SEASOFT-Win32:
SBE Data Processing

CTD Data Processing and Plotting Software for Windows 95/98/NT/2000/XP

User's Manual

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Section 1: Introduction

This section includes contact information, a brief description of SEASOFT-Win32, and a more detailed description of SBE Data Processing.

How to Contact Sea-Bird

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Except from April to October, when we are on 'summer time'
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Summary

SEASOFT-Win32 consists of modular, menu-driven routines for acquisition, display, processing, and archiving of oceanographic data acquired with Sea-Bird equipment. SEASOFT-Win32 is designed to work with a PC running Win 95/98/NT/2000/XP.

Note:
The following SEASOFT-DOS calibration modules are not yet available in SEASOFT-Win32:
- OXFIT – compute oxygen calibration coefficients
- OXFITW – compute oxygen calibration coefficients using Winkler titration values
- OXSAT – compute oxygen saturation as a function of temperature and salinity
- PHFIT – compute pH coefficients

See the SEASOFT-DOS manual.

SEASOFT-Win32 is actually several stand-alone programs:

- **SEATERM** terminal program that sends commands for status, setup, data retrieval, and diagnostics to a wide variety of Sea-Bird instruments.
- **SeatermAF** terminal program that sends commands for status, setup, data retrieval, and diagnostics to Sea-Bird instruments that power and operate an SBE 32 Carousel Water Sampler without real-time communication to surface (Auto Fire Module and SBE 17*plus* V2 SEARAM).
- **SEASAVE** program that acquires and displays real-time and raw archived data.
- **SBE Data Processing** program that converts, edits, processes, and plots data for a variety of Sea-Bird instruments.
- **Plot39** program for plotting SBE 39 and SBE 48 data.

This manual covers only SBE Data Processing.

System Requirements

Sea-Bird recommends the following minimum system requirements for SEASOFT-Win32: Pentium 90 CPU, 64 Mbyte RAM, Windows 98 or later.

Products Supported

SBE Data Processing supports the following Sea-Bird products:

- SBE 9*plus* CTD with SBE 11*plus* Deck unit (often referred to as 911*plus*) or with SBE 17 or 17*plus* SEARAM (often referred to as 917*plus*)
- SBE 16 SEACAT C-T (optional pressure) Recorder
- SBE 16*plus* and 16*plus*-IM SEACAT C-T (optional pressure) Recorder
- SBE 19 SEACAT Profiler
- SBE 19*plus* SEACAT Profiler
- SBE 21 SEACAT Thermosalinograph
- SBE 25 SEALOGGER CTD
- SBE 37-SM, 37-SMP, 37-IM, and 37-IMP MicroCAT Conductivity and Temperature (optional pressure) Recorder
- SBE 39 Temperature (optional pressure) Recorder
- SBE 45 MicroTSG Thermosalinograph
- SBE 48 Hull Temperature Sensor
- SBE 49 FastCAT CTD Sensor

Note:
SBE Data Processing support for SBE 39 and SBE 48 data is limited; see *Processing SBE 39 and 48 Data* in *Section 3: Typical Data Processing Sequences*.

Additionally, SBE Data Processing supports many other sensors / instruments interfacing with the instruments listed above, including Sea-Bird oxygen, pH, and ORP sensors; SBE 32 Carousel Water Sampler; and assorted equipment from third party manufacturers.

Software Modules

SBE Data Processing includes the following modules:

Type	Module Name	Module Description
Instrument configuration See *Section 4*.	**Configure** (equivalent to SEACON in SEASOFT-DOS)	Define instrument configuration and calibration coefficients.
Data conversion See *Section 5*.	**Data Conversion**	Convert raw .hex or .dat data to engineering units, and store converted data in .cnv file (all data) and/or .ros file (water bottle data).
	Bottle Summary (equivalent to ROSSUM in SEASOFT-DOS)	Summarize data from water sampler .ros file, storing results in .btl file.
	Mark Scan	Create .bsr bottle scan range file from .mrk data file.
Data processing Performed on converted data from a .cnv file. See *Section 6*.	**Align CTD**	Align data (typically conductivity, temperature, and oxygen) relative to pressure.
	Bin Average	Average data, basing bins on pressure, depth, scan number, or time range.
	Buoyancy	Compute Brunt Väisälä buoyancy and stability frequency.
	Cell Thermal Mass	Perform conductivity thermal mass correction.
	Derive	Calculate salinity, density, sound velocity, oxygen, etc.
	Filter	Low-pass filter columns of data.
	Loop Edit	Mark a scan with *badflag* if scan fails pressure reversal or minimum velocity test.
	Wild Edit	Mark a data value with *badflag* to eliminate wild points.
	Window Filter	Filter data with triangle, cosine, boxcar, Gaussian, or median window.
File manipulation See *Section 7*.	**ASCII In**	Add header information to .asc file containing ASCII data.
	ASCII Out	Output data and/or header from .cnv file to ASCII file (.asc for data, .hdr for header). Useful for exporting converted data for processing by non-Sea-Bird software.
	Section	Extract data rows from .cnv file.
	Split	Split data in .cnv file into upcast and downcast files.
	Strip	Extract data columns from .cnv file.
	Translate	Convert data in .cnv file from ASCII to binary, or vice versa.
Data plotting Performed on converted data from a .cnv file. See *Section 8*.	**SeaPlot** (equivalent to Seaplot and Contour in SEASOFT-DOS)	Plot data (C, T, P as well as derived variables, overlay plots, and TS contour plots). Plots can be sent to a printer, or saved to a file or the clipboard. SeaPlot can plot data at any point after Data Conversion has been run.
Miscellaneous Performed on data typed in by user. See *Section 9*.	**SeacalcW**	Calculate derived variables from one user-input scan of temperature, pressure, etc.

Differences from SEASOFT-DOS

SEASOFT was previously available in a DOS version. Following are the differences between SEASOFT-Win32 and SEASOFT-DOS, as they relate to data processing:

1. SEASOFT-Win32 does not include yet the following calibration modules that are available in SEASOFT-DOS:
   - OXSAT – Compute oxygen saturation as a function of temperature and salinity.
   - OXFIT – Compute oxygen coefficients.
   - OXFITW – Compute oxygen coefficients using Winkler titration values.
   - PHFIT – Compute pH coefficients.

2. SEASOFT-Win32 includes several stand-alone programs; you can install any or all of these programs as desired:
   - SBE Data Processing – replaces the data processing programs and SEACON in SEASOFT-DOS.
   - Terminal Programs - Windows-based terminal programs SEATERM and SeatermAF replace the terminal programs in SEASOFT-DOS (TERM1621, TERM17, TERM19, TERM25, TERM37, TERMAFM, TERM11, and TMODEM).
   - SEASAVE - Windows-based SEASAVE replaces SEASAVE and SEACON in SEASOFT-DOS.
   - Plot39 - Windows-based plotting program for SBE 39 and 48 data.

3. The SBE 9*plus* (with SBE 11*plus* Deck Unit or SBE 17 or 17*plus* SEARAM) is the only version of the SBE 9 that is supported in SBE Data Processing. Sea-Bird has been manufacturing the SBE 9*plus* since 1991.

4. The SBE 31 is not supported in SBE Data Processing.

5. Processing capability (for example, interfacing to additional auxiliary sensors) added to our software after November 2000 has been added only to the Windows version.

Section 2: Installation and Use

SBE Data Processing requires approximately 40 Mbytes of disk space during installation. Ensure there is room on your hard drive before proceeding. Sea-Bird recommends the following minimum system requirements for SEASOFT-Win32: Pentium 90 CPU, 64 Mbyte RAM, Windows 98 or later.

Installation

Note:
Sea-Bird supplies the current version of our software when you purchase an instrument. As software revisions occur, we post the revised software on our FTP site.
- You may not need the latest version. Our revisions often include improvements and new features related to one instrument, which may have little or no impact on your operation.

See our website (www.seabird.com) for the latest software version number, a description of the software changes, and instructions for downloading the software from the FTP site.

1. If not already installed, install SBE Data Processing and other Sea-Bird software programs on your computer using the supplied software CD:

   A. Insert the CD in your CD drive.

   B. Double click on **Seasoft-Win32.exe**.

   C. Follow the dialog box directions to install the software.

   The default location for the software is c:/Program Files/Sea-Bird. Within that folder is a sub-directory for each program. The installation program allows you to install the desired components. Install all the components, or just install SBE Data Processing.

