

SBE 21 SEACAT Thermosalinograph

*Conductivity and Temperature Recorder
with RS-232 Interface*



User's Manual

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Firmware Version 4.2a and later**

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Section 1: Introduction

This section includes contact information and photos of a standard SBE 21 shipment.

About this Manual

This manual is to be used with the SBE 21 SEACAT Thermosalinograph Conductivity and Temperature Recorder.

It is organized to guide the user from installation through operation and data collection. We've included detailed specifications, command descriptions, maintenance and calibration information, and helpful notes throughout the manual.

Sea-Bird welcomes suggestions for new features and enhancements of our products and/or documentation. Please e-mail any comments or suggestions to seabird@seabird.com.

How to Contact Sea-Bird

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(1600 to 0100 Universal Time)
Except from April to October, when we are on 'summer time'
(1500 to 0000 Universal Time)

Unpacking SBE 21

Shown below is a typical SBE 21 shipment.



SBE 21



PN 90158.1 –
SEACAT/SEALOGGER
RS-232 and Navigation
Interface Box



I/O Cable
(SBE 21 to Interface Box)



AC power cable for
Interface Box



Interface Box to
computer cable



NMEA Interface test cable
(Interface Box to NMEA navigation
device simulation computer)



Cell cleaning solution
(Triton X-100)



SBE 21
User Manual



Software, and Electronic Copies of
Software Manuals and User Manual

Section 2: Description of SBE 21

This section describes the functions and features of the SBE 21, including specifications and dimensions.

System Description

The SBE 21 SEACAT Thermosalinograph is an externally powered, high-accuracy, conductivity and temperature recorder, designed for shipboard determination of sea surface (pumped-water) conductivity and temperature. Data is simultaneously transmitted to a computer's serial port and stored in 8 Mb FLASH RAM memory, allowing both real-time data acquisition and independent data logging. An internal lithium back-up battery in the SBE 21 supports the real-time clock when the main power supply is off.

The SBE 21 is connected by cable to PN 90158.1 - SEACAT/SEALOGGER RS-232 and Navigation Interface Box. The Interface Box is AC-powered, provides isolated DC power and an optically-isolated RS-232 data interface for the SBE 21, and provides power and a NMEA 0183 receiver for a NMEA navigation device (not supplied by Sea-Bird). The NMEA interface appends navigation information to the SBE 21 data stream.

The platinum-electrode glass conductivity cell's unique internal-field geometry eliminates proximity effects. This feature is critically important in thermosalinographs, where the cell must operate in a water jacket's confined volume. The internal-field cell also allows the use of expendable AF24173 Anti-Foulant Devices (supplied).

For corrosion resistance, only plastic, titanium, and the glass/platinum conductivity cell are exposed to seawater. Valves control seawater circulation and fresh water flushing. The sensor assembly is easily removed for cleaning and calibration.

The PVC base or back plate may be drilled for mounting to the ship. Seawater connections (for normal use) and fresh water connections (for cleaning) are PVC pipes with 1-inch (25.4 mm) U.S. standard NPT threads. Mating female fittings are provided, and can easily be adapted to locally available pipe sizes.

Communication with the SBE 21 is over an internal, 3-wire, RS-232C link, providing real-time data transmission. Commands can be sent to the SBE 21 to provide status display, data acquisition setup, data retrieval, and diagnostic tests. Output format is raw, hexadecimal data. The SBE 21 samples using one of the following user-programmable schemes:

- **Continuously at 4 Hz:** At pre-programmed 3- to 600-second intervals, the SBE 21 averages all the data from within the sampling interval, stores the average in memory, and sends the average to the computer (through the Interface Box).
- **At pre-programmed intervals:** At pre-programmed 3- to 600-second intervals, the SBE 21 takes one sample, stores the sample in memory, and sends the sample data to the computer (through the Interface Box).

A standard SBE 21 can record the output of an optional remote temperature sensor (SBE 38), allowing for the measurement of sea surface temperature with minimum thermal contamination from the ship's hull. A stainless steel and plastic in-line pipe mount is available for safe below-waterline installation of the remote temperature sensor. See *Section 3: Installing System* for details.

A standard SBE 21 is supplied with:

- Bulkhead connectors:
 - one 4-pin I/O connector
 - one 6-pin connector for A/D inputs (four single-ended or two differential channels)
 - one 4-pin connector for remote temperature sensor
 - one 1-pin connector for ground to ship's hull
- 8 Mbyte FLASH RAM memory
- Anti-foulant device attachments and expendable AF24173 Anti-Foulant Devices on each end of the conductivity cell.
- PN 90158.1 – SEACAT/SEALOGGER RS-232 and Navigation Interface Box, providing power to the SBE 21, an optically isolated RS-232 interface, a NMEA 0183 input port for navigation data, and power for a NMEA navigation device.

SBE 21 options include:

- Remote temperature sensor (SBE 38) and mounting kit
- Sensors for dissolved oxygen, pH, fluorescence, light (PAR), light transmission, and turbidity (mounts not supplied)

The SBE 21 is supplied with a powerful Win 95/98/NT/2000/XP software package, SEASOFT-Win32, which includes:

- **SEATERM** –terminal program for easy communication and data retrieval.
- **SEASAVE** –program for acquiring, converting, and displaying real-time or archived raw data.
- **SBE Data Processing** - program for calculation and plotting of conductivity, temperature, data from auxiliary sensors, and derived variables such as salinity and sound velocity.

Notes:

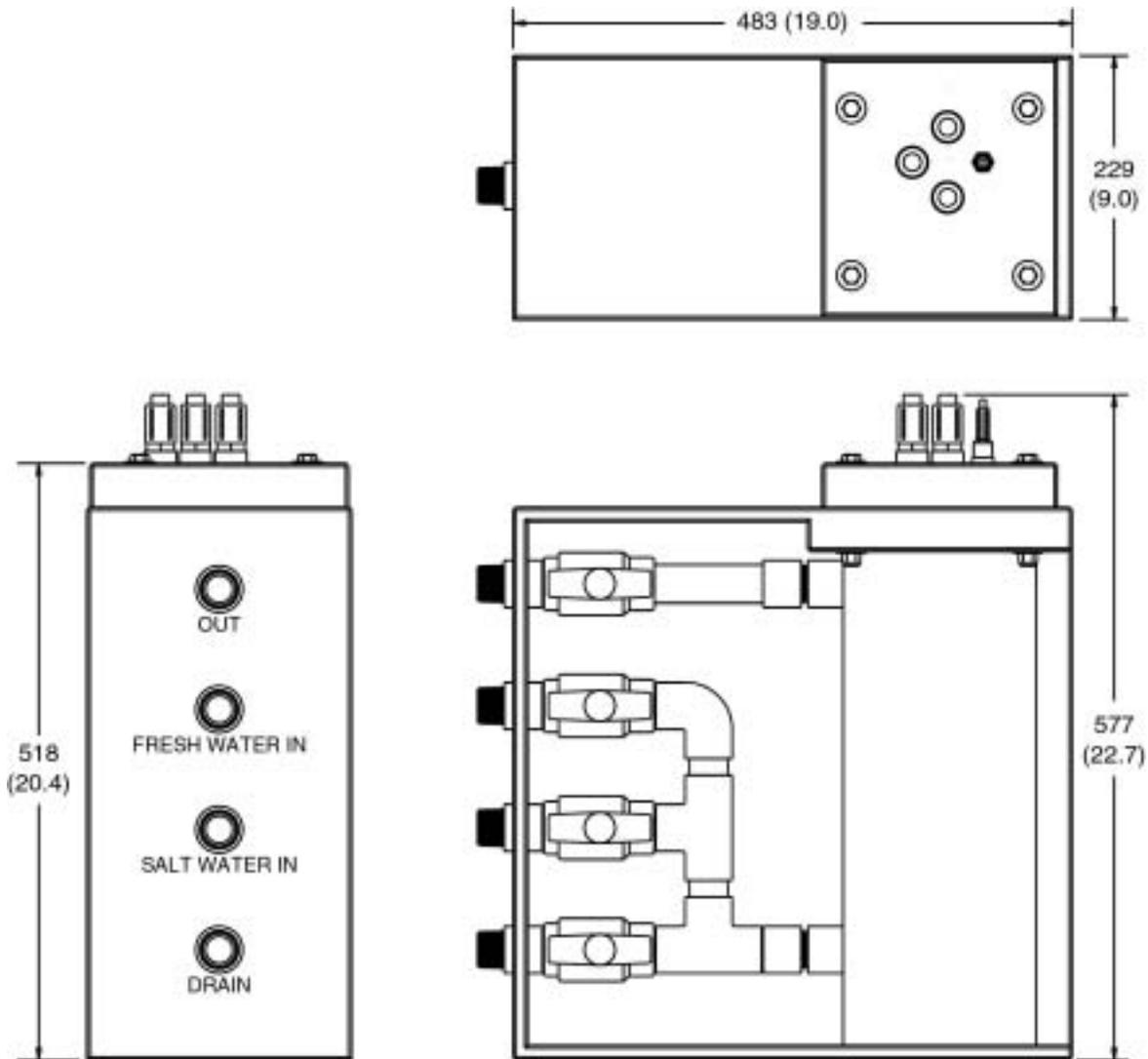
- Help files provide detailed information on the use of SEATERM, SEASAVE, and SBE Data Processing.
- Separate software manuals contain detailed information on the setup and use of SEASAVE and SBE Data Processing.
- Sea-Bird also supplies a DOS software package, SEASOFT-DOS. However, SEASOFT-DOS modules for real-time data acquisition and data analysis are not compatible with the data output format of the SBE 21; this manual details only the use of the Windows software with the SBE 21.

Specifications

	Conductivity (S/m)	Primary Temperature (°C)	SBE 38 Secondary Temperature (°C)
Measurement Range	0 to 7	-5 to +35	-5 to +35
Initial Accuracy	0.001	0.01	0.001
Resolution	0.0001	0.001	0.0003
Calibration (measurement outside these ranges may be at slightly reduced accuracy due to extrapolation errors)	0 to 7; physical calibration over the range 1.4 to 6 S/m, plus zero conductivity (air)	+1 to +32	-1 to +32
Memory	8 Mbyte non-volatile FLASH memory		
Data Storage	Recorded Parameter		Bytes/sample
	temperature and conductivity		4 (2 each)
	each external voltage		2
	SBE 38 or SBE 3 secondary temperature		3
Real-Time Clock	32,768 Hz TCXO accurate to ±1 minute/year		
Sample Rate	<i>Remote temperature not enabled:</i> 1 sample / 3 seconds to 1 sample / 600 seconds <i>Remote temperature enabled:</i> 1 sample / 4 seconds to 1 sample / 600 seconds Sample rate is incremented in 1-second steps		
Materials	PVC housing, water jacket, piping, and valves; titanium end cap		
Recommended Flow Rate	1 liter/second (15.8 gallons/minute)		
Auxiliary Voltage Sensors	Auxiliary power out: up to 500 mA at 10.5 - 11 VDC A/D resolution: 12 bits Input range: 0 - 5 VDC		
Maximum Safe Operating Pressure	34.5 decibars (50 psi)		
Weight	41 kg (90 lbs)		

Dimensions and Bulkhead Connectors

Dimensions in millimeters (inches)



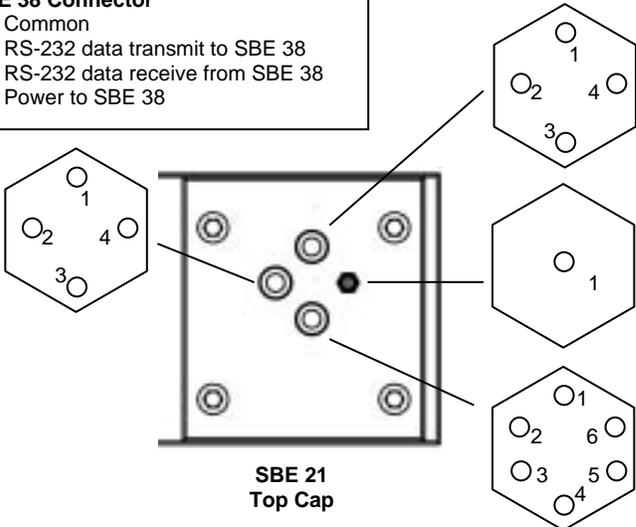
SBE 38 Connector
 1 Common
 2 RS-232 data transmit to SBE 38
 3 RS-232 data receive from SBE 38
 4 Power to SBE 38

I/O Connector - RS-232C Communications
 1 Common
 2 RX
 3 TX
 4 Power in
Note: I/O connector is counter-clockwise from ground connector. Do not connect I/O cable to 4-pin SBE 38 connector.

Ground
 1 Ground to ship's hull

A/D Inputs - Single-ended
 1 Common
 2 External Volt 0
 3 External Volt 3
 4 External Volt 1
 5 External Volt 2
 6 Power out

A/D Inputs - Differential
 1 Common
 2 Signal external Volt 0
 3 Com external Volt 0
 4 Signal external Volt 1
 5 Com external Volt 1
 6 Power out



**SBE 21
 Top Cap**

Data I/O

The SBE 21 receives set-up instructions and outputs diagnostic information or previously recorded data via a three-wire RS-232C link, and is factory-configured for 9600 baud, 7 data bits, 1 stop bit, and even parity. SBE 21 RS-232 levels are directly compatible with standard serial interface cards (IBM Asynchronous Communications Adapter or equal). The communications baud rate can be changed using the **BAUD=** command (see *Command Descriptions* in *Section 4: Setting Up SBE 21* for details).

Data Storage

Note:

If the FLASH memory is filled to capacity, data sampling and transmission of real-time data continue, but excess data is not saved in memory. **The SBE 21 will not overwrite data stored in memory.**

The SBE 21 has an 8 Mbyte FLASH memory. See *Specifications* in this section for storage space required for each parameter.

Example 1: no auxiliary sensors

T & C = 4 bytes/sample

Storage space $\approx 8,000,000 / 4 \approx 2,000,000$ samples

Example 2: 4 external voltages, SBE 38 secondary temperature sensor

T & C = 4 bytes/sample

External voltages = 2 bytes/sample x 4 voltages = 8 bytes/sample

SBE 38 = 3 bytes/sample

Storage space $\approx 8,000,000 / (4 + 8 + 3) \approx 533,333$ samples

Remote Temperature Sensor (optional)

The SBE 21 can record the output of an external SBE 38 temperature sensor. Often, the SBE 21 is mounted in the interior of the vessel. In this configuration the recorded conductivity is correct, but the water temperature changed as it passed through the plumbing system. The SBE 38 can be placed in a location that provides more accurate measurement of the sea surface water temperature. **The ideal location for the SBE 38 is at the seawater intake (before the pump) near the bow of the ship.** This minimizes contamination of the surface temperature measurement by the ship's own thermal mass.

To compute salinity, always use the data from the temperature sensor on the SBE 21, not from the SBE 38. Conductivity has a strong thermal coefficient; therefore, it is critical to know the temperature of the water when the conductivity sensor samples it in order to compute salinity correctly. On a typical installation, there may be 20 to 30 meters of plumbing between the SBE 38 and the SBE 21. As the water flows through the pipes it changes temperature dramatically, making the data from the SBE 38 an inaccurate representation of the temperature when the water reaches the conductivity sensor. Use the SBE 38 only to report surface temperature.

Note that the SBE 38 can be added to the system at any time, and does not need to be part of the original order for the SBE 21. No modifications to the SBE 21 are required to integrate the SBE 38, other than programming the SBE 21 to accept the sensor signal and updating the configuration (.con) file.

