

STANDARD OPERATING PROCEDURE FOR miniDOT DISSOLVED OXYGEN LOGGER



WATER QUALITY

State of Utah
Department of Environmental Quality
Division of Water Quality

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Foreword

Utah Division of Water Quality (DWQ) Standard Operating Procedures (SOPs) are adapted from published methods or developed by in-house technical experts. This document is intended primarily for internal DWQ use. This SOP should not replace any official published methods.

Any reference within this document to specific equipment, manufacturers, or supplies is only for descriptive purposes and does not constitute an endorsement of a product or service by DWQ. Additionally, any distribution of this SOP does not constitute an endorsement of a procedure or method.

Although DWQ will follow this SOP in most instances, there may be instances in which DWQ will use an alternative methodology, procedure, or process.

The methodology detailed below is the protocol followed by DWQ's monitoring staff and verified by DWQ's Quality Assurance officer.

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REVISION PAGE

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| 05/25/2015 | 0 | Initial document | | |
| 5/6/21 | 1.0 | Update language grammar and structure | All | Simplify protocol in line with field SOP requirements |
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Table of Contents

| | | |
|------|---|----|
| 1.0 | Scope and applicability | 5 |
| 2.0 | Summary of Method | 5 |
| 3.0 | Definitions..... | 5 |
| 4.0 | Health and Safety Warnings | 6 |
| 5.0 | Cautions | 6 |
| 6.0 | Interferences..... | 7 |
| 7.0 | Personnel Qualifications/Responsibilities | 7 |
| 8.0 | Equipment and Supplies | 7 |
| 9.0 | Procedure | 8 |
| 10.0 | Data and Records Management | 12 |
| 11.0 | Quality Assurance and Quality Control..... | 12 |
| 12.0 | References..... | 12 |
| 13.0 | Figures..... | 13 |
| 14.0 | Appendices..... | 17 |

1.0 SCOPE AND APPLICABILITY

This document presents the Utah Division of Water Quality's (DWQ) Standard Operating Procedure (SOP) for the collection of data using a miniDOT® dissolved oxygen meter. A miniDOT® is a high-frequency sensor used to measure dissolved oxygen (DO) and temperature in lotic and lentic waters. Dissolved oxygen refers to the level of free, non-compound oxygen present in water or other liquids. Low levels of dissolved oxygen in rivers and lakes limits the organism's ability to survive, making it an important parameter in assessing the health of Utah's waters. This SOP applies to all DWQ field staff, DWQ cooperators, and volunteer monitors trained on this SOP.

This SOP is adapted from the PME miniDOT® Logger User's Manual, refer to the manual for additional details and troubleshooting.

2.0 SUMMARY OF METHOD

miniDOT Loggers are factory calibrated and ready to install on arrival. It is set to measure and record time, battery voltage, temperature, oxygen concentration, and measurement quality once every 15 minutes and write 1 file of measurements daily. To launch, open the miniDOT Logger and switch the Recording Control Switch to the RECORD position. Once set, the miniDOT logger will record measurements for a year before the internal battery is expended. Re-close the miniDOT Logger prior to deploying it.

At the end of the deployment period, open the logger and connect it to a laptop via USB. The miniDOT logger will appear as a local drive. Download a text file from the logger containing the temperature and oxygen concentration measurements, a timestamp indicating the time the measurement was made, and serial number of the miniDOT logger. Save the files on a folder in the laptop.

Verification checks are necessary to validate that the logger is able to correctly measure the specific criteria. To do this a field crew will use an existing sonde to verify/validate the miniDOT's dissolved oxygen (DO) measurements by taking a measurement prior to cleaning and just after. This will be done for both pre- and post-deployment(s).

3.0 DEFINITIONS

| | |
|------------------------------|---|
| miniDOT: | high frequency sensor to measure dissolved oxygen |
| multiparameter sonde: | A multiparameter water measuring device. It measures a suite of parameters including temperature, dissolved Oxygen, pH, conductivity, etc. Different projects may use different parameters. |

Sampling and Analysis Plan (SAP): This document details the guidelines and data quality parameters specific for any project.

4.0 HEALTH AND SAFETY WARNINGS

Field personnel should be aware that hazardous conditions potentially exist at every waterbody. If unfavorable conditions are present at the time of sample collection, it is recommended that the sample collection be rescheduled. If hazardous conditions arise during sampling, such as lightning, high winds, rising water, or flash flood warning, personnel should cease sampling and move to a safe location.

