WHOI-2013-01

Woods Hole Oceanographic Institution

EcoMapper Operations---KN209-1

by

Benjamin A. Hodges and David M. Fratantoni

December 2012

Technical Report

Funding was provided by the National Aeronautics and Space Administration

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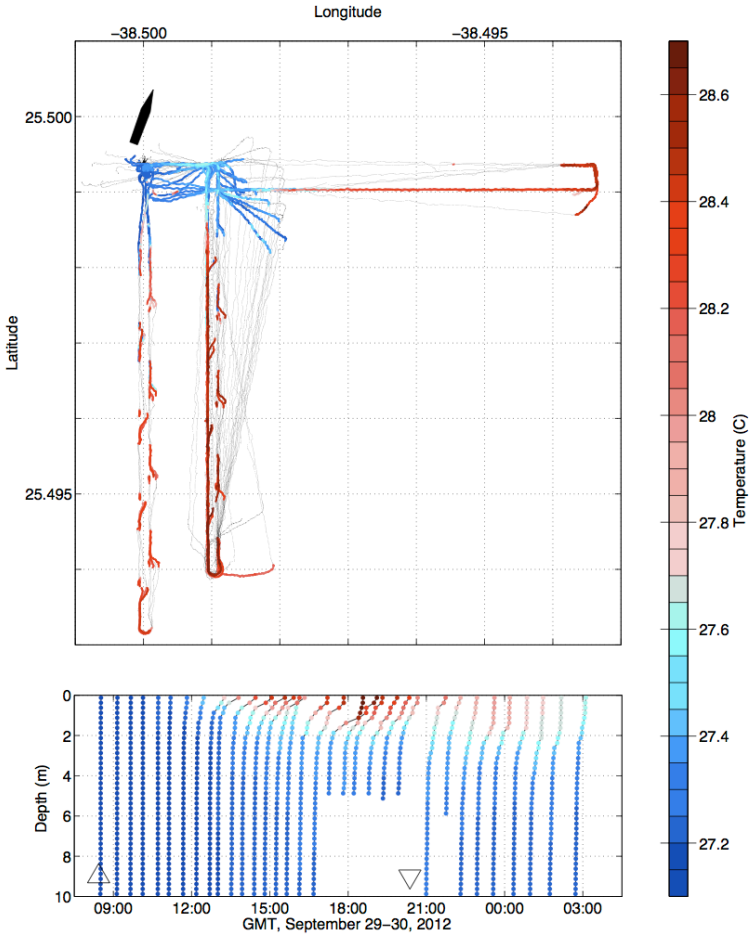

Woods Hole Oceanographic Institution
Woods Hole, MA 02543

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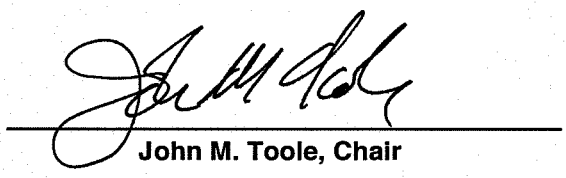

John M. Toole, Chair

Department of Physical Oceanography

Abstract

This report describes the collection of water property data from EcoMapper AUVs during the *R/V Knorr* 209-1 cruise as part of the SPURS (Salinity Processes Upper-ocean Regional Study) project. Post-processing was required to improve the quality of the raw data, particularly salinity, and is documented herein. Initial results from temperature and salinity records are presented. The measurements are concentrated in the upper 10 meters of the mixed layer during calm conditions, and reveal significant diurnal warming (up to 3°C) and salinification (up to 0.1 psu) of the surface (< 1 meter) layer. The mixing promoted by the motion of the research vessel destroys this shallow stratification, so the ability of the AUVs to sample undisturbed water hundreds of meters from the ship was critical to the effort of accurately resolving it.

Keywords: AUVs, salinity, diurnal cycles

Table of Contents

Introduction 4
Diurnal Stratification Experiment, 29-30 September 2012 5
Small Scale Horizontal Survey, 30 September 2012 9
Salinity Processing 10
Conductivity glitches 10
Sensor position and flushing rate 10
Conductivity cell thermal mass 10
Temperature sensor: response time and position relative to conductivity cell 10
High-frequency noise 11
Conductivity sensor drift 11
Processed data format 11
Acknowledgements 12
References 12
Appendix: Mission Description Figures 12

Figure 1: EcoMappers on deck just prior to deployment 4

Figure 2: Temperature measured during the diurnal stratification experiment 6

Figure 3: Evolution of salinity and temperature profiles during the diurnal stratification experiment 7

Figure 4: Objective map of temperature and average temperature profile during the survey experiment 9

Table 1: Diurnal stratification experiment mission descriptions 8

Introduction

OceanServer Technology, Inc., manufactures a small (~30 kg) propeller-driven autonomous underwater vehicle (AUV) called the Iver2. YSI, Inc., together with SonTek, outfits this vehicle with a suite of their sensors and sells it under a new name: EcoMapper. Capable of operating at depths of up to 200 meters at a maximum underwater speed of 3.5 knots, the AUV has an endurance of approximately 5 hours. Navigation is done by global positioning systems (GPS) at the surface and by compass and Doppler Velocity Log (DVL) when submerged.

This data report documents the use of EcoMappers during the *Knorr* 209-1 cruise, and the subsequent processing of the data they gathered. Dr. David Fratantoni was the principal investigator responsible for these operations. The *R/V Knorr* departed Woods Hole on September 6, 2012, and arrived in port in the Azores 33 days later, having spent the bulk of that period in the SPURS (Salinity Processes Upper Ocean Regional Study) area near 25°N, 38°W. For additional information about the cruise, see the Knorr 209-1 Cruise Report.

Two EcoMappers (serial numbers 106 and 107; Figure 1) completed a total of 34 science missions over 2 days as well as several test missions during the cruise. Each vehicle was equipped with a YSI conductivity, temperature, depth (CTD), a YSI oxygen sensor, a YSI chlorophyll fluorometer and turbidity sensor, a Neil Brown Ocean Sensors, Inc., CTD, and a 5-beam SonTek DVL. Their acoustic modems and sidescan sonars were not used.

Figure 1. EcoMappers on deck just prior to deployment from the fantail of the *R/V Knorr*.

Early in the cruise, both EcoMappers were lowered into the water as a rough ballast check. During this test, EcoMapper 107 detected a leak. Approximately 50 cc of water was found inside the pressure case; no damage was immediately apparent. Shortly thereafter, OceanServer announced by email that the propeller shaft seals they had just installed were a leak risk and needed to be repaired. Detailed instructions for the repair procedure, which consisted of adding a small spacer to the propeller shaft to prevent it from moving longitudinally, were obtained. A suitable spacer was located and installed in EcoMapper 107, which then passed leak tests in the lab and on deck in a bucket, where its propeller could be spun without risking damage.

Diurnal Stratification Experiment, 29-30 September 2012

Early on the morning of 29 September 2012, the *R/V Knorr* began holding station at 25° 30' N, 38° 30' W. At dawn, EcoMapper 106 was deployed, starting its first mission at 0820Z. Over the next 18.5 hours, EcoMapper 106 completed a total of 23 missions, and EcoMapper 107 completed 10. Each mission consisted of an outward leg to a distance of 600-700 meters from the ship, and a return leg following nearly the same track. The outbound legs were run either at the surface, at a constant depth of 1 meter, or undulating between depths of 0 and 5 meters. All of the return legs were undulating either between 0 and 5 or 0 and 10 meters. Twenty-eight of the missions ran to the south from the *R/V Knorr's* position; the remaining 5 ran to the east.

EcoMapper 107 did not complete normal undulations—she tended to stall at the bottom, seemingly slowing her descent rate to zero just above the desired depth and unsuccessfully attempting, often for tens of seconds, to descend the final few centimeters. The reason for this behavior is not known as of this writing. One possibility is a combination of ballasting error (vehicle tail-heavy or too light overall) and a non-optimal undulation algorithm. Several attempts were made to work around this problem, including adjustments to speed and dive angle, and missions with 'manual' undulations in which the vehicle was commanded to alternate between 0 and 5 meters at each waypoint (see Table 1).

In the morning, the surface layer was well mixed, but in the calm sunny conditions, significant stratification developed in the upper meter by midday. This stratification strengthened and deepened during the afternoon, reaching 1.5° C in temperature and 0.02 psu in salinity. Toward sunset it began to decay, and by 0200 local time it had weakened considerably, particularly in temperature (Figure 2, lower panel). To capture the evolution of this diurnal stratification, it is important to sample undisturbed water, far enough from the ship to avoid the churning of its screws and the mixing it causes as it bobs in the waves. The homogenizing influence of the ship on the upper meter or 2 is obvious out to a radius of over 2 ship-lengths (Figure 2, upper panel).

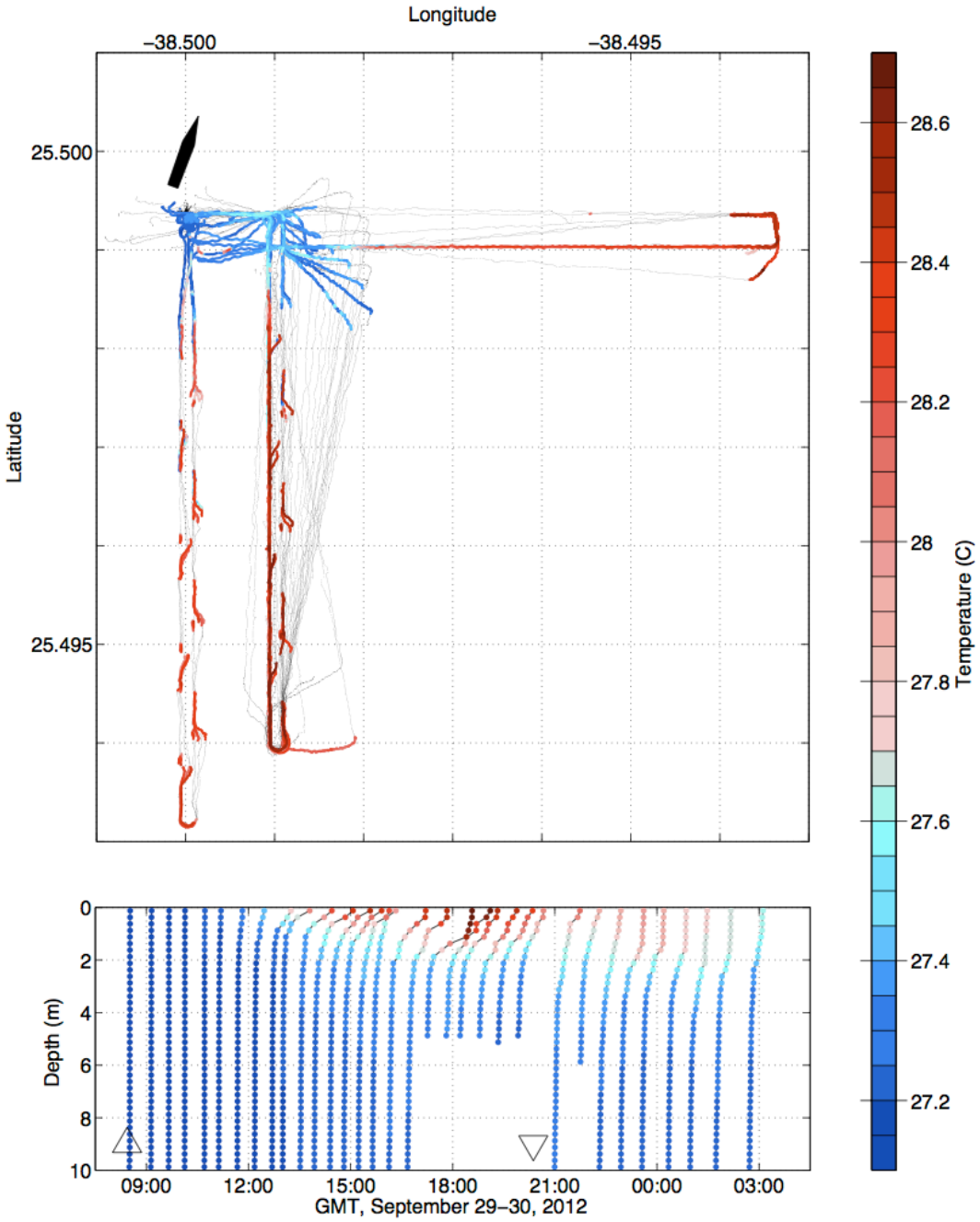

Figure 2. Temperature measured during the diurnal stratification experiment. Upper panel: tracks from all 33 missions; temperatures of the upper 30 cm made between 1300Z and 2000Z (the period of maximum stratification) are indicated by color. Segments of the tracks from other time periods and deeper layers are drawn lightly. Lower panel: average temperature profile, excluding contaminated measurements near the ship, for each of the 33 missions. Each profile is plotted at the time it was measured. The horizontal scaling of temperature is 1° C = 1 hour. Sunrise and sunset are indicated by upward and downward triangles, respectively.

The stratification signal in salinity is weaker than that in temperature, but the influence of evaporation is clear. Early in the day, the sampled water column was nearly homogenous. At midday, the salty surface layer was confined to the upper meter. By the end of the experiment, it had extended to a depth of 4 meters (Figure 3).

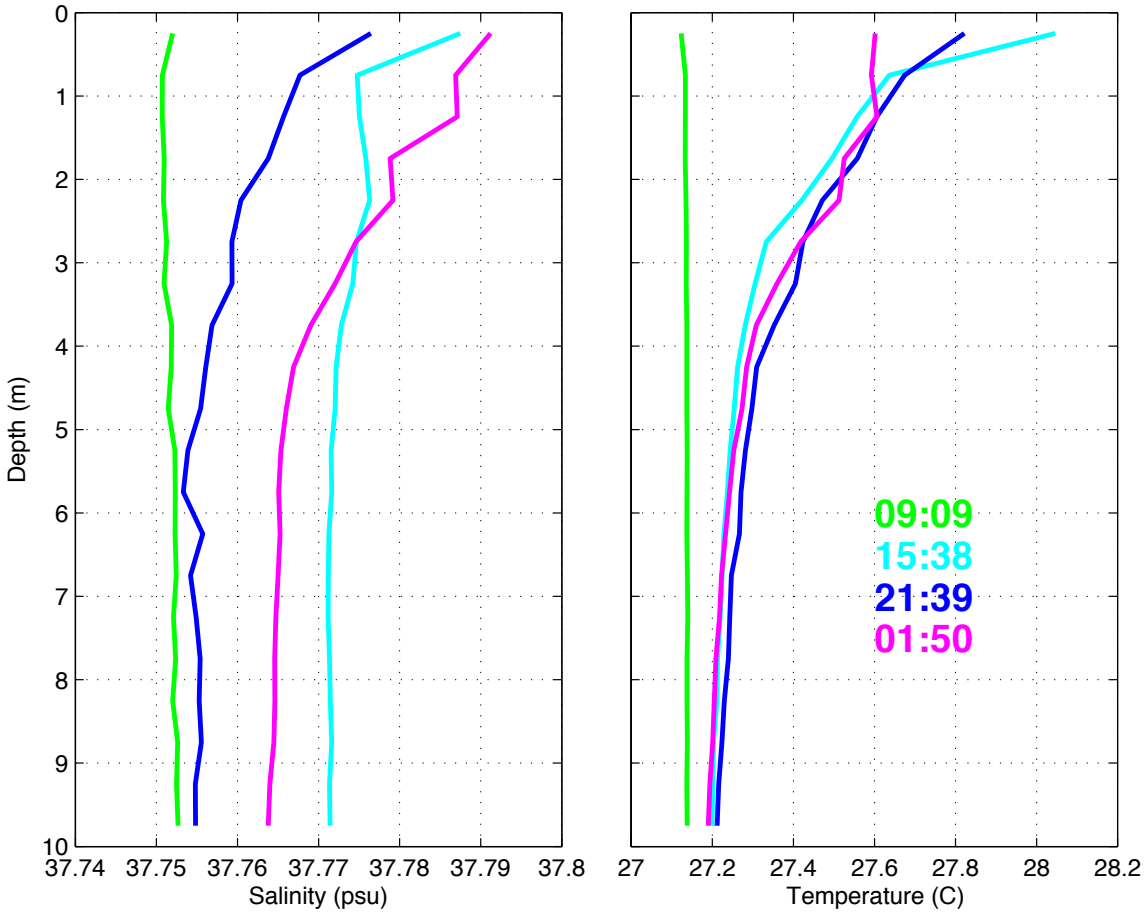

Figure 3. The evolution of the salinity (left) and temperature (right) profiles during the diel stratification experiment. Each vertical profile is formed by averaging 3 consecutive missions: 1-3, 15-17, 25-27, and 31-33, respectively. The 0.5-m bin averages include all measurements made at least 300 m from the *R/V Knorr*. The mean time (UTC) of the 3 missions used in each composite profile is printed in the corresponding color in the right-hand panel.

Table 1. Diurnal stratification experiment mission descriptions

Mission	Iver S/N	Date	Time (UTC)	Filename	Comments
	106	9/29/12	8:10		Vehicle deployed
1	106	9/29/12	8:20	20120929_082221_spurs_0_und_IVER2-106	Surface/undulate to 10, south
	106	9/29/12	8:54		Quit UVC, mission accidentally cancelled
2	106	9/29/12	9:00	20120929_085932_spurs_0_und_IVER2-106	Surface/undulate to 10, south, back 09:23
3	106	9/29/12	9:31	20120929_093020_spurs_1_und_IVER2-106	1 meter/undulate to 10, south, missed wpt circle at turn, back 09:51
4	106	9/29/12	9:57	20120929_095638_spurs_0_und_IVER2-106	Surface/undulate to 10, south, 75% battery
5	106	9/29/12	10:27	20120929_102727_spurs_1_und_IVER2-106	1 meter/undulate to 10, south, 70% --> 64% battery
6	107	9/29/12	11:00	20120929_105958_spurs_0_und_IVER2-107	Surface/undulate to 10, south, 92% --> 87%, weird undulations (stalls at bottom)
	106	9/29/12	11:05		Vehicle recovered; 1 T water in aftmost tail cavity
7	107	9/29/12	11:33	20120929_113233_spurs_0_und_IVER2-107	Surface/undulate to 10, south, 86% battery
8	107	9/29/12	12:03	20120929_120259_spurs_0_und_IVER2-107	Surface/undulate to 10, south, 79% --> 74%, change to 25 deg dive angle
9	107	9/29/12	12:34	20120929_123435_spurs_0_und_fast_IVER2-107	Surface/undulate to 10, south, 72%, change to 3.5 kt underwater
	106	9/29/12	12:45		Vehicle deployed
10	106	9/29/12	12:50	20120929_124959_spurs_0_und_IVER2-106	Surface/undulate to 10, south, 93%
	107	9/29/12	13:10		Vehicle recovered; LEAK! during park
11	106	9/29/12	13:19	20120929_131930_spurs_1_und_IVER2-106	1 meter/undulate to 10, south, 87%
12	106	9/29/12	13:46	20120929_134626_spurs_0_und_E_IVER2-106	Surface/undulate to 10, east, 80%; change to east (ship wake?)
13	106	9/29/12	14:13	20120929_141341_spurs_1_und_E_IVER2-106	1 meter/undulate to 10, east, 75% --> 69%, back 14:32
14	106	9/29/12	14:37	20120929_143746_spurs_0_und_E_IVER2-106	Surface/undulate to 10, east, 69% -->64%, back 14:57
15	106	9/29/12	15:03	20120929_150258_spurs_0_und_E_IVER2-106	Surface/undulate to 10, east, 64% -->59%
16	106	9/29/12	15:28	20120929_152802_spurs_1_und_E_IVER2-106	1 meter/undulate to 10, east, 59% -->52%, back 15:47
17	106	9/29/12	15:54	20120929_155338_spurs_0_und_IVER2-106	Surface/undulate to 10, south, 52% --> 46%, back 16:14
18	106	9/29/12	16:28	20120929_162821_spurs_0_und_IVER2-106	Surface/undulate to 10, south
	106	9/29/12	17:00		Vehicle recovered
	107	9/29/12	17:00		Vehicle deployed
19	107	9/29/12	17:02	20120929_170135_spurs_0_und_shallow_IVER2-107	Surface/undulate to 5, south, 89% -->83%, back 17:23
20	107	9/29/12	17:34	20120929_173410_spurs_square_wave_IVER2-107	Surface/square wave to 5, south, 82% --> 76%, back 17:55
21	107	9/29/12	17:59	20120929_175949_spurs_square_wave_IVER2-107	Surface/square wave to 5, south, 75% -->71%, back 18:18
22	107	9/29/12	18:34	20120929_183407_spurs_square_19_IVER2-107	Surface/square wave to 5, 19 deg dive angle, south, 68% -->63%, back 18:52
23	107	9/29/12	19:08	20120929_190720_spurs_square_19_IVER2-107	Surface/square wave to 5, 19 deg dive angle, south, 61% -->54%
24	107	9/29/12	19:44	20120929_194509_spurs_square_19_IVER2-107	Surface/square wave to 5, 19 deg dive angle, south, 53% -->47%
	107	9/29/12	20:35		Vehicle recovered
	106	9/29/12	20:40		Vehicle deployed
25	106	9/29/12	20:45	20120929_204627_spurs_0_und_IVER2-106	Surface/undulate to 10, south, 100% -->94%, back 21:05
26	106	9/29/12	21:30	20120929_213037_spurs_square_19_IVER2-106	Surface/square wave to 5, 19 deg dive angle, south, 92% -->87%
27	106	9/29/12	22:10	20120929_220931_spurs_1_und_IVER2-106	1 meter/undulate to 10, south, 86% --> 81%, back 22:30
28	106	9/29/12	22:47	20120929_224733_spurs_1_und_IVER2-106	1 meter/undulate to 10, south, modified to be 0.09 m from surface, 78% -->73%, nice
29	106	9/29/12	23:23	20120929_232328_spurs_1_und_IVER2-106	1 meter/undulate to 10, south, 72% --> 66%, back 23:45
30	106	9/30/12	0:09	20120930_000930_spurs_1_und_IVER2-106	1 meter/undulate to 10, south, 64% --> 58%, back 00:31
31	106	9/30/12	0:47	20120930_004703_spurs_1_und_IVER2-106	1 meter/undulate to 10, south, 56% --> 50%, back 01:10
32	106	9/30/12	1:33	20120930_013359_spurs_1_und_IVER2-106	1 meter/undulate to 10, south, 48% --> 42%, wind increased, very light rain
	106	9/30/12	2:06		Stern park mission started, 41%
33	106	9/30/12	2:33	20120930_023307_spurs_1_und_IVER2-106	1 meter/undulate to 10, south, 39% --> 33%, battery safety rules --> 25% / 20%

Small Scale Horizontal Survey, 30 September 2012

At 1600Z on 30 September 2012, EcoMapper 106 was deployed on its final mission of the cruise. The first leg of the mission, an undulation between the surface and 10 meters' depth, took the vehicle well into undisturbed water where it began a lawnmower-type survey of a 450-meter square at a nominal depth of 1 meter. Thirteen meridional transects 1 meter below the surface were connected by short turnaround segments at the surface, allowing for periodic GPS fixes and profiles of the upper meter.

