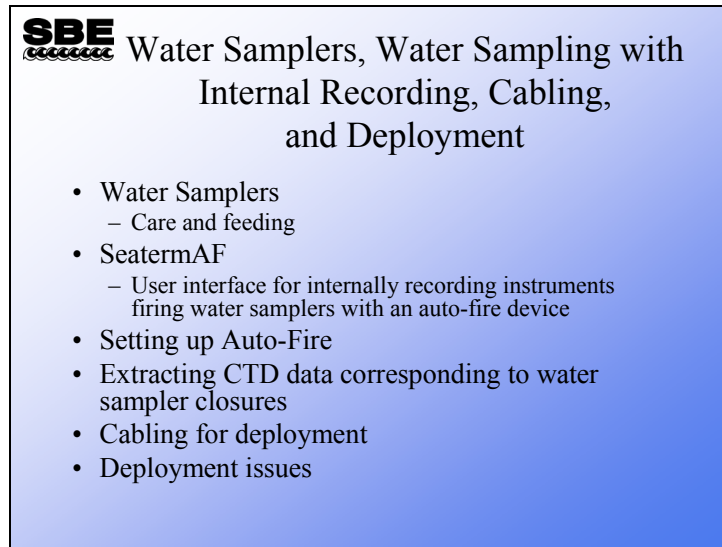


## **Module 4**

# **Water Sampling and Deployment**

## Overview



**SBE**  
Water Samplers, Water Sampling with  
Internal Recording, Cabling,  
and Deployment

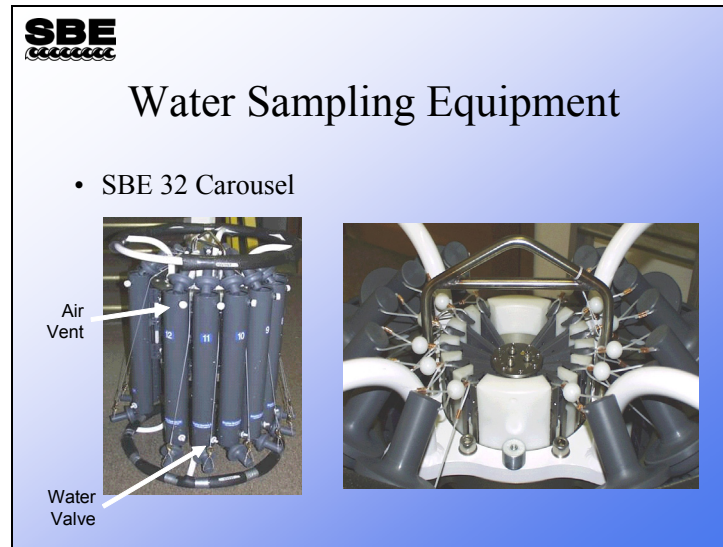
- Water Samplers
  - Care and feeding
- SeatermAF
  - User interface for internally recording instruments firing water samplers with an auto-fire device
- Setting up Auto-Fire
- Extracting CTD data corresponding to water sampler closures
- Cabling for deployment
- Deployment issues

We are going to discuss the workings of water samplers and techniques for collecting water samples with internally recording instruments. SeatermAF, the user interface for water sampling with an auto-fire device, will be presented. We will also cover deployment issues, cabling, and preparation of the instrument package to go over the side of the ship.

When we finish this module you should be able to:

- Maintain your Carousel water sampler.
- Use SeatermAF to set up your auto-fire device.
- Create data summary tables that correspond to water samples.
- Cable your instrument from your computer room to the instrument on deck.
- Maintain your underwater connectors.
- Plumb your sensors properly.
- Prepare your instrument to make measurements in the ocean.

## Water Sampling Components




Here are pictures of water sampling equipment.

The water sampling package consists of:


- water sample bottles with their lanyards
- trigger mechanism
- upper and lower pylons that hold the bottle on the frame
- upper and lower frame that protects the package from collision with the side of the ship

The Carousel trigger mechanism is an electro-mechanical device. It operates by energizing a solenoid magnet that pulls a mechanical trigger, releasing the nylon lanyards that hold the top and bottom caps of the water sampler open.

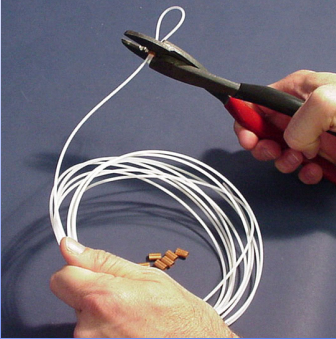
## Carousel Maintenance



### Carousel Maintenance



- Wash with fresh water after each use; Tiodized trigger surface is water lubricated
- Oil will gum triggers
- Replace worn lanyards



The trigger mechanism of the Carousel is made of titanium. The titanium pieces are coated with Tiodizing; this product is similar to anodizing aluminum. The Tiodized surface is water lubricating and should **never** be oiled with petroleum or silicon-based products. Rinse your trigger mechanism with fresh water after each cast and clean it periodically with soap and water.

Lanyards are made of nylon, 0.080-inch diameter, line-trimmer cord. They are crimped with copper nico-press sleeves. The line trimmer cord is available at most home and garden stores. The nico-press sleeves are available from Sea-Bird or most industrial supply stores.

