STANDARD OPERATING PROCEDURES

STREAM TEMPERATURE MONITORING

Water Temperature Working Group | 5/1/2018

A. PURPOSE

The purpose of this Standard Operation Procedure (SOP) is to establish a set of uniform procedures for deploying water temperature data loggers in streams as semi-permanent (1-5 years) monitoring sites. The epoxy and anchor methods are discussed as distinct deployment options based on physical site characteristics. Standardization of deployment and data retrieval methods is critical to maintaining the quality of data collected.

B. BACKGROUND

Maine, renowned for its cold-water fisheries, contains the last wild populations of Atlantic salmon and the largest populations of native brook trout on the East Coast of the United States. Knowing the potential for future species distributions of these thermally sensitive species is crucial for management decisions, particularly as the effects of climate change increase. In order to understand and establish the current baseline thermal regimes of Maine's watersheds, the Stream Temperature Working Group, comprised of federal and state agencies, tribes, NGOs and educational institutions, was created with the goal of increasing the quantity, quality, and permanence of water temperature monitoring sites in the state. The Working Group developed the following protocol in order to better characterize the aquatic thermal regime in Maine across a wider variety of drainages and elevations than has previously been represented; this information will then be used to model the impacts of future environmental change on indicator species such as brook trout.

C. MATERIALS

a. For Sensor Installation:

i. Onset UTBI-001 TidbiT v2 Loggers

ii. If using epoxy method:

1. PVC solar shield canister, top and base (see Isaak et al. for construction directions)
2. Underwater epoxy (FX-764 Splash Zone Epoxy from Simpson Strong-Tie)
3. Disposable rubber gloves
4. Plumber's tape
5. Wire brush
6. Two portable (2-4 oz) containers
7. Underwater viewing box (acrylic box as small as 4'' by 6'' may suffice)
8. Metal forestry tags (numbered)
9. Zip ties

iii. **If using the anchor method**:

Figure 1. TidbiT v2 water temperature data logger (UTBI-001)

1. 1 ½" -2" diameter PVC pipe, with predrilled holes to allow for securing points and stream flow around the logger.
2. Sturdy, heavy, nonpolluting anchors to hold data loggers in place (i.e. rebar, mushroom anchors, metal grating)
3. Metal chain or other securing device
4. Heavy duty zip ties

b. For Downloading and Processing Data
   i. HOBOware Pro Software
   ii. Waterproof data shuttle (U-DTW-1 Waterproof Shuttle) with fresh batteries **OR** Optic USB Base Station
   iii. USB cable

c. General Equipment
   i. GPS receiver
   ii. Camera
   iii. Datasheets
   iv. Thermometer (NIST-traceable)

D. PRE-DEPLOYMENT

d. Calibration
   i. If time allows, sensor accuracy should be tested prior to deployment. *See Attachment A for details.*

e. Launching the Loggers
   i. Open HOBOware Pro
   ii. Connect the waterproof shuttle or Optic USB Base Station to the computer using the USB cord. Place logger in the coupler, then attach to shuttle/base station. Firmly press the black lever to initiate communication. The green light should blink.
   iii. Click on the launch button in the upper left end of the toolbar.
   iv. Set the time interval for 30 minutes.
   v. Choose either delayed launch and set recordings to occur on the hour, or ½

Figure 2.Diagram illustrating the use of a base station for downloading logger data.

hour. Set the launch to begin at midnight to avoid a partial day's worth of data. Delayed launch saves battery when there is a time lag between launching and field placement.

vi. When finished, disconnect the logger and check that the red sensor lights are blinking.

E. DEPLOYMENT

a. Site Selection

1. **Epoxy Method:**

(Best for sites with high flows, cobble/boulder substrate and/or man-made structures such as bridge abutments where sensors can be placed without being dewatered in low flow situations).

a. Locate an attachment site, preferably a large rock or cement structure. The site should be well-marked and easy to find again, regardless of field crew turnover. However, avoid visible sites near high traffic areas to decrease potential tampering.
b. Suitable sites have flat downstream surfaces that are shielded during floods and have sufficient water depths to keep sensors submerged during low flows.
c. If you can move the attachment site, it is unsuitable.
d. *Ensure that the logger will remain underwater throughout all seasons.* Place the logger toward the deepest part of the channel, looking for signs of past dewatering events (i.e. presence of grass, moss, high water lines).