Take appropriate precautions when operating equipment and working on, in, or around water, as well as possibly steep and unconsolidated banks, bridges, or edges of ponds/lagoons. All field crews should follow DWQ health and safety procedures and be equipped with safety equipment such as proper wading gear, personal flotation devices (PFDs), gloves, first aid kits, cellular phone, etc.

Wear gloves or be sure to wash hands after sampling, especially when sampling wastewater discharges or ponds, lagoons, or other potentially contaminated sampling points at regulated facilities.

When working in Utah and other warm climates, precautionary steps should be taken to avoid heat induced illnesses such as heat stroke or heat exhaustion.

Use caution when working in waders as drowning hazards exist.

Bursting Hazard: Should water enter the miniDOT Logger and come into contact with the enclosed batteries, the batteries may generate gas causing the internal pressure to increase. This gas will likely exit via the same location where the water entered, but not necessarily. The miniDOT Logger is designed to release internal pressure as the end cap is unscrewed, prior to the disengagement of the end cap threads. If internal pressure is suspected, treat the miniDOT Logger with extreme caution.

5.0 CAUTIONS

DO NOT remove the stainless-steel screws in the black end cap. There are no user serviceable parts here. If the screws are removed, then you will damage the miniDOT Logger and it will have to be returned for repair.

Use caution when opening and closing the miniDOT. Lube o-ring occasionally with grease and inspect for debris. Avoid touching the circuit card. Do not overtighten as the miniDOT will get tighter during deployment.

When storing, remove the batteries and be sure the end is covered with the cap or aluminum foil to keep ambient light from reaching the sensing foil.

PME recommends Energizer L91 AA size lithium batteries or Duracell AA size alkaline batteries.

Use caution installing and replacing the batteries. Improper installation of the batteries, such as backwards installation, can do irrevocable damage to the device.

When cleaning, do not use acetone, chloroform, or toluene to clean the device as they will damage the foil.

6.0 INTERFERENCES

For best performance, be sure the sensor is cleaned at regular intervals, dependent on the fouling condition of the waterbody.

Ensure proper installation of miniDOT in the waterbody to collect representative DO data.

7.0 PERSONNEL QUALIFICATIONS/RESPONSIBILITIES

DWQ personnel performing water sampling must be familiar with sampling techniques, safety procedures, proper handling, and record keeping. Samplers are responsible for attending refresher meetings held each spring/summer to review procedures and techniques. New staff will be trained in the field by DWQ trained personnel.

Cooperators are required to read this SOP annually and acknowledge they have done so via a signature page that will be kept on-file at DWQ along with the official hard copy of this SOP (see **Appendix 1**).

The procedures discussed in this SOP can change over time as a result of the technological changes being implemented; such information generally is available from the manufacturer, either online or in an updated user manual or other technical guidance document. Monitors operating miniDOTs must stay current as to how their instrument operates and is maintained.

8.0 EQUIPMENT AND SUPPLIES

- Copy of this SOP
- PME miniDOT Manual
- miniDOT loggers
- Extra AA lithium or alkaline batteries
- USB connector
- Multiparameter / dissolved oxygen sonde for verification
- Computer to download data
- USB Distribution Software
- Tools for deployment

- ❑ Cable, rebar, deployment capsule (see **Figure 1**).

9.0 PROCEDURE

9.1 Operational Information

Closing and Opening the miniDOT

Close and open miniDOT like you would a flashlight: open by unscrewing the white cylinder from the black end cap. Close by screwing the white cylinder on, making sure the O-ring is clear of debris. When closings, crew the white cylinder on until it makes contact with the black end cap, being careful not to overtighten. Occasionally lube the o-ring with grease before closing to ensure a good waterproof seal.

Removal of the cover reveals the logger connections and controls, shown in **Figure 2**.

The Logger Control Switch controls the logger mode. You may switch the Recording Control Switch at any time.

Switched to Record, logger is recording measurements. (Except when connected to the USB, the logger switches by default to Halt.

Switched to Halt logger is not recording and is sleeping at low power.

The miniDOT Logger uses red and green lights to indicate operation mode. The table below presents LED indications:

| LED | Reason |
|---------------------------|--|
| 1 Green Flash | Normal. Presented immediately after new batteries are installed. Indicates that the CPU has started its program. |
| 1 Green Flash | Occurs at the time of sampling for sample intervals of 1 minute or less. |
| 5 Green Flashes | Normal. Indicates that miniDOT is beginning to record measurements. This indication appears in response to switching the Recording Control Switch to <i>Record</i> . |
| 5 Red Flashes | Normal. Indicates the miniDOT is ending recording of measurements. This indication appears in response to switching the Recording Control Switch to <i>Halt</i> . |
| Continuously Green | Normal. Indicates the miniDOT is connected to a host device via USB. |
| Continuously Flashing Red | SD card write error. Try removing/reinstalling batteries. Contact PME. |

Table 1. LED indications on the miniDOT

USB Connection: Allows communication between the logger and an external host computer. When connected, the logger is in halt mode regardless of the Logger Control Switch position.