Section 3: Installing System

This section provides instructions for:

- Installing software
- System installation guidelines
- Mounting and wiring the SBE 21 and Interface Box

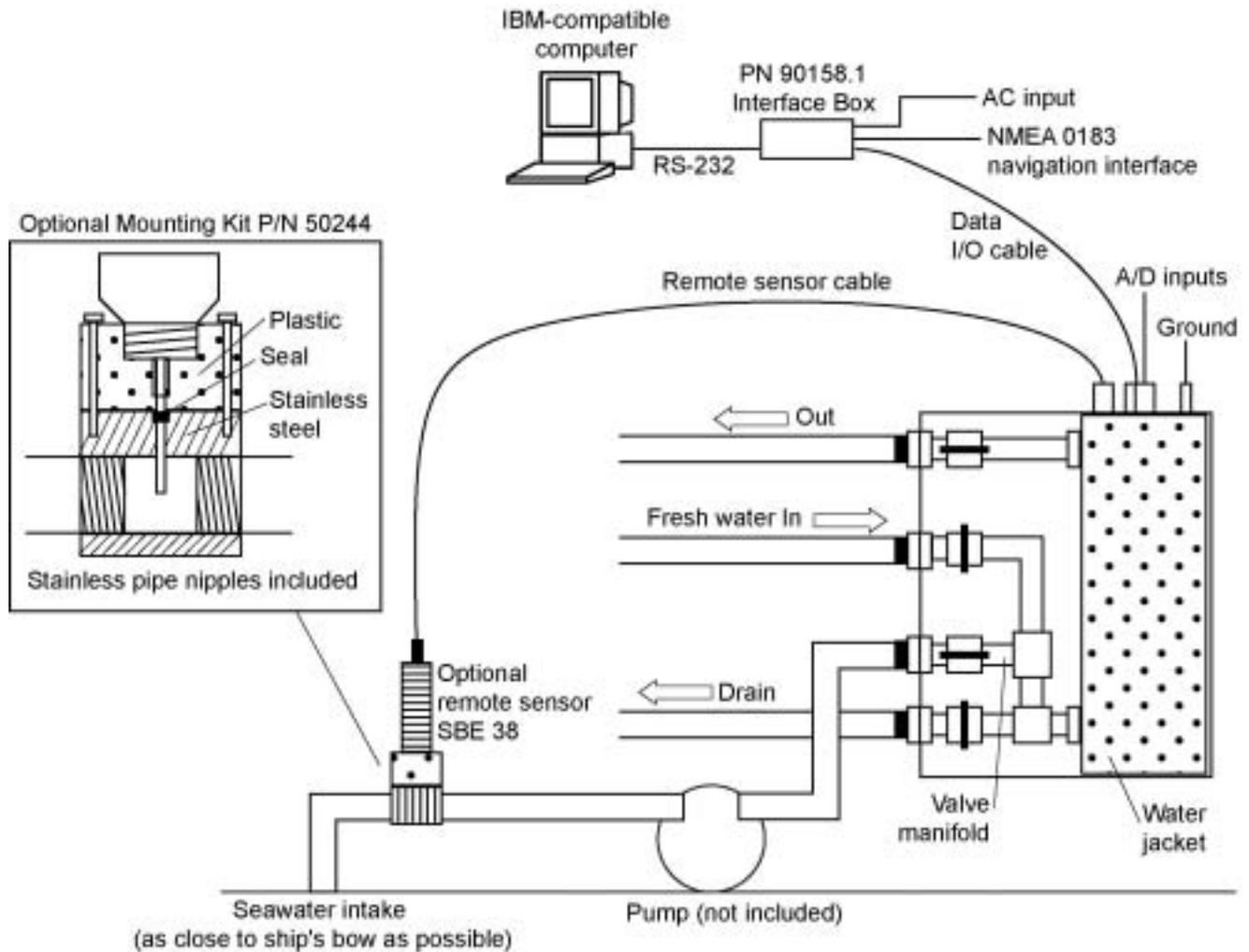
Installing Software

If not already installed, install Sea-Bird software programs on your computer using the supplied software CD.

1. With the CD in your CD drive, double click on **Seasoft-Win32.exe**.
2. Follow the dialog box directions to install the software.

The installation program allows you to install the desired components. Install all the components, or (for the SBE 21) just install SEATERM (terminal program), SEASAVE (real-time data acquisition program), and SBE Data Processing (data processing program). The default location for the software is c:/Program Files/Sea-Bird. Within that folder is a sub-directory for each component.

System Schematic and Installation Guidelines



Valves are shown in normal operating position. Valves are open when handle is horizontal, closed when handle is vertical.

Sea-Bird does not provide detailed installation instructions for the SBE 21 and remote temperature sensor, given the unique nature of every ship and type of installation. The installation of the SBE 21 should be done by qualified shipfitters, with the oversight of a competent ship designer or naval architect.

Consider the following:

- The SBE 21 can be mounted anywhere it will *fit* that is accessible for maintenance and cleaning. **For safety, mount the SBE 21 above the water line.**
 - If the remote temperature sensor is not used, mount the SBE 21 as close to the seawater intake as possible to avoid thermal contamination of long plumbing runs. Thermal contamination will not affect salinity accuracy, but the SBE 21 will report the temperature of the water when it reaches the instrument.
 - If the remote temperature sensor is used, the SBE 21 can be mounted in the ship's lab or other convenient location.
 - The maximum recommended cable length from the SBE 21 to the Interface Box is 100 meters.
- Sea-Bird does not recommend or supply a pump. The pump should be able to provide 1 liter/second (15.8 gallons/minute) flow. Pressure at the SBE 21 is limited to 50 psi.
- Bubbles in the plumbing of a flow-through system are a common problem and will cause noisy salinity data. To minimize bubbles:
 - Place the pump below the water line to *push* rather than *pull* the water.
 - Locate the SBE 21's hull intake as deep as possible, as far as possible from bubble sources (bow wake, propeller, etc.)
- Depending on the chosen design of a permanent seawater supply (including pump, intake fitting, pipes, etc.), a de-bubbling device may be needed to separate bubbles from the water before it enters the SBE 21. Note that a de-bubbler may cause additional temperature errors for the SBE 21's primary temperature sensor; salinity accuracy (and accuracy of an optional remote temperature sensor) is not affected. Not all ships require de-bubblers, but many do for best quality salinity data. Large single point salinity spikes can be removed with the WILD EDIT module in SBE Data Processing.
- Route cabling as cleanly as possible, avoiding sources of noise. Electric motors are a particular problem. Avoid routing the cable next to generators and air conditioners.
- If practical, mount the optional SBE 38 remote temperature sensor outside the hull. However, the remote temperature sensor is usually mounted in the remote sensor mount kit, which has 1-inch pipe threads on each end; plumb the mount kit into your seawater system. Install the SBE 38 as close to the seawater intake as possible (before the pump), near the bow of the ship. Since the installation is below the water line, consult with your ship's engineer / naval architect / shipyard regarding the actual installation. Sea-Bird cannot offer advice in this matter as each ship is different and plumbing regulations vary.
- The SBE 21 can record a maximum of four auxiliary voltages from auxiliary sensors. However, Sea-Bird has not developed methods for the mechanical integration of these auxiliary sensors with the SBE 21. When integrating auxiliary sensors with the SBE 21, consider the following issues:
 - Install the sensors in a flow-through chamber that receives the outflow from the SBE 21.
 - Design the flow-through chamber so sensors can be removed and replaced for service and calibration.
 - Protect auxiliary sensors (fluorometer, dissolved oxygen sensor, etc.) from bio-fouling.

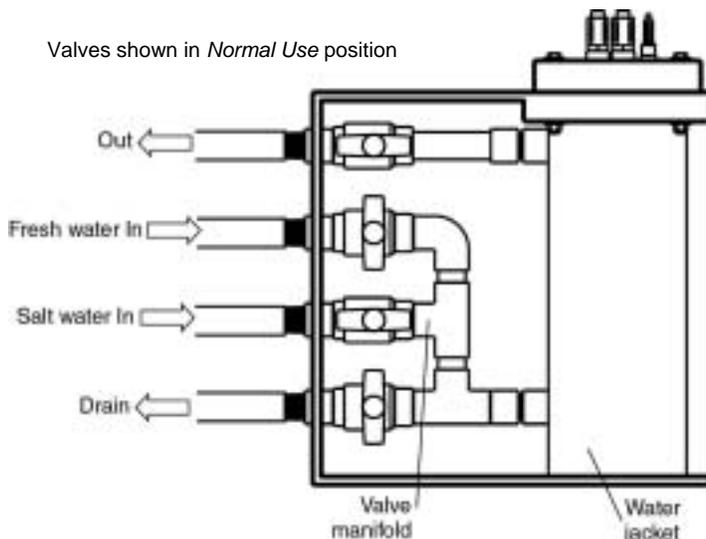
Mechanical Installation



1. A new SBE 21 is shipped with AF24173 Anti-Foulant Devices pre-installed. Verify that the Devices are installed (see *Removing Sensor/Electronics Module from SBE 21 Water Jacket* in *Section 7: Routine Maintenance and Calibration* and *Appendix IV: AF24173 Anti-Foulant Device*).
2. Mount the SBE 21 at the desired location:
 - Orient the SBE 21 with the bulkhead connectors at the top.
 - Provide minimum top clearance of 559 mm (22 inches) for removal of the sensor/electronics module from the water jacket.
 - Drill the PVC base or backplate, and mount to the ship using machine bolts.
3. Install the piping connections to the SBE 21. The connectors are 1-inch (25.4 mm) National (USA) threads. Female mating fittings suitable for connecting to PVC plastic pipe with glue are provided; they may be modified for use with existing piping.
 - A. Connect the Out fitting to the shipboard drain or to the low pressure side of salt water supply.
 - B. Connect the Fresh Water In fitting to the shipboard fresh water supply.
 - C. Connect the Salt Water In fitting to the shipboard sea surface water intake line.
 - D. Connect the Drain fitting to shipboard drain.
4. Set the valves, as described in the following table. The valve is open when the handle is horizontal and closed when the handle is vertical.

Valve	Normal Use	Fresh Water Flushing	Storage, Cleaning, or Removal of Sensor/Electronics Module
Out	Open	Open	Closed
Fresh Water In	Closed	Open	Closed
Salt Water In	Open	Closed	Closed
Drain	Closed	Closed	Closed

Valves shown in *Normal Use* position



Electrical Installation

Connecting SBE 21 to Interface Box

1. Locate the Interface Box near the computer.
 - If the distance between the SBE 21 and Interface Box is longer than the provided 10 meter I/O cable, cut the cable and splice it into the ship's cable. The ship's cable should have 3 conductors, preferably with at least 2 of the conductors shielded (RS-232 TX and RX) if engine ignition noise or other EM interference might be encountered. See drawing number 31063 for cable wiring details.
2. Connect the I/O cable to the SBE 21:
 - A. By hand, unscrew the locking sleeve from the SBE 21's I/O (4-pin) connector. If you must use a wrench or pliers, be careful not to loosen the I/O connector instead of the locking sleeve.
 - B. Remove the dummy plug from the SBE 21's I/O connector by pulling the plug firmly away from the connector.
 - C. Lightly lubricate the inside of the 4-pin cable connector with silicone grease (DC-4 or equivalent).
 - D. Install the 4-pin cable connector on the SBE 21, aligning the raised bump on the side of the connector with the large pin on the SBE 21's bulkhead connector. Remove any trapped air by *burping* or gently squeezing the connector near the top and moving your fingers toward the end cap.
 - E. Place the locking sleeve over the cable connector. Tighten the locking sleeve finger tight only. **Do not overtighten the locking sleeve, and do not use a wrench or pliers.**
3. Connect the MS-style metal shell connector on the I/O cable to *SEACAT Data I/O* on the Interface Box.

CAUTION:

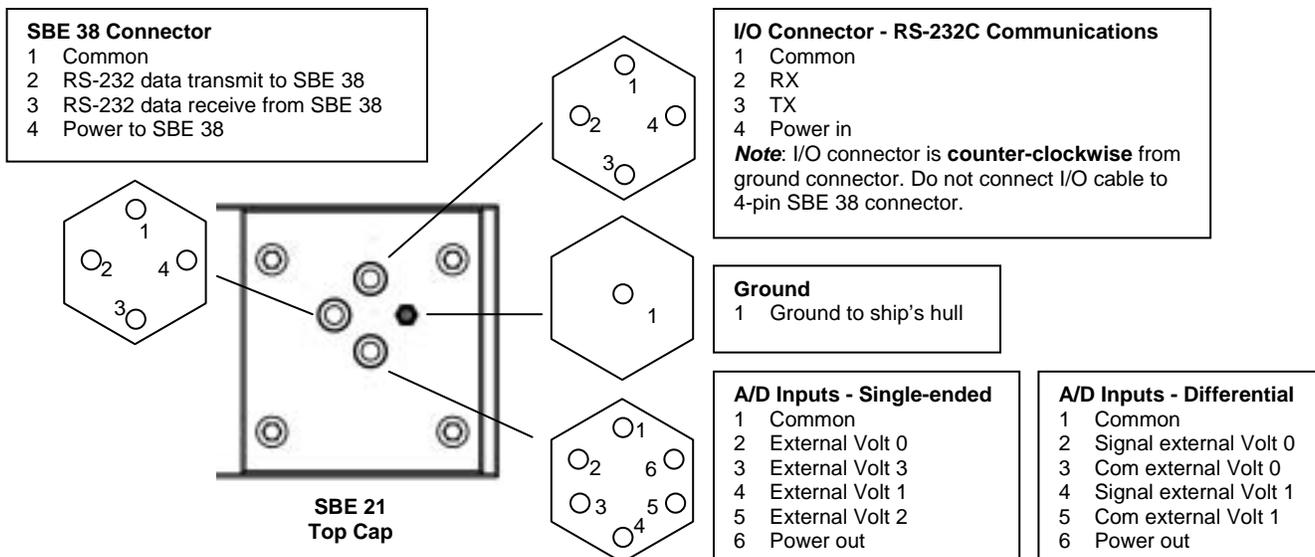
Do not use **WD-40** or other petroleum-based lubricants, as they will damage the connector.

Note:

Follow the procedure in Steps 2A through 2E for proper installation of all cables with similar connectors.

Connecting SBE 21 to Ground and to Auxiliary Sensors

1. Connect the SBE 21's 1-pin ground connector to ship's ground.
2. (optional) Install the cable between the SBE 21 and optional SBE 38 Remote Temperature Sensor.
3. (optional) Install the cable(s) for optional auxiliary voltage sensors.



Connecting Interface Box

1. Connect *RS-232C* on the Interface Box to the computer using the DB-9S / DB-9P cable.
2. Connect the Interface Box *AC Input* to a standard, 3-prong, grounded, AC outlet, using the supplied UL/IEC-approved power cord (AC voltage between 85-270 VAC).
3. (optional) Connect a NMEA navigation device to *NMEA Input* on the Interface Box with the supplied 5-pin MS connector (MS3106A14S-5P). The connector pin designations are:

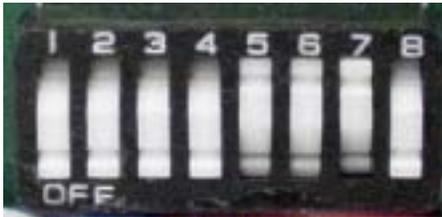
Interface Box	Function
Pin A	Optional power return
Pin B	NMEA <i>A</i> (signal)
Pin C	NMEA <i>B</i> (signal return)
Pin D	No connection
Pin E	Optional +12 DC power out, up to 2 amps

Section 4: Setting Up SBE 21

This section describes:

- Setting communications parameters with the Interface Box dip switch
- Testing power and communications and setting up the SBE 21 in SEATERM
- Setting up the configuration (.con) file in SEASAVE
- Command descriptions
- Data output format

Setting Interface Box Dip Switch



Note that a switch is ON when pushed IN at the position number.

In the photo at left:

- positions 1, 2, 3, 4, and 8 are ON
- positions 5, 6, and 7 are OFF

An 8-position dip switch in the PN 90158.1 - SEACAT/SEALOGGER RS-232 and Navigation Interface Box sets communication parameters. **The correct settings for the SBE 21 are shown in bold italic:**

WARNING!
Remove power from the Interface Box before opening the box to change the dip switch settings.

- Data bits and parity for communication (SBE 21 to Interface Box and Interface Box to computer)

Data Bits and Parity	Dip Switch Setting - Position 4
<i>7 data bits, even parity</i>	<i>ON</i>
8 data bits, no parity	OFF

- Baud rate between the SBE 21 and Interface Box

Baud Rate Between SBE 21 and Interface Box	Dip Switch Setting	
	Position 5	Position 6
<i>9600 (factory default)</i>	<i>ON</i>	<i>ON</i>
4800	OFF	ON
1200	ON	OFF
600	OFF	OFF

- Baud rate between the Interface Box and computer

Baud Rate Between Interface Box and Computer	Dip Switch Setting	
	Position 7	Position 8
19200	ON	ON
<i>9600 (factory default)</i>	<i>OFF</i>	<i>ON</i>
4800	ON	OFF
1200	OFF	OFF

Note:
See Section 5: Setting Up NMEA Interface for details.

