Sentry Operations Report for the Chadwick/NEMO 2015 Cruise DRAFT

WHOI Sentry Operations Group
Dr. Dana Yoerger, Justin Fujii, Zachary Berkowitz, Stefano Suman, Loral O'Hara

Sentry Expedition Leader: Dr. Dana Yoerger

Chief Scientist: Dr. William Chadwick, NOAA

RV Thomas G. Thompson — August 9, 2015 to August 29, 2015

Publication Date: August 28, 2015

1 Summary

This document summarizes operations with the *Sentry* autonomous underwater vehicle (AUV) during the 2015 Chadwick/NEMO cruise. Included in this report is the vehicle configuration; basic vehicle and sensor performance; and post-dive reports (with summary statistics and narratives). This report does not attempt to describe the scientific results or conclusions. A detailed description of the data files resulting from this cruise is provided in a separate document. Individual dive summaries for Sentry dives 336-341 follow — each of these is a free-standing document summarizing the dive.

2 Cruise Log

This section provides a brief chronological summary of *Sentry* activities during the cruise. Additional information on specific dives is available in the dive reports.

All times/dates are UTC. For the initial part of the cruise, local time was UTC-7 hrs.

August 10, 2015 This was the first day of the mobilization.

August 14, 2015 We left port and began our transit to the work site

August 15, 2015 Arrived on station. Casius USBL calibration.

Augst 16, 2015 Sentry336, survey of new flow at Northern Rift Zone (LRZ). the vehicle performeded very well on a 25 hr survey, but the multibeam failed.

August 17-19, 2015 weather delay

August 20, 2015 Sentry337, a test dive for sonar, bottom-following, and INS. Sonar failed again in the same way. Following Reson's advice, we dove again with the new head after resetting the software configuration. Bottom-following and INS gave very good results.

August 21, 2015 Sentry338. We surveyed the NE caldera following lines provided by David Clague (MBARI). We ran the spare receive head on the sonar and it worked very well.

August 23, 2015 Sentry339. Repeat MBARI AUV line and visit all benchmark stations

August 24, 2015 Sentry340. Wide-area deformation survey

August 26, 2015 Sentry341. Survey of new flow at the NE rim of the caldera

August 28, 2015 Begin transit to Seattle

August 29, 2015 Arrive at UW

3 Vehicle Configuration

Table 1 lists the science sensors installed on *Sentry* on this cruise.

4 Navigation

All dives were navigated using realtime DVL velocity inertial measurement unit (IMU) attitude measurements. External aiding during descent was performed with Ultra-Short Baseline (USBL) throughout the cruise. Dive specific notes on navigation are included in the dive reports. All final navigation consists of a track where the DVL/IMU track was fused with the USBL fixes in post-processing.

We used Jason's Ranger system.

The basic acoustic performance of the Sonardyne was very good out to about 1 water depth in horizontal range.

Table 1: Sentry Sensor Configuration

Sensor
APS 1540 Magnetometers (3)
Edgetech 4-24kHz Sub-Bottom Profiler (SBP)
Edgetech 120kHz/410kHz Sidescan sonar
Reson 7125 Multibeam Sonar
Seabird SBE49 Conductivity-Temperature-Depth (CTD)
Seapoint optical backscatter sensor (OBS)
Anderaa optode model 4330
300kHz RDI Doppler Velocity Log (DVL)
IXEA PHINS
Reson Sound Velocity Probe
NOAA MAPR

The vehicle spent much time out of range of the USBL system. During those times, we relied on the LBL ranges and the mission plan to keep track of the vehicle's position. This was aided by a spreadsheet that predicted the time of all major turns. Those turns were usually evident in the LBL trace.

The LBL system was critical. It preformed poorly with the vessel's in-hull transducer but worked very well with our ducer dangled over the side.

4.1 Coordinate origins

The vehicle's control system uses simple equidistant coordinates. This system uses an origin, defined in terms of latitude and longitude with the World Geodetic System 1984 (WGS84) datum, and a fixed scaling between meters displacement from the origin. We use the identical routines that have been used by the National Deep Submergence Facility (NDSF) assets Alvin and Jason for decades. Likewise we always used the same origin for Sentry and Alvin at each site. These simple coordinates have several advantages for realtime control of a vehicle. Unlike Universal Transverse Mercator (UTM) grid coordinates, the x and y axes intersect at right angles and align with true east and north respectively at the origin. These coordinates distort quickly as one moves away from the origin, but we solve that problem by putting the origin close to the operating area. We almost always report our results in latitude/longitude, so most users need not be aware of these details.

4.2 USBL Calibration and Performance Notes

A CASIUS calibration of the USBL system was conducted when we first arrived on station. A copy of the USBL calibration report is included in the appendices of this document

5 Items of Note

This section summarized details which are worthy of note or mention for future reference but which do not constitute problems:

N.1: We followed launch and recovery procedures worked out on the previous cruise on Atlantis and Thompson.

N.2: Launches and recoveries were performed on the stbd side of the vessel as far forward as possible with the deck layout.

N.3: We launched

6 Technical Issues

This section summarizes technical issues encountered by the *Sentry* operations group on the cruise. Issues which affected primarily individual dives are listed in the individual dive reports.

T.1: We have worked successfully on Thompson many times, this cruise was in keeping with that.

T.2: launch and recovery operations were generally very smooth.

T.3: The Reson7125 mapping sonar failed on the first dive. On advice from the manufacturer, we reinitialized the software configuration before the second dive. The sonar failed again in an identical manner. Following the second failure, the manufacturer determined they had sent us a receive head with the wrong firmware. We swapped the head, renormalized it, and it worked extremely well after that.

T.4: The LBL system did not work with the vessel's in-hull ducer. We used our "dangle ducer", which worked well on the 14.0/13.0 and 9.0 channels.

7 Sentry Operations Team

The *Sentry* team was comprised of 5 members on this cruise — Dr. Dana Yoerger, Justin Fujii, Zac Berkowitz, Stefano Suman, and Loral O'Hara. Dana Yoerger was the Expedition Leader and principal author of this report.

8 Acknowledgments

1. Thank you to the crew of the R/V Thompson for going out of their skill and cooperation in making this cruise a success. Likewise we thank the WHOI Jason group for their cooperation and assistance. Our mapping team consisting of members of the Sentry team, NOAA, and MBARI worked very well together.

Sentry 336 Dive Report
DRAFT

WHOI Sentry Operations Group
Dr. Dana Yoerger, Justin Fujii, Zachary Berkowitz, Stefano Suman, Loral O'Hara

Sentry Expedition Leader: Dr. Dana Yoerger

Chief Scientist: Dr. William Chadwick, NOAA

Summary

Weather: The weather was well within the operating window on launch, but challenging on recovery.

Reason for end of dive: We terminated the dive at the end of the last trackline.

Vehicle Configuration

The science sensing suite for this dive was:

Table 2: Sentry Sensor Configuration

Sensor
APS 1540 Magnetometers (3)
Edgetech 4-24kHz SBP
Edgetech 120kHz/410kHz Sidescan sonar
Reson 7125 Multibeam Sonar
Seabird SBE49 CTD
Seapoint OBS
Anderaa optode model 4330
300kHz RDI DVL
IXEA PHINS
Reson Sound Velocity Probe
NOAA MAPR

This dive was navigated using the DVL/INS system in real time. USBL provided post-dive corrections. In realtime, we monitored the vehicle's progress using the long-baseline transponder/beacon system, which provides a single range between the vessel and the vehicle. The single range enables the watch to determine if the ranges are consistent with the mission plan, especially with regard to turns.

Important Positions

Dive Origin: 45 55.000'N 130 1.500'W

Launch Position: sentry336 launch position: 46 4.531'N 129 58.248'W

Narrative

We launched Sentry conventionally, Jason was not in the water.

Sentry336 used tracklines supplied by Dr. David Clague of MBARI to map the 2015 northern rift zone (NRZ) eruption, which was known from a recent vessel multibeam survey. We reversed Clagues lines on direction from Chadwick, as we wanted to prioritize the SE and western areas. We added crossing lines to Clagues lines.

We had concerns about the weather, which was well within our operation window at launch but was expected to increase over the course of the dive.

We launched around noon local (1722Z). Descent and the first trackline (a crossing line) were uneventful. After watching for over an hour, we pulled the USBL pole and left the site to check on the elevator, which had failed to release. LBL performance with the vessel hull-mounted ducer was disappointing, extending just a bit past USBL range (about 2km). The transit to the elevator site took about 1 hrs. At the elevator site, they ran Medea to the seafloor to stretch out the cable and test the winch. They were able to look at the elevator, it appeared to be stuck in the mud. We returned to the Sentry site at about 2000 local (0300Z), Sentry was right on the trackline at the expected position. We were able to track Sentry much of the time during its long jog to the south (following the eruptive fissure).

At midnight local (0700Z), Jason was launched. We got periodic fixes and acomms from Sentry when it was in range. They recovered Jason starting at about 0730 local (1430Z) due to weather concerns. We chose to leave Sentry in and were able to track it for much of the remainder of the dive. We checked the weather constantly and did not feel that the sea state was increasing.

We chose to pull Sentry at about 1400 local (2100Z) as it had finished the last of the western block tracklines supplied by Clague. The seas seemed to be starting to build, and we thought the remaining tracklines that could be run did not have very high value.

When the vehicle reached the surface, we monitored the freewave. SNR looked as expected, -91/-107.

The recovery was a bit rough, although we did no damage to the vehicle and no personnel were ever in danger. We had to make several passes to get hooked up.

The multibeam failed. The beamforming was corrupted. No possibility of repair in post-processing.

1 Issues and Proposed Solutions

We had many exchanges with Reson about the sonar. They advised we had a corrupted software configuration. In fact, they had sent us a refurbished receive head with outdated firmware.

Chief Scientist Comments

The Chief scientist is requested to include any desired comments.

Dive Statistics

Sentry336 Summary Launch: 2015/08/16 19:22:10
Survey start: 2015/08/16 20:08:22
Latitude: 46.075566 Longitude -129.970845
Depth: 1666.18
Survey end: 2015/08/17 21:03:34
Latitude: 46.083475 Longitude -130.006932
Depth: 1691.73
Ascent begins: 2015/08/17 21:03:34
On the surface: 2015/08/17 21:39:17
On deck: 2015/08/17 22:01:58
descent rate: 36.1 m/min
ascent rate: 47.4 m/min
survey time: 24.9 hours
deck-to-deck time 26.7 hours
Mean survey depth: 1684m
Mean survey height: 65m
distance travelled: 88.82km
average speed; 0.99m/s
average speed during photo runs: 0.00 m/s over 0.00 km
average speed during multibeam runs: 0.99 m/s over 88.82 km
total vertical during survey: 8605m
Battery energy at launch: 20.3 kwhr
Battery energy at survey end: 1.5 kwhr
Battery energy on deck: 1.3 kwhr
Battery energy used for survey: 18.6 kwhr
Average power during survey: 745.0 watts

Plots and Images

This section contains selected images of data products and plots of vehicle navigation and selected sensors.

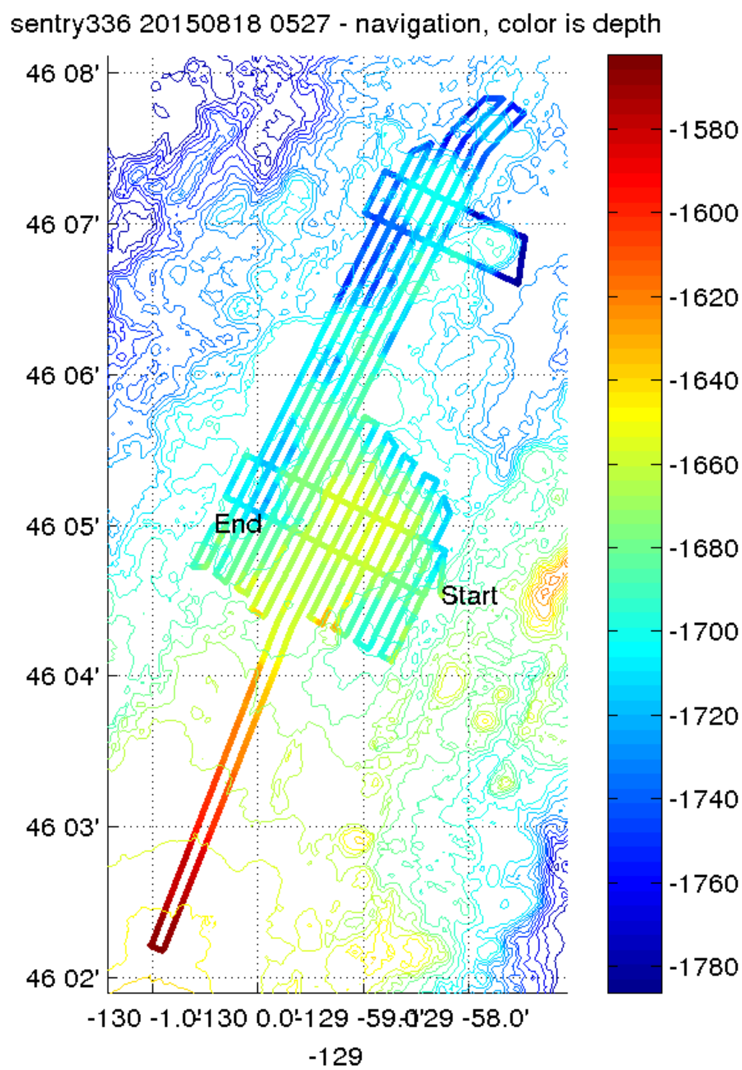


Figure 1: Latitude/Longitude plot of Sentry dive 336 based on post-processed navigation. The color indicates vehicle depth.

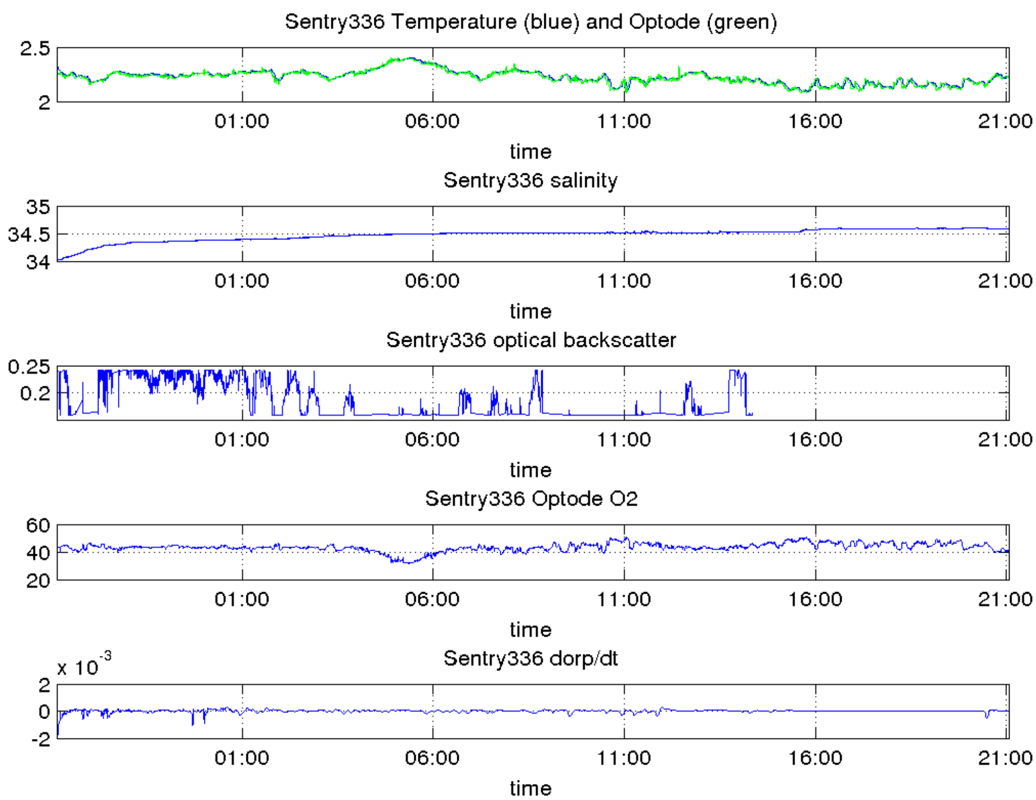


Figure 2: Time series plot of five of the basic sensors on Sentry, from top to bottom, temperature, salinity, optical backscatter, dissolved Oxygen, and derivative w.r.t. time of the ORP voltage.

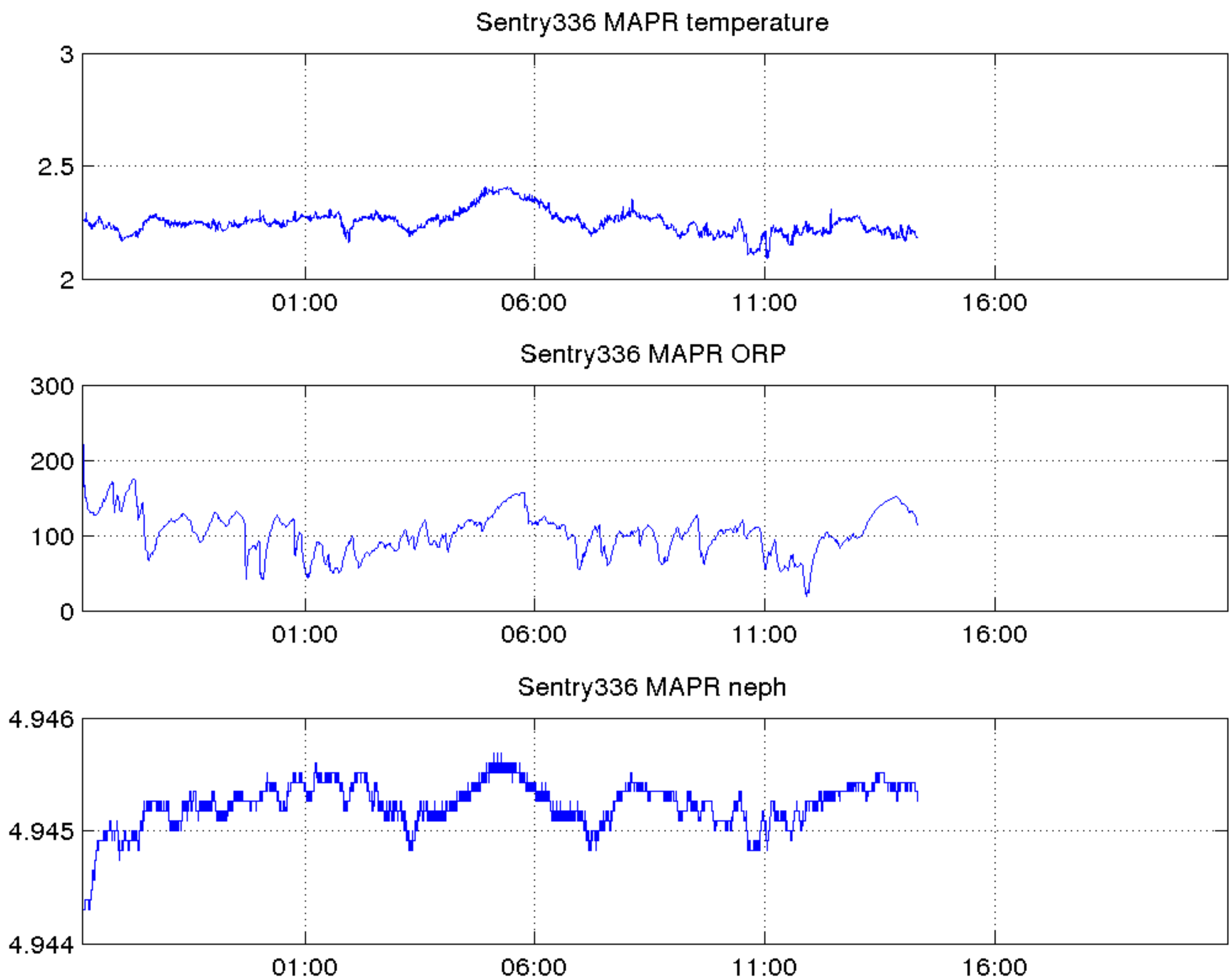


Figure 3: time plots from MAPR (temperature, ORP, and nephelometer) on dive 336.

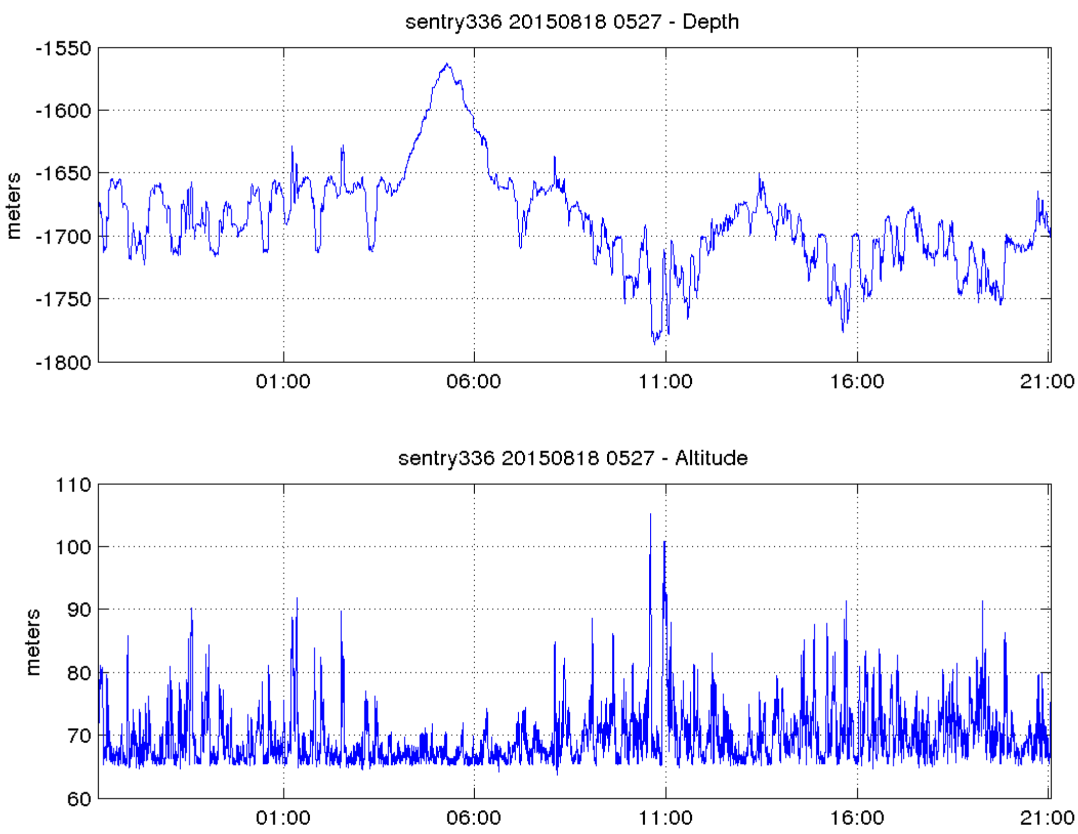


Figure 4: Depth and Altitude of Sentry during dive 336.

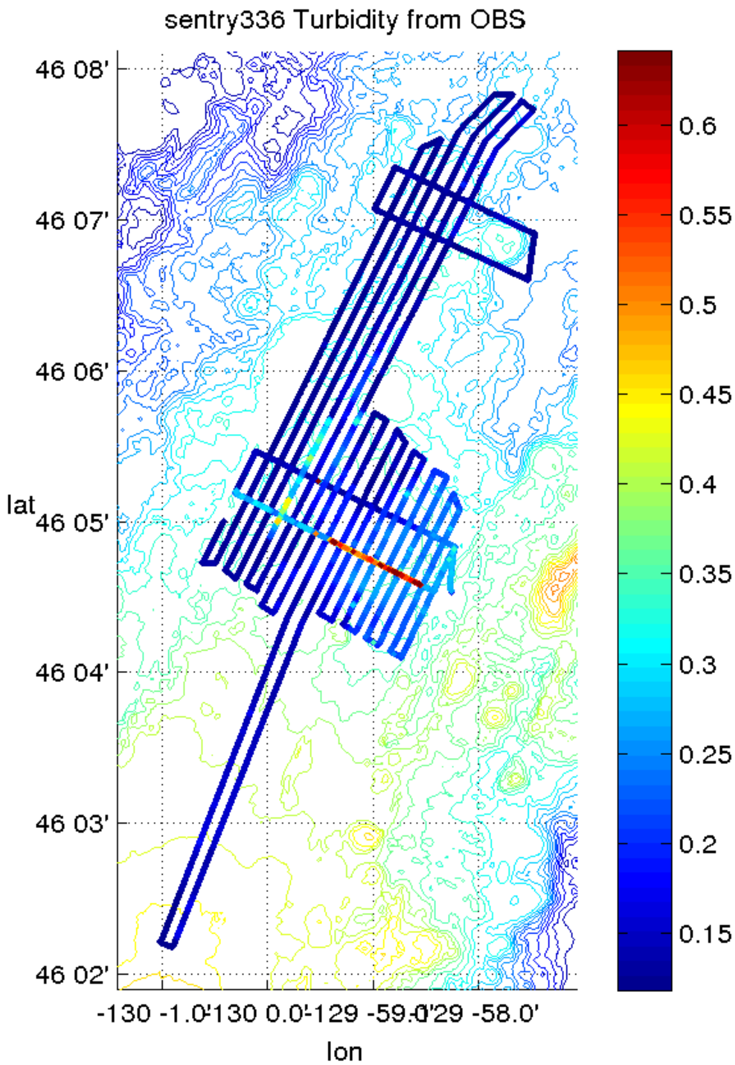


Figure 5: Optical backscatter on dive 336.

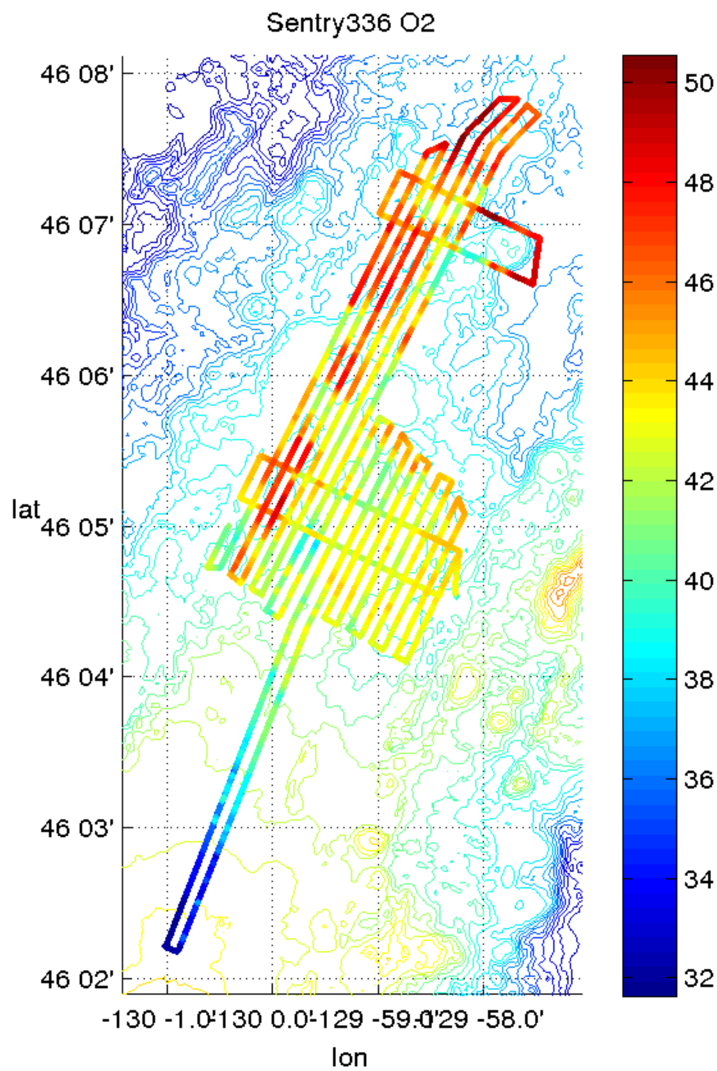


Figure 6: O2 Concentration on dive 336.

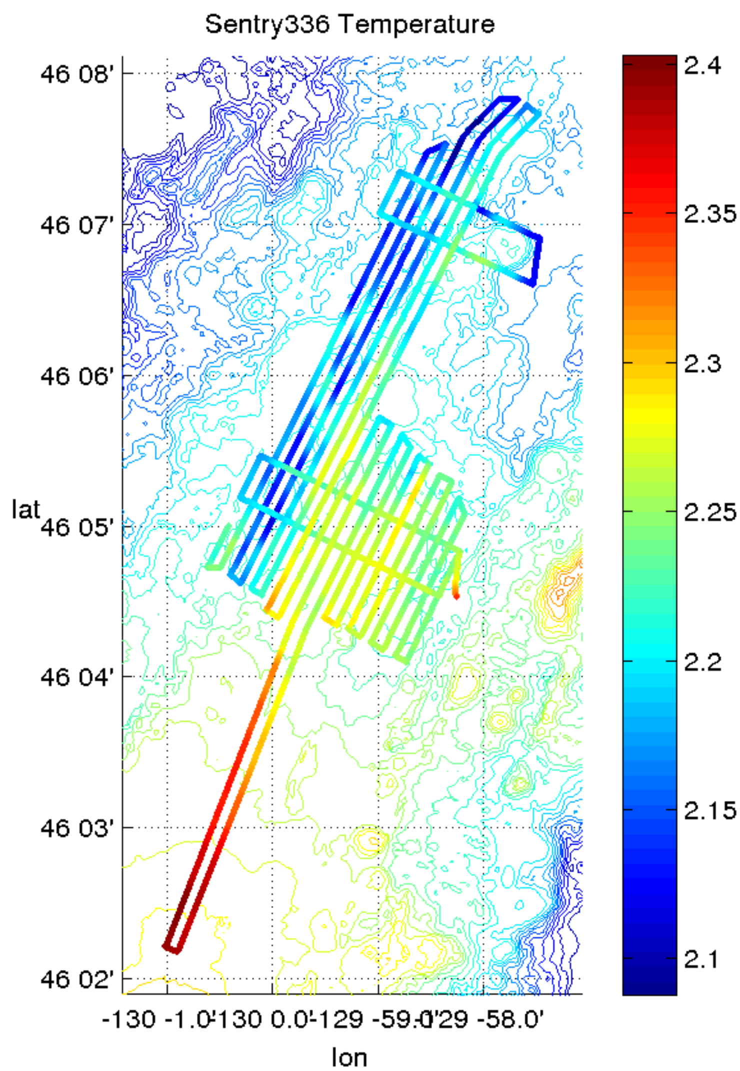


Figure 7: Seabird SBE49 temperature on dive 336.

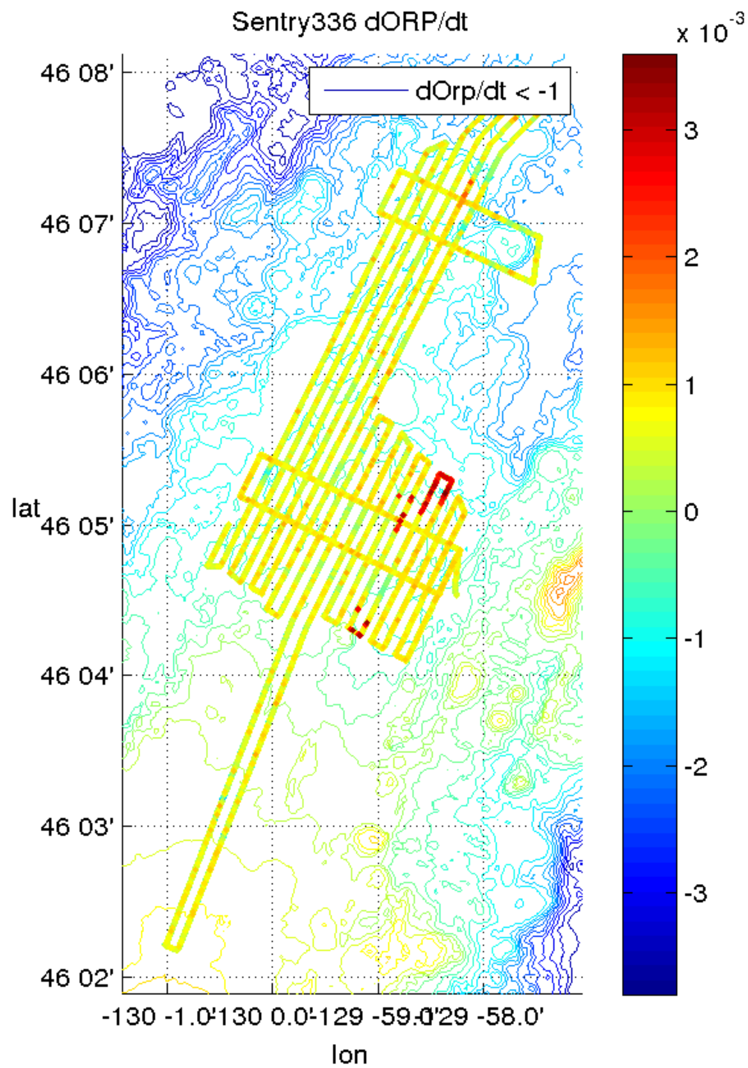


Figure 8: Redox potential (dORP/dt) on dive 336.

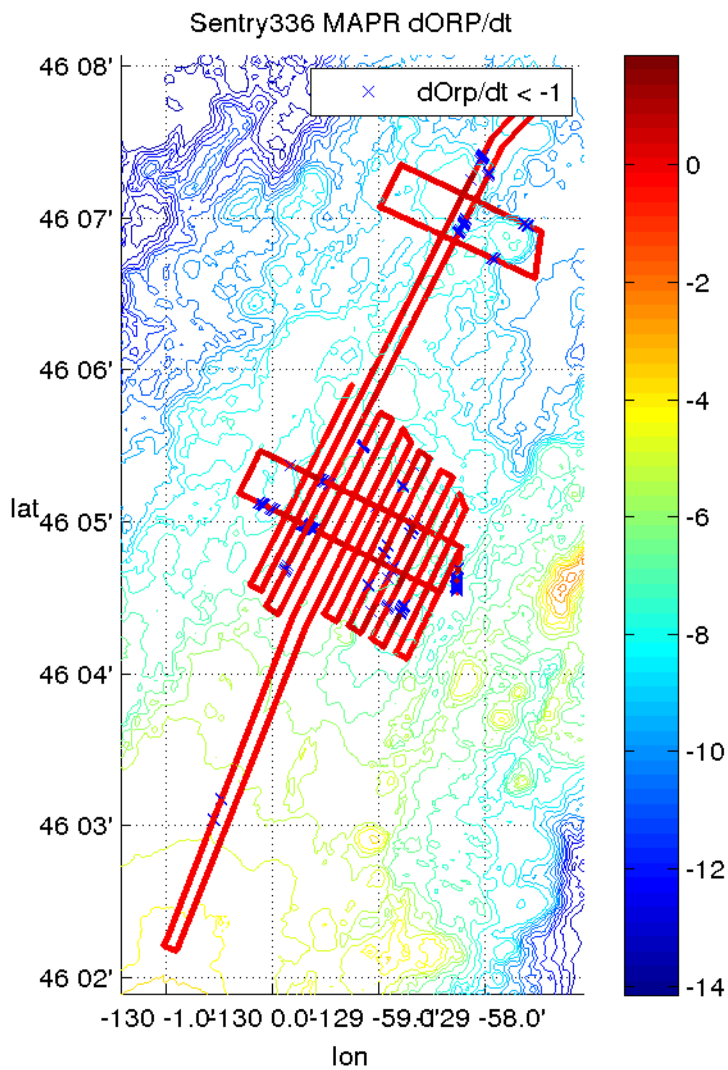


Figure 9: Redox potential from MAPR (dORP/dt) on dive 336.