2. **Anchor Method**

(*Best for sites without suitable attachment points such as smaller or sandy, low gradient streams).*

a. Locate a site where turbulence and mixing occurs: riffles, runs.
b. The site should be well-marked and easy to find again, regardless of field crew turnover. However, avoid visible sites near high traffic areas to decrease potential tampering.
c. *Ensure that the logger will remain underwater throughout all seasons.* Place the logger toward the deepest part of the channel, looking for signs of past dewatering events (i.e. presence of grass, moss, high water lines).

b. Placing the Loggers

1. Epoxy Method

a. Check logger for blinking sensor lights.

b. Record the sensor serial number and metal forestry tag number on the datasheet.
c. Use a zip tie to attach the sensor to the PVC cap. Apply plumber's tape to base, then screw cap on base.
d. Use wire brush to thoroughly scrub attachment site. Make sure that the sensor will remain submerged during low flows.
e. Put on gloves. Wet fingers and scoop out equal parts white and black epoxy, being careful not to mix colors in source containers. Begin mixing until mixture turns gray (about 1 minute). It should be about the size of a golf ball. Note that quite a bit of epoxy may stick to the gloves, so start with more than you think necessary, and re-wet fingers to limit mixture adhesion to gloves.
f. Attach metal forestry tag above the water surface with a small amount of epoxy, covering the tag edge with a lip of epoxy.
g. Use remaining epoxy and apply to base of PVC canister. Mold over the lip of the base, as the epoxy will not bond directly to the PVC, but avoid putting epoxy against the cap itself.
h. Hold assembly underwater, gently push and twist onto the attachment site. Mold and smooth epoxy edges onto the attachment site, making sure the epoxy "collar" does not impinge on the PVC cap.

Figure 3. Cobble leaning on PVC housing to ensure that the epoxy sets.

i. Gently lean a flat cobble against the assembly, ensuring completely horizontal pressure (downward pressure may cause epoxy to detach from attachment site, or force epoxy against the cap). This keeps the logger in place as the epoxy sets (about 24 hours).

j. Use a plastic viewing box to see your work. If there are any gaps, etc. re-mold the epoxy and change cobble placement. Check to be sure cap rotation will not be limited by epoxy, but be careful not to loosen the base.
k. Record the GPS coordinates, the time the logger was placed in the water, sketch the site and mark with flagging if necessary.

2. **Anchor Method**
   a. Check the logger for blinking sensor lights.
   b. Secure the logger to the chosen anchor and place in the stream, choosing a deep, shaded spot unlikely to be de-watered at low flows.
   c. Either secure the anchor in the substrate (rebar) or secure the anchor with chain or line to an immoveable object, such as a tree or large boulder. This object will serve as a permanent landmark for later retrieval.
   d. Ensure that the anchor is not easily seen from the shore
   e. Record the GPS coordinates, the time the logger was placed in the water, sketch the site and mark with flagging if necessary.

b. <u>Photos</u>

1. Take a minimum of four photos so that the sensor can be easily located by others in the future. They should:
   a. Show the metal tag and PVC housing or the chain and anchor.

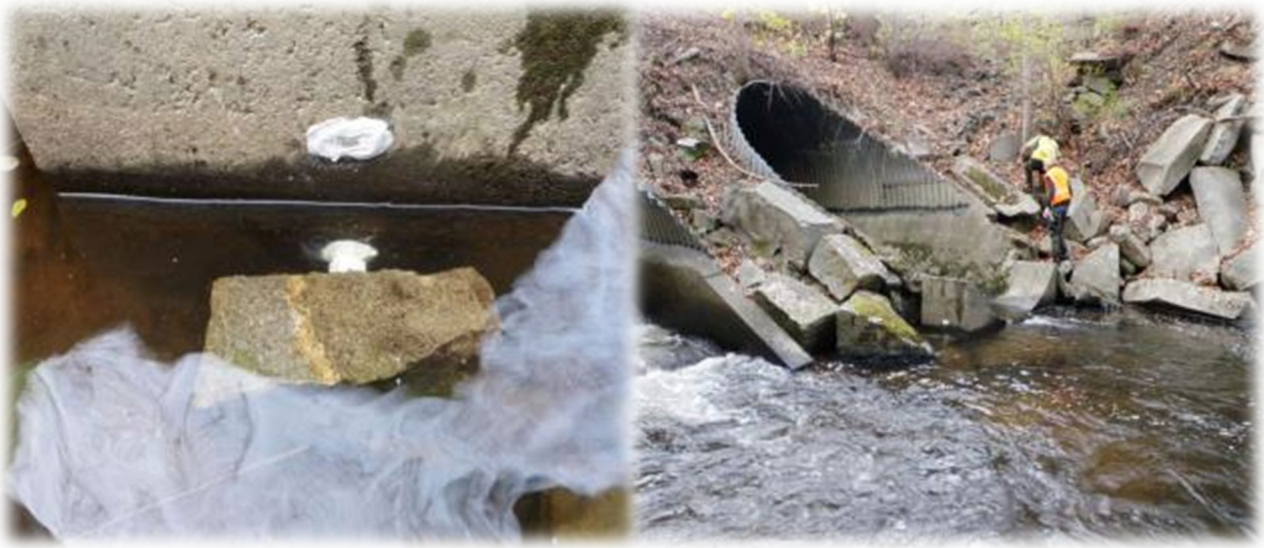

Figure 4. Photo A depicts the metal tag and PVC housing. Photo B gives a wide view of the site.