- NMEA message to decode

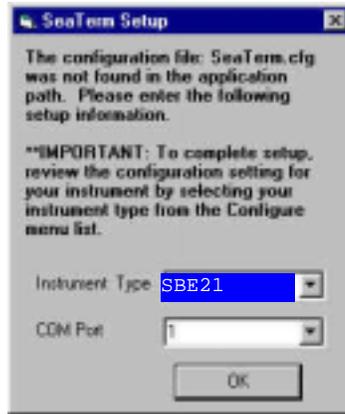
NMEA Message to Decode	Dip Switch Setting		
	Position 1	Position 2	Position 3
GGA	ON	ON	ON
GLL	OFF	ON	ON
RMA	ON	OFF	ON
RMC (factory default)	OFF	OFF	ON
TRF	ON	ON	OFF

Power and Communications Test and SBE 21 Setup in SEATERM

Notes:

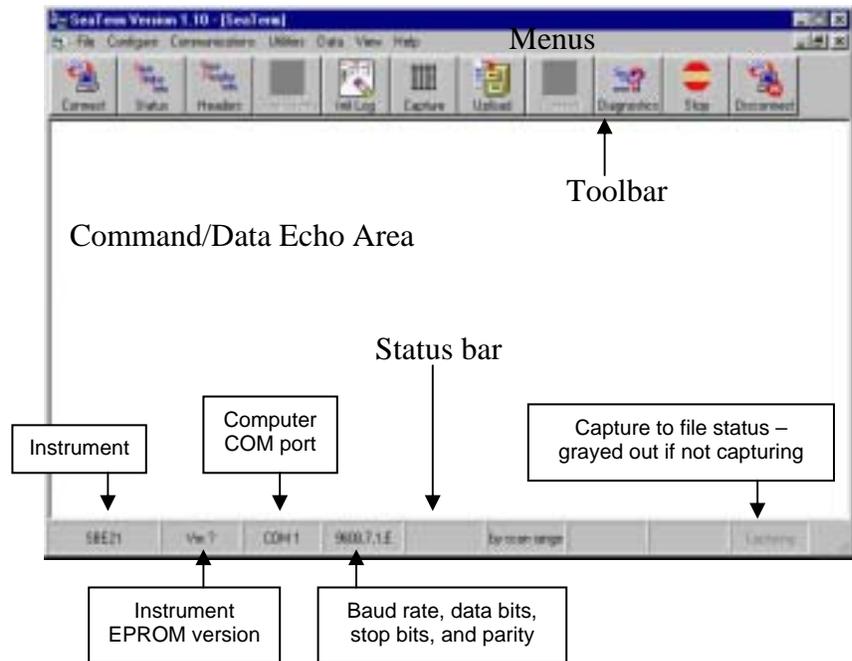
- See SEATERM's help files for detailed information on the use of the program.
- It is possible to use the SBE 21 without SEATERM by sending direct commands from a dumb terminal or terminal emulator, such as Windows HyperTerminal.

1. Wire the SBE 21 to the Interface Box, wire the Interface Box to the computer, and provide power to the Interface Box, as described in *Electrical Installation* in *Section 3: Installing System*.
2. Double click on SeaTerm.exe. If this is the first time the program is used, the setup dialog box appears:



Select the instrument type (SBE 21) and the computer COM port for communication with the SBE 21. Click OK.

3. The main screen looks like this:



Note:

There is at least one way, and as many as three ways, to enter a command:

- Manually type a command in Command/Data Echo Area
- Use a menu to automatically generate a command
- Use a Toolbar button to automatically generate a command

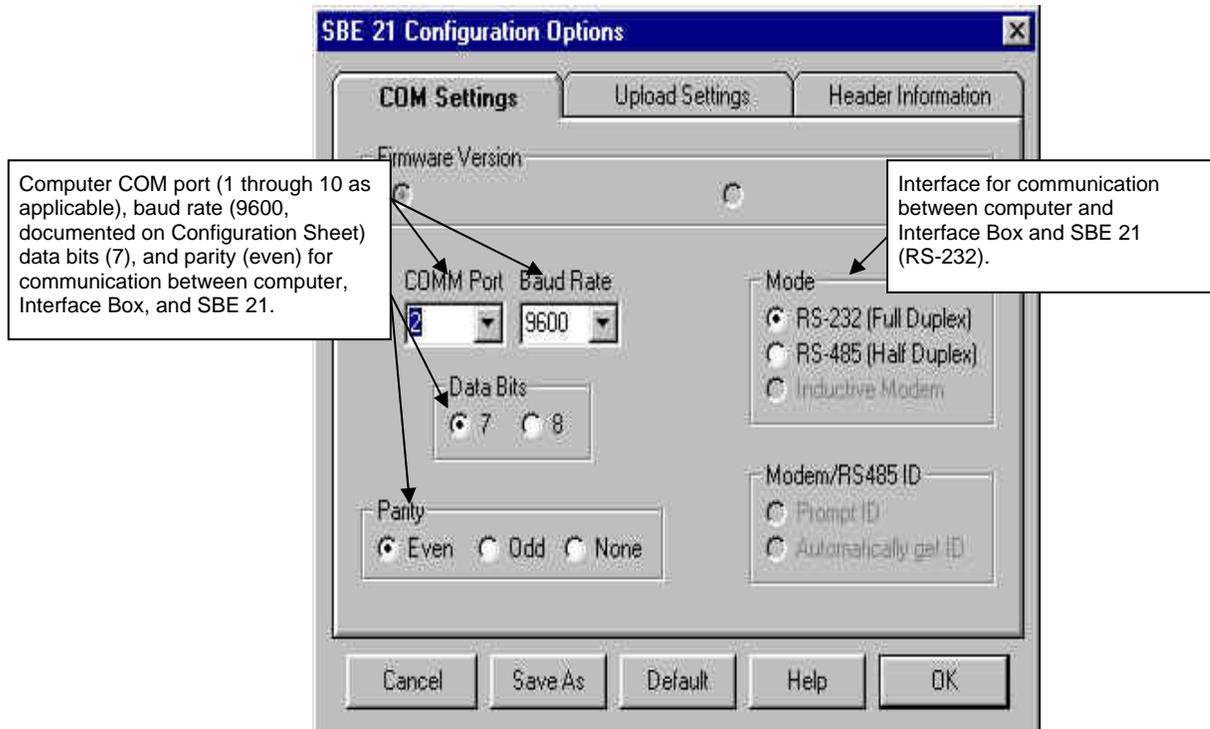
- **Menus** – Contains tasks and frequently executed instrument commands.
- **Toolbar** – Contains buttons for frequently executed tasks and instrument commands. All tasks and commands accessed through the Toolbar are also available in the Menu. To display or hide the Toolbar, select View Toolbar in the View menu. Grayed out Toolbar buttons are not applicable.
- **Command/Data Echo Area** – Echoes a command executed using a Menu or Toolbar button, as well as the instrument's response. Additionally, a command can be manually typed in this area, from the available commands for the instrument. Note that the instrument must be *awake* for it to respond to a command (use the Connect button on the Toolbar to wake up the instrument).
- **Status bar** – Provides status information. To display or hide the Status bar, select View Status bar in the View menu.

Following are the Toolbar buttons applicable to the SBE 21:

Toolbar	Description	Equivalent Command*
Connect	Re-establish communications with SBE 21. Computer responds with S> prompt.	(press Enter key)
Status	Display instrument setup and status (logging, samples in memory, etc.).	DS
Headers	View data headers (header number, date and time, first and last sample, and sample interval). New header is generated at start of logging and every subsequent 1000 scans.	DH
Init Log	Reset data pointers and cast numbers. This should be performed after existing data has been uploaded from SBE 21 and prior to recording new data.	IL
Capture	Capture instrument responses on screen to file; may be useful for diagnostics. File has .cap extension. Press Capture again to turn off capture. Capture status displays in Status bar.	—
Upload	Upload data stored in memory, in format Sea-Bird's post-processing software can use. Uploaded data has .hex extension. Before using Upload: <ul style="list-style-type: none"> • Configure upload and header parameters in Configure menu. • Stop logging by sending QL command. 	DD (use Upload key if will be data processing with SBE Data Processing)
Diagnostics	Perform one or more diagnostic tests on SBE 21. Test(s) accessed in this manner are non-destructive –they do not write over any existing instrument settings.	DS, FR, and VR
Stop	Interrupt and end current activity, such as uploading or diagnostic test.	(press Esc key or Ctrl C)
Disconnect	Free computer COM port used to communicate with SBE 21. COM port can then be used by another program.	—

*See *Command Descriptions* in this section.

4. In the Configure menu, select SBE 21. The dialog box looks like this:



Make the selections in the Configuration Options dialog box. Click OK to overwrite an existing COM/Upload/Header Settings file, or click Save As to save the settings as a new filename.

5. Turn on power to the Interface Box. The red PWR LED should light. The display in SEATERM looks like this:

Note:

See Section 5: Setting Up NMEA Interface for details on the NMEA Interface menu.

```
NMEA interface box V 2.3 setup:
PC baud rate = 9600
SEACAT baud rate = 9600
7 data bits, even parity
NMEA message to decode = RMA
Mode = add Lat/Lon to real-time Hex data
Menu time out enabled
```

Press @ to change the NMEA interface box setup

This shows that correct communications **between the computer and Interface Box** has been established. If the system does not respond as shown:

- Verify the SBE 21 was selected in the Configure menu and the settings were entered correctly in the dialog box.
- Check cabling between the computer and Interface Box.

6. Type @ to access the interface setup menu. The display looks like this:

```
NMEA interface set up menu:
1. Echo characters to and from the instrument
2. Add Lat/Lon to the real-time HEX data from the instrument
3. Transmit Lat/Lon only
```

the current mode = 2. Add Lat/Lon to the real-time HEX data

Enter 1, 2, or 3 to change the NMEA interface box mode, or press @ to exit the set up menu.

Selection =

7. Type *I* and press the Enter key. The display then shows the current mode as *I*. *Echo characters to and from the instrument*, which is the mode required for communicating with the SBE 21 to set it up.
8. Type @ to exit the setup menu.
9. Click the Connect button on the Toolbar. The display looks like this:

```
S>*ds
SC21, 3164, 4.0b, 206, 1, 6, N
S>
```

The first two lines are a factory-diagnostic status command and reply (reply indicates instrument serial number, firmware version, etc.).

The S> shows that correct communications between the computer and SBE 21 (through the Interface Box) have been established. If the system does not respond as shown:

- Click the Connect button again.
 - Verify the correct instrument was selected in the Configure menu and the settings were entered correctly in the Configuration Options dialog box. The baud rate is documented on the instrument Configuration Sheet.
 - Check cabling between the computer, Interface Box, and SBE 21.
10. Display SBE 21 status information by clicking the Status button on the Toolbar. The display looks like this:


```
SEACAT THERMOSALINOGRAPH V4.2a SERIAL NO. 4300 05/15/2003 14:23:14
ioper = 50.7 ma,   vmain = 11.4,   vlith = 8.8
samples = 0, free = 1396736
sample interval = 5 seconds
sample external SBE 38 temperature sensor
no. of volts sampled = 0
output format = SBE21
start sampling when power on = no
average data during sample interval = yes
logging data = no
voltage cutoff = 7.5 volts
```
 11. Command the SBE 21 to take a sample by typing **TS** and pressing the Enter key. The display looks like this (if output format=SBE 21, number of volts sampled=0, and no external temperature sensor):


```
78610428
```

where 7861 = raw Hex temperature data
 0428 = raw Hex conductivity data

See *Data Output Formats* in this section to interpret the data and determine if they are reasonable (i.e., room temperature and zero conductivity if running in air, or expected temperature and conductivity for water).
 12. Set up the SBE 21 as desired. See *Command Descriptions* in this section for details.
 13. Command the SBE 21 to go to sleep (quiescent state) by typing **QS** and pressing the Enter key.
 14. Turn off power to the Interface Box.

Command Descriptions

This section describes commands in detail and provides examples of their use. See *Appendix III: Command Summary* for a summarized command list.

Commands are entered in SEATERM. When entering commands:

- Input commands in upper or lower case letters and register commands by pressing the Enter key.
- The SBE 21 sends ? CMD if an invalid command is entered.
- If the system does not return an S> prompt after executing a command, press the Enter key to get the S> prompt.
- If in quiescent state, re-establish communications by pressing Connect on the Toolbar or the Enter key to get an S> prompt.
- If the SBE 21 is logging and transmitting data and you want to send a command, press the Esc key or Stop on the Toolbar (or type ^C) and then press the Enter key to get the S> prompt. This **temporarily** stops logging that is in progress, and allows you to enter a limited number of commands (**DS**, **SS**, **TS**, **QL**, and **QS** can be entered while logging). After 30 seconds elapses without transmission of a command, logging resumes.
- The SBE 21 cannot have samples with different scan lengths (more or fewer data fields per sample) in memory. If the scan length is changed by commanding it to add or subtract a data field (such as an external voltage), the SBE 21 must initialize logging. Initializing logging sets the sample number and header number to 0, so the entire memory is available for recording data with the new scan length. **Initializing logging should only be performed after all previous data has been uploaded.** Therefore, commands that change the scan length (**SVx**, **SBE38=**, and **SBE3=**) prompt the user for verification before executing, to prevent accidental overwriting of existing data.

Entries made with the commands are permanently stored in the SBE 21 and remain in effect until you change them.

- The only exception occurs if J1 is removed from the Power PCB (top board in PCB assembly) to replace the back-up lithium battery or to do a reset of the instrument. Upon reassembly, set the date and time (**ST**) and initialize logging (**IL**). (See *Appendix II: Electronics Disassembly/Reassembly* for details on accessing the PCBs. See *Section 8: Troubleshooting* for details on performing a reset of the instrument.)

Status Command

Note:

If the external power is below the cut-off voltage (7.5 volts), the following displays in response to the status command: **WARNING: LOW BATTERY VOLTAGE!!**

DS

Display operating status and setup parameters. Equivalent to Status button on Toolbar.

List below includes, where applicable, command used to modify parameter.

- firmware version, serial number, and date and time [**ST**]
- operating current (milliamps), external power voltage, and lithium battery voltage
- number of samples and available sample space in memory
- sample interval [**SI**]
- Enable sampling of SBE 3 remote temperature sensor [**SBE3=x**]?
(only appears in status if SBE 3 enabled [custom application])
- Enable sampling of SBE 38 remote temperature sensor [**SBE38=x**]?
(only appears in status if SBE 38 enabled)
- number of external voltages enabled [**SVx**]
- output format [**Fx**]
- start sampling automatically when power on? [**AUTORUN=x**]
- average data during sample interval? [**AVERAGE=x**]
- logging status
- power cutoff voltage

Example: Display status for SBE 21 that has SBE 38 remote temperature sensor enabled (user input in bold).

```
S>>DS
SEACAT THERMOSALINOGRAPH V4.2a SERIAL NO. 4300 05/15/2003 14:23:14
ioper = 50.7 ma,          vmain = 11.4,          vlith = 8.8
samples = 0, free = 1396736
sample interval = 5 seconds
sample external SBE 38 temperature sensor
no. of volts sampled = 0
output format = SBE21
start sampling when power on = no
average data during sample interval = yes
logging data = no
voltage cutoff = 7.5 volts
```

Setup Commands

ST

Set real-time clock date and time as prompted.

Example: Set date and time to October 5, 2002 12:00:00 (user input in bold).

```
S>>ST
Date (MMDDYY) =100502
Time (HHMMSS) =120000
```

Note:

The SBE 21 baud rate (set with **BAUD=**) must be the same as SEATERM's baud rate (set in the Configure menu).

BAUD=x

x= baud rate (600, 1200, 2400, 4800, 9600, 19200, or 38400). Default 9600.

Setup Commands (*continued*)**Notes:**

- The SBE 21 configuration (.con) file must match the selection of remote temperature sensor and external voltages when viewing real-time data in SEASAVE or processing uploaded data. View and edit the .con file in SEASAVE or SBE Data Processing. These parameters are factory-set to match the ordered instrument configuration.
- The SBE 21 requires verification when **SBE38=**, **SBE3=**, or **SVx** are sent. Instrument responds: *this command will change the scan length and initialize logging. Proceed Y/N?* Press the Y and the Enter key to proceed. The SBE 21 responds: *Scan length has changed, Initializing logging*

Note:

- Output format does not affect how data is stored in memory.
- **If you will be using Sea-Bird software (SEASAVE and/or SBE Data Processing), set the format to SBE 21 (F1).**
- See *Data Output Formats* in this section for a complete description of the data output.

SBE38=x

x= Y: Enable sampling of SBE 38 secondary temperature sensor.