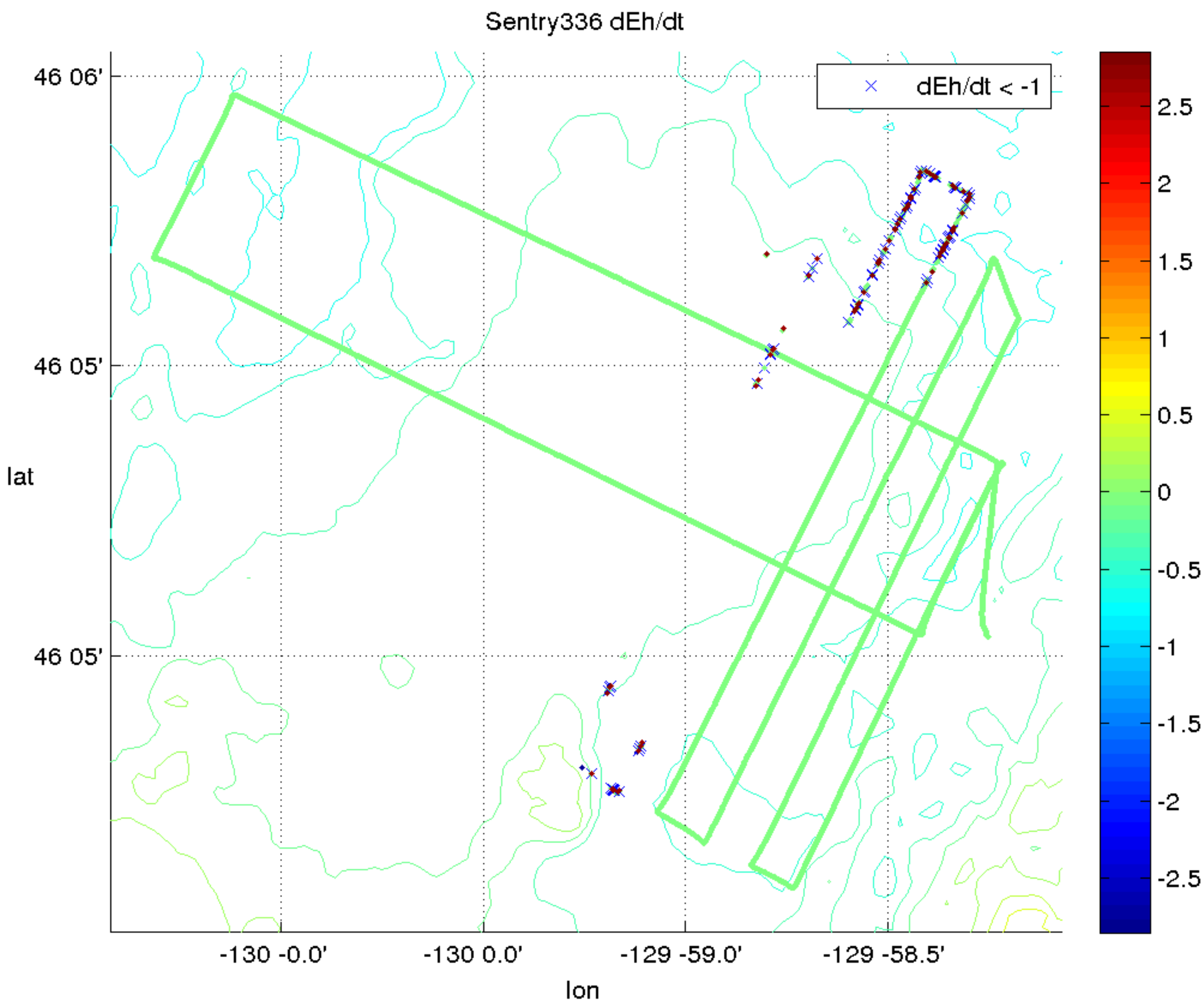


Figure 10: Redox potential (deh/dt) on dive 336.

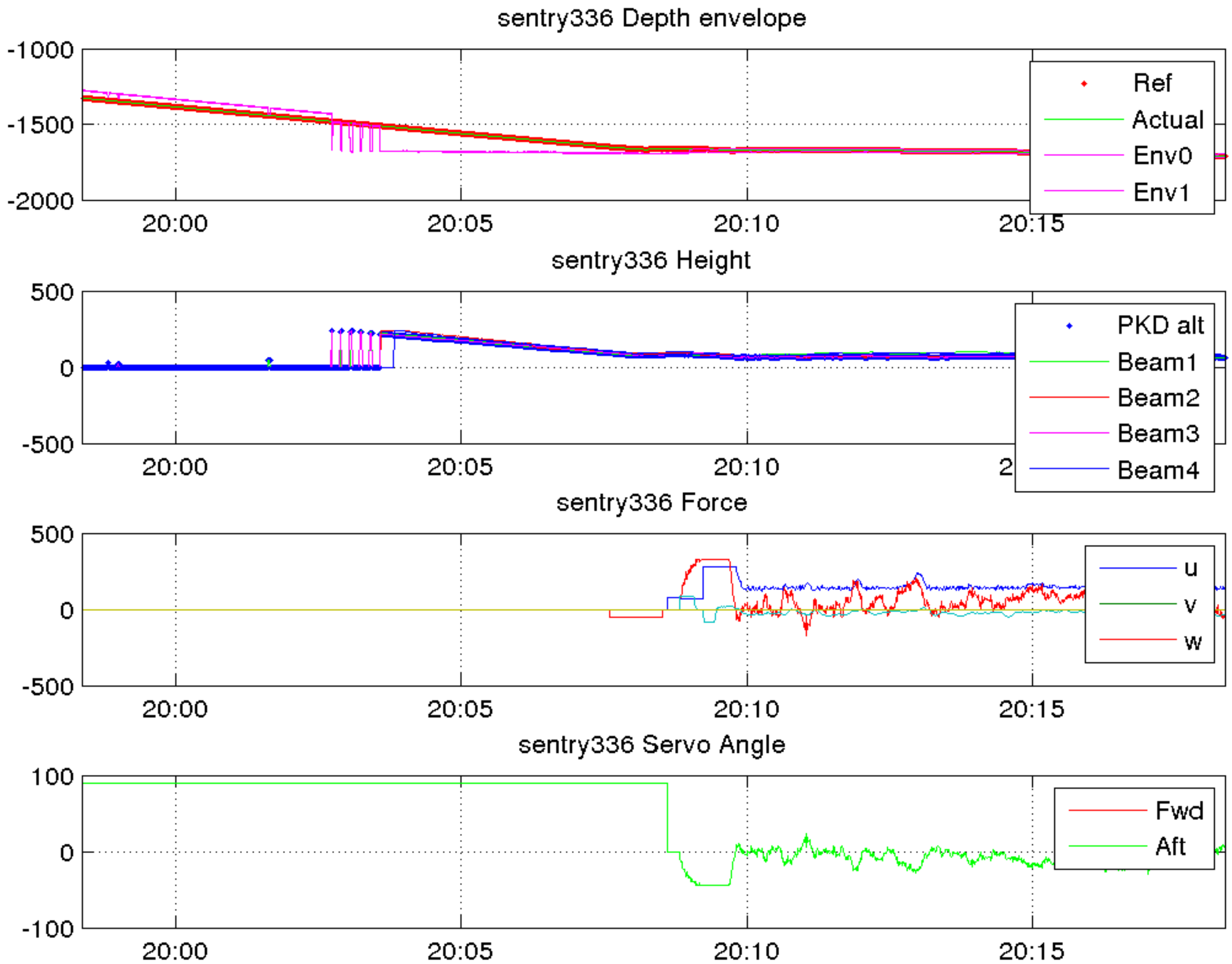


Figure 11: The bottom approach was nominal for dive 336.

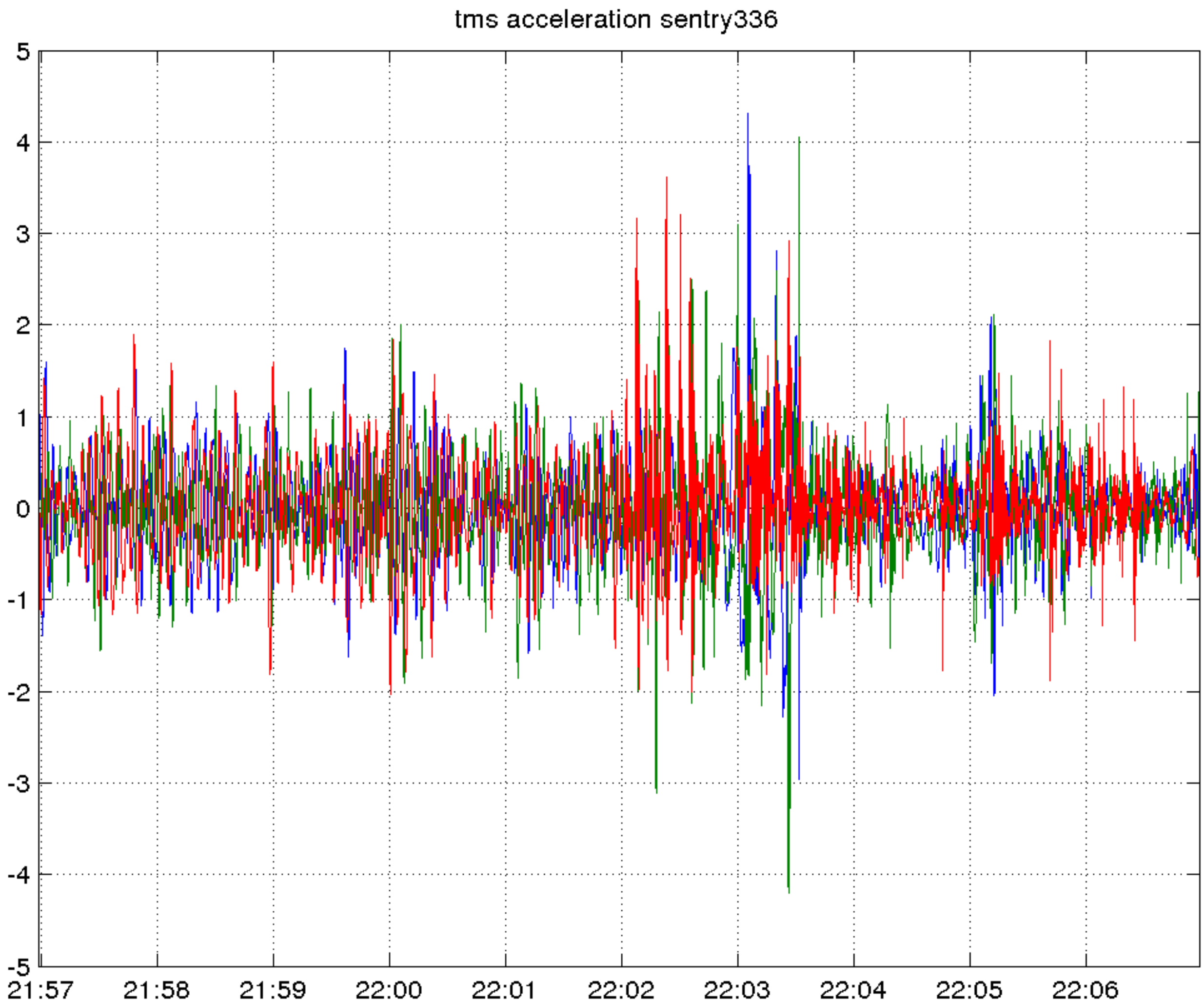


Figure 12: Accelerations on recovery were high on recovery for dive 336.

Sentry 337 Dive Report
DRAFT

WHOI Sentry Operations Group
Dr. Dana Yoerger, Justin Fujii, Zachary Berkowitz, Stefano Suman, Loral O'Hara

Sentry Expedition Leader: Dr. Dana Yoerger

Chief Scientist: Dr. William Chadwick, NOAA

Summary

Weather: The weather was well within the operating window.

Reason for end of dive: We terminated the dive to meet schedule using an acoustic command.

Vehicle Configuration

The science sensing suite for this dive was:

Table 3: Sentry Sensor Configuration

Sensor
APS 1540 Magnetometers (3)
Edgetech 4-24kHz SBP
Edgetech 120kHz/410kHz Sidescan sonar
Reson 7125 Multibeam Sonar
Seabird SBE49 CTD
Seapoint OBS
Anderaa optode model 4330
300kHz RDI DVL
IXEA PHINS
Reson Sound Velocity Probe
NOAA MAPR

This dive was navigated using the DVL/INS system in real time. USBL provided post-dive corrections. In realtime, we monitored the vehicle's progress using the long-baseline transponder/beacon system, which provides a single range between the vessel and the vehicle. The single range enables the watch to determine if the ranges are consistent with the mission plan, especially with regard to turns.

Important Positions

Dive Origin: 45 55.000'N 130 1.500'W

Launch Position: sentry337 launch position: 45 56.242'N 130 0.813'W

Narrative

Sentry was launched conventionally, Jason was not in the water.

We made a short dive to test the multibeam, which failed again in the same way. We also tested the new bottom follower and the on-vehicle INS solution.

The vehicle did a completely overlapping grid draped over the western scarp. The vehicle navigated up and down without a problem, although the DVL had 3 or 4 beam solutions the entire run. We also repeated the first grid (east-west) at 100m height with 100 deg coverage to test the idea that flying higher with tighter coverage would improve results. That was all lost due to multibeam failure.

We tried to keep sentry down by adding tracklines, but a trackline timed out because we had dropped the speed.

Recovery challenging, winds about 20kts but seas still built up from previous winds.

The multibeam failed again with the same symptoms.

1 Issues and Proposed Solutions

We had many exchanges with Reson about the sonar. They advised we had a corrupted software configuration. In fact, they had sent us a refurbished receive head with outdated firmware.

Chief Scientist Comments

The Chief scientist is requested to include any desired comments.

Dive Statistics

Sentry337 Summary Launch: 2015/08/20 11:21:27
Survey start: 2015/08/20 12:03:24
Latitude: 45.936930 Longitude -130.013010
Depth: 1477.73
Survey end: 2015/08/20 17:41:04
Latitude: 45.939669 Longitude -130.026070
Depth: 1293.76
Ascent begins: 2015/08/20 17:41:04
On the surface: 2015/08/20 18:09:04
On deck: 2015/08/20 18:33:19
descent rate: 35.2 m/min
ascent rate: 46.2 m/min
survey time: 5.6 hours
deck-to-deck time 7.2 hours
Mean survey depth: 1386m
Mean survey height: 82m
distance travelled: 17.39km
average speed; 0.85m/s
average speed during photo runs: 0.00 m/s over 0.00 km
average speed during multibeam runs: 0.86 m/s over 17.39 km
total vertical during survey: 2509m
Battery energy at launch: 20.7 kwhr
Battery energy at survey end: 15.9 kwhr
Battery energy on deck: 15.8 kwhr
Battery energy used for survey: 4.4 kwhr
Average power during survey: 784.1 watts

Plots and Images

This section contains selected images of data products and plots of vehicle navigation and selected sensors.

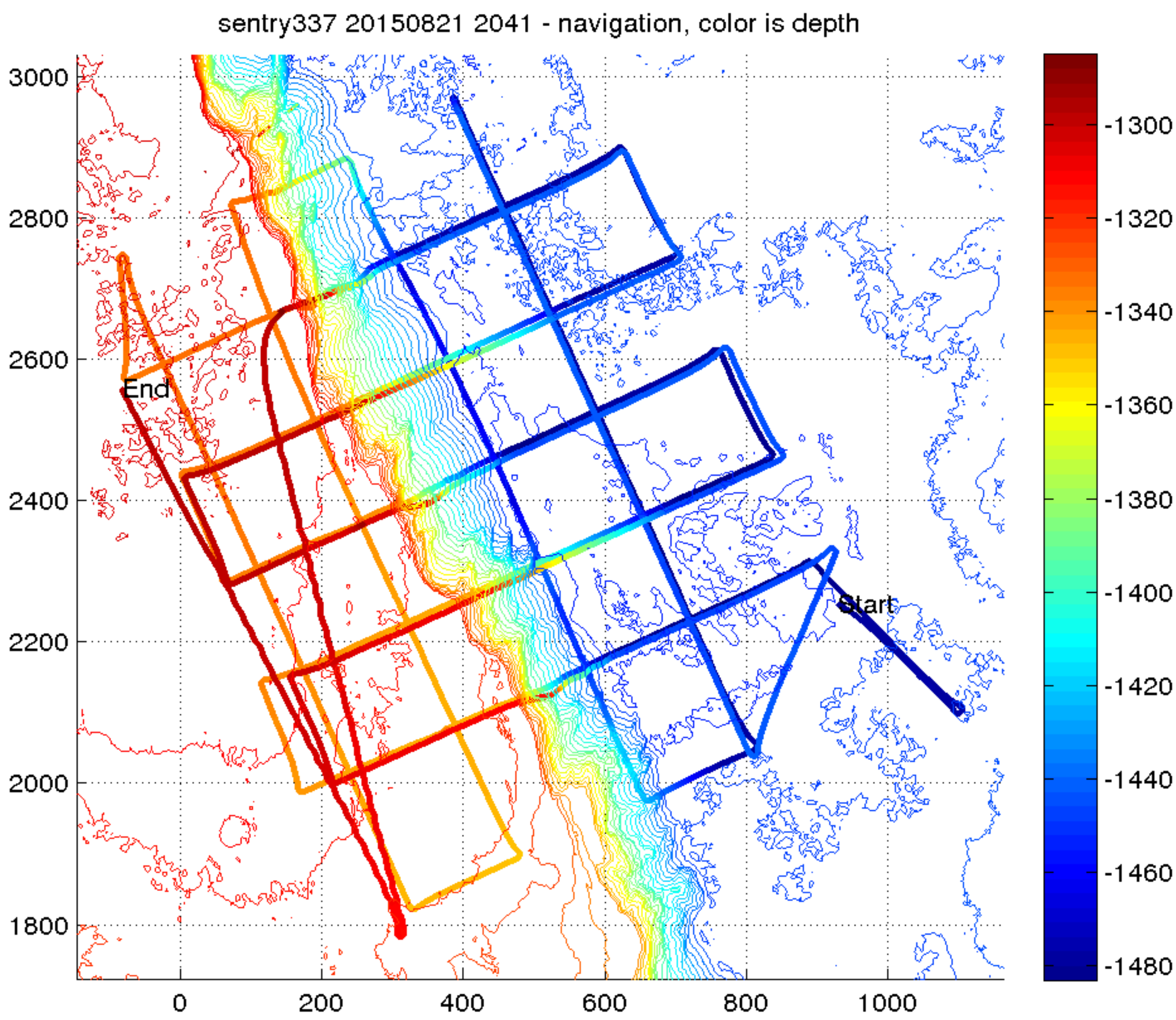


Figure 13: Latitude/Longitude plot of Sentry dive 337 based on post-processed navigation. The color indicates vehicle depth.

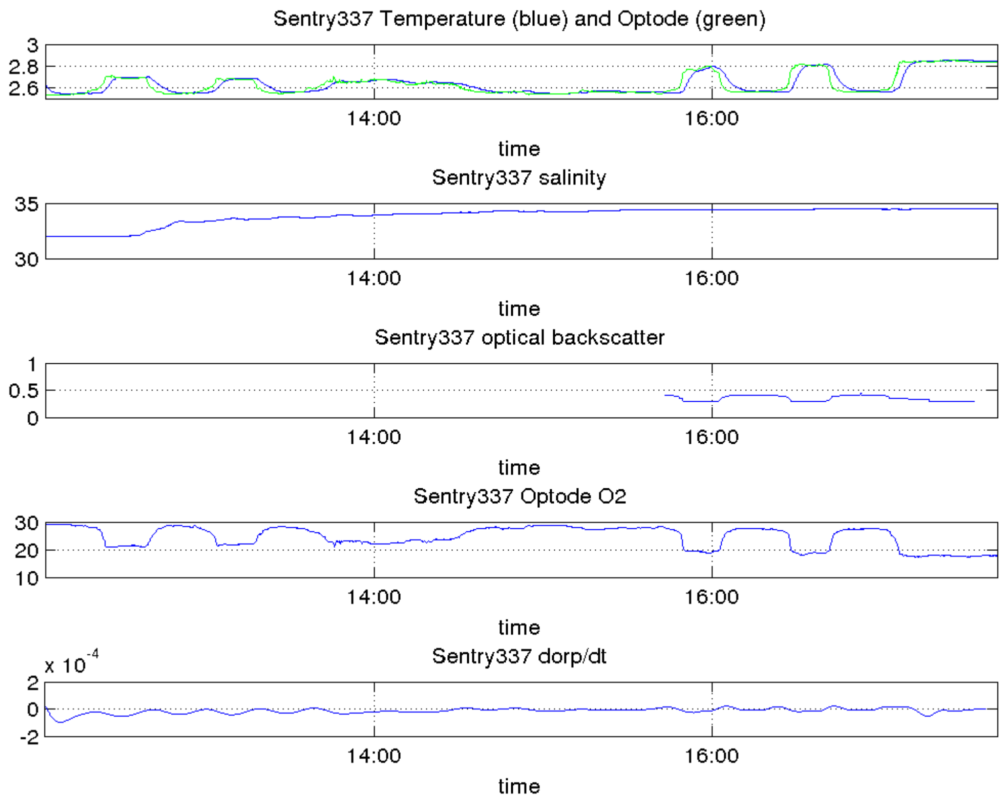


Figure 14: Time series plot of five of the basic sensors on Sentry, from top to bottom, temperature, salinity, optical backscatter, dissolved Oxygen, and derivative w.r.t. time of the ORP voltage.

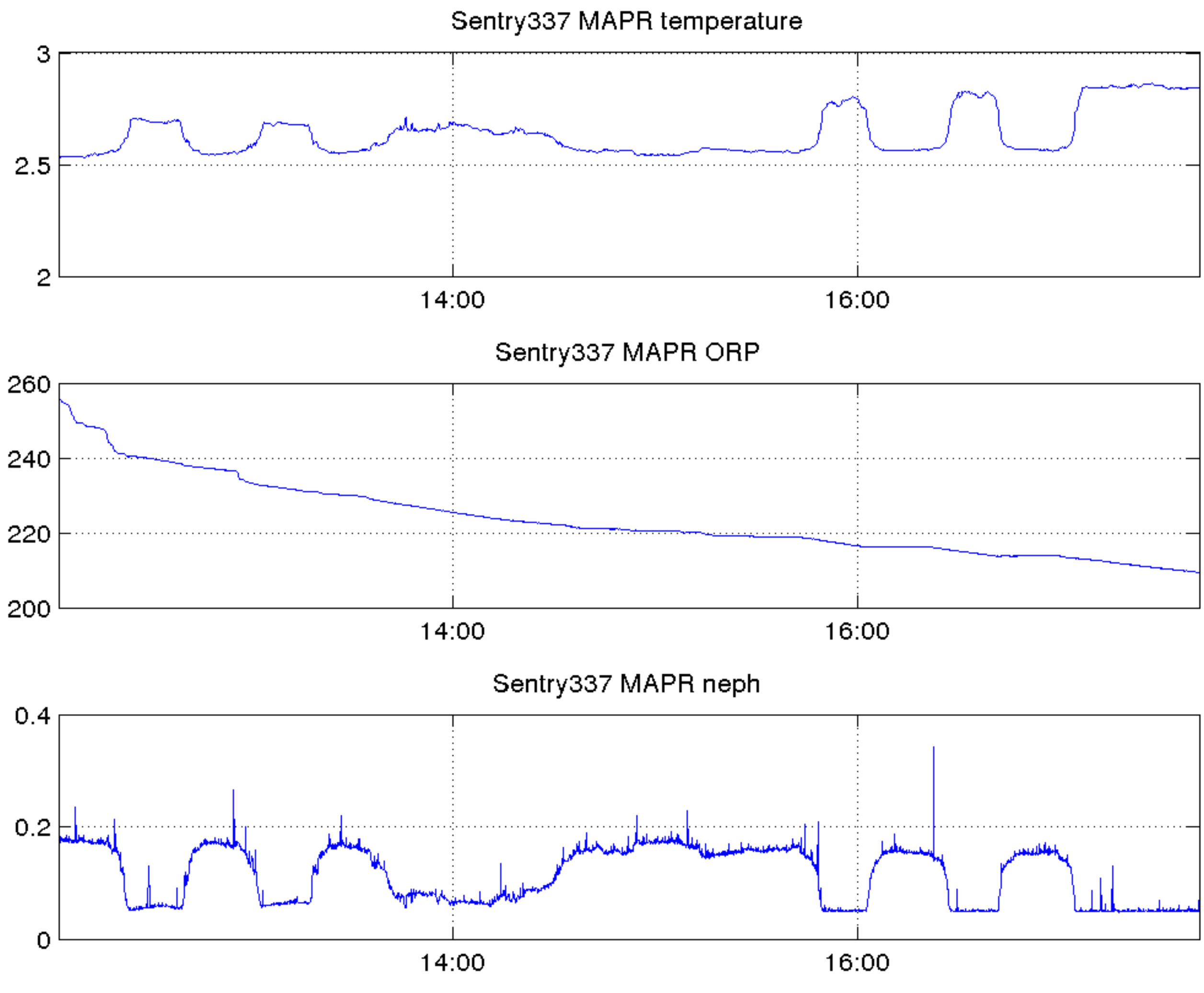


Figure 15: time plots from MAPR (temperature, ORP, and nephelometer) on dive 337.

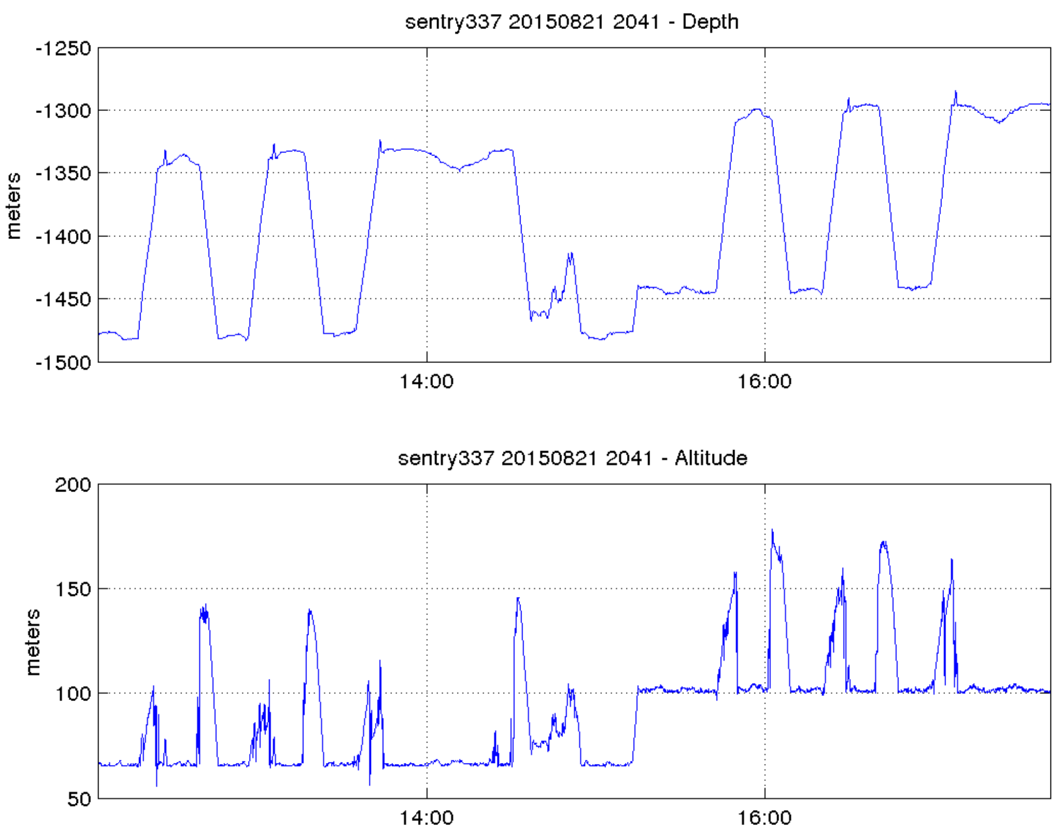


Figure 16: Depth and Altitude of Sentry during dive 337.

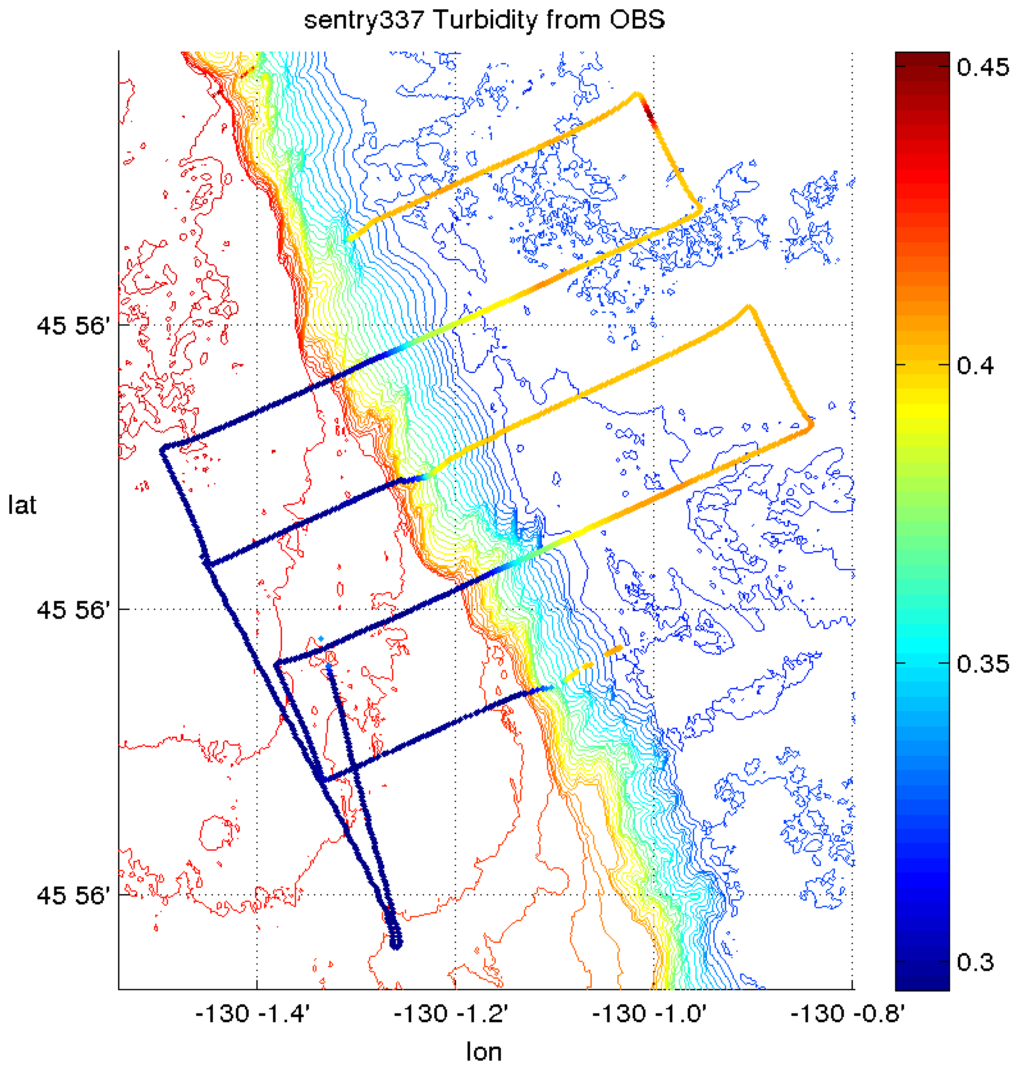


Figure 17: Optical backscatter on dive 337.

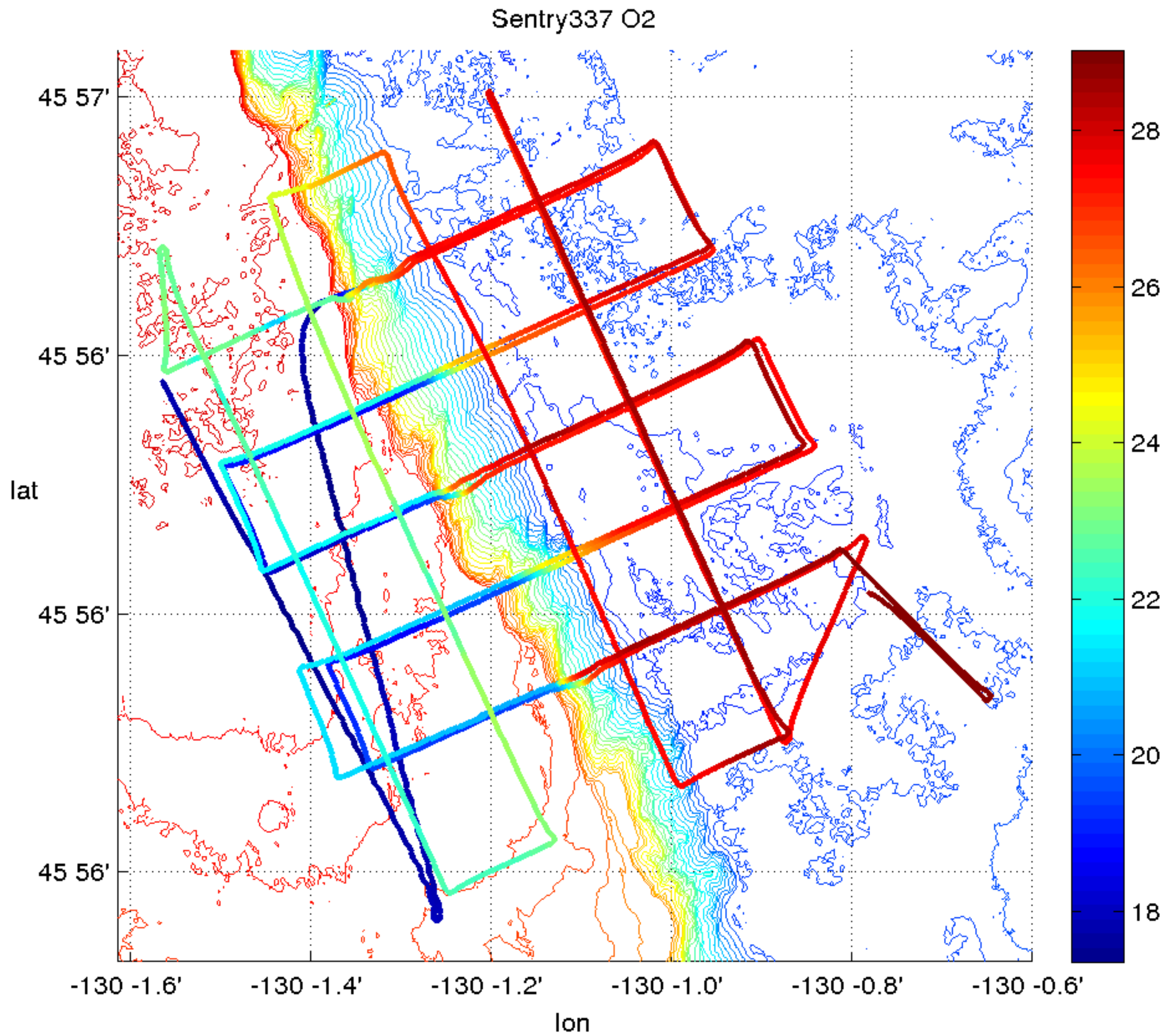


Figure 18: O2 Concentration on dive 337.

