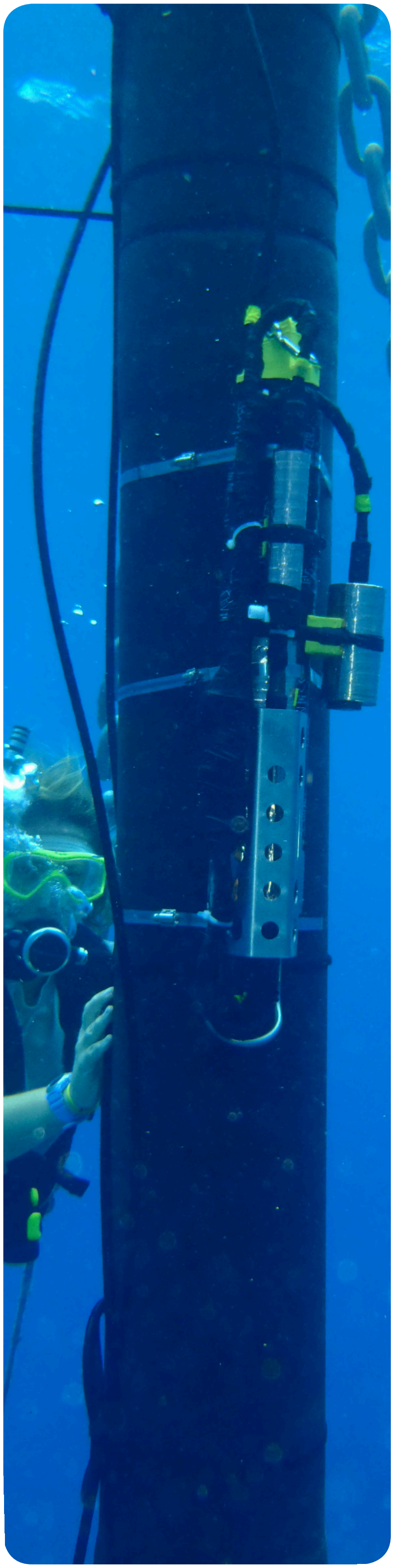
Technical Note



Troubleshooting Basics: Moored CTDs

Tips for Identifying and Addressing Common Problems

Greg Ikeda, November 2018

Introduction

Moored CTDs are a crucial asset for any monitoring program. Fixed in a single location, they create long-term datasets with minimal maintenance. By reducing the number of required visits to a field site, these CTDs and associated sensors can dramatically cut costs and improve data resolution.

However, this advantage comes with a risk: any unmanned instrument is vulnerable to problems and potential damage. If these issues cannot be immediately noticed and addressed, a moored CTD can produce several months of unusable data, often unknown to the operator until the instrument is back on land. Therefore, knowing how to troubleshoot and service a problematic CTD between mooring visits is crucial for data quality. This guide is designed to aid in diagnosing and fixing common problems.

Problems with Moored CTDs are often related to the following:

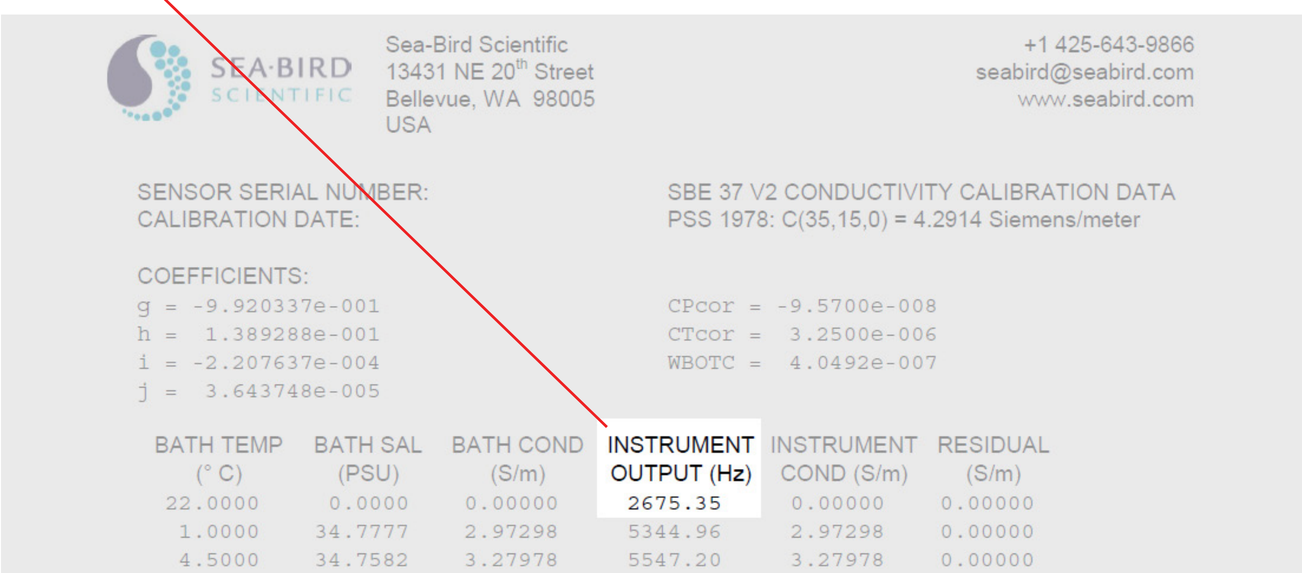
- Fouling, internal and external
- Objects or bubbles in the conductivity cell
- Issues with plumbing
- Battery failure
- Sensor damage/malfunction

One important point: while all measured parameters can be affected by CTD problems, **errors in conductivity data are the most common for moored CTDs**. While the temperature and pressure sensors are relatively resistant to fouling and damage, the conductivity cell is fragile and will be affected by fouling, sediment loading, or issues with plumbing. Fortunately every moored CTD has anti-fouling protection and a conductivity cell guard. That said, conductivity data is often a strong indicator of the root cause while diagnosing any CTD problems.

Conductivity Cells: Zero Conductivity Frequency Test

All Sea-Bird conductivity cells have a unique frequency output that corresponds with a clean, dry, and empty conductivity cell: this is called the "**zero conductivity frequency**". This value represents the baseline output from the conductivity sensor after a fresh calibration. Changes to the zero conductivity frequency result from fouling or damage, and will result in changes in your sensor's calibration. Comparing the CTD's measured zero conductivity frequency to the zero conductivity frequency from calibration will help identify if a cell needs to be cleaned or if it has been damaged. The following is a general procedure for identifying if your Sea-Bird conductivity sensor has drifted significantly:

1. Completely dry the conductivity cell by shaking out water droplets. If possible, let it dry overnight. **Do not attempt to dry with compressed air**.
2. Once dry, measure the raw conductivity frequency.
   - 16plusV2/19plusV2: connect to a terminal and send the "TCR" command. The CTD will output the raw conductivity frequency.
   - SBE 37: Send the "TSR" command. The CTD will output a string on data in raw decimal format; conductivity is the second data column. The value should be around 2500.000±500 (e.g. 2886.656).
   - Alternative Method: Log data when the conductivity cell is dry. Upload the data and convert the file in SBE Data Processing. Select "Frequency Channel 1" as an output variable—this is the raw frequency from the conductivity sensor.
3. Compare the measured zero conductivity value to the value from the most recent calibration certificate:



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SENSOR SERIAL NUMBER:
CALIBRATION DATE:

SBE 37 V2 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -9.920337e-001
h = 1.389288e-001
i = -2.207637e-004
j = 3.643748e-005

CPcor = -9.5700e-008
CTcor = 3.2500e-006
WBOTC = 4.0492e-007

BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (Hz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
22.0000	0.0000	0.00000	2675.35	0.00000	0.00000
1.0000	34.7777	2.97298	5344.96	2.97298	0.00000
4.5000	34.7582	3.27978	5547.20	3.27978	0.00000