Note: **You must also set up SBE 38 to interface with SBE 21.** Connect SBE 38 directly to computer, and set:

- SBE 38 baud (**BAUD=**) to same baud as SBE 21;
- interface to RS-232 (**INTERFACE=232**);
- sampling to begin when power applied (**AUTORUN=Y**); and
- output format to converted data (**FORMAT=C**).

See SBE 38 manual for command details.

x= N: Do not enable SBE 38.

SBE3=x

x= Y: Enable sampling of SBE 3 secondary temperature sensor (custom applications only).

x= N: Do not enable SBE 3.

SVx

x= number of external voltages to be acquired (0, 1, 2, 3, or 4). Maximum is 4 if single-ended A/D channels are installed, or 2 if differential A/D channels are installed.

Fx

x=1: Set data format to SBE 21. Outputs raw data (in Hex): primary temperature, conductivity, remote temperature, voltages.

x=2: Set data format to SBE 16 (custom applications not using Sea-Bird software). Outputs raw data (in Hex): # (attention character), primary temperature, conductivity, remote temperature, voltages, linear count (starting at 0).

FLASHINIT

Map bad blocks and erase FLASH memory, **destroying all data**. SBE 21 requires you to enter command twice, to provide verification. All data bits are set to 1. Sample number, header number, and data pointers are set to 0. Allow 15 minutes to initialize entire memory.

Send this command (after uploading all data) if encountering FLASH Read errors in Status (**DS**) response. If not encountering errors, use of command is optional, as SBE 21 writes over recorded information when **IL** command is used before beginning logging. However, knowledge of initial memory contents (i.e., all ones) can be a useful cross-check when data is uploaded from memory.

QS

Quit session and place SBE 21 in quiescent (sleep) state. Quiescent current is only 30 microamps. Memory retention is not affected.

Logging Commands

Note:

- In SEATERM, to save real-time data to a file, click the Capture button on the Toolbar before beginning logging.
- If the FLASH memory is filled to capacity, data sampling and transmission of real-time data continue, but excess data is not saved in memory. **The SBE 21 will not overwrite the data stored in memory.**
- If the SBE 21 is logging data and the external voltage is less than 7.5 volts for ten consecutive scans, the SBE 21 halts logging and displays **WARNING: LOW BATTERY VOLTAGE** in response to the status (**DS**) command.

Logging commands configure the SBE 21's response upon waking up, and direct the SBE 21 to sample data at pre-programmed intervals. When commanded to start sampling with the **GL** or **RL** command, or upon powering up (if **AUTORUN=Y**), the SBE 21 responds as follows:

If AVERAGE=Y	If AVERAGE=N
1. Take samples continuously at 4 Hz (every 0.25 seconds) and average the samples taken within each sample interval [SI],	1. Take 1 sample every sample interval [SI] seconds,
2. Store averaged data in FLASH memory and transmit averaged data real-time, and	2. Store data in FLASH memory and transmit data real-time, and
3. Write a header to memory, listing logging start date and time, sample interval, and sample number range. A new header is also written after every 1000 samples.	

The SBE 21 does not enter quiescent (sleep) state between samples.

AVERAGE=x

x=Y: Set SBE 21 to **sample continuously at 4 Hz** (every 0.25 seconds) and average samples taken within each sample interval [**SI**] seconds, store averaged data in memory, and transmit averaged data real-time.

x=N: Set SBE 21 to take **1** sample every sample interval [**SI**] seconds, store data in memory, and transmit data real-time.

SI

Set interval (seconds) between samples or sample averages. Minimum interval 3 seconds (4 seconds for custom application with SBE 3 remote temperature sensor), maximum interval 600 seconds.

Example: Set sample interval to 5 seconds (user input in bold).

S>**SI**

Sample interval (seconds) =**5**

If **AVERAGE=Y**: When logging starts, every 5 seconds SBE 21 takes ~20 samples (1 sample every 0.25 seconds), averages data, stores averaged data in FLASH memory, and transmits averaged data real-time.

If **AVERAGE=N**: When logging starts, every 5 seconds SBE 21 takes 1 sample, stores data in FLASH memory, and transmits data real-time.

Logging Commands (*continued*)**Notes:**

- **IL** and **SAMPLENUMBER=0** have identical effects. Use either command to initialize logging.
- **Do not initialize logging until all data has been uploaded.** These commands do not delete data; they reset the data pointer. **If you accidentally initialize logging before uploading,** recover data as follows:
 1. Set **SAMPLENUMBER=a** and **HEADERNUMBER=b**, where **a** and **b** are your estimate of number of samples and headers in memory.
 2. Upload data. If **a** is more than actual number of samples in memory or **b** is more than actual number of headers in memory, data for non-existent samples/headers will be bad, random data. Review uploaded data file carefully and delete any bad data.
 3. If desired, increase **a** and/or **b** and upload data again, to see if there is additional valid data in memory.

IL

Initialize logging - after all previous data has been uploaded from SBE 21, initialize logging before starting to log again to make entire memory available for recording. This command sets sample number (**SAMPLENUMBER=**) and header number (**HEADERNUMBER=**) to 0 internally. **Do not send IL until all existing data has been uploaded.** SBE 21 requires verification before it proceeds.

If **AUTORUN=Y**: If **IL** is not sent, when power is applied logging resumes, storing data to memory without resetting sample number (does not overwrite recorded data).

If **AUTORUN=N**: Overwriting of data is controlled by which command is used to start logging - **GL** (start logging, storing data at beginning of memory) or **RL** (resume logging, storing data without resetting sample number).

Example (user input in bold):

```
S>IL
Initialize logging Y/N ? y
Are you sure ^Y/N ? ^y (Note: ^ indicates Ctrl key.
Hold down Ctrl key while typing y or n.)
```

SAMPLENUMBER=x

x= sample number for first sample when logging begins. Typically used to recover data if you accidentally initialize logging (using **IL**) before uploading existing data.

HEADERNUMBER=x

x= header number for first sample when logging begins. Typically used to recover data if you accidentally initialize logging (using **IL** or **SAMPLENUMBER=0**) before uploading existing data.

GL

Start logging now. SBE 21 overwrites any recorded data and headers in memory. SBE 21 requires verification before it proceeds. SBE 21 takes first sample 3 seconds after command is verified.

Example (user input in bold):

```
S>GL
Start logging Y/N ? y
Are you sure ^Y/N ? ^y (Note: ^ symbol indicates
Ctrl key. Hold down Ctrl key while typing y or n.)
```

Logging Commands (*continued*)**RL**

Resume logging now. SBE 21 resumes writing data and headers to memory without resetting sample or header number (it does not overwrite recorded data). SBE 21 requires verification before it proceeds. SBE 21 takes first sample 3 seconds after command is verified.

Example (user input in bold):

```
S>RL
resume logging Y/N ? y
Are you sure ^Y/N ? ^y (Note: ^ symbol indicates
Ctrl key. Hold down Ctrl key while typing y or n.)
```

Note:

After sending **AUTORUN=Y**, you must turn power to the SBE 21 off and then on again to start logging.

AUTORUN=x

x=Y: Automatically start logging when power is applied. When power is applied, SBE 21 resumes writing data and headers to memory without resetting sample number or header number (does not overwrite recorded data).

x= N: Do not automatically start logging when power is applied.

Notes:

- You may need to type the **QL** command several times to get the SBE 21 to respond.
- If the SBE 21 does not appear to respond to the **QL** command, press Ctrl Z several times, and then try the **QL** command again.
- If **AUTORUN=Y**, remove power to stop logging.
- You must stop logging before uploading data.

QL

Stop logging. Press Enter key to get S> prompt before entering this command. SBE 21 requires verification before it proceeds.

Example (user input in bold):

```
S>QL
quit logging Y/N ? y
Are you sure ^Y/N ? ^y (Note: ^ symbol indicates
Ctrl key. Hold down Ctrl key while typing y or n.)
```

Data Upload Commands

Stop logging before uploading data.

Notes:

- To save data to a file, click the Capture button on the Toolbar before entering the **DD** or **DH** command.
- See *Data Output Formats* after these *Command Descriptions*.
- **To upload data in a form that can be used by SBE Data Processing:**
 1. Set the output format to SBE 21 using the **F1** command before uploading.
 2. Use the Upload button on the Toolbar or Upload Data in the Data menu. Manually entering the data upload command does not produce data in the correct format for processing by SBE Data Processing.

DDb,e

Upload data in raw Hex form from scan **b** to scan **e**. If **b** and **e** are omitted, all data is uploaded. First sample is number 0.

Example: Upload samples 0 through 199 to a file (user input in bold):
(Click Capture on Toolbar and enter desired filename in dialog box.)
S>**DD0,199**

DH

Upload all headers. First header is 0. New header was written when logging started or resumed and every 1000 samples thereafter. Header includes:

- header number
- month, day, year, hour, minute, and second when header was written
- first and last sample for header
- interval between samples (**SI**)

Example: Upload headers to a file (user input in bold).
(Click Capture on Toolbar and enter desired filename in dialog box.)
S>**DH**
hdr 0 01/15/2002 12:30:33 samples 0 to 4, interval=60 sec
hdr 1 01/15/2002 13:02:12 samples 5 to 10, interval=60 sec

Sampling Commands

These commands request a single sample. The SBE 21 always stores data for the most recent sample in its buffer.

SS

Output last sample from buffer (sample obtained with **TS** command, or latest sample from logging).

TS

Sample for 1 second at 4 Hz (take 4 samples), average data, store averaged data in buffer, and output averaged data.
Data is not stored in FLASH memory.

Note:

The SBE 21 has a buffer that stores the most recent data samples. Unlike data in the FLASH memory, data in the buffer is erased upon removal or failure of power.

Diagnostic Commands

The SBE 21 outputs 100 samples for each diagnostic test. Data is not stored in FLASH memory. Press the Esc key or Stop button to stop the test.

FR

Display frequencies:

Column	Output
1	Raw temperature A/D counts
2	Raw conductivity frequency
3	Temperature frequency converted to match older SBE 21 (firmware version < 4.0)
4	Conductivity frequency converted to match older SBE 21 (firmware version < 4.0)
5	External frequency (custom application with SBE 3 remote temperature sensor)

VR

Display external voltages with offset and scale factors applied.

Column	Output
1	External voltage 0
2	External voltage 1
3	External voltage 2
4	External voltage 3
5 - 8	Diagnostics for factory use

T38

Display output from SBE 38 remote temperature sensor.

Coefficients Command**Notes:**

- Calibration coefficients for the conductivity and primary temperature sensor, and for any auxiliary sensors, are stored in the SBE 21's configuration (.con) file. View and/or modify the calibration coefficients using the Configure menu in SBE Data Processing or SEASAVE. See *Checking SBE 21 Configuration (.con) File in SEASAVE* in this section for details.

DCAL

Display calibration coefficients.

- Voltage (0, 1, 2, and 3) channel offset and slope, as determined at Sea-Bird:
Output voltage =
(slope * calculated V from sensor equation) + offset
- conductivity zero frequency - characteristic frequency of conductivity sensor for 0 conductivity, as determined at Sea-Bird from a cell thoroughly rinsed in distilled or de-ionized water, with all the water shaken out. Zero frequency that has changed by a few tenths of a Hz indicates a dirty cell. Zero frequency that has changed by more may indicate a cell that is damaged or considerably out of calibration.
- External frequency scale factor for SBE 3 remote temperature sensor (custom application)

Example: Display coefficients for SBE 21 (user input in bold).

```
S>>DCAL
SEACAT THERMOSALINOGRAPH V4.0b SERIAL NO. 3166 01/15/2002 14:30:14
volt 0: offset = -4.662333e-02, slope = 1.249281e+00
volt 1: offset = -4.658000e-02, slope = 1.249034e+00
volt 2: offset = -4.699667e-02, slope = 1.248704e+00
volt 3: offset = -4.707333e-02, slope = 1.249847e+00
Cfo = 2596.697
```

Checking SBE 21 Configuration (.con) File in SEASAVE

Note:

When Sea-Bird ships a new instrument, we include a .con file that reflects the current instrument configuration as we know it. The .con file is named with the instrument serial number, followed with the .con extension. For example, for an instrument with serial number 2375, Sea-Bird names the .con file 2375.con. You may rename the .con file if desired; this will not affect the results.

SEASAVE, Sea-Bird's real-time data acquisition and display program, requires a .con file, which defines the instrument - auxiliary sensors integrated with the instrument, and channels, serial numbers, and calibration dates and coefficients for all the integrated sensors (conductivity and temperature as well as auxiliary sensors). SEASAVE (as well as our data processing software) uses the information in the .con file to interpret and process the raw data. **If the .con file does not match the actual instrument configuration, the software will not be able to interpret and process the data correctly.**

To verify the contents of the .con file:

1. Double click on Seasave.exe.
2. In SEASAVE's Configure menu, select *New Style Instrument Configuration/Select Instrument Configuration*. In the dialog box, select the appropriate .con file and click Open.
3. In the Configure menu, select *Modify Selected Instrument Configuration*. The configuration dialog box appears. Verify that the sensors match those on your instrument, and that auxiliary sensors are assigned to the correct voltage channels. Verify that the calibration coefficients for all the sensors are up-to-date.

Channel/Sensor table reflects this choice (shows additional frequency-based temperature channel if SBE 3 selected, or RS-232 channel if SBE 38 selected). Must agree with **SBE3=** or **SBE38=** command programmed into SBE 21 to enable / disable remote temperature sensor; see reply from status command (**DS**). If remote temperature is selected, SEASAVE and SBE Data Processing (DATA CONVERSION and DERIVE modules) use remote temperature data when calculating density and sound velocity.

Channel/Sensor table reflects this choice. Must agree with number programmed into SBE 21 with **SVx** (x=0, 1, 2, 3, or 4) command; see reply from status command (**DS**).

Time between scans. Used to calculate elapsed time, if you select time as a parameter for a display window. For elapsed time calculation to be correct, this entry must agree with number programmed into SBE 21 with **SI** command; see reply from status command (**DS**).

Select if your Interface Box is connected to a NMEA navigation device. If selected, SEASAVE automatically adds current latitude, longitude, and universal time code to data header. Select NMEA (Lat/Lon) Interface in SEASAVE's Configure menu to control how Lat/Lon data is incorporated.

Shaded sensors cannot be removed or changed to another type of sensor. All others are optional.

New to create new .con file. Open to select different .con file. Save or Save As to save current .con file settings.

Click a (non-shaded) sensor and click **Select** to pick a different sensor for that channel. A dialog box with a list of sensors appears. Select sensors after number of voltage and frequency channels have been specified above.

Click a sensor and click **Modify** to change calibration coefficients for that sensor.

Channel	Sensor	New
1. Frequency	Temperature	
2. Frequency	Conductivity	Open...
3. Serial RS-232	Temperature, SBE 38	Save
4. A/D voltage 0	pH	Save As...

4. Click *Save* or *Save As* to save any changes to the .con file. Click *Exit* when done reviewing / modifying the .con file.

Data Output Formats

The SBE 21 outputs data in raw, hexadecimal form as described below.

The inclusion of some output parameters is dependent on the system configuration - if the specified sensor is not enabled (see *Command Descriptions* above), the corresponding data is not included in the output data stream, shortening the data string.

Note:

SBE 21 always outputs an even number of voltage characters. If you enable 1 or 3 voltages, it adds a 0 to the data stream before the last voltage, as shown below:

- 1 voltage enabled -
ttttcccrrrrr0uuu or
#ttttcccrrrrr0uuunnnn
- 3 voltages enabled -
ttttcccrrrrruuuvv0www
#ttttcccrrrrruuuvv0wwwnnnn

- SBE 21 Format (**F1**) - ttttcccrrrrruuuvvwwwxxx (use this format if you will be using SEASAVE to acquire real-time data and/or SBE Data Processing to process the data)
- SBE 16 Format (**F2**) - #ttttcccrrrrruuuvvwwwxxxxnnnn (custom format)

where

tttt = primary temperature

cccc = conductivity

rrrrr = remote temperature (from SBE 38 or SBE 3 remote sensor)

uuu, vvv, www, xxx = voltage outputs 0, 1, 2, and 3 respectively

= attention character

nnnn = lineal sample count (0, 1, 2, etc.)

Data is output in the order listed, with no spaces or commas between parameters. Shown with each parameter is the number of digits.

Calculation of the parameter from the data is described below (use the decimal equivalent of the hex data in the equations).

