Washington State Department of Ecology

Environmental Assessment Program

Standard Operating Procedures for Marine Waters Sensor Performance Assessment – Field Procedures

Version 1.1

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Any reference to specific equipment, manufacturer, or supplies is for descriptive purposes only and does not constitute an endorsement of a particular product or service by the author or by the Department of Ecology.

Although Ecology follows the SOP in most instances, there may be instances in which Ecology uses an alternative methodology, procedure, or process.

SOP Revision History

Revision Date	Rev number	Summary of changes	Sections	Reviser(s)
10/25/2013	1.0	SOP development	All	S. Pool, D. Mora, J. Bos
05/27/2016	1.1	Minor edits, updated links to Safety Data Sheets and manufacturer manuals	All	S. Pool

1.0 Purpose and Scope

1.1 This document is the Environmental Assessment Program (EAP) Standard Operating Procedures (SOP) for conducting sensor performance tests in the field. In particular, this SOP focuses on assessments of dissolved oxygen sensors before deployment to confirm sensor functionality and at the end of their moored deployments to determine amount of electrical drift and effects of biofouling. These tests also assure satisfactory operation of other sensors attached to a dissolved oxygen sensor. The sensors are typically deployed for 4 to 16 weeks, depending on the location and its access.

1.2 We conduct field performance tests of moored sensors to determine the following:

- An "end point" status to compare with "start point" status.
- Verification of sensor performance after transport from the laboratory to its sampling location.
- Whether each sensor is performing as expected.
- Whether physical or biological fouling effects have occurred during deployments.
- Factors for adjusting dissolved oxygen data to account for changes in precision, stability, and electrical drift.

1.3 The SOP is based on experience and manufacturer recommendations for adjusting data collected by moored dissolved oxygen sensors. These recommendations include collecting and titrating dissolved oxygen Winkler samples to determine dissolved oxygen concentrations and comparing to a well characterized, pristine sensor. Data adjustment procedures are not covered in this SOP.

1.4 The SOP also covers comparing two dissolved oxygen sensors, one that is recently retrieved from a mooring and one that is to be deployed on the mooring. Before deployment, the latter sensor should have a performance test in the laboratory to verify appropriate functionality and to meet data expectations. This sensor-to-sensor comparison will verify that the deploying sensor remained intact during transport into the field.

1.5 While the specific purpose of this SOP is to quantify dissolved oxygen sensor performance, we also use this SOP as a guide for qualitative assessment of temperature, conductivity, and pressure variables that are used without a dissolved oxygen sensor or in conjunction with dissolved oxygen sensor voltages which calculate dissolved oxygen concentrations.

2.0 Applicability

2.1 This SOP should be conducted on all dissolved oxygen sensors to be deployed and those retrieved from mooring stations established and maintained by the Marine Monitoring Unit. In addition, it should be conducted twice a year on sensors with a conductivity variable but without the dissolved oxygen variable.

3.0 Definitions

3.1 Anti-foulants: Plastic cylinders impregnated with bis(tributylin) oxide installed on oceanographic sensors. Their purpose is to reduce biofouling of sensors during deployments.

3.2 Conductivity-Temperature-Depth (CTD): A set of sensors that is combined into a submersible instrument package used for collecting continuous data of conductivity, temperature, and depth in the water. Depending on manufacturer and model, the CTD can be equipped with auxiliary sensors to measure additional variables and a pump to draw water through the sensors. The CTD and auxiliary sensors are operated and maintained according to manufacturer's recommended protocols, with factory calibration occurring annually. It is commonly used in both marine and freshwater applications.

3.3 Dissolved Oxygen (DO): The amount of gaseous oxygen (O_2) dissolved in water. Oxygen gets into water by diffusion from the surrounding air, by aeration (rapid movement), and as a product of photosynthesis. Dissolved oxygen levels are used as an indicator of water quality.

3.4 End Point: When a moored instrument package is retrieved from the water, this is considered the end of a deployment and thus, called the "end point" to identify the end of each deployment period for sensor exchanges, sensor performance tests, and data adjustments.

3.5 Field Bath: An apparatus which was built to conduct sensor performance in the field. A 12-inch diameter by 39-inch long PVC pipe is capped at the bottom and provides sufficient space for up to three CTDs. It has a valve near the bottom for drawing water samples. It also has a lid fitted with holes to allow passage of instrument communication cables and to stabilize the interior bath environment. The apparatus is rigged to a dolly for ease of transport to mooring stations.

3.6 Safety Data Sheet: Safety Data Sheets provide both field staff and emergency personnel with proper procedures for handling or working with a particular substance. Safety Data Sheets include information such as physical data (e.g., melting pint, boiling point, flash point, etc.), toxicity, health effects, first aid, reactivity, storage, disposal, protective equipment, and spill/leak procedures.

3.7 Sea-Bird Electronics, Inc. (SBE) 16*plus*: Manufacturer and model of CTD sensor currently used in moored deployments for monitoring marine water quality.

3.8 SBE 37-SM: Manufacturer and model of CTD sensor with firmware 2.6b currently used in moored deployments for monitoring marine water quality.

3.9 SBE 37-SMP: Manufacturer and model of CTD sensor with firmware 2.6a currently used in moored deployments for monitoring marine water quality.

3.10 SBE 37-SMP-ODO: Manufacturer and model of CTD sensor with integrated optical DO sensor for monitoring marine water quality.

3.11 SBE 43: Manufacturer and model of DO sensor currently used in moored deployments for monitoring marine water quality.

3.12 SBE 63: Manufacturer and model of optical DO sensor that is integrated into a SBE 37-SMP-ODO.

3.13 Start Point: When a moored instrument package is deployed into the water, this is considered the start of a deployment and thus, called the "start point" to identify the beginning of each deployment period for sensor exchanges, sensor performance tests, and data adjustments.

3.14 Winkler Samples: Water samples collected and analyzed for DO concentrations. The Winkler samples are analyzed in the laboratory using chemical titration techniques to determine the amount of dissolved oxygen in a water sample. Data from these samples are used to confirm the validity of DO sensor performance and the field bath assessment.

4.0 Personnel Qualifications/Responsibilities

4.1 Experience with oceanographic sensors.

4.2 Familiarity with marine water conditions and data.

4.3 Experience with seawater sampling, particularly dissolved oxygen samples.

4.4 Field Lead who is responsible that this SOP is current and being followed by the mooring project team. This staff member is also trained in the use of Sea-Bird Electronics, Inc. equipment (oceanographic sensors) and software, particularly the most current SBE SeaTerm and SBE SeaTermV2 programs.

4.5 Field Technician who is responsible for following this SOP and ensuring that field staff are properly instructed on conducting a sensor performance assessment. This staff member is also trained in the use of Sea-Bird Electronics equipment, Inc. and software, particularly SBE SeaTerm and SBE SeaTermV2 programs.

4.6 At least one staff is required for conducting a sensor performance assessment in the field. Two field staff is preferred.

5.0 Equipment, Reagents, and Supplies

5.1 Computer Equipment

- Laptop computer with SBE SeaTerm and SBE SeaTerm V2 software.
- Data communication cables to connect the CTD to laptop.
- RS-232 to USB adapter.

5.2 CTD Equipment

- SBE 16*plus* CTD with SBE 43 DO sensor and SBE 5T pump retrieved from its mooring (Figure 1).
- SBE 16*plus* CTD with SBE 43 DO sensor and SBE 5T pump which has had a laboratory sensor performance assessment and which was transported from the laboratory into the field for deployment.
- SBE 37-SM or SBE 37-SMP retrieved from its mooring.
- SBE 37-SM or SBE 37-SMP which has had a laboratory sensor performance assessment and which was transported from the laboratory into the field for deployment.
- SBE 37-SMP-ODO retrieved from its mooring or which has had a laboratory sensor performance assessment.

Figure 1. A SBE 16*plus*, SBE 43, and SBE 5T package with barnacle biofouling.

5.3 Field Bath Equipment

- Notched stick about 4 feet long.
- Transparent Tygon tubing 1.0-m long, 3/8-inch inner diameter, and 1/2-inch outer diameter to fit into intake of CTD's conductivity cell.
- Two bungee cords with no hooks on one end.
- 100-ml or 60-ml plastic syringes with a 6-inch length of transparent Tygon tubing that fits on the syringe.
- 5-gal bucket with rope.
- Field bath rigged to a dolly (Figure 2).

Figure 2. A field bath rigged to a dolly.

5.4 Dissolved Oxygen Sampling Supplies

- Wooden boxes each containing 10 125-ml glass flasks and stoppers for collection of dissolved oxygen samples.
- Tygon tubing of 25-cm length with inner diameter to fit on the field bath valve.
- 3 M Manganese chloride ($MnCl_2$) obtained from the University of Washington's Marine Chemistry Lab. This chemical is stable for 2 years when stored in sealed plastic bottles and kept in the dark. The Safety Data Sheet can be found at www.avantormaterials.com/Documents/MSDS/USA/SAP/00015677.PDF.
- 8 N Sodium hydroxide-sodium iodide-sodium azide ($NaOH$-NaI-NaN_3; also named as alkaline iodide azide) obtained from the University of Washington's Marine Chemistry Lab. This chemical is stable for 2 years when stored in sealed plastic bottles and kept in the dark. The Safety Data Sheet can be found at www.spectrumchemical.com/MSDS/LC10690.pdf.
- De-ionized water (18 megohm resistance).

- Calibrated bottle-top dispensers or 1-ml automatic pipettes with tips for dispensing chemicals.

5.5 Salinity Sampling Supplies

- Opaque, brown 125-ml polyethylene bottles partially filled with seawater to maintain osmotic equilibration of the plastic.

5.6 Field Service Log Form

- Log form printed on waterproof paper for recording DO field bath activities and samples (Appendix). It also contains related information on mooring retrieval and deployment. This information is transferred to a digital form upon completion of field work. A version of the electronic form can be used directly in the field if conditions allow.

6.0 Summary of Procedure

Before starting this procedure, ensure that the retrieved CTD package was stopped from further sampling and removed from the mounting board attached to the mooring equipment.

6.1 Field Bath Setup

Wind, water temperature fluctuations, air bubbles, or oil in the field bath can affect performance tests and/or instrument stability and reliability. Therefore, filling the field bath with seawater should be one of the first tasks to complete upon arriving at a mooring station. The following steps should be taken:

1. Close bath valve.
2. Monitor water surface at mooring station for oil sheens.
3. Avoid collecting seawater from areas of oil sheens.
4. Using a 5-gal bucket with rope, lower bucket into water, haul it up, and pour seawater into bath. Alternately, if a plumbed seawater system is available, use a hose to fill the bath and let it run for several minutes to ensure any seawater sitting in the system has been flushed through.
5. Fill field bath until water overflows.
6. Let bath stand for 15 minutes to allow time for air bubbles and oily residues to surface.
7. If a small amount of sheen is observed, sniff the bath for hydrocarbon odors.
8. If hydrocarbon odor is present, discard bath water, clean bath with Triton-X, and refill.
9. Otherwise, if oil sheen does not have odor, then skim off oil sheen and wipe down bath exterior that may have been exposed to the oil sheen.

6.2 Computer Setup

All computer, software, and instrument configuration and communications are conducted according to manufacturer protocols. Steps are separated into subsections for: 1) SBE 16*plus* with SBE 43, 2) SBE 37-SM and SBE 37-SMP, and 3) SBE 37-SMP-ODO. Specific information on these protocols is found in the manufacturer's "User's Manual" for the:

- SBE 16*plus* at: www.seabird.com/old-manuals/SBE_16plus/16plus_RS-232/1.8c_Firmware_017-018Manual/16plus_rs232_018.pdf.
- SBE 37-SM with firmware 2.6b at: www.seabird.com/old-manuals/SBE_37/SBE_37-SM/37-SM_RS-232/2.6b_Firmware_025-026Manual/37SM_rs232_026.pdf.
- SBE 37-SMP with firmware 2.6a at: www.seabird.com/old-manuals/SBE_37/SBE_37-SMP/37-SMP_RS-232/2.6a_Firmware_004-006Manual/37SMP_RS232_006.pdf.
- SBE 37-SMP-ODO at: www.seabird.com/old-manuals/SBE_37/SBE_37-SMP-ODO/37-SMP-ODO_RS-232/2.2.0_Firmware_004Manual/37SMP-ODO_RS232_004.pdf.

6.3 Performance Test Procedures

6.3.1 SBE 16*plus* – Software Configurations

1. Open SBE SeaTerm (Note: SBE SeaTerm V2 is not compatible with our current SBE 16*plus* sensors)
2. Go to menu **Configure** and select **SBE 16plus…** which will open the **SBE 16plus Configuration Options** dialog (Figure 3).
3. In the **COM Settings** tab, confirm:
    a. correct **COMM** port is selected
    b. **Baud** rate is **9600**
    c. **Parity** is **none**
    d. **Mode** is **RS-232 (Full duplex)**

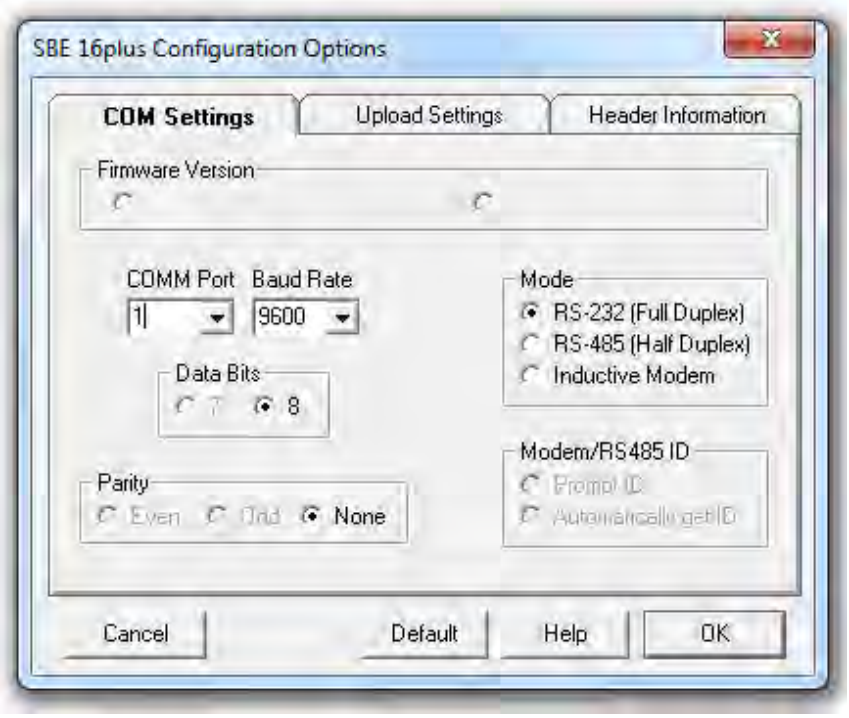


Figure 3. Image of COM Settings tab within the SBE 16plus Configuration Options dialog box.

