INSTRUCTIONS FOR THE OPERATION AND MAINTENANCE OF THE EP OCEANOGRAPHIC/MISO 1010 HI-TEMPERATURE VENT FLUID AND ATTITUDE DATA LOGGER 4-PIN CONNECTOR

M-1010-002

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1.0 INTRODUCTION

The EP Oceanographic 1010 Hi-T Data Logger is the most recent evolution of the Woods Hole Oceanographic Institution's (WHOI) Multidisciplinary Instrumentation in Support of Oceanography (MISO) Facility High-Temperature Vent Fluid and Attitude Logger. Based around Commercial Off-The-Shelf (COTS) boards from Onset Computer Corporation and Lowell Instruments, LLC, the 1010 Hi-T Data Logger is an accurate, rugged (Titanium housing and tip), and easily deployed sensor for collecting hydrothermal vent fluid temperatures from 0°C to 450°C in corrosive environments while monitoring vent stability and movement over long time periods (weeks to years). In 2021, improvements were made to the loggers by relocating the cold-junction thermistor from the Onset logger board to the location of the cold junction inside the logger tip. This necessitated that the underwater connector be changed to a 4-pin configuration.

1.1 SPECIFICATIONS

Weight in air (logger with 30" probe):	1.21 kg (2.65 pounds)
Weight in air (with syntactic foam):	2.41 kg (5.30 pounds)
Weight in water (with syntactic foam):	0.20 kg (0.44 pounds)
Length (instrument with 30" probe):	100.3 cm (39.5 inches)
Length (instrument housing only):	16.8 cm (6.625 inches)
Housing Diameter:	5.9 cm (2.0 inches)
Housing Material:	6AL-4V Titanium
Housing Low-Pressure Seal Device	1.4mm (approx. 200 pound test) monofilament in groove
Probe Material:	Grade 2 (CP) Titanium
Connector (Housing):	SubConn, MCBH4F, Titanium
Connector (Probe):	SubConn, MCBH4F, Titanium
Temperature Logger Board:	Onset UX100-014M 22-bit, modified
Attitude Logger Board:	Lowell Instruments MAT-1
Power (Internal):	Renata CR2477N Coin Cell (Onset) 18505 Cylindrical Cell with wired connector (Lowell)
Depth Rating:	10,000 PSI/6,000 meters, Alvin Certified to 4,000 meters
Temperature Probe Range	
J-type Thermocouple:	0°C to 450°C (32°F to 840°F)
T-type Thermocouple:	0°C to 250°C (32°F to 480°F)
Maximum Probe Range	
J-type Thermocouple:	0°C to 500°C (32°F to 930°F)
T-type Thermocouple:	0°C to 400°C (32°F to 750°F)

Temperature Accuracy/Resolution (Onset):	±0.6°C (±1.08°F) / 0.03°C (0.06°F)
J-Type Thermocouple Accuracy:	±2.2°C (±4.0°F) or 0.75% of value, whichever is higher
T-Type Thermocouple Accuracy:	±1.0°C (±1.8°F) or 0.75% of value, whichever is higher
Attitude Accuracy/Resolution:	
Magnetometer:	±1° Compass Bearing / <0.001 Gauss
Accelerometer:	0±.01 g / < 0.01 g
Storage (Onset):	512KB Internal Memory (~200,000 measurements)
Storage (Lowell):	4GB MicroSD Card
Clock Accuracy:	±1 minute/month
Download Port (Internal):	Mini USB (Onset) Micro USB (Lowell)

1.2 UNDERWATER CONNECTOR PIN ASSIGNMENTS

Pin assignments for the 4-pin temperature probe connector are:
Pin 1: Housing-isolated thermocouple ground
Pin 2: Thermocouple positive
Pin 3: Thermistor (non-polarized)
Pin 4: Thermistor (non-polarized)

2.0 OPERATION

The 1010 Hi-T Logger is based around COTS boards from Onset Computer Corporation and Lowell Instruments, LLC. The Onset board provides thermocouple and cold-junction temperature logging, while the Lowell board provides attitude and internal housing temperature logging. The larger battery installed in the Onset board will provide ~3 years of temperature logging, as long as the logging interval is configured correctly. The Lowell board can also be configured to provide ~3 years of attitude logging with the correct configuration. Both batteries should be replaced every 5 years, regardless of deployment count or duration.

2.1 OPENING LOGGER HOUSING

Prior to opening the housing, ensure that the housing and probe, if connected, have been rinsed with fresh water and are clean and dry. Locate both the etched arrow, which indicates where the locking filament entry hole is positioned, and the filament keyhole, as indicated by the label. Rotate the endcap counter clockwise, using a rubber strap wrench or by holding the housing with non-slip rubber dishwashing gloves if the endcap is too tight to rotate by hand. The locking filament will be pushed out of the keyhole as the endcap is rotated (Figure 1). When the etched arrow lines up with the filament keyhole, pull the filament out of the endcap entry hole. The locking filament should be inspected for dirt, damage, or chafing. If damage is found, discard the locking filament and replace with another piece before closing the housing (See Section 3.1, below, for details of monofilament diameter and length). Close attention should be paid to the

bend where the filament enters the endcap entry hole. If the filament breaks at this location, it will be difficult to remove the stub from the endcap.

Figure 1. Housing showing etched arrow marking alignment of locking filament entry hole so that it can be aligned properly with the filament keyhole

Using dry, oil-free canned or compressed air (suitable for electronics and camera/optical uses), blow out the locking filament groove. Ten, holding the housing in one hand, pull the endcap straight away from the housing, being careful not to bind the endcap by rocking it during removal.

Figure 2 shows the opened housing, with the electronics chassis attached to the endcap. Dry the housing O-ring seat area with a clean lint-free wipe (e.g. Precisionwipe or Kimwipe), and place the housing in a location free from dust or water, ensuring that it does not tip over or roll away.

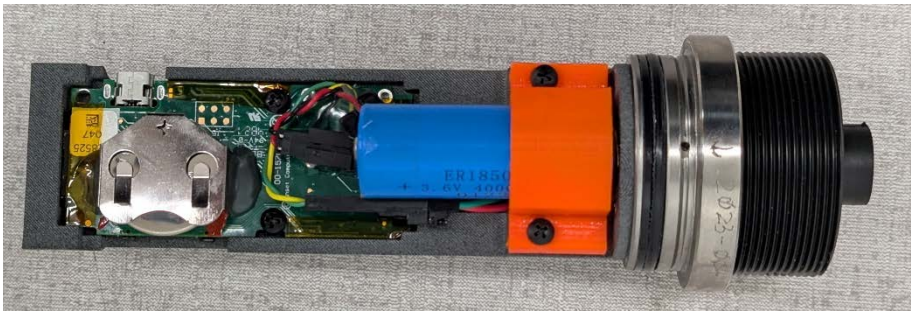


Figure 2. Opened housing and electronics chassis

Inspect the electronics chassis. If there is obvious damage or water ingress, please proceed to section 3.2 to remove the batteries, and contact EP Oceanographic, LLC for troubleshooting instructions. If both boards appear intact, then proceed to section 2.2 to setup the loggers for a new deployment or download the data.

2.2 DATA LOGGER SETUP

Note: Thermocouple probe should be connected to endcap during setup process. If the probe is not connected, see Section 2.5 for installation instructions.

A Windows PC is used to set up both the Onset temperature logger and the Lowell Instruments attitude sensor. The PC must have at least one, and preferably two USB 2.0 ports available. Install both the HOBOware (Standard or Pro) and DOMINO software packages according to their manufacturer's instructions.

Plug a Mini-USB cable into one port, and a Micro-USB cable into the other. **Ensure that the PC clock is set to the time zone and date/time that is desired to be used on the loggers, because both boards will synchronize their internal clocks with the PC's clock. This is usually UTC time.**

If the attitude sensor will not be used, the Onset board can be programmed using a Macintosh Computer. See the Onset software website for the applicable HOBOware software for the Mac OSX.

2.2.1 ONSET TEMPERATURE LOGGER SETUP

Plug the Mini-USB cable into the port on the Onset logger board (Figure 3), taking care not to bend the port.

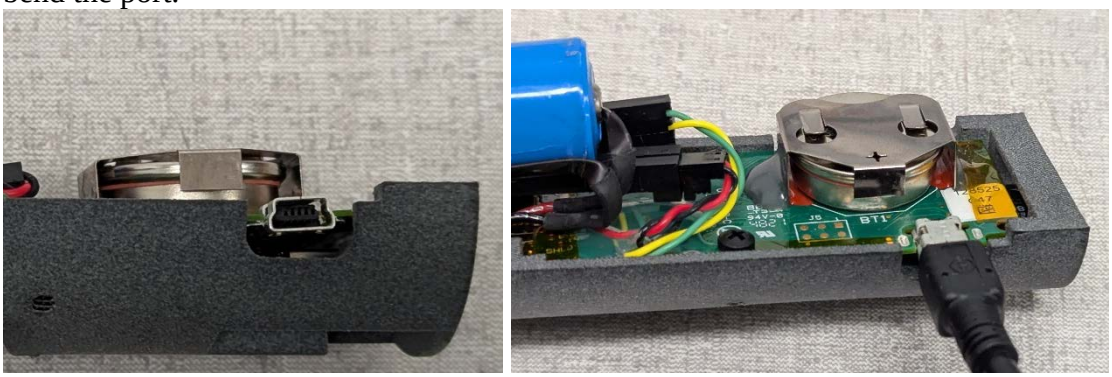


Figure 3. Mini USB Port and Cable Connected to Onset PCB

The computer should indicate that a new device has been plugged in, and install the drivers if necessary. Open HOBOware. The Device ID (UX100-014M) and serial number should be displayed in the lower left corner, as shown in Figure 4. If the logger has not been downloaded, continue to Section 2.6.1 and download the logger before launching a new log.

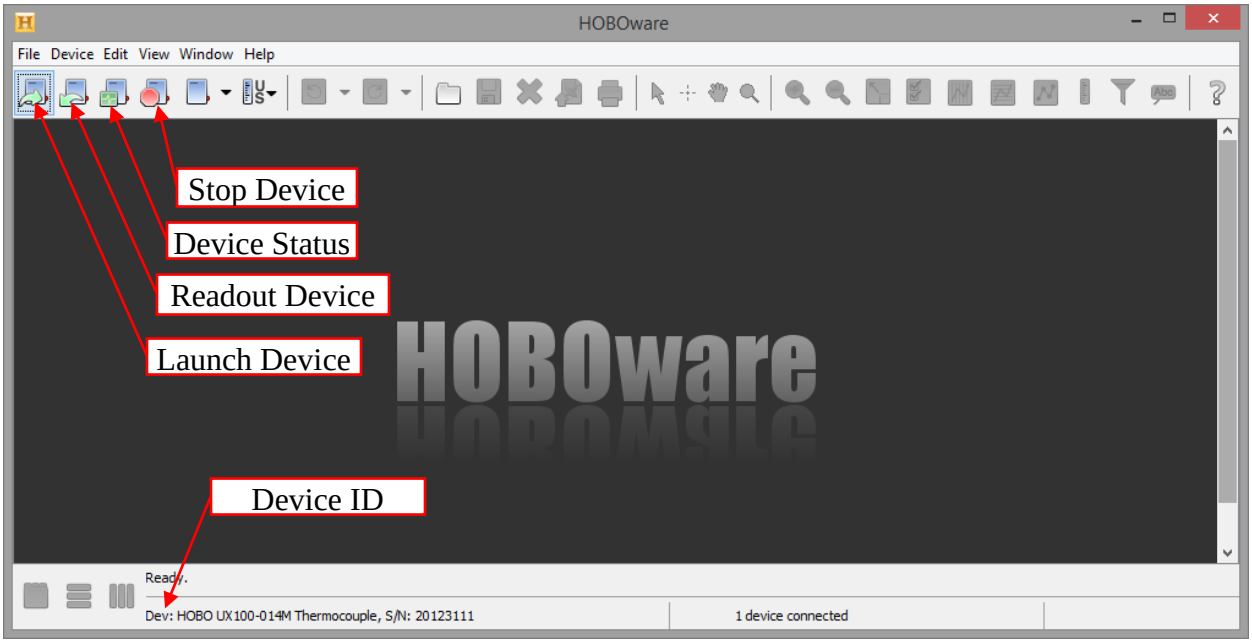


Figure 4. HOBOware Opening Screen

Click the “Device status” button at the top of the window. This will bring up the current settings and status of the temperature logger board. If a warning about power being reset or battery level being low appears, or the percentage reads less than 90%, unplug the logger and proceed to Section 3.2 and replace the battery before returning to set up the logger.

