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Sentry Operations Report for the PC1705 Demopoulos Cruise DRAFT

WHOI Sentry Operations Group
Sean Kelley, Andy Billings, Mike Jakuba, Ian Vaughn, Jennifer Vaccaro

Sentry Expedition Leader: Sean Kelley

Chief Scientist/PI: Amanda Demopoulos, United States Geological Survey (USGS).

NOAA Ship Pisces — Sept 12, 2017 to September 25th, 2017

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1 Summary

This document summarizes operations with the *Sentry* autonomous underwater vehicle (AUV) during the PC1705 Demopoulos 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 454 - 456 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.

12 Sep 2017 Departure from Norfolk VA, for kitty hawk site.

13 Sep 2017 Launch sentry454 in the morning for multibeam and camera surveys at kitty hawk.

14 Sep 2017 Recovery sentry454 09:00. Launch sentry455 18:30 local

15 Sep 2017 Recover Sentry455 15:00 local. Transit to Morehead City at 18:00 to avoid weather from hurricane Jose.

16 to 19 Sep 2017 Tied up in Morehead City, NC.

19 Sep 2017 Depart Morehead City for Stetson Bank dive site.

20 Sep 2017 Deploy Sentry456 at Stetson Bank.

21 Sep 2017 Recover sentry456, transit to Norfolk, VA. to avoid weather from hurricane Maria

22 Sep 2017 Arrival into Norfolk, VA.

23 -24 Sep 2017 Demobilization

25 Sep 2017 Sentry Offload from Pisces

3 Vehicle Configuration

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

Table 1: Sentry Sensor Configuration

Sensor
APS 1540 Magnetometers (3)
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)
Digital Still Camera
Blue View P900-90 Forward Looking Sonar
IXEA PHINS
Reson Sound Velocity Probe
Dual Cs Magneteometer
NOAA PMEL ORP Sensor
SBE27 Ph Sensor

4 Navigation

All dives were navigated using real time 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.

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 on the previous cruise. A copy of the USBL calibration report is included in this report.

5 Items of Note

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

6 Ship Specific Information

This section summarizes ship specific information factual, good, and bad and is meant primarily to facilitate more effective use of the same vessel in the future.

S.1: Sentry's Ranger2 USBL system was installed on the Pisces' centerboard using a custom-built cable. This system is critical for the high current operation areas.

S.2: Sentry Group provided spectra for the stbd side crane for Sentry launch and recoveries.

7 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: The SBE27 Ph probe appears to be out of calibration. While data from the probe looks viable, the calibration curve from the manufacture does not match expected values. Sensor needs to be sent back to manufacture for calibration and dive data needs to be re-run with this new calibration.

8 Sentry Operations Team

The *Sentry* team was comprised of 5 members on this cruise — Sean Kelley, Andy Billings, Mike Jakuba, Ian Vaughn, Jennifer Vaccaro. Sean Kelley was the Expedition Leader and the principal author of this report.

9 Acknowledgments

1. Thank you to NOAA OER for funding this expedition.

2. Thank you to the crew of NOAA Ship Pisces for safe operations and support.

10 Comments from Science

Sentry 454 Dive Report
DRAFT

WHOI Sentry Operations Group
Sean Kelley, Andy Billings, Mike Jakuba, Ian Vaughn, Jennifer Vaccaro

Sentry Expedition Leader: Sean Kelley

Chief Scientist/PI: Amanda Demopoulos, United States Geological Survey (USGS).

Summary

Weather: Weather was ideal for launch, wind 5knots with minimal swell.

Reason for end of dive: The dive was ended in order to get back on deck and have enough charge time for a dinner time launch.

Vehicle Configuration

The science sensing suite for this dive was:

Table 2: Sentry Sensor Configuration

Sensor
APS 1540 Magnetometers (3)
Edgetech 120kHz/410kHz Sidescan sonar
Reson 7125 Multibeam Sonar
Seabird SBE49 CTD
Seapoint OBS
Anderaa optode model 4330
300kHz RDI DVL
Digital Still Camera
Blue View P900-90 Forward Looking Sonar
IXEA PHINS
Reson Sound Velocity Probe
NOAA PMEL ORP Sensor
SBE27 Ph Sensor

This dive was navigated using the DVL/INS system in real time. USBL provided post-dive corrections.

Important Positions

Dive Origin: 35 50 -74 -50

Launch Position: sentry454 launch position: 35 56.343'N 074 48.559'W

Narrative

Sentry454 was the first dive of the cruise at the kitty hawk dive site. This is a shallow site ranging from 200m depth down to 500m depth. The dive targeted two main areas, capturing multibeam with water column data and photo surveys at both areas. The dive began at the northern survey, capturing a large multibeam block 1500m by 1200m. The multibeam survey went well, and without any issues. Following the multibeam survey was two camera surveys at 5m altitude. The first camera survey was in the north western section of the multibeam survey capturing an area of 200m by 200m with 5m grid spacing. The final camera survey at the northern target was a larger camera survey 550m by 260m with 7 meter spacing. Due to difficult terrain, the camera survey took longer than usual, and the south eastern section of the camera survey was cancelled to ensure time at the 2nd camera survey area.

The lower survey area was smaller and constricted by time. The multibeam survey completed without issue covering 500m by 450m square. Following the multibeam was a final camera survey which only completed 4 survey lines due to time.

Data from the dive looked good and no issues were reported or appeared throughout the dive. Vessel operations for both launch and recovery went smoothly.

Chief Scientist Comments

None.

Dive Statistics

0.1 sentry454 Summary

sentry454 Summary
Origin: 35.833333 -74.833333
Origin: 35 50.000'N 074 50.000'W
Launch: 2017/09/13 11:46:39
Survey start: 2017/09/13 11:51:22
Survey start: Lat:35.939257 Lon:-74.810544
Survey start: Lat:35 56.355'N Lon:074 48.633'W
Survey end: 2017/09/14 12:33:60
Survey end: Lat:35.906095 Lon:-74.812546
Survey end: Lat:35 54.366'N Lon:074 48.753'W
Ascent begins: 2017/09/14 12:33:60
On the surface: 2017/09/14 12:44:49
On deck: 2017/09/14 12:56:03
descent rate: 35.2 m/min
ascent rate: 48.1 m/min
survey time: 24.7 hours
deck-to-deck time 25.2 hours
Min survey depth: 130m
Max survey depth: 560m
Mean survey depth: 331m
Mean survey height: 23m
distance travelled: 57.01km
average speed; 0.64m/s
average speed during photo runs: 0.52 m/s over 31.25 km
average speed during multibeam runs: 0.92 m/s over 25.76 km
total vertical during survey: 9519m
Battery energy at launch: 19.8 kwhr
Battery energy at survey end: 2.7 kwhr
Battery energy on deck: 2.6 kwhr

Sensor Information

This is a recently added section with selected sensor metadata. This section will be expanded in coming months. Additional data is available in the sentry454/nav-sci/proc directory within the sentry454_config matlab structure as well as in ascii text logs in sentry454/metadata. At present metadata is not yet automatically collected on all sensors.

0.2 sentry454 Devices

Instrument	Model	Serial Num.	Comments	Config File
USBL	Sonardyne AvTrak2	U001A91		avtrak_20170913_0902.cfg
DVL	RDI Navigator (300kHz)	727-2000-00M	CX: 1, WP: 0	dvl300_20170913_0907.cfg
CTD	SBE 49	222		sbe49_20170913_0908.cfg
SAIL	obs A/D	13	A: 5, G: 1.00, O: 0	a2d2-pods_20170913_0925.cfg
	orp A/D	9	A: 3, G: 1.00, O: 0.002	
	sbe27 A/D	10	A: 2, G: 1.00, O: 0.0009	

Plots and Images

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

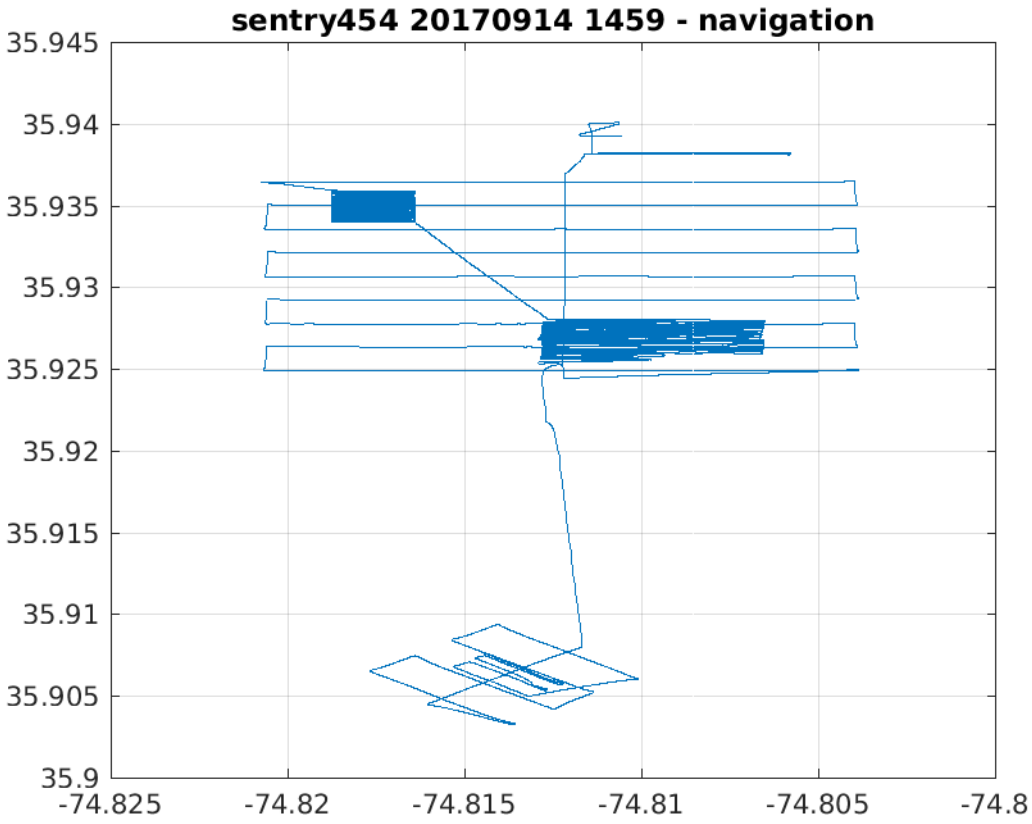


Figure 1: Latitude/Longitude plot of Sentry dive 454 based on post-processed navigation.

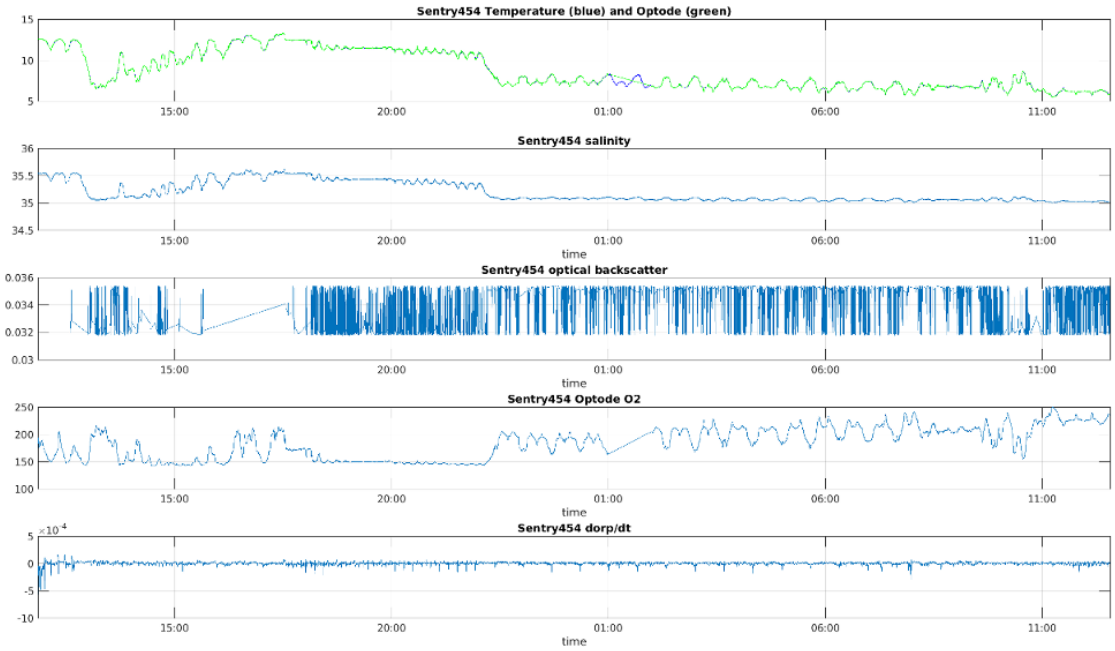


Figure 2: Time series plot of five of the basic sensors on Sentry, from top to bottom, temperature, salinity, optical backscatter, dissolved Oxygen, and ORP.

