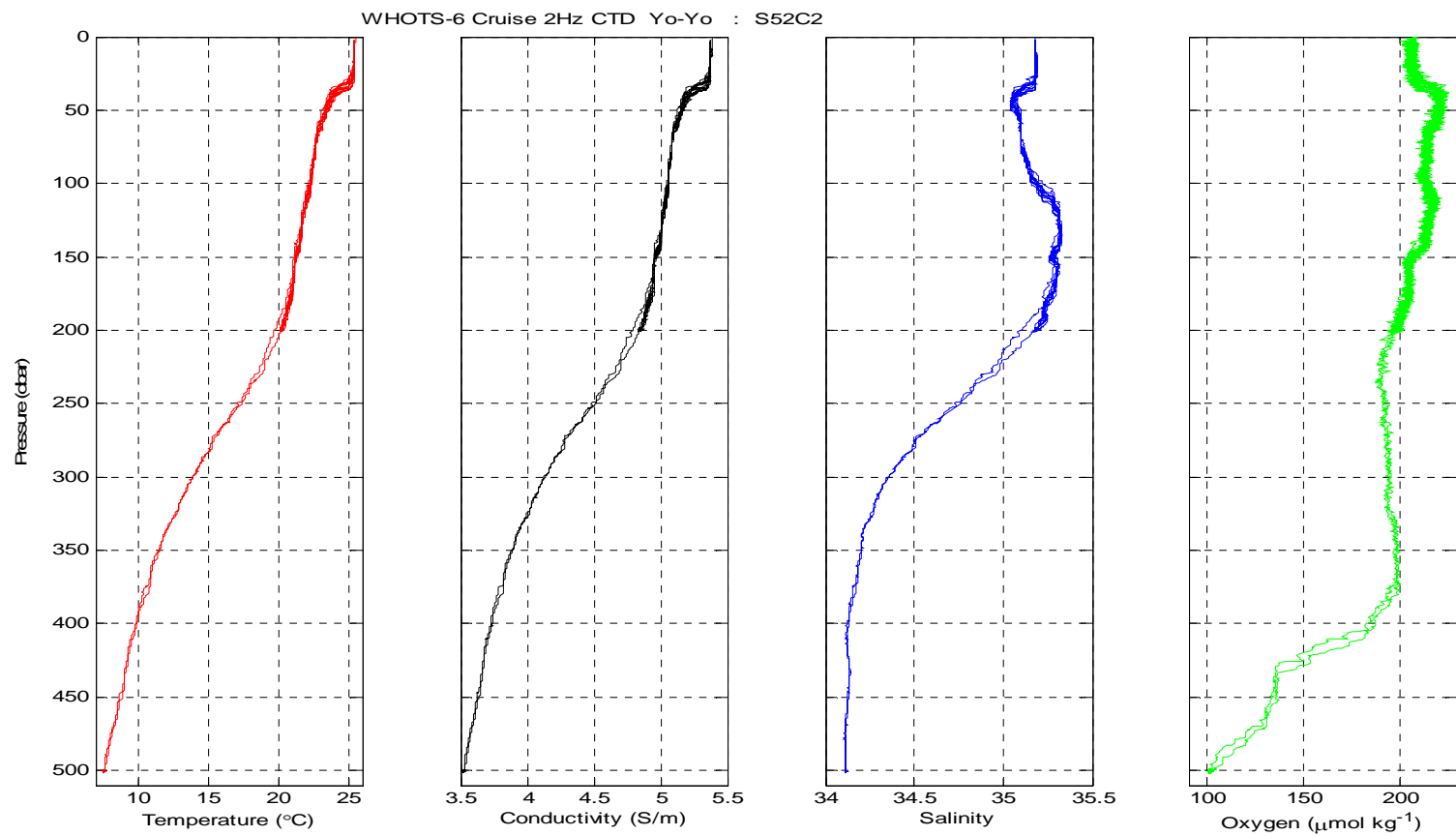


Figure B2. Profiles of 2 Hz temperature, conductivity, salinity, and oxygen data during CTD S52C2.

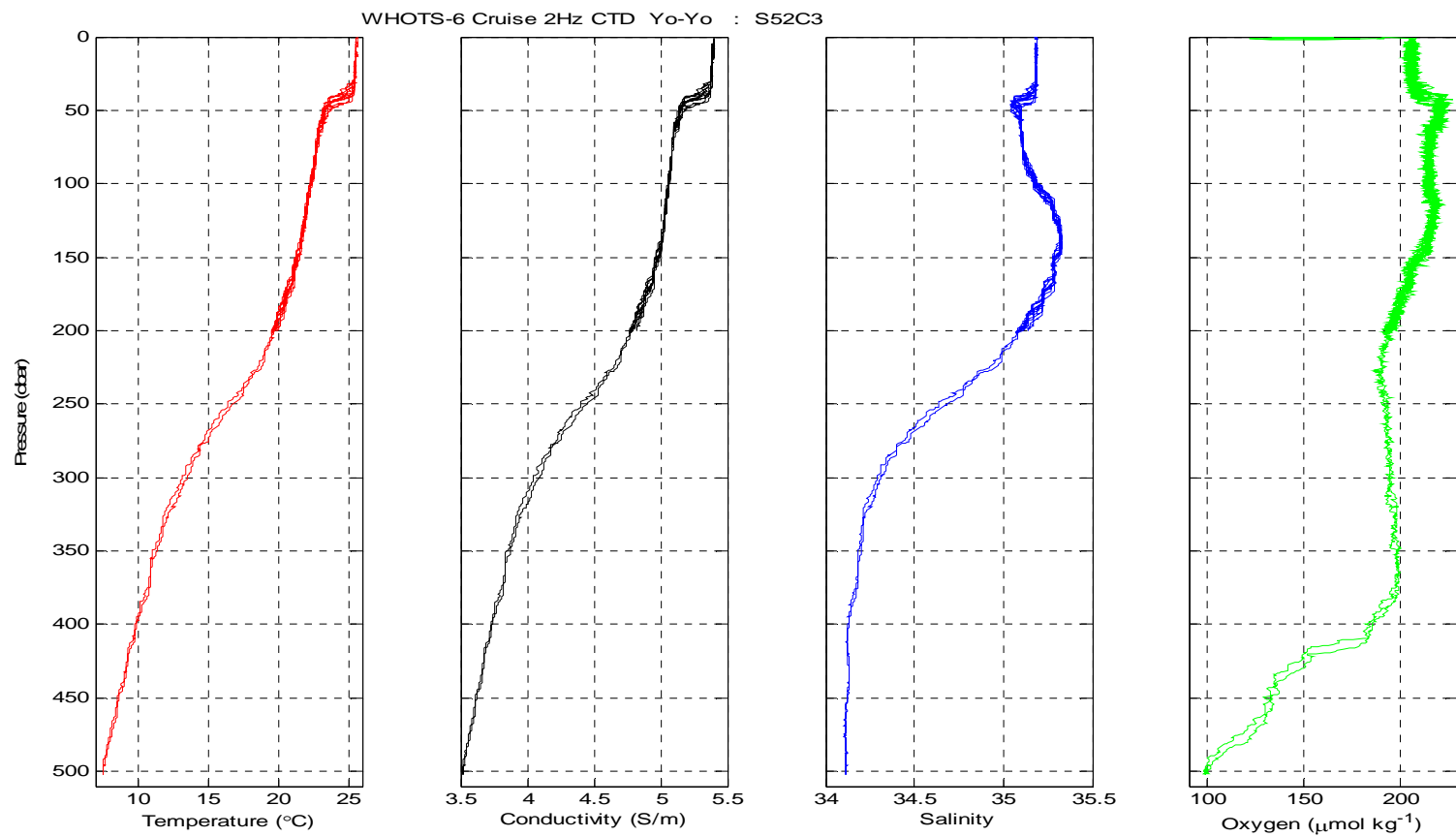


Figure B3. Profiles of 2 Hz temperature, conductivity, salinity, and oxygen data during CTD S52C3

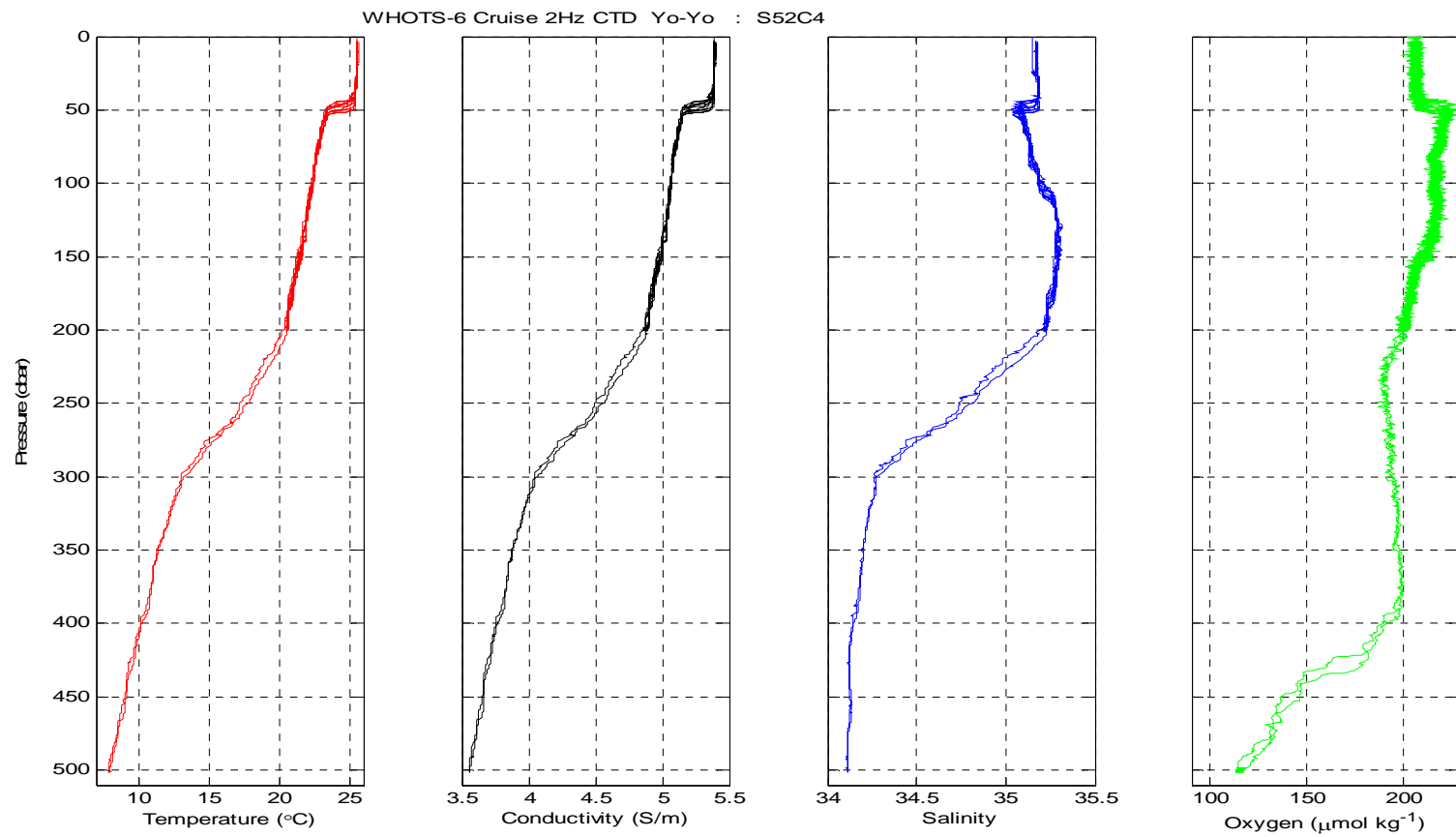


Figure B4. Profiles of 2 Hz temperature, conductivity, salinity, and oxygen data during CTD S52C4.