Getting Started

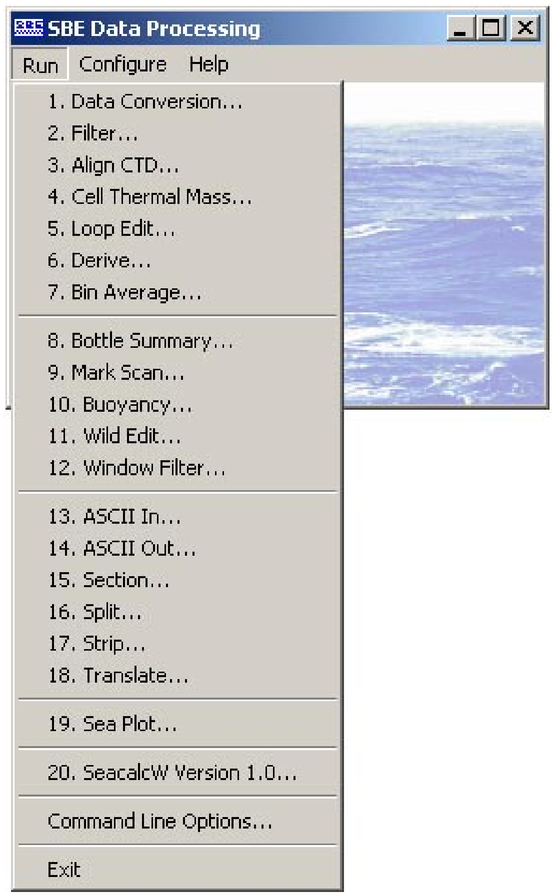
> **Note:**
> SBE Data Processing modules can be run from the command line. Also, batch file processing can be used to process a batch file to automate data processing tasks. See *Appendix I: Command Line Options, Command Line Operation, and Batch File Processing*.

SBE Data Processing Window

To start SBE Data Processing:

- Double click on SBEDataProc.exe (default location c:/Program Files/Sea-Bird/SBEDataProcessing-Win32), **or**
- (for Windows 98 and later) Left click on Start and follow the path Programs/Sea-Bird/SBEDataProcessing-Win32

The SBE Data Processing window looks like this:



The window's menus are described below.

- Run -
  - List of data processing modules, separated into categories: typical processing for profiling CTDs (1-7), other data processing (8-12), file manipulation (13-18), plotting (19), and seawater calculator (20). Select the desired module to set up the module parameters and process data. *Module Dialog Box* provides an overview of the module dialog box for all modules except SeaPlot and SeacalcW; Sections 5 through 9 provide details for each module.
  - Command Line Options: Select Command Line Options to assist in automating processing. See *Appendix I: Command Line Options, Command Line Operation, and Batch File Processing*.
  - Exit: Select to exit the program.
- Configure - List of instruments that require a configuration (.con) file, which defines the number and type of sensors interfacing with the instrument, as well as the sensor calibration coefficients. Select the desired instrument to modify or create a .con file. See *Section 4: Configuring Instrument (Configure)*.
- Help - General program help files as well as context-specific help.

Module Dialog Box

To open a module, select it in the Run menu of the SBE Data Processing window. Each module's dialog box has three menus:

> **Note:**
> Previous versions (5.30a and earlier) of SBE Data Processing used program setup files with a .psu extension instead of a .psa extension. Program setup files with a .psa extension can be opened, viewed, and modified in any text editor or XML editor.
> SBE Data Processing can still use your existing .psu files. However, if you make any changes to the setup (for example, change output variables), SBE Data Processing will save the changes to a new .psa file.

