



Water Sampling with Internally Recording Instruments

Sea-Bird Scientific University Module 5



Overview

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

This module covers the following:

- Water sampling equipment
- Autonomous water sampling with internally recording instruments
 - SeatermAF V2 Software
 - Autofire bottle closure logic
- Real-time water sampling with internally recording instruments
 - Instruments and cabling
- Comparing CTD data with water samples
 - How bottle closures are recorded in the data
 - Creating .btl files with Sea-Bird Data Processing software

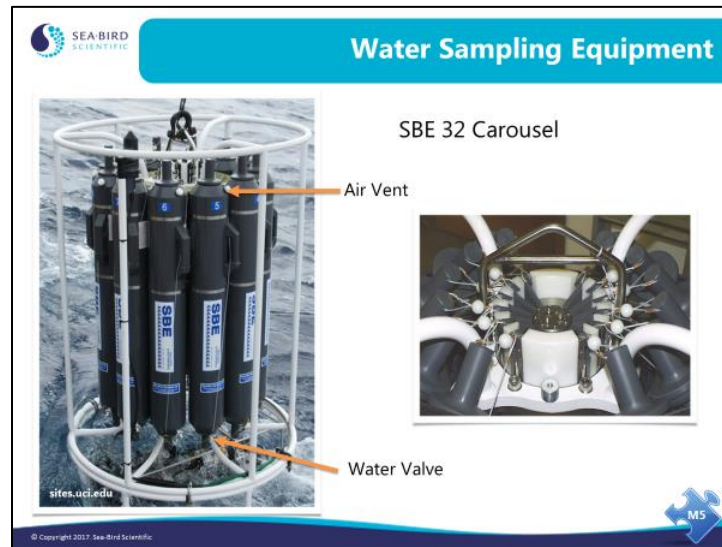
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We are going to discuss the workings of water samplers and techniques for collecting water samples with internally recording instruments. SeatermAF V2, the user interface for water sampling with an auto-fire device, will be presented. We will also 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 SBE 32 Carousel or SBE 55 ECO water sampler.
- Use SeatermAF V2 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 SBE 32 Carousel 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.

Autonomous Water Sampling with Internally Recording Instruments

Autonomous Water Sampling with Internally Recording Instruments

- Auto Fire Module (AFM) with SBE 32 Carousel
 - AFM receives pressure information from SBE 19, 19plus, 19plus V2, 25, 25plus, or 50
- SBE 17plus Version 2 Searam with SBE 32 Carousel
 - SBE 17plus V2 receives pressure information from SBE 9plus
 - SBE 17plus V2 also provides battery power and internal data recording (16 Mbyte of memory) for SBE 9plus
- SBE 55 ECO Water Sampler
 - Receives pressure information from SBE 19, 19plus, 19plus V2, 25, 25plus, or 50
 - Built-in capability similar to SBE 32 Carousel integrated with AFM
- All receive closure protocol from user via SeatermAF V2

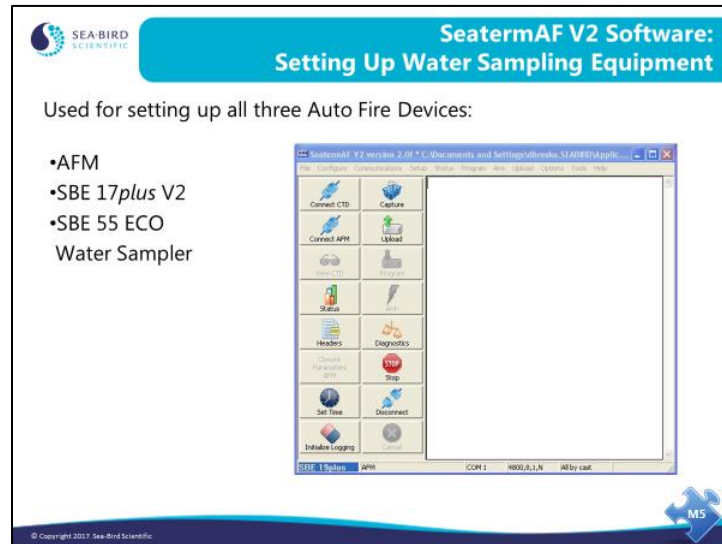
AFM SBE 17plus SBE 55 ECO Water Sampler

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Sea-Bird offers several products for closing water sampler bottles remotely. These products receive pressures from the CTD and are programmed to close bottles on operator-chosen criteria.


- The AFM / SBE 32 Carousel system is compatible with several CTDs, as well as with an SBE 50 Pressure Sensor. The AFM 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 17plus / SBE 32 Carousel system is much more straightforward to use, because there are fewer options. The SBE 17plus only closes bottles on the upcast, and is only used with one type of CTD, the SBE 9plus.
- The SBE 55 ECO Water Sampler has built-in auto-fire capability similar to that of an AFM integrated with an SBE 32 Carousel.

Setting up Water Sampling Equipment with SeatermAF V2



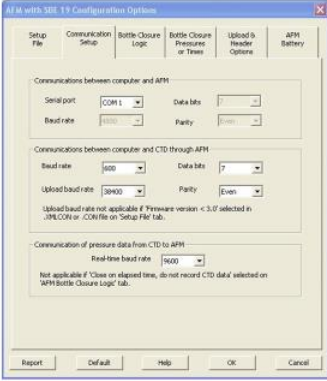
SeatermAF V2 includes a simple interface for entering bottle closure parameters, and transfers that information to the auto-fire equipment. It is also used to set up the SBE 19, 19plus, 19plus V2, 25, 25plus, or 50 for operation, and to upload data from the auto-fire equipment (AFM, SBE 17plus V2, or SBE 55 ECO Water Sampler) and CTD.

SeatermAF V2: Setting Up CTD Communications



SeatermAF V2 Software: Setting Up CTD Communications

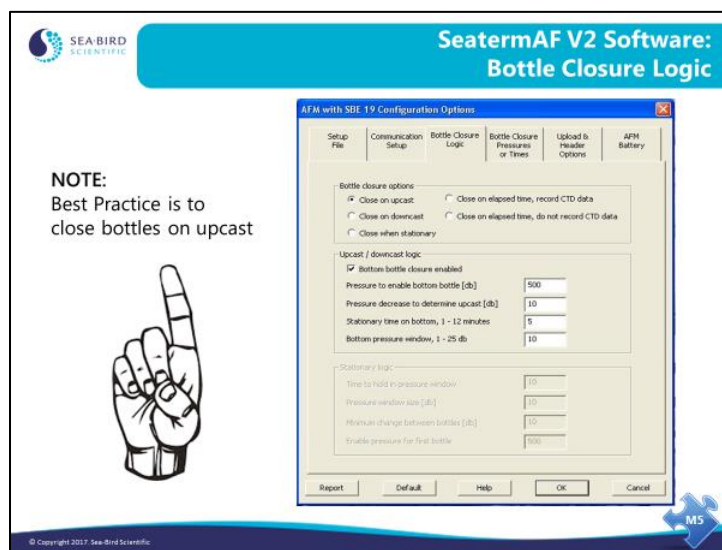
- To access this dialog box, Click on the Configure menu bar, and select the CTD and water sampling equipment you are using.
- Example:
AFM with SBE 19 configuration



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The CTD communications form allows you to select the communications parameters for your instrument as well as data transfer protocol and header options. Instruments with older firmware revisions are not able to change baud rate during data transfers.

SeatermAF V2: Setting up Sampling Protocol




The bottle closure logic tab contains almost all the information that the AFM, SBE 17*plus* V2, or SBE 55 ECO need to close water sample bottles based on the closure protocol you select.

- AFM or SBE 55 ECO Water Sampler - you have the choice of closing bottles during downcast, during upcast, when the instrument package is stationary, or on time elapsed since the auto-fire was armed.
- SBE 17*plus* V2 - you can close bottles on the upcast only.

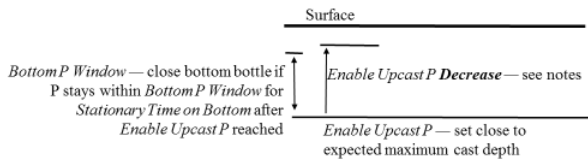
The closure logic follows.

SeatermAF V2: Setting up Sampling Protocol (continued)



**SeatermAF V2 Software:
Bottle Closure Logic**

- Downcast/Upcast Logic
 - Note: downcast firing options not applicable to SBE 17plus V2
 - Pressure change to enable upcast ensures that a bottom bottle closes if you do not meet other criteria (see notes)



The diagram illustrates the pressure profile of a water sampling cast. A horizontal line at the top represents the 'Surface'. A vertical line descends from the surface, representing the pressure increase as the instrument package descends. A horizontal line is drawn at a certain depth, labeled 'Enable Upcast P — set close to expected maximum cast depth'. Below this line, the text 'Enable Upcast P Decrease — see notes' is written. A vertical line ascends from the 'Enable Upcast P' line towards the surface, representing the pressure decrease during upcast. A horizontal line is drawn at a shallower depth, labeled 'Bottom P Window — close bottom bottle if P stays within Bottom P Window for Stationary Time on Bottom after Enable Upcast P reached'. A vertical line descends from this 'Bottom P Window' line, representing the pressure increase during downcast. A small blue icon with the letters 'M5' is located in the bottom right corner of the diagram area.


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The AFM, SBE 17plus V2, and SBE 55 ECO can all collect water samples during **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 package stationary on the bottom, and the pressure window within which the package will be considered stationary. In addition, you must specify *pressure decrease to determine upcast*. Interpretation of the parameters varies slightly, depending on the instrument.

- AFM and SBE 55: *pressure decrease to determine upcast* ensures that a bottom bottle is closed if you do not hold the package stationary for a sufficient length of time.
- 17plus V2: *pressure decrease to determine upcast* overrides the pressure to enable the bottom bottle. In other words, if the package does not go as deep as anticipated, this ensures that a bottom bottle is closed.

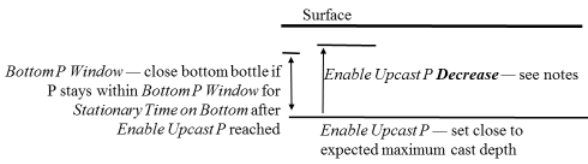
The AFM and SBE 55 ECO can also collect water samples during **downcast** (instrument package is falling); parameters similar to those required for collecting on upcast define the closure logic. Click *bottom bottle closure enabled* to take a sample at the deepest part of the cast. To collect a bottom bottle, 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 V2: Setting up Sampling Protocol (continued)




**SeatermAF V2 Software:
Bottle Closure Logic**

- Downcast/Upcast Logic
 - Note: downcast firing options not applicable to SBE 17*plus* V2
 - Pressure change to enable upcast ensures that a bottom bottle closes if you do not meet other criteria (see notes)



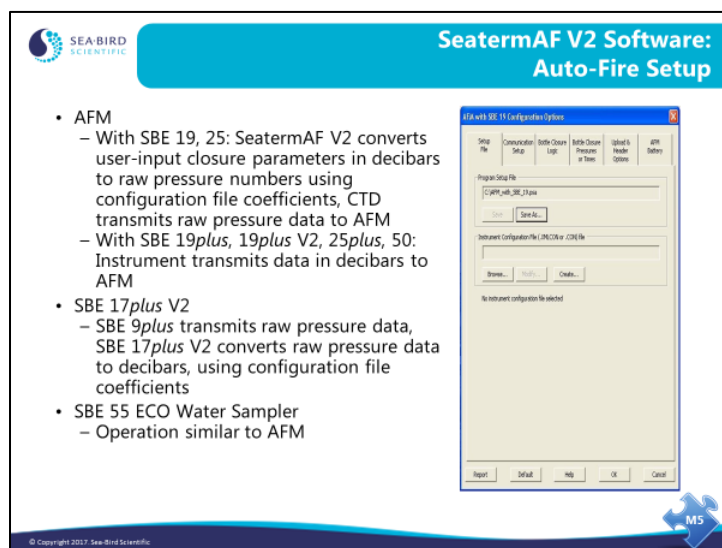
The diagram illustrates the logic for bottle closure. A horizontal line represents the 'Surface'. Below it, a vertical line indicates the 'Enable Upcast P' threshold, which is set close to the expected maximum cast depth. A horizontal line below this threshold represents the 'Enable Upcast P Decrease' level. A vertical line indicates the 'Bottom P Window' duration, which is the time the pressure (P) stays within a specific window after reaching the 'Enable Upcast P' threshold. The text 'Bottom P Window — close bottom bottle if P stays within Bottom P Window for Stationary Time on Bottom after Enable Upcast P reached' is associated with this window. The text 'Enable Upcast P Decrease — see notes' is associated with the decrease in pressure. The text 'Enable Upcast P — set close to expected maximum cast depth' is associated with the threshold line.

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With an AFM (and SBE 32 Carousel Water Sampler) or with an SBE 55 ECO Water Sampler, 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 or ECO 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 or SBE 55 ECO Water Sampler, samples can be collected on elapsed time. The AFM and ECO have an internal clock and close water bottles on time from when they were given the Arm command.

SeatermAF V2: Setting up Sampling Protocol (continued)



There is an entry for the configuration (.con or .xmlcon) file on the Setup File tab.

- For the SBE 19 and SBE 25, the configuration 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 V2 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*, 19*plus* V2, 25*plus*, and SBE 50 send pressure in decibars to the AFM, so a configuration file is not required.
- For the SBE 9*plus*, the configuration 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.
- Operation with the SBE 55 ECO Water Sampler is similar to that of an AFM with an SBE 32 Carousel Water Sampler.


SeatermAF V2: Setting up Sampling Protocol (continued)

- AFM, SBE 17*plus*, and SBE 55 ECO close bottles on pressure
- AFM and SBE 55 ECO can also close bottles on elapsed time in minutes from when armed

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 or SBE 55 ECO 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 Instruments



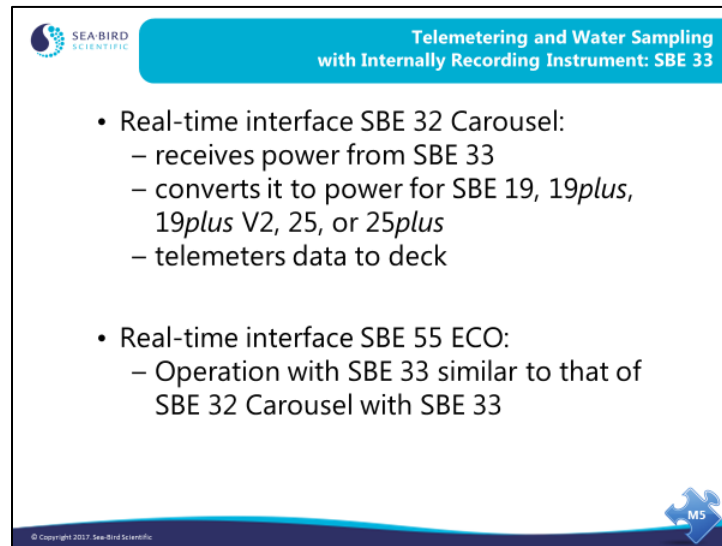
Data Recorded in Auto Fire Instrument

- AFM
 - 5 CTD scans are recorded in AFM at time of each bottle closure
- SBE 17*plus* V2
 - Since 17*plus* V2 is also memory module for SBE 9*plus*, all 9*plus* CTD data is recorded in 17*plus* V2
 - Bottle closure bit in status byte is set for 36 scans to indicate time of each bottle closure
- SBE 55 ECO Water Sampler
 - 5 CTD scans are recorded in ECO at time of each bottle closure



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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, 19*plus*, 19*plus* V2, 25, or 25*plus*
 - telemeters data to deck
- Real-time interface SBE 55 ECO:
 - Operation with SBE 33 similar to that of SBE 32 Carousel with SBE 33

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M5


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

Correlating CTD Data with Water Samples



Correlating CTD Data with Water Samples

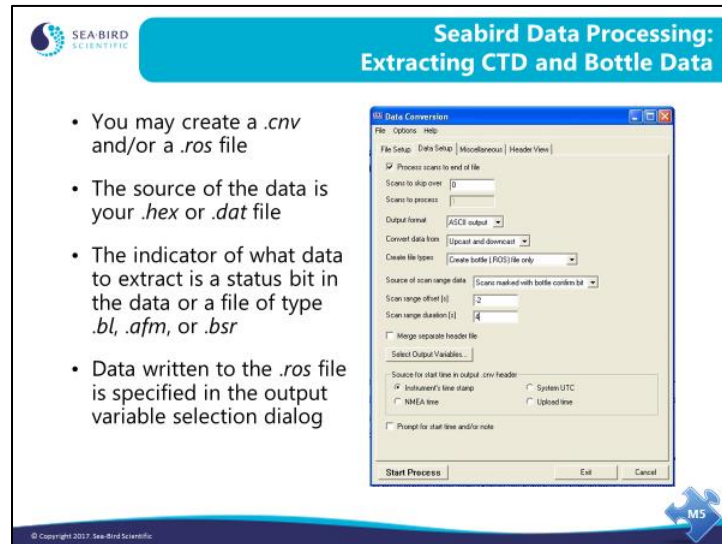
- Water sampler closure events are captured in data
 - GO 1015 systems mark the *9plus* data stream with a status bit
 - SBE 32 Carousel and SBE 55 ECO systems use a list of scan numbers created by Seasave, *.bl* file
- This information is used by *Data Conversion* module to extract CTD data at time of water sampler closure into a *.ros* file
- Extracted data may be summarized into a table by *Bottle Summary* module



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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



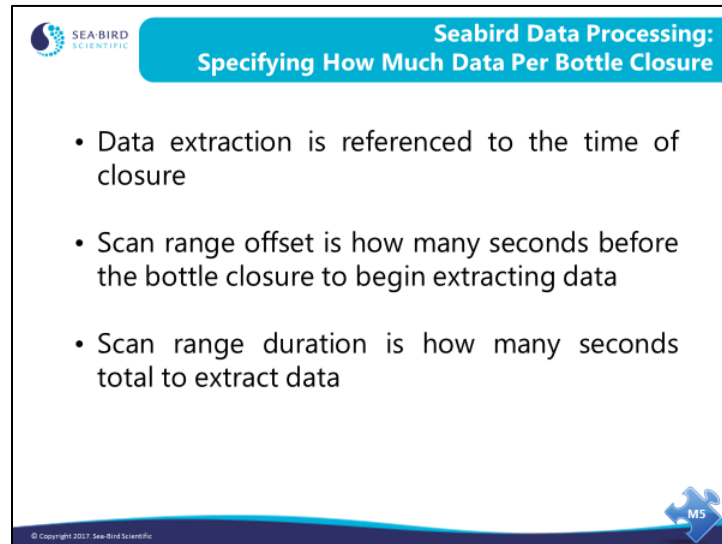
The Data Conversion module creates a *.ros* file containing the same variables that the *.cnv* file contains, with scans logged around the moment a water sample was collected. For real-time water sampling, Data Conversion determines when the water sample was taken by:

- a status bit in the SBE *9plus* data stream when a G.O. 1015 is used to collect samples, or
- a *.bl* file that is created by Seasave when the instrument package is equipped with an SBE 32 Carousel or SBE 55 ECO, or
- a *.bsr* file created with a text editor

For autonomous water sampling, Data Conversion determines when the water sample was taken by:

- a status bit in the uploaded data from the SBE *17plus*, or
- a *.afm* file uploaded from the AFM, or
- a *.afm* file uploaded from the SBE 55 ECO Water Sampler. The SBE 55 ECO's built-in electronics perform the same function as the AFM.

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

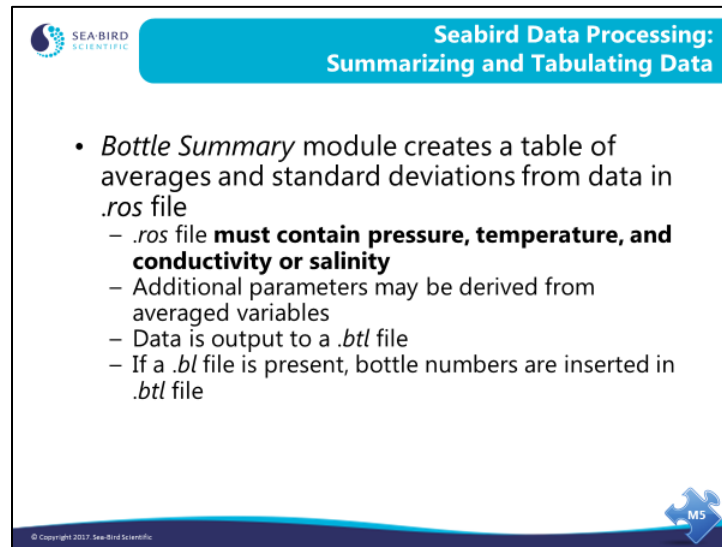


The slide features the Seabird Scientific logo in the top left corner. A blue header bar at the top right contains the text "Seabird Data Processing: Specifying How Much Data Per Bottle Closure". The main content area lists three bullet points. In the bottom right corner, there is a blue puzzle piece icon with the text "M5". The bottom left corner contains the copyright notice "© Copyright 2017 Sea-Bird Scientific".

- 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 9*plus* 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



The slide features the Seabird Scientific logo in the top left corner. A blue header bar at the top right contains the text "Seabird Data Processing: Summarizing and Tabulating Data". The main content area is white and contains a bulleted list. The bottom of the slide has a dark blue footer with a copyright notice and a small blue puzzle piece icon with the letters "MS" on it.

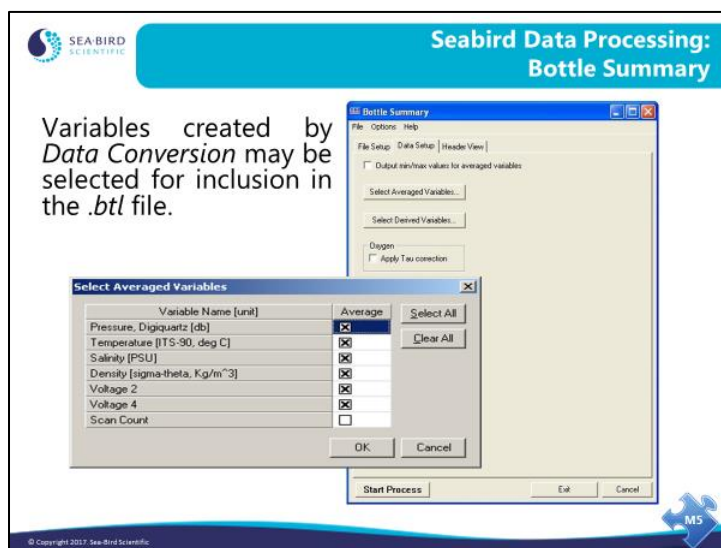
Seabird Data Processing:
Summarizing and Tabulating Data

- *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 *.btl* file
 - If a *.bl* file is present, bottle numbers are inserted in *.btl* file

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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)



Bottle Summary: Summarizing Water Sample Data (continued)

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

The screenshot displays the Seabird Data Processing software interface. At the top, a blue banner reads "Seabird Data Processing: Bottle Summary, Deriving Parameters". Below this, the "Bottle Summary" window is open, showing a menu bar (File, Options, Help) and a toolbar with buttons for "File Setup", "Data Setup", "Header View", "Output min/max values for averaged variables", "Select Averaged Variables...", and "Select Derived Variables...". The "Select Derived Variables" dialog is also open, featuring a list of variables on the right and a table on the left for managing the list.

Seq	Variable Name [unit]
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	

Buttons in the dialog include: Add, Change, Delete, Insert, Delete All, Shrink All, Expand All, Shrink, and Expand. The list of variables on the right includes: Density, Nitrogen Saturation, Oxygen Saturation, Potential Temperature, Sound Velocity, and Specific Volume Anomaly [10⁻⁶ m³/Kg].

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Activity: Create .ros and .bt1 Files

1. In SBE Data Processing, run *1. Data Conversion* to create a .ros file:
 - A. File Setup tab - C:\Data\Module4\Hawaii.dat and Hawaii.con
 - B. Data Setup tab -
 - Upcast and downcast
 - Create .ros file only
 - Use .bt1 file as source of scan range
 - Scan range offset -2
 - Scan range duration 4
 - Output Variables pressure, temperature, salinity
 - C. Click *Start Process*.
 - D. File Setup tab – Save Program setup file (.psa) to same directory as output file
2. In SBE Data Processing, run *8. Bottle Summary* to create a .bt1 file:
 - A. File Setup tab - C:\Data\Module4\Hawaii.ros and Hawaii.con
 - B. Data Setup tab –
 - Click *Select Averaged Variables*. In dialog box, click *Select All* and click *OK*.
 - Click *Select Derived Variables*. In dialog box,
 - Click the first Variable name line.
 - Click *Density* -> $\sigma\text{-}t$, Kg/m^3 .
 - Click *Add*.
 - Click *OK*.
 - *Apply Tau correction* has no effect (no oxygen data in this activity).
 - C. Click *Start Process*.
 - D. File Setup tab – Save Program setup file (.psa) to same directory as output file
3. Check your results with Notepad.