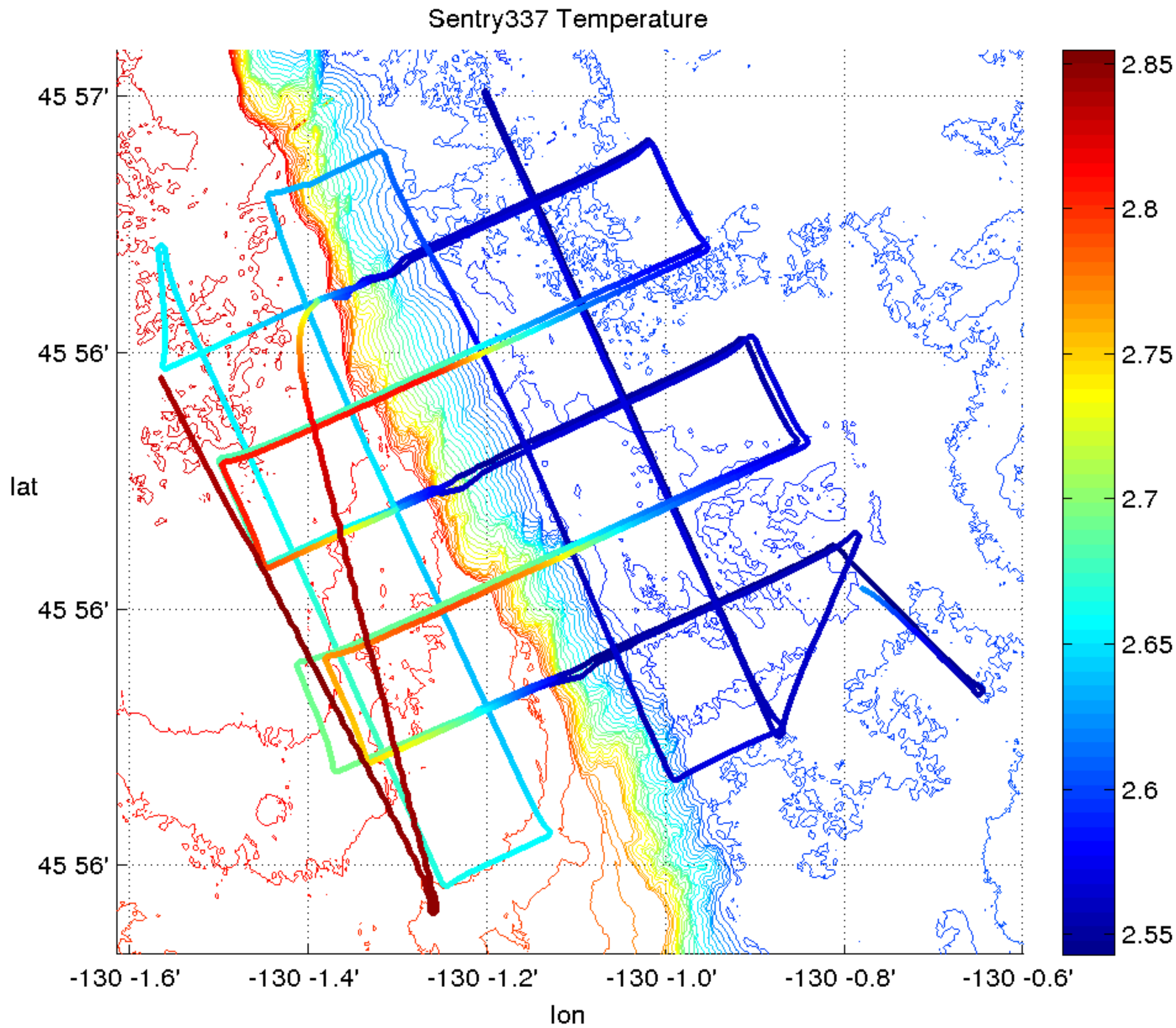


Figure 19: Seabird SBE49 temperature on dive 337.

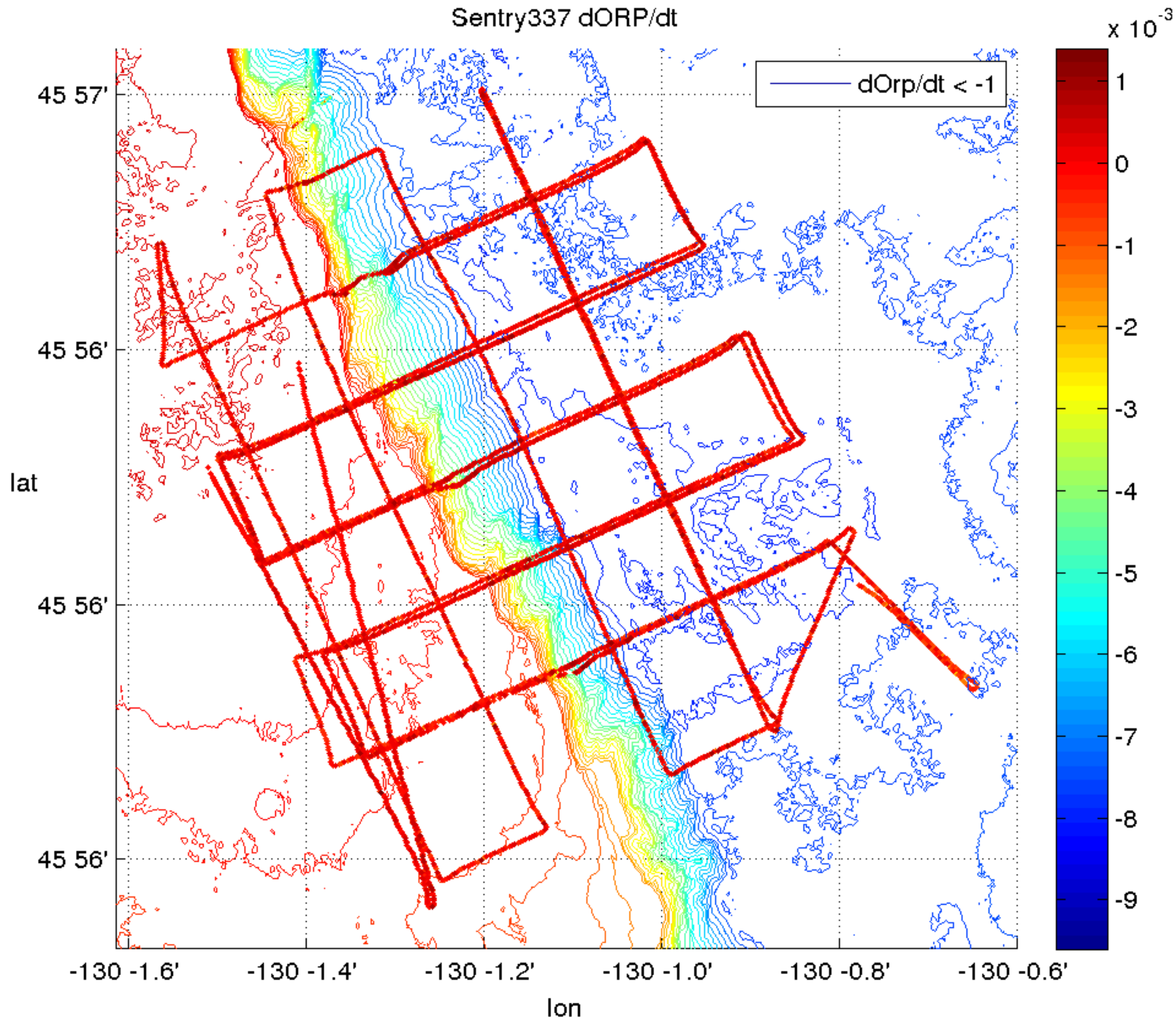


Figure 20: Redox potential (dORP/dt) on dive 337.

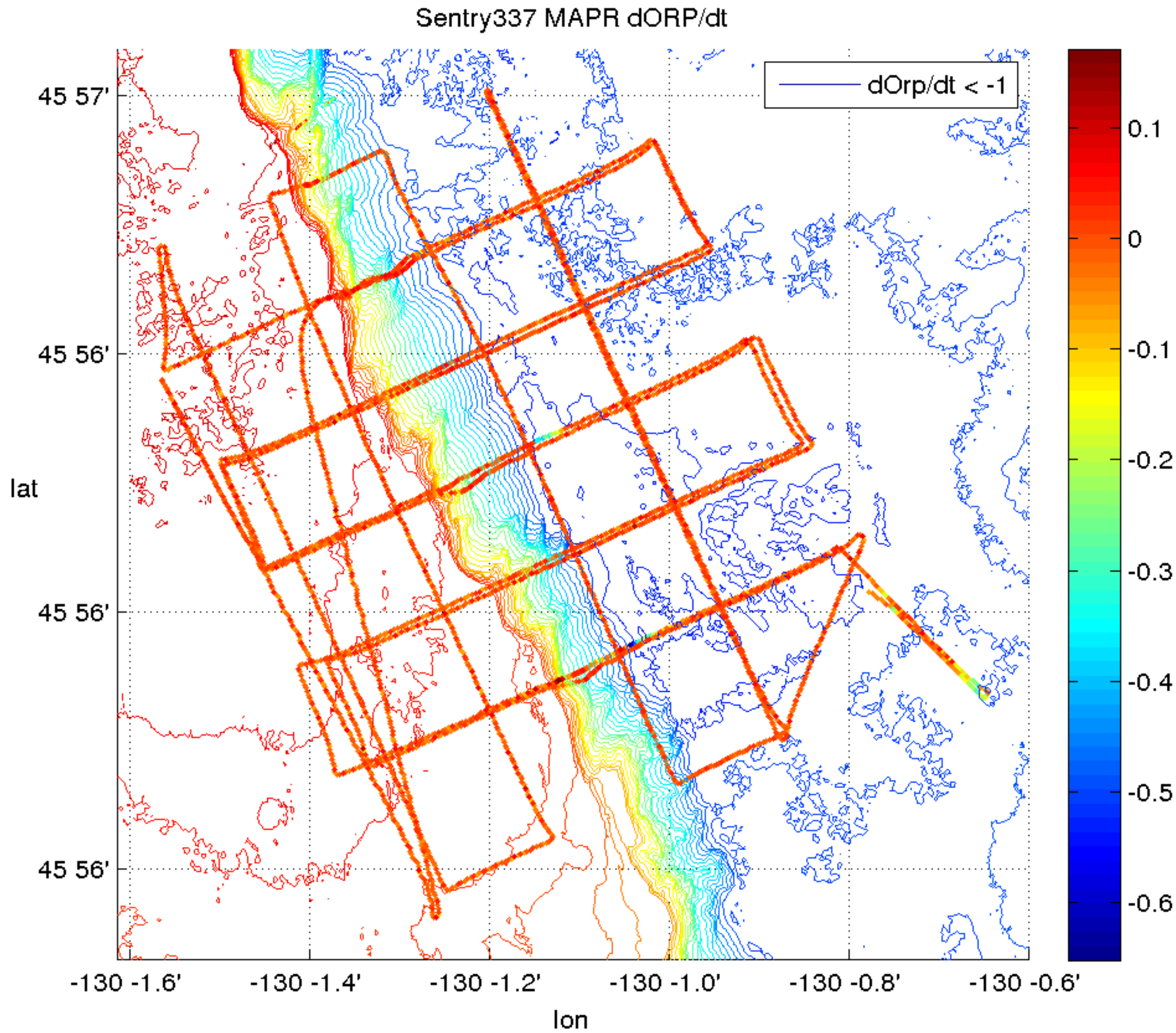


Figure 21: Redox potential from MAPR (dORP/dt) on dive 337.

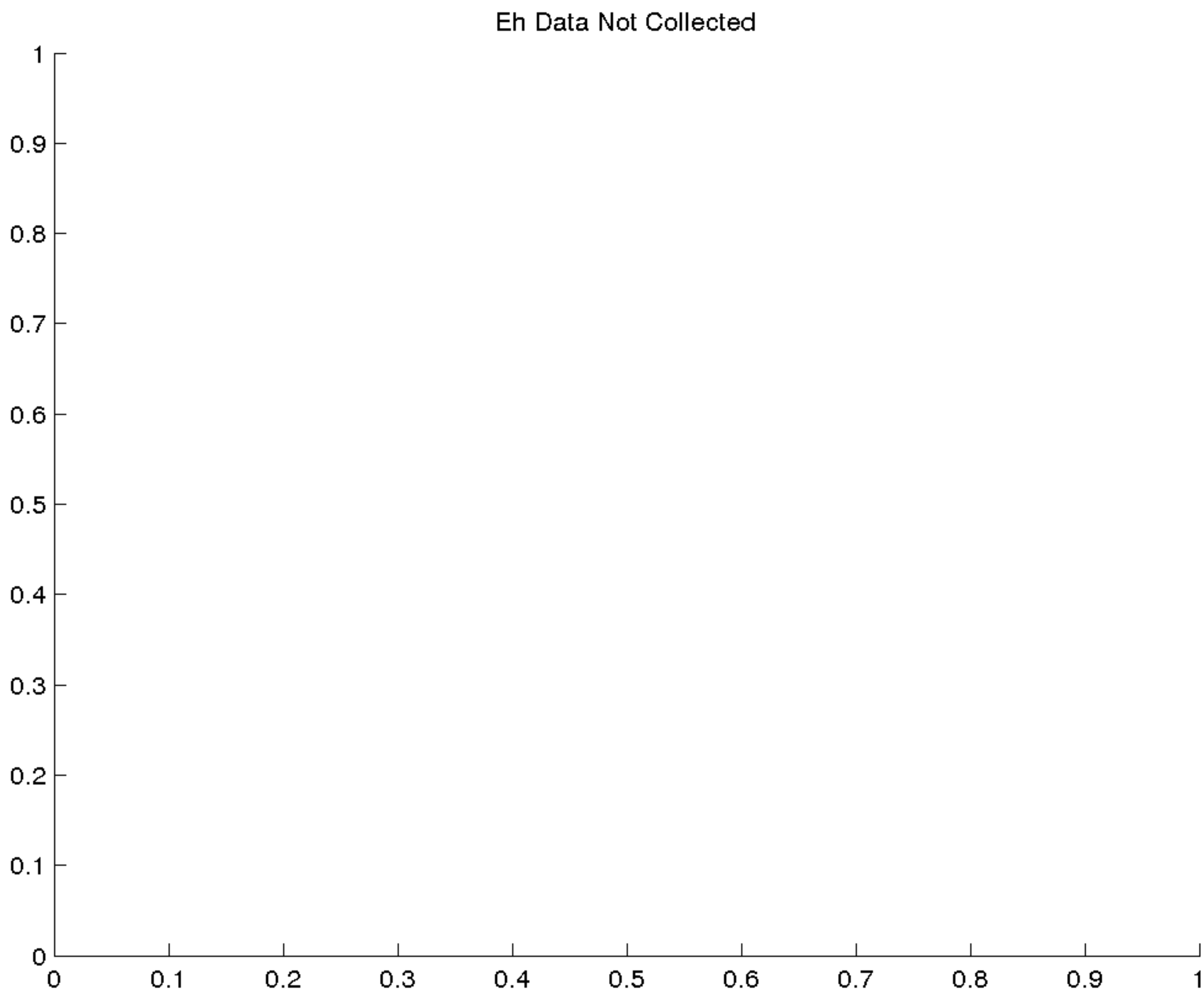


Figure 22: Redox potential (deh/dt) on dive 337.

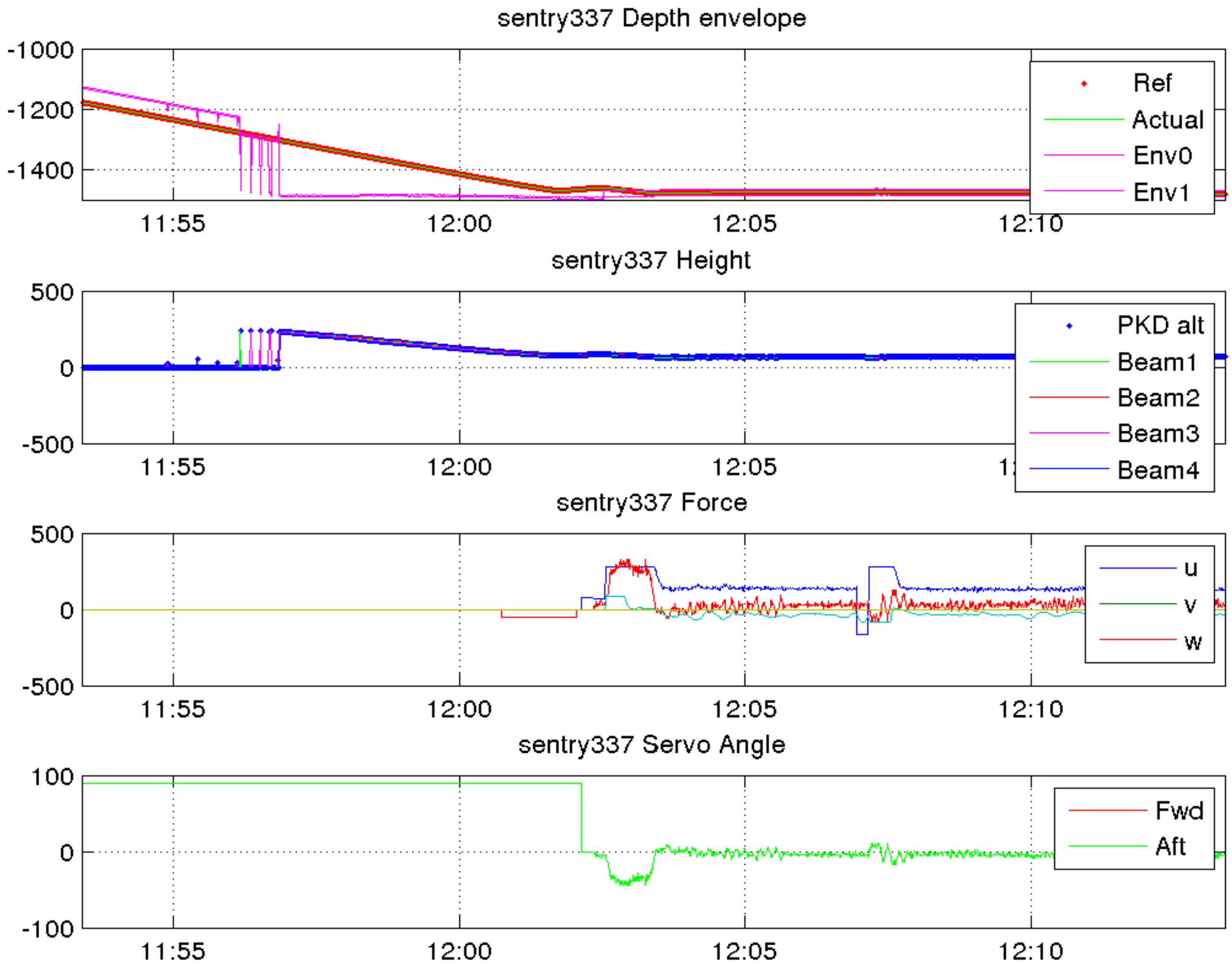


Figure 23: The bottom approach was nominal for dive 337.

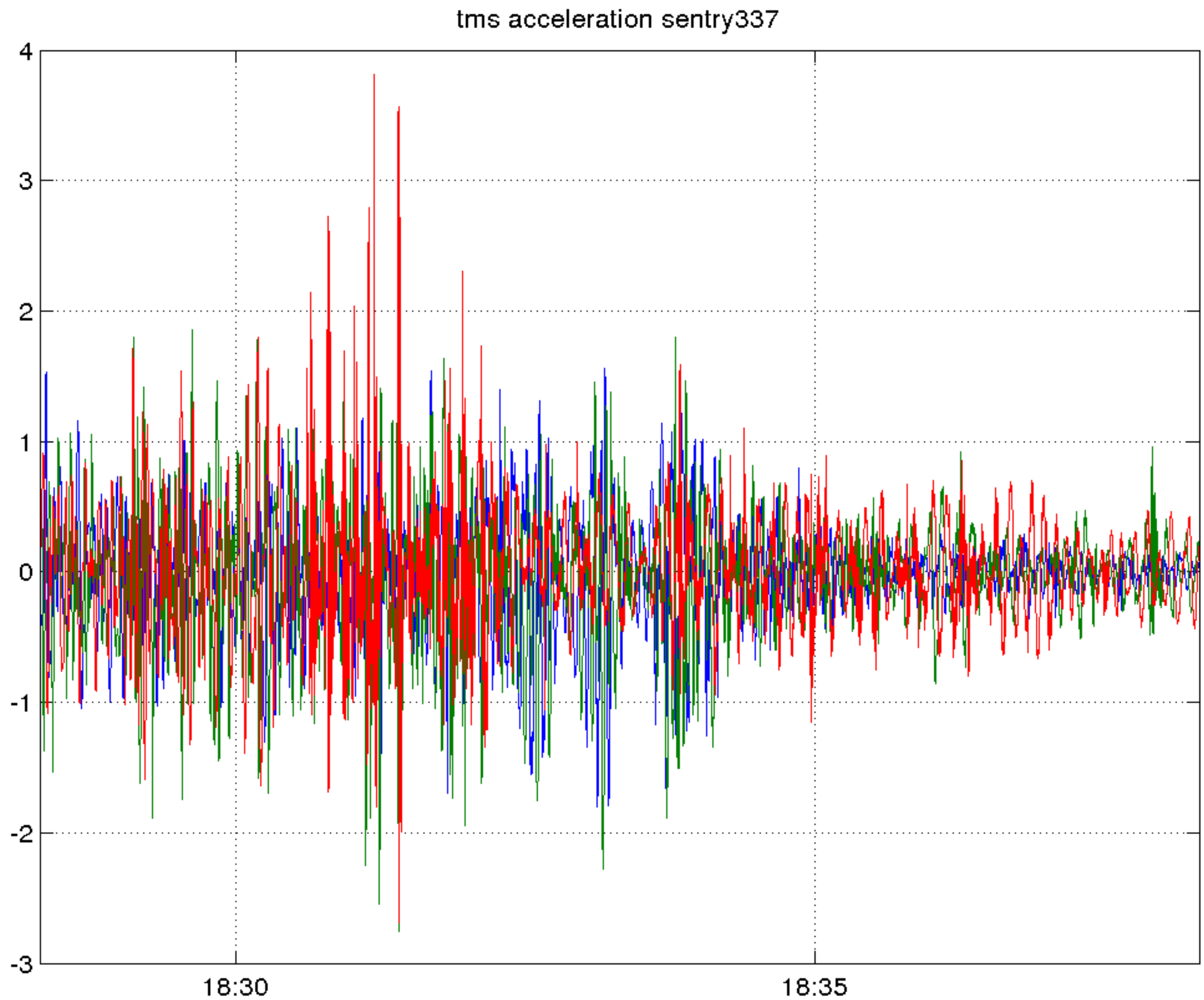


Figure 24: Accelerations on recovery were high on recovery for dive 337.

Sentry 338 Dive Report
DRAFT

WHOI Sentry Operations Group
Dr. Dana Yoerger, Justin Fujii, Zachary Berkowitz, Stefano Suman, Loral O'Hara

Sentry Expedition Leader: Dr. Dana Yoerger

Chief Scientist: Dr. William Chadwick, NOAA

Summary

Weather: The weather was well within the operating window.

Reason for end of dive: We terminated the dive to meet schedule using an acoustic command.

Vehicle Configuration

The science sensing suite for this dive was:

Table 4: Sentry Sensor Configuration

Sensor
APS 1540 Magnetometers (3)
Edgetech 4-24kHz SBP
Edgetech 120kHz/410kHz Sidescan sonar
Reson 7125 Multibeam Sonar
Seabird SBE49 CTD
Seapoint OBS
Anderaa optode model 4330
300kHz RDI DVL
IXEA PHINS
Reson Sound Velocity Probe
NOAA MAPR

This dive was navigated using the DVL/INS system in real time. USBL provided post-dive corrections. In realtime, we monitored the vehicle's progress using the long-baseline transponder/beacon system, which provides a single range between the vessel and the vehicle. The single range enables the watch to determine if the ranges are consistent with the mission plan, especially with regard to turns.

Important Positions

Dive Origin: 45 55.000'N 130 1.500'W

Launch Position: sentry338 launch position: 45 58.569'N 129 59.994'W

Narrative

We had many exchanges with Reson about the broken sonar. They finally admitted that the new head was faulty. In fact, it had been loaded with outdated firmware, which explains our observation that the channels had been assigned incorrectly in a systematic fashion. They provided us with some key diagnostics (cal tone for example) that confirmed that the beamformer was working correctly (no possibility we had corrupted the configuration). We also did a renormalization, which we suspect improved performance.

We launched with Jason in the water working at International District. The winds were about 18 kts, they had held steady for ¿ 12 hrs. Seas reasonable. The fly-away launch went fine, although we observed that the driving forward and down aspect was not working.

Sentry ran the NE Caldera tracks provided by Dave Clague (MBARI). We had added a number of crossing lines and some additional lines to the west to connect this survey with the upcoming MBARI repeat survey.

Conditions for recovery were mild. We had one difficulty (dropped lift line), but that was easily handled and the vehicle was not endangered.

The run went very well, the multibeam performed better than we are accustomed to. We are unsure whether that was due to the normalization or due to the nature of the seafloor. Data processing went smoothly and we had a rough map in about an hour. Jenny Paduan (MBARI) reprocessed the map, making a nav adjustment. The final product is excellent.

We programmed Sentry to loiter at the end of its run to better rendezvous with the vessel. During this period, Sentry did a multibeam grid at higher altitude (100, 110, and 120m) with tighter coverage (100 degrees instead of the usual 120 degrees). This test was very successful.We made a short dive to test the multibeam, which failed again in the same way. We also tested the new bottom follower and the on-vehicle INS solution.

The vehicle did a completely overlapping grid draped over the western scarp. The vehicle navigated up and down without a problem, although the DVL had 3 or 4 beam solutions the entire run. We also repeated the first grid (east-west) at 100m height with 100 deg coverage to test the idea that flying higher with tighter coverage

1 Issues and Proposed Solutions

Chief Scientist Comments

The Chief scientist is requested to include any desired comments.

Dive Statistics

Sentry338 Summary Launch: 2015/08/21 15:57:45
Survey start: 2015/08/21 16:44:18
Latitude: 45.973267 Longitude -130.001026
Depth: 1473.89
Survey end: 2015/08/22 02:40:27
Latitude: 45.978007 Longitude -130.021995
Depth: 1509.72
Ascent begins: 2015/08/22 02:40:27
On the surface: 2015/08/22 03:13:17
On deck: 2015/08/22 03:37:45
descent rate: 31.7 m/min
ascent rate: 46.0 m/min
survey time: 9.9 hours
deck-to-deck time 11.7 hours
Mean survey depth: 1485m
Mean survey height: 65m
distance travelled: 35.69km
average speed; 1.00m/s
average speed during photo runs: 0.00 m/s over 0.00 km
average speed during multibeam runs: 1.00 m/s over 35.69 km
total vertical during survey: 1881m
Battery energy at launch: 20.0 kwhr
Battery energy at survey end: 11.9 kwhr
Battery energy on deck: 11.8 kwhr
Battery energy used for survey: 7.7 kwhr
Average power during survey: 770.5 watts

Plots and Images

This section contains selected images of data products and plots of vehicle navigation and selected sensors.

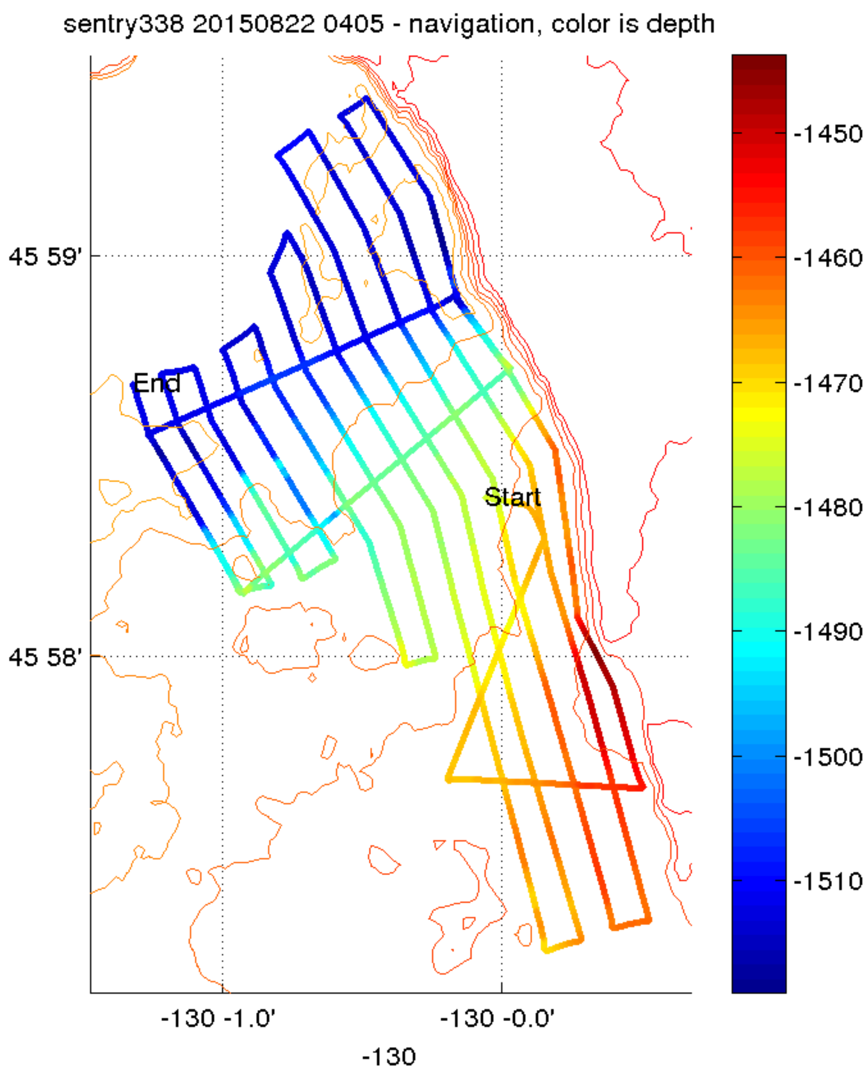


Figure 25: Latitude/Longitude plot of Sentry dive 338 based on post-processed navigation. The color indicates vehicle depth.

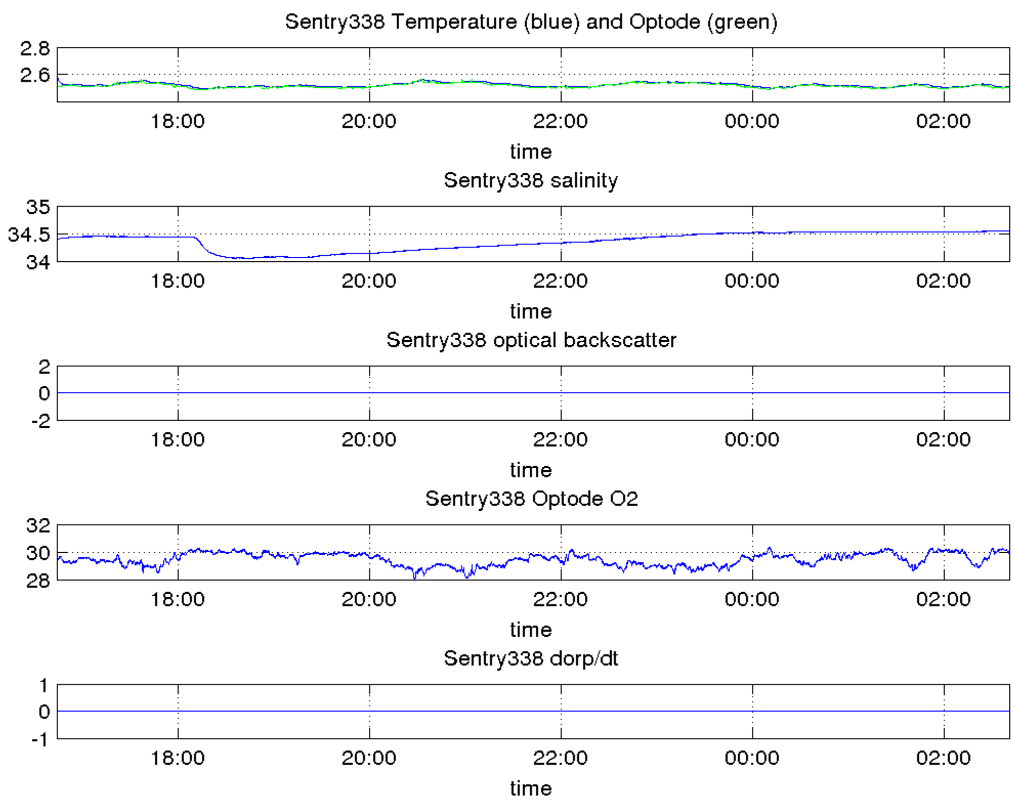


Figure 26: Time series plot of five of the basic sensors on Sentry, from top to bottom, temperature, salinity, optical backscatter, dissolved Oxygen, and derivative w.r.t. time of the ORP voltage.

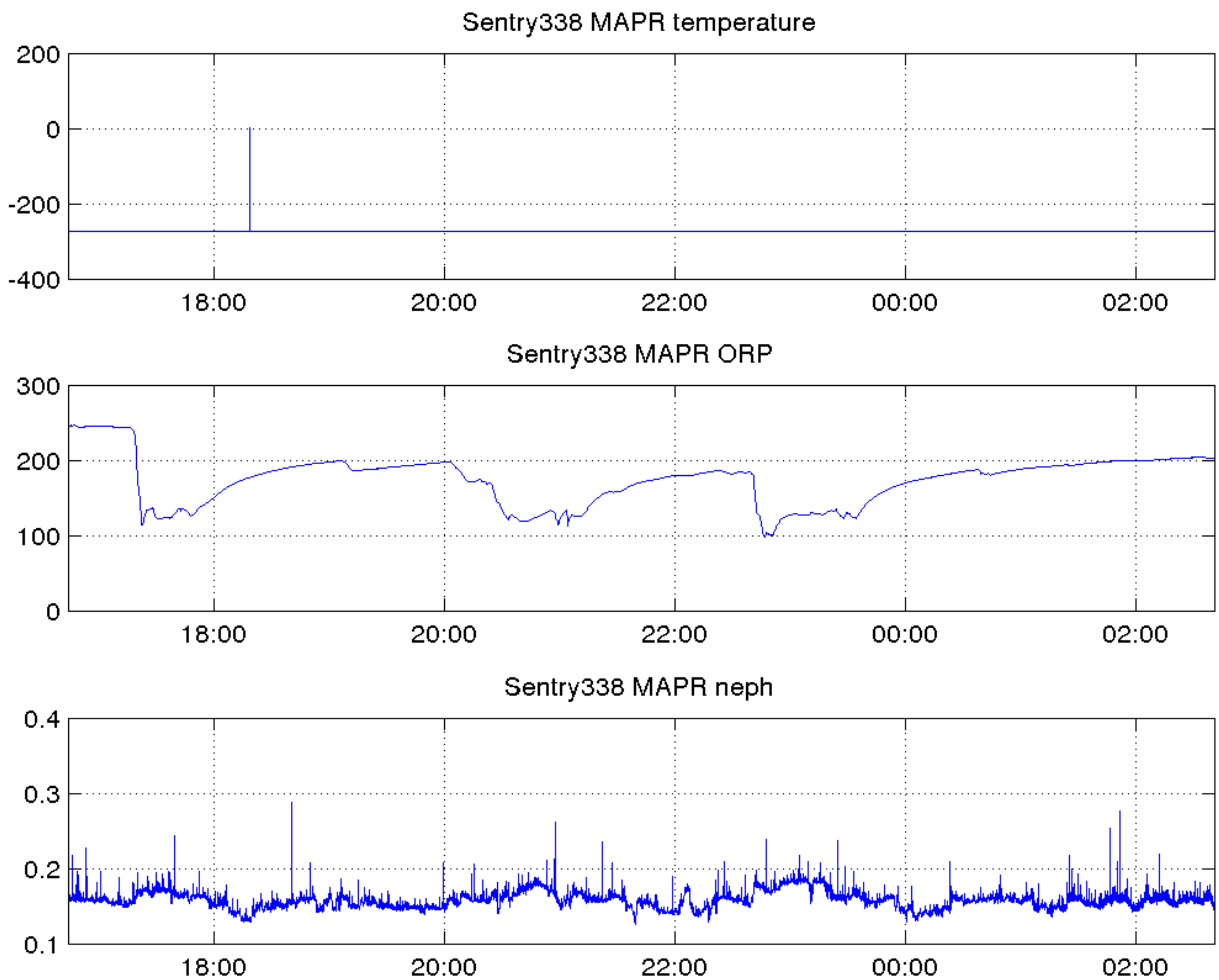


Figure 27: time plots from MAPR (temperature, ORP, and nephelometer) on dive 338.

