R/V *Falkor*/AUV *Sentry* Expedition FK140626 Cruise Report:

Hydrothermal Iron Biogeochemistry and Microbial Habitats at Loihi Seamount*

Expedition Dates and Ports 25 June 2014 to 7 July 2014, Honolulu, HI to Honolulu, HI

(mobilization 22 June 2014, demobilization 08 July 2014)

Chief Scientist: B. Glazer (University of Hawaii)

Cruise Coordinator: L. Rolley (SOI)

AUV Expedition Leader: Dana Yoeger (WHOI)

Hydrothermal Iron Biogeochemistry and Microbial Habitats at Loihi Seamount

Table of Contents

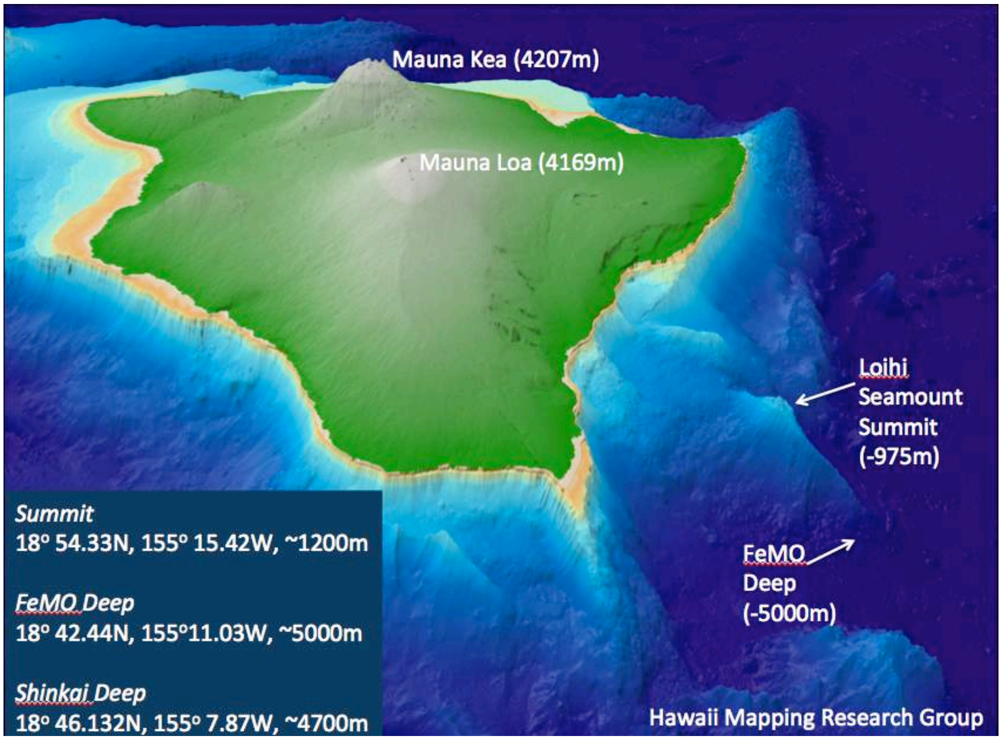


Figure 1 – 3D bathymetric overview of Hawaii Island and adjacent study site of Loihi Seamount.

I. Summary:

R/V *Falkor* Expedition_FK140626 sailed to Loihi Seamount, Hawaii (Figs. 1, 2) to study deep-sea hydrothermal processes associated with the hot spot volcano. Loihi Seamount offers at least four distinct microbial habitats that support an ecologically and biogeochemically significant class of microorganisms, the iron oxidizing bacteria: (1) sites of warm, iron-rich hydrothermal vents at the volcano's summit (1,000m), (2) fluids in the dispersing hydrothermal plume (~1100m), (3) sites of cold, ultra-diffuse iron-rich hydrothermal fluids at 5,000m, and (4) sites of bare basalts with no localized active hydrothermal fluids. Our initial project, "*Biogeochemistry and microbial ecology at Loihi Seamount, Hawaii: evolution and significance of massive microbial iron-oxidizing hydrothermal habitats*" aimed to use CTD hydrocasts and HROV *Nereus* on a 31-day expedition with deployments to: (i) quantify chemical transformations in the Loihi Summit hydrothermal dispersing plume, (ii) map and photo-image the extent of novel, cold (~0.2^{o}C above ambient) iron-oxidizing microbial mat

deposits found at ~5000m, (iii) map and photo-image the relatively unexplored, warm (~6^{o}C above ambient) microbial mats found at ~4700m, and (iv) recover instruments and samplers deployed in the mats in 2013 and collect fresh microbial mat samples from deep and summit sites alike. With the unexpected loss of the *Nereus* vehicle in May 2014, we modified our expedition plan to use CTD hydrocasts and AUV *Sentry* on a 12-day expedition to accomplish as many goals as possible. The expedition resulted in successfully collecting data and samples to tackle objectives (i) – (iii) listed above. During transits between the seamount summit and base, we also conducted shipboard multibeam mapping.

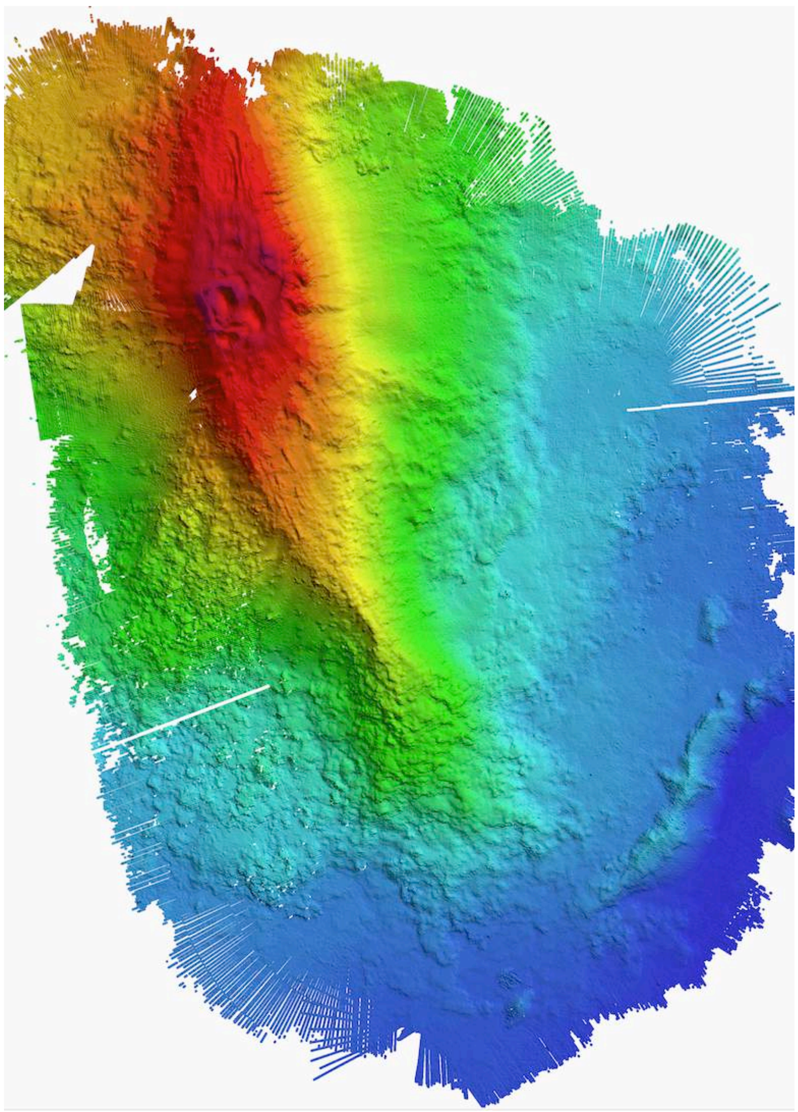


Figure 2 – Bathymetric overview of Loihi Seamount generated during FK140626.

II. Personnel:

Figure 3 – Crew, Sentry team, and science party of FK140626.

RV Falkor Crew

Heiko Volz	Dante Banquisio Sarzuelo
Paul Shepherd	Mario Sagristani
Jason Thomas Garwood	Albert Barcelo
Allan Doyle	Verena Neher
Lars Tonsfeldt	Shiella Marie Bonita
Mateusz Wroblewsi	Mildred Dadis
Sandra Malgorzata Faryna	Matthew Knight
Erik Suits	Arkadiusz Ochocki
Luke MacNutt	Leighton Rolley
Miroslav Mirchev	Peter Keen
Dan Buehler	James Cooper
Ramon Tabaque	Carlie Wiener
Todor Gerasimov	

AUV Sentry Engineers

Zac Berkowitz (WHOI)

Ivo Bruno (Brazil)

Justin Fujii (WHOI)

Johanna Hansen (WHOI)

Chris Taylor (WHOI)

Dana Yoeger (WHOI)

Science Party

Isabelle Baconnais (IFREMER)

Kristen Fogaren (Univ. Hawaii)

Brian Glazer (Univ. Hawaii)

Angelos Hannides (Univ. Hawaii)

Sarah Nicholas (Univ. Minnesota)

Mike Ottman (Univ. Minnesota)

Olivier Rouxel (IFREMER)

Arne Sturm (Univ. Hawaii)

Gabi Weiss (Univ. Hawaii)

Anna Williams (Univ. Hawaii)

III. Cruise Narrative

The expedition event log is given as *Appendix 1*, details for CTD hydrocasts are given in *Appendix 2*, and details of the AUV deployments are provided in *Appendix 3*. All operations are briefly summarized here in '*III. Cruise Narrative*', followed by more detailed descriptions of operations methodology in '*IV. Shipboard Multibeam Bathymetry Operations*', '*V. CTD Hydrocast Operations*', and '*VI. AUV Sentry Operations*'. Finally, a description of scientific achievements and an overview of sample status is given in '*VII. Scientific Research Objectives and Achievements*'.

R/V *Falkor* Cruise FK140626 explored and investigated Loihi Seamount, an active submarine volcano on the flanks of the Big Island of Hawaii, USA, between June 25, 2014 and July 7, 2014. Our initial project, "*Biogeochemistry and microbial ecology at Loihi Seamount, Hawaii: evolution and significance of massive microbial iron-oxidizing hydrothermal habitats*" planned for a 31-day expedition using CTD hydrocasts aimed at understanding the dispersing hydrothermal plume from the summit area (1,100m), and HROV *Nereus* deployments aimed at exploring, mapping and sampling recently discovered hydrothermal microbial mats found at the seamount base (5,000m). Specific objectives were to: (i) quantify chemical transformations in the Loihi Summit hydrothermal dispersing plume, (ii) map and photo-image the extent of novel, cold (~0.2^{o}C above ambient) iron-oxidizing microbial mat deposits found at ~5000m, (iii) map and photo-image the relatively unexplored, warm (~6^{o}C above ambient) microbial mats found at ~4700m, and (iv) recover instruments and samplers deployed in the mats in 2013 and collect fresh microbial mat samples from deep and summit sites alike. With the unexpected loss of the *Nereus* vehicle in May 2014, we modified our expedition plan to use CTD hydrocasts and AUV *Sentry* on a 12-day expedition to accomplish as many goals as possible. The expedition resulted in successfully collecting AUV data and hydrocast samples to tackle objectives (i) – (iii) listed above.

Mobilization began in Honolulu, Hawaii and June 22, with AUV Sentry loading, assembly, and preparation. As this expedition was AUV *Sentry's* first deployment on board R/V

Falkor, extensive planning, testing and practicing of AUV *Sentry* launch and recovery operations took place through June 25 (Figure 4), with the Cassius USBL calibration procedure carried out over night on the 25th – 26th. Following a test CTD hydrocast (CTD-01) and sound velocity profile on June 26, we began the 16-hour transit to Loihi Seamount at 18:15 UTC on June 26.

Figure 4 – Dockside testing of optimal launch and recovery procedures for AUV *Sentry* aboard R/V *Falkor* (photo credit: C. Wiener).

Upon arrival at Loihi Seamount on 27 June 2014, the first priority was to perform a CTD hydrocast for biogeochemical sampling of the summit's Pele's Pit rising and dispersing hydrothermal plume (CTD-02, 18º54'N, 155º15'W, 1165m TWD), then transit to the FeMO Deep area to prepare for AUV *Sentry* Dive 264. Shipboard multibeam surveys were collected during all transits between local sites.

Upon arrival at the FeMO Deep site (18º46'N, 155º08'W), we attempted the first deployment of AUV *Sentry* (*Sentry*-264). Unfortunately, this dive ended very early when the forward control wing slipped its clutch and the vehicle was unable to control its depth. We subsequently transited back to the summit area to perform CTD Hydrocast-03 (18º53'N, 155º16'W, 1926m TWD), thus beginning our hydrocast sequence aimed at mapping the dispersing plume from the Loihi Summit hydrothermal vents.

By 11:15 UTC on 28 June 2014, we had transited back to FeMO Deep to attempt redeployment of AUV *Sentry* (*Sentry*-265). The vehicle performed multibeam and photo surveys. The vehicle's heading control was poor, but the maps produced were of high-quality. Unfortunately, sidescan, Eh, and optical backscatter instruments were inoperative.

Following recovery of *Sentry*-265, at 10:30 UTC 29 June 2014 we transited back to the summit area to conduct a sequence of CTD hydrocasts (CTD-04 through CTD-07). These casts were a series of three short vertical profiles to take advantage of turbidity, Eh, & pH in situ sensor data, and a subset of wet chemistry analyses to resolve the overall plume dispersion shape. The final cast in the series (CTD-07, 18º53'N, 155º15'W, 1923m TWD) was near the location of CTD-03, and selected based upon in situ data showing a particle maxima. CTD-07 was fully processed for all wet chemistry samples.

By 04:00 UTC on 30 June 2014, we had transited to the Shinkai Deep area and launched the AUV for *Sentry*-266 (18º46'N, 155º8'W). The vehicle performed multibeam and photo surveys, performing very well. The multibeam map produced is probably the highest quality obtained during the expedition and identifies many intriguing targets of interest for future ROV expeditions. Unfortunately, sidescan, Eh, and optical backscatter instruments were still inoperative.

Following recovery of *Sentry*-266, at 04:45 UTC 1 July 2014 we transited back to the summit area to our dispersing plume chemical mapping sequence of CTD hydrocasts (CTD-08 through CTD-10). These casts were a pair of short vertical profiles to take advantage of turbidity, Eh, & pH in situ sensor data, as well as a subset of wet chemistry analyses to resolve the overall plume dispersion shape. The final cast of this series (CTD-10) before the next Sentry launch was in Pele's Pit, near the location of CTD-02, and was fully processed for all wet chem.

Sentry-267 launched at 21:00 UTC on 1 July 2014 and targeted a previously-undescribed apparent ridge feature to the east of the Shinkai Deep site (18º46'N, 155º7'W). The dive plan consisted of two multibeam blocks with a short camera survey at the top of each of the two apparent peaks on the suspected ridge feature. The vehicle performed multibeam and photo surveys, but multibeam data suffered a data logging/setup problem resulting in poor-quality map coverage. The photo survey was effective, and Eh was operational. Unfortunately, the optical backscatter instrument had a logging problem, and sidescan was still inoperable.

Following *Sentry*-267, we returned to summit plume chemical mapping operations at 23:30 UTC 02 July 2014. CTD hydrocasts 11 through 14 were series of three short vertical profiles to take advantage of in situ sensors for turbidity, Eh, & pH followed by CTD-14 at the same location as CTD-13, but collected bottle samples at 5 depths for the full suite of chemical sampling.

By 16:30 UTC on 3 July 2014, we had transited back to the Shinkai Deep ridge area and launched the AUV for *Sentry*-267 (18º47'N, 155º7'W). We had planned for this dive to repeat an interesting section of the northern part of the ridge identified in *Sentry*-266, however the DVL navigation failed and the vehicle could not navigate. The dive was aborted with a 7-hour deck-to-deck time. The Sentry team felt that a short surface interval was likely, so we conducted a CTD hydrocast (CTD-15) at the Shinkai Deep site, rather than return to the Summit area for continued plume mapping.

The AUV team successfully replaced the DVL unit on the vehicle during the surface interval and *Sentry*-269 launched at 07:00 UTC on 04 July 2014 to attempt the aborted dive plan from *Sentry*-268. The vehicle collected good multibeam data and photos, Eh and optical backscatter were operational, but sidescan was not. The terrain on this dive was more challenging than expected, resulting in the vehicle hitting bottom a few times, but it successfully recovered without damage. Sea state during recovery was also challenging (2+ meter seas), but recovery went well considering the conditions.

We returned to the summit area to complete our plume chemical mapping survey (CTD-16 through 18) at our westward most direction, farthest from Pele's Pit. CTD-16 was a quick cast to collect in situ sensor data used to select optimal depths for full sampling on CTD-17 and CTD-18. All three casts in this sequence took place in the same location (18º53'N, 155º17'W, 3000m TWD).

Having projected time for one final Sentry deployment, we transited back to the Shinkai Deep area and deployed *Sentry*-270 at 17:45 UTC on 05 July 2014. The dive plan was to collect high-resolution multibeam data over interesting topographic features adjacent and to the south of the area covered during *Sentry*-266. The multibeam map produced is one of the highest quality obtained during the expedition and identifies many intriguing targets of interest for future ROV expeditions. The vehicle contacted the bottom several times during the photo survey, but overall collected high quality images. Eh and optical backscatter instruments were operational, but sidescan was not. Following recovery of the AUV, we had completed science operations and began the transit back to Honolulu at 16:00 UTC on 06 July 2014. We docked at Snug Harbor and began the offloading process at 18:30 UTC on 07 July 2014.

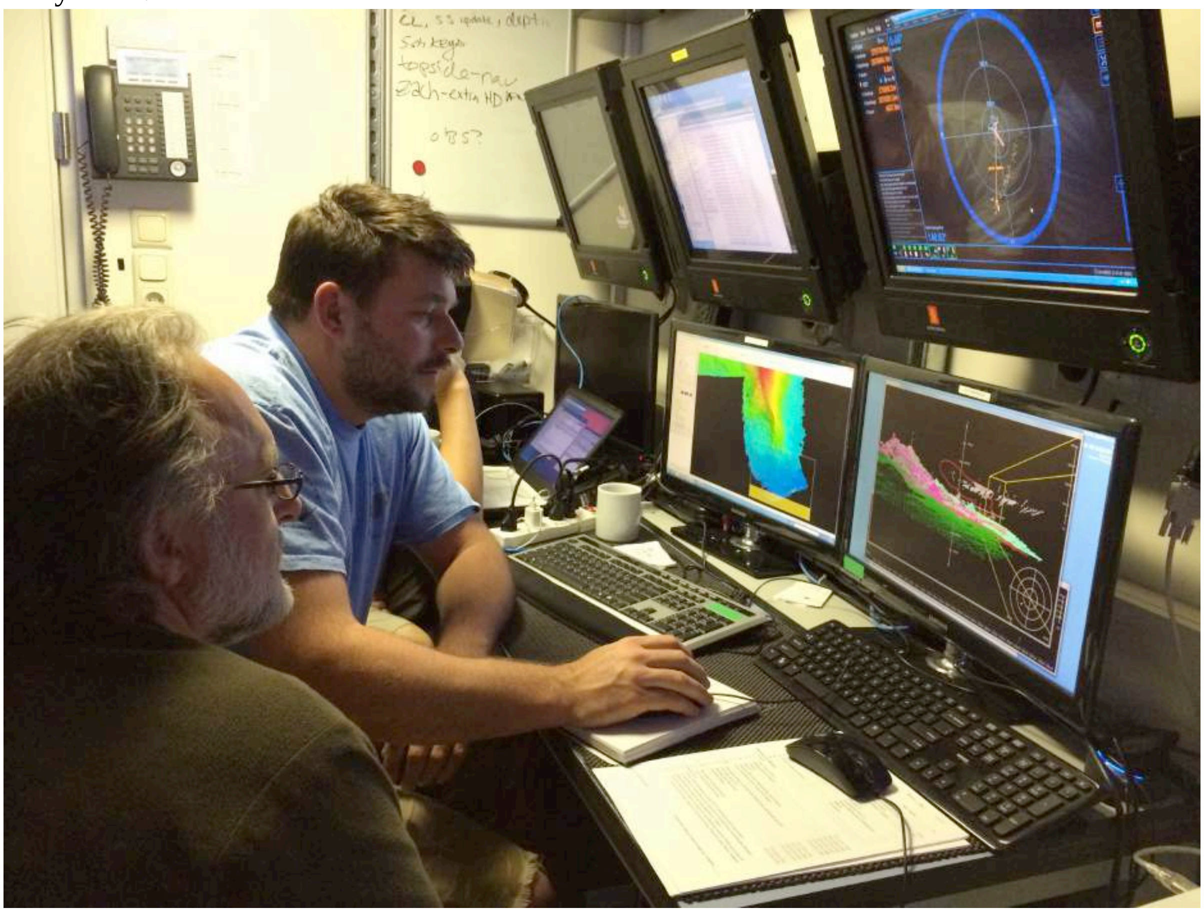


Figure 5 – *SOI* Marine Techs Leighton Rolly and Peter Keen review Falkor multibeam data for Loihi Seamount.

IV. Shipboard Multibeam Bathymetry Operations

Multibeam mapping involved the use of the *Falkor*'s Kongsberg EM 302 and EM 710 multibeam sonars. Links to downloadable documents providing complete specifications to these instruments are:

http://www.km.kongsberg.com/ks/web/nokbg0397.nsf/AllWeb/A915A71E90B6CFAEC12571B1003FE84D/$file/306106_em_302_product_specification.pdf

http://www.tdi-bi.com/vessels/em710.pdf

Falkor MTs Rolly and Keen provided raw multibeam data files, conducted preliminary QA/QC data editing using CARIS (Figure 5), and generated grid files (e.g., netCDF) for the science party, which were used to generate figures (e.g., Figure 2).

V. CTD Hydrocast Operations

A summary of overall CTD hydrocast operations is summarized here, with preliminary results presented in section VII, and a complete list of bottle samples in Appendix II.

Equipment

The standard CTD and winch on the R/V *Falkor* were used:

- Seabird Underwater Unit for 9/11plus CTD (6800m housing) with Wet pluggable connectors on CTD, T&C sensors, pump and pressure sensor (0- 10,000 psia / 6800m)
- Secondary T-C sensors, 6800 m, with TC Duct, Pump with wet-pluggable connectors.
- Seabird carousel water sampler (standard) fitted with 24-x 12 litre PVC sample bottles (internal Teflon coated springs).
- Seabird Deck Unit for 9/11plus CTD (Firmware V5) with added NMEA input.
- SEASOFT Software (Seasave V7, SBE Data Processing, Seaterm V2).
- MacArtney MASH CTD Oceanographic Winch (Type 10000/8,2-31-RA) fitted with 10,000m of 0.322" EM coax wire. The coax wire is managed with routing via flag sheave to the A-Frame.
- SWL on the wire is 1744kg. Thus, the CTD can achieve a maximum deployment depth (reached on this cruise) of ca. 5250m (5500m wire out) Extra Sensors integrated with

the CTD for this cruise included:

- Turbidity Meter (Seapoint STM11)
- Oxygen (SBE 43)
- Additionally, a custom, self-contained, multi-parameter data logger from RBR, Inc. was attached to the CTD rosette and recorded dissolved oxygen (Aanderaa 4330F), conductivity, temperature, pressure, ORP and pH (Idronaut)

Hydrocast procedures

The CTD package performed well throughout the cruise, although sampling of bottles on the fantail was problematic at times, from the standpoint of supplying gas lines for pressure filtering and fantail movement during transits. We performed CTD hydrocasts to physically and chemically map the dispersing hydrothermal plume from Loihi's actively venting summit. No transmissometer was available on the CTD rosette during FK140626, however the Wet Labs ECO-FLNTU proved sensitive enough to provide real-time indications of the plume particle maxima during downcasts and upcasts, and the RBR data logger ORP and pH data were quickly downloaded upon CTD rosette recoveries, with plots being generated prior to subsequent casts, allowing us to optimally select discrete depths for tripping rosette bottles for conducting full chemical sample analyses. CTD rosette individual bottles were subsampled by slightly pressurizing bottles with inert, ultra-high purity Nitrogen gas. Prior to the expedition, all bottle springs were removed, inspected for corrosion, and any potentially compromised springs were treated with epoxy paint or replaced.

SBE911 sensor data processing

Overarching goal

The goal of this work was to generate readable files of all the sensor data, acquired from the SBE911 platform during hydrocasts, for all the cruise participants and their collaborators. Advanced processing of data was limited to flagging major spikes, soaking or stationary times, etc. Another goal was the extraction of sensor data associated with each bottle of each cast that people sampled. These data were entered into the sample and data log (MS Excel file). This document describes all the steps involved in the process.

SBE911 original data

Data location

The raw data collected from the SBE911 during hydrocasts was automatically loaded on the Cruise Data folder of the server (10.23.9.200) at:

CruiseData > FK140626 > Oceanography > CTD

Types of data files

There are typically four (4) types of data files associated with each cast, each with a separate suffix:

- hdr – This is the header file; it contains cast details (date, time, location, etc.)
- XMLCON – This is the configuration file; it lists the available sensors (types, serial numbers, etc.) and their calibration specifications
- hex – This file contains all the data acquired by the platform and sensors during the cast
- bl – This file contains the date and time each bottle was fired, as well as the relevant sensor scan(s) number(s)

The names of the files are all the same and consist of the following, separated by underscores:

- the cruise code name, FK140626,
- the CTD deployment number, e.g., CTD012 (not our cast number), and
- the date of the cast (in GMT), in year-month-date, e.g., 20140701.

You need all four files to properly use the platform data to the max.

Data processing

By far, the easiest way to process the data is by using SeaBird Scientific's SBEDataProcessing software, found here: http://www.seabird.com/software/SBEDataProcforWindows.htm.

It's best to use the latest version, 7.23.2, issued earlier in 2014, since it includes the necessary algorithms to calculate thermodynamic parameters (e.g., salinity, potential temperature, density, etc.) with the new TEOS-10 standards.

Please note that the manual is particularly useful in explaining the conventions or common practices for data conversion and processing. Note that the platform we are using, SBE911, is an SBE 9plus with the SBE 11plus deck unit.

Data conversion and inspection

Data conversion

The data from the cast found in the .hex file are in hexadecimal format, e.g., a scan looks like this:

1331611844D281712C13D6BD19093A996FFFFC3F68FFFFFF03AFFF0E6CC47673BC40 8D87451B7AA222

The first, and really the only necessary, step is to convert this hex string into all the information you need, whether it's platform data or sensor data, into columns of decimal values, each column corresponding to each parameter. The Run > Data Conversion option does exactly that, generating a data file with the suffix cnv.

I selected the following parameters for the cnv file:

- scan number (a scan being a stored row of data, collected 24 times every second)
- pressure,
- temperature (2 sensors),
- conductivity (2 sensors),
- dissolved oxygen concentrations (in mmol L^{-1}, mmol kg^{-1}, and % saturation),
- Chl a fluorescence (mg m^{-3}),
- Turbidity (NTU), bottles fired (used with scan number to identify bottle-associated sensor data independently),
- Bottles fired (containing the number of the last bottle fired; the first instance a new bottle number appears indicates the point at which that bottle was fired).

The same Run > Data Conversion option, in conjunction with the .bl file, extracts all the sensor data for the period between the instance each of the 24 bottles of the rosette were fired and the next two seconds (49 scans each) and stores them in a file with the suffix ros. You have to actively select the available option in the Data Setup tab to process the .bl file.

By «instance», I don't mean the single scan closest to the moment the bottle is triggered. Instead, I went with the common practice (and the suggestion of the manual), which was to average the 49 scans from 0-2 s from the trigger time, therefore setting scan range offset=0 s, scan range duration=2 s, in the Data Setup tab.

Data inspection

Next, I inspected the data using Run > SeaPlot to inform me on specific needs for advanced processing. I focused on profiles of pressure against temperature and conductivity sensors which, alongside Temperature-derived Salinity plots, indicated major problems with any one of these sensors (e.g., spikes). I also examined turbidity profiles with depth, since we used turbidity as a diagnostic for the plume depth throughout the cruise.

Advanced processing

As previously mentioned, data processing was limited to prescribed practices, especially those listed for this platform on p. 20 of the manual. I conducted the following processing steps, all found under the Run menu option.

Filter

Applied a low-pass filter (0.15 s) on the pressure data only,

Align CTD

Advanced oxygen measurements by 4 s, due to the relative temperatures and pressures we sampled at (see p. 85 for details). Note that the suggested correction for conductivity (0.073 s) is automatically performed during the cast.

Cell thermal mass

Both conductivity sensors were corrected by a=0.03 and 1/b=7

Loop Edit

This routine flagged backward travel, especially the soak depth data, but also various stationary periods, in order to eliminate clusters of scans in the profiles. I used a minimum velocity of 0.1 m/s and a soak depth of 10 m (min=5 m, and max=20 m). Loop edit very effectively flagged very large spikes in all sensors at the surface (0-10 m).

Wild edit

This routine was used to flag isolated spikes on the fluorescence and turbidity data, as shown in the table below. It is not meant to substitute any smoothing techniques that are left at your discretion when you decide how to explore and plot these profiles.

Cast/ CTD #	Parameter	Standard dev., 1st pass	Standard dev., 2nd pass	Scans/block	Times performed
2/003	Turbidity	2	10	500	1
3/004	Turbidity	2	7	500	1
4/006	Turbidity	2	7	500	2
5/007	Turbidity	2	7	500	2
6/008	-	-	-	-	-
7/009	Turbidity, Chl *a*	2	10	500	1
8/010	-	-	-	-	-
9/011	Turbidity	2	10	500	1
10/012	Turbidity	2	10	500	1
11/014	Turbidity, Chl *a*	2	7	500	2
12/015	Turbidity, Chl *a*	2	7	500	2
13/016	-	-	-	-	-
14/017	Turbidity	2	7	500	1
15/018	Turbidity, Chl *a*	2	10	500	2
16/019	Turbidity	2	7	500	1
17/020	-	-	-	-	-
18/021	-	-	-	-	-

Derived parameters

Run > Derive was used to append the following derived parameters to each scan, including thermodynamic parameters using EOS-80 definitions:

- Depth (m),
- Practical salinity (psu; EOS-80) for both temperature-conductivity sensor-pairs,
- Density (sigma-t) for both temperature-conductivity sensor-pairs,
- Potential temperature (^{o}C; ITS-90) for both temperature-conductivity sensor-pairs.

Derived TEOS-10 parameters

Run > Derive TEOS-10 was used to append to each scan thermodynamic parameters derived using the new TEOS-10 definitions:

- Absolute salinity (g kg^{-1}; EOS-80) for both temperature-conductivity sensor-pairs,
- Density (kg m^{-3}) for both temperature-conductivity sensor-pairs,
- Potential temperature (^{o}C; ITS-90) for both temperature-conductivity sensor-pairs.

Note that latitude and longitude, which are necessary for the calculation of TEOS-10 parameters, manually, are acquired from the prescribed navigation device and incorporated in the header (NMEA latitude and longitude) at the time of its generation (beginning of cast).

Downcast and upcast data files

The routine at Run > Split divides the data in the .cnv file into downcast and upcast .cnv files, that bear the same file name as the original .cnv file but are preceded by d and u, respectively (the original .cnv file is preserved).

Binning

The downcast .cnv files were binned using the Run > Bin Average ... routine by depth at a bin size of 1 (m) while excluding flagged scans. The word «Binned» was appended to the saved file name. These binned files were created to enable quick and straight-forward plotting of the main parameters of interest during the cruise. Again, these data are not smoothed or groomed in any fashion, but they allow us a first glimpse at broader patterns when viewed side-by-side.

Bottle-associated sensor data

The routine Run > Bottle Summary generates a data file with the suffix btl, that includes averages and standard deviations of all original sensor parameters from the first 2 seconds after triggering a bottle.

Unfortunately, the same calculations are not possible for many derived parameters, such as TEOS-10 absolute salinity or density. Therefore, a simple Matlab routine was written to extract averages and standard deviations of all original sensor parameters and derived parameters from the first 2 seconds (49 scans) after triggering each bottle. These data were introduced into the MS Excel spreadsheet FK140626_SampleandDataLog.xlsx, which can be found in:

PublicData > LoihiCruise > CTD > CompletedCTDlogs.

Location of processed data files

All the data files generated by SBEDataProcessing can be found at:

PublicData > LoihiCruise > CTD > SBE911CTDsensorData

Each folder is named after our cast number and the CTD deployment number, e.g., Cast8_CTD010, and it contains:

- The four (4) .cnv files: one complete data set, a downcast set (prefix d), an upcast set (prefix u), and a binned downcast set (see sections 0, 0, and 0),
- The .ros file (see section 0),
- The .btl file (see section 0).

In addition, the MS Excel spreadsheet FK140626_SampleandDataLog.xlsx, which can be found in PublicData > LoihiCruise > CTD > CompletedCTDlogs, contains all the bottle relevant sensor reading averages and standard deviations for every bottle of every cast, so that you can easily associate your measurements with sensor readings.

VI. AUV Sentry Operations

A summary of overall Sentry operations is presented here, with preliminary results presented in section VII, and a detailed operations report in Appendix III. As mentioned above, Expedition FK140626 was the first time AUV *Sentry* sailed on R/V *Falkor*, and was only integrated into the expedition plan following the catastrophic loss of HROV *Nereus* in May 2014. Teams at the Schmidt Ocean Institute, the National Science Foundation, and the Woods Hole Oceanographic Institution put forth heroic efforts to mobilize AUV *Sentry* on short notice to salvage the expedition.

Mobilization and launch and recovery procedures

The server and workshop shipping container for AUV Sentry was mounted on the aft, starboard deck of Falkor, and other supplies and equipment were loaded into spaces in the hangar shared with the science party. The AUV was secured on the aft port deck, and launch and recovery took place using a knuckle-boom crane near the aft port quarter. While clearance was limited, conducting safe launch and recoveries was not a problem. For recovery, vessel speed was matched to vehicle drift speed, and the AUV was driven toward the hull at an angle that allowed for an aft escape route, which was utilized during increased sea state ($\sim 2^{+}$ m seas). The extra day spent for dockside rehearsals and practice recoveries in open waters at the sea buoy were time well spent and likely contributed to the smooth launch and recovery series throughout the expedition.

Vehicle configuration and operability

Science sensors installed on *Sentry* during the expedition are listed in Table I. Unfortunately, optical back scatter and Eh were not working on the first several dives.

Table 1: Sentry Sensor Configuration

Sensor
APS 1540 Magnetometers (3)
Edgetech Dynamically Focused 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
IXEA PHINS
Reson Sound Velocity Probe
Koichi Nakomura EH sensor

Additionally, the Edgetech dynamically-focused sidescan sonar did not collect any useable data during the entire expedition. Aside from these problems, the vehicle performed quite well leading to the production of high-quality multibeam bathymetry maps, high-quality bottom imaging, and several successful dives with sensor data from the optical backscatter and Eh instruments.

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.