The calm, sunny conditions produced an average stratification over the survey area of 3° C (with surface temperatures in some locations reaching 30.8° C) and approximately 0.1 psu over the upper 10 meters, most of it in the upper meter. This stratified layer supported internal waves, which were visible from the ship as surface slicks, and are the dominant features in the plan view of 1-meter temperature measurements (Figure 4).

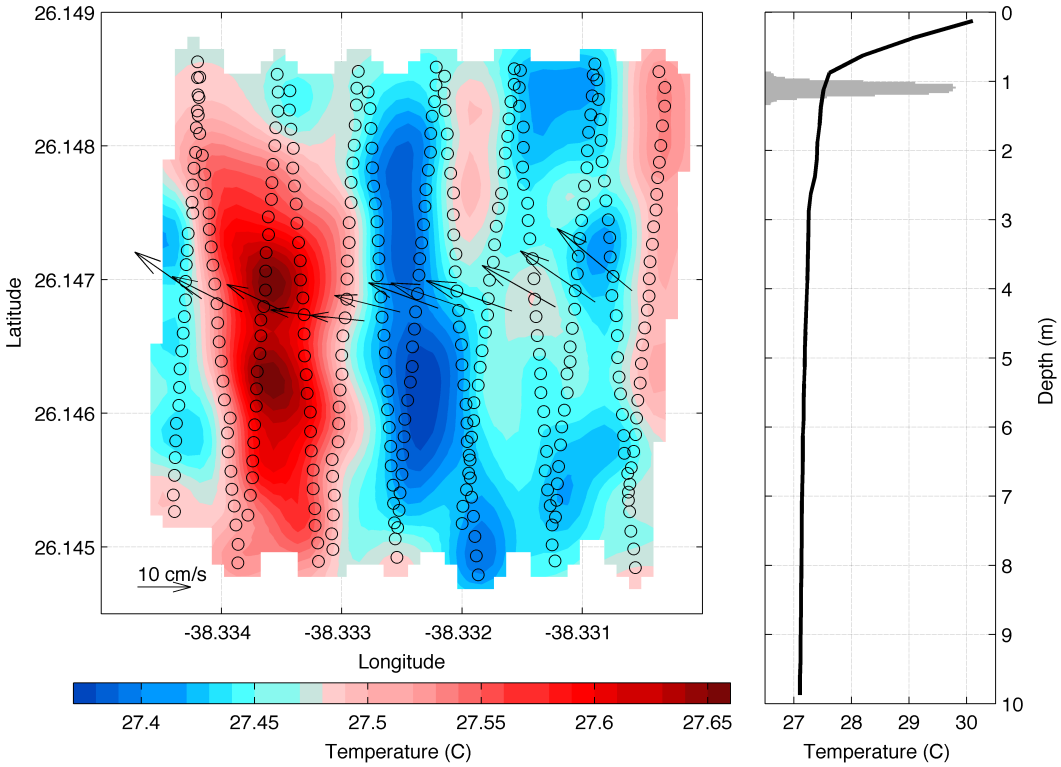

Figure 4. Left panel: Objective map of temperature at 1.1 meters below the surface. The vehicle deviated from this surface by 6 cm RMS, and the effect of these deviations is corrected for using the local vertical temperature gradient prior to mapping. Circles mark the locations of boxcar-averaged measurements used in the map, and arrows the average current inferred from each north-south round trip. Note the internal wave crest and trough. Right panel: Average temperature profile from the entire mission. The gray histogram represents the depths at which the measurements used in constructing the map were made. Note the extreme stratification in the upper meter.

Salinity Processing

A number of operations were required to improve the accuracy of the raw Neil Brown salinity measurements. They are described here in the order in which they were applied.

Conductivity glitches

Spurious conductivity datapoints are common, and are likely the result of air bubbles passing through the sensing volume. The worst of these are removed by setting a threshold below which measurements are discarded. Three second and 11 second windows around each datapoint are then examined, and values which are significant outliers in both windows are identified as glitches. Finally, any remaining glitches are removed manually.

Sensor position and flushing rate

The Neil Brown CT sensor is located near the tail of the EcoMapper, while the other sensors, including pressure and DVL (which are used to determine depth) are located near the bow. Due to this separation, and perhaps also partly to delays associated with imperfect flushing and/or thermal mass of the cell, vertical features in the raw data appear shallower on ascents and deeper on descents. To counteract this effect, the C and T data are lagged by 1 sample (1 second) relative to the rest of the data.

Conductivity cell thermal mass

When a conductivity sensor encounters a rapid temperature gradient, the temperature of the solid material surrounding the sensing volume lags behind the temperature of the water. After the water temperature has been measured, it changes slightly as heat is exchanged, affecting the measured conductivity. The resulting salinity error becomes apparent when a sharp vertical temperature gradient is profiled both upward and downward: the two temperature-salinity (T-S) curves do not coincide.

Following Morison (1994), we apply an iterative correction to the measured temperature before using it to compute salinity. Two parameters are involved in this procedure: β^{-1} is the cell thermal equilibration time constant; and α is the initial temperature error as a fraction of a hypothetical step-function temperature variation. The values $\beta = 0.15\ s^{-1}$ and $\alpha = 0.015$ were chosen to eliminate the average T-S curve bias between fully processed upward and downward profiles.

Temperature sensor: response time and position relative to conductivity cell

As implied above, the temperature sensor is positioned in front of the conductivity cell; a result of this spatial lag is that the former sees water a little earlier than the latter (call this time difference L). While the response of the conductivity sensor is relatively instantaneous, the temperature sensor requires a finite amount of time to equilibrate with its environment (call this thermistor response time τ). By applying a transfer function to the raw temperature data in Fourier space, we can reconstruct the water temperature at the location of the conductivity cell

for any given τ and L. As conductivity is primarily influenced by temperature, and only secondarily by salinity, we can determine τ and L empirically by comparing the conductivity record with the reconstructed temperature. For each vehicle, a nonlinear minimization algorithm was used to find the combination of τ and L resulting in the lowest mean-square cross-spectral phase difference between the two records. These values (L ~ 0.02 seconds, τ ~ 0.6 seconds) were used to correct the raw temperature data.

High-frequency noise

Correcting for the response time of the thermistor "sharpens" the temperature record, introducing some unwanted high-frequency noise. Similarly, at sufficiently high frequencies, the noise inherent to the conductivity sensor (which is essentially white) swamps the signal (which is red). Accordingly, both records are low-passed at a frequency of 0.3 Hz. The salinity computed from these records is then smoothed a final time with a 7 second running median filter.

Conductivity sensor drift

Both vehicles' Neil Brown conductivity sensors are woefully unstable, drifting by as much as 0.2 psu over the course of a day. This behavior was observed in the calibration tank prior to the cruise as well as in the field. Fortunately, however, the drift appears to be fairly steady: during science missions, conductivity values recorded by the Neil Brown sensors increased monotonically relative to other measurements (YSI and the *R/V Knorr's* thermosalinograph (TSG)) while the sensor remained submerged. As the YSI conductivity sensors have their own problems (including a spurious oscillation with an amplitude of 0.07 psu and a variable period of approximately 150 seconds) and as there was little stratification or horizontal structure below the upper few meters, it was determined that the most reliable way to correct for the sensor drift was to use the TSG as a standard. For each mission, the salinity was shifted by a constant offset such that the average of all measurements made between 4 and 10 meters matched the average salinity from the TSG (intake depth: 5 meters) during the same period.

Processed data format

For each of the two experiments described above, two MATLAB structures were created: *iver* contains the 1-Hz science data including the processed salinity (for the 29-30 September 2012, experiment, data from all 33 missions are concatenated, with temporal gaps between missions); and *iver_avg* contains processed temperature and salinity averaged into vertical profiles, one for each mission. These structures are saved in the files *spurs_iver_diel_strat.mat* and *spurs_iver_survey.mat*.

In addition, there is a *.mat* file for each mission, named according to the mission start time and date, the mission name, and the vehicle serial number. Each file contains 4 MATLAB structures: *data* contains all of the raw data from the EcoMapper log file (including science and engineering variables), parsed into fields named according to the log file header; likewise, *dvl* contains the parsed vehicle velocity data from the EcoMapper dvl file; *Pfd* contains the raw water velocity data, binned by depth relative to the vehicle; and *sci* contains processed position, time, and salinity, as well as raw data from the rest of the science sensors. Underwater positions (*iver.lon,*

iver.lat, sci.lon, sci.lat) differ from those recorded in the raw data—they have been corrected using the difference between the expected and actual surfacing locations, assuming a uniform drift while submerged due to current and DVL bias. For access to raw or processed data, contact dfratantoni@whoi.edu or bhodges@whoi.edu.

Acknowledgements

We would like to thank the captain and crew of the *R/V Knorr* for their able assistance. Raymond Schmitt, the Chief Scientist on KN209-1, organized the efforts of the several groups aboard, enabling EcoMapper operations on the precious calm, sunny days without unduly impacting other operations. Deb Taylor assisted in the formatting of this report. We gratefully acknowledge the support of NASA under Grant No. NNX11AE82G.

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Morison, J., R. Andersen, N. Larson, E. D'Asaro, and T. Boyd, 1994: The correction for thermal-lag effects in Sea-Bird CTD data. *J. Atmos. Oceanic Technol.,* 11, 1151-1164.

KNORR 209-1 Cruise Report, in prep, WHOI.

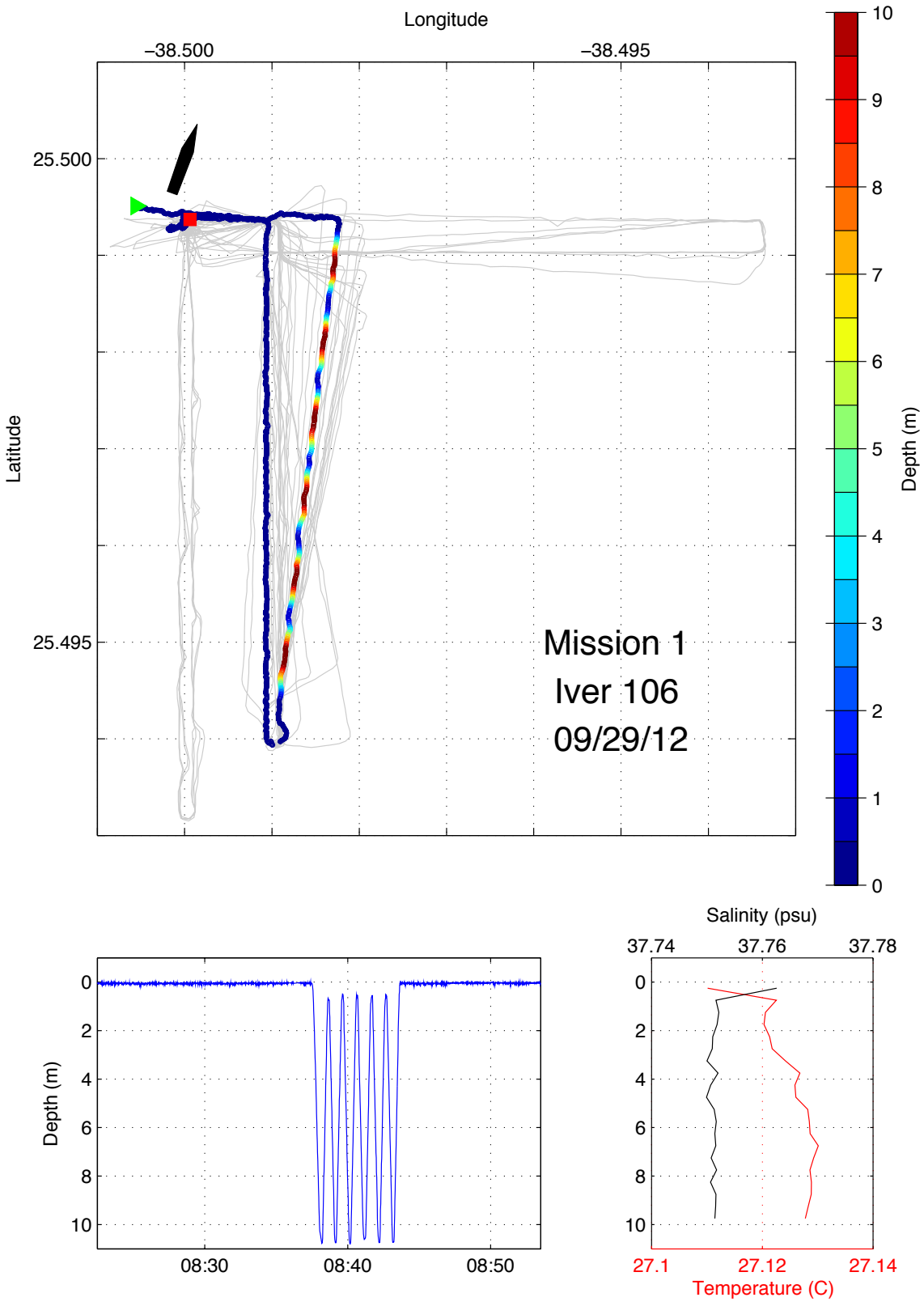
Appendix: Mission Description Figures

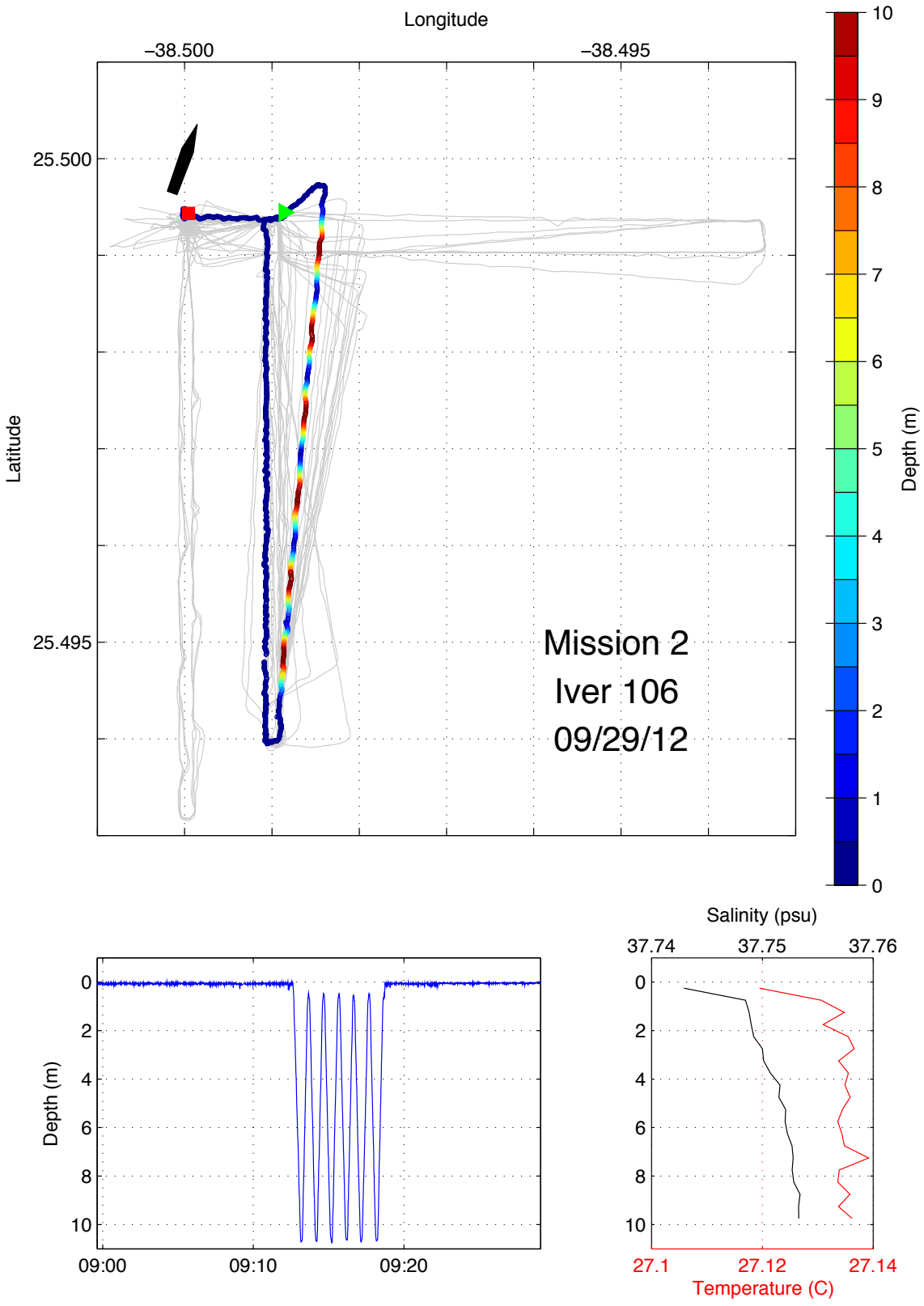
Each of the following pages graphically summarizes a single EcoMapper mission. In each case, the layout is identical:

Upper panel: a plan view of the track followed by the vehicle. Green triangles and red squares mark mission start and end points, respectively. The vehicle track is colored according to vehicle depth, with tracks from other missions indicated in gray. During each mission but the final one, *R/V Knorr* held station; her position is displayed as a black silhouette. Mission number, vehicle serial number, and date at the start of the mission (in UTC) are printed in available space in each figure.

Lower left panel: a time series of vehicle depth. Times on the x-axis are in UTC.

Lower right panel: mission-average profiles of temperature and processed salinity. The profiles are formed from points far enough from the *R/V Knorr* to be largely undisturbed, and are averaged into 0.5-m depth bins.