## Autonomous Water Sampling with Internally Recording Instruments

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### Autonomous Water Sampling with Internally Recording Instruments

- AFM – Auto Fire Module
  - Receives pressure information from SBE 19, SBE 19*plus*, SBE 25, or SBE 50
- SBE 17*plus* Version 2
  - Receives pressure information from SBE 9*plus*
  - Also provides battery power and internal data recording (16 Mbyte of memory) for SBE 9*plus*
- Both receive closure protocol from user via SeatermAF

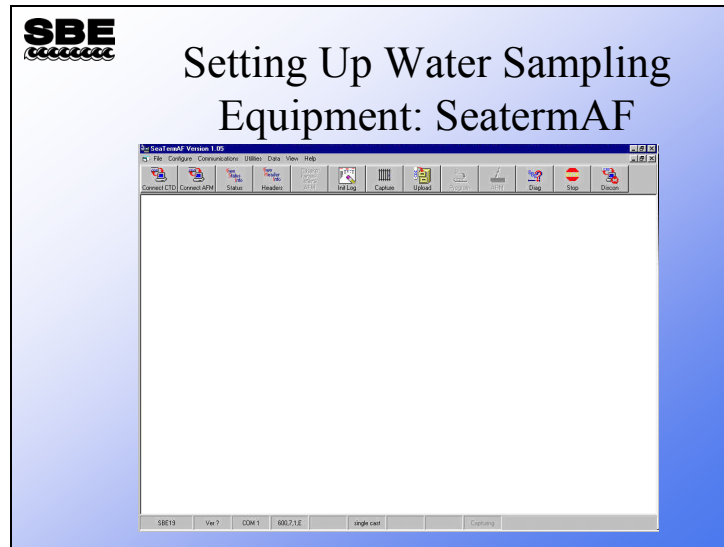


**SBE 17*plus* V2**

Sea-Bird offers two products for closing water sampler bottles remotely. The AFM and the SBE 17*plus* V2 SEARAM both receive pressures from the CTD and are programmed to close bottles on operator-chosen criteria.

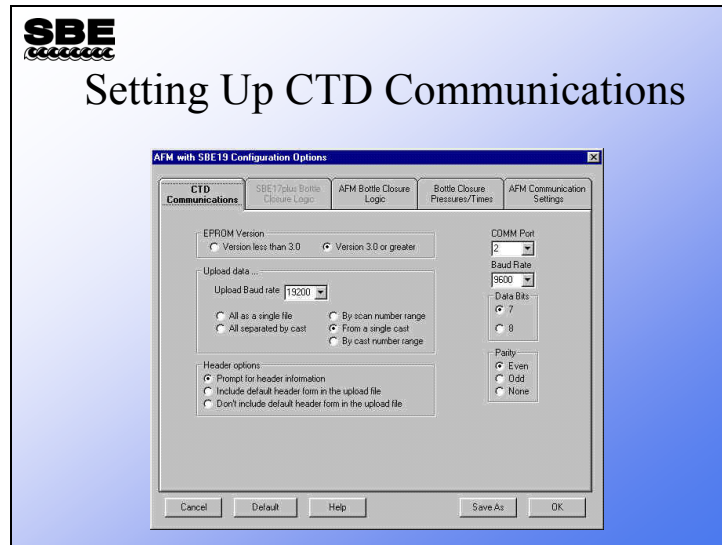
- The AFM is compatible with several CTDs, and closes bottles on downcast (descending), upcast (ascending), when the instrument package is stationary, or on elapsed time. For all options except elapsed time without CTD, the AFM must receive data from the CTD. If using the elapsed time option, you may record CTD data in the AFM each time a bottle is closed or you may use the AFM by itself, without a CTD.
- The SBE 17*plus* is much more straightforward to use, because there are fewer options. It only closes bottles on the upcast, and is only used with one type of CTD, the SBE 9*plus*.

## Setting up Water Sampling Equipment with SeatermAF



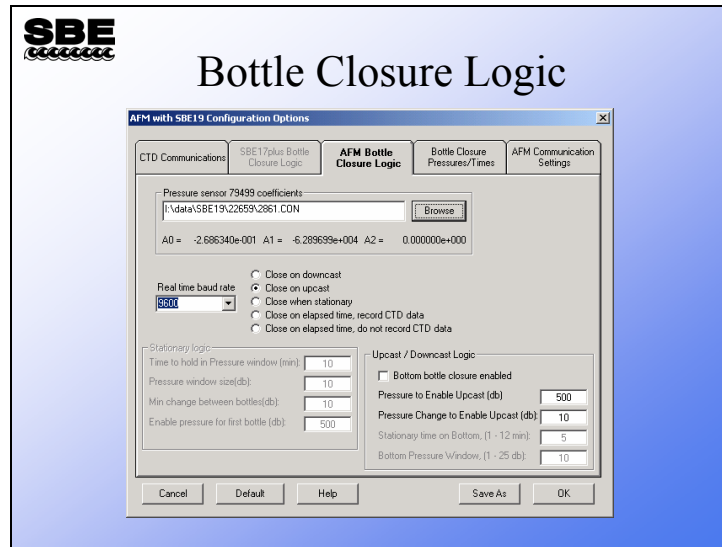
SeatermAF is a superset of Seaterm; it includes a simple interface for entering bottle closure parameters, and transfers that information to the auto-fire equipment. It is also used to set up the SBE 19, 19*plus*, 25, or 50 for operation, and to upload data from the auto-fire equipment (AFM or SBE 17*plus* V2).

## SeatermAF: Setting Up CTD Communications



The CTD communications form allows you to select the communications parameters for your instrument as well as data transfer protocol and header options. As before, instruments with older firmware revisions are not able to change baud rate during data transfers. This form is an abbreviated version of the configuration form found in Seaterm.