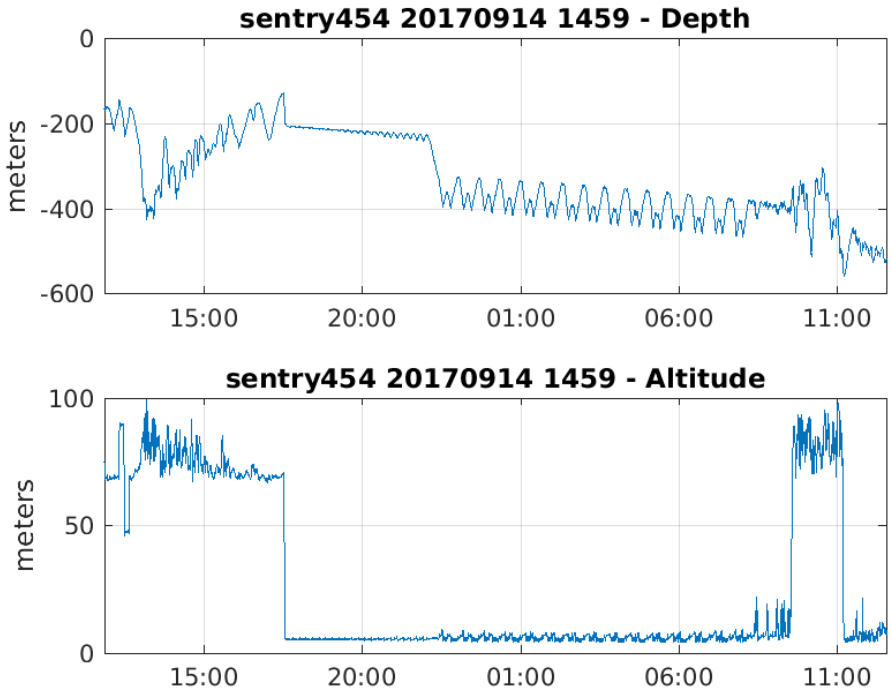


Figure 3: Depth and Altitude of Sentry during dive 454.

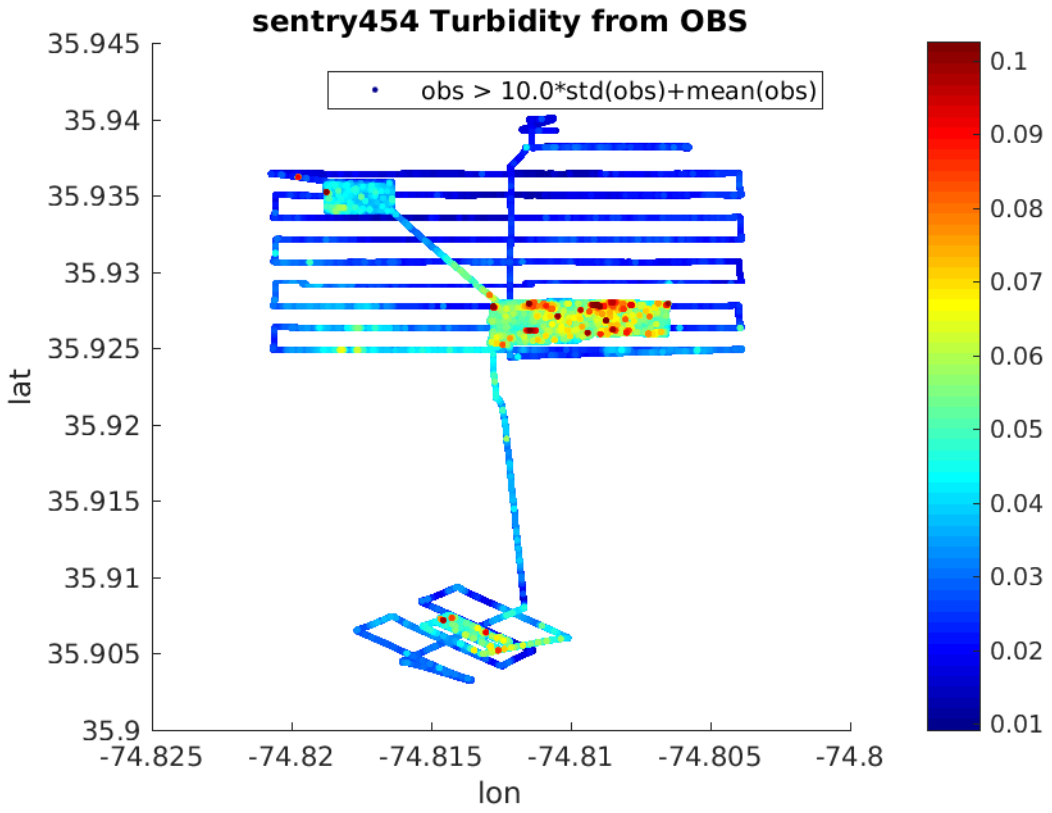


Figure 4: Optical backscatter on dive 454.

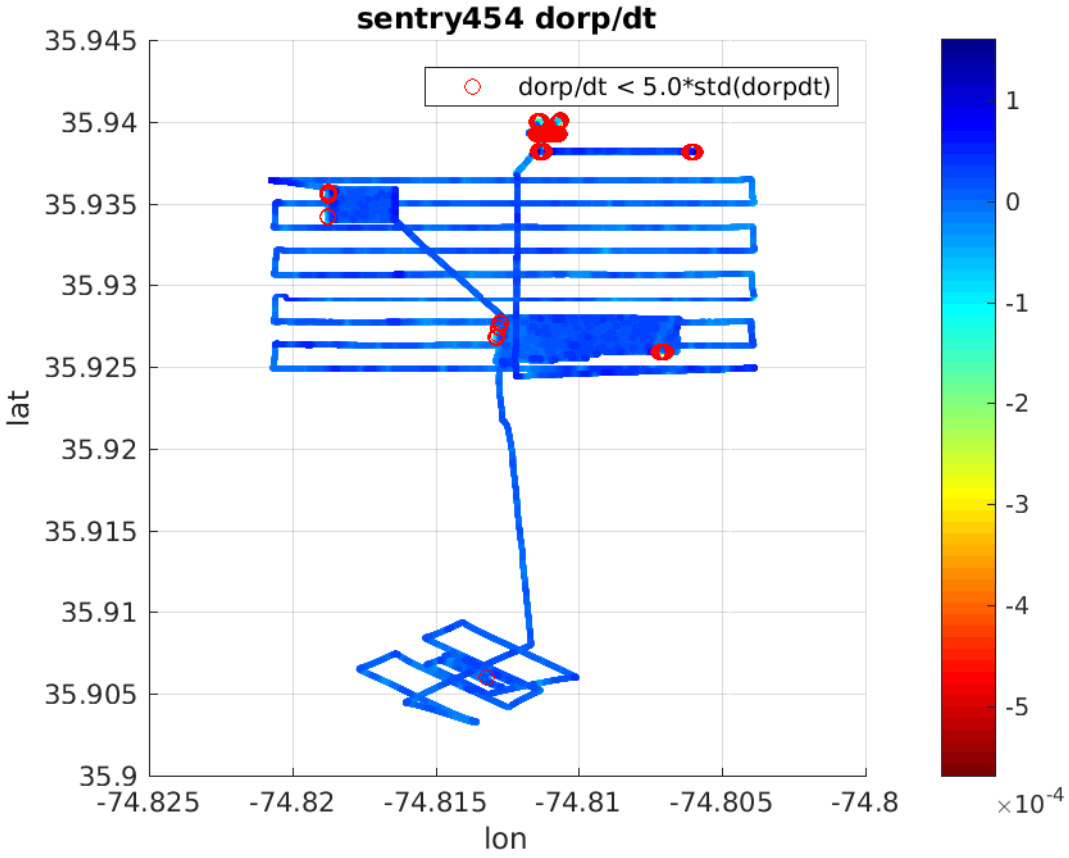


Figure 5: ORP sensor data during dive 454.

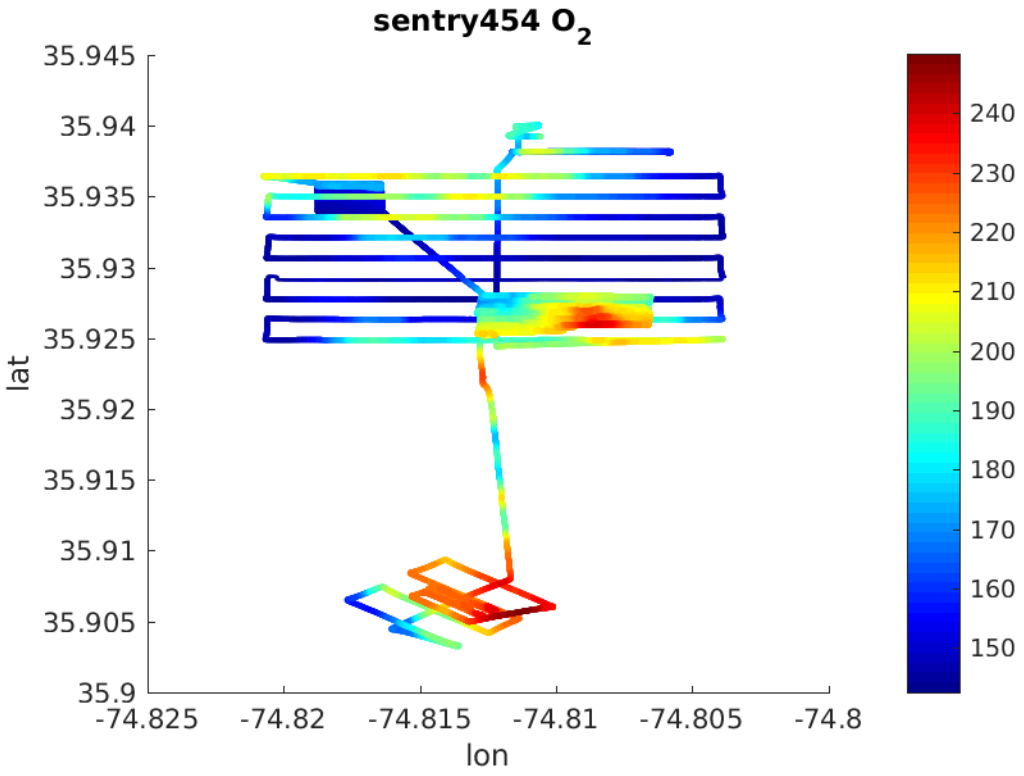


Figure 6: O2 sensor data during dive 454.

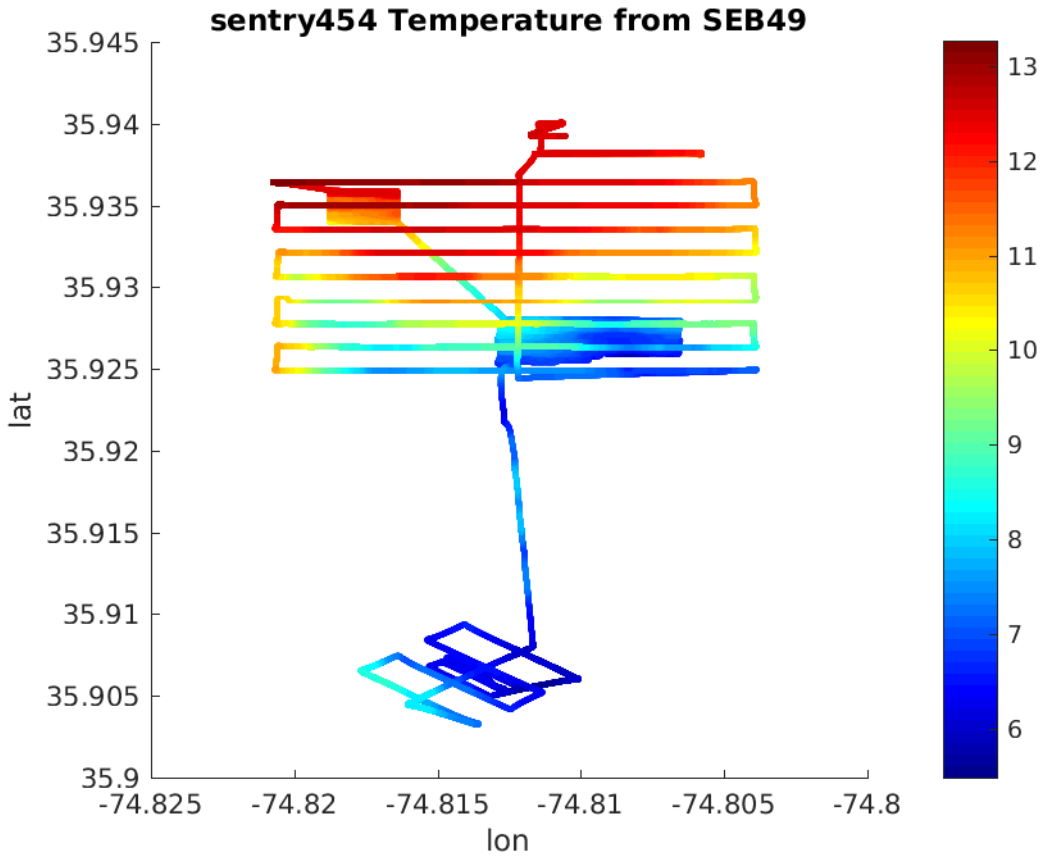


Figure 7: Temperature sensor data during dive 454.