Longitude
−38.500
−38.495
25.500
25.495
Latitude
Mission 1
Iver 106
09/29/12
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
0
2
4
6
8
10
08:30
08:40
08:50
Salinity (psu)
37.74
37.76
37.78
27.1
27.12
27.14
Temperature (C)


Longitude
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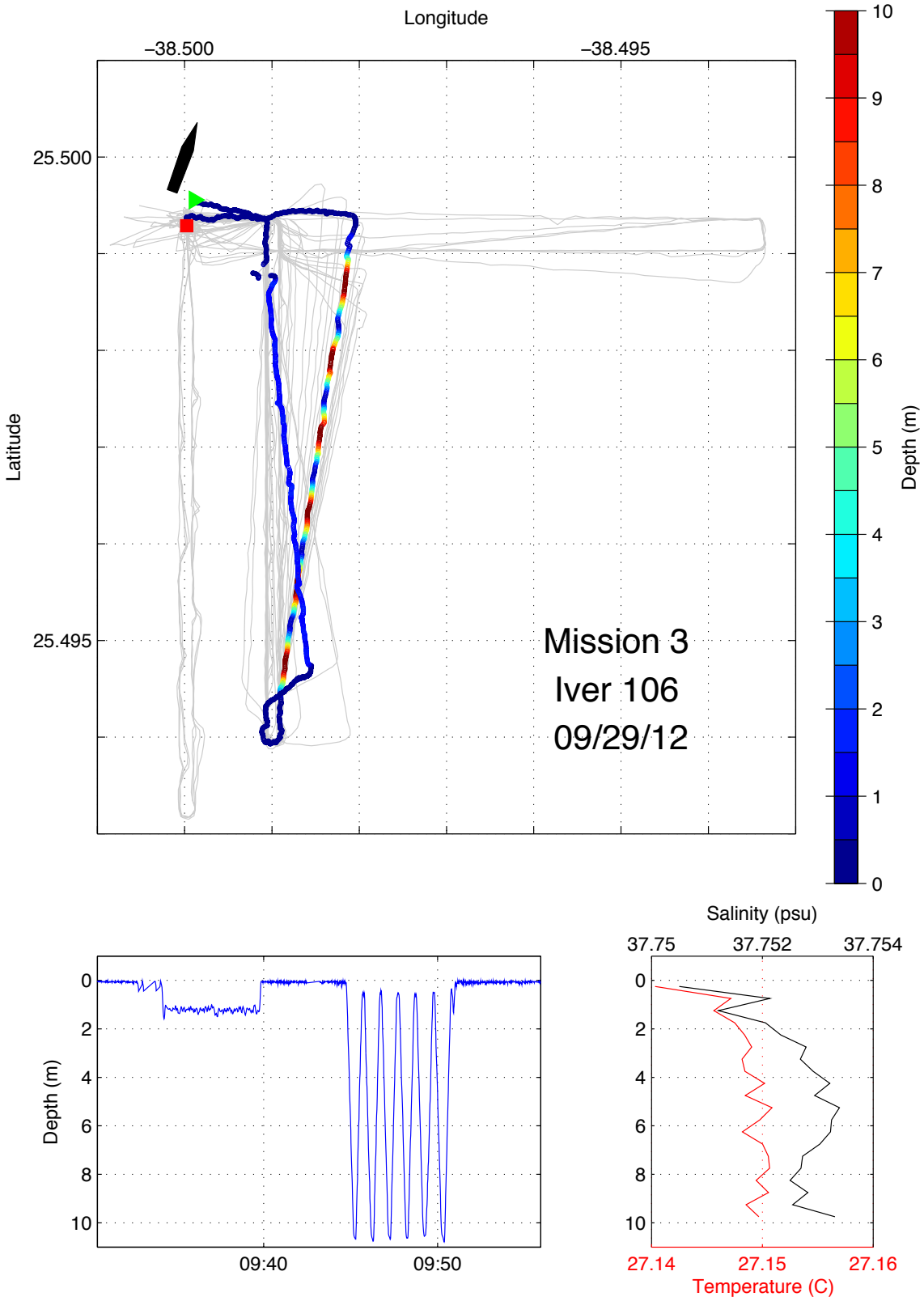
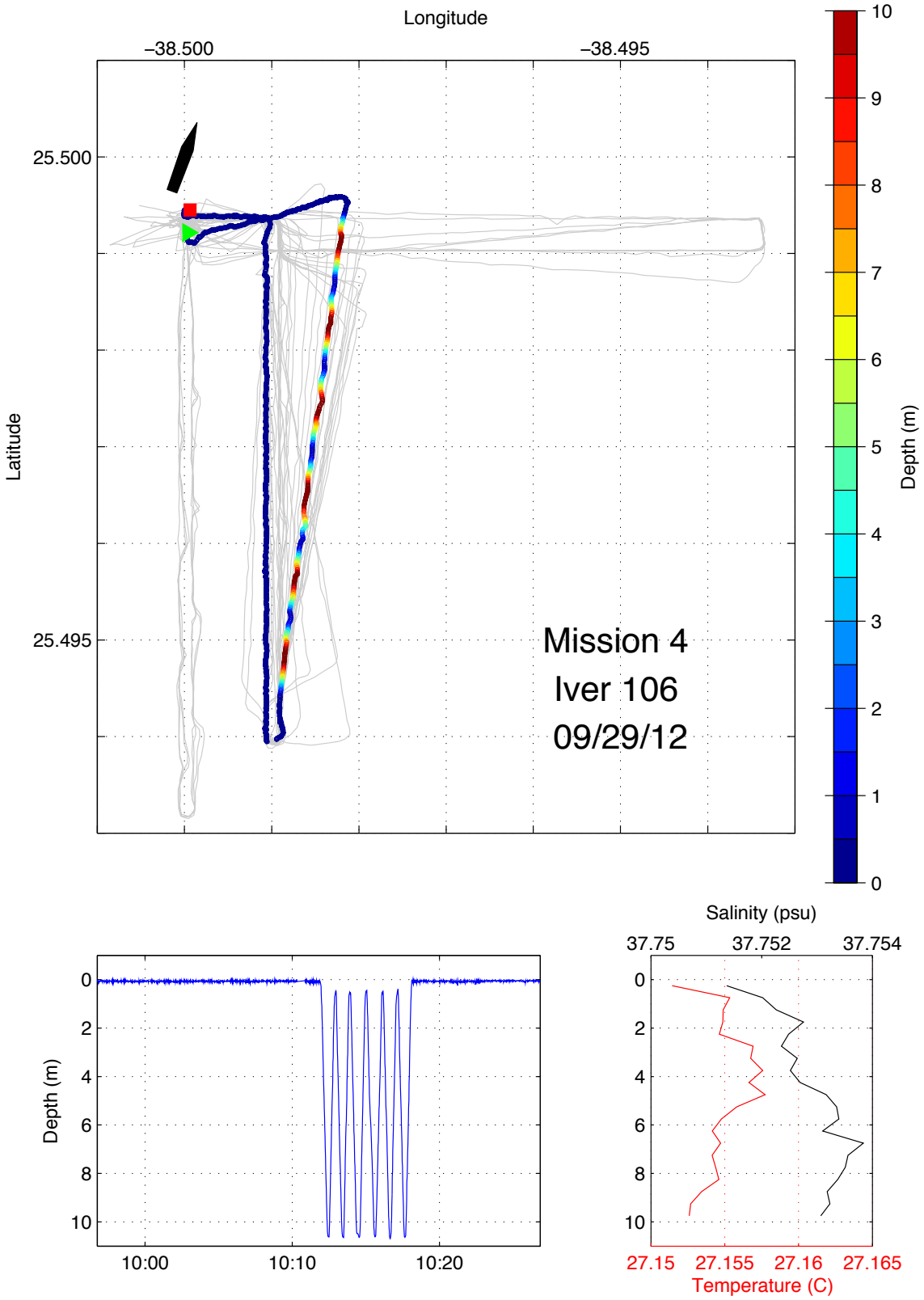
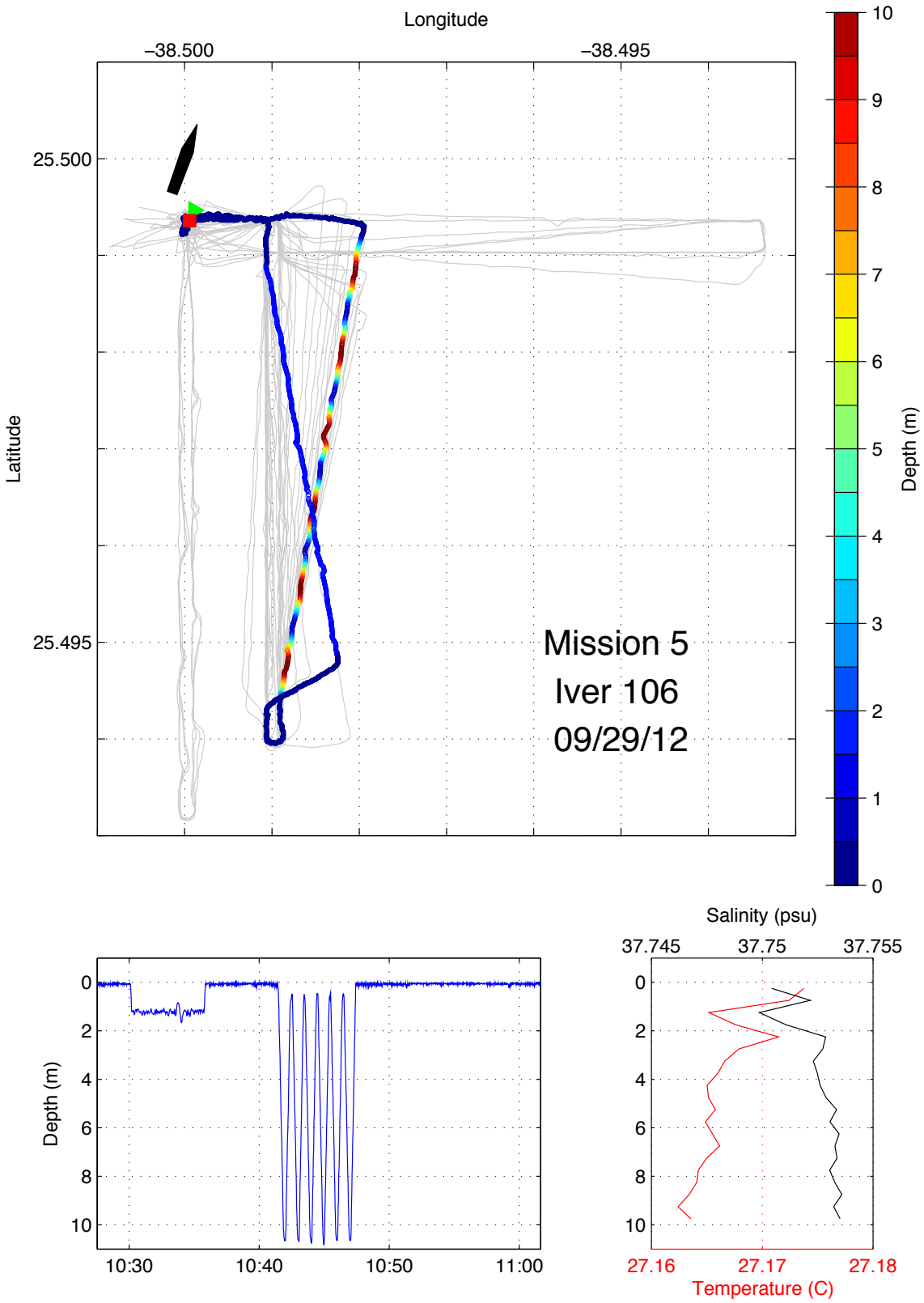
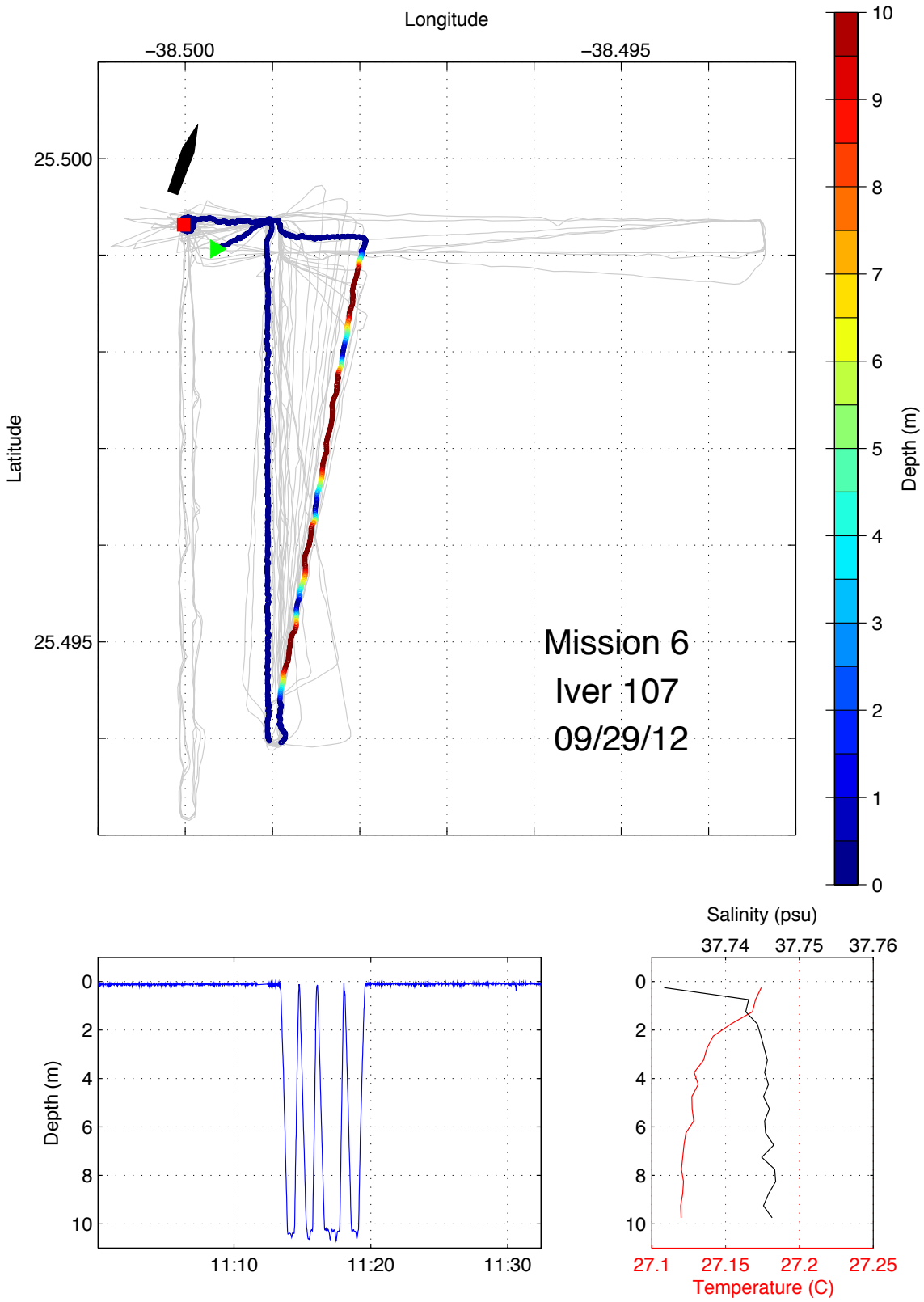
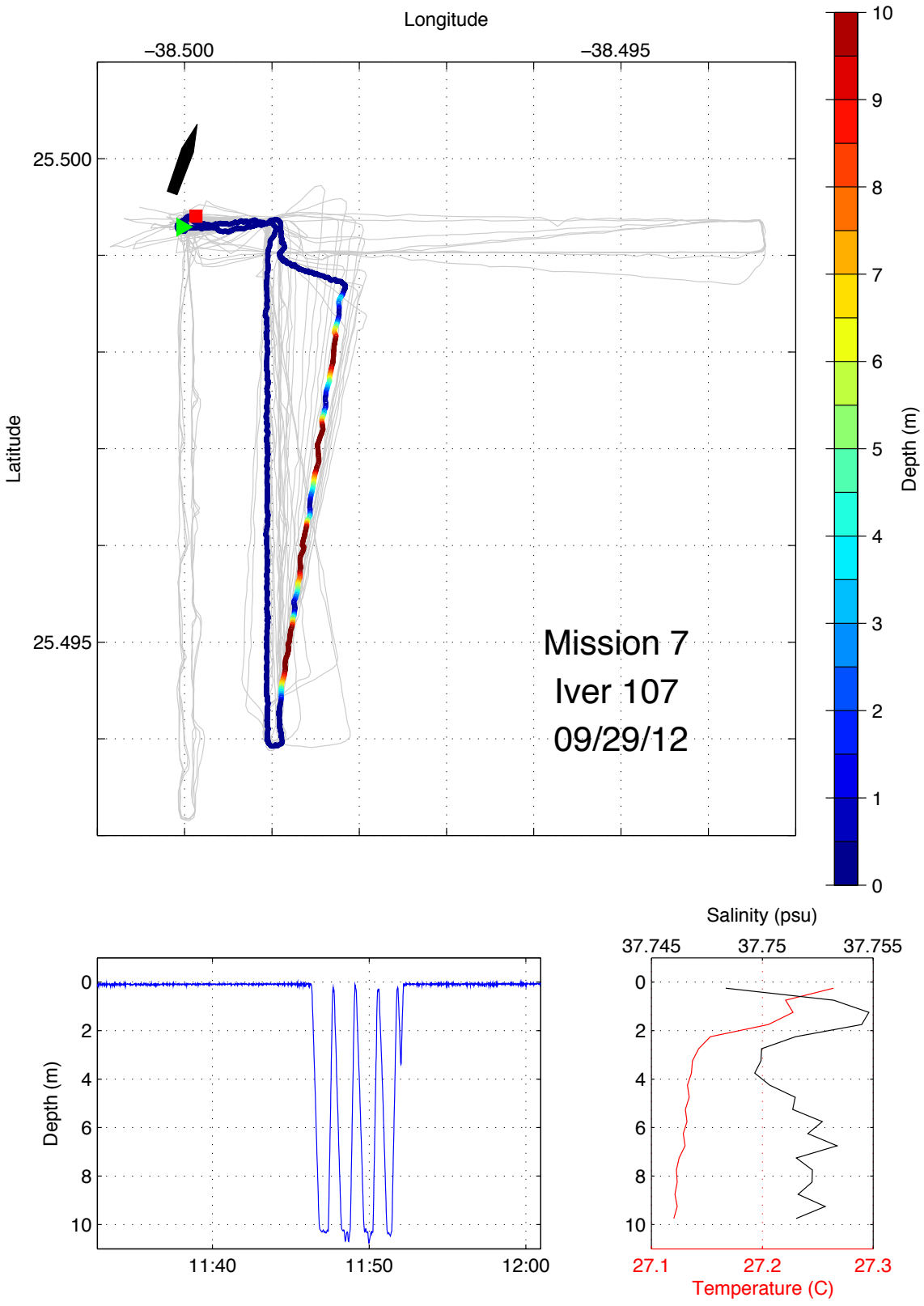
25.495
Latitude
Mission 2
Iver 106
09/29/12
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
0
2
4
6
8
10
09:00
09:10
09:20
Salinity (psu)
37.74
37.75
37.76
27.1
27.12
27.14
Temperature (C)

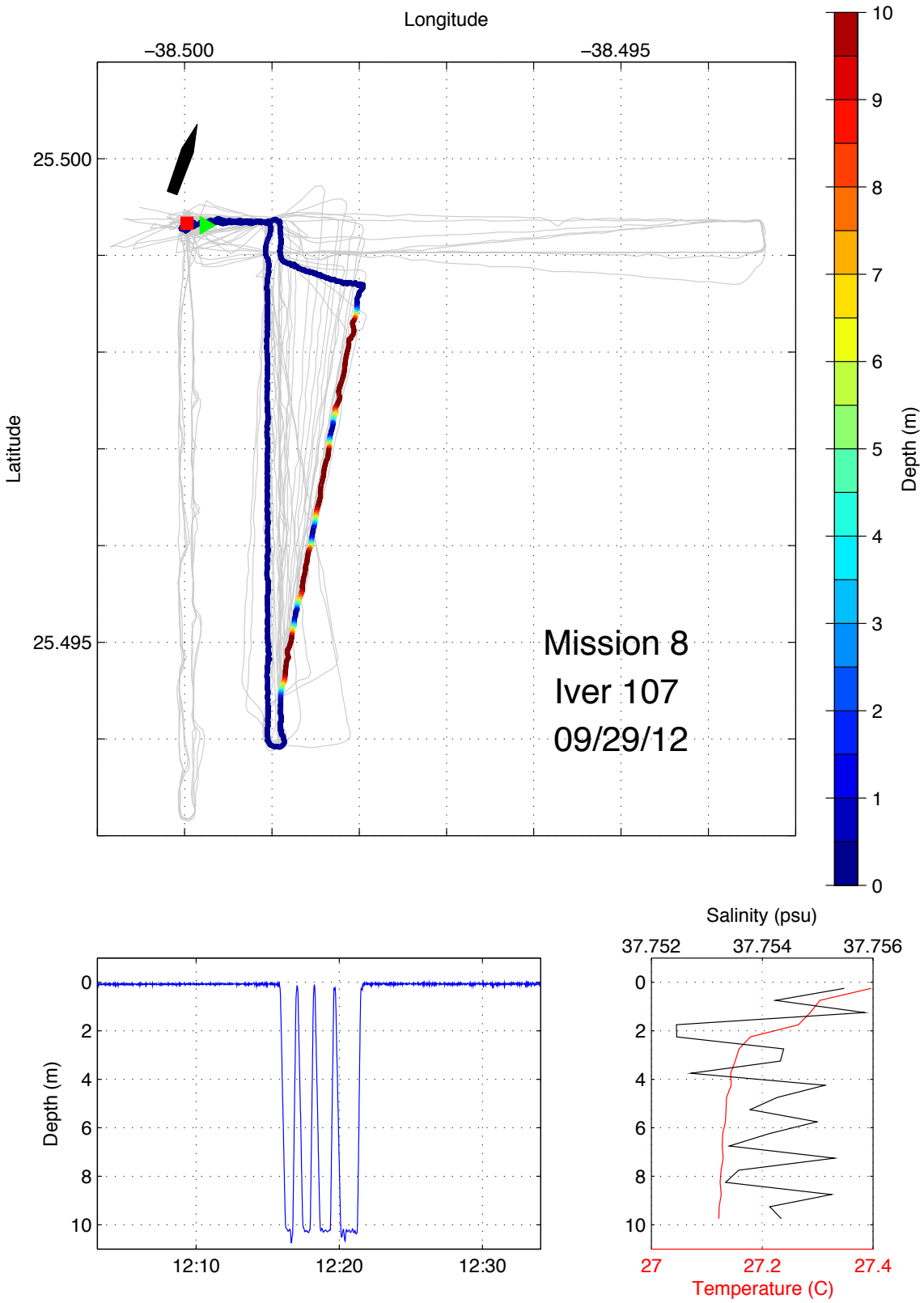

Longitude
−38.500
−38.495
25.500
25.495
Latitude
Mission 3
Iver 106
09/29/12
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
0
2
4
6
8
10
09:40
09:50
Salinity (psu)
37.75
37.752
37.754
27.14
27.15
27.16
Temperature (C)