- **File** -
  - *Start Process* - begin to process data as defined in dialog box
  - *Open* - select a different program setup (.psa) file
  - *Save* or *Save As* - save all current settings to a .psa file
  - *Restore* - reset all settings to match last saved .psa file
  - *Default File Setup* - reset all settings on File Setup tab to defaults
  - *Default Data Setup* - reset all settings on Data Setup tab to defaults
  - *Exit* or *Save & Exit* - exit module and return to SBE Data Processing window

- **Options** (where applicable) -
  - *Confirm Program Setup Change* -
    - If **selected**, program provides a prompt to save the program setup (.psa) file if you make changes and click the Exit button or select Exit in the File menu without clicking or selecting Save or Save As.
    - If **not selected**, program changes *Exit* to *Save & Exit*; to exit without saving changes, use the Cancel button.
  - *Confirm Instrument Configuration Change* -
    - If **selected**, program provides a prompt to save the configuration (.con) file if you make changes and then click the Exit button in the Configuration dialog box without clicking Save or Save As.
    - If **not selected**, program changes *Exit* button to *Save & Exit*; to exit without saving changes, use the Cancel button.
  - *Overwrite Output File Warning* -
    - If **selected**, program provides a warning if output data will overwrite an existing file.
    - If **not selected**, program automatically overwrites an existing file with the same file name as the output file.
  - *Inconsistent Data Setup Warning* -
    - If **selected**, program provides a warning if the configuration (.con) file and/or the input data file are inconsistent with the selected output variables. For example, if the user-selected output variables include conductivity difference, but you remove the second conductivity sensor from the .con file, a warning will appear. The warning details what output variable cannot be calculated, and allows you to retain the change to the .con file (and remove the inconsistent output variable) or restore the .con file to the previous configuration.
    - If **not selected**, program automatically changes the user-selected output variables to be consistent with the selected configuration or data file.
  - *Sort Input Files* –
    - If **selected**, SeaPlot sorts the input files in alphabetical order.
    - If **not selected**, SeaPlot maintains the order of the files as you selected them using the Ctrl key; use this feature if there is a particular data set you want to use as the *base* on a waterfall overlay plot. Note that using the Shift key to select files will not maintain the selected order.

- **Help** - contains general program help files as well as context-specific help (where applicable)

> **Note:**
> The dialog box for SeaPlot and SeacalcW differ from the other modules. See *Section 8: Data Plotting Module – SeaPlot* and *Section 9: Miscellaneous Module - SeacalcW*.

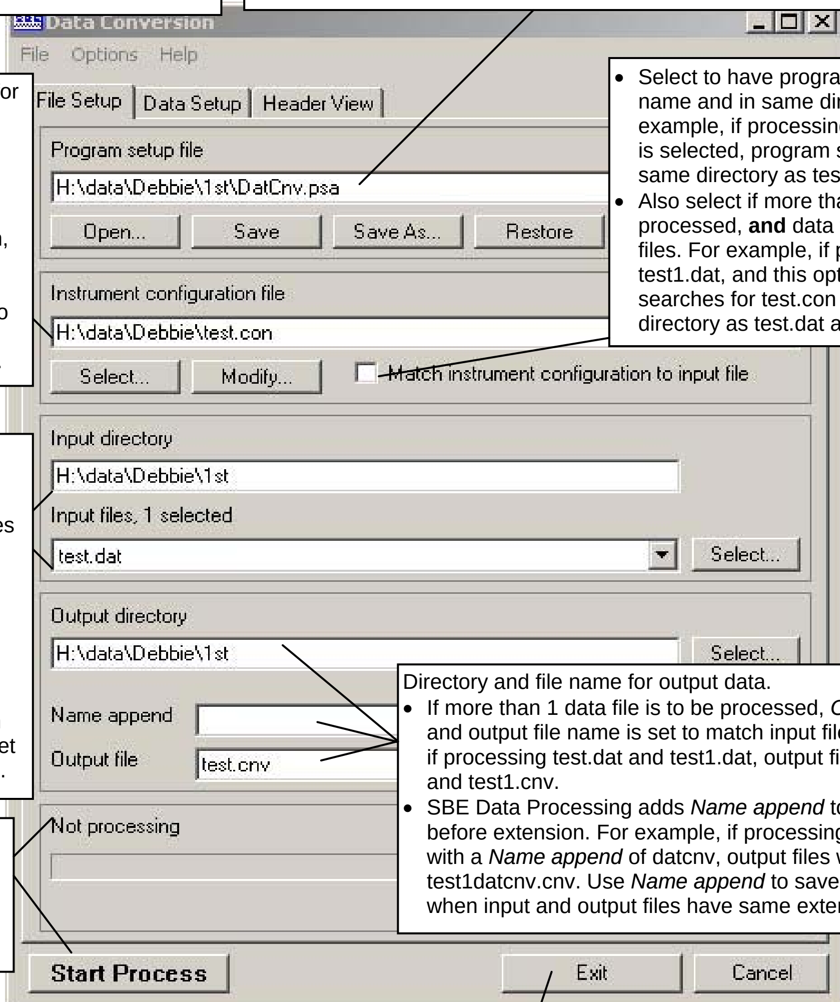
Each module's dialog box typically has three tabs - File Setup, Data Setup, and Header View. The File Setup and Header View tabs are similar for most of the modules, and are discussed below. The Data Setup tab contains input parameters specific to the module - see the module discussions in Sections 5 through 7.