AUV Data

Both Chief Scientist Glazer and *Schmidt Ocean Institute* received copies of all *Sentry* data (3TB) at the end of the expedition. Sentry cruise data is organized into a number of directories. The top level directory structure contains the directories:

- dives- All raw and processed data from individual dives
- docs- Documents pertaining to the cruise such as launch positions and dive statistic summaries
- planning- Files pertaining to mission planning. These are not generally needed by science
- planning-bathy- This is the bathymetry provided by science for planning purposes
- plots- Auto-generated plots from the post processing pipeline
- products- The best at sea derived data products from the cruise
- raw-usbl- Log and configuration files from the Sonardyne USBL system
- svp- Sound velocity profiles used during the cruise

The products directory contains a directory for each dive in the format sentryxxx. Most data products include a time and date stamp in the file name. For images that is the time the image was taken, for all other products that is the time of the renavigation process and can be matched to other files created with the same navigation. Within each dive directory the following directories are included:

• blueview- This contains any data products created from the blueview sonar. Note that products are not normally created even if that sonar is installed and this directory is often empty

• hf-S8S- This directory contains data products generated from the 410kHz sidescan sonar system. Note that for a particular survey it is typical to have only HF or LF products, not both.

• 1£-88s- This directory contains data products generated from the 120kHz sidescan sonar system. Note that for a particular survey it is typical to have only HF or LF products, not both.

• multibeam- This directory contains the data products from Sentry's multibeam sonar including grd and pdf files. Most users will want to use the file
where X is the grid size. If _nav_ is included in the file name this means that mbnavadjust was applied. This is not common but if available these files are probably preferred to others.

• photos- This directory contains thumbnails and movies of the photos collected by Sentry. Full resolution photos can be found in the dives directory.

• sbp- This directory contains the products from the sub-bottom profiler.

• scc- SCCs are 1Hz ASCII files containing post processed navigation and selected other science data. The timestamps on the SCCs can be matched to other data products.

This flat ASCII file contains the date, time, latitude, longitude, depth, pressure, conductivity, temperature, optical backscatter, Nakamura redox probe (if available), and data from all three magnetometers (if installed). The file name contains both the dive number and the date on which the scc file was generated. If there are multiple sec files for a single dive, *use the file with the most recent date.* All fields in the scc file have been interpolated onto a 1 second time base. Users wanting to load the data into Matlab should use the mat files in the nav-sci directory.

The dives directory contains the raw and intermediate data for each dive. Within the dives directory there will be a directory for each dive labeled as sentryxxx. Typically there will also be a directory labeled pre-cruise that contains assorted data from tests conducted prior to the first dive. Within each dive directory the following directories exist:

• blueview- This directory contains the raw data from the blueview sonar if installed and active

• multibeam- We provide the raw and processed data in several formats. The most common products used by our scientific collaborators are 2D plots (pdf, ps, pug) and gridded bathymetry in GMT-compatible grd files and asc files for input into other GIS tools. The gridded data has been edited using our automated scripts and the soundings geolocated using our post-processed navigation. MB-system or Caris tools can be used by the client to hand-edit soundings, however our automated scripts work well. We also provide the edited data in fbt format, which can be imported directly to Fledermaus for griding and display. The structure of this directory is:

multibeam
raw --- raw s7k files
proc --- all mbsystem files and inputs
ppl --- vehicle naVigation data
timing_test (optional) --- separate directory used to compute or check timing

• nav-sci- This directory contains all of the navigation, science, and engineering data logged by the vehicle during the dive. Most of this data is provided for archival purposes only - the sec files provide all standard sensor and vehicle navigation data. Users wishing to load data into Matlab, can use the mat files in /proc. The structure of this directory is:

nav-sci
proc
rall
acomm --- log files from WHOI micro-modem if installed
topside-nay --- topside tracking data
dvlsend --- rall subsea dvl files
me --- mission controller files
nay --- raw vehicle navigation data

rov --- raw science sensor and engineering data in ASCII files

dvlnav --- legacy topside tracking data - generally no longer present

• photos-We provide images in several fonnats with different levels of processing. These include the raw bayer encoded (color) tif files directly from the camera real-time software should users choose to reprocess those images. We also provide automated processing for color compensation and equalization. Filenames include date and time and can be used in conjunction with the see to obtain information on vehicle state and scientific sensors. The photos are stored in the following directory structure:

photos

rall --- Bayer encoded original images

proc --- color corrected and unsharped color tif photos

movie - contains movies in .ogb and .mp4 formats

thumbnails --- reduced resolution jpgs of each processed image

Presently, Sentry takes photos during the planned camera surveys and in the event that the dive ends with a photo survey, also during the ascent. Thus there will be photos of the water column.

• sss-sbp- All of the data from Sentry's sub--bottom profiler and sidescan sonar. We provide the raw and processed Edgetech sonar data. These data are processed using commercial software 'SonarWiz5' developed by Cheasepeake Inc. into which the raw sonar files (.jsf) are imported. The software generates a project directory structure, associated files and populates the directories for each sonar data set processed. For each dive, there is a folder containing the raw data Usf) files, the navigated data files and a SonarWiz project sub-directory for each processed sonar (LF=120kHz, HF=420kHz, SBP=Chirp Subbottom).

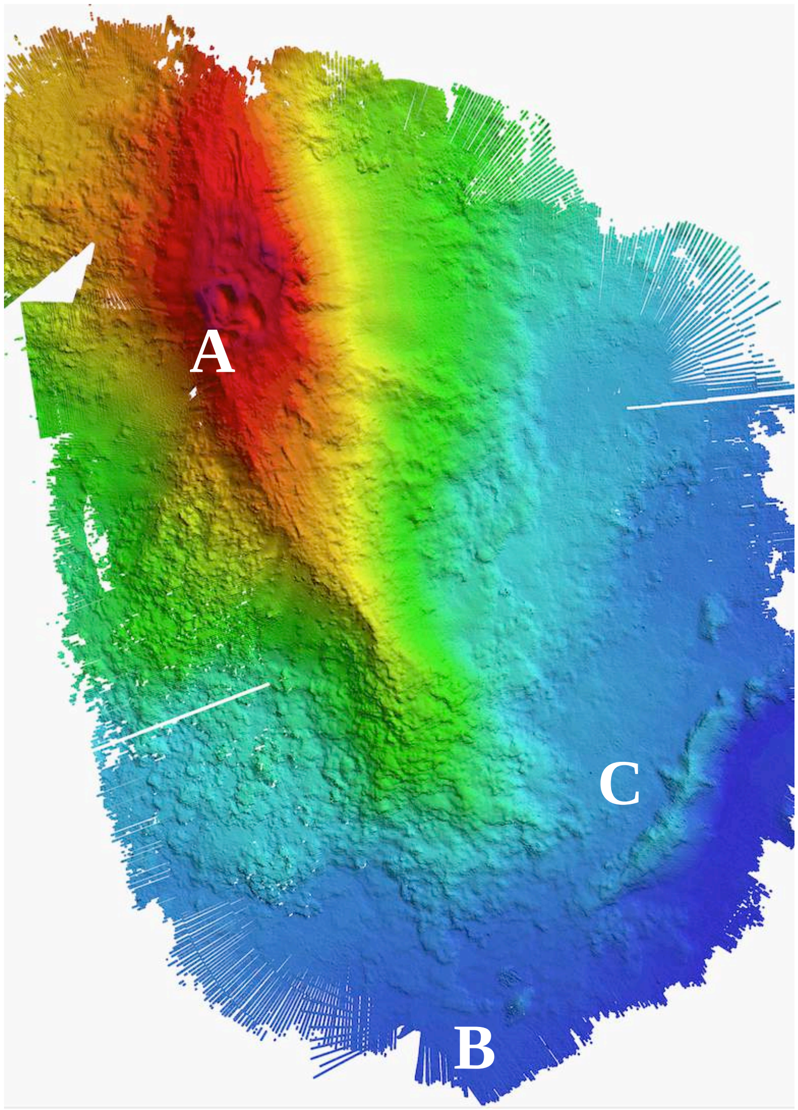


Figure 6 – Bathymetric overview of Loihi Seamount generated during FK140626. Primary work areas were (A) Loihi Seamount Summit, (B) FeMO Deep, (C) Shinkai Deep.

VII. Scientific Research Objectives and Achievements

Overview

R/V *Falkor* Expedition_FK140626 sailed to Loihi Seamount, Hawaii to study deep-sea hydrothermal processes at three distinct sites associated with the hot spot volcano (Figure 6). As mentioned above, our original plan aimed to use CTD hydrocasts and HROV *Nereus* on a

31-day expedition with deployments to: (i) quantify chemical transformations in the Loihi Summit hydrothermal dispersing plume, (ii) map and photo-image the extent of novel, cold (~0.2^{o}C above ambient) iron-oxidizing microbial mat deposits found at ~5000m, (iii) map and photo-image the relatively unexplored, warm (~6^{o}C above ambient) microbial mats found at ~4700m, and (iv) recover instruments and samplers deployed in the mats in 2013 and collect fresh microbial mat samples from deep and summit sites alike. With the unexpected loss of the *Nereus* vehicle in May 2014, we modified our expedition plan to use CTD hydrocasts to focus on understanding the hydrothermal plume dispersing from the Loihi Summit, and to use AUV *Sentry* to focus on obtaining high-resolution acoustic maps and bottom images of the areas surrounding the intriguing iron-oxidizing bacterial mats discovered at the FeMO Deep and Shinkai Deep sites. Over the course of our 12-day expedition we successfully tackled objectives (i) – (iii) listed above. During transits between the seamount summit and base, we also conducted multibeam bathymetry mapping to take advantage of *Falkor*'s superior shipboard multibeam mapping capabilities.

Hydrothermal dispersing plume

We conducted 18 CTD hydrocasts, 16 of which were focused upon understanding the distribution and biogeochemical transformations of iron and carbon in the Loihi Summit dispersing plume. Loihi's summit area is home to actively venting hydrothermal sources that are rich in iron, and low in sulfide, and because the summit intersects the oxygen minimum zone, limiting oxidation and precipitation, the potential exists for widespread delivery of iron from Loihi to the Pacific Ocean.

In addition to the Seabird sensor data collected on the Rosette package, we deployed a self-contained multi-parameter data logger (RBR, Inc. *Maestro*) on each CTD hydrocast to complement the rosette sensor dataset with additional measurements. The RBR added measurements for ORP and pH, and duplicated measurements for O_2, temperature, conductivity, and pressure. RBR datasets were downloaded upon each CTD rosette recovery, and rapid plotting of pH and ORP profiles helped inform discrete depths to target on subsequent casts (e.g., Figure 7). All Seabird and RBR sensor cast profile data have been processed and are being integrated into plans for manuscripts to submit for publications describing iron and carbon dynamics in the dispersing plume. Comprehensive overview products are given in Fig. 8.

A complete listing of locations and depths for CTD hydrocasts and bottle sampling depths collected is given in *Appendix II*. Briefly, we subsampled CTD rosette bottles that were collected at varying depths bracketing the dispersing plume particle maxima. Most hydrocasts targeted between 900m and 1350m depths in the vicinity of the Loihi Summit, to achieve a high-resolution characterization of the dispersing plume. Upon return of samples to deck, Niskin bottles were pressurized using ultra-high purity Nitrogen gas cylinders for inline filtration directly from selected bottles and to limit exposure to atmospheric oxygen contamination.

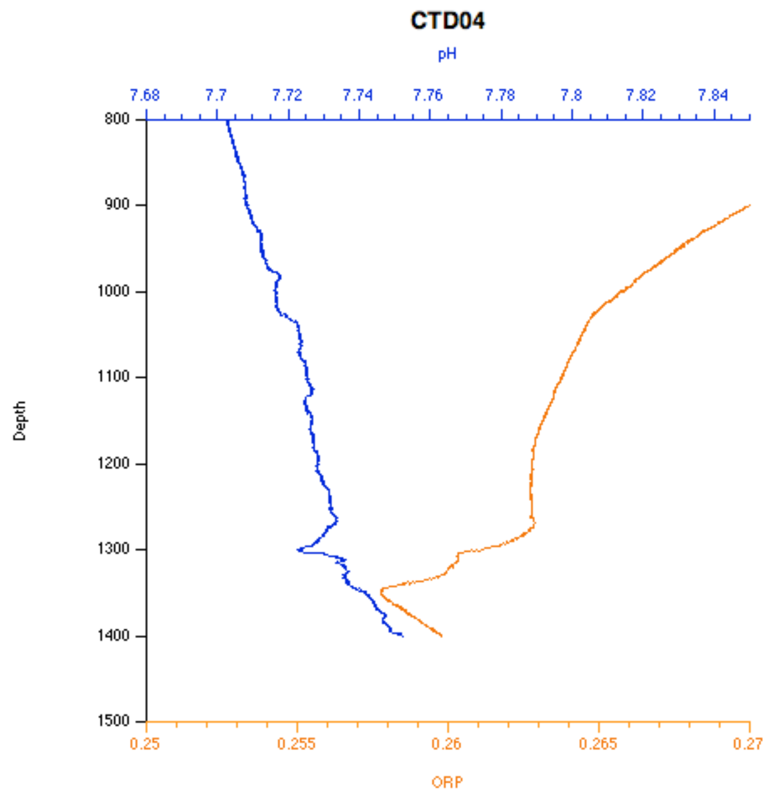
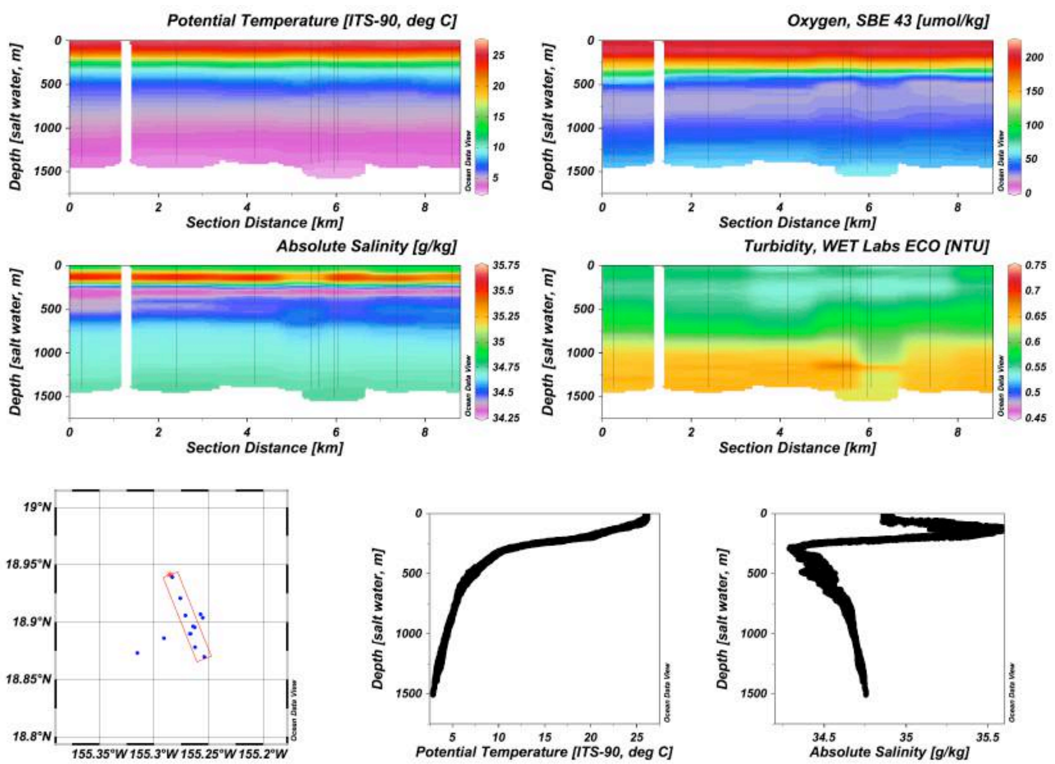
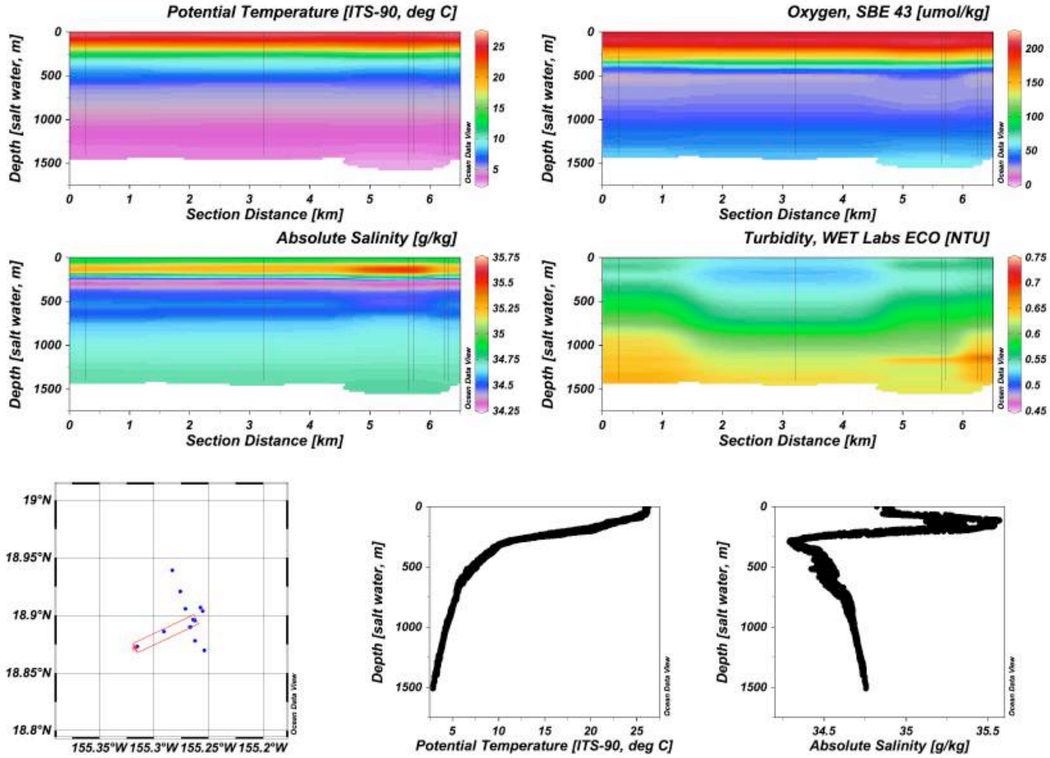


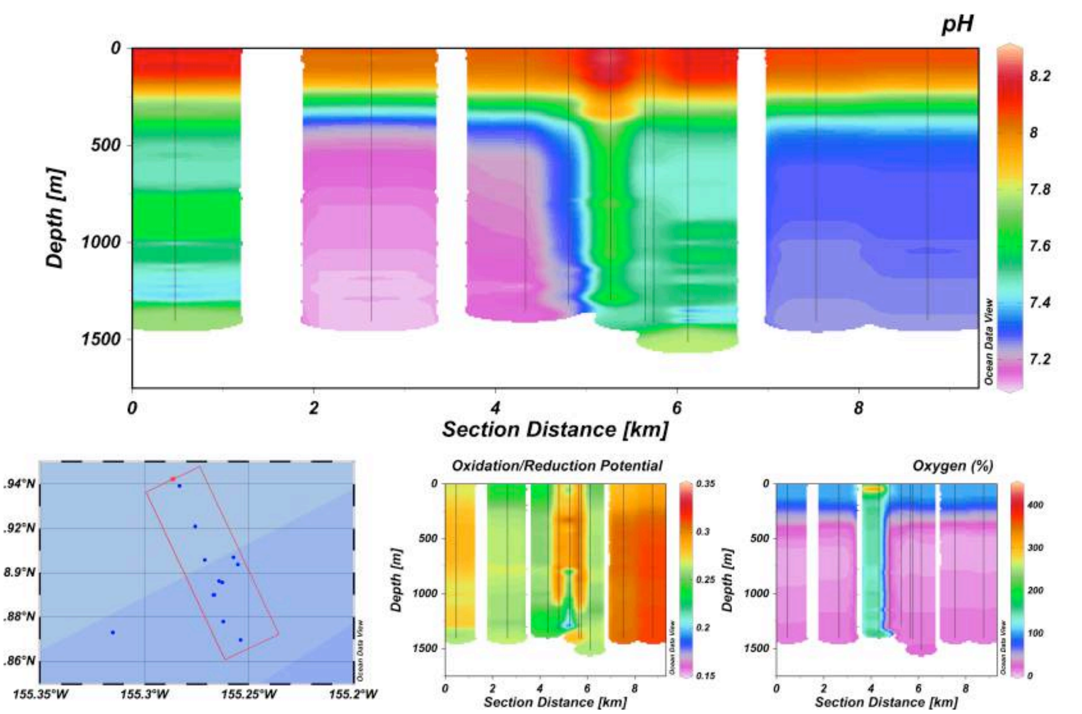
Figure 7 – pH and Oxidation-Reduction Potential (ORP) profiles collected on CTD Hydrocast 04 revealed anomalies associated with the dispersing hydrothermal plume at 1300m to 1350m, and informed specific depths to collect bottle samples on Casts-05, -06, -07.

A manifest of hydrocast subsamples is provided in *Appendix II*. Briefly, samples were processed with a prioritization for iron species, and methods to limit contamination were employed. Subsamples were collected from every sampled depth for analyses of total iron via particle concentration and dissolution, for total dissolved iron via sequential injection analysis lab on a valve, and for inorganic nutrients. Subsamples were collected for Total Organic Carbon (TOC), Dissolved Organic Carbon (DOC), total iron, total dissolved iron, and particulate iron on CTD hydrocasts -02, -07, -11, -14, -15, and -18. Subsamples were collected for measuring dissolved iron ligands via competitive ligand exchange-adsorptive cathodic stripping voltammetry (CLE-ACSV) on CTD hydrocasts -02, -07, -11, -14, -15, -18. Additional subsamples were collected for measuring soluble ligands (additionally filtered at 0.02um via cross-flow filtration) on CTD hydrocasts -02, and -07. Total iron and total dissolved iron measurements have been analyzed, other samples are awaiting laboratory analyses, all will be integrated into plans for manuscripts to submit for publication.

Figure 8 (*below and following page*) – Overview spatial contour plots of CTD rosette and RBR Maestro sensor data for all plume mapping casts, as analyzed in Ocean Data View.




Potential Temperature [ITS-90, deg C]
Oxygen, SBE 43 [umol/kg]
Absolute Salinity [g/kg]
Turbidity, WET Labs ECO [NTU]
Depth [salt water, m]
Section Distance [km]
Ocean Data View
19°N
18.95°N
18.9°N
18.85°N
18.8°N
155.35°W 155.3°W 155.25°W 155.2°W


pH
Depth [m]
Section Distance [km]
Ocean Data View
Oxidation/Reduction Potential
Oxygen (%)
155.35°W
155.3°W
155.25°W
155.2°W

Seafloor AUV exploration

Seafloor hydrothermal activity at mid-ocean ridges (MOR) is one of the fundamental processes known to control the exchange of heat and chemical species between seawater and ocean rocks, but there is increasing evidence that off-axis vent fields and sea mounts may also significantly affect biogeochemical cycles and oceanic elemental budget. As part of the ROV *Jason-II* expedition series funded by the NSF Iron-oxidizing Microbial Observatory (K. Edwards lead PI, 2006-2010), Glazer, Edwards, Rouxel and colleagues discovered the FeMO Deep site at the base of Loihi Seamount in 5,000m TWD. FeMO Deep is characterized by laterally extensive (100's of m^2), massive Fe-oxyhydroxide deposition, with no detectable hydrothermal fluid flux to overlying seawater. No vents, chimneys, shimmering waters or plumes have been discovered. Preliminary mineralogical, morphological, and biological evidence indicates that neutrophilic iron-oxidizing bacteria (FeOB) are largely responsible for the Fe-oxyhydroxide deposition that results in formation of laterally extensive, Fe-rich microbial mat ecosystems. Laterally extensive iron deposits at FeMO Deep likely formed from hydrothermal fluids that are enriched in Fe, Mn, and Si and that have cooled and mixed with seawater in the subsurface. The extensive mat fields at FeMO Deep differ significantly from the flocs and mats found at the more widely studied Loihi summit sites (1,000m) associated with actively venting fluids. There is no obvious advective expression of hydrothermal fluids at FeMO Deep, and there is only a 0.2^oC higher temperature difference within the FeMO Deep mats compared with background seawater. Loihi summit sites exhibit actively venting fluids up to 30^oC. The mat field at FeMO Deep is massive, with nearly continuous thick (up to 2m) coverage of at least $4,000m^2$, while mats at the summit are thin (<10cm) and are closely associated with shimmering, venting hydrothermal fluids.

In 2013, during a single ROV *Jason-II* dive, confirmation was made of similar microbial mat iron oxide deposits ~9km NE of FeMO Deep, at a site herein named Shinkai Deep. Again, no shimmering fluids or vents were discovered, but iron oxide flocs were up to 6ºC above ambient bottom water. **AUV operations during FK140626 were aimed at providing as much high-resolution multibeam sonar bathymetry maps of the vicinities surrounding FeMO Deep and Shinkai Deep to inform future ROV-based expeditions that would be capable of surveying and sampling mats, rocks, and any venting fluids. Sentry**

operations during FK140626 successfully expanded by over five-fold our coverage area of high-resolution bathymetry data at the base of Loihi Seamount, producing high-quality maps of FeMO Deep (Figure 9), Shinkai Deep (Figure 10), an interesting ridge feature to the east of Shinkai Deep (Figure 11), and interesting topography to the southwest of Shinkai Deep (Figure 12).

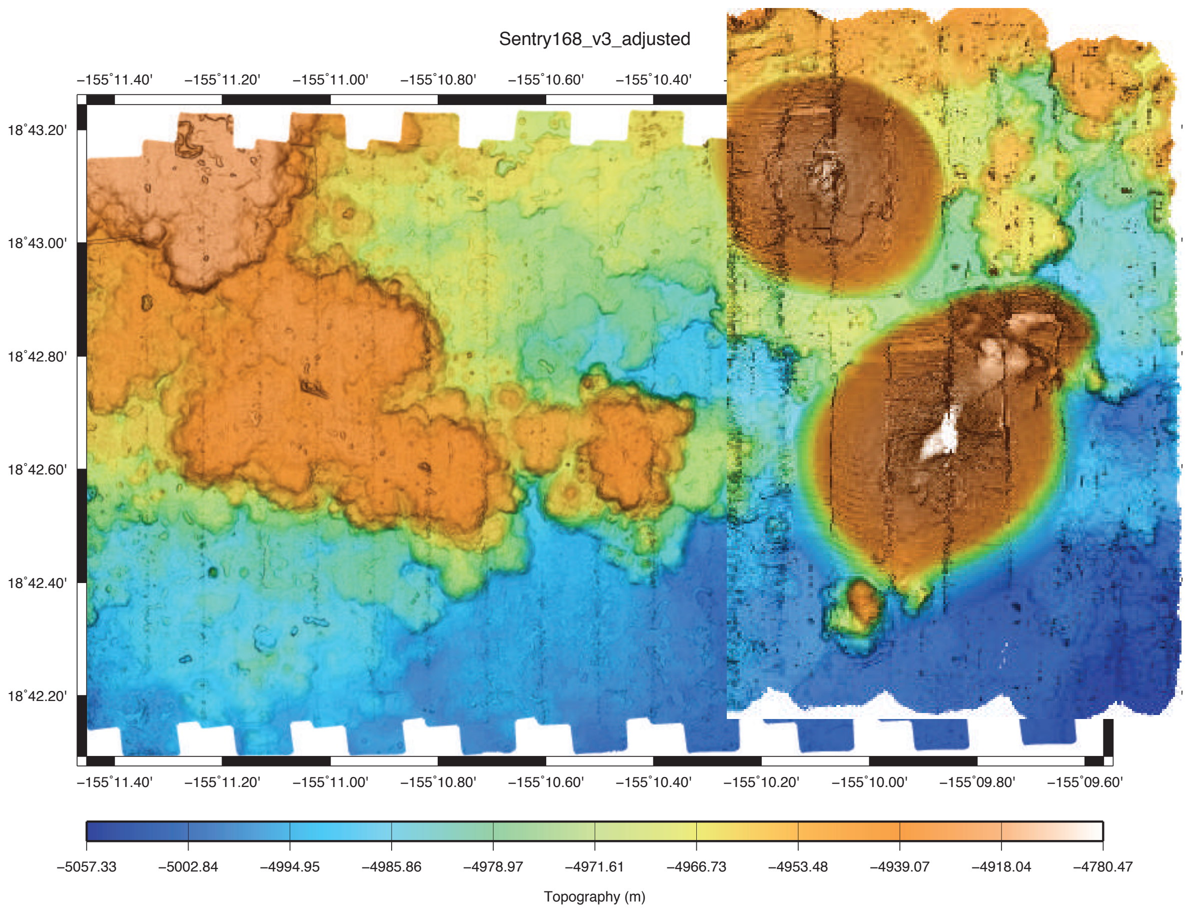


Figure 9 –Multibeam sonar bathymetry map of the FeMO Deep mats area and adjacent basalt features. Map is merged from three AUV *Sentry* dives, nav adjusted (*Sentry*-168 and *Sentry*-264, and *Sentry* 265).

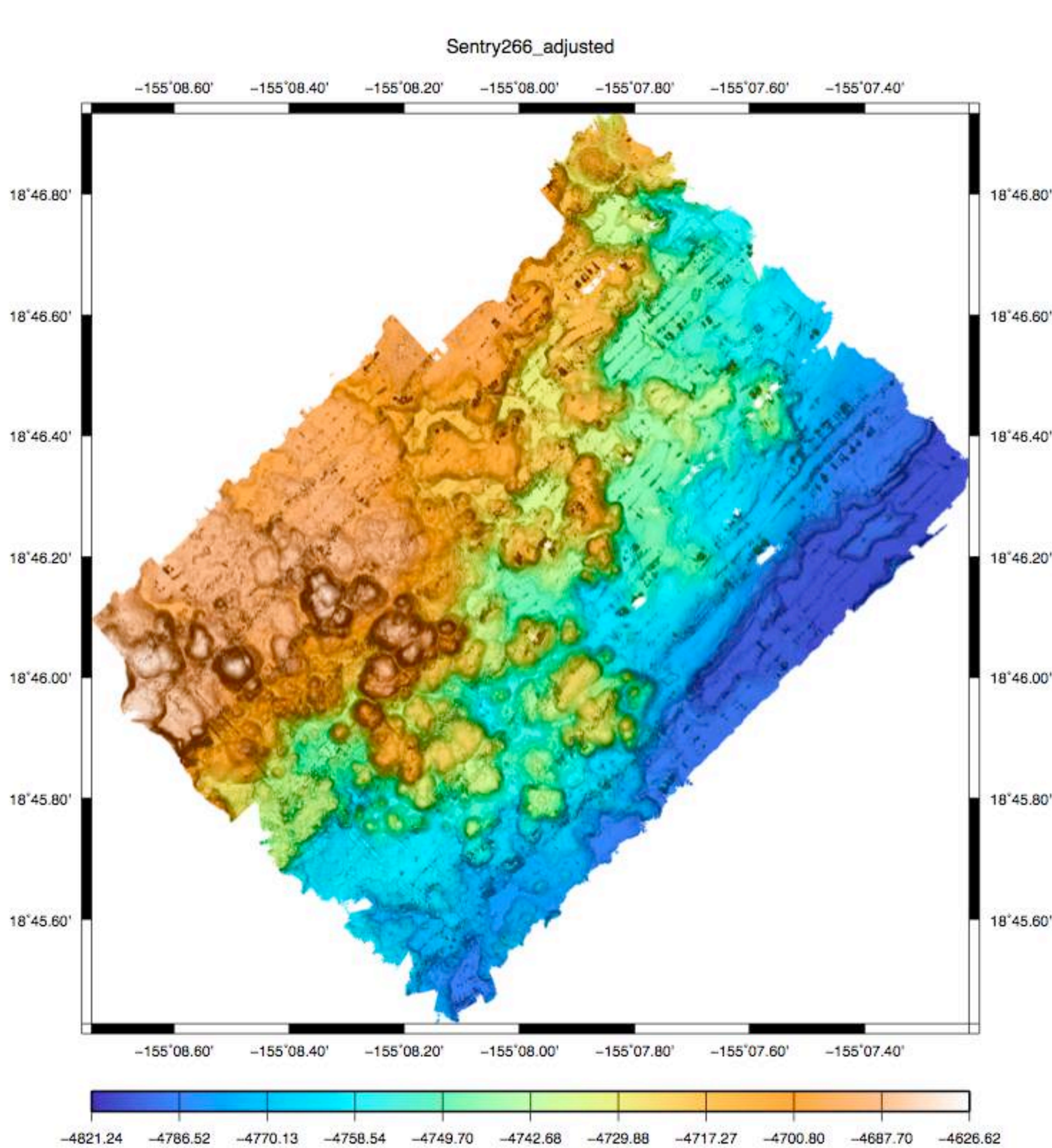


Figure 10 –Multibeam sonar bathymetry map of the Shinkai Deep area and adjacent basalt features. Map is a product of *Sentry*-266.

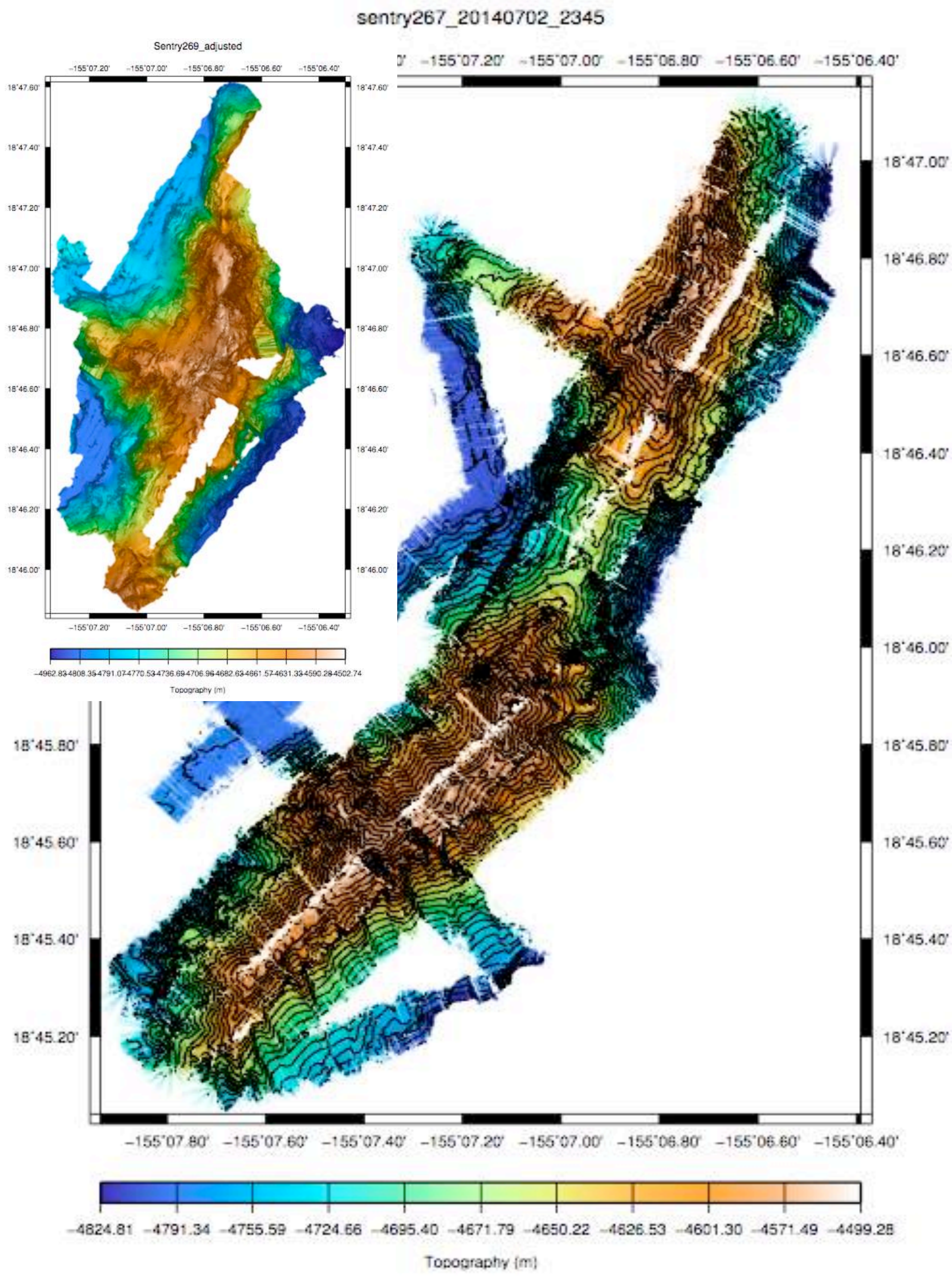


Figure 11 – Multibeam sonar bathymetry map of the ridge feature to the east of Shinkai Deep. Map is a product of *Sentry*-267. Inset is a higher resolution map of the northern summit of the longer ridge feature (product of *Sentry* 269).