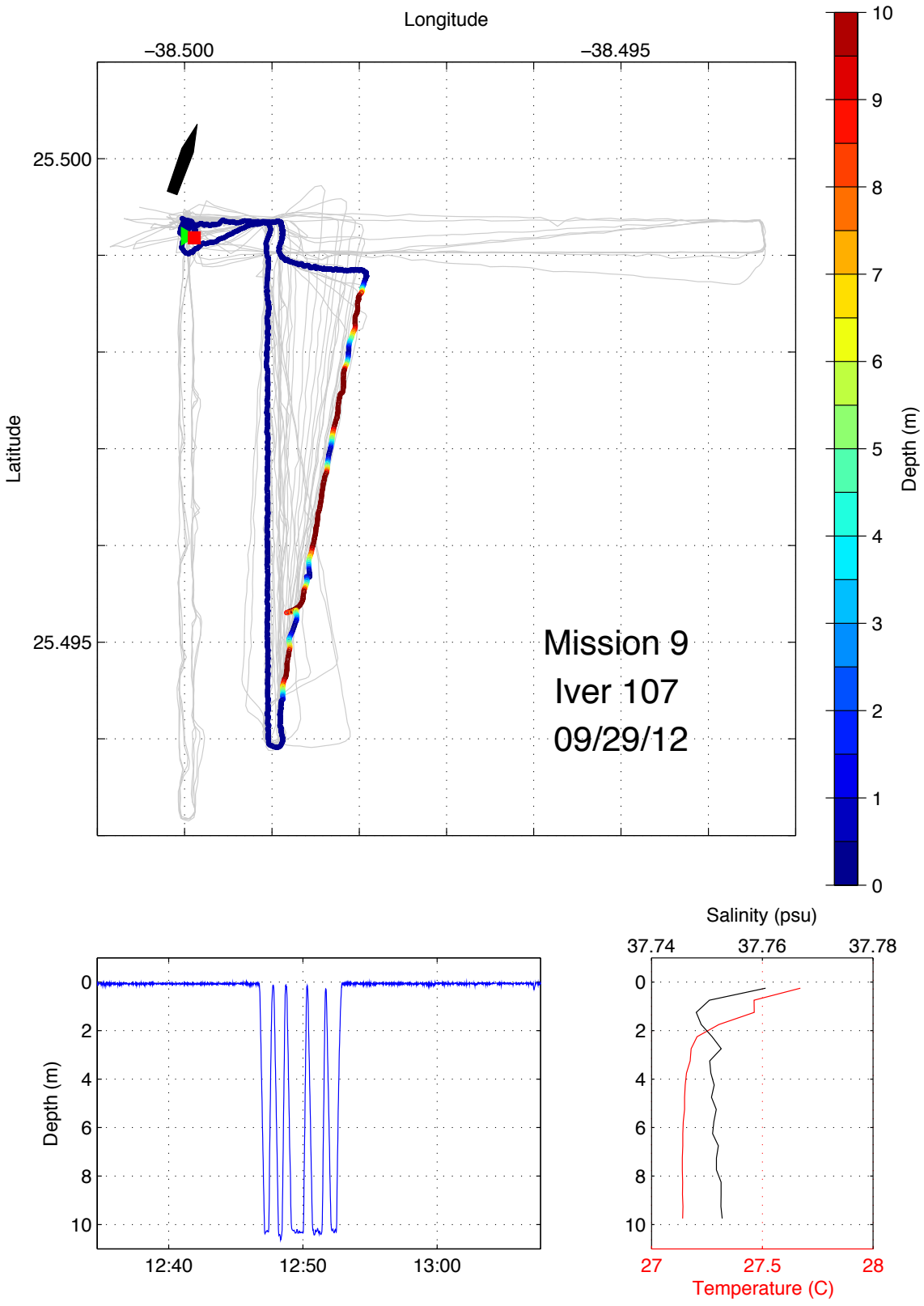

Longitude
−38.500
−38.495
25.500
25.495
Latitude
Mission 4
Iver 106
09/29/12
Depth (m)
10
9
8
7
6
5
4
3
2
1
0
Depth (m)
0
2
4
6
8
10
10:00
10:10
10:20
Salinity (psu)
37.75
37.752
37.754
27.15
27.155
27.16
27.165
Temperature (C)

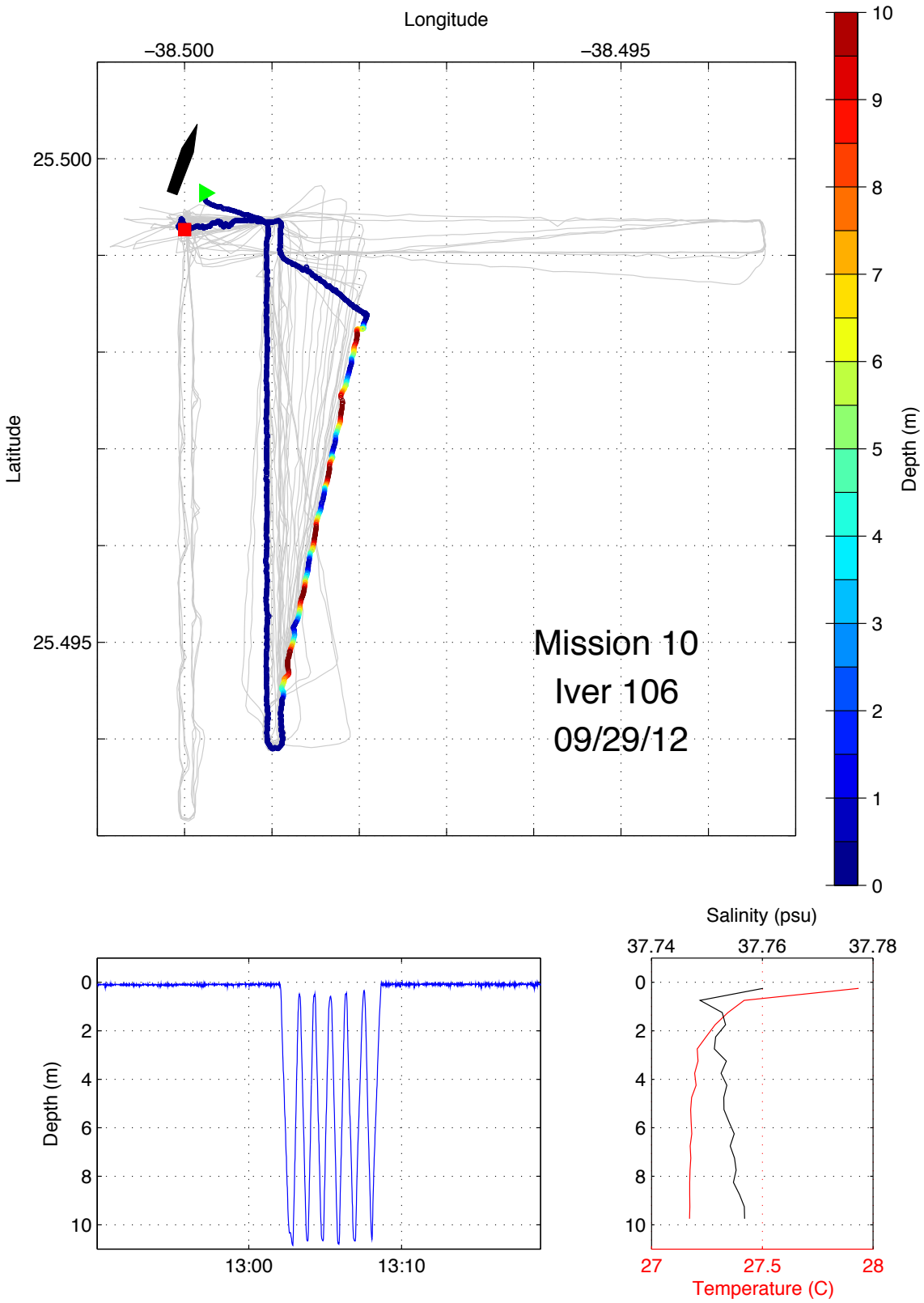

Longitude
−38.500
−38.495
25.500
25.495
Latitude
Mission 5
Iver 106
09/29/12
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
Salinity (psu)
37.745
37.75
37.755
Depth (m)
0
2
4
6
8
10
10:30
10:40
10:50
11:00
27.16
27.17
27.18
Temperature (C)

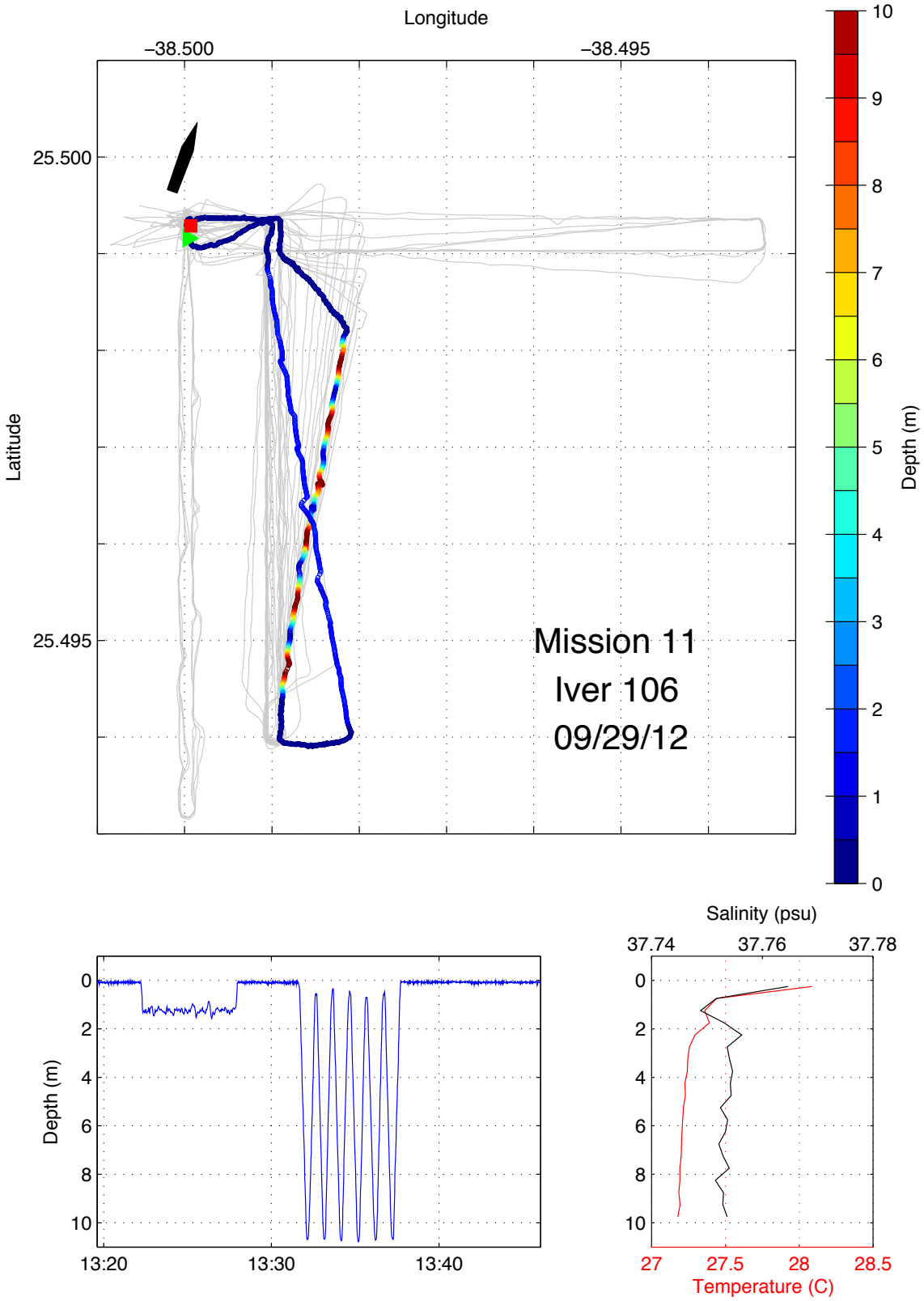

Longitude
−38.500
−38.495
25.500
25.495
Latitude
Mission 6
Iver 107
09/29/12
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
0
2
4
6
8
10
11:10
11:20
11:30
Salinity (psu)
37.74
37.75
37.76
27.1
27.15
27.2
27.25
Temperature (C)

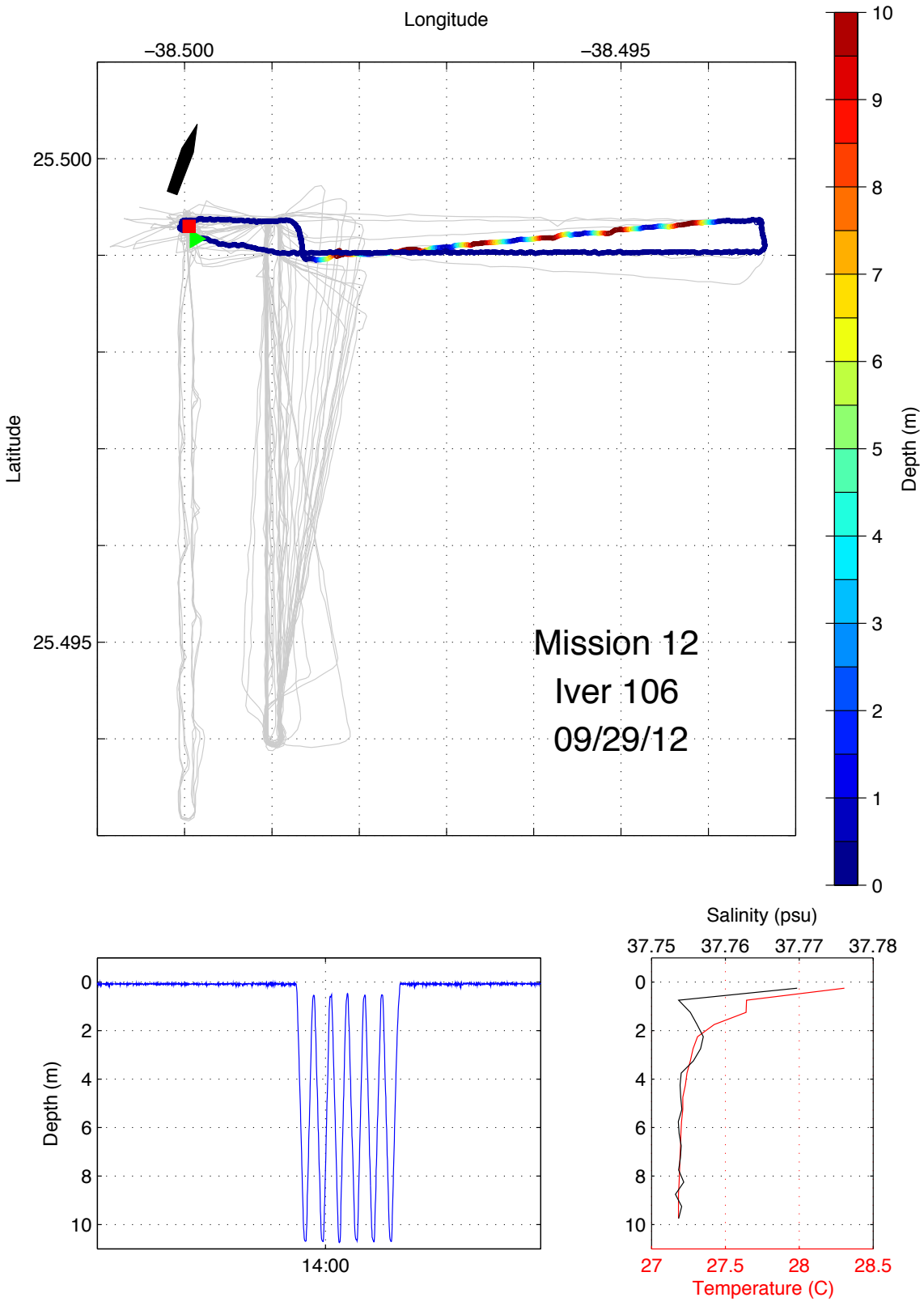

Longitude
−38.500
−38.495
25.500
25.495
Latitude
Mission 7
Iver 107
09/29/12
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
0
2
4
6
8
10
11:40
11:50
12:00
Salinity (psu)
37.745
37.75
37.755
27.1
27.2
27.3
Temperature (C)

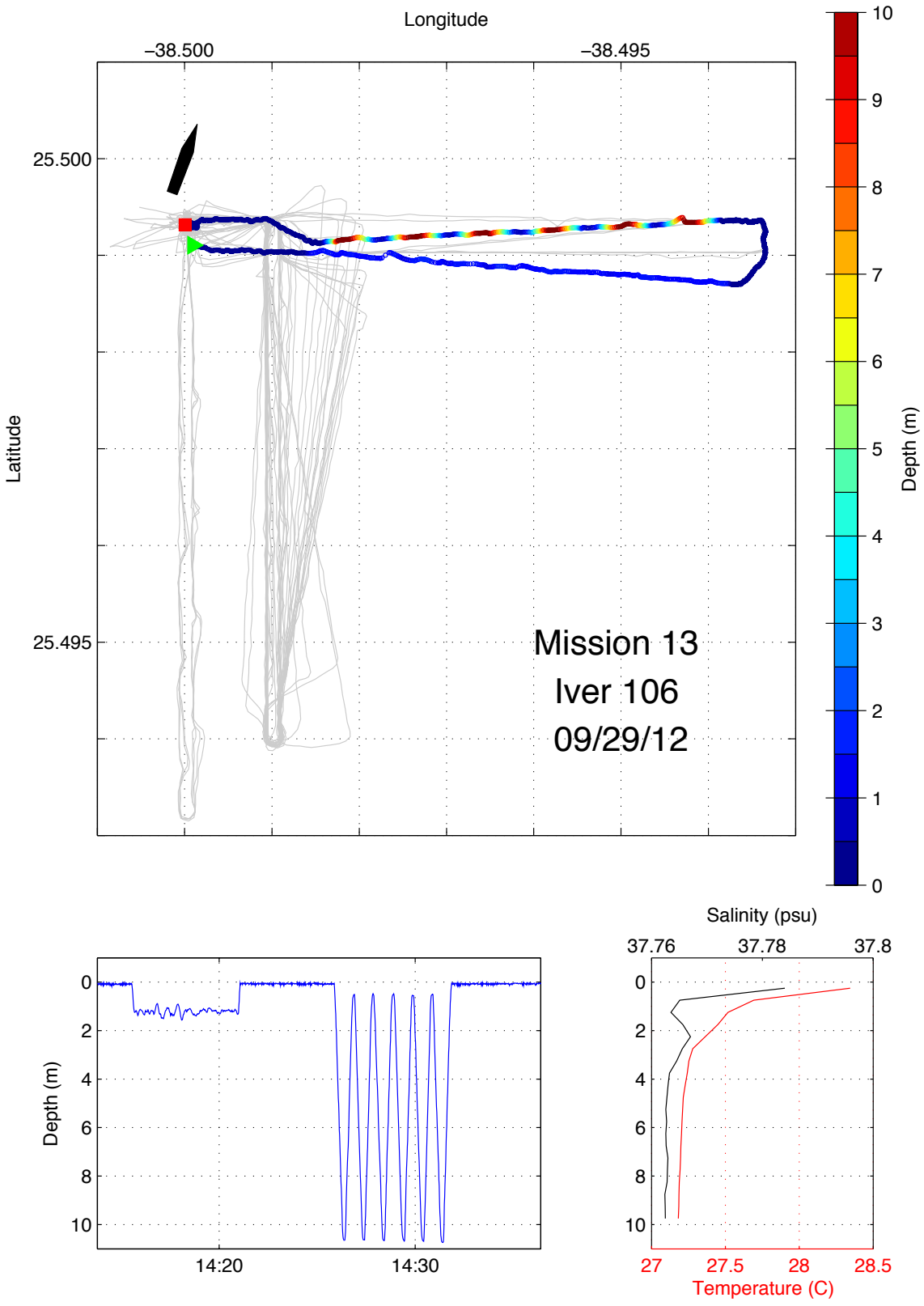

Longitude
−38.500
−38.495
25.500
25.495
Latitude
Mission 8
Iver 107
09/29/12
Depth (m)
10
9
8
7
6
5
4
3
2
1
0
Salinity (psu)
37.752
37.754
37.756
Depth (m)
0
2
4
6
8
10
12:10
12:20
12:30
27
27.2
27.4
Temperature (C)