Note:
Previous versions (5.30a and earlier) of SBE Data Processing used program setup files with a .psu extension instead of a .psa extension. Program setup files with a .psa extension can be opened, viewed, and modified in any text editor or XML editor.
SBE Data Processing can still use your existing .psu files. However, if you make any changes to the setup (for example, change output variables), SBE Data Processing will save the changes to a new .psa file.

The following examples and discussion of the File Setup and Header View tabs is for Data Conversion. The other modules (except SeaPlot and SeacalcW) are similar; however, not all fields are applicable to all modules.

File Setup Tab

Directory and file name for file to store **all** information input in File Setup and Data Setup tabs. **Open** to select a different .psa file, **Save** or **Save As** to save current settings, or **Restore** to reset all settings to match last saved version.
As a default, .psa file is stored in same directory as SBEDataProc.exe (default c:/Program Files/Sea-Bird/SBEDataProcessing-Win32). PostProcSuite.ini, located in Windows directory, contains location and file name of last saved .psa file and options settings for each module. **See note above**.



Directory and file name for instrument configuration (.con) file, which defines instrument configuration and sensor calibration coefficients. This file is used in Data Conversion, Bottle Summary, and Derive. **Select** to pick a different file, or **Modify** to view and/or modify instrument configuration.

- Select to have program find .con file with same name and in same directory as data file. For example, if processing test.dat and this option is selected, program searches for test.con (in same directory as test.dat).
- Also select if more than 1 data file is to be processed, **and** data files have different con files. For example, if processing test.dat and test1.dat, and this option is selected, program searches for test.con and test1.con (in same directory as test.dat and test1.dat).

Directory and file names for input data. **Select** to pick a different file. To process multiple data files from same directory:
1. Click **Select**.
2. In Select dialog box, hold down Ctrl key while clicking on each desired file.

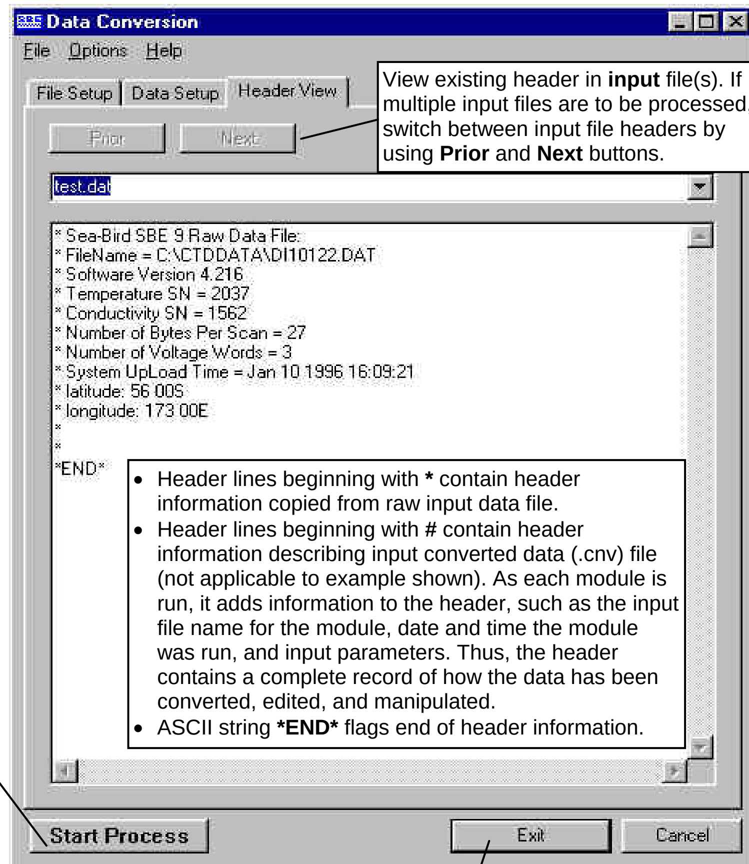
If multiple files are selected, header in each file must contain same set of sensors and variables.