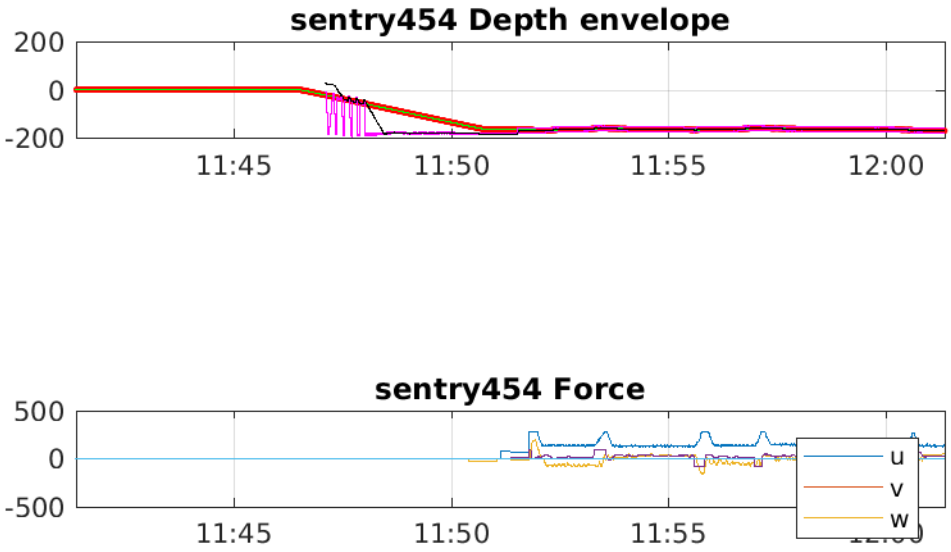


Figure 8: Bottom Approach for during dive 454.

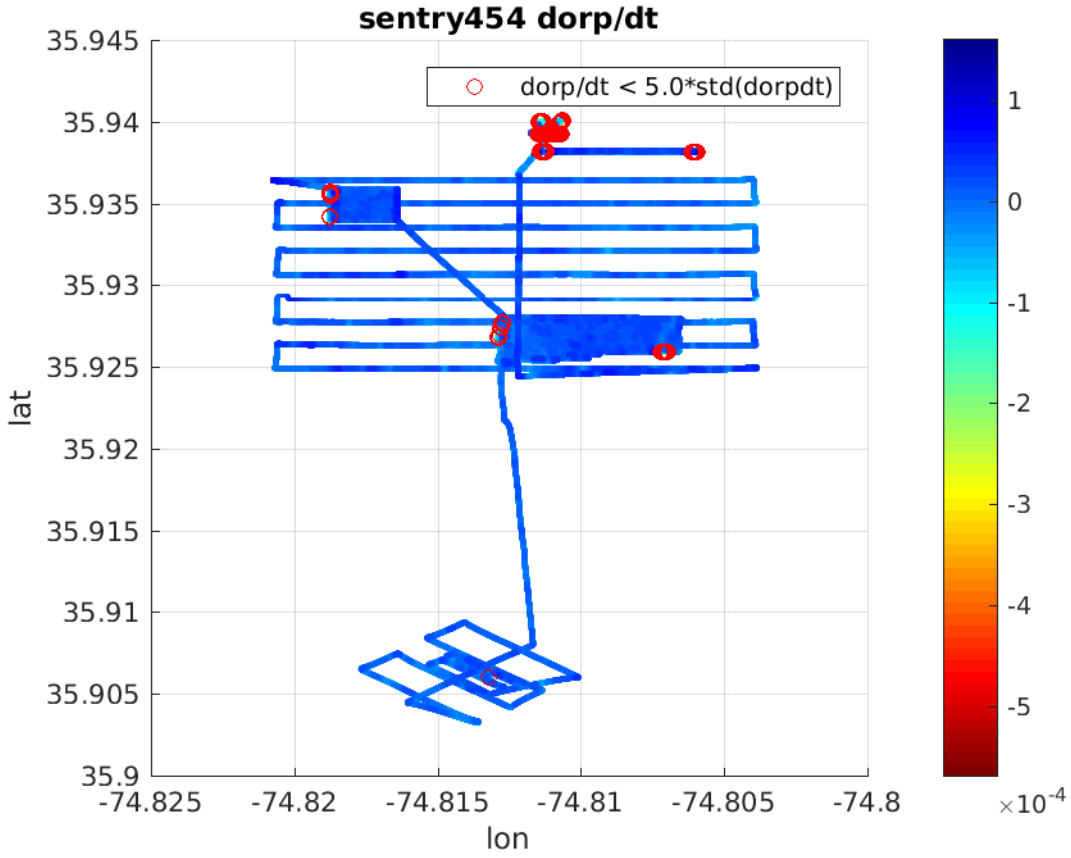


Figure 9: MAPR orp data during dive 454.

Sentry 455 Dive Report
DRAFT

WHOI Sentry Operations Group
Sean Kelley, Andy Billings, Mike Jakuba, Ian Vaughn, Jennifer Vaccaro

Sentry Expedition Leader: Sean Kelley

Chief Scientist/PI: Amanda Demopoulos, United States Geological Survey (USGS).

Summary

Weather: winds were light with seas less than 1 foot.

Reason for end of dive: The dive was ended in order to leave station due to on coming weather.

Vehicle Configuration

The science sensing suite for this dive was:

This dive was navigated using the DVL/INS system in real time. USBL provided post-dive corrections.

Table 3: Sentry Sensor Configuration

Sensor
APS 1540 Magnetometers (3)
Edgetech 120kHz/410kHz Sidescan sonar
Reson 7125 Multibeam Sonar
Seabird SBE49 CTD
Seapoint OBS
Anderaa optode model 4330
300kHz RDI DVL
Digital Still Camera
Blue View P900-90 Forward Looking Sonar
IXEA PHINS
Reson Sound Velocity Probe
NOAA PMEL ORP Sensor
SBE27 Ph Sensor

Important Positions

Dive Origin: 35 40 -74 -50

Launch Position: sentry455 launch position: 35 41.763'N 074 48.858'W

Narrative

Sentry455 was the second dive of the cruise at the Pea island B dive site. Similar to the previous dive, sentry455 planned to capture both multibeam and photos at various known targets from ships multibeam data. The first survey of the dive, started at the northern targets, capturing multibeam with water column data. Two camera surveys followed the multibeam, covering targets in the north western and south eastern section of the multibeam. There were no issues from either survey, all systems worked well.

Following the northern survey was another multibeam and camera survey 2500 meters south of the first survey. This survey was much smaller at 500m by 300m rectangle block. This second survey went well, and completed the mission.

Issues

- Optode failed to work. Cause unkown, no optode data for this dive. Additional check has been added to the sentry pre-dive to check this sensor before launch.

Chief Scientist Comments

The Chief scientist is requested to include any desired comments.

Dive Statistics

0.3 sentry455 Summary

sentry455 Summary
Origin: 35.666667 -74.833333
Origin: 35 40.000'N 074 50.000'W
Launch: 2017/09/14 22:36:27
Survey start: 2017/09/14 22:43:09
Survey start: Lat:35.698050 Lon:-74.810147
Survey start: Lat:35 41.883'N Lon:074 48.609'W
Survey end: 2017/09/15 18:24:46
Survey end: Lat:35.673493 Lon:-74.793686
Survey end: Lat:35 40.410'N Lon:074 47.621'W
Ascent begins: 2017/09/15 18:24:46
On the surface: 2017/09/15 18:31:38
On deck: 2017/09/15 18:42:33
descent rate: 32.6 m/min
ascent rate: 48.0 m/min
survey time: 19.7 hours
deck-to-deck time 20.1 hours
Min survey depth: 168m
Max survey depth: 574m
Mean survey depth: 414m
Mean survey height: 20m
distance travelled: 43.45km
average speed; 0.61m/s
average speed during photo runs: 0.52 m/s over 26.63 km
average speed during multibeam runs: 0.92 m/s over 16.82 km
total vertical during survey: 9008m
Battery energy at launch: 18.2 kwhr
Battery energy at survey end: 4.6 kwhr
Battery energy on deck: 4.5 kwhr

Sensor Information

This is a recently added section with selected sensor metadata. This section will be expanded in coming months. Additional data is available in the sentry455/nav-sci/proc directory within the sentry455_config matlab structure as well as in ascii text logs in sentry455/metadata. At present metadata is not yet automatically collected on all sensors.

0.4 sentry455 Devices

Instrument	Model	Serial Num.	Comments	Config File
USBL	Sonardyne AvTrak2	U001A91		avtrak_20170914_2115.cfg
DVL	RDI Navigator (300kHz)	727-2000-00M	CX: 1, WP: 0	dvl300_20170914_2116.cfg
CTD	SBE 49	222		sbe49_20170914_2116.cfg
SAIL	obs A/D	13	A: 5, G: 1.00, O: 0	a2d2-pods_20170914_2116.cfg
	orp A/D	9	A: 3, G: 1.00, O: 0.002	
	sbe27 A/D	10	A: 2, G: 1.00, O: 0.0009	

Plots and Images

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

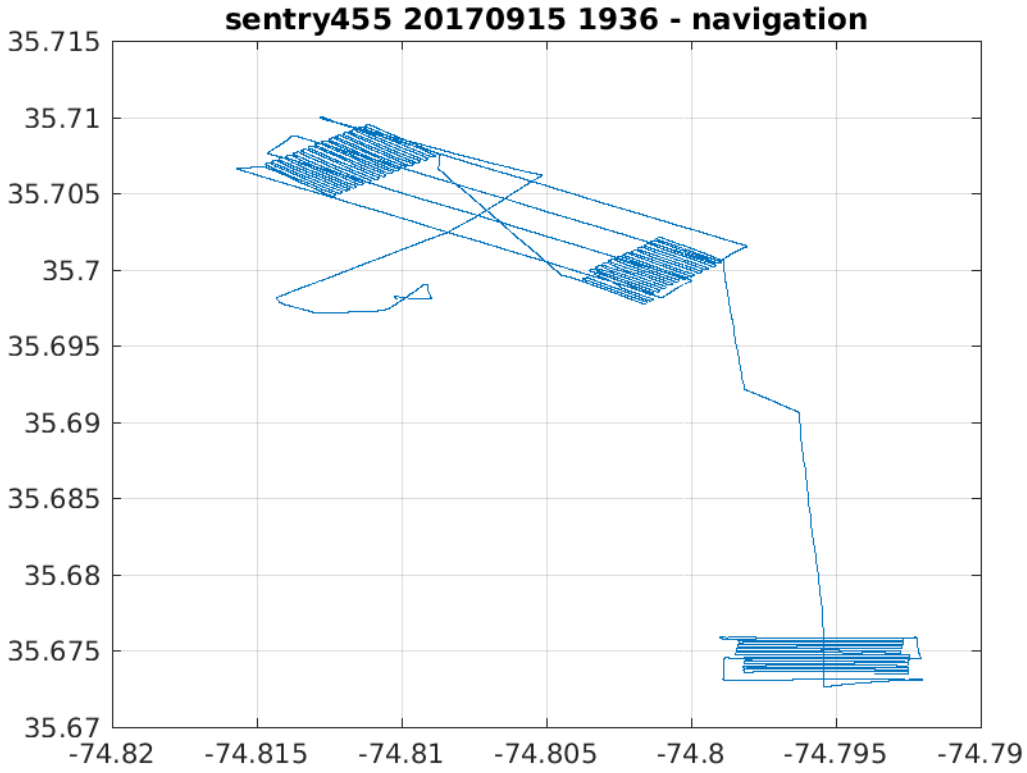


Figure 10: Latitude/Longitude plot of Sentry dive 455 based on post-processed navigation.