Your miniDOT Logger will return to recording measurements after you disconnect the USB connection.

Note: On occasion some computers don't read the miniDOT as a thumb drive. If this is the case an alternative way to retrieve the data is to go here: <https://www.pme.com/products/minidot> and download the "USB Distribution Software". Once loaded on your computer use it to connect and download the data.

Battery Life

The miniDOT Logger consumes battery power mostly from the measurement of dissolved oxygen, but also from additional activities such as keeping track of time and writing files.

Alkaline batteries, especially at low temperatures, will have a shorter life than lithium batteries and will give somewhat less performance than lithium, especially at low temperatures. For short deployments of a month or two, alkaline batteries will provide adequate performance. For longer deployments, or for deployments in cold environments, lithium batteries are recommended. Figure 3 provides a general guide to battery life with regards to sample interval and battery life.

| Sample Interval (Minutes) | Main AA Battery life (Months) | Number of Samples |
|---------------------------|-------------------------------|-------------------|
| 1 | 12 | 500K |
| 10 | >12 | >52,000 |
| 60 | >12 | >8,000 |

Table 2. Battery life and sample interval

The miniDOT Logger uses a coin cell for backup of the clock when the power is switched off and should last for several years. If a replacement coin cell battery is necessary, contact PME.

9.2 Instrument Calibration and Verification

Verification of DO measurement

Verify the calibration of your miniDOT. Do this by placing the miniDOT in a black 5-gallon bucket containing 4 gallons of fresh water (See **Figure 3**). The picture in Figure 3 shows a white bucket so that miniDOT's are more easily seen. The miniDOT sensor end (black) is heavy and the miniDOT will tend to flip so that this end is down. Prevent this somehow. miniDOT must be placed in the bucket with the sensor end upwards. Otherwise bubbles will accumulate in the sensing end and miniDOT will not sense water DO correctly. Use an aquarium pump and air stone in the water to provide a bubble stream. Cover the bucket with a black lid to prevent light from enabling algal growth.

Record measurements for at least several hours up to a day to allow enough time for the miniDOT temperature to come to equilibrium with the water. During the experiment find the local air pressure, either from measurements or from a local weather station.

Use a calibrated multiparameter sonde and record the DO values for analysis of sensor drift. These measurements can be used during analysis to correct errant data. During this verification process, determine the absolute barometric pressure at your elevation.

Use miniDOTPlot to examine the measurements. Saturation values should be very close to 100%, depending upon the accuracy of the barometric pressure

Recalibration: The miniDOT Logger is factory calibrated. Loggers should be returned to PME for recalibration. PME suggests that this be done every ½ million samples. THEREFORE FIELD CREWS WILL FOLLOW FIELD VERIFICATION PROTOCOL BELOW.

9.3 Field verification and deployment procedure

In order to identify drift as the result of bio-fouling as well as a logger that may be compromised resulting in errant data, perform a verification for every pre and post deployment.

Deployment:

Make sure the optical field, sensor face, of the logger is clean.

1. Connect the logger to a field computer via a USB-2.0 cord and create a folder using the MLID as the title. The logger can be found under “Computer” then under a local disk as “DO_serial number of logger”.
2. Open “miniDOTControl” to connect to the logger. Make sure the “Set sample interval” is set to 15 minutes. See **Figure 4**.
3. Start the logger by flipping the switch to “record” and note the time and date, logger name, location (use GPS) in a field notebook or on a deployment sheet.
4. Using the logger deployment device, install a logger in the relevant section of flowing water and attach the device to rebar on the bank (see picture and diagram in **Figure 5**).
5. Deploy the DO logger using the deployment device and make sure it’s affixed to the rebar on the bank.
6. Using a calibrated multiparameter sonde (see DWQ SOP for Multiparameter Sonde Calibration and Use) record the instantaneous DO and salinity also noting time and date. Additionally, record the elevation. This is imperative for post-deployment correction via miniDOTConcatenate and miniDOTPlot programs.

The miniDOT is now deployed and recording continuous DO data

Post-deployment:

1. Using a calibrated multiparameter sonde, measure the instantaneous DO and salinity and record observations in a field notebook or deployment sheet.