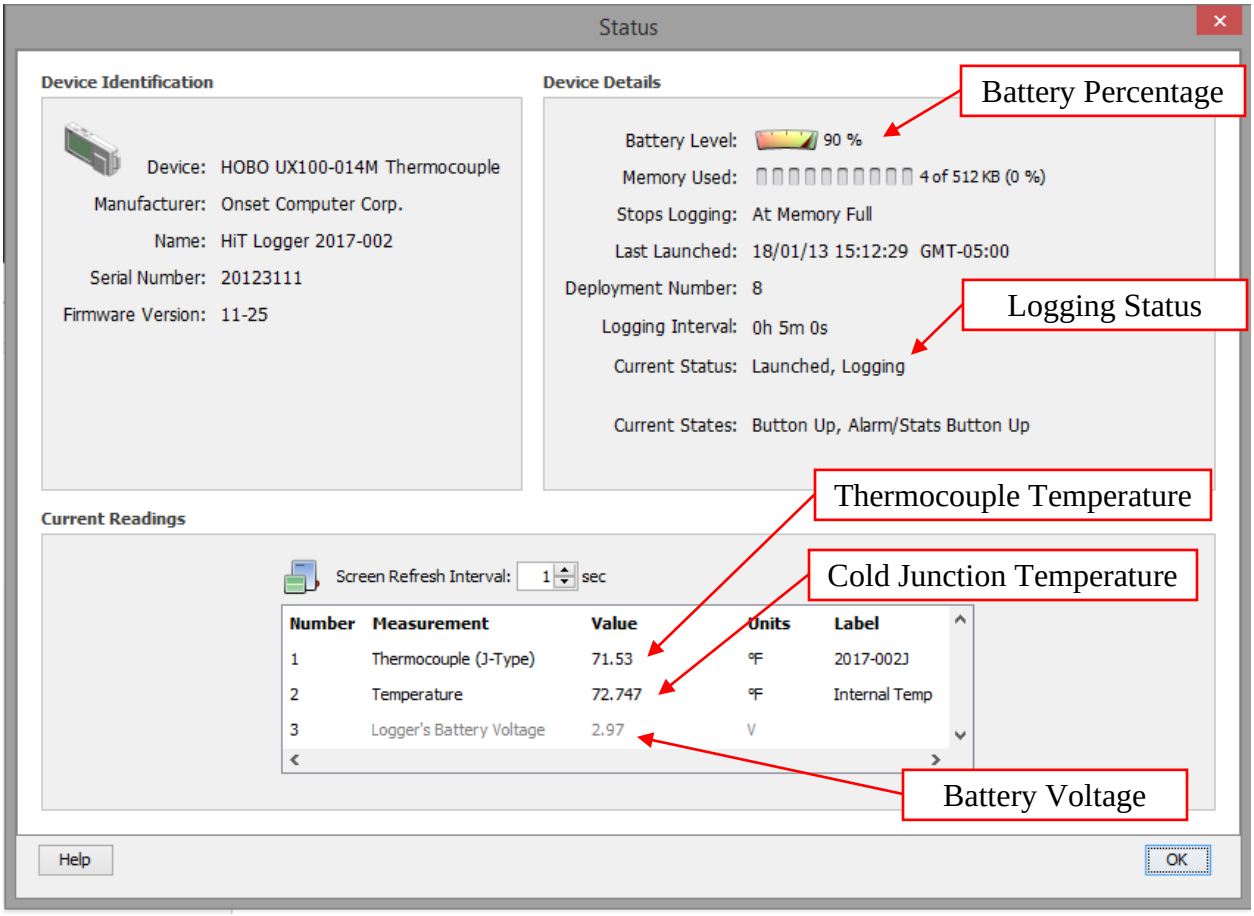


Figure 5. HOBOware Device Status Screen

Click the “Launch device” button to bring up a window displaying the options for the temperature logger, as seen in Figure 6. Give the logger a suitable name, select the type of thermocouple installed in the probe (printed on probe shaft label and engraved in probe base), and name the probe with its serial number or identifying marks. Ensure that “Temperature” is selected for logging. This is the **COLD JUNCTION** temperature inside the logger tip, not the temperature of the housing. Give this temperature a name like “CJ Temp” or “Internal Temp”. Select a logging interval which will span the expected deployment time. HOBOware displays the calculated logging memory duration to assist with the logging interval choice. Select “Now” for the start logging time. Select “When memory fills” for the “Stop Logging” section to prevent the data from being overwritten if recovery is delayed. Also select “Turn LCD Off” from the Options section. This will minimize power usage.

Note: Selecting the incorrect thermocouple type will result in large non-linear offsets of the logged temperatures. Ensure that the correct thermocouple type is selected.

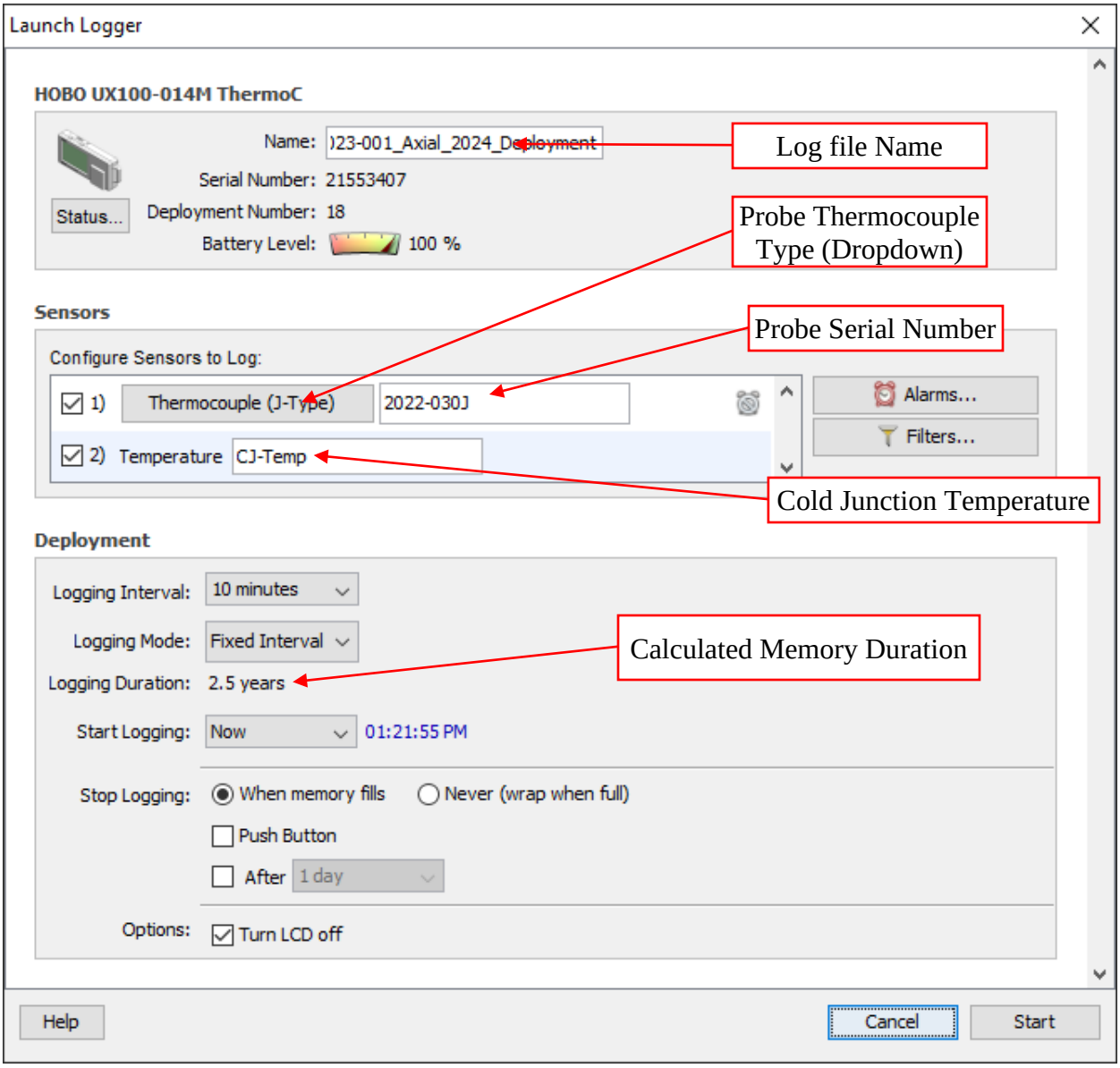


Figure 6. HOBOware Launch Logger Screen

After verifying that all settings are correct, click “Start” to begin logging. The software will send a configuration to the logger (Figure 7), and when the configuration is complete, the window will disappear.

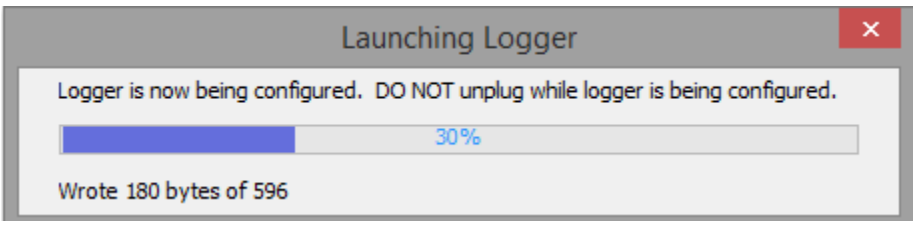


Figure 7. HOBOware Configuring Logger Popup

To verify that the logger is running correctly, click the “Device status” button again. The device status window will appear, and all settings can be verified. The current internal and probe temperature should be displayed and be correct, the battery voltage and percentage should be displayed, and the device’s current status should say “Launched, Logging” with the correct interval specified. Once all settings, temperatures, and battery voltage have been verified, the logger can be unplugged. Take care to apply slight pressure to the PCB adjacent to the connector to avoid flexing the PCB, and pull the Mini-USB connector straight away from the port to disconnect the cable.

Additional information about more advanced setup parameters is available from Onset Computer’s User Manual for the UX100-014.

2.2.2 LOWELL INSTRUMENTS ATTITUDE LOGGER SETUP

Plug the Micro-USB cable into the port on the end of the Lowell Instruments MAT-1 board (Figure 8), being careful not to apply sideways pressure the port. The green LED on the logger board should light up, and the PC should indicate that a new device has been plugged in and install the drivers if necessary.

First, download any existing files from the board. A Windows Explorer window should open automatically, displaying the contents of the MicroSD card. Ensure you copy any existing data (*.lid files) from the card onto your computer (and delete from the board if desired), then close the window. If the board is logging, the PC will recognize that the board is plugged in but you will not be able to manipulate the files. Follow the instructions in Section 2.6.2 to stop the logging and download the data files before starting a new log.