4. In the **Upload Settings** tab (Figure 4), confirm:
   a. **Upload Baud** rate is **9600**
   b. **Upload data** selection is **By scan number range**

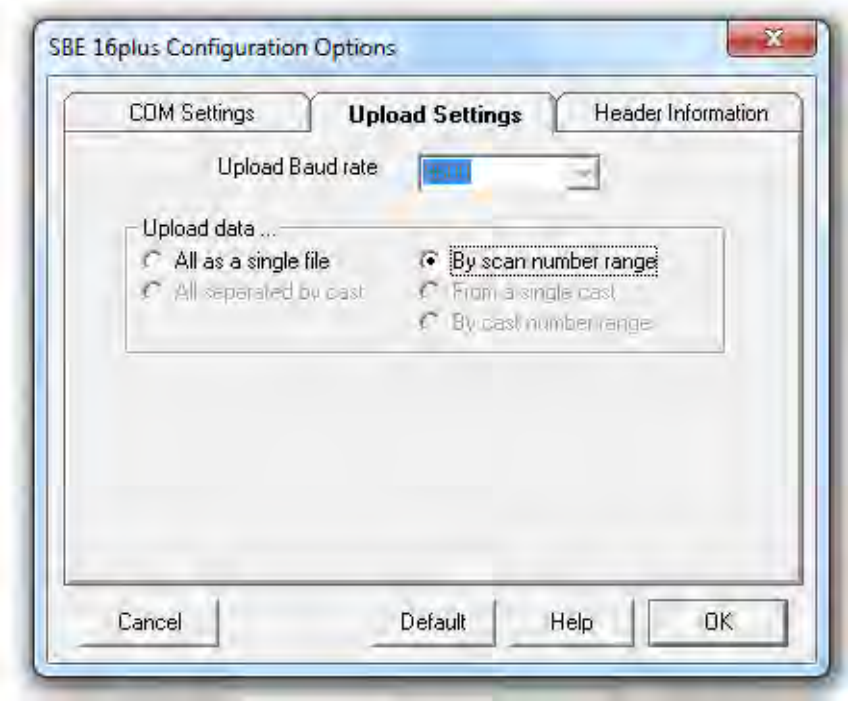


Figure 4. Image of Upload Settings tab within the SBE 16plus Configuration Options box.

5. In the **Header Information** tab, confirm that **Prompt for header information** is selected (Figure 5).

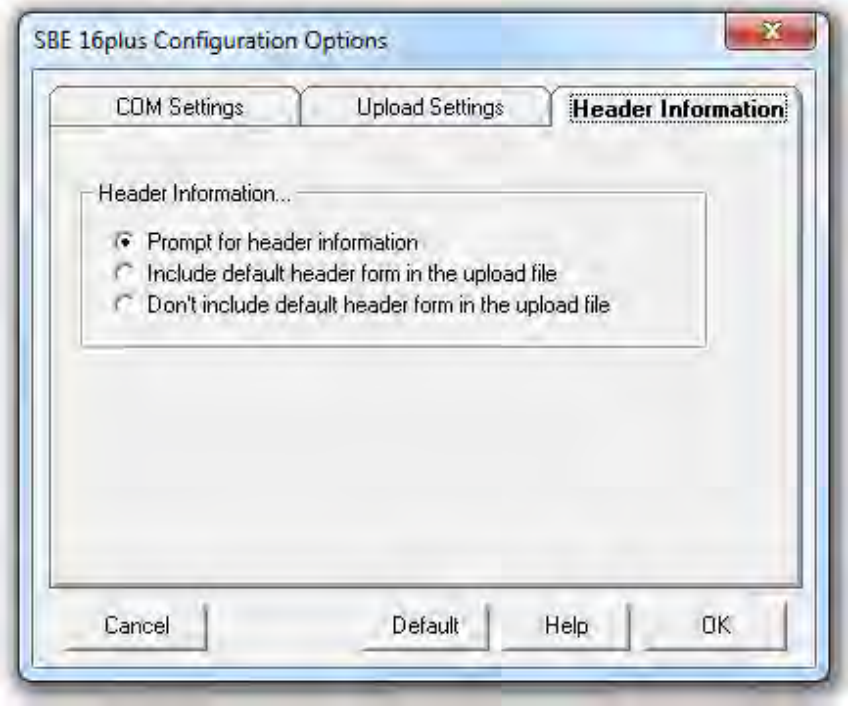


Figure 5. Image of Header Information tab within the SBE 16plus Configuration Options box.

6. Click on **OK** in the dialog box.
7. Go to menu **Configure** and select **Header Form…** at the bottom of the list.
8. Confirm that the **Edit Header Prompts** dialog box has these entries in the **Prompt for** lines (Figure 6):
    a. Station:
    b. Servicing Date:
    c. CTD sn:
    d. SBE 43 sn:
    e. Fluorometer sn:
    f. Deployment data (y/n):
    g. Bath data (y/n):

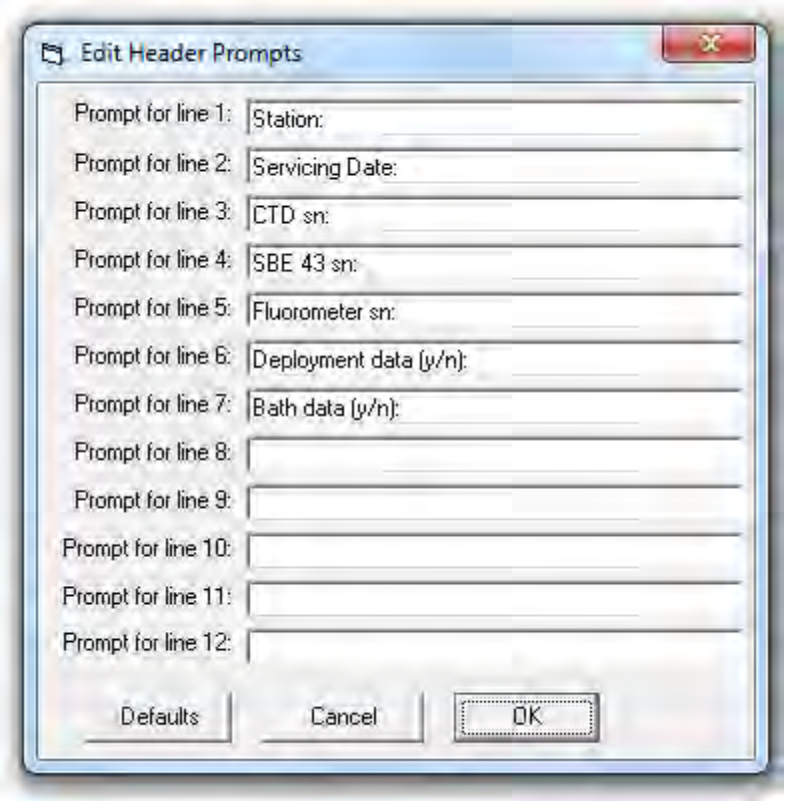


Figure 6. Image of Edit Header Prompts dialog box.

9. Click on **OK** in the dialog box.

6.3.2 SBE 16*plus* – Placing Sensors into Field Bath

1. Put on laboratory gloves.
2. Record serial numbers of both the deploying and retrieved CTD and DO sensors.
3. Except for the area around the conductivity cell intake and pump exhaust, clean retrieved CTD exterior of any major biofouling.

4. Connect the 4-pin end of a computer-to-CTD communication cable to each CTD.
5. Connect the serial end of the communication cable to the laptop. The serial end can also be connected to a serial-to-USB adapter and the USB end plugged into the laptop.
6. Use the SBE SeaTerm software to confirm that each CTD's battery power is sufficient for running the sensor performance test.
    a. Open SeaTerm.
    b. Click on the **Connect** button.
    c. Type **ds** for display status.
    d. In the status lines, check what the **vmain** or **vbatt** is (each represents the CTD's voltage) (Figure 7).

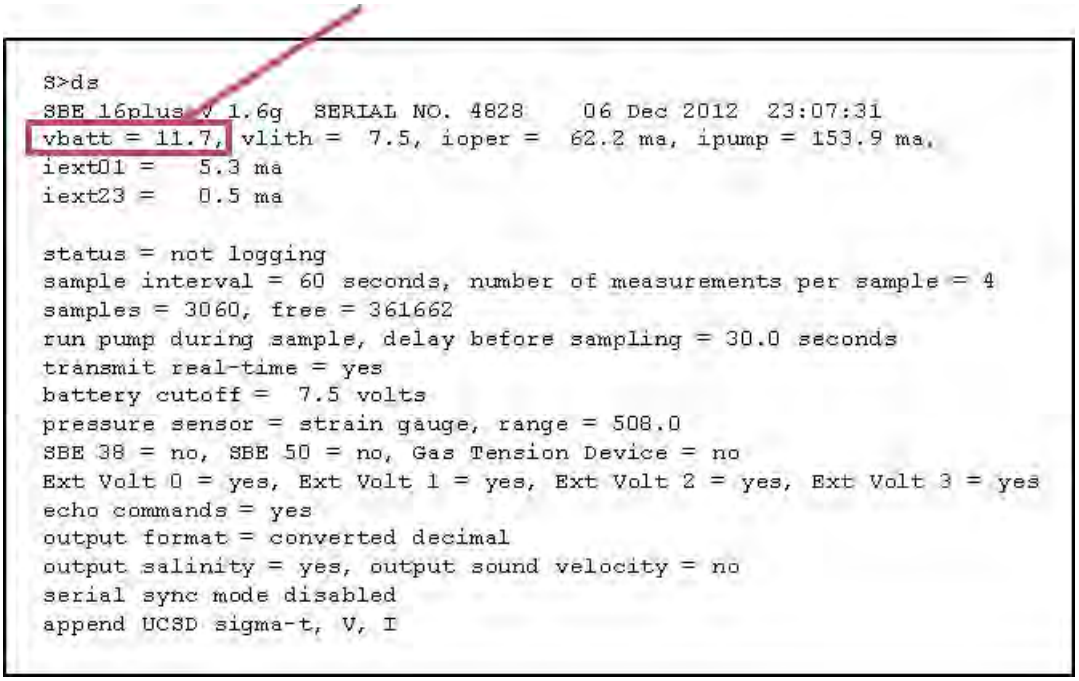


Figure 7. Example text of display status shown in the SeaTerm communication screen. Red box highlights where to find vmain or vbatt.

7. If CTD battery power is low (<11.3 volts), replace the CTD batteries before proceeding with the bath.
8. Connect a 5-foot length of transparent Tygon tubing (R-3603 with 1/2-inch outer diameter, 3/8-inch inner diameter) to the intake of the conductivity cell.
9. To this tubing, insert a 6-inch length of Tygon tubing with a slightly smaller diameter connected to a plastic syringe on the other end. This second length of tubing is to adjust for the difference in diameter between the conductivity cell's intake and the syringe. An alternative is to use an appropriately sized tube connector between the two tubings.
10. Attach a bungee cord to the top of the CTD (i.e., exterior battery cap).
11. Lower CTD into the bath, ensuring that the syringe remains out of water.

12. Secure one end of bungee cord to bath lid or dolly frame.

6.3.3 SBE 16*plus* – Air Bubble Removal

DO sensor membranes that are exposed to air bubbles will provide an inaccurate measurement of DO concentrations. Air bubbles will also cause an inaccurate measurement of salinity which affects the calculation of DO concentrations. Therefore, it is necessary to ensure that air bubbles are removed from the entire CTD package plumbing (via the conductivity cell, tubing, and auxiliary sensors). The following steps should be taken:

1. Put on laboratory gloves, if not already removed after placing sensors into field bath.
2. While keeping the CTD submerged, gently rock the CTD package up and down and sideways.
3. Using the syringe and transparent Tygon tubing, which was previously inserted into the conductivity cell intake, gently push and pull the stopper in the syringe several times to move air bubbles. Avoid hard and rapid pumping of syringe so as not to form air bubbles with high pressure that could damage sensors. Ensure that air is eliminated from sensors and tubings and not pumped into the conductivity cell intake.
4. Repeat the pumping until air bubbles are no longer visibly coming out of the CTD pump exhaust or present in the transparent Tygon tubing.
5. Using a long stick with a notch on one end, remove the Tygon tubing from the conductivity cell intake and then from the bath.

6.3.4 SBE 16*plus* – Verifying Air Bubble Removal

To verify that air bubbles are pumped out of each CTD package, sensor stability, particularly that of the DO sensor, is tested. The following steps should be taken:

1. In SeaTerm, confirm settings and follow instructions for “Software Configurations” in section 6.3.1.
2. Click on the **Capture** button or go to menu **Communications** and select **Capture to File…** (Figure 8).

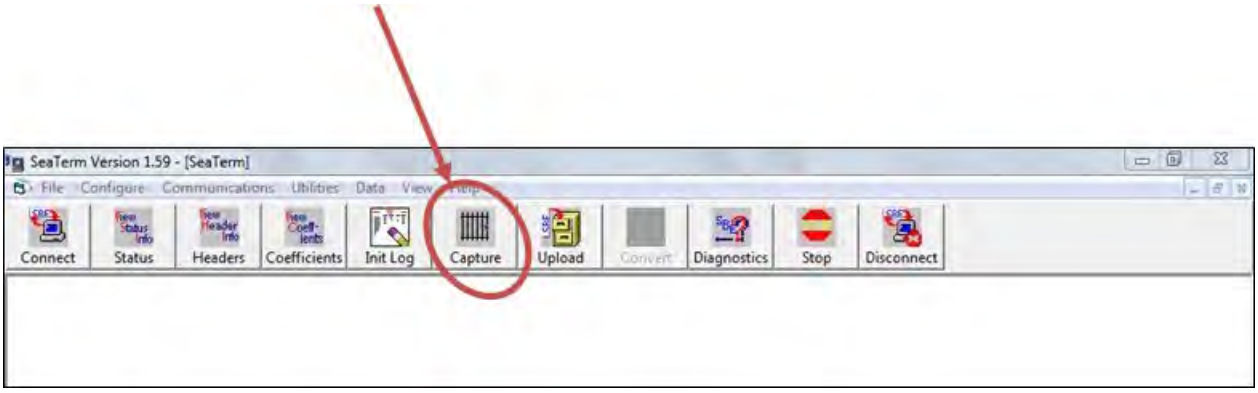


Figure 8. SeaTerm software with the Capture button highlighted.

3. In the dialog box, enter file name following this format: YYMMDD_DOSN_XP_STANM where:
   a. YYMMDD = 2-digit year, 2-digit month, and 2-digit day, e.g., 121217 for 17 Dec 2012.
   b. DOSN = 4-digit serial number of DO sensor.
   c. XP = acronym for indicating whether this is a start point (SP) or end point (EP) bath assessment.
   d. STANM = station name, e.g., ADM01 for Admiralty Reach station.
4. Click **OK** to close dialog box.
5. Type **ds** for displaying the CTD's status.
6. Confirm that CTD date is current and time is set to Greenwich Mean Time (GMT) (Figure 9). Otherwise, reset them by following these steps:
   a. Type **mmddyy = today's date**, e.g., 121712 for 17 Dec 2012.
   b. Type **hhmmss = next minute in GMT**, e.g., 180000 for 10:00 a.m. Pacific Standard Time. Use local time + 7 hours to convert to GMT for Pacific Daylight Time and local time + 8 hours to convert to GMT for Pacific Standard Time.