2. Retrieve device from location. Be sure to dry off the logger prior to opening the vessel and motherboard.
3. Attach the logger to a computer and navigate to miniDOTPlot.jar and open the program.
4. Once open, enter the surface elevation (meters) of the site via the GPS in meters and salinity (ppt-parts per thousand). To compute salinity one can use the handheld sonde. Enter both of these into miniDOTPlot, see **Figure 6**.
5. Rename the folder using this type of file structure: DO_device serial #_date (post-deployment) MLID.
6. Copy and paste that folder to the folder on the computer.
7. Open the folder in the logger and download the CAT.txt file for the site. Review file for correctness.
8. Make sure all data has been copied to the computer and no data remains on the logger. Effectively wiping the logger clean of older data. DO NOT ERASE THE MANUAL.PDF OR ANY OF THE FILES THAT CONTAIN *.JAR AS THESE FILES RUN THE LOGGER.
9. Turn off the logger by depressing the switch to “Halt”.

Storing Device:

Remove the batteries. Keep the black end covered with the cap supplied by PME. If the cap is lost, cover the end with aluminum foil. There may be a calibration effect of ambient lighting so attempt to keep ambient light from reaching the sensing foil as much as possible.

Battery Replacement:

1. Move the Logger Control Switch to the Halt position.
2. Remove the depleted batteries noting the position of the (+) terminal.
3. Install fresh (new, fully charged batteries of the same type) with the (+) position the same as the removed battery. The (+) position is also marked on the inside of the battery holder.
4. The miniDOT Logger LED Light should flash to indicate that the software is beginning operation within a second or two after you complete the battery installation. At this time the logger will enter the mode selected by the Logger Control Switch (which should initially be Halt from Step 1).

Sensor cleaning

Clean the sensor at regular intervals depending on the *fouling* condition (i.e., How nutrient-rich and therefore how much potential for bioaccumulation on the sensor window) at the site. The cleaning procedure of the sensor spots should be done with caution so that the protective coating is not removed. If the fouling is calcareous it can normally be dissolved with household vinegar. If the marine growth remains, then use Q-tips to gently wipe it off after it has been softened by soaking in vinegar or CLR (lime remover).

After cleaning the sensor, it should be rinsed well in clean tap water before storing or reuse. The sensor membrane can also be cleaned by rinsing it with ethanol. The plastic case of the miniDOT

Logger can be gently scrubbed. Do not use other organic solvents such as acetone, chloroform, or toluene since these and others will damage the foil.

10.0 DATA AND RECORDS MANAGEMENT

Project-specific data and records management requirements can be found in the SAP. Data from the miniDOT should be saved in the appropriate Monitor folder in the DWQ drive along with scanned copies of field notes.

11.0 QUALITY ASSURANCE AND QUALITY CONTROL

miniDOTs must be verified before use and verification (and reverification) must be documented as described in this SOP and other project-specific documentation.

Quality assurance and quality control requirements for normal operation are described in project-specific Sampling and Analysis Plans (SAPs) and must be communicated to the field team by the Project Manager.

Representative water-quality data is to be collected, according to the sampling conditions required under the project-specific SAP. miniDOT operators should not alter designated sampling locations or times unless otherwise directed by a project manager. If hydrologic conditions are significantly different from those targeted in the SAP, operators should contact the project manager for further instructions. Operators should record in field notes any site conditions that may lead to an unrepresentative field reading and should take site photographs to record these observations.

12.0 REFERENCES

Precision Measurement Engineering 2020, miniDOT-User Manual., www.PME.com Pgs. 1-22.

Related DWQ SOPs:

DWQ SOP for Calibration, Maintenance, and Use of Multiparameter Water Quality Sondes

13.0 FIGURES



Figure 1. miniDOT Logger



Figure 2. Internal miniDOT connections and controls.



Figure 3. miniDOT verification procedure.