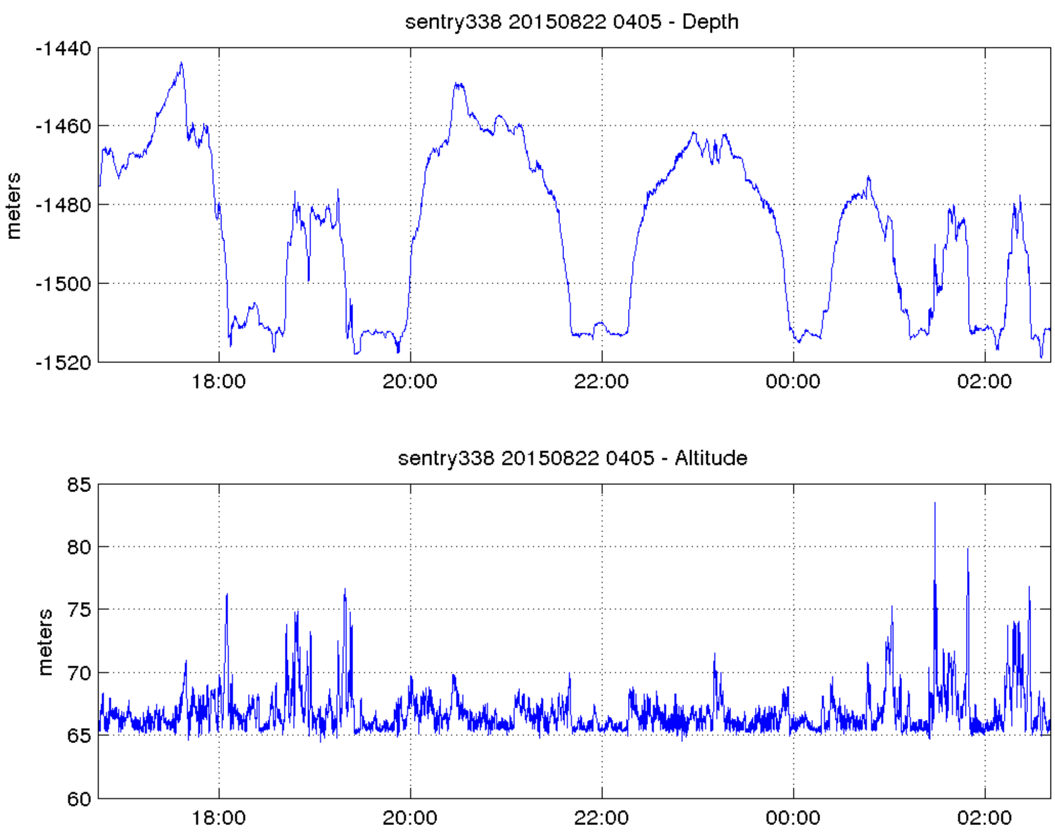


Figure 28: Depth and Altitude of Sentry during dive 338.

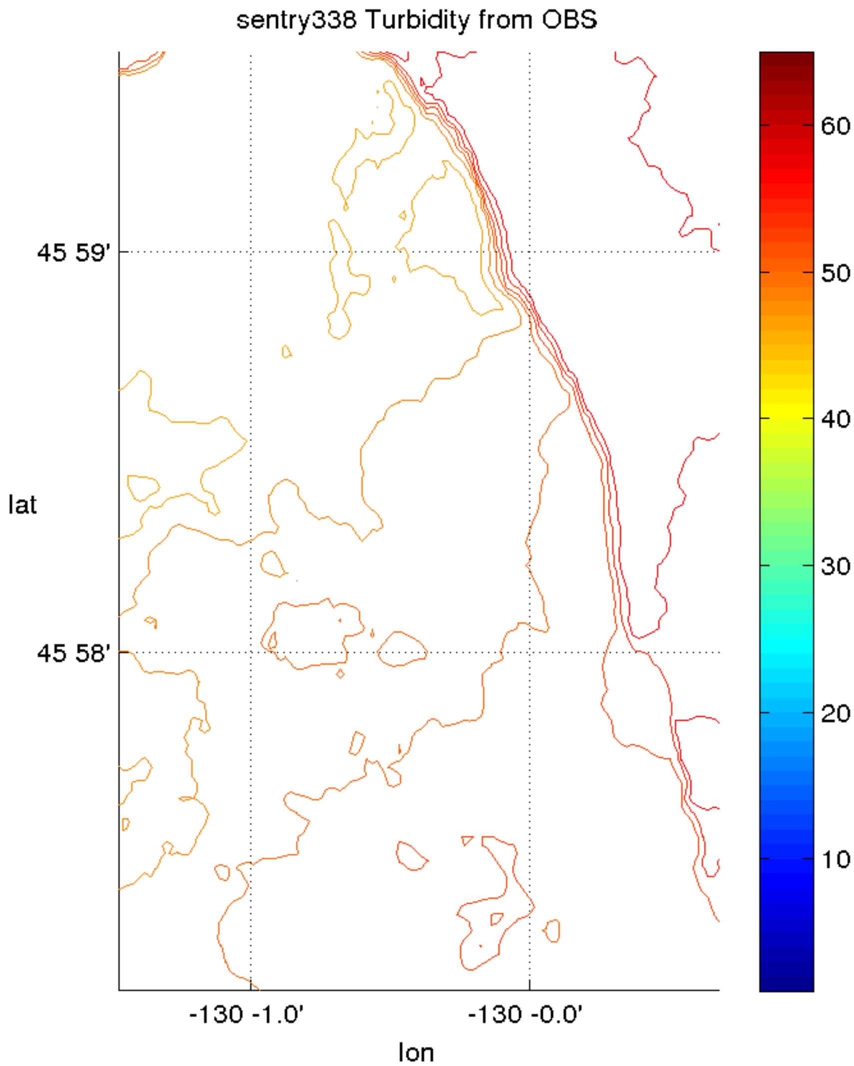


Figure 29: Optical backscatter on dive 338.

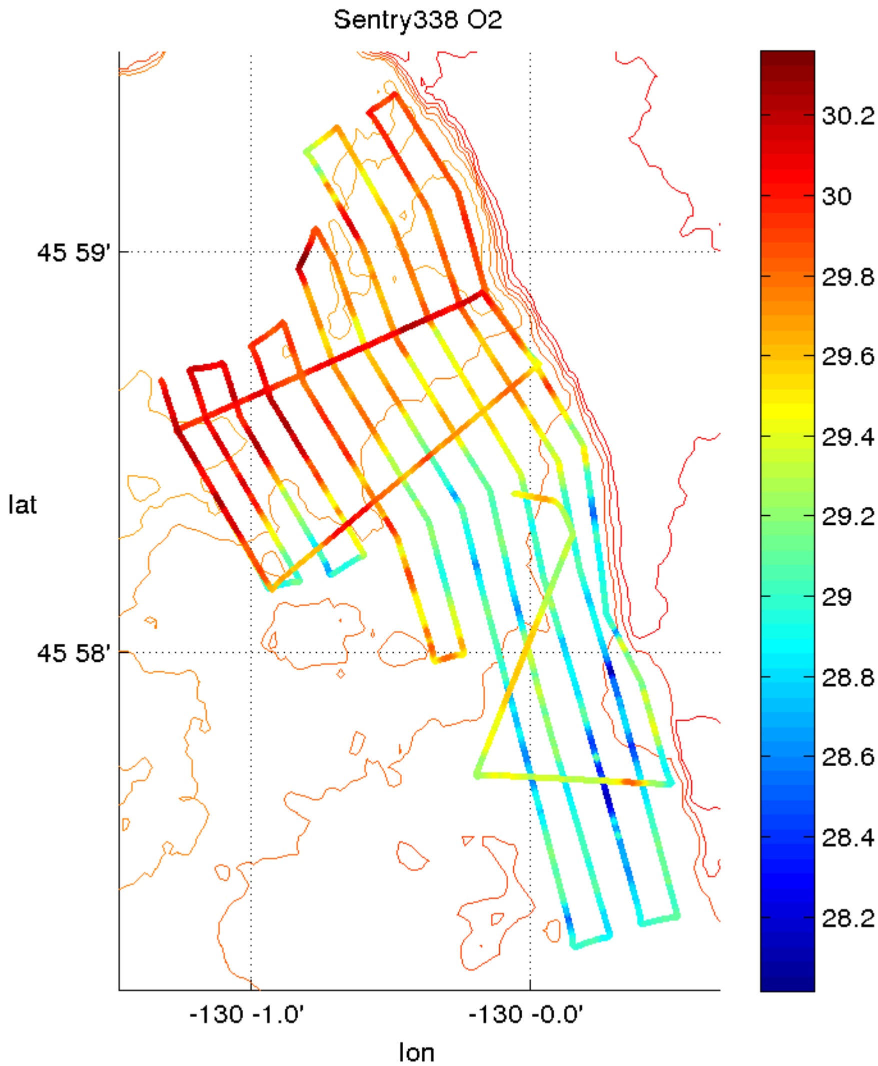


Figure 30: O2 Concentration on dive 338.

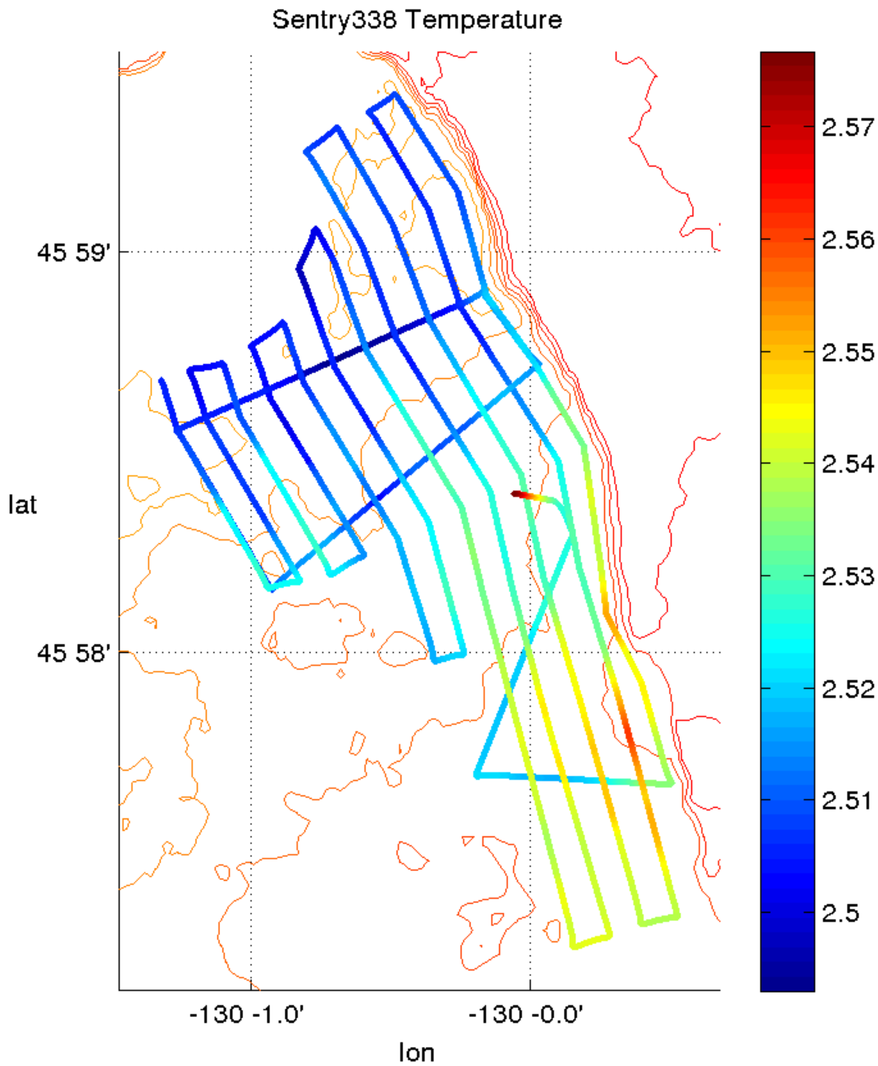


Figure 31: Seabird SBE49 temperature on dive 338.

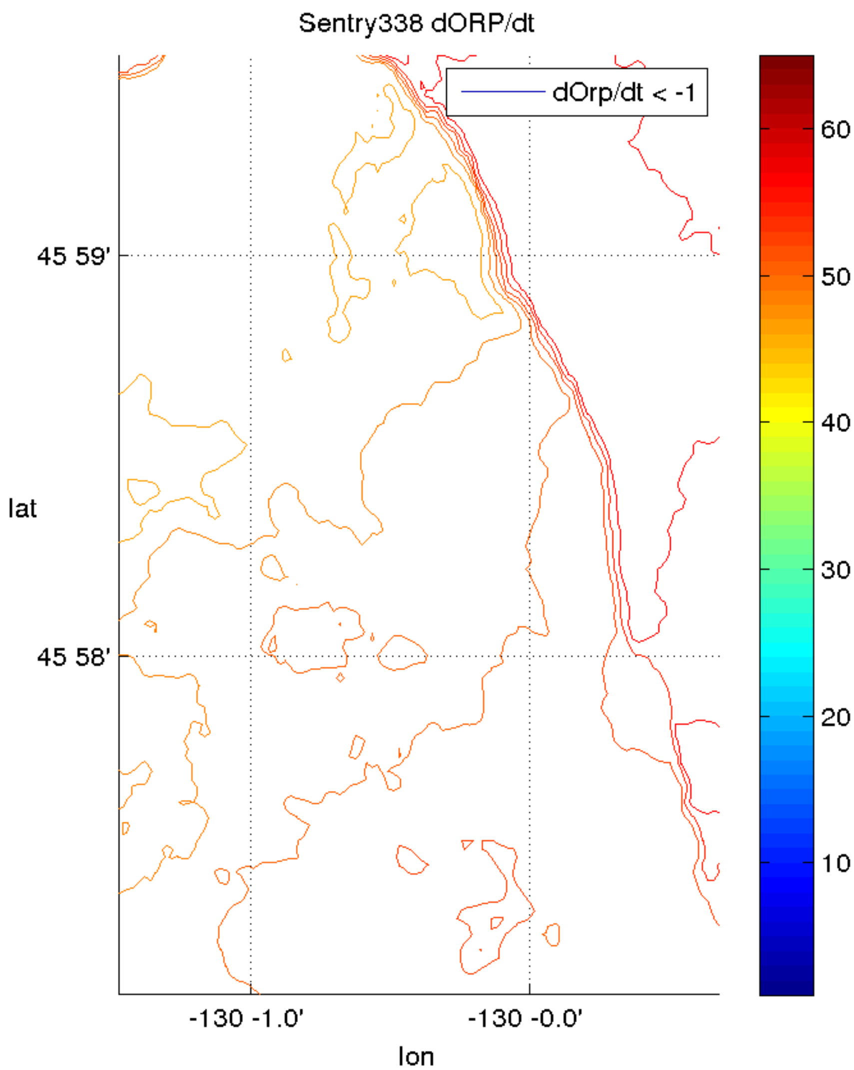


Figure 32: Redox potential (dORP/dt) on dive 338.

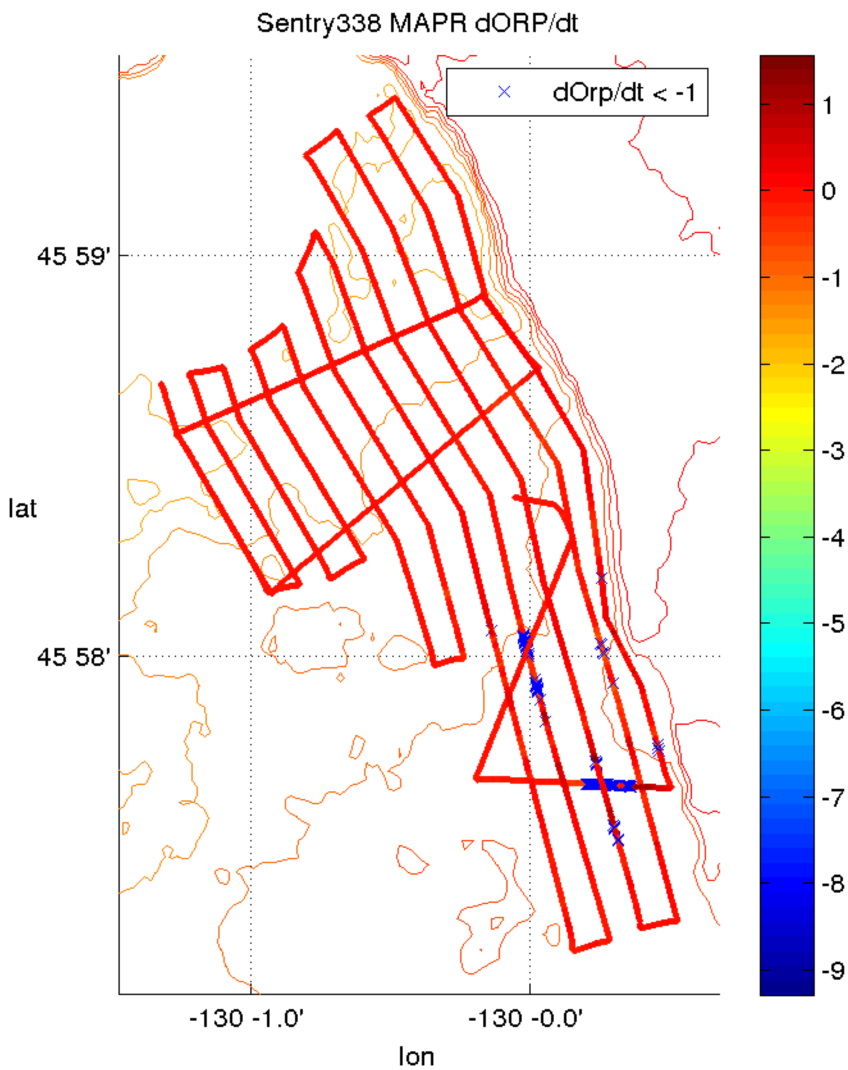


Figure 33: Redox potential from MAPR (dORP/dt) on dive 338.

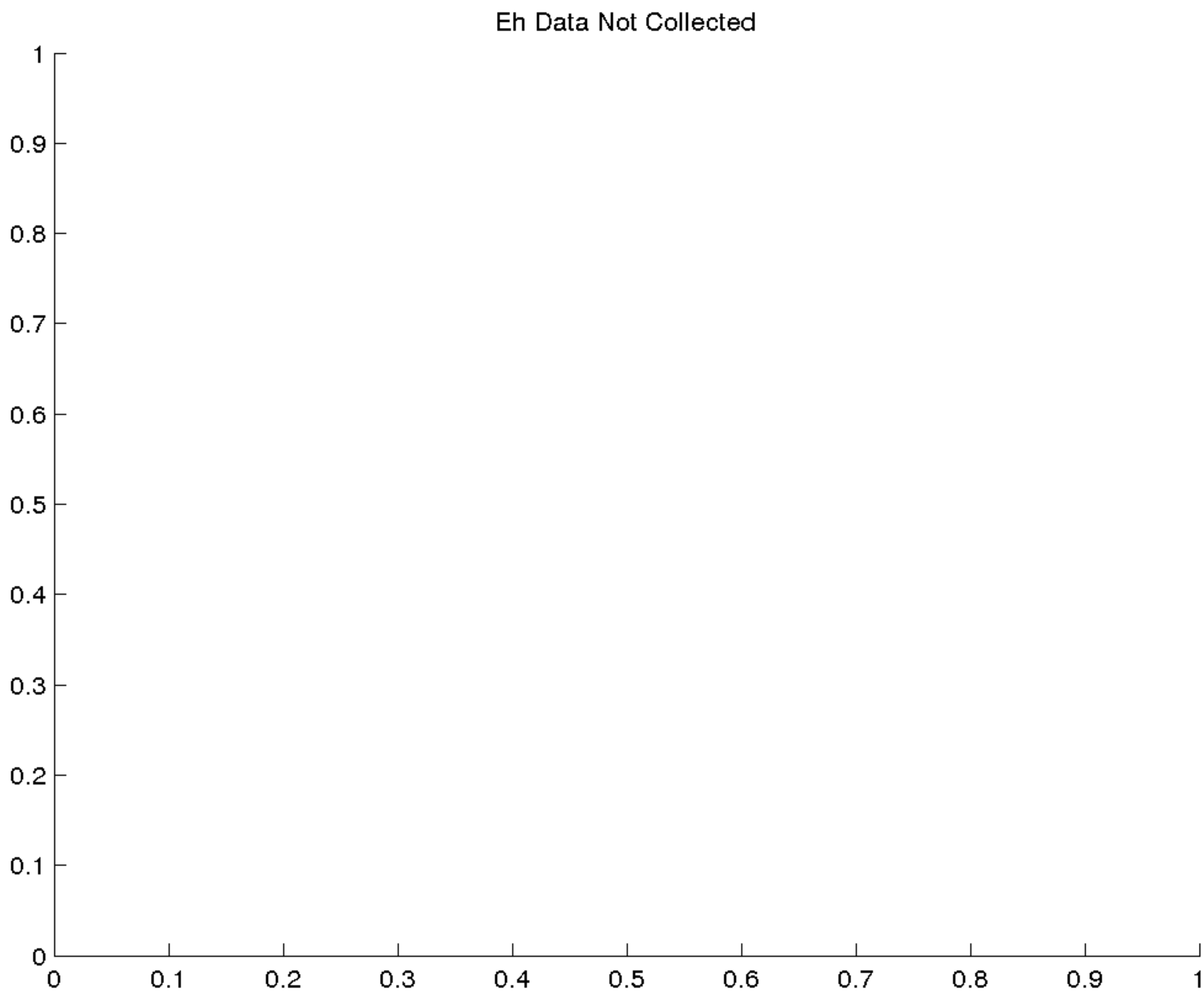


Figure 34: Redox potential (deh/dt) on dive 338.

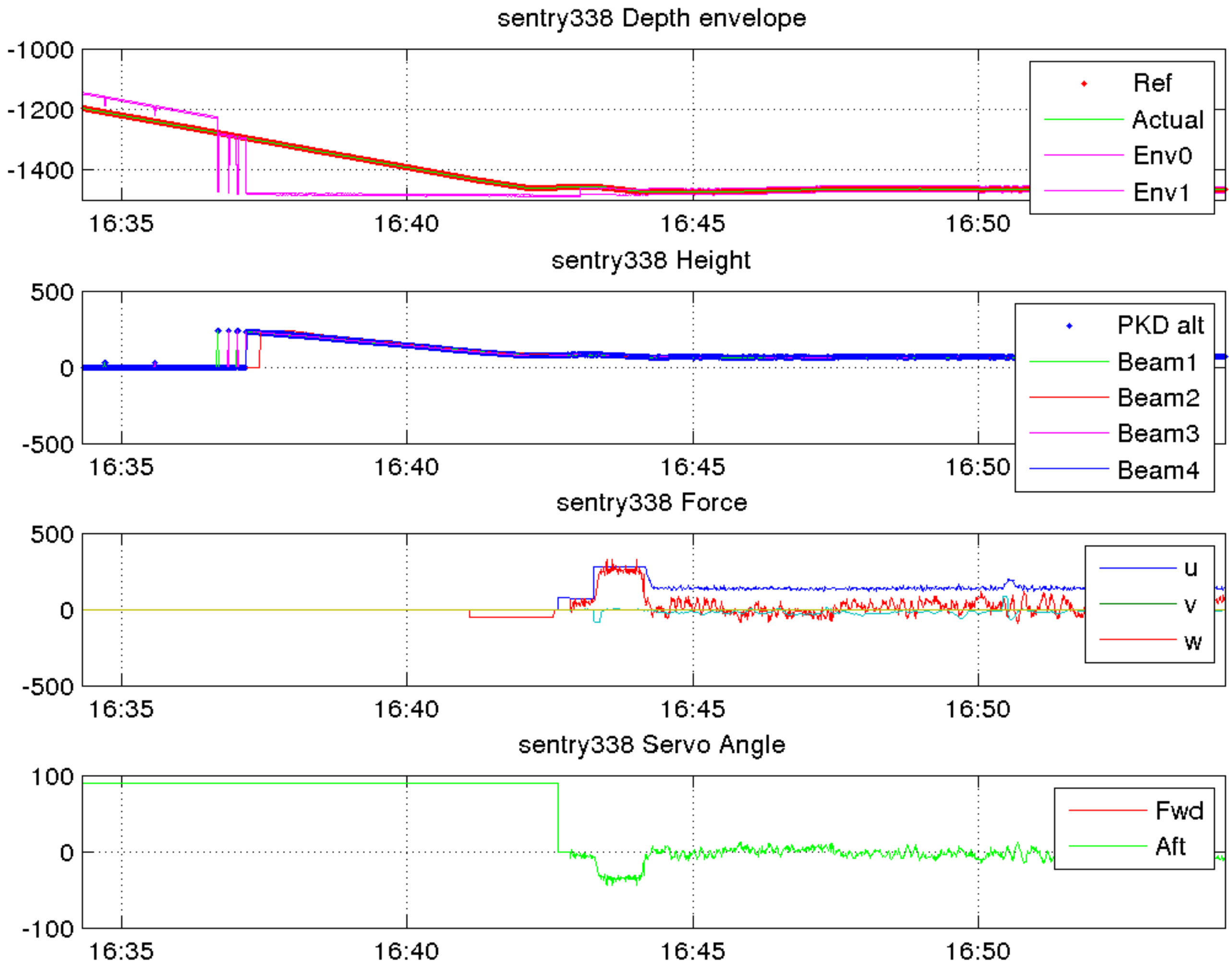


Figure 35: The bottom approach was nominal for dive 338.

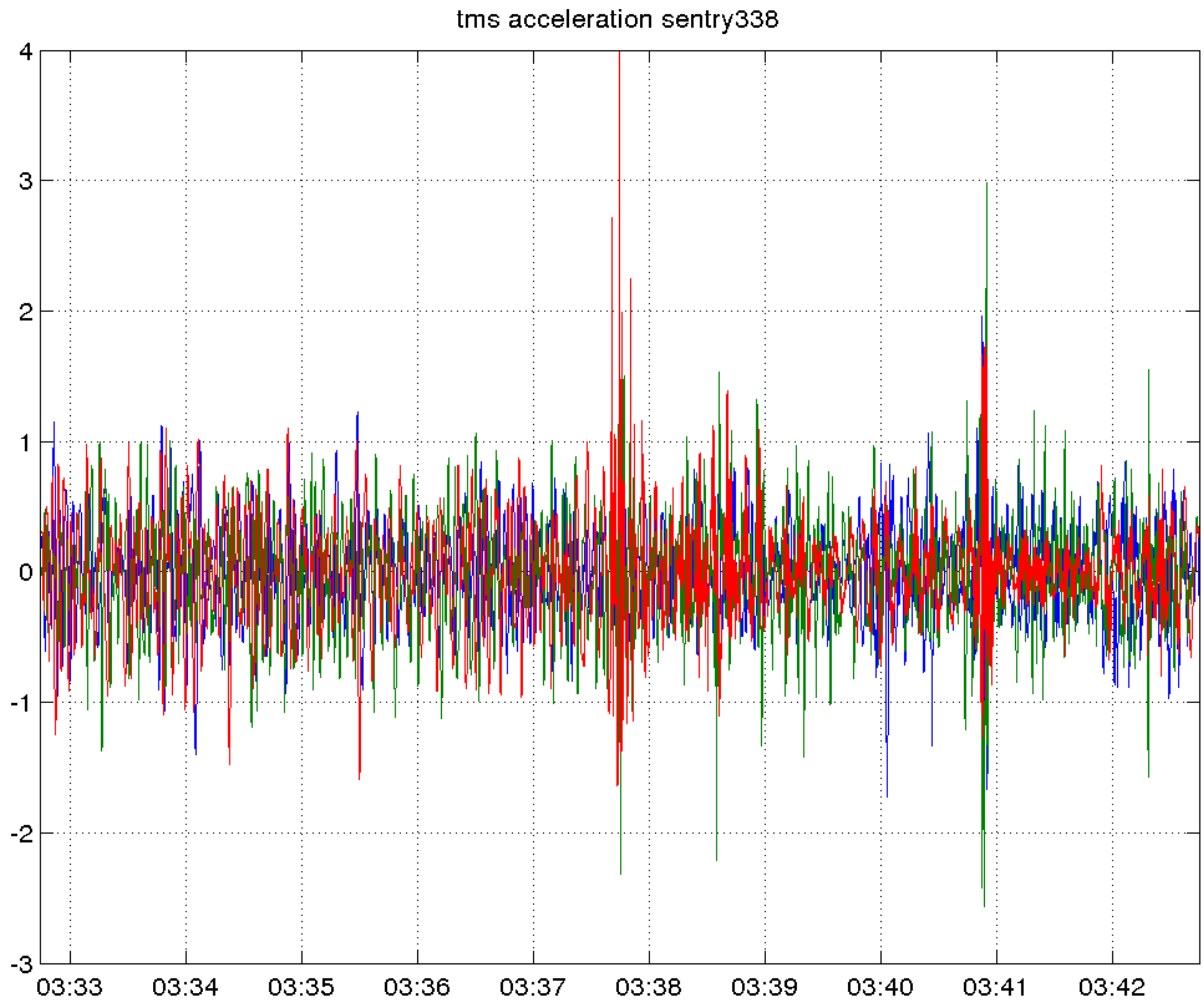


Figure 36: Accelerations on recovery were high on recovery for dive 338.

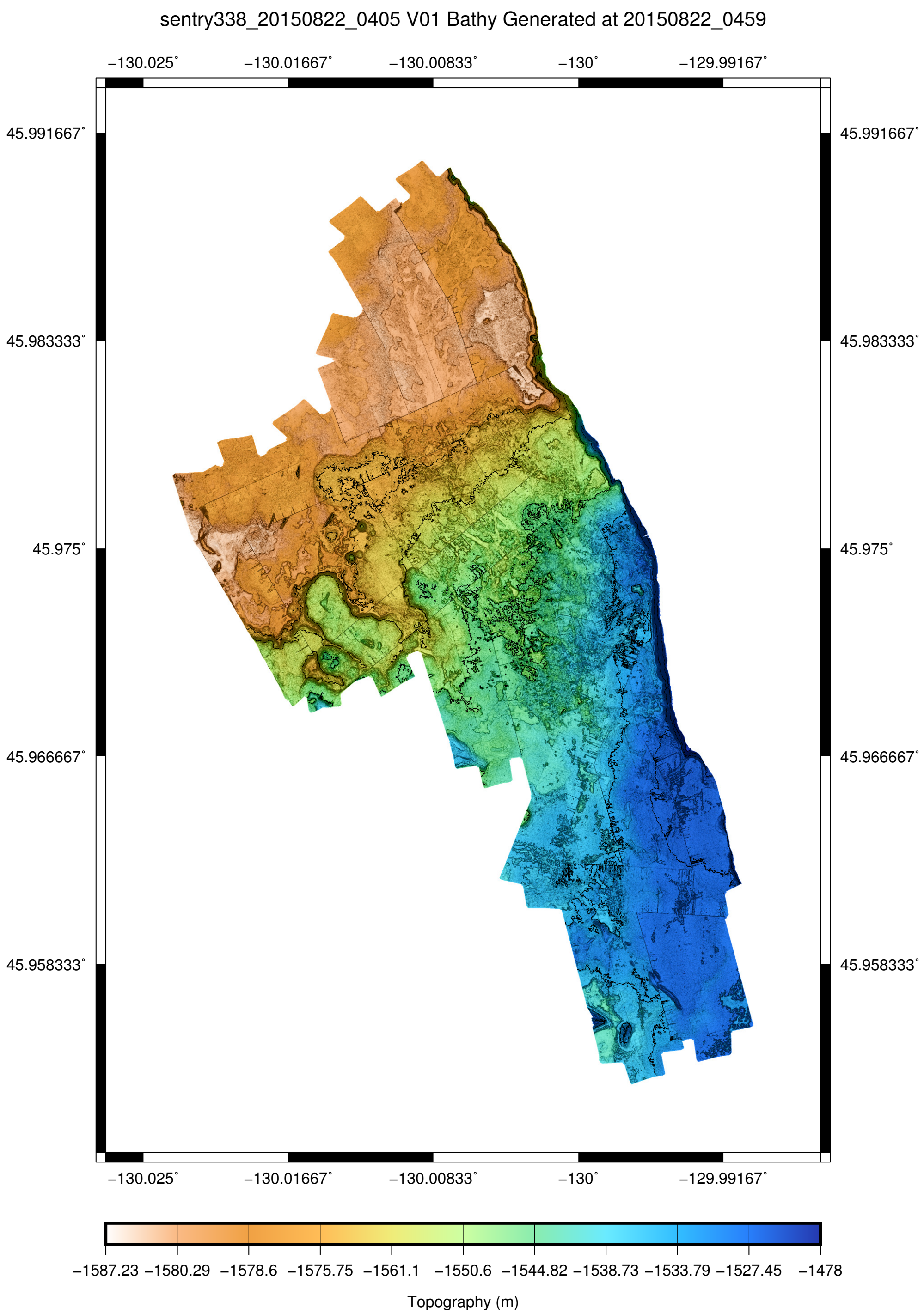


Figure 37: Preliminary multibeam bathymetry dive 338.

Sentry 339 Dive Report
DRAFT

WHOI Sentry Operations Group
Dr. Dana Yoerger, Justin Fujii, Zachary Berkowitz, Stefano Suman, Loral O'Hara

Sentry Expedition Leader: Dr. Dana Yoerger

Chief Scientist: Dr. William Chadwick, NOAA

Summary

Weather: The weather was well within the operating window.

Reason for end of dive: We terminated the dive to meet schedule using an acoustic command.

Vehicle Configuration

The science sensing suite for this dive was:

Table 5: Sentry Sensor Configuration

Sensor
APS 1540 Magnetometers (3)
Edgetech 4-24kHz SBP
Edgetech 120kHz/410kHz Sidescan sonar
Reson 7125 Multibeam Sonar
Seabird SBE49 CTD
Seapoint OBS
Anderaa optode model 4330
300kHz RDI DVL
IXEA PHINS
Reson Sound Velocity Probe
NOAA MAPR

This dive was navigated using the DVL/INS system in real time. USBL provided post-dive corrections. In realtime, we monitored the vehicle's progress using the long-baseline transponder/beacon system, which provides a single range between the vessel and the vehicle. The single range enables the watch to determine if the ranges are consistent with the mission plan, especially with regard to turns.

Important Positions

Dive Origin: 45 55.000'N 130 1.500'W

Launch Position: sentry339 launch position: 45 55.568'N 129 58.605'W

Narrative

This dive was a multibeam dive but we made very sparse, distributed lines to determine inflation/deflation. Sentry repeated the MBARI AUV survey lines and visited all the bottom-pressure stations where Jason either worked or would later work. We launched with Jason in the water, using a drive away launch. The forward and downward driving worked well this time after our software change.

We had some difficulty implementing the navigational shift at the beginning of the dive, but we managed to get the proper command through before the vehicle went out of range. The vehicle was out of USBL range for most of the dive, but we did get periodic updates when the vehicle came close to the vessel. We made another shift (about 40m by 50m) about 7 hours into the dive.

Recovery was routine in very moderate seas.

Data quality was excellent again. As one example, we got an excellent map of the eruptive fissure extending to the south of the caldera. We ran the multibeam at our usual settings (Mode 0, 65m height, 120 degree coverage).

1 Issues and Proposed Solutions

We had many exchanges with Reson about the sonar. They advised we had a corrupted software configuration. In fact, they had sent us a refurbished receive head with outdated firmware.

Chief Scientist Comments

The Chief scientist is requested to include any desired comments.

Dive Statistics

Sentry339 Summary Launch: 2015/08/23 00:06:51
Survey start: 2015/08/23 00:47:15
Latitude: 45.925943 Longitude -129.973410
Depth: 1444.58
Survey end: 2015/08/23 23:17:44
Latitude: 45.955656 Longitude -129.998930
Depth: 1400.89
Ascent begins: 2015/08/23 23:17:44
On the surface: 2015/08/23 23:47:41
On deck: 2015/08/24 00:19:24
descent rate: 35.8 m/min
ascent rate: 46.8 m/min
survey time: 22.5 hours
deck-to-deck time 24.2 hours
Mean survey depth: 1465m
Mean survey height: 76m
distance travelled: 73.89km
average speed; 0.91m/s
average speed during photo runs: 0.00 m/s over 0.00 km
average speed during multibeam runs: 0.91 m/s over 73.89 km
total vertical during survey: 4665m
Battery energy at launch: 20.4 kwhr
Battery energy at survey end: 4.1 kwhr
Battery energy on deck: 3.9 kwhr
Battery energy used for survey: 16.0 kwhr
Average power during survey: 712.7 watts

Plots and Images

This section contains selected images of data products and plots of vehicle navigation and selected sensors.