## SeatermAF: Setting up the Sampling Protocol



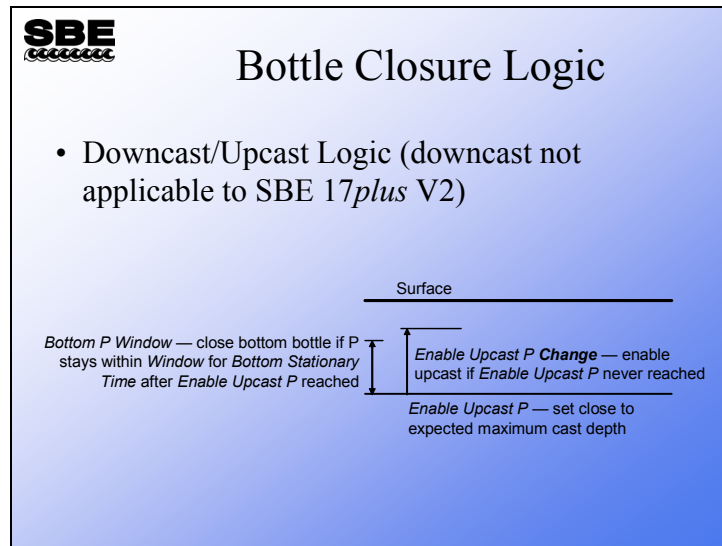
The bottle closure logic tab contains almost all the information that the AFM or SBE 17*plus* V2 need to close water sample bottles based on the closure protocol you select.

- With the AFM, you have the choice of closing bottles during downcast, during upcast, when the instrument package is stationary, or on time elapsed since the AFM was armed.

With the SBE 17*plus* V2, you can close bottles on the upcast only. The closure logic for the 17*plus* V2 follows.




## SeatermAF: Setting up the Sampling Protocol (continued)



The AFM and SBE 17plus V2 can both collect water samples during the upcast (as the instrument package is rising). Click *bottom bottle closure enabled* to take a sample at the deepest part of the cast. To collect a bottom bottle, you must specify a pressure to enable the bottom bottle, a length of time you will hold the instrument package stationary on the bottom, and the pressure window within which the instrument package will be considered stationary. In addition, you must specify *pressure change to enable upcast*. This parameter ensures that bottles are closed if the enabling pressure is not reached.

The AFM can also collect water samples during the downcast (as the instrument package is falling); parameters similar to those required for collecting on the upcast define the closure logic. Click *bottom bottle closure enabled* to take a sample at the deepest part of the cast. To collect a bottom bottle, you must specify a pressure to enable the bottom bottle, a length of time you will hold the instrument package stationary on the bottom, and the pressure window within which the instrument package will be considered stationary.

## SeatermAF: Setting up the Sampling Protocol (continued)




### Bottle Closure Logic

- Stationary logic (AFM only)
  - Once CTD has reached *Enable pressure for first bottle*, bottle closes each time P remains within *Pressure window size* for *Time to hold in Pressure window*.
- Elapsed time (AFM only)

With an AFM, samples can be collected when the instrument package is held stationary. The stationary logic dictates what constitutes stationary: how long to hold the package still and how large the pressure window is. You must set the pressure window size to allow for the rocking of the ship and set the time that you will hold the instrument in that window. You must also set an enable pressure; the package must go below this depth before the AFM will close any bottles. Also, you must specify the minimum pressure change between bottles to avoid multiple closures at essentially the same location.

With an AFM, samples can be collected on elapsed time. The AFM has an internal clock and closes water bottles on time from when it was given the Arm command.

## SeatermAF: Setting up the Sampling Protocol (continued)




### Auto-Fire Setup

- AFM
  - With SBE 19 or 25: AFM converts user-input closure parameters in decibars to raw pressure numbers using .con file coefficients, CTD transmits raw pressure data to AFM
  - With SBE 19*plus* or 50: Instrument transmits data in decibars to AFM
- SBE 17*plus* Version 2
  - SBE 9*plus* transmits raw pressure data, SBE 17*plus* V2 converts raw pressure data to decibars, using .con file coefficients

You might remember that there was an entry for the configuration (.con) file on the Bottle Closure Logic tab.

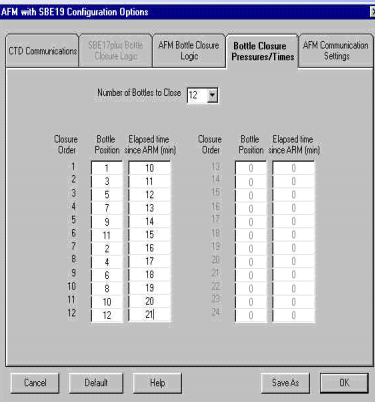
- For the SBE 19 and SBE 25, the instrument configuration (.con) file (which includes pressure calibration coefficients) is required because the AFM receives raw data from the CTD. Rather than require the AFM to process the CTD pressure data, SeatermAF calculates what the raw pressure sensor output would be for the user-input closure pressures; these raw numbers are used by the AFM to determine when to close a bottle.
- The SBE 19*plus* and the SBE 50 send pressure in decibars to the AFM, so a configuration file is not required.
- For the SBE 9*plus*, the instrument configuration (.con) file (which includes pressure calibration coefficients) is required because the SBE 17*plus* V2 receives raw data from the CTD. The SBE 17*plus* V2 calculates pressures in decibars as data is received from the 9*plus*, and compares these pressures to the user-input closure pressures to determine when to close a bottle.

## SeatermAF: Setting up the Sampling Protocol (continued)



### Bottle Closure Pressures or Times

- SBE 17*plus* and AFM close bottles on pressure
- AFM will close bottles on elapsed time in minutes from when the AFM is armed



Closure Order	Bottle Position	Elapsed time since ARM (min)	Closure Order	Bottle Position	Elapsed time since ARM (min)
1	1	10	13	0	0
2	3	11	14	0	0
3	5	12	15	0	0
4	7	13	16	0	0
5	9	14	17	0	0
6	11	15	18	0	0
7	2	16	19	0	0
8	4	17	20	0	0
9	6	18	21	0	0
10	8	19	22	0	0
11	10	20	23	0	0
12	12	21	24	0	0

Once you have defined the governing bottle closure logic – on upcast, on downcast, when stationary, or on elapsed time – you need to enter the number of bottles to close and which bottle to close when. Bottles may be closed in any order desired.

- If closing on downcast, closure pressures must increase from closure 1 to the last closure (e.g., 10 db, 20 db, 50 db, etc.).
- If closing on upcast, closure pressures must decrease from closure 1 to the last closure (e.g., 500 db, 400 db, 350 db, etc.).
- If closing on elapsed time (time since AFM was armed), closure times must increase from closure 1 to the last closure (e.g., 2 minutes, 5 minutes, 10 minutes, etc.).