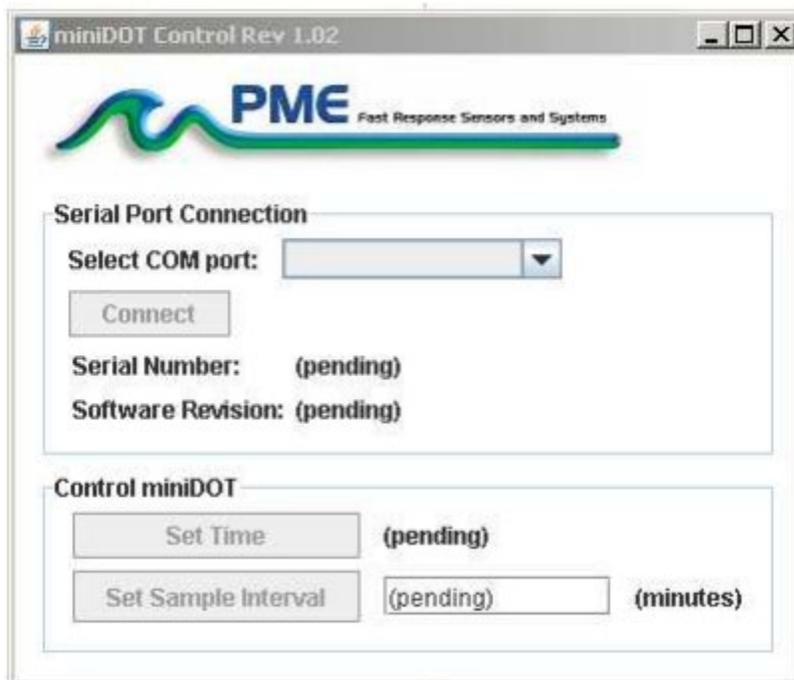


Figure 4: miniDOT Control.

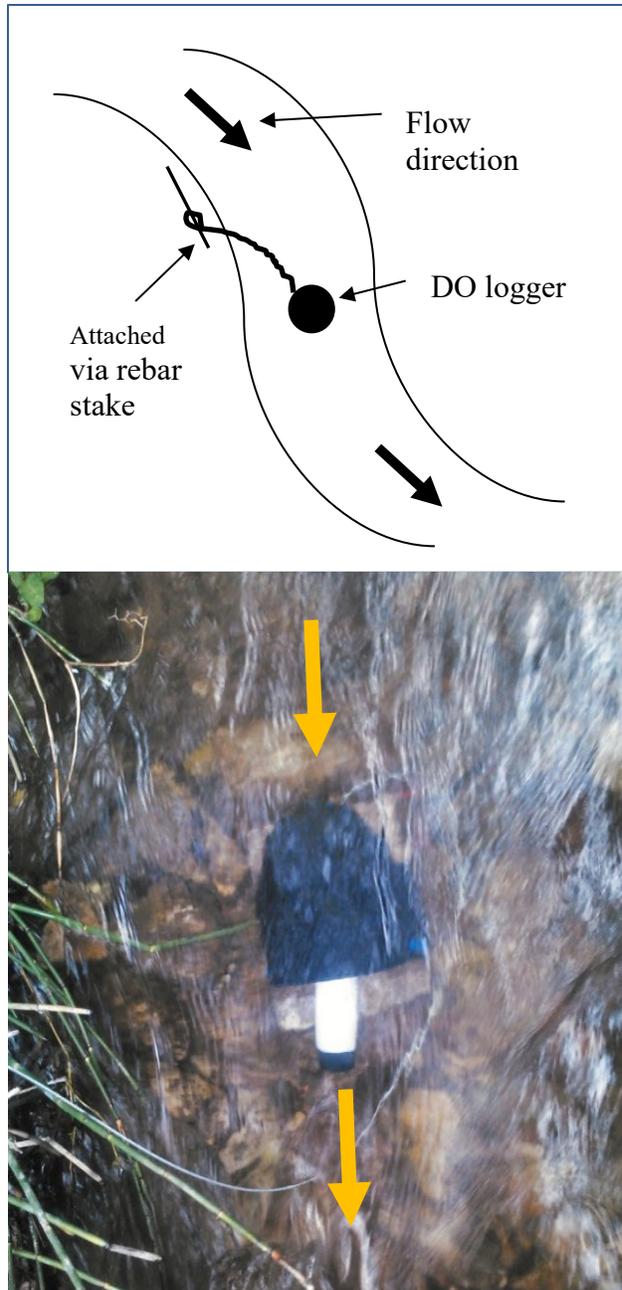


Figure 5. Deployment diagram and example stream deployment.