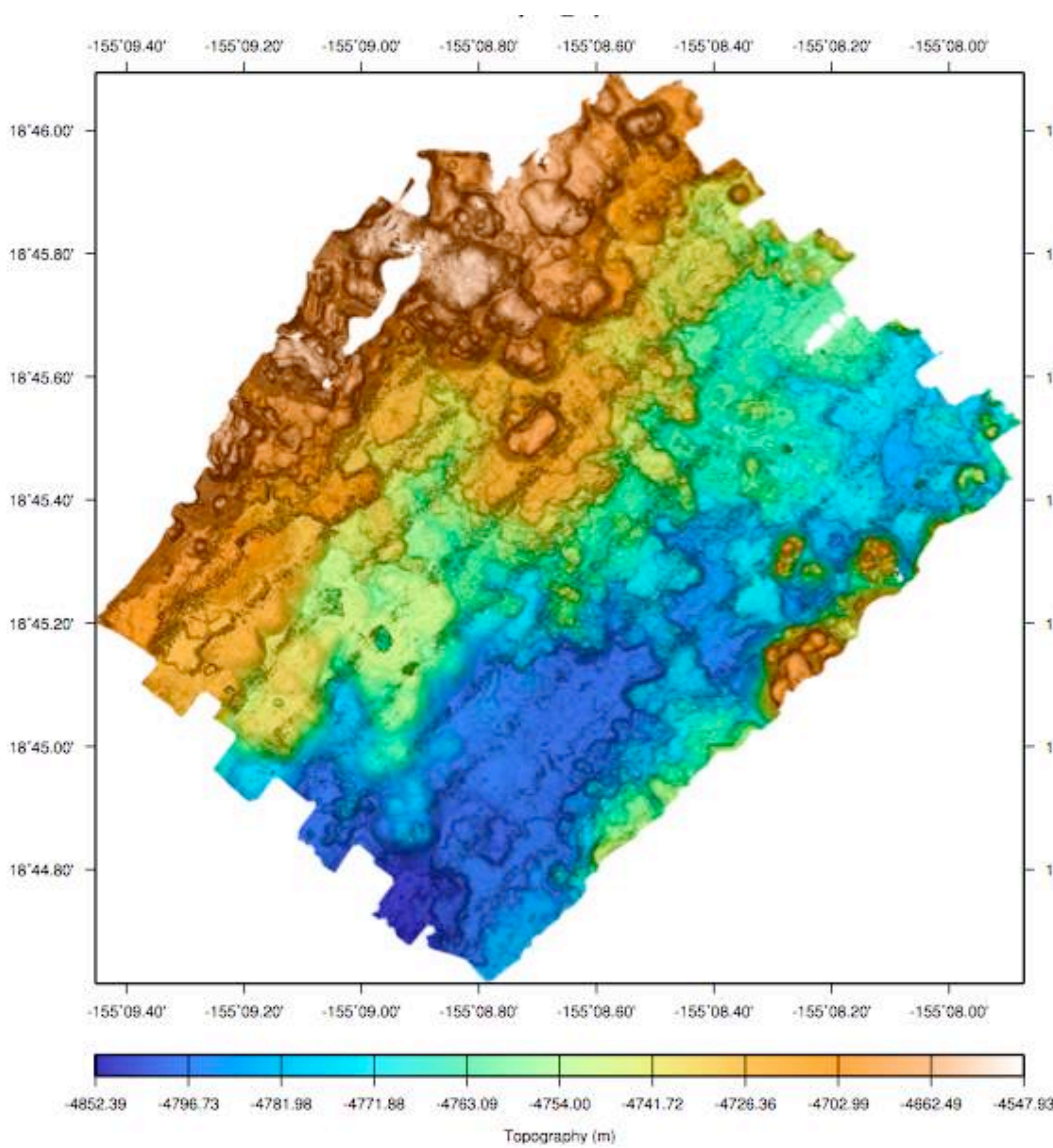


Figure 12 - Multibeam sonar bathymetry map of the basin and adjacent basalt features to the SW of Shinkai Deep. Map is a product of *Sentry*-270.

In addition to providing high-resolution wide coverage bathymetry maps using multibeam sonar, Sentry collected over 30,000 photo images of selected subsets of seafloor. All photos have been viewed to date. While no definitive visual evidence for venting was obvious in the photos, many images provide intriguing incentive to revisit the area with an ROV for seafloor chemical profiling, exploration, and sampling. Two sample images are given in Figures 13 and 14.

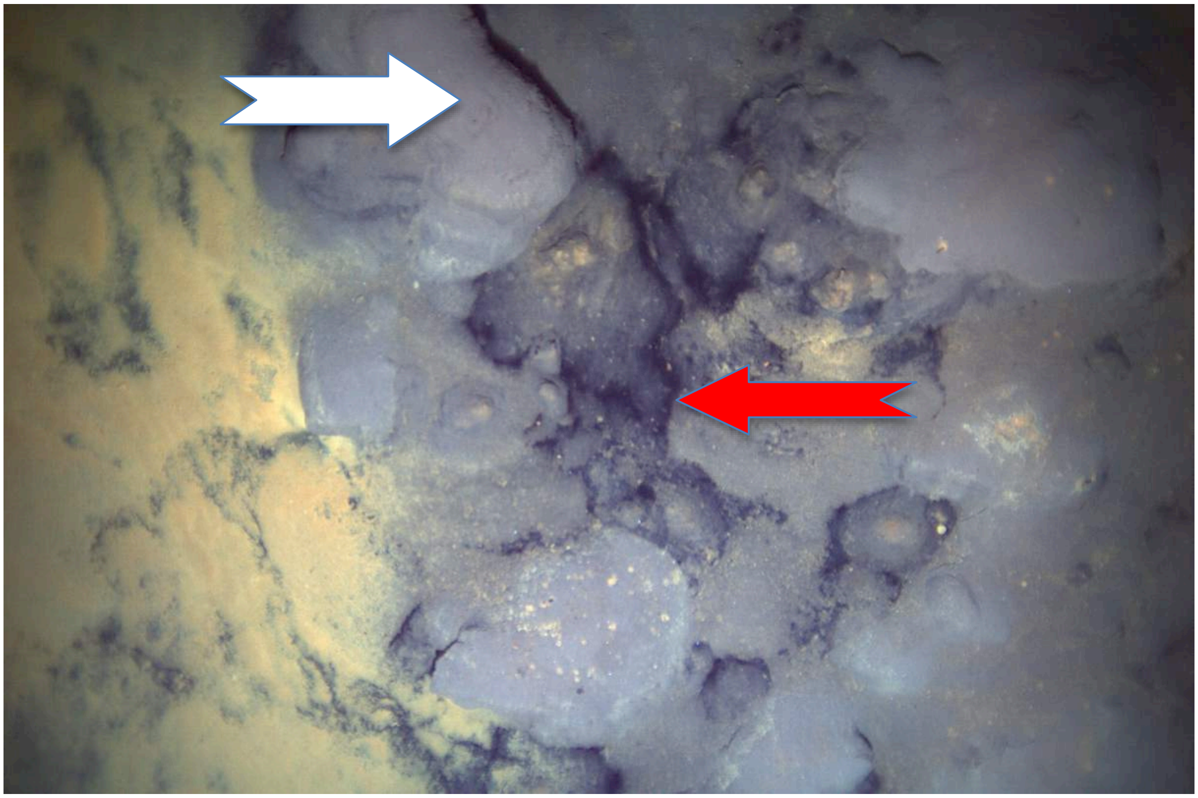


Figure 13 – Bottom-looking photo collected by AUV *Sentry* during Dive 265 at the FeMO Deep microbial mat field. Collected at a depth of 4981m, from an altitude of 4m, the field of view is approximately 1.5m, and depicts aged, gray, pillow basalts (white arrow), thin gray & black ferro-manganese oxide crusts (red arrow), and yellow iron oxides produced by iron-oxidizing bacterial mats that underlie the ferro-manganese oxide crust. Some pools of mats have been measured at >1m deep, containing >100uM Fe(II) (Edwards et al. 2011).

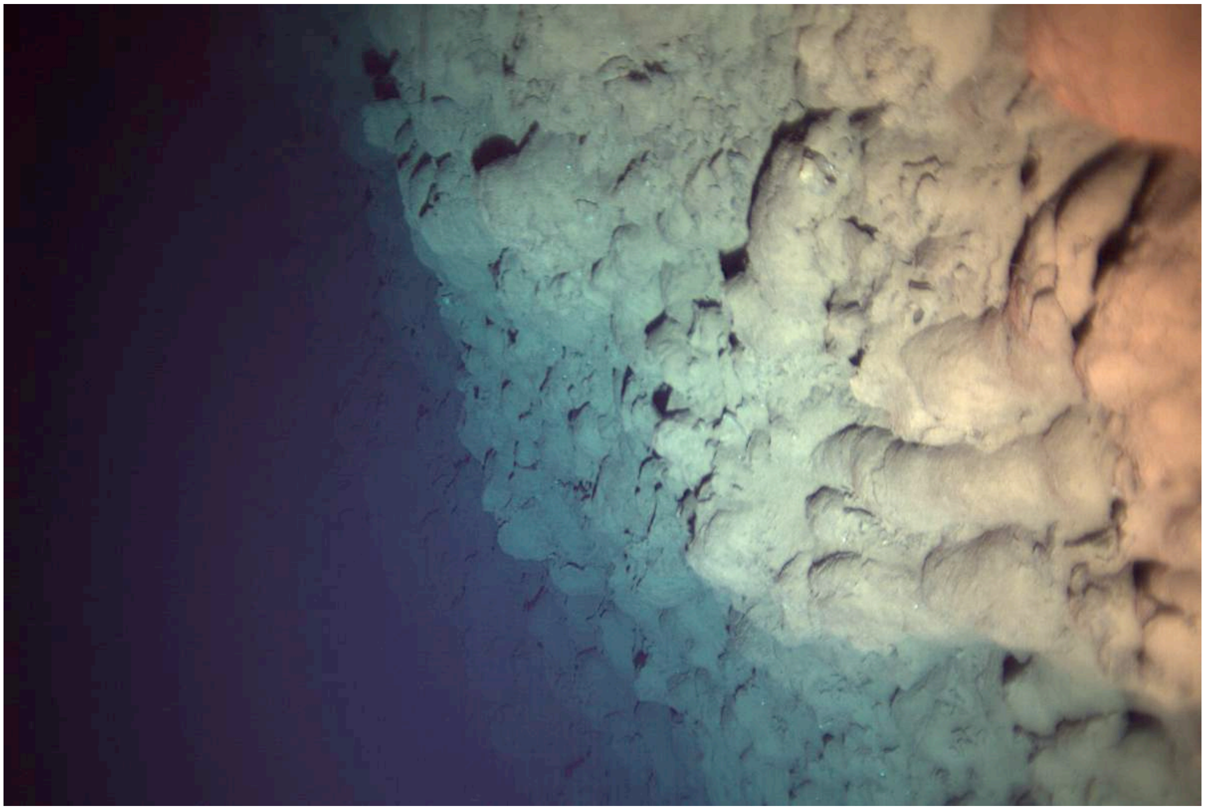


Figure 14 – Bottom-looking photo collected by AUV Sentry during Dive 270 in the vicinity of the ridge-like feature to the east of the Shinkai Deep microbial mat field (18.763, -155.143). Collected at a depth of 4657m, the field of view spans a steep basalt wall >10m high.

Finally, while AUV multibeam surveys produce excellent high-quality bathymetry maps that are useful for identifying geologic features and interfaces, multibeam cannot detect the difference between sediment and FeMO Deep style microbial flocs. While bottom-imaging photo surveys can indicate likely areas of microbial flocs, conducting photo surveys is time-consuming, and can only cover limited areal coverage on a given dive. Therefore, another objective for AUV acoustic operations was to test a new dynamically-focused sidescan system to investigate if FeMO Deep style mat systems are detectable using acoustic techniques. Unfortunately, the DF sidescan system did not collect any useable or interpretable data during the expedition.

VIII. Acknowledgements

Primary support for this expedition, in the form of all support for the R/V *Falkor* and AUV *Sentry*, came from a Joint Project Agreement between the *Schmidt Ocean Institute* and the University of Hawaii, with UH obligations carried out by expedition PI and chief scientist, B.T. Glazer. It is noteworthy, however, that SOI operates as a facility provider, with financial support going to WHOI for Sentry operations, but no funds provided for research activities, scientific achievements, or participation of any of the scientific party aboard ship or processing post-cruise analyses. Further, much of the federal research support originally planned to leverage this expedition in the form of collecting and processing seafloor samples collected by HROV *Nereus* became unavailable when the HROV was lost at sea. Many collaborators were still committed to the work and participated on the expedition, and are following up with sample analyses using other highly leveraged funds from a variety of sources and awards including, but not limited to:

NSF Division of Ocean Sciences OCE-1061827 (B. Glazer)
NSF Division of Ocean Science OCE-1354000 (B. Glazer)
NSF Division of Ocean Science OCE-1031947 (B. Glazer)
NSF Division of Ocean Science OCE-1235101 (C. Measures)
Labex Mer grant ANR-10-LABX-19-01 (O. Rouxel)
Faculty Development Grant, University of Minnesota-Twin Cities (B. Toner)

We also thank Captain H. Volz and the officers and crew of the R/V *Falkor* on this first attempt to support AUV *Sentry* on a 24h/day deep-ocean research expedition. We especially acknowledge marine technicians Leighton Rolley, Peter Keen, and James Cooper who provided a superb level of support and coordination for our science operations, and Carlie Wiener who provided world-class coordination and leadership in outreach endeavours. Additionally, AUV expedition leader Dana Yoeger and the *Sentry* team performed with excellence, triumphing over unpredictable challenges and going beyond expectations to deliver results.

Appendices

Appendix 1 -- Event Log for R/V Falkor FK140626

Task	Effort	Start	End
• 1) FK140626 Underway for Sentry LARS tests	7.5h	6/25/14, 8:00 AM	6/25/14, 3:30 PM
• 2) USBL Calibration	12.75h	6/25/14, 7:30 PM	6/26/14, 8:15 AM
• 3) CTD01 (Sound Velocity; -157 28.82, 20 46.48)	1h	6/26/14, 6:30 AM	6/26/14, 7:30 AM
• 4) Transit HNL to Loihi	16h	6/26/14, 8:15 AM	6/27/14, 12:15 AM
• 5) CTD02 (-155 15.318, 18 54.227; 1329m TWD)	< 2.75h	6/27/14, 1:16 AM	6/27/14, 4:00 AM
• 6) Shipboard MB, Transit to FeMO Deep	4h	6/27/14, 4:15 AM	6/27/14, 8:15 AM
• 7) Sentry 264 (-155.1772833, 187144767)	< 8.25h	6/27/14, 9:00 AM	6/27/14, 5:10 PM
• 8) Shipboard MB, Transit to Summit	2.5h	6/27/14, 5:15 PM	6/27/14, 7:45 PM
• 9) CTD03 (-155 16.013, 18 53.394; 1926m TWD)	< 2.75h	6/27/14, 7:52 PM	6/27/14, 10:30 PM
• 10) Shipboard MB, Transit to FeMO Deep	2.5h	6/27/14, 10:45 PM	6/28/14, 1:15 AM
• 11) Sentry 265 (-155 8.243, 18 46.683)	< 22.75h	6/28/14, 1:15 AM	6/28/14, 11:59 PM
• 12) Transit to Summit	1.5h	6/29/14, 12:30 AM	6/29/14, 2:00 AM
• 13) CTD04 (-155.28367, 18.939050; 1777m TWD)	< 2.75h	6/29/14, 2:20 AM	6/29/14, 5:00 AM
• 14) CTD05 (-155.2762, 18.9100; 1400m TWD)	< 2.5h	6/29/14, 6:00 AM	6/29/14, 8:25 AM
• 15) CTD06 (-155.2711167, 18.9058167; 1667m TWD)	> 2.25h	6/29/14, 9:13 AM	6/29/14, 11:33 AM
• 16) CTD07 (-155 15.9898, 18 53.3981; 1923m TWD)	> 2h	6/29/14, 12:32 PM	6/29/14, 2:37 PM
• 17) Shipboard MB, Transit to Shinkai Deep	2.5h	6/29/14, 3:00 PM	6/29/14, 5:30 PM
• 18) Sentry 266 (-155 8.243, 18 46.683)	24.75h	6/29/14, 6:00 PM	6/30/14, 6:45 PM
• 19) Transit to Summit	1.5h	6/30/14, 6:45 PM	6/30/14, 8:15 PM
• 20) CTD08 (-155 15.7272, 18 52.6637; 1907m TWD)	< 3.25h	6/30/14, 9:00 PM	7/1/14, 12:10 AM
• 21) CTD09 (-155 15.2161, 18 52.1863; 1992m TWD)	2.75h	7/1/14, 1:00 AM	7/1/14, 3:45 AM
• 22) CTD10 (-155 15.4532, 18 54.4153; 1330m TWD)	> 2.25h	7/1/14, 4:54 AM	7/1/14, 7:15 AM
• 23) Shipboard MB, Transit to Shinkai Deep	3.5h	7/1/14, 7:15 AM	7/1/14, 10:45 AM
• 24) Sentry 267	25h	7/1/14, 11:00 AM	7/2/14, 12:00 PM
• 25) Transit to Summit	1h	7/2/14, 12:15 PM	7/2/14, 1:15 PM
• 26) CTD11 (-155.290, 18.886; 3000m TWD)	4h	7/2/14, 1:30 PM	7/2/14, 5:30 PM
• 27) CTD12 (-155.315, 18.873; 3675m TWD)	4h	7/2/14, 5:30 PM	7/2/14, 9:30 PM
• 28) CTD13 (-155.264, 18.897; 1510m TWD)	4h	7/2/14, 9:30 PM	7/3/14, 1:30 AM
• 29) CTD14 (same; -155.264, 18.897; 1510m TWD)	4h	7/3/14, 1:30 AM	7/3/14, 5:30 AM
• 30) Transit to Shinkai Deep	1h	7/3/14, 5:30 AM	7/3/14, 6:30 AM
• 31) Sentry 268 (TBD, near Ridge-No.)	7.25h	7/3/14, 6:30 AM	7/3/14, 1:45 PM
• 32) Shipboard MB	2h	7/3/14, 1:45 PM	7/3/14, 3:45 PM
• 33) CTD15 (Shinkai Deep)	4.75h	7/3/14, 3:45 PM	7/3/14, 8:30 PM
• 34) Sentry 269	21.5h	7/3/14, 9:00 PM	7/4/14, 6:30 PM
• 35) Shipboard MB, Transit to Summit	1.5h	7/4/14, 6:30 PM	7/4/14, 8:00 PM
• 36) CTD16 (-155.290, 18.886; 3000m TWD)	2h	7/4/14, 8:50 PM	7/4/14, 10:50 PM
• 37) CTD17 (-155.290, 18.886; 3000m TWD)	> 2.25h	7/4/14, 11:10 PM	7/5/14, 1:30 AM
• 38) CTD18 (-155.290, 18.886; 3000m TWD)	2.75h	7/5/14, 3:00 AM	7/5/14, 5:45 AM
• 39) Shipboard MB, Transit to near Shinkai	1.5h	7/5/14, 6:00 AM	7/5/14, 7:30 AM
• 40) Sentry 270	22.25h	7/5/14, 7:45 AM	7/6/14, 6:00 AM
• 41) Transit to HNL	< 18h	7/6/14, 6:00 AM	7/6/14, 11:54 PM
• 42) Dock and Unload at Snug	8.5h	7/7/14, 8:30 AM	7/7/14, 5:00 PM

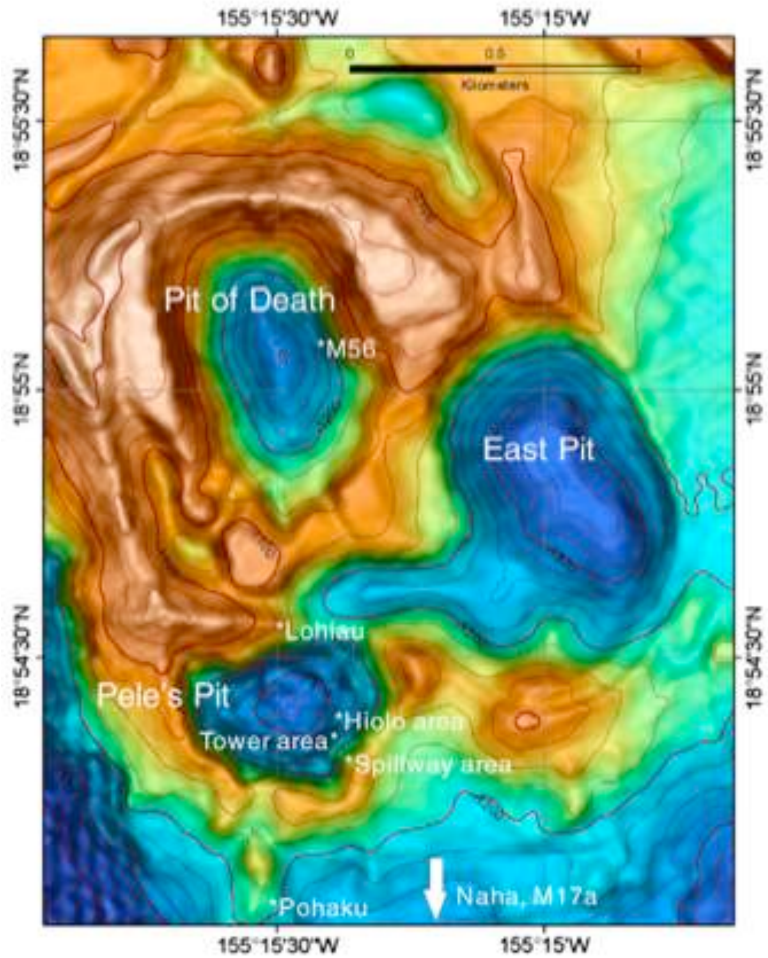
Appendix 2 -- CTD Hydrocasts

CTD 01 – Test Cast

Brief functionality test cast outside Honolulu Harbor, no samples collected.

CTD 02 – Pele's Pit

-155.2553, 18.9038, 1329m TWD; 27 June 2014 11:49 (GMT)



Cast Instructions:

Monitor altimeter & TWD; slow descent at ~50m off bottom, stop at ~3m off bottom, hold position 10 minutes for thermistor chain; come up ~10m/min to target bottle depths; hold 10 minutes after tripping final bottle for thermistor chain.

Bottle Depths:

1300m, 1160m, 1110m, 1058m, 806m (see spreadsheet for bottle #'s)

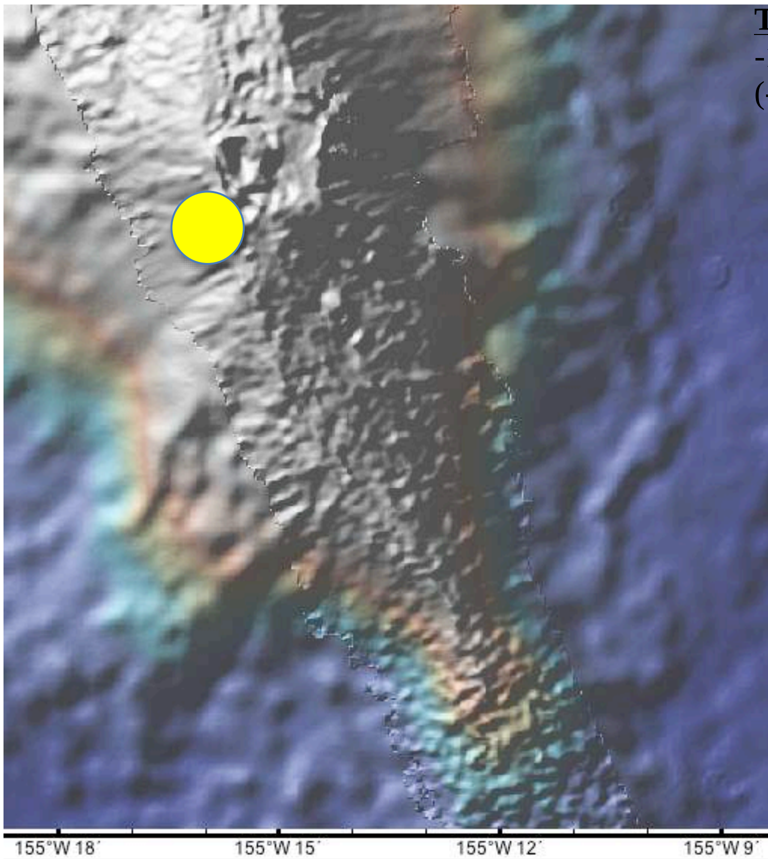
Thermistors:

+9" (Antares 1854510yellow); +18" (RBR 015778white); +24" (RBR Concerto); +42" (Antares 1854508green); +62" (Antares 1854509red)

CTD 02 – Pele's Pit Bottle Data

Bottle #	Depth (m)	Time (GMT)	Temperature 1 (deg C)	O2 (umol/L)	Turbidity (NTU)	Potent. Temp. 1 (deg C)
1	1286.3	11:49:02	3.8986	44.357	0.726	3.7985
2	1288.1	11:49:06	3.8978	44.234	0.732	3.7975
3	1287.4	11:49:09	3.8985	44.391	0.738	3.7982
4	1287.1	11:49:12	3.8986	44.348	0.739	3.7983
5	1150.2	12:08:11	3.9545	43.559	0.732	3.8657
6	1150.1	12:08:14	3.9556	43.612	0.738	3.8668
7	1149.5	12:08:17	3.9640	43.366	0.731	3.8751
8	1150	12:08:19	3.9617	43.436	0.734	3.8728
9	1149.1	12:08:25	3.9614	43.143	0.735	3.8726
10	1099.2	12:14:56	4.0426	41.960	0.699	3.9574
11	1101.2	12:14:59	4.0460	41.948	0.697	3.9606
12	1098.6	12:15:03	4.0440	41.954	0.702	3.9588
13	1100.3	12:15:05	4.0461	41.997	0.697	3.9608
14	1100.3	12:15:10	4.0458	41.923	0.702	3.9605
15	1049.7	12:22:07	4.2452	40.011	0.656	4.1626
16	1050.5	12:22:10	4.2376	40.102	0.656	4.1550
17	1050.1	12:22:12	4.2431	40.354	0.649	4.1605
18	1048.8	12:22:15	4.2557	39.937	0.643	4.1731
19	1051.4	12:22:17	4.2244	40.177	0.648	4.1418
20	800.36	12:51:18	5.3250	25.953	0.639	5.2569
21	799.8	12:51:20	5.3299	26.065	0.647	5.2619
22	799.56	12:51:23	5.3299	25.931	0.638	5.2619
23	799.97	12:51:25	5.3276	25.899	0.641	5.2596
24	800.04	12:51:27	5.3274	26.042	0.646	5.2594

CTD 03 – Plume Mapping



Target: 28 June 2014 06:44 GMT
-155.2669°, 018.8899 °, 1941 TWD
(-155° 16.014', 18° 53.394')

Cast Instructions: This cast takes place at the midpoint of a NE-SW historical tow-yo. Descend rosette to 1500m, trip bottles on ascent.

Target Bottle Depths:

24 depths, 1 bottle per depth between 1300m & 900m (see spreadsheet for bottle #'s)

Thermistors: RBR multiparameter logger

CTD 03 – Plume Mapping

Bottle #	Depth (m)	Time (GMT)	Temperature 1 (deg C)	O2 (umol/L)	Turbidity (NTU)	Potent. Temp. 1 (deg C)
1	1375.2	6:44:34	3.2188	57.110	0.635	3.1179
2	1325.7	6:48:36	3.3540	51.442	0.640	3.2559
3	1300	6:51:10	3.3902	50.933	0.644	3.2938
4	1274.8	6:53:09	3.4517	50.387	0.644	3.3569
5	1250.7	6:55:33	3.6033	49.146	0.649	3.5091
6	1229.9	6:57:25	3.6833	47.870	0.656	3.5901
7	1220.1	6:59:33	3.7011	47.536	0.661	3.6086
8	1205.8	7:02:03	3.7122	47.389	0.653	3.6208
9	1190.6	7:04:40	3.7552	46.619	0.670	3.6647
10	1174.7	7:07:19	3.7974	45.976	0.679	3.7078
11	1161.4	7:09:59	3.8751	44.476	0.698	3.7861
12	1145.1	7:12:46	3.9232	43.676	0.683	3.8351
13	1131.4	7:15:16	3.9894	42.583	0.657	3.9019
14	1114.7	7:18:03	3.9968	42.551	0.647	3.9107
15	1100.6	7:20:25	4.0509	41.074	0.646	3.9655
16	1084	7:23:03	4.1146	40.721	0.649	4.0301
17	1060.5	7:26:29	4.1406	40.691	0.652	4.0579
18	1034.8	7:30:04	4.2249	40.043	0.651	4.1438
19	1009.1	7:33:38	4.2858	39.559	0.641	4.2064
20	984.44	7:36:53	4.3909	37.514	0.637	4.3128
21	960.09	7:40:21	4.4266	36.341	0.638	4.3504
22	930.82	7:44:41	4.6214	34.760	0.643	4.5464
23	900.54	7:48:45	4.7562	31.869	0.640	4.6829
24	675.55	7:57:40	5.7068	27.832	0.640	5.6481

CTD 04 through 07 – Plume Mapping Series

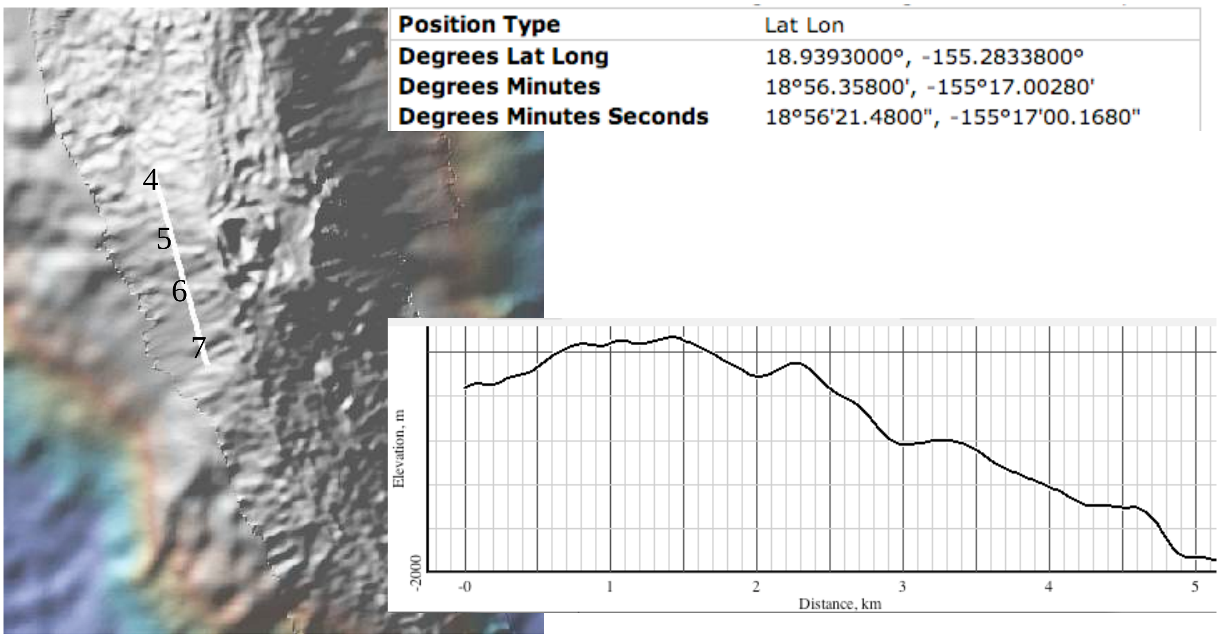
29 June 2014 14:10 GMT start

(4) 155.28338, 18.9393, 1585m TWD; pH/Eh$_{-BG}$, Fe$_{tot-OR}$, Fe$_{tot-GW}$, pH$_{-AW}$, Nuts$_{-KF}$

(5) 155.2762, 018.9210; 1468m TWD; pH/Eh$_{-BG}$, Fe$_{tot-OR}$, Fe$_{tot-GW}$, pH$_{-AW}$, Nuts$_{-KF}$

(6) 155.2716, 018.9054; 1693m TWD; pH/Eh$_{-BG}$, Fe$_{tot-OR}$, Fe$_{tot-GW}$, pH$_{-AW}$, Nuts$_{-KF}$

(7) 155.2669, 018.8899, 1941 TWD; all sampling & analyses



<u>Cast Instructions:</u> *These casts are a series of three (estimated) short vertical profiles to take advantage of Turbidity, Eh, & pH in situ data, and limited wet chem analyses to resolve the overall plume dispersion; the final cast in the series will be near the location of CTD 03, unless in situ data show a particle max farther north, and that cast will be fully processed for all wet chem.* Fast down to 800m, then slow downcast at ~10m/min from 800 – 1400m for high-resolution sensor data; make note of Turbidity max, target 5 depths for bottles on upcast.