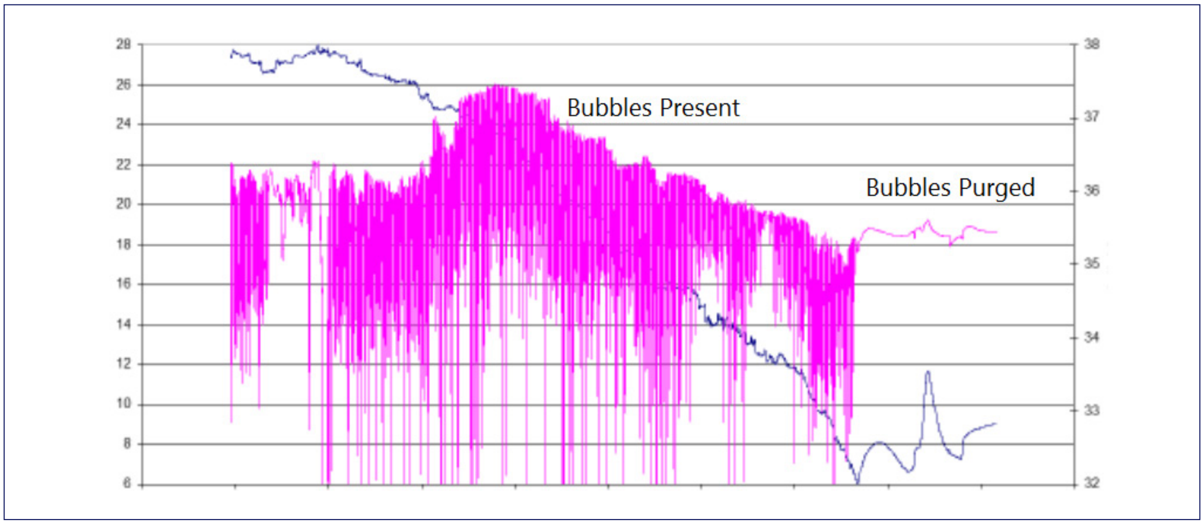
Variation of more than 0.5 Hz indicates that the conductivity sensor has changed from the last calibration. The inside of the cell may have been fouled, or the sensor may have been damaged.

1. Clean the conductivity cell with a dilute Triton X-100 Solution, or a white vinegar solution for severely fouled cells.
2. Re-check the zero conductivity frequency. If it appears to improve after cleanings, continue cleaning until it reaches the original zero frequency.

Conductivity Cell Problems: Data Examples

Bubbles in the conductivity cell can result when the flow path is clogged. These will generate downward spikes in the conductivity data. These spikes can look similar to electrical noise if large air bubbles are present in the plumbing.