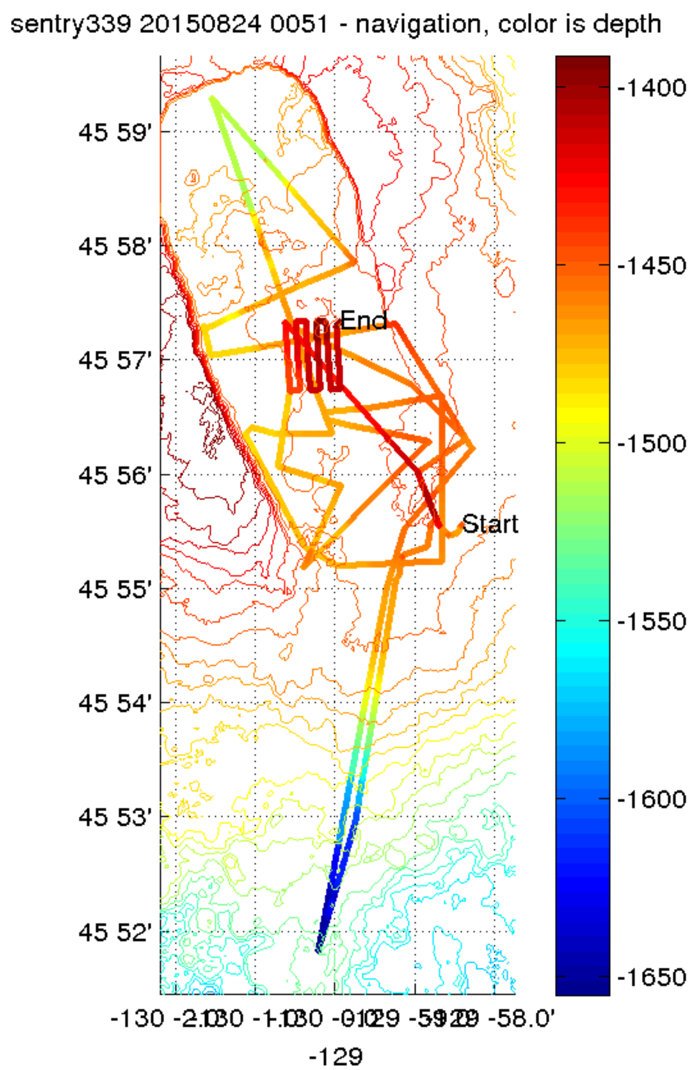


Figure 38: Latitude/Longitude plot of Sentry dive 339 based on post-processed navigation. The color indicates vehicle depth.

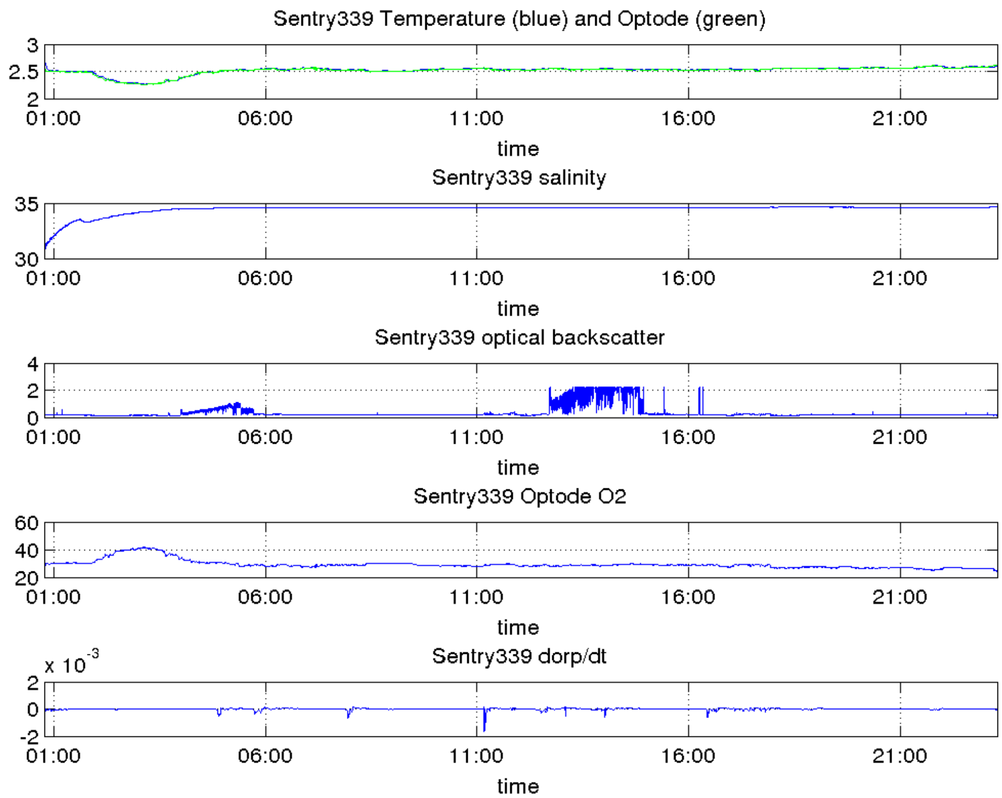


Figure 39: Time series plot of five of the basic sensors on Sentry, from top to bottom, temperature, salinity, optical backscatter, dissolved Oxygen, and derivative w.r.t. time of the ORP voltage.

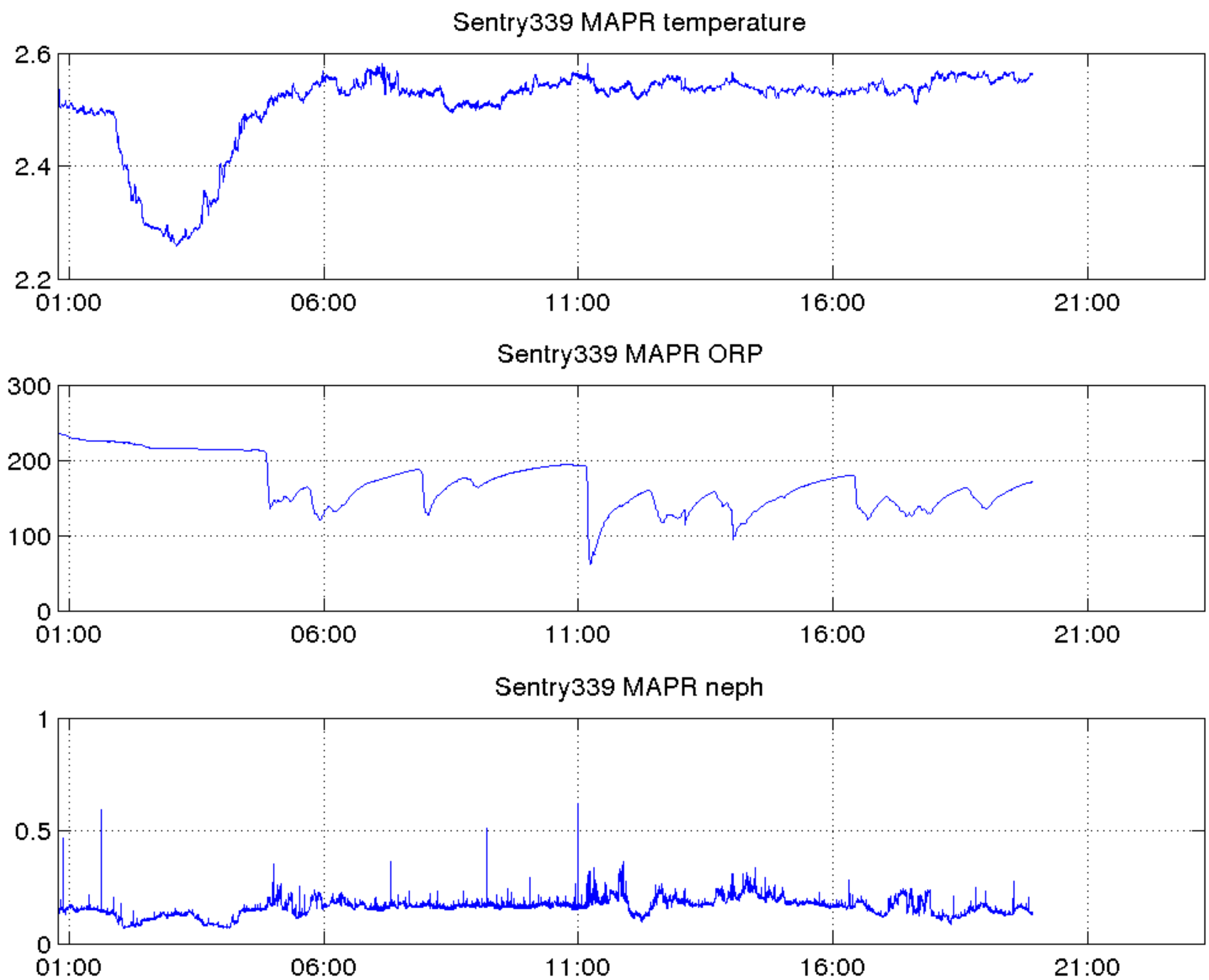


Figure 40: time plots from MAPR (temperature, ORP, and nephelometer) on dive 339.

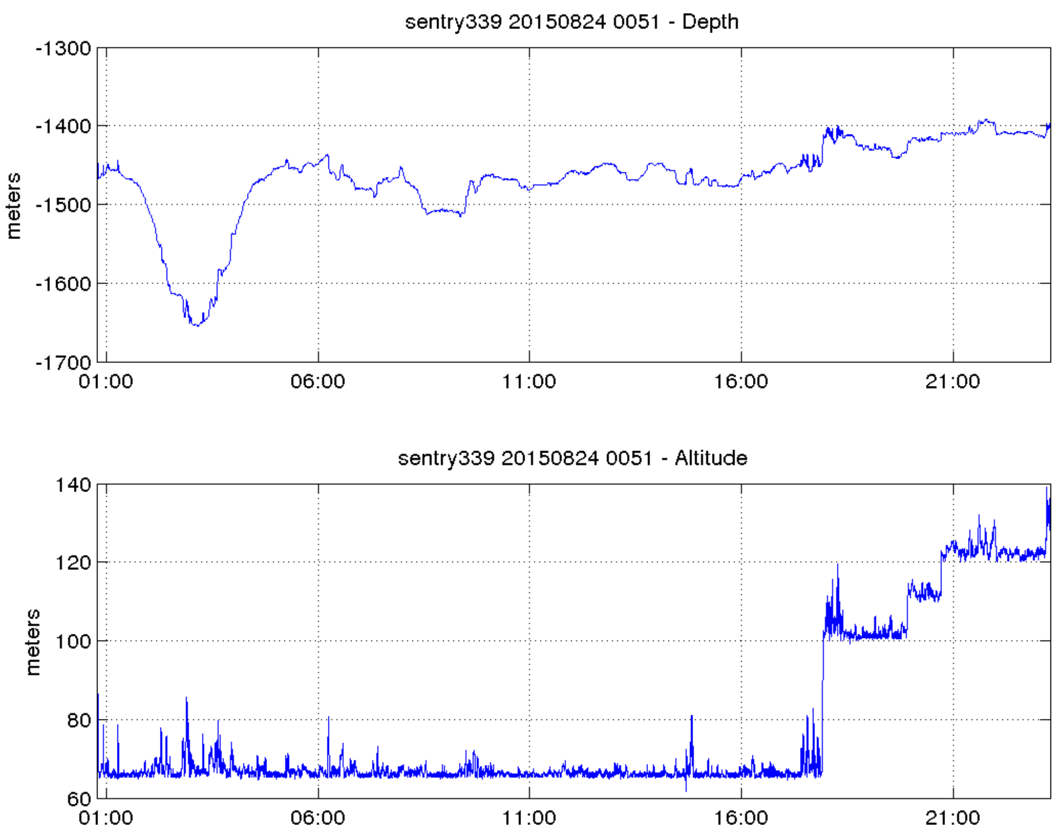


Figure 41: Depth and Altitude of Sentry during dive 339.

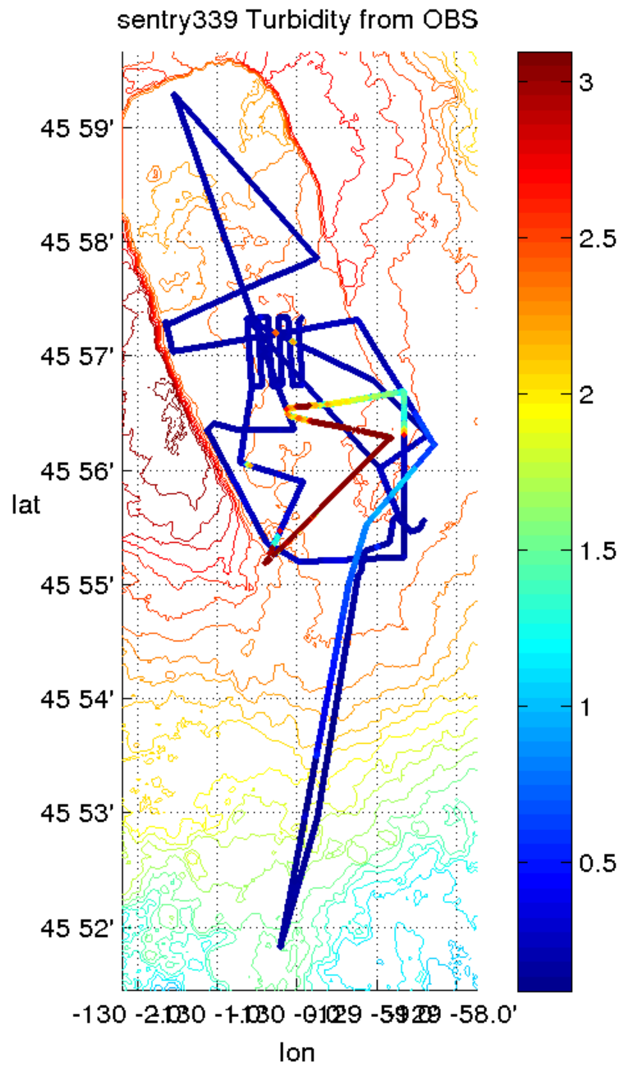


Figure 42: Optical backscatter on dive 339.

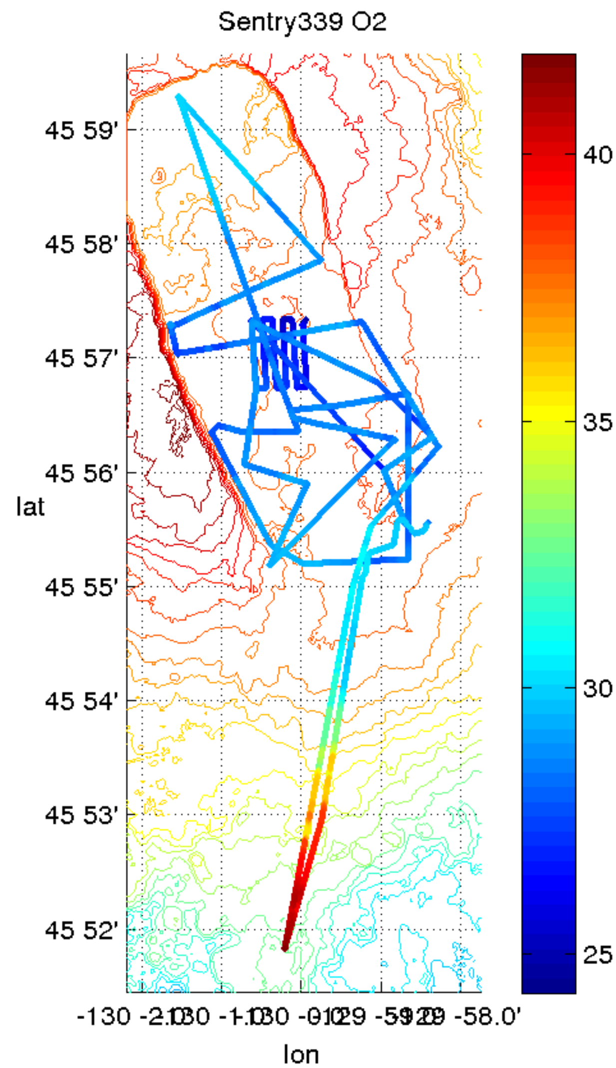


Figure 43: O2 Concentration on dive 339.

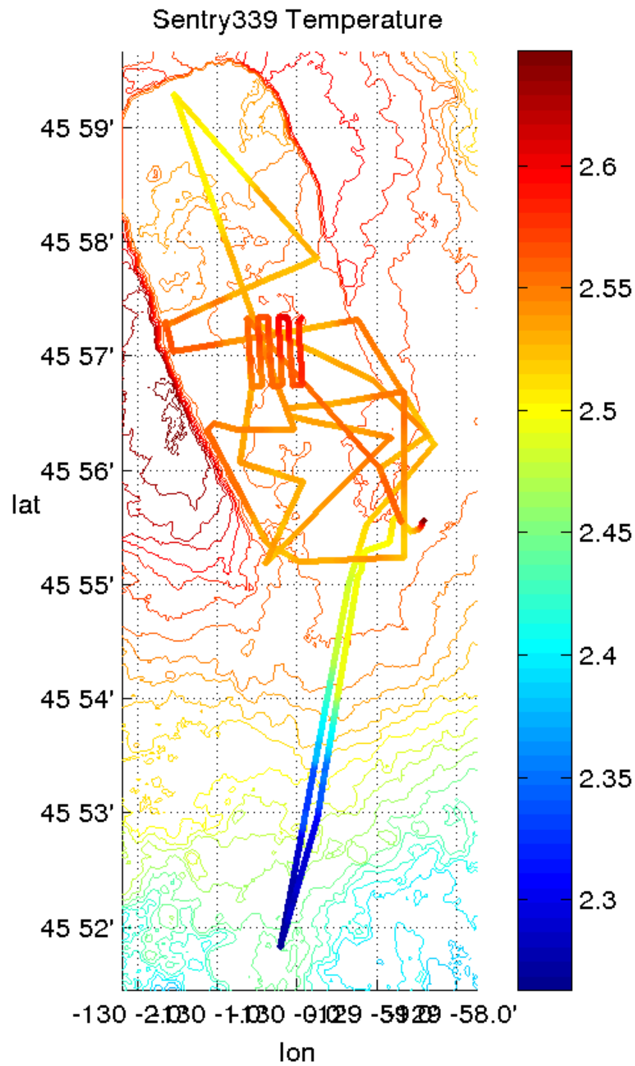


Figure 44: Seabird SBE49 temperature on dive 339.

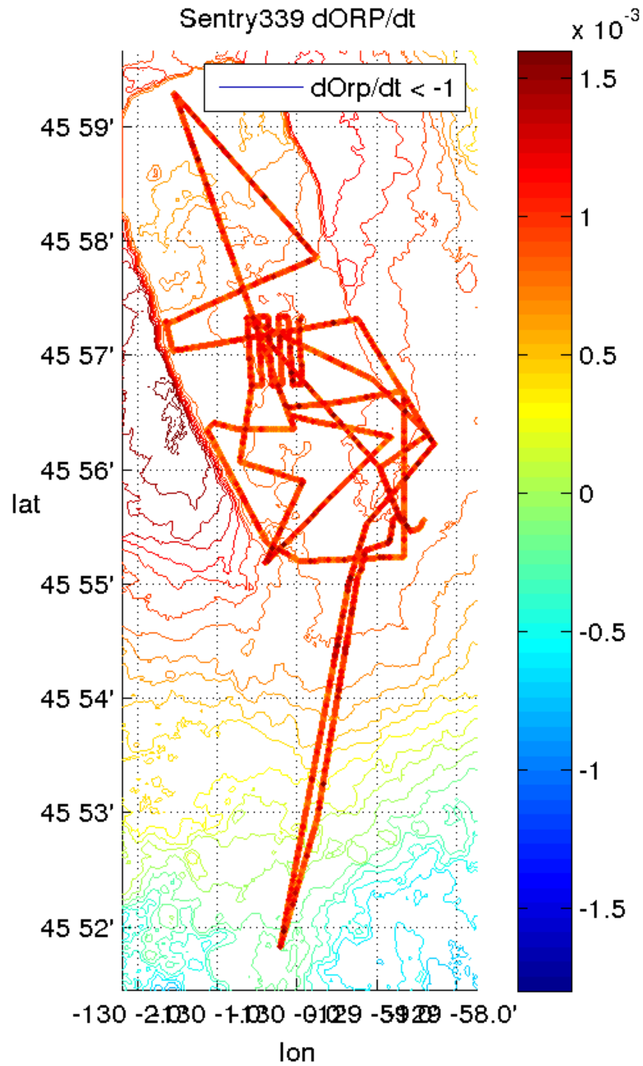


Figure 45: Redox potential (dORP/dt) on dive 339.

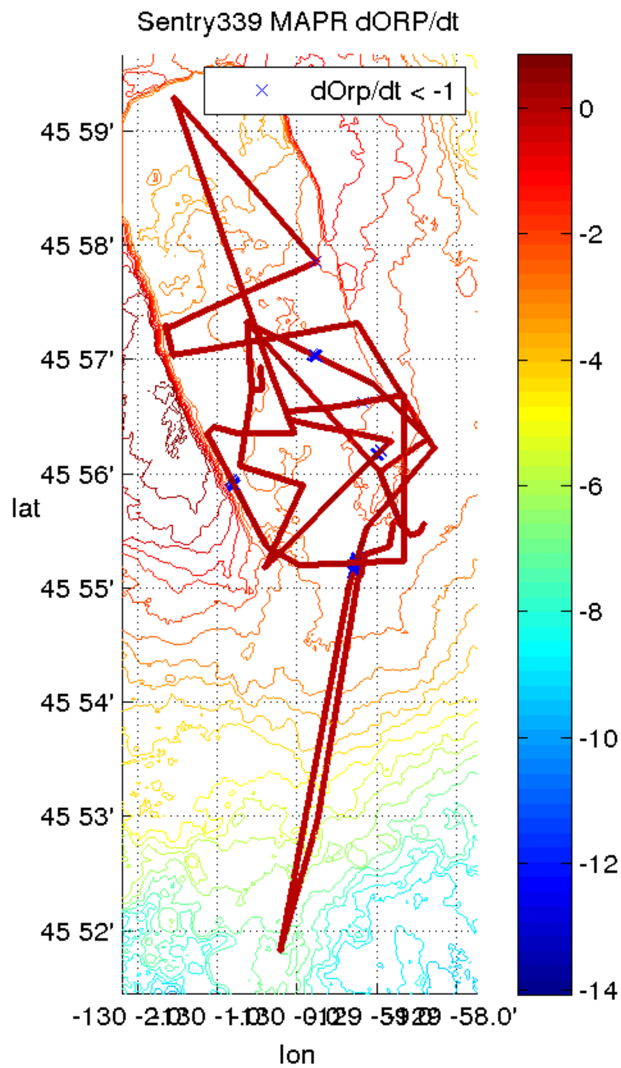


Figure 46: Redox potential from MAPR (dORP/dt) on dive 339.

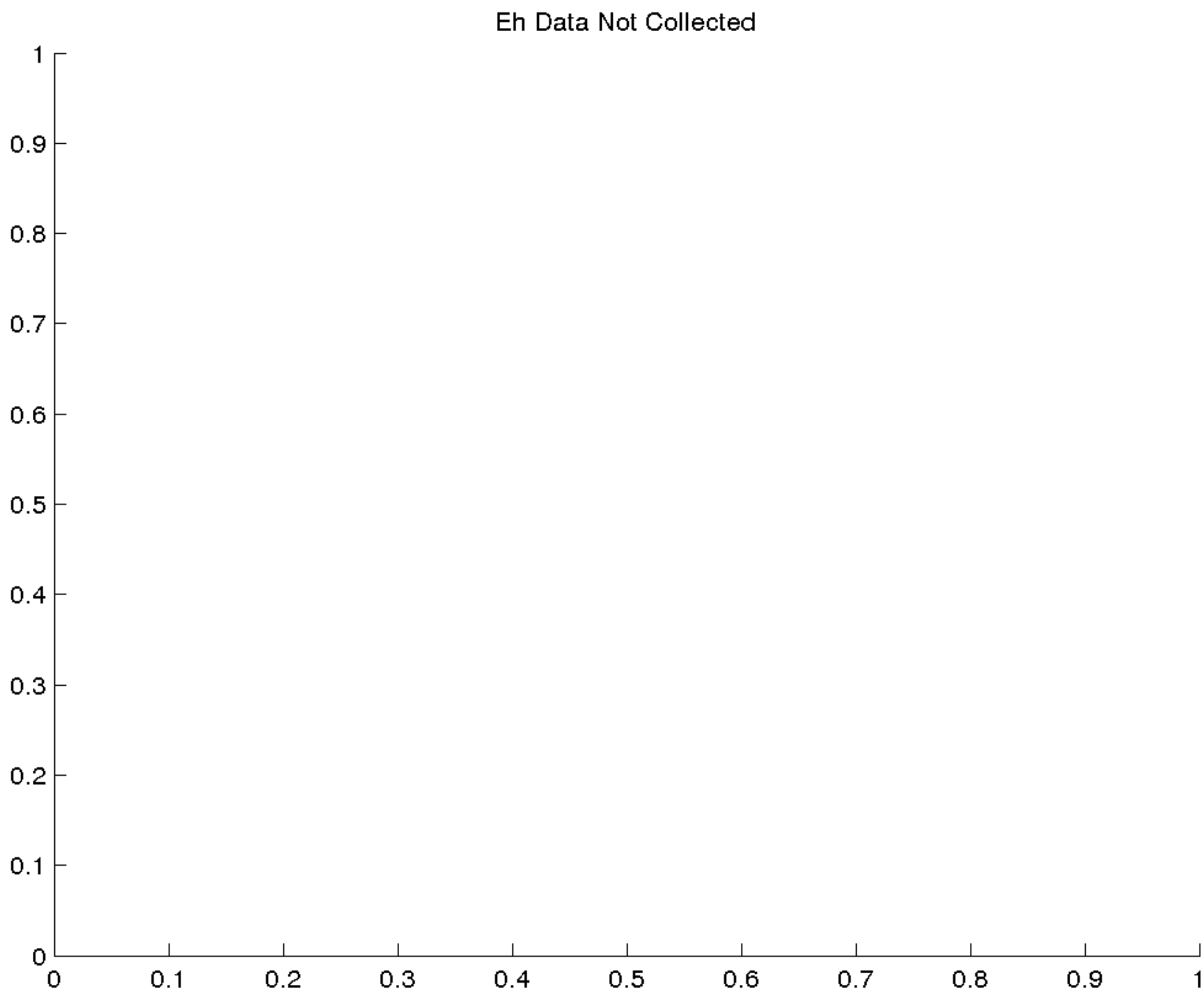


Figure 47: Redox potential (deh/dt) on dive 339.

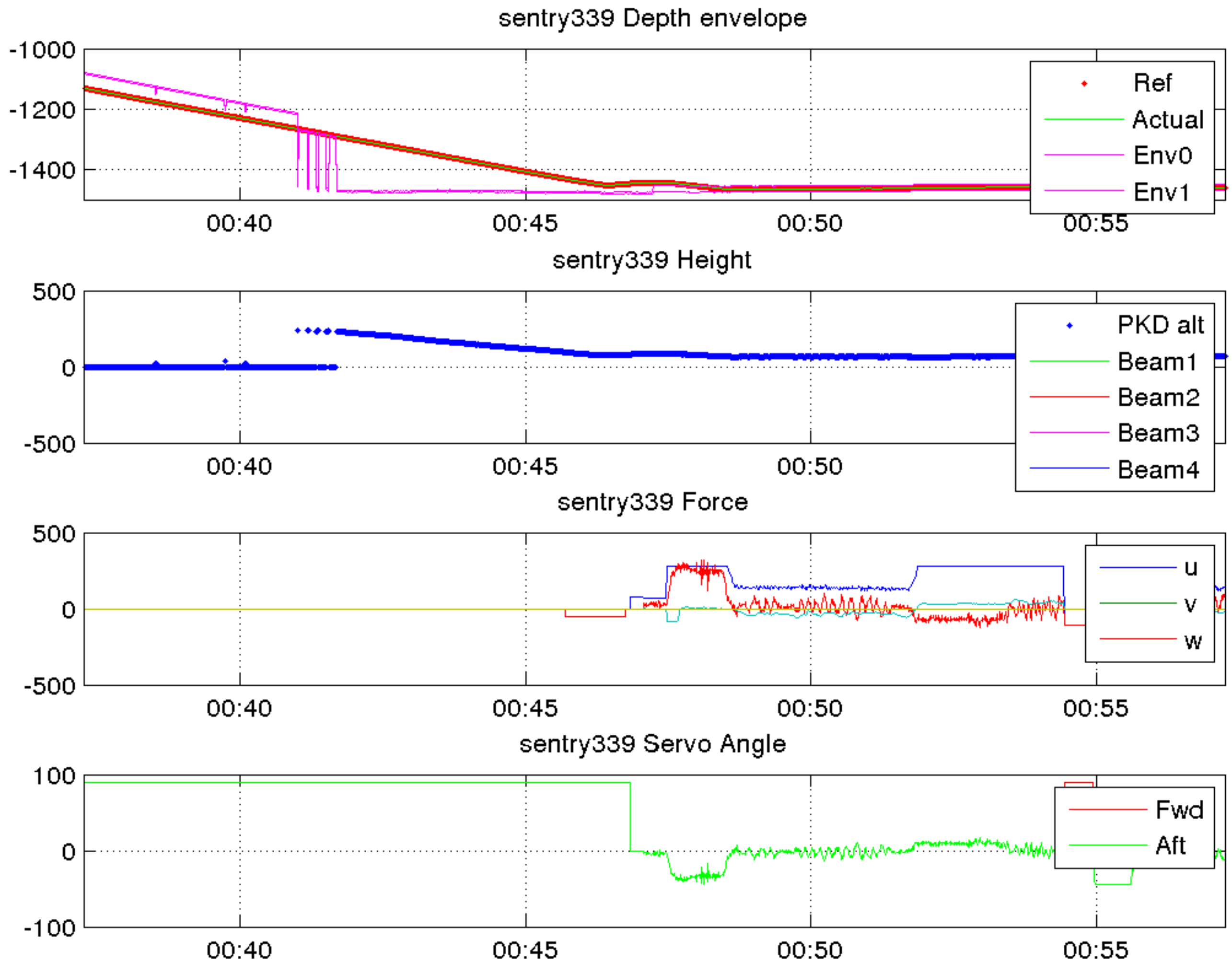


Figure 48: The bottom approach was nominal for dive 339.

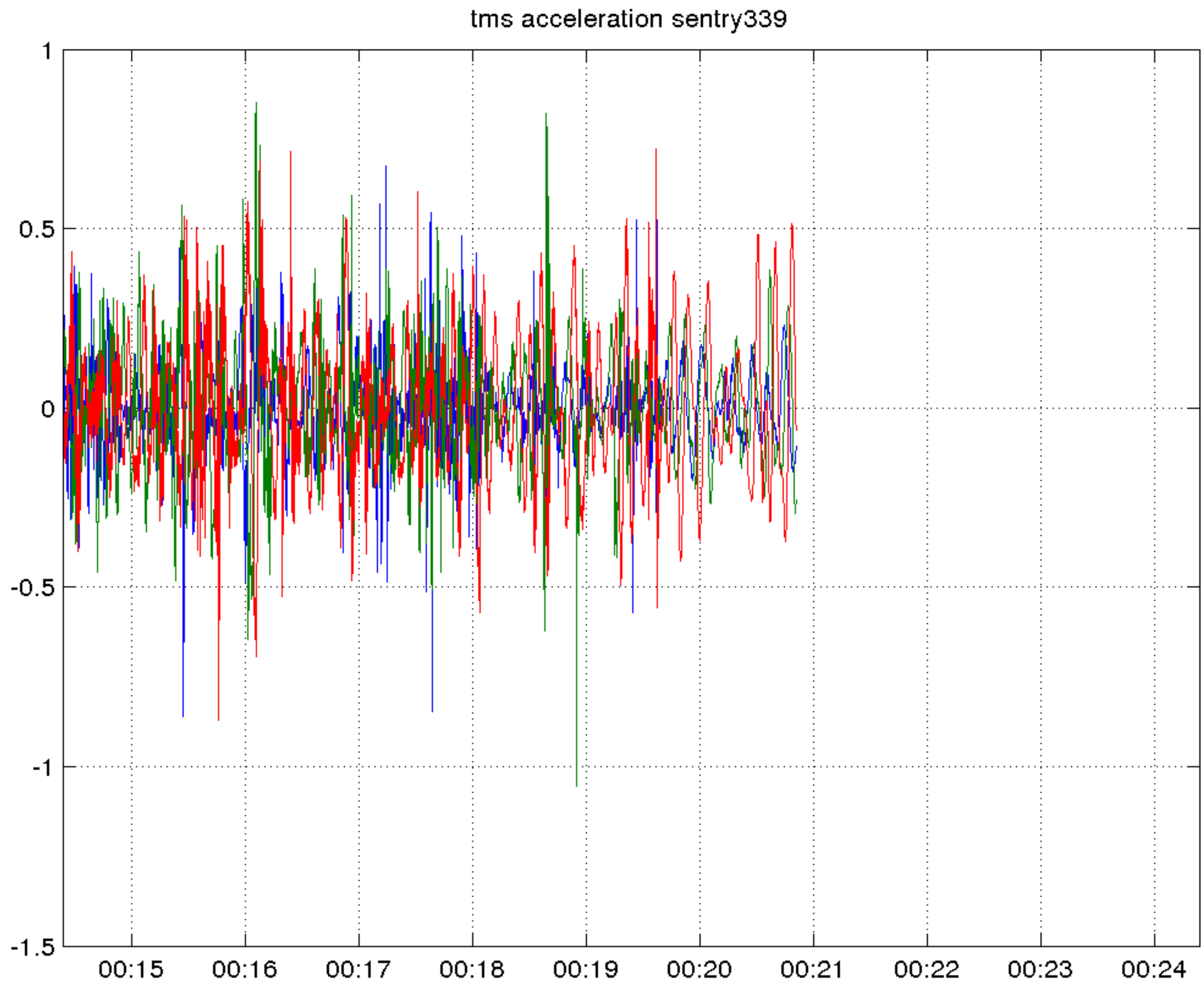


Figure 49: Accelerations on recovery were high on recovery for dive 339.

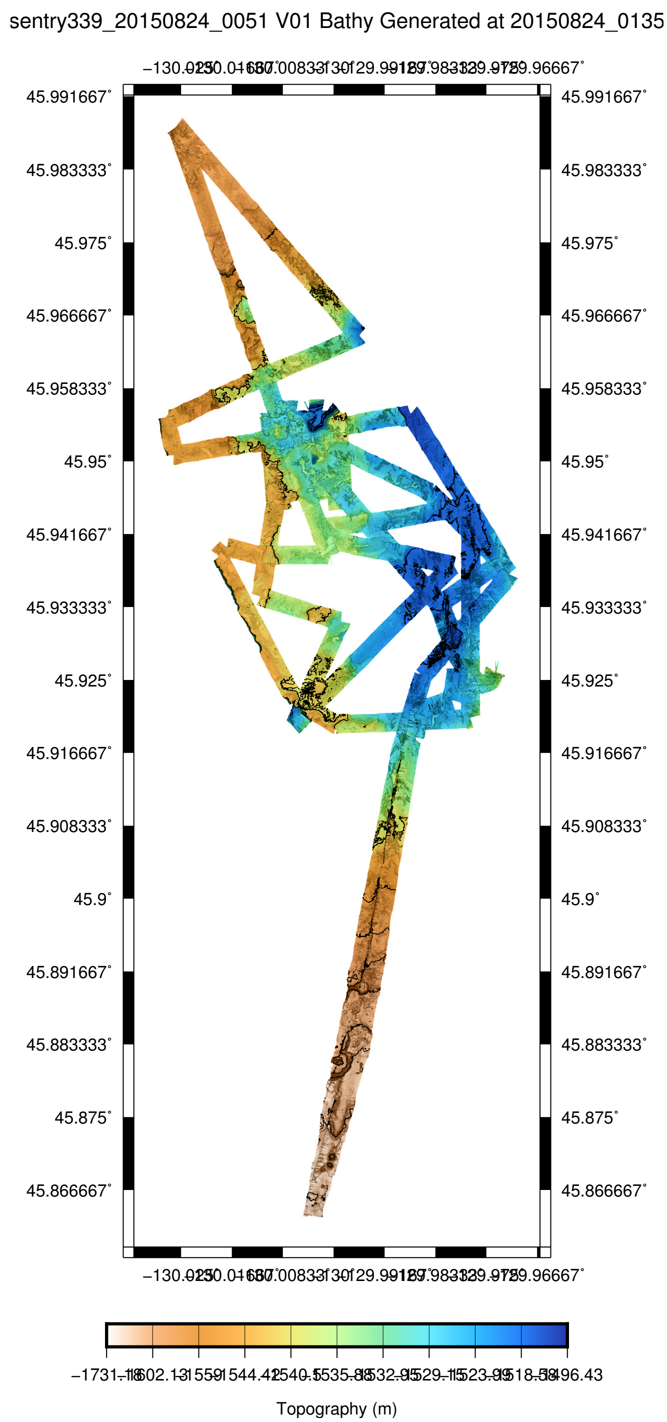


Figure 50: Preliminary multibeam bathymetry dive 339.

Sentry 340 Dive Report
DRAFT

WHOI Sentry Operations Group
Dr. Dana Yoerger, Justin Fujii, Zachary Berkowitz, Stefano Suman, Loral O'Hara

Sentry Expedition Leader: Dr. Dana Yoerger

Chief Scientist: Dr. William Chadwick, NOAA

Summary

Weather: The weather was well within the operating window.