Directory and file name for output data.
- If more than 1 data file is to be processed, *Output file* field disappears and output file name is set to match input file name. For example, if processing test.dat and test1.dat, output files will be test.cnv and test1.cnv.
- SBE Data Processing adds *Name append* to (each) output file name, before extension. For example, if processing test.dat and test1.dat with a *Name append* of datcnv, output files will be testdatcnv.cnv and test1datcnv.cnv. Use *Name append* to save intermediate data files when input and output files have same extension.

Click **Start Process** to begin processing data. Status field shows *Processing complete* when done.

Return to SBE Data Processing window.
- If *Confirm Program Setup Change* was selected in Options menu - If you made changes and did not Save or Save As, program asks if you want to save changes.
- If *Confirm Program Setup Change* was not selected in Options menu - Button says **Save & Exit**.
  If you do not want to save changes, use Cancel button to exit.

Header View Tab



View existing header in **input** file(s). If multiple input files are to be processed, switch between input file headers by using **Prior** and **Next** buttons.

- Header lines beginning with ***** contain header information copied from raw input data file.
- Header lines beginning with # contain header information describing input converted data (.cnv) file (not applicable to example shown). As each module is run, it adds information to the header, such as the input file name for the module, date and time the module was run, and input parameters. Thus, the header contains a complete record of how the data has been converted, edited, and manipulated.
- ASCII string ***END*** flags end of header information.

Begin processing data. Status field on File Setup tab shows *Processing complete* when done.

Return to SBE Data Processing window.
- If *Confirm Program Setup Change* was selected in Options menu - If you made changes in the File Setup or Data Setup tab and did not Save or Save As, program asks if you want to save changes.
- If *Confirm Program Setup Change* was not selected in Options menu - Button says **Save & Exit**. If you do not want to save changes made on the File Setup or Data Setup tab, use Cancel button to exit.

File Formats

File extensions are used by SEASOFT to indicate the file type:

Extension	Description
.afm	Bottle sequence, date and time, firing confirmation, and 5 scans of CTD data, created by Auto Fire Module (AFM).
.asc	Data file: • Data portion of .cnv converted data file written in ASCII by ASCII Out • File written by SEATERM for SBE 37-IM, 37-IMP, 37-SM, or 37-SMP, 39, or 48. (**Note**: Convert button on SEATERM's toolbar can convert .asc file to .cnv file that can be used by SBE Data Processing to process data.)
.bl	Bottle sequence number, position, date, time, and beginning and ending scan numbers, created by SEASAVE when bottle fire confirmation received.
.bmp	SeaPlot output bitmap graphics file.
.bsr	Bottle scan range file created by Mark Scan, and used by Data Conversion to create a .ros file.
.btl	Averaged and derived bottle data from a .ros file, created by Bottle Summary.
.cnv	Converted (engineering units) data file, with an ASCII header preceding data. Created by: • Data Conversion, or • SEATERM's Convert button (SBE 37-IM, 37-IMP, 37-SM, 37-SMP, 39, or 48 only).
.con	Instrument configuration (number and type of sensors, channel assigned to each sensor, and calibration coefficients). Latest version of .con file for your instrument is supplied by Sea-Bird when instrument is purchased, upgraded, or calibrated. If you make changes to instrument (add or remove sensors, recalibrate, etc.), you must update .con file. Created in Configure; used (and can be modified) in SEASAVE, Data Conversion, Derive, and Bottle Summary.
.dat	Data file - binary raw data file created by SEASAVE from real-time data stream from SBE 911*plus*. File includes header information.
.dsf, .dso, .dss	Data display parameters for a fixed, overlay (plot), and scrolled display window in SEASAVE.
.hdr	Header portion of .cnv converted data file written by ASCII Out, or header recorded when acquiring real-time data (same as header information in .hex or .dat data file).
.hex	Data file: • Hexadecimal raw data file: created by SEASAVE from real-time data stream from SBE 16, 16*plus*, 19, 19*plus*, 21, 25, or 49, or uploaded from SBE 16, 16*plus*, 16*plus*-IM, 19, 19*plus*, 21, or 25 memory. • Data uploaded from SBE 17*plus* (used with SBE 9*plus* CTD). • Converted (engineering units) data file created by SEASAVE from real-time data stream from SBE 45. File includes header information.
.jpg	SeaPlot output JPEG graphics file.
.mrk	Marker file created by SEASAVE upon user prompting; can be used to indicate bottle closures.
.psa	File containing input file name and data path, output data path, and module-specific parameters used by SBE Data Processing.
.ros	File containing data for each scan associated with a bottle closure, as well as data for a user-selected range of scans before and after each closure; created by Data Conversion.
.txt	Easy-to-read file (for viewing and printing only; cannot be modified) that shows all parameters in .con file. Created by clicking Report in Configuration dialog box, or by running ConReport.exe.
.wmf	SeaPlot output Windows metafile graphics file.