<u>Target Bottle Depths:</u>

(see spreadsheets for bottle #’s)

<u>Loggers:</u> only RBR multiparameter logger on this cast

CTD 04

Bottle #	Depth (m)	Time (GMT)	Temperature 1 (deg C)	O2 (umol/L)	Turbidity (NTU)	Potent. Temp. 1 (deg C)
1	1350.2	14:10:09	3.4372	50.663	0.650	3.3361
2	1350.3	14:10:15	3.4377	50.648	0.646	3.3366
3	1351.2	14:10:22	3.4369	50.742	0.658	3.3357
4	1349.9	14:10:31	3.4384	50.613	0.641	3.3373
5	1223.4	14:24:57	3.9378	44.387	0.655	3.8428
6	1223.6	14:25:04	3.9373	44.259	0.655	3.8423
7	1223.1	14:25:10	3.9383	44.351	0.654	3.8433
8	1222.2	14:25:18	3.9373	44.230	0.650	3.8424
9	1183.9	14:28:35	4.0311	42.062	0.649	3.9386
10	1183.4	14:28:42	4.0310	42.079	0.650	3.9386
11	1183.7	14:28:49	4.0317	42.053	0.645	3.9393
12	1183.1	14:28:55	4.0316	41.870	0.653	3.9392
13	1160.7	14:30:59	4.0437	41.662	0.654	3.9531
14	1160.9	14:31:05	4.0437	41.443	0.654	3.9531
15	1160.5	14:31:12	4.0467	41.659	0.656	3.9561
16	1160.7	14:31:18	4.0483	41.561	0.652	3.9577
17	1121.6	14:34:14	4.1016	40.855	0.659	4.0140
18	1120.6	14:34:19	4.1032	40.864	0.647	4.0156
19	1121.3	14:34:24	4.1077	40.829	0.653	4.0201
20	1121.9	14:34:31	4.1119	41.003	0.665	4.0242
21	1002.3	14:39:48	4.4088	37.376	0.649	4.3290
22	1002.8	14:39:59	4.4099	37.384	0.652	4.3301
23	1003.1	14:40:05	4.4105	37.389	0.648	4.3307
24	1002.8	14:40:13	4.4119	37.327	0.652	4.3321

CTD 05

Bottle #	Depth (m)	Time (GMT)	Temperature 1 (deg C)	O2 (umol/L)	Turbidity (NTU)	Potent. Temp. 1 (deg C)
1	1350.2	17:36:59	3.4372	50.663	0.650	3.3361
2	1350.3	17:37:07	3.4377	50.648	0.646	3.3366
3	1351.2	17:41:36	3.4369	50.742	0.658	3.3357
4	1349.9	17:41:43	3.4384	50.613	0.641	3.3373
5	1223.4	17:45:52	3.9378	44.387	0.655	3.8428
6	1223.6	17:45:59	3.9373	44.259	0.655	3.8423
7	1223.1	17:46:07	3.9383	44.351	0.654	3.8433
8	1222.2	17:46:19	3.9373	44.230	0.650	3.8424
9	1183.9	17:48:31	4.0311	42.062	0.649	3.9386
10	1183.4	17:48:38	4.0310	42.079	0.650	3.9386
11	1183.7	17:48:44	4.0317	42.053	0.645	3.9393
12	1183.1	17:48:51	4.0316	41.870	0.653	3.9392
13	1160.7	17:50:19	4.0437	41.662	0.654	3.9531
14	1160.9	17:50:25	4.0437	41.443	0.654	3.9531
15	1160.5	17:50:32	4.0467	41.659	0.656	3.9561
16	1160.7	17:50:39	4.0483	41.561	0.652	3.9577
17	1121.6	17:52:53	4.1016	40.855	0.659	4.0140
18	1120.6	17:53:00	4.1032	40.864	0.647	4.0156
19	1121.3	17:53:07	4.1077	40.829	0.653	4.0201
20	1121.9	17:53:19	4.1119	41.003	0.665	4.0242
21	1002.3	17:58:26	4.4088	37.376	0.649	4.3290
22	1002.8	17:58:33	4.4099	37.384	0.652	4.3301
23	1003.1	17:58:41	4.4105	37.389	0.648	4.3307
24	1002.8	17:58:48	4.4119	37.327	0.652	4.3321

CTD 06

Bottle #	Depth (m)	Time (GMT)	Temperature 1 (deg C)	O2 (umol/L)	Turbidity (NTU)	Potent. Temp. 1 (deg C)
1	1350.9	20:45:59	3.2737	55.536	0.650	3.1743
2	1350.9	20:46:02	3.2739	55.593	0.651	3.1745
3	1351.1	20:46:05	3.2738	55.659	0.651	3.1744
4	1350.5	20:46:09	3.2740	55.709	0.642	3.1746
5	1220.4	20:53:25	3.5806	50.153	0.656	3.4892
6	1220.3	20:53:29	3.5806	50.184	0.652	3.4892
7	1220	20:53:32	3.5812	49.973	0.661	3.4898
8	1220	20:53:35	3.5812	50.167	0.655	3.4898
9	1180.3	20:58:51	3.6671	48.788	0.654	3.5782
10	1179.8	20:58:54	3.6666	48.554	0.656	3.5778
11	1179	20:58:56	3.6667	48.581	0.649	3.5780
12	1179.8	20:58:58	3.6670	48.643	0.653	3.5782
13	1159.8	21:01:23	3.7384	46.262	0.655	3.6507
14	1159.4	21:01:25	3.7385	46.486	0.655	3.6508
15	1159.3	21:01:27	3.7391	46.512	0.653	3.6514
16	1160.1	21:01:29	3.7404	46.175	0.652	3.6526
17	1119.1	21:04:54	3.9493	42.340	0.648	3.8632
18	1119.1	21:04:57	3.9493	42.416	0.655	3.8632
19	1119.5	21:04:59	3.9473	42.519	0.655	3.8612
20	1119.5	21:05:02	3.9476	42.500	0.650	3.8614
21	998.27	21:11:18	4.3850	37.168	0.654	4.3058
22	999.04	21:11:20	4.3863	37.168	0.654	4.3070
23	999.98	21:11:22	4.3874	37.201	0.658	4.3080
24	998.53	21:11:25	4.3872	37.372	0.653	4.3080

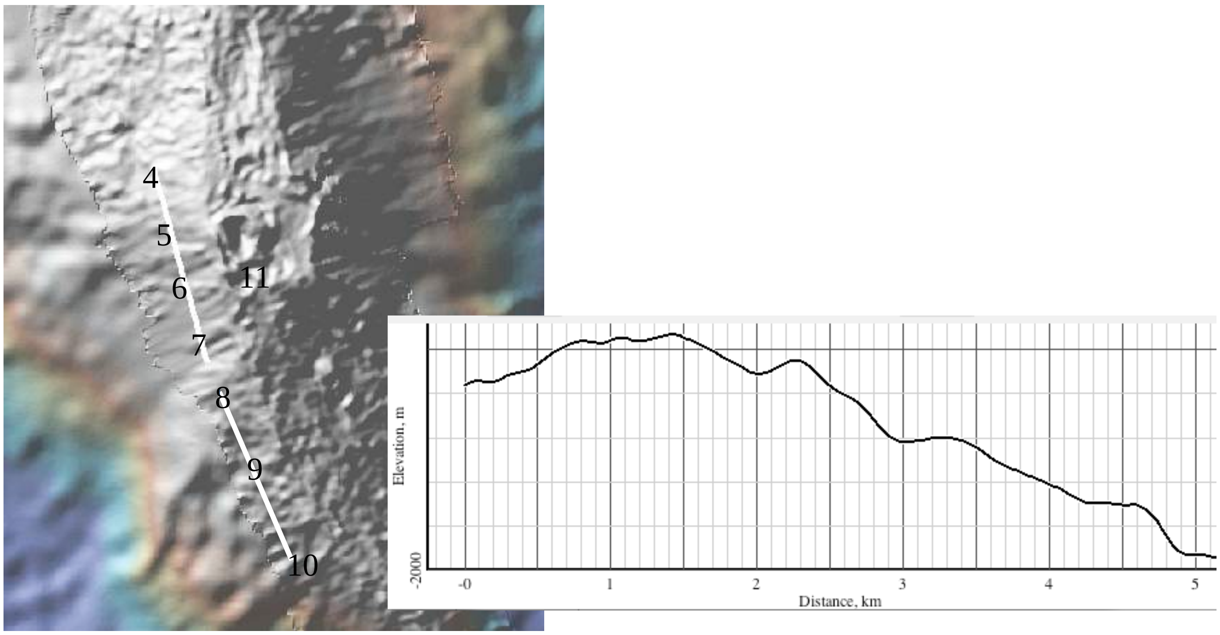
CTD 07

Bottle #	Depth (m)	Time (GMT)	Temperature 1 (deg C)	O2 (umol/L)	Turbidity (NTU)	Potent. Temp. 1 (deg C)
1	1350.5	23:35:52	3.3721	52.022	0.636	3.2717
2	1349.6	23:35:55	3.3707	51.854	0.630	3.2704
3	1350.9	23:35:57	3.3722	52.108	0.631	3.2718
4	1349.5	23:36:00	3.3716	52.031	0.638	3.2713
5	1200.8	23:43:19	3.7505	47.143	0.653	3.6592
6	1199.8	23:43:21	3.7512	47.032	0.656	3.6599
7	1199.5	23:43:24	3.7511	47.002	0.653	3.6599
8	1200.4	23:43:26	3.7504	46.989	0.656	3.6591
9	1200.8	23:43:29	3.7505	46.978	0.648	3.6592
10	1170.9	23:47:40	3.8482	45.228	0.662	3.7585
11	1171.1	23:47:42	3.8494	45.040	0.668	3.7597
12	1170.3	23:47:45	3.8555	44.955	0.671	3.7658
13	1170.7	23:47:47	3.8539	45.027	0.663	3.7642
14	1171.5	23:47:50	3.8494	45.286	0.670	3.7597
15	1120.6	23:51:18	4.0242	40.827	0.641	3.9374
16	1119.8	23:51:21	4.0292	40.842	0.643	3.9423
17	1120.1	23:51:24	4.0282	40.916	0.633	3.9413
18	1120.1	23:51:26	4.0296	40.856	0.650	3.9427
19	1119.7	23:51:29	4.0274	40.856	0.641	3.9406
20	1000.1	23:57:48	4.4080	37.021	0.638	4.3285
21	1000.5	23:57:50	4.4086	36.799	0.644	4.3290
22	1001	23:57:52	4.4085	37.213	0.643	4.3289
23	999.38	23:57:54	4.4091	37.084	0.647	4.3296
24	998.49	23:57:57	4.4088	36.922	0.647	4.3294

CTD 08 through 10 – Plume Mapping Series

Targets: 1 July 2014 08:57 GMT start

(8) 18^{o} 52.6644’, -155^{o} 15.7652’; TWD = 2000m; pH/Eh$_{-BG}$, Fe$_{tot-OR}$, Fe$_{tot-GW}$, pH$_{-AW}$, Nuts$_{-KF}$
(9) 18^{o} 52.1974’, -155^{o} 15.2235’;TWD = 1933m; pH/Eh$_{-BG}$, Fe$_{tot-OR}$, Fe$_{tot-GW}$, pH$_{-AW}$, Nuts$_{-KF}$
(10) 18^{o} 51.3943, -155^{o} 14.9433’, TWD = 2193m; pH/Eh$_{-BG}$, Fe$_{tot-OR}$, Fe$_{tot-GW}$, pH$_{-AW}$, Nuts$_{-KF}$



<u>Cast Instructions:</u> *These casts are a series of three (estimated) short vertical profiles to take advantage of Turbidity, Eh, & pH in situ data, and limited wet chem analyses to resolve the overall plume dispersion; the final cast before the next Sentry launch will be in Pele’s Pit, near the location of CTD 02, and that cast will be fully processed for all wet chem.* Fast down to 800m, then slow downcast at ~10m/min from 800 – 1400m for high-resolution sensor data; make note of Turbidity max, target 6 depths for bottles on upcast of 8-10, 5 depths on cast 11.

<u>Target Bottle Depths:</u>
(see spreadsheets for bottle #’s)

<u>Loggers:</u> only RBR multiparameter logger on this cast

CTD 08

Bottle #	Depth (m)	Time (GMT)	Temperature 1 (deg C)	O2 (umol/L)	Turbidity (NTU)	Potent. Temp. 1 (deg C)
1	1350.4	8:57:23	3.3850	52.943	0.644	3.2845
2	1349.9	8:57:25	3.3848	52.930	0.642	3.2843
3	1351	8:57:27	3.3841	52.740	0.652	3.2835
4	1351.2	8:57:30	3.3840	52.815	0.650	3.2834
5	1219.6	9:14:46	3.6337	48.601	0.639	3.5419
6	1220.2	9:14:49	3.6326	48.440	0.650	3.5407
7	1220.6	9:14:51	3.6313	48.446	0.647	3.5394
8	1220.3	9:14:54	3.6322	48.566	0.653	3.5403
9	1180.7	9:20:44	3.7141	48.470	0.656	3.6248
10	1179.8	9:20:50	3.7151	48.427	0.648	3.6259
11	1180.8	9:20:52	3.7128	48.292	0.652	3.6235
12	1180.1	9:20:58	3.7138	48.437	0.650	3.6246
13	1152.7	9:24:03	3.7292	48.120	0.649	3.6421
14	1151.6	9:24:06	3.7303	47.857	0.654	3.6433
15	1152.4	9:24:08	3.7304	48.264	0.649	3.6434
16	1150.8	9:24:11	3.7317	47.825	0.645	3.6447
17	1121	9:30:03	3.9553	44.863	0.650	3.8690
18	1119.2	9:30:05	3.9557	44.624	0.638	3.8696
19	1120.9	9:30:08	3.9554	44.726	0.641	3.8691
20	1120.3	9:30:10	3.9564	44.593	0.643	3.8701
21	998.66	9:45:11	4.3344	37.412	0.648	4.2556
22	999.59	9:45:13	4.3271	37.484	0.644	4.2483
23	999.86	9:45:16	4.3260	37.558	0.650	4.2471
24	997.77	9:45:18	4.3360	37.254	0.642	4.2573

CTD 09

Bottle #	Depth (m)	Time (GMT)	Temperature 1 (deg C)	O2 (umol/L)	Turbidity (NTU)	Potent. Temp. 1 (deg C)
1	1350.6	12:43:35	3.4186	52.753	0.669	3.3177
2	1350.1	12:43:41	3.4201	52.620	0.656	3.3192
3	1349.6	12:43:48	3.4203	52.453	0.647	3.3195
4	1349.1	12:43:55	3.4204	52.503	0.647	3.3196
5	1221	12:50:10	3.6397	48.642	0.657	3.5477
6	1220.2	12:50:17	3.6401	48.604	0.648	3.5481
7	1220	12:50:24	3.6402	48.764	0.657	3.5483
8	1221.6	12:50:30	3.6396	48.722	0.654	3.5475
9	1180.4	12:56:04	3.7113	47.961	0.649	3.6221
10	1180.6	12:56:10	3.7120	47.992	0.647	3.6227
11	1181.4	12:56:16	3.7130	48.056	0.662	3.6237
12	1181.8	12:56:23	3.7130	48.096	0.670	3.6236
13	1161.9	13:00:19	3.7939	46.861	0.674	3.7055
14	1162	13:00:25	3.7946	46.822	0.663	3.7062
15	1161.6	13:00:31	3.7975	46.880	0.650	3.7091
16	1161.6	13:00:41	3.7985	46.742	0.651	3.7101
17	1122.4	13:06:20	3.9723	44.700	0.658	3.8857
18	1122.3	13:06:27	3.9742	44.580	0.644	3.8876
19	1122.1	13:06:33	3.9749	44.545	0.652	3.8883
20	1122.4	13:06:41	3.9756	44.516	0.660	3.8890
21	1001.2	13:14:27	4.3089	39.937	0.650	4.2300
22	1000.9	13:14:35	4.3096	39.650	0.652	4.2308
23	999.79	13:14:42	4.3138	39.555	0.652	4.2350
24	1000.7	13:14:51	4.3131	39.590	0.656	4.2343

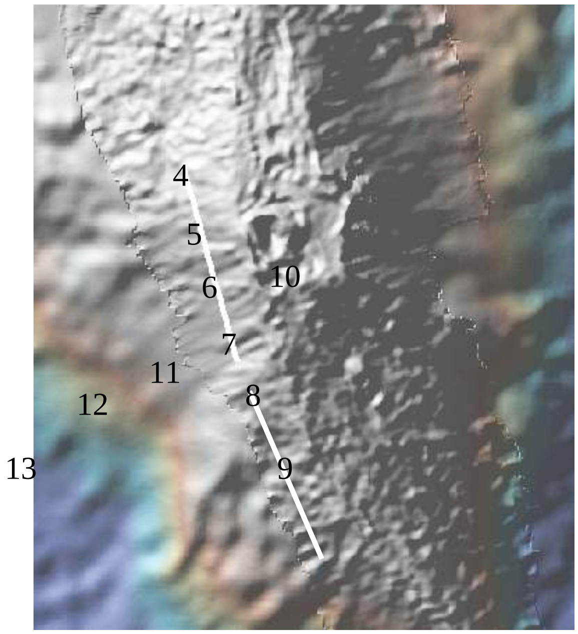
CTD 10

Bottle #	Depth (m)	Time (GMT)	Temperature 1 (deg C)	O2 (umol/L)	Turbidity (NTU)	Potent. Temp. 1 (deg C)
1	1291.7	16:23:23	3.8690	44.919	0.675	3.7687
2	1291.6	16:23:29	3.8691	44.981	0.677	3.7688
3	1291.5	16:23:37	3.8693	44.988	0.675	3.7690
4	1291.1	16:23:45	3.8698	44.972	0.680	3.7695
5	1252.1	16:28:51	3.8946	44.533	0.683	3.7975
6	1251.6	16:28:58	3.8947	44.354	0.672	3.7977
7	1251.4	16:29:05	3.8938	44.347	0.676	3.7967
8	1251	16:29:12	3.8931	44.396	0.671	3.7961
9	1201.5	16:35:10	3.9023	44.252	0.674	3.8095
10	1201.5	16:35:17	3.9103	44.050	0.669	3.8175
11	1201.3	16:35:24	3.9139	44.109	0.668	3.8210
12	1201.4	16:35:36	3.9105	44.266	0.674	3.8176
13	1201.6	16:35:45	3.8886	44.450	0.682	3.7959
14	1141.7	16:54:08	3.9825	42.851	0.698	3.8941
15	1141.9	16:54:15	3.9829	43.025	0.689	3.8946
16	1141.3	16:54:26	3.9838	42.953	0.683	3.8955
17	1141.4	16:54:33	3.9840	42.909	0.677	3.8956
18	1140	16:54:41	3.9841	42.701	0.682	3.8959
19	1140.6	16:54:54	3.9855	42.760	0.680	3.8972
20	801.64	17:12:10	5.0757	31.752	0.645	5.0091
21	801.9	17:12:21	5.0775	31.829	0.653	5.0109
22	801.12	17:12:26	5.0779	31.841	0.647	5.0113
23	802.16	17:12:30	5.0777	31.701	0.640	5.0110
24	800.49	17:12:35	5.0783	31.740	0.647	5.0118

CTD 11 through 14 – Plume Mapping Series

Targets: 3 July 2014 0:58 GMT start

(11) 18.886, -155.290; TWD = 3000m; pH/Eh_{-BG}, Fe_{tot-OR}, Fe_{tot-GW}, pH_{-AW}, $Nuts_{-KF}$
(12) 18.873, -155.315;TWD = 3675m; pH/Eh_{-BG}, Fe_{tot-OR}, Fe_{tot-GW}, pH_{-AW}, $Nuts_{-KF}$
(13) 18.860, -155.345, TWD = 3893m; pH/Eh_{-BG}, Fe_{tot-OR}, Fe_{tot-GW}, pH_{-AW}, $Nuts_{-KF}$
(14) 18.89, -155.2643; all sampling & analyses



Cast Instructions: *These casts are a series of three (estimated) short vertical profiles to take advantage of Turbidity, Eh, & pH in situ data, and limited wet chem analyses to resolve the overall plume dispersion; the final cast before the next Sentry launch will be near the location of CTD 07, and that cast will be fully processed for all wet chem.* Fast down to 800m, then slow downcast at ~10m/min from 800 – 1400m for high-resolution sensor data; make note of Turbidity max, target 12 depths for bottles on upcast of 11-13; TBD on 14.

Target Bottle Depths:

(see spreadsheets for bottle #'s)

Loggers: only RBR multiparameter logger on this cast

CTD 11

Bottle #	Depth (m)	Time (GMT)	Temperature 1 (deg C)	O2 (umol/L)	Turbidity (NTU)	Potent. Temp. 1 (deg C)
1	1350.3	0:58:02	3.4032	51.305	0.636	3.3025
2	1350.4	0:58:10	3.4072	51.491	0.637	3.3064
3	1302.2	1:01:05	3.5347	48.639	0.644	3.4368
4	1301.9	1:01:13	3.5349	48.596	0.641	3.4370
5	1281.2	1:03:40	3.5875	48.243	0.642	3.4908
6	1280.6	1:03:49	3.5898	48.222	0.651	3.4932
7	1262.1	1:06:32	3.6625	47.733	0.642	3.5668
8	1260.1	1:06:41	3.6651	47.678	0.632	3.5695
9	1240.7	1:08:55	3.7192	46.985	0.648	3.6247
10	1239.3	1:09:03	3.7174	46.876	0.642	3.6231
11	1221.1	1:11:22	3.7379	46.989	0.638	3.6449
12	1220.9	1:11:30	3.7375	47.029	0.648	3.6445
13	1199.8	1:13:41	3.7579	47.523	0.652	3.6666
14	1200.3	1:13:50	3.7581	47.594	0.635	3.6667
15	1180.1	1:15:50	3.7956	47.052	0.645	3.7057
16	1180.6	1:15:58	3.8000	46.908	0.641	3.7100
17	1159.6	1:18:24	3.8637	46.091	0.645	3.7749
18	1159.6	1:18:36	3.8655	46.183	0.641	3.7766
19	1139.4	1:20:41	3.9124	45.302	0.644	3.8248
20	1140.5	1:20:51	3.9153	45.378	0.649	3.8277
21	1120.9	1:22:57	3.9831	44.017	0.652	3.8966
22	1120.9	1:23:06	3.9835	44.038	0.644	3.8969
23	999.14	1:29:35	4.3539	38.924	0.643	4.2749
24	1000	1:29:44	4.3539	38.898	0.645	4.2748

CTD 12

Bottle #	Depth (m)	Time (GMT)	Temperature 1 (deg C)	O2 (umol/L)	Turbidity (NTU)	Potent. Temp. 1 (deg C)
1	1350.3	5:16:23	3.3457	54.235	0.653	3.2456
2	1351.4	5:16:26	3.3438	54.669	0.658	3.2436
3	1299.7	5:22:50	3.4602	49.268	0.649	3.3632
4	1299.9	5:22:53	3.4619	49.324	0.658	3.3649
5	1280.8	5:25:50	3.5427	48.089	0.659	3.4465
6	1281.4	5:25:53	3.5424	47.998	0.656	3.4461
7	1259.6	5:29:11	3.5917	47.151	0.643	3.4968
8	1259.9	5:29:13	3.5915	46.975	0.650	3.4966
9	1241	5:32:29	3.6154	46.983	0.656	3.5219
10	1241.1	5:32:33	3.6166	46.868	0.654	3.5231
11	1220	5:35:46	3.6658	46.230	0.652	3.5736
12	1220.5	5:35:49	3.6658	46.513	0.650	3.5735
13	1201.6	5:38:51	3.6978	47.046	0.646	3.6069
14	1200.6	5:38:53	3.7032	46.828	0.652	3.6124
15	1180.3	5:42:10	3.7836	45.413	0.654	3.6937
16	1180.1	5:42:13	3.7841	45.443	0.657	3.6942
17	1159.9	5:45:23	3.8230	46.154	0.653	3.7345
18	1159.7	5:45:26	3.8233	46.159	0.659	3.7348
19	1139.3	5:48:37	3.8832	45.575	0.648	3.7959
20	1139.9	5:48:40	3.8825	45.400	0.650	3.7952
21	1120.4	5:51:45	3.9557	43.386	0.650	3.8694
22	1121.5	5:51:49	3.9553	43.304	0.671	3.8689
23	1000	6:07:29	4.4043	37.134	0.653	4.3248
24	999.27	6:07:32	4.4100	36.739	0.648	4.3306

CTD 13

Bottle #	Depth (m)	Time (GMT)	Temperature 1 (deg C)	O2 (umol/L)	Turbidity (NTU)	Potent. Temp. 1 (deg C)
1	1317.8	9:43:53	3.4434	52.200	0.652	3.3450
2	1319.3	9:43:55	3.4410	52.265	0.649	3.3426
3	1248	9:53:37	3.6352	49.074	0.662	3.5409
4	1250	9:53:40	3.6323	49.148	0.660	3.5379
5	1200.1	10:00:37	3.7163	47.668	0.660	3.6254
6	1200.1	10:00:40	3.7157	47.738	0.662	3.6248
7	1189.7	10:02:47	3.7202	47.781	0.668	3.6301
8	1188.7	10:02:50	3.7203	47.496	0.664	3.6303
9	1169.7	10:05:47	3.7413	47.190	0.663	3.6527
10	1171.3	10:05:55	3.7400	47.178	0.664	3.6513
11	1160.4	10:07:51	3.7527	46.946	0.662	3.6648
12	1160.1	10:07:59	3.7507	46.941	0.661	3.6628
13	1151.2	10:10:26	3.8188	45.965	0.660	3.7311
14	1150.2	10:10:34	3.8196	45.922	0.669	3.7319
15	1142.2	10:12:34	3.8441	45.488	0.663	3.7569
16	1140.8	10:12:42	3.8450	45.320	0.667	3.7580
17	1130.9	10:15:34	3.8694	44.837	0.678	3.7830
18	1130.9	10:15:43	3.8715	44.851	0.686	3.7851
19	1110.9	10:19:06	3.9657	43.413	0.690	3.8802
20	1110.6	10:19:12	3.9635	43.357	0.685	3.8780
21	1091.9	10:22:07	3.9934	43.235	0.675	3.9093
22	1091.5	10:22:17	3.9938	43.122	0.682	3.9097
23	898.36	10:34:08	4.8220	33.047	0.651	4.7484
24	898.6	10:34:17	4.8246	32.939	0.637	4.7510

CTD 14

Bottle #	Depth (m)	Time (GMT)	Temperature 1 (deg C)	O2 (umol/L)	Turbidity (NTU)	Potent. Temp. 1 (deg C)
1	1349.5	13:50:33	3.4204	52.489	0.652	3.3196
2	1350.6	13:50:41	3.4218	52.478	0.652	3.3208
3	1350.6	13:50:49	3.4218	52.474	0.645	3.3209
4	1349.9	13:50:58	3.4222	52.603	0.655	3.3213
5	1182.6	13:58:44	3.8409	45.651	0.668	3.7503
6	1181.5	13:58:52	3.8414	45.630	0.675	3.7509
7	1181.4	13:59:00	3.8419	45.576	0.668	3.7514
8	1181.2	13:59:09	3.8420	45.591	0.665	3.7515
9	1182.2	13:59:20	3.8415	45.563	0.670	3.7509
10	1149.5	14:04:13	3.9085	44.979	0.668	3.8201
11	1150.3	14:04:20	3.9088	44.818	0.665	3.8203
12	1149.9	14:04:27	3.9086	44.621	0.669	3.8202
13	1150.2	14:04:34	3.9093	44.699	0.676	3.8209
14	1150.6	14:04:41	3.9093	44.487	0.674	3.8209
15	1111.3	14:11:31	3.9933	44.055	0.664	3.9075
16	1111.4	14:11:38	3.9930	43.973	0.659	3.9072
17	1111.5	14:11:45	3.9926	43.915	0.656	3.9068
18	1111.1	14:11:53	3.9934	44.025	0.669	3.9076
19	1111.1	14:12:10	3.9926	44.030	0.662	3.9068
20	799.18	14:25:41	5.1829	30.624	0.644	5.1159
21	800.06	14:25:48	5.1842	30.576	0.640	5.1171
22	800.13	14:25:54	5.1864	30.654	0.645	5.1192
23	800.77	14:26:01	5.1891	30.604	0.641	5.1218
24	800.88	14:26:08	5.1889	30.539	0.641	5.1217

CTD 15 - Shinkai Deep

Bottle #	Depth (m)	Time (GMT)	Temperature 1 (deg C)	O2 (umol/L)	Turbidity (NTU)	Potent. Temp. 1 (deg C)
1	4743.6	4:02:11	1.4991	151.600	0.654	1.0858
2	4744.8	4:02:15	1.4991	151.560	0.653	1.0856
3	4744	4:02:18	1.4992	152.210	0.654	1.0859
4	4744	4:02:21	1.4991	151.250	0.654	1.0858
5	4713.1	4:07:38	1.4952	151.390	0.651	1.0858
6	4712.5	4:07:40	1.4953	151.710	0.664	1.0860
7	4713.2	4:07:42	1.4952	151.510	0.652	1.0858
8	4714.2	4:07:44	1.4952	152.080	0.652	1.0856
9	4682.8	4:12:09	1.4923	151.680	0.650	1.0867
10	4682.8	4:12:11	1.4923	150.930	0.657	1.0867
11	4684.3	4:12:13	1.4923	151.760	0.654	1.0865
12	4684.1	4:12:15	1.4925	151.910	0.657	1.0867
13	4652.8	4:16:51	1.4899	150.920	0.653	1.0880
14	4653.5	4:16:54	1.4899	151.270	0.663	1.0879
15	4654.6	4:16:56	1.4899	151.510	0.656	1.0878
16	4652.9	4:16:59	1.4901	150.990	0.658	1.0881
17	4601.9	4:23:23	1.4843	150.840	0.657	1.0887
18	4601.9	4:23:35	1.4842	150.800	0.660	1.0887
19	4601.3	4:23:43	1.4844	150.880	0.654	1.0890
20	4601.4	4:23:51	1.4844	150.910	0.652	1.0890
21	3496.1	4:58:48	1.4914	132.610	0.654	1.2207
22	3496.9	4:58:51	1.4915	132.790	0.665	1.2207
23	3495.6	4:58:53	1.4918	132.690	0.658	1.2212
24	3496.6	4:58:56	1.4915	132.840	0.660	1.2207

CTD 16 - Plume Mapping Series, quick cast for sensor data, no bottles

CTD 17 – Plume Mapping Series

Bottle #	Depth (m)	Time (GMT)	Temperature 1 (deg C)	O2 (umol/L)	Turbidity (NTU)	Potent. Temp. 1 (deg C)
1	1423	10:40:45	3.1519	58.298	0.649	3.0476
2	1422.8	10:40:52	3.1519	58.197	0.648	3.0477
3	1400.9	10:43:40	3.2152	57.260	0.658	3.1122
4	1401.9	10:43:49	3.2144	57.029	0.655	3.1113
5	1382	10:46:27	3.2876	55.701	0.646	3.1854
6	1382.9	10:46:34	3.2822	55.834	0.647	3.1800
7	1360.8	10:48:03	3.3401	54.199	0.648	3.2391
8	1360.1	10:48:13	3.3421	54.324	0.645	3.2412
9	1340.3	10:49:54	3.4192	51.595	0.651	3.3191
10	1340.7	10:50:02	3.4196	51.761	0.644	3.3196
11	1319.8	10:51:50	3.4875	48.980	0.649	3.3885
12	1321.6	10:52:00	3.4939	49.107	0.647	3.3947
13	1303.3	10:53:16	3.5260	50.897	0.657	3.4280
14	1302.7	10:53:22	3.5271	51.085	0.644	3.4292
15	992.39	11:05:19	4.3649	39.776	0.644	4.2864
16	991.85	11:05:27	4.3648	39.519	0.653	4.2863
17	959.3	11:07:50	4.4989	38.381	0.655	4.4223
18	959.15	11:08:03	4.5001	38.131	0.664	4.4235
19	949.01	11:10:52	4.5397	37.363	0.653	4.4636
20	947.78	11:11:00	4.5404	37.235	0.641	4.4644
21	899.05	11:13:35	4.7167	34.870	0.651	4.6438
22	899.14	11:14:02	4.7176	34.701	0.646	4.6447
23	860.06	11:16:00	4.8729	33.628	0.645	4.8023
24	859.6	11:16:07	4.8807	33.975	0.653	4.8102

CTD 18 – Plume Mapping Series

Bottle #	Depth (m)	Time (GMT)	Temperature 1 (deg C)	O2 (umol/L)	Turbidity (NTU)	Potent. Temp. 1 (deg C)
1	1402	14:52:13	3.2166	57.063	0.646	3.1134
2	1401	14:52:21	3.2156	56.880	0.650	3.1126
3	1400.4	14:52:29	3.2175	56.841	0.645	3.1144
4	1399.9	14:52:38	3.2200	56.473	0.649	3.1169
5	1320.1	14:56:43	3.4786	49.240	0.659	3.3797
6	1320.9	14:56:48	3.4788	49.123	0.657	3.3798
7	1319.3	14:56:52	3.4794	49.316	0.658	3.3805
8	1321	14:56:55	3.4785	48.999	0.654	3.3796
9	1297.5	14:59:29	3.5643	50.316	0.656	3.4665
10	1297.7	14:59:32	3.5649	50.473	0.652	3.4670
11	1297.3	14:59:34	3.5652	50.394	0.657	3.4674
12	1297	14:59:36	3.5654	50.482	0.650	3.4676
13	1281.5	15:01:14	3.6003	50.099	0.650	3.5035
14	1280.9	15:01:16	3.6010	49.947	0.653	3.5042
15	1281.7	15:01:18	3.6021	50.035	0.653	3.5053
16	1280.9	15:01:20	3.6009	49.975	0.650	3.5041
17	1191.5	15:05:42	3.7699	47.483	0.651	3.6792
18	1191.2	15:05:43	3.7702	47.412	0.651	3.6795
19	1191.3	15:05:45	3.7712	47.319	0.648	3.6805
20	1191.6	15:05:46	3.7723	47.527	0.651	3.6815
21	1090	15:10:42	4.0604	43.251	0.657	3.9758
22	1089.1	15:10:44	4.0633	43.301	0.652	3.9788
23	1087.6	15:10:54	4.0651	43.093	0.647	3.9807
24	1090.3	15:10:59	4.0616	43.257	0.644	3.9770

CTD Hydrocast Sample Manifest

Where is it?					UMN	UMN	Arne Sturm (UH)	S522 (UMN)
Cast	**Niskin**	**Depth**	**Lat**	**Lon**	**TFe**	**dFe**	**dFe-ligand**	**pFe (PC)**
2	1	1350	18.90677	-155.2578,	500	500	120	yes
2	5	1180	18.90677	-155.2578,	500	500	120	yes
2	10	1150	18.90677	-155.2578,	500	500	120	yes
2	15	1110	18.90677	-155.2578,	500	500	120	yes
2	20	800	18.90677	-155.2578,	500	500	120	yes
7	1	1350	18deg 53.4020'N	155deg 15.996'W	500	500	120	yes
7	5	1200			500	500	120	yes
7	10	1170			500	500	120	yes
7	15	1120			500	500	120	yes
7	20	1100			500	500	120	yes
14	1	1350	18deg 53.767'N	155deg 15.866'W	500	500	120	yes
14	5	1180			500	500	120	yes
14	10	1150			500	500	120	yes
14	15	110			500	500	120	yes
14	20	800			500	500	120	yes
11 (10)	1	1290	18deg 54.406'N	155deg 14.455'W	500	500	120	yes
11 (10)	5	1251			500	500	120	yes
11 (10)	10	1202			500	500	120	yes
11 (10)	15	1140			500	500	120	yes
11 (10)	20	802			500	500	120	yes
15	1	4744	18deg 46.097'N	155deg 7.898'W	500	500	120	yes
15	5	4714			500	500	120	yes
15	9	4684			500	500	120	yes
15	14	4654			500	500	120	yes
15	17	4600			500	500	120	yes
15	21	3500			500	500	120	yes
18	1		18deg 53.216'N	155deg 17.486'W	500	500	120	yes
18	5				500	500	120	yes
18	9				500	500	120	yes
18	14				500	500	120	yes
18	17				500	500	120	yes
18	21				500	500	120	yes

CTD Hydrocast Sample Manifest (continued)

Where is it?					S522 (UMN)	Arne Sturm (UH)	Arne Sturm (UH)	S522 (UMN)
Cast	**Niskin**	**Depth**	**CFF RET**	**CFF PERM**	**CFF RECIRC RET**	**sFe**	**sFe-ligand**	**whole water for CFF**
2	1	1350						
2	5	1180						
2	10	1150	yes	yes	yes	yes	not labeled	no
2	15	1110						
2	20	800						
7	1	1350						
7	5	1200						
7	10	1170				yes	not labeled	yes
7	15	1120						
7	20	1100						
14	1	1350						
14	5	1180						
14	10	1150	yes	yes	yes	yes		yes
14	15	110						
14	20	800						
11 (10)	1	1290						
11 (10)	5	1251						
11 (10)	10	1202	yes	yes	yes	yes		yes
11 (10)	15	1140						
11 (10)	20	802						
15	1	4744	yes	yes	yes	yes		yes
15	5	4714						
15	9	4684			yes			
15	14	4654						
15	17	4600						
15	21	3500						
18	1							
18	5							
18	9		yes	yes	yes	yes		yes
18	14							
18	17							
18	21							

CTD Hydrocast Sample Manifest (continued)

Where is it?					Arne Sturm (UH)	Arne Sturm (UH)	
Cast	Niskin	Depth (m)	Lat	Lon	POC (GFF)	DOC (mL)	Filtered (L)
bottle bkg	2	-	-	-	yes	40	9.4
bottle bkg	20	-	-	-	yes	40	10
bottle bkg	24	-	-	-	yes	40	10.5
bottle bkg	1	-	-	-	yes	40	10.2
bottle bkg	4	-	-	-	yes	40	9.3
2	3	1350	18.90677	-155.2578,	yes	40	12
2	8	1180			yes	40	12
2	13	1150			yes	40	12
2	18	1110			yes	40	12
2	23	800			yes	40	12
7	3	1350	18deg 53.4020'N	155deg 15.996'W	yes	40	12
7	8	1200			yes	40	12
7	13	1170			yes	40	12
7	18	1120			yes	40	12
7	23	1100			yes	40	12
14	3	1350	18deg 53.767'N	155deg 15.866'W	yes	40	12
14	8	1180			yes	40	12
14	13	1150			yes	40	12
14	18	110			yes	40	12
14	23	800			yes	40	12
11 (10)	3	1290	18deg 54.406'N	155deg 14.455'W	yes	40	12
11 (10)	8	1251			yes	40	12
11 (10)	13	1202			yes	40	12
11 (10)	18	1140			yes	40	12
11 (10)	23	802			yes	40	12
15	3	4744	18deg 46.097'N	155deg 7.898'W	yes	40	12
15	8	4714			yes	40	12
15		4684					
15	13	4654			yes	40	12
15	18	4600			yes	40	12
15	23	3500			yes	40	12
18	3		18deg 53.216'N	155deg 17.486'W	yes	40	12
18	8				yes	40	12
18							
18	13				yes	40	12
18	18				yes	40	12
18	23				yes	40	12

Appendix 3 -- AUV Operator Report

Sentry Operations Report for the Glazer 2014 Cruise DRAFT

WHOI Sentry Operations Group
Dr. Dana Yoerger, Chris Taylor, Justin Fuji, Johanna Hansen, Zac Berkowitz

Sentry Expedition Leader: Dr. Dana Yoerger

Chief Scientist: Professor Brian Glazer, University of Hawaii

R/V Falkor — June 25, 2014 to July 7, 2014

Publication Date: July 11, 2014

1 Summary

This document summarizes operations with the *Sentry* autonomous underwater vehicle (AUV) during the 2014 Glazer cruise, FK140626, Iron Eaters of Loihi. 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 264 - 270 follow. Each of these is a free-standing document summarizing the dive. High level objectives of each dive included multibeam survey, sidescan survey, and photo surveys along with near-bottom chemical measurements such as CTD, optical backscatter, Eh, and O2.