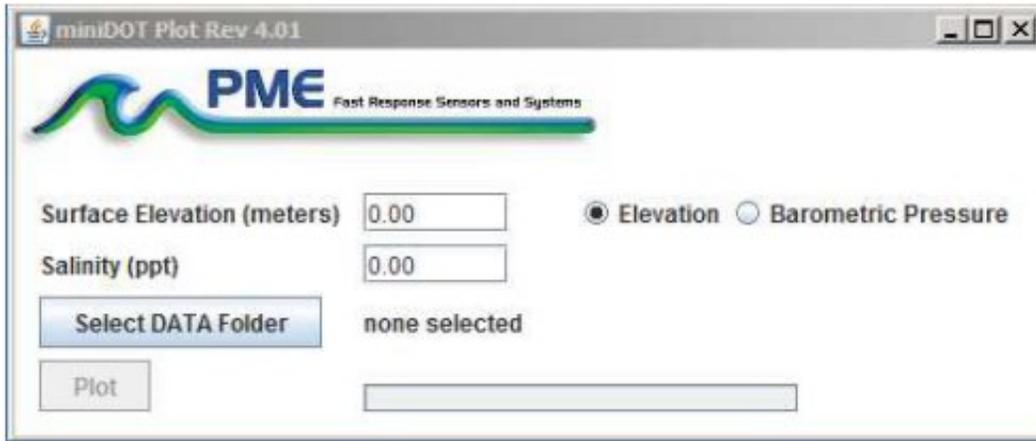


Figure 6. miniDOT Plot

APPENDIX 2: Additional Software and Data Review Information

Refer to MiniDOT manual for more details.

The miniDOT arrives with these four files:

- MiniDOTControl.jar allows you to see the state of the logger as well as set the recording interval.
- MiniDOTPlot.jar allows you to see plots of the recorded measurements.
- MiniDOTConcatenate.jar gathers all the daily files into one CAT.txt file.
- Manual.pdf this manual.

These files are located in the root directory of the miniDOT. PME suggests you leave these programs where they are on the miniDOT, but you may copy them to any folder on your computer's hard drive.

MiniDOTControl, miniDOTPlot, and miniDOTConcatenate are Java language programs that require the host computer to have the Java Runtime Engine V1.7 (JRE) or later installed. This engine is commonly required for internet applications and will likely already be installed on the host computer. You can test this by running miniDOTPlot. If this program displays its graphical user interface then the JRE is installed. If not then the JRE can be downloaded via internet from http://www.java.com/en/download/windows_xpi.jsp

At this time miniDOT Logger is supported on Windows operating systems, but may also operate on Macintosh and perhaps Linux.

miniDOTControl

Begin program operation by clicking on miniDOTControl.jar. Software presents the screen shown below:



The miniDOT must be connected to USB at this time. When correctly connected the miniDOT LED will display a constant green light. Click the Connect button - The software will contact the logger. If the connection is successful the button will turn green and display “Connected”. The Serial Number and other parameters will be filled in from information taken from the miniDOT.

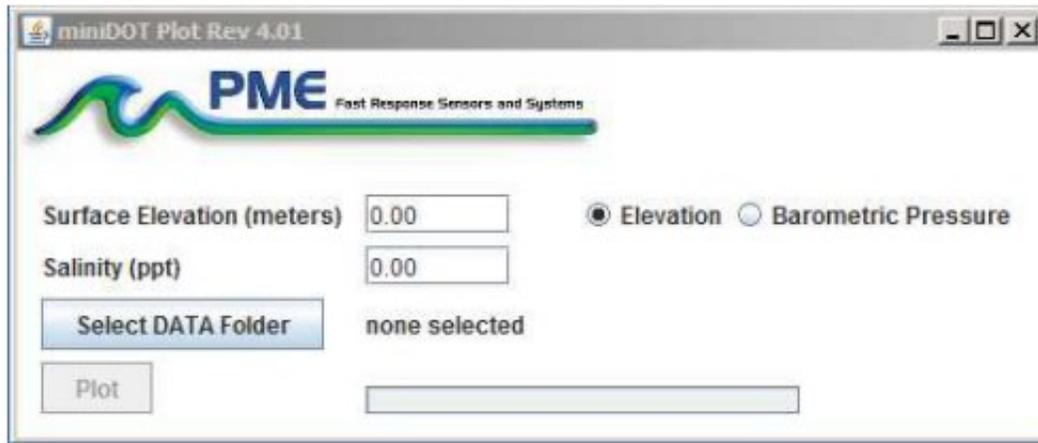
If the host computer is connected to the internet, the current difference between an internet time server’s time and the miniDOT Logger internal clock will be displayed. And, if more than a week has passed since time was last set, the miniDOT clock will be set and a check mark icon will appear. If the host computer is not connected to the internet no time services will occur.

The current miniDOT Logger sample interval will be displayed next to the Set Sample Interval button. If this interval is acceptable the interval need not be set. To set the interval, enter an interval not less than 1 minute and not greater than 60 minutes. Click the Set Sample Interval button. Shorter and faster intervals are available. Contact PME.