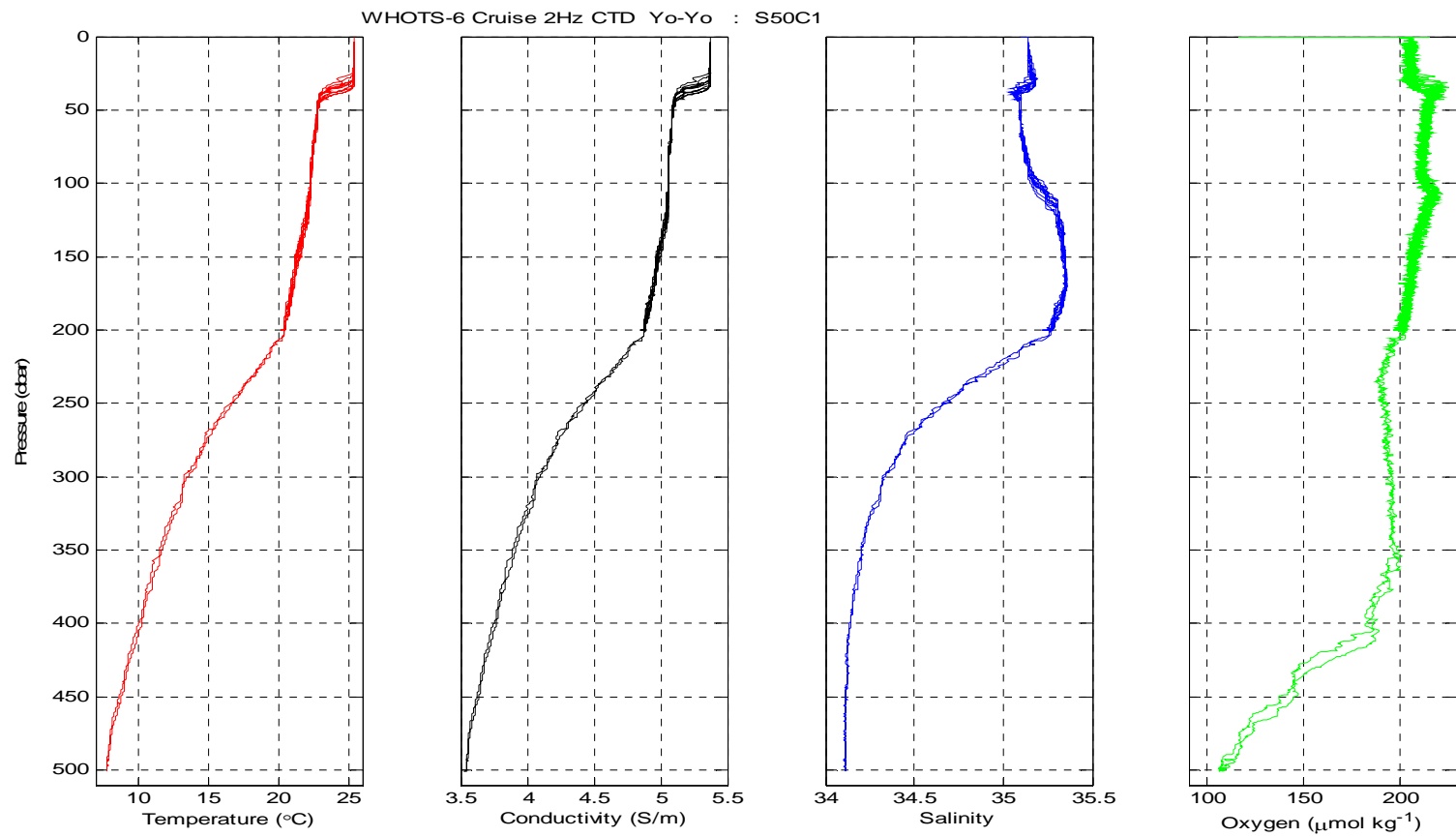


Figure B5. Profiles of 2 Hz temperature, conductivity, salinity, and oxygen data during CTD S50C1.

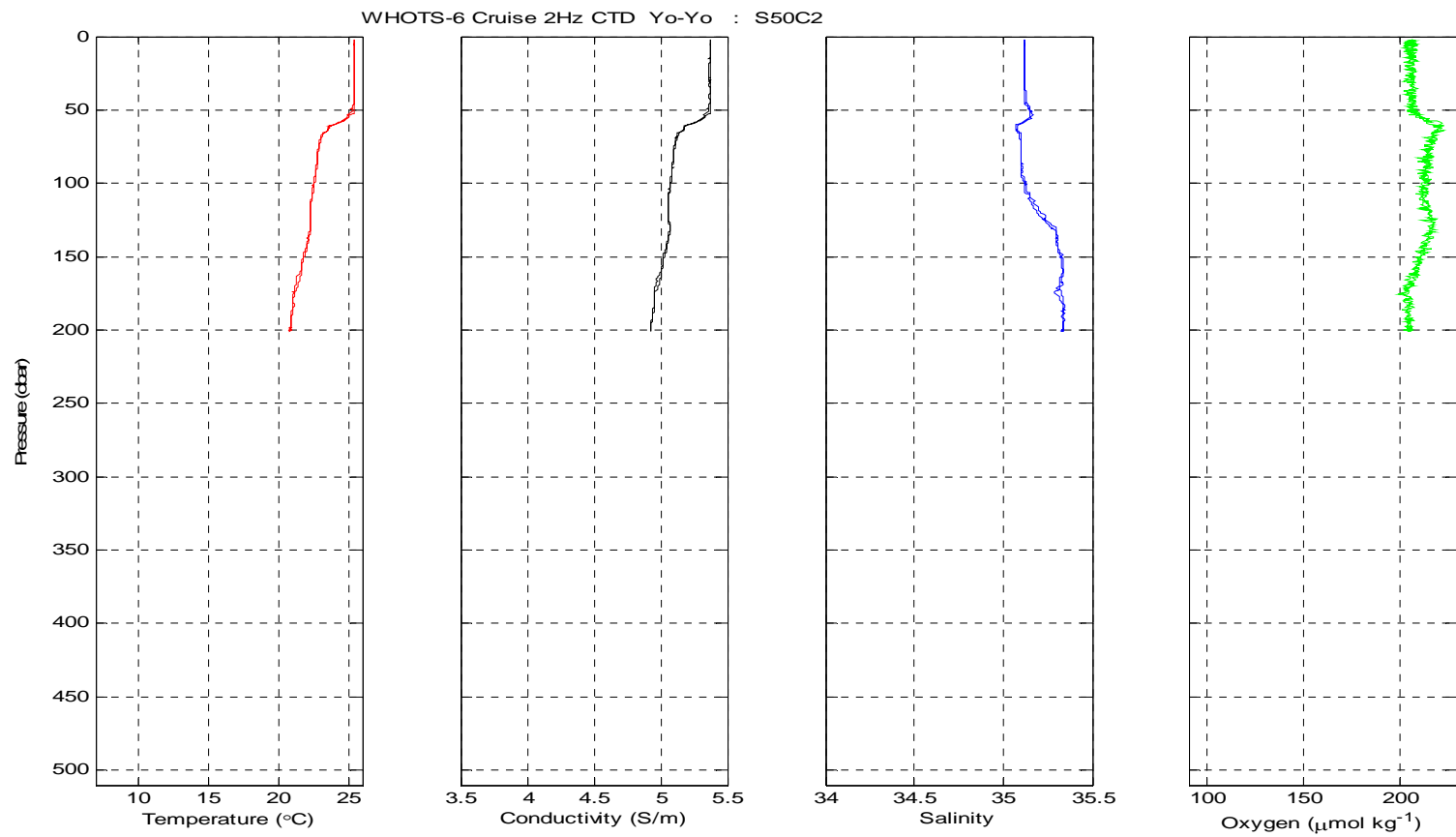


Figure B6. Profiles of 2 Hz temperature, conductivity, salinity, and oxygen data during CTD S50C2.

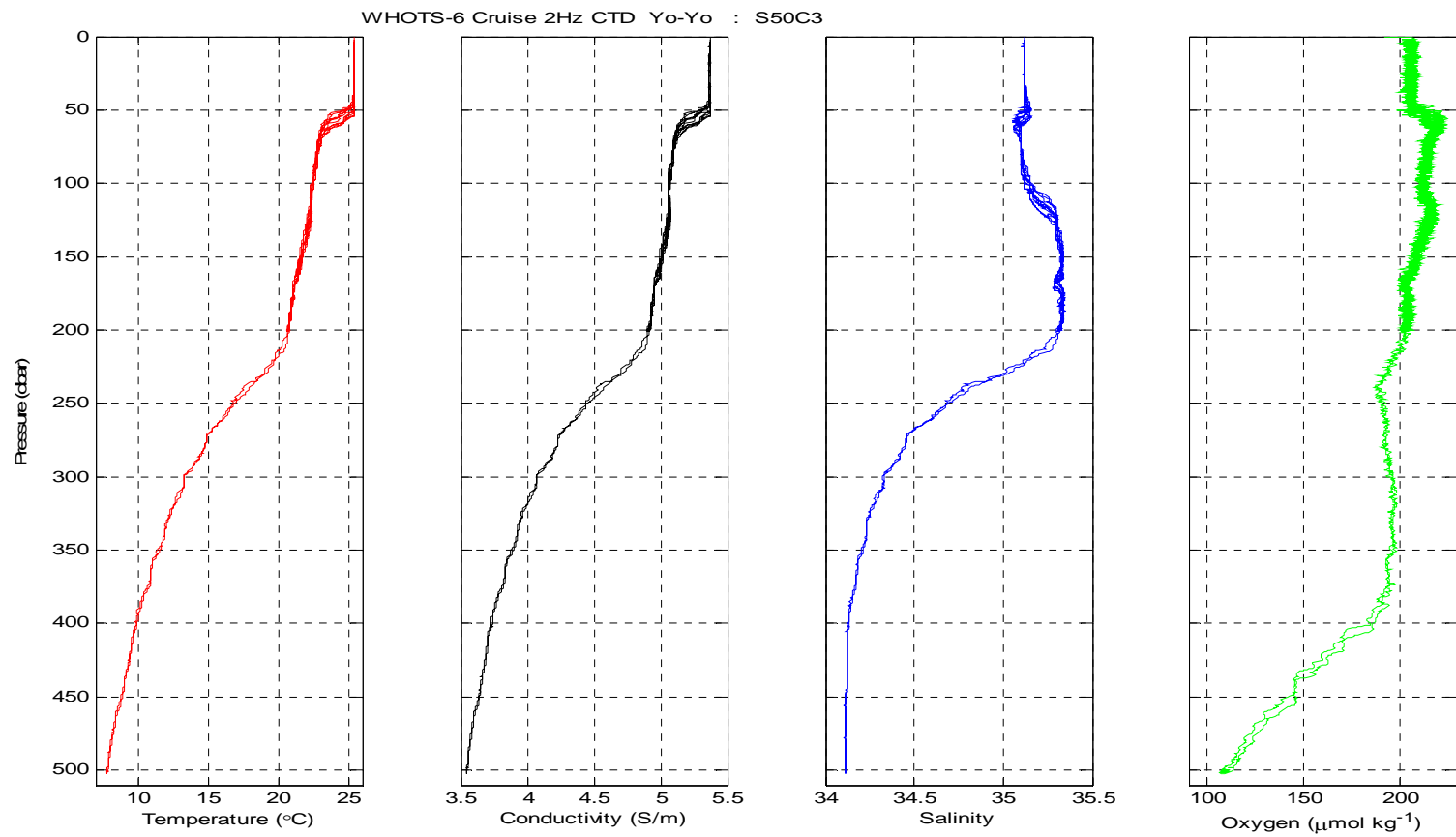


Figure B7. Profiles of 2 Hz temperature, conductivity, salinity, and oxygen data during CTD S50C3.