The general operations for the cruise are shown below.

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.

June 21 - June24 This was the first day of the mobilization. The green (server/workshop) van was placed on the aft deck, the blue (vehicle) van was unpacked and the contents stored in the ship's hangar.

June 22- June 24 Continue mobilization in port, including practice recoveries

June 25 Leave port with Kaiser, Duester, and Pietro aboard. Practice recoveries in open water at the sea buoy. These tests went well and Kaiser, Duester, and Pietro departed by small boat.

June 26 Cassius USBL calibration and first CTD cast

June 27 First Sentry dive at FEMO site, Sentry264. This dive ended very early when the forward control wing slipped its clutch and the vehicle was unable to control its depth.

June 28-29 Sentry265, also at the FEMO site. The vehicle did multibeam, sidescan, and photo surveys. Heading control was poor but the maps came out OK. Eh and optical backscatter inoperative (corroded connectors)

June 30-July 1 Sentry266, Multibeam, Sidescan, and photo survey in Shinkai Deep. Very good results, but Eh and optical backscatter not yet repaired.

July 1-July 2 Sentry267, Multibeam, Sidescan, and photo survey on the northern and southern sections of the Shinkai Ridge to the east of Shinkai Deep. We got good coverage but the multibeam was spotty due to a data logging/setup problem. Photo survey went well

July 2-July 3 Sentry 268, Multibeam, Sidescan, and photo survey on the northern section of the Shinkai Ridge to the east of Shinkai Deep. The doppler velocity log failed and the vehicle recovered after 3 hrs of survey.

July 4-July 5 Sentry269, Multibeam, sidescan, and photo survey. Multibeam, Sidescan, and photo survey on the northern section of the Shinkai Ridge, repeated the dive plan for Sentry268 after replacing the DVL. The DVL struggled on the steep terrain and we had one gap in our multibeam coverage. Photos survey produced good results.

July 5-July 6 Sentry270. Multibeam, sidescan, and photo survey extending coverage on the Shinkai Deep to the south of the Sentry266 survey. Multibeam as expected. Several crashes during the photo survey.

July 6 Transit to Honolulu

July 7 Dock, offload, Sentry vans sent to the airport

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 Dynamically Focused 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
IXEA PHINS
Reson Sound Velocity Probe
Koichi Nakomura EH sensor

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.

For the most part, the USBL functioned well. We ran with an update of 20 seconds. While there were dropouts, each dive was well navigated.

Acomms recepetions were very spotty at the surface. During descent, we would obtain acomms messages until the vehicle reached about 4000m, after which we received no more than about 1/hour. We always sent shift commands during descent to ensure that some got through. However, acomms messages were typically received reliably on the vehicle. We had no problem aborting dives acoustically, resetting bottom following parameters, or shifting the navigation. We sent all commands three times, generally they were all received.

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.

We used one origin for the entire cruise. It is listed with each dive.

4.2 USBL Calibration and Performance Notes

A CASIUS calibration of the USBL system was conducted by Falkor personnel onJune 26, 2014. The offsets obtained during this calibration were used for all Sentry dives. 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 used a different recovery strategy on Falkor. We recovered using a knuckle-boom crane near the port aft quarter.

N.2: we matched the vessel speed to the vehicle drift speed before bringing Sentry in

N.3: Rather than driving in a path normal to the vessel, we came in at an angle that allowed an escape aft. This worked well.

N.4: We did not need the air tugger, the short whip on the knuckle-boom crane prevented swinging. We kept it on in case of an emergency, but only used the air tugger to help position the vehicle into the cradle.

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 had a significant problem with our Phins INS on the first dive. It reported values sporadically, the the update interval ranging from 0.1-2.0 seconds where the nominal value should be 0.2 seconds. This resulted in poor heading control for Sentry264

T.2: This problem was not properly diagnosed before Sentry265. We lowered the control gains in an attempt to stabilize heading, but control was again poor. The Phins update problem did not reoccur.

T.3: For dives 266 through 270, the heading gains from the previous two cruises were used and the heading control worked as expected. We checked the update rate on the Phins as part of our deck tests and never saw the problem again.

T.4: Both AD modules (AD2 and AD5) had corroded connectors. These were replaced. We had some logging problems as well. Eh was operational for Sentry267 forward, optical backscatter for Sentry268 forward.

T.5: The clutch on the forward control surface released on the first dive, resulting in a loss of depth control and forcing us to end the dive.

T.6: the RDI 300khz DVL failed on dive 268, forcing us to end the dive. We replaced it with our spare. There was no sign of a problem on the previous dives and no obvious physical damage on the unit.

7 Sentry Operations Team

The *Sentry* team was comprised of 5 members on this cruise — Chris Taylor, Johanna Hansen, Justin Fuji, Zac Berkowitz, and Dana Yoerger. Dana Yoerger was the Expedition Leader and principal author of this report. Carl Kaiser, Al Duester, and Ben Pietro participated in the mobilization in Honolulu HI.

8 Acknowledgments

1. Thank you to the officers and crew of Falkor (Heiko Volz, Master) for excellent ship handling and launch and recovery as well as for going out of the way to assist in any way possible.

2. Thanks to the NDSF and SOI operations teams for enabling this cruise on short notice with such tight constraints on shipping, mobilization, and demobilization

3. Thanks to Carl Kaiser, Al Duester, and Ben Pietro for their help in mobilization and working out details of Sentry launch and recovery.

Sentry 264 Dive Report
DRAFT

WHOI Sentry Operations Group
Dr. Dana Yoerger, Chris Taylor, Justin Fuji, Johanna Hansen, Zac Berkowitz

Sentry Expedition Leader: Dr. Dana Yoerger

Chief Scientist: Professor Brian Glazer, University of Hawaii

Summary

Weather: The weather was well within the operating window.

Reason for end of dive: We terminated the dive with an acoustic command when we observed that the vehicle was not able to control depth.

Vehicle Configuration

The science sensing suite for this dive was:

Table 2: Sentry Sensor Configuration

Sensor
APS 1540 Magnetometers (3)
Edgetech Dynamically Focused Sidescan sonar
Reson 7125 Multibeam Sonar
Seabird SBE49 CTD
Seapoint OBS
Anderaa optode model 4330
300kHz RDI DVL
Digital Still Camera
IXEA PHINS
Reson Sound Velocity Probe
Koichi Nakomura EH sensor

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

Important Positions

Dive Origin: femo_deep.org: 18 39' -155 -15'

Launch Position: sentry264 launch position: 18 42.868'N 155 10.637'W

Narrative

The goals of this dive were multibeam, sidescan, and photo survey at the FEMO Deep site. This dive ended early when the forward wing clutch released, which prevented the vehicle from properly controlling depth. We saw the vehicle flying too high (dvl height -3 on an acomms msg) and tried to force it down with the acoustic joystick command. This was unsuccessful (as it should have been given that the system could not control the forward wing). We aborted the dive using acomms XRD command. We also sent an abort via whifflenav but that was not received at the vehicle.

We lost comms with the emergency controller XR1 shortly after the dive was aborted. We fixed this by removing the XR1 housing and cleaning the connector. The unit failed again on the next dive.

The vehicle had very poor heading control, limit cycling when the vehicle was making moderate depth changes. Heading stabilized when the vehicle drove down hard in flight mode. In hindsight, this was caused by bad sensor data from the Phins INS. Normally, the Phins updates every 0.2 seconds, while on this dive the update intervals ranged from 0.1 to 2.0 seconds.

USBL performance was good, we had consistent tracking for most of the dive. We had decent acomms on descent and ascent but topside receptions were very rare during the dive. Acomms was lost somewhere between 4000 and 4900 m.

We got no replies from the optical backscatter sensor. The eH sensor gave confusing data until quitting just before recovery.

Launch and recovery went smoothly with seas 0.5-1 meter and moderate winds (15 kts).

1 Issues and Proposed Solutions

We reset the clutch and tightened it

In an attempt to solve the heading issue, we reduced the gains on the heading loop as we had not diagnosed the update rate issue

Chief Scientist Comments

The Chief scientist is requested to include any desired comments.

Dive Statistics

1.1 sentry264 Summary

sentry264 Summary
Origin: 18.650000 -155.250000
Launch: 2014/06/27 17:29:40
Survey start: 2014/06/27 19:32:47
Survey start: Lat:18.714787 Lon:-155.177598
Survey end: 2014/06/28 01:16:56
Survey start: Lat:18.714086 Lon:-155.168360
Ascent begins: 2014/06/28 01:21:46
On the surface: 2014/06/28 02:51:06
On deck: 2014/06/28 03:05:49
descent rate: 39.7 m/min
ascent rate: 48.5 m/min
survey time: 5.7 hours
deck-to-deck time 9.6 hours
Mean survey depth: 4798m
Mean survey height: 64m
distance travelled: 14.18km
average speed; 0.69m/s
average speed during photo runs: 0.80 m/s over 2.79 km
average speed during multibeam runs: 0.66 m/s over 11.39 km
total vertical during survey: 2469m
Battery energy at launch: 13.2 kwhr
Battery energy at survey end: 7.8 kwhr
Battery energy on deck: 7.4 kwhr

Plots and Images

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

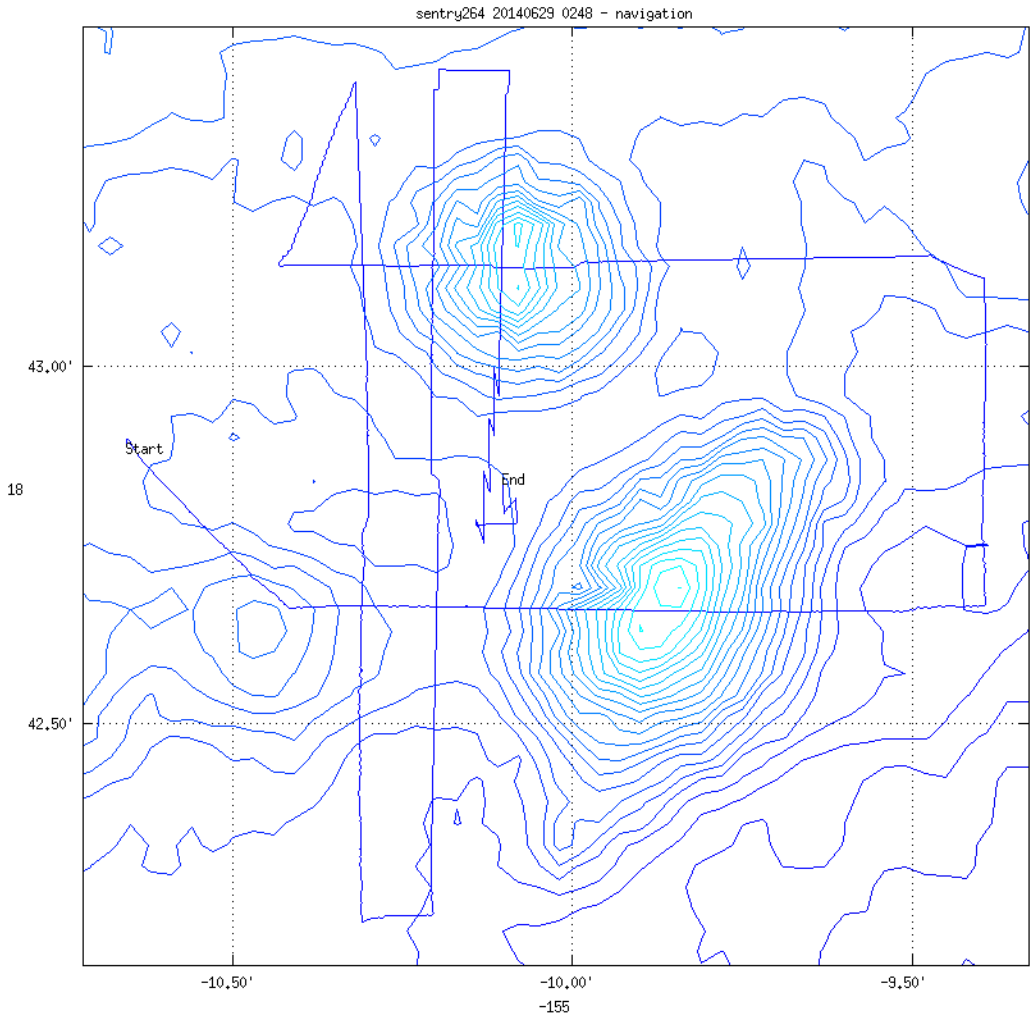


Figure 1: Latitude/Longitude plot of Sentry dive 264 based on post-processed navigation.

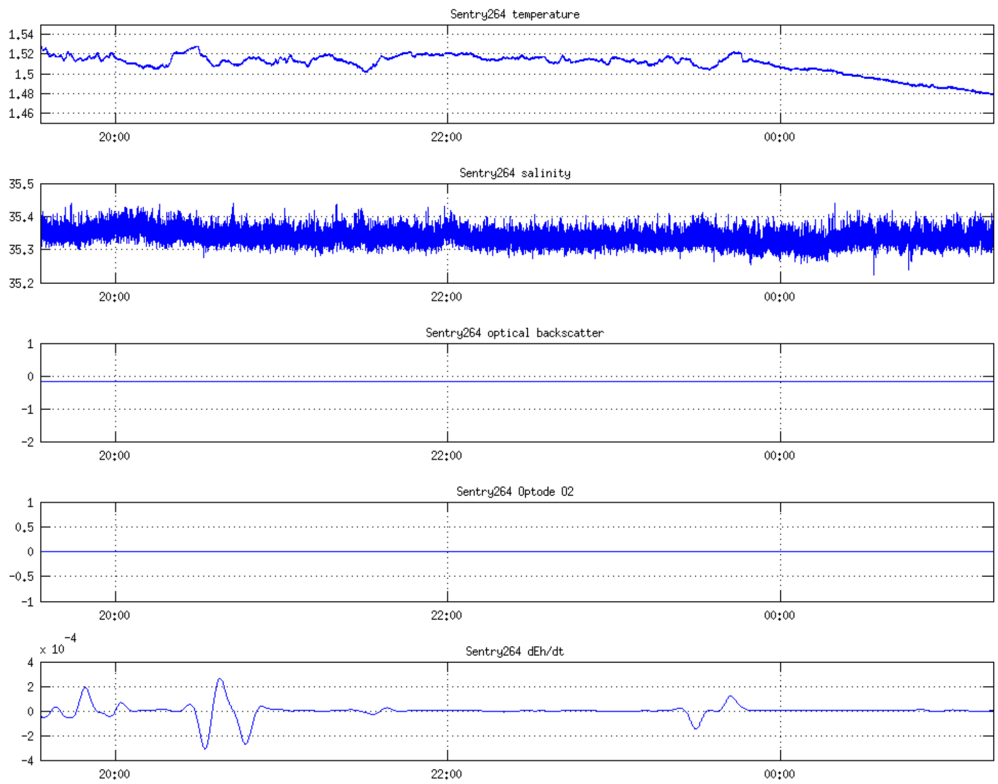


Figure 2: Time series plot of five of the basic sensors on Sentry, from top to bottom, temperature, salinity, optical backscatter, and dissolved Oxygen.

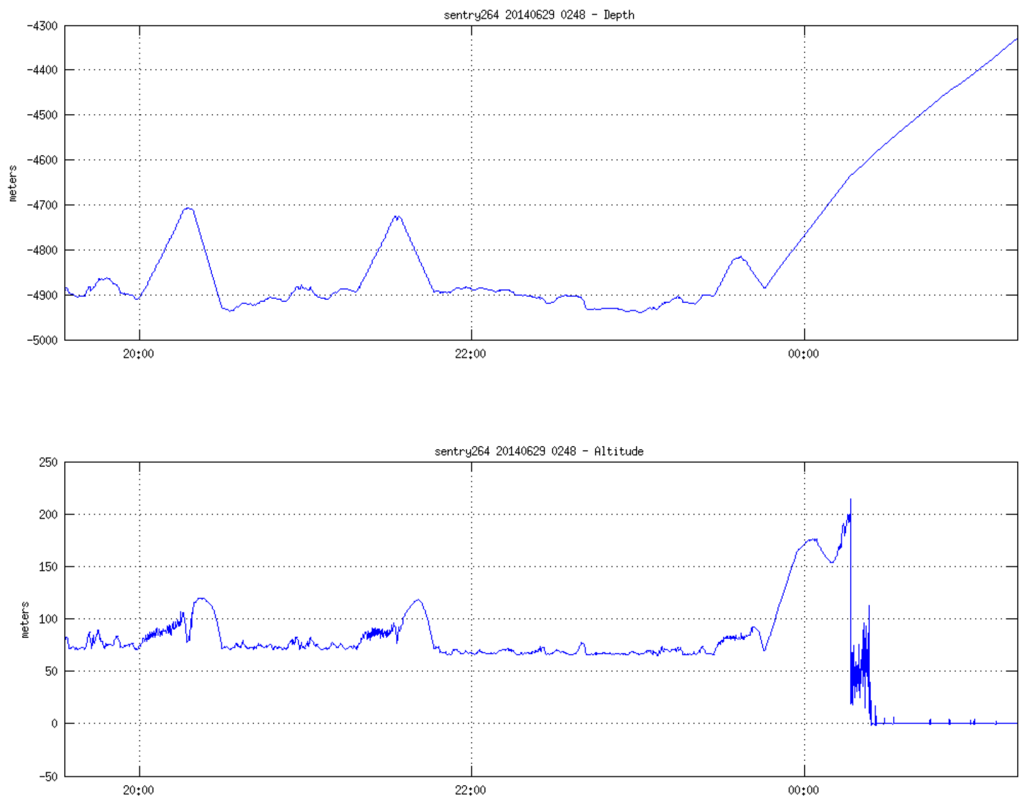


Figure 3: Depth and Altitude of Sentry during dive 264.

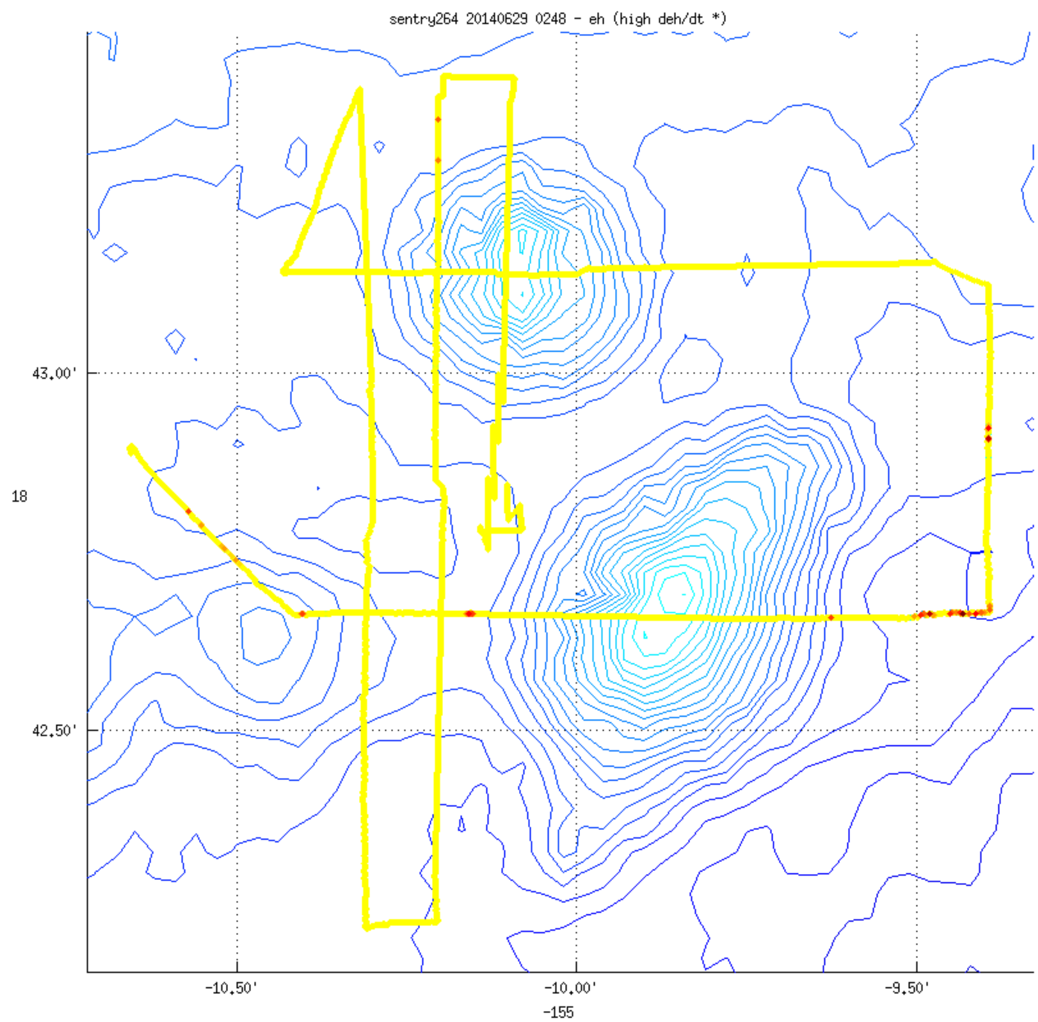


Figure 4: Redox potential (deh/dt) on dive 264.

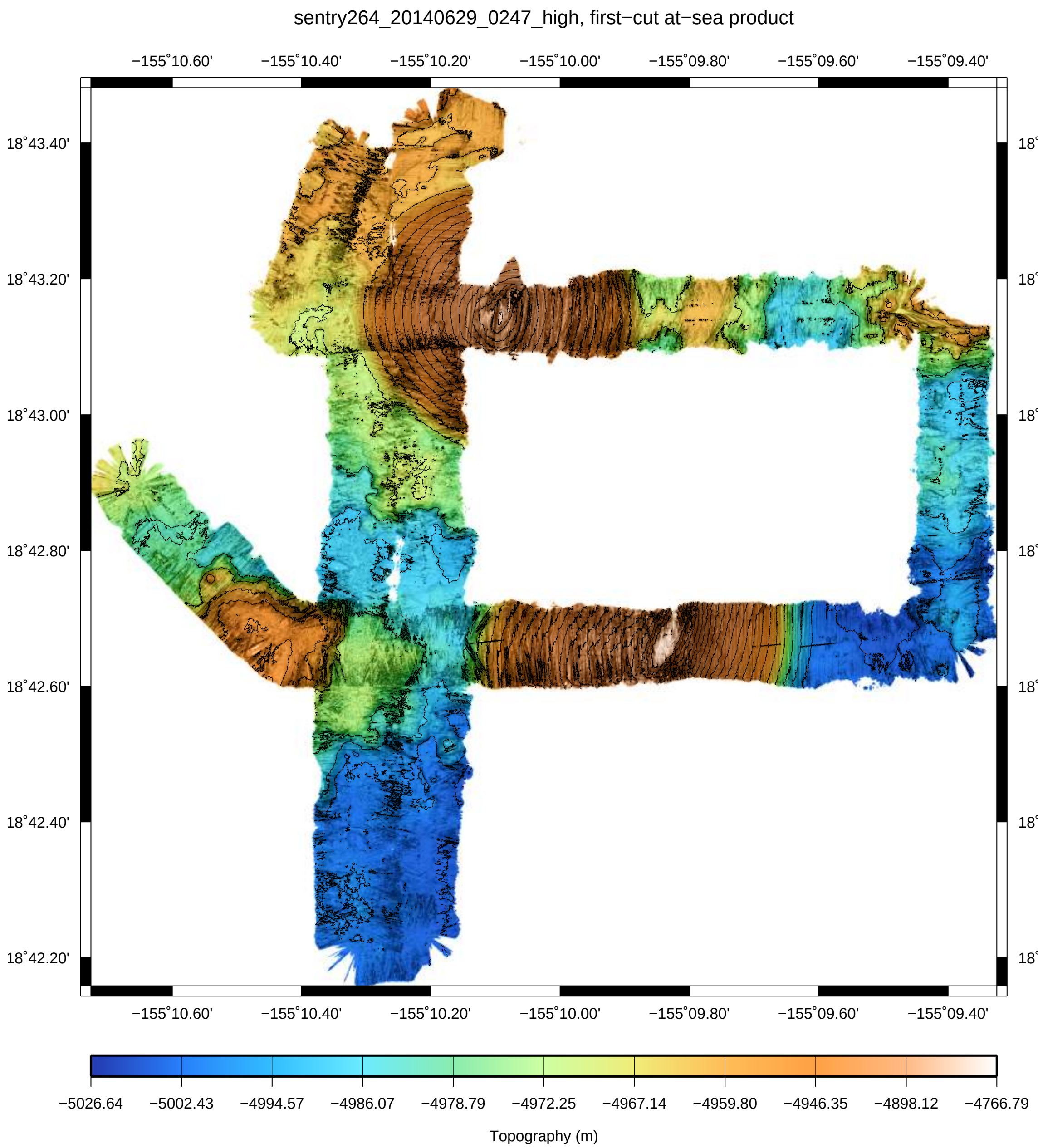


Figure 5: Multibeam bathymetry dive 264.

Sentry 265 Dive Report
DRAFT

WHOI Sentry Operations Group
Dr. Dana Yoerger, Chris Taylor, Justin Fuji, Johanna Hansen, Zac Berkowitz

Sentry Expedition Leader: Dr. Dana Yoerger

Chief Scientist: Professor Brian Glazer, University of Hawaii

Summary

The goals of this dive were multibeam, sidescan, and photo survey at the FEMO Deep site, continuing Sentry264. The dive ran to completion, although the heading control was sloppy.

Weather: The weather was well within the operating window.

Reason for end of dive: The mission ended when we reached the end of the last trackline. 20% battery remaining, we should have included a few more hours of tracklines.

Vehicle Configuration

The science sensing suite for this dive was:

Table 3: Sentry Sensor Configuration

Sensor
APS 1540 Magnetometers (3)
Edgetech Dynamically Focused Sidescan sonar
Reson 7125 Multibeam Sonar
Seabird SBE49 CTD
Seapoint OBS
Anderaa optode model 4330
300kHz RDI DVL
Digital Still Camera
IXEA PHINS
Reson Sound Velocity Probe
Koichi Nakomura EH sensor

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

Important Positions

Dive Origin: femo_deep.org: 18 39' -155 -15'

Launch Position: sentry265 launch position: 18 43.404'N 155 10.319'W

Narrative

The dive ran until the mission plan ran out of tracklines with about 20% battery remaining.

Heading had a problem on this dive as well. The Phins update problem had disappeared (no explanation). But I (DY) had reduced the heading gains in an attempt to improve the heading performance. The Phins update issue had not been diagnosed before launch. My thinking was that the heading control was OK when the vehicle was flying down hard in the flight mode, in which case the overall open-loop gain would be reduced (due to the the angle of the aft wing) and damping would be increased. So it seemed to make sense to reduce the heading gain. Given the sparsity of acomms msgs when the vehicle was working on the seafloor, we were unable to assess heading performance in real-time. Heading control was poor (+-10-20 deg) during the multibeam legs, +-10 deg on the sidescan legs, and +-5 during the camera legs. In hindsight, the gains should not have been changed.

The camera legs were very successful. The multibeam and sidescan legs were compromised by the heading problems although the multibeam map has some value.

We got no responses from the analog science sensors (eH and optical backscatter). After the dive, we found corrosion on the connector pins. The connectors were replaced.

Launch and recovery went smoothly with seas 0.5-1 meter and moderate winds (15 kts).

1 Issues and Proposed Solutions

Since the Phins INS is now functioning normally, we should reset the heading gains to their values from the previous two cruises

repair connectors on AD pods

Chief Scientist Comments

The Chief scientist is requested to include any desired comments.

Dive Statistics

1.1 sentry265 Summary

sentry265 Summary
Origin: 18.650000 -155.250000
Launch: 2014/06/28 10:21:34
Survey start: 2014/06/28 12:24:23
Survey start: Lat:18.723044 Lon:-155.173945
Survey end: 2014/06/29 06:18:38
Survey start: Lat:18.635529 Lon:-155.261782
Ascent begins: 2014/06/29 06:19:14
On the surface: 2014/06/29 08:09:47
On deck: 2014/06/29 08:35:27
descent rate: 39.7 m/min
ascent rate: 45.0 m/min
survey time: 17.9 hours
deck-to-deck time 22.2 hours
Mean survey depth: 4939m
Mean survey height: 31m
distance travelled: 36.02km
average speed; 0.56m/s
average speed during photo runs: 0.41 m/s over 14.24 km
average speed during multibeam runs: 0.73 m/s over 21.73 km
total vertical during survey: 5319m
Battery energy at launch: 12.9 kwhr
Battery energy at survey end: 2.5 kwhr
Battery energy on deck: 2.0 kwhr

Plots and Images

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

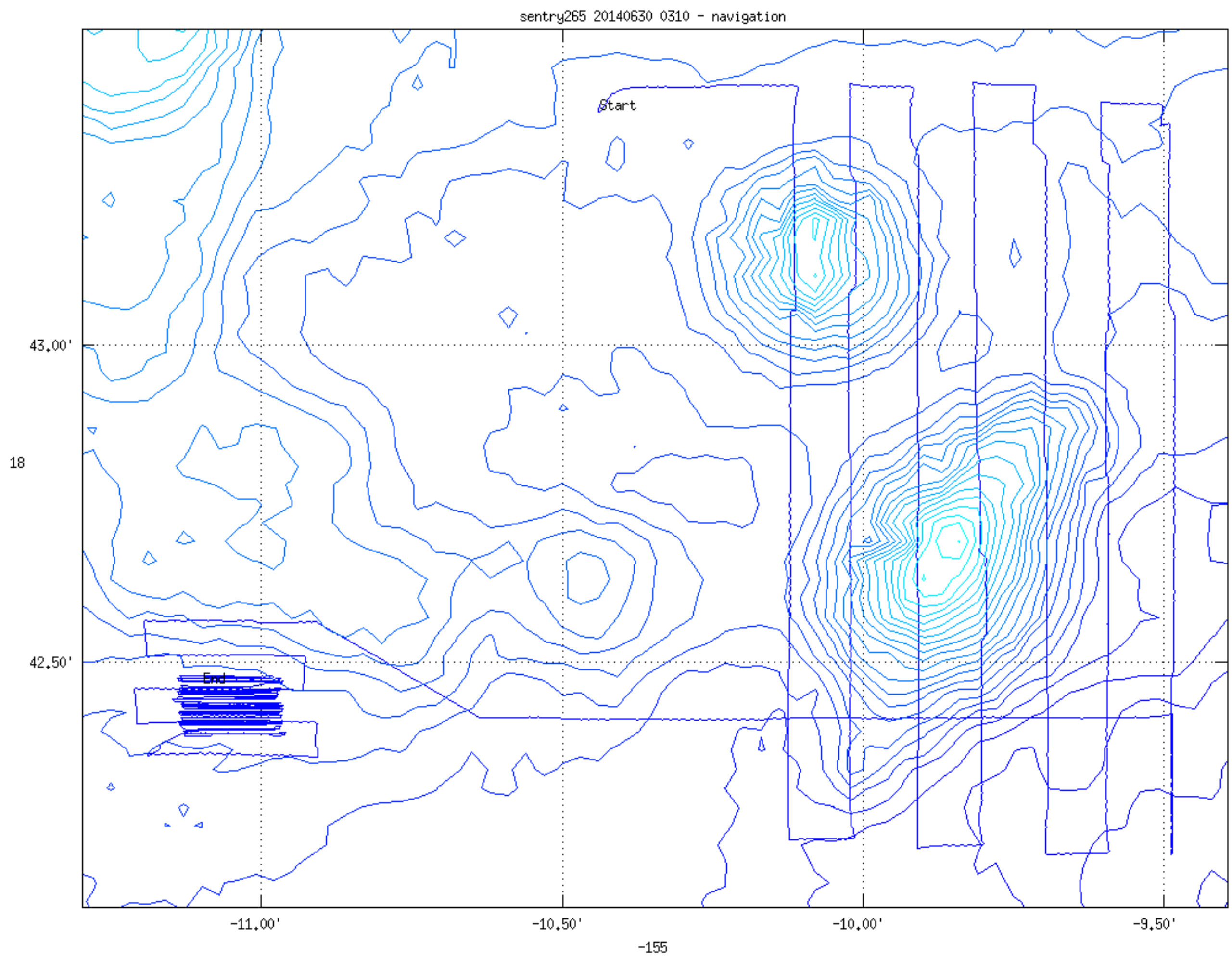


Figure 6: Latitude/Longitude plot of Sentry dive 265 based on post-processed navigation.