End miniDOTControl by closing the window. Unplug miniDOT USB connection. Upon disconnection of the USB cable the miniDOT will begin logging or remain halted as indicated by the position of the Logger Control Switch.

miniDOTPlot

Begin program operation by clicking on miniDOTPlot.jar. Software presents the screen shown below.



miniDOTPlot plots the files recorded by the miniDOT Logger. The software reads all miniDOT files in a folder, except the CAT.txt file. The software will also compute oxygen saturation from dissolved oxygen measurements. To do this software must know the air pressure and salinity. It calculates air pressure based on elevation of the water surface above sea level or uses the barometric pressure you enter if Barometric Pressure is selected. If Elevation is entered, no compensation for weather-induced barometric pressure variation is made. Enter elevation or barometric pressure. Enter water salinity.

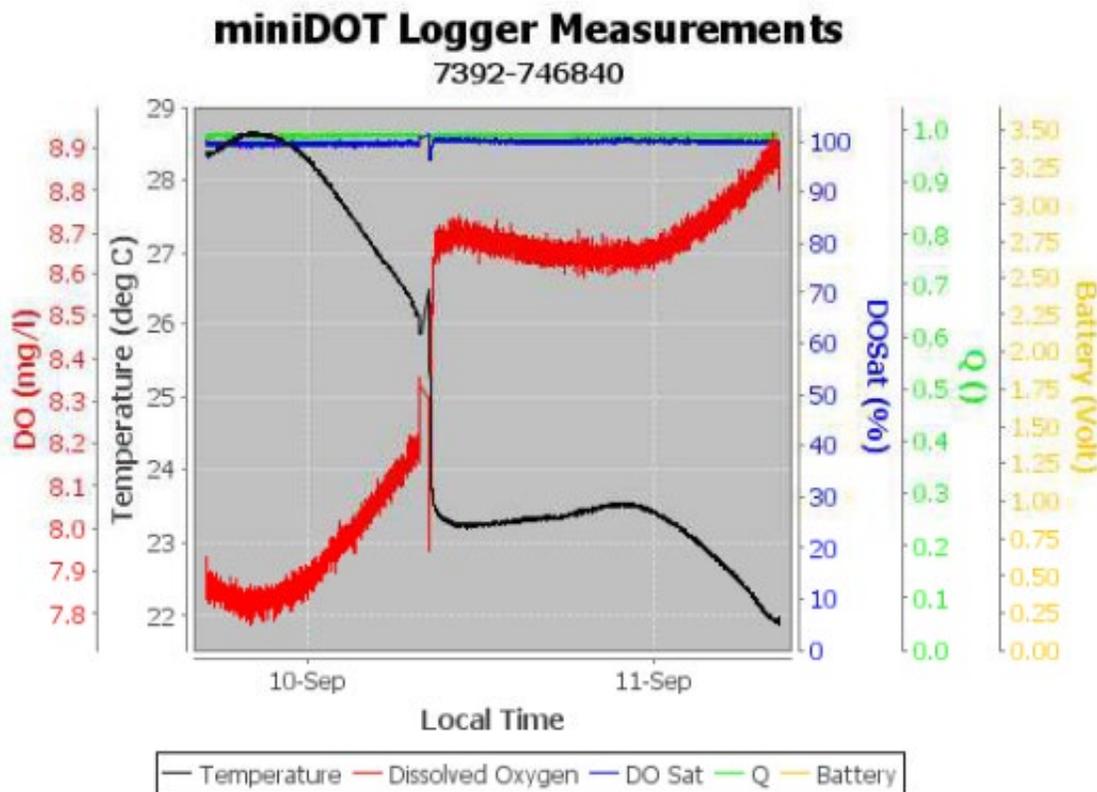
Select the folder that contains the files recorded by miniDOT. If miniDOTPlot is run directly from the miniDOT the program will suggest the folder located on the miniDOT SD card. You

may accept this by clicking on Process, or you may click on Select Data Folder to browse to your computer's hard drive. If the number of measurements recorded is small, say a few thousand, these can conveniently be plotted directly from miniDOT storage. However, it is best to copy large measurement sets to the host computer and select them there since file access to miniDOT is slow.

miniDOT measurement folders must NOT contain any files besides those miniDOT records and the CAT.txt file.

Press Plot to begin plotting. The software reads all miniDOT Logger data files in the selected folder.