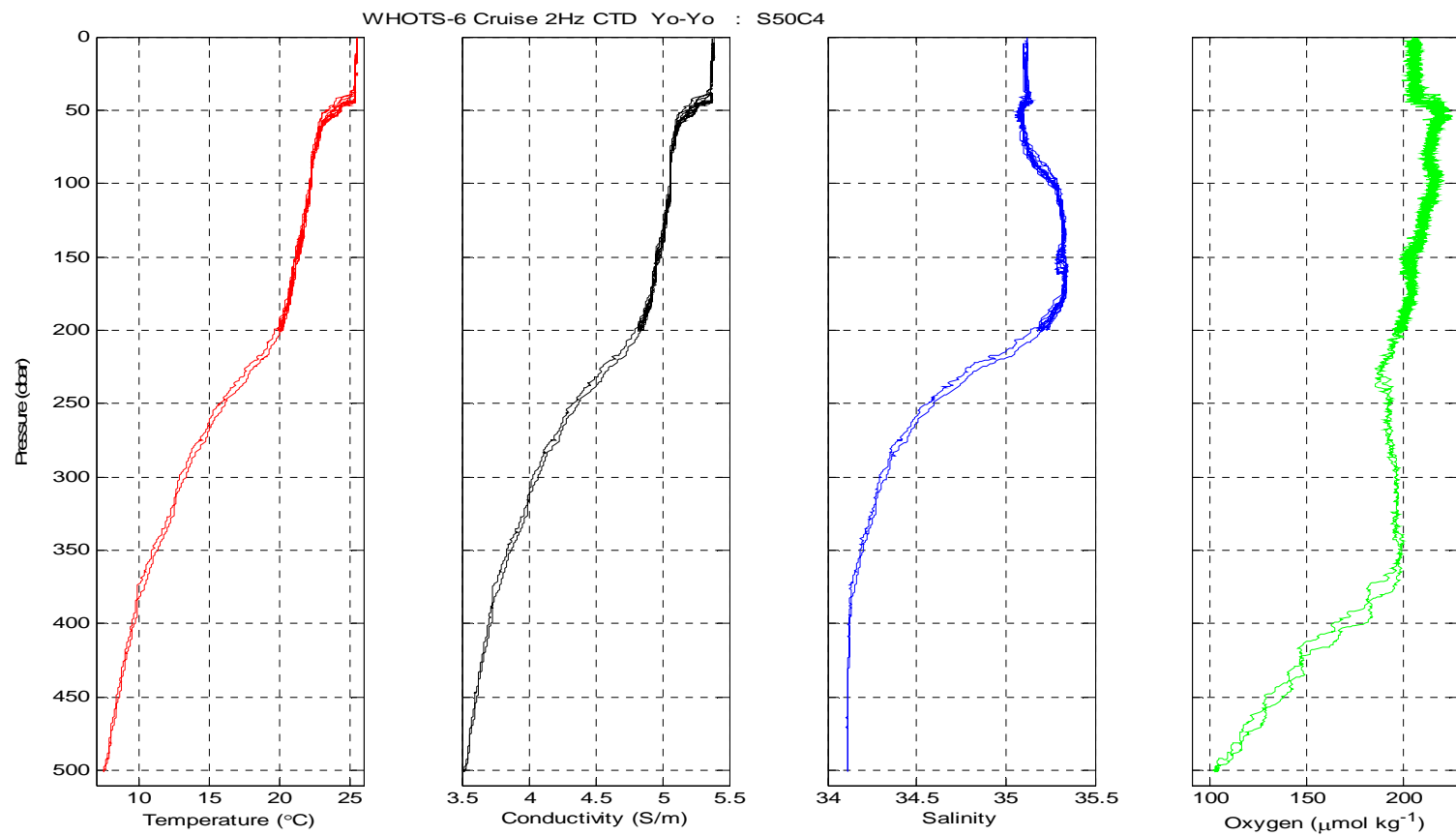


Figure B8. Profiles of 2 Hz temperature, conductivity, salinity, and oxygen data during CTD S50C4

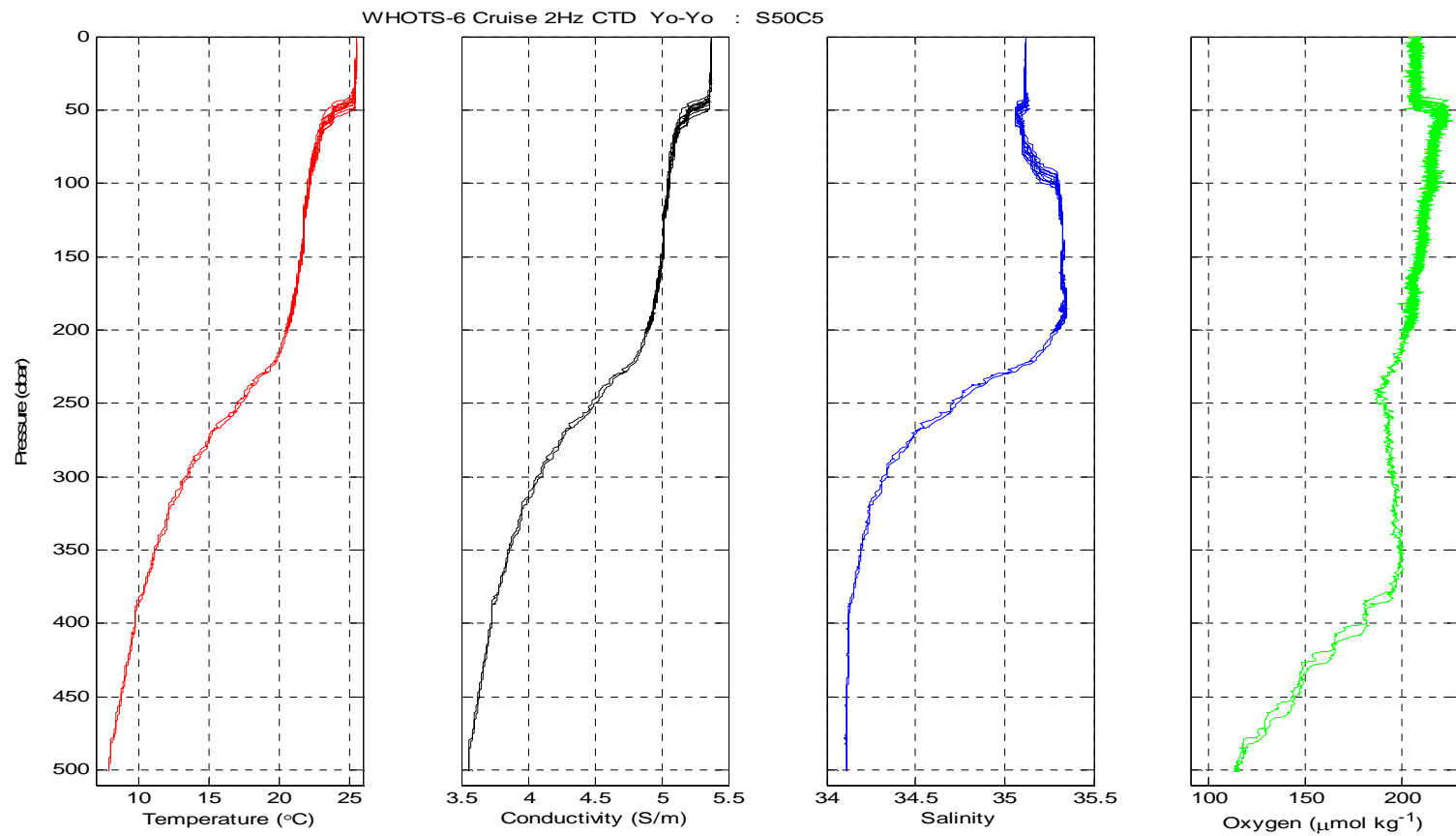


Figure B9. Profiles of 2 Hz temperature, conductivity, salinity, and oxygen data during CTD S50C5.

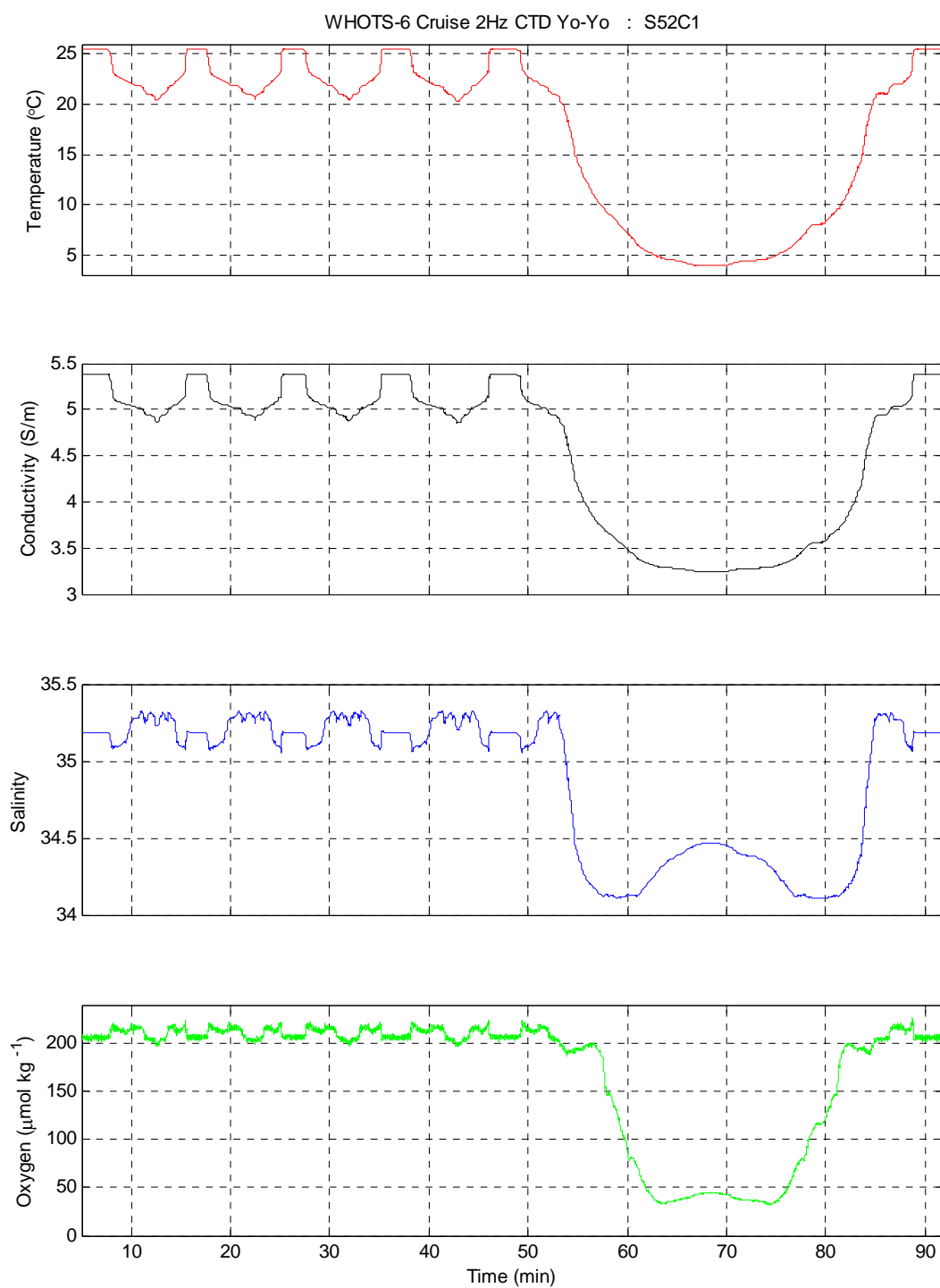


Figure B10. Profiles of 2 Hz temperature, conductivity, salinity, and oxygen data during CTD S52C1.