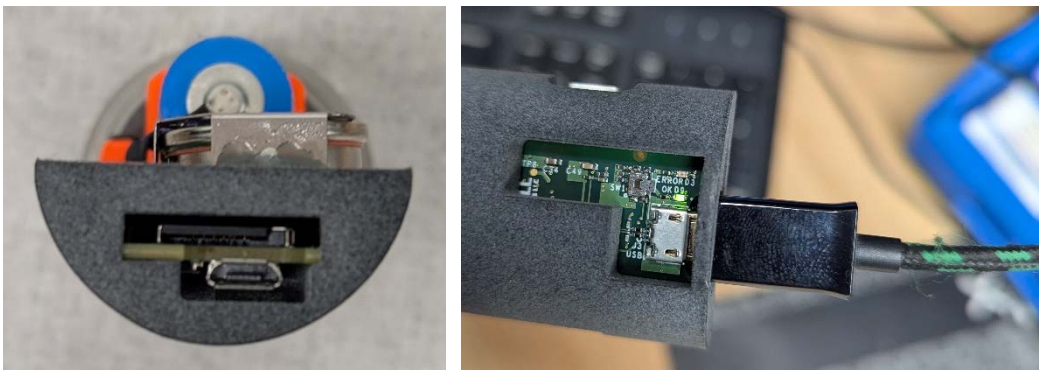


Figure 8. MicroUSB Connector and Cable Attached to Lowell Instruments PCB

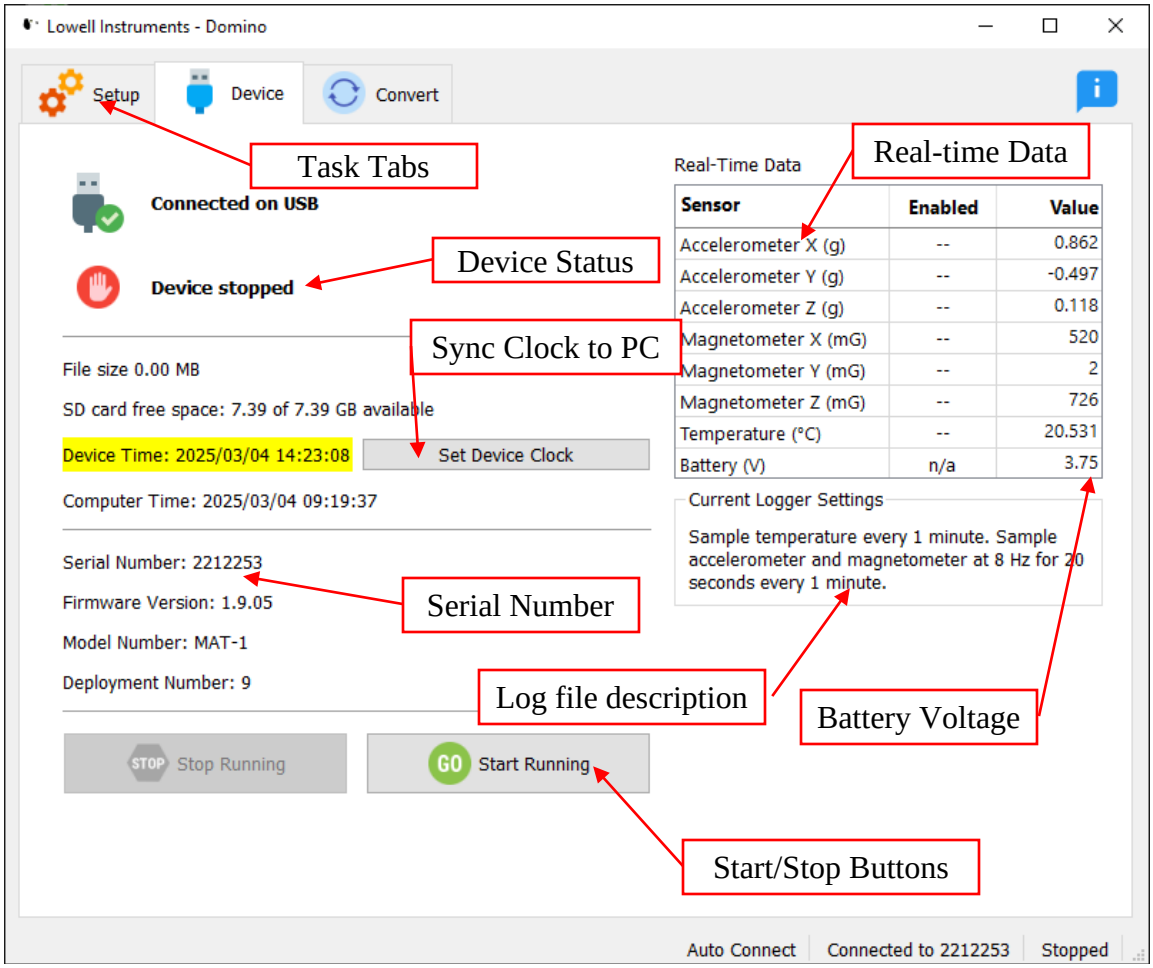


Figure 9. Domino Software Device Screen

Open the Domino software, as seen in Figure 9. Click on the Device tab at the top. The software should recognize the logger and the Real-time Data section on the right will become active, and the values should change as the logger is moved. Check that the battery voltage is above 3.4V. The logger time will be listed on the right in the Status section. If this time does not match the PC time within a few seconds, it will be highlighted in yellow or red. If this is the case, click the "Set Device Clock" button which will synchronize the logger's internal clock with the PC's clock. If all values are updating and correct, then a setup file can be created.

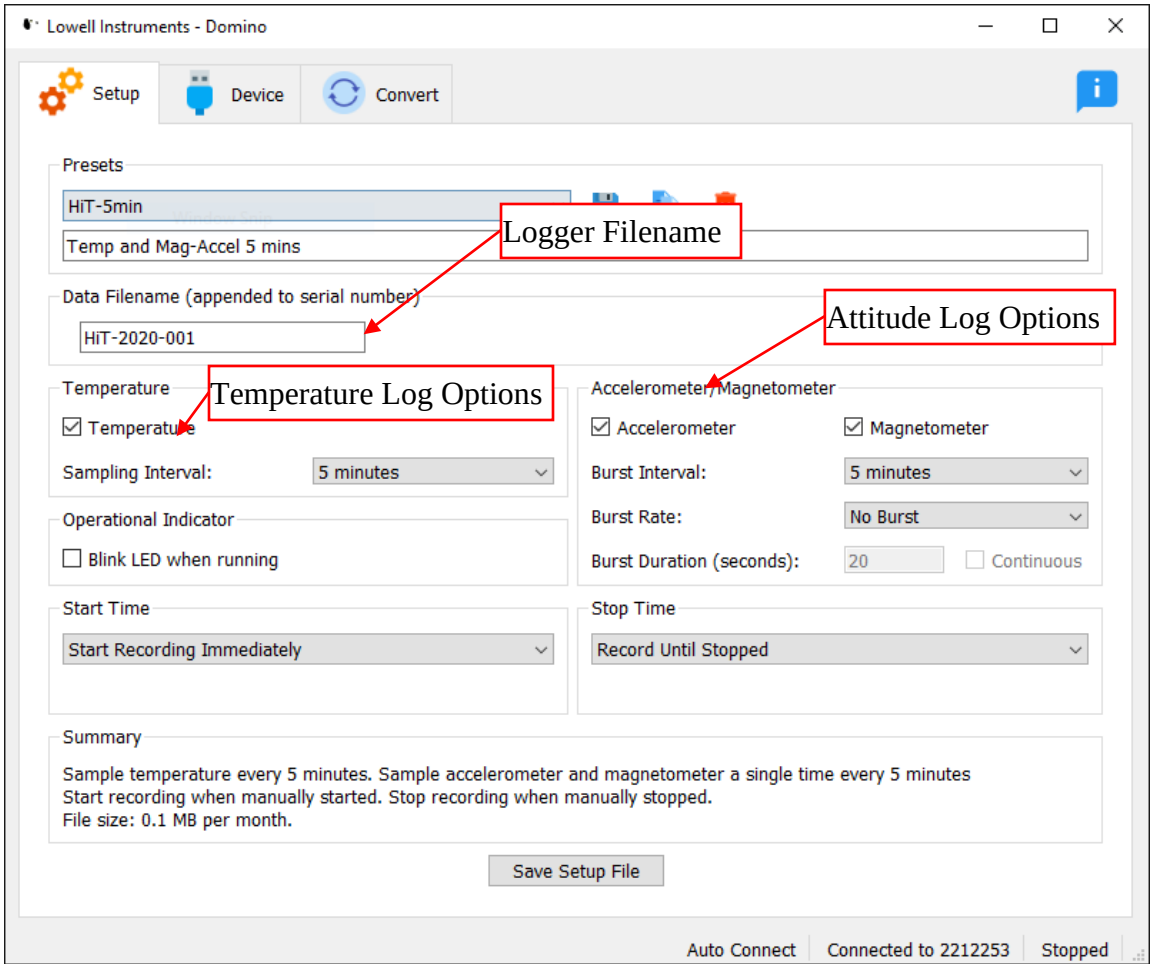


Figure 10. Domino Software Setup Screen

Click the “Setup” button at the top of the window to display the setup screen as shown in Figure 10. Enter a description for the logger file. Select if internal temperature is to be logged, which is automatically used to compensate the compass and can be compared to the cold junction temperature from the Onset logger board. Turn off the “Blink LED on temperature measurement” checkbox to conserve battery power. Select an interval for recording accelerometer and magnetometer data in the “Burst Interval” selection, and turn “Burst Rate” to off. Select “No Delayed Start” and “Log Until Stopped”, then click “Save Setup File”. An Explorer window will pop up asking to save a “MAT.CFG” file. Save this file in the root directory of the logger’s MicroSD card without renaming it. Once the file is saved, a warning will pop up stating that the file has been saved, but that the logger must be started manually. If this window doesn’t automatically open, click on the “Device” button. Click the “Start Running” button to start the logger. Wait until the “Start Running” button turns grey and the status says “Device running”. The logger is now actively recording, and ready for deployment. Unplug the MicroUSB cable without putting sideways pressure on the port.

Additional information about the MAT-1 logger and MAT Logger Commander software is available from Lowell Instruments:
https://www.lowellinstruments.com/download_files/Universal_User_Guide.pdf

2.3 CLOSING LOGGER HOUSING

Prior to closing the housing, remove the O-ring and backup ring from the endcap using a plastic O-ring pick or zip tie end. **Do not use metal tools to remove O-ring or backup ring.** Clean the O-ring and backup ring with isopropyl alcohol and lint-free wipes, and inspect both parts for damage or dirt/debris/hair. Replace any sealing components that are damaged. Lubricate the O-ring and backup ring with a **light** coat of Dow Corning #4 or similar O-ring lubricant.

Clean the housing/endcap O-ring grooves/surfaces with isopropyl alcohol and lint-free wipes. Lubricate the interior housing seal surface with a light coat of Dow Corning 4 or similar silicone O-ring lubricant. Do not overlubricate.

The sealing system is comprised of a single O-ring with a hard rubber backup ring, as shown in Figure 11. The curved face of the backup ring should face the O-ring, and the backup ring should be installed farther from the water-facing side of the endcap. The backup ring functions to prevent the O-ring from extruding into the housing under pressure.

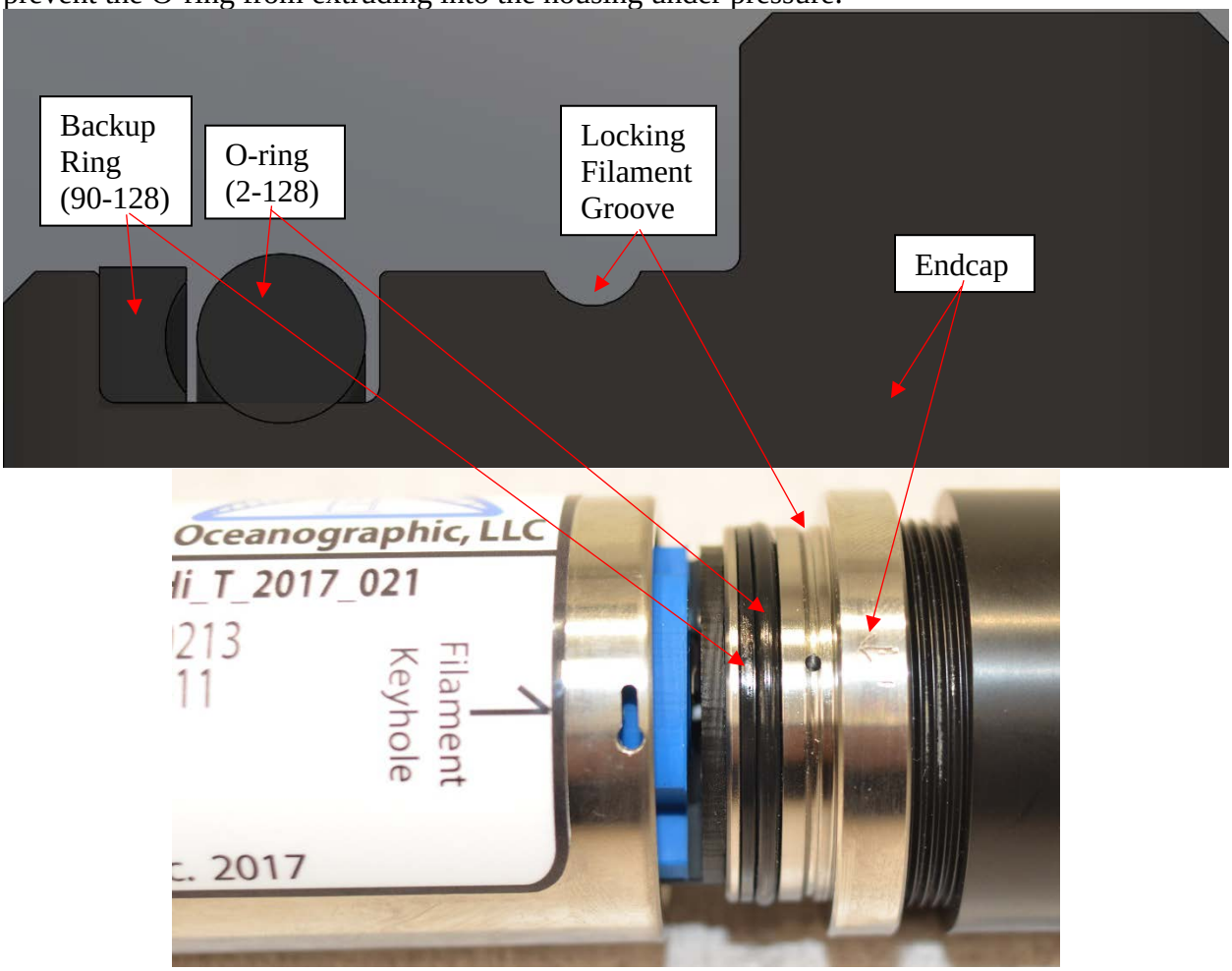


Figure 11. Endcap Sealing Components and Arrangement

Install the O-ring first by sliding it over the electronics chassis and lightly stretching it into the groove. Install the backup ring in the same fashion, taking care not to roll the backup ring, and make sure that the curved face is oriented correctly. Install the electronics chassis and endcap

partially into the housing and purge the housing with dry nitrogen or canned air (Appendix A) to displace all traces of moisture from the housing. When the housing is purged, press the endcap down evenly into the housing, with the etched arrow lined up with the filament entry keyhole. When the endcap is flush with the housing, insert the locking filament through the keyhole into the entry hole in the endcap, and rotate the endcap clockwise one full rotation. The etched arrow should be pointing at the keyhole, and ~1" of filament should remain outside the housing. Take care to protect the free end of the filament, because removal will be incredibly difficult if the end is broken flush with the logger body.