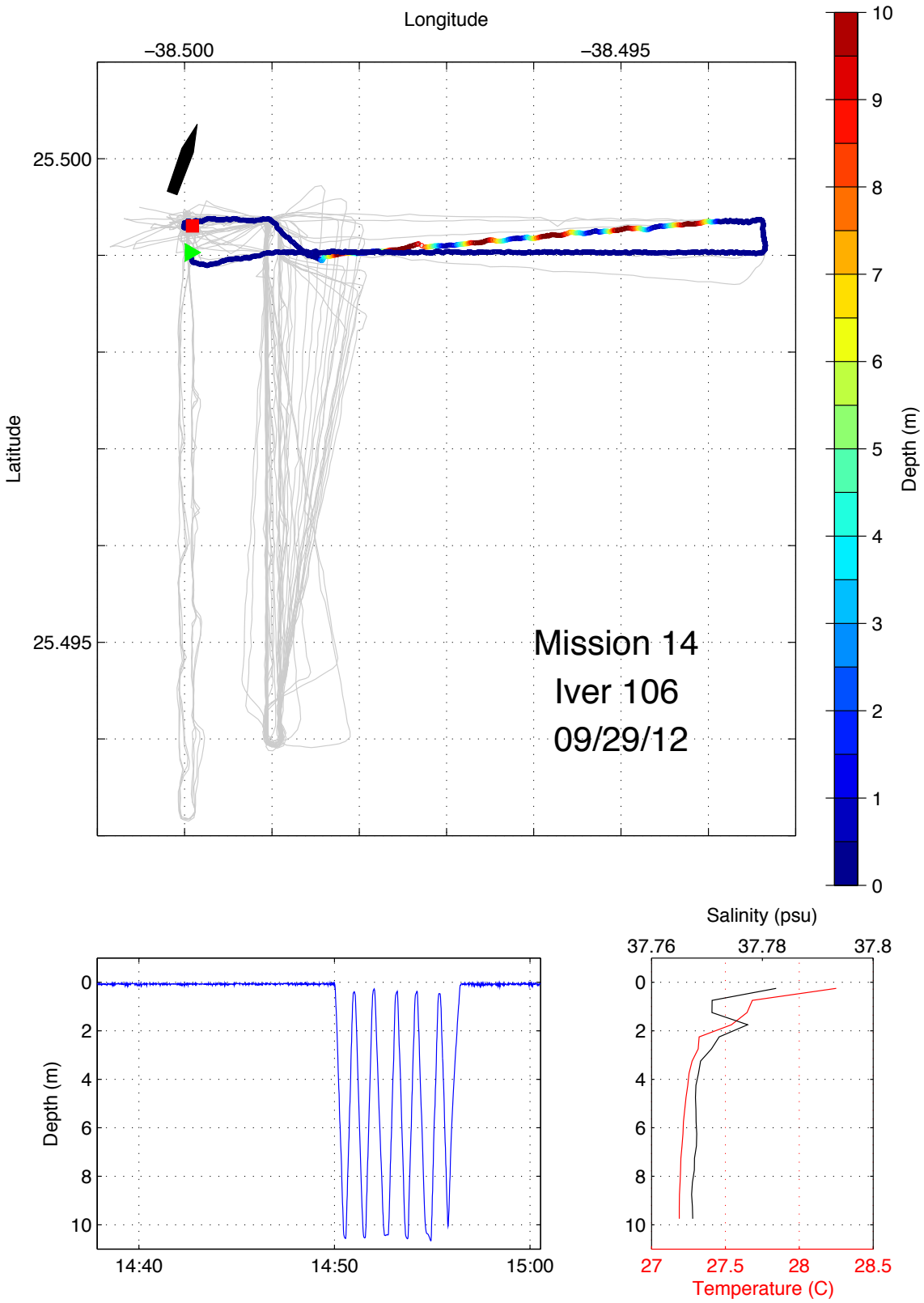

Longitude
−38.500
−38.495
25.500
25.495
Latitude
Mission 9
Iver 107
09/29/12
Depth (m)
10
9
8
7
6
5
4
3
2
1
0
Depth (m)
0
2
4
6
8
10
12:40
12:50
13:00
Salinity (psu)
37.74
37.76
37.78
27
27.5
28
Temperature (C)

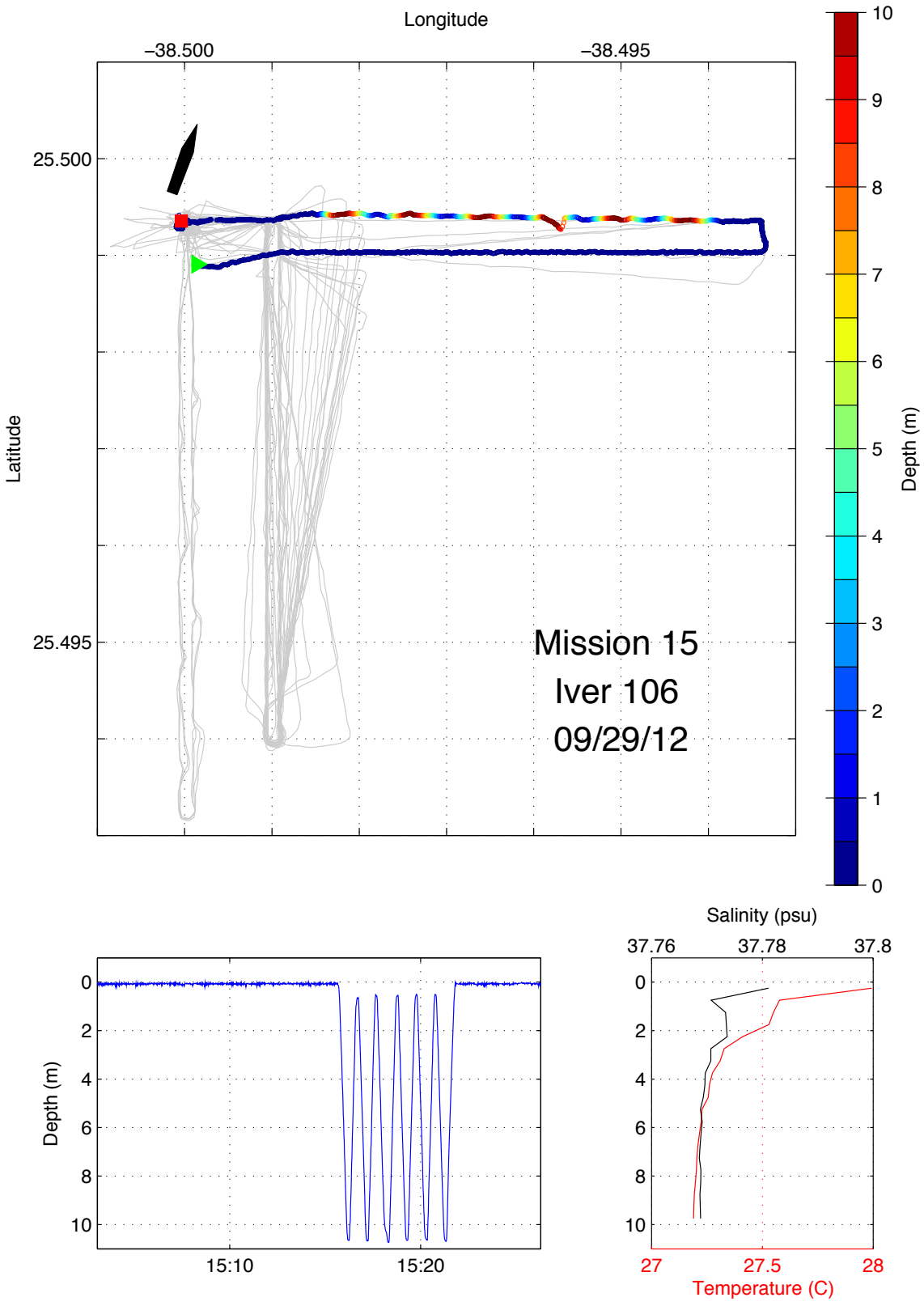

Longitude
−38.500
−38.495
25.500
25.495
Latitude
Mission 10
Iver 106
09/29/12
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
0
2
4
6
8
10
13:00
13:10
Salinity (psu)
37.74
37.76
37.78
27
27.5
28
Temperature (C)

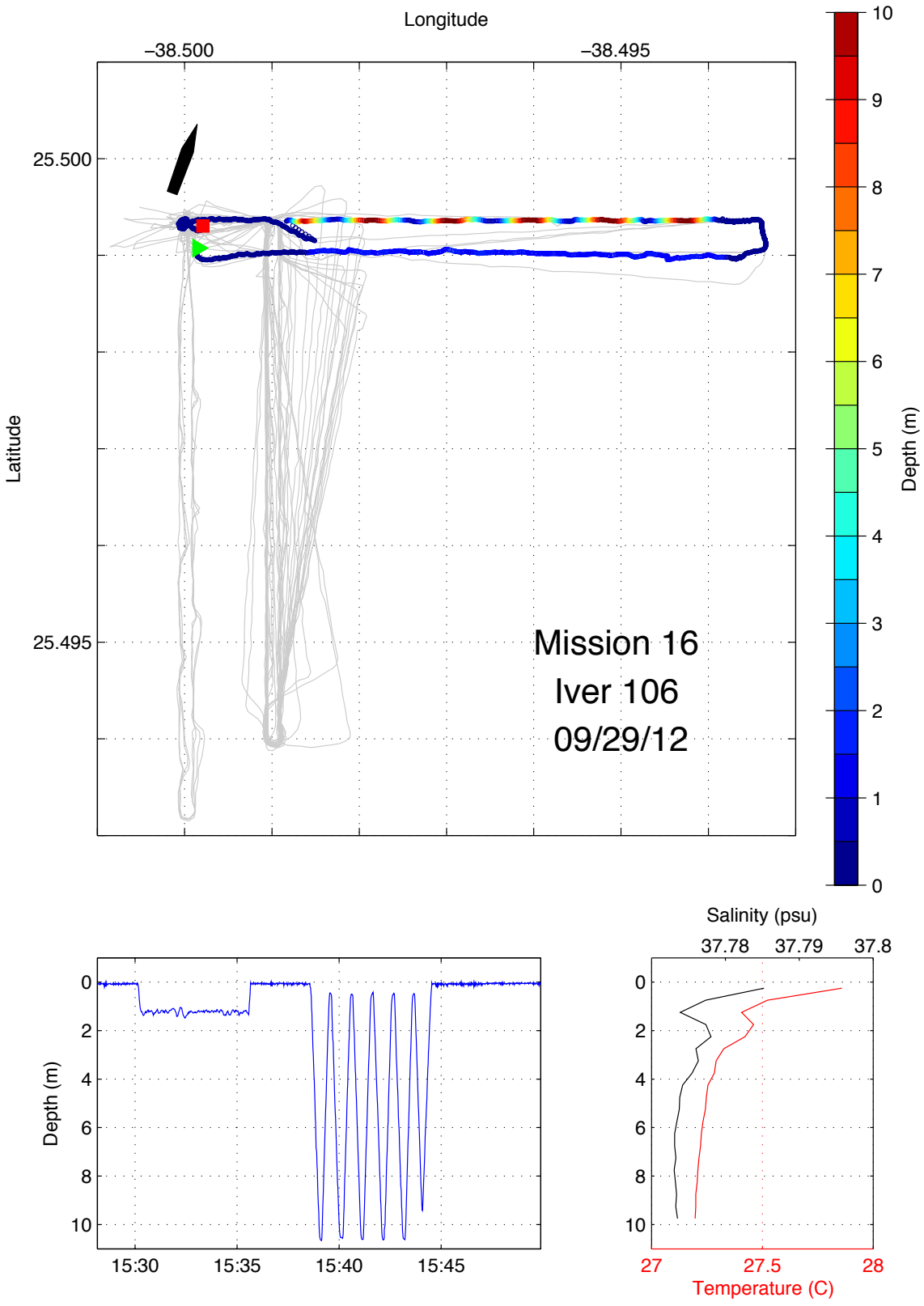

Longitude
−38.500
−38.495
25.500
25.495
Latitude
Mission 11
Iver 106
09/29/12
Depth (m)
10
9
8
7
6
5
4
3
2
1
0
Depth (m)
0
2
4
6
8
10
13:20
13:30
13:40
Salinity (psu)
37.74
37.76
37.78
27
27.5
28
28.5
Temperature (C)

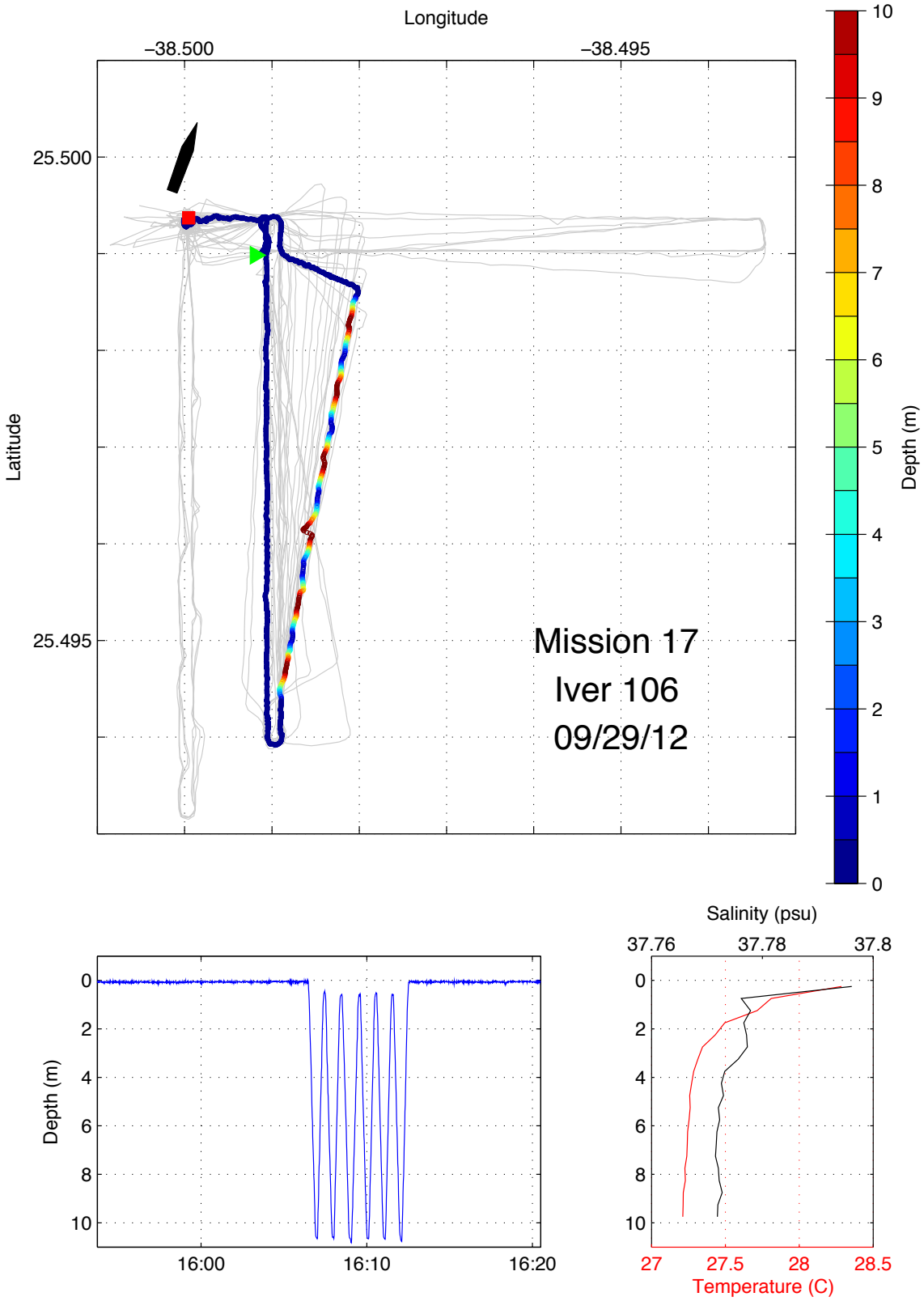

Longitude
−38.500
−38.495
25.500
25.495
Latitude
Mission 12
Iver 106
09/29/12
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
0
2
4
6
8
10
14:00
Salinity (psu)
37.75
37.76
37.77
37.78
27
27.5
28
28.5
Temperature (C)

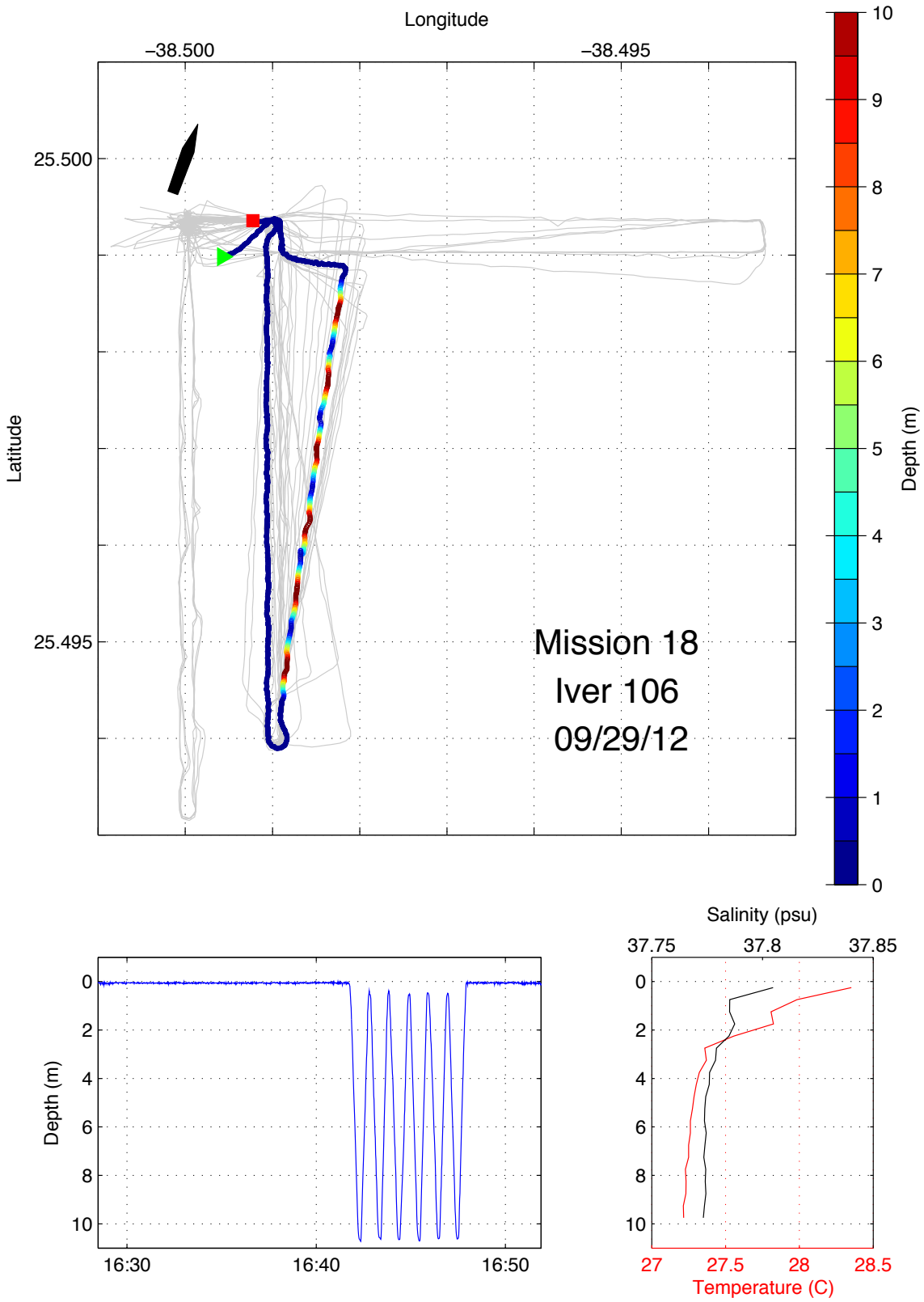

Longitude
−38.500
−38.495
25.500
25.495
Latitude
Mission 13
Iver 106
09/29/12
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
0
2
4
6
8
10
14:20
14:30
Salinity (psu)
37.76
37.78
37.8
0
2
4
6
8
10
27
27.5
28
28.5
Temperature (C)

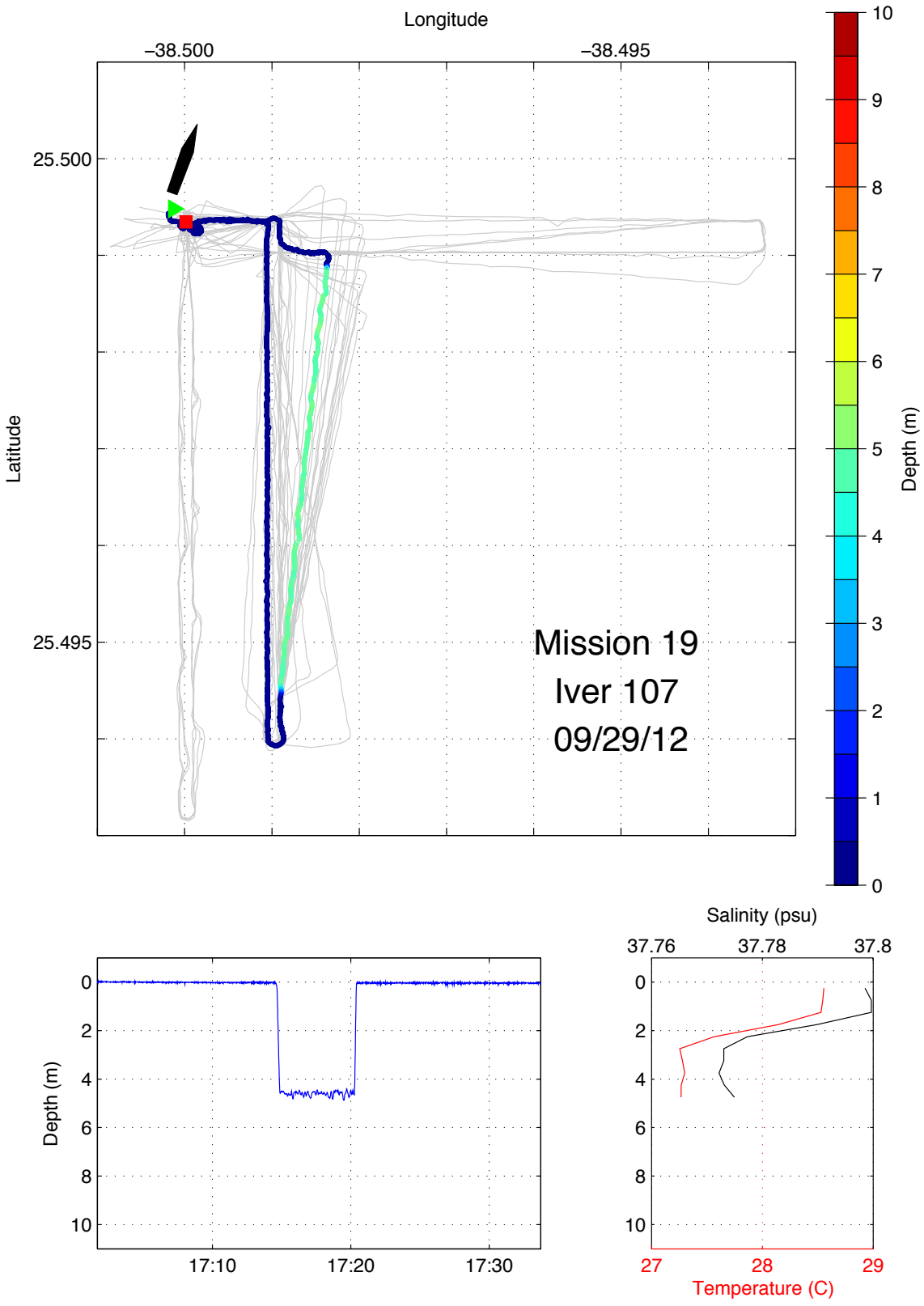

Longitude
−38.500
−38.495
25.500
25.495
Latitude
Mission 14
Iver 106
09/29/12
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
0
2
4
6
8
10
14:40
14:50
15:00
Salinity (psu)
37.76
37.78
37.8
27
27.5
28
28.5
Temperature (C)