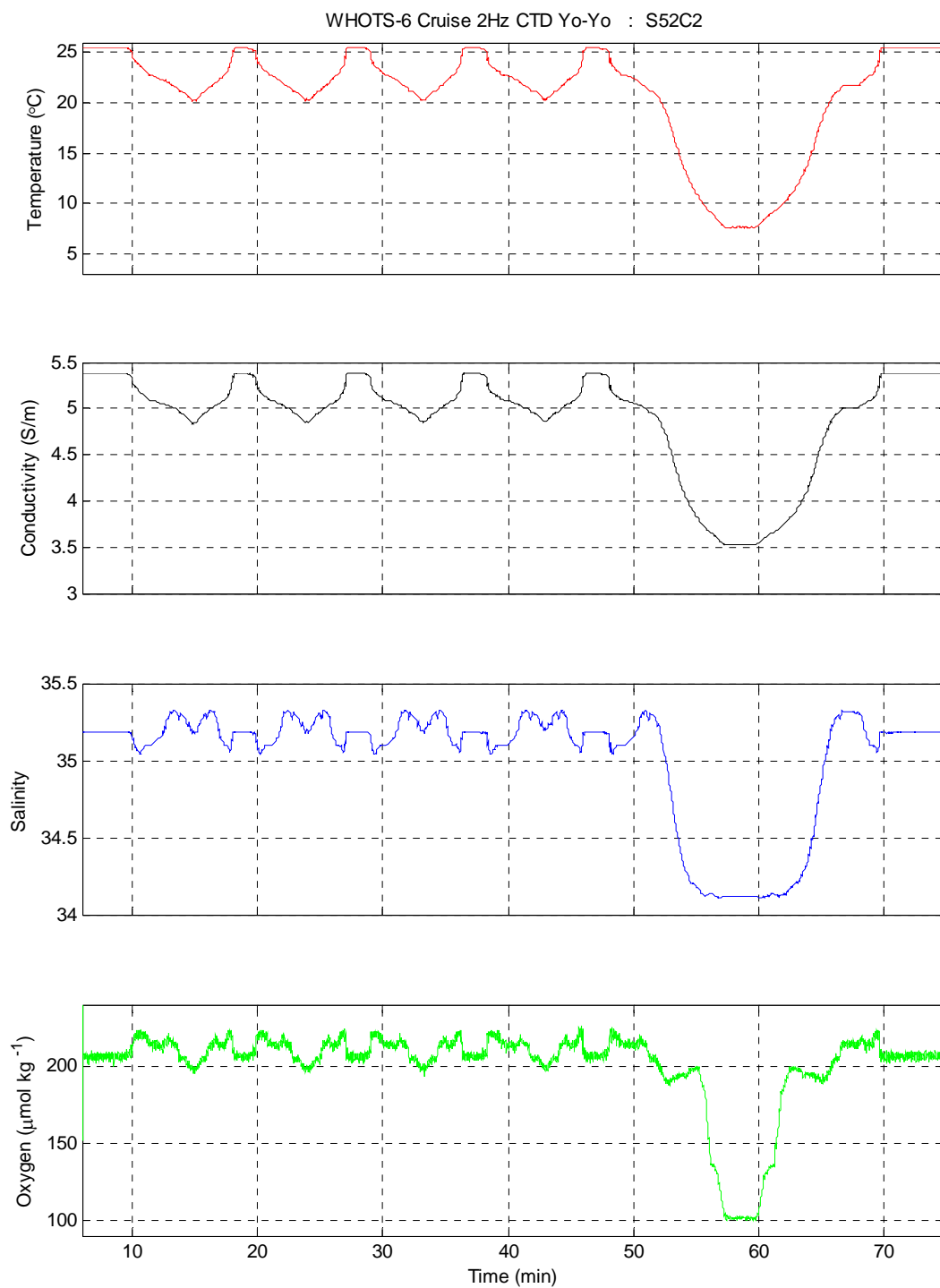


Figure B11. Time-series of 2 Hz temperature, conductivity, salinity, and oxygen data during CTD S52C2.

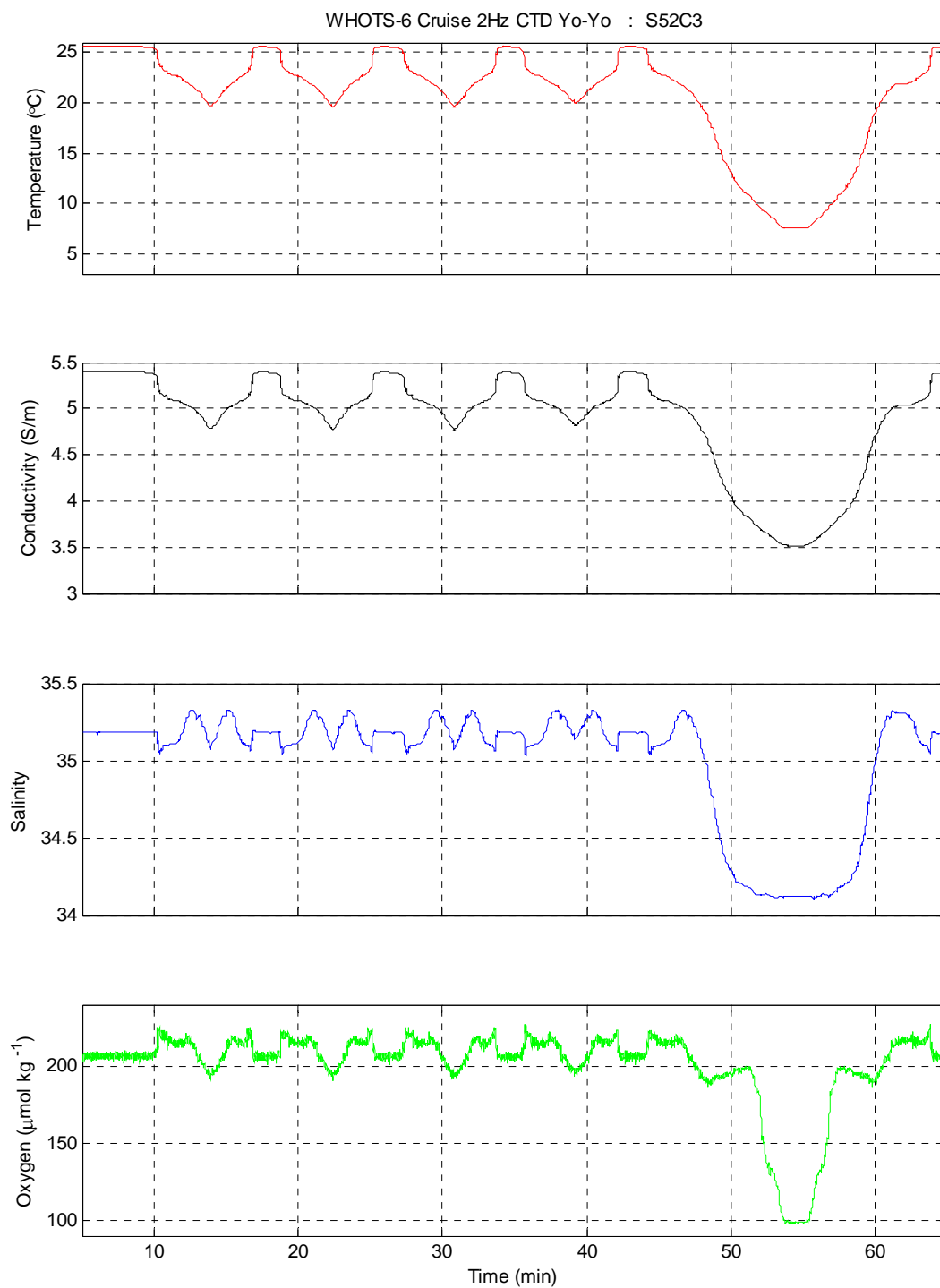


Figure B12. Time-series of 2 Hz temperature, conductivity, salinity, and oxygen data during CTD S52C3.

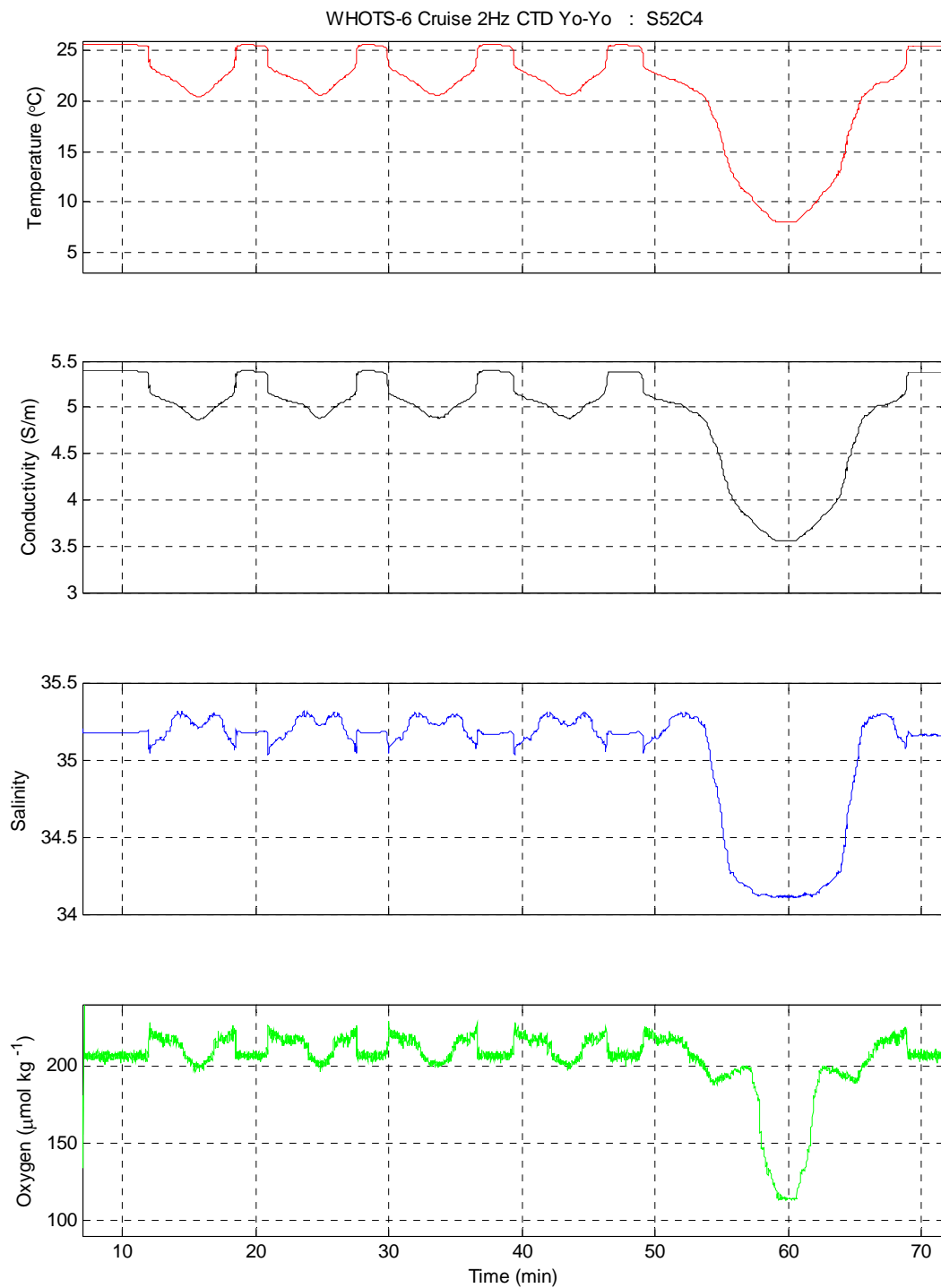


Figure B13. Time-series of 2 Hz temperature, conductivity, salinity, and oxygen data during CTD S52C4.