2.4 BENDING OF PROBE TIP

Under normal deployments in hydrothermal chimney orifices, the tip of the temperature probe must be bent to form a shallow-'J' shape to facilitate installation and retrieval of the loggers without endangering the logger electronics or the deep submergence vehicle. The titanium probe tubing is capable of being bent with a good quality commercial tubing bender such as the Rigid 600-series, but will kink if bent by hand.

Bending the tubing beyond a 45° angle will effectively trap the black plastic connector bell and shoulder washer on the probe shaft. **It is required that the connector bell and shoulder washer be installed prior to bending.**

Leaving a minimum 6"-8" of straight tubing at the end of the logger is recommended for vent placement stability and post-recovery calibrations. Multiple shallow bends can be added spaced a few inches apart if needed, rather than a single sharp bend. Do not attempt to straighten or re-bend a section of tubing that has been previously bent. Titanium work-hardens, and will likely snap if bent a second time.

2.5 PROBE INSTALLATION

The temperature probe is secured to the logger housing by means of a 2-part threaded system, with the electrical connection provided by the 4-pin wet-mateable connectors on the probe tip and the housing. The first part of the system is an annular connector thread adapter which screws onto the housing's underwater connector and has a large male thread on the outside. The second part is a connector "bell", which holds the probe to the housing and mates the underwater connectors via the threaded adapter. A nylon shoulder washer is used to center the probe shaft in the exit point of the bell. **Overtightening the bell will result in deformation of the underwater connectors, which could lead to leakage or electrical contact corrosion.** Only thread the bell onto the thread adapter until the probe shaft is secured axially, and no tighter than just barely finger-tight. The threads multiply the force of tightening, so overtightening generates immense force on the rubber underwater connectors. **Take care during endcap tightening not to rotate the connector bell additionally.**

Note: Wrapping the connector bell and endcap with a piece of 2" wide good-quality electrical tape will prevent loosening of the bell, and help keep the locking filament from being broken off.

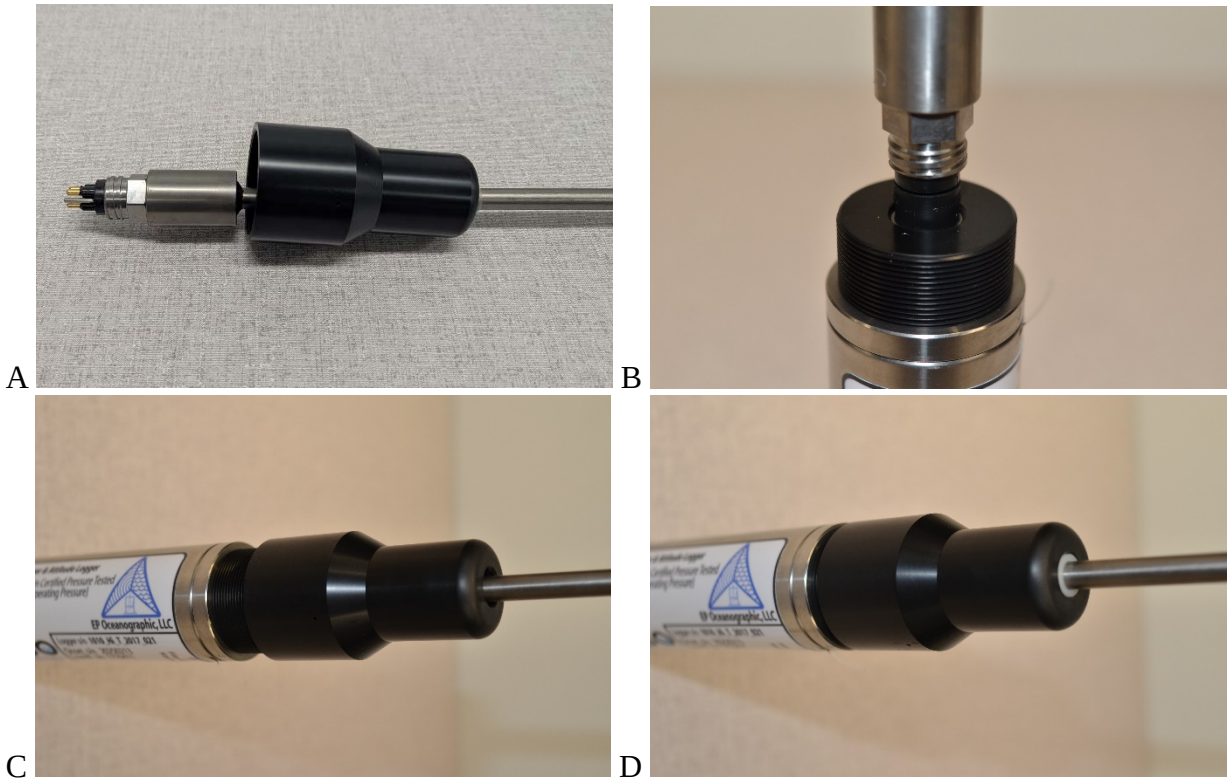


Figure 12. Probe Securing System Components and Arrangement
A: Probe Connector; B: Annular Connector Thread Adapter;
C: Connector Bell; D: Fully Assembled Probe with Shoulder Washer Visible

2.6 DATA DOWNLOAD

Downloading the data from both the Onset and Lowell Instruments boards is accomplished by opening the housing as discussed in Section 2.1. The same PC software which was used in Section 2.2 to setup and launch the loggers is used to download the data.

2.6.2 ONSET TEMPERATURE LOGGER DOWNLOAD

Plug the Mini-USB cable into the port on the Onset logger board, taking care not to bend the port. The PC should indicate that a new device has been plugged in, and install the drivers if necessary. Open HOBOware, and notice that the device type (UX100-014M) and serial number should be displayed in the lower right corner, as shown in Figure 3.

Click the “Stop Device” button at the top of the window. The software will ask if you want to stop the logging. Select Yes, and the software will inform you that the logging has been stopped, as shown in Figure 13.

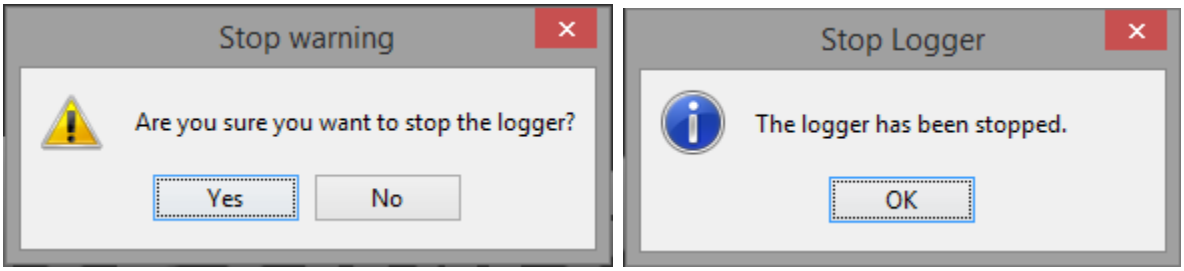


Figure 13. Stopping the Onset Logger

Click the "Readout device" button to download the data from the logger, as shown in Figure 14.

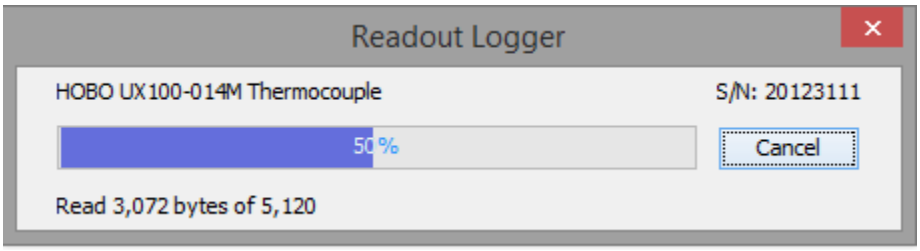


Figure 14. Downloading the Onset Logger

The software will ask for a filename and location, and once "Save" is clicked, the logger data will be downloaded to the specified file. The next window will prompt the user to plot the data, as shown in Figure 15.

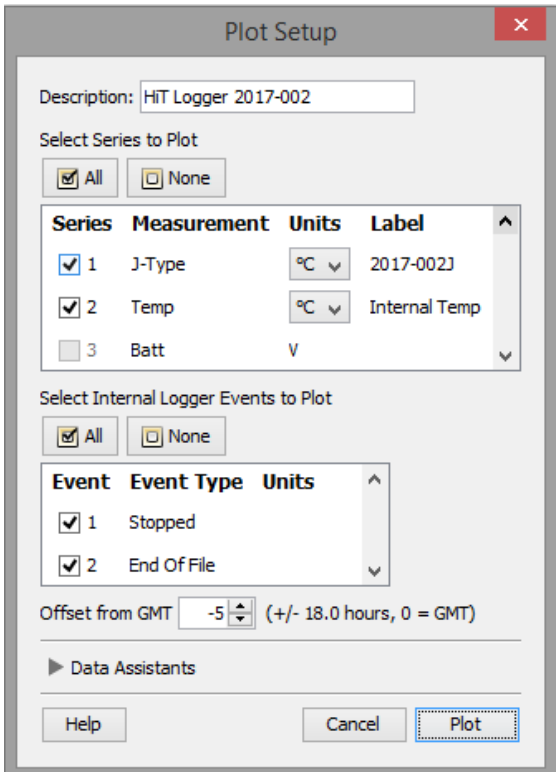


Figure 15. Plotting Onset Data

Select the parameters and units to be plotted, and click “Plot” to plot the data in HOBOware. The data can also be exported to other software using the “File->Export Table Data” function.

If another deployment/logging session is required, follow the instructions in Section 2.2.1 to start another log. Once all settings, temperatures, and battery voltage have been verified, the logger can be unplugged. Take care to apply slight pressure to the PCB adjacent to the connector when pulling the Mini-USB connector straight away from the port to disconnect the cable. This will help prevent the logger board from flexing as the cable is unplugged.

Additional information about more advanced setup parameters is available from Onset Computer’s User Manual for the UX100-014.

2.6.2 LOWELL INSTRUMENTS ATTITUDE LOGGER DOWNLOAD

Plug in the Micro-USB cable into the port on the end of the Lowell Instruments MAT-1 board, being careful not to put sideways pressure the port. The green LED on the logger board should light up, and the PC should indicate that a new device has been plugged in and install the drivers if necessary. Open Domino. The Status box should indicate that the logger is running and display the file size. Click “Stop” to stop the logging. Within a few seconds, the computer should see the MicroSD card attached as an external drive. Open a Windows Explorer window, and navigate to the contents of the MicroSD card. Copy the existing data (*.lid files) from the card, and then close the Explorer window.