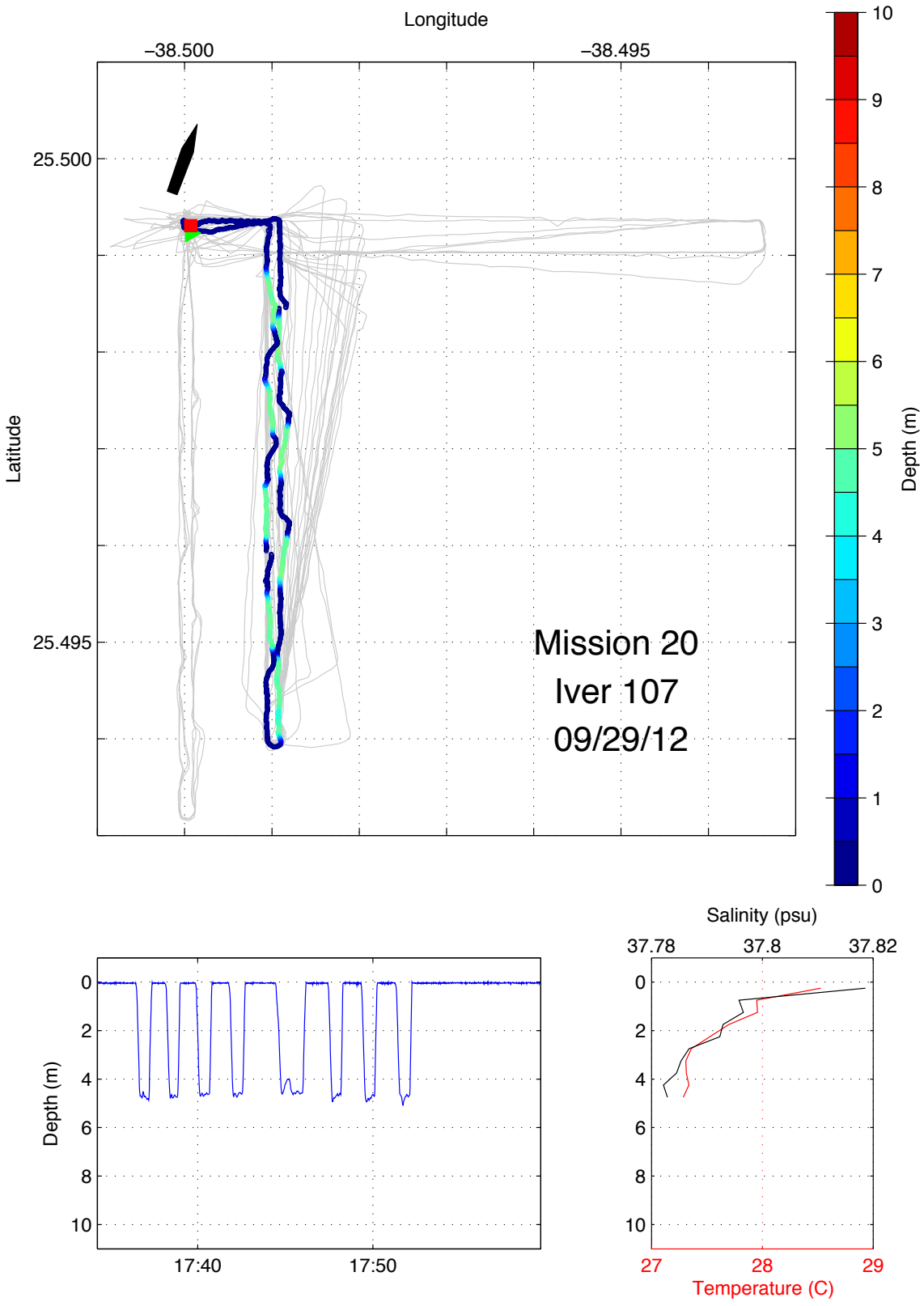

Longitude
−38.500
−38.495
25.500
25.495
Latitude
Mission 15
Iver 106
09/29/12
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
0
2
4
6
8
10
15:10
15:20
Salinity (psu)
37.76
37.78
37.8
27
27.5
28
Temperature (C)

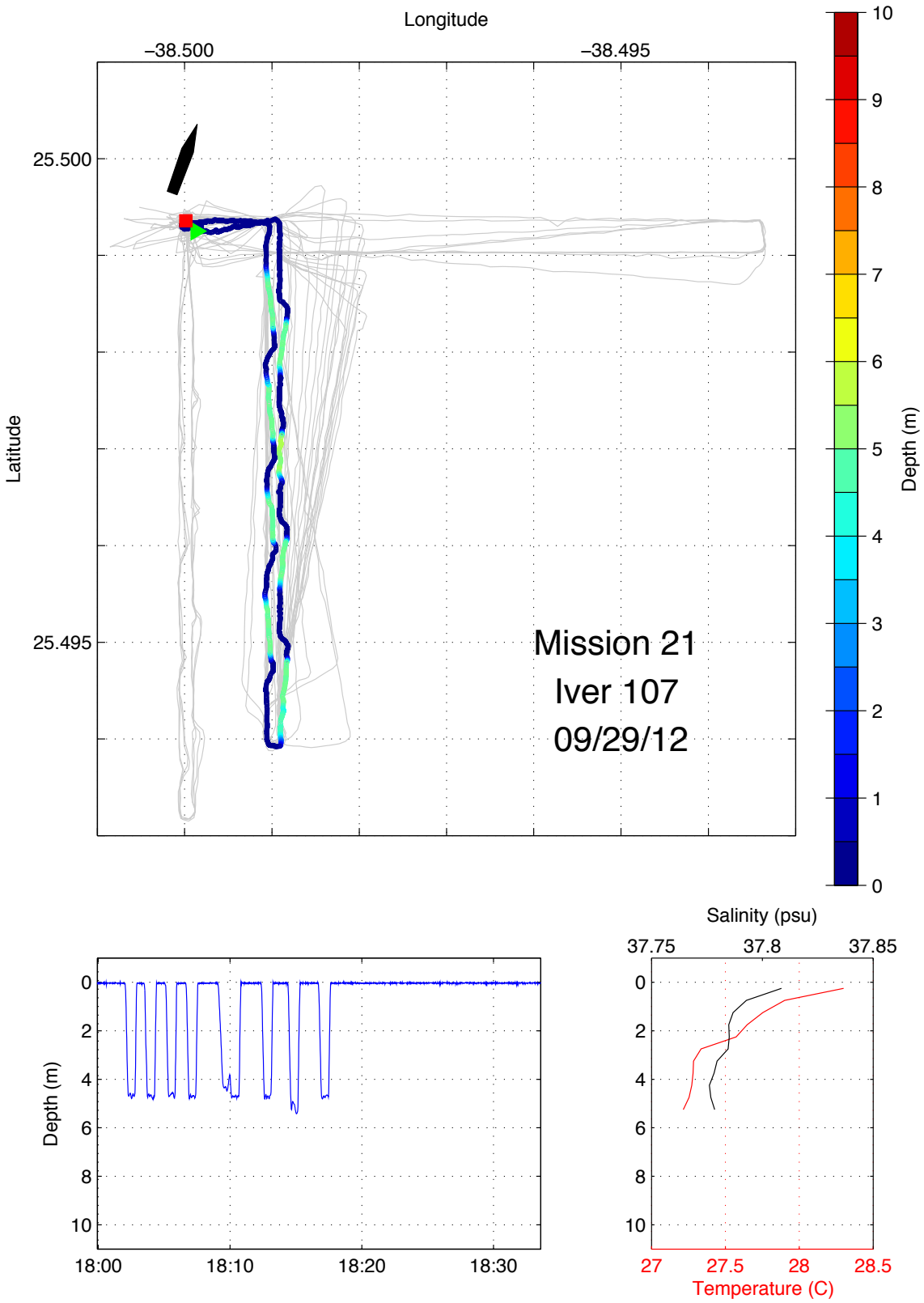

Longitude
−38.500
−38.495
25.500
25.495
Latitude
Mission 16
Iver 106
09/29/12
Depth (m)
10
9
8
7
6
5
4
3
2
1
0
Salinity (psu)
37.78
37.79
37.8
Depth (m)
0
2
4
6
8
10
15:30
15:35
15:40
15:45
27
27.5
28
Temperature (C)

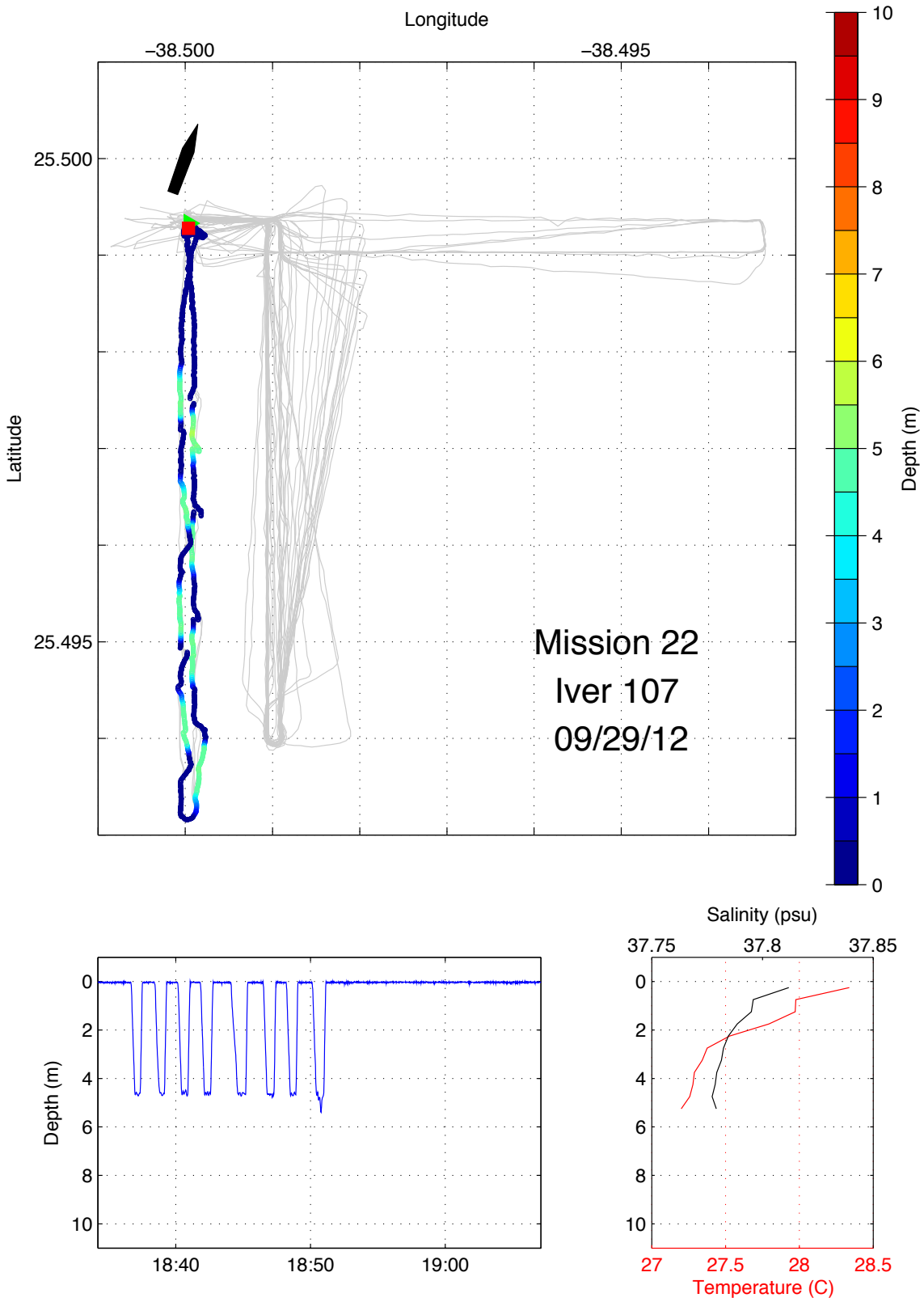

Longitude
−38.500
−38.495
25.500
25.495
Latitude
Mission 17
Iver 106
09/29/12
Depth (m)
10
9
8
7
6
5
4
3
2
1
0
Depth (m)
0
2
4
6
8
10
16:00
16:10
16:20
Salinity (psu)
37.76
37.78
37.8
27
27.5
28
28.5
Temperature (C)

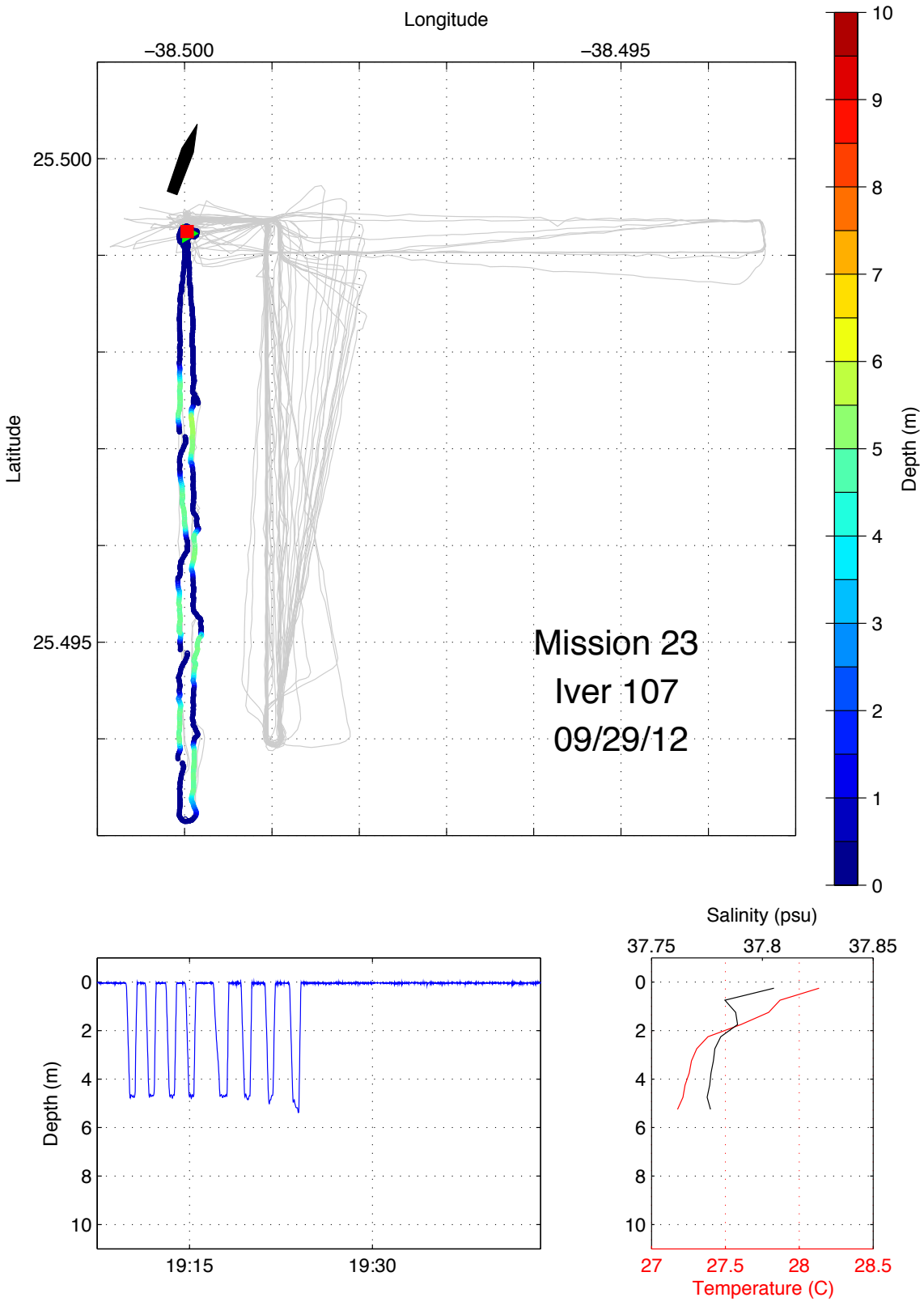

Longitude
−38.500
−38.495
25.500
25.495
Latitude
Mission 18
Iver 106
09/29/12
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
0
2
4
6
8
10
16:30
16:40
16:50
Salinity (psu)
37.75
37.8
37.85
27
27.5
28
28.5
Temperature (C)

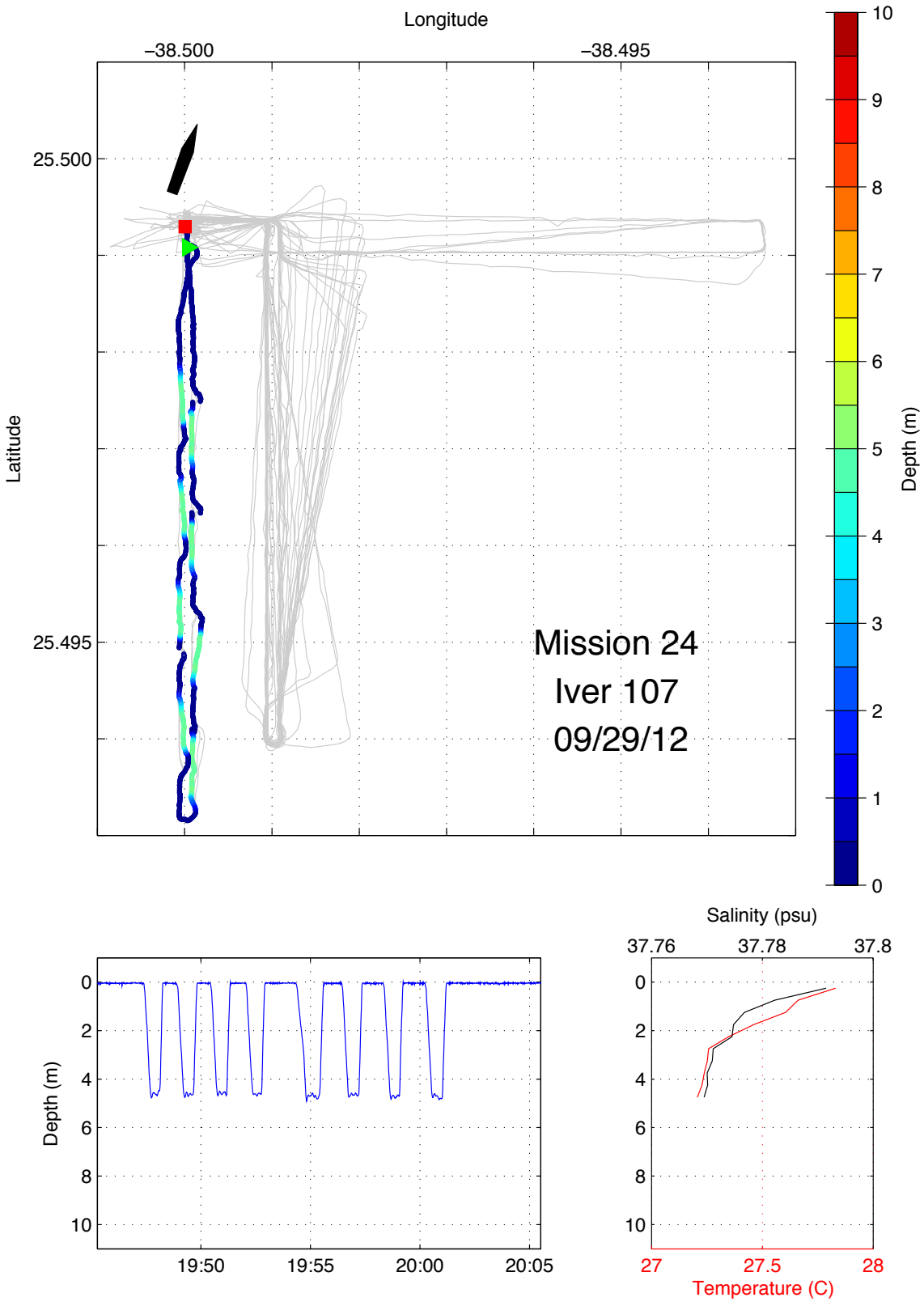

Longitude
−38.500
−38.495
25.500
25.495
Latitude
Mission 19
Iver 107
09/29/12
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
0
2
4
6
8
10
17:10
17:20
17:30
Salinity (psu)
37.76
37.78
37.8
27
28
29
Temperature (C)