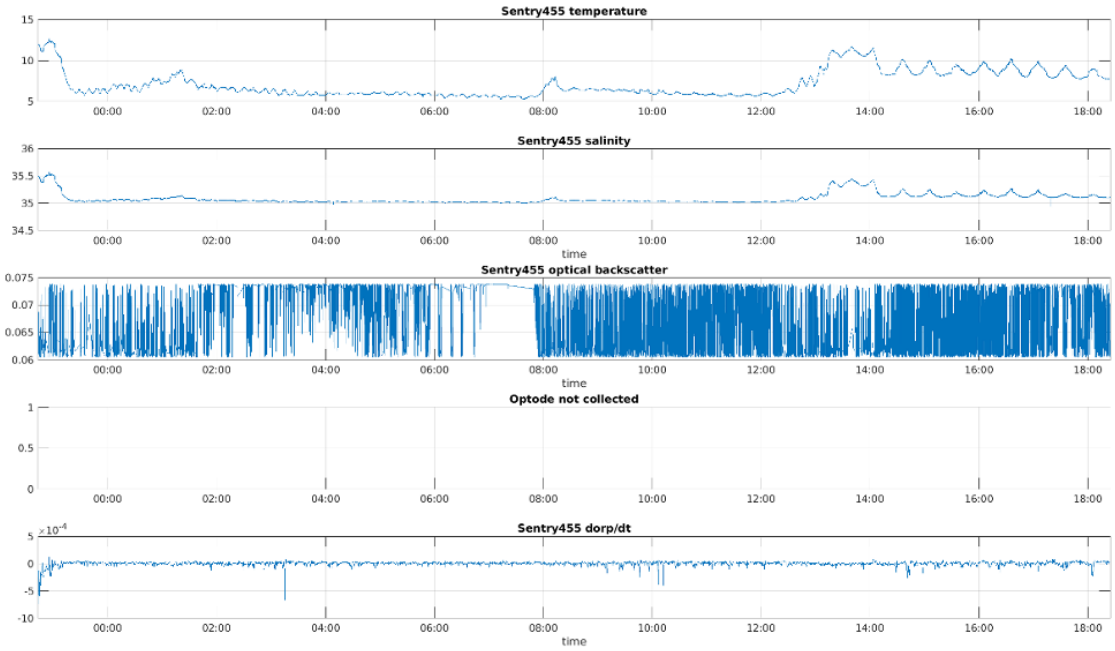


Figure 11: Time series plot of five of the basic sensors on Sentry, from top to bottom, temperature, salinity, optical backscatter, dissolved Oxygen, and ORP.

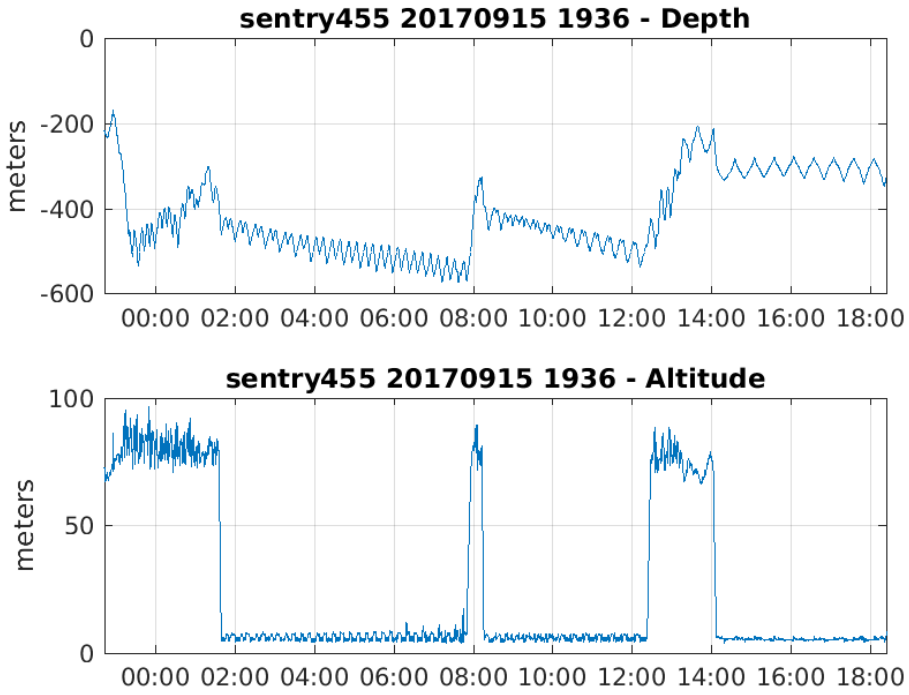


Figure 12: Depth and Altitude of Sentry during dive 455.

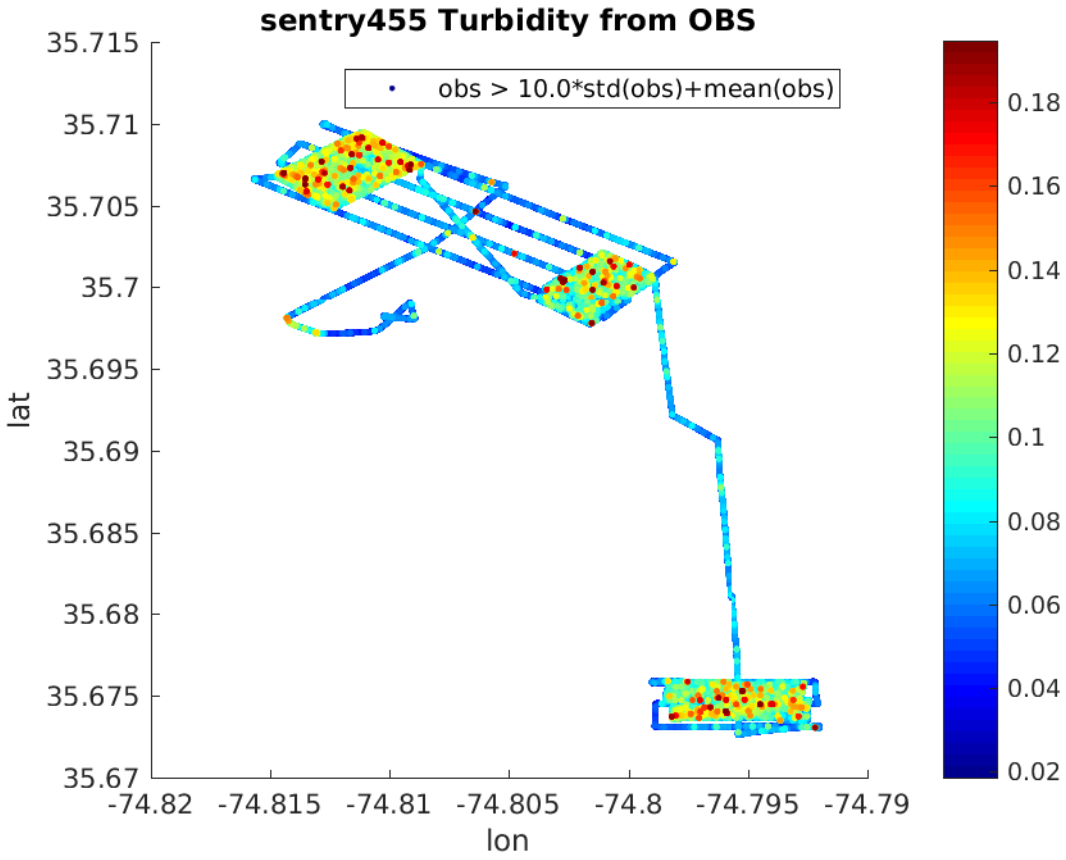


Figure 13: Optical backscatter on dive 455.

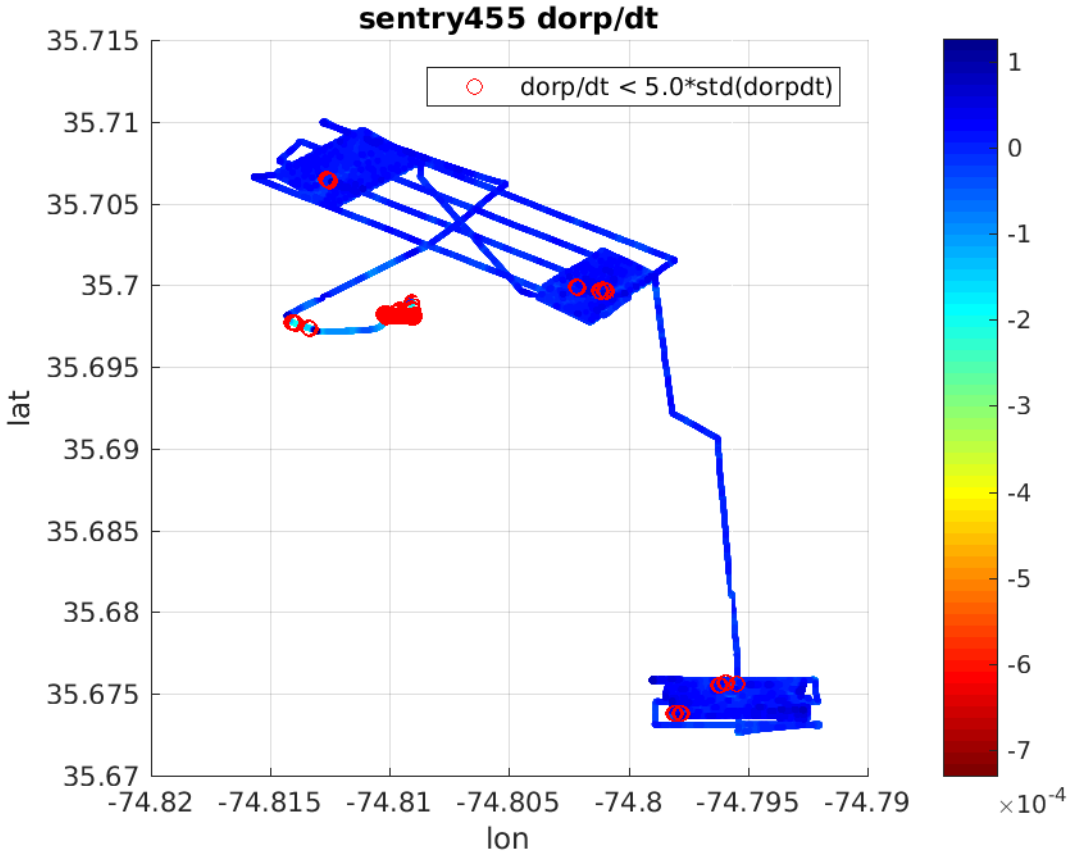


Figure 14: ORP sensor data during dive 455.

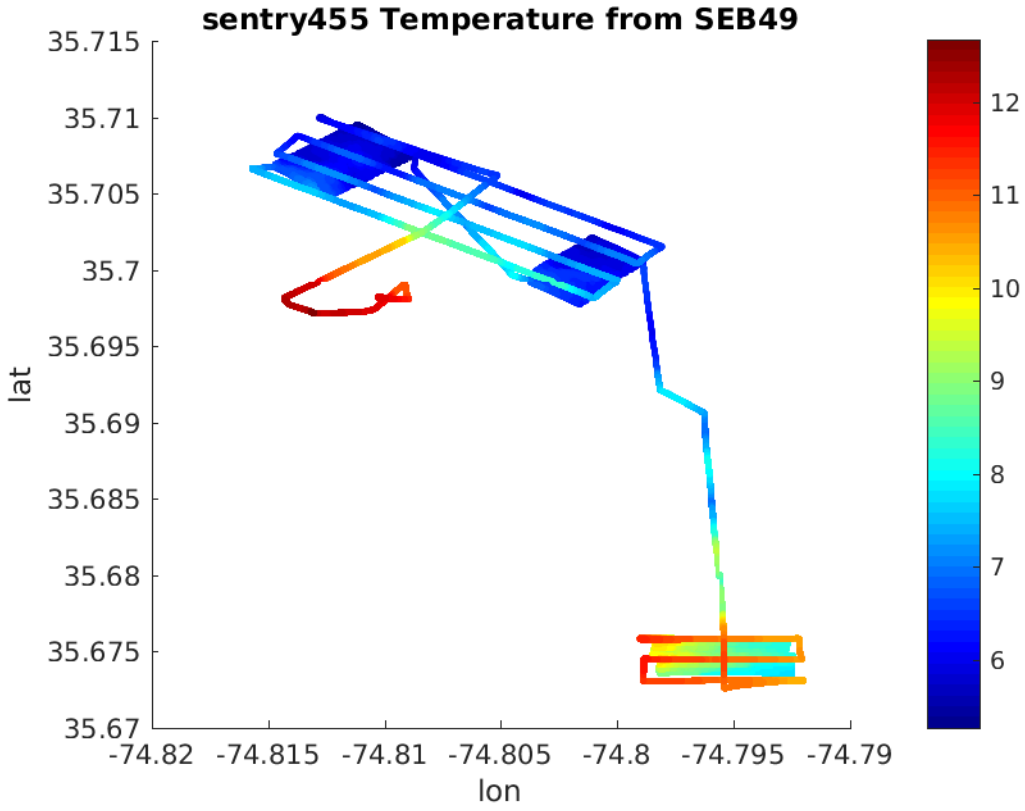


Figure 15: Temperature sensor data during dive 455.