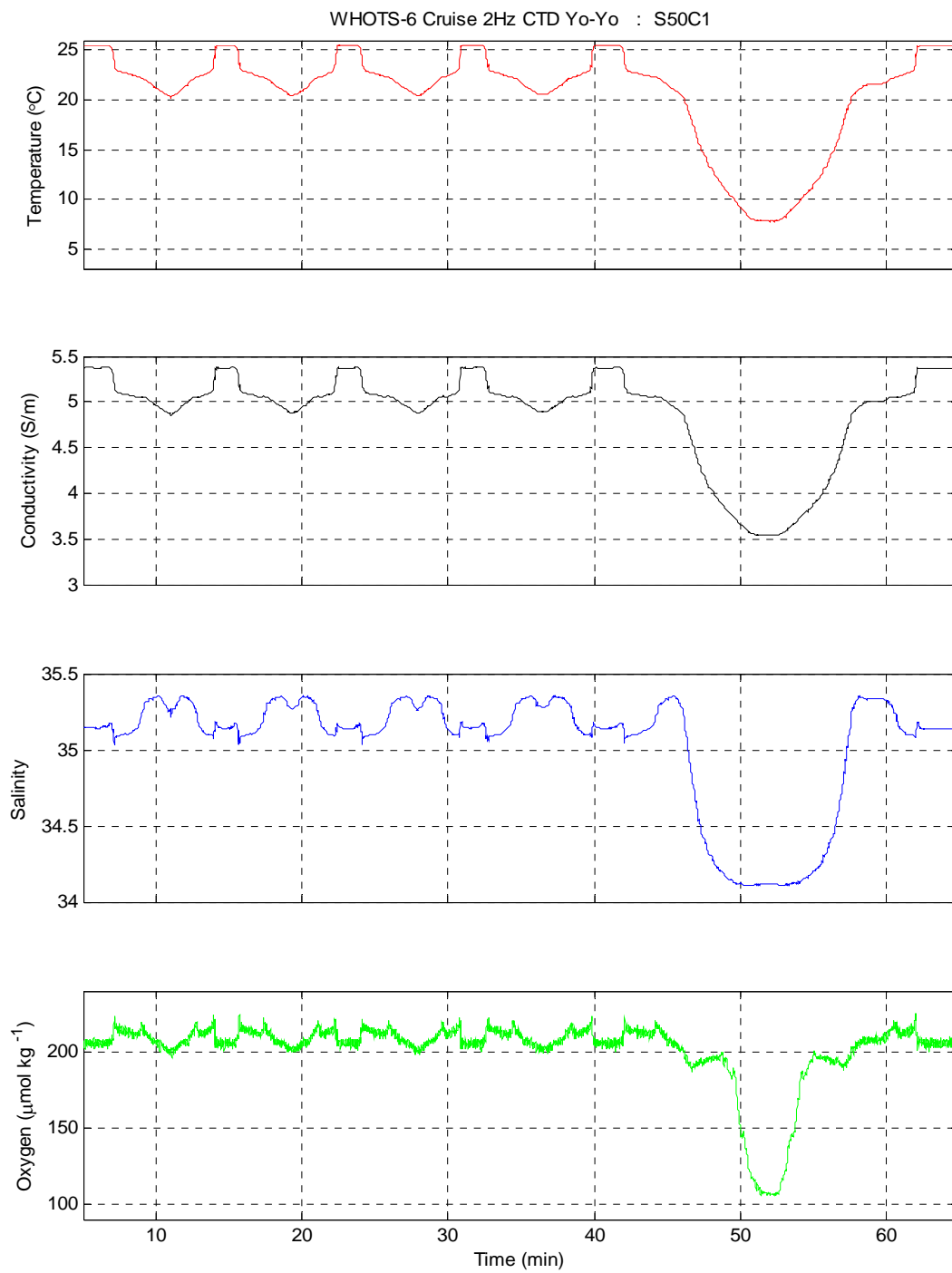


Figure B14. Time-series of 2 Hz temperature, conductivity, salinity and oxygen data during CTD S50C1.

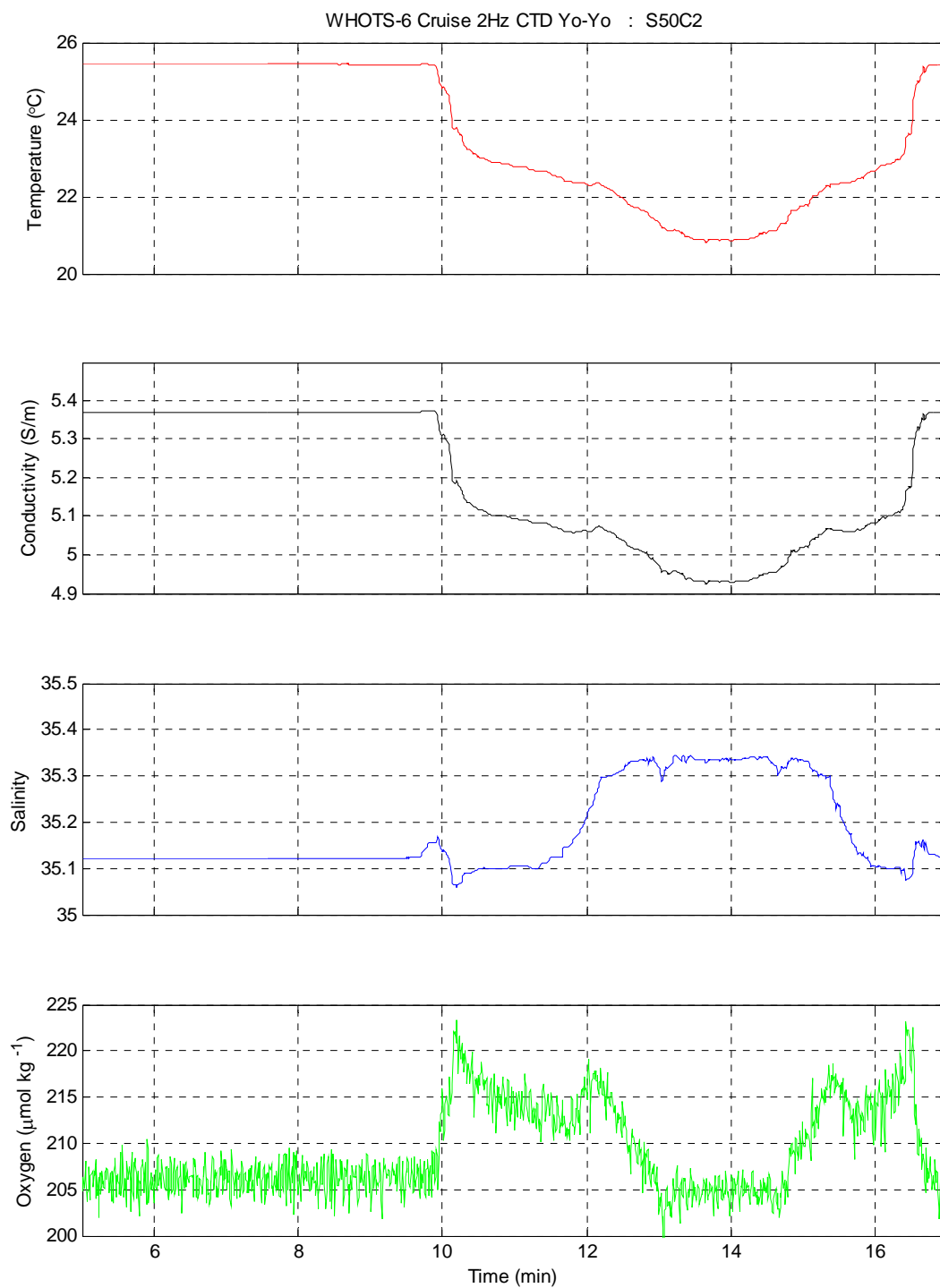


Figure B15. Time-series of 2 Hz temperature, conductivity, salinity, and oxygen data during CTD S50C2.

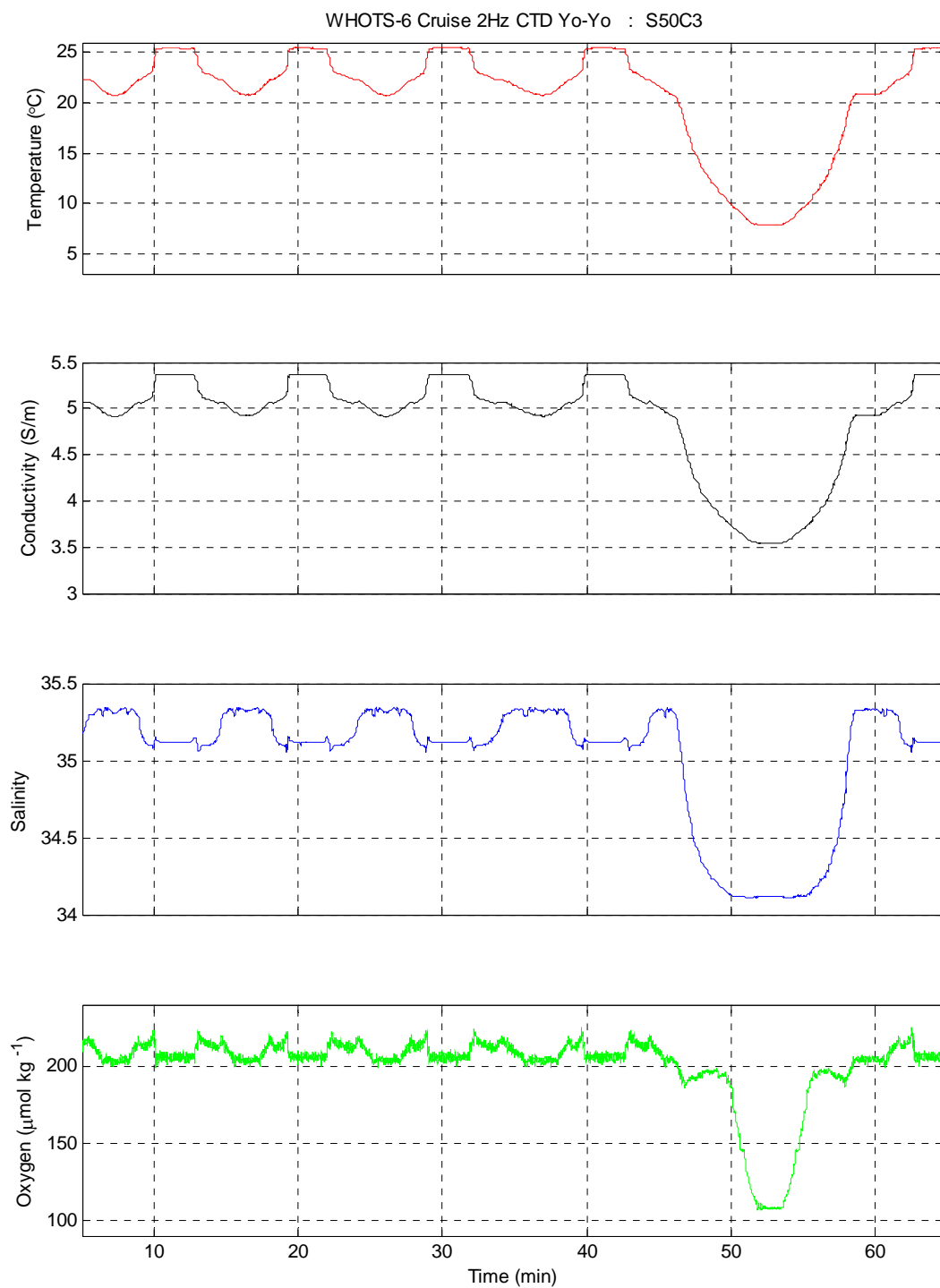


Figure B16. Time-series of 2 Hz temperature, conductivity, salinity, and oxygen data during CTD S50C3.