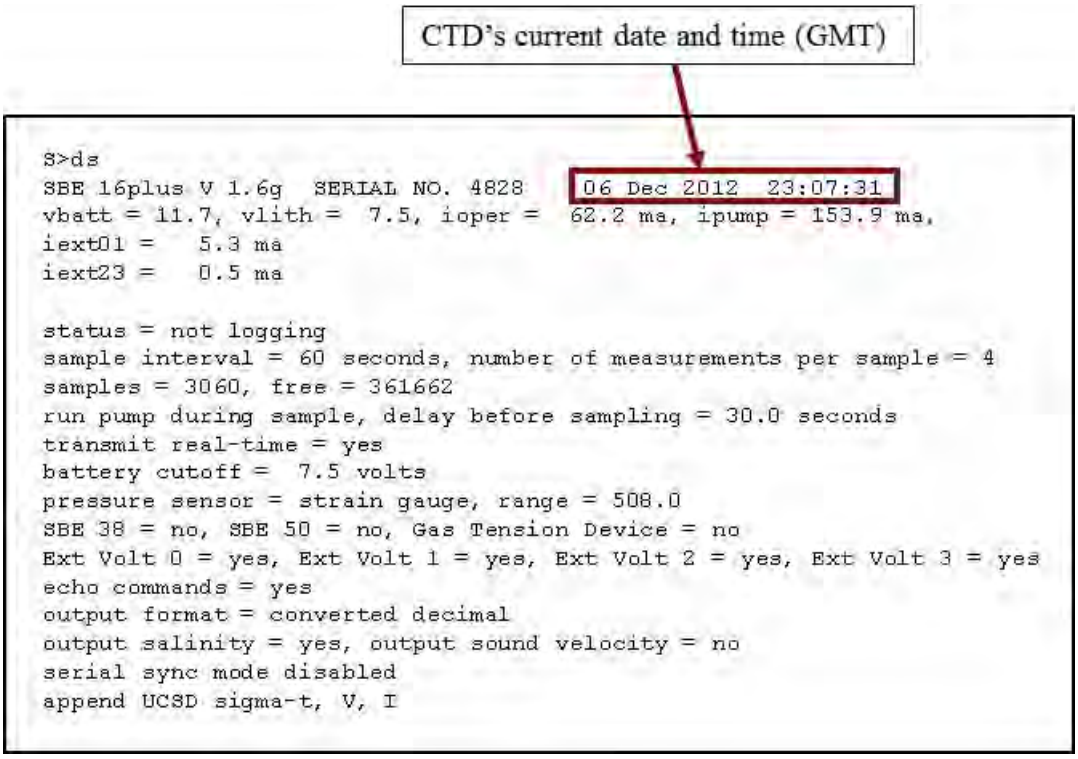


Figure 7. Example text of display status shown in the SeaTerm communication screen. The red box highlights where to find the current CTD date and time is.

7. Check the sensor stability by testing voltage readings for the DO sensor until readings stabilize to a difference of 0.005 volts or less between readings. Follow these steps:
   a. Type **pumpon** to turn on the auxiliary pump.
   b. Immediately type **tv** to test the voltages.
   c. Read voltages in first column (i.e., voltage from auxiliary sensor channel 0) which is typically the external voltage channel configured for DO sensors (Figure 10).
   d. Record approximate voltages on field log sheet.

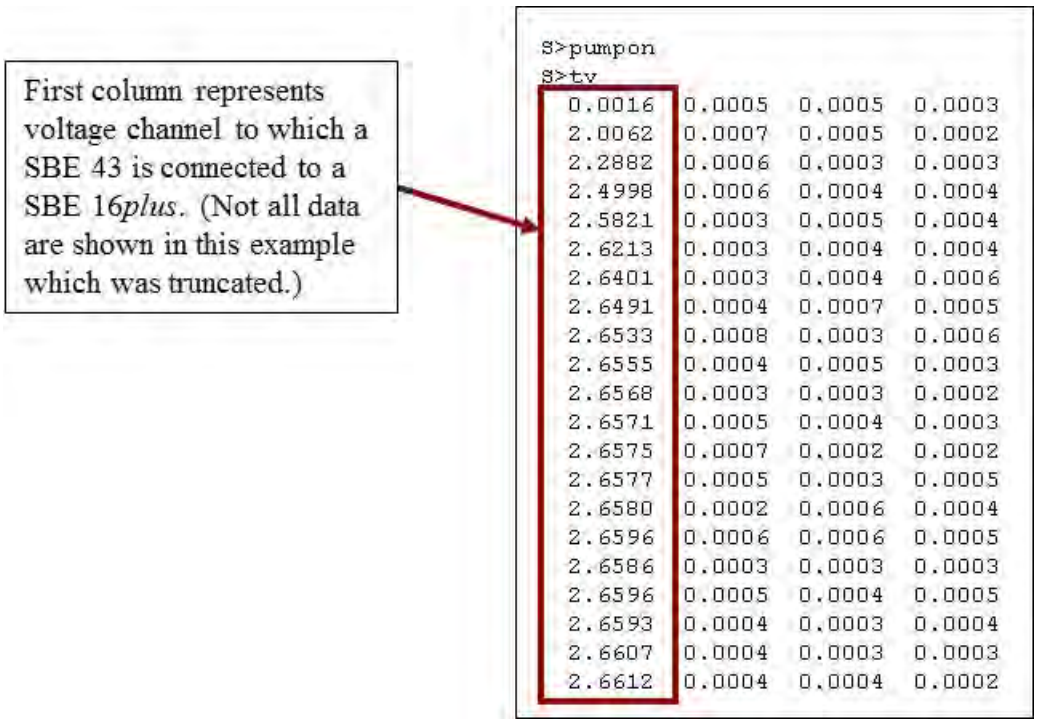


Figure 10. Example text of voltages displayed on the SeaTerm communication screen. The red box highlights where voltages from CTD voltage channel zero would be displayed.

6.3.5 SBE 16*plus* – Confirm Sensor and Bath Stability

Once each DO sensor has stabilized, proceed with testing CTD and bath stability.

1. Type **sampleinterval=60** to set the CTD to take measurements every 60 seconds.
2. Type **outputformat=3** to generate a converted decimal output on the SeaTerm command screen.
3. For more than one SBE 16*plus*, effort should be made to have all CTDs sample the field bath water as simultaneously as possible, no more than 10 seconds apart. To do this:
    a. Type in command without executing it for each SeaTerm window that is open.
    b. Then, hit the **Enter** key and immediately switch to other window to execute as soon as possible.
4. Type **ts** for the "taking sample" command. Expect data to be displayed in the following column order:
    a. Temperature (°C)
    b. Conductivity (Siemens/meter)
    c. Pressure (decibars)
    d. Voltage from auxiliary sensor channel 0
    e. Voltage from auxiliary sensor channel 1

f. Voltage from auxiliary sensor channel 2
g. Voltage from auxiliary sensor channel 3
h. Salinity (psu)
i. Date (dd mmm yyyy)
j. Time (hh:mm:ss GMT)

5. Type **ts** two more times to generate multiple samples.
6. Compare temperature, voltage 0 (i.e., DO sensor voltage), and salinity readings among each CTD and their samples to confirm stability (Figure 11). The values for these parameters should be reasonable based on ambient bath conditions. The goal for confirming bath and sensor stability is to have:
    a. Pressure near 1.0 decibars and stable to within 0.1 decibars.
    b. Temperature stable to within 0.05 °C.
    c. Conductivity stable to within 0.01 Siemens/meter.
    d. Salinity stable to within 0.02 psu.
    e. DO sensor voltage stable to within 0.005 volts.

```
S>ts
  8.5587,  3.18458,    0.699, 2.2536, 0.0004, 0.0004, 0.0004,  29.8707, 06 Dec 2012, 23:10:26
S>ts
  8.5525,  3.18395,    0.697, 2.2537, 0.0005, 0.0003, 0.0004,  29.8694, 06 Dec 2012, 23:12:44
S>ts
  8.5500,  3.18390,    0.703, 2.2534, 0.0003, 0.0005, 0.0004,  29.8710, 06 Dec 2012, 23:13:25
```

Figure 11. Example text of CTD samples on SeaTerm communication screen.

6.3.6 SBE 16*plus* – Synchronized DO Sensor and DO Winkler Sampling

Collection of DO seawater samples from the field bath is synchronized with CTD and DO sensor measurements to obtain the best verification possible of DO sensor performance. Note that a water pump on the CTD package turns on 30 seconds prior to measurements and that the CTD takes measurements every 60 seconds. DO seawater samples are collected ideally every 120 seconds at the same time the CTD takes a measurement of the seawater. Specific procedures for collecting and preserving DO seawater samples can be found in section 6.0 of "Standard Operating Procedure for Seawater Sampling" at: www.ecy.wa.gov/programs/eap/quality.html. The main difference between that SOP and this one is that seawater is drawn from the field bath, not a Niskin bottle sampler. The seawater sampling steps from that SOP are summarized here for ease of following procedures specific to conducting a sensor performance assessment using the field bath. Steps are outlined for the SBE 16*plus* with SBE 43 and are not applicable to the SBE 37-SM or SBE 37-SMP.

1. CTD sampling time, scan line numbers, and bottle numbers are to be recorded on the field log sheet.
2. Set up chemicals, glass flasks, and pipettes on a laboratory mat or large paper towel on a plastic garbage bag. This set up provides containment for any reagent spills.
3. Connect a 25-cm length of Tygon tubing to the field bath valve.

4. When obtaining bath seawater samples, great care is taken to avoid introducing air bubbles into the samples.
5. To collect DO Winkler samples and take synchronized CTD measurements every 120 seconds, the following steps should be taken:
    a. On the laptop, check in SeaTerm to confirm that the capture file for each CTD remains open.
    b. Have a digital hand-held timer ready to start.
    c. Type **startnow** to start CTD sampling measurements of the bath water.
    d. Watch SeaTerm and start the timer when the first sample is displayed.
    e. The data are displayed in the following column order (Figure 12):
        i. Temperature (°C)
        ii. Conductivity (Siemens/meter)
        iii. Pressure (decibars)
        iv. Voltage from auxiliary sensor channel 0
        v. Voltage from auxiliary sensor channel 1
        vi. Voltage from auxiliary sensor channel 2
        vii. Voltage from auxiliary sensor channel 3
        viii. Salinity (psu)
        ix. Date
        x. Time
        xi. Density (kg/m^3)
        xii. CTD battery voltage
        xiii. Operating current (milliamps)

```
S>startnow
start now

#  8.5464,  3.18363,    0.682, 2.2435, 0.0004, 0.0003, 0.0004,  29.8713, 06 Dec 2012, 23:15:25,
23.1718, 10.8, 174.9

#  8.5443,  3.18348,    0.672, 2.2471, 0.0004, 0.0004, 0.0004,  29.8714, 06 Dec 2012, 23:16:25,
23.1722, 10.8, 163.6

#  8.5410,  3.18323,    0.658, 2.2476, 0.0003, 0.0002, 0.0003,  29.8717, 06 Dec 2012, 23:17:25,
23.1728, 10.8, 173.4

#  8.5388,  3.18298,    0.644, 2.2475, 0.0004, 0.0003, 0.0004,  29.8709, 06 Dec 2012, 23:18:25,
23.1725, 10.8, 140.8

#  8.5370,  3.18288,    0.633, 2.2471, 0.0004, 0.0003, 0.0003,  29.8714, 06 Dec 2012, 23:19:25,
23.1732, 10.8, 180.0

#  8.5335,  3.18254,    0.616, 2.2473, 0.0003, 0.0003, 0.0004,  29.8708, 06 Dec 2012, 23:20:25,
23.1732, 10.7, 146.7

#  8.5322,  3.18226,    0.607, 2.2472, 0.0004, 0.0004, 0.0003,  29.8691, 06 Dec 2012, 23:21:25,
23.1721, 10.7, 144.9

#  8.5277,  3.18200,    0.600, 2.2470, 0.0003, 0.0004, 0.0004,  29.8702, 06 Dec 2012, 23:22:25,
23.1735, 10.7, 146.7

#  8.5251,  3.18186,    0.585, 2.2471, 0.0003, 0.0003, 0.0003,  29.8709, 06 Dec 2012, 23:23:25,
23.1745, 10.7, 135.3
```

Figure 12. Example text of CTD continuously sampling and displaying data.

f. Compare the timer reading with the second CTD sample to confirm that the timer reading is on zero seconds and synchronizing with display of reading of each CTD.
g. Note that each CTD will sample every 1 min whereas the DO Winkler sample will be collected on every 2 min.
h. Determine when to start the DO seawater flow for rinsing and sample collection. The objective is to start water flow 30 seconds prior to display of reading of each CTD and collect the sample itself during the next 30 seconds until when the next sample reading is displayed.
i. Let both CTDs take one or two more samples before beginning collection of DO Winkler samples.
j. On pre-determined timer reading, collect a DO Winkler sample following the SOP for Seawater Sampling with the exception of using the field bath in place of a Niskin bottle sampler.
k. Record the flask number and CTD sample time on the field log sheet when the sample is taken.
l. Repeat until 3 DO Winkler samples are collected.

6.3.7 SBE 16*plus* – Synchronized Sensor and Salinity Sampling

After DO sample collection is complete, watch the timer reading for the next 2-min interval and collect one salinity sample from the field bath water. Except for using the field bath instead of a Niskin bottle sampler, follow the salinity sampling procedure found in section 6 of the SOP for Seawater Sampling.

6.3.8 SBE 16*plus* – Stopping the Assessment

1. Stop each CTD by one of the following methods:
   a. Press **Enter** key until the S> command prompt appears and then type **stop**. This may require a few tries.
   b. Click on the **Stop** button and then **OK** in the dialog box that appears.
   c. Press **ESC** key until the S> command prompt appears.
   d. Press **Ctrl** and **C** keys and then **Enter** key to get the S> command prompt.
2. Type **ds** to display the status and verify (Figure 13):
   a. **status = not logging** which indicates CTD is no longer sampling.
   b. **vmain** or **vbatt** which indicates the CTD's battery power.
   c. **samples** for number of samples in CTD's memory.

```
S>ds
SBE 16plus V 1.6g  SERIAL NO. 4828    06 Dec 2012  23:24:55
vbatt = 11.4, vlith =  7.5, ioper =  62.2 ma, ipump = 152.9 ma,
iext01 =   5.4 ma
iext23 =   0.6 ma

status = not logging
sample interval = 60 seconds, number of measurements per sample = 4
samples = 3070, free = 361652
run pump during sample, delay before sampling = 30.0 seconds
transmit real-time = yes
battery cutoff =  7.5 volts
pressure sensor = strain gauge, range = 508.0
SBE 38 = no, SBE 50 = no, Gas Tension Device = no
Ext Volt 0 = yes, Ext Volt 1 = yes, Ext Volt 2 = yes, Ext Volt 3 = yes
echo commands = yes
output format = converted decimal
output salinity = yes, output sound velocity = no
serial sync mode disabled
append UCSD sigma-t, V, I
```

Figure 13. Example text of CTD's status displayed on SeaTerm communication screen. The red boxes highlight where vbatt, status = not logging, and samples would be given.

