

Integrated Monitoring Protocol for Cave Entrance Communities and Cave Environments in the Klamath Network

Standard Operating Procedure #5: Climate

Version 2017Feb10

Citation:

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To create a new version of this SOP, carefully follow the instructions in SOP #18: Revising the Protocol (<https://irma.nps.gov/DataStore/Reference/Profile/2238840>). Use the Revision History Log below to describe the revisions:

- Populate the top table of the revision history log, providing the previous version date, author of the change, a specific but concise description of the changes made, the footnote number associated with change details, and a new version date.
- In the bottom table, add a footnote and as much text as needed to describe in detail the reasons for and implications of the change.

Revision History Log

Previous Version Date	Author of Change	Changes Made	Footnote #	New Version Date

Footnote #	Detailed Reasons for and Implications of the Changes

1 Introduction

Cave environmental conditions can affect biological and chemical processes, can be altered by human activities and changing surface climate patterns, and often are linked to phenomena like ice accumulation/loss or the location and behavior of bats. This Standard Operating Procedure (SOP) provides guidance on measuring temperature and relative humidity (RH) using Onset Computing HOBO Pro v2 data loggers (HOBO U23-series; hereafter referred to as data loggers) (Figure 5-1). The data loggers will record data at hourly intervals in caves at both Lava Beds National Monument (LABE) and Oregon Caves National Monument and Preserve (ORCA).

It is foreseeable that changes in the availability of data loggers or advances in technology will necessitate the updating and revision of this SOP. In the event that this is necessary, a crosswalk study using both the previous and new methodology should be undertaken to either ensure compatibility or to determine a crosswalk or a regression model to allow continuity of data.

Thermometers within the data loggers reliably record temperatures typical of caves in LABE and ORCA (temp range of -40° to 70°C , accuracy of $\pm 0.21^{\circ}\text{C}$); however, measuring relative humidity (RH) is problematic. Cave middle and deep zones may be “condensing environments,” with the air at or near saturation. Because RH sensors in high humidity environments of 90-100% RH can experience an accuracy range of $\pm 4.5\%$ (whereas below 90%, they are rated to $\pm 2.5\%$), caves with an actual RH of 95% or less will record an RH value of $<100\%$, while caves with an actual RH of $>95\%$ may record a constant 100% value due to decreasing accuracy and hysteresis (i.e., latching) effect. Because parks are primarily interested in detecting caves drying out (i.e., dropping below a threshold RH of $\sim 90\%$), the reduced accuracy above 90% does not impede our overall objective.

However, to mitigate the effects of deploying data loggers in high humidity, we implement 2 programmatic steps. First, loggers should be periodically “rested,” by being replaced and stored in an office environment (details about rest periods and frequency follow). Second, data are evaluated post deployment for “suspect data” (e.g., data which has data patterns, trends, or near-constant values that diverge significantly from previous patterns).

While Onset has not evaluated lifespan for loggers operating above 90%, they agreed that our plan to periodically “rest” or “dry out” sensors seemed appropriate. They do note that the U23’s RH sensor may be replaced independently of the temperature sensor and logger body itself. Specifications indicate sensor drift of up to 1% RH and 0.2°F per year for the U23. Regular replacement of RH sensors may be necessary if they are found to deteriorate more quickly than the temperature sensors. Advances in technology may yield more durable and accurate humidity sensors in the future, and the LABE Natural Resource Program Manager and park Field Leads should stay current on developing technology.

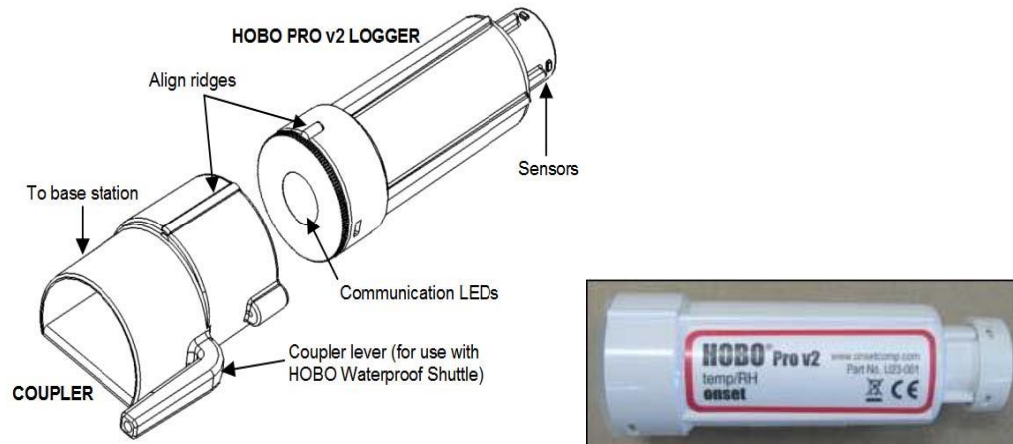


Figure 5-1. HOBO Pro v2 (part no. U23-001) data logger and coupler for downloading.

2 General Instructions

Climate monitoring data will be collected year-round and downloaded by park staff 2 times each year. Temperature (°F) and relative humidity (%) will be measured hourly on the surface near the entrance and inside caves using data loggers. Battery voltage will also be recorded for each unit to ensure data quality (data analysis shows that wildly anomalous values may be recorded by the U23 once battery voltage drops below 2.9V).