Reason for end of dive: We terminated the dive to meet schedule using an acoustic command.

Vehicle Configuration

The science sensing suite for this dive was:

Table 6: Sentry Sensor Configuration

Sensor
APS 1540 Magnetometers (3)
Edgetech 4-24kHz SBP
Edgetech 120kHz/410kHz Sidescan sonar
Reson 7125 Multibeam Sonar
Seabird SBE49 CTD
Seapoint OBS
Anderaa optode model 4330
300kHz RDI DVL
IXEA PHINS
Reson Sound Velocity Probe
NOAA MAPR

This dive was navigated using the DVL/INS system in real time. USBL provided post-dive corrections. In realtime, we monitored the vehicle's progress using the long-baseline transponder/beacon system, which provides a single range between the vessel and the vehicle. The single range enables the watch to determine if the ranges are consistent with the mission plan, especially with regard to turns.

Important Positions

Dive Origin: 45 55.000'N 130 1.500'W

Launch Position: sentry340 launch position: 45 55.834'N 130 1.214'W

Narrative

This dive was another multibeam dive with sparse lines. In this case, we ran the bow tie pattern over and outside the caldera and made a very long N-S line.

We launched Sentry with Jason in the water. This launch was particularly challenging, as the vessel was positioned for Jason to work on the western edge of caldera floor. The vessel lost position when the winds and seas shifted and had to change heading just before our scheduled launch. This required that we replan the mission. As the vessel was pointing almost south (about 200 deg), the vehicle would move west after launch. This raised the possibility that Sentry could arrive at the seafloor either on the caldera floor, on the steep cliff, or at the shallower area to the west. We decided to lengthen the burn during the fly-away by making it drive forward until 500 meters depth instead of the usual 250 meters. We also assigned the fly-away heading so the that vehicle headed almost due west, which was at about 030 relative to the vessel. This worked very well, and the vehicle was comfortably over the plateau when it dropped its weights.

We had more confusion to get the position adjustment correct. Our confusion arose because during the fly-away, the vehicle state estimator (navest) builds up a substantial xy value as its model responds to the thrust. We have this sorted out and have a written procedure.

Sentry was out of USBL range for most of the dive. During its run to the north, the LBL signal was weak as the vehicle was about 10km away. We maintained the single-range track using our dangle transducer.

About 10 hour into the run, Sentry passed almost directly under the vessel, Jason was up off the bottom. We had a chance to revise the offset but saw no need, the vehicle was within 10m or so of the line. We had several other opportunities to correct the position but saw no need.

We commanded the mission to end when the vehicle track passed near the vessel. Jason was still in the water. Recovery was routine in moderate seas.

1 Issues and Proposed Solutions

We resolved the issue of how to enter the offset correctly when the vehicle landed far from it's initial 0,0 point

Chief Scientist Comments

The Chief scientist is requested to include any desired comments.

Dive Statistics

Sentry340 Summary Launch: 2015/08/24 21:06:07
Survey start: 2015/08/24 21:42:02
Latitude: 45.930710 Longitude -130.019080
Depth: 1340.66
Survey end: 2015/08/25 19:29:07
Latitude: 45.921500 Longitude -129.997749
Depth: 1471.91
Ascent begins: 2015/08/25 19:29:07
On the surface: 2015/08/25 20:00:38
On deck: 2015/08/25 20:28:35
descent rate: 37.3 m/min
ascent rate: 46.7 m/min
survey time: 21.8 hours
deck-to-deck time 23.4 hours
Mean survey depth: 1504m
Mean survey height: 65m
distance travelled: 74.96km
average speed; 0.98m/s
average speed during photo runs: 0.00 m/s over 0.00 km
average speed during multibeam runs: 0.96 m/s over 74.96 km
total vertical during survey: 6130m
Battery energy at launch: 19.5 kwhr
Battery energy at survey end: 3.3 kwhr
Battery energy on deck: 3.1 kwhr
Battery energy used for survey: 15.9 kwhr
Average power during survey: 729.1 watts

Plots and Images

This section contains selected images of data products and plots of vehicle navigation and selected sensors.

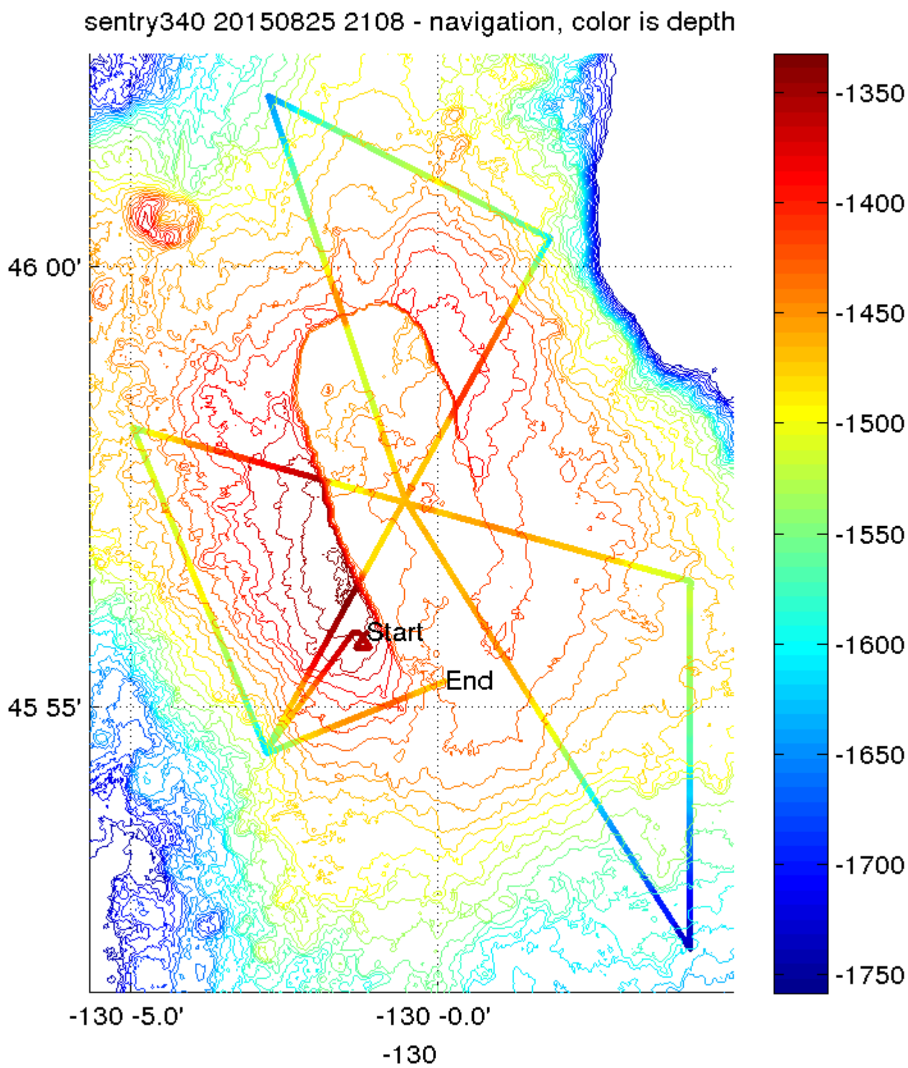


Figure 51: Latitude/Longitude plot of Sentry dive 340 based on post-processed navigation. The color indicates vehicle depth.

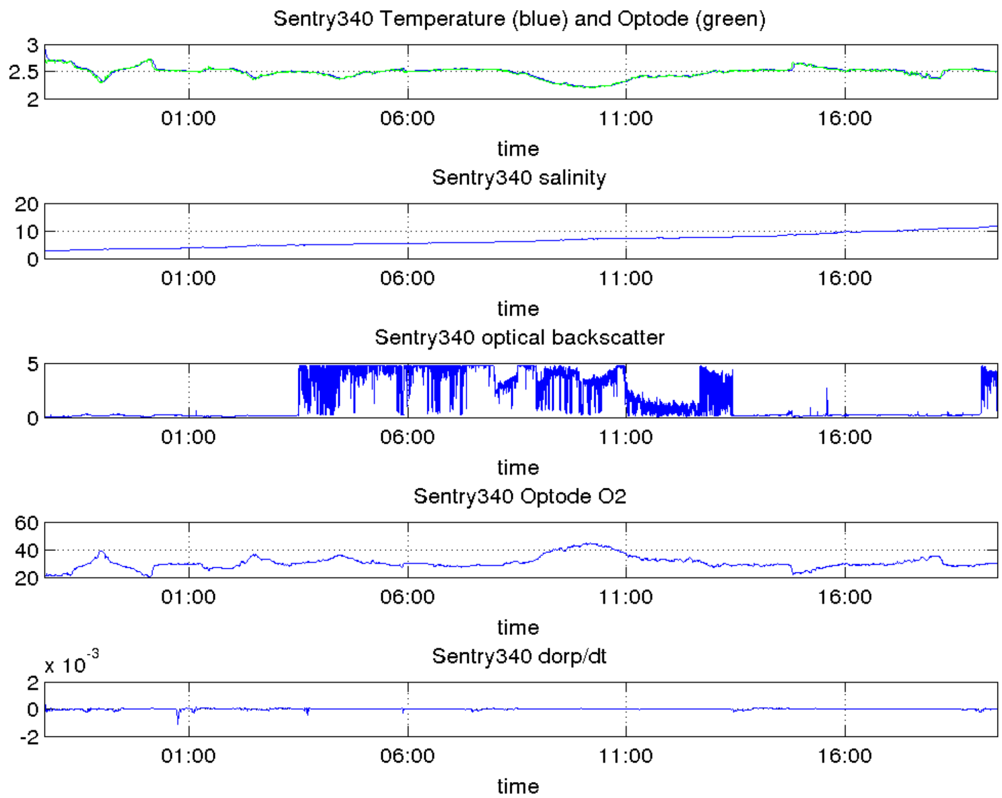


Figure 52: Time series plot of five of the basic sensors on Sentry, from top to bottom, temperature, salinity, optical backscatter, dissolved Oxygen, and derivative w.r.t. time of the ORP voltage.

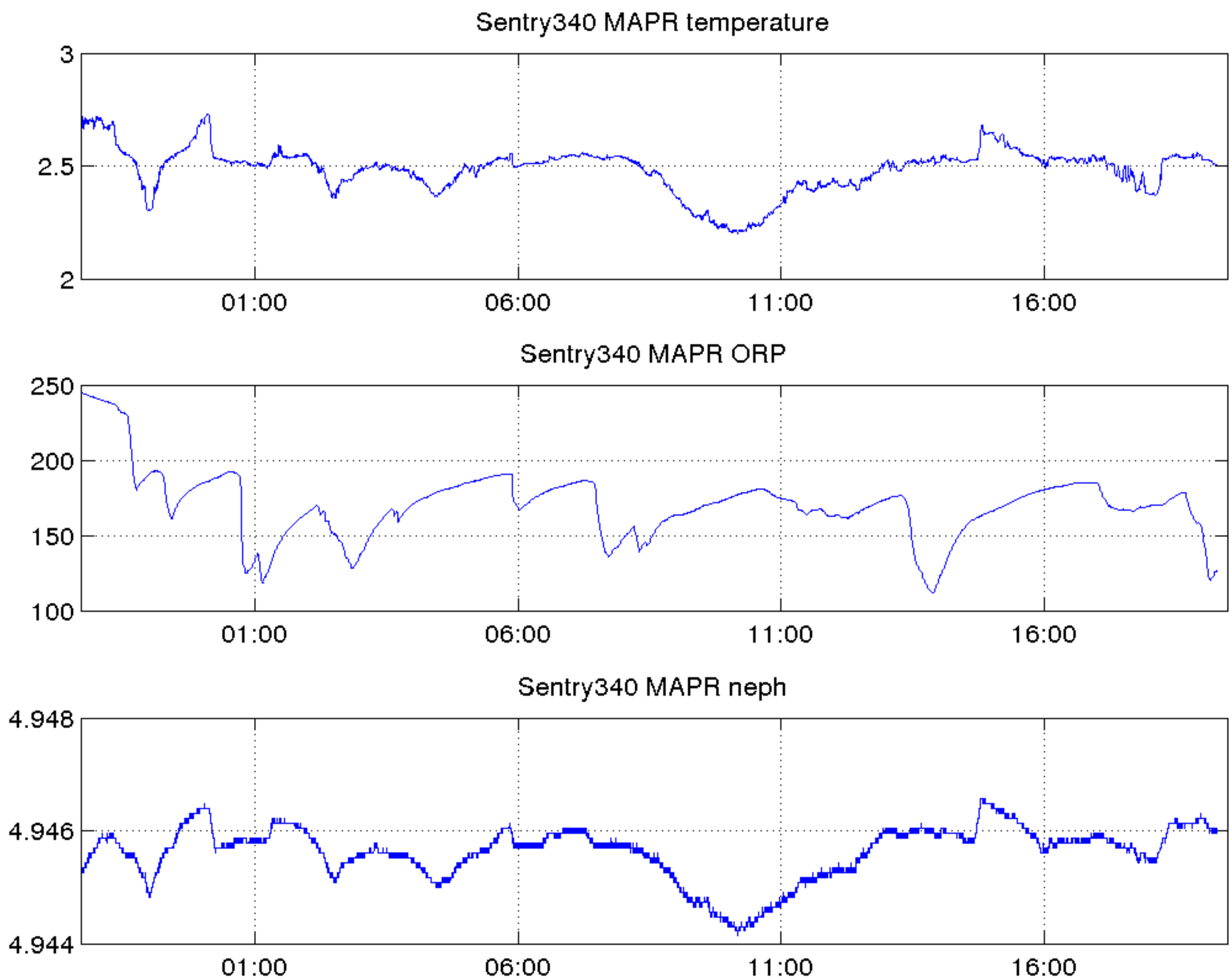


Figure 53: time plots from MAPR (temperature, ORP, and nephelometer) on dive 340.

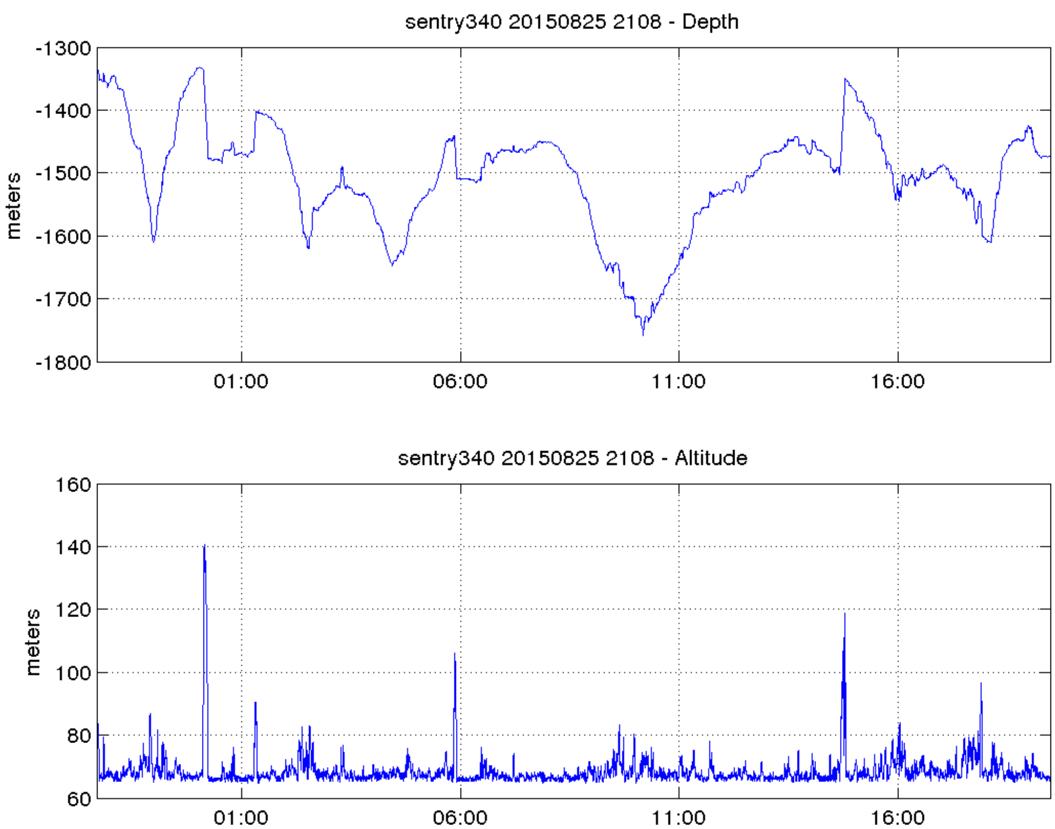


Figure 54: Depth and Altitude of Sentry during dive 340.

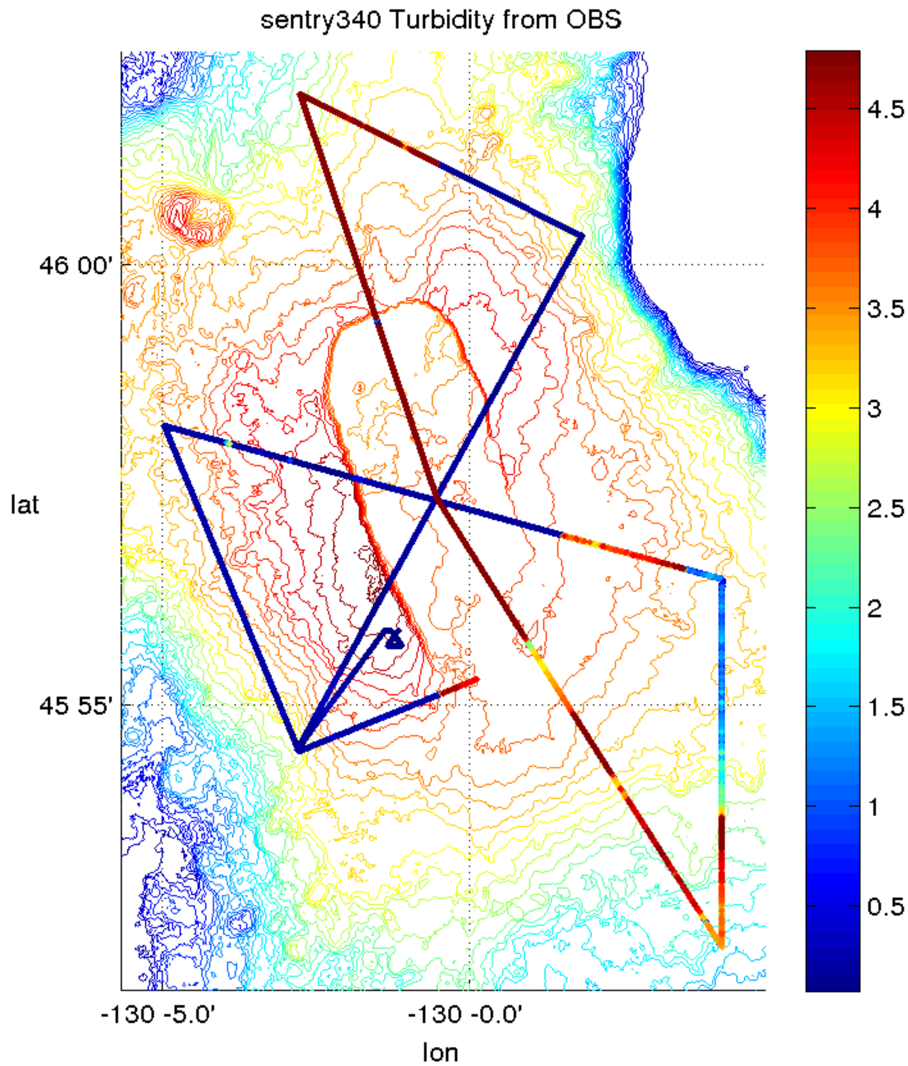


Figure 55: Optical backscatter on dive 340.

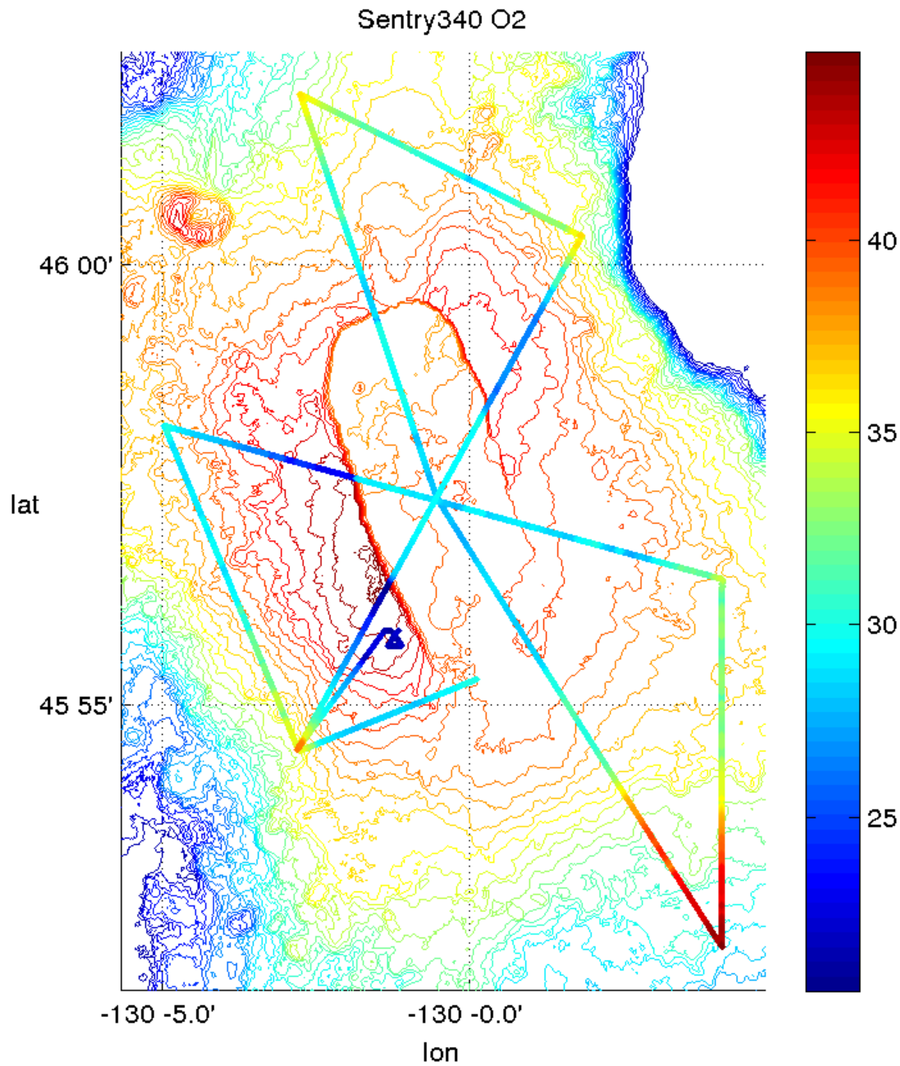


Figure 56: O2 Concentration on dive 340.

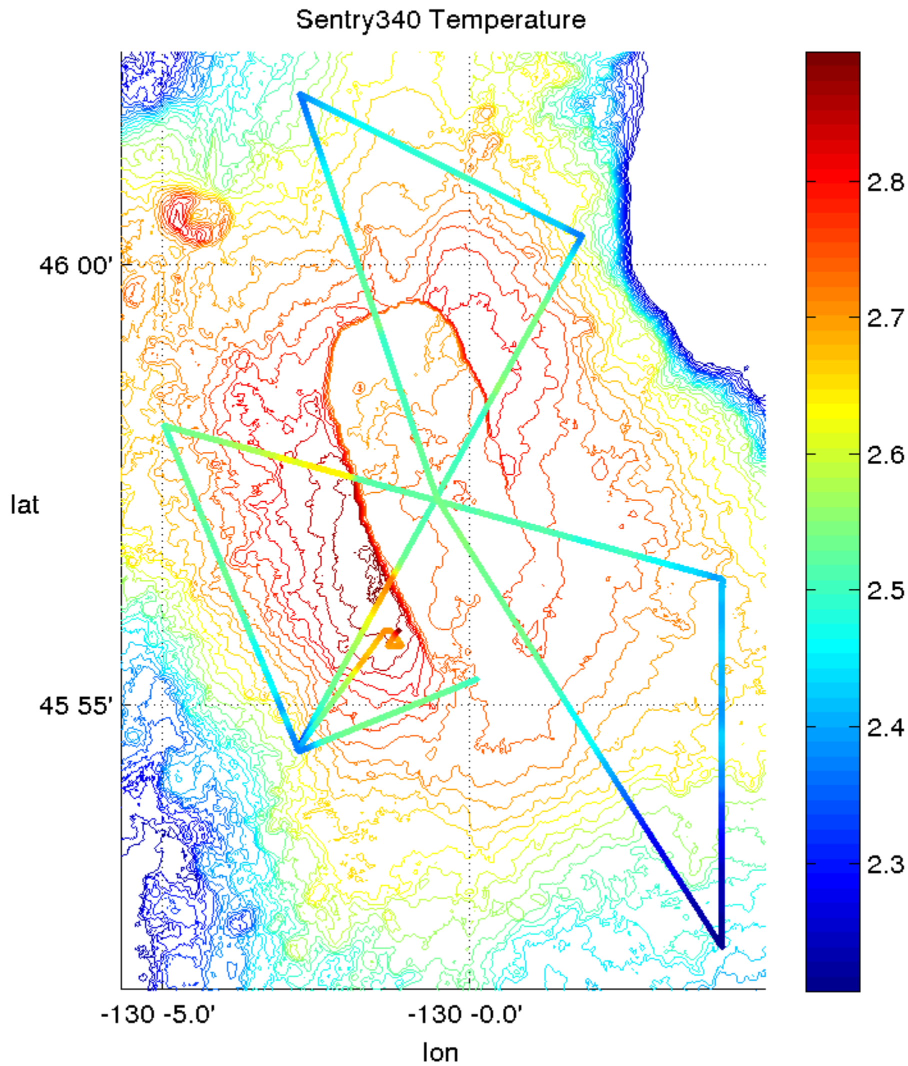


Figure 57: Seabird SBE49 temperature on dive 340.

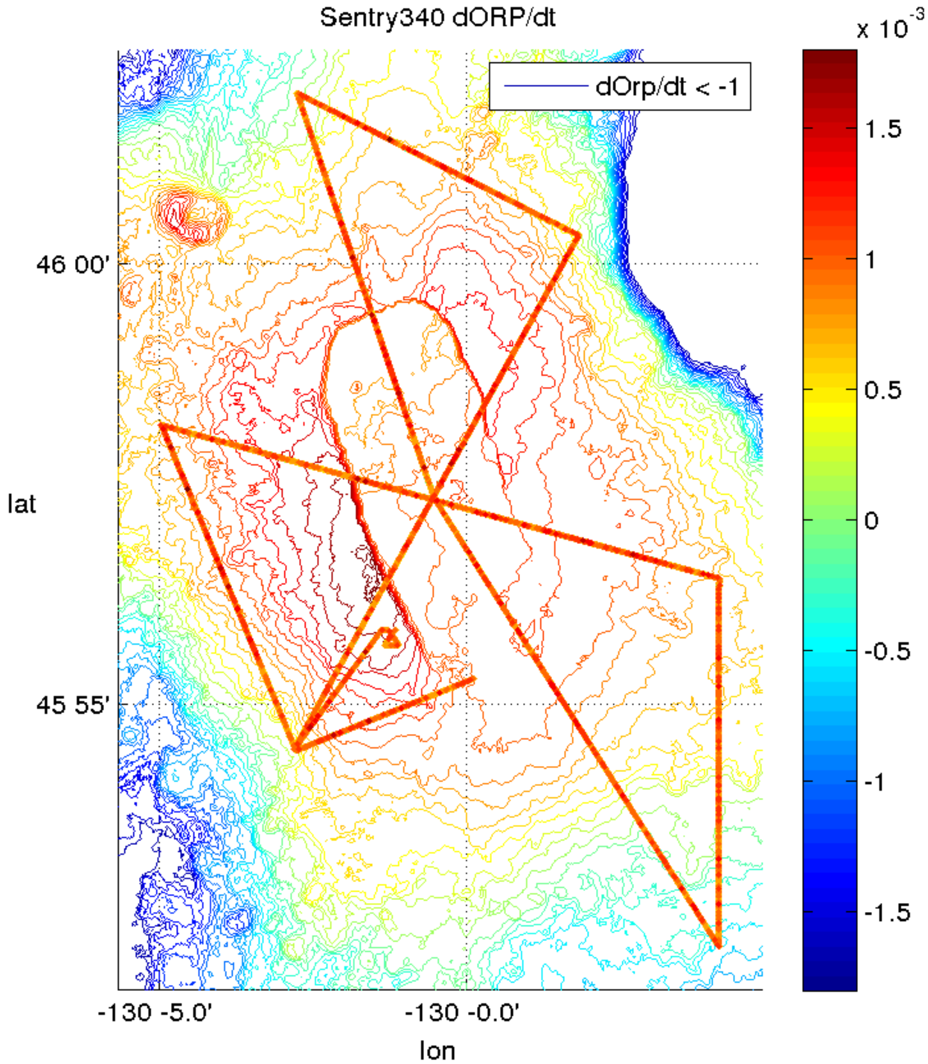


Figure 58: Redox potential (dORP/dt) on dive 340.

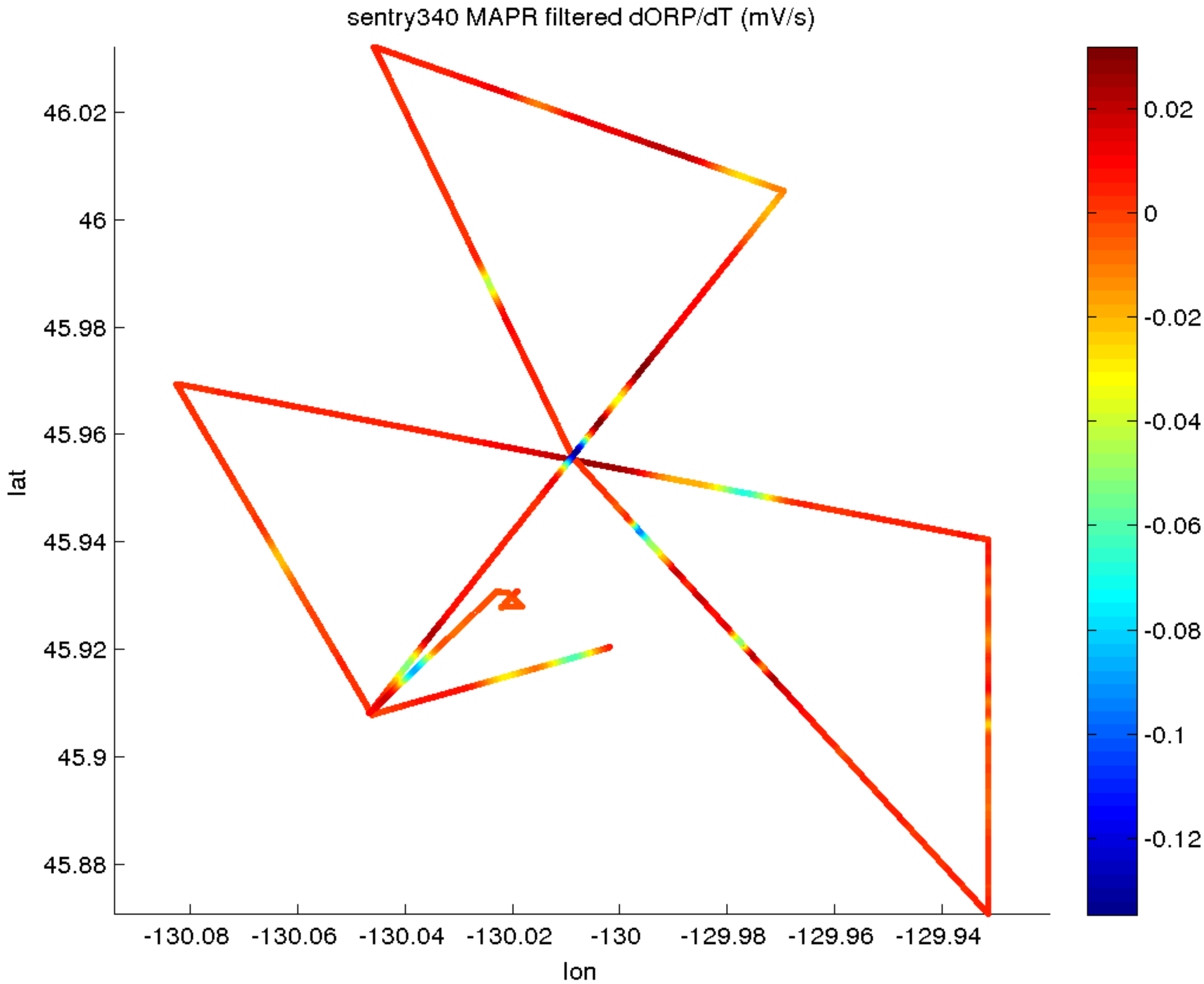


Figure 59: Redox potential from MAPR (dORP/dt) on dive 340.

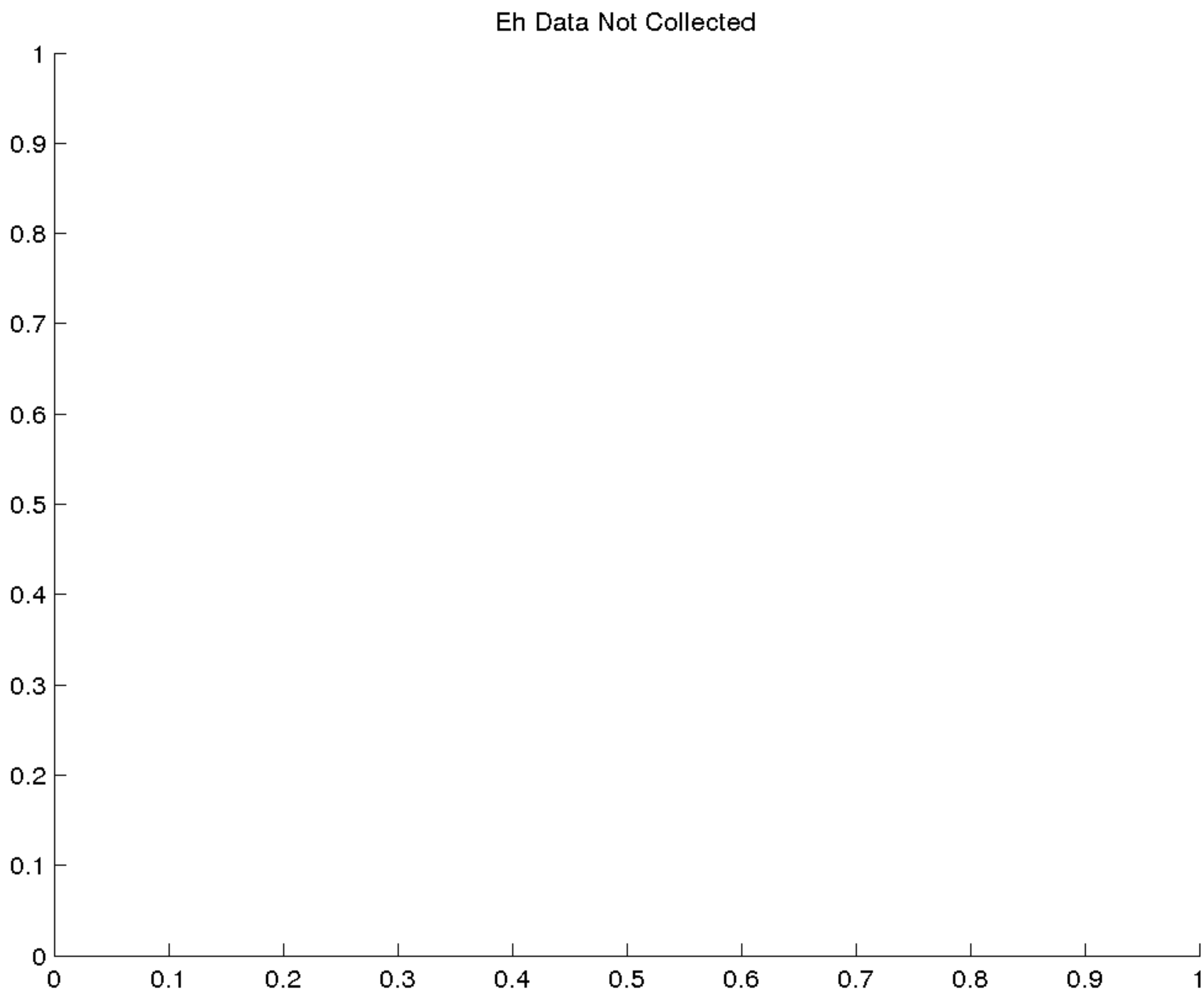


Figure 60: Redox potential (deh/dt) on dive 340.