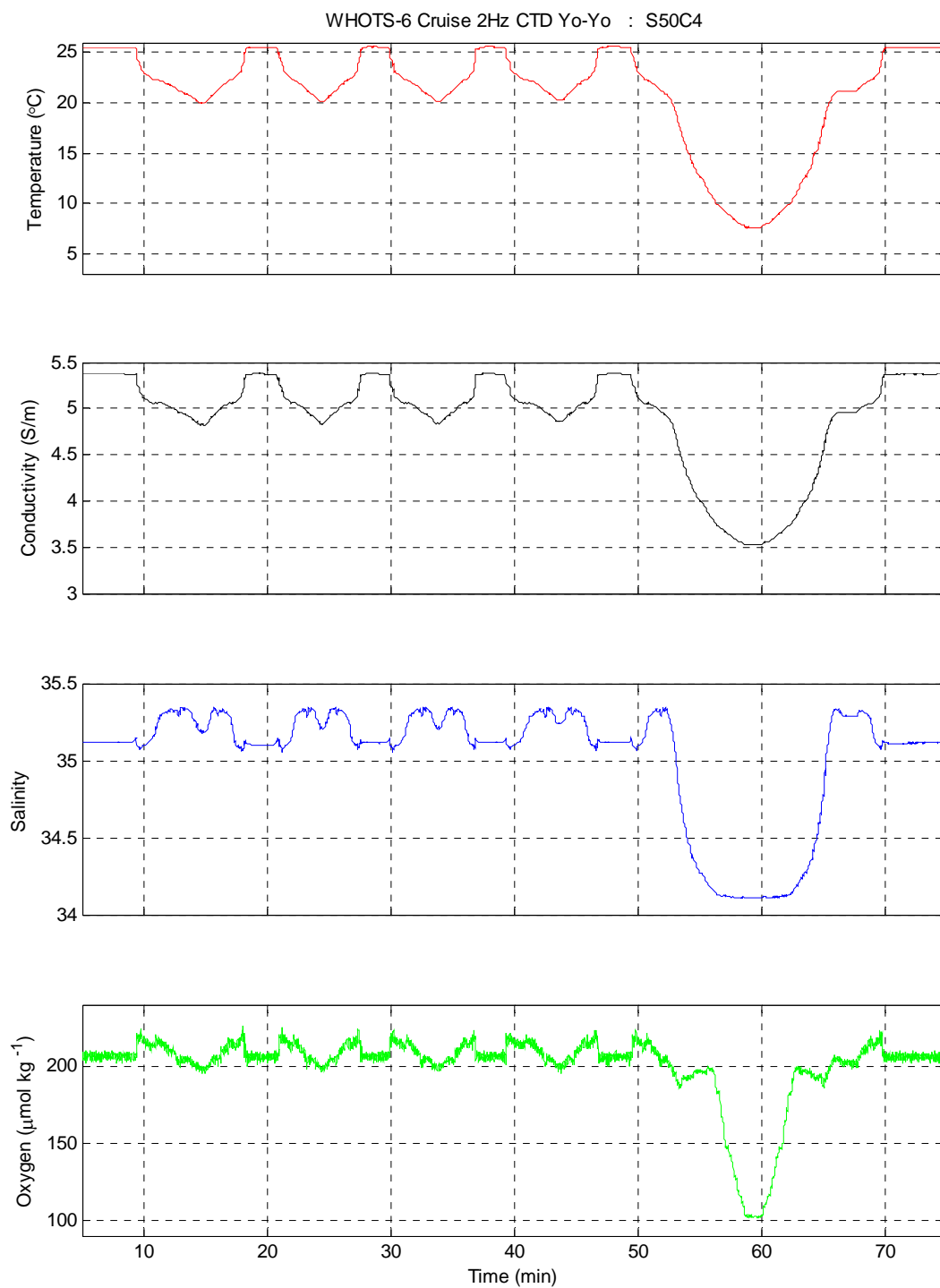


Figure B17. Time-series of 2 Hz temperature, conductivity, salinity, and oxygen data during CTD S50C4.

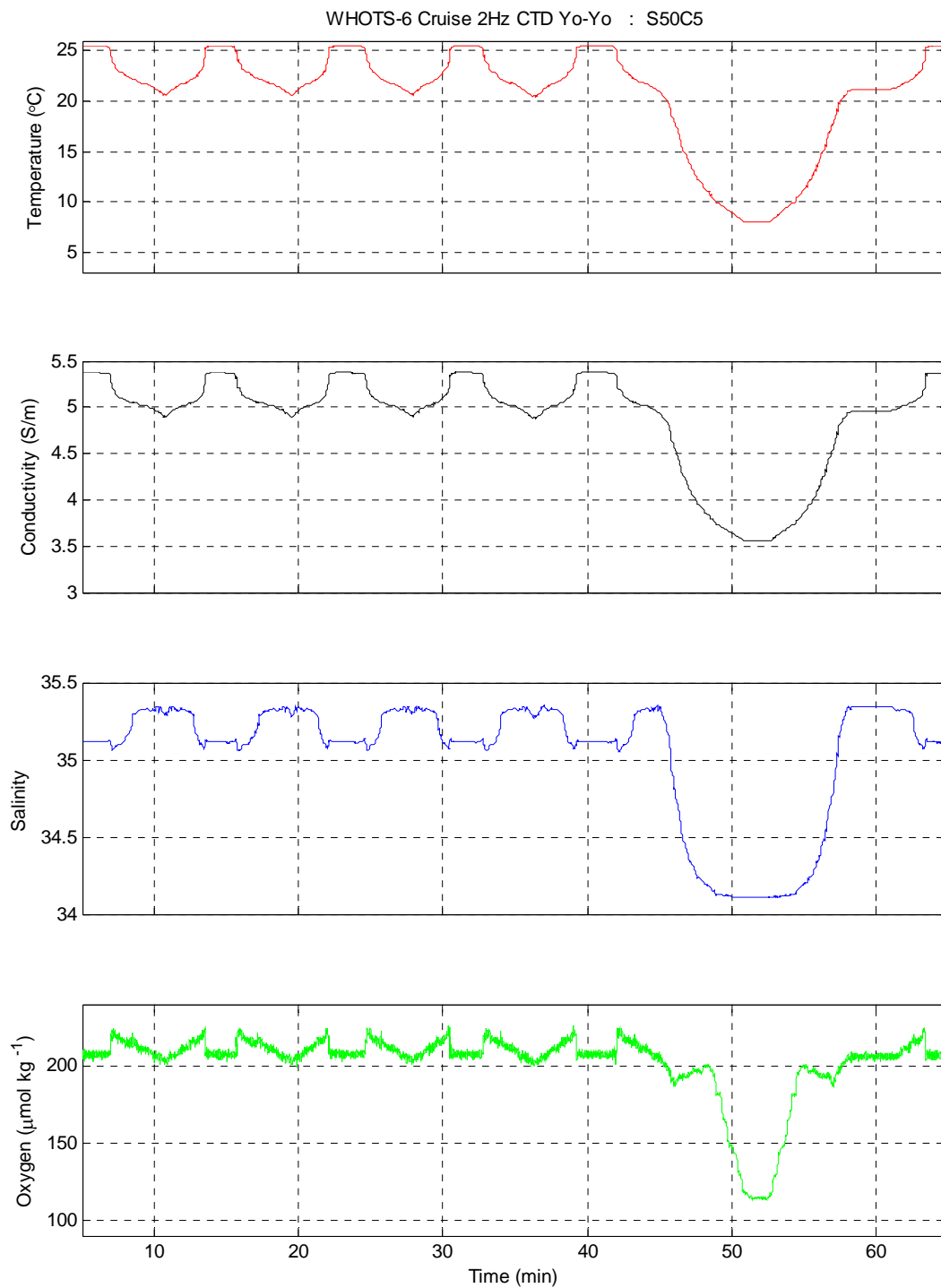


Figure B18. Time-series of 2 Hz temperature, conductivity, salinity, and oxygen data during CTD S50C5.

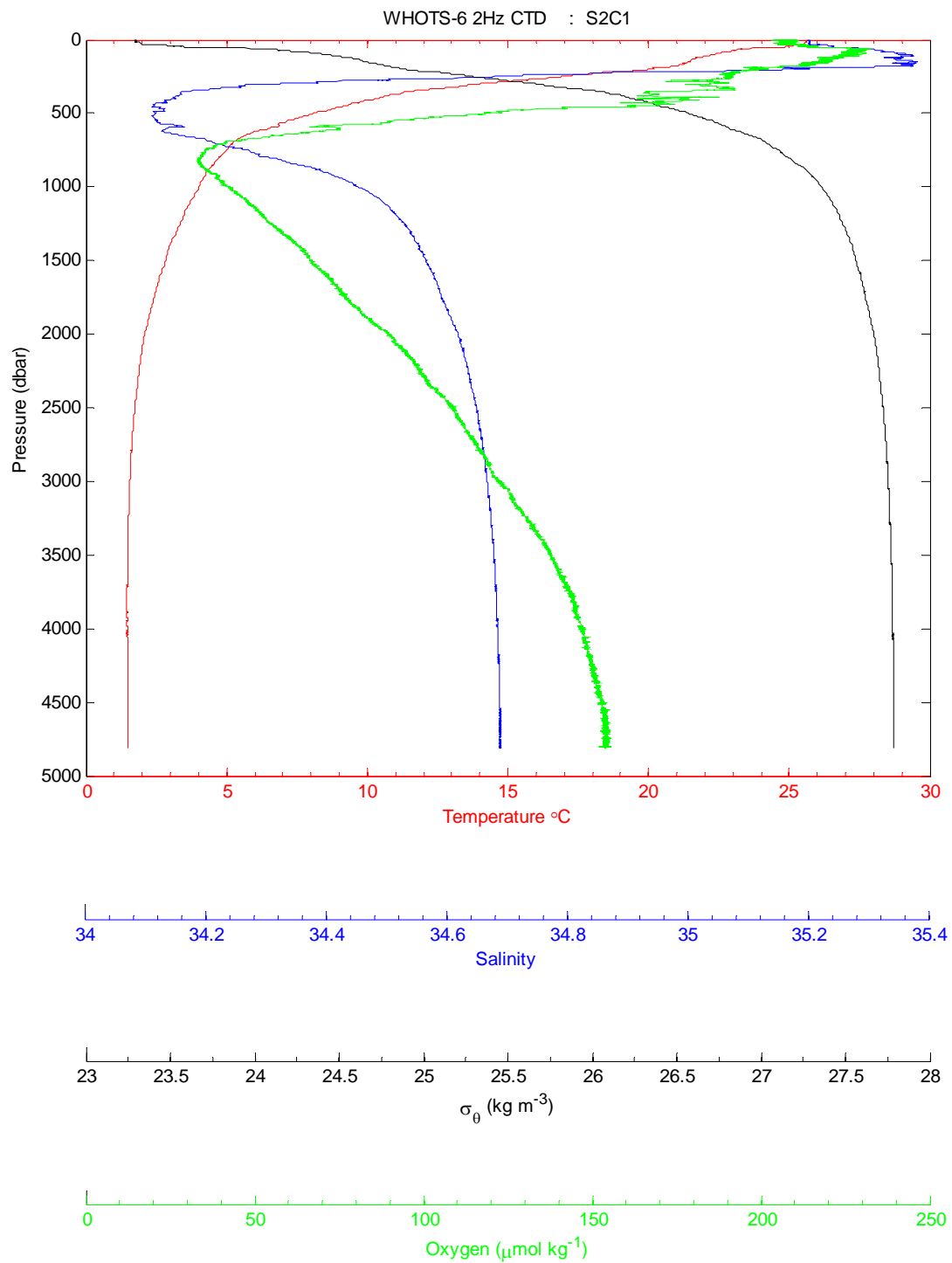


Figure B19. Profiles of 2 Hz temperature, salinity, sigma-theta and dissolved oxygen data plotted against pressure during CTD S2C1.