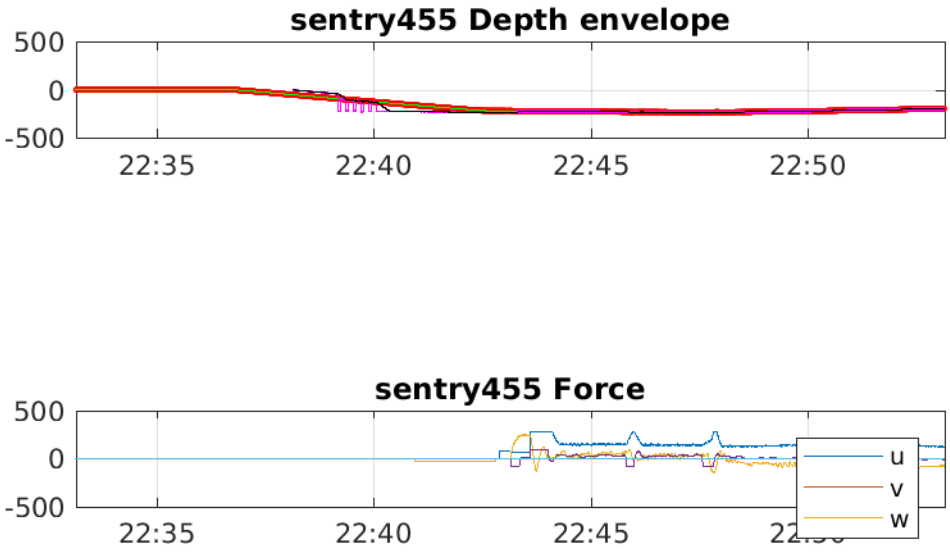


Figure 16: Bottom Approach for during dive 455.

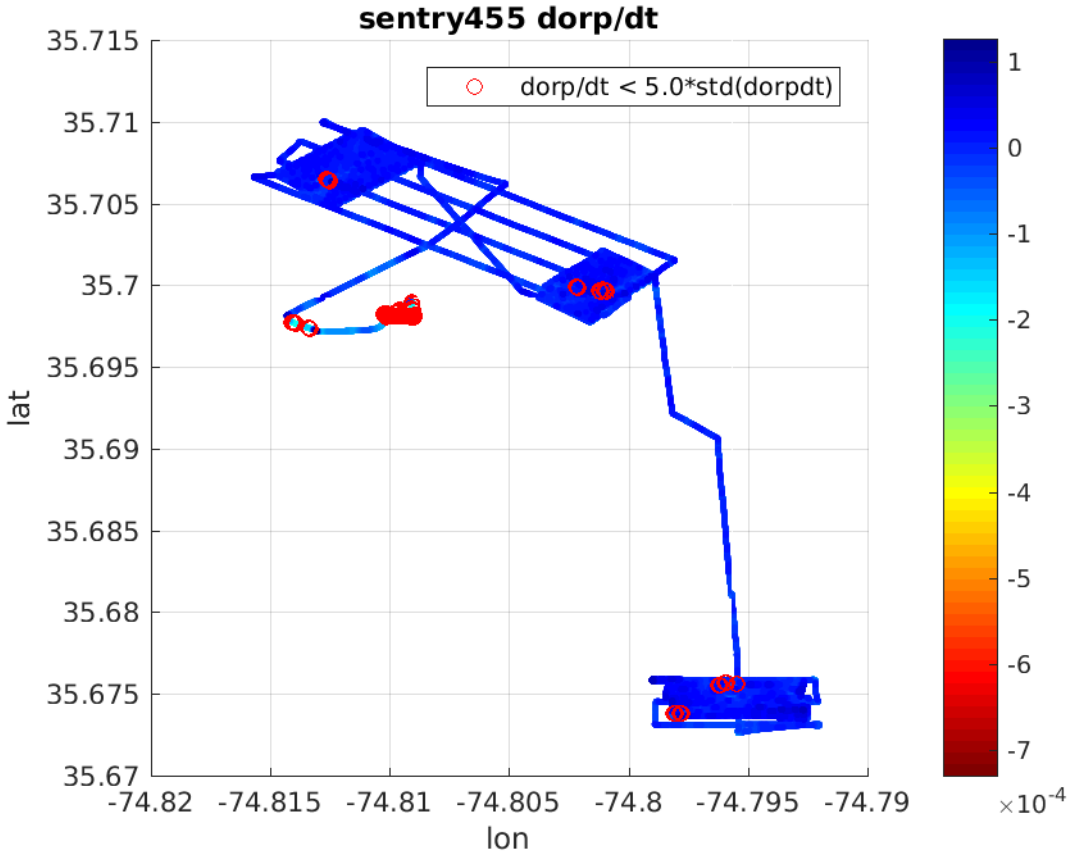


Figure 17: MAPR orp data during dive 455.

Sentry 456 Dive Report
DRAFT

WHOI Sentry Operations Group
Sean Kelley, Andy Billings, Mike Jakuba, Ian Vaughn, Jennifer Vaccaro

Sentry Expedition Leader: Sean Kelley

Chief Scientist/PI: Amanda Demopoulos, United States Geological Survey (USGS).

Summary

Weather: Large period swells with light and variable winds for both launch and recovery.

Reason for end of dive: The dive was ended in order to leave station on time so the ship could avoid on coming weather.

Vehicle Configuration

The science sensing suite for this dive was:

Table 4: Sentry Sensor Configuration

Sensor
APS 1540 Magnetometers (3)
Edgetech 120kHz/410kHz Sidescan sonar
Reson 7125 Multibeam Sonar
Seabird SBE49 CTD
Seapoint OBS
Anderaa optode model 4330
300kHz RDI DVL
Digital Still Camera
Blue View P900-90 Forward Looking Sonar
IXEA PHINS
Reson Sound Velocity Probe
NOAA PMEL ORP Sensor
SBE27 Ph Sensor

This dive was navigated using the DVL/INS system in real time. USBL provided post-dive corrections.

Important Positions

Dive Origin: 32 15 -77 -30

Launch Position: sentry456 launch position: 32 17.876'N 077 29.016'W

Narrative

Sentry456 was the third and final dive of the cruise. After avoiding weather from Hurricane jose, this was the final attempt for a dive at Stetson bank, as hurricane maria was starting to track north. Launch was less than ideal with to much forward speed on the ship and a considerable north eastern current. This caused sentry to be over 1km away from the launch position once it reached bottom at 500m depth. Due to this error, the crossing line for the first multibeam block timed out and was not completed. During the first line of the multibeam block Sentry was continually shifted back and forth in order to align it with the planned track. The remainder of this first multibeam block went went and without any issues. This first multibeam block covered 800m by 500m square area.

The second multibeam block of the dive was a much larger 2500m by 620m square block. This multibeam survey went well and without any issues. Both multibeam surveys were also collecting water column data.

Following the multibeam survey was a 750m by 405m photo survey. Initial observations looked good for the photo survey, until checking on the camera status through acoustic communications. It was clear that the camera was not taking photos from the camera status, additionally the blueview status displayed a bad sonar status. It was assumed that the camera was not taking pictures and could be a total loss. After some discussion, it was concluded due to weather and night time conditions, leaving the vehicle in the water was the best option. There was no reason to believe that other sensors were not working. Due to the lack

of obstacle avoidance and failure of the camera, Sentry was set to a working altitude of 15 meters from 5 meters. The PI suggested high resolution multibeam as an alternative survey due to all of these conditions. The remainder of the first camera block and most of the second camera block ran with the high resolution multibeam and captures no photos.

Issues

- Camera: Camera failed to take photos during the dive. After looking into this issue on deck, the camera driver that is the control software for the camera appears to have crashed during the dive. Reasons for the camera driver crash are inconclusive.
- Blueview: Blueview also failed to work during the dive and suffered the same fate as the camera. Looking into the logs, it is clear the blueview may have crashed before Sentry was launched. To mitigate this issue in the future, a status indicator is being added to our sentry gui that will indicate any issues on launch.

Chief Scientist Comments

The Chief scientist is requested to include any desired comments.

Dive Statistics

0.5 sentry456 Summary

sentry456 Summary
Origin: 32.250000 -77.500000
Origin: 32 15.000'N 077 30.000'W
Launch: 2017/09/20 12:46:48
Survey start: 2017/09/20 13:02:10
Survey start: Lat:32.302491 Lon:-77.474819
Survey start: Lat:32 18.149'N Lon:077 28.489'W
Survey end: 2017/09/21 10:54:56
Survey end: Lat:32.291079 Lon:-77.494688
Survey end: Lat:32 17.465'N Lon:077 29.681'W
Ascent begins: 2017/09/21 10:54:56
On the surface: 2017/09/21 11:21:40
On deck: 2017/09/21 11:21:40
descent rate: 36.3 m/min
ascent rate: 21.3 m/min
survey time: 21.9 hours
deck-to-deck time 22.6 hours
Min survey depth: 473m
Max survey depth: 634m
Mean survey depth: 563m
Mean survey height: 31m
distance travelled: 45.30km
average speed; 0.53m/s
average speed during photo runs: 0.48 m/s over 7.27 km
average speed during multibeam runs: 0.61 m/s over 38.02 km
total vertical during survey: 7848m
Battery energy at launch: 20.2 kwhr
Battery energy at survey end: 5.7 kwhr
Battery energy on deck: 5.6 kwhr

Sensor Information

This is a recently added section with selected sensor metadata. This section will be expanded in coming months. Additional data is available in the sentry456/nav-sci/proc directory within the sentry456_config matlab structure as well as in ascii text logs in sentry456/metadata. At present metadata is not yet automatically collected on all sensors.

0.6 sentry456 Devices

Instrument	Model	Serial Num.	Comments	Config File
USBL	Sonardyne AvTrak2	U001A91		avtrak_20170920_0915.cfg
DVL	RDI Navigator (300kHz)	727-2000-00M	CX: 1, WP: 0	dvl300_20170920_0916.cfg
CTD	SBE 49	222		sbe49_20170920_0916.cfg
SAIL	obs A/D	13	A: 5, G: 1.00, O: 0	a2d2-pods_20170920_0915.cfg
	orp A/D	9	A: 3, G: 1.00, O: 0.002	
	sbe27 A/D	10	A: 2, G: 1.00, O: 0.0009	

Plots and Images

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

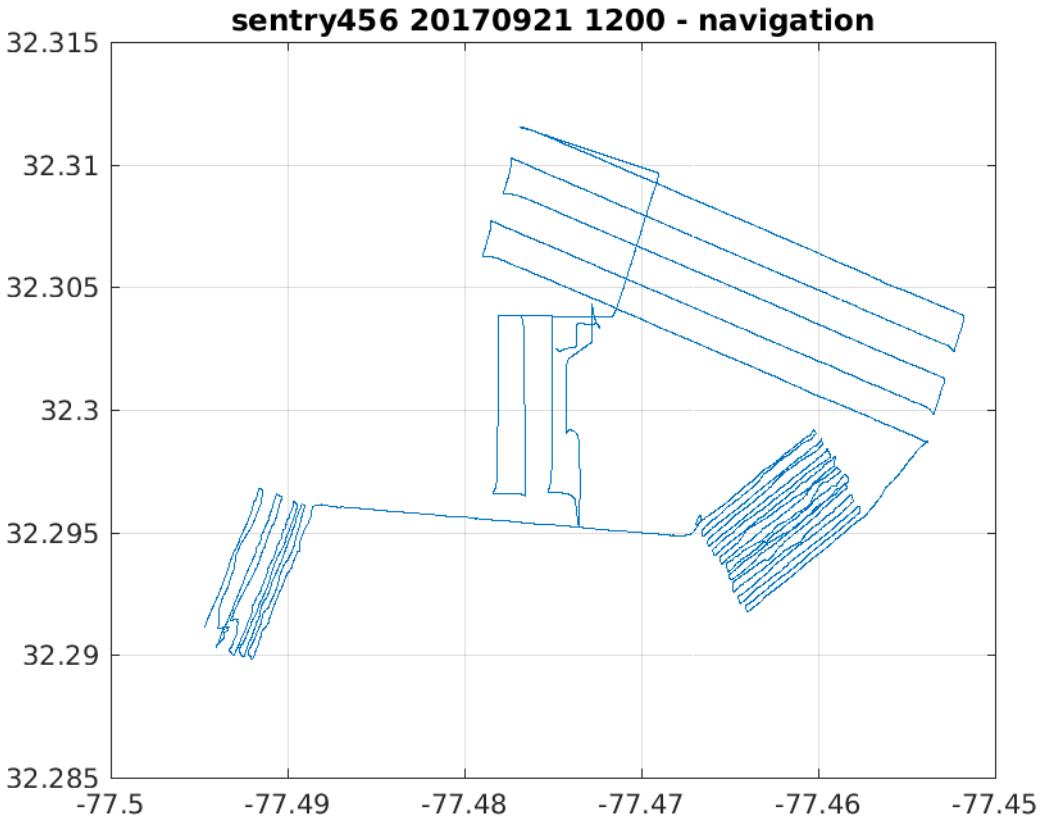


Figure 18: Latitude/Longitude plot of Sentry dive 456 based on post-processed navigation.