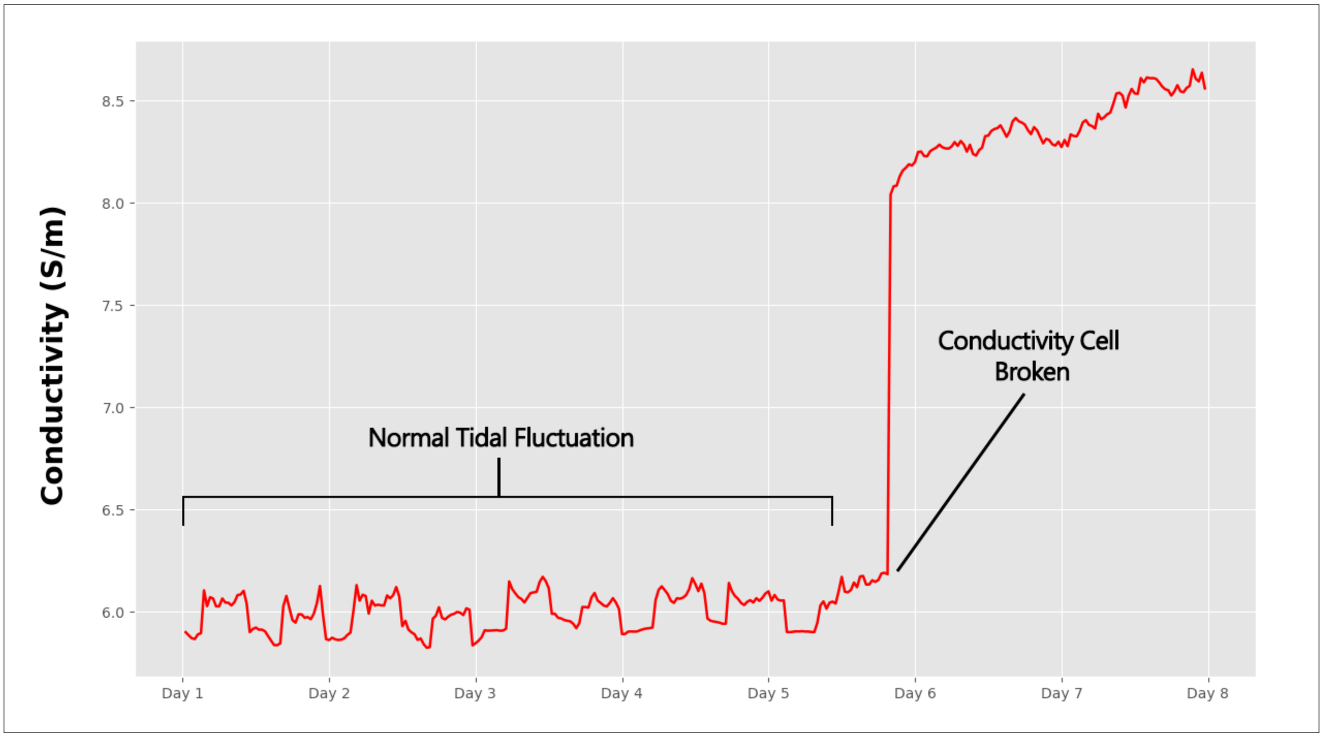
- Spikes will always be towards low conductivity.
- Spikes often disappear at higher pressures or when the pump kicks in.
- Bubbles may be more common for CTDs deployed near the surface.
- This is true for both moored and profiling CTDs.



Sediment/material in the conductivity cell will be similar to bubbles, possibly persisting longer.

- Spikes will also be low of correct.
- Often forms a more “rounded off” spike, especially in high-sediment areas.

A broken conductivity cell will often form a single jump towards higher conductivity that stays constant or drifts gradually.