3. Stop the capture file by clicking on the **Capture** button (Figure 14).

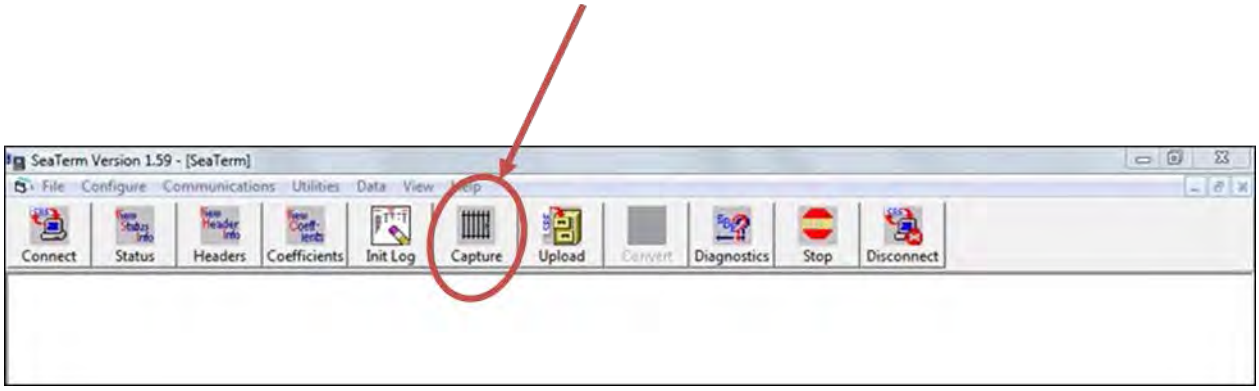


Figure 14. Image of SeaTerm software with Capture button highlighted.

4. Upload bath data, note the scan range for the bath data to distinguish between deployment data still saved in CTD memory and field bath data, and then enter the scan range for the field bath data and subsequent header prompts (Figure 15).

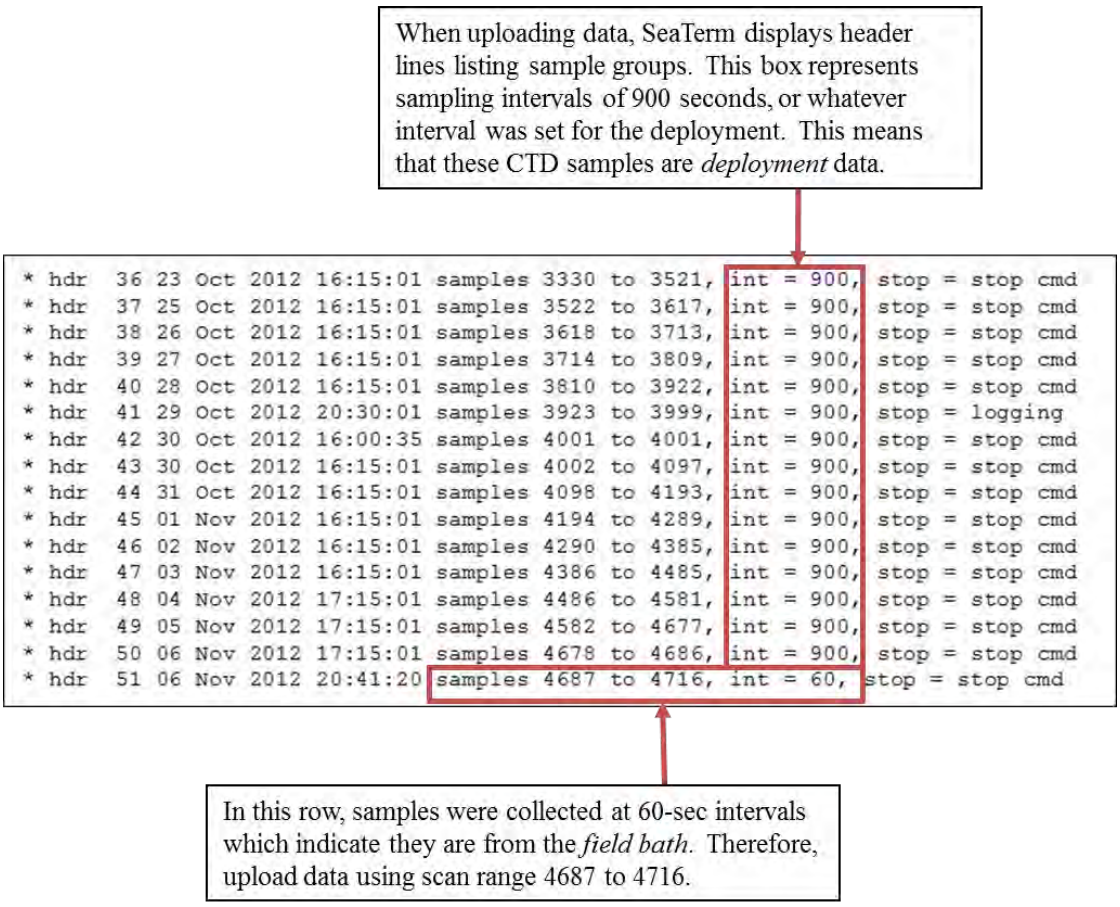


Figure 15. Example text generated during a hexadecimal file upload in SeaTerm. The top red box highlights deployment data whereas the bottom box highlights field bath data.

5. For each CTD, save file as YYMMDD_DOSN_XP_STANM.hex where:
    a. YYMMDD = 2-digit year, 2-digit month, and 2-digit day, e.g., 121217 for 17 Dec 2012.
    b. DOSN = 4-digit serial number of DO sensor.
    c. XP = 2-letter acronym for sensor performance assessment; EP for “end point” and SP for “start point”.
    d. STANM = station name, e.g., ADM01 for Admiralty Reach station.
6. Confirm using either Notepad or SeaSave software that all bath data were uploaded.
7. Type **qs** to put the CTD into quiescent state.
8. Click on the **Disconnect** button to close the laptop port that the communication cable is plugged into (Figure 16).

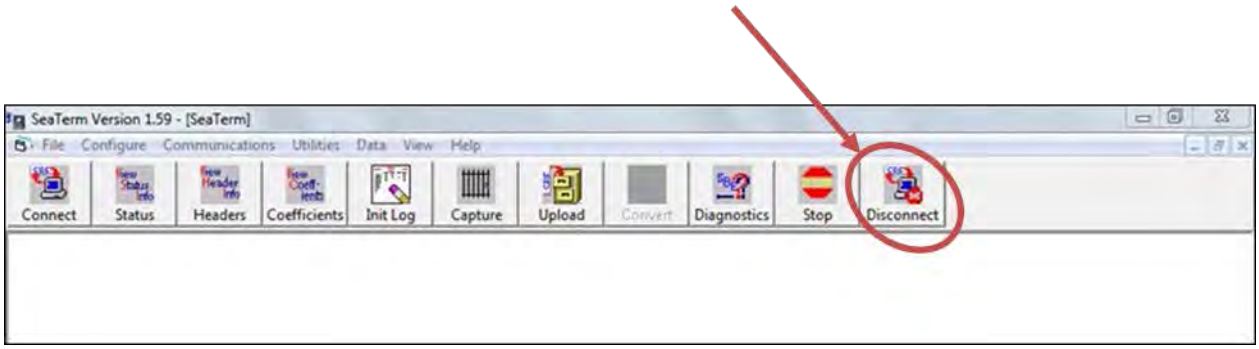


Figure 16. Image of SeaTerm software with Disconnect button highlighted.

9. Copy bath data files onto a memory stick or card. This step will assure that there are at least two copies of data in the event that one copy is lost while in the field.
10. Remove each CTD from the field bath, disconnect communication cables, and plug in SBE dummy plugs to protect pins on all cables.
11. After all DO Winkler samples have settled for 15-20 minutes, re-shake each sample and seal the stopper following the SOP for Seawater Sampling.

6.3.9 SBE 37-SM and SBE 37-SMP – Software Configurations

1. Open SBE SeaTerm (*Note*: SBE SeaTerm V2 is not compatible with our current SBE 37-SM or SBE 37-SMP sensors)
2. Go to menu **Configure** and select **SBE 37…**
3. Making this selection will open the **SBE 37 Configuration Options** dialog box which has three tabs.
4. In the **COM Settings** tab, confirm (Figure 17):
    a. correct **COMM** port is selected
    b. **Baud** rate is **9600**
    c. **Parity** is **none**
    d. **Mode** is **RS-232 (Full duplex)**

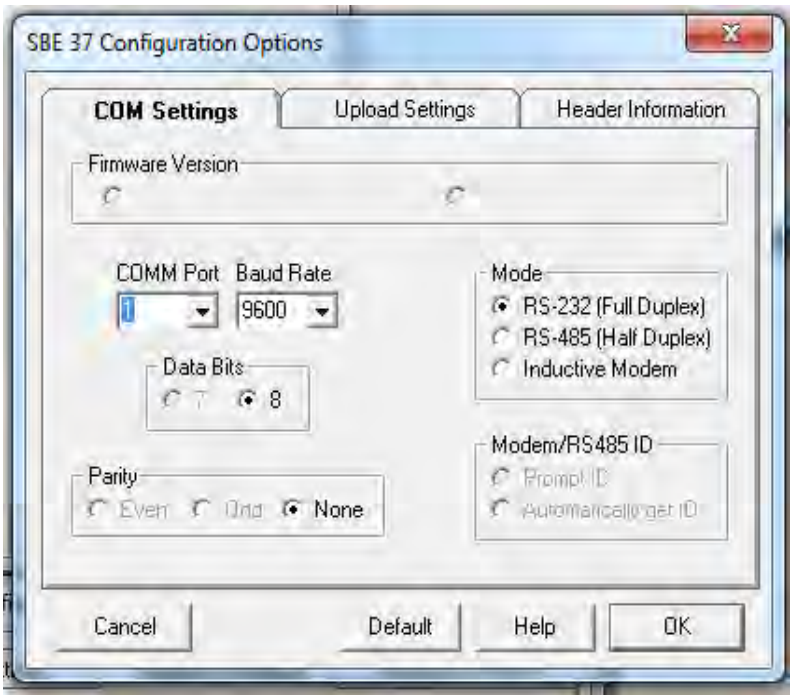


Figure 17. Image of COM Settings tab within the SBE 37 Configuration Options dialog box.

5. In the **Upload Settings** tab, confirm (Figure 18):
    a. **Upload Baud** rate is **9600**
    b. **Upload data** selection is **By scan number range**

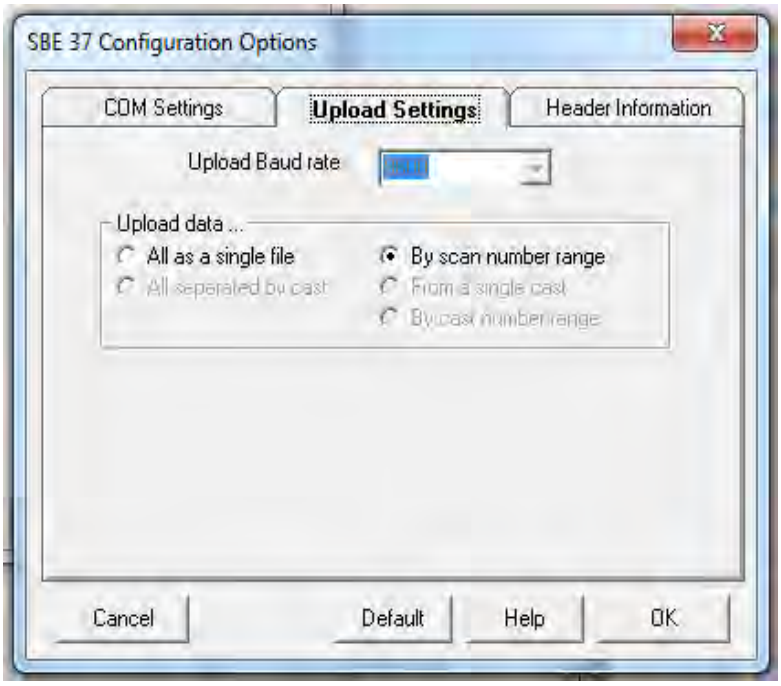


Figure 18. Image of Upload Settings tab within the SBE 37 Configuration Options box.

6. In the **Header Information** tab, confirm that **Prompt for header information** is selected (Figure 19).

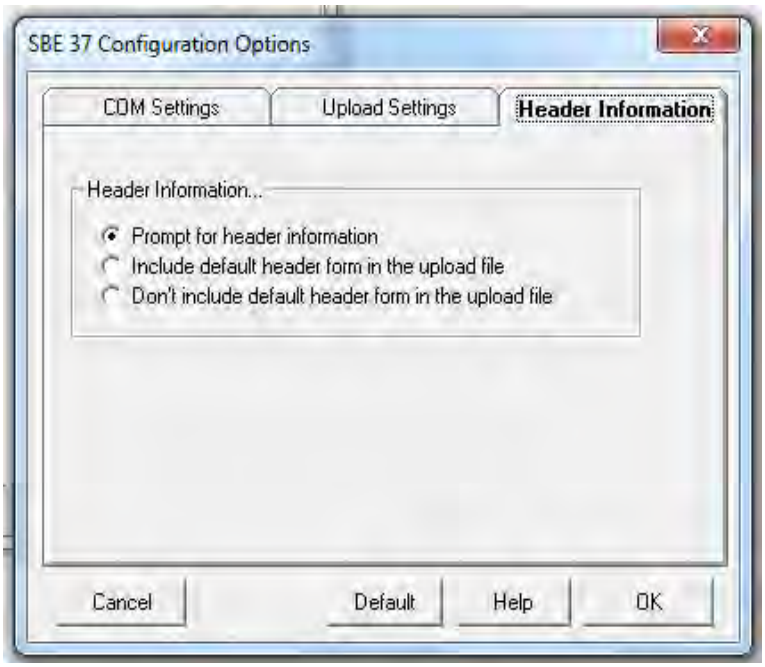


Figure 19. Image of Header Information tab within the SBE 37 Configuration Options box.

7. Click on **OK** in the dialog box.
8. Go to menu **Configure** and select **Header Form…** at the bottom of the list.
9. Confirm that the **Edit Header Prompts** dialog box has these entries in the **Prompt for** lines (Figure 20):
    a. Station:
    b. Servicing Date:
    c. CTD sn:
    d. SBE 43 sn:
    e. Fluorometer sn:
    f. Deployment data (y/n):
    g. Bath data (y/n):

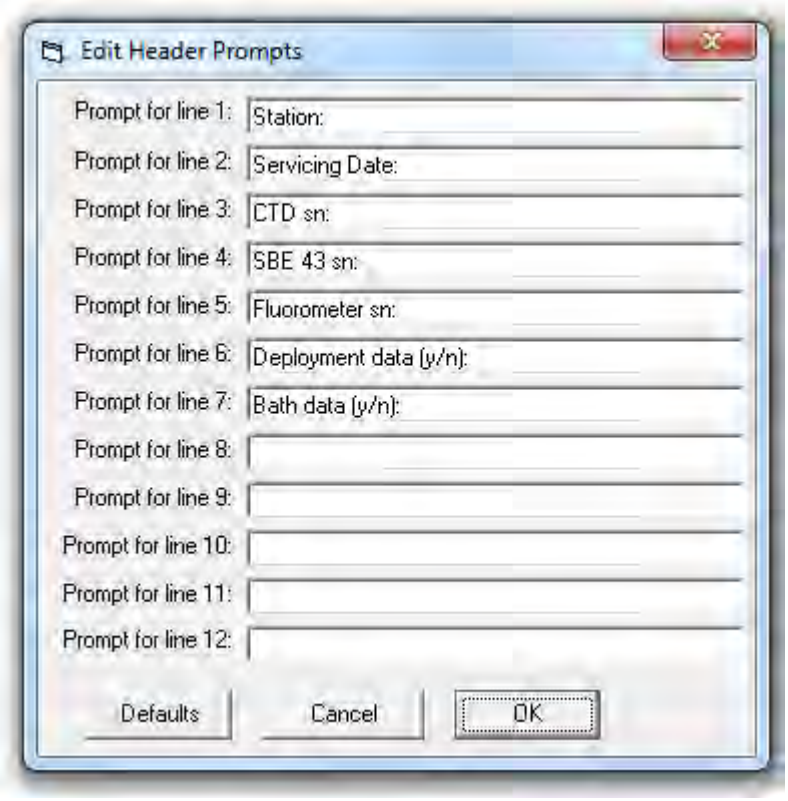


Figure 20. Image of Edit Header Prompts dialog box.