Notes:

- Sea-Bird's software (SEASAVE and SBE Data Processing) uses the equations shown to perform these calculations; it then uses the calibration coefficients in the configuration (.con) file to convert the raw frequencies and voltages to engineering units. Alternatively, you can use the equations to develop your own processing software.
- Sea-Bird software treats the SBE 38 as a *pseudo* frequency sensor, and automatically enters these calibration coefficients in the .con file: G = 4.0e-3, H = 2.0e-4, I = 0, J = 0, and f0 = 1000. SEASAVE and SBE Data Processing apply these coefficients to the *pseudo* frequency and output remote temperature in °C (ITS-90).

1. Temperature

$$\text{temperature frequency (Hz)} = (\text{tttt} / 19) + 2100$$

2. Conductivity

$$\text{conductivity frequency (Hz)} = \text{square root} [(\text{cccc} * 2100) + 6250000]$$

3. SBE 3 secondary temperature (if **SBE3=Y**)

$$\text{SBE 3 temperature frequency (Hz)} = \text{rrrrr} / 256$$

4. SBE 38 secondary temperature (if **SBE38=Y**)

$$\text{SBE 38 temperature } pseudo \text{ frequency (Hz)} = \text{rrrrr} / 256$$

5. External voltage 0 (if 1 or more external voltages defined with **SVx**)

$$\text{external voltage 0 (volts)} = \text{uuu} / 819$$

6. External voltage 1 (if 2 or more external voltages defined with **SVx**)

$$\text{external voltage 1 (volts)} = \text{vvv} / 819$$

7. External voltage 2 (if 3 or more external voltages defined with **SVx**)

$$\text{external voltage 2 (volts)} = \text{www} / 819$$

8. External voltage 3 (if 4 external voltages defined with **SVx**)

$$\text{external voltage 3 (volts)} = \text{xxx} / 819$$

Example: SBE 21 with SBE 38 and two external voltages sampled, example scan = ttttcccrrrrruuuvv = A80603DA1B58001F5A21

- Temperature = tttt = A806 (43014 decimal);
temperature frequency = $(43014 / 19) + 2100 = 4363.89$ Hz
- Conductivity = cccc = 03DA (986 decimal);
conductivity frequency =
square root $[986 * 2100 + 6250000] = 2884.545$ Hz
- SBE 38 = rrrrr = 1B5800 (1,792,000 decimal)
temperature *pseudo* frequency (Hz) = $(1,792,000 / 256) = 7000$ Hz
- First external voltage = uuu = 1F5 (501 decimal);
voltage = $501 / 819 = 0.612$ volts
- Second external voltage = vvv = A21 (2593 decimal);
voltage = $2593 / 819 = 3.166$ volts

Section 5: Setting Up NMEA Interface

The PN 90158.1 – SEACAT/SEALOGGER RS-232 and Navigation Interface Box includes a NMEA 0183 Interface that permits position data to be merged with the SBE 21 data. The NMEA Interface is designed to decode messages that are output from navigation devices supporting NMEA 0183 protocol.

A complete description of the Interface Box - specifications, setup, troubleshooting, data format, and NMEA simulation programs - is provided in a separate manual. However, setup information is repeated in this section for ease-of-use.

The decoded Latitude and Longitude can be appended to the SBE 21 data stream in the Interface Box and passed to the computer for storage and/or display with the SBE 21 data. Position data is appended to the end of the SBE 21 data, with the position data always last. Position data format is detailed in the Interface Box manual. The Yellow *TX NMEA* LED on the Interface Box flashes each time a NMEA message is received (should be the same rate at which your navigation device is transmitting). The Interface Box appends the same NMEA message multiple times, until a new message is decoded.

Example: A navigation device outputs its NMEA message once every 5 seconds. The Yellow *TX NMEA* LED flashes every 5 seconds, and the same message is appended to each scan of SBE 21 data within that 5 seconds.

Setting Interface Box PCB Dip Switch

An 8-position dip switch on the Interface Box PCB sets the baud rates between the SBE 21 and the Interface Box and between the Interface Box and the computer, the data bits and parity, and the NMEA message to decode. The dip switch positions are shown in *Section 4: Setting Up SBE 21*. For reference when setting up the NMEA interface, the NMEA message to decode settings are repeated below:

Message to Decode	Position 1	Position 2	Position 3
GGA - Global Positioning System Fix Data	ON	ON	ON
GLL - Geographic Position: Latitude/Longitude	OFF	ON	ON
RMA - Recommended Minimum Specific Loran-C Data	ON	OFF	ON
RMC (factory default) - Recommended Minimum Specific GPS/TRANSIT Data	OFF	OFF	ON
TRF - TRANSIT Fix Data	ON	ON	OFF

If you are not sure which NMEA message your navigation device is sending, see the Interface Box manual for information on viewing the raw NMEA message using the NMEA Interface's diagnostic mode.

NMEA Operating Modes

The NMEA Interface has three normal operating modes and two diagnostic modes. The mode is set in the NMEA Interface menu while communicating with the Interface Box with SEATERM (see *Setting Up and Testing NMEA* below).

Notes:

- In SEATERM, use the @ character to access and exit the NMEA Interface menu.
- To enter diagnostic modes (4 or 5), first put the NMEA Interface in Mode 3. Then, enter a 4 or 5 at the mode selection prompt.
- To exit diagnostic modes (4 or 5), turn off power to the Interface Box.
- In the NMEA Interface menu, Diagnostic level 1 = Mode 4
Diagnostic level 2 = Mode 5

The modes are:

Type	Mode	Description
Operating	1: Echo only	Characters to and from SBE 21 pass through NMEA Interface. No position data is sent. Useful for setting up SBE 21.
	2: Add Lat/Lon to hex data (default power-up mode)	Seven bytes of hex latitude/longitude data are added to each line of hex data from SBE 21. Used when position data is required with SBE 21 data.
	3: Transmit Lat/Lon only	Data from SBE 21 is not transmitted. Hex latitude/longitude data is converted to ASCII text whenever a new position is received from NMEA navigation device. Format is: <i>LAT 47 37.51 N</i> <i>LON 122 09.41 W</i> If NMEA message RMC is decoded, date and time display on next line. Format is: <i>DDMMYY HHMMSS</i>
Diagnostic	4 (diagnostic level 1): Transmit raw NMEA message only	All NMEA messages received are echoed to computer in raw form. Used to determine which NMEA messages are being received by NMEA Interface.
	5 (diagnostic level 2): Transmit raw and decoded NMEA message	All NMEA messages received are echoed to computer in raw form. If a correct NMEA message is received, decoded data displays below raw data. Decoded format same as for Mode 3.

Setting Up and Testing NMEA

Note:

The Interface Box must be connected to the SBE 21 to test the NMEA interface. If it is not connected, noise on the open *SEACAT Data I/O* connector may interfere with communication with the Interface Box.

After connecting the NMEA navigation device, Interface Box, computer, and SBE 21, run SEATERM.

1. Double click on seaterm.exe.
2. In the Configure menu, select the SBE 21.
 - A. In the Configuration Options dialog box, click on the COM Settings tab.
 - B. Set the COM Settings to:
 - Comm Port 1 through 10 as applicable
 - 9600 baud, 7 data bits, and even parity
 - RS-232
 Click *OK* or *Save As* to save the settings and exit the dialog box.
3. Turn on power to the Interface Box. The red PWR LED should light. The display in SEATERM looks like this:

```
NMEA interface box V 2.3 setup:
PC baud rate = 9600
SEACAT baud rate = 9600
7 data bits, even parity
NMEA message to decode = RMA
Mode = add Lat/Lon to real-time Hex data
Menu time out enabled
```

Press @ to change the NMEA interface box setup

Looking at selected lines:

Text	Description
PC baud rate	Communication between computer and Interface Box, set on Interface Box PCB switch positions 7 and 8 (factory set to 9600)
SEACAT baud rate	Communication between Interface Box and SBE 21, set on Interface Box PCB switch positions 5 and 6 (factory set to 9600)
7 data bits, even parity	Set on Interface Box PCB switch position 4 (factory set to 7 data bits, even parity)
NMEA message to decode	Set on Interface Box PCB switch positions 1 to 3 (must match output from NMEA navigation device)
Mode=add Lat/Lon to real-time Hex data	Default power-up mode, enabling system to acquire navigational data along with real-time thermosalinograph data
Menu time out enabled	If in the setup menu and no user input is received within 90 seconds, the Interface Box times out, exits the setup menu, and sets the mode to <i>Add Lat/Lon to real-time Hex Data</i> . Re-enter the setup menu by typing @. Note that the menu time out feature cannot be disabled.

Note:

In SEASAVE, Lat/Lon data transmission is determined by the setting in the SBE 21 configuration (.con) file. So even though the Interface Box default power-up mode is set to append Lat/Lon data, you must also set the .con file to append NMEA data.

4. Type @ to access the NMEA Interface menu. The display looks like this:

NMEA interface set up menu:

1. Echo characters to and from the instrument
2. Add Lat/Lon to the real-time HEX data from the instrument
3. Transmit Lat/Lon only

the current mode = 2. Add Lat/Lon to the real-time HEX data

enter 1, 2, or 3 to change the NMEA interface box mode, or press @ to exit the set up menu

selection =

5. Type 3 and press the Enter key to switch to mode 3. The display looks like this:

NMEA interface set up menu:

1. Echo characters to and from the instrument
2. Add Lat/Lon to the real-time HEX data from the instrument
3. Transmit Lat/Lon only

the current mode = 3. Transmit Lat/Lon only

enter 1, 2, or 3 to change the NMEA interface box mode, or press @ to exit the set up menu

selection =

6. Type @ to exit the menu. You should begin seeing position data display in SEATERM. Each time position data is received, the yellow *TX NMEA* LED on the Interface Box should flash. If the data is correct and is updating properly, the Interface Box is working.

- If position data does not appear, verify that the Interface Box is connected to the NMEA navigation device and that the proper cable is used.
- See the Interface Box manual for troubleshooting instructions if needed.

7. Turn off power to the Interface Box.

Troubleshooting NMEA Interface

See the Interface Box manual for troubleshooting.

Setting Up SBE 21 Configuration (.con) File

Notes:

When Sea-Bird ships a new instrument, we include a .con file that reflects the current instrument configuration as we know it. The .con file is named with the instrument serial number, followed with the .con extension. For example, for an instrument with serial number 2375, Sea-Bird names the .con file 2375.con. You may rename the .con file if desired; this will not affect the results.

The Interface Box integrates the position data from the NMEA navigation device into the SBE 21 data stream. SEASAVE, Sea-Bird's real-time data acquisition and display program, stores and optionally displays the NMEA data along with the thermosalinograph data. SEASAVE requires a .con file, which defines the SBE 21 - auxiliary sensors integrated with the instrument, and channels, serial numbers, and calibration dates and coefficients for all the integrated sensors (conductivity and temperature as well as auxiliary sensors). SEASAVE (as well as our data processing software) uses the information in the .con file to interpret and process the raw data. If the .con file does not match the actual instrument configuration, the software will not be able to interpret and process the data correctly.

The .con file must indicate if position data is being added to the SBE 21 data by the Interface Box. See *Section 4: Setting Up SBE 21* for details on viewing and modifying the .con file in SEASAVE. Note that the .con file setup overrides the mode selection in the NMEA interface setup menu (default power-up mode is to add Lat/Lon to the real-time Hex data from the instrument). In other words, the real-time transmission of NMEA position data is dependent on the .con file setting in SEASAVE.

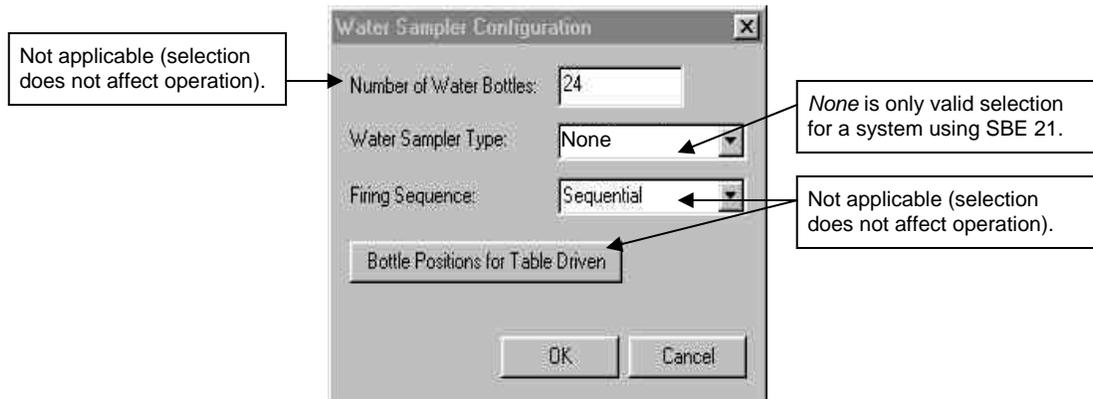
Section 6: Operating System

This section covers:

- Acquiring real-time data with SEASAVE
- Uploading SBE 21 data from memory

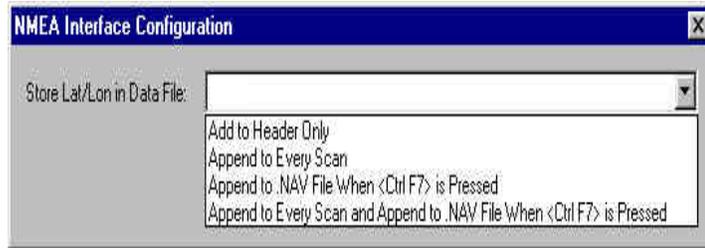
Acquiring Real-Time Data with SEASAVE

1. Turn on power to the Interface Box.
 - If **AUTORUN=Y** (SBE 21 set up to start logging automatically when power turned on): SBE 21 will start logging and will store data in its internal memory. Note that the data will not appear in SEASAVE until you tell SEASAVE to start real-time data acquisition below.
 - If **AUTORUN=N** (SBE 21 not set up to start logging automatically when power turned on): Run SEATERM and send **GL** or **RL** to start logging, then close SEATERM (see *Section 4: Setting Up SBE 21*).
2. Double click on Seasave.exe.
3. In the Configure menu, select *Water Sampler Configuration*. The dialog box looks like this:



Make the desired selections and click OK.

4. (For Interface Box connected to NMEA navigation device)
In the Configure menu, select *NMEA [Lat/Lon] Interface*. The dialog box looks like this:



Make the desired selection for how to store the NMEA data and click OK:

Notes:

- The .nav file has the same file name and is placed in the same directory as the data (.hex) file. For example, if the data file is test.hex, the .nav file is test.nav.
- When running the post-processing software (DATA CONVERSION module in SBE Data Processing): if a .nav file is found in the same directory as the .hex file, the contents of the .nav file are added to the output converted data file (.cnv) header.

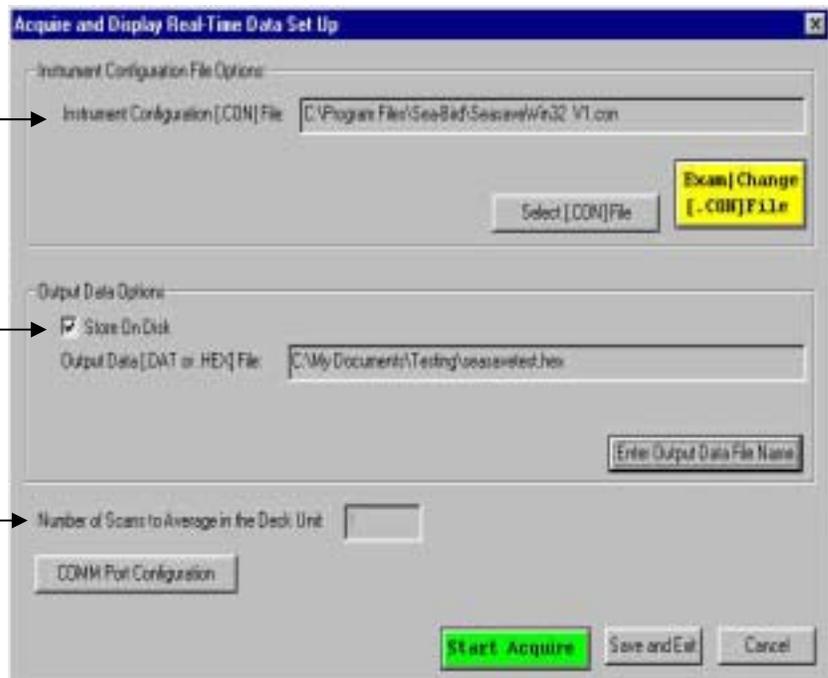
- *Add to Header Only* - Latitude, longitude, and time are written to the header when data acquisition is started.
- *Append to Every Scan* - Latitude, longitude, and time are written to the header when data acquisition is started. Additionally, 7 bytes of Lat/Lon data are appended to every scan of SBE 21 data.
- *Append to .NAV File when <Ctrl F7> is Pressed* - Latitude, longitude, and time are written to the header when data acquisition is started. Additionally, latitude, longitude, time, and scan number are written to a .nav file every time Ctrl F7 is pressed or Add to .NAV File is clicked (View menu, NMEA Data Display dialog box).
- *Append to Every Scan and Append to .NAV File when <Ctrl F7> is Pressed* - Latitude, longitude, and time are written to the header when data acquisition is started. Additionally, 7 bytes of Lat/Lon data are appended to every scan of SBE 21 data. And, latitude, longitude, time, and scan number are written to a .nav file every time Ctrl F7 is pressed or Add to .NAV File is clicked (View menu, NMEA Data Display dialog box).