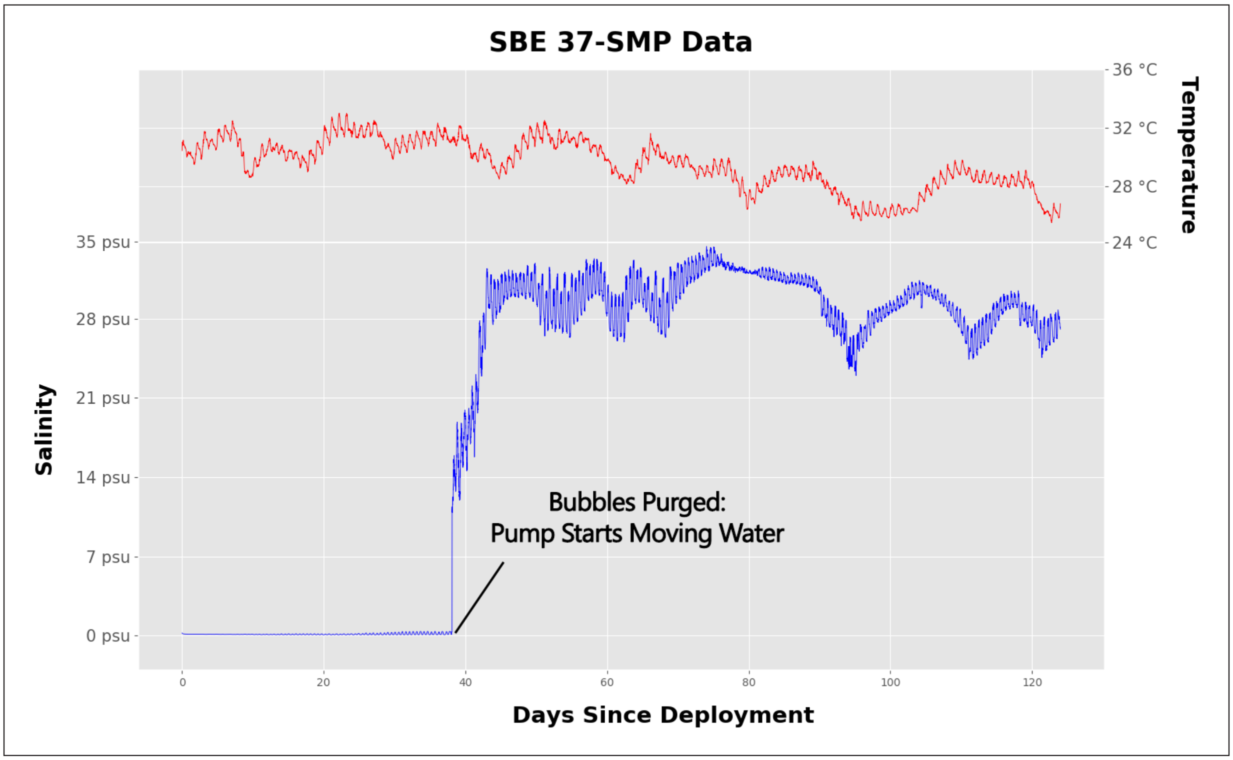


Pump Operation

The pumps on Sea-Bird Scientific CTDs help provide optimal data quality and ensure that new water always flushes through the CTD before sampling. Issues with pumps can occur if air bubbles are not able to escape, or if the plumbing is clogged with sediment or biofouling.

Identifying a Stuck Pump

Sea-Bird pumps are not self priming; air bubbles must be purged before the pump is able to operate properly. Common reasons a pump will not start are because the pathway for air bubbles to escape is clogged. An unprimed pump is usually evident when viewing data: conductivity and salinity will often appear static relative to temperature, or will stay at a near-zero value until the pump turns on if large air bubbles are caught in the conductivity cell. Once bubbles are purged and the pump is able to flush water, conductivity and salinity will usually recover quickly.