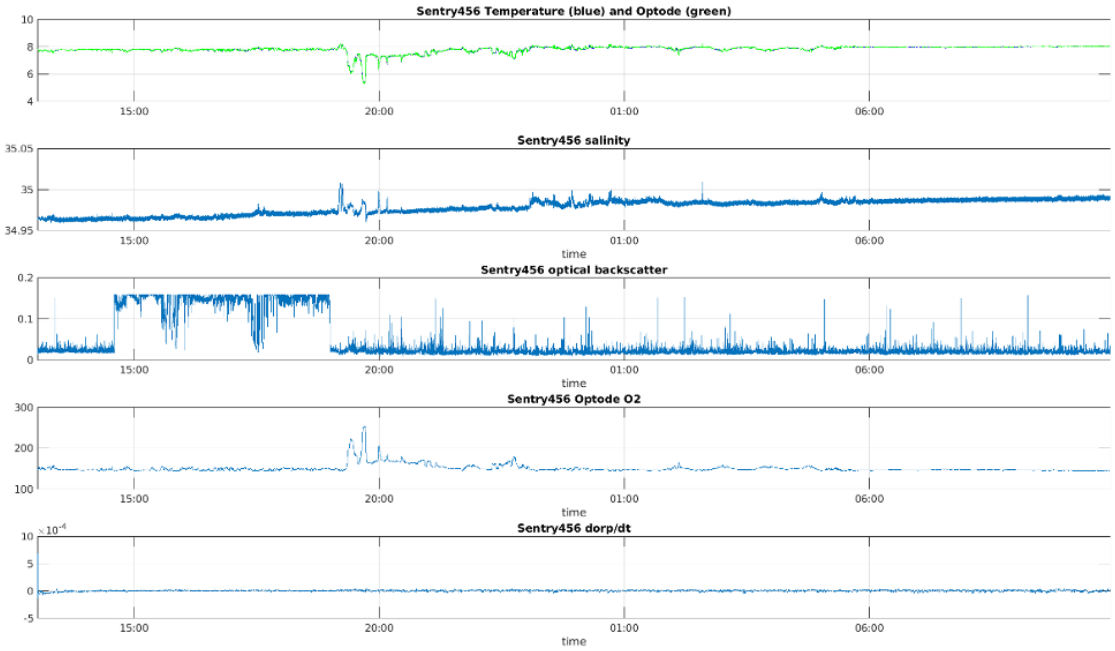


Figure 19: Time series plot of five of the basic sensors on Sentry, from top to bottom, temperature, salinity, optical backscatter, dissolved Oxygen, and ORP.

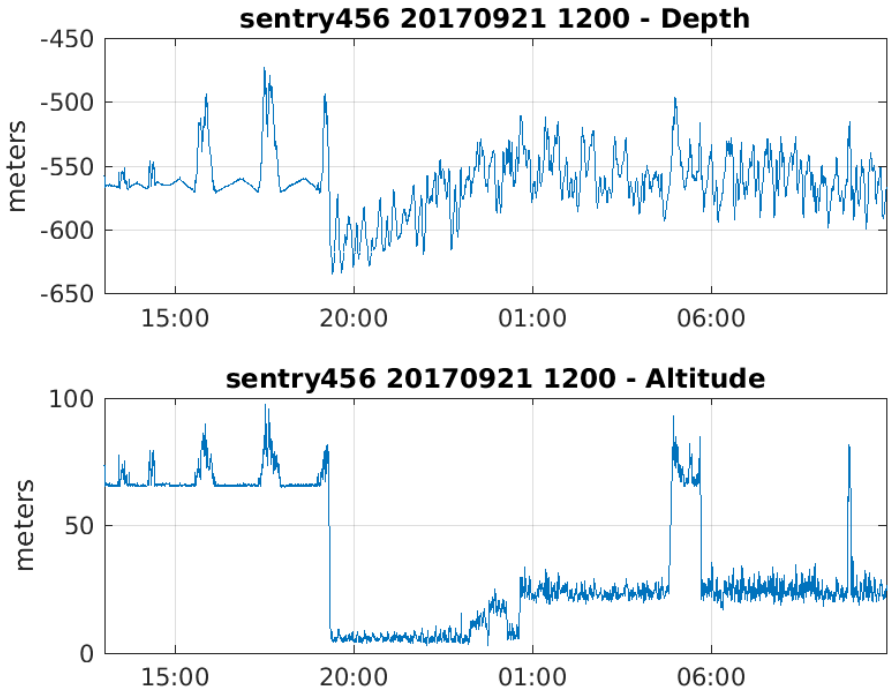


Figure 20: Depth and Altitude of Sentry during dive 456.

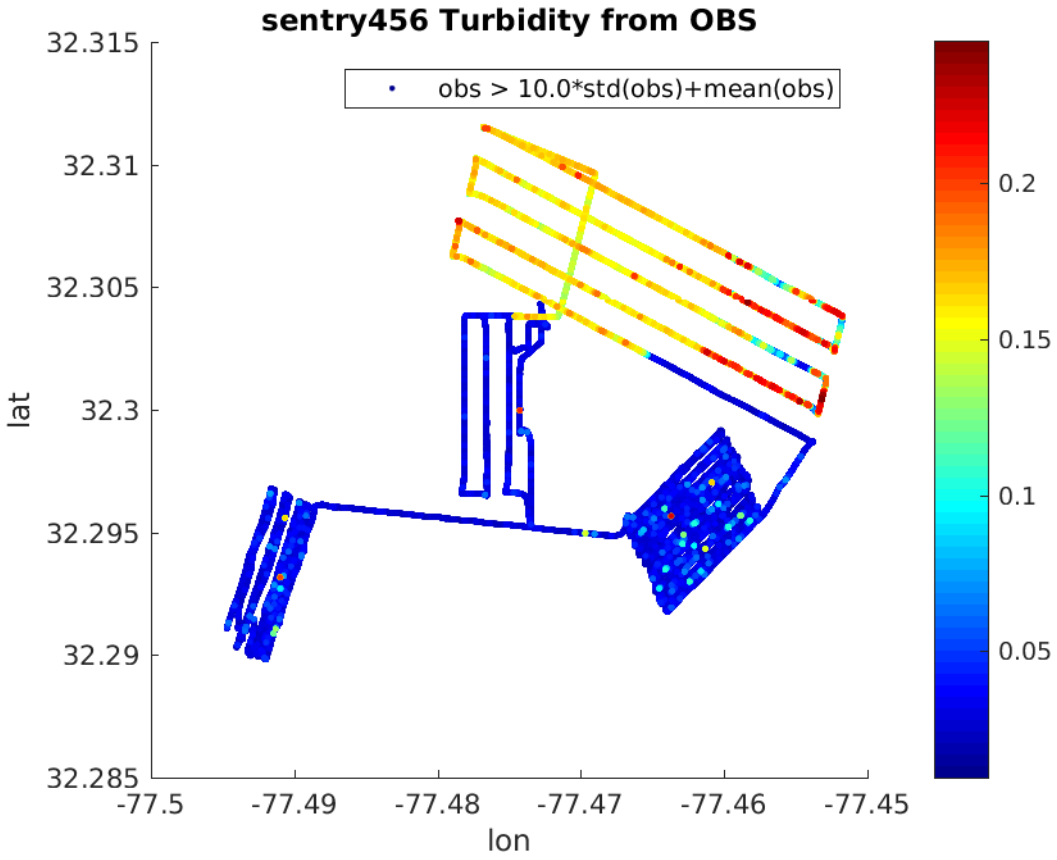


Figure 21: Optical backscatter on dive 456.

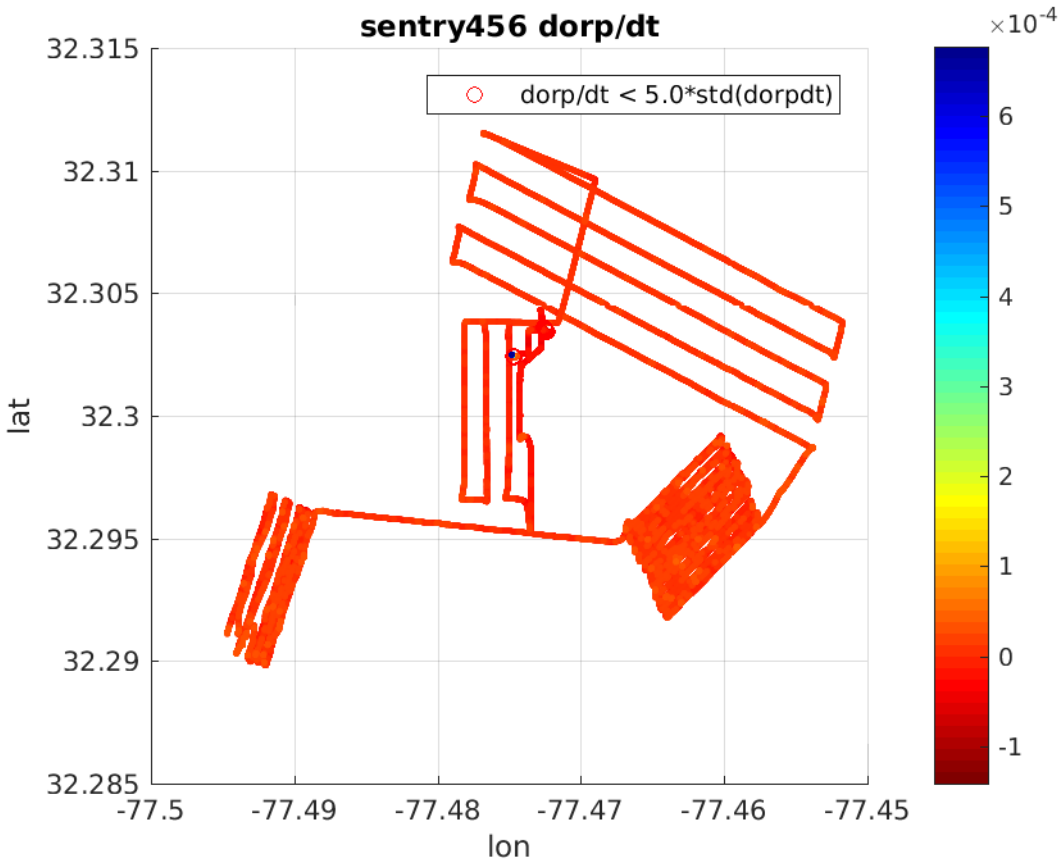


Figure 22: ORP sensor data during dive 456.

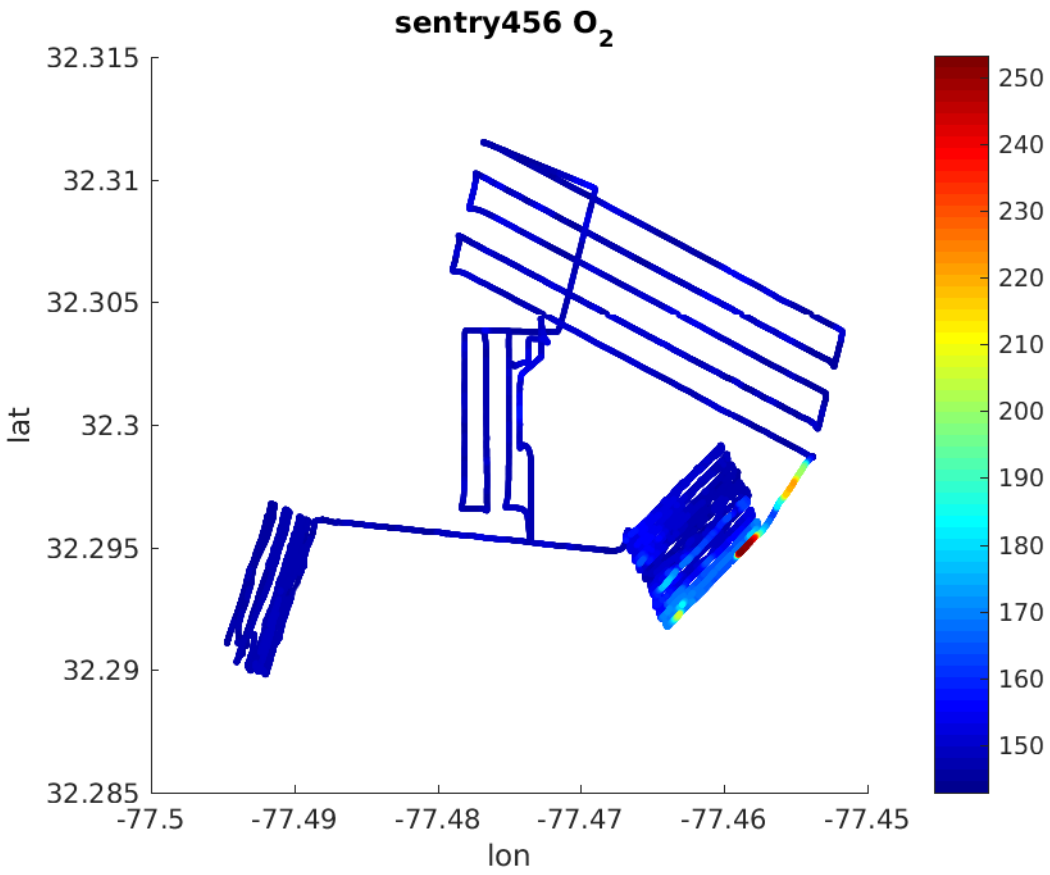


Figure 23: O2 sensor data during dive 456.