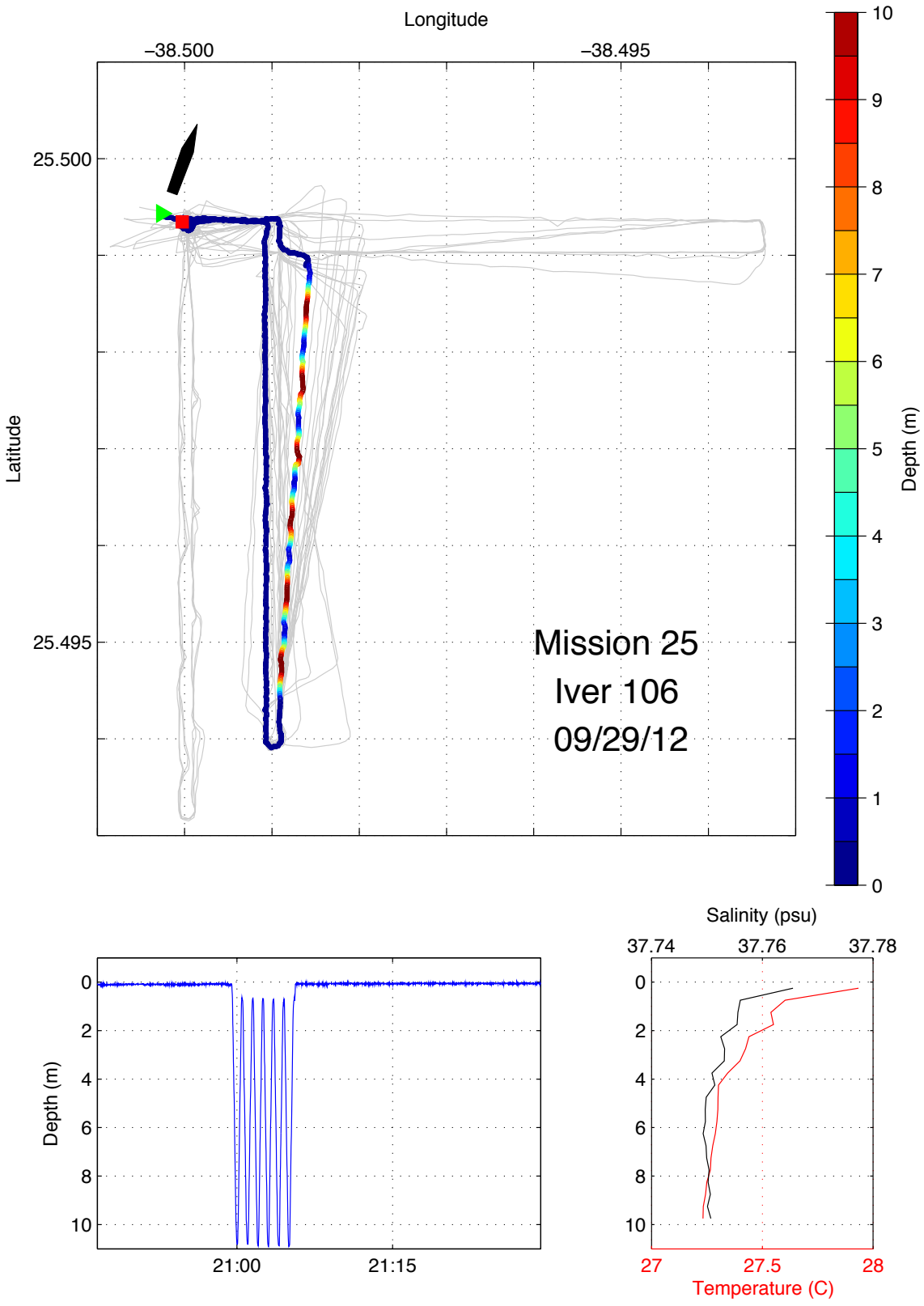

Longitude
−38.500
−38.495
25.500
25.495
Latitude
Mission 20
Iver 107
09/29/12
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
0
2
4
6
8
10
17:40
17:50
Salinity (psu)
37.78
37.8
37.82
0
2
4
6
8
10
27
28
29
Temperature (C)

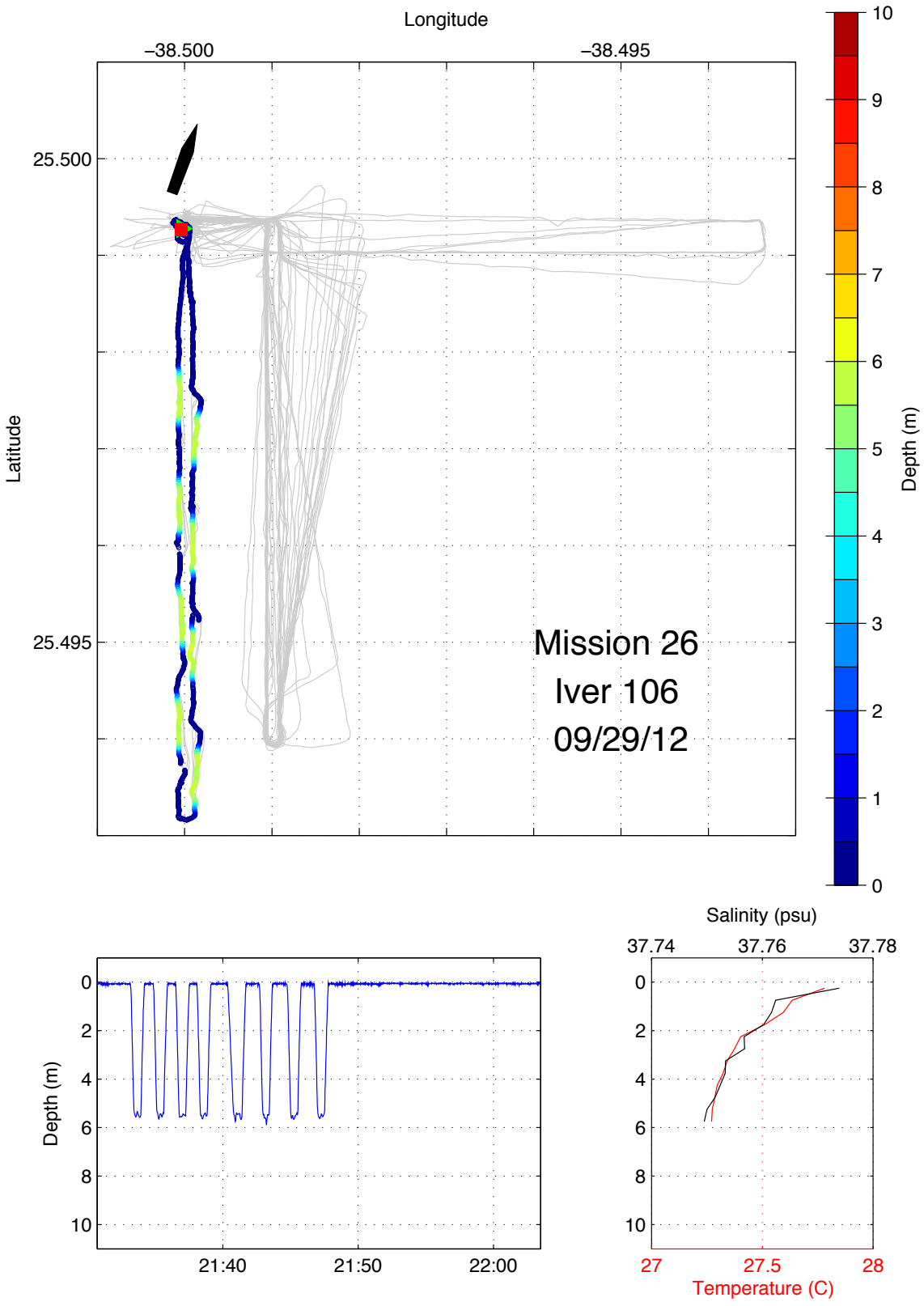

Longitude
−38.500
−38.495
25.500
25.495
Latitude
Mission 21
Iver 107
09/29/12
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
0
2
4
6
8
10
18:00
18:10
18:20
18:30
Salinity (psu)
37.75
37.8
37.85
27
27.5
28
28.5
Temperature (C)

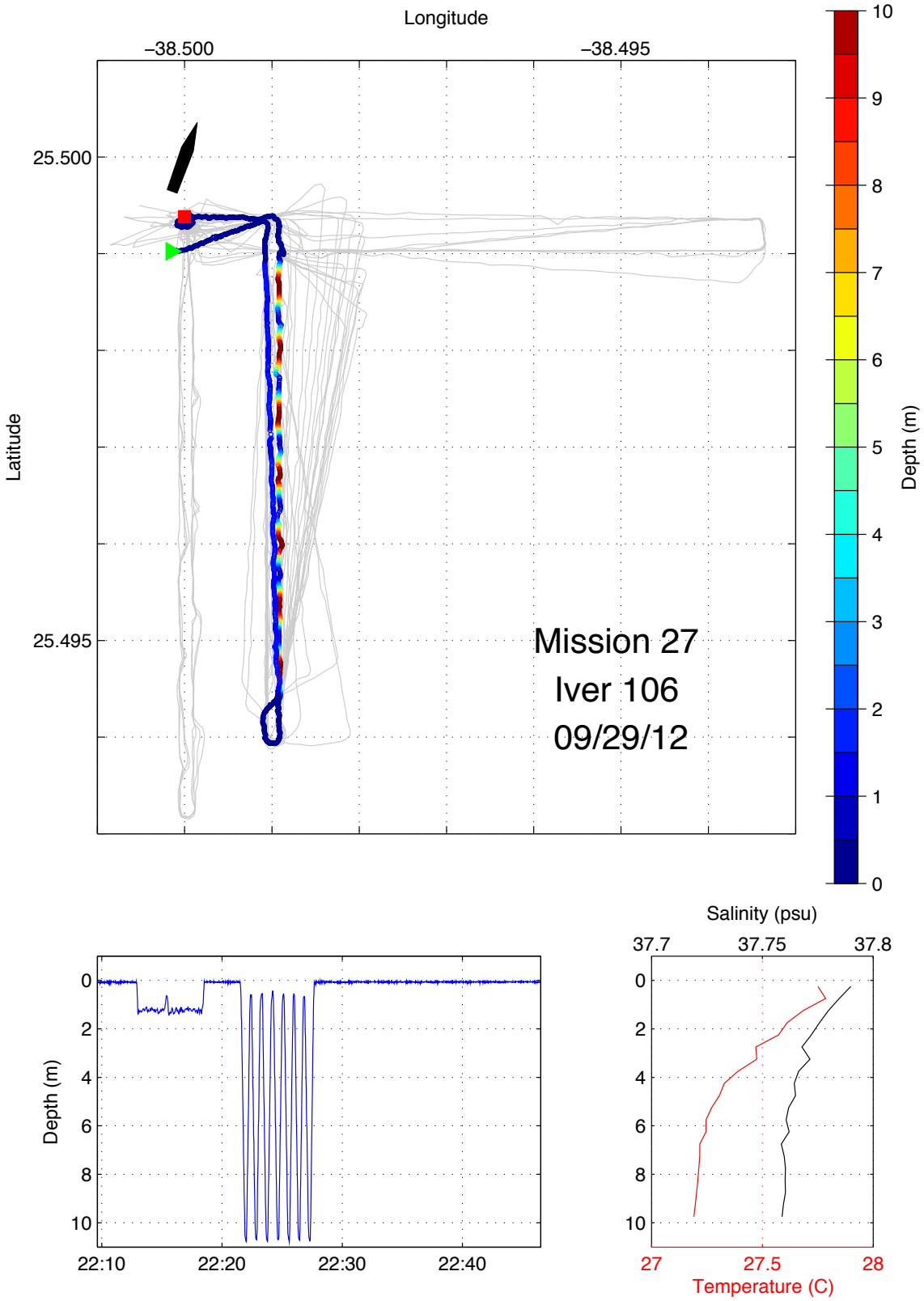

Longitude
−38.500
−38.495
25.500
25.495
Latitude
Mission 22
Iver 107
09/29/12
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
0
2
4
6
8
10
18:40
18:50
19:00
Salinity (psu)
37.75
37.8
37.85
27
27.5
28
28.5
Temperature (C)

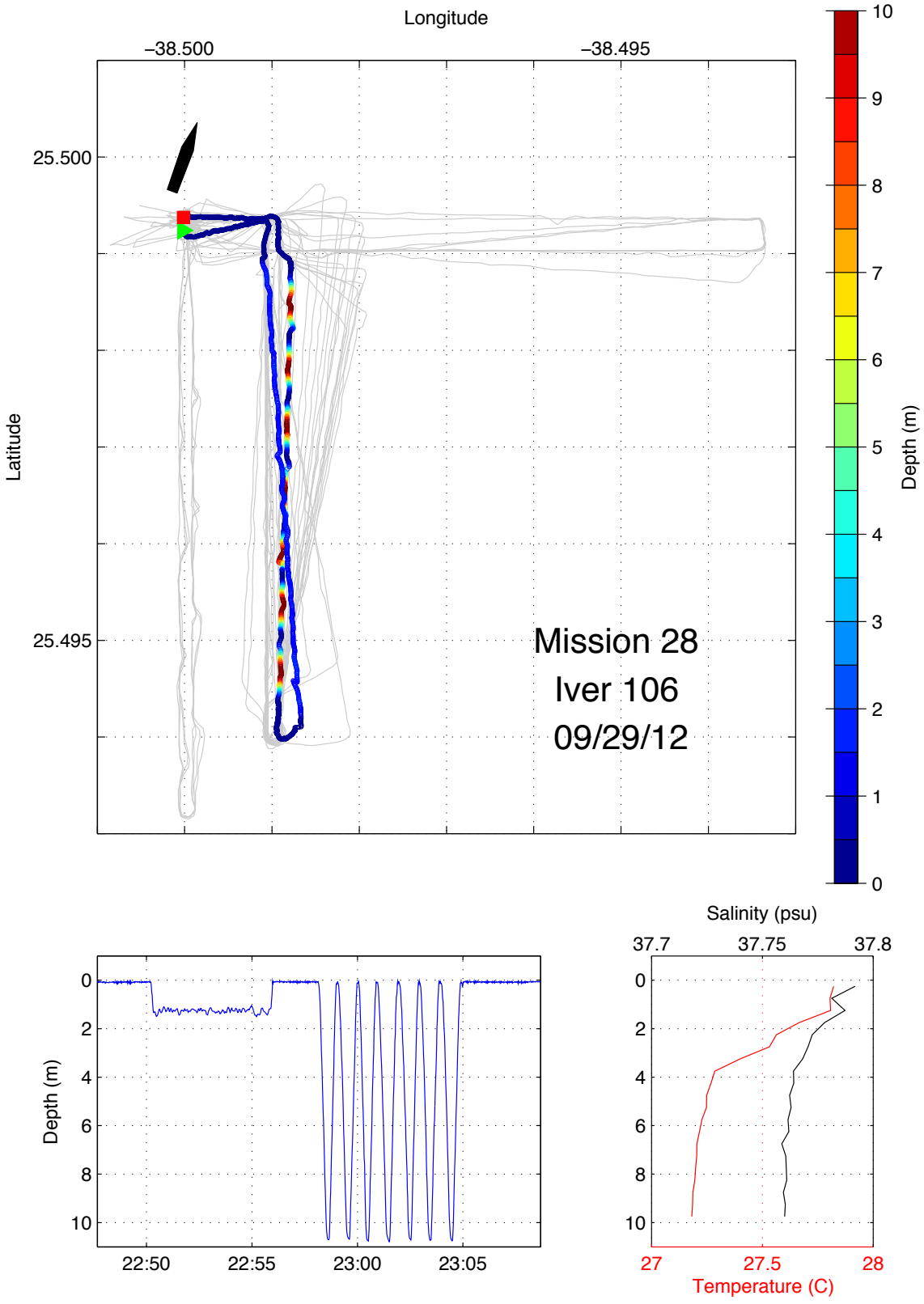

Longitude
−38.500
−38.495
25.500
25.495
Latitude
Mission 23
Iver 107
09/29/12
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
0
2
4
6
8
10
19:15
19:30
Salinity (psu)
37.75
37.8
37.85
27
27.5
28
28.5
Temperature (C)

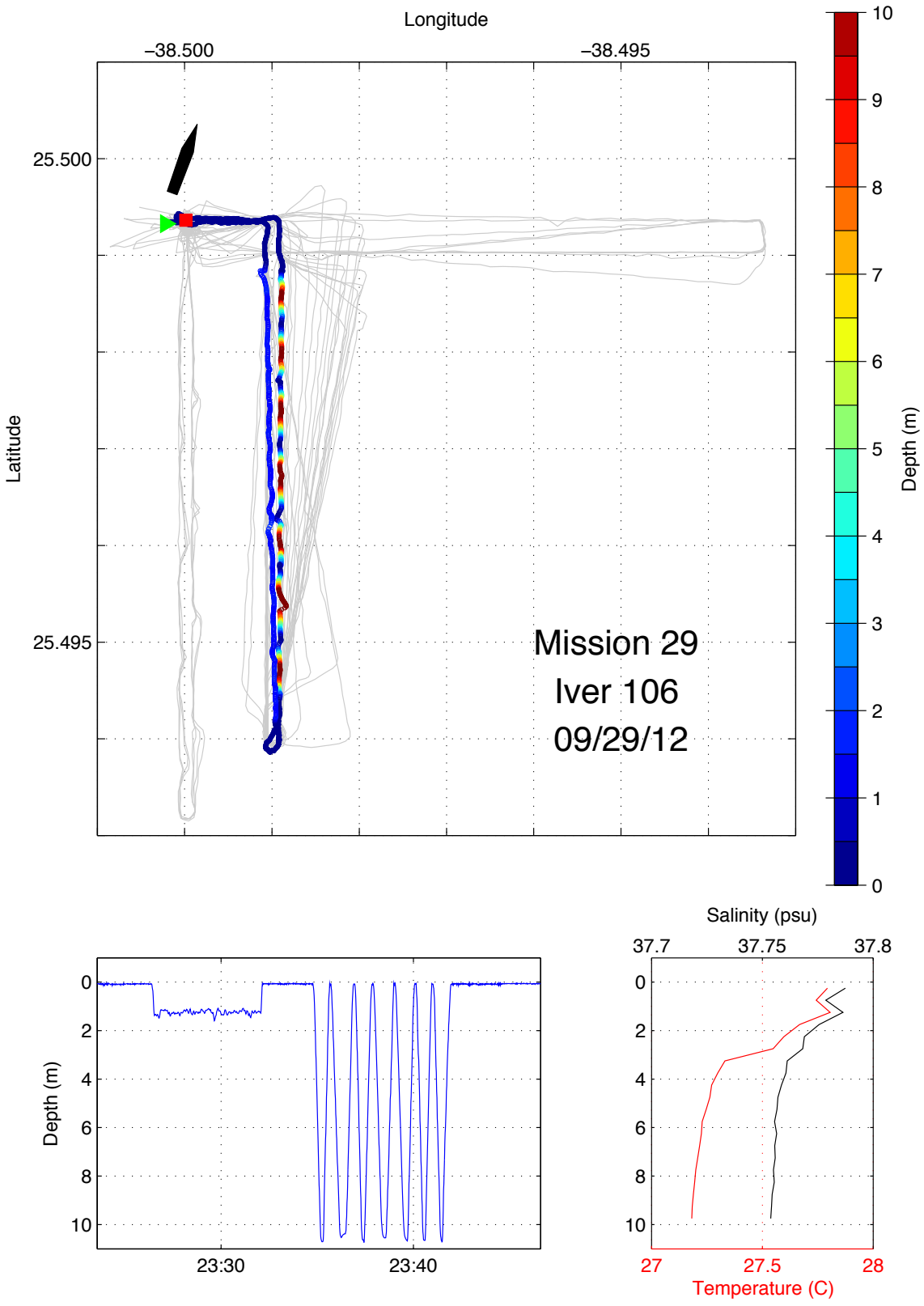

Longitude
−38.500
−38.495
25.500
25.495
Latitude
Mission 24
Iver 107
09/29/12
Depth (m)
10
9
8
7
6
5
4
3
2
1
0
Salinity (psu)
37.76
37.78
37.8
Depth (m)
0
2
4
6
8
10
19:50
19:55
20:00
20:05
27
27.5
28
Temperature (C)