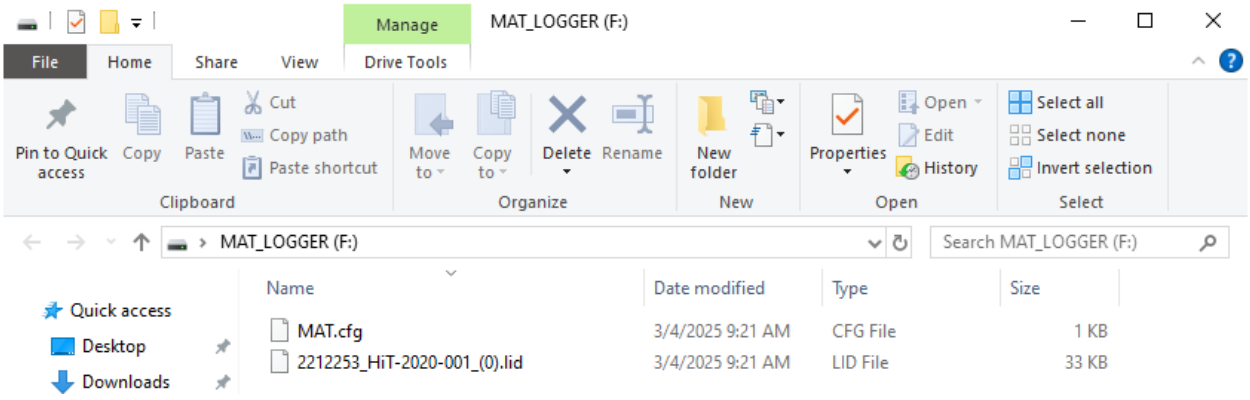
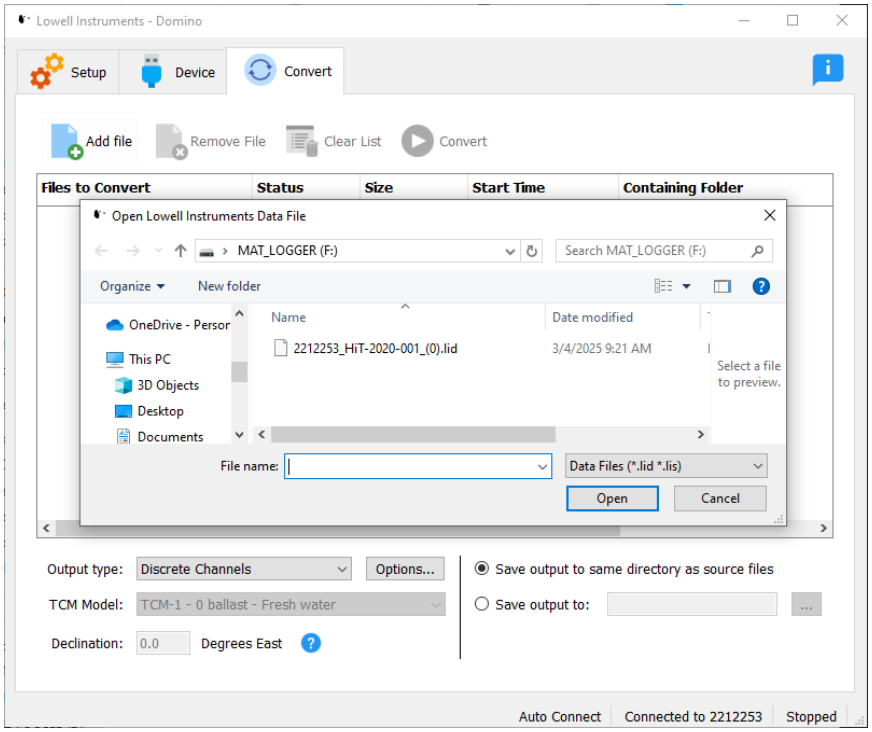
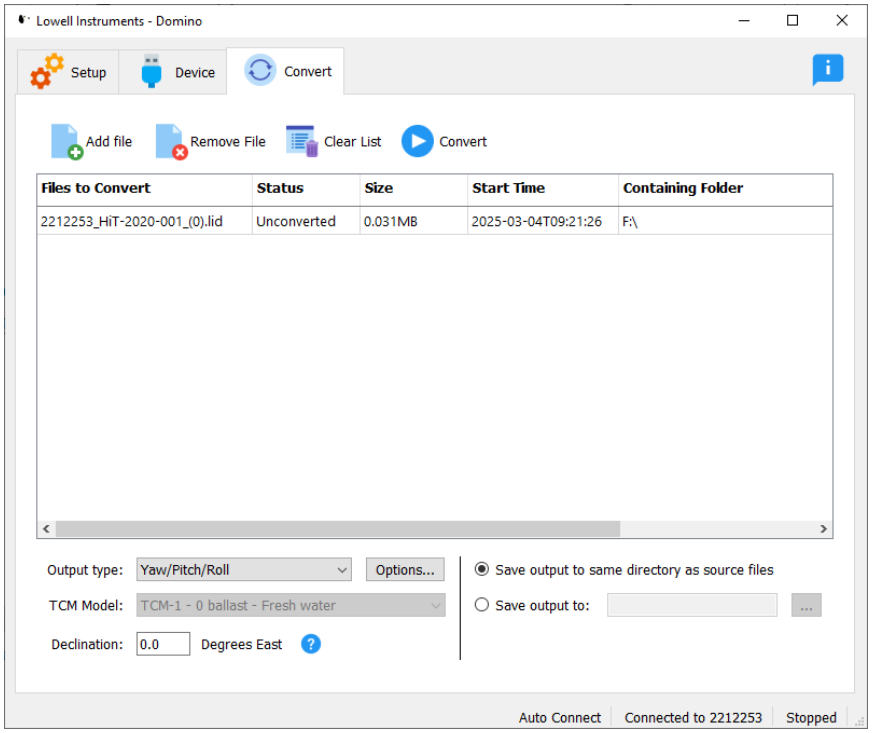


Figure 16. Lowell MAT-1 Data on Logger SD Card

The data can be converted to XYZ, Yaw/Pitch/Roll, or Heading data by using the “Convert Files” tab in Domino. Select the data to be converted by clicking the “Add file” button, selecting the *.lid file(s), choose the output options including the compass declination, and click “Convert”. The software will convert the file and placed into the same directory as the original *.lid file(s). It is recommended to convert the files after copying them from the MicroSD card.


Lowell Instruments - Domino
Setup
Device
Convert
Add file
Remove File
Clear List
Convert
Files to Convert
Status
Size
Start Time
Containing Folder
Open Lowell Instruments Data File
MAT_LOGGER (F:)
Search MAT_LOGGER (F:)
Organize
New folder
OneDrive - Persor
This PC
3D Objects
Desktop
Documents
Name
Date modified
2212253_HiT-2020-001_(0).lid
3/4/2025 9:21 AM
Select a file to preview.
File name:
Data Files (*.lid *.lis)
Open
Cancel
Output type:
Discrete Channels
Options...
Save output to same directory as source files
TCM Model:
TCM-1 - 0 ballast - Fresh water
Save output to:
Declination:
0.0
Degrees East
Auto Connect
Connected to 2212253
Stopped


Lowell Instruments - Domino
Setup
Device
Convert
Add file
Remove File
Clear List
Convert
Files to Convert
Status
Size
Start Time
Containing Folder
2212253_HiT-2020-001_(0).lid
Unconverted
0.031MB
2025-03-04T09:21:26
F:\
Output type:
Yaw/Pitch/Roll
Options...
Save output to same directory as source files
TCM Model:
TCM-1 - 0 ballast - Fresh water
Save output to:
Declination:
0.0
Degrees East
Auto Connect
Connected to 2212253
Stopped

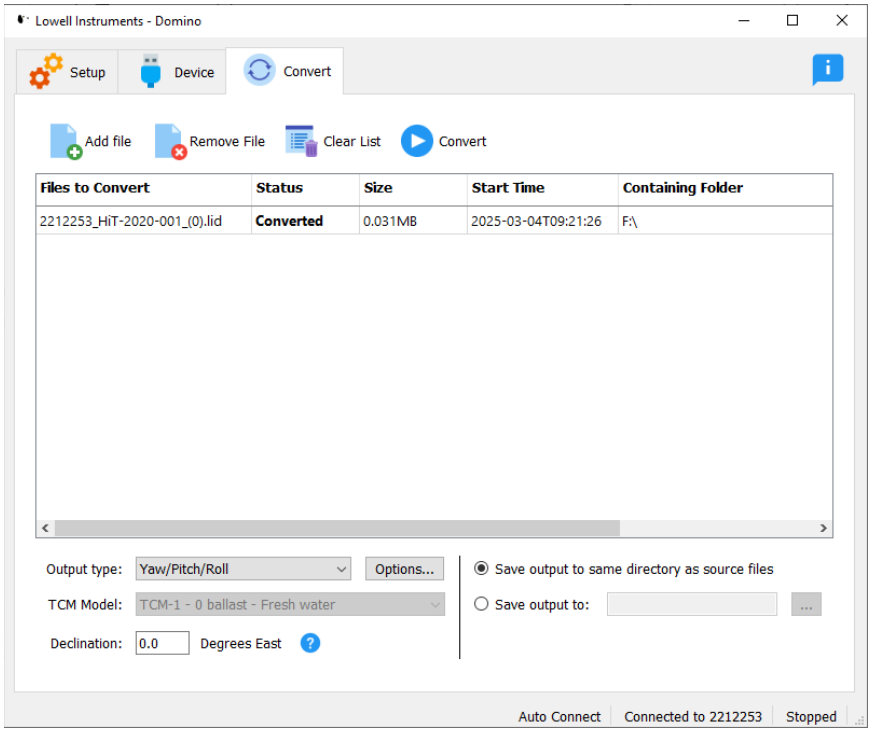


Figure 17. Converting Lowell MAT-1 Data

If another logging session is needed, follow the directions in Section 2.2.2 to start another log. Unplug the MicroUSB cable without putting sideways pressure on the port.

Additional information about the MAT-1 logger and Domino is available from Lowell Instruments: https://www.lowellinstruments.com/download_files/Universal_User_Guide.pdf

2.7 SYNTACTIC FOAM HANDLES AND DEPLOYMENT/RECOVERY CONSIDERATIONS

A machined block of syntactic foam and titanium hose clamps are provided to counterbalance the weight of the logger housing in seawater. With the foam installed, the logger has a negative buoyancy of ~0.4 lb. This prevents the logger from floating away and reduces tension on the vent chimney and probe tubing. **The foam should be installed on the opposite side of the logger housing as the bend to prevent the foam from trying to rotate the housing out of the vent opening.** A loop of floating rope can be tied through a hole in the foam to assist in recovering the logger if dropped underwater.

It is strongly suggested that the deep submergence vehicle pilots be consulted in regards to deployment methods and the size and quality of vent orifices to be instrumented, which will help determine bend angle of the probe. If the pilot has never deployed these instruments before, photographs of previous successful deployments should be shared as examples. The loggers with pre-bent tips also must be secured during vehicle launch and descent so that they cannot float away or get tangled in other equipment. Usually, a milk crate with bungie cords is utilized, but care must be taken to avoid the long probe tips from catching other equipment or obstructing other vehicle work tasks.

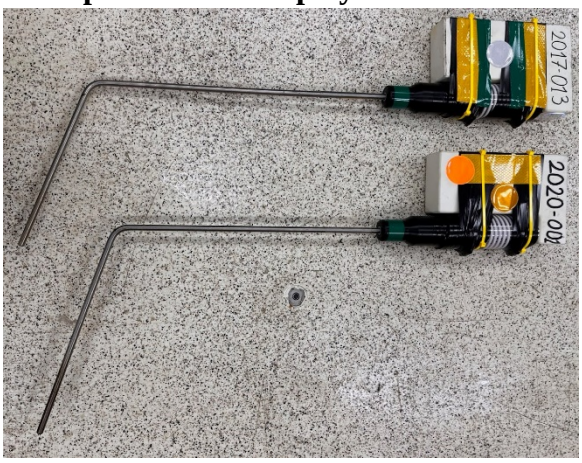
The tubing must be bent using a 3/8" OD tubing bender, preferably one with roller bending dies, **never by the vehicle's manipulators at depth. The logger should be handled by the vehicle's manipulator ONLY by gripping the tubing near the "J" bend**. Every effort should be made to prevent stress from being put on the syntactic foam float, housing, endcap, or plastic connector bell. The manipulator will easily crack the Acetal connector bell or crush the syntactic foam. The orientation of the deployed logger should be away from the vent structure, in open water, and away from any other satellite vent that may grow up into the area where the logger housing resides.