## Data Recorded in Auto Fire Instrument



### Data Recorded in Auto Fire Instrument

- AFM
  - 5 CTD scans are recorded in AFM at time of each bottle closure
- SBE *17plus V2*
  - Since *17plus V2* is also memory module for SBE *9plus*, all *9plus* CTD data is recorded in *17plus V2*
  - Bottle closure bit in status byte is set for 36 scans to indicate time of each bottle closure

## Real-Time Data and Water Samples from an Internally Recording Instrument

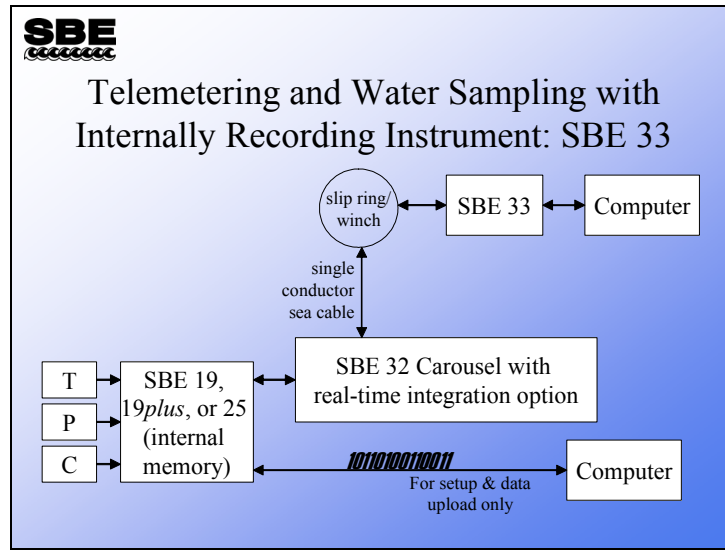
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### Telemetry and Water Sampling with Internally Recording Instrument: SBE 33

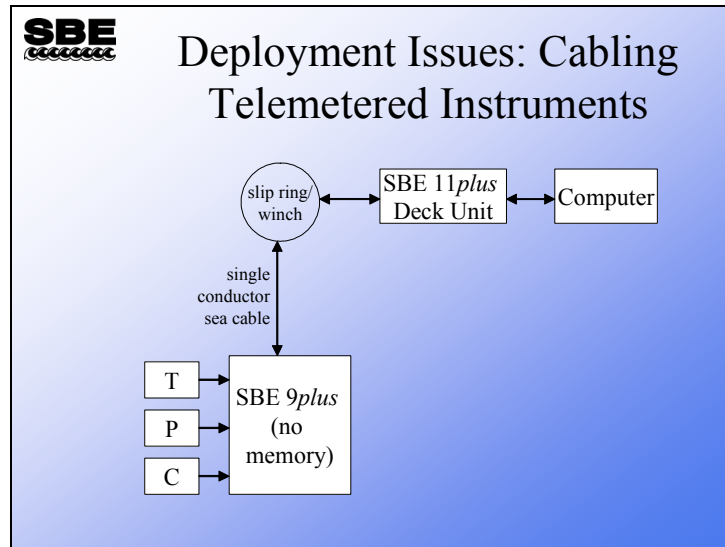
- Real-time interface SBE 32 Carousel:
  - receives power from SBE 33
  - converts it to power for SBE 19, *19plus*, or 25
  - telemeters data to deck

The SBE 33 provides power and telemetry for internally recording instruments. Telemetry capability is over 10 km of sea cable.

## Cabling for the SBE 33

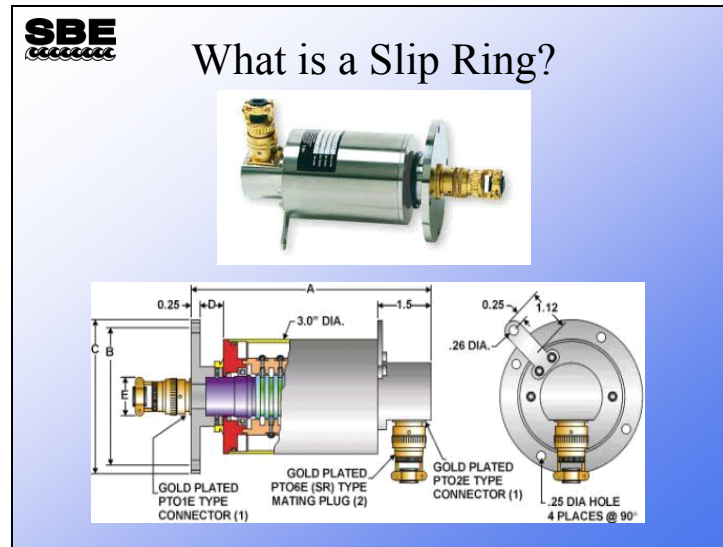


## Deployment Issues





## Deployment Components: Slip Rings



A slip ring is an electromechanical device that mounts to the part of the winch that rotates: the drum. When the instrument package is raised or lowered the drum turns, winding sea cable in or letting it out. The slip ring makes a connection between the sea cable rotating on the drum and the cable that connects to the SBE 11*plus* in the lab.

One side of the slip ring connects to the sea cable's internal conductor and the armor of the sea cable; this side has rings of metal separated by insulators arranged in a cylinder. The other side, which connects to the SBE 11*plus*, has conducting fingers that rest on the metal rings, providing continuity between the sea cable and the cable connecting to the 11*plus*.