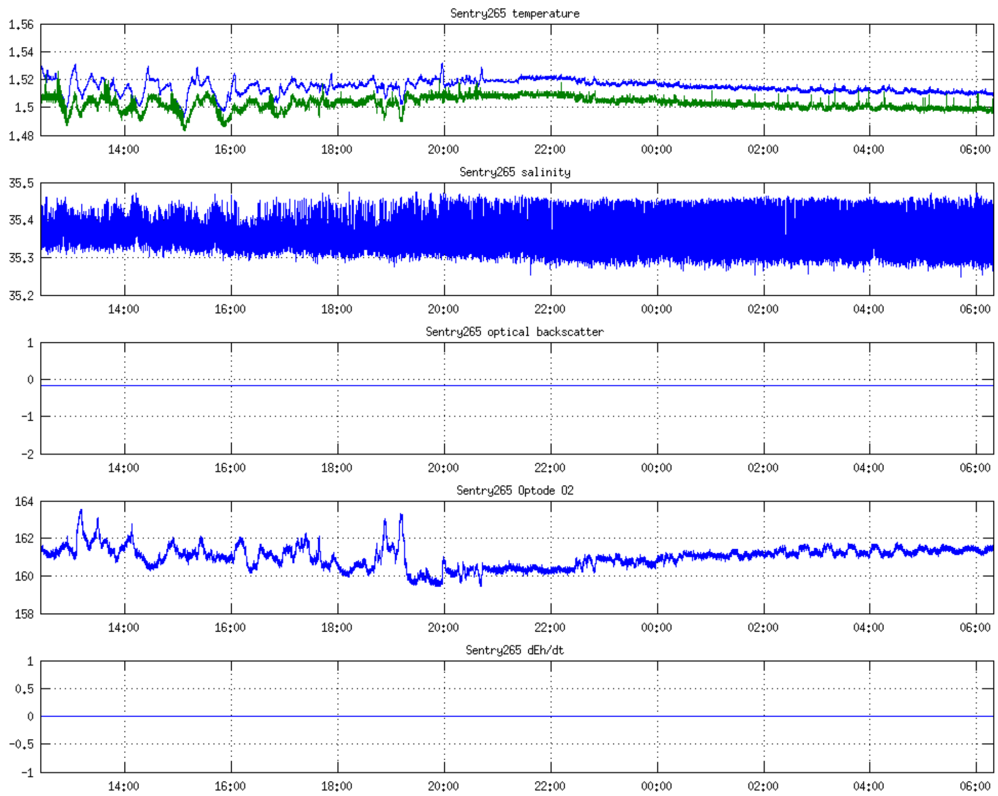


Figure 7: Time series plot of five of the basic sensors on Sentry, from top to bottom, temperature, salinity, optical backscatter, and dissolved Oxygen.

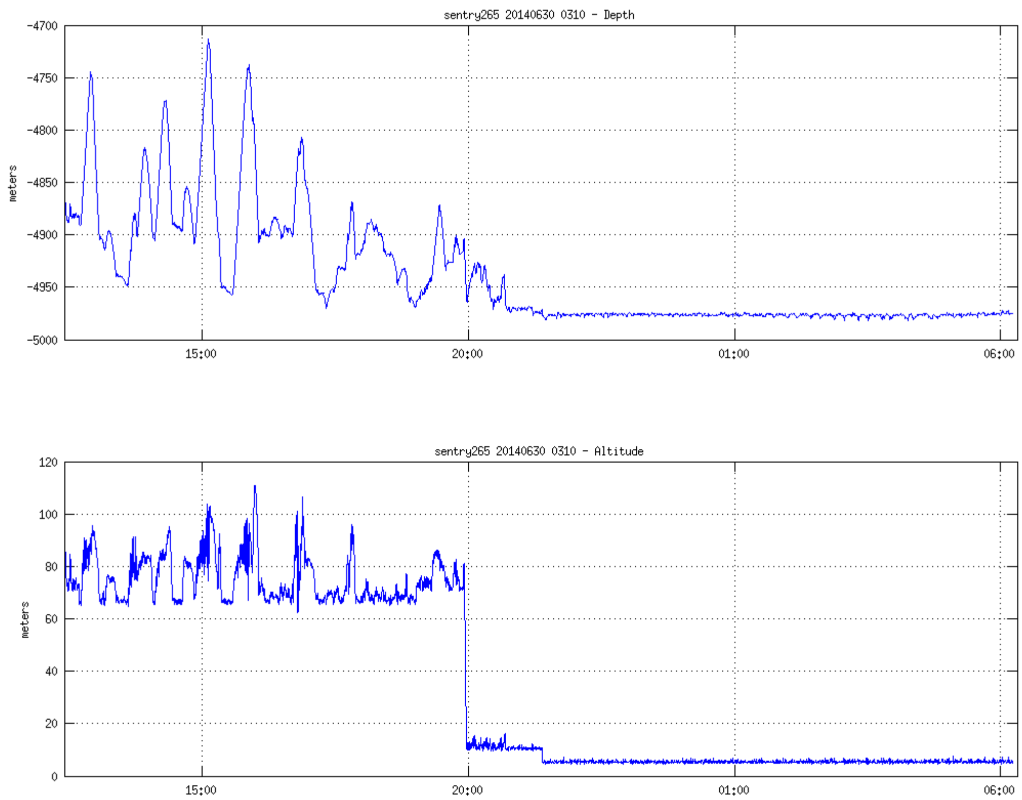


Figure 8: Depth and Altitude of Sentry during dive 265.

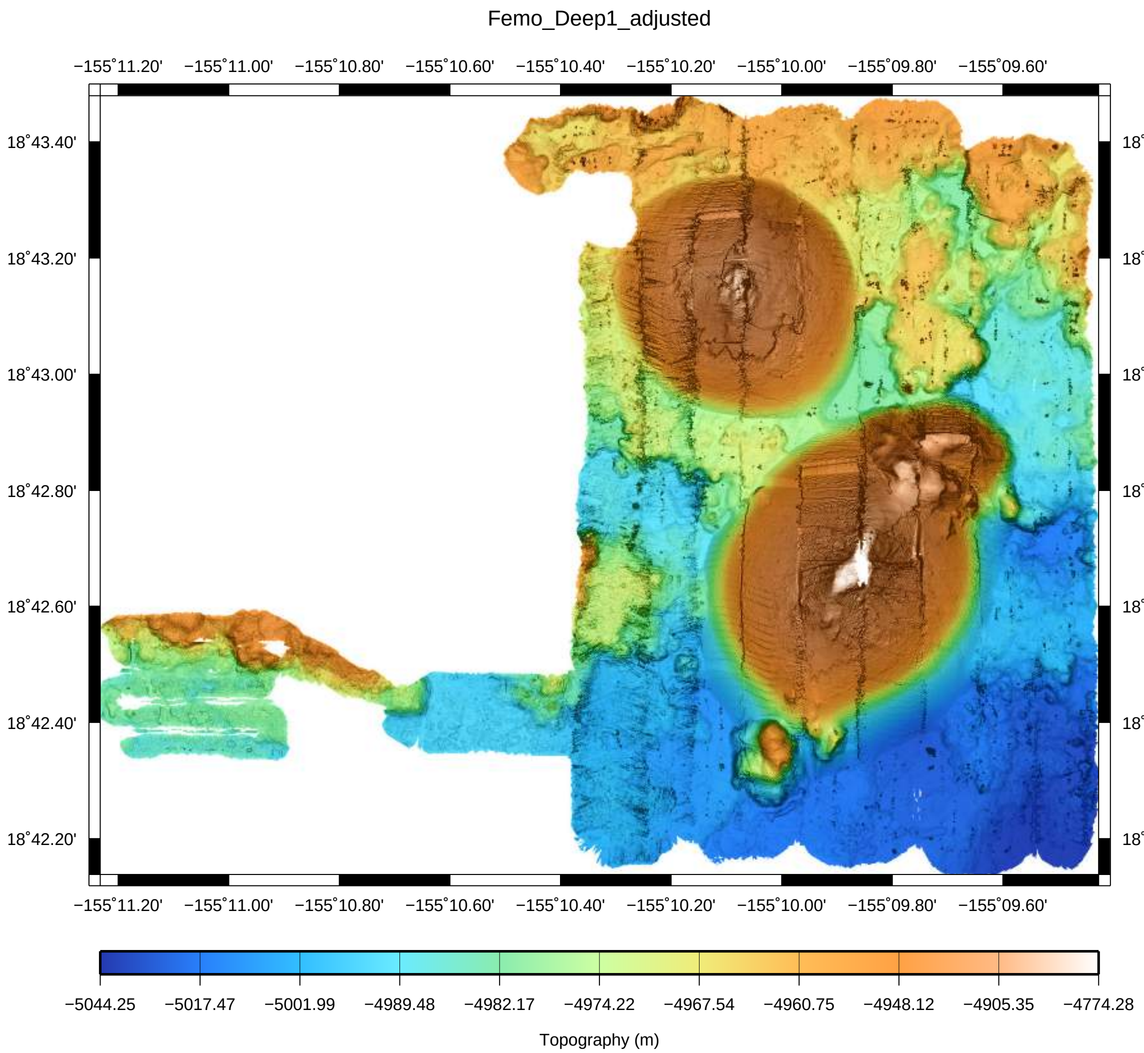


Figure 9: Adjusted multibeam bathymetry for dives 264 and 265, nav adjusted.

Sentry 266 Dive Report
DRAFT

WHOI Sentry Operations Group
Dr. Dana Yoerger, Chris Taylor, Justin Fuji, Johanna Hansen, Zac Berkowitz

Sentry Expedition Leader: Dr. Dana Yoerger

Chief Scientist: Professor Brian Glazer, University of Hawaii

Summary

This dive consisted of multibeam (0.9m/s), sidescan (0.7m/s) and camera (0.5m/s) segments in the Shinkai Deep to the west of Shinkai Ridge. The vehicle performed well.

Weather: The weather was well within the operating window.

Reason for end of dive: We terminated the dive with an acoustic command when we observed that the vehicle was not able to control depth.

Vehicle Configuration

The science sensing suite for this dive was:

Table 4: Sentry Sensor Configuration

Sensor
APS 1540 Magnetometers (3)
Edgetech Dynamically Focused Sidescan sonar
Reson 7125 Multibeam Sonar
Seabird SBE49 CTD
Seapoint OBS
Anderaa optode model 4330
300kHz RDI DVL
Digital Still Camera
IXEA PHINS
Reson Sound Velocity Probe
Koichi Nakomura EH sensor

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

Important Positions

Dive Origin: femo_deep.org: 18 39' -155 -15'

Launch Position: sentry266 launch position: 18 46.683'N 155 8.243'W

Narrative

This dive consisted of multibeam (0.9m/s), sidescan (0.7m/s) and camera (0.5m/s) segments. The vehicle performed well. The heading problems were solved. We still did not figure out why the Phins INS was reporting at erratic intervals on the first dive, but we checked the update before launch and will continue to do that. I reset the heading gains to the values used on the Cordes and Vandover cruises, and heading performed as expected.

Launch was uneventful. We got the vehicle in just at 1800 local so we did not interfere substantially with dinner. Recovery was at 1815 local the next day, the captain had the galley start dinner 15 minutes early so everyone could eat before recovery. Wind (mid 20 kts) and swell (1 meter +) were higher than our previous recoveries but caused us no problems. As on our previous recoveries, we did a good job of centering the crane above the vehicle before hauling in on the whip. The air tugger was used for an extra safety mechanism but kept slack until it was used to help align the vehicle into the cradle.

Vehicle heading, speed control, and bottom-following were all satisfactory. The multibeam run was made at 0.9 m/s and the thrusters rarely saturated. No doubt the vehicle can do 1.0 under most circumstances. With the multibeam running and the vehicle driving at 0.9 m/s, the battery consumption averaged 4.64

percent/hour. When running the camera only at 0.5 m/s, the battery consumption dropped to 3.22 percent/hour. I set the battery lower limit at 10%, in hindsight we could have set that lower and gained another hour or so of camera coverage.

1 Issues and Proposed Solutions

We had a long offload time for camera data due to ethernet problems. We will run a cable direct to the imaging pod after the next dive

xxx

Chief Scientist Comments

The Chief scientist is requested to include any desired comments.

Dive Statistics

1.1 sentry266 Summary

sentry266 Summary
Origin: 18.650000 -155.250000
Launch: 2014/06/30 04:00:09
Survey start: 2014/06/30 05:56:42
Survey start: Lat:18.778642 Lon:-155.138317
Survey end: 2014/07/01 02:37:10
Survey start: Lat:18.640617 Lon:-155.249594
Ascent begins: 2014/07/01 02:37:29
On the surface: 2014/07/01 04:16:17
On deck: 2014/07/01 04:36:45
descent rate: 39.6 m/min
ascent rate: 47.2 m/min
survey time: 20.7 hours
deck-to-deck time 24.6 hours
Mean survey depth: 4699m
Mean survey height: 32m
distance travelled: 46.63km
average speed; 0.63m/s
average speed during photo runs: 0.45 m/s over 17.00 km
average speed during multibeam runs: 0.80 m/s over 29.61 km
total vertical during survey: 7557m
Battery energy at launch: 12.9 kwhr
Battery energy at survey end: 1.2 kwhr
Battery energy on deck: 0.8 kwhr

Plots and Images

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

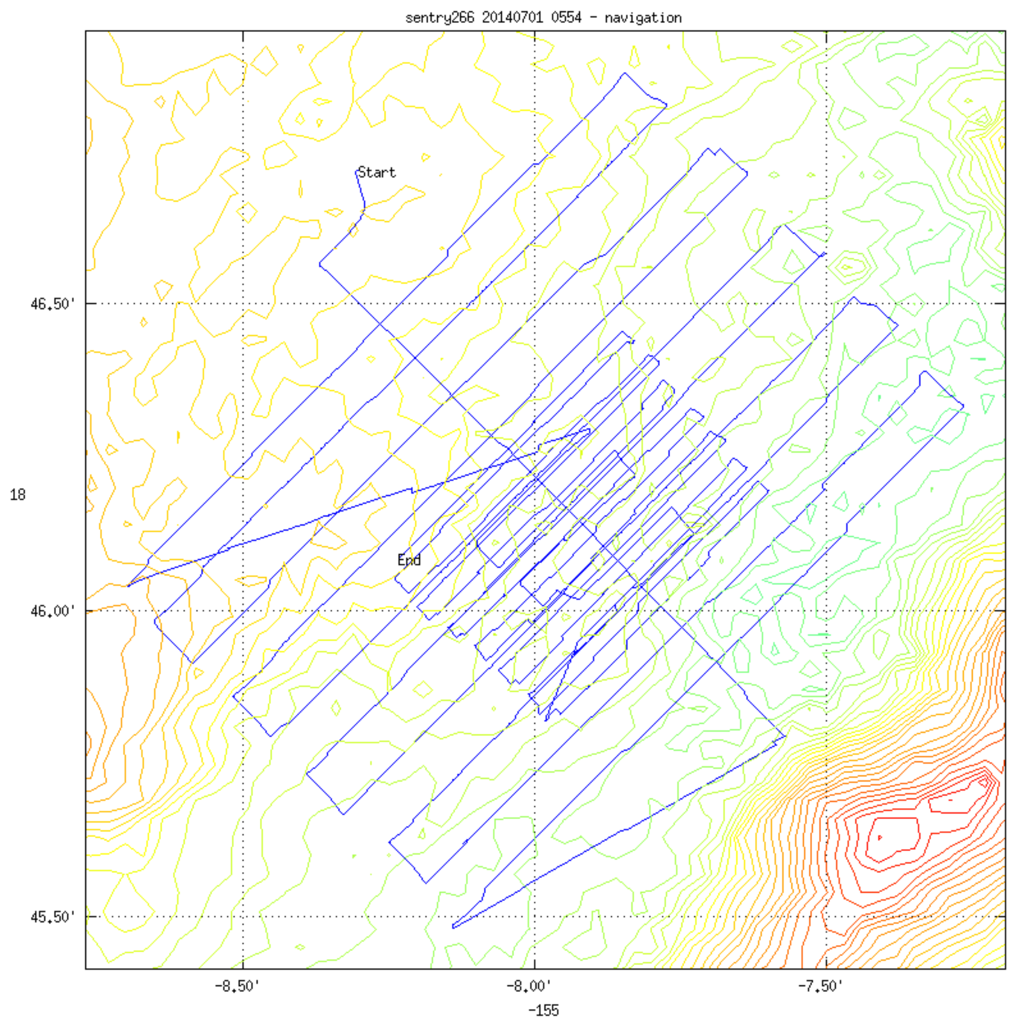


Figure 10: Latitude/Longitude plot of Sentry dive 266 based on post-processed navigation.

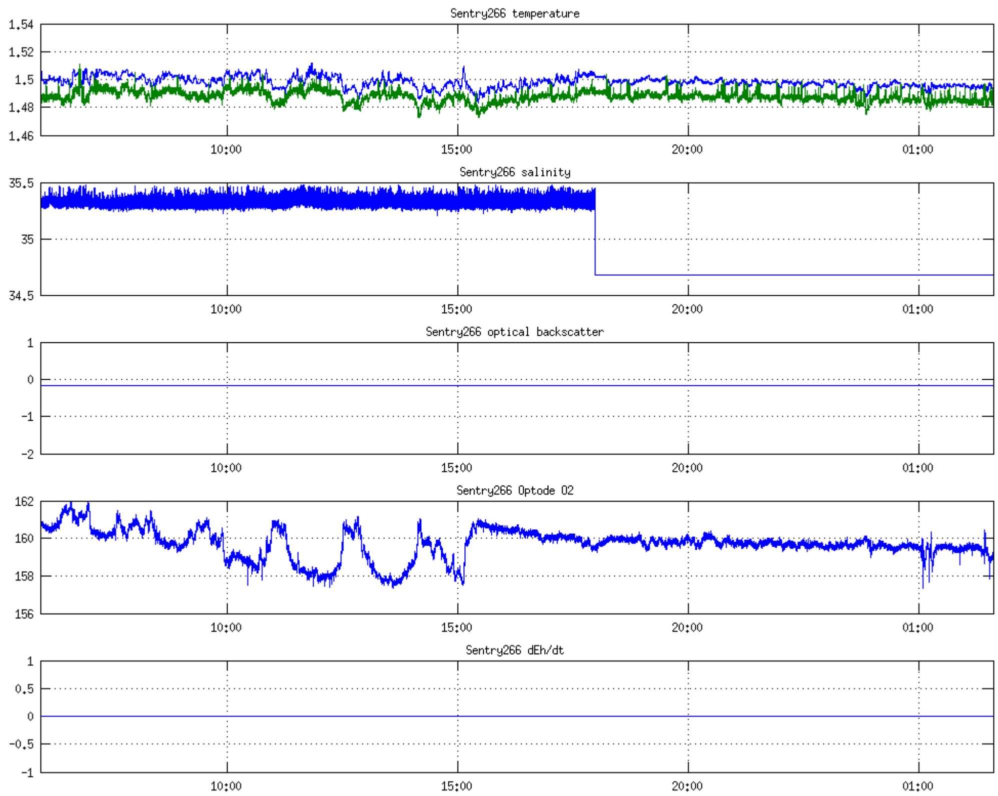
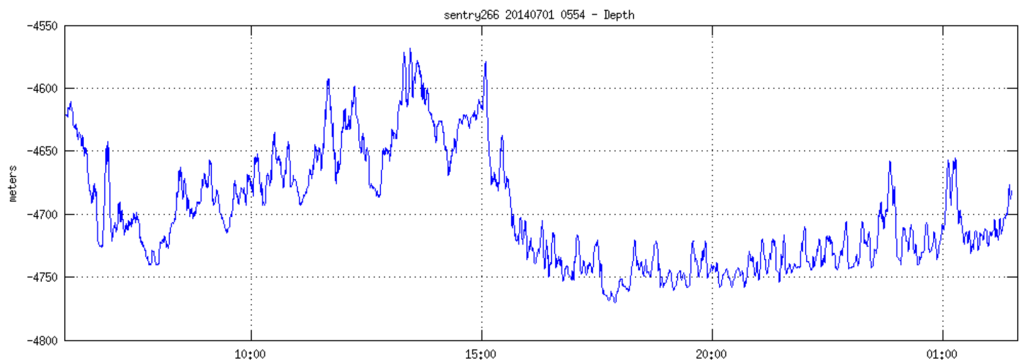


Figure 11: Time series plot of five of the basic sensors on Sentry, from top to bottom, temperature, salinity, optical backscatter, and dissolved Oxygen.



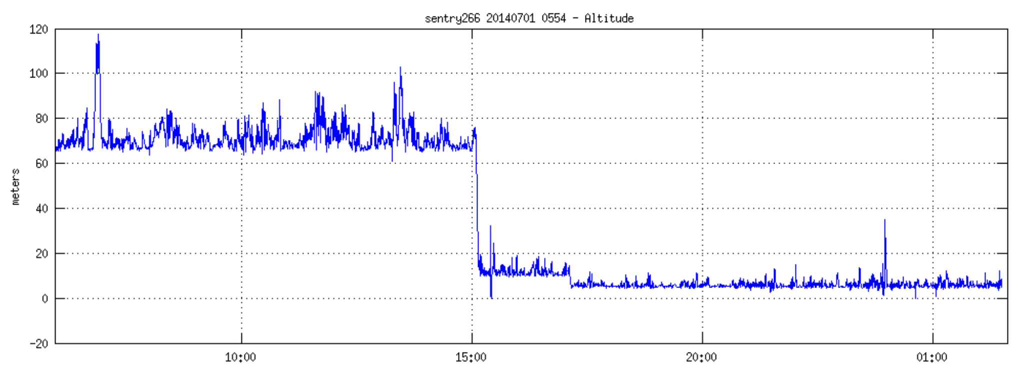


Figure 12: Depth and Altitude of Sentry during dive 266.

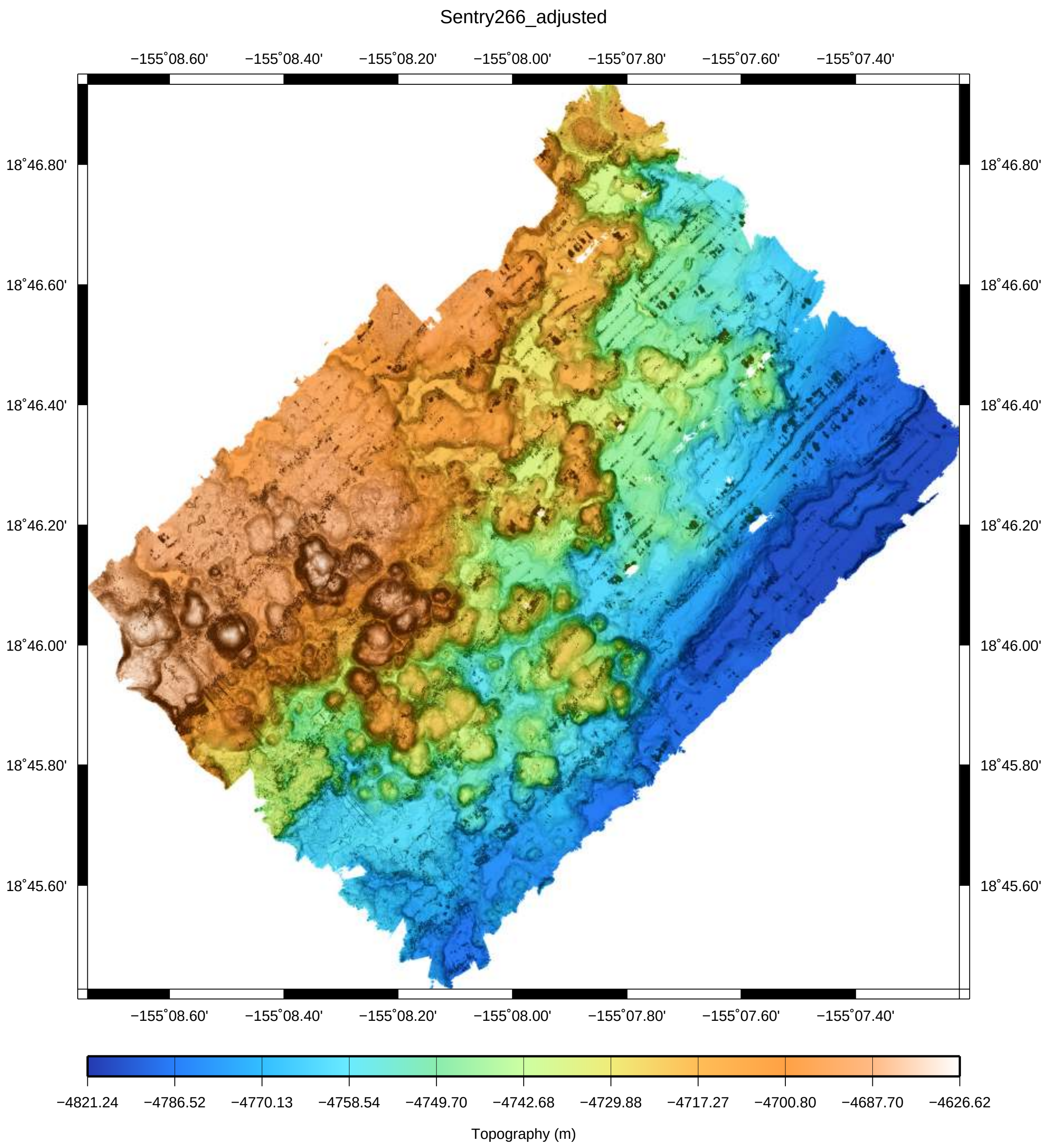


Figure 13: Adjusted multibeam bathymetry for dive 266, nav adjusted.

Sentry 267 Dive Report
DRAFT

WHOI Sentry Operations Group
Dr. Dana Yoerger, Chris Taylor, Justin Fuji, Johanna Hansen, Zac Berkowitz

Sentry Expedition Leader: Dr. Dana Yoerger

Chief Scientist: Professor Brian Glazer, University of Hawaii

Summary

This dive took place over the ridge north of FEMO Deep. The dive plan consisted of two multibeam blocks with a short camera survey at the top of each of the two peaks on the ridge. The multibeam performed poorly.

Weather: The weather was well within the operating window.

Reason for end of dive: The dive terminated on low battery (10%)

Vehicle Configuration

The science sensing suite for this dive was:

Table 5: Sentry Sensor Configuration

Sensor
APS 1540 Magnetometers (3)
Edgetech Dynamically Focused Sidescan sonar
Reson 7125 Multibeam Sonar
Seabird SBE49 CTD
Seapoint OBS
Anderaa optode model 4330
300kHz RDI DVL
Digital Still Camera
IXEA PHINS
Reson Sound Velocity Probe
Koichi Nakomura EH sensor

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

Important Positions

Dive Origin: femo_deep.org: 18 39' -155 -15'

Launch Position: sentry267 launch position: 18 46.202'N 155 7.753'W

Narrative

This dive took place over the ridge north of FEMO Deep. The dive plan consisted of two multibeam blocks with a short camera survey at the top of each of the two peaks on the ridge. The vehicle ran very well, no collisions in some pretty lively terrain. In fact, the vehicle rarely switched to ROV mode during the multibeam survey, I had increased the envelope size to 20meters. This put the vehicle at no additional risk of collision (in this terrain) and made the control far smoother and allowed the speed to remain near the desired speed.

The Reson performed poorly on this dive. We think we had a startup problem, although this was not diagnosed definitively. On startup, the sonar showed an error on the transmitter. We shut the 7125 down and restarted it. The sonar recorded very short records, so there are gaps in the pings. We suspect that we may have had two copies of the Reson driver running, but we have no theory as to how two versions of the driver might have been started.

The photos look very good and the vehicle negotiated some difficult terrain without collision.

We examined some interesting Eh and temperature anomalies during the photo surveys, but the photos showed no obvious venting. We also noted a temperature anomaly during the multibeam survey.

The Eh probe worked, the optical backscatter sensor had a logging problem.

1 Issues and Proposed Solutions

The multibeam had a bad logging problem. The files were logged in 12000 small files, each with between 0 and 5 pings of data. Our procesing methods worked, although the large number of files caused some of our matlab-based scripting to run very poorly.

the multibeam coverage was not as wide as expected, leaving some holidays

Chief Scientist Comments

The Chief scientist is requested to include any desired comments.

Dive Statistics

1.1 sentry267 Summary

sentry267 Summary
Origin: 18.650000 -155.250000
Launch: 2014/07/01 21:16:30
Survey start: 2014/07/01 23:16:32
Survey start: Lat:18.771253 Lon:-155.129542
Survey end: 2014/07/02 19:49:10
Survey start: Lat: Lon:
Ascent begins: 2014/07/02 19:49:30
On the surface: 2014/07/02 21:27:22
On deck: 2014/07/02 21:45:07
descent rate: 38.8 m/min
ascent rate: 46.6 m/min
survey time: 20.5 hours
deck-to-deck time 24.5 hours
Mean survey depth: 4585m
Mean survey height: 50m
distance travelled: 41.51km
average speed; 0.56m/s
average speed during photo runs: 0.32 m/s over 5.67 km
average speed during multibeam runs: 0.64 m/s over 35.84 km
total vertical during survey: 12141m
Battery energy at launch: 13.2 kwhr
Battery energy at survey end: 1.2 kwhr
Battery energy on deck: 0.9 kwhr

Plots and Images

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

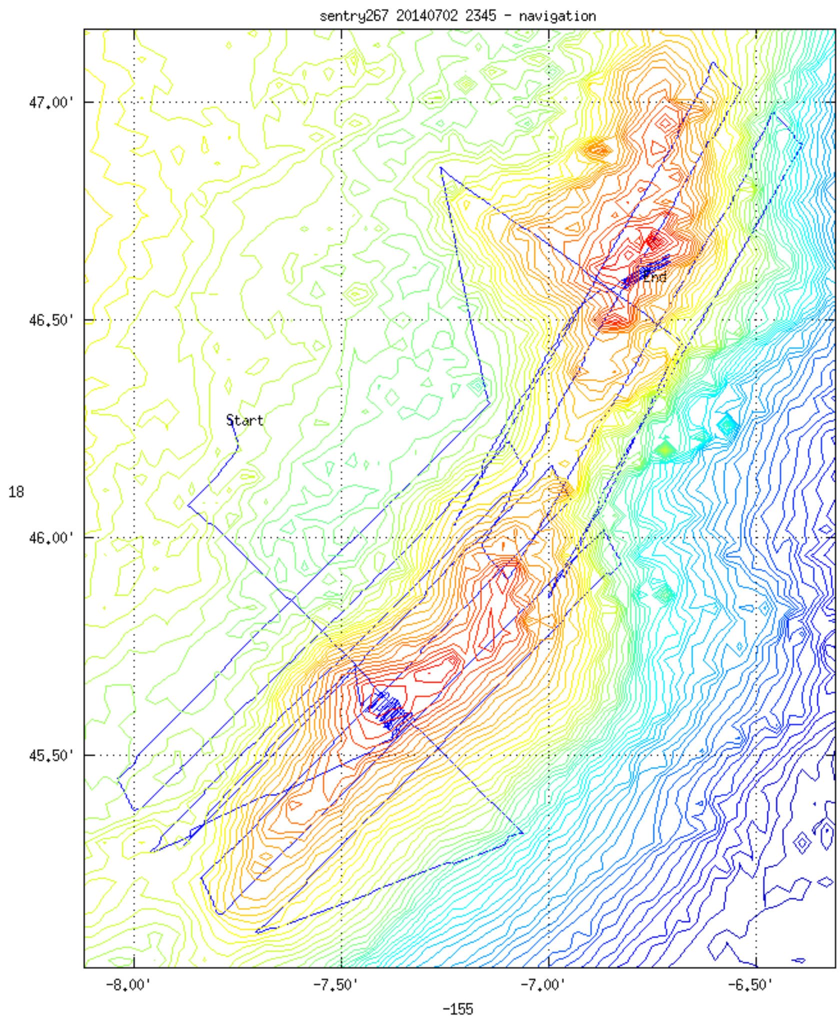


Figure 14: Latitude/Longitude plot of Sentry dive 267 based on post-processed navigation.