10. Click on **OK** in the dialog box.

6.3.10 SBE 37-SM and SBE 37-SMP – Placing Sensors into Field Bath

1. Put on laboratory gloves.
2. Record serial numbers of both the deploying and retrieved CTDs.
3. Except for the area around the conductivity cell intake and exhaust, clean retrieved CTD exterior of any major biofouling.
4. Connect the 4-pin end of a computer-to-CTD communication cable to each CTD.
5. Connect the serial end of the communication cable to the laptop. The serial end can also be connected to a serial-to-USB adapter and the USB end plugged into the laptop.
6. Unlike the SBE 16*plus*, confirming battery power must be done by removing battery pack and using a volt meter. Refer to instrument manuals for further guidance (Sea-Bird Electronics, Inc., 2006, 2007b).
7. Connect a 5-foot length of transparent Tygon tubing (R-3603 with 1/2-inch outer diameter, 3/8-inch inner diameter) to the intake of the conductivity cell.
8. To this tubing, insert a 6-inch length of Tygon tubing with a slightly smaller diameter connected to a plastic syringe on the other end. This second length of tubing is to adjust for the difference in diameter between the conductivity

cell's intake and the syringe. An alternative is to use a tube connector between the tubings.

9. Attach a bungee cord to the top of the CTD (i.e., around plastic mount).
10. Lower CTD into the bath, ensuring that the syringe remains out of water.
11. Secure one end of bungee cord to bath lid or dolly frame.

6.3.11 SBE 37-SM and SBE 37-SMP – Air Bubble Removal

This group of sensors does not have a DO sensor. However, air bubbles in the conductivity cell will cause an inaccurate measurement of salinity. Therefore, it is necessary to ensure that air bubbles are removed from the conductivity cell. The following steps should be taken:

1. Put on laboratory gloves, if not already removed after placing sensors into field bath.
2. While keeping the CTD submerged, gently rock the CTD package up and down and sideways.
3. Using the syringe and transparent Tygon tubing, which was previously inserted into the conductivity cell intake, gently push and pull the stopper in the syringe several times to move air bubbles. Avoid hard and rapid pumping of syringe so as not to form air bubbles with high pressure that could damage sensors. Ensure that air is eliminated from sensors and tubings and not pumped into the conductivity cell intake.
4. Repeat the pumping until air bubbles are no longer visibly coming out of the conductivity cell exhaust or present in the transparent Tygon tubing.
5. Using a long stick with a notch on one end, remove the Tygon tubing from the conductivity cell intake and then from the bath.

6.3.12 SBE 37-SM and SBE 37-SMP – Start Capture File

Unlike the SBE 16*plus*, no **tv** command is given to the SBE 37-SM or SBE 37-SMP to check on sensor stability. This is because such a command is not available for either sensor. Therefore, this subsection focuses on starting a file to capture commands, settings, and data. The following steps should be taken:

1. Open SeaTerm.
2. Confirm settings and follow instructions for "Computer Setup" in section 6.2.
3. Click on the **Capture** button or go to menu **Communications** and select **Capture to File…** (Figure 21).

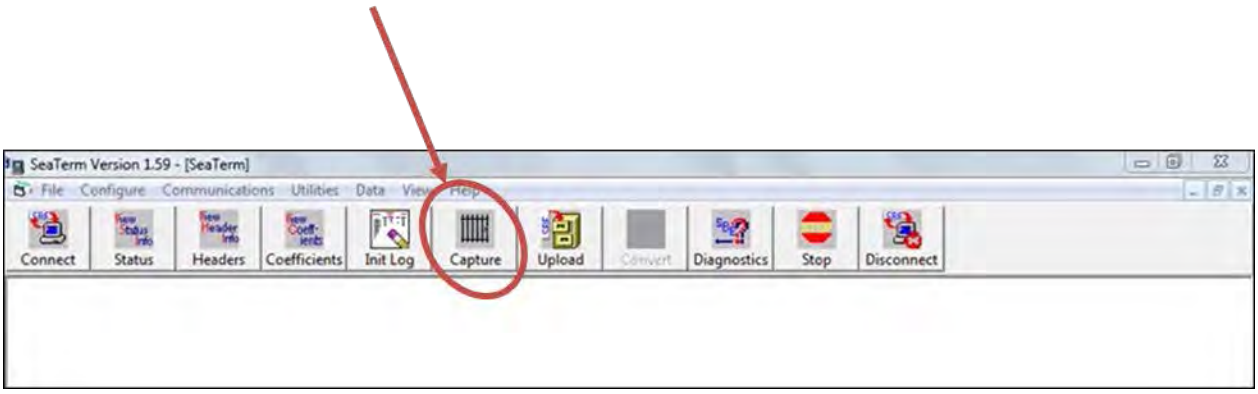


Figure 21. SeaTerm software with the Capture button highlighted.

4. In the dialog box, enter file name following this format: YYMMDD_CTDN_XP_STANM where:
   a. YYMMDD = 2-digit year, 2-digit month, and 2-digit day, e.g., 121217 for 17 Dec 2012.
   b. CTDN = 4-digit serial number of CTD.
   c. XP = 2-letter acronym for sensor performance assessment; EP for "end point" and SP for "start point".
   d. STANM = station name, e.g., ADM01 for Admiralty Reach station.
5. Click **OK** to close dialog box.
6. Type **ds** for displaying the CTD's status.
7. Confirm that CTD date is current and time is set to Greenwich Mean Time (GMT) (Figure 22). Otherwise, reset them by following these steps:
   a. Type **mmddyy = today's date**, e.g., 121712 for 17 Dec 2012.
   b. Type **hhmmss = next minute in GMT**, e.g., 180000 for 10:00 a.m. Pacific Standard Time. Use local time + 7 hours to convert to GMT for Pacific Daylight Time and local time + 8 hours to convert to GMT for Pacific Standard Time.

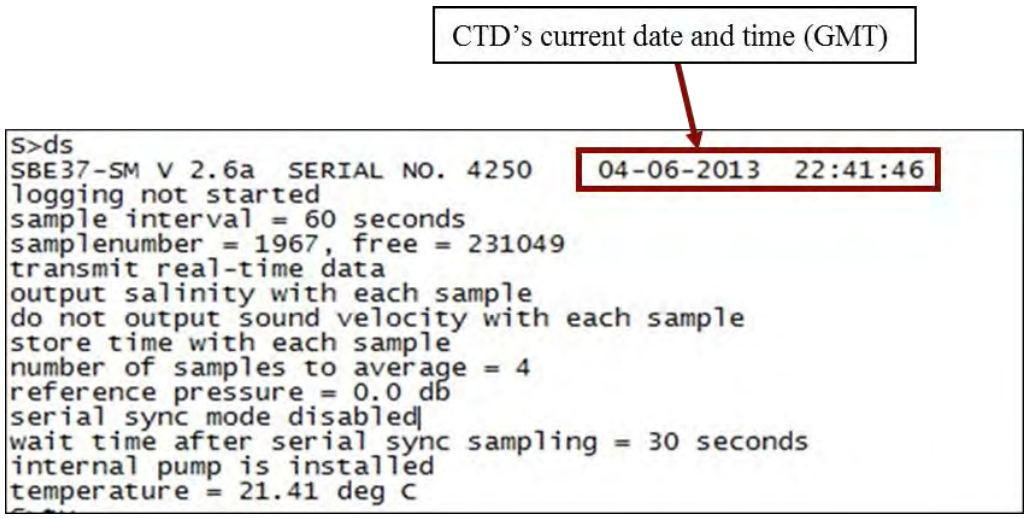


Figure 22. Example text of display status shown in the SeaTerm communication screen. The red box highlights where to find the current CTD date and time.

6.3.13 SBE 37-SM and SBE 37-SMP – Confirm Sensor and Bath Stability

Proceed with testing CTD and bath stability as follows:

1. Type **interval=60** to set the CTD to take measurements every 60 seconds.
2. For more than one SBE 37-SMs, effort should be made to have all CTDs sample the field bath water as simultaneously as possible, no more than 10 seconds apart. To do this:
    a. Type in command without executing it for each SeaTerm window that is open.
    b. Then, hit the **Enter** key and immediately switch to other SeaTerm window to execute as soon as possible.
3. Type **ts** for the "taking sample" command. Expect data to be displayed in the following column order:
    a. Temperature (°C)
    b. Conductivity (Siemens/meter)
    c. Pressure (decibars); not available on our current SBE 37-SMPs
    d. Salinity (psu)
    e. Date
    f. Time
4. Type **ts** 2 more times to generate multiple samples.
5. Compare temperature, conductivity, and salinity readings among each CTD and their samples to confirm stability. The values for these parameters should be reasonable based on ambient bath conditions. The goal for confirming bath and sensor stability is to have:
    a. Pressure near 1.0 decibars and stable to within 0.1 decibars.
    b. Temperature stable to within 0.05 °C.
    c. Conductivity stable to within 0.01 Siemens/meter.
    d. Salinity stable to within 0.02 psu.

6.3.14 SBE 37-SM and SBE 37-SMP – Synchronized Sensor and Salinity Sampling

Start timer for the next 2-min interval. Synchronize when to collect one salinity sample from the field bath water while the sensor measures the water. Except for using the field bath instead of a Niskin bottle sampler, follow the salinity sampling procedure found in section 6 of the SOP for Seawater Sampling.

6.3.15 SBE 37-SM and SBE 37-SMP – Stopping the Assessment

1. Stop each CTD by one of following methods:
    a. Press **Enter** key until the S> command prompt appears and then type **stop**. This may require a few tries.
    b. Click on the **Stop** button and then **OK** in the dialog box that appears.
    c. Press **ESC** key until the S> command prompt appears.

d. Press **Ctrl** and **C** keys and then **Enter** key to get the S> command prompt.

2. Type **ds** to display the status and verify (Figure 23):
   a. **not logging: received stop command** which indicates CTD is no longer sampling.
   b. **samplenumber** for number of samples in CTD's memory.

```
S>
S>
top
cmd not allowed while logging
stop
S>
stop
S>ds
SBE37-SM V 2.6a  SERIAL NO. 4251    07-24-2013  23:20:47
not logging: received stop command
sample interval = 60 seconds
samplenumber = 14  free = 233002
transmit real-time data
output salinity with each sample
do not output sound velocity with each sample
store time with each sample
number of samples to average = 4
reference pressure = 0.8 db
serial sync mode disabled
wait time after serial sync sampling = 30 seconds
internal pump is installed
temperature = 23.30 deg C
S>
```

Figure 23. Example text of SBE 37-SM's status displayed on SeaTerm communication screen. The red boxes highlight where not logging status and sample number would be given.

3. Stop the capture file by clicking on the **Capture** button (Figure 24).

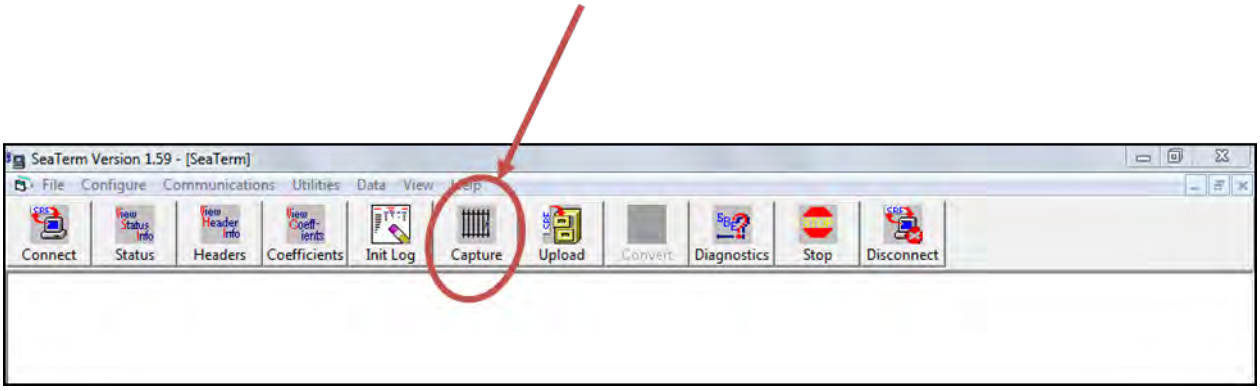


Figure 24. Image of SeaTerm software with Capture button highlighted.

4. Upload bath data, note what scan number for data upload to start at and enter this number when prompted. Doing this will distinguish between deployment data still saved in CTD memory and field bath data.
5. For each CTD, save file as YYMMDD_CTDN_XP_STANM.asc where:

a. YYMMDD = 2-digit year, 2-digit month, and 2-digit day, e.g., 121217 for 17 Dec 2012.
b. CTDN = 4-digit serial number of DO sensor.
c. XP = 2-letter acronym for sensor performance assessment; EP for "end point" and SP for "start point".
d. STANM = station name, e.g., ADM01 for Admiralty Reach station.

6. Confirm using either Notepad or SeaSave software that all bath data were uploaded.
7. Type **qs** to put the CTD into quiescent state.
8. Click on the **Disconnect** button to close the laptop port that the communication cable is plugged into (Figure 25).

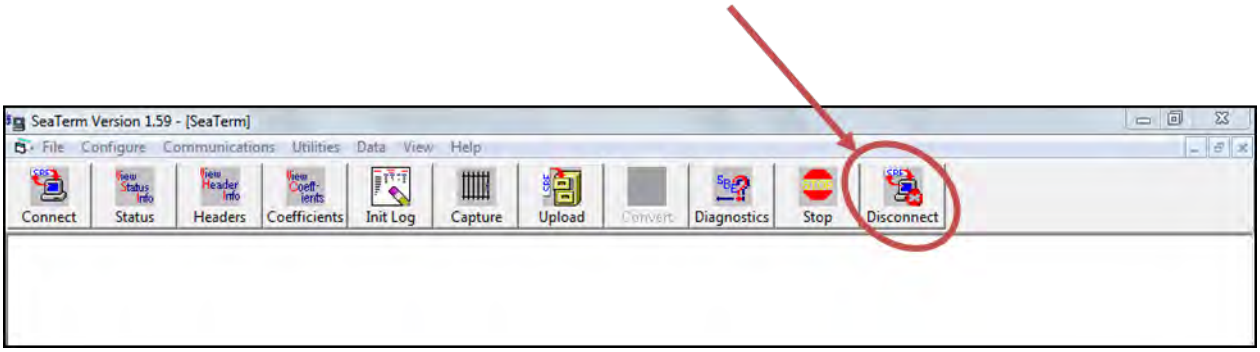


Figure 25. Image of SeaTerm software with Disconnect button highlighted.

9. Copy bath data files onto a memory stick or card. This step will assure that there are at least two copies of data in the event that one copy is lost while in the field.
10. Remove each CTD from the field bath, disconnect communication cables, and plug in SBE dummy plugs to protect pins on all cables.