Note:
Previous versions (5.30a and earlier) of SBE Data Processing used program setup files with a .psu extension instead of a .psa extension. Program setup files with a .psa extension can be opened, viewed, and modified in any text editor or XML editor.
SBE Data Processing can still use your existing .psu files. However, if you make any changes to the setup (for example, change output variables), SBE Data Processing will save the changes to a new .psa file.

Converted Data File (.cnv) Format

Converted files consist of a descriptive header followed by converted data in engineering units. The header contains:

1. Header information from the raw input data file (these lines begin with *).

2. Header information describing the converted data file (these lines begin with #). The descriptions include:
   - number of rows and columns of data
   - variable for each column (for example, pressure, temperature, etc.)
   - interval between each row (scan rate or bin size)
   - historical record of processing steps used to create or modify file

3. ASCII string ***END** to flag the end of the header information.

Converted data is stored in rows and columns of ASCII numbers (11 characters per value) or as a binary data stream (4 byte binary floating point number for each value). The last column is a flag field used to mark scans as *bad* in Loop Edit.

Editing .hex and .dat Data Files

Note:
See *Section 5: Raw Data Conversion Modules* and *Section 7: File Manipulation Modules* for converting the data to a .cnv file and then editing the data.

Sometimes users want to edit the raw .hex or .dat data file before beginning processing, to remove data at the beginning of the file corresponding to instrument *soak* time, remove blocks of bad data, edit the header, or add explanatory notes about the cast. **Editing the raw .hex or .dat 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), and then use other SBE Data Processing modules to edit the .cnv file as desired.

.dat Files

Sea-Bird is not aware of a technique for editing a .dat file that will not corrupt it. Opening a .dat file with any text editor corrupts the file by leaving behind invisible characters (for example, carriage returns, line feeds, etc.) when the file is closed. These characters, inserted semi-randomly through the file, corrupt the data format. Sea-Bird distributes a utility program, called Fixdat, which *may* repair a corrupted .dat file.

- Fixdat.exe is installed with, and located in the same directory as, SBE Data Processing.

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.**

.hex Files

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. The Open dialog box appears. For *Files of type*, select *All Documents (*.*)*. Browse to the desired .hex data file and click Open.

4. Edit the file as desired, **inserting any new header lines after the System Upload Time line and before *END***. 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 3: Typical Data Processing Sequences

Notes:

- The processing sequence may differ for your application.
- SeaPlot can display data at any point after a .cnv file has been created.
- Use ASCII Out to export converted data (without header) to other software.
- Oxygen computed by SEASAVE and Data Conversion differs from oxygen computed by Derive. Both algorithms use the derivative of the oxygen signal with respect to time:
  - Quick estimate - SEASAVE and Data Conversion compute the derivative looking back in time, because SEASAVE cannot use future values while acquiring real-time data.
  - Most accurate results - Derive uses a user-input centered window (equal number of points before and after scan) to compute the derivative.