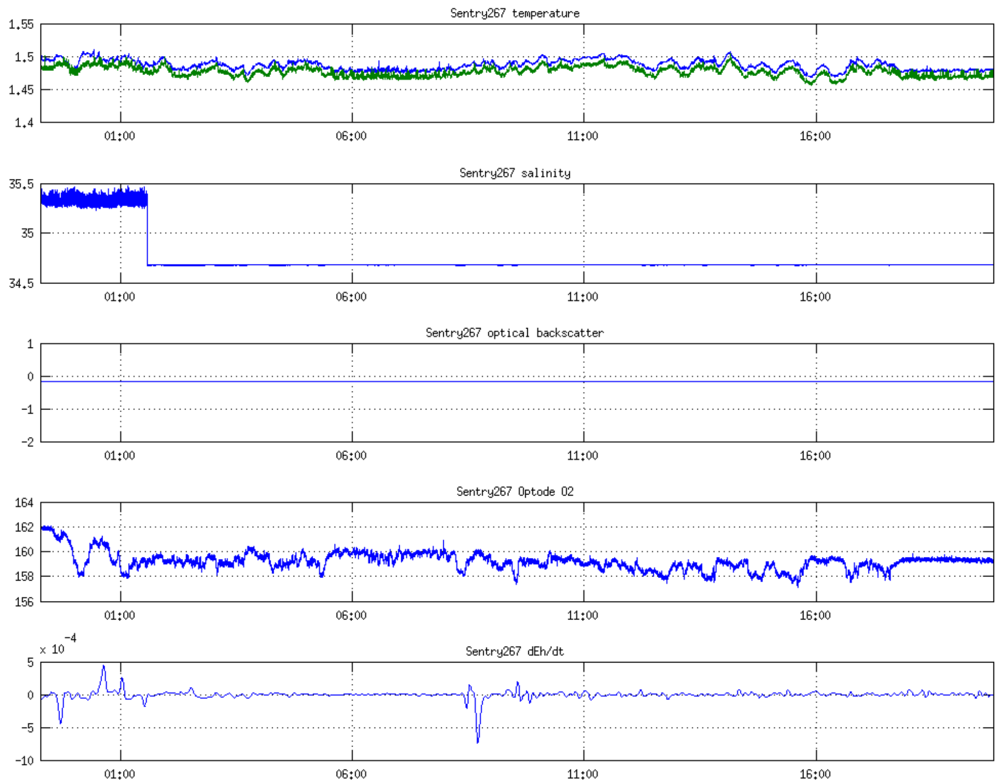


Figure 15: Time series plot of five of the basic sensors on Sentry, from top to bottom, temperature, salinity, optical backscatter, and dissolved Oxygen.

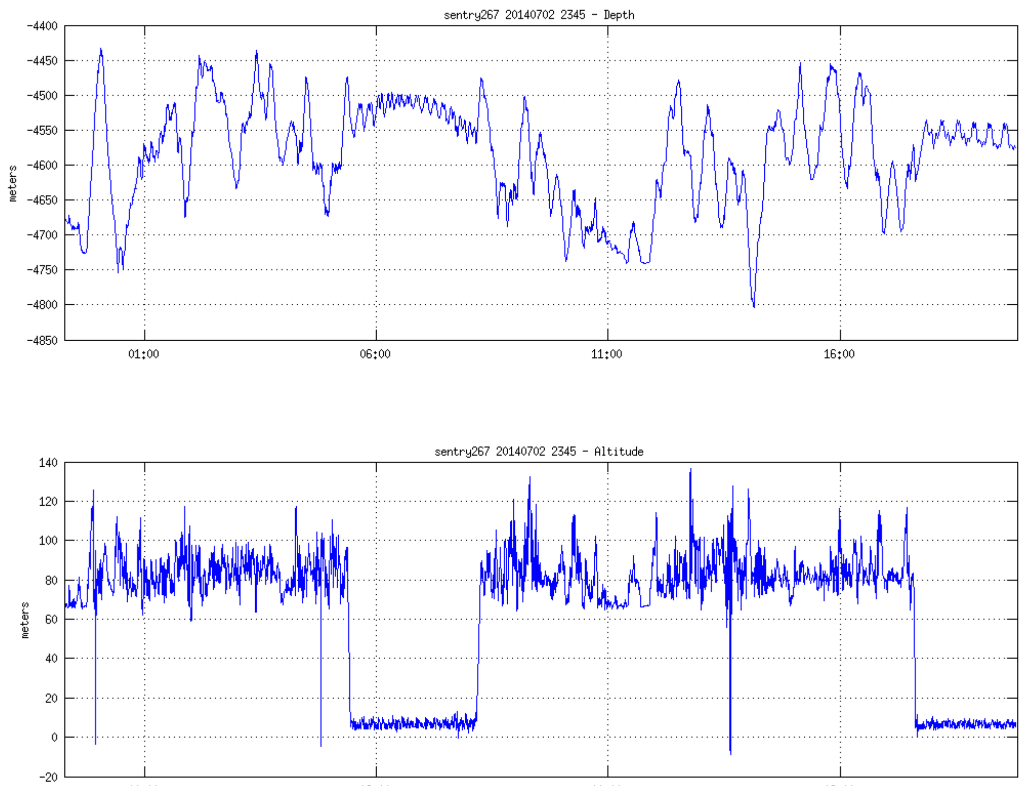


Figure 16: Depth and Altitude of Sentry during dive 267.

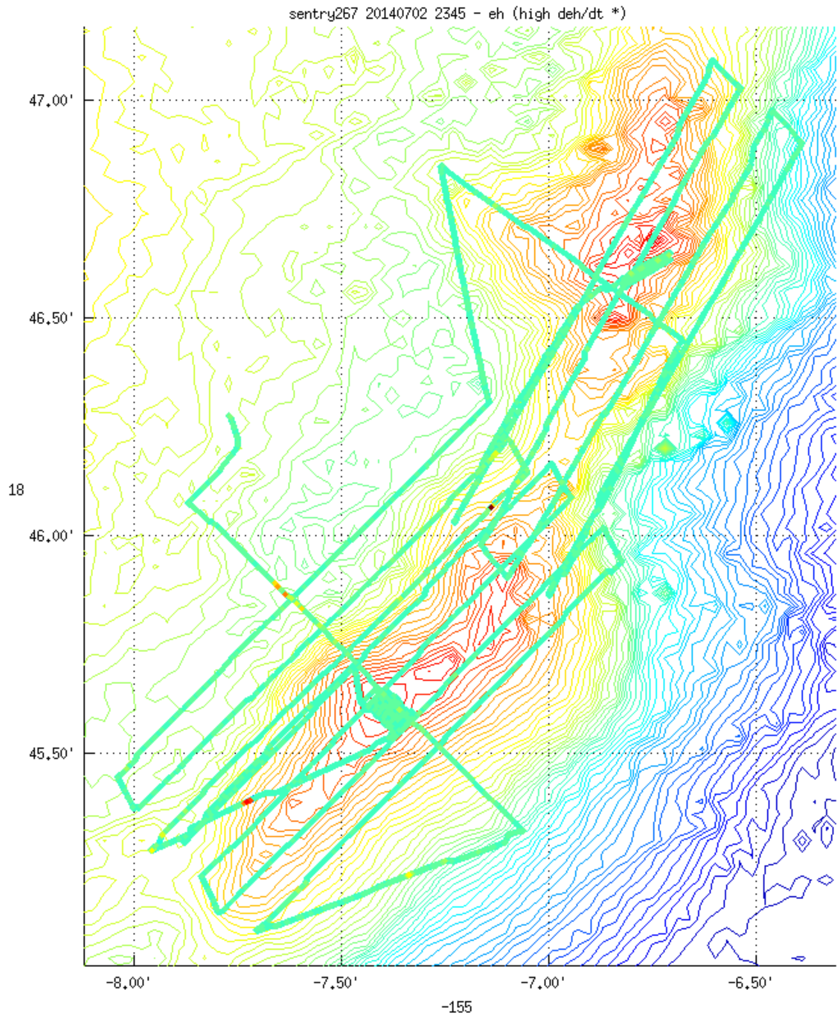


Figure 17: Redox potential (deh/dt) on dive 267.

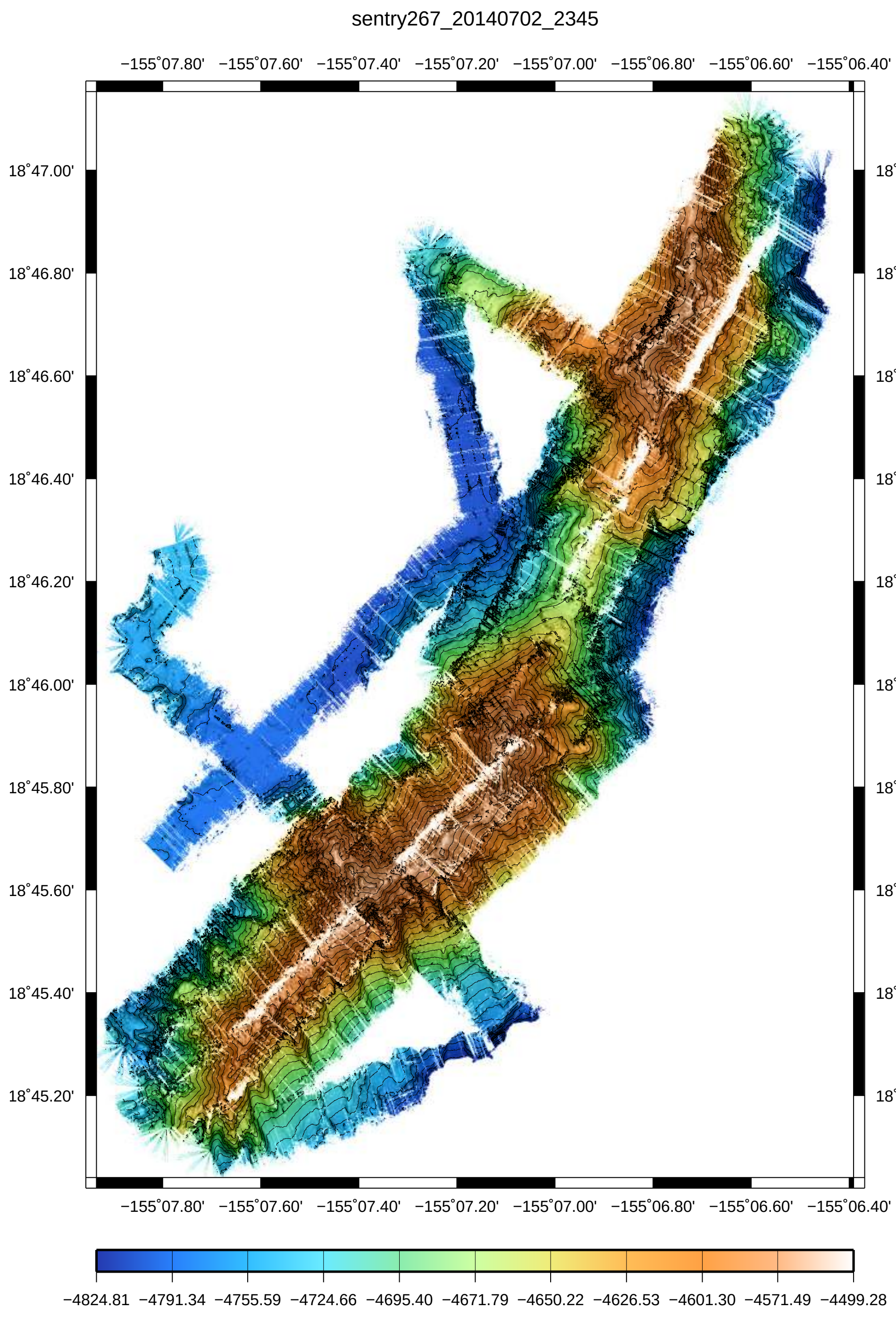


Figure 18: Multibeam bathymetry for dive 266, no adjustment.

Sentry 268 Dive Report
DRAFT

WHOI Sentry Operations Group
Dr. Dana Yoerger, Chris Taylor, Justin Fuji, Johanna Hansen, Zac Berkowitz

Sentry Expedition Leader: Dr. Dana Yoerger

Chief Scientist: Professor Brian Glazer, University of Hawaii

Summary

We planned this dive on the northern part of Shinkai Ridge. The DVL failed and the vehicle could not navigate. We called the vehicle back when we saw it was not making sufficient progress.

Weather: The weather was well within the operating window.

Reason for end of dive: We called the vehicle back because it was not making good progress and we feared it might be hitting the seafloor. In hindsight, it did not hit the seafloor but could not possibly have succesded with a malfunctioning DVL.

Vehicle Configuration

The science sensing suite for this dive was:

Table 6: Sentry Sensor Configuration

Sensor
APS 1540 Magnetometers (3)
Edgetech Dynamically Focused Sidescan sonar
Reson 7125 Multibeam Sonar
Seabird SBE49 CTD
Seapoint OBS
Anderaa optode model 4330
300kHz RDI DVL
Digital Still Camera
IXEA PHINS
Reson Sound Velocity Probe
Koichi Nakomura EH sensor

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

Important Positions

Dive Origin: femo_deep.org: 18 39' -155 -15'

Launch Position: sentry268 launch position: 18 47.135'N 155 7.187'W

Narrative

Launch normal, seas up a bit 2m. Recovery was lively but went very well.

Vehicle moving very slowly on-bottom. Based on sparse acomms messages we thought the vehicle had hit the bottom several times (altitude=-3). So we gave a bottom-follow parameter change through the acoustic comms that would force the vehicle up. That appeared to work and the vehicle started moving again. But that was a misinterpretation. After 3 hours we aborted the mission. The vehicle was not making much progress and we feared it was repeatedly hitting the seafloor.

In looking at the data, the DVL was giving very poor results. Beam 1 dead, beam 2 gave only a few good responses when the vehicle was close to the seafloor. Beams 3 and 4 gave decent data but with repeating dropouts of about 8 cycles after a few good hits. The vehicle did not hit the bottom, but came close once.

Both Eh and optical backscatter logged, but did not show anything of obvious interest on the seafloor survey. We saw some Eh activity during descent.

We swapped out the DVL for the spare.

1 Issues and Proposed Solutions

swap out the DVL. Carefully review configuration and setup. Test as possible on deck

Chief Scientist Comments

The Chief scientist is requested to include any desired comments.

Dive Statistics

1.1 sentry268 Summary

sentry268 Summary
Origin: 18.650000 -155.250000
Launch: 2014/07/03 16:39:10
Survey start: 2014/07/03 18:40:20
Survey start: Lat:18.784296 Lon:-155.121696
Survey end: 2014/07/03 21:48:36
Survey start: Lat: Lon:
Ascent begins: 2014/07/03 21:48:55
On the surface: 2014/07/03 23:22:21
On deck: 2014/07/03 23:45:26
descent rate: 38.8 m/min
ascent rate: 49.3 m/min
survey time: 3.1 hours
deck-to-deck time 7.1 hours
Mean survey depth: 4644m
Mean survey height: 28m
distance travelled: 3.60km
average speed; 0.32m/s
average speed during photo runs: 0.44 m/s over 1.93 km
average speed during multibeam runs: 0.24 m/s over 1.67 km
total vertical during survey: 1612m
Battery energy at launch: 13.4 kwhr
Battery energy at survey end: 10.6 kwhr
Battery energy on deck: 10.3 kwhr

Plots and Images

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

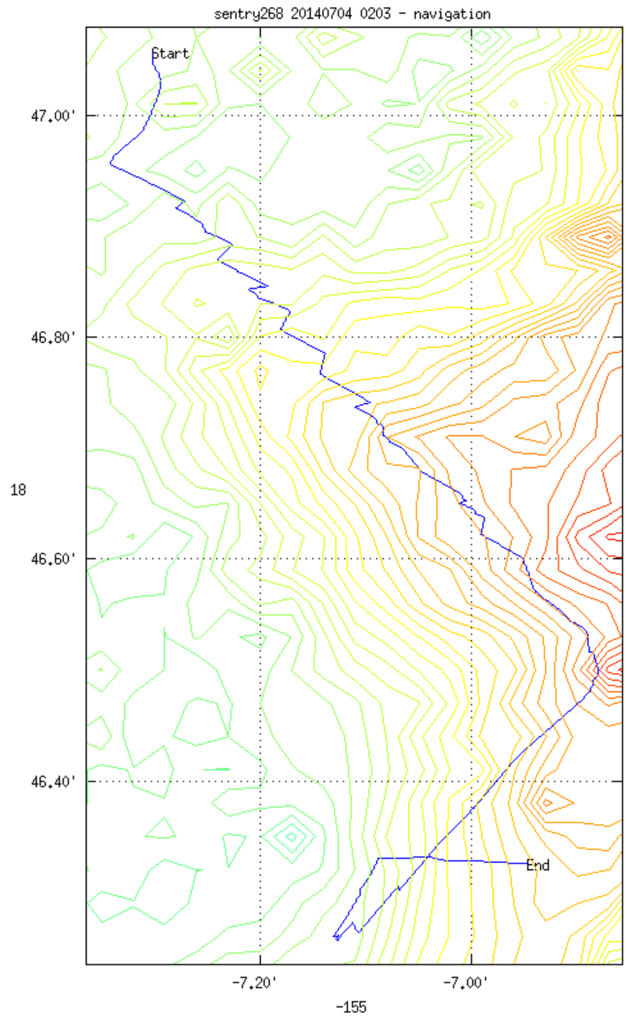


Figure 19: Latitude/Longitude plot of Sentry dive 268 based on post-processed navigation.

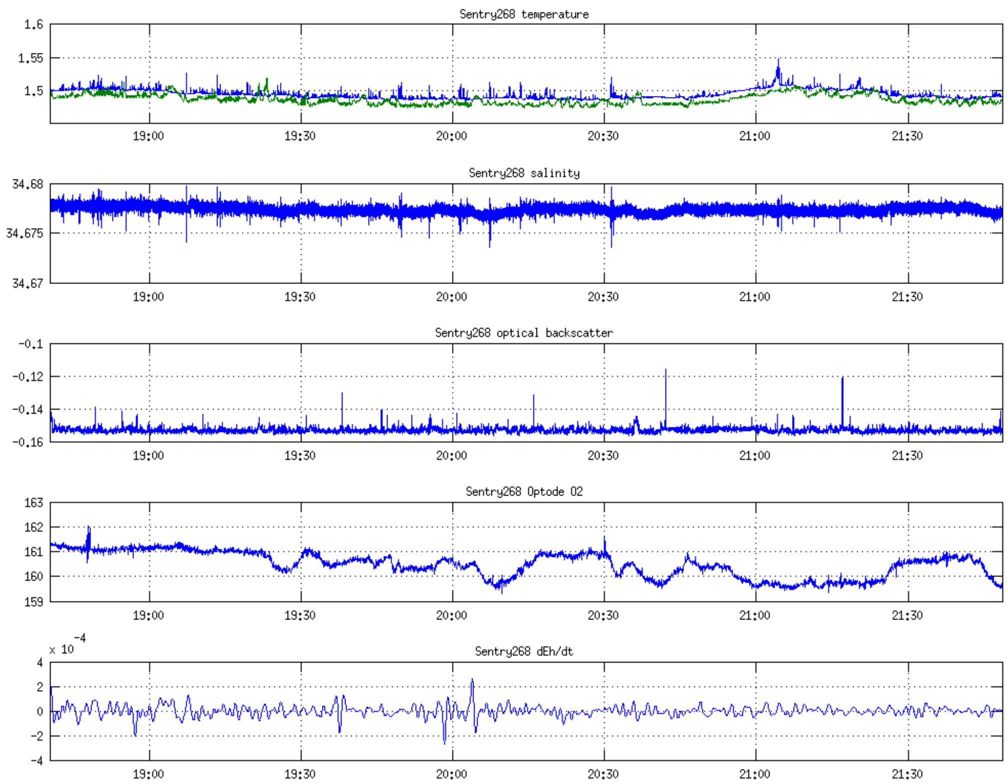


Figure 20: Time series plot of five of the basic sensors on Sentry, from top to bottom, temperature, salinity, optical backscatter, and dissolved Oxygen.

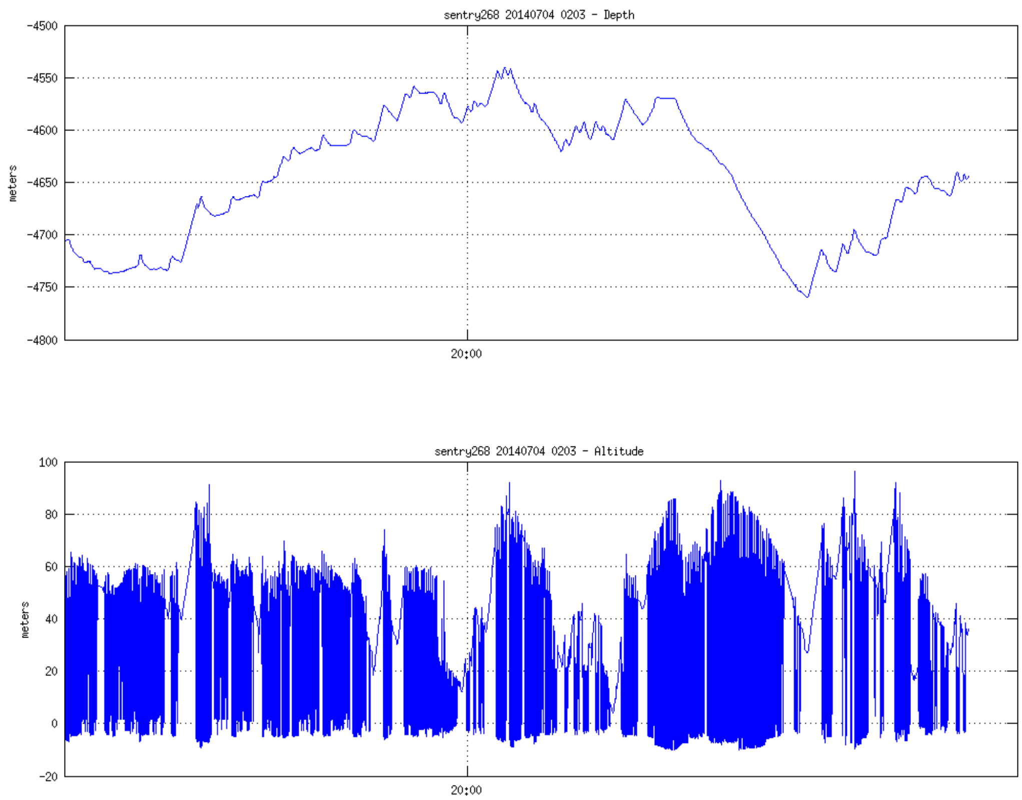


Figure 21: Depth and Altitude of Sentry during dive 268.

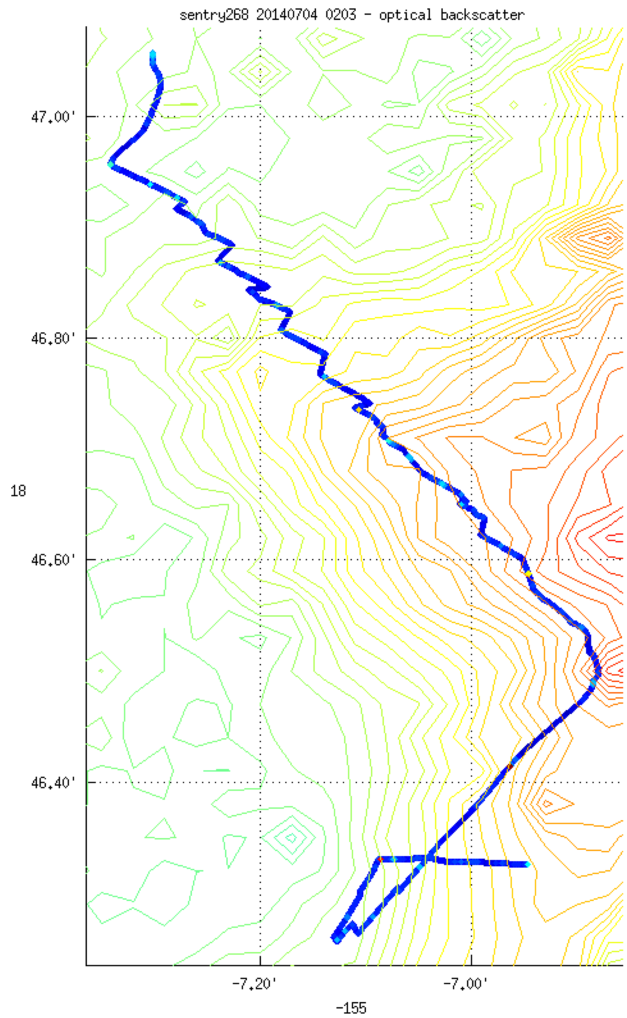


Figure 22: Optical backscatter on dive 268.

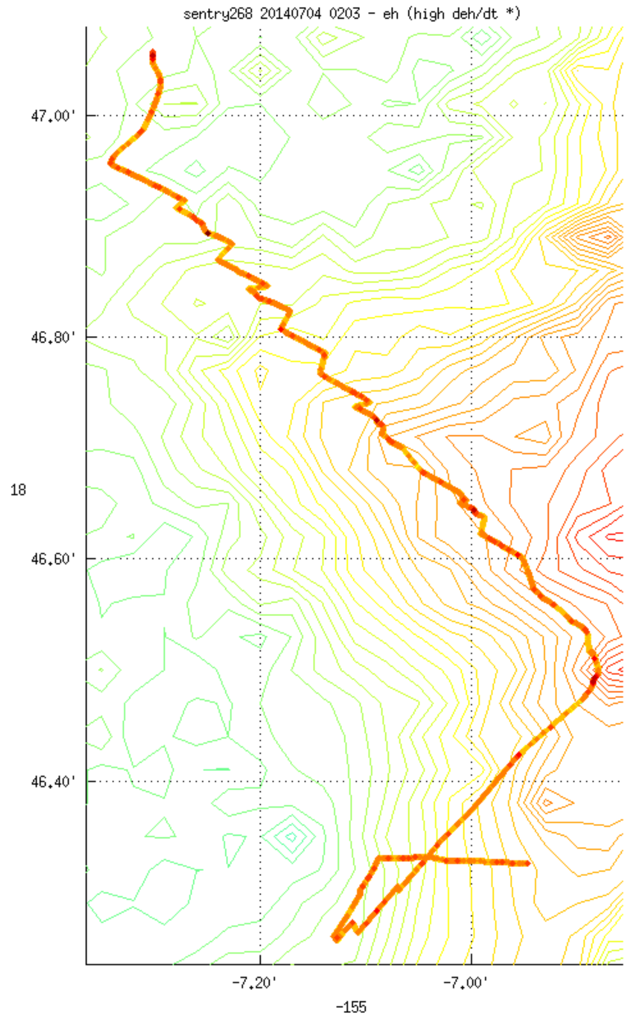


Figure 23: Redox potential (deh/dt) on dive 268.

Sentry 269 Dive Report
DRAFT

WHOI Sentry Operations Group
Dr. Dana Yoerger, Chris Taylor, Justin Fuji, Johanna Hansen, Zac Berkowitz

Sentry Expedition Leader: Dr. Dana Yoerger

Chief Scientist: Professor Brian Glazer, University of Hawaii

Summary

The vehicle made a multibeam and camera survey on the northern crest of the ridge to the east of Shinkai Deep. The mission plan was the same as the previous dive where the DVL failed.

Weather: The weather was well within the operating window.

Reason for end of dive: The dive ended when the battery limit was reached.

Vehicle Configuration

The science sensing suite for this dive was:

Table 7: Sentry Sensor Configuration

Sensor
APS 1540 Magnetometers (3)
Edgetech Dynamically Focused Sidescan sonar
Reson 7125 Multibeam Sonar
Seabird SBE49 CTD
Seapoint OBS
Anderaa optode model 4330
300kHz RDI DVL
Digital Still Camera
IXEA PHINS
Reson Sound Velocity Probe
Koichi Nakomura EH sensor

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

Important Positions

Dive Origin: femo_deep.org: 18 39' -155 -15'

Launch Position: sentry269 launch position: 18 47.135'N 155 7.187'W

Narrative

Launch and descent were normal.

The replacement DVL worked but struggled badly on some of the steep terrain. The problems were similar to those we saw on the Smith cruise, on a steep sideslope the velocities appear to rotate. In response, we had to send many shift commands. In one case, we got our shift in late which resulted in a cap in the multibeam coverage. Performance of the DVL improved a lot on less extreme terrain.

The multibeam map looks good, with the exception of the holiday from the shift command, which was given at the end of the second line.

The vehicle hit at 21:20 during the photo survey. The terrain in that area was very challenging, with vertical changes in the bathymetry greater than the survey height of 5 meters. As verified in the photos, the vehicle recovered immediately and suffered no apparent damage. Photo quality overall was good.

Challenging recovery in 2+ meter seas. We went around 4 times, but got a good hookup on the 5th. The pickup was pretty clean considering the conditions.

1 Issues and Proposed Solutions

DVL problems seem fundamental to the RDI unit on steep sideslopes. To some extent we can correct this in postprocessing.

Chief Scientist Comments

The Chief scientist is requested to include any desired comments.

Dive Statistics

1.1 sentry269 Summary

sentry269 Summary
Origin: 18.650000 -155.250000
Launch: 2014/07/04 06:59:41
Survey start: 2014/07/04 09:00:57
Survey start: Lat:18.784751 Lon:-155.120964
Survey end: 2014/07/05 02:58:26
Survey start: Lat: Lon:
Ascent begins: 2014/07/05 03:01:13
On the surface: 2014/07/05 04:35:02
On deck: 2014/07/05 05:03:19
descent rate: 38.7 m/min
ascent rate: 48.4 m/min
survey time: 18.0 hours
deck-to-deck time 22.1 hours
Mean survey depth: 4601m
Mean survey height: 45m
distance travelled: 32.84km
average speed; 0.51m/s
average speed during photo runs: 0.33 m/s over 7.28 km
average speed during multibeam runs: 0.60 m/s over 25.57 km
total vertical during survey: 10514m
Battery energy at launch: 12.7 kwhr
Battery energy at survey end: 2.9 kwhr
Battery energy on deck: 2.4 kwhr

Plots and Images

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

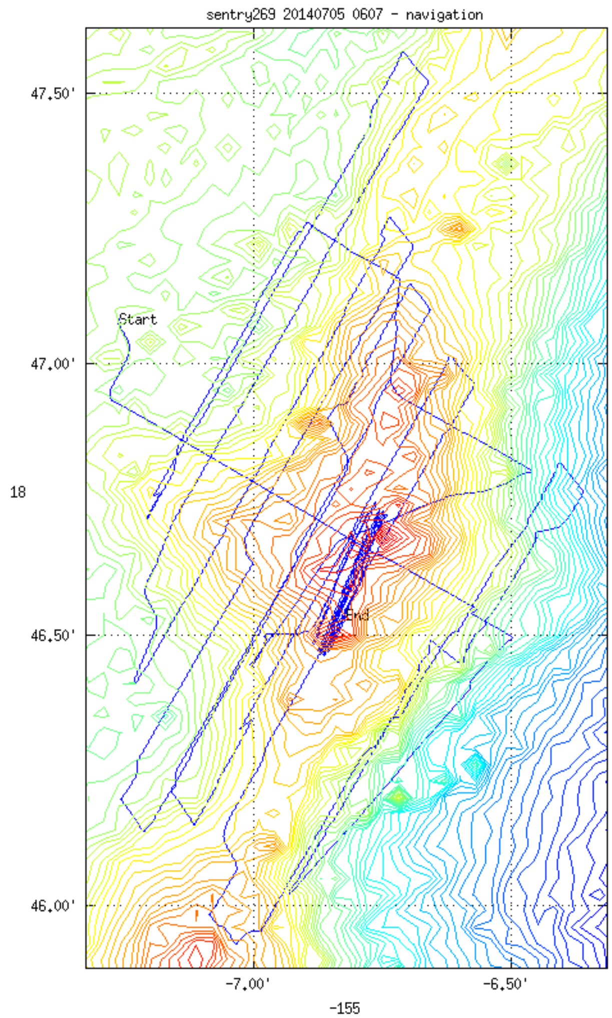


Figure 24: Latitude/Longitude plot of Sentry dive 269 based on post-processed navigation.

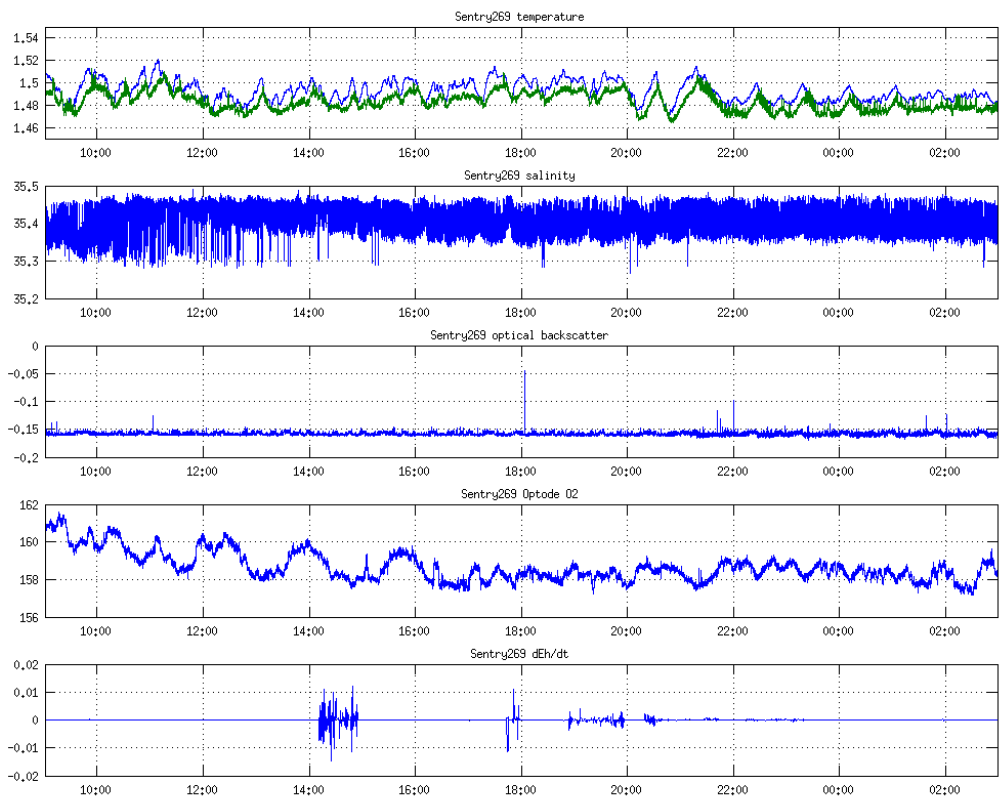


Figure 25: Time series plot of five of the basic sensors on Sentry, from top to bottom, temperature, salinity, optical backscatter, and dissolved Oxygen.