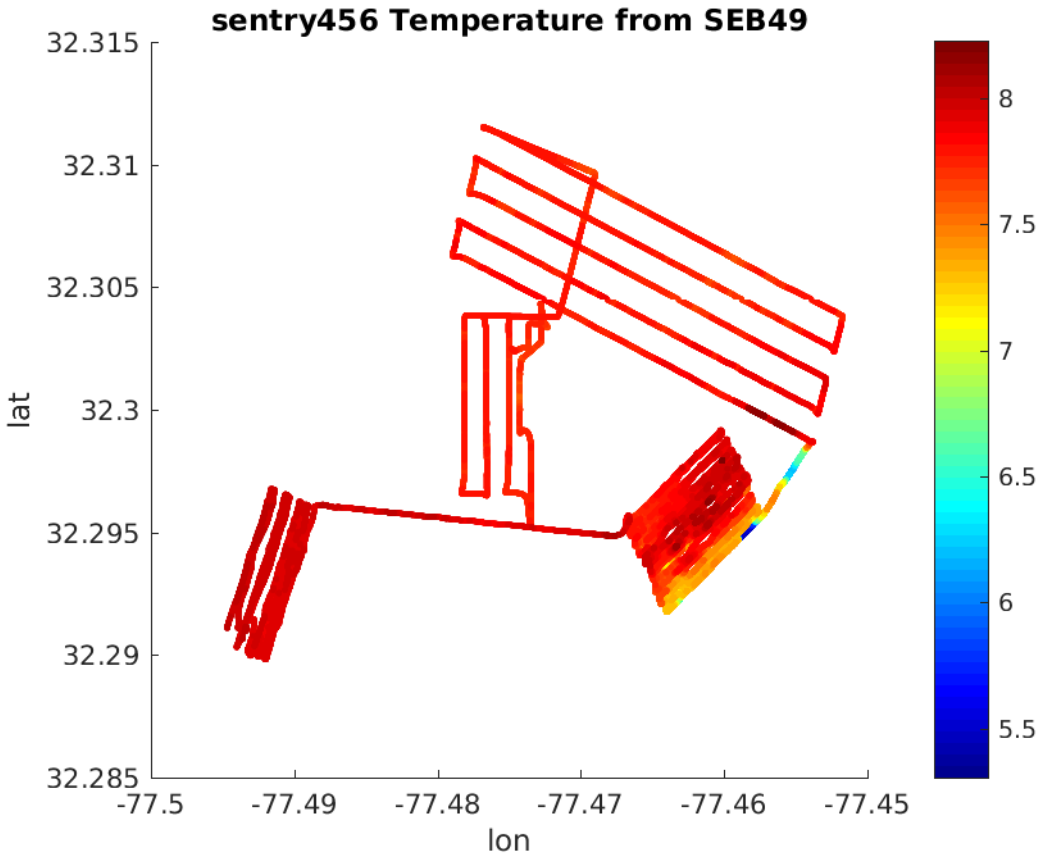


Figure 24: Temperature sensor data during dive 456.

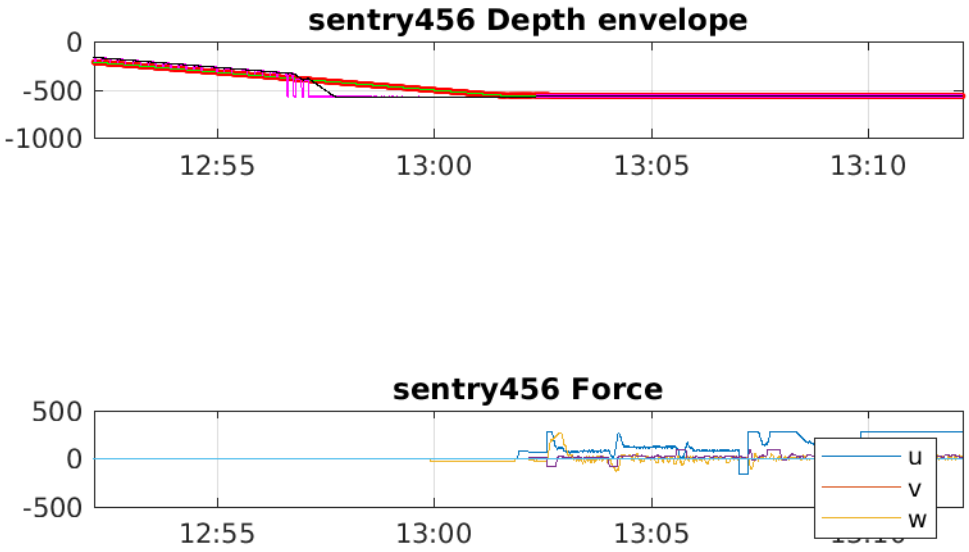


Figure 25: Bottom Approach for during dive 456.

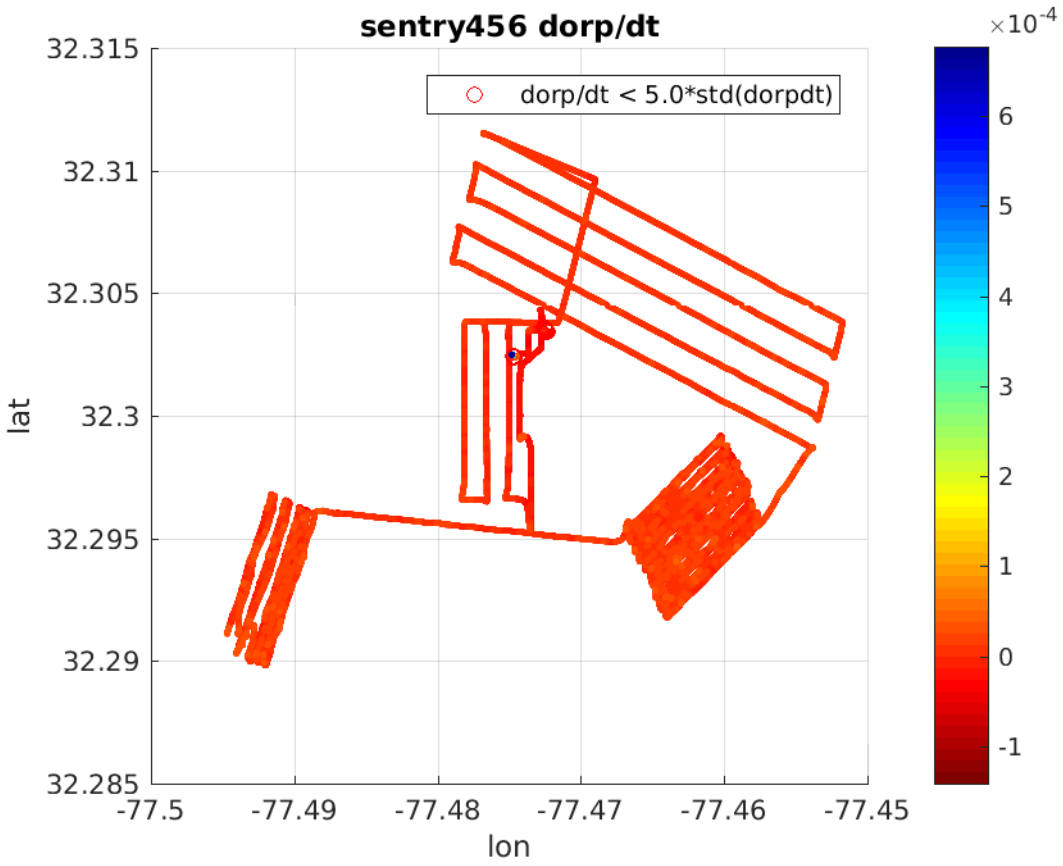


Figure 26: MAPR orp data during dive 456.

CASIUS Calibration Report

Vessel: NOAA Pisces **Device No:** 4395 **Date/Time:** 31 August 2017 17:19:36

Tcvr=Transceiver 1; Beacon=WSM6 QsW2; GPS=Position 1; Heading=Lodestar USBL 1 [Corrections(P:0,R:0,H:0)]; Attitude=Lodestar USBL 1 [Corrections(P:0,R:0,H:0)]

Settings:

Initial Estimates for BoxIn	
Transceiver depth offset	0.978m
Transceiver depth	0.978m
Antenna starboard offset	-6.000m
Antenna forward offset	-31.200m
Antenna height offset	14.302m

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	WSM6 QsW2
Turn Around Time	240.0ms

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	1493.2m/s

Results:

Beacon BoxIn	Beacon Eastings	Beacon Northings	Beacon Depth	Sound Velocity	Transceiver Starboard Offset	Transceiver Forward Offset
Before	535103.65m	3955724.09m	1455.28m	1493.24m/s	0.00m	0.00m
Calculated	535097.59m	3955717.09m	1452.99m	1493.69m/s	-0.21m	-1.12m
Calculated Accuracy	0.09m	0.10m	0.38m	0.25m/s	0.07m	0.08m

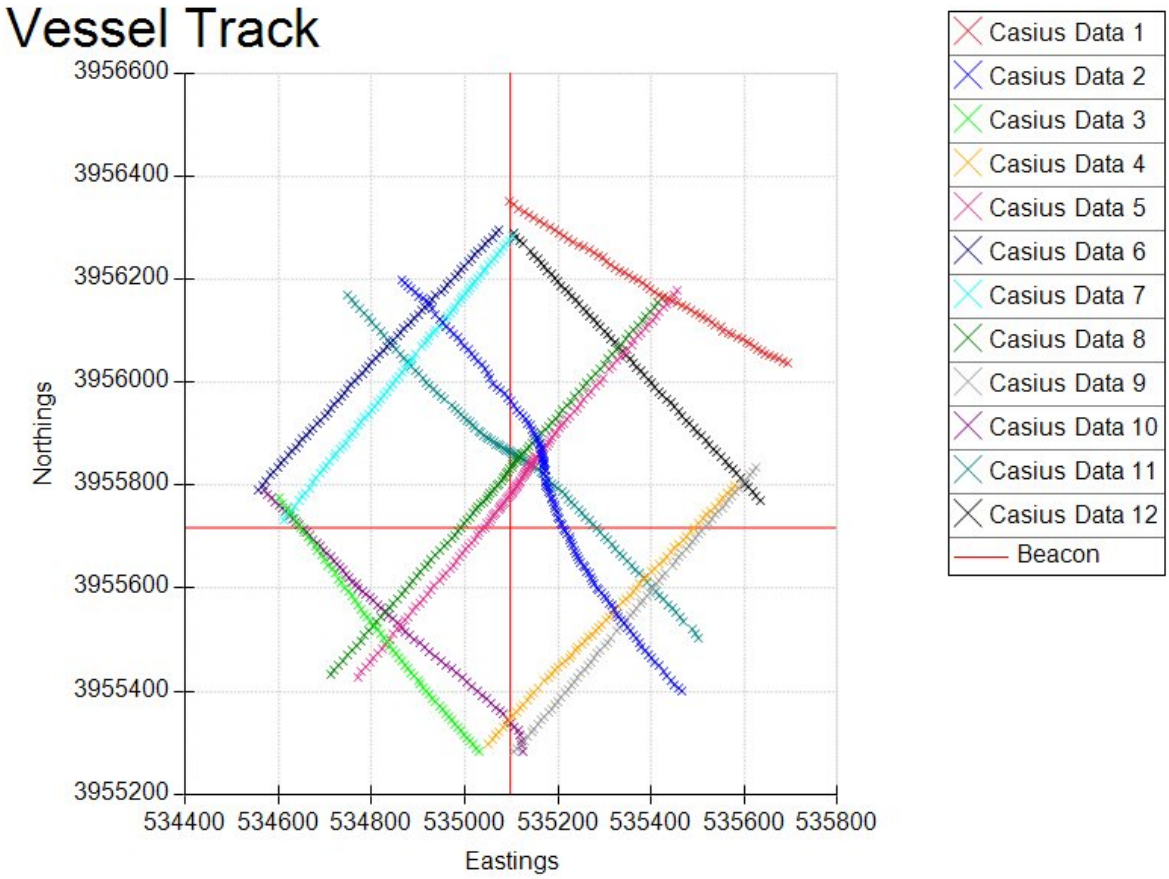
Transceiver Attitude	Pitch Correction	Roll Correction	Heading Correction
Before	0.00º	0.00º	0.00º
Calculated	**-0.17º**	**-0.34º**	**0.52º**
Calculated Accuracy	0.00º	0.00º	0.01º