Data loggers are tracked using the Klamath Network database and instructions are included in SOP #13: Data Entry, as well as within this SOP. The database will track the location of each piece of equipment, its serial number, dates installed/removed /tested, and additional notes for each climate file. All raw csv (comma separated values) file names will contain metadata describing the serial number, location, and download date, following this example:

ANGL_deep_34343434_20160819.csv

where ANGL is the cave code, deep is the deployment zone, 34343434 is the serial number, and the download date is August 19, 2016

Aquarius Time Series software by Aquatics Informatics will be used to manage climate data and the data will be updated each time data loggers are checked, offloaded, or replaced. All data loggers should be tested for accuracy relative to a NIST (National Institute of Standards and Technology) certified unit (available from Onset). Confirmation of accuracy should be recorded, and units that fail the accuracy check should be either disposed of or sent back to the manufacturer for repair. The thresholds for rejecting data loggers are $\pm 2.5\%$ RH and $\pm 0.4^\circ\text{F}$ given “room” (average indoor office conditions) temperature and humidity (per Onset’s U23 specifications).

At ORCA, there were several existing Onset HOBO Pro units (Model H08-032-08m, “hockey-puck style”) inside of The Cave and on the surface at Blind Leads Cave that had been in place for years prior to the initiation of this protocol. Efforts will be made calibrate the H08 and U23 models by running them simultaneously side-by-side in the same environment for a year. Table 5-1 indicates when old H08 units were replaced with newer U23 units. Placement and operation of all new HOBO U23 data loggers will follow this protocol and data from all data loggers will be collected according to the schedule provided. It is particularly important to link the HOBO model and serial number with the data it collects because existing HOBO data loggers might have different errors or tolerances and researchers may need to account for this during analyses. This will be the subject of a future NRR (Natural Resource Report) as time and staffing allow.

3 Climate Monitoring Caves

Climate will be monitored at Oregon Caves (“The Cave”) and Blind Leads Cave in ORCA, and at all 37 randomly and nonrandomly selected caves (judgment sites) in LABE.

4 Timing and Frequency

Data will be offloaded twice per year: once during the winter between December 1 and March 1 (coincident with bat monitoring at both parks and water monitoring at ORCA), and once during the summer between May 1 and August 31 (coincident with scat and visible organics and invertebrates monitoring during even years). Data loggers will be swapped and rested each time data are downloaded to help mitigate long-term saturation damage of RH sensors. After 6 months of rest (ventilated storage in a climate-controlled area, i.e., park offices), they can be redeployed in caves. Before data loggers are installed each time, they should be tested for accuracy as described below. If needed, batteries will be changed when swapping the data loggers; they must be at least 66% full (or at the 3/5 “tick marks” on the battery scale given by the HOBOWare software) when placed in caves and must be replaced whenever they show less charge (see section on replacing batteries below). If in doubt, the crew should change the battery prior to deployment.

Unlike the timing of other biological parameters (vegetation, invertebrates, bats), the timing of data logger downloads does not have to be within a certain time span to minimize variations since the collection of data is continuous and ongoing.

5 Location of Climate Monitoring Stations

In ORCA’s Blind Leads Cave and in all monitored caves at LABE, 3 HOBO data loggers are installed: one in the entrance zone, one in the middle zone, and one in the deep zone. Information on delineating zones and marking sites is available in SOP #3: Site Selection and Marking. The current location of each of the sites is shown on cave maps (referenced in Appendix C: Examples of Cave Site Dossier Materials). While some deployment areas might have landmarked tags, some may only have narrative descriptions and photographs. In addition to the in-cave sites, data loggers will be deployed near the monitored caves to record surface temperature and RH; (~10 at LABE; ~3 at ORCA: 2 outside The Cave and 1 outside Blind Leads Cave). At LABE, these surface data loggers are placed in solar radiation shields painted “light sage green” to visually match the landscape and have a consistent thermal effect on all loggers. At ORCA, surface data loggers hang in trees

approximately 6 feet above ground inside plastic coverings made from milk jug bottoms to shield the logger from rain.

Inside the cave, data logger locations should be selected where conditions are representative of the entire zone and are easily relocated with supporting maps, photos, and written descriptions. Additionally, data loggers should be placed away from dripping water and/or oriented with the relative humidity sensor down to reduce the risk of damage to this fragile part. Where public visitors are likely to see the loggers, they will be hidden under a caprock or behind an obstruction to avoid tampering. Testing indicated that small differences in positioning within a zone (e.g., ceiling, wall, or floor) had little effect on readings (Thomas 2010).

In rare situations where loggers cannot be relocated upon searching, efforts will be made to place a new logger as close as possible to the original location described in the cave site dossier, which is referenced in Appendix C. If there is any doubt about the exact repeat of an original placement, notes should be made in the equipment log and database detailing the situation.

In The Cave (ORCA), there are 23 climate monitoring stations (Table 5-1).

Table 5-1. List of climate monitoring stations within Oregon Caves (“The Cave”) at Oregon Caves National Monument and Preserve, including 2-letter codes, relative location, year established, year replaced, and model of HOBO data logger.