5. Perform any other desired setup in the Configure menu.
6. Perform any desired setup in the ScreenDisplay menu.
7. In the RealTime Data menu, select *Start Acquisition*. The dialog box looks like this:

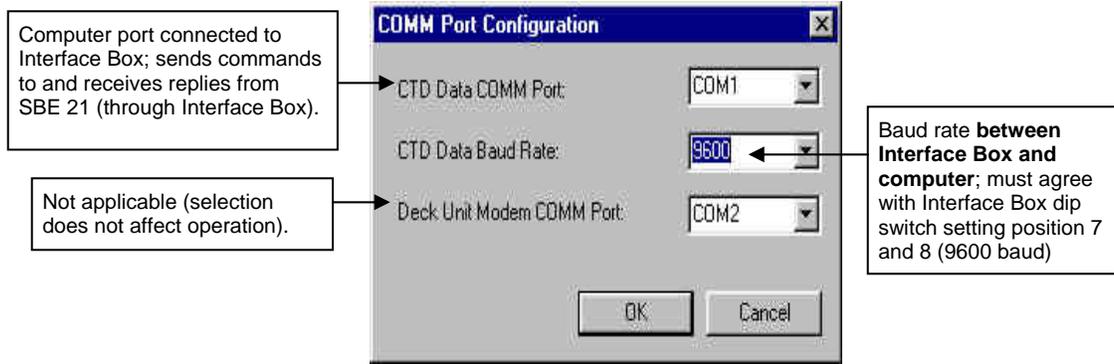
Configuration file defines the auxiliary sensors integrated with the instrument, and channels, serial numbers, and calibration dates and coefficients for all the integrated sensors (conductivity and temperature as well as auxiliary sensors). Verify that .con file matches your instrument setup. See *Checking SBE 21 Configuration (.con) File in SEASAVE* in Section 4: Setting Up SBE 21 for details.

Select to save real-time data to a file.

Not applicable.



8. Click *COMM Port Configuration*. The dialog box looks like this:

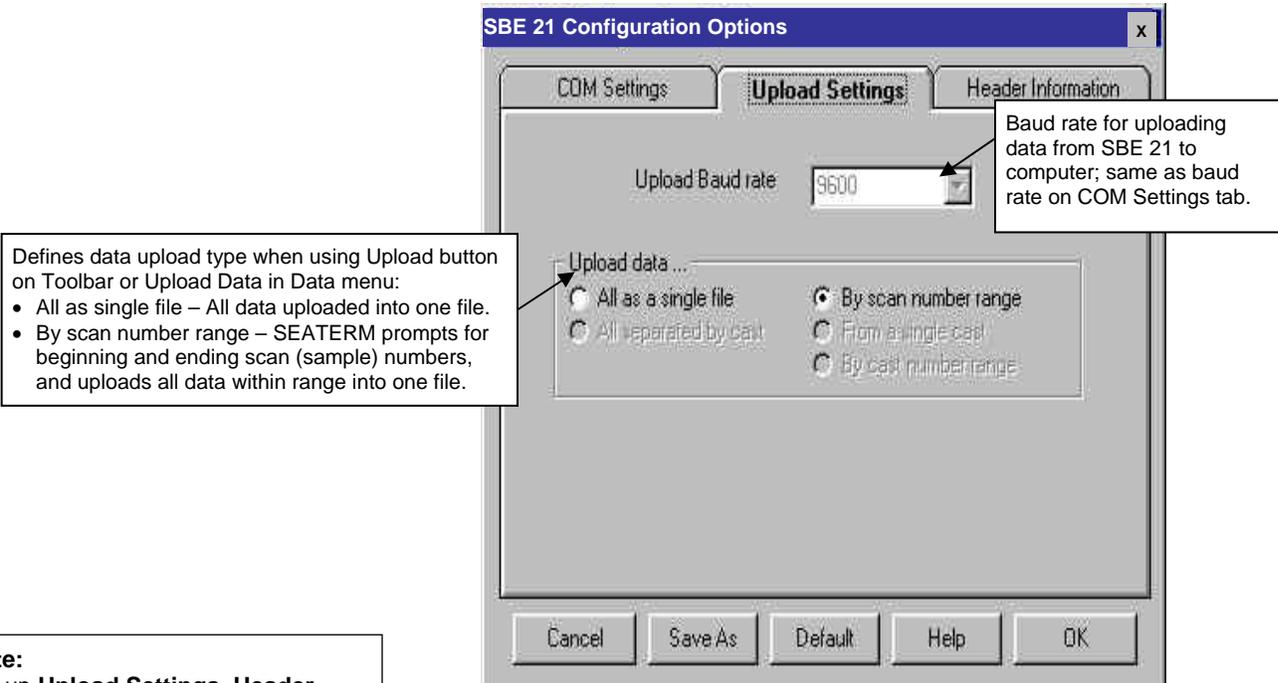


Make the desired selections and click OK.

9. In the *Acquire and Display Real Time Data Set Up* dialog box, click *Start Acquire*.
- A. If SEASAVE was set up to prompt for header information (Configure menu / Header Form), the Header Information dialog box appears. Fill in the desired information to be added to the header portion of the real-time data acquisition .hex file, and click OK.
 - B. SEASAVE automatically sends a command to put the NMEA Interface in Mode 1 (do not transmit NMEA data) or Mode 2 (append position data to SBE 21 data), depending on whether the SBE 21 .con file was set to add NMEA data. If the .con file was set to add NMEA data, the screen then displays: *Getting Latitude, Longitude and Time from the NMEA Interface*.
 - C. Real-time data then starts appearing in the screen display(s).
10. When done acquiring data, in the RealTime Data menu, select *Stop Acquisition*.
11. Close SEASAVE.
12. Double click on seaterm.exe.
- A. Establish communications with the SBE 21 by pressing the Enter key several times. The SBE 21 should respond with an S> prompt.
 - B. Send **QL** to stop logging.
 - C. If you want to upload data from the SBE 21's memory now, see *Uploading SBE 21 Data from Memory* below.
 - D. Send **QS** to place the SBE 21 in quiescent (sleep) state.
13. Turn off power to the Interface Box.

Uploading SBE 21 Data from Memory

1. Double click on SeaTerm.exe. The display shows the main screen.
2. In the Configure menu, select *SBE 21*. Click on the Upload Settings tab. The dialog box looks like this:

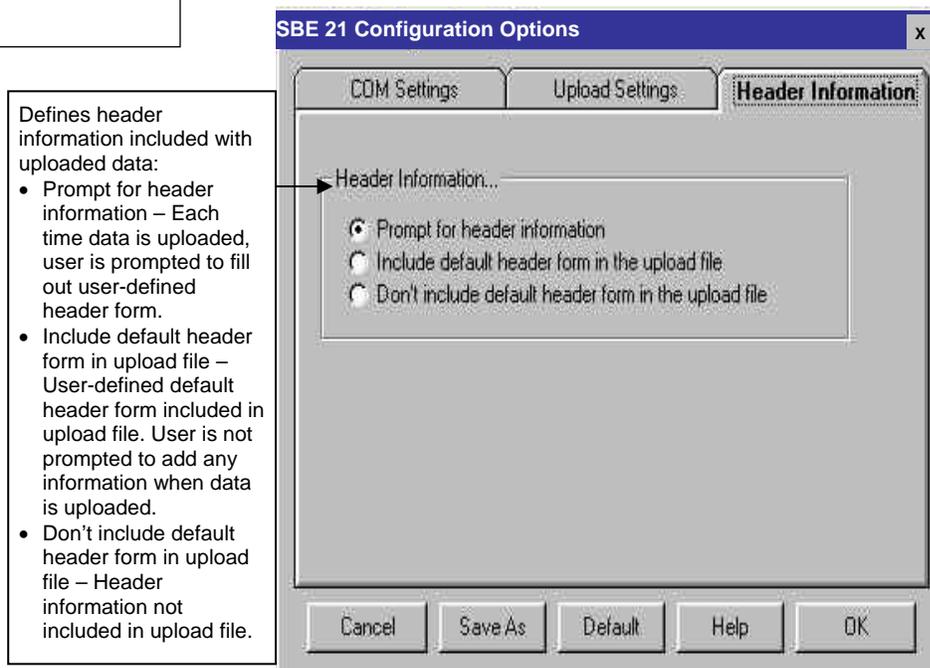


Note:
Set up **Upload Settings**, **Header Information**, and/or **Header Form** (Steps 2 through 4):

- The first time you upload data, and
- If you want to change upload or header parameters.

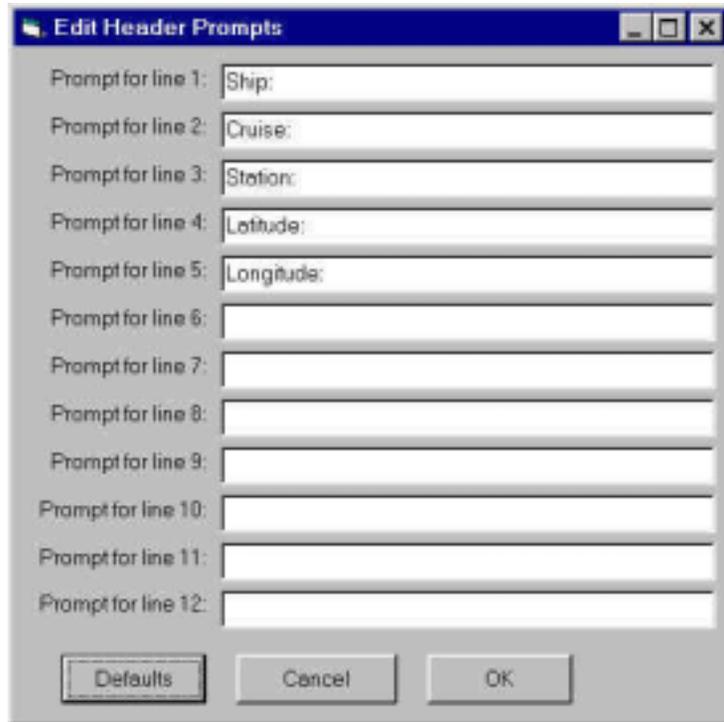
Make the selection for Upload Settings.

3. Click on the Header Information tab. The dialog box looks like this:



Select the desired header information option. Click OK to overwrite an existing configuration file, or click Save As to save the configuration as a new filename.

4. In the Configure menu, select Header Form to customize the header. The dialog box looks like this (default prompts are shown):



The entries are free form, 0 to 12 lines long. This dialog box establishes:

- the header prompts that appear for the user to fill in when uploading data, if *Prompt for header information* was selected in the Configuration Options dialog box (Step 3)
- the header included with the uploaded data, if *Include default header form in upload file* was selected in the Configuration Options dialog box (Step 3)

Enter the desired header/header prompts. Click OK.

5. Turn on power to the Interface Box. Type @ to access the NMEA interface setup menu. Type I and press the Enter key to echo characters from the SBE 21. Type @ to exit the setup menu.
6. Click Connect on the Toolbar to begin communications with the SBE 21. The display looks like this:

```
S>*ds
SC21, 3164, 4.0b, 206, 1,6, N
S>
```

This shows that correct communications between the computer and the SBE 21 has been established.

If the system does not respond as shown above:

- Click Connect again.
- Check cabling between the computer, Interface Box, and SBE 21.
- Verify the correct instrument was selected and the COM settings were entered correctly in the Configure menu.

7. Display SBE 21 status information by clicking Status on the Toolbar. The display looks like this:

```
SEACAT THERMOSALINOGRAPH V4.2a SERIAL NO. 4300 05/15/2003 14:02:13
ioper = 50.7 ma   vmain = 11.4,   vlith = 8.8
samples = 50000, free = 1346736
sample interval = 5 seconds
sample external SBE 38 temperature sensor
no. of volts samples = 0
output format = SBE21
start sampling when power on = no
average data during sample interval = yes
logging data = no
voltage cutoff = 7.5 volts
```

8. If the status reply indicates that the SBE 21 is still logging, command the SBE 21 to stop logging by pressing the Enter key and sending **QL**. You may need to send the command several times.
9. If *output format = SBE16* in the status display, and you intend to use Sea-Bird data processing software, send **F1** to change the output format to SBE 21. Verify *output format = SBE21* by clicking Status on the Toolbar again.
10. Click Upload on the Toolbar to upload stored data in a form that our data processing software can use. SEATERM responds as follows:
- SEATERM sends the status (**DS**) command, displays the response, and writes the command and response to the upload file. This command provides with information regarding the number of samples in memory, scan interval, etc.
 - SEATERM sends the header (**DH**) command, displays the response, and writes the command and response to the upload file. This command provides information regarding the number of samples in each *cast* (SBE 21 writes a header each time sampling is restarted, as well as every 1000 scans), the date and time the cast was started, and the sample interval.
 - If you selected *By scan number range in the Configuration Options dialog box (Configure menu)*** – a dialog box requests the range. Enter the desired value(s), and click OK.
 - If you selected *Prompt for header information in the Configuration Options dialog box (Configure menu)*** – a dialog box with the header form appears. Enter the desired header information, and click OK.
 - In the Open dialog box, enter the desired upload file name and click OK. The upload file has a .hex extension.
 - SEATERM sends the data upload (**DDb,e**) command.
 - When the data has been uploaded, SEATERM shows the S> prompt.
11. Ensure all data has been uploaded from the SBE 21 by reviewing and processing the data:
- Use **SEASAVE** to display the *raw* hexadecimal data from the SBE 21 in engineering units (see SEASAVE's manual and/or Help files for details on displaying archived data).
 - Use **SBE Data Processing** to process and plot the data (see SBE Data Processing's manual and/or Help files for details).

Notes:

To prepare the SBE 21 for re-deployment:

- After all data has been uploaded, send **IL**. If this command is not sent and logging is started with **RL** or by applying power, new data will be stored after the last recorded sample, preventing use of the entire memory capacity.
- Send **QS** to put the SBE 21 in quiescent (sleep) state until ready to restart logging.
- Turn off power to the Interface Box.

Processing Data

Note:

See the SBE Data Processing manual and/or Help files for details on processing the data.

Note:

Although we provide this technique for editing a raw .hex file, **Sea-Bird's strong recommendation, as described above, is to always convert the raw data file and then edit the converted file.**

Process the data in SBE Data Processing:

1. Convert the .hex (raw data) file (created by SEASAVE or uploaded from SBE 21 memory) to a .cnv (engineering units) file in SBE Data Processing's DATA CONVERSION module.
2. Once the data is converted: perform further processing (align, filter, remove bad data, etc.), calculate derived variables, and plot data using SBE Data Processing's other modules.

Sometimes users want to edit the raw .hex data file before beginning processing, to remove data at the beginning of the file corresponding to instrument *soak* time, to remove blocks of bad data, to edit the header, or to add explanatory notes about the cast. **Editing the raw .hex file can corrupt the data, making it impossible to perform further processing using Sea-Bird software.** We strongly recommend that you first convert the data to a .cnv file (using DATA CONVERSION in SBE Data Processing), and then use other SBE Data Processing modules to edit the .cnv file as desired.