6.3.16 SBE 37-SMP-ODO – Software Configurations

Note that the **Execute** button in the SeaTerm V2 software needs to be clicked on twice as first click usually gives an invalid command error.

1. Open SBE SeaTerm V2 (older version SeaTerm is not compatible with our current SBE 37-SMP-ODO sensor)
2. Select **G. SBE 37 RS232**
3. This selection will automatically send a **GetHD** command to **get and display hardware data**
4. Confirm the configuration for latop-to-sensor communication:
   a. Go to menu **Communications** and then **Configure…** (Figure 26).

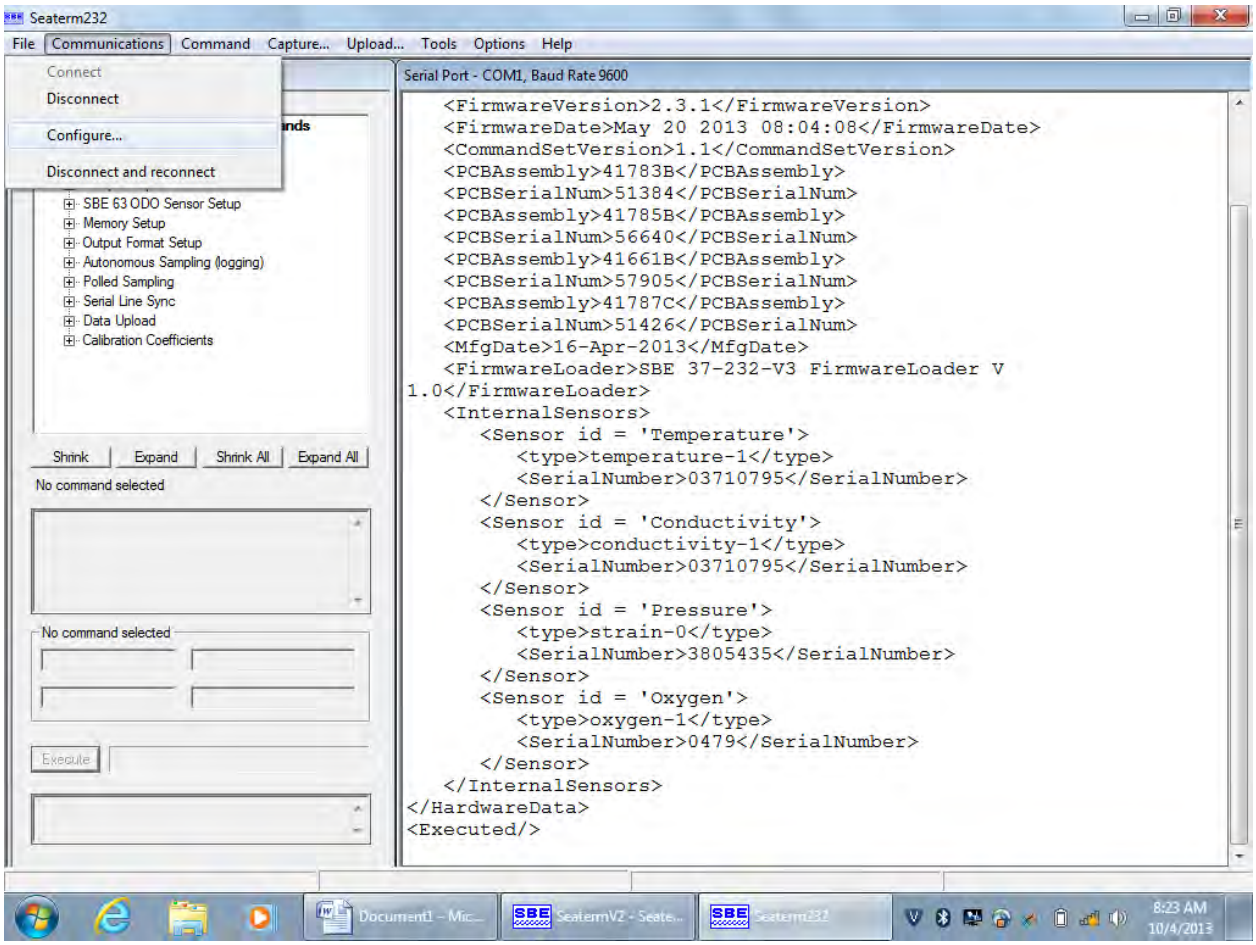


Figure 26. Image of SeaTerm V2 window with menu selection for configuration of communications settings.

b. Check that **port** is **COM1** and **baud rate** is **9600**
c. Change either in the configuration dialog box, particularly for running a sensor performance test with more than one CTD where more than one COM ports are being used

1. <u>SBE 37-SMP-ODO – Placing Sensors into Field Bath</u>

1. Put on laboratory gloves.
2. Record serial numbers of both the deploying and retrieved CTDs.
3. Except for the area around the conductivity cell intake and exhaust, clean retrieved CTD exterior of any major biofouling.
4. Connect the 4-pin end of a computer-to-CTD communication cable to each CTD.
5. Connect the serial end of the communication cable to the laptop. The serial end can also be connected to a serial-to-USB adapter and the USB end plugged into the laptop.

6. Use the SBE SeaTerm V2 software to confirm that each CTD's battery power is sufficient for running the sensor performance test (Figure 27).
    a. Open SeaTerm V2.
    b. Connect and initiate communication with CTD.
    c. Type **DS** for "Display status and configuration parameters".
    d. In the status lines, check what the **vMain** is.

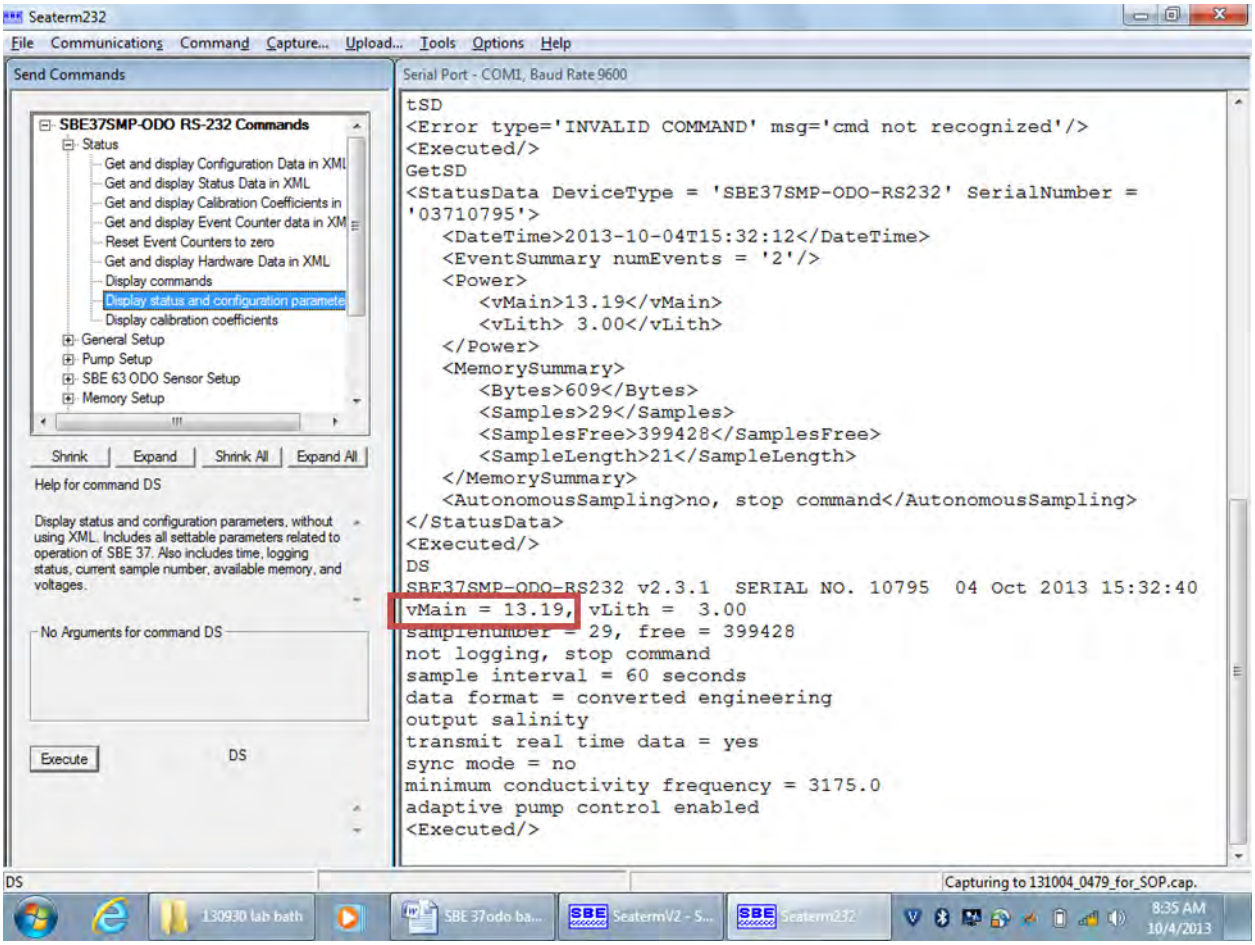


Figure 27. Image showing status of SBE 37-SMP-ODO in bottom of data echo area. Red box highlights where to find sensor battery voltage.

7. If CTD battery power is insufficient, replace the CTD batteries before proceeding with the bath.
8. Attach a bungee cord to the top of the CTD (i.e., around plastic mount).
9. Lower CTD into the bath, ensuring that the syringe remains out of water.
10. Secure one end of bungee cord to bath lid or dolly frame.

6.3.18 SBE 37-SMP-ODO – Air Bubble Removal

Unlike the SBE 43 which we attach to SBE 16*plus*, this group of sensors uses an integrated optical DO sensor (SBE 63) to determine DO amounts in water. Air bubbles

will cause an inaccurate measurement of salinity which affects the calculation of DO concentrations. Therefore, it is necessary to ensure that air bubbles are removed from the CTD conductivity cell. For this sensor, the following steps should be taken:

1. Gently rock sensor in bath water.
2. Type **PumpOn** and let pump run for about a minute.
3. Type **PumpOff** to stop pump.

6.3.19 SBE 37-SMP-ODO – Verifying Air Bubble Removal

To verify that air bubbles are pumped out of each CTD package, sensor stability, particularly that of the DO sensor, is tested. The following steps should be taken:

1. Start a capture file.
    a. Select from menu **Capture…**
    b. Save file using this naming format:
    YYMMDD_DOSN_XP_STANM where:
        i. YYMMDD = YYMMDD = 2-digit year, 2-digit month, and 2-digit day, e.g., 121217 for 17 Dec 2012.
        ii. DOSN = 4-digit serial number of DO sensor.
        iii. XP = acronym for indicating whether this is a start point (SP) or end point (EP) bath assessment.
        iv. STANM = station name, e.g., ADM01 for Admiralty Reach station.
2. Click **OK** to close dialog box.
3. Confirm that CTD date is current and time is set to Greenwich Mean Time (GMT; local time + 7 hours to convert to GMT for Pacific Daylight Time and local time + 8 hours to convert to GMT for Pacific Standard Time). Otherwise, reset them by following these steps:
    a. Go to the **Send Commands** window.
    b. In list, select **General Setup** and then **Set Date and Time**.
    c. Enter date and time following the format given in the window.
    d. Click on **Execute**.
    e. Confirm that command was executed.
4. Set sample interval to 60 seconds.
    a. In **Send Commands** window, select **Autonomous Sampling (logging)**, then **Set interval (sec) between samples** and enter **60** for argument.
    b. Alternative is to type **sampleinterval=60** in data echo area.
5. Confirm settings by typing **DS** in data echo area.
6. Take a set of five polled samples to check air bubble removal by looking for minimal variation of measurements.
    a. In **Send Commands** window, select **Polled Sampling**, then **Take multiple samples** that uses **TPSN** command.
    b. In argument box, enter **5** for **# of samples to take**.
    c. Alternative is to type **TPSN:5** in data echo area.

d. Five samples will be displayed as shown in next image with data being displayed in the following column order (Figure 28):

i. Temperature (°C)
ii. Conductivity (Siemens/meter)
iii. Pressure (decibars)
iv. Dissolved oxygen concentration (mg/l)
v. Salinity (psu)
vi. Date (dd mmm yyyy)
vii. Time (hh:mm:ss GMT)

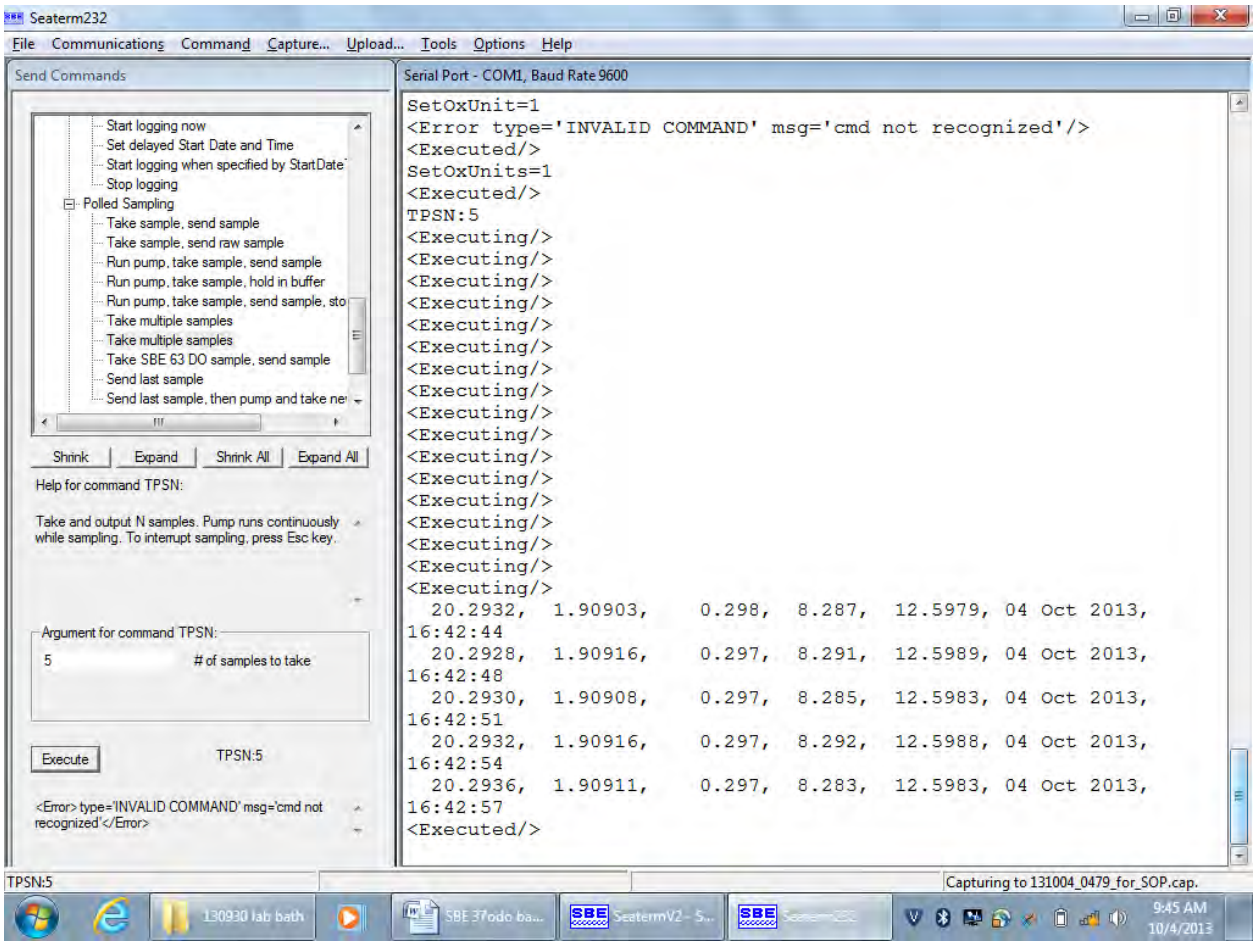


Figure 28. In bottom of data echo area, five polled samples are displayed as a result of the TPSN:5 command.