Number	Location	Code	Zone	Year established (logger model)	Year replaced (logger model)
1	Outside Main Entrance	OM	Surface	2012 (U23)	n/a
2	Main Entrance	ME	Entrance	2012 (U23)	n/a
3	Watson's Grotto	WG	Entrance	2005 (H08)	2012 (U23)
4	Belly of the Whale	BW	Middle	2005 (H08)	2012 (U23)
5	Icebox Entrance	IE	Entrance	2012 (U23)	n/a
6	Jack's Pass	JP	Deep	2012 (U23)	n/a
7	Beehive Room Floor	BRF	Middle	2005 (H08)	2012 (U23)
8	Beehive Room Ceiling	BRC	Middle	2005 (H08)	2012 (U23)
9	110 Entrance	110	Entrance	2012 (U23)	n/a
10	King & Queen's Throne Room	KQ	Deep	2012 (U23)	n/a
11	Wind Tunnel	WT	Deep	2005 (H08)	2012 (U23)
12	Miller's Chapel	MC	Deep	2005 (H08)	2012 (U23)
13	Ghost Room Ceiling	GRC	Deep	2006 (H08)	2012 (U23)
14	Ghost Room Floor	GRF	Deep	2005 (H08)	2012 (U23)
15	Jules Verne Well	JV	Deep	2012 (U23)	n/a
16	Paradise Lost	PL	Deep	2005 (H08)	2012 (U23)
17	Wedged Rock	WR	Deep	2012 (U23)	n/a
18	South Room	SR	Middle	2005 (H08)	2012 (U23)
19	Sand Room	SA	Deep	2012 (U23)	n/a
20	Bear Bones	BB	Deep	2005 (H08)	2012 (U23)
21	Clay Pocket	CP	Middle	2006 (H08)	2012 (U23)
22	Exit Tunnel	ET	Middle	2012 (U23)	n/a
23	Outside Exit Tunnel	OT	Surface	2012 (U23)	n/a

Three hundred two data loggers are used for implementation and continual monitoring, with regular resting of devices (Table 5-2). There are 147 data logger sites in the caves and on the surface that are associated with this SOP. One additional data logger (NIST certified by Onset) will be left in the office at each park for testing other HOBO data loggers.

Table 5-2. Total number of climate data loggers required by location type. Number of active loggers is equal to number of sites multiplied by number of loggers per cave, and number of resting loggers (i.e., drying out) is equal to number of active loggers (except In Office loggers).

Location type	# loggers/site	# sites	Active loggers	Resting loggers	Total loggers
LABE - all caves	3 (entrance, mid, deep)	37	111	111	222
LABE - surface	1 (landscape)	10	10	10	20
ORCA - Oregon Caves	23	1	23	23	46
ORCA - Blind Leads Cave	3 (entrance, mid, deep)	1	3	3	6
ORCA - surface	1 (landscape)	3	3	3	6
In Office	2	2	2	0	2
Total		54	152	150	302

6 Equipment

6.1 Hobo Data Logger

The complete HOBO Pro v2 (U23-00x) data logger package includes the weatherproof data logger, clamp and mounting screws, UV protective cap, a coupler with HOBO waterproof shuttle, and HOBOware Pro 2.2.1 software. Replacement accessories for the sensors, cables, and the UV protective cap are also available.

The user manual is available online and on the Klamath Network (KLMN) and park drives in the following locations:

Online: http://www.onsetcomp.com/files/manual_pdfs/10694-N%20MAN-U23.pdf

KLMN common drive: S:\Monitoring\Caves\Cave_Documents\Protocol\Supporting_docs

LABE common drive: S:\TEAMS\Resource Management\Branches\Caves_Bats\Cave Program\I & M\Cave_Documents\Equipment_Events\Equipment_Manuals

ORCA common drive: O:shdata\Public\Manuals\Equipment

6.2 Equipment List

- Dedicated and/or decontaminated caving equipment including: helmet with mounted light(s), backup lights, kneepads, gloves, boots
- Cave zone maps
- Cave Climate Field Data Sheet (see end of this SOP)
- Watch
- Pencils

- HOBO data loggers (model # U23-001): tested for accuracy and battery life, and marked as operational
- Data shuttle (part # U-DTW-1)
- Flathead screwdriver (for battery replacement)
- Replacement batteries (part number HP-B): At least 147 per year, more if more HOBO data loggers are in use
- Solar radiation shield or protective shield to prevent splashing (constructed from ½ gallon milk jug) for surface deployed units
- Camera and survey gear (to record position of data loggers upon initial setup; position information is then recorded in cave site dossiers)
- Station marking gear (screws, aluminum wire and tags, survey equipment: see SOP #3: Site Selection and Marking), if descriptions/photos insufficient
- HOBOWare software
- Computer for storing and managing data, with HOBOWare software installed
- Interface cable for connection between HOBO U23 data logger and computer or data shuttle

7 Instructions

First, carefully read all the information about each device to be used in this SOP and read manufacturer instructions.

7.1 Process Overview

7.1.1 PART I: Office (pre-field)

Conduct accuracy check, obtain 3 data loggers per cave, launch data loggers, and fill in the “Serial Number Installed” column of the Field Data Sheet. Pack HOBO Pro v2 waterproof shuttle, Field Data Sheet denoting serial number and cave placement location (ent, mid, deep), and field descriptions and map (for each cave) from black binder labeled “Klamath Inventory & Monitoring Network Cave Protocol: Site Dossiers”

7.1.2 PART II: Field

Download the old logger with the HOBO shuttle, transfer ID tag from old logger to new logger, place new logger at the monitoring site, arrange rocks to conceal logger and match field description, and pack out the old loggers from the cave.

7.1.3 PART III: Office (post-field)

Offload the HOBO shuttle using HOBOWare Pro software, stop loggers from logging, and place them in "on holiday" storage container.