It concatenates these and presents the plot shown below:



You may zoom this plot by drawing a square from upper left to lower right (click and hold left mouse button) that defines the zoom region. To zoom completely out, attempt to draw a square from lower right to upper left. Right click on the plot for options such as copy and print. The plot can be scrolled with the mouse while the Control key is held depressed. Copies of the plot can be obtained by right clicking on the plot and selecting Copy from the pop-up menu.

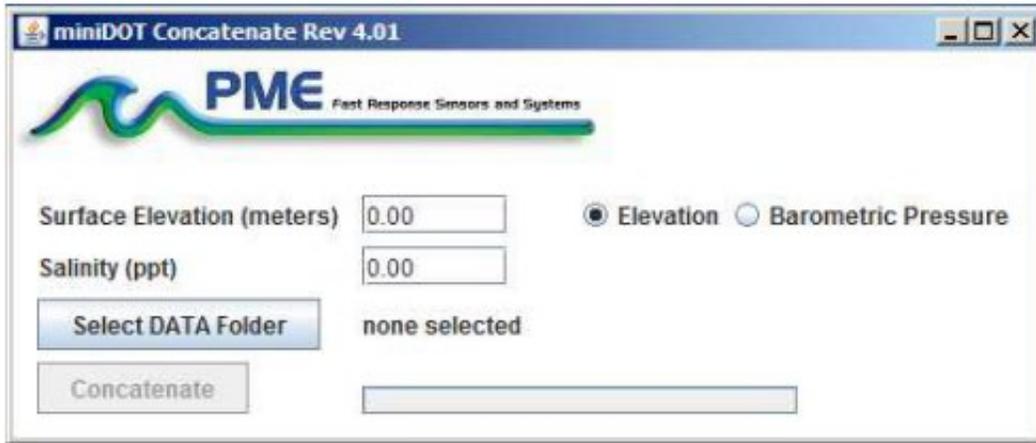
Different DATA Folders can be selected during one session of the program. In this case the software produces multiple plots. Unfortunately, the plots are presented exactly on top of each other and so when a new plot appears it is not obvious that the old plot is still there. It is. Just move the new plot to see it. The software can be re-run at any time. If an already processed

DATA Folder is selected the software simply reads the miniDOT Logger measurement files again. End miniDOTPlot by closing the window.

Special note: plotting of sample sets of more than 200K samples may consume all memory available to the JRE. miniDOTPlot will present a partial plot and freeze in this case. A simple solution is to separate the files into multiple folders and plot each folder individually. A special miniDOTPlot that sub-samples can be provided by PME. Please contact PME in this case.

miniDOTConcatenate

Begin program operation by clicking on miniDOTConcatenate.jar. Software presents the screen shown below.



miniDOTConcatenate reads and concatenates the files recorded by the miniDOTLogger. Software produces CAT.txt in the same folder as selected for the data. CAT.txt contains all the original measurements and contains two additional statements of time and oxygen saturation. To compute saturation, software must know the air pressure and salinity. It calculates air pressure based on elevation of the water surface above sea level or uses the barometric pressure you enter if Barometric Pressure is selected. If Elevation is entered, no compensation for weather-induced barometric pressure variation is made. Enter elevation or barometric pressure. Enter water salinity.

Select the folder that contains the files recorded by miniDOT. If miniDOTPlot is run directly from the miniDOT the program will suggest the folder located on the miniDOT. You may accept this by clicking on Process, or you may click on Select Data Folder to browse to your computer's hard drive. If the number of measurements recorded is small, say a few thousand, these can conveniently be plotted directly from miniDOT storage. However, it is best to copy large measurement sets to the host computer and select them there since file access to miniDOT is slow. miniDOT measurement folders must NOT contain any files besides those miniDOT records and the CAT.txt file.

Press Concatenate to begin concatenating files and create the CAT.txt file. The CAT.txt file will resemble the following:

```

1 MiniDOT Logger Concatenated Data File
2 Sensor: 7392-0002
3 Concatenation Date: 2014Jun30 10:20:40 PDT
4
5 DO concentration compensated for salinity: 0.0 (ppt)
6 Saturation computed at elevation: 0.0 (meter)
7
8 Unix Timestamp, UTC_Date_&_Time, Pacific Standard Time, Battery,
9 (Second), (none), (none), (Volt),
10 1402942957, 2014-06-16 18:22:37, 2014-06-16 11:22:37, 3.310000,
11 1402942959, 2014-06-16 18:22:39, 2014-06-16 11:22:39, 3.320000,
12 1402942961, 2014-06-16 18:22:41, 2014-06-16 11:22:41, 3.320000,
13 1402942963, 2014-06-16 18:22:43, 2014-06-16 11:22:43, 3.320000,

```