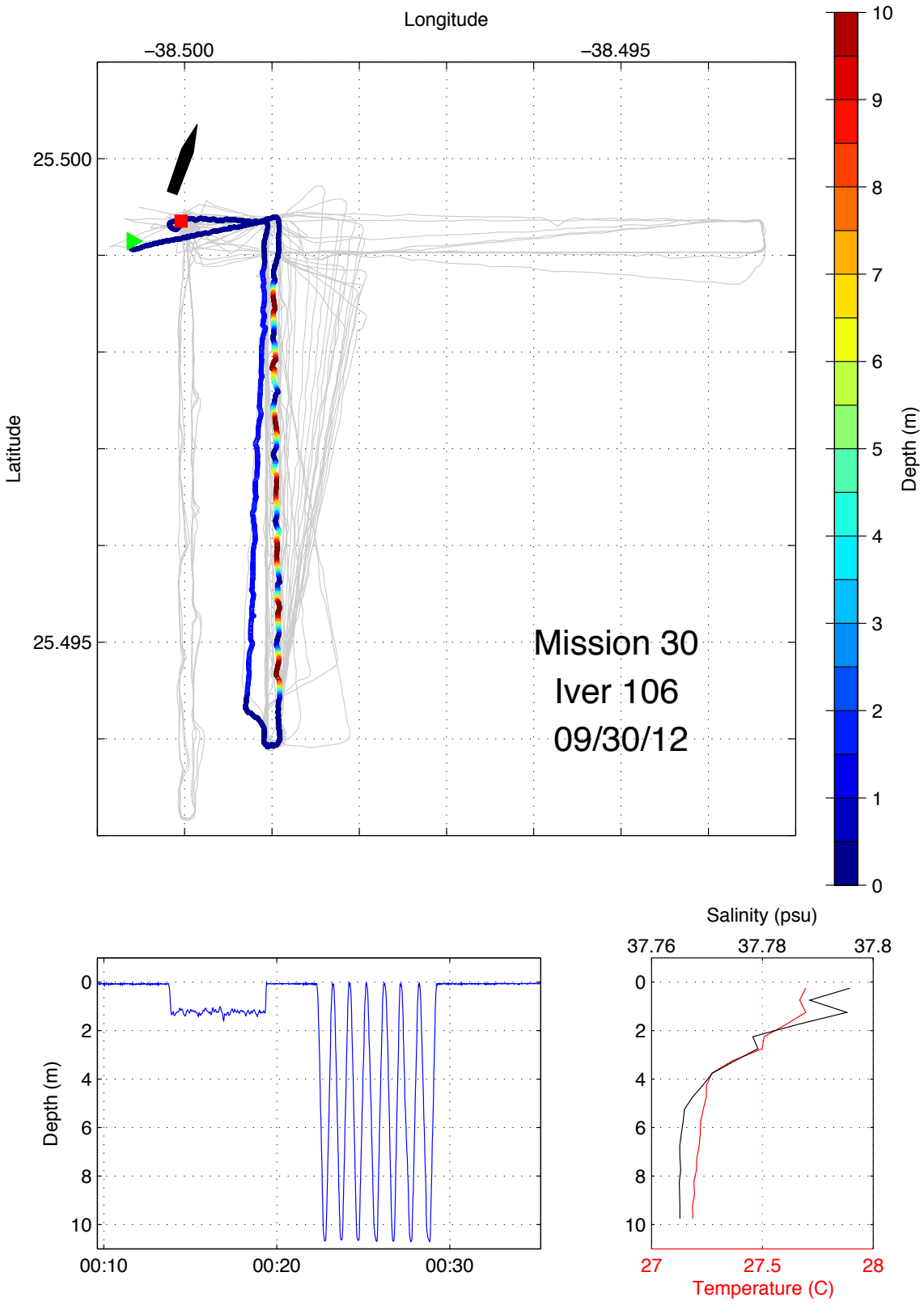

Longitude
−38.500
−38.495
25.500
25.495
Latitude
Mission 25
Iver 106
09/29/12
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
0
2
4
6
8
10
21:00
21:15
Salinity (psu)
37.74
37.76
37.78
27
27.5
28
Temperature (C)

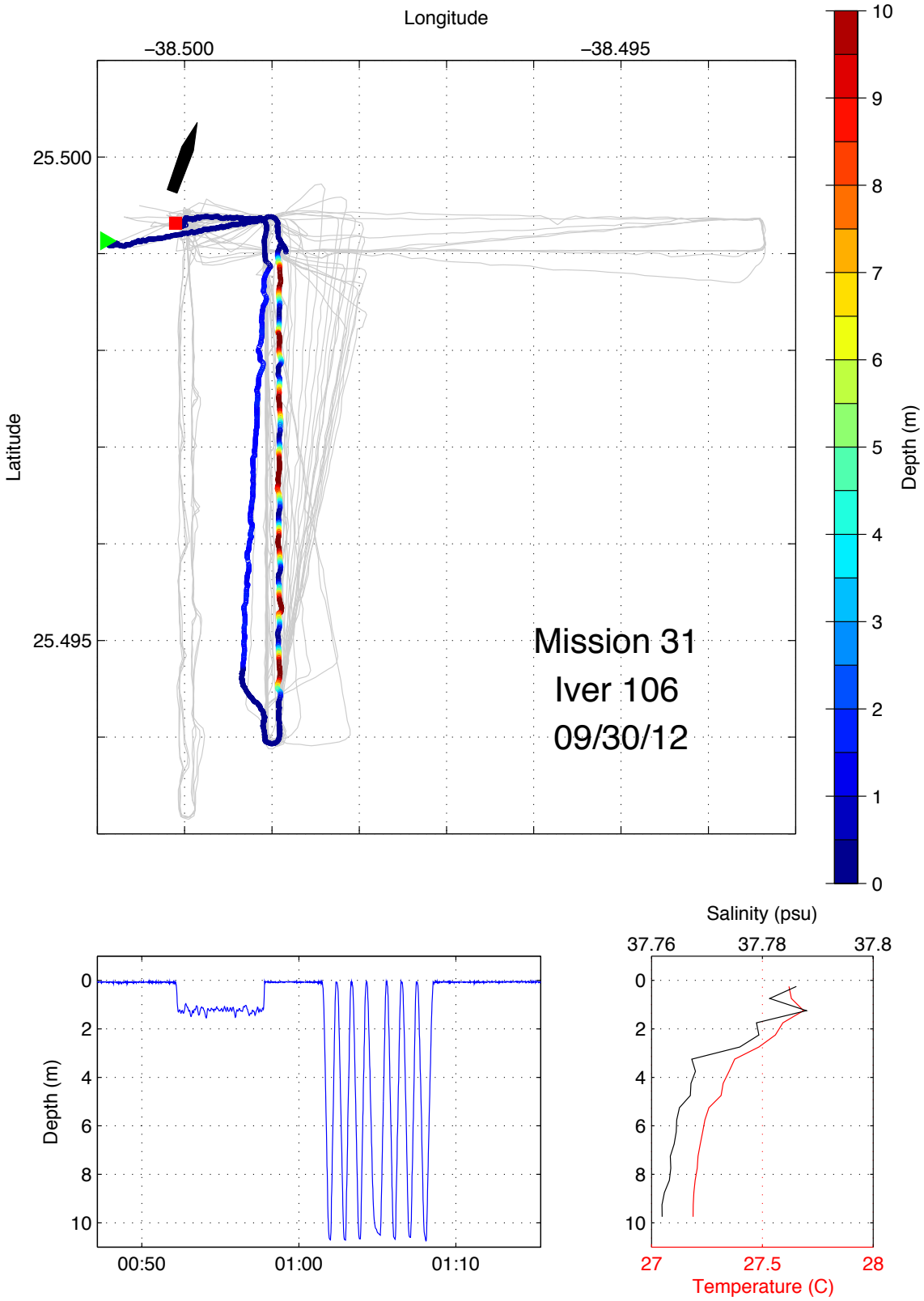

Longitude
−38.500
−38.495
25.500
25.495
Latitude
Mission 26
Iver 106
09/29/12
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
0
2
4
6
8
10
21:40
21:50
22:00
Salinity (psu)
37.74
37.76
37.78
27
27.5
28
Temperature (C)

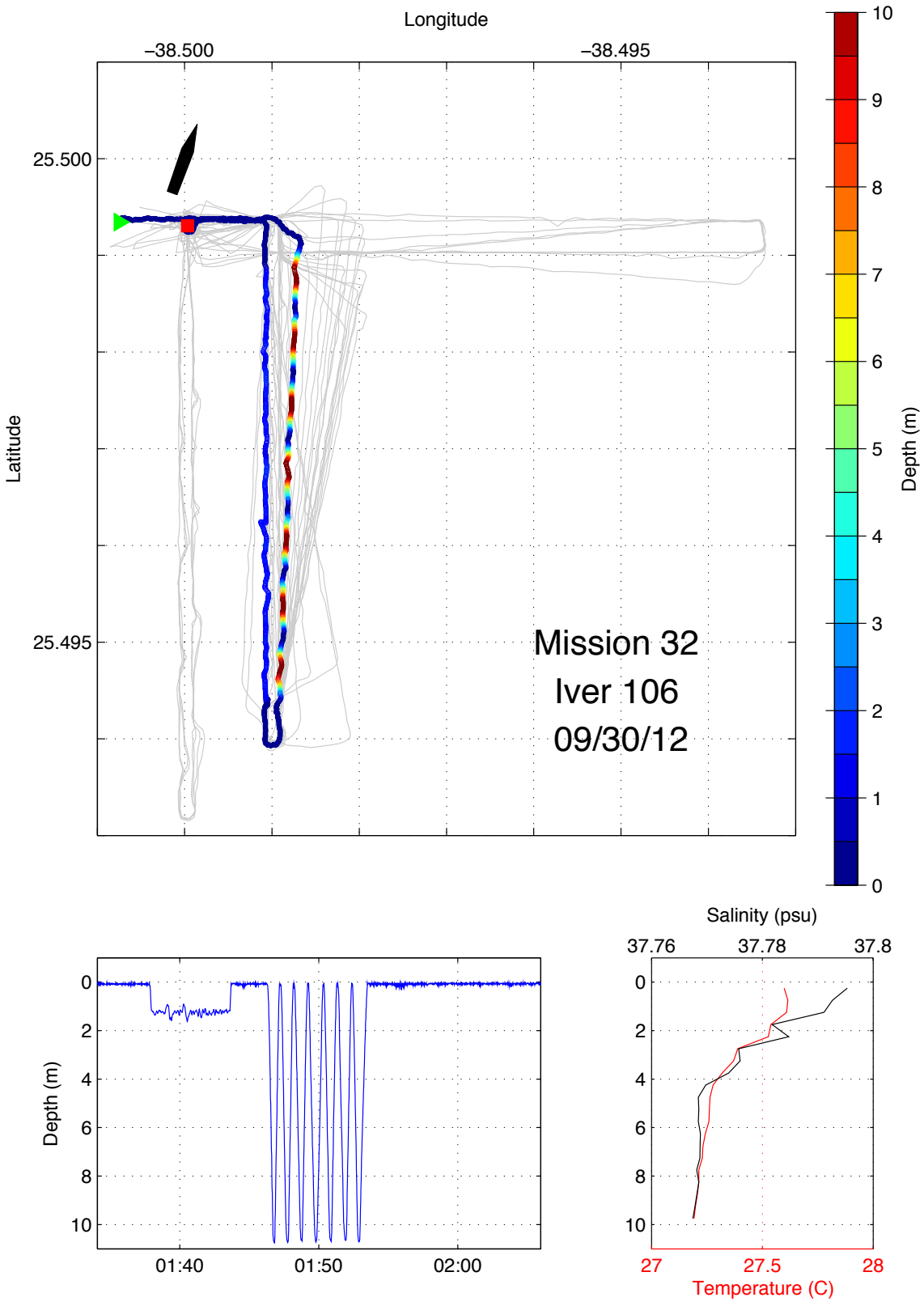

Longitude
−38.500
−38.495
25.500
25.495
Latitude
Mission 27
Iver 106
09/29/12
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
0
2
4
6
8
10
22:10
22:20
22:30
22:40
Salinity (psu)
37.7
37.75
37.8
27
27.5
28
Temperature (C)

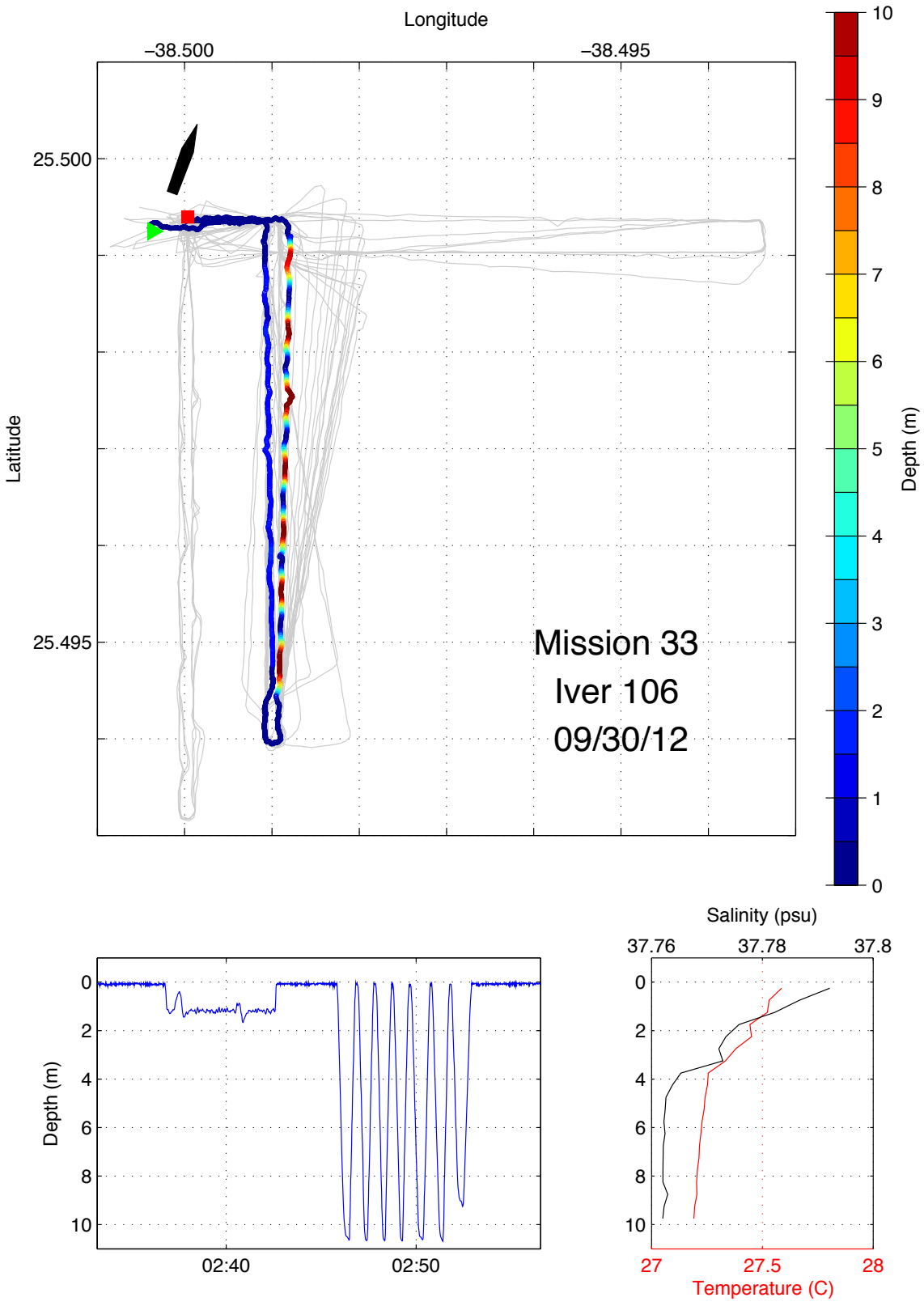

Longitude
−38.500
−38.495
25.500
25.495
Latitude
Mission 28
Iver 106
09/29/12
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
0
2
4
6
8
10
22:50
22:55
23:00
23:05
Salinity (psu)
37.7
37.75
37.8
27
27.5
28
Temperature (C)

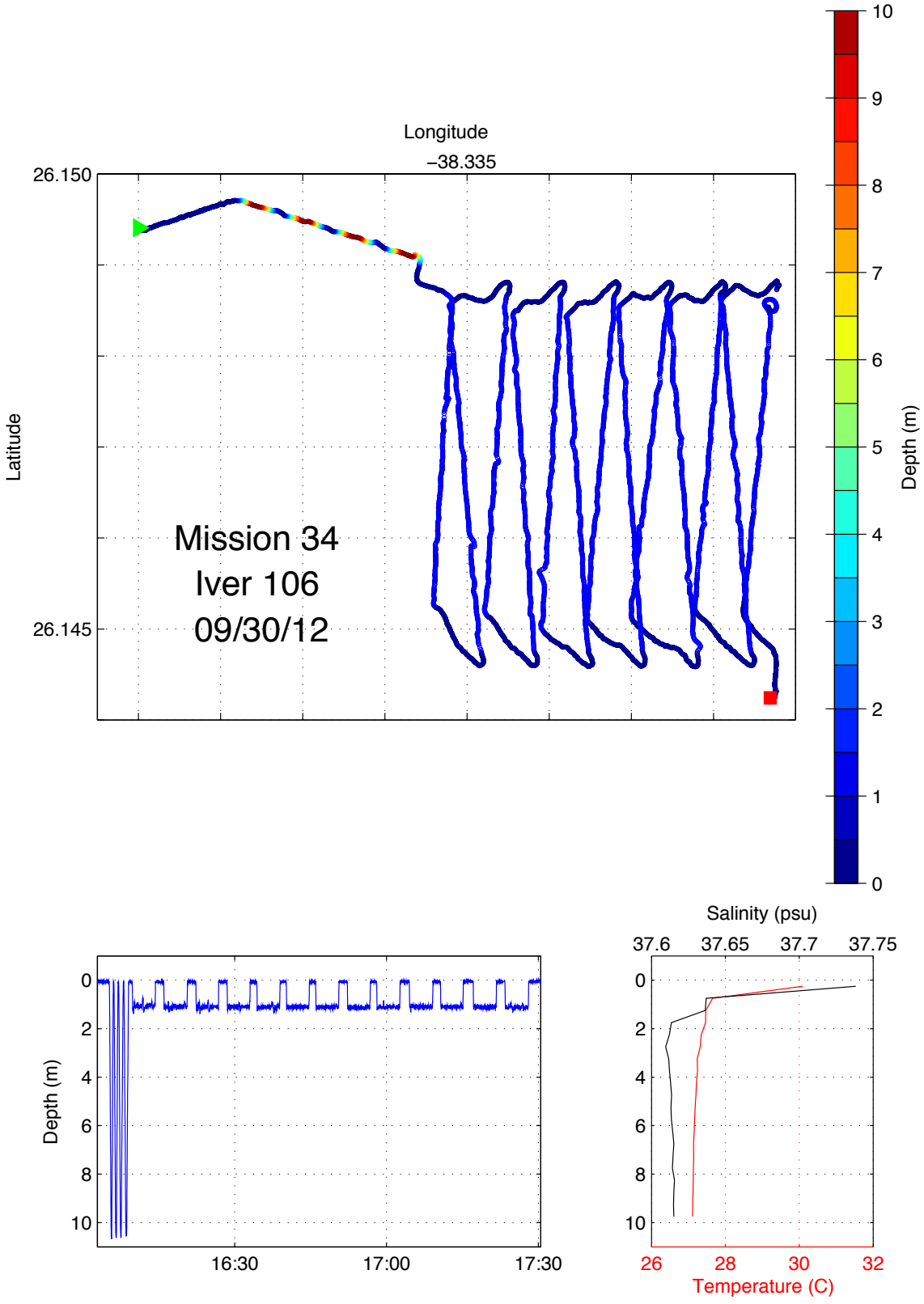

Longitude
−38.500
−38.495
25.500
25.495
Latitude
Mission 29
Iver 106
09/29/12
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
0
2
4
6
8
10
23:30
23:40
Salinity (psu)
37.7
37.75
37.8
0
2
4
6
8
10
27
27.5
28
Temperature (C)


Longitude
−38.500
−38.495
25.500
25.495
Latitude
Mission 30
Iver 106
09/30/12
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
0
2
4
6
8
10
00:10
00:20
00:30
Salinity (psu)
37.76
37.78
37.8
27
27.5
28
Temperature (C)


Longitude
−38.500
−38.495
25.500
25.495
Latitude
Mission 31
Iver 106
09/30/12
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
0
2
4
6
8
10
00:50
01:00
01:10
Salinity (psu)
37.76
37.78
37.8
27
27.5
28
Temperature (C)


Longitude
−38.500
−38.495
25.500
25.495
Latitude
Mission 32
Iver 106
09/30/12
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
0
2
4
6
8
10
01:40
01:50
02:00
Salinity (psu)
37.76
37.78
37.8
27
27.5
28
Temperature (C)


Longitude
−38.500
−38.495
25.500
25.495
Latitude
Mission 33
Iver 106
09/30/12
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
0
2
4
6
8
10
02:40
02:50
Salinity (psu)
37.76
37.78
37.8
0
2
4
6
8
10
27
27.5
28
Temperature (C)


Longitude
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26.150
26.145
Latitude
Mission 34
Iver 106
09/30/12
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
0
2
4
6
8
10
16:30
17:00
17:30
Salinity (psu)
37.6
37.65
37.7
37.75
26
28
30
32
Temperature (C)

50272-101

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16. Abstract (Limit: 200 words)
This report describes the collection of water property data from EcoMapper AUVs during the R/V Knorr 209-1 cruise as part of the SPURS (Salinity Processes Upper-ocean Regional Study) project. Post-processing was required to improve the quality of the raw data, particularly salinity, and is documented herein. Initial results from temperature and salinity records are presented. The measurements are concentrated in the upper 10 meters of the mixed layer during calm conditions, and reveal significant diurnal warming (up to 3°C) and salinification (up to 0.1 psu) of the surface (< 1 meter) layer. The mixing promoted by the motion of the research vessel destroys this shallow stratification, so the ability of the AUVs to sample undisturbed water hundreds of meters from the ship was critical to the effort of accurately resolving it.

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salinity
diurnal cycles

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

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