7.2 Process Detail

7.2.1 PART I: Office (pre-field)

Preliminary Accuracy Check

1. Following the instructions on how to launch a logger (below), launch all the needed loggers for the upcoming week of deployment and set to record temperature and RH every 10 seconds. Similarly, ensure that the “In Office” NIST certified logger is also collecting every 10 seconds.
2. It may be advantageous to delay start for ~1 hour to give time to prep all the loggers to an equal starting time.
3. Let the loggers record for 30 minutes, giving 180 measurements for each logger.
4. After the 30 minutes is up, follow the instructions below to download the data, then export the data as .csv files, and import into a spreadsheet (such as Microsoft Excel).
5. For the 180 measurements that correspond to each logger being tested, and the “In Office” NIST certified logger, calculate the mean, minimum, maximum, and variance (Standard Deviation).
6. Identify any errant loggers:
 - a. The mean temperature and RH of the loggers to be deployed should be within 0.4°F and 2.5% RH of the In Office NIST logger.
 - b. Using the mean reading is the standard, but it can also be beneficial for the crew to examine the minimum, maximum, and variance against the In Office NIST logger. Any loggers that show large discrepancies should be evaluated.
 - c. Record results of the accuracy check.

Deployment Methods

1. Obtain enough accuracy checked data loggers to cover 3 per cave (1 for each zone: entrance, middle, deep). These loggers should have been rested for ~6 months.

NOTE: New loggers will need to be labeled with 2 separate label stickers printed on Rite in the Rain label paper:

- "Property of National Park Service DO NOT REMOVE"
- "Long Term Study in Progress Temperature and Humidity Data Logger"



Figure 5-2. Data logger label and location of serial number on the data logger.

Labels need to be cut and placed in an open area on the side of the logger (do not cover up the serial number) (Figure 5-2). A template label page is located at the end of this SOP.

2. Launch logger using HOBOWare Pro from the start menu on your computer. Figure 5-3 is the main screen with the 4 most useful icons: “Launch,” “Readout,” “Stats,” and “Stop.”

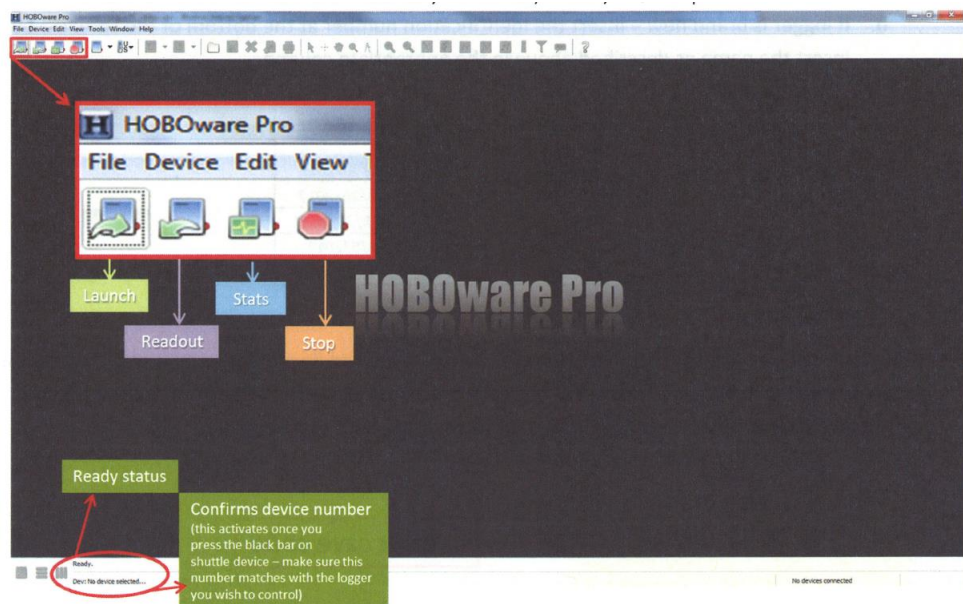


Figure 5-3. Main screen of the HOBOWare Pro software application, showing the 4 most useful icons and some added notation.

- a. Plug in HOBOWare Pro v2 shuttle via the USB port and connect your first data logger (Figure 5-4). The logger's thicker end has relief on the bottom rim that lines up with the black indent on the shuttle. Connect the logger to the shuttle and firmly press the black magnetic bar found above the lighting cues. The light on the shuttle should first indicate yellow, then transition to green. Watch for the logger identification number to appear in the bottom left corner of the HOBOWare window.

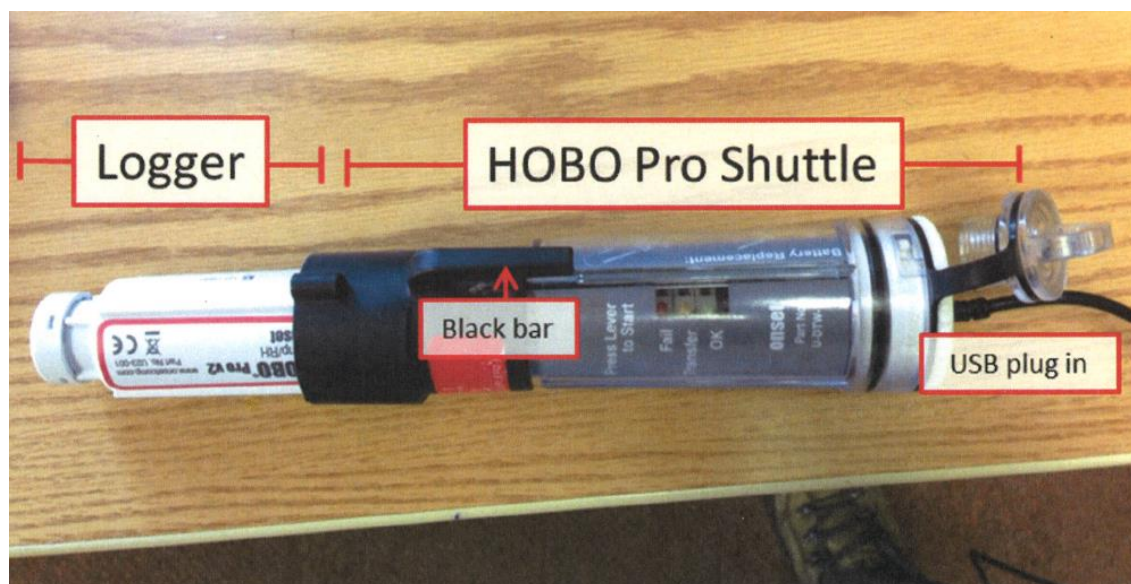


Figure 5-4. HOBO Pro data logger and shuttle.

- b. Select “Launch” from the upper left hand icon bar and confirm once again that you have the correct device by checking the serial number (Figure 5-5).

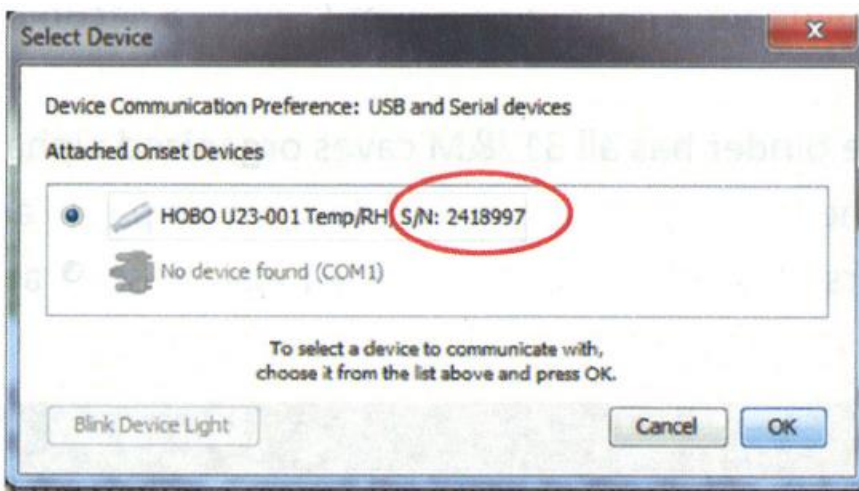


Figure 5-5. Select Device window showing the HOBO data logger serial number.

- c. The screen below allows you to program the logger (Figure 5-6). Read the text boxes to know where to make the appropriate adjustments to the standard settings. (Note: if launching for accuracy test, set logging interval to 10 seconds.)

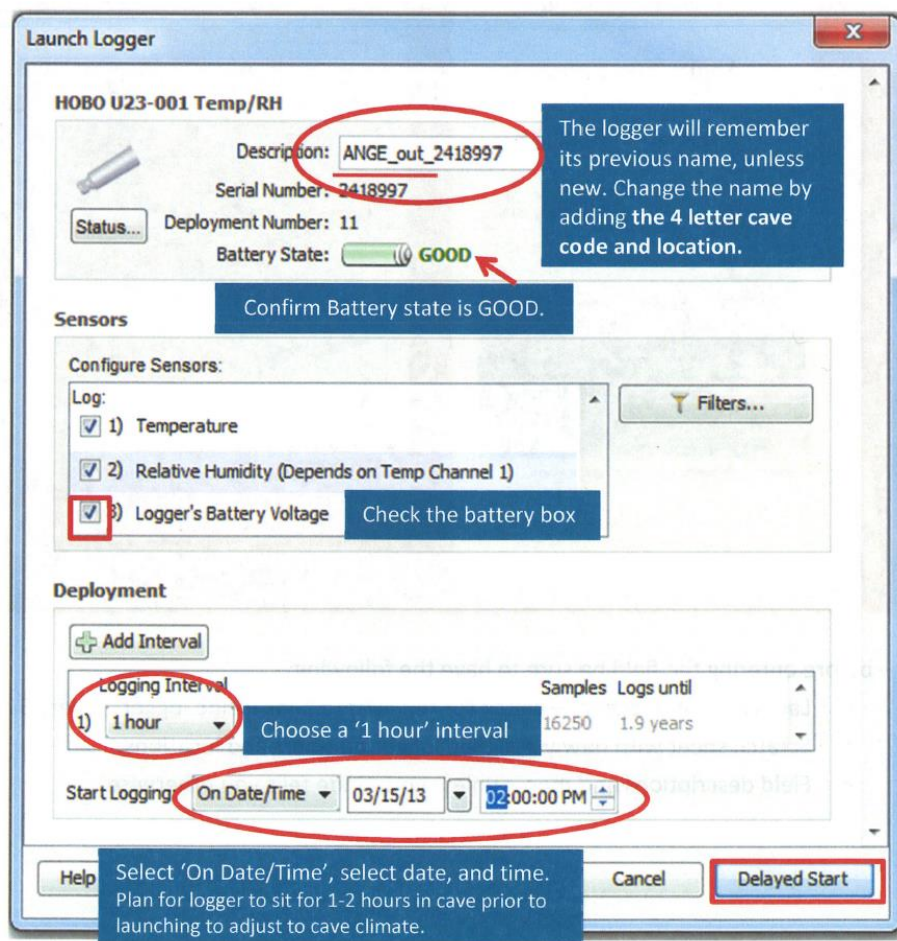


Figure 5-6. *Launch Logger* screen with added instructions for programming the data logger.

- d. Press “delayed start” to finish and watch the data logger launch (it’s quick!). Do this for all loggers and then close the program. You can check the success of your launch by looking at the thick end of the logger and watching for a red blinking light (every 8 seconds).
- e. Place 3 new or redried 0.5 gram indicating silica gel dessicant packets inside the unit. Some types of silica gel packets can be redried at 175 °F for 10–15 minutes and stored in airtight bags to facilitate multiple uses.
5. Fill in the “Serial Number Installed” column of the climate data sheet for each datalogger that is launched. Gather maps and location descriptions (Figure 5-7). The binder has all caves/sites.

organized alphabetically. Each cave has sheet protectors containing the logger photo / written description pages, and a map displaying the locations of the in-cave loggers.

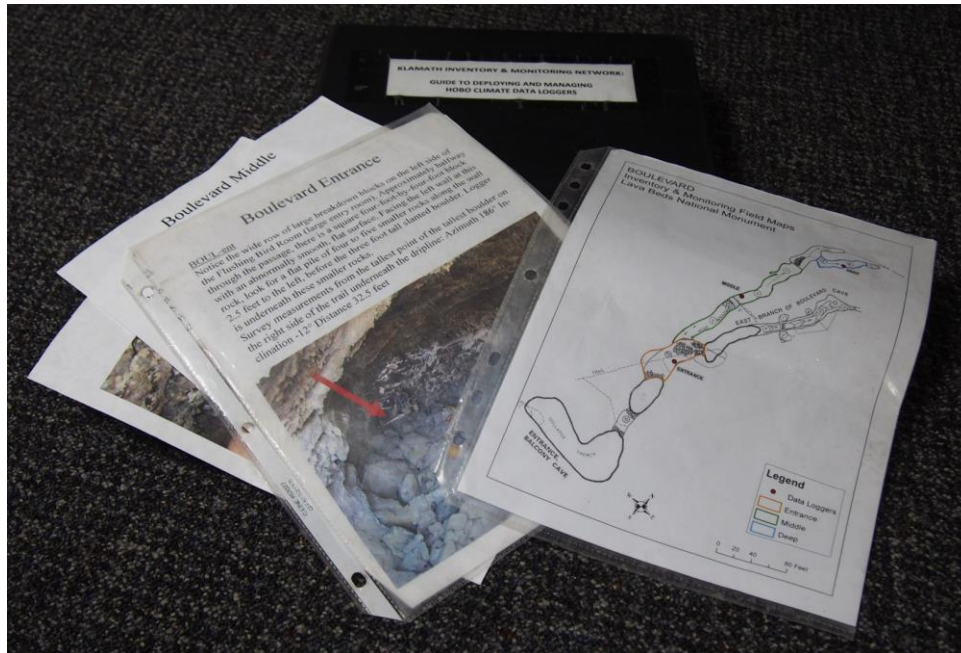


Figure 5-7. Examples of a cave map and written descriptions of data logger locations in the cave.

6. Review—before entering the field be sure to have the following:

- Launched data loggers—watch for red light to blink inside logger every 8 secs
- Field Data Sheet with newly assigned logger numbers and locations
- Field descriptions and map—(unless your pride tells you otherwise)

7.2.2 PART II: Field

While in the field, the order of download by zone does not matter. Ideally, download each logger at the monitoring site using the HOBO Pro v2 Shuttle so that data get cropped before the logger collects data outside the cave (in pack or office). The shuttle device will transfer and store the data for multiple data loggers. The loggers will continue to collect data once you've switched them out with the new ones. This is okay as long as they were downloaded at the monitoring site; the data we want is then stored on the shuttle and not on the unit. Without the shuttle, files will need to be manually cropped to eliminate false data (from logging in your pack)—record the time they were collected to facilitate this. Later in the office you will stop the loggers to save battery before putting them to rest.

Field Download Process

1. Locate the logger and remove the small silver tag (if present) that has the cave/site code etched on the front.

2. Record the serial number of the logger you just removed on the Field Data Sheet.
3. Connect the “old” logger to the shuttle (same as before—lining up the relief piece on the bottom rim of the logger and the indent piece on the shuttle).
4. Press the black bar on the shuttle and wait for the yellow light to turn green
5. Once the solid green light appears, the data have been downloaded and it is okay to remove the logger. Place the logger in your pack to bring back to the office.
6. NOTE: It is possible that you will get the red failed light. Remove the logger, wipe off any mud or sediment that has collected on the logger and try again. If it continues to be red as you reconnect, it may mean that the battery needs replacing; therefore, you cannot continue to download—simply note it, and move on to the next one.
7. Using your handy Field Data Sheet, select the logger that is assigned to your location and place the silver tag around the logger.
8. Place the logger back in the “rock pile” you found it in and cover with the same caprock in the same orientation. It is important to leave the site in the same condition as found so that it matches the photo / written description pages. Be sure to position the device with the humidity sensor down (smaller end with holes and Gore-Tex paper lining) to protect the sensor from saturation. In caves with high visitation, also be sure to cover the large end of the device to hide the red light that blinks every 8 seconds to indicate normal activity. When moisture cannot be avoided (only at ORCA), cover with a vented protective shield to avoid trapping humid air. These can be constructed by cutting out the bottom and part of the sides of a ½ gallon plastic milk container. Label the drip shield “Cave Climate Monitoring” and place it over the data logger in such a way that it shields against drips but allows airflow.
9. Double check that you removed the proper logger and are leaving the “new” logger.
10. Great job—now go do the next one!

7.3.3 PART III: Office (post-field)

Upload Files to the Computer

1. Open HOBOWare Pro from the Start Menu, plug in the HOBO Pro v2 Shuttle via the USB port, and select the “Readout” icon in the upper left hand corner, second from the left.
2. Files will automatically start to load. Once the files have loaded, make sure the “Save” boxes are checked to the left of each file to be saved.
3. Navigate to the “Save Folder” line and select “Choose” on the right side. Save files here per the guidance in SOP #15: Data Transfer, Storage and Archiving (Figure 5-8).
4. Once you've browsed to the appropriate file structure, select “Save Checked.”

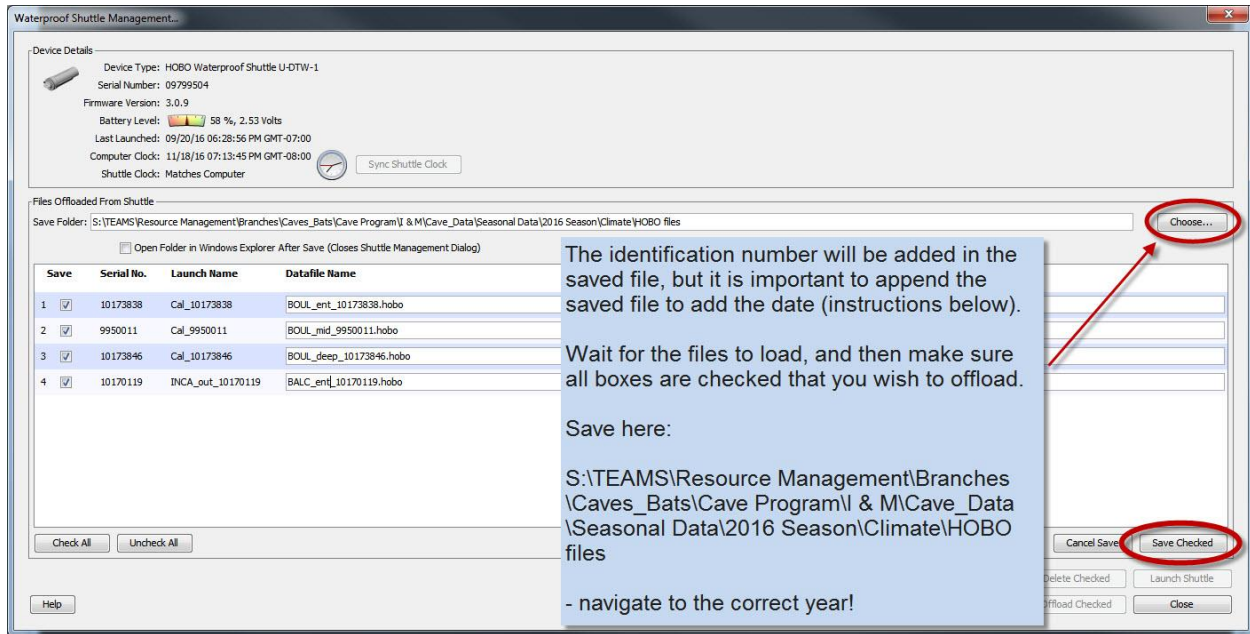


Figure 5-8. Device Readout screen, with added notation for saving uploaded files. The download location may change.

- After saving, the window below (Figure 5-9) will appear; this is where you will delete and clear the shuttle, but first check to see that the files were correctly saved.

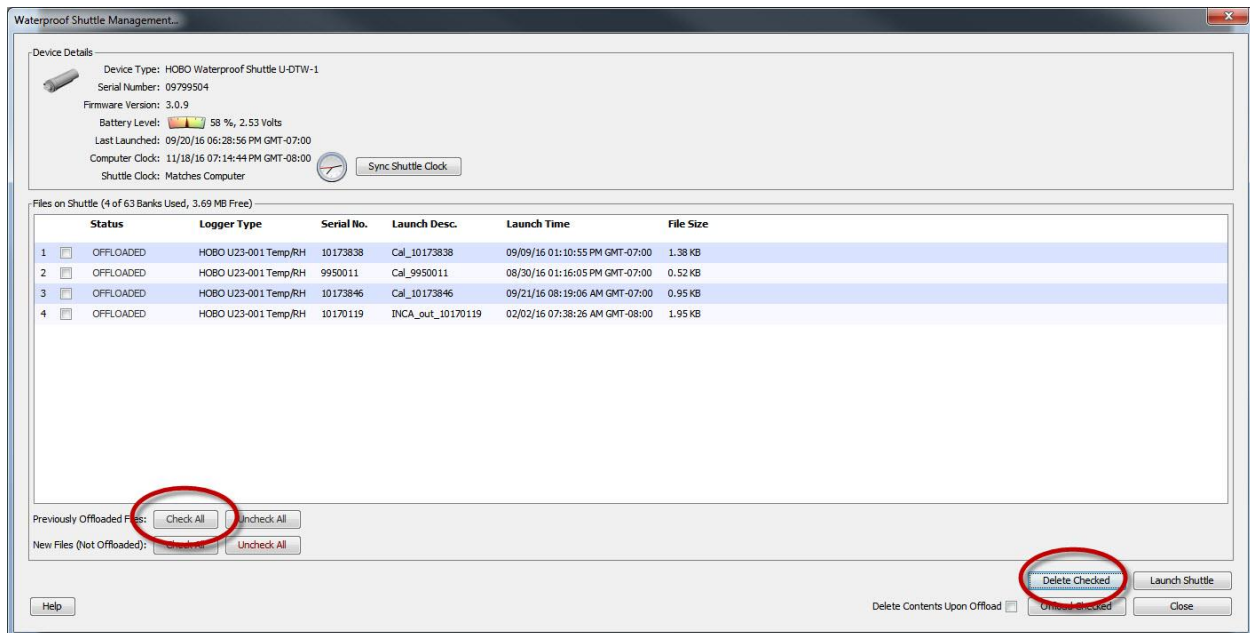


Figure 5-9. Waterproof Shuttle Management screen that appears after saving uploaded files and allows the shuttle to be deleted and cleared.

6. To ensure that the files were properly saved, plot them using HOBOWare. Navigate to the saved location, double click on the file, select “plot,” and you will see the temperature and relative humidity graph. As long as that exists, it is okay to go ahead and clear the shuttle.
7. Change the file name to add the date the logger was removed from the cave. Example for ANGL Cave: file will appear with the name, “ANGL_out_10170196”; append the download date to the file name so that it becomes, “ANGL_out_10170196_yyyymmdd.”
8. ****Troubleshooting**** If you don't see the file, double check where you saved it. If you didn't properly set the save location, it will most likely be in 1 of 2 places: on your local (C:/) drive in a folder labeled “HOBO files” or in the correct HOBO file folder but under its own subfolder.
9. Once confirmed that all data are accepted and saved, delete all files to ensure the shuttle is never full while in the field and “close” the Waterproof Shuttle Management window.

Stop the Loggers (save battery!)

Remember the loggers have continued to collect and store data outside the cave, which is why you must now stop them and prepare them for the rest period.

1. Connect the shuttle with one of the loggers you removed from the cave. Press the black bar and watch for the device to be recognized in the lower left hand corner (again, making sure the identification numbers match).
2. On the main HOBOWare menu select the “Stop” icon, fourth from the left. It will confirm that you wish to stop the logger (Figure 5-10), select “Yes,” then “Ok.” (Notice, small red light inside thick part of logger will stop flashing.)

Update the Database

Update the database with serial numbers from the Field Data Sheet. All done!

8 Replacing Batteries

U-series HOBO batteries operate for approximately 3 years and batteries will be replaced when data loggers show status less than 66% full (or 3/5 “tick marks” on the battery scale given by HOBOWare) upon launching. Logging battery voltage is required as it indicates low quality data when voltage falls below 2.9V, often shown by unusually high or low spikes in temperature and/or RH. The batteries, Onset part number HP-B, can be ordered through the Onset Corporation website and are quoted to have a shelf life of 10 years.

Replace the HOBO Data Logger Battery

1. Turn the optical sensor's plastic end piece counterclockwise until it stops. Use your fingers or a small flathead screwdriver to pull the end piece out.
2. Remove the circuit board, being careful not to lose the desiccant packets inside the unit.
3. Pull out the battery and place it in the battery recycle bin.

4. Insert a new battery and check the battery status using HOBOWare.
5. Download, relaunch, or stop the data logger according to the field schedule.
6. Record the battery change in the database.

9 HOBO Data Logger Troubleshooting

If battery replacement does not fix a failed data logger, record the error, data logger serial number, and date on the Event and Equipment Log and relay this information to the KLMN Data Manager. If a data logger begins logging inaccurately or otherwise appears to be malfunctioning, it must be retired and replaced; this should also be noted in the database. This should also prompt a review of the faulty logger's previous deployments for suspicious data.

10 Testing and Sensor Replacement

HOBO data logger units that fail the accuracy check cannot be calibrated outside the factory. A device which measures inaccurately cannot be corrected or compensated; however, they can be tested and compared with other devices in order to verify accuracy.

For the purposes of this SOP, field data loggers will be verified prior to deployment against an "office" (reference) data logger known to be accurate, as described in the instructions above. The office logger should initially and periodically be calibrated against a National Institute of Standards & Technology (NIST) traceable reference data logger (above). Onset Corporation, the manufacturer of HOBO data loggers, offers both temperature and humidity certification, including a three-point RH certification that tests the device at 25%, 50%, and 75% RH, with a 1–2 week turnaround. Onset recommends that NIST calibration be certified annually, given the possibility of sensor drift over time.

Loggers whose RH sensors are out of specification should have their RH sensor replaced (Onset part number HUM-RHPCB-2). Temperature sensors are not replaceable on the U23; therefore, devices with out-of-specification temperature values should be retired.

11 Tracking, Reporting, and Analysis

An Equipment and Event Log form (see end of this SOP) should be completed for each park and year of implementation. It should be used for recording issues and events related to equipment, including but not limited to the data loggers, such as battery/sensor replacement or equipment damage/malfunction/repair.

General information on analysis and reporting is provided in SOP #17: Data Analysis and Reporting. It is important for researchers to be aware of any previously encountered problems. Occasionally, different HOBO data loggers might report slightly different humidity levels. Exposure to elements in a cave, especially the high humidity found there, can gradually affect the devices and cause drift. The instructions in this SOP attempt to prevent this through regular replacement and resting of devices. However, if it appears that there is a sudden change in humidity levels, the timing of this change should be examined to see if it coincides with a new device being installed. This is an indication that

the devices are reading differently from one another and should be considered as an alternative interpretation of the data.

12 Literature Cited

Thomas, S. 2010. Draft: Monitoring cave entrance communities and cave environments in the Klamath Network. National Park Service Unpublished Report, Lava Beds National Monument, Tulelake, California.

13 Datasheets

Cave Climate Field Data Sheet

Required equipment: map of cave and climate site locations, this field form and pencil, HOBO data shuttle, HOBO data loggers to be launched, standard caving gear.

Data sheet reviewed by (initial):

[illegible]

HOBO Data Logger Labels

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