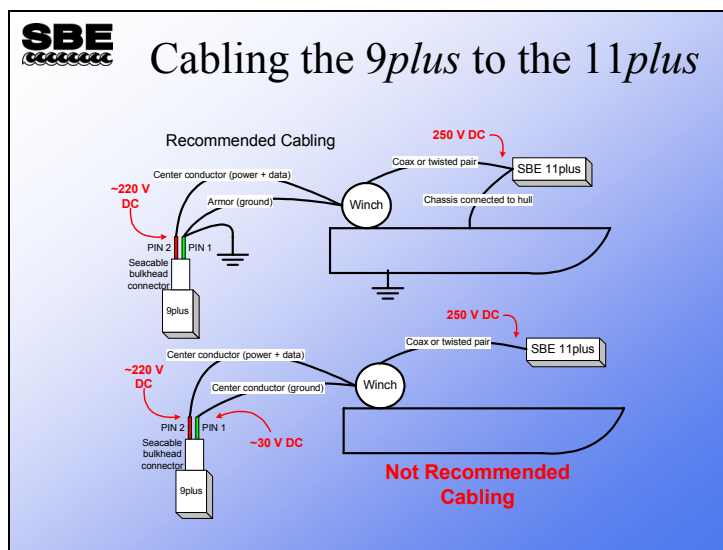
## Cabling the *9plus* to the *11plus*



### Cabling the *9plus* to the *11plus*

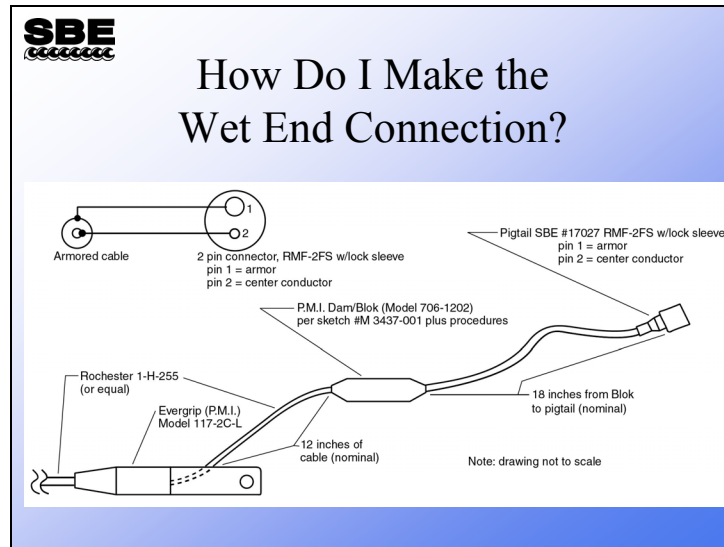
- Use #20 twisted pair or coax to cable between SBE *11plus* and winch
- Seacable is typically single or multi-conductor armored cable up to 10,000 meters, with less than 350 ohms resistance
- Grounding considerations
  - Use armor of sea cable for ground
  - Remember, salt water conducts, ship is metal (usually)
  - Ground chassis of your deck unit to hull of ship

## Cabling the 9plus to the 11plus (continued):



The slide above illustrates the recommended cabling for the SBE 9plus and the 11plus as well as a *not* recommended method. The primary difference between the two is that the recommended method utilizes the seacable armor as the return or ground for the SBE 9plus. This ensures that the underwater instrument package will be at the same potential, presumably ground, as the ship's hull. If the *not* recommended method is used, there is the possibility that the instrument package will be at a higher potential than the ship's hull and may cause injury to the crew that handles the over-the-side equipment.


## Deployment Components: Wet End Termination



## Deployment Components: Batteries

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### Changing Batteries



NIMH Batteries

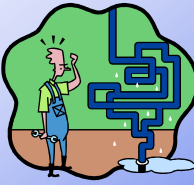
Ni-Cad Batteries

## Deployment: Instrument Plumbing

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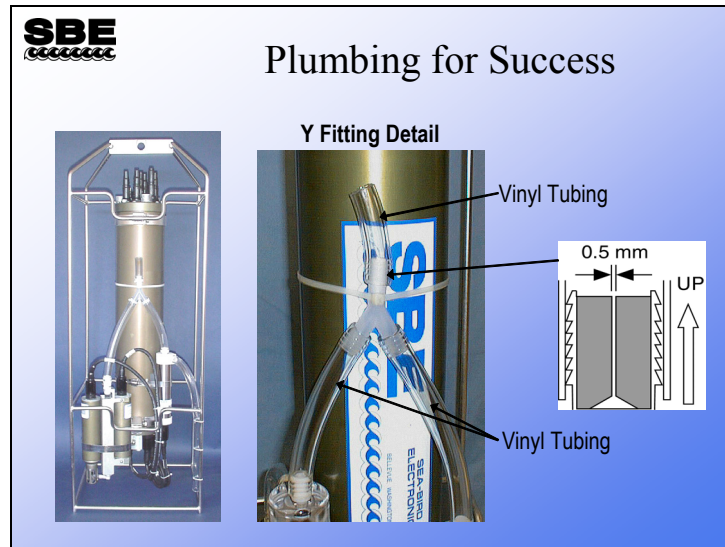
### Plumbing for Success

- Sea-Bird conductivity cells and oxygen plenums rely on water passing through them, usually via a pump
- Pump is magnetically coupled impeller type, not self-priming
- Arrange tubing on instrument package to allow all air to escape from plumbing



Sea-Bird CTDs use a pump to maintain a constant flow of water through the conductivity cell and past the oxygen electrode. While this technique complicates the instrument package, it pays off in data quality. The tubing that connects the pump and the sensors must be arranged to allow all the air that is in the system while it is on deck to escape quickly when it is submerged. Failure to allow a path for the air to escape causes problems in the first 10 meters of data collection. Beyond 10 meters, the bubbles usually collapse sufficiently for the system to operate correctly. If bubbles collect in the pump, it will fail to prime. If bubbles are caught in the conductivity cell, the pump will fail to turn on. If bubbles are caught in the dissolved oxygen plenum, the dissolved oxygen signal will be in error.

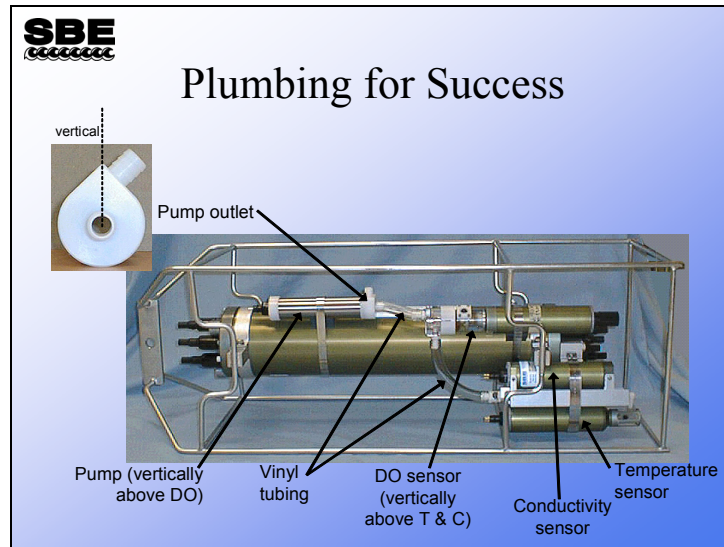
## Deployment: Plumbing Examples



This slide shows the proper way to run the tubing for an instrument in a cage meant to be deployed vertically. Note the highest point in the plumbing is the top of the *Y*; there is a fitting with a small hole in the top of the *Y* that allows the air in the tubing to vent as the instrument goes into the water.

For the SBE *9plus*, an exhaust tube runs from the pump outlet down the side of the cage, stopping at the same height as the T-C duct inlet. This equalizes pressure at the plumbing inlet and outlet, eliminating any acceleration / deceleration of water in the plumbing (which can cause small errors in the measurements). The exhaust tube is usually omitted for the SBE *19plus* and SBE 25, due to the lower accuracy of those systems.

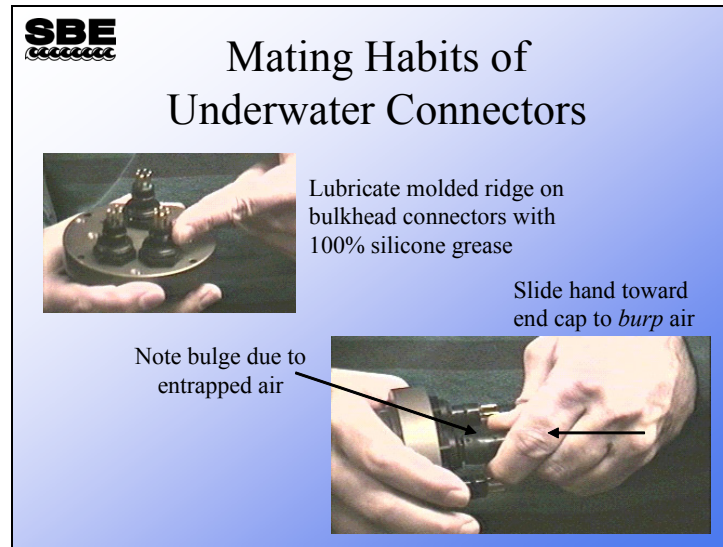
## Deployment: Plumbing Examples (*continued*)



Instruments meant for horizontal deployment are easier to plumb. The pump is oriented so that the outlet is the highest point on the plumbing. Care must be taken to ensure there are no loops in the plumbing that would trap air. Because this system is meant to be deployed horizontally, there is no *sloshing* effect and no requirement for the SBE *9plus* that the inlet and outlet be at the same height.



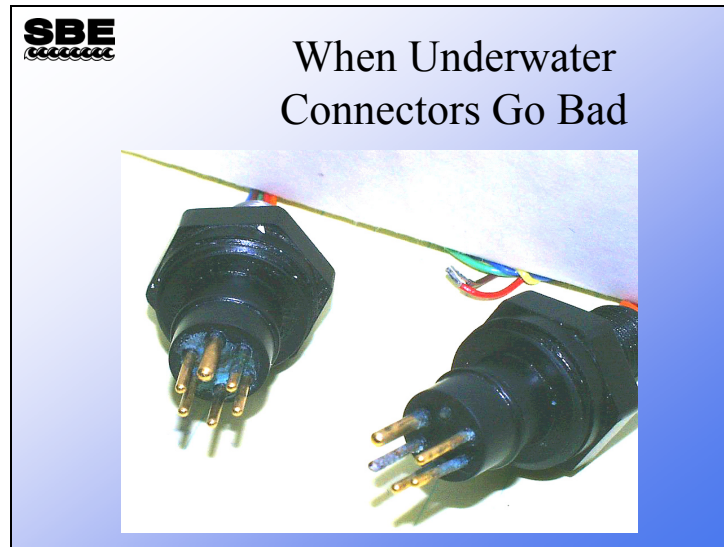
## Deployment: Underwater Connections



Underwater connectors require some care. The bulkhead connector is the part that is mounted on the end cap of the instrument. The bulkhead connector should be lubricated with a light coating of silicon grease; this acts as a lubricant and a sealant. When the cable is pressed onto the bulkhead connector, there is often air trapped inside between the bulkhead connector and the cable connector. If you slide your fingers down the body of the connector, you can force any trapped air out from between the two. This is described as *burping* the connector.


Avoid lubricants meant to break adhesions between bolts and nuts such as WD-40. This sort of lubricant can cause the seal between the rubber and metal parts of the underwater connectors to partially dissolve and part, resulting in the flooding of your instrument.

## Deployment: Failed Underwater Connections



These connectors were not burped. As the instrument descended into the water, the air between the bulkhead and cable was compressed, allowing water to seep into the connection. Because there are numerous paths between power and ground present, the pins quickly corroded. You can observe this as a failed or noisy auxiliary sensor, or as main power dropping below that required to operate the instrument. In a pinch, you can try cleaning these up to continue using them, but they should be replaced as soon as possible.

## Deployment: Be Neat!



**Make a Neat Underwater Package**

- Cable tie or tape all loose cabling to frame of package
  - Loose cables flap as package rises or drops, resulting in fatigue
- Make sure no cables are in path of inlet to temperature sensors
- Check zincs occasionally; grounding problems can cause them to disappear


Neatness counts! Secure all your loose cables. When you lower your instrument package at 1 meter per second, any loose cabling will flap. This sort of repetitive motion will fatigue the cables and shorten their working life.

## Deployment: Final Preparation

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### What Do You Mean, *Soak the Fish?*

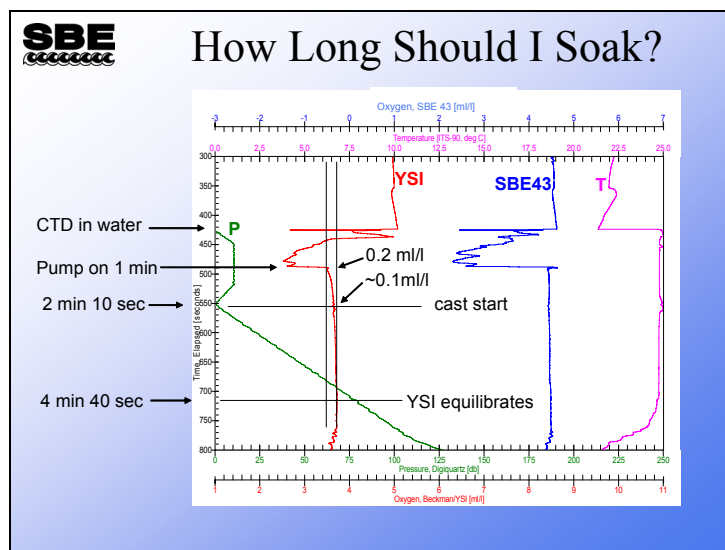
- This is not done in the galley!
- Soaking means putting the instrument package over the side and into water at a safe but shallow depth (like 10 meters)
- Soaking tip: use 2 display types
  - Fixed text display to check all sensors and other parameters on deck and during soak
  - Multi-line plot for the cast



As you prepare to take a cast, it is considered good practice to place the instrument package in the water and allow it to equilibrate. This allows several good things to happen. The whole package comes to the surface temperature rather than the air temperature on deck, the conductivity cell wets with seawater, and the oxygen sensor comes to surface temperature (and in the case of older sensors, the oxygen sensor polarizes). Further, if you are working in real-time, you can quickly confirm the operation of the instrument and all the sensors. This is a great idea because nothing irritates the deck crew more than starting the cast only to bring the instrument package back aboard a few minutes later.

If you are using a real-time system, use 2 different display types in Seasave: a text display (fixed and/or scrolled) for deck and surface soak checkout, and a plot for the cast. The text display will tell you that the sensors are working and when the pump comes on.

## Deployment: Final Preparation (*continued*)



In this example the CTD was placed in the water and lowered to 10 meters for a brief soak. The YSI oxygen sensor began polarization and equilibration when the CTD was powered on. The plot clearly shows when the pump came on. At the time the cast started, the YSI was approximately 0.1 ml/l from the surface oxygen value. This represents about a 3% error. The YSI was fully equilibrated at about 4 minutes 40 seconds, or 65 meters into the cast. The SBE 43 is much faster to equilibrate and is ready as soon as the air leaves the system and the pump comes on.

## Deployment: Final Preparation (*continued*)



### Using Your CTD in Very Cold Places

- Glass conductivity cell is subject to breakage due to water freezing in cell
- Remove all water from cell
  - Repeated ice formation (film or droplets) on electrodes will degrade calibration at 0.001 - 0.020 PSU level
- Make a solution of 1% triton in sterile seawater
  - Use 0.5 micron filtered seawater
  - Or boiled seawater
- Never use anti-freezes like glycol or alcohol

Commercially available alcohol or glycol antifreezes contain trace amounts of oils that will coat the conductivity cell and the electrodes.

## Correlating CTD Data with Water Samples




### Correlating CTD Data with Water Samples

- Water sampler closure events are captured in data
  - GO 1015 systems mark the *9plus* data stream with a status bit
  - SBE Carousel systems use a list of scan numbers created by Seasave, *.bl* file
- This information is used by *Data Conversion* module to extract CTD data at time of water sampler closure into a *.ros* file
- Extracted data may be summarized into a table by *Bottle Summary* module

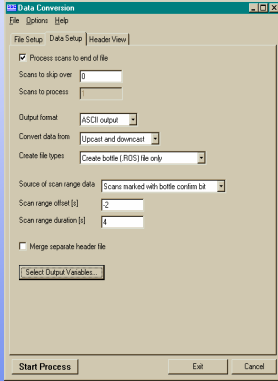
Water samples are typically used in analyses that cannot be performed *in-situ*, usually of a chemical or biological nature. These analyses are much more useful when they can be combined with CTD measurements made at the time of the water sample. There are two steps to providing a table of CTD data that corresponds to water samples. The *Data Conversion* module creates a *.ros* file that contains CTD data scans from the data logged at the time the water sample was collected. The *Bottle Summary* module creates averages and standard deviations from this data, rendering the data into a format that can be easily used by spreadsheets or other applications.

## Extracting CTD Data for Water Samples with Data Conversion



### Extracting CTD Data with Data Conversion

- You may create a *.cnv* and/or a *.ros* file
- The source of the data is your *.hex* or *.dat* file
- The indicator of what data to extract is a status bit in the data or a file of type *.bl*, *.afm*, or *.bsr*
- Data written to the *.ros* file is specified in the output variable selection dialog



The Data Conversion module creates a *.ros* file containing the same variables that the *.cnv* file contains, with scans logged around the moment a water sample was collected. Data Conversion determines when the water sample was taken by either a status bit in the SBE *9plus* data stream when a G.O. 1015 is used to collect samples, or by a *.bl* or a *.bsr* file that is created by Seasave when the instrument package is equipped with an SBE 32 Carousel.