The key considerations when deploying loggers are:

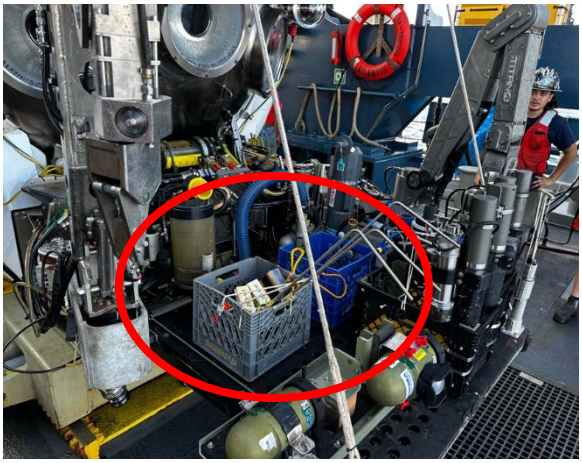
- Bend the tubing to conform to the morphologies of the vent orifices to be instrumented, usually a 70°-80° "J" bend located ~25cm" from the end of the logger tip is ideal.
- Determining appropriate recording intervals and duration based on expected deployment duration and data density requirements
- Plan the deployments such that once deployed, the loggers will not be disturbed by further manipulation or sampling (i.e., deploy the loggers after excavation of the orifice, sulfide recovery and fluid sampling are completed)
- Mark the logger handles/syntactic foam with numbers and/or colored/reflective tape so that unequivocal identification of the logger is possible from either video, photographic, or direct observations from various angles
- Document the deployment position in x/y space, depth, photographically, and visually in order to facilitate recovery after long deployments
- Work with the pilots on the deployment strategy to avoid the loggers becoming entrained in the high-T fluid flow from adjacent chimneys or orifices, or being destroyed/encapsulated by nearby vents that may grow to the position of the logger housing.
- Carefully note the bend angle of each probe to aid in later recovery without damaging the probes if the chimney hasn't grown around the probe. Often, this occurs, and there is no way to recover the tip without damaging it. If the chimney has fully encapsulated the probe tip, the best course of action is to grab the tubing adjacent to the chimney surface, and pull vertically (up) on the tip. Pulling laterally (left/right) will not dislodge the tip because 25cm of the tip is inside the chimney. If the tip can't be removed intact, or if chimney collapse is a concern, then the tubing can be broken by repeatedly bending it with the manipulator until the tubing fatigues and breaks.

All of these factors should be carefully considered when planning for logger deployments.

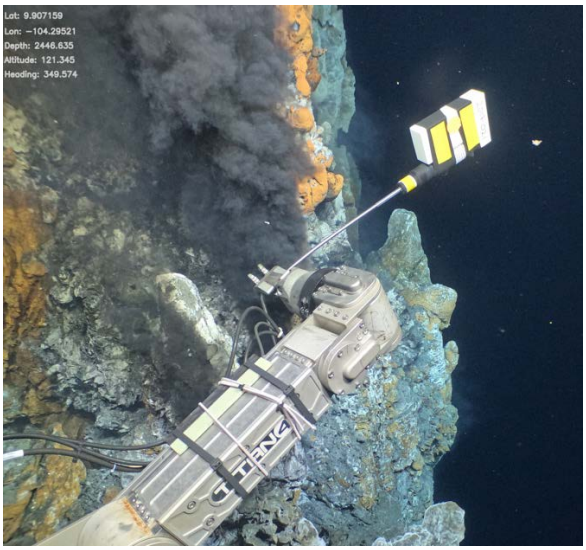
Example Previous Deployment:



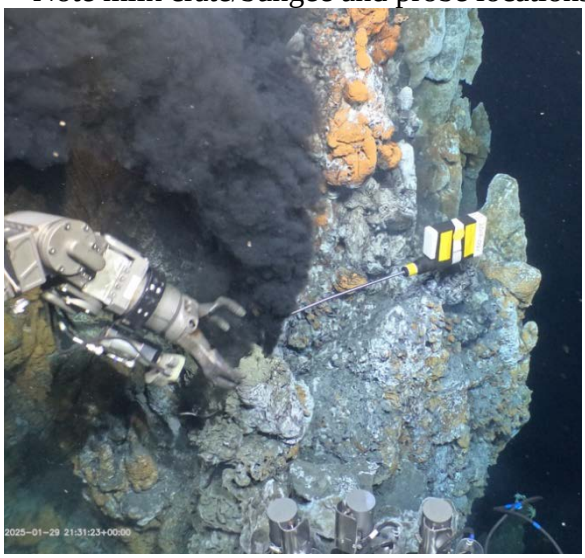
Two Loggers prepared for deployment.
Note bend location, foam float, and labeling



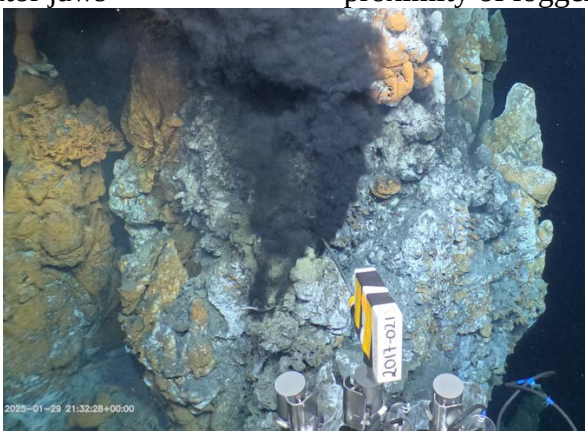
3x Loggers prepared for deployment on HOV *Alvin*
Note milk crate/bungee and probe locations



Logger being placed in vent orifice
Note location of manipulator jaws



Logger after placement. This is not ideal due to proximity of logger body to chimney surface



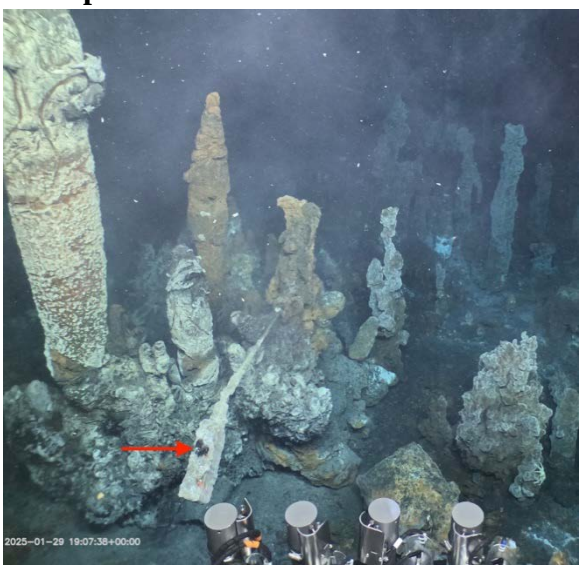
Final Logger deployment location. The logger body is hanging in open water, away from vent fluids and the chimney surface.

Figure 18. Example Deployment

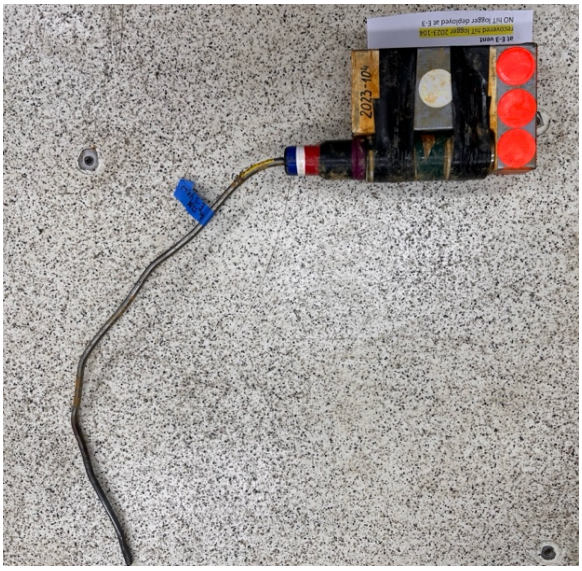
The key considerations when recovering loggers are:

- Review recent survey and video data from deployment to familiarize pilot/operator on the locations of the loggers and the surroundings in which they were deployed.
- Build a table of serial numbers and deployment notes to ensure that all loggers are accounted for and recovery can be maximized.
- Upon locating a logger, examine the vent structure and have the pilot approach from a safe angle.
- If the logger tip is not fully encapsulated by the chimney, have the operator grab the probe tip near the chimney and attempt to extract it by gently pulling vertically (up). Pulling laterally (left/right) will not normally dislodge the tip because 25cm of the tip is inside the chimney.
- If the chimney has fully encapsulated the probe tip, the best course of action is to grab the tubing adjacent to the chimney surface, and pull firmly vertically (up) on the tip. The tubing may bend and tear parts of the encrusting chimney material as it tries to free itself.
- If the tip can't be removed intact, or if chimney collapse is a concern, then the tubing can be broken by repeatedly bending it with the manipulator until the tubing fatigues and breaks. It is best to break the tubing off near the chimney surface if possible.
- The logger tips are not generally reused, and damage from recovery operations is customary.
- Upon retrieval, cut off any tape, remove the hose clamps, and remove the syntactic foam block. Unscrew the connector bell and remove the remains of the probe tip from the housing. Wash the housing and scrape off any encrusting material from the endcap.
- Follow the steps in Section 2.1 to open the logger housing, and Section 2.6 to download the data from the loggers.

Example Previous Recoveries:



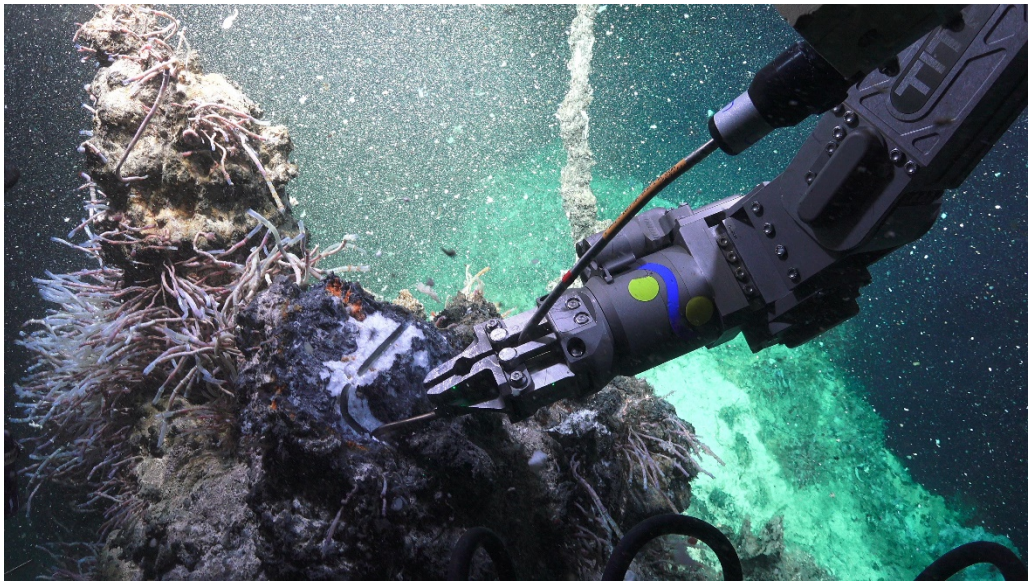
Logger deployed for ~1 year with thick bacterial mat and tip encapsulation by chimney.



Recovered logger after washdown showing badly bent/damaged tip from recover operations.

Logger recovered with tip largely intact

Logger recovered with tip broken off



Logger tip being broken off by manipulator

Figure 19. Example Recoveries

2.8 COLD JUNCTION COMPENSATION

Thermocouples are constructed by connecting two known dissimilar metals at a single point, called the hot junction. However, where the ends of these dissimilar metals meet the copper wiring that leads to the measurement device (the Onset Logger in this case) also function as thermocouples. Additionally, thermocouple look-up tables and models are referenced to 0 °C, which is not practical in most thermocouple applications. In order to calculate an accurate thermocouple hot junction temperature, the temperature of the cold junction must be accurately monitored. This is accomplished on the Onset logger by using a PCB-mounted thermistor. However, because the thermistor is inside the housing, and not located at the cold junction inside the probe tip, there could be inaccuracies in the measured thermocouple temperature, especially if the housing and first several inches of the logger tip are not isothermal. Previous deployments showed that there could indeed be significant temperature changes of the housing and cold junction due to vent activity and tidal forces/flow. This necessitated the relocation of the cold junction thermistor into the probe tip. The thermistor is thermally-coupled to the thermocouple cold junction with thermal compound, and encased in heat shrink tubing. These changes have maximized the accuracy and minimized cold junction temperature anomalies as much as is practical for these low-cost and high-temperature sensors.

Figure 20. Relocated Cold Junction Thermistor

3.0 MAINTENANCE

3.1 HOUSING ASSEMBLY

The housing of the logger is fabricated from 6AL-4V titanium, providing very high strength combined with excellent corrosion resistance and light weight. It is, however, recommended that the unit be washed down thoroughly with warm fresh water after each use. The Acetal connector bell and connector thread adapter should be loosened from one another and rinsed thoroughly before being reinstalled. A small amount of Loctite 245 plastic-safe threadlocking compound can be applied to the internal threads of the connector thread adapter to secure it to the housing-side connector and prevent loosening when the connector bell is removed. Two holes are provided in the upper surface of the connector thread adapter to allow a pin spanner or needle-nose pliers to be used to remove the adapter if needed.

O-rings used in this logger housing are:

2-128	O-ring, end cap, Radial, 70A Duro, Buna-N
90-128	Backup ring, Dished, Radial, 90A Duro, Buna-N

The locking filament is Nylon monofilament fishing line with a diameter of 1.4mm (~0.055 inches), and a length of 180mm (~7 inches). Fishing line diameter is not usually specified on packaging, but it has been found that approximately 200# breaking strength line is usually the right diameter. EP Oceanographic, LLC keeps a supply of this filament on hand, and can provide replacement filament on demand.