6.3.20 SBE 37-SMP-ODO – Confirm Sensor and Bath Stability

Once each DO sensor has stabilized, proceed with testing CTD and bath stability.

1. For more than one SBE 37-SMP-ODO or in conjunction with a SBE 16*plus*, effort should be made to have all CTDs sample the field bath water as simultaneously as possible, no more than 10 seconds apart. To do this:

a. Type in command without executing it for each SeaTerm V2 or SeaTerm window that is open.
b. Then, hit the **Execute** button and immediately switch to other window to execute as soon as possible.

2. Take one polled sample as simultaneously as possible to check air bubble removal by looking for minimal variation of measurements.
   a. In **Send Commands** window, select **Polled Sampling**, then **Take multiple samples** that uses **TPSN** command.
   b. In argument box, enter **1** for **# of samples to take**.
   c. Alternative is to type **TPSN:1** in data echo area.
3. Execute **TPSN:1** command two more times to generate multiple samples.
4. Compare temperature, DO concentrations, and salinity readings among each CTD and their samples to confirm stability. The values for these parameters should be reasonable based on ambient bath conditions. The goal for confirming bath and sensor stability is similar to those listed for the SBE 16*plus*.

6.3.21 SBE 37-SMP-ODO – Synchronized DO Sensor and DO Winkler Sampling

Steps to follow are very similar to those for the SBE 16*plus*. Therefore, refer to the "SBE 16*plus* – Synchronized DO Sensor and DO Winkler Sampling" subsection. The main difference will be in what data are displayed in the data echo area. These are displayed in the following column order (Figure 29):

1. Temperature (°C)
2. Conductivity (Siemens/meter)
3. Pressure (decibars)
4. Dissolved oxygen concentration (mg/l)
5. Salinity (psu)
6. Date
7. Time

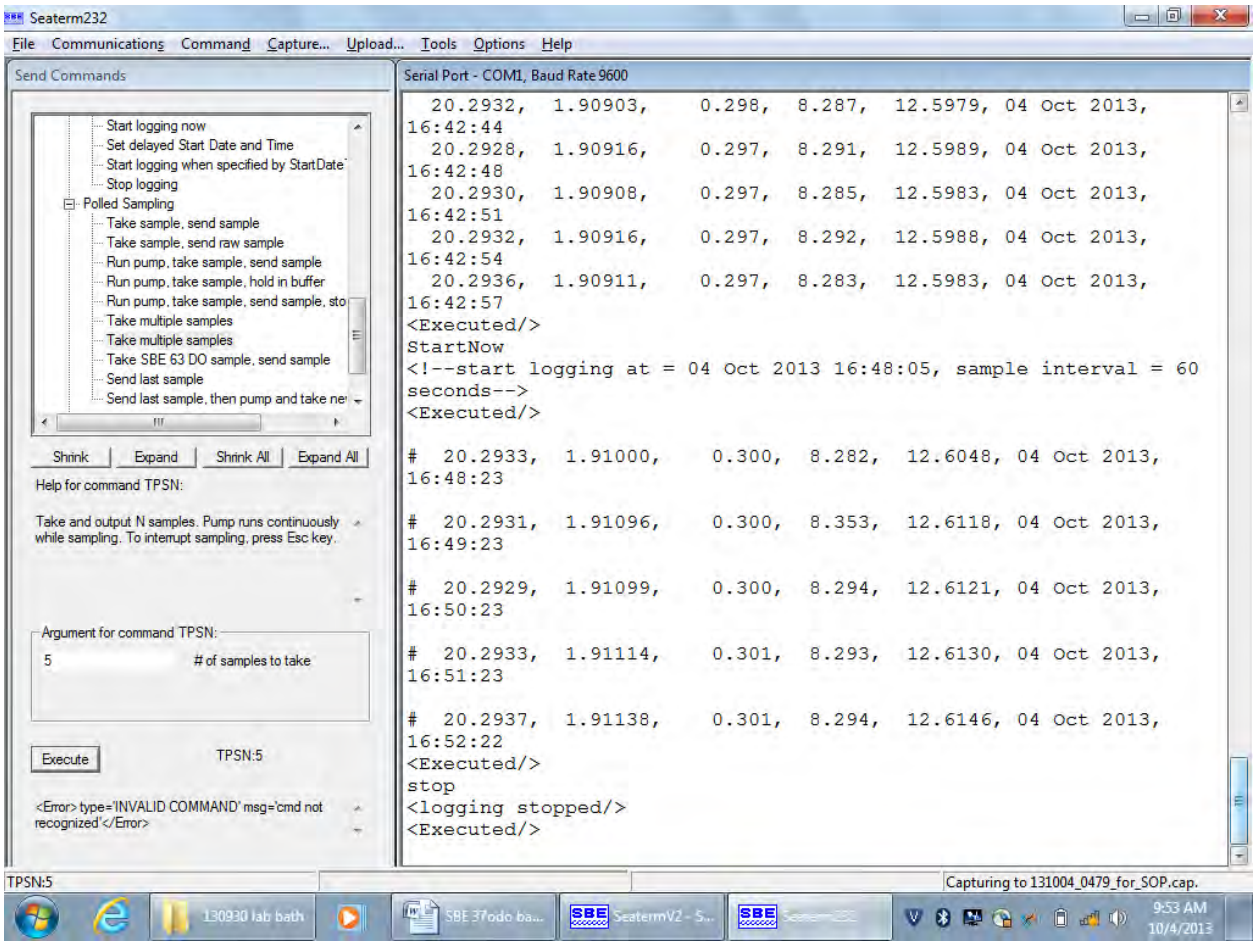


Figure 29. Example of how data are displayed during sampling. Data that have the "#" symbol preceding them are those that are synchronized with water sampling.

6.3.22 SBE 37-SMP-ODO – Synchronized Sensor and Salinity Sampling

Steps to follow are very similar to those for the SBE 16*plus*. Therefore, refer to the "SBE 16*plus* – Synchronized Sensor and Salinity Sampling" subsection. The main difference will be in what data are displayed in the data echo area as described in previous section.

6.3.23 SBE 37-SMP-ODO – Stopping the Assessment

1. Stop each CTD by one of following methods:
    a. Press **Enter** key until the **<Executed>** command prompt appears and then type **stop**.
    b. This may require a few tries.
2. Type **DS** to display the status and verify (Figure 30):
    a. Status is **not logging, stop command** which indicates CTD is no longer sampling.
    b. **vMain** which indicates the CTD's battery power.

c. **samplenumber** for number of samples in CTD's memory.

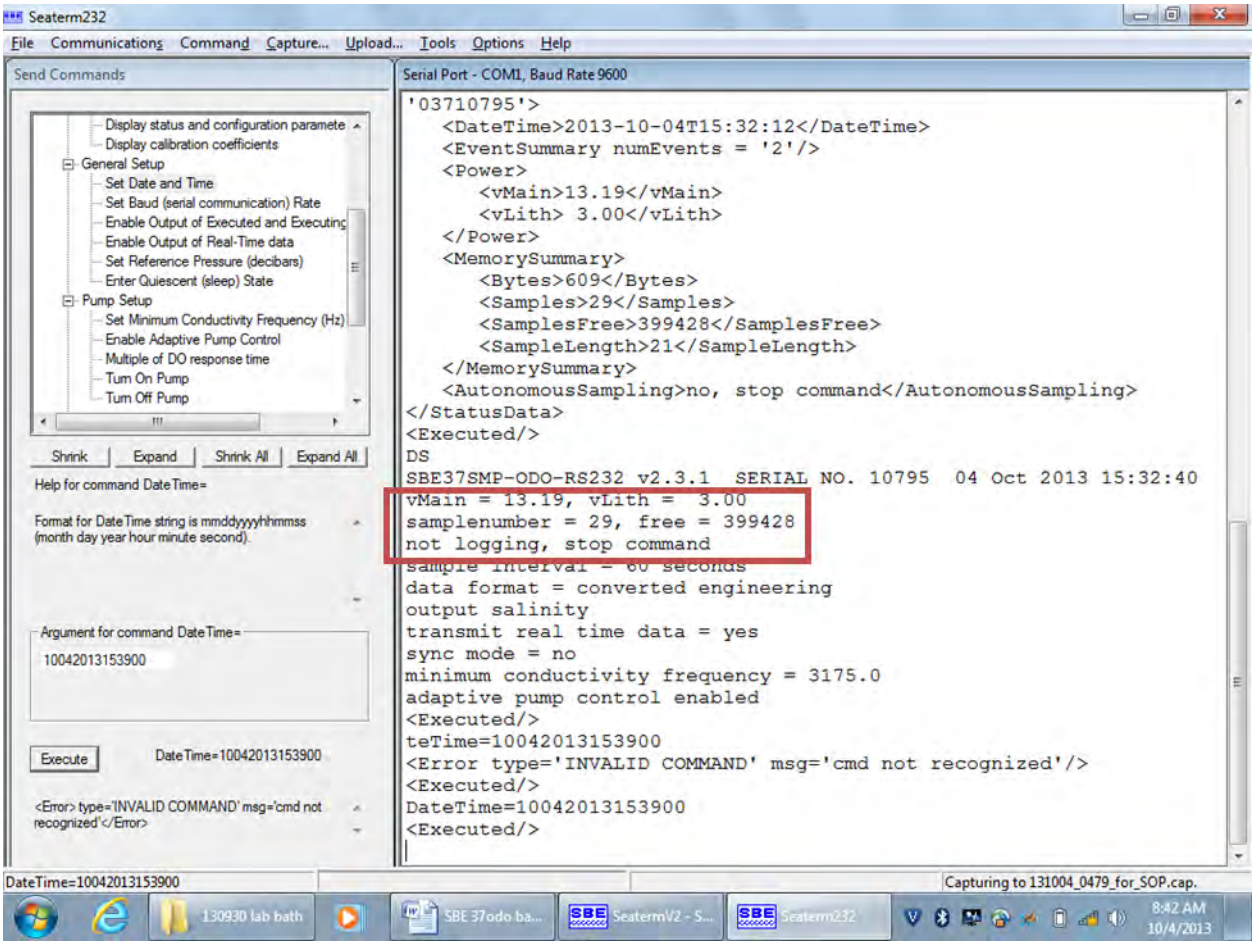


Figure 30. Example text of SBE 37-SMP-ODO's status displayed on SeaTerm V2 communication screen. The red boxes highlight where vMain, not logging, and sample number would be displayed.

3. Upload bath data:
   a. Go to toolbar menu and select **Upload…**
   b. A dialog box appears that prompts for file name.
   c. Save file with this naming format, YYMMDD_DOSN_XP_STANM.xml.
   d. Next dialog box that is displayed prompts for what data types and scans to upload and whether to prompt for header information.
   e. In the **Upload Data** tab, enter scan range (Figure 31).

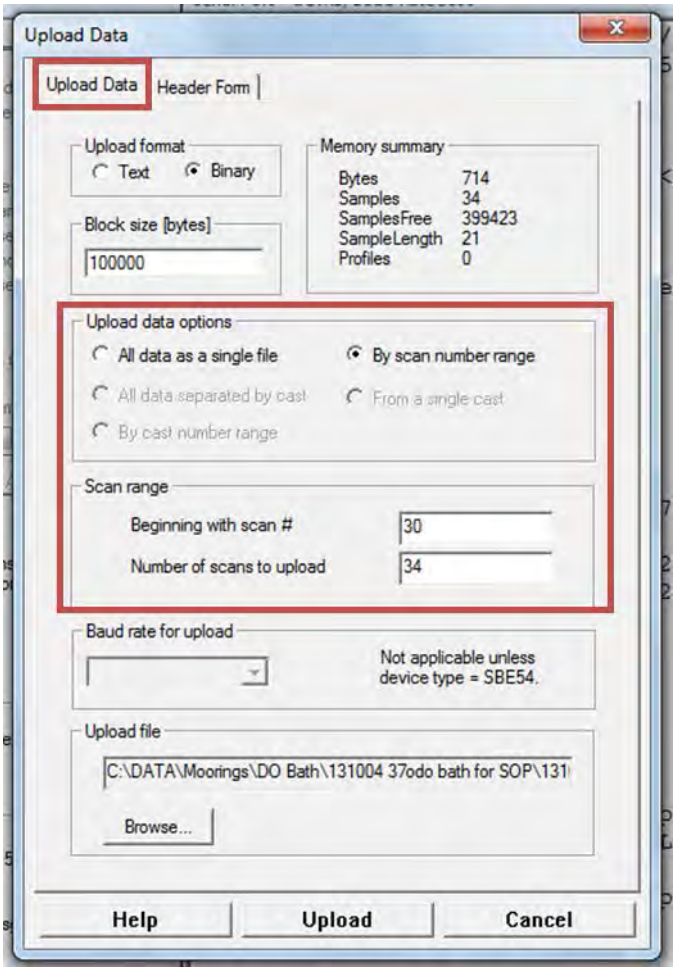


Figure 31. Image of Upload Dialog box for SBE 37-SMP-ODO.

4. In the **Header Form** tab, confirm that prompt requests follow that in next image (Figure 32):

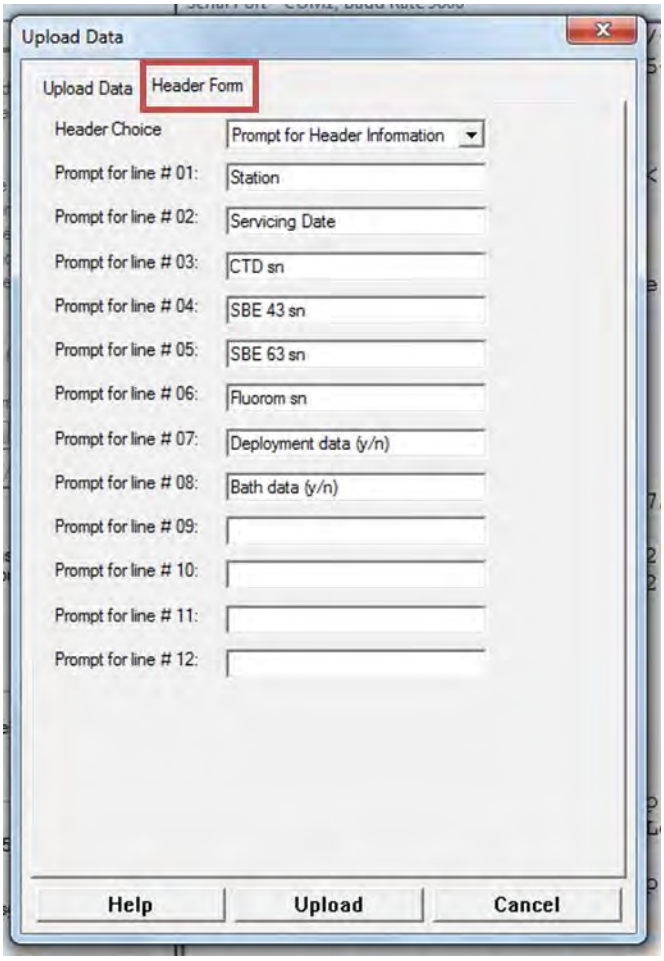


Figure 32. Image of Header Form tab for the SBE 37-SMP-ODO.