Statistics:

	Before CASIUS (distance)	After CASIUS (distance)	Before CASIUS (% depth)	After CASIUS (% depth)
39.4% Beacon Positions (1 sigma)	9.0m	2.1m	0.62	0.14
50.0% Beacon Positions (CEP)	9.9m	2.4m	0.68	0.17
63.2% Beacon Positions (1 Drms)	11.3m	2.9m	0.78	0.20
86.5% Beacon Positions (2 sigma)	14.0m	4.6m	0.97	0.31
98.2% Beacon Positions (2 Drms)	17.5m	9.2m	1.20	0.63

General:

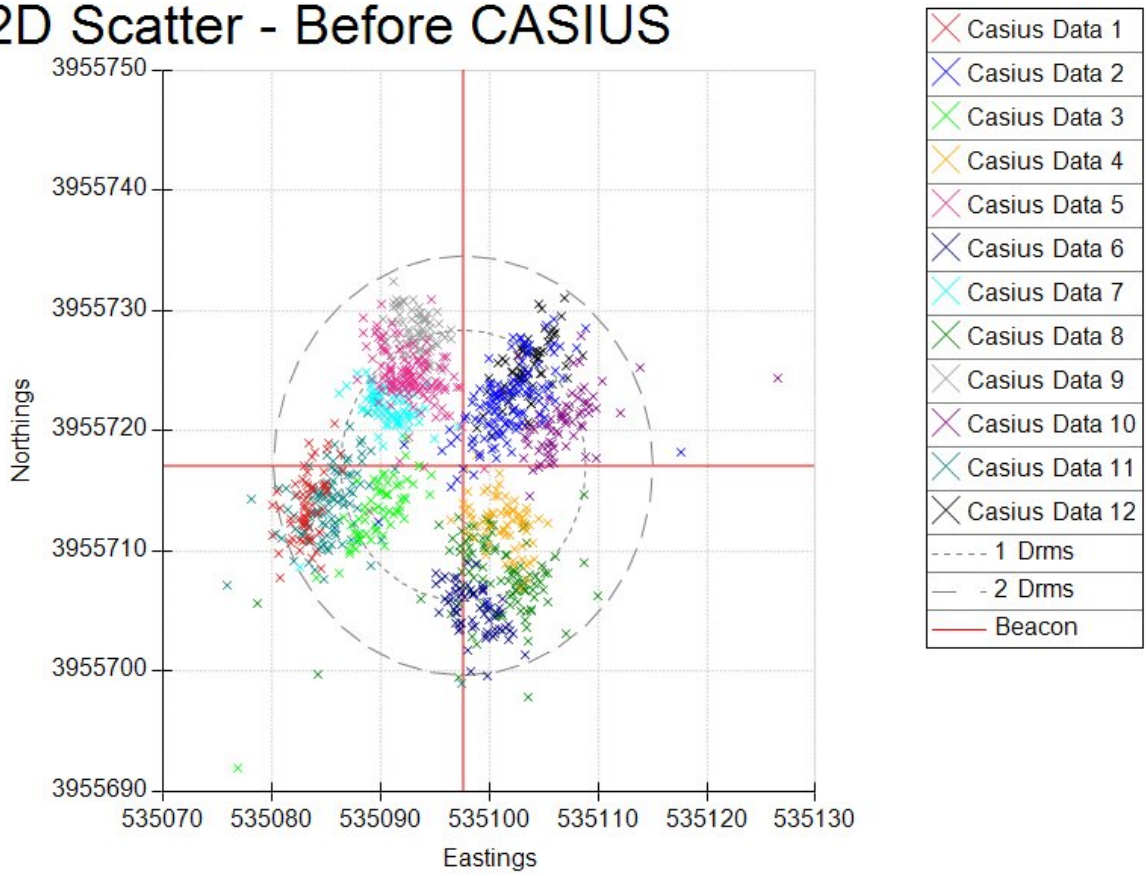
	Beacon BoxIn	Transceiver Attitude
Number of Iterations	3	2
Number of Fixes Used	1006	1006
Number Depth Aided		18
Average weighted residuals	0.019	0.260



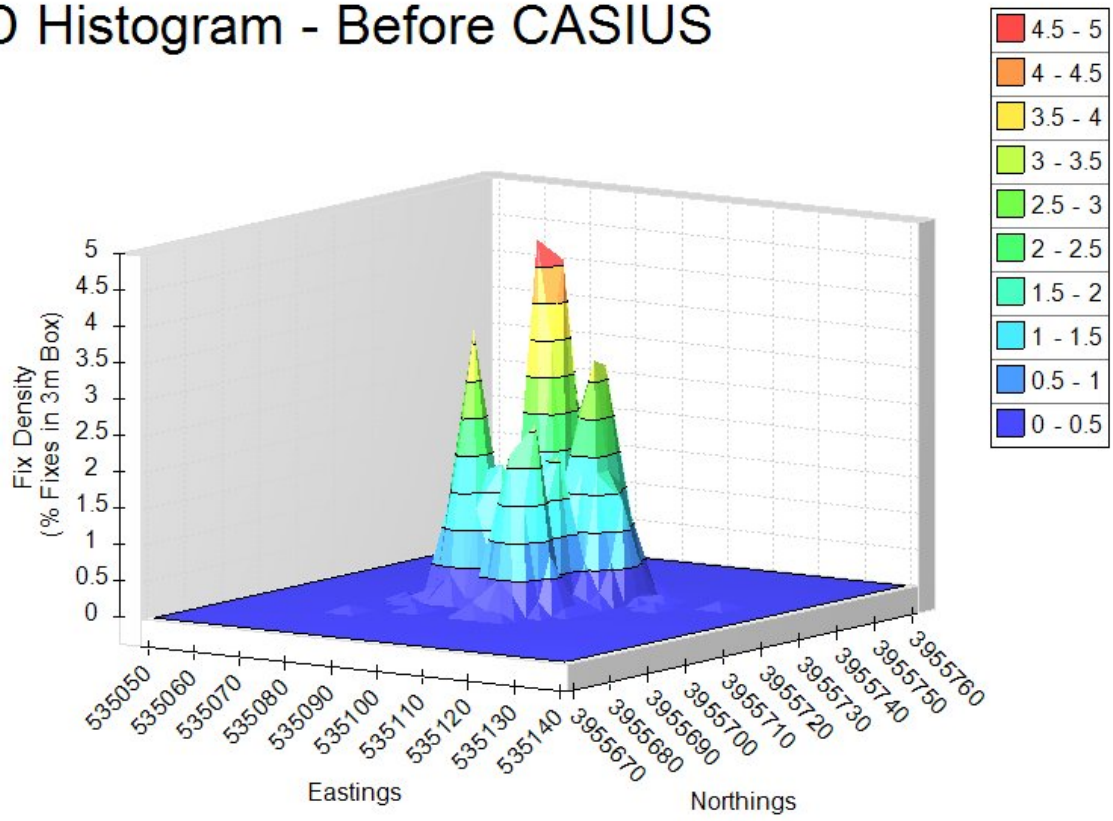
Data used:

Name	Filename	Start	End	#Acoustic	#Position
Casius Data 1	n/a	31/08/2017 17:19:36	31/08/2017 17:24:50	63	626
Casius Data 2	n/a	31/08/2017 17:35:09	31/08/2017 17:45:49	128	1280
Casius Data 3	n/a	31/08/2017 17:55:28	31/08/2017 18:00:42	64	628
Casius Data 4	n/a	31/08/2017 18:05:48	31/08/2017 18:11:30	68	684
Casius Data 5	n/a	31/08/2017 18:18:41	31/08/2017 18:29:13	127	1264
Casius Data 6	n/a	31/08/2017 18:36:15	31/08/2017 18:41:59	70	687
Casius Data 7	n/a	31/08/2017 18:54:13	31/08/2017 19:00:36	76	766
Casius Data 8	n/a	31/08/2017 19:06:24	31/08/2017 19:14:34	100	980
Casius Data 9	n/a	31/08/2017 19:22:11	31/08/2017 19:28:21	73	740
Casius Data 10	n/a	31/08/2017 19:34:28	31/08/2017 19:40:12	69	688
Casius Data 11	n/a	31/08/2017 19:47:46	31/08/2017 19:56:40	106	1068
Casius Data 12	n/a	31/08/2017 20:02:34	31/08/2017 20:08:13	67	678

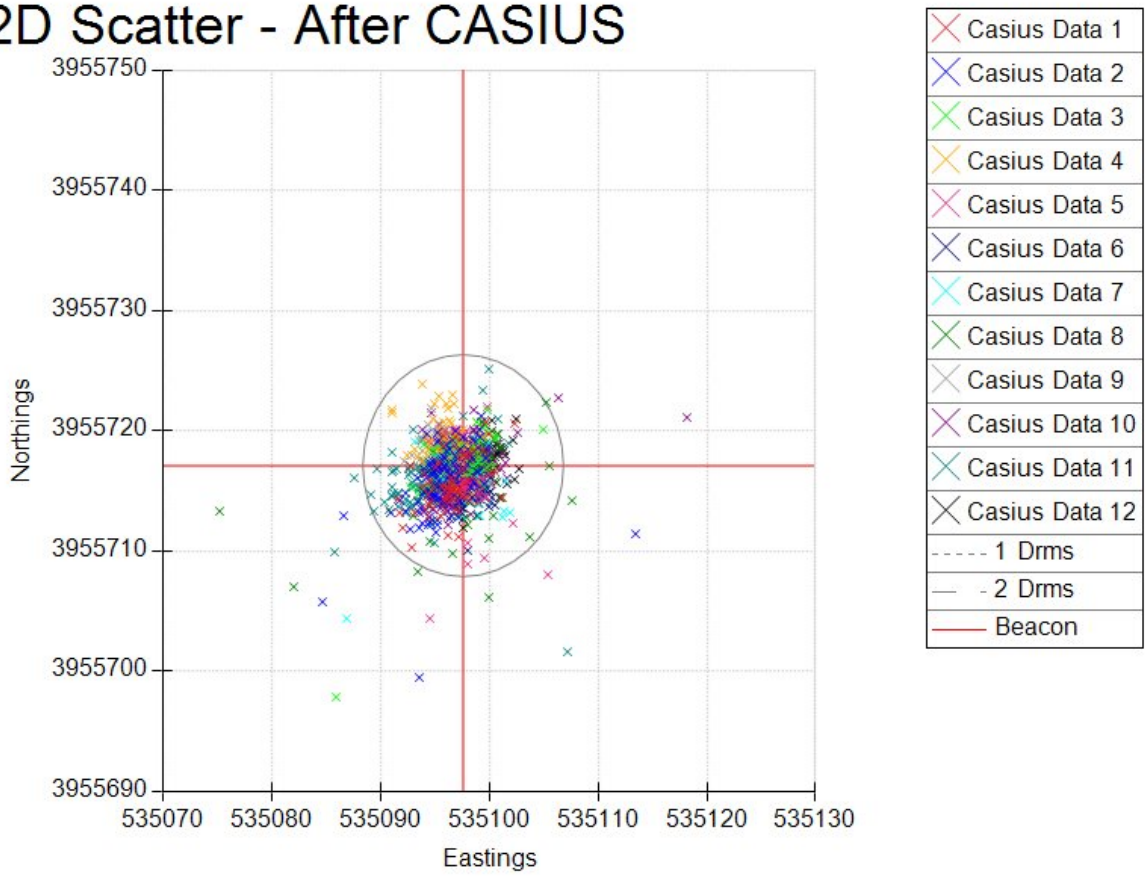
2D Scatter - Before CASIUS



3D Histogram - Before CASIUS



2D Scatter - After CASIUS



3D Histogram - After CASIUS