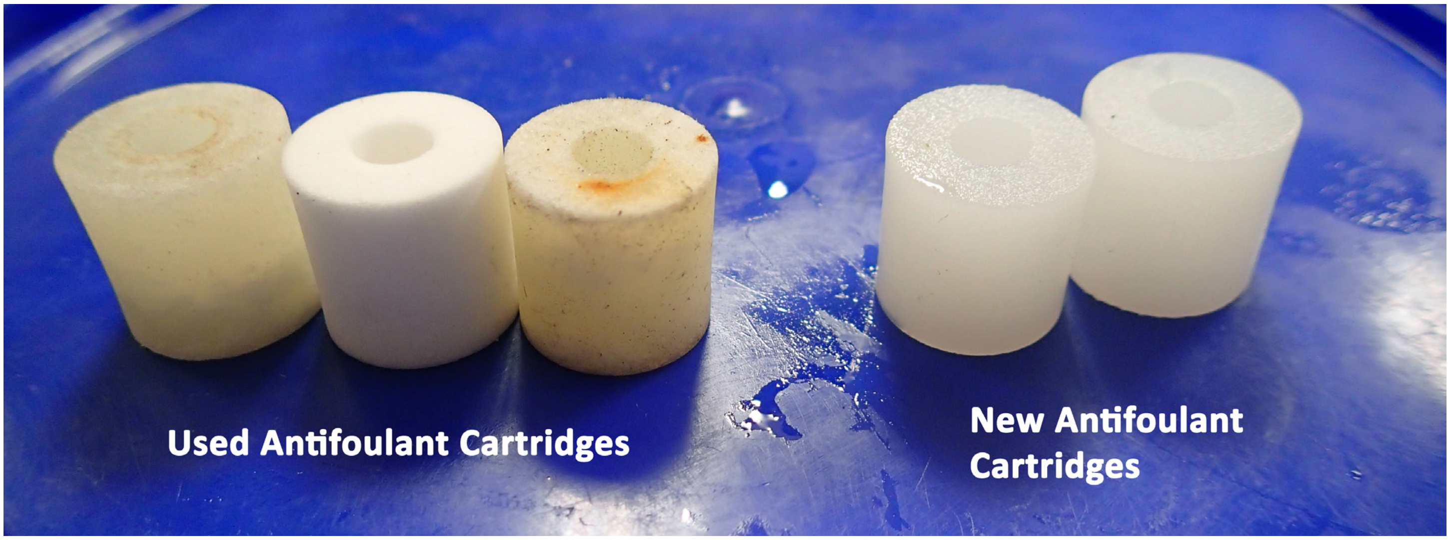


Tips for Preventing Pump Issues

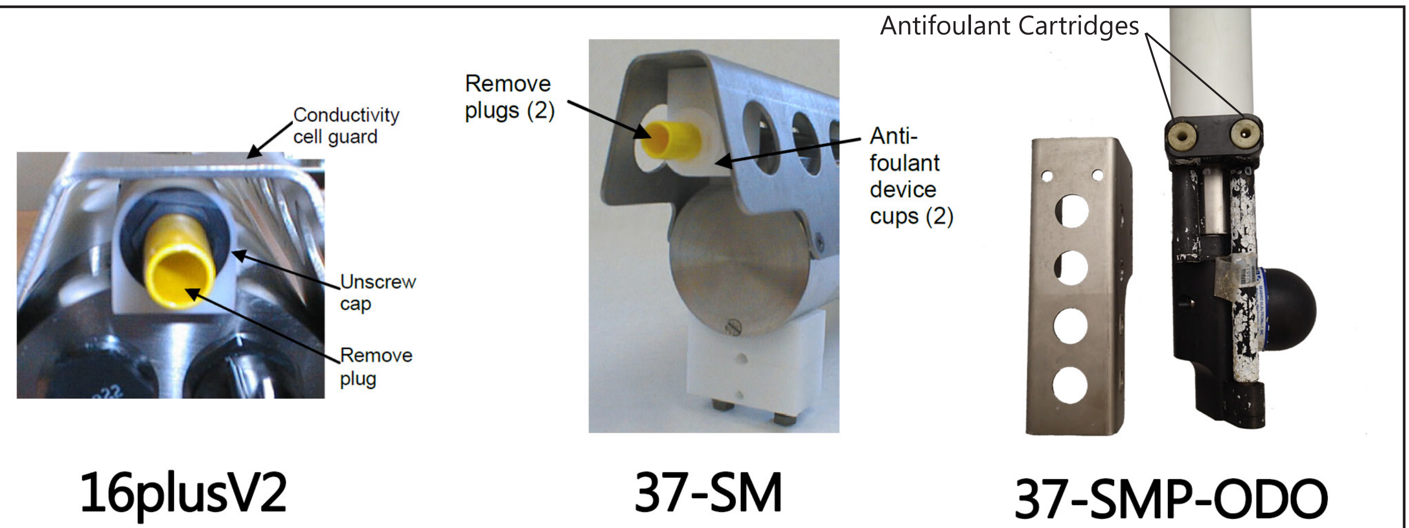
- Deploy the CTD in an orientation that allows bubbles to escape—typically with the air bleed hole at the highest point
- Clear the air bleed hole on pumped CTDs regularly
- Flush the flow path regularly, especially in high-sediment environments
- Avoid deploying the CTD close to the surface on fixed marine moorings. At low tide, the sensor may be above the surface; bubbles may remain in the plumbing after resubmerging.