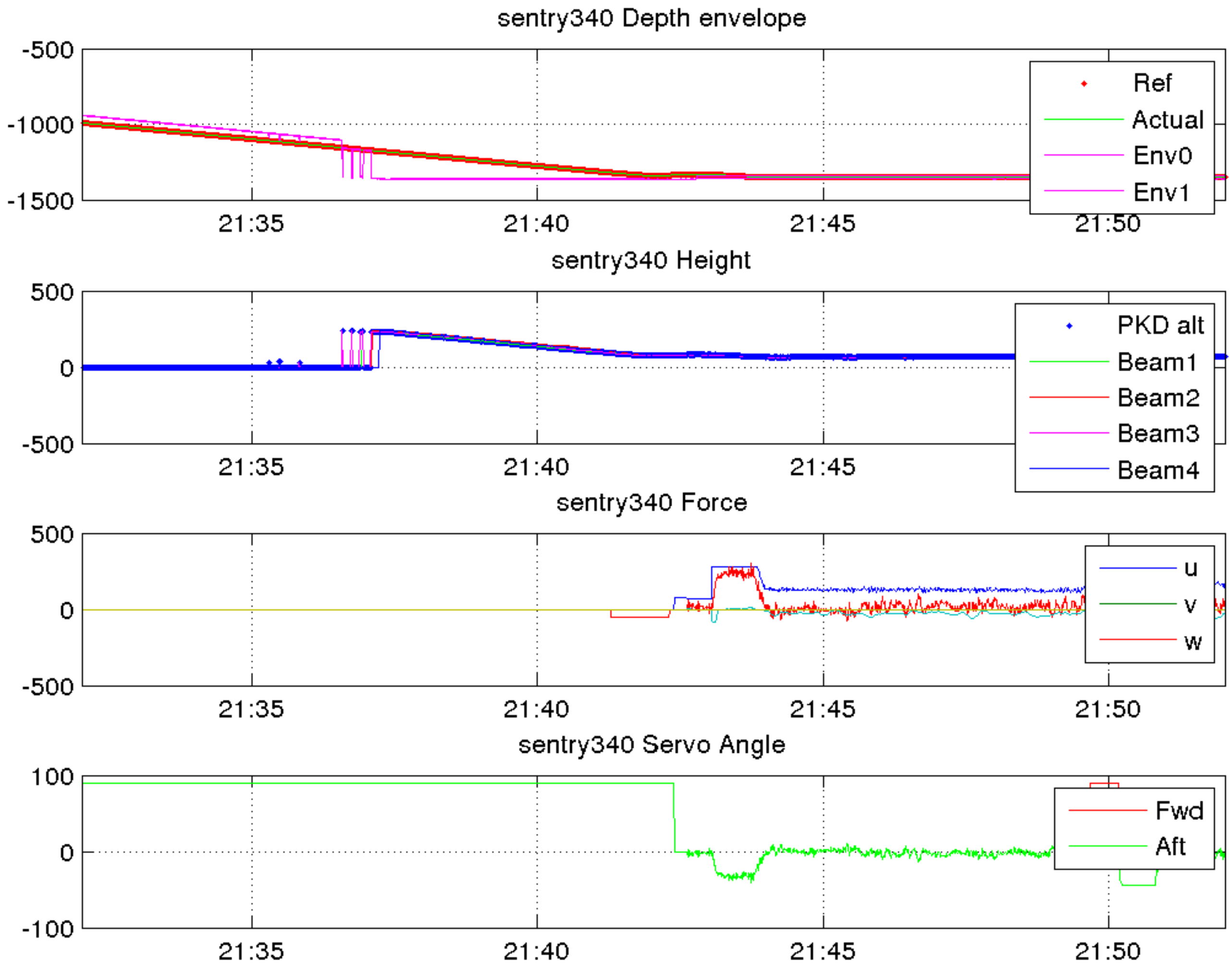


Figure 61: The bottom approach was nominal for dive 340.

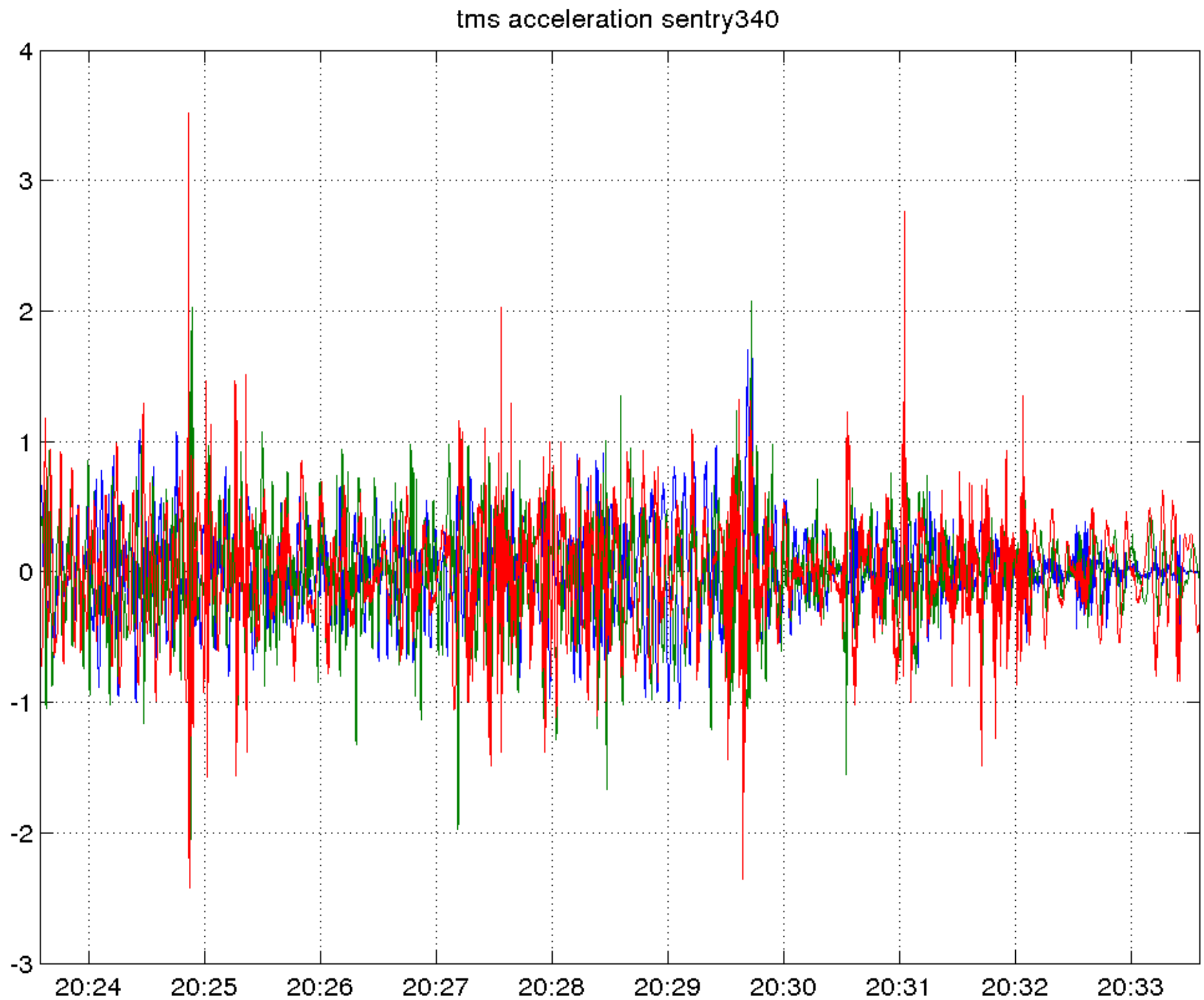


Figure 62: Accelerations on recovery were high on recovery for dive 340.

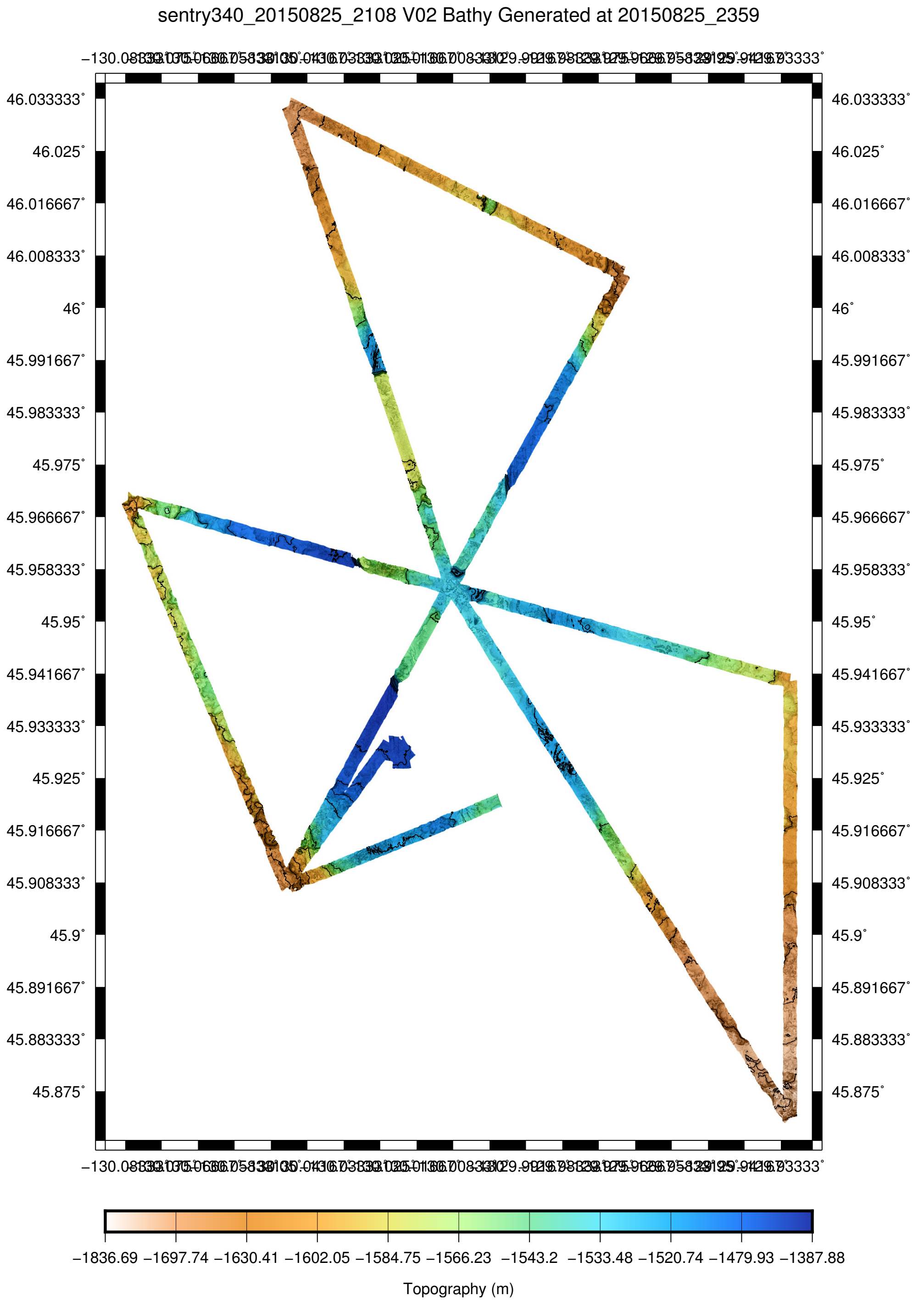


Figure 63: Preliminary multibeam bathymetry dive 340.

Sentry 341 Dive Report
DRAFT

WHOI Sentry Operations Group
Dr. Dana Yoerger, Justin Fujii, Zachary Berkowitz, Stefano Suman, Loral O'Hara

Sentry Expedition Leader: Dr. Dana Yoerger

Chief Scientist: Dr. William Chadwick, NOAA

Summary

Weather: The weather was well within the operating window.

Reason for end of dive: We terminated the dive to meet schedule using an acoustic command.

Vehicle Configuration

The science sensing suite for this dive was:

Table 7: Sentry Sensor Configuration

Sensor
APS 1540 Magnetometers (3)
Edgetech 4-24kHz SBP
Edgetech 120kHz/410kHz Sidescan sonar
Reson 7125 Multibeam Sonar
Seabird SBE49 CTD
Seapoint OBS
Anderaa optode model 4330
300kHz RDI DVL
IXEA PHINS
Reson Sound Velocity Probe
NOAA MAPR

This dive was navigated using the DVL/INS system in real time. USBL provided post-dive corrections. In realtime, we monitored the vehicle's progress using the long-baseline transponder/beacon system, which provides a single range between the vessel and the vehicle. The single range enables the watch to determine if the ranges are consistent with the mission plan, especially with regard to turns.

Important Positions

Dive Origin: 45 55.000'N 130 1.500'W

Launch Position: sentry341 launch position: 45 57.694'N 130 0.515'W

Narrative

This dive started with Jason in the water near the center of the caldera. Sentry ran connector lines out of the caldera up a gentle slope to the east, then ran along the rim to the survey area on the NE rim. The objective was to map an eruptive fissure and a new flow.

Sentry went out of USBL range when it headed north, but the vessel headed that way with Jason in tow. We had good USBL for much of the dive.

We lost the USBL tracking system shortly before we were scheduled to end the dive. We saw problems with both the Octans and multiple NCU problems with inoperative ports. We managed to get the system working well enough to get a range and depth (invalid Octans input) and to get acomms working. The Whifflenav LBL system provided confiirmation that the vehicle was still on schedule, turning when expected. We aborted first using Whifflenav, we saw some pings in response but were uncertain that the vehicle had aborted. We used the Sonardyne acomms to abort and got acknowledgement by an acomms message and by pings.

The weather for recovery was very good and the operation went very smoothly.

1 Issues and Proposed Solutions

The USBL system failed at the end of the dive (Octans connector). We should be better prepared to use the backup LBL abort system.

Chief Scientist Comments

The Chief scientist is requested to include any desired comments.

Dive Statistics

Sentry341 Summary Launch: 2015/08/26 23:49:11
Survey start: 2015/08/27 00:30:57
Latitude: 45.960878 Longitude -130.014349
Depth: 1467.27
Survey end: 2015/08/27 13:58:50
Latitude: 45.996626 Longitude -130.019907
Depth: 1469.39
Ascent begins: 2015/08/27 13:58:50
On the surface: 2015/08/27 14:29:58
On deck: 2015/08/27 14:49:53
descent rate: 35.1 m/min
ascent rate: 47.2 m/min
survey time: 13.5 hours
deck-to-deck time 15.0 hours
Mean survey depth: 1468m
Mean survey height: 65m
distance travelled: 48.16km
average speed; 0.99m/s
average speed during photo runs: 0.00 m/s over 0.00 km
average speed during multibeam runs: 0.99 m/s over 48.16 km
total vertical during survey: 3147m
Battery energy at launch: 20.2 kwhr
Battery energy at survey end: 9.2 kwhr
Battery energy on deck: 9.1 kwhr
Battery energy used for survey: 10.5 kwhr
Average power during survey: 782.4 watts

Plots and Images

This section contains selected images of data products and plots of vehicle navigation and selected sensors.

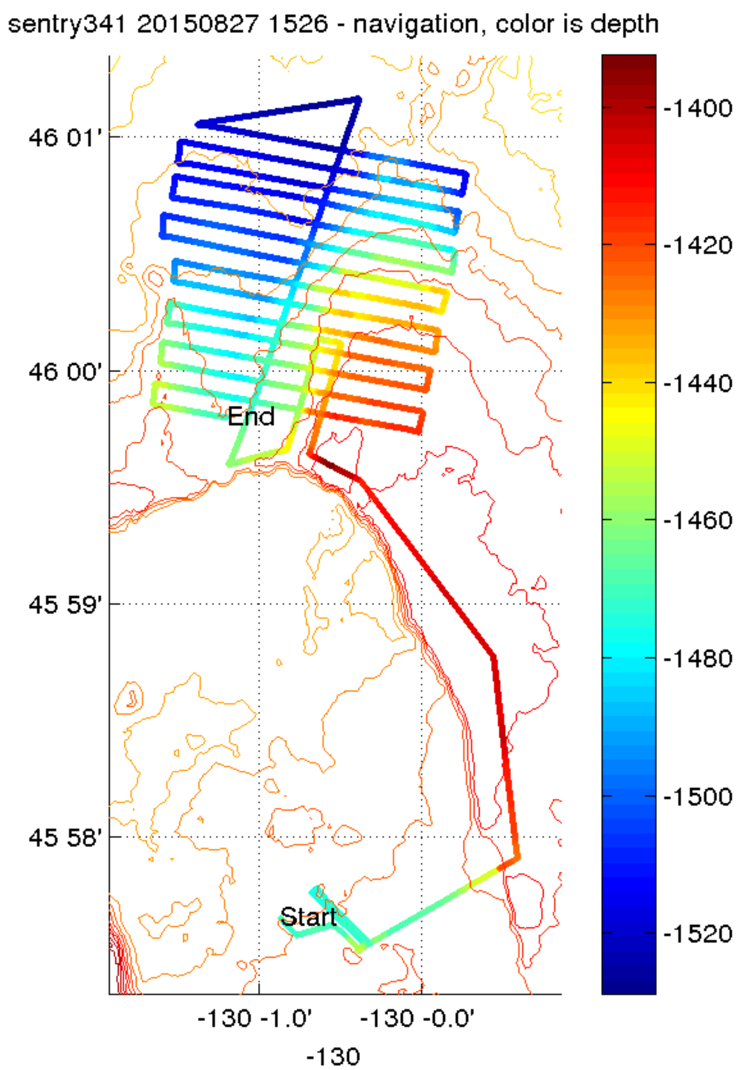


Figure 64: Latitude/Longitude plot of Sentry dive 341 based on post-processed navigation. The color indicates vehicle depth.

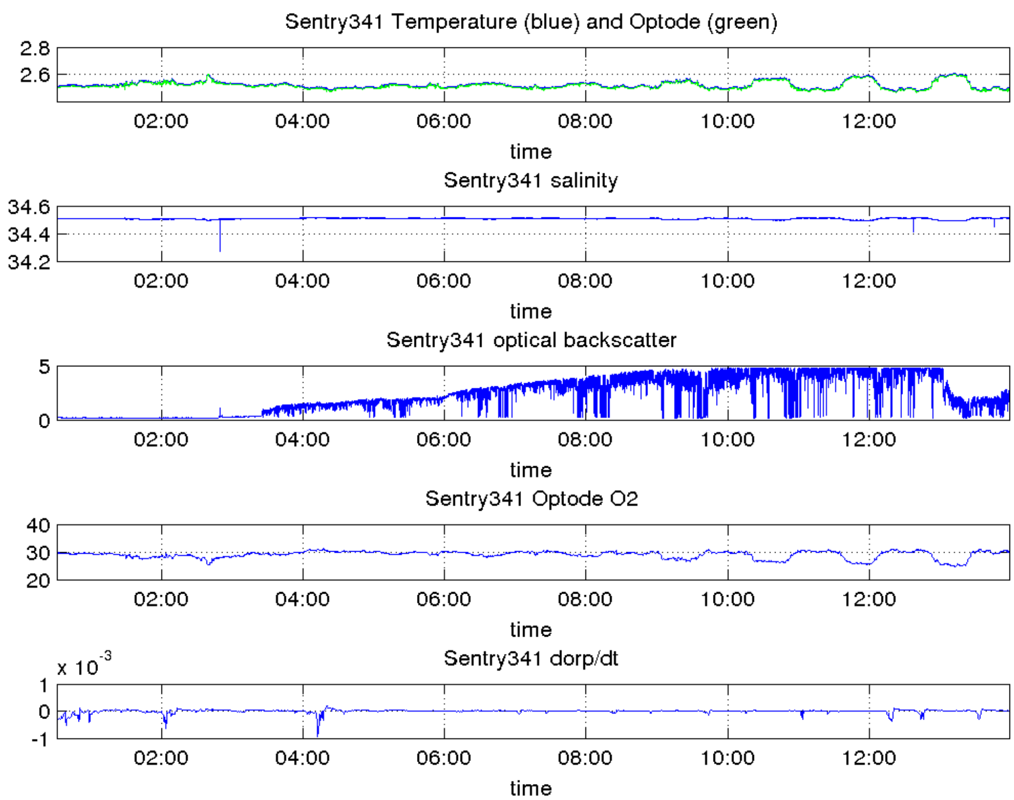


Figure 65: Time series plot of five of the basic sensors on Sentry, from top to bottom, temperature, salinity, optical backscatter, dissolved Oxygen, and derivative w.r.t. time of the ORP voltage.

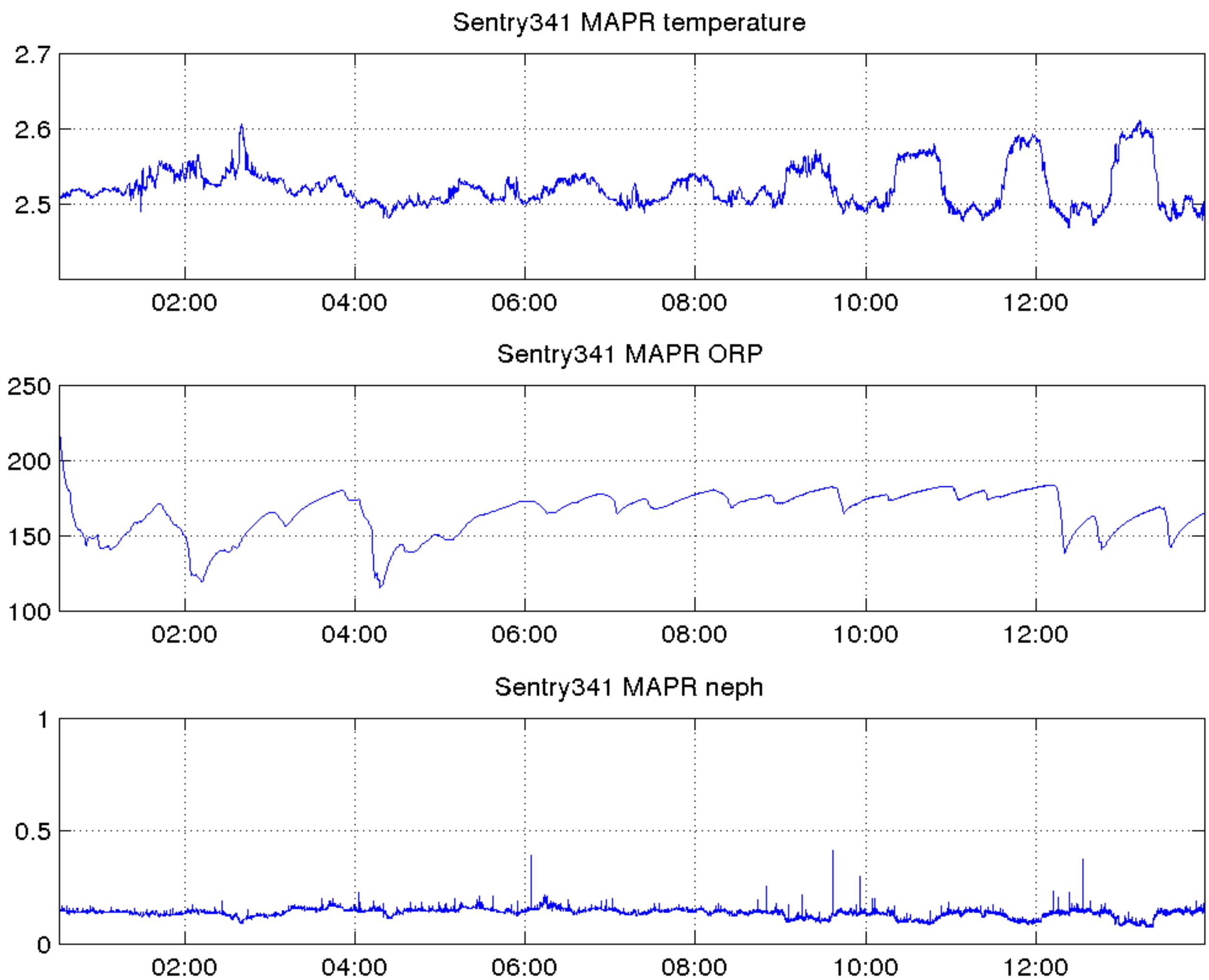


Figure 66: time plots from MAPR (temperature, ORP, and nephelometer) on dive 341.

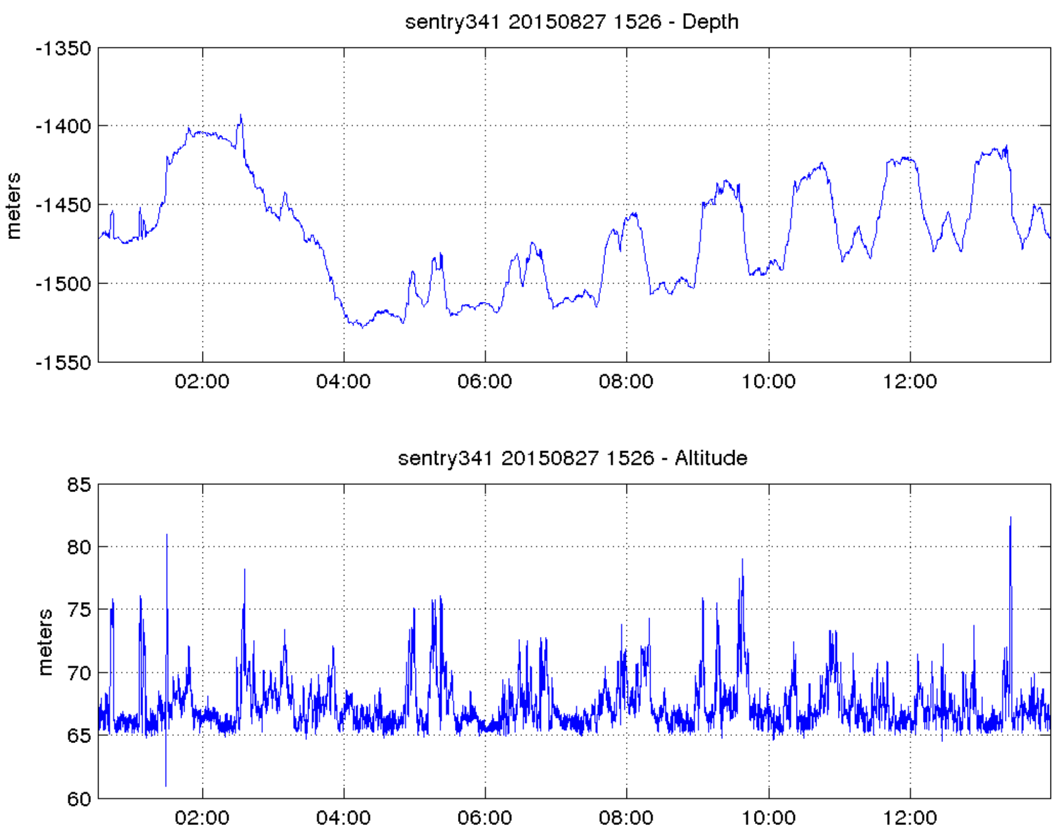


Figure 67: Depth and Altitude of Sentry during dive 341.

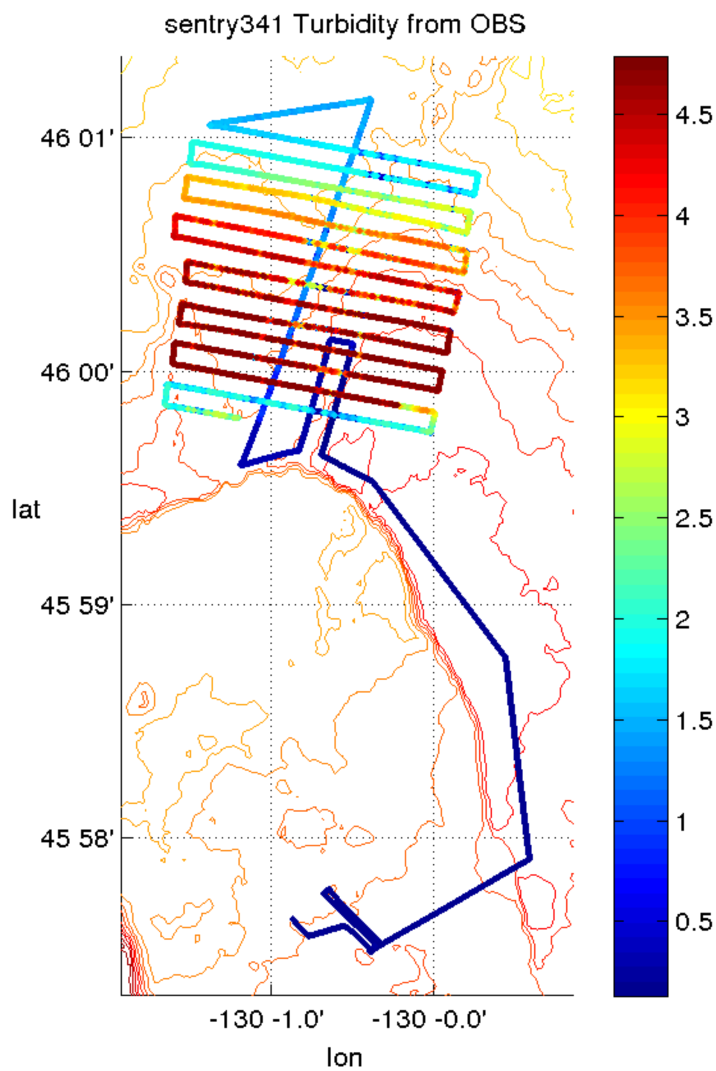


Figure 68: Optical backscatter on dive 341.

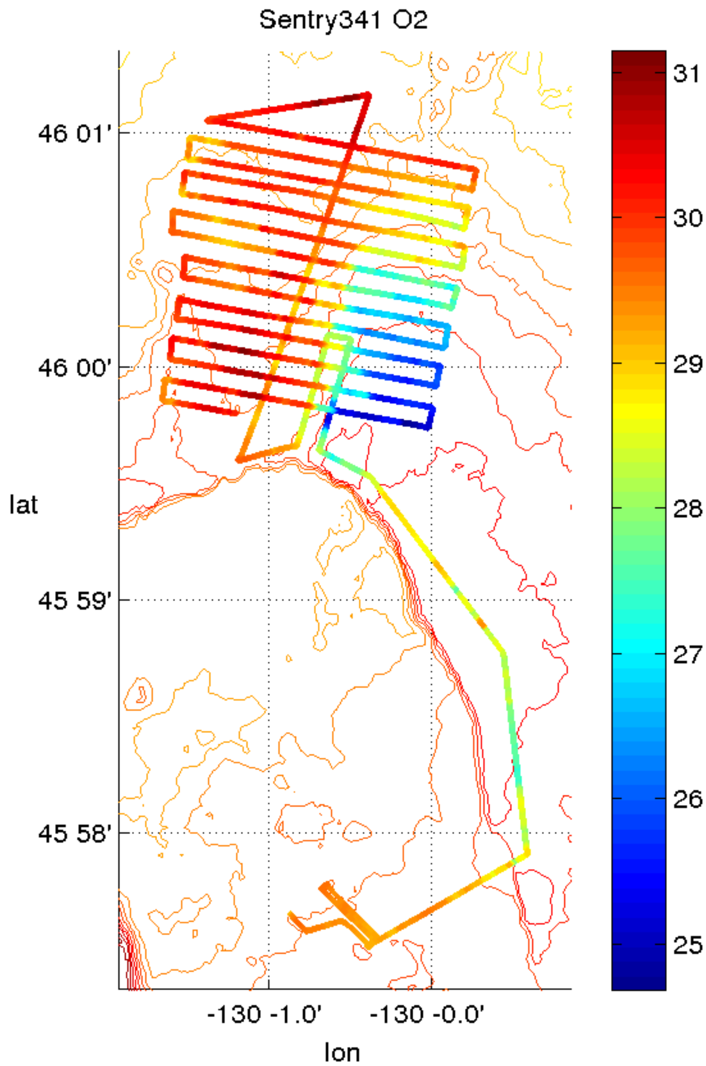


Figure 69: O2 Concentration on dive 341.

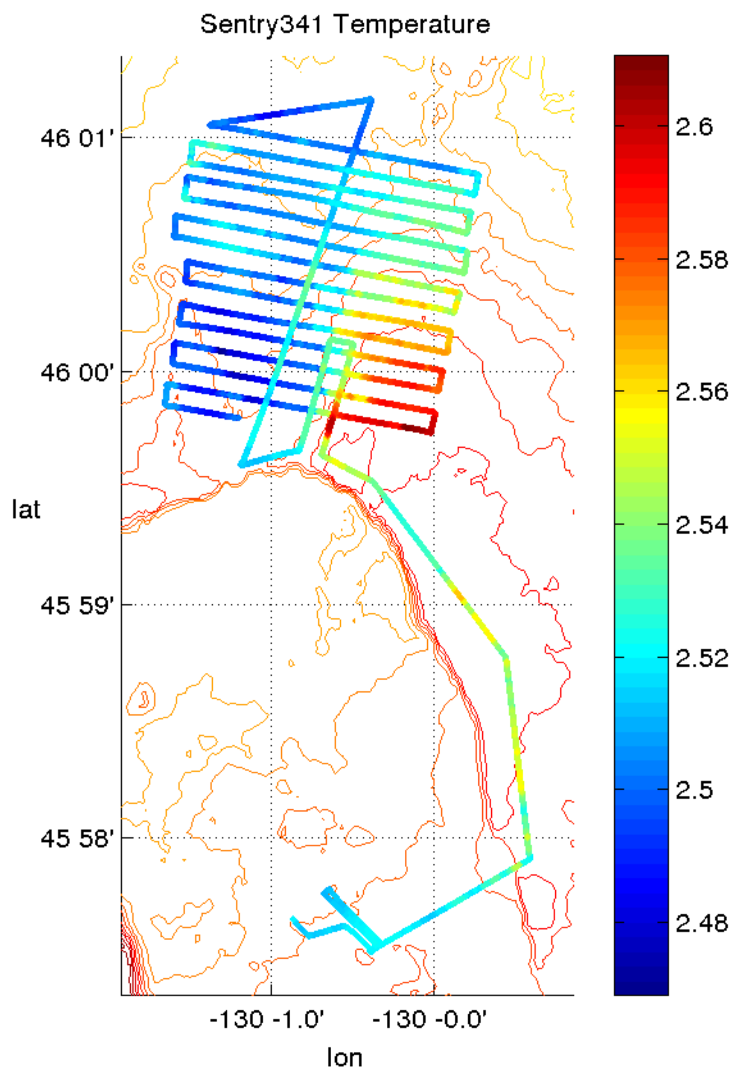


Figure 70: Seabird SBE49 temperature on dive 341.

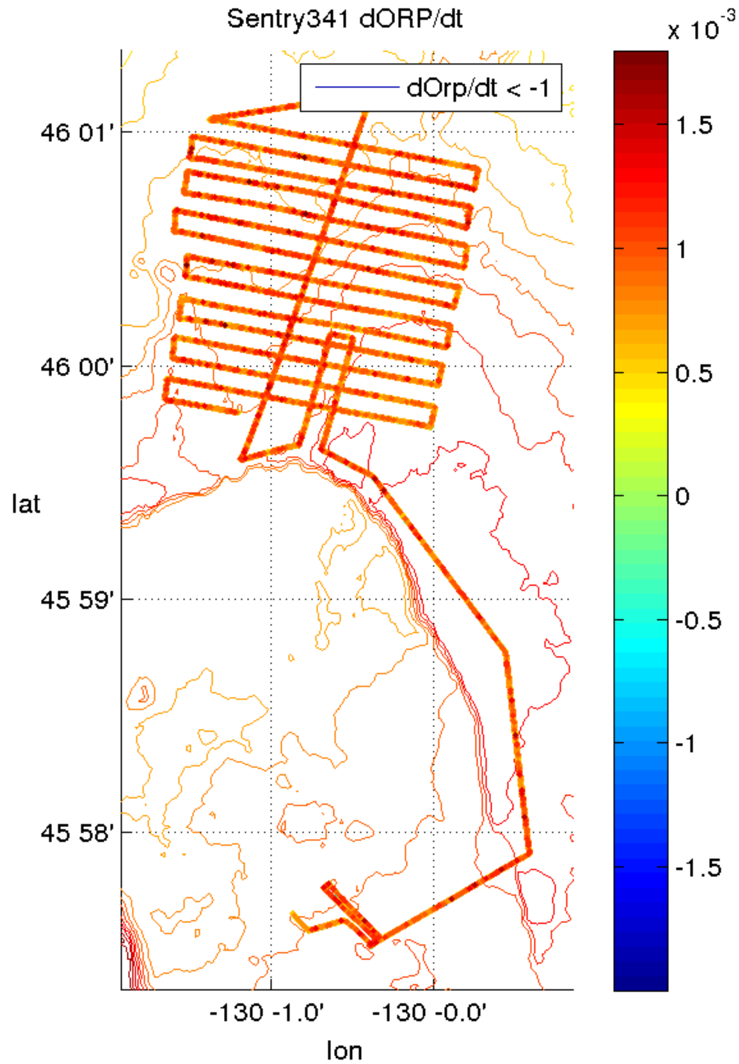


Figure 71: Redox potential (dORP/dt) on dive 341.