The O-rings and sealing surfaces should be lightly greased with Dow Corning #4 or similar silicone grease. Only use plastic tools to remove O-ring and backup ring. **Never use metal picks on O-rings or seal surfaces**. Inspect O-ring and backup ring for dirt, dust, or hair every time the housing is opened. Clean O-ring and backup ring with isopropyl alcohol and a lint-free wipe during inspection. The backup ring's curved surface faces the O-ring, and is installed behind the O-ring to prevent O-ring extrusion under pressure.

If housing becomes corroded or encrusted with vent materials, return it to EP Oceanographic, LLC for refurbishment or replacement.

3.2 BATTERY REPLACEMENT

Replacement of the Onset battery can be accomplished by sliding the Renata CR2477 coin cell out of the PCB-mounted holder, and sliding a new battery cell into place. It is important to **only** use Renata brand CR2477N cells to ensure proper fit in the battery clip. The positive terminal faces away from the PCB. If the battery is replaced, the next time HOBOware is used to communicate with the logger board a warning about power being reset will appear. When a new log is started, this warning will be reset.

Replacement of the Lowell Instruments battery is more difficult. If time allows, return the logger to EP Oceanographic, LLC for Lowell battery replacement. The battery must be ordered from Lowell Instruments, as it is not a standard off-the-shelf part. First, remove the two #4-40 nylon screws that secure the Lowell battery holder to the chassis and swing the battery out of the way.

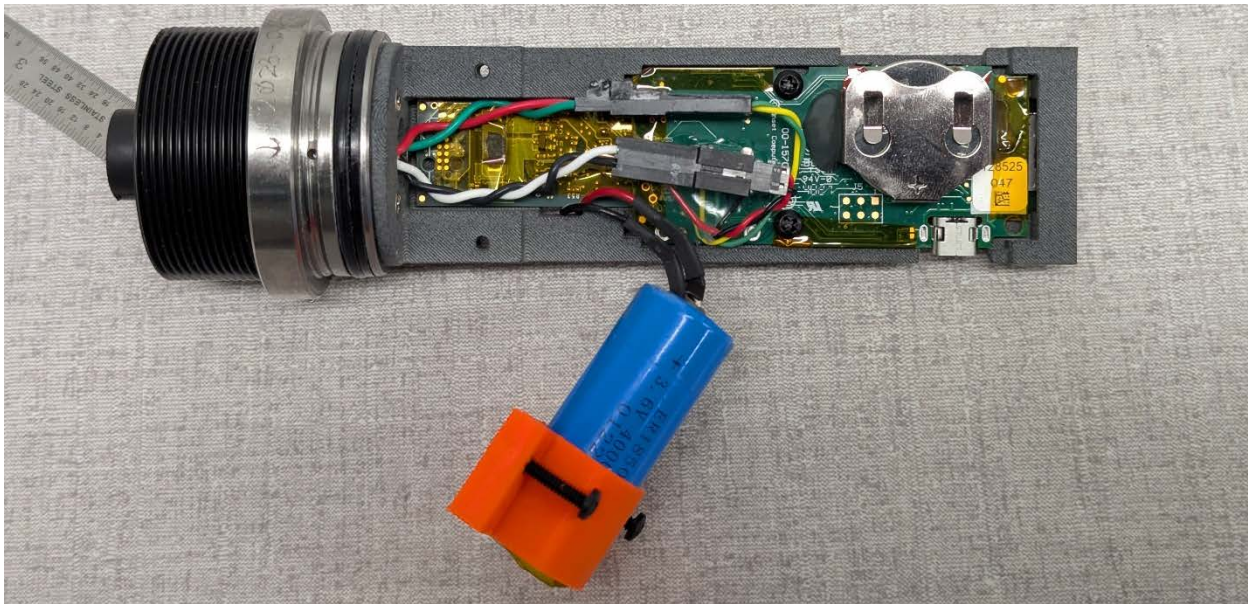


Figure 21. Logger with Lowell Battery Holder Removed

Next, disconnect the two black 2-pin connectors that lead from the Onset PCB to the probe connector and remove the two #4-40 nylon screws that secure the Onset board. Remove the Onset PCB and place it to the side.

Figure 22. Connectors Unplugged

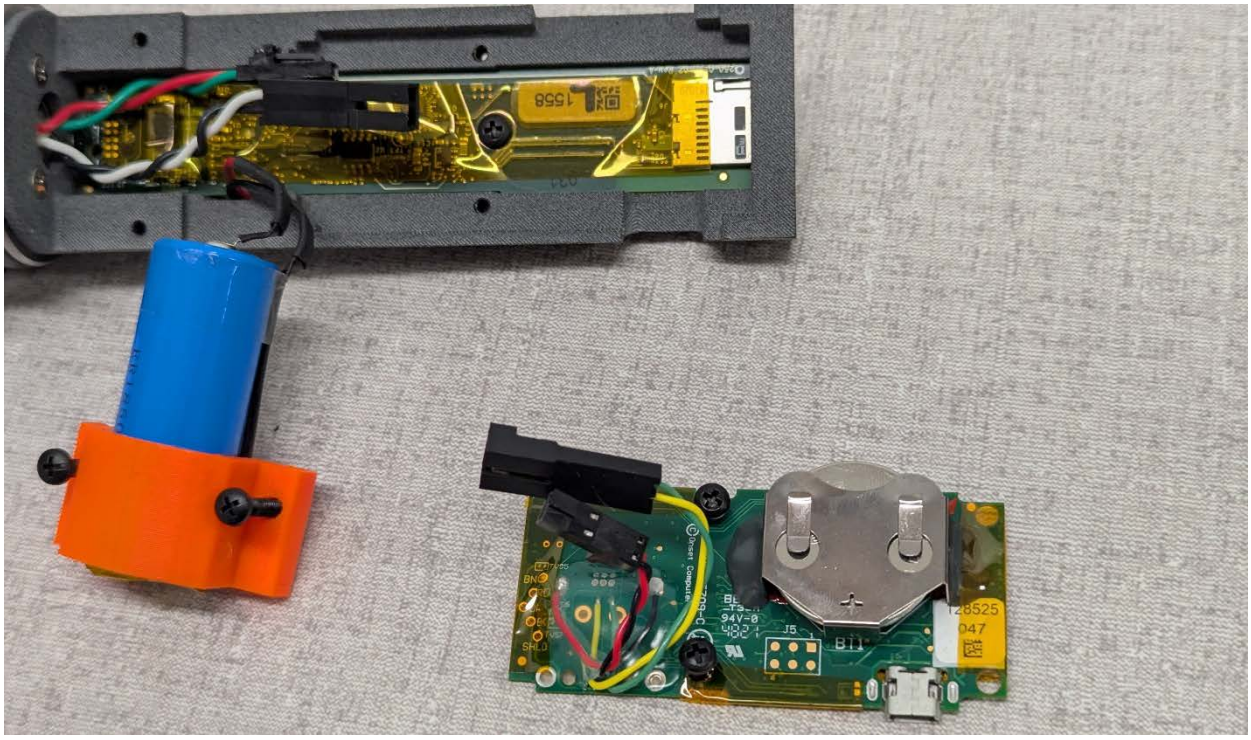


Figure 23. Onset PCB Removed

Remove the single #4-40 screw that secures the Lowell PCB. Remove the PCB and battery holder from the chassis by bending the connector wires flat against the endcap and angling the PCB out of its recess.

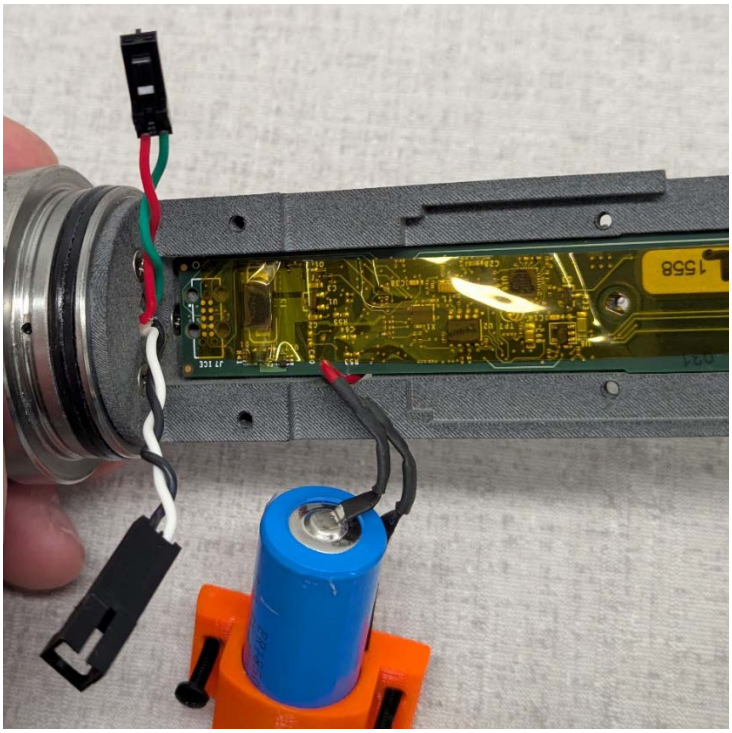


Figure 24. Connector Wires Bent Flat to Endcap

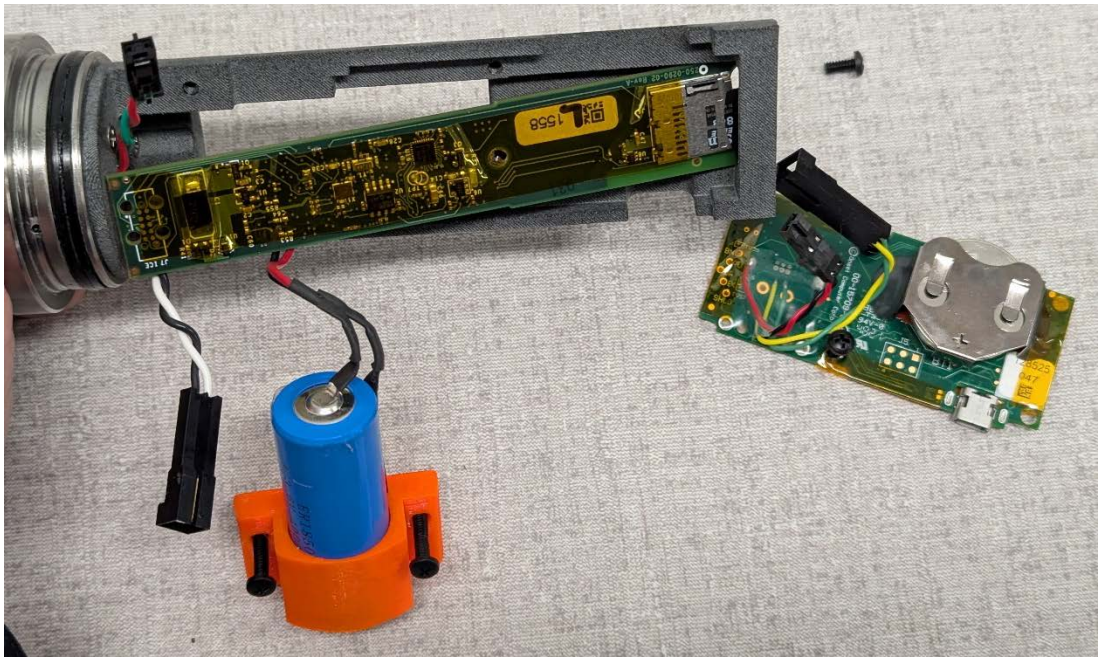


Figure 25. Lowell PCB Angled For Removal

Slide the battery out of the holder. Carefully unplug the battery connector from the Lowell PCB, making sure not to damage the PCB. Immediately plug in the new battery. Install the new battery into the holder. Angle the PCB and place the end with the SD card into the recess in the chassis. Once the PCB has been slid fully into the chassis, it can be rotated into place, avoiding the connector wiring. Once the PCB is loosely installed in plastic chassis, make sure to route the battery wiring through the notch in the housing so the wires aren't pinched. Then install the single nylon 4-40 screw to secure the Lowell PCB.