Antifoulant Cartridges

Two Bis(tributyltin) oxide (aka "TBTO") antifouling cartridges housed inside the CTD's plumbing prevent biofouling on the sensors connected to the flow path. These cartridges saturate the water inside of the plumbing to prevent biological growth between samples. Even when the housing becomes unrecognizable from biological growth, the flow path and conductivity cell should remain clear of fouling for the duration of the deployment. Whenever possible, it is best to remove and visually inspect the cartridges—spent cartridges will have a mottled or bleached appearance:



The lifespan of the TBTO cartridges is highly dependent on factors such as temperature, growth rates in the surrounding environment, and sampling regime. Therefore, estimating when to replace the TBTO cartridges is difficult. The locations of TBTO cartridges for common moored CTDs are below:



NOTE: Anti-Foulant Devices contain bis(tributyltin) oxide. Handle the devices only with rubber or latex gloves. Wear eye protection. Wash with soap and water after handling.

Unexpected Stops & Fewer Samples Than Expected

Most moored CTDs have enough memory and battery power to sample for several months. However, in some rare instances, a recovered CTD may have few or no samples present on the memory, even though pre-deployment capture files indicate that the instrument was logging before it was left. These are typically from two primary reasons:

Low Battery

Moored CTDs have a "cutoff voltage". If the CTD's main battery voltage drops below the cutoff voltage, it will may automatically stop sampling.

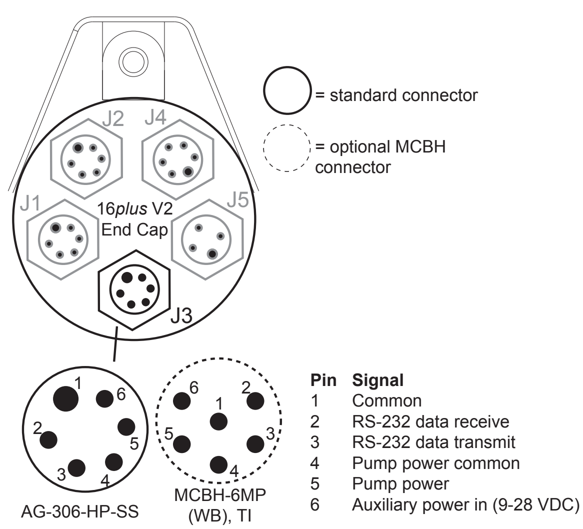
Installing fresh batteries between deployments and calculating the CTD's deployment endurance can help avoid this problem. When installing new batteries, **always ensure that the battery pack (SBE 37s) or battery cover plate (SBE 16plusV2/19plusV2) is securely installed**; if the batteries become momentarily disconnected, the CTD may register the main voltage as below the cutoff voltage and stop logging.

CTD	Cutoff Voltage
37-SM/IM	6.15 V
37-SMP/SMP-ODO	7.1 V
37-IMP/IMP-ODO	7.1 V
HydroCAT/HydroCAT-EP	7.1 V
16plusV2/19plusV2	7.5 V

Unknown stops from "not logging, stop command" / "stop = stop cmd"

If a "stop" command was not manually sent to the CTD via a terminal, but the CTD indicates that logging stopped due to receipt of the "stop" command, moisture may have contacted the Data I/O connector. The resulting electrical noise can trigger a "stop" signal for the CTD, causing it to halt logging prematurely.

- Clean the connector pins with high-purity alcohol
- Clean and regrease the connector with DC4 Silicone insulating compound
- Clean and regrease all cables and dummy plugs
- Check for signs of damage or corrosion
- Inspect the bulkhead connector for chips, cracks, or other flaws that may compromise the seal
- Ensure the cable or dummy plug is securely connected before redeployment



Data I/O, Pump, and External Power

Pre-Deployment Checklist

Model Number:
(e.g. SBE 37) ______________________________

Instrument Serial Number: ______________________________

Last Calibration Date: ______________________________ (mm/dd/yyyy)

Operator(s): ______________________________

Date: ______________________________ (mm/dd/yyyy)

Time: ______________________________ UTC

Location: ______________________________

Main Battery Voltage: ______________________________ V

Free Samples in Memory: ______________________________

Sample Interval: ______________________________ seconds

Data Output Format: ______________________________

Transmit in Real Time? Yes / No

Minimum Conductivity Frequency: ______________________________ Hz

Deployment Depth: ______________________________ m

Deployment Duration: ______________________________ days

Notes: