
SEA-BIRD
SCIENTIFIC
Introduction to Profiling Equipment
Sea-Bird Scientific University
Module 1
M1
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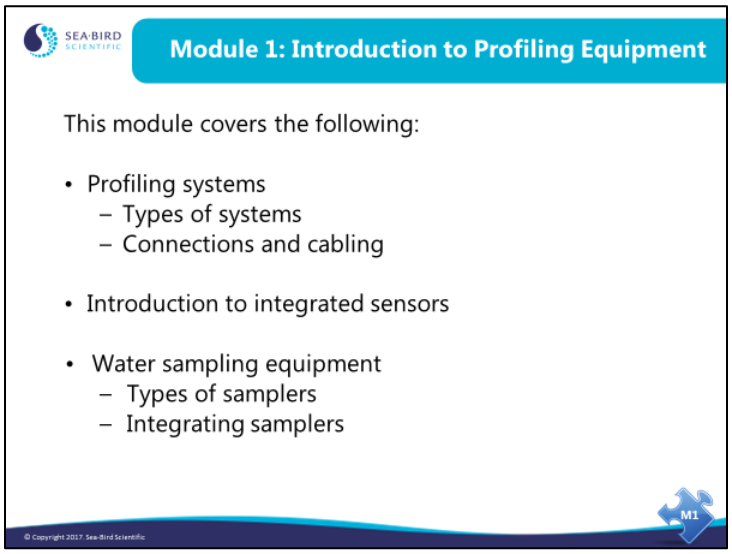
Overview

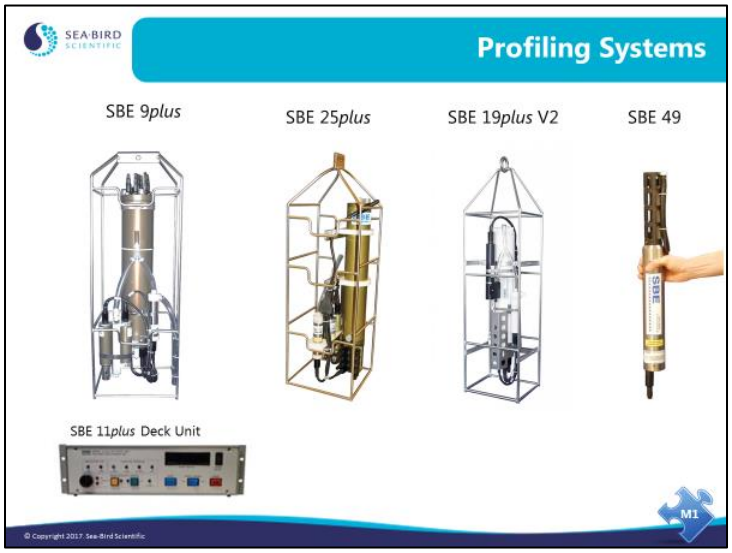


In this module we are going to present Sea-Bird's equipment offerings for profiling. We will present internally recording instruments first, followed by real-time instruments and then water sampling equipment.

At the end of this module you should be:

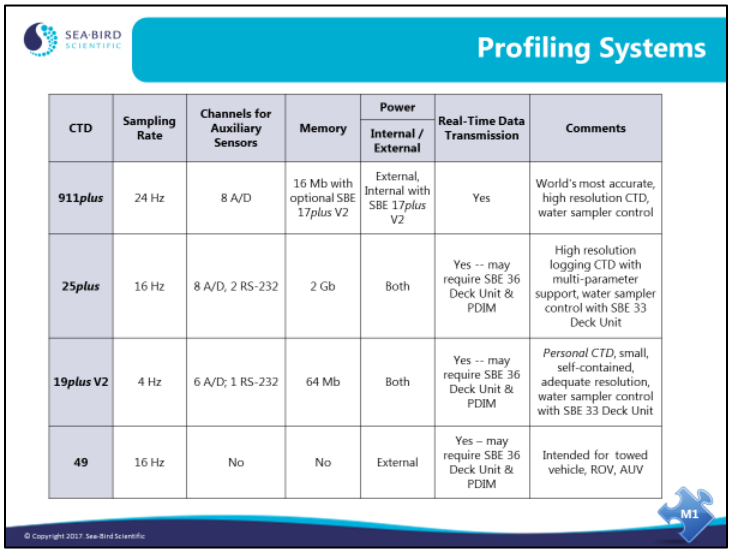
- Familiar with Sea-Bird's profiling product line.
- Aware of the difference between real-time and internally recording instruments.
- Familiar with the water sampling options available.
- Able to install Seasoft.

Profiling Systems



Sea-Bird offers 4 profiling instruments: the real-time SBE 9*plus*/11*plus* system, the internally recording SBE 25*plus* and SBE 19*plus* V2, and the real-time SBE 49. The capabilities of these instruments are contrasted in the following pages.

Profiling Systems (*continued*)



CTD	Sampling Rate	Channels for Auxiliary Sensors	Memory	Power: Internal / External	Real-Time Data Transmission	Comments
911*plus*	24 Hz	8 A/D	16 Mb with optional SBE 17*plus* V2	External, Internal with SBE 17*plus* V2	Yes	World's most accurate, high resolution CTD, water sampler control
25*plus*	16 Hz	8 A/D, 2 RS-232	2 Gb	Both	Yes -- may require SBE 36 Deck Unit & PDIM	High resolution logging CTD with multi-parameter support, water sampler control with SBE 33 Deck Unit
19*plus* V2	4 Hz	6 A/D; 1 RS-232	64 Mb	Both	Yes -- may require SBE 36 Deck Unit & PDIM	*Personal CTD*, small, self-contained, adequate resolution, water sampler control with SBE 33 Deck Unit
49	16 Hz	No	No	External	Yes – may require SBE 36 Deck Unit & PDIM	Intended for towed vehicle, ROV, AUV

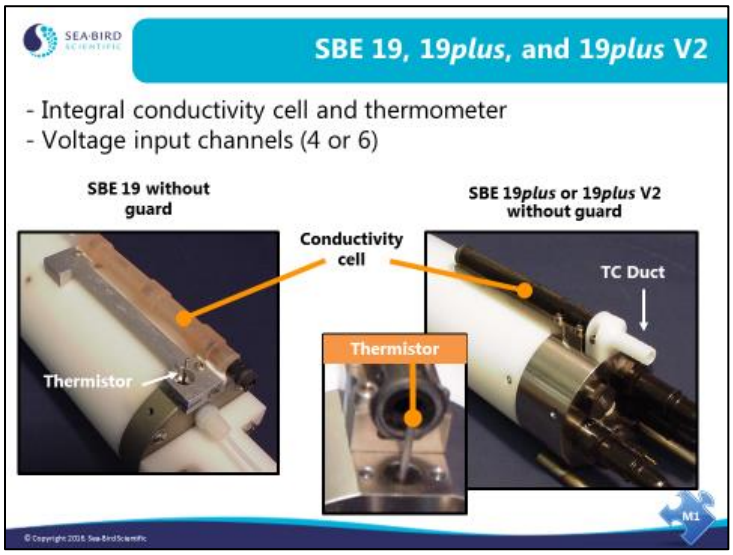
Sea-Bird's flagship CTD is the SBE 9*plus* and SBE 11*plus*. The 9*plus* is the underwater part of the system; it houses acquisition, telemetry, and power supply circuitry. The 9*plus* receives power from the 11*plus* deck unit and operates over more than 10 kilometers of sea cable. It can operate several types of water samplers and may be configured with a serial port multiplexed into the data stream, to accommodate instruments with serial output rather than the traditional voltage or frequency. It comes standard with pressure, 2 temperature and 2 conductivity channels, and 8 voltage channels.

The SBE 25*plus* features internal recording at up to a 16 Hz sample rate. It supports temperature, conductivity, and pressure, plus 8 voltage channels and 2 RS-232 channels. The 25*plus* makes a smaller instrument package and is battery powered with internal memory.

The SBE 19 and 19*plus* have been in the field since 1987, and there are over 2500 instruments in use at present. The SBE 19*plus* V2 is an enhancement of the 19*plus*. It is also battery powered with internal memory. It features independent temperature and conductivity channels, an integral T-C duct (hardware to improve the flow of water past the sensors), and 6 voltage channels. The 19*plus* V2 samples up to a rate of 4 Hz and averages 1 to 32767 scans (decreases the sample rate).

The SBE 49 is an integrated CTD sensor intended for use as a modular component in towed vehicles, ROVs, AUVs, or other platforms that can supply DC power and acquire serial data. The 49's pump-controlled, TC-ducted flow minimizes salinity spiking. The SBE 49 samples at 16 Hz.

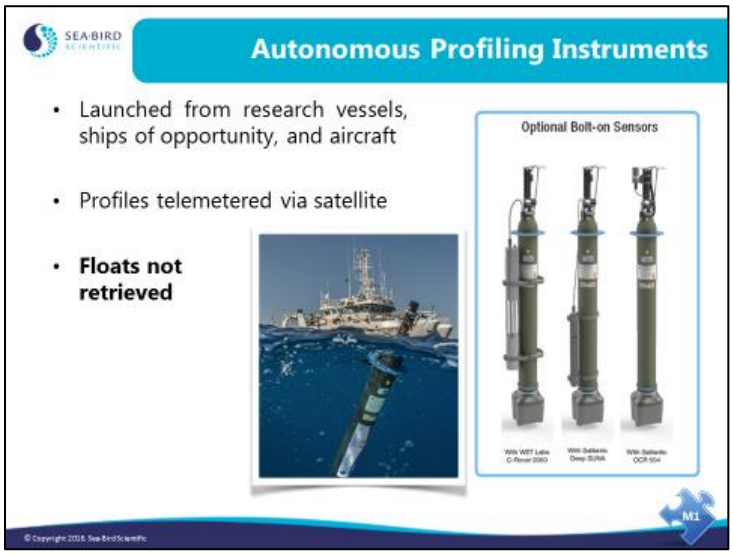
SBE 19 vs SBE 19*plus* / 19*plus* V2 : Sensor Placement



The SBE 19 has side-by-side temperature and conductivity sensors. The SBE 19*plus* and 19*plus* V2 feature inline sensors and an integral ducting system, which ensures that water that passes the thermometer goes into the conductivity cell.

The SBE 19*plus* V2 has 6 voltage input channels, an improvement over the 4 channels available with the SBE 19 and 19*plus*. It also has more memory to accommodate the additional data.

Autonomous Profiling Instruments

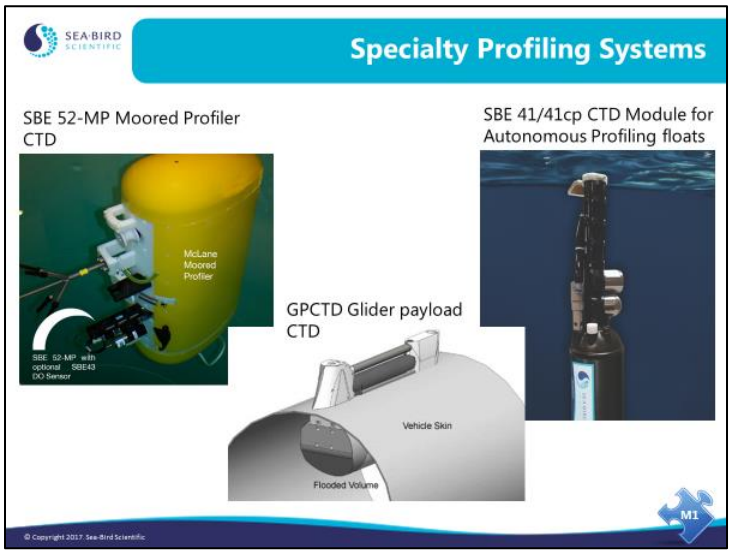


The SBE 41, 41cp, and 41N are CTDs that are used with buoyancy engines. After deployment they become negatively buoyant, sinking to ~1000 or 2000 meters, resting for 10 days, and then making themselves positively buoyant, collecting a profile as they rise through the ocean. Once on the surface, they transmit their data via a satellite back to the scientist who deployed them. Because they receive no handling after deployment and have minimal time on the surface, they provide an excellent example of conductivity sensor drift in an optimum environment.

In 2011, Sea-Bird began producing our own buoyancy engine, the Navis float. Biogeochemical sensors, such as the SBE 63 oxygen sensor, WET Labs ECO-MCOMS fluorometer, and Float Deep SeaFET pH sensor can also be integrated.

- The ECO-MCOMS supplies three optical sensors in one, providing chlorophyll a, backscattering, and CDOM, or chlorophyll a and 2 backscattering channels. ECO-MCOMS is integrated directly into the float end cap and co-located with DO and physical measurements.

Specialty Profiling Systems



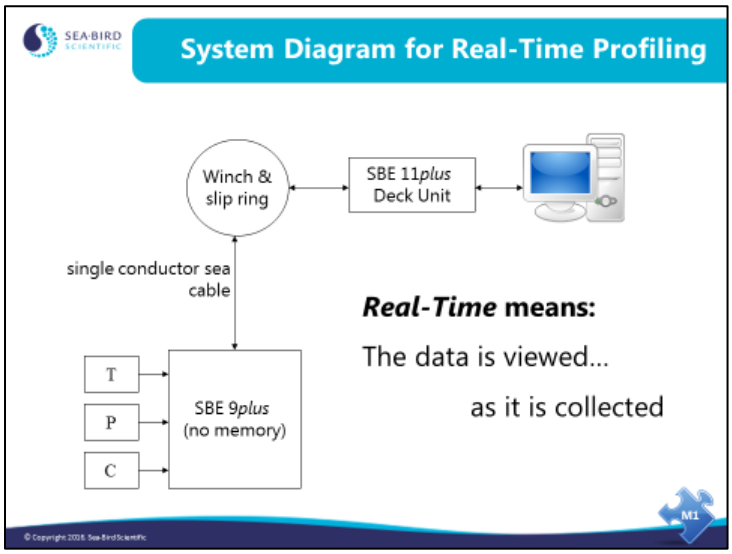
In addition to the *general purpose* profiling CTDs, Sea-Bird offers several CTDs for specific applications.

The SBE 52-MP Moored Profiler CTD that is designed for moored profiling applications in which the instrument makes vertical profile measurements from a device that travels vertically beneath a buoy, or from a buoyant sub-surface sensor package that is winched up and down from a bottom-mounted platform. The 52-MP samples at 1 Hz, is externally powered, and can store up to 28,000 samples. It can optionally be configured with an SBE 43F Dissolved Oxygen sensor.

The Glider Payload CTD (GPCTD) is an OEM, modular, low-power profiling instrument for autonomous gliders with the high accuracy necessary for research. The GPCTD samples at 1 Hz or at user-programmable sample intervals, and can store up to 559,000 samples. It can optionally be configured with an SBE 43F Dissolved Oxygen sensor.

The SBE 41 and 41CP are OEM CTDs for sub-surface oceanographic floats for the Argo program. We'll talk more about this at the end of the module.

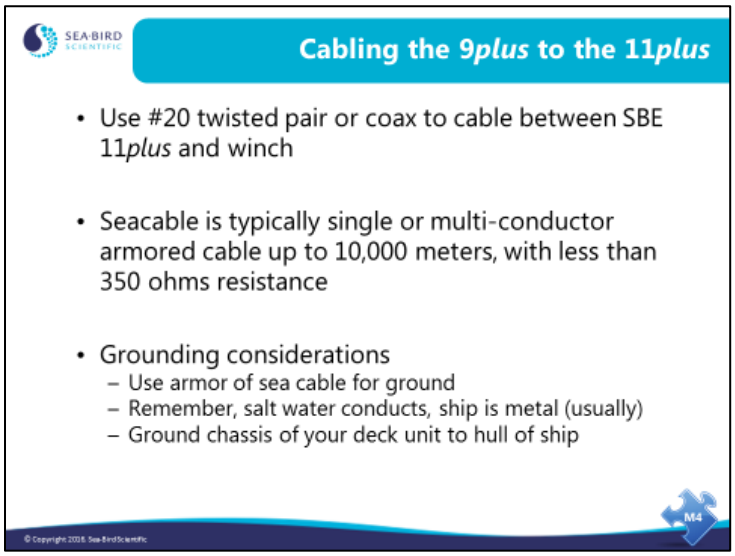
Real-Time Profiling



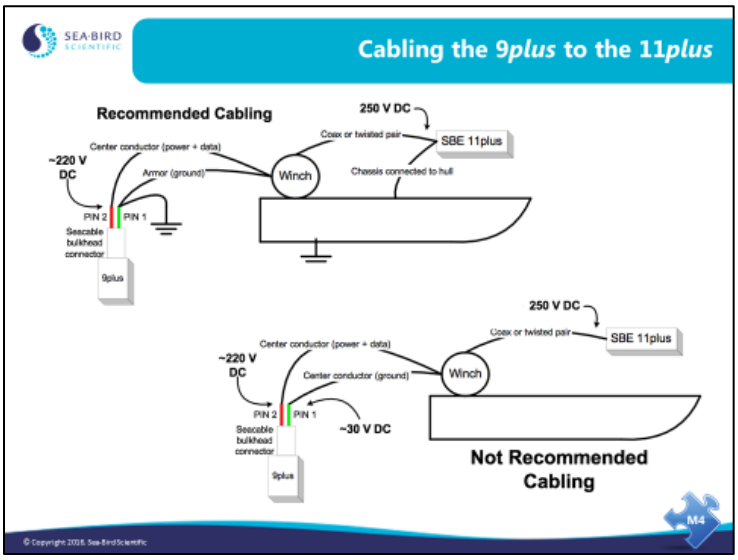
Real-time profiling means that you are viewing and storing data on your computer at almost the same time that the measurement is being made at the end of the winch cable. The *almost* part is because there is some time involved in packaging the bits up and sending them up the wire to the deck unit and then onto your computer.

The system consists of sensors that convert environmental parameters to electrically measurable quantities like voltage or frequency. The data acquisition component measures the sensors' outputs and telemeters them up the sea cable. The deck unit receives the telemetered data, does some minor manipulation, and transmits the data to your computer for display and storage. In the middle of all this is the winch and slip ring, which provide the mechanical means of getting the instrument package down into the ocean and the electrical data stream up to the deck unit.

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

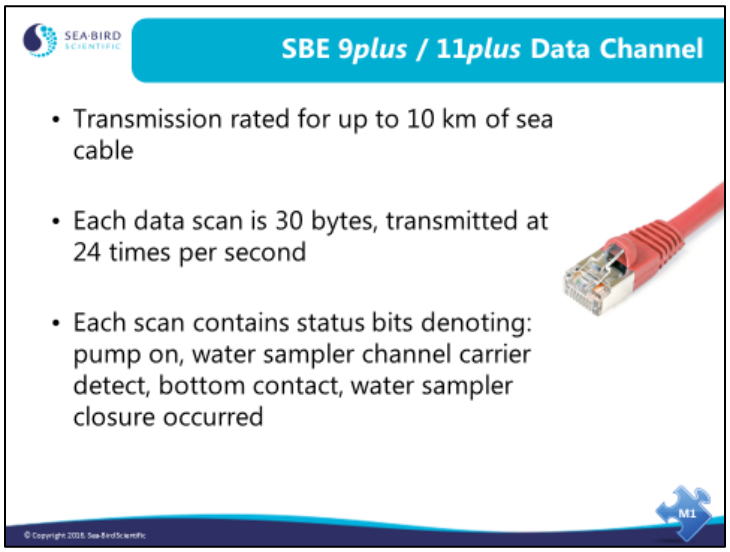


Cabling the 9*plus* to the 11*plus* (*continued*):



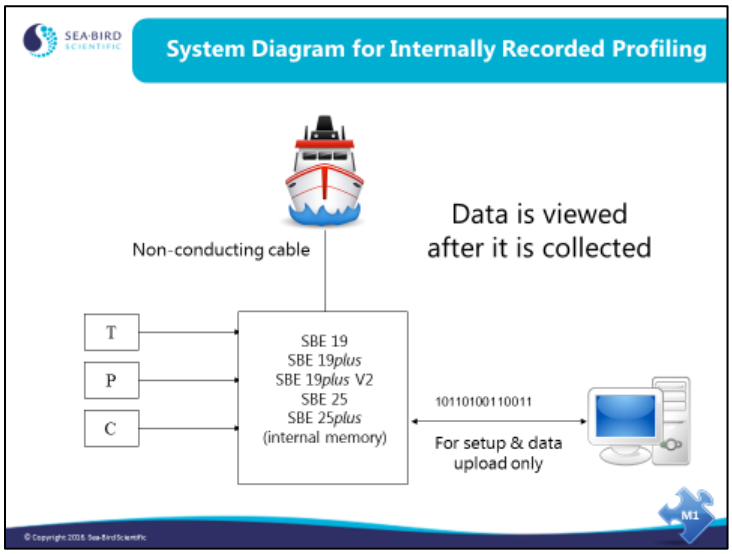
The slide above illustrates the recommended cabling for the SBE 9*plus* and the 11*plus* as well as a *not* recommended method. The primary difference between the two is that the recommended method utilizes the seacable armor as the return or ground for the SBE 9*plus*. This ensures that the underwater 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.

SBE 9*plus*/11*plus* Data Telemetry



The data transmission rate of the 9*plus* is constrained by the 24 Hz scan rate. Of the 30 bytes that make up a scan, 29 of them are transmitted in standard asynchronous format, 1 start bit, 8 data bits, and 1 stop bit. The 30th byte is all zeros; it is not transmitted. This lack of a data byte is used by the 11*plus* and the 17*plus* to synchronize the data acquisition. Synchronization occurs with each data scan. As an option, the data transmission speed can be doubled and serial data at 9600 baud from a remote instrument can be time dimension multiplexed into the telemetry stream. This option requires a hardware change; it finds use with some optical instrumentation that transmits data at 9600 baud. The disadvantage to deploying this option is the data transmission is not as robust, and some lower quality sea cables will not allow transmission to occur over the whole 10 km.

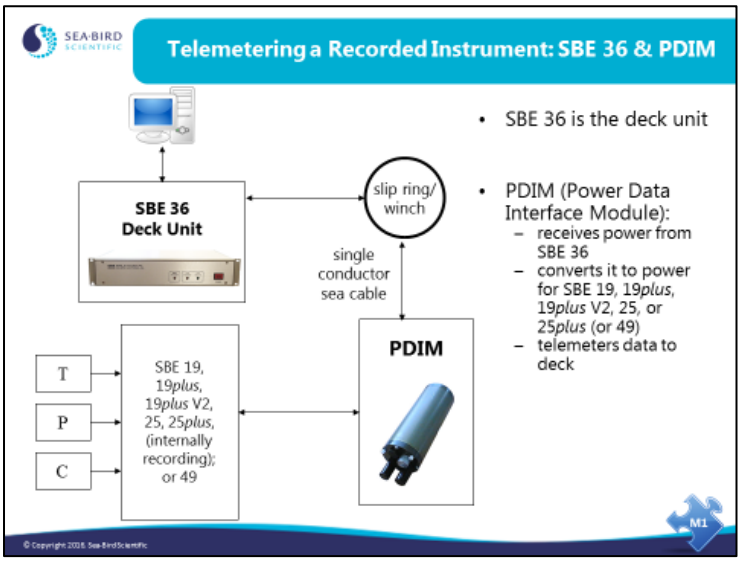
Internally Recorded Profiling



Internally recorded profiling means that the measurements are stored in semiconductor memory inside the instrument and are downloaded to your computer and viewed *after* the equipment is on deck. The ship is not required to have a sea cable with an internal conductor.

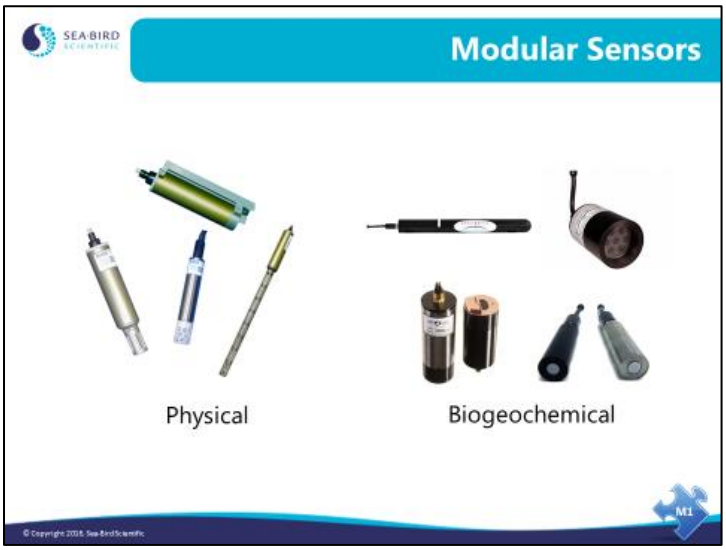
The measurement system consists of sensors that convert environmental parameters to electrically measurable quantities. The data acquisition portion of the system converts the sensor output to digital data and stores it internally.

Real-Time Options for Internally Recording Instruments



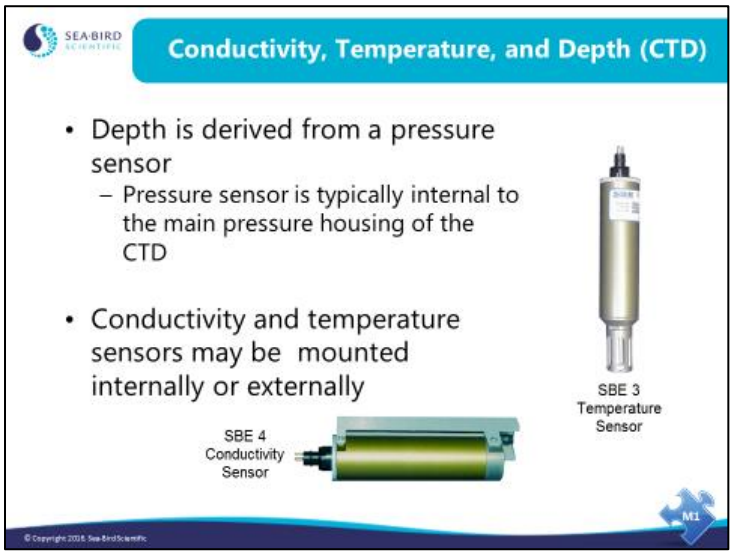
The SBE 36 and PDIM provide power and telemetry, but no water sampling capability.

Modular Sensors



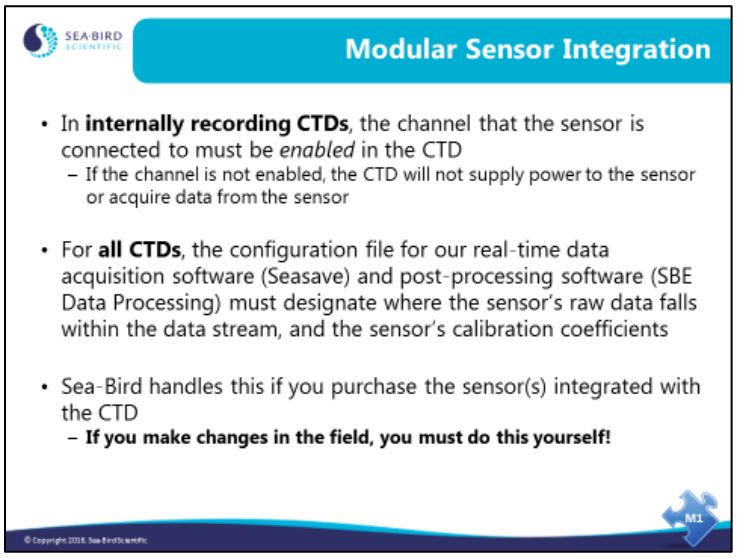
Sea-Bird offers a variety of modular sensors of our own manufacture and also many from other manufacturers. These sensors have various outputs: voltage, frequency, or serial ASCII data. In addition to temperature and conductivity, dissolved oxygen and pH are offered, as are oxidation potential, light, transmittance, fluorescence, and turbidity.

Modular Sensors (*continued*)



The pressure sensor is typically housed internally to protect it from shock and from rapid temperature change. Note however that we also measure temperature at the pressure sensor, and mathematically compensate for the temperature effect on the output.

Modular Sensors (*continued*)

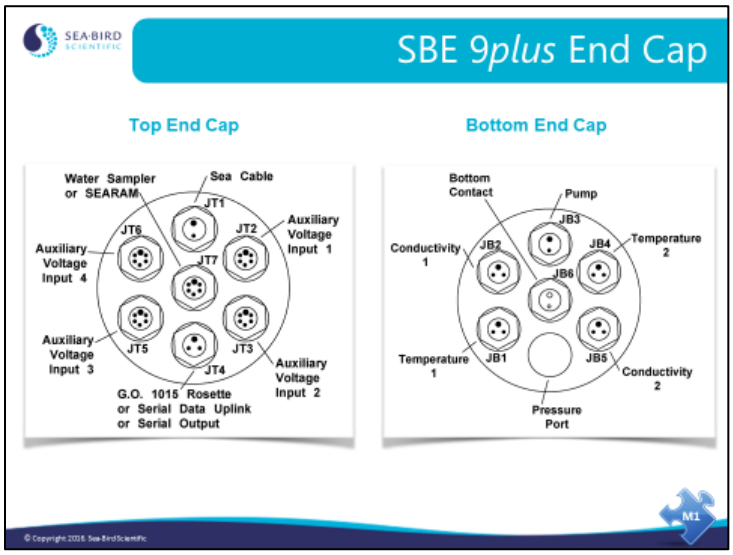


We will cover this in more detail in Modules 24 and 25.

Sea-Bird's website includes a number of Application Notes providing details on setting up the CTD to work with auxiliary sensors and calculating calibration coefficients to enter in our software (see www.seabird.com/application-notes). Following is a list of the application notes and their associated sensors:

- 7: Sea Tech and Chelsea (Alphatracka) Transmissometers
- 9: Sea Tech Fluorometer and WET Labs Flash Lamp Fluorometer (FLF)
- 11General: PAR Light Sensors
- 11Chelsea: Chelsea PAR Light Sensor *with* Built-In Log Amplifier
- 11Licor: Licor Underwater Type SA PAR Light Sensor *without* Built-In Log Amplifier
- 11QSP-L: Biospherical PAR Sensor *with* Built-In Log Amplifier
- 11QSP-PD: Biospherical PAR Sensor *without* Built-In Log Amplifier
- 11S: Biospherical Surface PAR Light Sensor with SBE 11*plus* Deck Unit
- 16: D&A Instruments OBS-3 Optical Backscatter Sensor
- 39: Chelsea Aquatracka Fluorometer
- 41: WET Labs WETStar Fluorometer
- 48: Seapoint Turbidity Meter
- 54: Seapoint Fluorometer
- 61: Chelsea Minitracka Fluorometer
- 62: WET Labs ECO-AFL and ECO-FL Fluorometer, ECO-NTU Turbidity Meter, and ECO-FL-NTU Fluorometer/Turbidity Meter
- 63: Turner SCUFA (I, II, or III) Fluorometer/OBS
- 72: WET Labs ECO-FL Fluorometer with Bio-Wiper™
- 74: Turner Cyclops-7 Fluorometer or Turbidity Sensor
- 77: Seapoint *Ultraviolet* Fluorometer
- 81: Campbell Scientific/D&A OBS-3+ Optical Backscatter Sensor
- 87: Wet Labs ECO-BB Scattering / Turbidity Meter
- 91: WET Labs C-Star Transmissometer
- 95: Teledyne Benthos Altimeter

Modular Sensors (*continued*)

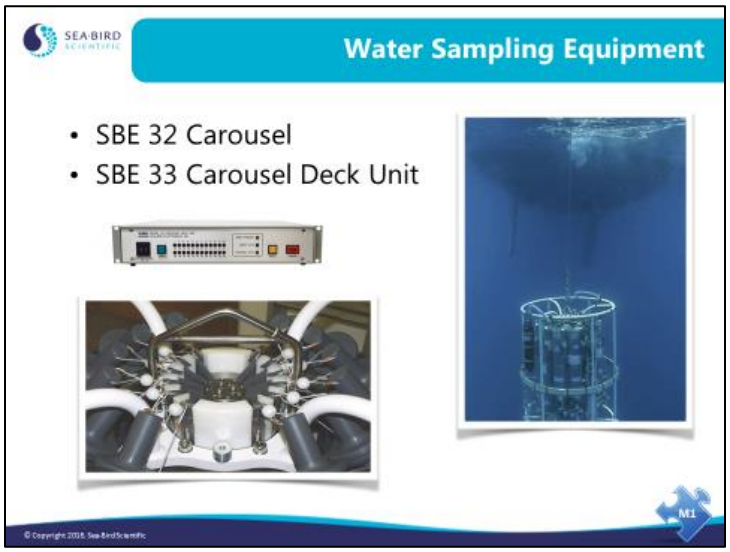


The **top end cap** of the 9*plus* has bulkhead connectors for all auxiliary sensors. Auxiliary sensors are those that are not temperature, conductivity, or pressure. Each auxiliary bulkhead has inputs for two 0 – 5V differential input channels. In addition, there is a 2-pin connector for the sea cable and a 3-pin connector for a GO 1015 rosette sampler. The center connector connects to the SBE 17*plus* (a memory module), a remote instrument, or an SBE 32 Carousel Water Sampler.

The **bottom end cap** has connectors for pairs of temperature and conductivity sensors, pump power, and a bottom contact switch. The bottom contact switch is mechanical, with a weight that hangs below the instrument package. When the weight contacts the ocean bottom, a bit is set in the data stream and an alarm in the SBE 11*plus* deck unit sounds.

WARNING! Do not plug the sea cable into the pump or bottom contact connector; this could cause serious damage to the CTD. In 2007, Sea-Bird changed the bottom contact connector to a female connector to reduce the possibility of this error; older units can be retrofitted if desired.

Water Sampling Equipment

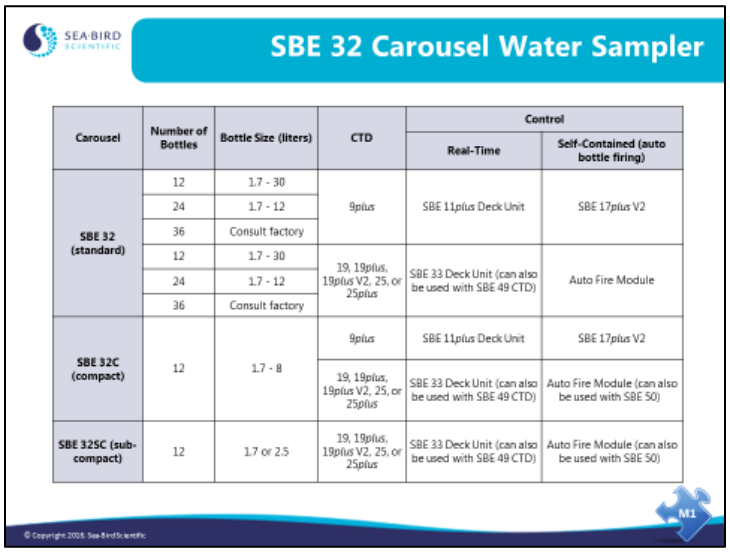


As a companion to CTD profilers, Sea-Bird supplies water sampling equipment. Sea-Bird manufactures the framework, mechanism for closing bottles, and deck power supply and sampler control. The water sample bottles for the SBE 32 are not manufactured by Sea-Bird. The SBE 32 is the portion of the equipment that triggers the bottle closure.

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.

For the SBE 9*plus* CTD, the 11*plus* Deck Unit provides real-time water sampler control. The SBE 33 Deck Unit shown above provides real-time water sampler control for internally recording CTDs (SBE 19, 19*plus*, 19*plus* V2, 25, or 25*plus*) as well as for the SBE 49 FastCAT CTD.

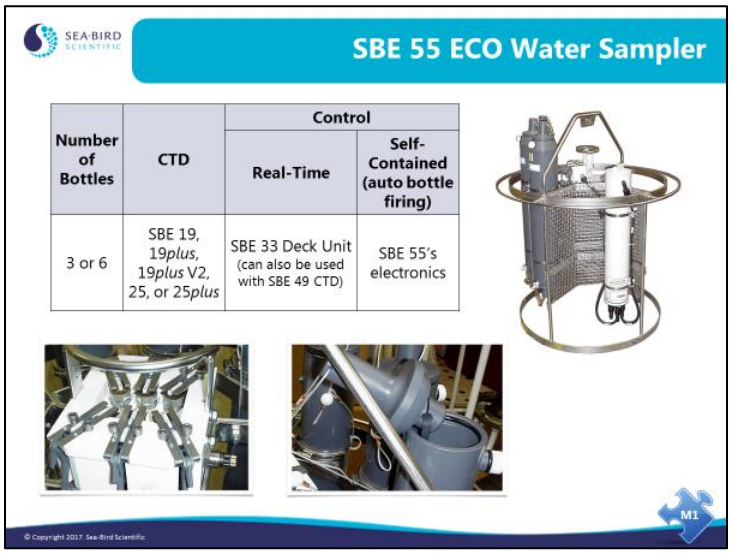
Water Sampling Equipment (*continued*)



Carousel	Number of Bottles	Bottle Size (liters)	CTD	Control	
				Real-Time	Self-Contained (auto bottle firing)
SBE 32 (standard)	12	1.7 - 30	9*plus*	SBE 11*plus* Deck Unit	SBE 17*plus* V2
	24	1.7 - 12			
	36	Consult factory			
	12	1.7 - 30	19, 19*plus*, 19*plus* V2, 25, or 25*plus*	SBE 33 Deck Unit (can also be used with SBE 49 CTD)	Auto Fire Module
	24	1.7 - 12			
	36	Consult factory			
SBE 32C (compact)	12	1.7 - 8	9*plus*	SBE 11*plus* Deck Unit	SBE 17*plus* V2
			19, 19*plus*, 19*plus* V2, 25, or 25*plus*	SBE 33 Deck Unit (can also be used with SBE 49 CTD)	Auto Fire Module (can also be used with SBE 50)
SBE 32SC (sub-compact)	12	1.7 or 2.5	19, 19*plus*, 19*plus* V2, 25, or 25*plus*	SBE 33 Deck Unit (can also be used with SBE 49 CTD)	Auto Fire Module (can also be used with SBE 50)

In autonomous (self-contained) mode, the system can be programmed to fire bottles at pre-defined pressures or times. The SBE 50 Pressure Sensor can be used in place of a CTD to provide the pressure measurements for autonomous bottle firing.

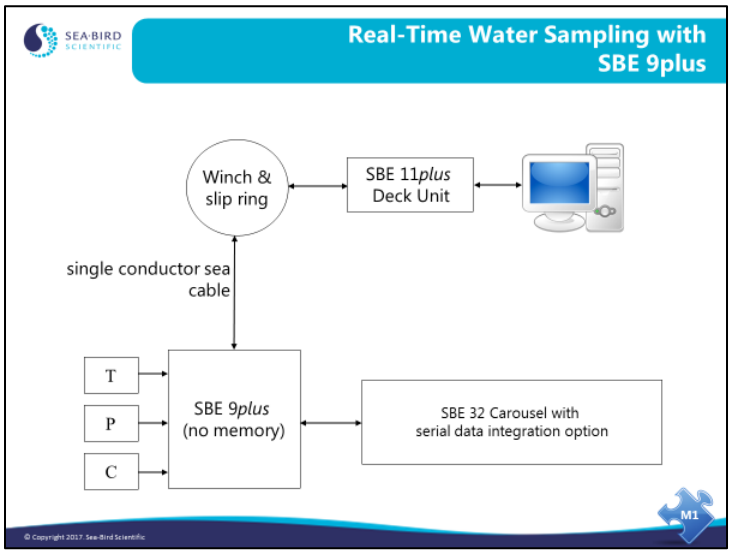
Water Sampling Equipment (*continued*)



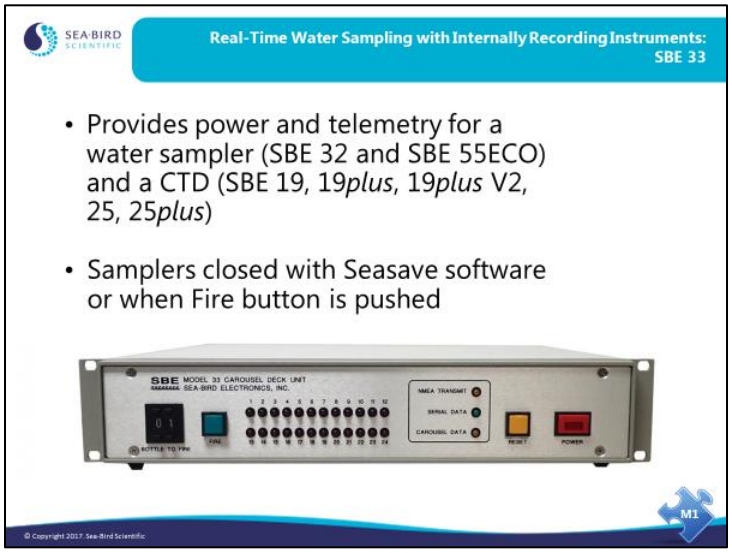
The SBE 55 is a small, 3- or 6-bottle water sampler, intended for sampling in depths to 600 meters. Its trigger mechanism operates in the same way as the mechanism on the Carousel, and its electronics are similar. Sea-Bird manufactures the water sample bottles for the SBE 55.

The ECO is compatible with the SBE 33 Deck Unit for real-time applications. It has built-in auto-fire capability, so an Auto Fire Module is not required for autonomous applications. The ECO is not intended for use with the SBE 9*plus* / 11*plus* system (which is typically deployed for deeper applications).

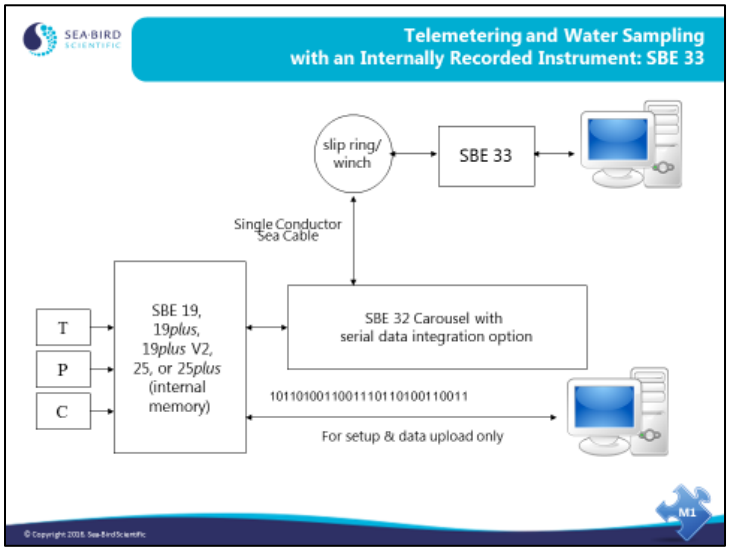
Real-time Water Sampling with SBE 9plus



Real-time Water Sampling with Internally Recording Instruments



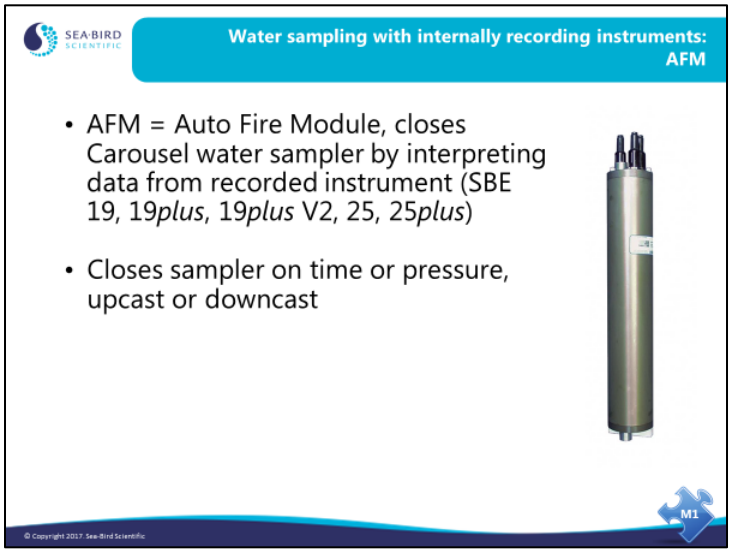
Real-time Water Sampling with Internally Recording Instruments *(continued)*



This setup can also be used with an SBE 49 FastCAT CTD, which has no internal memory.

The diagram also applies to a standard SBE 55 ECO Water Sampler (serial data integration capability is built into the standard ECO).

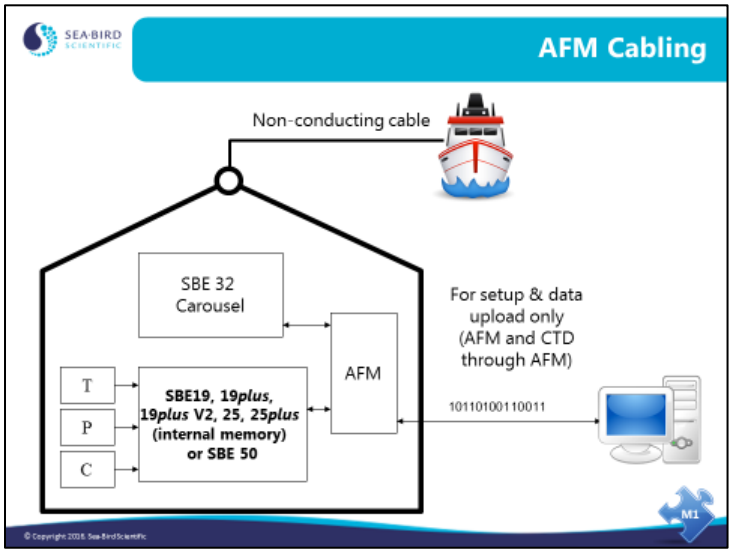
Autonomous Water Sampling with Internally Recording Instruments



Internally recording instruments output a real-time, RS-232 serial data stream. This data stream is suitable for real-time telemetry over short cables only. The data stream is used by the AFM to monitor the depth of the sampling package for the purpose of closing water samplers.

Autonomous vs Real-Time Water Sampling: Autonomous sampling does not provide water sample quality that is equal to that from real-time sampling; it is a compromise intended to serve users who do not have real-time capability on their vessel. For real-time sampling, you typically stop the winch before each sample, ensuring the sample is actually taken where you think it is. Autonomous sampling usually provides some *smearing* of the sample, as the package continues to move while the bottle is closing. You can program the AFM to sample when stationary, but you are estimating the depth based on the cable payout, and do not have exact knowledge of the water features before you take the sample.

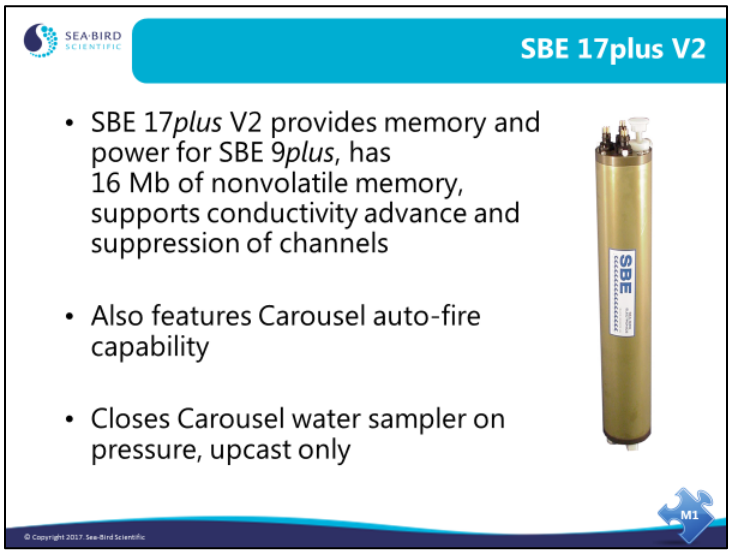
Autonomous Water Sampling with Internally Recording Instruments *(continued)*



The AFM is programmed to close water samplers at the required depths, and then it is armed. It receives pressure data from the CTD; when the closure parameter for a water sample has been met, it actuates the Carousel and records a small amount of CTD data. When the CTD is retrieved, the data in the CTD and AFM are uploaded to the computer. The data in the AFM is used in post-processing to get a table of CTD parameters to go with whatever is gleaned from the water samples.

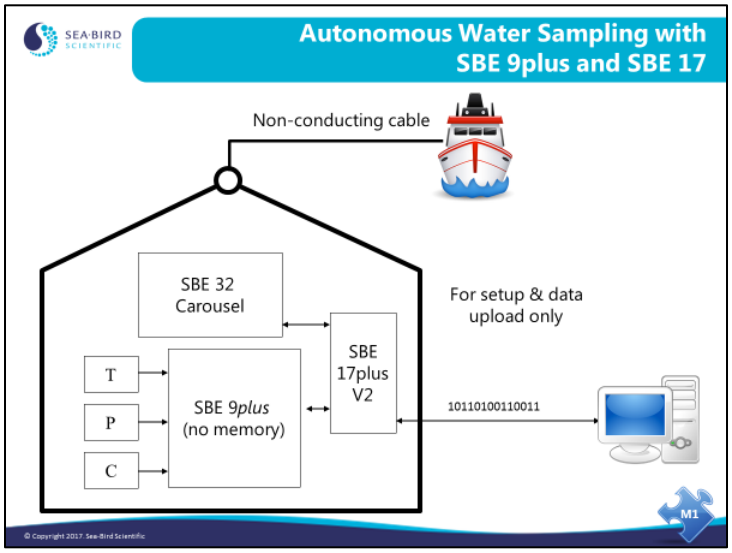
The SBE 55 ECO Water Sampler's built-in electronics operate similarly to the AFM / SBE 32 Carousel Water Sampler combination. The ECO has built-in auto-fire capability, so no auxiliary equipment is required for autonomous applications. Like the AFM, it closes bottles on time or pressure, on upcast or downcast.

Autonomous Water Sampling with the SBE 9plus

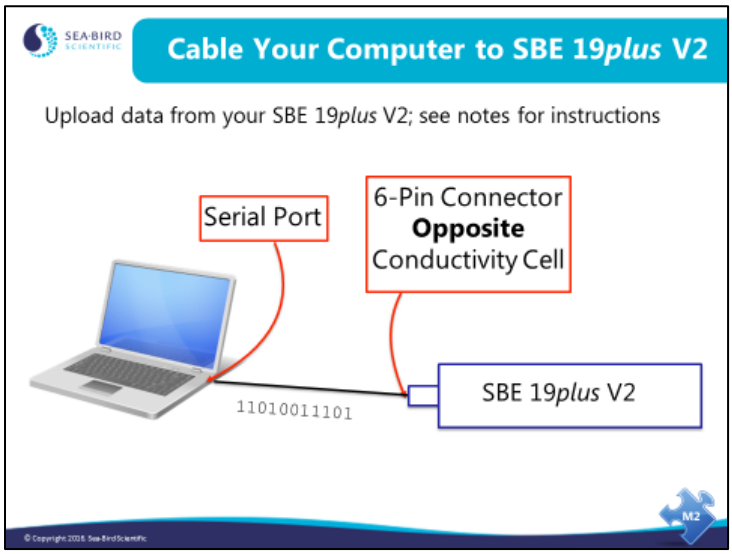


The SBE 17*plus* V2 acts as battery power and internally recording memory for the SBE 9*plus*. This device has the capability to close water samplers as well. It only closes bottles on the upcast.

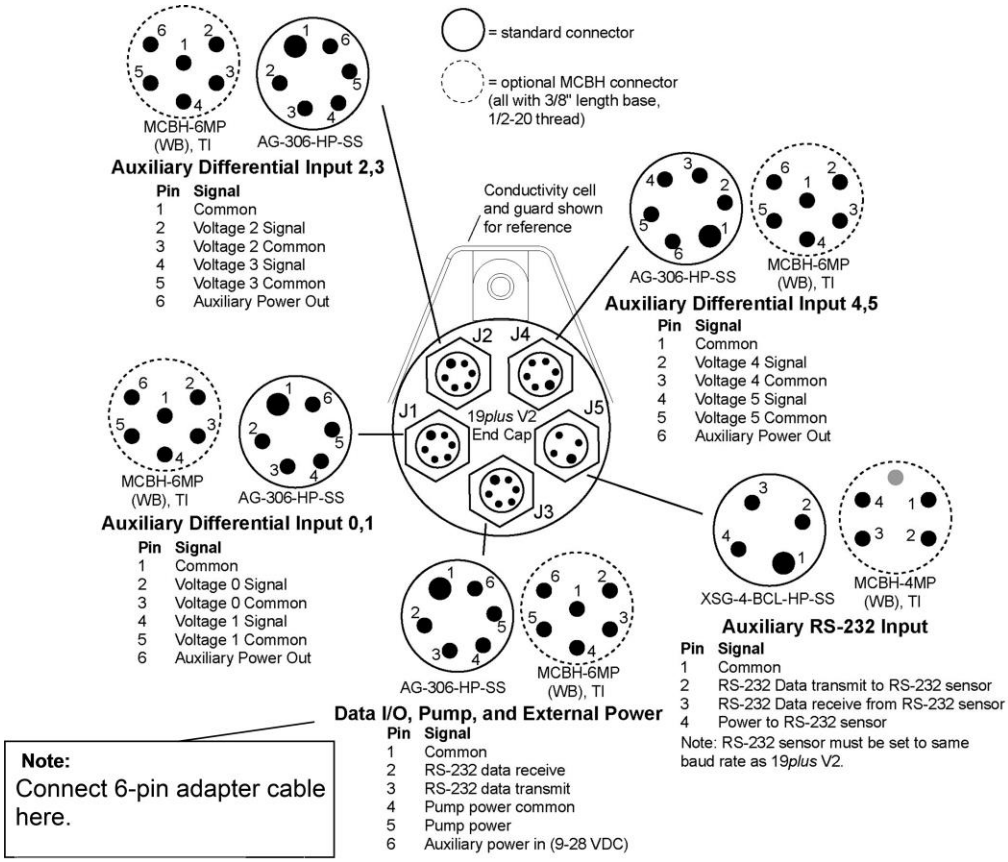
Autonomous Water Sampling with the SBE 9plus *(continued)*



Activity: Cable Computer to SBE 19*plus* V2



In class, we are connecting the 6-pin Data I/O-Pump connector with a 6-pin to 4-pin adapter cable and a 4-pin to DB-9 data I/O cable. The end cap diagram is below:



Note: In a real deployment, a Y-cable connects to the 6-pin Data I/O – Pump connector. The 2-pin leg of the cable connects to the pump; the 4-pin leg of the cable connects to the computer or deck unit if obtaining real-time data.

If you are using a **USB to RS-232 converter, you need to know what COM port your computer has assigned to the connection**. Follow these directions (written for Windows 7) to determine the COM port:

1. Select Start icon.
2. Select Control Panel.
3. Click on *Device Manager*.
    A. Click *Ports.*
    B. Write down what COM port designation has been assigned to the USB Serial Port.

If no USB Serial Port is shown in Device Manager, then you may need to manually install the drivers for the USB/RS-232 converter device. The drivers can be found on the data memory stick that you received for class. Save the driver files to your PC, and then try to run the Setup application file to update your drivers