Appendix C. Thermosalinograph Figures

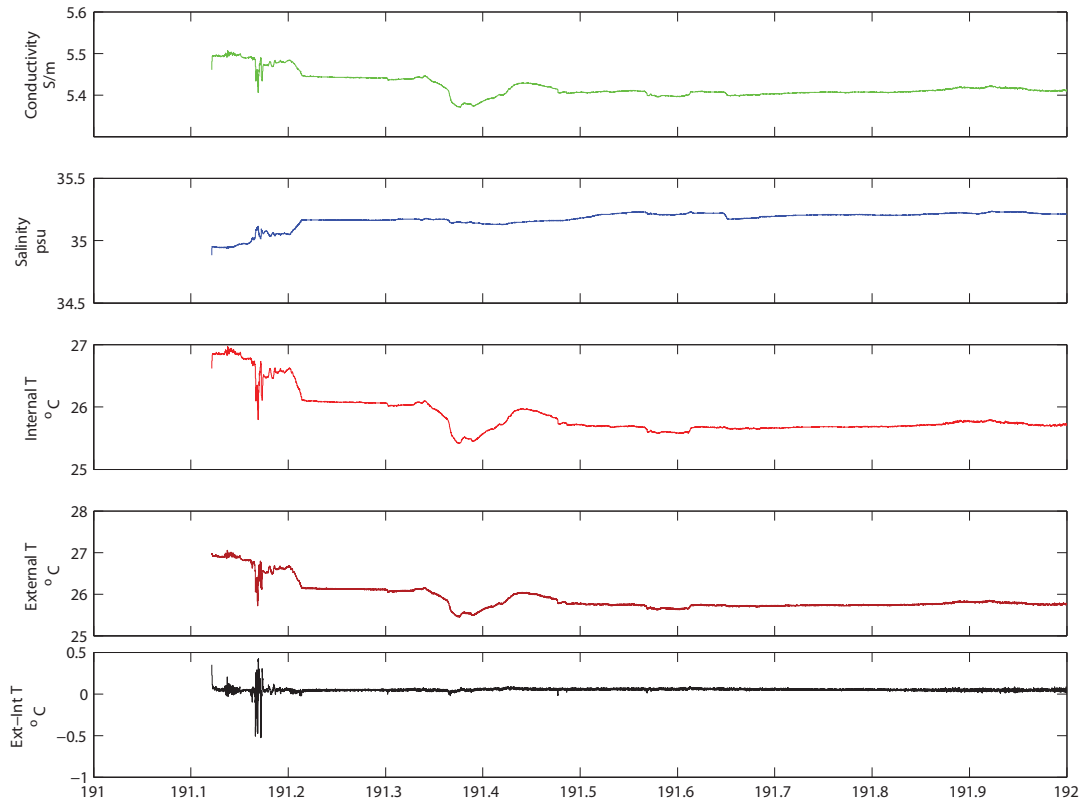


Figure C1. Time-series plots of thermosalinograph conductivity, salinity, internal sensor temperature, remote sensor temperature, and remote - internal temperature difference data during 10 July 2009. The time axis is in Julian days.

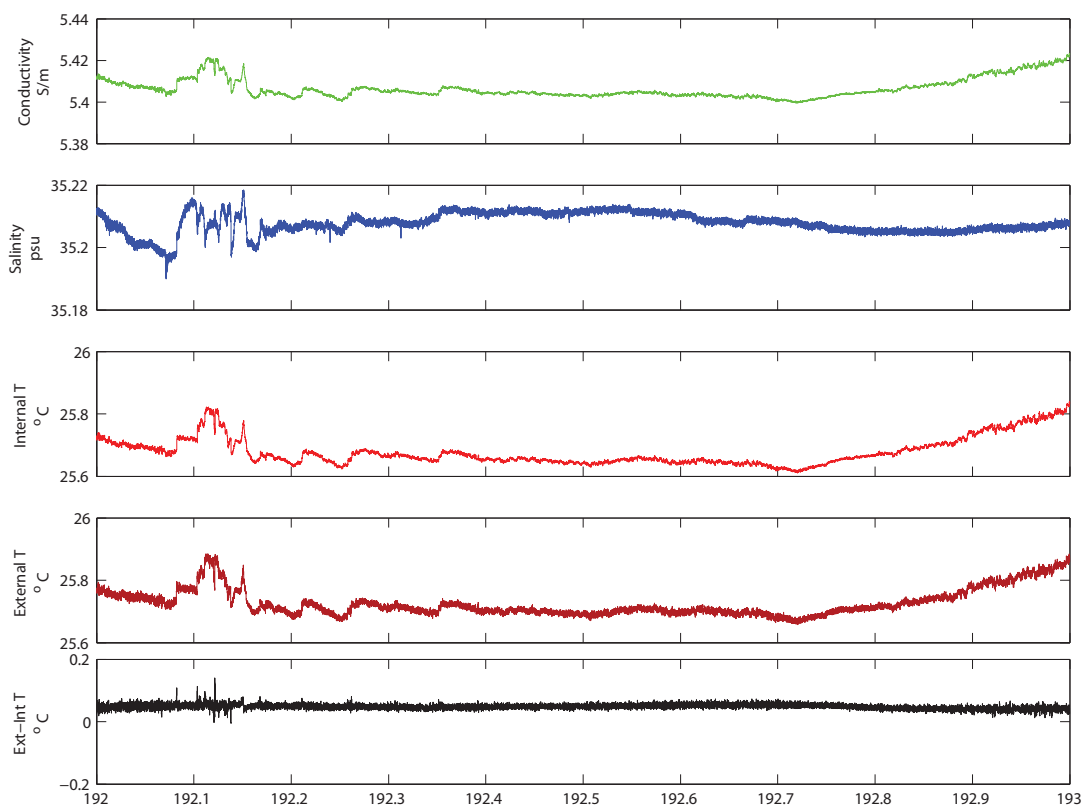


Figure C2. Time-series plots of thermosalinograph conductivity, salinity, internal sensor temperature, remote sensor temperature, and remote - internal temperature difference data during 11 July 2009. The time axis is in Julian days.

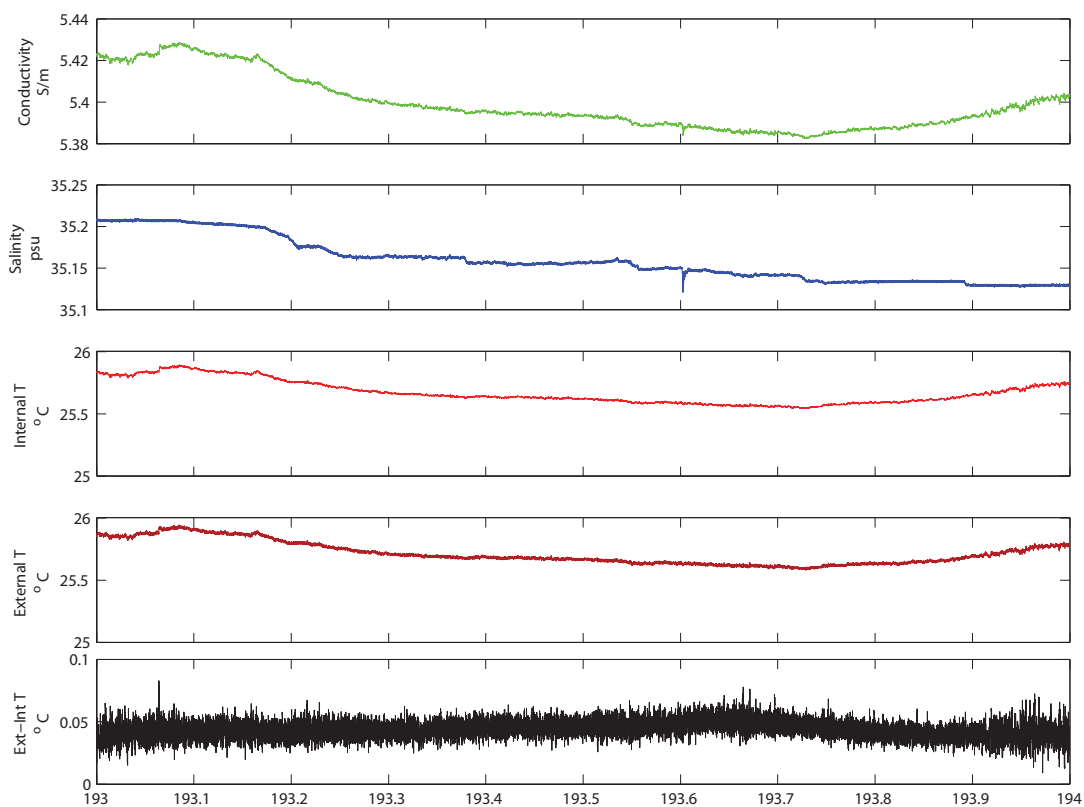


Figure C3. Time-series plots of thermosalinograph conductivity, salinity, internal sensor temperature, remote sensor temperature, and remote - internal temperature difference data during 12 July 2009. The time axis is in Julian days.

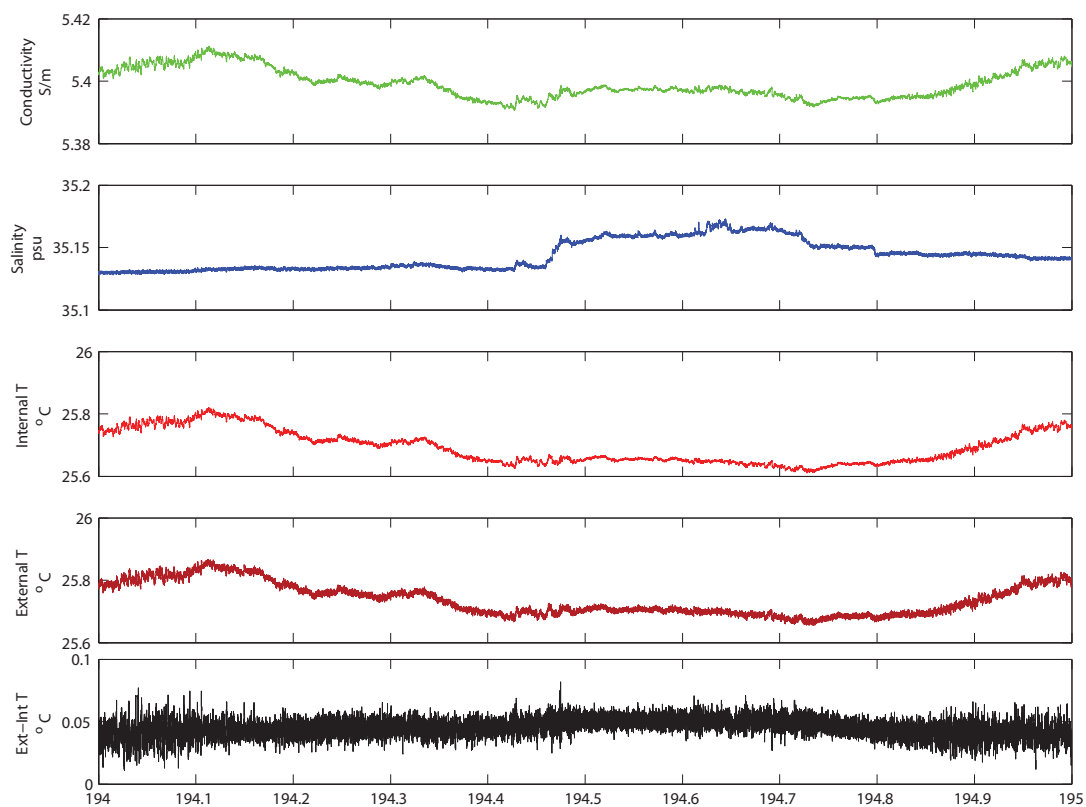


Figure C4. Time-series plots of thermosalinograph conductivity, salinity, internal sensor temperature, remote sensor temperature, and remote - internal temperature difference data during 13 July 2009. The time axis is in Julian days.