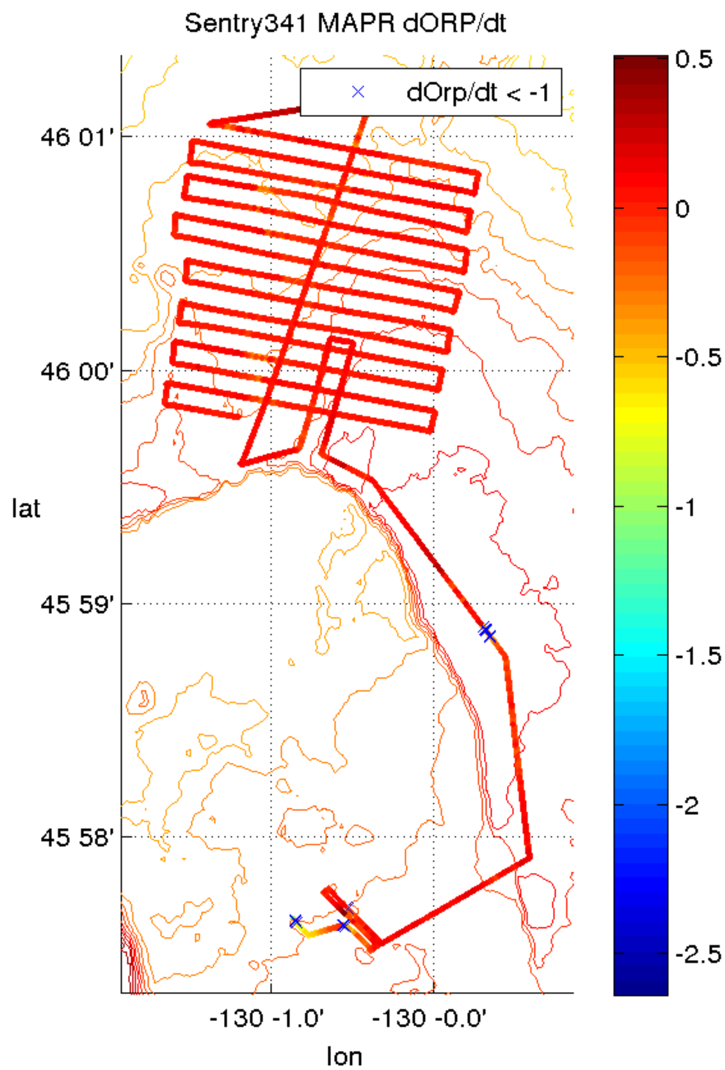


Figure 72: Redox potential from MAPR (dORP/dt) on dive 341.

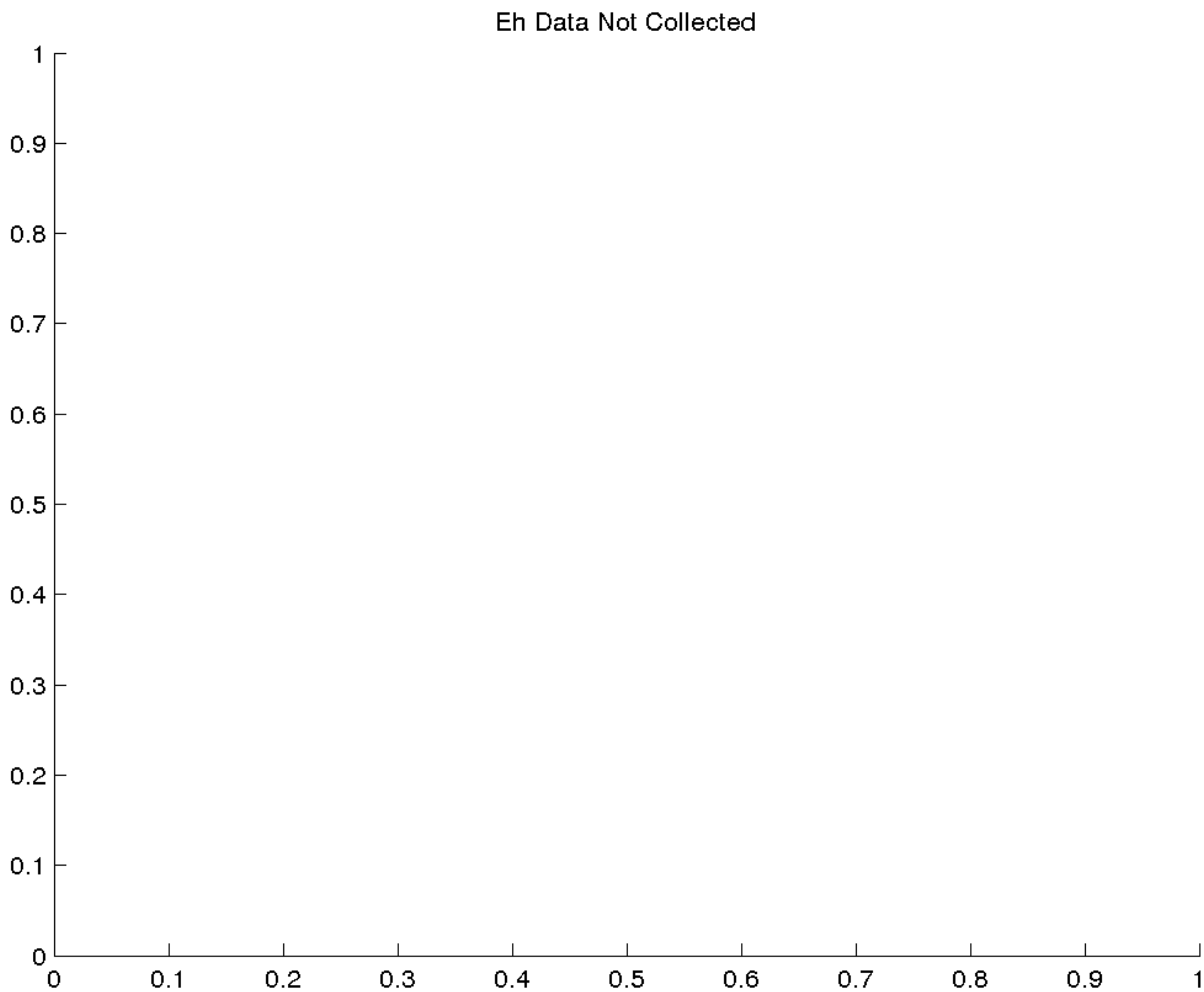


Figure 73: Redox potential (deh/dt) on dive 341.

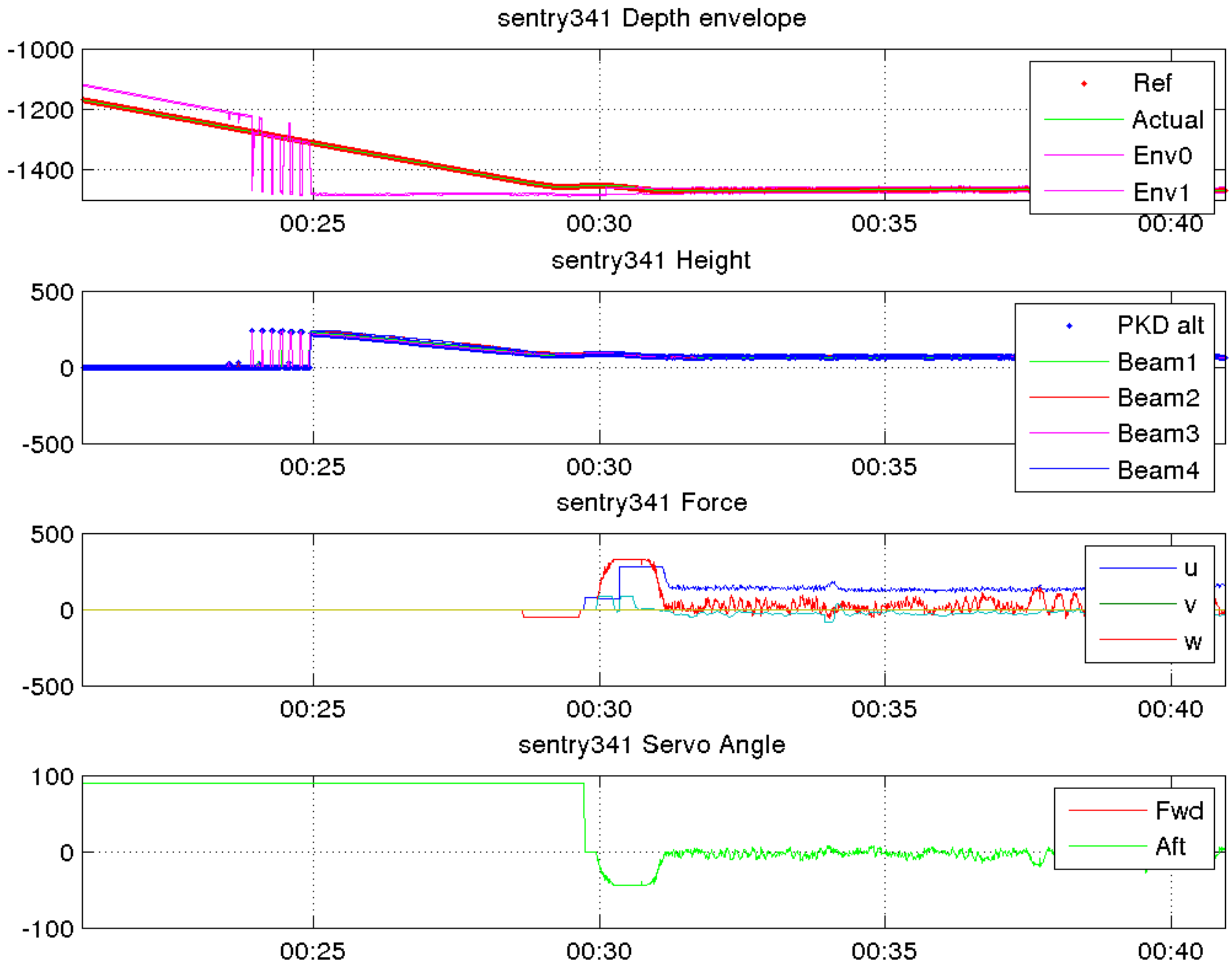


Figure 74: The bottom approach was nominal for dive 341.

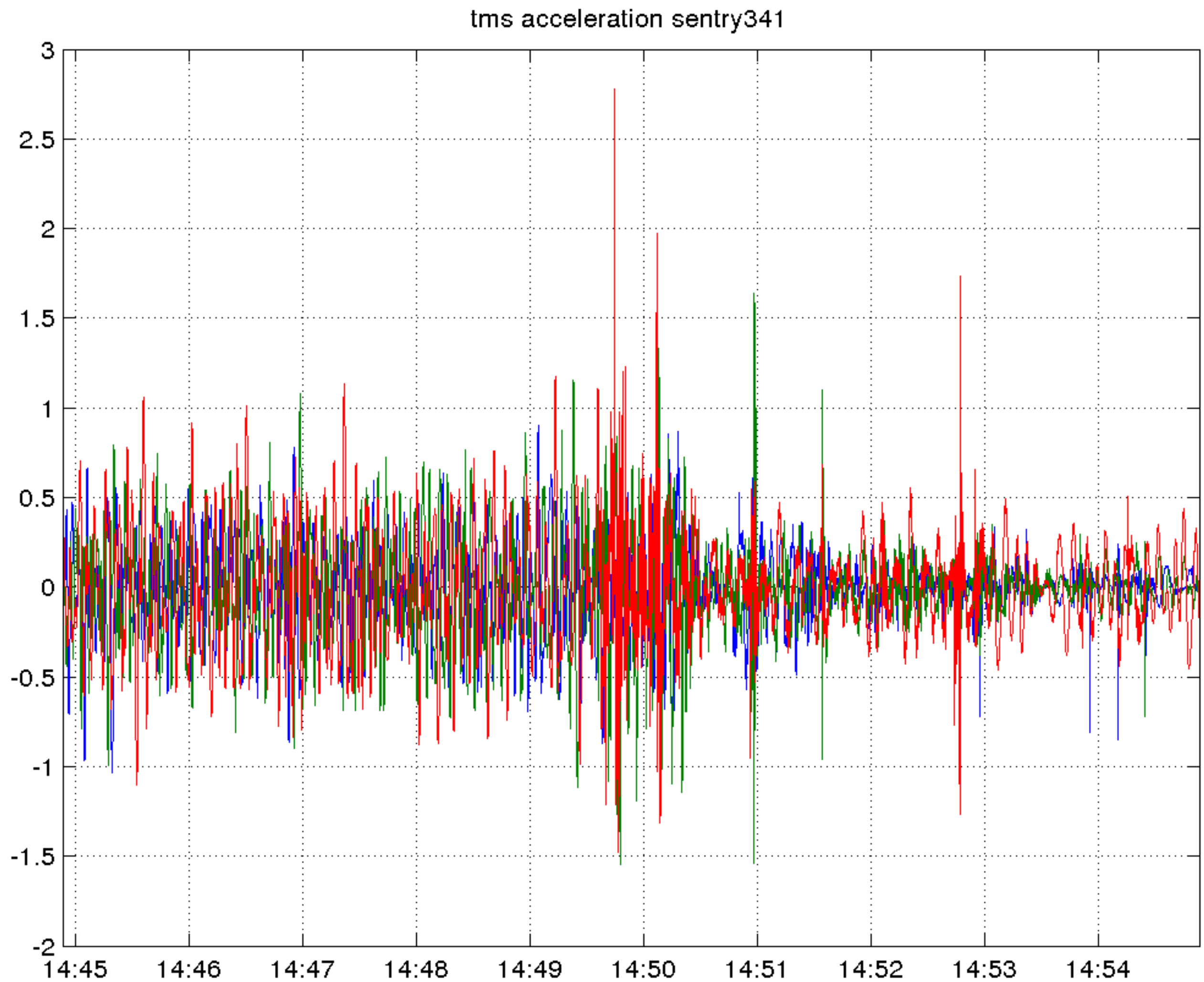


Figure 75: Accelerations on recovery were high on recovery for dive 341.

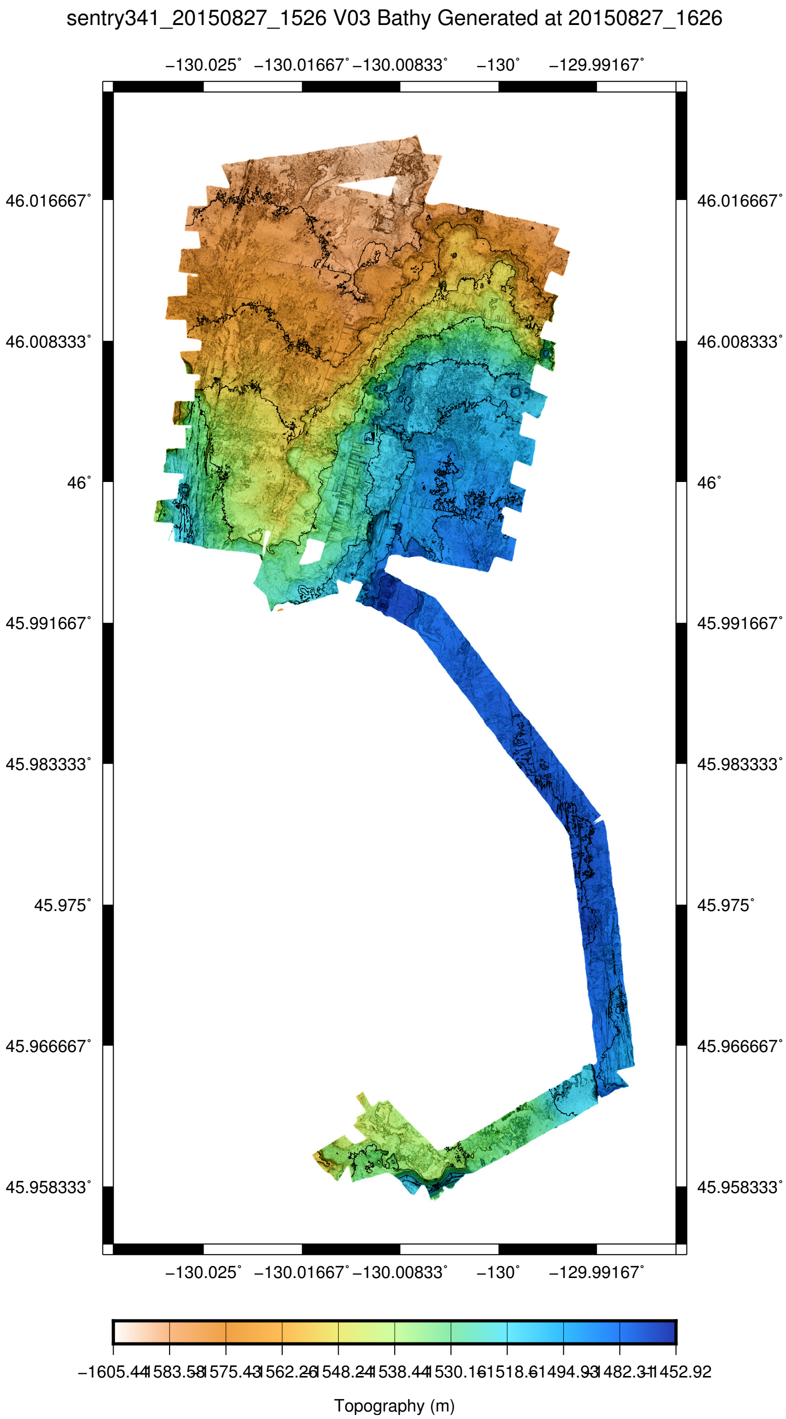


Figure 76: Preliminary multibeam bathymetry dive 341.

CASIUS Calibration Report

Vessel: **Device No:** **Date/Time:** 16 August 2015 03:32:30

Settings:

Initial Estimates for BoxIn	
Transceiver depth offset	0.000m
Transceiver depth	0.000m
Antenna starboard offset	-5.500m
Antenna forward offset	8.000m
Antenna height offset	29.500m

Error Estimates for BoxIn	
DGPS lags USBL	0.00s
Range measurement	0.2m
Range gate	1.0m
DGPS position	2.0m
Beacon position	30.0m
Beacon depth	5.0m
Sound velocity	15.0m/s
Transceiver depth	0.5m
Transceiver offset	1.0m

Transceiver & Beacon	
Transceiver Index	11
Beacon Name	ELV
Turn Around Time	320.0ms

Depth Aiding	
Boresight Angle Limit	22.0º
Depth Difference Limit	1.0m

Transceiver Attitude Calculation Inputs	
Angle Gate	2.0º
Known Heading Correction	n/a

Values Used During Data Collection	
Transceiver Pitch Correction	0.00º
Transceiver Roll Correction	0.00º
Transceiver Heading Correction	0.00º
Sound Velocity	1483.1m/s

Results:

Beacon BoxIn	Beacon Eastings	Beacon Northings	Beacon Depth	Sound Velocity	Transceiver Starboard Offset	Transceiver Forward Offset
Before	438702.80m	5124530.50m	2115.40m	1483.13m/s	0.00m	0.00m
Calculated	438647.95m	5124487.62m	2119.44m	1483.27m/s	-0.17m	-0.91m
Calculated Accuracy	0.08m	0.08m	0.36m	0.16m/s	0.06m	0.07m

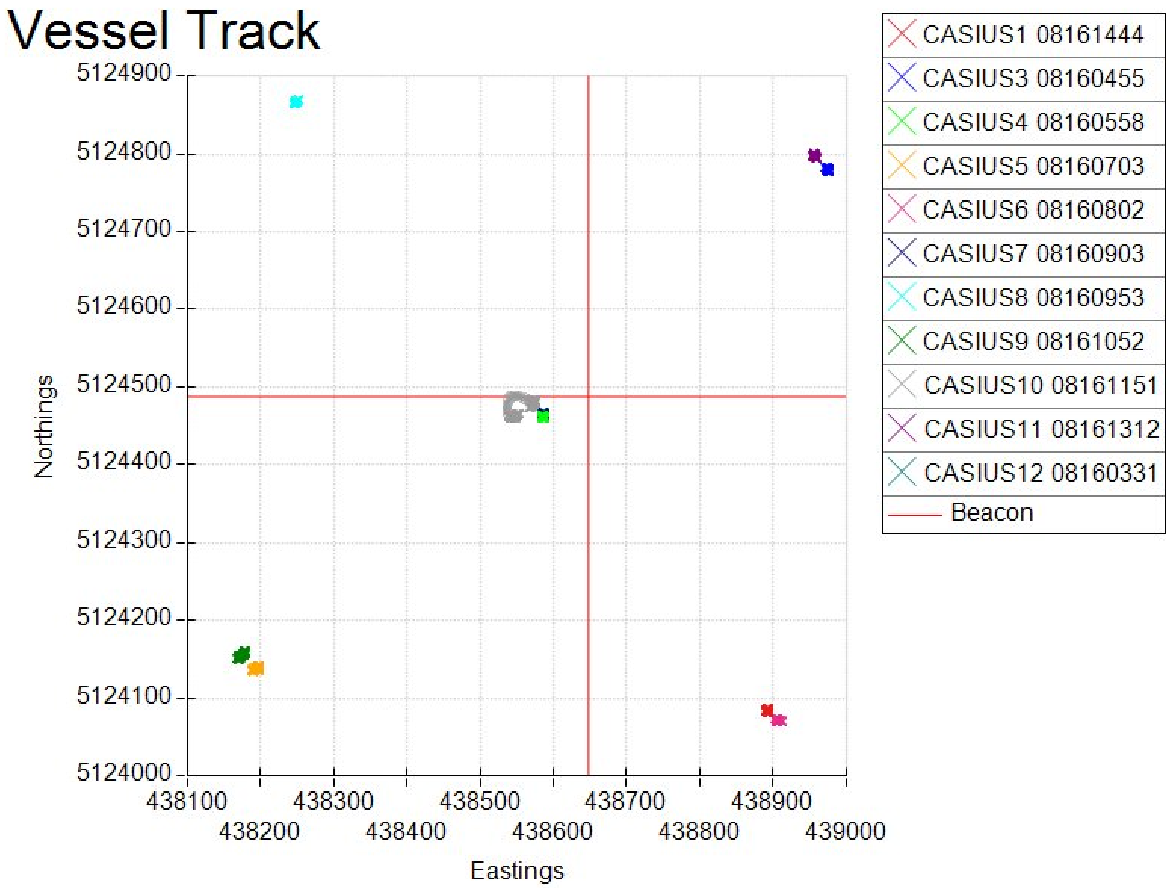
Transceiver Attitude	Pitch Correction	Roll Correction	Heading Correction
Before	0.00º	0.00º	0.00º
Calculated	**0.16º**	**1.87º**	**0.41º**
Calculated Accuracy	0.00º	0.00º	0.01º

Statistics:

	Before CASIUS (distance)	After CASIUS (distance)	Before CASIUS (% depth)	After CASIUS (% depth)
39.4% Beacon Positions (1 sigma)	66.7m	2.7m	3.15	0.13
50.0% Beacon Positions (CEP)	68.0m	3.3m	3.21	0.15
63.2% Beacon Positions (1 Drms)	69.3m	4.1m	3.27	0.19
86.5% Beacon Positions (2 sigma)	71.5m	7.0m	3.37	0.33
98.2% Beacon Positions (2 Drms)	75.6m	12.9m	3.57	0.61

General:

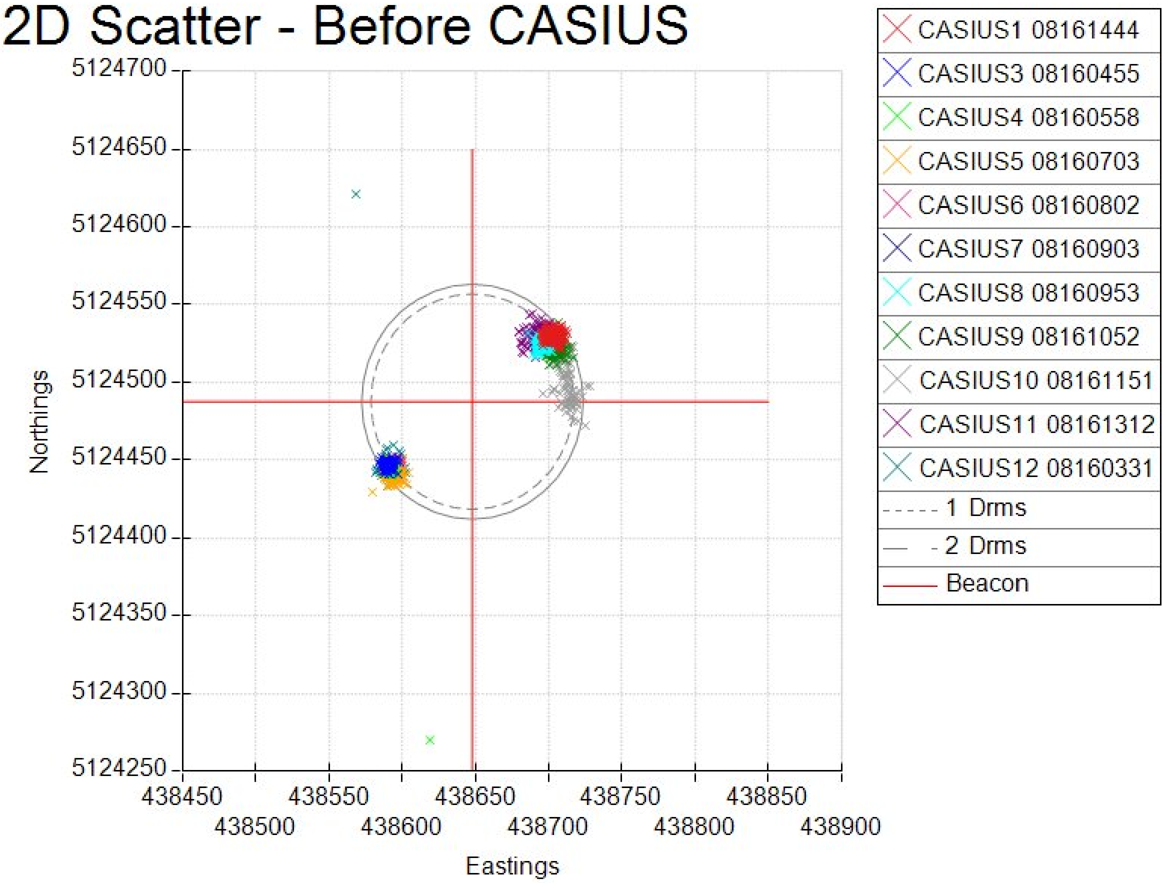
	Beacon BoxIn	Transceiver Attitude
Number of Iterations	4	3
Number of Fixes Used	2212	2212
Number Depth Aided		0
Average weighted residuals	0.015	0.351



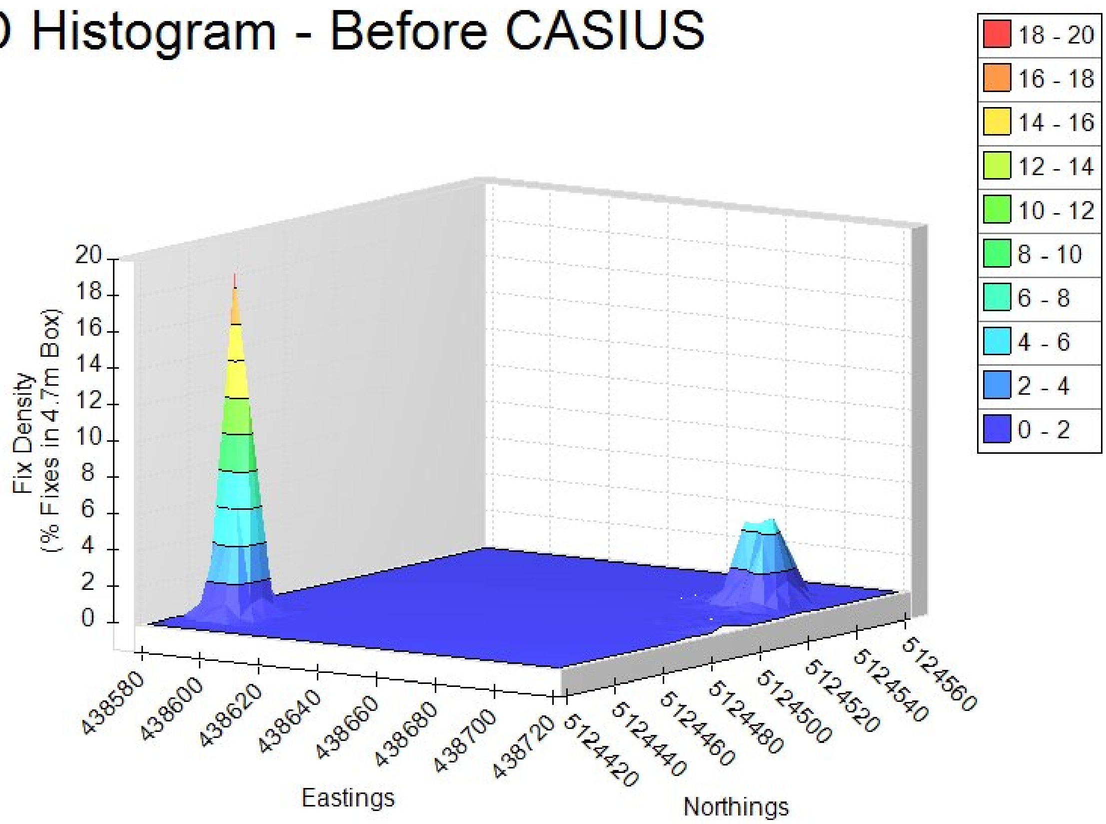
Data used:

Name	Filename	Start	End	#Acoustic	#Position
CASIUS1 08161444	C:\Ranger Files\CASIUS\2015-chadwick-tgt-final\CASIUS1 08161444.csv	16/08/2015 14:47:02	16/08/2015 15:10:23	201	1408
CASIUS3 08160455	C:\Ranger Files\CASIUS\2015-chadwick-tgt-final\CASIUS3 08160455.csv	16/08/2015 05:24:32	16/08/2015 05:58:39	206	2058
CASIUS4 08160558	C:\Ranger Files\CASIUS\2015-chadwick-tgt-final\CASIUS4 08160558.csv	16/08/2015 06:30:24	16/08/2015 07:03:52	202	2007
CASIUS5 08160703	C:\Ranger Files\CASIUS\2015-chadwick-tgt-final\CASIUS5 08160703.csv	16/08/2015 07:29:00	16/08/2015 08:02:25	201	2018
CASIUS6 08160802	C:\Ranger Files\CASIUS\2015-chadwick-tgt-final\CASIUS6 08160802.csv	16/08/2015 08:29:54	16/08/2015 09:03:39	203	2035
CASIUS7 08160903	C:\Ranger Files\CASIUS\2015-chadwick-tgt-final\CASIUS7 08160903.csv	16/08/2015 09:20:02	16/08/2015 09:53:18	201	2002
CASIUS8 08160953	C:\Ranger Files\CASIUS\2015-chadwick-tgt-final\CASIUS8 08160953.csv	16/08/2015 10:19:13	16/08/2015 10:52:51	203	2025
CASIUS9 08161052	C:\Ranger Files\CASIUS\2015-chadwick-tgt-final\CASIUS9 08161052.csv	16/08/2015 11:28:16	16/08/2015 11:51:48	202	1418
CASIUS10 08161151	C:\Ranger Files\CASIUS\2015-chadwick-tgt-final\CASIUS10 08161151.csv	16/08/2015 12:49:17	16/08/2015 13:12:43	201	1412
CASIUS11 08161312	C:\Ranger Files\CASIUS\2015-chadwick-tgt-final\CASIUS11 08161312.csv	16/08/2015 13:47:01	16/08/2015 14:10:14	200	1400
CASIUS12 08160331	C:\Ranger Files\CASIUS\2015-chadwick-tgt-final\CASIUS12 08160331.csv	16/08/2015 03:32:30	16/08/2015 04:06:16	203	2035

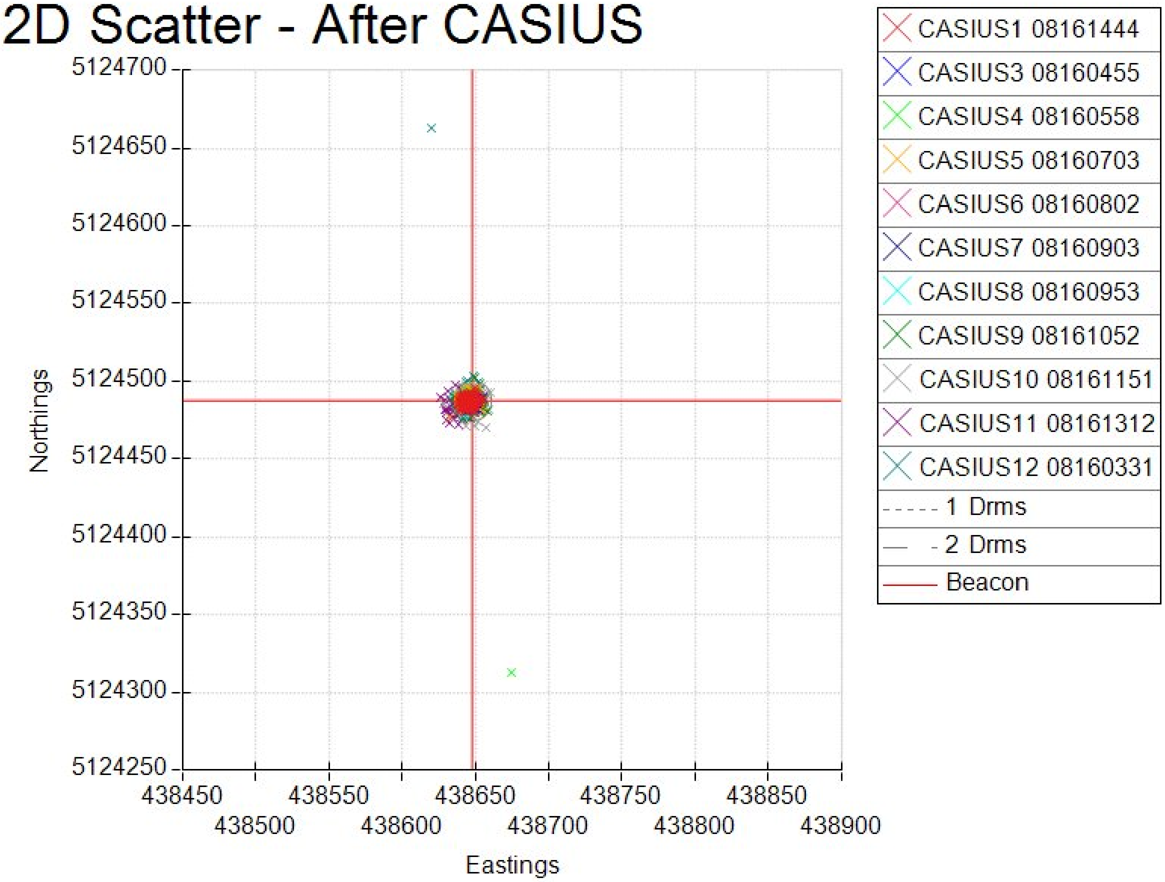
2D Scatter - Before CASIUS



3D Histogram - Before CASIUS



2D Scatter - After CASIUS



3D Histogram - After CASIUS