5. Click on **Upload** in the dialog box and follow prompts until data are uploaded.
6. For each CTD, save file as YYMMDD_DOSN_XP_STANM.hex where:
    a. YYMMDD = 2-digit year, 2-digit month, and 2-digit day, e.g., 121217 for 17 Dec 2012.
    b. DOSN = 4-digit serial number of DO sensor.
    c. XP = 2-letter acronym for sensor performance assessment; EP for "end point" and SP for "start point".
    d. STANM = station name, e.g., ADM01 for Admiralty Reach station.
7. Confirm using either Notepad or SeaSave software that all bath data were uploaded.
8. Type **QS** to put the CTD into quiescent state.
9. Close SeaTerm V2 program.
10. Copy bath data files onto a memory stick. This step will assure that there are at least two copies of data in the event that one copy is lost while in the field.
11. Remove each CTD from the field bath, disconnect communication cables, and plug in SBE dummy plugs to protect pins on all cables.

12. After all DO Winkler samples have settled for 15-20 minutes, re-shake each sample and seal the stopper following the SOP for Seawater Sampling.

6.3.24 Cleaning Field Bath

The field bath should be rinsed with a hose and tap water after every assessment. This can be done upon return to the laboratory. Thorough cleaning may be performed using 1% Triton-X detergent with a sponge or soft scrubber, and rinsing with tap water.

7.0 Records Management

7.1 Field Service Log Form

An example of the field service log form is in the appendix. The field bath portion of the log sheet should be filled out for every sensor performance assessment conducted in the field. Upon returning from the field, information from the field log is transferred to an electronic file which is stored on a secure, frequently backed-up agency server. The paper field log is stored in an organized paper file system and when data are finalized, archived according to agency protocols.

7.2 Tracking of Sensor Performance Assessments

It is critical to maintain and organize information from sensor assessment tests. Such information include, but is not limited to, test date, sensor sampling times, sensor serial numbers, digital file names, and DO Winkler sample collection. This information and data from bath assessments are used to assess sensor performance based on analysis and comparison with start point lab bath assessments, factory calibrations, and other related information. The analysis is then used to determine if electrical drift, physical or biological fouling, or any other event affected DO sensor performance during deployment. In addition, similar analysis will confirm the functionality of sensors that have been transported into the field and before deployment.

7.3 Computer Files

7.3.1 Sensor Performance Assessment Files

a. All file naming formats described in earlier sections of this SOP should be followed.
b. In the field, all files will be copied and archived onto a memory stick or card.
c. Upon return to the laboratory, all files will be transferred to a designated network server.

7.3.2 Database Management

a. Sensor performance assessment data recorded onto the field service log form will be entered into a designated database on a secure network server which is routinely backed up.

b. Sensor data collected using the CTD (i.e., hexadecimal data) are processed using Sea-Bird Electronics' data processing software and protocols and then transferred to the designated database.
c. Laboratory results of DO Winkler samples are entered into the database and then calculated and checked.

8.0 Quality Control and Quality Assurance Section

8.1 Manufacturer Calibrations

Calibrations of all CTDs and DO sensors are performed by the manufacturer after one year of deployment. The number of days a sensor has been deployed at various mooring stations is tracked and after one year of use, the sensor is returned to the manufacturer for service and calibration.

8.2 Sea-Bird Electronics Software

For the SBE 16*plus* CTDs, with or without the auxiliary SBE 43 DO sensor, and the SBE 37-SM and SBE 37-SMP, the SBE SeaTerm software (not SeaTerm V2) is used. The latest version 1.59, released in 2007, is the terminal program compatible with SBE 16*plus* and both SBE 37 models.

For the SBE 37-SMP-ODO CTDs, the SBE SeaTerm V2 software is used. SBE Data Processing software version 1.1i or later is used for processing bath data collected by the SBE 37-SMP-ODO. Version 1.1i is when the manufacturer included software compatibility with the SBE 37-SMP-ODO.

SBE Data Processing software is used for processing bath data collected by SBE 16*plus* and SBE 37-SMP-ODO. As the SBE 37-SM and SBE 37-SMP upload data as ASCII files, it is not necessary to use this software for data processing.

SBE SeaSave software is used for plotting data to confirm all data were successfully uploaded and sensors were operational and performing as expected.

8.3 Sensor Assessment Information Management

To assure that all data meet credible data policy, it is critical to assess sensor performance before and after deployments. Each mooring deployment requires both a start point bath assessment and an end point bath assessment. For proper assessment, it is necessary to record and keep track of each bath assessment. Therefore, field service log sheets, chain of custody records, log sheets for laboratory bath assessments, and the designated database are managed systematically and routinely verified for correctness and completeness.

8.4 Sensor Cleaning and Maintenance

Manufacturer recommendations for cleaning oceanographic sensors should be followed. Application notes for cleaning and maintaining SBE 16*plus* CTDs, SBE 5T pumps, and SBE 43 DO sensors can be found at the Sea-Bird Electronics website: www.seabird.com/application_notes/ANindex.htm.

8.5 Replicate DO Winkler Samples

Collecting 3 consecutive DO Winkler samples during a field bath assessment assures high quality data from replication that will determine and improve accuracy of sample collection and analysis.

9.0 Safety

9.1 Follow general procedures for safety found in the *Environmental Assessment Program Safety Manual* (Washington State Department of Ecology 2015).

9.2 Laboratory gloves and safety glasses should be worn when collecting and preserving DO Winkler samples.

9.3 Ensure communication cables are completely connected to the CTD data extension cable to avoid electrical shock before sensors are placed in bath. In addition, assure that communication cable connections to the laptop computer will not become wet, whether from rain, water spills, or a wet dock.

10.0 References

10.1 Bos, J. 2010. Standard Operating Procedure for Seawater Sampling, version 2.0. Washington Department of Ecology, Olympia, WA. SOP No. EAP025. www.ecy.wa.gov/programs/eap/quality.html

10.2 Sea-Bird Electronics, Inc. 2006. SBE 37-SMP MicroCAT: Conductivity and Temperature Recorder with RS-232 Interface and Integral Pump, Manual Version #006, 12/27/06, Firmware Version 2.6a and later. Sea-Bird Electronics, Inc., Bellevue, WA. www.seabird.com/old-manuals/SBE_37/SBE_37-SMP/37-SMP_RS-232/2.6a_Firmware_004-006Manual/37SMP_RS232_006.pdf

10.3 Sea-Bird Electronics, Inc. 2007a. SBE 16*plus* SEACAT: Conductivity and Temperature Recorder (pressure optional) with RS-232 Interface, User's Manual Version #018, 12/19/07, Firmware Version 1.8c and later. Sea-Bird Electronics, Inc., Bellevue, WA. www.seabird.com/old-manuals/SBE_16plus/16plus_RS-232/1.8c_Firmware_017-018Manual/16plus_rs232_018.pdf

10.4 Sea-Bird Electronics, Inc. 2007b. SBE 37-SM MicroCAT: Conductivity and Temperature Recorder with RS-232 Interface, Manual Version #026, 06/14/07, Firmware Version 2.6b and later. Sea-Bird Electronics, Inc., Bellevue,

WA. www.seabird.com/old-manuals/SBE_37/SBE_37-SMP/37-SMP_RS-232/2.6a_Firmware_004-006Manual/37SMP_RS232_006.pdf

10.5 Sea-Bird Electronics, Inc. 2008. Application Note No. 64-1, Plumbing Installation – SBE 43 DO Sensor and Pump on a CTD, revised April 2008. Sea-Bird Electronics, Inc., Bellevue, WA. www.seabird.com/document/an64-1-plumbing-installation-sbe-43-do-sensor-and-pump-ctd

10.6 Sea-Bird Electronics, Inc. 2012. Application Note No. 64-2, SBE 43 Dissolved Oxygen Sensor Calibration and Data Corrections, revised June 2012. Sea-Bird Electronics, Inc., Bellevue, WA. www.seabird.com/document/an64-2-sbe-43-dissolved-oxygen-sensor-calibration-and-data-corrections

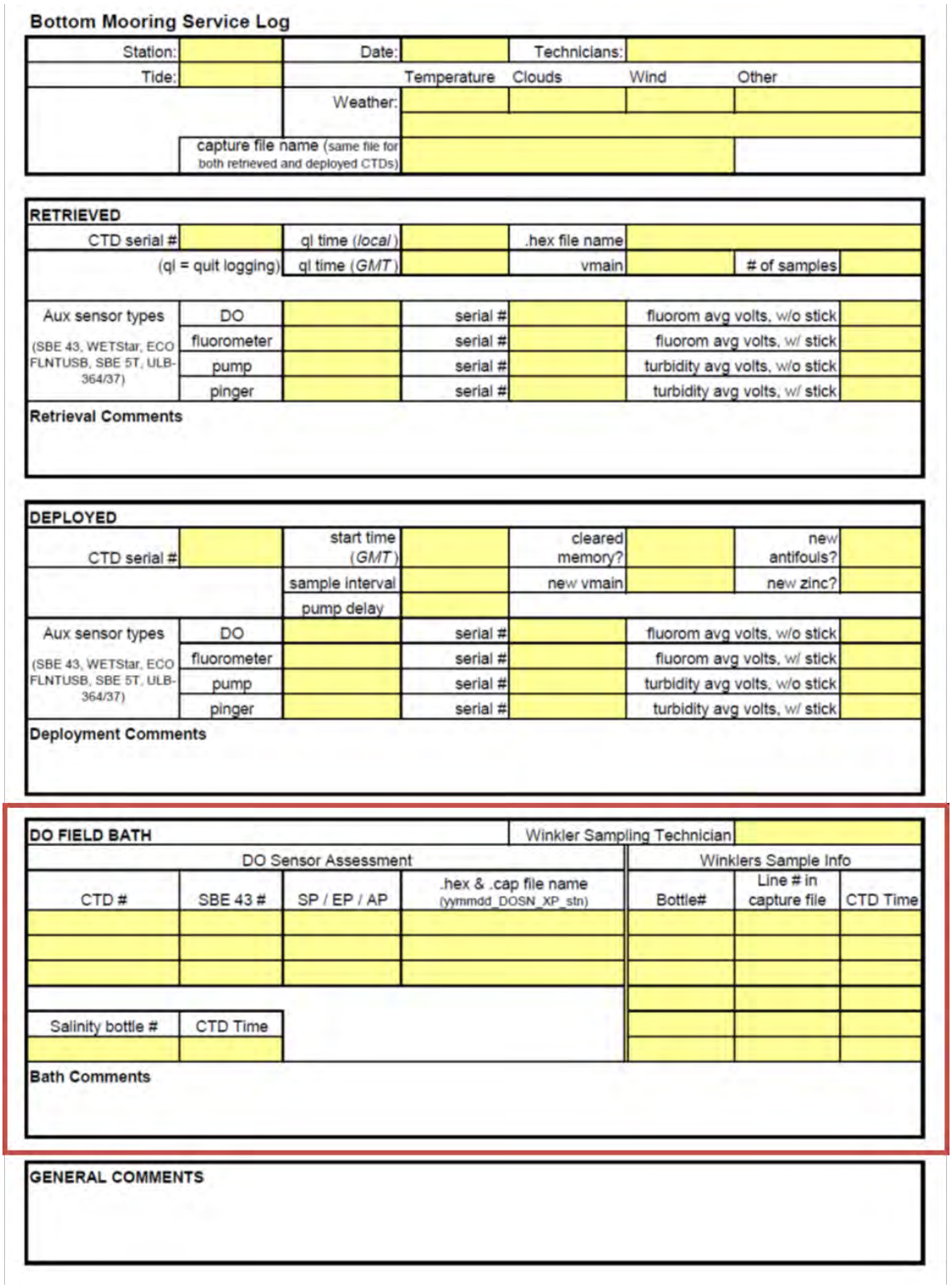
10.7 Sea-Bird Electronics, Inc. 2013a. Application Note No. 64, SBE 43 Dissolved Oxygen Sensor – Background Information, Deployment Recommendations, and Cleaning and Storage, revised June 2013. Sea-Bird Electronics, Inc., Bellevue, WA. www.seabird.com/document/an64-sbe-43-dissolved-oxygen-sensor-background-information-deployment-recommendations

10.8 Sea-Bird Electronics, Inc. 2013b. SBE 37-SMP-ODO MicroCAT: Conductivity, Temperature, (optional) Pressure, and Optical Dissolved Oxygen Recorder with RS-232 Interface and Integral Pump, Manual Version #004, 03/21/13, Firmware Version 2.2.0 and later. Sea-Bird Electronics, Inc., Bellevue, WA. www.seabird.com/old-manuals/SBE_37/SBE_37-SMP-ODO/37-SMP-ODO_RS-232/2.2.0_Firmware_004Manual/37SMP-ODO_RS232_004.pdf

10.9 Washington State Department of Ecology. 2015. Environmental Assessment Program Safety Manual. March 2015. Washington State Department of Ecology. 193 pp.

Appendix -- Example of a Field Service Log Form

Red box highlights the field bath portion of the bottom mooring service log sheet that is completed for every sensor performance assessment conducted in the field.



Bottom Mooring Service Log

Station:		Date:		Technicians:		
Tide:			Temperature	Clouds	Wind	Other
		Weather:				
	capture file name (same file for both retrieved and deployed CTDs)					

RETRIEVED

CTD serial #		ql time (*local*)		.hex file name			
(ql = quit logging)		ql time (*GMT*)		vmain		# of samples	
Aux sensor types (SBE 43, WETStar, ECO FLNTUSB, SBE 5T, ULB-364/37)	DO		serial #		fluorom avg volts, w/o stick		
	fluorometer		serial #		fluorom avg volts, w/ stick		
	pump		serial #		turbidity avg volts, w/o stick		
	pinger		serial #		turbidity avg volts, w/ stick		

Retrieval Comments

DEPLOYED

CTD serial #		start time (*GMT*)		cleared memory?		new antifouls?	
		sample interval		new vmain		new zinc?	
		pump delay					
Aux sensor types (SBE 43, WETStar, ECO FLNTUSB, SBE 5T, ULB-364/37)	DO		serial #		fluorom avg volts, w/o stick		
	fluorometer		serial #		fluorom avg volts, w/ stick		
	pump		serial #		turbidity avg volts, w/o stick		
	pinger		serial #		turbidity avg volts, w/ stick		

Deployment Comments

DO FIELD BATH — Winkler Sampling Technician

DO Sensor Assessment				Winklers Sample Info		
CTD #	SBE 43 #	SP / EP / AP	.hex & .cap file name (yymmdd_DOSN_XP_stn)	Bottle#	Line # in capture file	CTD Time

Salinity bottle #	CTD Time

Bath Comments

GENERAL COMMENTS