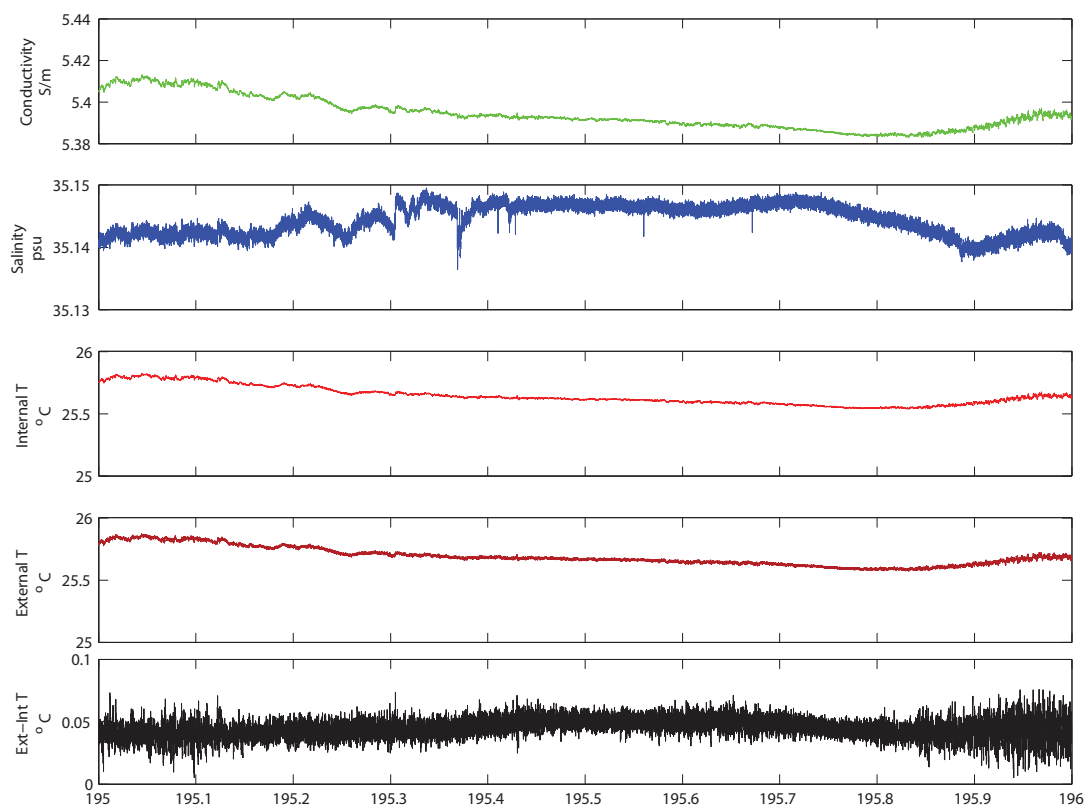


Figure C5. Time-series plots of thermosalinograph conductivity, salinity, internal sensor temperature, remote sensor temperature, and remote - internal temperature difference data during 14 July 2009. The time axis is in Julian days.

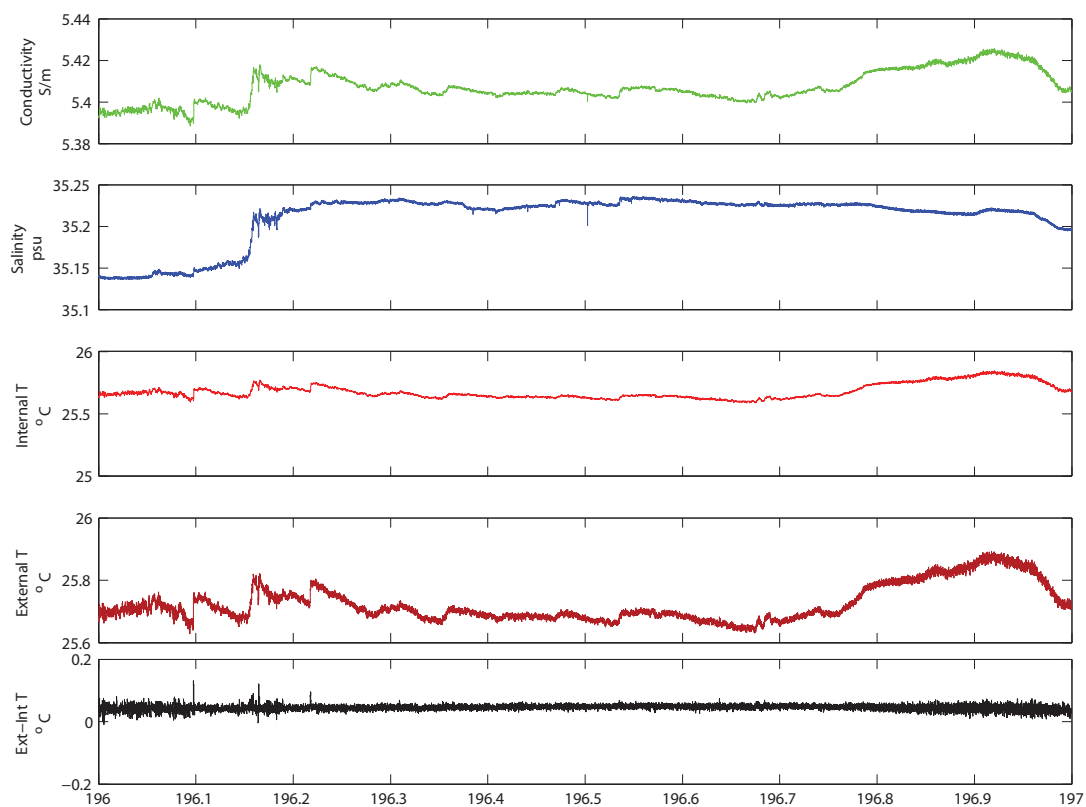


Figure C6. Time-series plots of thermosalinograph conductivity, salinity, internal sensor temperature, remote sensor temperature, and remote - internal temperature difference data during 15 July 2009. The time axis is in Julian days.

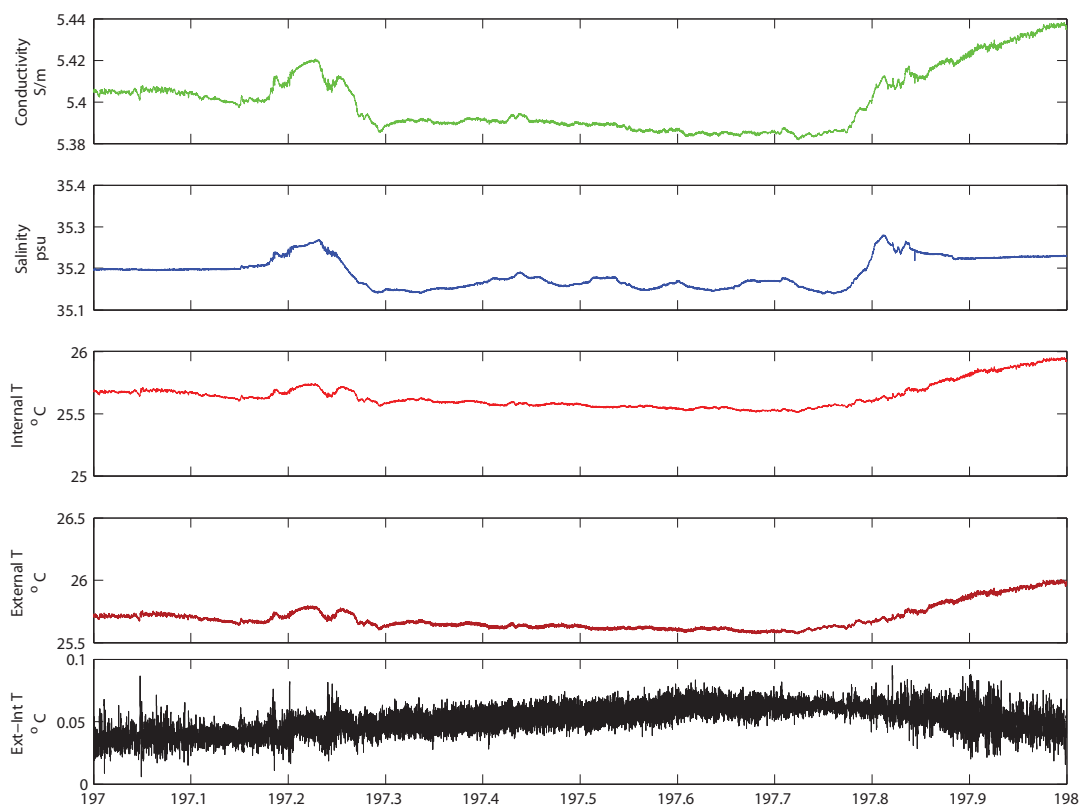


Figure C7. Time-series plots of thermosalinograph conductivity, salinity, internal sensor temperature, remote sensor temperature, and remote - internal temperature difference data during 16 July 2009. The time axis is in Julian days.

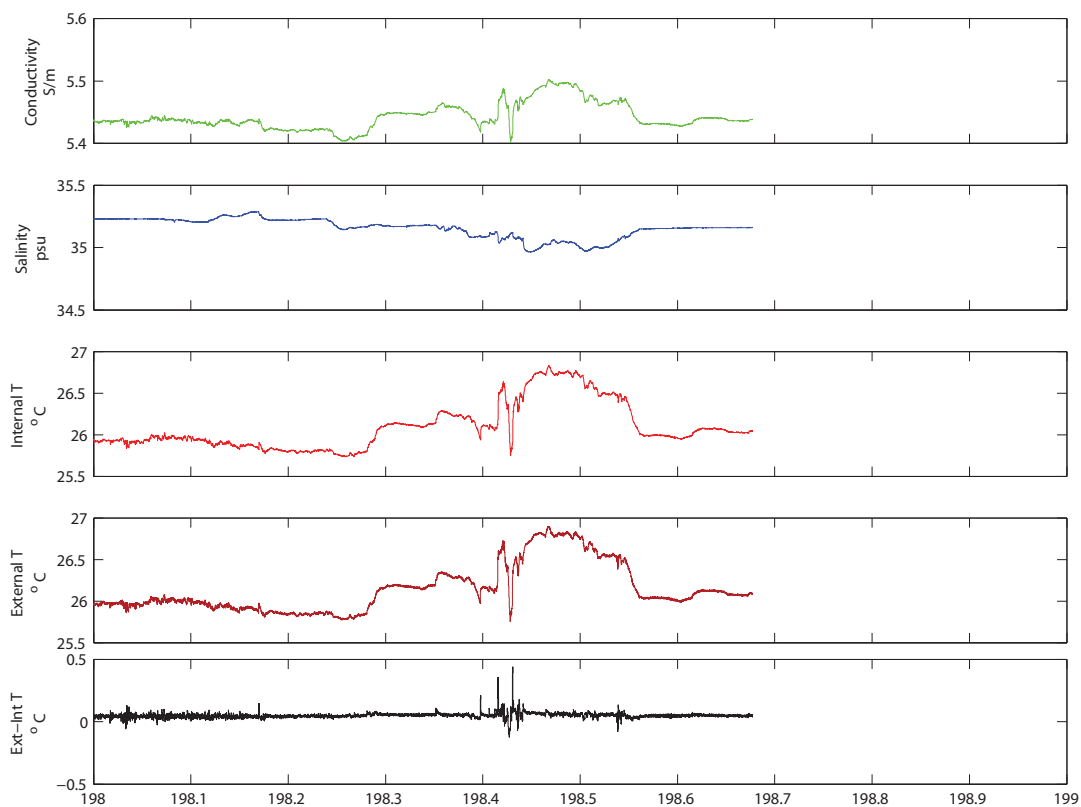


Figure C8. Time-series plots of thermosalinograph conductivity, salinity, internal sensor temperature, remote sensor temperature, and remote - internal temperature difference data during 17 July 2009. The time axis is in Julian days.