Figure 26. Lowell PCB Angled For Installation

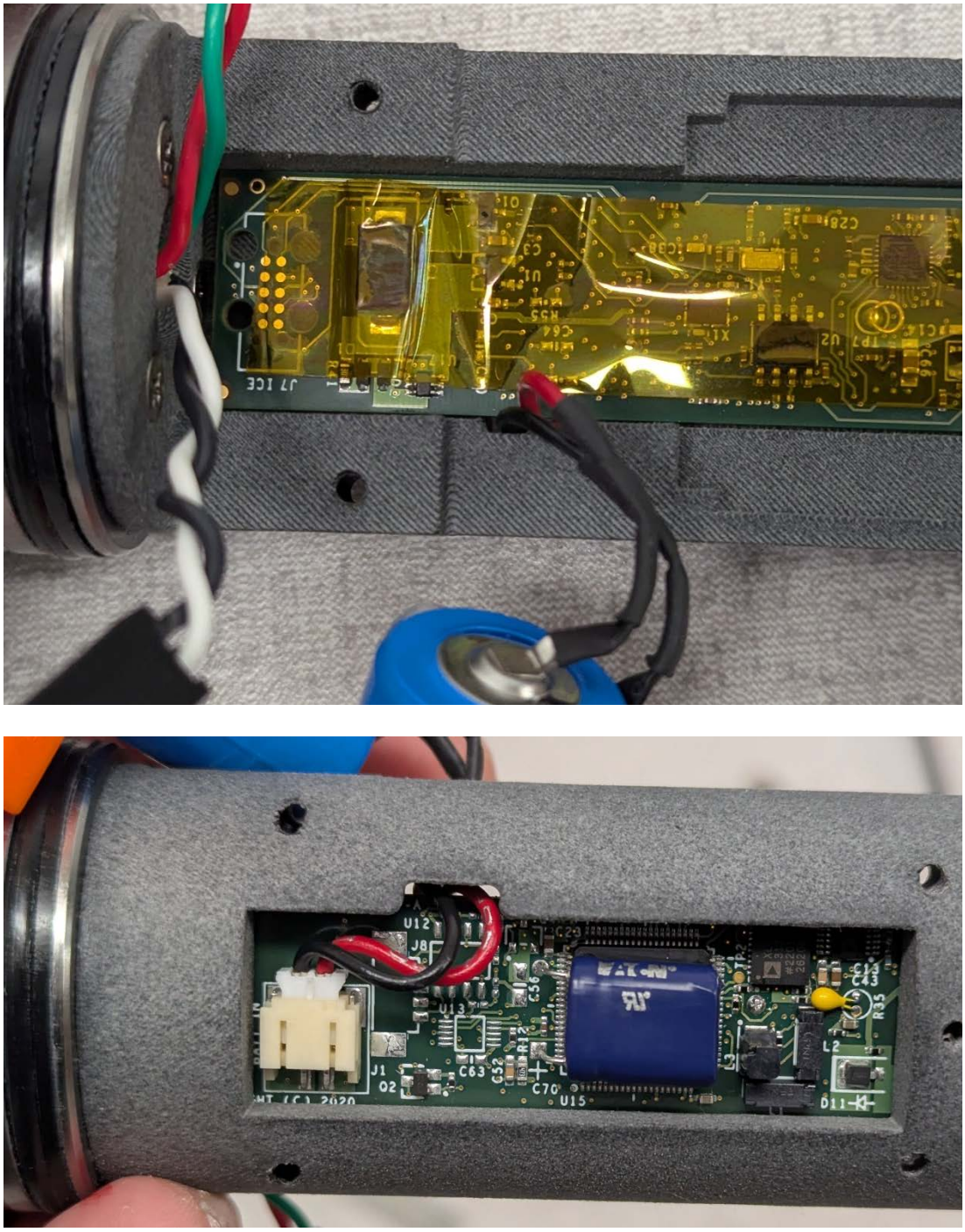


Figure 27. Lowell Battery Wire Routing

Using the correct screws, reinstall the Onset PCB. Do not overtighten the screws on the Onset PCB. Reconnect the temperature probe connectors to the Onset PCB connectors, and arrange the wires and connectors so the Lowell battery holder can sit flush on the chassis. Reinstall the Lowell battery holder and verify that no wires are pinched or connectors are pressing into any of the PCBs.

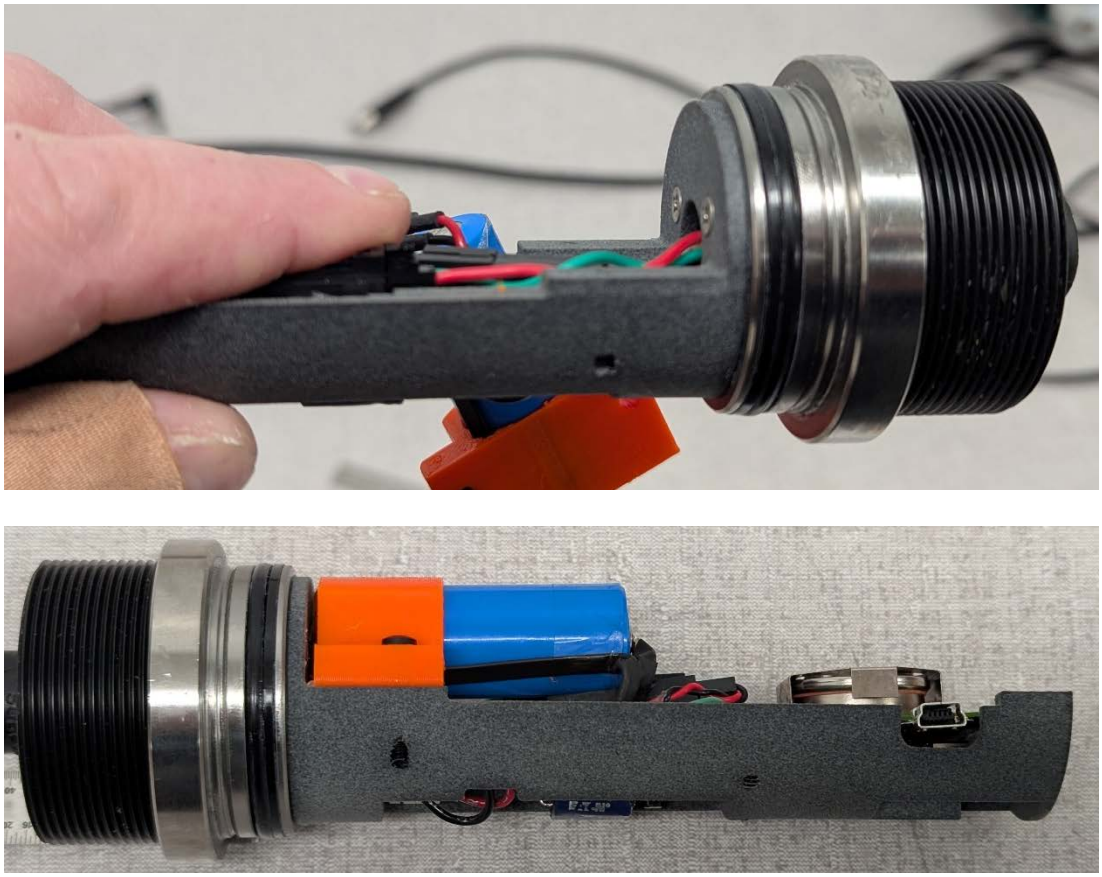


Figure 28. Wiring Arranged and Logger Reassembled

Finally, reconnect to each logger board to verify communications and operation.

Warning: This logger contains two lithium batteries. Do not cut open, incinerate, heat above 85°C (185°F), or attempt to recharge the lithium batteries. The batteries may explode if the logger is exposed to extreme heat or conditions that could damage or destroy the batteries' cases. Do not dispose of loggers or batteries in fire. Do not expose the batteries or their contents to water. Dispose of the batteries according to local regulations for lithium batteries.

3.3 USE OF LIQUEFIED GAS

Each time the 1010 logger housing is closed, the air in the housing should be displaced with an inert liquefied gas (i.e., nitrogen or dry canned air suitable for photographic equipment/lenses). This will reduce the possibility of corrosion and deterioration by elimination of oxygen. It also reduces the possibility of condensation of by eliminating water vapor in the housing. One of the most convenient ways of doing this is to put a small amount of liquefied gas into the housing before it is closed. This is best done with an inert gas that is heavier than air, installed with the housing open in a vertical position. Immediately after all the liquefied gas has evaporated, the unit should be closed. The gas should also be added to the housing before the logger is placed in storage. Suggested products and suppliers are listed in Appendix A.

4.0 CALIBRATIONS

Calibrations of each logger were conducted prior to delivery. Low-temperature calibrations were accomplished using the WHOI CTD water bath in 10°C increments from 0°C to 50°C. High-temperature calibrations were accomplished using an OMEGA HotPoint dry block probe calibrator, with ~5-minute duration tests at 50°C increments from 100°C to 250°C for T-type thermocouple probes, and 100°C to 350°C for J-type thermocouple probes. Each logger probe tip was submerged in ice water between test temperatures. Typical response time is between 90 and 180 seconds. A minimum undisturbed deployment time of 5 minutes is recommended before the probe is removed and relocated. See Appendix B for details.

Calibrations of the Lowell Instruments MAT-1 loggers was accomplished by Lowell Instruments. If recalibration is required, return the logger to EP Oceanographic, LLC for disassembly and transport to Lowell Instruments for recalibration.

APPENDIX A

Gas Products

The following are some of the gases available to displace air in the camera housing during use and storage. They are listed in order of their increasing environmental effect with regard to the problem of ozone depletion. We welcome suggestions for other appropriate gases that are readily available and environmentally safe. The desired properties are inert, dry, heavier than air, non-toxic, non-flammable, and easily available.

BOTTLED DRY NITROGEN -
Available from welder's suppliers in 80cu. ft. and larger bottles

HFC-134 (1,1,1,2-Tetrafluoroethane) BASED PRODUCTS:

DUST OFF
Falcon Safety Products
Branchburg, New Jersey
(908) 707-4900

AERO-DUSTER MS222-N
Miller-Stephenson Chemical Company
Danbury, Connecticut
(800) 992-2424

APPENDIX B

Technical Specifications and Calibrations

Thermocouple Tolerances
(Reference junction at 0°C)

ANSI Code	Range	Tolerance (whichever value is greater)
J	>0 to 750°C	2.2°C or 0.75%
T	>0 to 350°C	1.0°C or 0.75%

Onset Logger Accuracy and Resolution

ANSI Code	Range	Accuracy	Resolution
J	-210°C to 760°C	±0.6°C ± thermocouple probe accuracy	0.03°C
T	-260° to 400°C	±0.6°C ± thermocouple probe accuracy	0.02°C

Example Accuracy Assessment of Loggers 2017-011 through 2017-020

Low-temperature tests were carried out using the WHOI CTD water bath in 10°C increments from 0°C to 50°C. High-temperature calibrations were accomplished using an OMEGA HotPoint dry block probe calibrator, with ~5-minute duration tests at 50°C increments from 100°C to 250°C for T-type thermocouple probes, and 100°C to 350°C for J-type thermocouple probes. Each logger probe tip was submerged in ice water between test temperatures.

The following table shows the average steady temperature reading for each logger.

Temp °C	011 (T)	012 (T)	013 (T)	014 (J)	015 (J)	016 (J)	017 (J)	018 (J)	019 (J)	020 (J)
0.1	-1.9	-2.6	-2.5	-1.5	-1.7	-2.1	-1.7	-0.5	-1.7	-0.3
10	8.2	7.5	7.4	8.3	8.3	7.8	8.1	9.6	8.3	9.6
20	18.4	17.8	17.6	18.3	18.4	17.9	18.1	19.7	18.5	19.5
30	28.5	27.9	27.7	28.3	28.4	27.9	28.1	29.7	28.5	29.4
40	38.4	37.8	37.6	38.1	38.5	37.8	38.0	39.5	38.3	39.2
50	49.5	49.2	49.0	49.0	49.5	48.9	48.9	49.9	49.2	49.5
100	97	97	97	98	99	98	98	98	98	98
150	145	146	145	148	148	148	147	147	148	148
200	196	193	195	196	198	197	198	196	197	197
250	251	245	242	247	246	247	246	247	246	247
300				298	296	297	296	297	294	296
350				347	345	347	346	347	345	347

Response Time of Loggers

Each logger probe tip was submerged in ice water between test temperatures, and the time in minutes to reach a steady temperature reading is recorded in the table below.

Temp °C	011	012	013	014	015	016	017	018	019	020
100	2.9	2.2	2.8	2.4	2.8	2.6	2.8	2.5	2.7	2.6
150	3.3	2.5	3.2	2.8	3.2	2.8	3.2	2.9	3.2	2.9
200	2.5	3.1	2.6	3.2	2.7	3.4	2.7	3.4	2.7	3.2
250	2.5	2.6	3.4	2.9	3.2	2.9	3.2	2.9	3.2	2.8
300				2.9	3.4	3.0	3.2	3.1	3.0	2.6
350				3.0	3.1	3.0	3.1	3.3	3.3	2.8