For instrument packages using the AFM, a file of data stored by the AFM (*.afm*) is the source of the scan markers.



## Extracting CTD Data for Water Samples with Data Conversion (*continued*)




### Specifying How Much Data Per Bottle Closure

- Data extraction is referenced to the time of closure
- Scan range offset is how many seconds before the bottle closure to begin extracting data
- Scan range duration is how many seconds total to extract data

The range of data to copy out of the .cnv file into the .ros file is specified in seconds. You may copy a maximum of 1440 scans per bottle closure. For an SBE *9plus* system operating at 24 Hz, 4 seconds of data is 96 scans. For an SBE 19 operating at 2 Hz, 4 seconds of data is only 8 scans.

## Bottle Summary: Summarizing Water Sample Data



### Summarizing and Tabulating Data

- *Bottle Summary* module creates a table of averages and standard deviations from data in *.ros* file
  - *.ros* file must contain pressure, temperature, and conductivity or salinity
  - Additional parameters may be derived from averaged variables
  - Data is output to a *.bl* file
  - If a *.bl* file is present, bottle numbers are inserted in *.bl* file

The *.ros* file created by *Data Conversion* contains a set of data scans for each water sample taken. The *Bottle Summary* module takes the process one step further by averaging the scans for each water sample into a single line of data that contains averages and standard deviations for each of the parameters in the *.ros* file. In addition, you may add derived parameters to this list. The derived parameters are calculated from the averages of the data contained in the *.ros* file.

## Bottle Summary: Summarizing Water Sample Data (continued)

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### Bottle Summary

- Variables created by *Data Conversion* may be selected for inclusion in the *.bt1* file

Variable Name [unit]	Average	Select All
Pressure, Digiquartz [db]	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Temperature [ITS-90, deg C]	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Salinity [PSU]	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Density [Sigma-t, Kg/m <sup>3</sup> ]	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Voltage 2	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Voltage 4	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Scan Count	<input type="checkbox"/>	<input type="checkbox"/>

## Bottle Summary: Summarizing Water Sample Data (continued)

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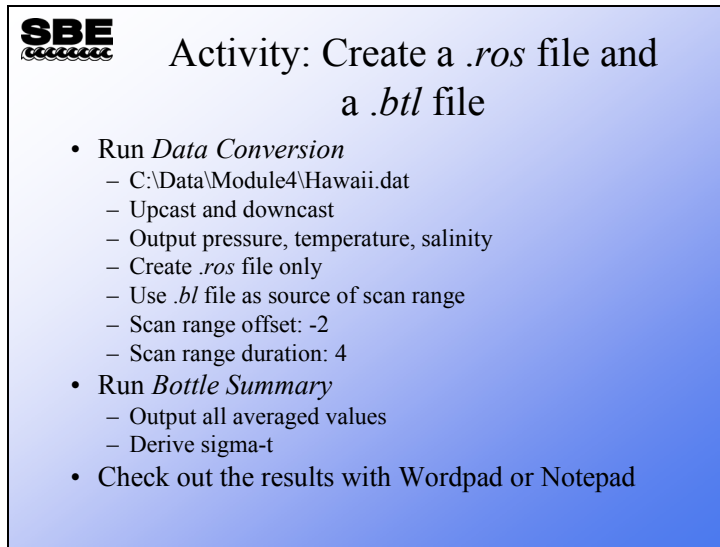
### Bottle Summary, Deriving Parameters

- Parameters derived from the averages may be added to the .btl list

The screenshot displays two overlapping dialog boxes from the SBE software. The background dialog is titled "Bottle Summary" and has a menu bar with "File", "Options", and "Help". It contains a "File Setup" section with "Data Setup" and "Header View" options. A checkbox labeled "Output min/max values for averaged variables" is present. Below it are two buttons: "Select Averaged Variables..." and "Select Derived Variables...". The foreground dialog is titled "Select Derived Variables" and features a table with 15 rows. The first row is highlighted. To the right of the table are buttons for "Add", "Change", "Delete", "Insert", and "Delete All". Further right is a list of variables with checkboxes: "Density", "Nitrogen Saturation", "Oxygen Saturation", "Potential Temperature", "Sound Velocity", and "Specific Volume Anomaly (10^-6 m^3/Kg)". On the far right are buttons for "Shrink All", "Expand All", "Stretch", and "Expand". At the bottom of the foreground dialog are "OK" and "Cancel" buttons. Below the foreground dialog, the "Start Process" button from the background dialog is visible.

Seq. #	Variable Name (.btl)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	

## Activity



**SBE**  
Activity: Create a *.ros* file and a *.btl* file

- Run *Data Conversion*
  - C:\Data\Module4\Hawaii.dat
  - Upcast and downcast
  - Output pressure, temperature, salinity
  - Create *.ros* file only
  - Use *.bl* file as source of scan range
  - Scan range offset: -2
  - Scan range duration: 4
- Run *Bottle Summary*
  - Output all averaged values
  - Derive sigma-t
- Check out the results with Wordpad or Notepad

Because you are already familiar with *Data Conversion*, we will not list step-by-step instructions for this part of the activity.

After you have run *Data Conversion*, run *Bottle Summary* (number 8 on the data processing menu)

Select an instrument configuration file, C:\Data\Module4\Hawaii.con

Select a data file, C:\Data\Module4\Hawaii.ros

Click the Data Setup tab

Click the Select Averaged Variables button

Click the Select All button

Click OK

Click the Select Derived Variables button

Click the first Variable name entry

Click Density -> sigma-t

Click the Add button

Click OK

Click Start Process