b. Provide a wide shot of the site and important landmarks.

c. Show the upstream view
d. Show the downstream view

2. Make a site sketch on the deployment form depicting upstream/downstream and river right, river left. Clearly indicate the logger location and include measurements to specific locations, such as culvert inlet, RR cedar tree, etc.
3. Record photo numbers on data sheet.

F. MIDSEASON SITE CHECK

a. Each logger should be visited at least once during the field season. If possible, data should be downloaded at this time as well, to reduce risk of loss.
b. Bring the original datasheet, a thermometer, a GPS receiver and any photos.
c. Water temperature, time, and condition of the logger and site should be recorded in the "midseason" section of the form.
d. In case of low water or other issues, move the logger to a more suitable location, and record the new coordinates, photos, etc. on the data sheet.

G. LOGGER RETRIEVAL

b. <u>If replacing the original logger:</u>
   i. Unscrew the PVC cap (if tight, or epoxied shut, use large pipe wrench or gap-jaw pliers to gently twist open; be sure to have epoxy in case canister needs to be remounted) **OR** locate the anchor and pull from the water.
   ii. Cut the zip tie and check the logger to see if the indicator lights are still blinking.
   iii. Replace with a fresh logger. Ensure the indicator lights are blinking on this one as well.
   iv. Record date/time/water temperature when logger was replaced, as well as the serial number of the new logger. *Use the original deployment data sheet.*
b. <u>If re-using the same logger:</u>
   i. Open the PVC cap, cut the zip tie and retrieve the logger **OR** pull up the anchor and retrieve the logger.
   ii. Place the logger in the coupler. Attach the coupler to the waterproof shuttle.
   Note: do not change the data shuttle batteries (AA) in the field! This will stop the shuttle's internal clock and prevent downloading of data.
   iii. Squeeze the black lever to begin the download. The amber light will begin blinking if the download is occurring properly.

1. If the download is not occurring, the red light will begin blinking.
2. Clean the logger's sensors, reinsert the logger and squeeze the lever again.

iv. Once data has been successfully downloaded and the logger has automatically been re-launched, a green indicator light will blink.

v. Ensure that the indicator lights on the logger are blinking red and redeploy.

H. DOWNLOADING DATA

a. Using the shuttle as a base station (**logger present**) or using the Optic base station

i. Open HOBOware Pro.

ii. Link the waterproof shuttle/base station to the computer with a USB cord.

iii. Place the logger in the coupler on whatever you are using as a base station.

iv. Squeeze the black lever, pressing hard enough so the lever bends.

v. The amber LED will blink, then the green LED will glow to indicate that the logger can now communicate with HOBOware Pro.

vi. In HOBOware, locate the "Readout Device" button in the upper left end of the toolbar.

vii. Click this option to offload, graph and save your data.

b. Offload data directly from the shuttle (**logger still in the field**)

i. Open HOBOware Pro. Link the shuttle to the computer with a USB cord.

ii. Go to "Device/Manage Shuttle" in the Toolbar. The dialog box will show you how many banks are occupied and whether they have already been offloaded and saved to the host computer.

iii. Offload and save data from the banks of your choice.

iv. Review the list of banks and delete any unnecessary ones. Check the battery life and update the shuttle clock.

I. REFERENCES

1. Idaho Division of Environmental Quality, 1999. Protocol for placement and retrieval of temperature data loggers in Idaho Streams. Water Quality Monitoring Protocols- Report NO.10.
2. Isaak, Daniel J.; Horan, Dona L.; and Wollrab, Sherry P. 2013. A Simple Protocol Using Underwater Epoxy to Install Annual Temperature Monitoring Sites in Rivers and Streams. Gen. Tech. Rep. RMRS-GTR-314. Fort Collins, CO: U.S. Department of Agriculture.
3. Dunham, Jason; Chandler, Gwynne; Rieman, Buce; Martin, Don. 2005. Measuring Stream Temperature with Digital Data Loggers: A User's Guide. Gen.

Tech. Rep. RMRS-GTR-150WWW. For Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 15 p.

4. Arter, Barbara S. 2004. Water Quality Monitoring Protocol Manual For Maine Atlantic Salmon Rivers. BSA Environmental Consulting.

J. ATTACHMENTS

a. Temperature Logger and Accuracy Check
b. Logger Deployment Form
c. Field Checklist

ATTACHMENT A: TEMPERATURE LOGGER AND ACCURACY CHECK

NORTHEAST FISHERIES SCIENCE CENTER
POPULATION DYNAMICS BRANCH
ATLANTIC SALMON RESEARCH AND CONSERVATION TASK

Courtesy Richard Dill, Maine Atlantic Salmon Commission, 207-941-4465

(Revision 2, September25, 2002)

Objective:

This procedure is to check the accuracy of temperature data loggers prior to their deployment in the field.

Cross-Reference Documents:

Standard Operating Procedures: G-11

Appendices: Temp Logger Check Form (A-06)

Setup:

1.Interferences: In order to check accuracy and precision data loggers must be tested in a controlled environment using a certified thermometer.

Equipment List:

- 1-2 medium sized coolers.
- 1-2 calibrated thermometers (NIST) accurate to 0.2ºC
- Temperature logger calibration forms. **(Appendix A-06)**
- Temperature loggers and watertight cases (if needed).
- Timer (clock) synchronized with data loggers (computer).
- Water.
- Ice.

Procedure:

Preparing Data Loggers

Set the delay start time of each data logger so they will all begin recording temperatures at the same time (e.g. 9:00am) and at the same interval (e.g. every 2 minutes). If working with loggers that do not have a delay start option record the time at which the logger was initially launched. Synchronize the computer and data logger clocks and the timer (watch) to be used during the actual procedure. Set up all

loggers to be tested prior to getting the ice bath ready. Begin filling out a calibration form for each individual data logger **(see Appendix A-06).**

B. Ice Bath
   1. Place water and ice into a cooler creating a thick ice slurry. The level should be high enough to completely cover the loggers. It is best if the slurry is consistent to the bottom of the cooler. Allow at least 30 minutes for the ice bath to equilibrate.
   2. Place the loggers in the ice bath at least 15 minutes before they are to begin recording temperatures to allow them to equilibrate. Be sure that the thermocouple of the data logger is not touching any surface of the cooler.
   3. Place the certified thermometer in the bath as well. It should be as close to the loggers as possible without touching any of them. Secure it so that it is not touching the bottom or sides of the cooler. A ring stand and clamp work best.
   4. At the set start time (e.g. 9:00am) begin recording time and instantaneous temperatures of the thermometer at each interval (e.g. every 2 minutes). Continue recording until the desired calibration time is completed. Record the stop time.
   5. Take the data loggers out of the ice bath and up load the temperature information. Create a spreadsheet for times vs. temperatures recorded for the thermometer and each data logger.
   6. Compare the temperatures recorded by the each data logger to the temperature of the thermometer for each time interval.
   7. Calculate and record any observed differences.
   8. If there is no difference in temperature between the data logger and instantaneous thermometer readings, or if any observed difference is less than +/- 0.7^{o}C, the data logger requires no further testing at this temperature.
   9. If the difference of the instantaneous thermometer readings vs. any data logger reading for the same time interval is greater than +/- 0.7^{o}C repeat the ice bath procedure for each out of bounds data logger.
   10. If the difference is no longer greater than +/- 0.7^{o}C, the procedure should be repeated a third time to verify the results.
   11. If the difference is again greater than +/- 0.7^{o}C do not use the logger and contact the manufacturer.

C. Room Temperature
   1. Set up a cooler in a shaded room half full of tap water at least 12 hours prior to beginning.
   2. Prepare data loggers as described above in **Procedure** (Section A. Preparing Data Loggers).
   3. Place loggers in the cooler at least 15 minutes before they are to begin recording temperatures and close lid to allow them to equilibrate.
   4. Place the certified thermometer in the bath as well. It should be as close to the loggers as possible without touching any of them. Secure it so that it is not touching the bottom or sides of the cooler. A ring stand and clamp work best.

5. At the set start time (e.g. 9:00am) begin recording time and instantaneous temperatures of the thermometer at each interval (e.g. every 2 minutes). Continue recording until the desired calibration time is completed. Record the stop time.
6. Take the data loggers out of the ice bath and up load the temperature information. Create a spreadsheet for times vs. temperatures recorded for the thermometer and each data logger.
7. Compare the temperatures recorded by the each data logger to the temperature of the thermometer for each time interval.
8. Calculate and record the any differences
9. If there is no difference in temperature between the data logger and instantaneous thermometer readings, or if any observed difference is less than +/- 0.7ºC, the data logger requires no further testing at this temperature.
10. If the difference of the instantaneous thermometer readings vs. any data logger reading for the same time interval is greater than +/- 0.7ºC repeat the room temperature bath procedure for each out of bounds data logger.
11. If the difference is no longer greater than +/- 0.7ºC, the procedure should be repeated a third time to verify the results.
12. If the difference is again greater than +/- 0.7ºC do not use the logger and contact the manufacturer.

Reference:

1. Idaho Division of Environmental Quality, 1999. Protocol for placement and retrieval of temperature data loggers in Idaho Streams. Water Quality Monitoring Protocols-Report NO. 10

ATTACHMENT B: LOGGER DEPLOYMENT FORM

		(Forestry Tag) **Site ID**	
Deployment #			
Reported by	Date	Barrier ID	
Drainage	Branch	Subreach	
Town	County	Road	
Logger ID#	UTMS		Delayed Start
Time In	Water Temp °C		Indicator Lights Blinking Y/ N

Site characteristics (percent canopy cover, stream stage or velocity, adjacent land use, location of known surface water and ground water influences, water depth at logger locale)

Reported by_____ **Organization**_____ **Site ID**_____

Permanent Landmarks/ References

Site Sketch or Photo

Photo ID	Description

Comments:

MIDSEASON SITE CHECK

Sketch:

Date _____ **Water Temp ◦C** _____

Check Instrument _____

Condition of Site/Logger:

_____
_____

ATTACHMENT C: FIELD CHECKLIST FOR DATA LOGGER DEPLOYMENT

FIELD EQUIPMENT

- ☐ Calibrated and delay-launched data loggers
- ☐ Field thermometer
- ☐ Metal forestry tags
- ☐ PVC caps and bases or housing
- ☐ Metal chain
- ☐ Anchor of choice
- ☐ Wire brush
- ☐ Rubber gloves
- ☐ 1 small (8-24 oz) jar of black epoxy
- ☐ 1 small (8-24 oz) jar of white epoxy
- ☐ Underwater viewing box
- ☐ Waders
- ☐ Datasheets
- ☐ Pencils and extra pencils!
- ☐ Pocket knife or Leatherman
- ☐ Zip ties
- ☐ Pipe wrench and/or file
- ☐ Plumber's Tape
- ☐ Wooden tongue depressors
- ☐ Trash bags and paper towels
- ☐ Camera (+ extra battery)
- ☐ AA Batteries
- ☐ GPS unit
- ☐ Waterproof shuttle (if offloading data in the field)

DID YOU REMEMBER TO…

- ☐ Record the logger sensor ID?
- ☐ Take the water temperature?
- ☐ Record the Site ID?
- ☐ Take pictures and make a sketch map?
- ☐ Be sure the shuttle has fresh batteries (if offloading data in the field)

ATTACHMENT D: FIELD EQUIPMENT AND PRICING (updated 4/2017)

EPOXY METHOD

Recommended in Protocol:

- **Fox Industries FX-764 Splash Zone Epoxy**

  This is a specialty item not readily available at all hardware stores – call Fox Industries at 1-800-999-5099 to find a distributor near you. A.H. Harris & Sons in Portland, ME has sold this in the past. Sherwin-Williams or HD Supply stores near you may be able to order it.

  In 2015, it cost $160 for a 2-gallon kit (black and white epoxy paste) from A.H. Harris & Sons.

  Visit http://www.foxind.com or call 1-800-999-5099 for more product/ordering information.

- **PVC Housing/Bushing**

  Use schedule 40 PVC, 1 ½" threaded female cap and 1 ½ x ¾" threaded bushing with a wide lip. (The lip is especially important because epoxy will not adhere directly to PVC.)

  Product descriptions from E.J. Prescott in Portland, ME:
  Cap: 1 ½" SCH 40 CAP FEIP ($.89 ea)
  Base: 1 ½ X ¾" SCH 40 RED TXT ($1.59 ea)

  For more information or to place an order, call E.J. Prescott at (207) 797-3330.

ANCHOR METHOD

- **Aluminum chain link**
- **Cables**
- **Bushings**
- **Metal grating**

Prices of cables and chains will vary. Most products are widely available at local hardware stores.

TIDBIT LOGGERS

HOBO TidbiT v2 Water Temperature Data Logger, $133 ea

Order online from www.onset.com, or use the following link:

http://www.onsetcomp.com/products/data-loggers/utbi-001?gclid=CIPby5mavdMCFVNMDQodiPsCXA