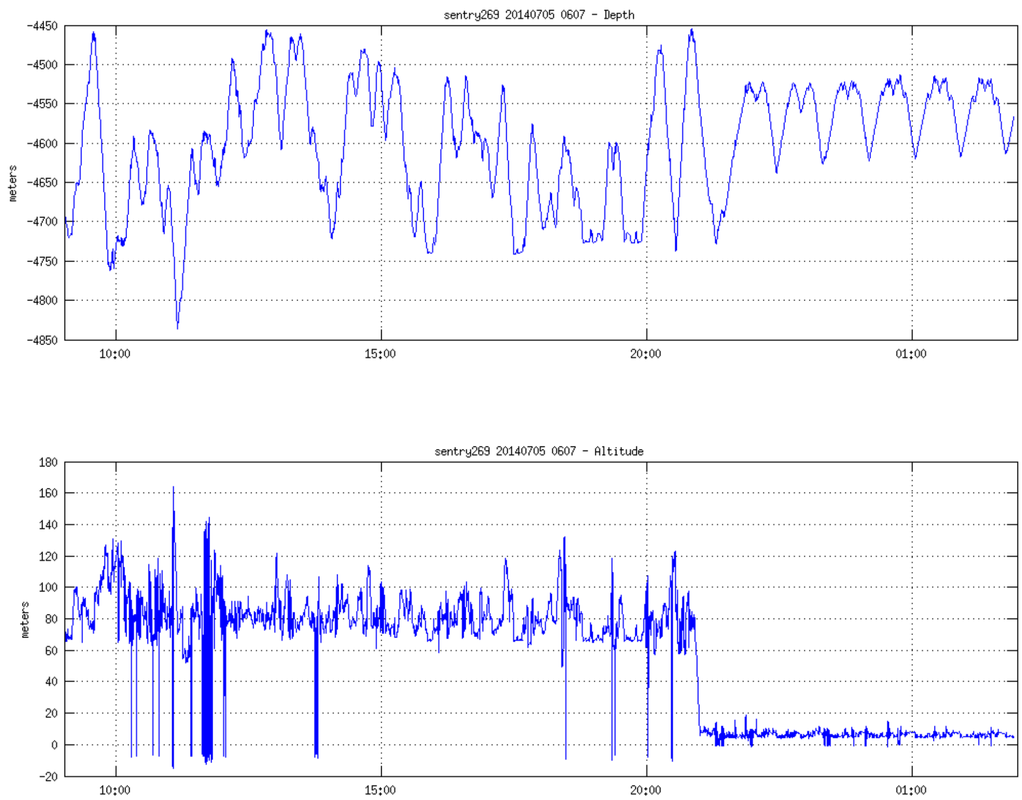


Figure 26: Depth and Altitude of Sentry during dive 269.

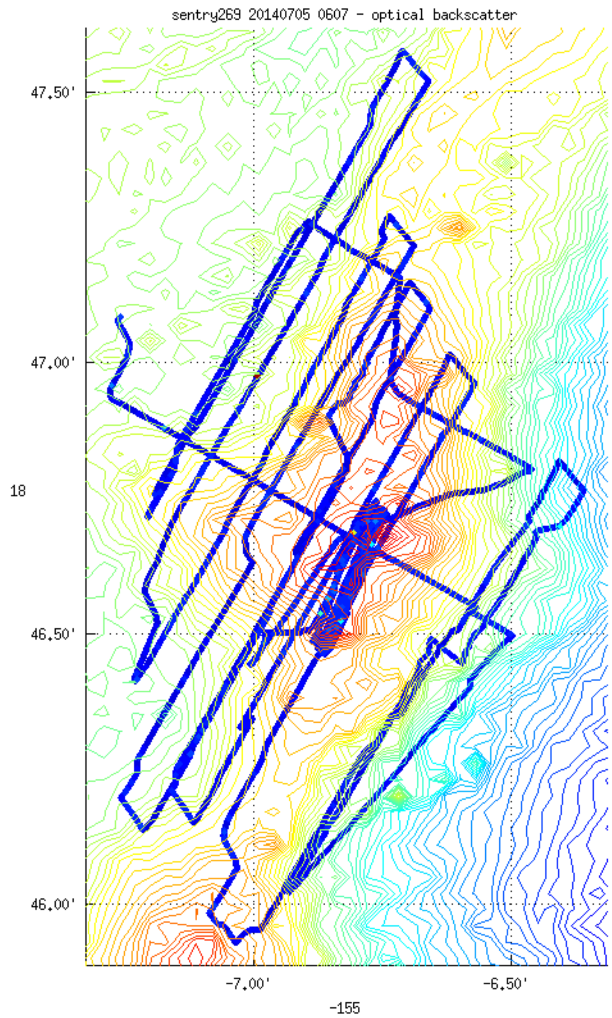


Figure 27: Optical backscatter on dive 269.

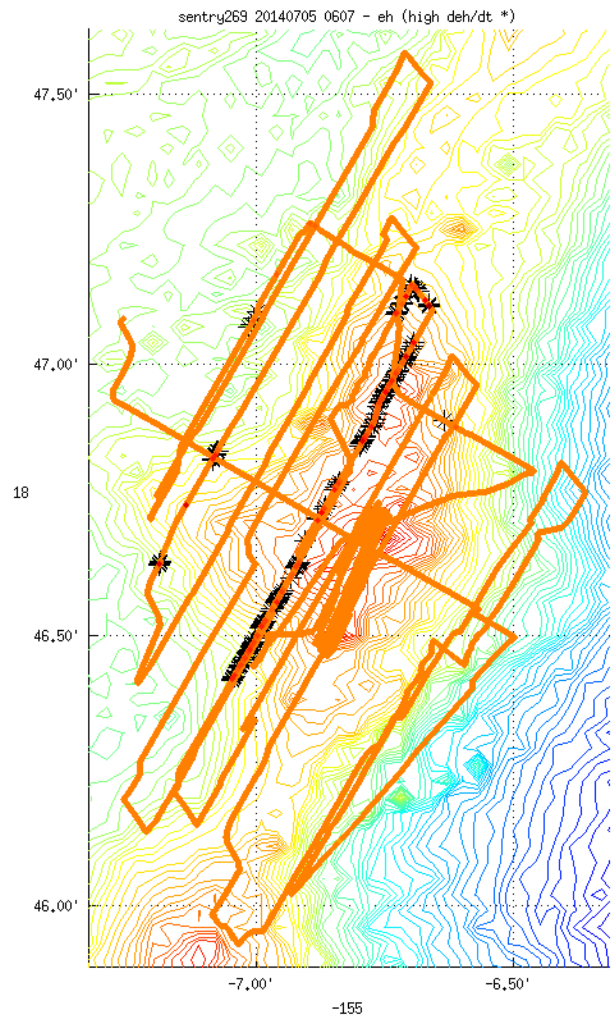


Figure 28: Redox potential (deh/dt) on dive 269.

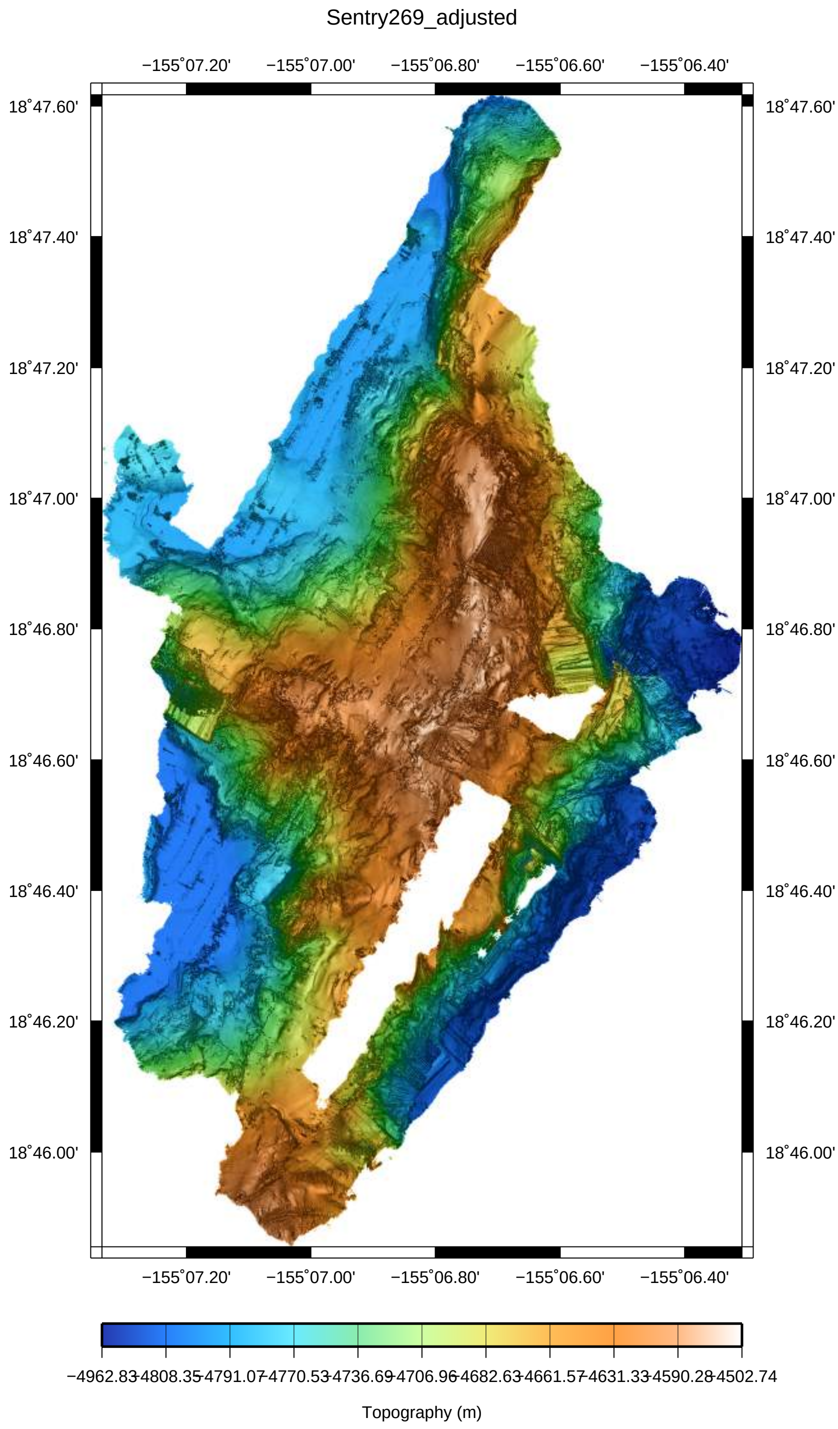


Figure 29: Multibeam bathymetry for dive 269.

Sentry 270 Dive Report
DRAFT

WHOI Sentry Operations Group
Dr. Dana Yoerger, Chris Taylor, Justin Fuji, Johanna Hansen, Zac Berkowitz

Sentry Expedition Leader: Dr. Dana Yoerger

Chief Scientist: Professor Brian Glazer, University of Hawaii

Summary

The vehicle made a multibeam and camera survey in the Shinkai Deep in an area adjacent to the south of the survey area for Sentry266.

Weather: The weather was well within the operating window.

Reason for end of dive: The dive ended when we sent an acoustic abort command to meet the departure schedule.

Vehicle Configuration

The science sensing suite for this dive was:

Table 8: Sentry Sensor Configuration

Sensor
APS 1540 Magnetometers (3)
Edgetech Dynamically Focused Sidescan sonar
Reson 7125 Multibeam Sonar
Seabird SBE49 CTD
Seapoint OBS
Anderaa optode model 4330
300kHz RDI DVL
Digital Still Camera
IXEA PHINS
Reson Sound Velocity Probe
Koichi Nakomura EH sensor

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

Important Positions

Dive Origin: femo_deep.org: 18 39' -155 -15'

Launch Position: sentry270 launch position: 18 45.073'N 155 8.002'W

Narrative

In real-time, the multibeam run appeared to go as plan. After a few lines into the camera survey, we could see by USBL fixes that the vehicle was not moving forward while on the NE-bound track. We raised the bottom-follower floor though an acoustic command, but that did not seem to free it. Eventually, we could see that the vehicle was moving to the SE, apparently the tracklines had timed out. We could see that the nav had shifted, so we sent an appropriate shift command.

Excellent recovery in 1.5m seas, winds in the low 30kt range. Hooked up directly on the first approach. We were on deck at almost exactly 0600 local as planned.

The vehicle collided with the seafloor multiple times during the photo run. In several cases, it did not recover until we sent an acoustic command to raise the bottom-follower depth limit or until the trackline timed out. The vehicle broke the forward starboard prop blade, otherwise we saw no damage.

The multibeam map is of high quality, standard processing and corrections were applied without difficulty. Photos were of good quality with the exception of the collisions.

1 Issues and Proposed Solutions

DVL problems seem fundamental to the RDI unit on steep sideslopes. To some extent we can correct this in postprocessing.

Chief Scientist Comments

The Chief scientist is requested to include any desired comments.

Dive Statistics

1.1 sentry270 Summary

sentry270 Summary
Origin: 18.650000 -155.250000
Launch: 2014/07/05 17:40:44
Survey start: 2014/07/05 19:42:06
Survey start: Lat:18.750345 Lon:-155.134137
Survey end: 2014/07/06 13:55:16
Survey start: Lat:18.669636 Lon:-155.254595
Ascent begins: 2014/07/06 13:56:06
On the surface: 2014/07/06 15:27:16
On deck: 2014/07/06 15:53:05
descent rate: 38.7 m/min
ascent rate: 51.6 m/min
survey time: 18.2 hours
deck-to-deck time 22.2 hours
Mean survey depth: 4676m
Mean survey height: 39m
distance travelled: 41.36km
average speed; 0.63m/s
average speed during photo runs: 0.40 m/s over 10.89 km
average speed during multibeam runs: 0.80 m/s over 30.47 km
total vertical during survey: 8723m
Battery energy at launch: 13.0 kwhr
Battery energy at survey end: 2.1 kwhr
Battery energy on deck: 1.7 kwhr

Plots and Images

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

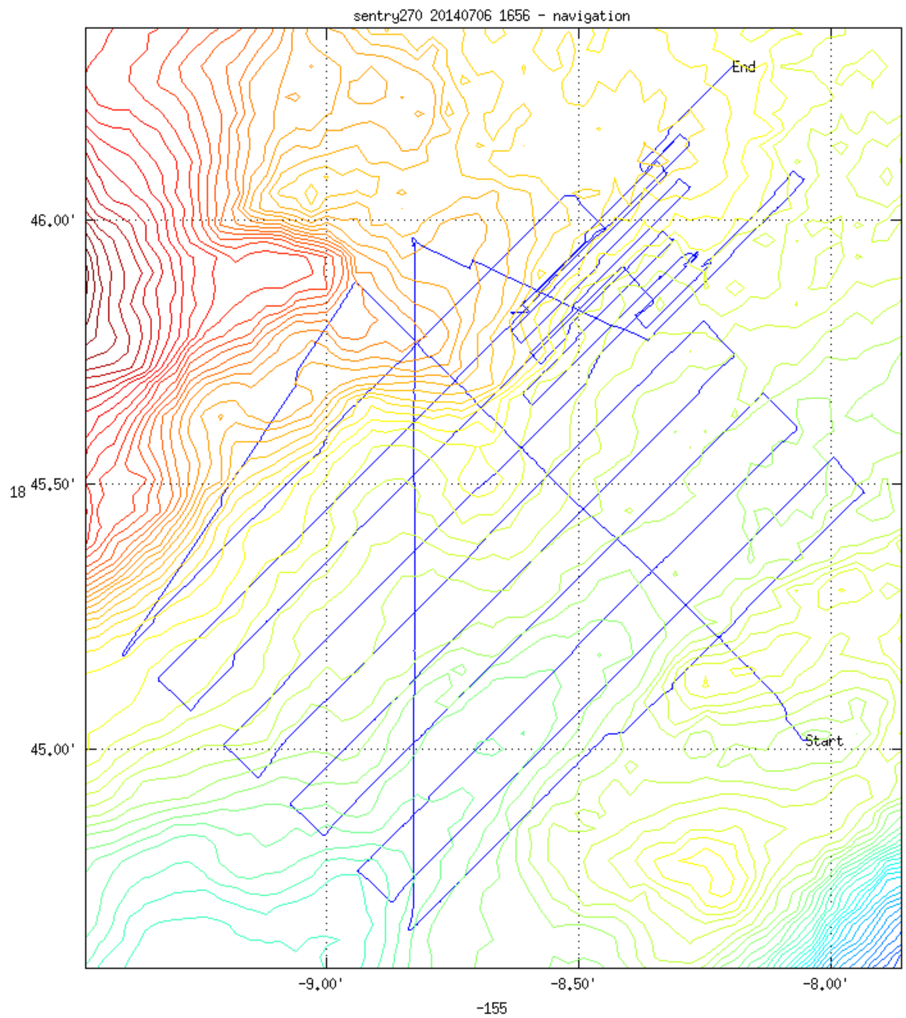


Figure 30: Latitude/Longitude plot of Sentry dive 270 based on post-processed navigation.

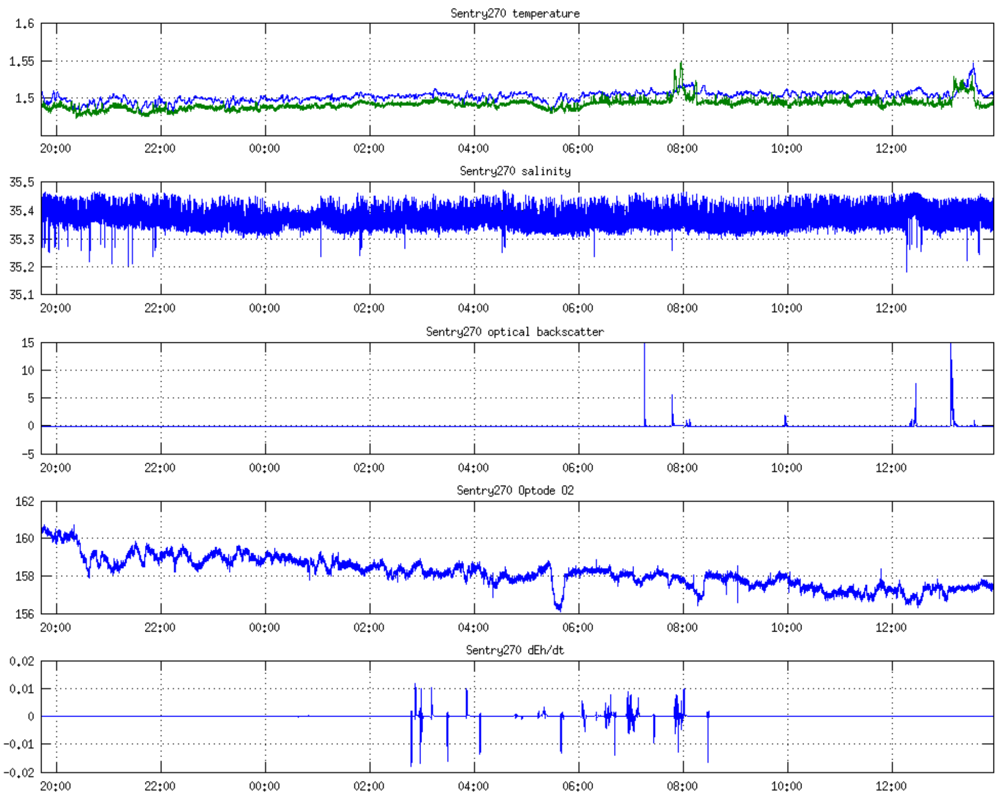


Figure 31: Time series plot of five of the basic sensors on Sentry, from top to bottom, temperature, salinity, optical backscatter, and dissolved Oxygen.

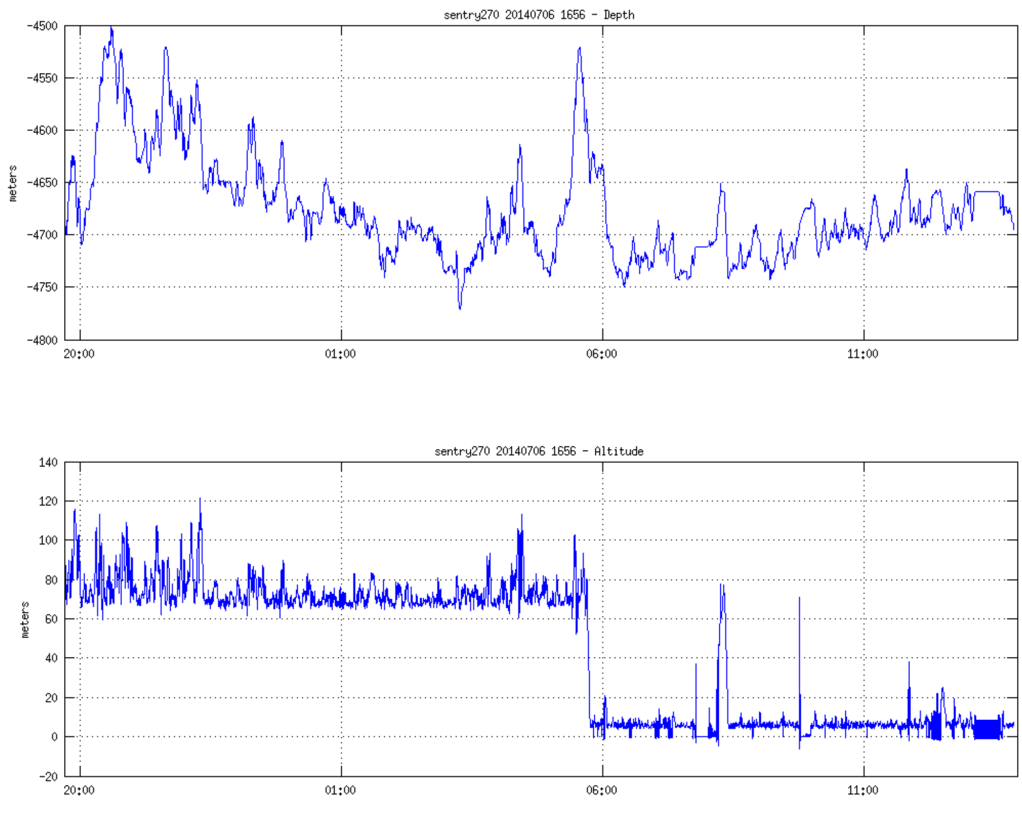


Figure 32: Depth and Altitude of Sentry during dive 270.

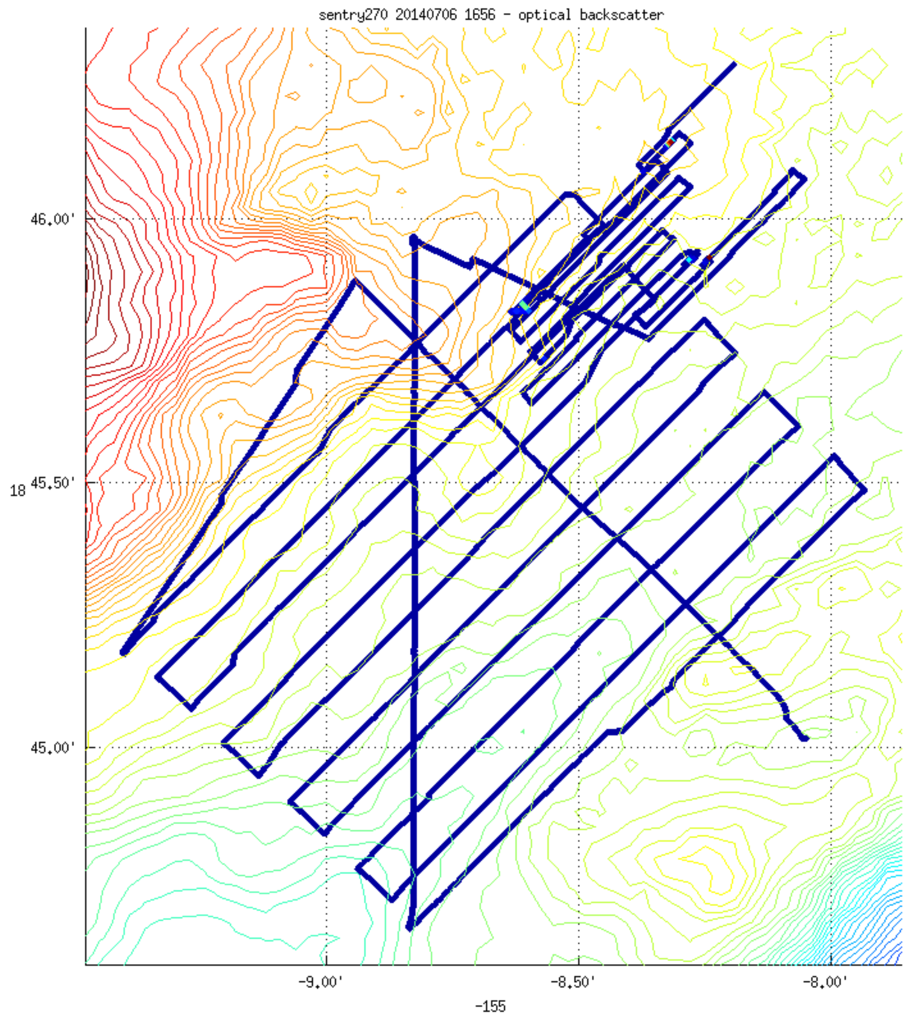


Figure 33: Optical backscatter on dive 270.

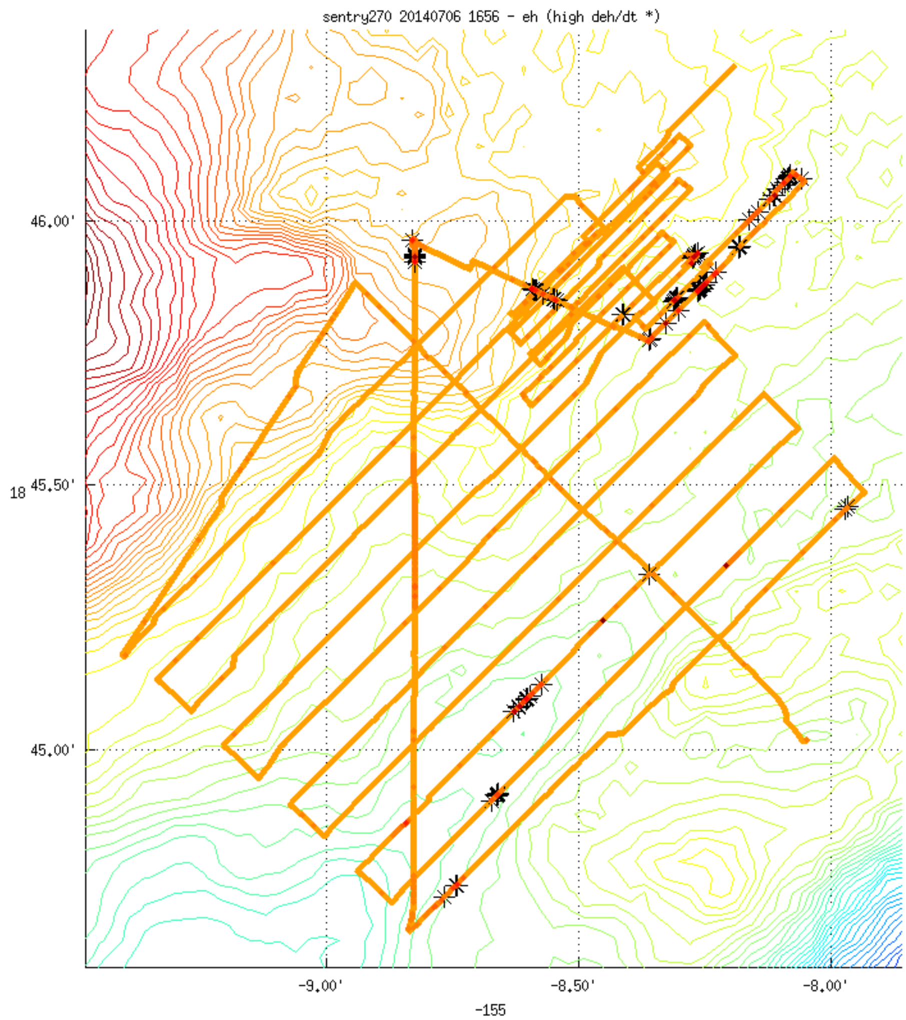


Figure 34: Redox potential (deh/dt) on dive 270.

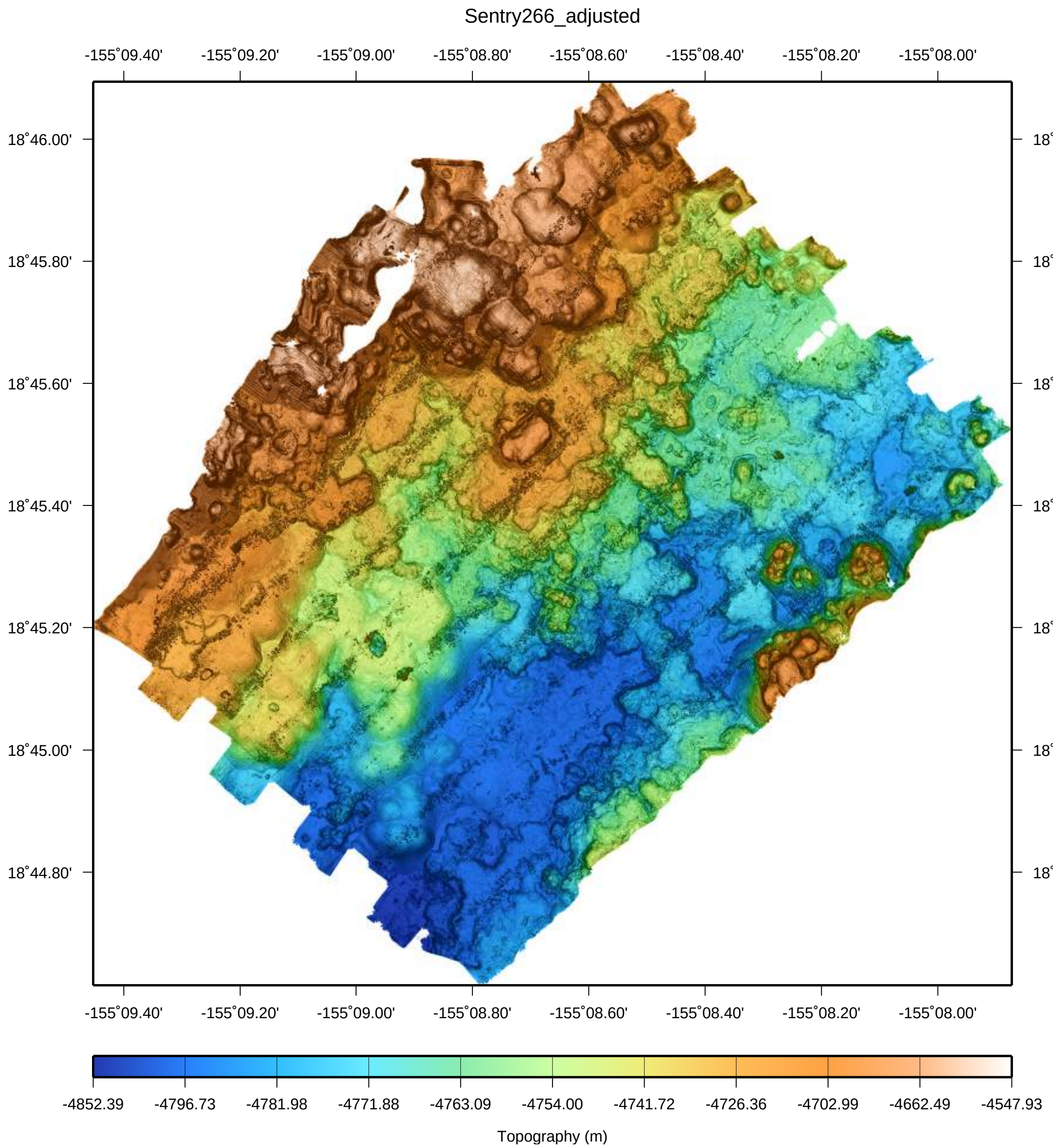


Figure 35: Multibeam bathymetry for dive 270.

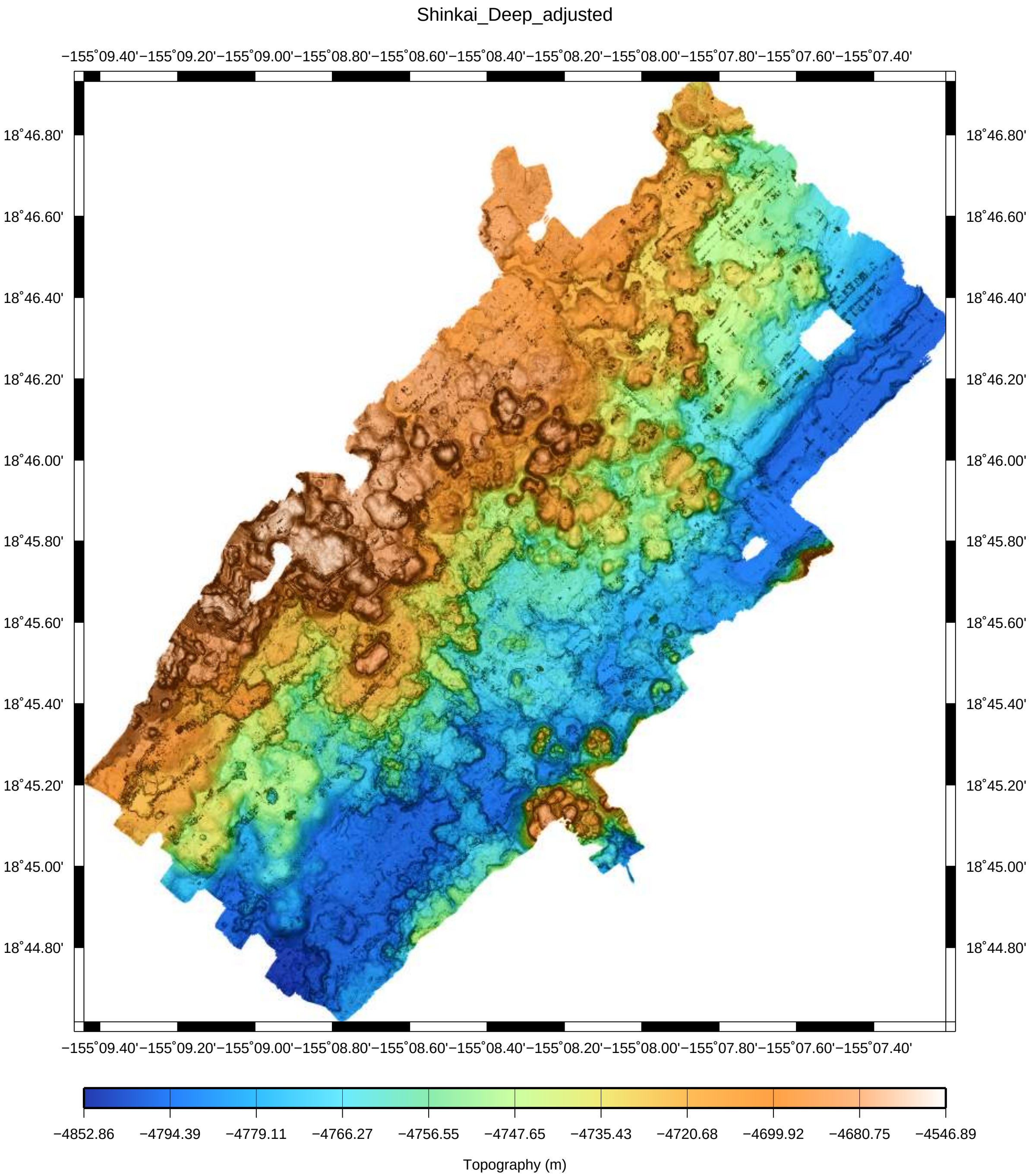


Figure 36: Combined ultibeam bathymetry for dives 266 and 270.