The procedure for editing a .hex data file described below has been found to work correctly on computers running Windows 98, 2000, and NT. **If the editing is not performed using this technique, SBE Data Processing may reject the edited data file and give you an error message.**

1. **Make a back-up copy of your .hex data file before you begin.**
2. Run **WordPad**.
3. In the File menu, select Open. In the Open dialog box: for *Files of type*, select *All Documents (*.*)*. Browse to the desired .hex file and click Open.
4. Edit the file as desired, **inserting any new header lines after the System Upload Time line**. Note that all header lines must begin with an asterisk (*), and *END* indicates the end of the header. An example is shown below, with the added lines in bold:


```
* Sea-Bird SBE 21 Data File:
* FileName = C:\Odis\SAT2-ODIS\oct14-19\oc15_99.hex
* Software Version Seasave Win32 v1.10
* Temperature SN = 2366
* Conductivity SN = 2366
* System UpLoad Time = Oct 15 1999 10:57:19
* Testing adding header lines
* Must start with an asterisk
* Place anywhere between System Upload Time & END of header
* NMEA Latitude = 30 59.70 N
* NMEA Longitude = 081 37.93 W
* NMEA UTC (Time) = Oct 15 1999 10:57:19
* Store Lat/Lon Data = Append to Every Scan and Append to .NAV
File When <Ctrl F7> is Pressed
** Ship:          Sea-Bird
** Cruise:       Sea-Bird Header Test
** Station:
** Latitude:
** Longitude:
*END*
```
5. In the File menu, select Save (**not Save As**). If you are running Windows 2000, the following message displays:
You are about to save the document in a Text-Only format, which will remove all formatting. Are you sure you want to do this?
Ignore the message and click *Yes*.
6. In the File menu, select Exit.

Section 7: Routine Maintenance and Calibration

This section reviews corrosion precautions, removing the sensor / electronics module from the SBE 21 water jacket, conductivity cell cleaning and storage, and sensor calibration. The accuracy of the SBE 21 is sustained by the care and calibration of the sensors and by establishing proper handling practices.

Corrosion Precautions

All hardware exposed to seawater is titanium; the housing is plastic. No corrosion precautions are required. The SBE 21 should be cleaned as described below after use and prior to storage.

Removing Sensor/Electronics Module from SBE 21 Water Jacket

Remove 4 bolts
securing square end
cap to top plate

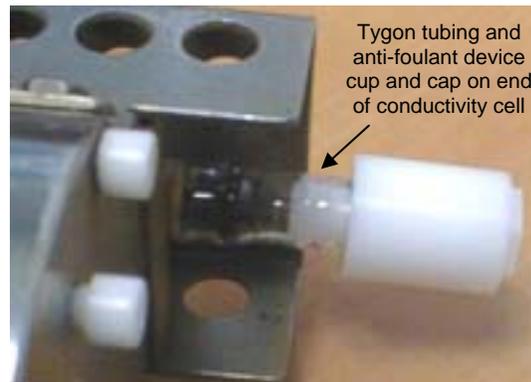


Sensor/Electronics Module
(anti-foulant device fittings not shown;
see detail at right)



Connector used only for
factory calibration and testing

1. **Close all 4 valves (valve is closed when the handle is vertical).**
2. Remove sensor/electronics module from water jacket:
 - A. Remove the 4 bolts, washers, and nuts securing the square end cap to the SBE 21 top plate.
 - B. Lift the square end cap straight up, removing the sensor/electronics module from the water jacket.
 - C. Protect the o-ring on the top plate from damage or contamination.
3. When desired, replace the sensor/electronics module in the water jacket:
 - A. Inspect the top plate o-ring and mating surfaces for dirt, nicks, and cuts. Clean or replace as necessary. Apply a light coat of o-ring lubricant (Parker Super O Lube) to o-ring and mating surfaces.
 - B. Carefully replace the sensor/electronics module in the water jacket, aligning the bolt holes on the square end cap and top plate.
 - C. Reinstall the 4 bolts, washers, and nuts to secure the end cap to the top plate.



Detail showing anti-foulant device fitting
(typical, each end of conductivity cell) –
see *Appendix IV: AF24173 Anti-Foulant Device* for handling details

Cleaning and Storage

CAUTION:

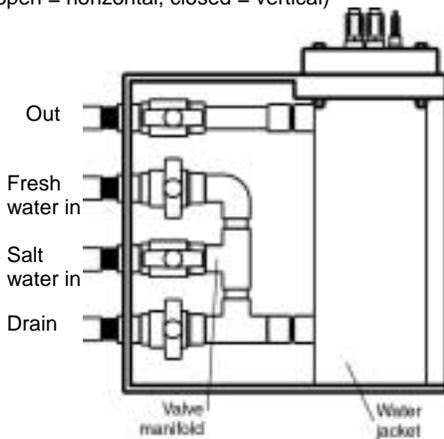
The SBE 21's conductivity cell is shipped dry to prevent freezing in shipping. **Do not store the SBE 21 with water in the conductivity cell.** Freezing temperatures (for example, in Arctic environments or during air shipment) can break the cell if it is full of water.

Clean the SBE 21 and conductivity cell:

- Monthly (during sustained use)
- Before periods of non-use – If the cell is not rinsed between usage, salt crystals may form on the platinized electrode surfaces. When the instrument is used next, sensor accuracy may be temporarily affected until these crystals dissolve.
- If the data looks incorrect –
 - Unusually *noisy* data may be caused by debris going through the cell.
 - Unusually *smooth* data may be caused by a blockage in the flow path or in the cell.
 - Shifted data may be caused by fouling inside the cell.

Follow this cleaning procedure:

Valves shown in *Normal Use* position
(open = horizontal, closed = vertical)



Step 1: Flush with Fresh Water and Drain

- A. Flush the system with fresh water by placing the SBE 21 valves in the following positions:
 - Out** - open
 - Fresh water in** - open
 - Salt water in** - closed
 - Drain** - closed
- B. Place the valves in the following positions and allow the water to drain:
 - Out** - closed
 - Fresh water in** - closed
 - Salt water in** - closed
 - Drain** - open

Step 2: Inspect Water Jacket

- A. Close all four valves.
- B. Remove the sensor/electronics module from the water jacket.
See *Removing Sensor/Electronics Module from SBE 21 Water Jacket* for details.
- C. Use a flashlight to inspect the inside of the water jacket for debris, fine deposits, or oil film. If this is a routine monthly maintenance, and there is no evidence of debris, fine deposits or oil film, proceed to *Step 5: Reinstall Sensor/Electronics Module*.

Step 3: Clean Water Jacket

- A. Use paper towels to remove any deposits inside the water jacket.

Step 4: Flush Inside of Conductivity Cell**WARNING!**

Use protective eyewear and wear gloves when working with hydrochloric acid. Avoid breathing the acid fumes. Dilute and rinse any spills with fresh water, or neutralize large spills with baking soda (sodium bicarbonate powder).

- A. Remove the anti-foulant device fittings from each end of the conductivity cell. See *Appendix IV: AF24173 Anti-Foulant Device* for handling details.
- B. Clean the inside of the conductivity cell with a series of flushes, using Tygon tubing.
 - i. Fresh water to remove debris and deposits.
 - ii. 1 liter of 1-normal hydrochloric acid, slow flow through the cell (Produce 1-normal hydrochloric acid as follows: Start with muriatic acid, which is 31.45% HCl (20 degrees Baume) by weight. Dilute 0.1 liters of muriatic acid into 0.9 liters of fresh water.)
 - iii. 10 liters of fresh water to rinse the acid.
 - iv. (optional) 1 liter of 1% solution of Triton X-100 (Triton X-100 is included with shipment).

If fouling remains in the conductivity cell after these procedures, return the sensor/electronics module to Sea-Bird for cleaning and recalibration.

- C. Rinse the exterior of the instrument to remove any spilled acid from the surface.
- D. If the SBE 21 is being stored, remove larger droplets of water by blowing through the conductivity cell. **Do not use compressed air**, which typically contains oil vapor.

CAUTION:

Do not put a brush or any object inside the conductivity cell to clean it or dry it. Touching and bending the electrodes can change the calibration. Large bends and movement of the electrodes can damage the cell.

Step 5: Reinstall Sensor/Electronics Module

- A. See *Removing Sensor/Electronics Module from SBE 21 Water Jacket* for details on reinstalling the module.
- B. If you will not be immediately using the SBE 21, leave all the valves in the closed position.
For Normal use, place the valves in these positions:
 - Out** - open
 - Fresh water in** - closed
 - Salt water in** - open
 - Drain** - closed

If the data still looks incorrect after cleaning, it may be caused by:

- a problem with the electrical connections
- a problem with the PCBs inside the sensor/electronics module housing
- internal fouling in the conductivity cell that was not removed by flushing
- sensors that need to be recalibrated

CAUTION:

To remove the electronics from the housing for troubleshooting, see *Appendix II: Electronics Disassembly/Reassembly* for details.

Sensor Calibration

Note:

After recalibration, Sea-Bird ships the instrument back to the user with Calibration Certificates showing the new coefficients. The user must enter the coefficients in the instrument configuration (.con) file in the Configure menu in SEASAVE or SBE Data Processing.

Sea-Bird sensors are calibrated by subjecting them to known physical conditions and measuring the sensor responses. Coefficients are then computed which may be used with appropriate algorithms to obtain engineering units. The conductivity and temperature sensors on the SBE 21 are supplied fully calibrated, with coefficients printed on their respective Calibration Certificates (see back of manual).

We recommend that the SBE 21's sensor/electronics module be returned to Sea-Bird for calibration (see *Removing Sensor/Electronics Module from SBE 21* above).

Conductivity Sensor Calibration

The conductivity sensor incorporates a fixed precision resistor in parallel with the cell. When the cell is dry and in air, the sensor's electrical circuitry outputs a frequency representative of the fixed resistor. This frequency is recorded on the Calibration Certificate and should remain stable (within 1 Hz) over time.

The primary mechanism for calibration drift in conductivity sensors is the fouling of the cell by chemical or biological deposits. Fouling changes the cell geometry, resulting in a shift in cell constant.

Accordingly, the most important determinant of long-term sensor accuracy is the cleanliness of the cell. We recommend that the conductivity sensor be calibrated before and after deployment, but particularly when the cell has been exposed to contamination by oil slicks or biological material.

Temperature Sensor Calibration

The primary source of temperature sensor calibration drift is the aging of the thermistor element. Sensor drift will usually be a few thousandths of a degree during the first year, and less in subsequent intervals. Sensor drift is not substantially dependent upon the environmental conditions of use, and — unlike platinum or copper elements — the thermistor is insensitive to shock.

Section 8: Troubleshooting

This section reviews common problems in operating the SBE 21, and provides the most common causes and solutions.

Problem 1: Unable to Communicate with Interface Box

The Interface Box setup message indicates that communications between the Interface Box and computer have been established. Before proceeding, attempt to establish communications again by typing @ several times.

Cause/Solution 1: The I/O cable connection may be loose. Check the cabling between the Interface Box and computer.

Cause/Solution 2: The communication settings entered in SEATERM may not match the dip switch settings in the Interface Box. Select the SBE 21 in the Configure menu and verify the settings in the Configuration Options dialog box. If necessary, change communication settings or dip switch settings.

Problem 2: Unable to Communicate with SBE 21

The S> prompt indicates that communications between the SBE 21 and computer have been established. Before proceeding, attempt to establish communications again by clicking Connect on SEATERM's toolbar or hitting the Enter key several times.

Cause/Solution 1: The I/O cable connection may be loose. Check the cabling between the SBE 21 and Interface Box.

Cause/Solution 2: The instrument type and/or its communication settings may not have been entered correctly in SEATERM. Select the SBE 21 in the Configure menu and verify the settings in the Configuration Options dialog box. The settings should match those on the instrument Configuration Sheet.

Cause/Solution 3: The communication settings entered in SEATERM may not match the dip switch settings in the Interface Box. Select the SBE 21 in the Configure menu and verify the settings in the Configuration Options dialog box. If necessary, change communication settings or dip switch settings.

Cause/Solution 4: The I/O cable connecting the SBE 21 to the Interface Box may not be the correct one. Verify the cable is the correct one.

Problem 3: No Data Recorded

Cause/Solution 1: The SBE 21's memory may be full; once the memory is full, no further data will be recorded. Verify that the memory is not full using **DS** (*free = 0* or *1* if memory is full). Sea-Bird recommends that you upload all previous data before beginning another deployment. Once the data is uploaded, use **IL** to reset the memory. After the memory is reset, **DS** will show *samples = 0*.

Problem 4: Nonsense or Unreasonable Data

Notes:

When Sea-Bird ships a new instrument, we include a .con file that reflects the current instrument configuration as we know it. The .con file is named with the instrument serial number, followed with the .con extension. For example, for an instrument with serial number 2375, Sea-Bird names the .con file 2375.con. You may rename the .con file if desired; this will not affect the results.

The symptom of this problem is a data file that contains nonsense values (for example, 9999.999) or unreasonable values (for example, values that are outside the expected range of the data).

Cause/Solution 1: A data file with nonsense values may be caused by incorrect instrument configuration in the .con file (i.e., assignment of sensors to channels in the .con file does not match the actual installation). Verify the settings in the instrument .con file match the instrument Configuration Sheet.

Cause/Solution 2: A data file with unreasonable (i.e., out of the expected range) values for temperature, conductivity, etc. may be caused by incorrect calibration coefficients in the instrument .con file. Verify the calibration coefficients in the instrument .con file match the instrument Calibration Certificates.

Problem 5: Salinity Lower than Expected

Cause/Solution 1: A fouled conductivity cell will report lower than correct salinity. Large errors in salinity indicate that the cell is extremely dirty, has something large lodged in it, or is broken. Proceed as follows:

1. Clean the conductivity cell as described in *Cleaning and Storage in Section 7: Routine Maintenance and Calibration*.
2. Remove larger droplets of water by blowing through the conductivity cell. **Do not use compressed air**, which typically contains oil vapor.
3. Running the SBE 21 in air, collect some data in SEASAVE and look at the raw conductivity frequency. It should be within 1 Hz of the zero conductivity value printed on the conductivity cell Calibration Sheet. If it is significantly different, the cell is probably damaged.

Problem 6: Program Corrupted

Note:

Performing a reset affects the SBE 21's memory.

- Download all data in memory before performing the reset.
- After performing the reset, set the date and time (**ST**) and initialize logging (**IL**). Other setup parameters are unaffected.

Cause/Solution 1: In rare cases, a severe static shock or other problem can corrupt the program that controls the SBE 21's microprocessor. This program can be reset by removing the J1 jumper on the Power PCB. Proceed as follows to initialize:

1. Remove the sensor/electronics module from the water jacket (see *Section 7: Routine Maintenance and Calibration*), and remove the electronics from the housing (see *Appendix II: Electronics Disassembly/Reassembly*).
2. Remove the J1 jumper from the Power PCB (top board in the PCB assembly). This jumper is used to disconnect the back-up lithium battery from the electronics. Leave the jumper off for several minutes.
3. Reinstall the J1 jumper.
4. Reinstall the electronics in the housing, and replace the sensor/electronics module in the water jacket.
5. Establish communications with the SBE 21 (see *Section 4: Setting Up SBE 21*). Initialize logging with **IL**, and set the date and time with **ST**. Use **DS** to verify that the date and time and sample number are correct.

Glossary

Fouling – Biological growth in the conductivity cell during deployment.

PCB – Printed Circuit Board.

PN 90158.1 – SEACAT/SEALOGGER RS-232 and Navigation

Interface Box – Box provides:

- Power and an opto-isolated RS-232C interface for the SBE 21
- Power and an opto-isolated NMEA receiver for a NMEA navigation device (not supplied by Sea-Bird)
- An RS-232C computer interface

SBE Data Processing – Sea-Bird’s Win 95/98/NT/2000/XP data processing software, which calculates temperature and conductivity, as well as data from auxiliary sensors, and derives variables such as salinity and sound velocity.

Scan – One data sample containing temperature and conductivity, as well as data from auxiliary sensors.

SEACAT – High-accuracy conductivity, temperature, and pressure recorder. The SEACAT is available as the SBE 16*plus* (moored applications), SBE 19*plus* (profiling or moored applications), and SBE 21 (thermosalinograph, no pressure).

SEASAVE – Sea-Bird’s Win 95/98/NT/2000/XP software used to acquire, convert, and display real-time or archived raw data.

SEASOFT-DOS – Sea-Bird’s complete DOS software package, which includes software for communication, real-time data acquisition, and data analysis and display. SEASOFT-DOS modules for real-time data acquisition and data analysis are **not compatible** with the data output format of the SBE 21.

SEASOFT-Win32 – Sea-Bird’s complete Win 95/98/NT/2000/XP software package, which includes software for communication, real-time data acquisition, and data analysis and display. SEASOFT-Win32 includes **SEATERM**, **SeatermAF**, **SEASAVE**, **SBE Data Processing**, and **Plot39**.

SEATERM – Sea-Bird’s Win 95/98/NT/2000/XP terminal program used to communicate with the Interface Box and SBE 21. SEATERM can send commands to the SBE 21 to provide status display, data acquisition setup, data display and capture, data upload from memory, and diagnostic tests.

TCXO – Temperature Compensated Crystal Oscillator.

Triton X-100 – Concentrated liquid non-ionic detergent, used for cleaning the conductivity cell.

Appendix I: Functional Description

Sensors

The SBE 21 embodies the same sensor elements (3-electrode, 2-terminal, borosilicate glass cell and pressure-protected thermistor) previously employed in Sea-Bird's modular SBE 3 and SBE 4 sensors and in the original SEACAT design. The current version of the SBE 21 differs from older versions of the SBE 21 in that it uses two independent channels to digitize temperature and conductivity concurrently. Multiplexing is not used for these channels.

Sensor Interface

Temperature is acquired by applying an AC excitation to a bridge circuit containing an ultra-stable aged thermistor with a drift rate of less than 0.002 °C per year. The other elements in the bridge are VISHAY precision resistors. A 24-bit A/D converter digitizes the output of the bridge. AC excitation and ratiometric comparison avoids errors caused by parasitic thermocouples, offset voltages, leakage currents, and reference errors.

Conductivity is acquired using an ultra-precision Wein-Bridge oscillator to generate a frequency output in response to changes in conductivity.

The four external 0 to 5 volt DC voltage channels are processed by differential amplifiers with an input resistance of 50K ohms and are digitized with a 12-bit A/D converter.

Real-Time Clock

To minimize power and improve clock accuracy, a temperature-compensated crystal oscillator (TCXO) is used as the real-time-clock frequency source. The TCXO is accurate to ± 1 minute per year (0 °C to 40 °C).

Power

The Power PCB contains three series-connected lithium cells (non-hazardous) which are diode OR'd with the external power source. The lithium supply is capable of supporting all SBE 21 functions and serves to permit orderly shutdown in the event of failure or removal of external power. External power can be removed without disturbing memory or the real-time clock.

Appendix II: Electronics Disassembly/Reassembly

Note:

Do not disassemble the SBE 21 electronics to send the sensors or PCBs to Sea-Bird for recalibration or repair. Package the sensor/electronics module for shipment (see *Removing Sensor/Electronics Module from SBE 21 Water Jacket in Section 7: Routine Maintenance and Calibration*).

Do not disassemble the SBE 21 electronics unless you are troubleshooting a problem, and need to access the PCBs.

Sea-Bird provides a jackscrew kit with the SBE 21, to assist in removal of the electronics end cap. The kit contains:

- 2 Allen wrenches
- 3 jackscrews

Jackscrew kit



Disassembly

1. As a precaution, upload any data in memory before beginning. See *Uploading SBE 21 Data from Memory in Section 6: Operating System*.



Do not remove socket head screw attaching guard to sensor end cap (2 places)

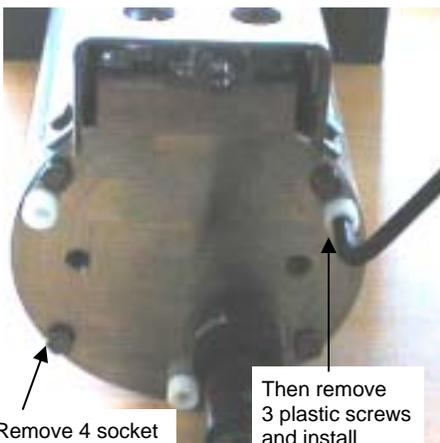
Remove slotted head screw (2 places)

2. Remove the SBE 21 sensor/electronics module from the water jacket, as described in *Removing Sensor/Electronics Module from SBE 21 Water Jacket in Section 7: Routine Maintenance and Calibration*.

3. Remove the 2 slotted head screws securing the sensor guard to the housing. **Do not remove the 2 screws holding the conductivity cell guard to the sensor end cap.**

4. Remove the sensor end cap (with attached conductivity cell and cell guard) and electronics as follows:

- A. Wipe the outside of the sensor end cap and housing dry, being careful to remove any water at the seam between them.
- B. Remove the 4 socket head screws securing the end cap to the housing.
- C. Remove the 3 plastic hex head screws from the end cap using the larger Allen wrench. Insert the three jackscrews in these three holes in the end cap. When you begin to feel resistance, use the smaller Allen wrench to continue turning the screws. Turn each screw 1/2 turn at a time. As you turn the jackscrews, the end cap will push away from the housing.
- D. When the end cap is loosened, carefully slide the end cap and attached electronics out of the housing.
- E. Remove any water from the o-rings and mating surfaces inside the housing with a lint-free cloth or tissue.
- F. Disconnect the Molex connectors connecting the PCB assembly to the housing.
- G. Be careful to protect the o-rings from damage or contamination.



Remove 4 socket head screws

Then remove 3 plastic screws and install jackscrews in their place

CAUTION:

Avoid getting anything on the PCB, which can be damaged by water or other materials.

Reassembly

Note:

Before delivery, a desiccant package is inserted in the housing and the electronics chamber is filled with dry Argon gas. These measures help prevent condensation. To ensure proper functioning:

1. Install a new desiccant bag each time you open the electronics chamber. If a new bag is not available, see *Application Note 71: Desiccant Use and Regeneration (drying)*.
2. If possible, dry gas backfill each time you open the housing. If you cannot, wait at least 24 hours before redeploying, to allow the desiccant to remove any moisture from the housing.

1. Remove any water from the O-rings and mating surfaces with a lint-free cloth or tissue. Inspect the O-rings and mating surfaces for dirt, nicks, and cuts. Clean as necessary. Apply a light coat of O-ring lubricant (Parker Super O Lube) to O-rings and mating surfaces.
2. Reconnect the Molex connectors to the PCB assembly.
3. Carefully fit the PCB assembly into the housing, aligning the holes in the end cap and housing, and the holes in the conductivity cell guard and housing.
4. Reinstall the 4 socket head screws to secure the end cap to the housing.
5. Reinstall the 3 plastic screws in the end cap.
6. Reinstall the 2 slotted screws to secure the conductivity cell guard to the housing.

Appendix III: Command Summary

CATEGORY	COMMAND	DESCRIPTION
Status	DS	Display status and setup parameters.
Setup	ST	Set real-time clock date and time.
	BAUD=x	x= baud rate (1200, 2400, 4800, 9600, 19200, or 38400). Default 9600.
	SBE38=x	x=Y: Enable SBE 38 secondary temperature sensor. x=N: Do not.
	SBE3=x	x=Y: Enable SBE 3 secondary temperature sensor. x=N: Do not.
	SVx	x=0, 1, 2, 3, or 4: Enable 0, 1, 2, 3, or 4 external voltages.
	Fx	x=1: output raw data in SBE 21 format. x=2: output raw data in SBE 16 format.
	FLASHINIT	Map bad blocks and erase FLASH memory, which destroys all data in SBE 21.
	QS	Enter quiescent (sleep) state.
Logging	AVERAGE=x	x=Y: Set SBE 21 to sample continuously at 4 Hz and average samples taken within each sample interval [SI] seconds, store averaged data in memory, and transmit averaged data real-time. x=N: Set SBE 21 to take 1 sample every sample interval [SI] seconds, store data in memory, and transmit data real-time.
	SI	Set interval (seconds) between samples or sample averages (3 - 600 seconds).
	IL	After all data uploaded, send command before starting to log to make entire memory available for recording. If not sent, data stored after last sample. Equivalent to SAMPLENUMBER=0 .
	SAMPLENUMBER=x	x= sample number for first sample when logging begins. After all data has been uploaded, set to 0 before starting to log to make entire memory available for recording. If not reset to 0, data stored after last sample. Equivalent to IL .
	HEADERNUMBER=x	x= header number for first header when logging begins.
	GL	Start logging now. SBE 21 starts logging at beginning of memory, overwriting any samples already in memory.
	RL	Resume logging now, placing data in memory <i>after</i> last sample (SBE 21 does not overwrite any samples in memory).
	AUTORUN=x	x=Y: Automatically start logging when power applied, placing data in memory <i>after</i> last sample (SBE 21 does not overwrite any samples in memory). x=N: Do not automatically start logging when power applied.
	QL	Stop logging. Press Enter key to get S> prompt before entering command. Must stop logging before uploading data.

Note:
Use the Upload button on the Toolbar or Upload Data in the Data menu to upload data that will be processed by SBE Data Processing. Manually entering the data upload command does not produce data in the correct format for processing by SBE Data Processing.

CATEGORY	COMMAND	DESCRIPTION
Data Upload	DDb,e	Upload data beginning with scan b, ending with scan e. Stop logging before sending this command.
	DH	Upload all headers. Stop logging before sending this command.
Sampling	SS	Output last sample from buffer.
	TS	Take sample, store data in buffer, output data.
Diagnostics Outputs 100 samples for each test; data not stored in FLASH memory. Press Esc key or Stop button to stop test.	FR	Display frequencies: raw temperature A/D counts, raw conductivity frequency, temperature frequency converted to match older SBE 21 (firmware version < 4.0), conductivity frequency converted to match older SBE 21 (firmware version < 4.0), and external frequency.
	VR	Display external voltages with offset and scale factors applied: external voltage 0, 1, 2, and 3; and diagnostics for factory use.
	T38	Display output from SBE 38 remote temperature sensor.
Coefficients Calibration coefficients for conductivity and primary temperature sensor, and for auxiliary sensors, are stored in (.con) file. View and/or modify coefficients using Configure menu in SEASAVE or SBE Data Processing.	DCAL	Display calibration coefficients: voltage channel offsets and slopes, conductivity zero frequency, and external frequency scale factor for SBE 3 remote temperature sensor.

Appendix IV: AF24173 Anti-Foulant Device

AF24173 Anti-Foulant Devices supplied for user replacement are supplied in polyethylene bags displaying the following label:

AF24173 ANTIFOULANT DEVICE	
FOR USE ONLY IN SEA-BIRD ELECTRONICS' CONDUCTIVITY SENSORS TO CONTROL THE GROWTH OF AQUATIC ORGANISMS WITHIN ELECTRONIC CONDUCTIVITY SENSORS.	
ACTIVE INGREDIENT:	
Bis(tributyltin) oxide.....	53.0%
OTHER INGREDIENTS:	<u>47.0%</u>
Total.....	100.0%
DANGER	
See the complete label within the Conductivity Instrument Manual for Additional Precautionary Statements and Information on the Handling, Storage, and Disposal of this Product.	
Net Contents: Two antifoulant devices (7.14 g)	
EPA Registration No. 74489-1	Sea-Bird Electronics, Inc
EPA Establishment No. 74489-WA-1	1808 - 136 th Place NE
	Bellevue, WA 98005

AF24173 Anti-Foulant Device

FOR USE ONLY IN SEA-BIRD ELECTRONICS' CONDUCTIVITY SENSORS TO CONTROL THE GROWTH OF AQUATIC ORGANISMS WITHIN ELECTRONIC CONDUCTIVITY SENSORS.

ACTIVE INGREDIENT:

Bis(tributyltin) oxide.....	53.0%
OTHER INGREDIENTS:	<u>47.0%</u>
Total.....	100.0%

DANGER

See Precautionary Statements for additional information.

FIRST AID	
If on skin or clothing	<ul style="list-style-type: none"> • Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15-20 minutes. • Call a poison control center or doctor for treatment advice.
If swallowed	<ul style="list-style-type: none"> • Call poison control center or doctor immediately for treatment advice. • Have person drink several glasses of water. • Do not induce vomiting. • Do not give anything by mouth to an unconscious person.
If in eyes	<ul style="list-style-type: none"> • Hold eye open and rinse slowly and gently with water for 15-20 minutes. • Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. • Call a poison control center or doctor for treatment advice.
HOT LINE NUMBER	
Note to Physician	Probable mucosal damage may contraindicate the use of gastric lavage.
Have the product container or label with you when calling a poison control center or doctor, or going for treatment. For further information call National Pesticide Telecommunications Network (NPTN) at 1-800-858-7378.	

Net Contents: Two Anti-Foulant Devices (7.14 g)

Sea-Bird Electronics, Inc.
1808 - 136th Place Northeast
Bellevue, WA 98005

EPA Registration No. 74489-1
EPA Establishment No. 74489-WA-1

PRECAUTIONARY STATEMENTS**HAZARD TO HUMANS AND DOMESTIC ANIMALS****DANGER**

Corrosive - Causes irreversible eye damage and skin burns. Harmful if swallowed. Harmful if absorbed through the skin or inhaled. Prolonged or frequently repeated contact may cause allergic reactions in some individuals. Wash thoroughly with soap and water after handling.

PERSONAL PROTECTIVE EQUIPMENT**USER SAFETY RECOMMENDATIONS**

Users should:

- Remove clothing immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.
- Wear protective gloves (rubber or latex), goggles or other eye protection, and clothing to minimize contact.
- Follow manufacturer's instructions for cleaning and maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.
- Wash hands with soap and water before eating, drinking, chewing gum, using tobacco or using the toilet.

ENVIRONMENTAL HAZARDS

Do not discharge effluent containing this product into lakes, streams, ponds, estuaries, oceans, or other waters unless in accordance with the requirements of a National Pollutant Discharge Elimination System (NPDES) permit and the permitting authority has been notified in writing prior to discharge. Do not discharge effluent containing this product to sewer systems without previously notifying the local sewage treatment plant authority. For guidance contact your State Water Board or Regional Office of EPA. This material is toxic to fish. Do not contaminate water when cleaning equipment or disposing of equipment washwaters.

PHYSICAL OR CHEMICAL HAZARDS

Do not use or store near heat or open flame. Avoid contact with acids and oxidizers.

DIRECTIONS FOR USE

It is a violation of Federal Law to use this product in a manner inconsistent with its labeling. For use only in Sea-Bird Electronics' conductivity sensors. Read installation instructions in the applicable Conductivity Instrument Manual.

STORAGE AND DISPOSAL

PESTICIDE STORAGE: Store in original container in a cool, dry place. Prevent exposure to heat or flame. Do not store near acids or oxidizers. Keep container tightly closed.

PESTICIDE SPILL PROCEDURE: In case of a spill, absorb spills with absorbent material. Put saturated absorbent material to a labeled container for treatment or disposal.

PESTICIDE DISPOSAL: Pesticide that cannot be used according to label instructions must be disposed of according to Federal or approved State procedures under Subtitle C of the Resource Conservation and Recovery Act.

CONTAINER DISPOSAL: Dispose of in a sanitary landfill or by other approved State and Local procedures.

Appendix V: Replacement Parts

Part Number	Part	Application Description	Quantity in SBE 21
801347	AF24173 Anti-Foulant Device	Bis(tributyltin) oxide device inserted into anti-foulant device mount kit	2
50315	External anti-foulant device mount kit (contains 2 mounting cups and caps and Tygon tubing)	For placement at both ends of conductivity cell, to hold AF24173 Anti-Foulant Device	1
30200	Bolt, 3/8-16 x 3 3/4 Hex, stainless steel	Secures square end cap to SBE 21 top plate	4
30210	Nut, 3/8-16 nylon stop, stainless steel	Use with 30200	4
30257	Washer, 3/8 flat, stainless steel, 7/8 OD max	Use with 30200	8
30092	O-ring, Parker 2-363N674-70	O-ring between SBE 21 top plate and square end cap	1
30444	Bolt, 10-24 x 1/2 hex head, titanium	Attaches conductivity cell guard to sensor/electronics module end cap	2
30491	Machine screw, 8-32 x 5/16 slot, titanium	Attaches conductivity cell guard to sensor/electronics module housing	2
30493	Machine screw, 10-24 x 1 1/4 hex head, titanium	Attaches sensor/electronics module end cap to housing	4
30815	O-ring, Parker 2-233E603-70	Seal for sensor/electronics module end cap	1
50091	Triton X-100	Conductivity cell cleaning solution	1
80438	4-pin RMG-4FS to 4-pin MS3106A-14S-2P I/O cable, 10 m (33 ft) long	From SBE 21 to Interface Box	1
801373	DB-9P to DB-9S I/O cable, 2.4 m (8 ft) long	From Interface Box to computer	1
171012	4-pin RMG-4FS to 4-pin RMG-4FS cable, 10 m (33 ft) long	From SBE 38 to SBE 21	1
50298	Spare hardware/O-ring kit for SBE 21 compatible with SBE 38	Assorted hardware and O-rings	-
50107	Spare hardware/O-ring kit for SBE 21 compatible with SBE 3	Assorted hardware and O-rings	-

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