This section includes *typical* data processing sequences for each instrument, broken into four categories:

- Profiling CTDs that have a configuration (.con) file– SBE 9*plus*, 19, 19*plus*, 25, and 49
- Other instruments (moored CTDs and thermosalinographs) that have a configuration (.con) file – SBE 16, 16*plus*, 16*plus*-IM, 21, and 45
- Moored instruments that do not have a configuration (.con) file – SBE 37-SM, 37-SMP, 37-IM, and 37-IMP
- Moored instruments that do not have a configuration (.con) file and have limited compatibility with SBE Data Processing – SBE 39 and 48

Processing Profiling CTD Data (SBE 9*plus*, 19, 19*plus*, 25, and 49)

Notes:
- The example assumes that a configuration (.con) file is available. A .con file is provided by Sea-Bird when the instrument is purchased, based on the user-specified configuration and the factory-calibration. An existing .con file can be modified in Configure, Data Conversion, Derive, or Bottle Summary, or in SEASAVE. If you do not have a .con file, use SBE Data Processing's Configure menu to create the .con file.
- The order for running Bin Average and Derive can be switched, **unless oxygen is being computed in Derive**.
- See the program modules for Sea-Bird recommendations for typical parameter values for filtering, aligning, etc. Use judgment in evaluating your data set to determine the best values.

The processing sequence is based on a *typical* situation with a boat at low latitude lowering an instrument at 1 meter/second.

Program / Module	Function
1. SEASAVE, SEATERM, or SeatermAF	Acquire real-time raw data (SEASAVE) or upload data from memory (Upload button in SEATERM or SeatermAF, as applicable).
2. Data Conversion	Convert raw data to a .cnv file, selecting ASCII as data conversion format. Converted data includes: • pressure, temperature, and conductivity • (if applicable) dissolved oxygen current and dissolved oxygen temperature (SBE 13 or 23); dissolved oxygen signal (SBE 43) • (if applicable) light transmission, pH, fluorescence, etc.
3. Filter	Low-pass filter pressure to increase pressure resolution for Loop Edit, and low-pass filter temperature and conductivity to smooth high frequency data.
4. Align CTD	Advance conductivity, temperature, and oxygen relative to pressure, to align parameters in time. This ensures that calculations of salinity, dissolved oxygen, and other parameters are made using measurements from same parcel of water.
5. Cell Thermal Mass	Perform conductivity cell thermal mass correction if salinity accuracy of better than 0.01 PSU is desired in regions with steep gradients.
6. Loop Edit	Mark scans where CTD is moving less than minimum velocity or traveling backwards due to ship roll.
7. Derive	Compute: • salinity, density, and other parameters • oxygen from oxygen current and oxygen temperature (SBE 13 or 23) or oxygen signal (SBE 43) Note that input file must include conductivity, temperature, and pressure.
8. Bin Average	Average data into desired pressure or depth bins.
9. SeaPlot	Plot data.

Processing SBE 16, 16*plus*, 16*plus*-IM, 21, and 45 Data

Notes:
- The example assumes that a configuration (.con) file is available. A .con file is provided by Sea-Bird when the instrument is purchased, based on the user-specified configuration and the factory-calibration. An existing .con file can be modified in Configure, Data Conversion, Derive, or Bottle Summary, or in SEASAVE. If you do not have a .con file, use SBE Data Processing's Configure menu to create the .con file.
- Even if your instrument does not have a pressure sensor (SBE 21 and 45; SBE 16, 16*plus*, and 16*plus*-IM without optional pressure sensor): Select pressure as an output variable in Data Conversion if you plan to calculate salinity, density, or other parameters that require pressure in Derive or SeaPlot. For the 16, 16*plus*, and 16*plus*-IM, Data Conversion inserts a column with the moored pressure (entered in the .con file *Data* dialog) in the output .cnv file. For the SBE 21 and 45, Data Conversion inserts a column of 0's for pressure in the output .cnv file.
- The SBE 45 outputs data in engineering units. However, you must still run Data Conversion to put the data in a format that can be used by SBE Data Processing's other modules.
- For an SBE 21 or 45: If the thermosalinograph has a remote temperature sensor, SEASAVE, Data Conversion, and Derive all use the remote temperature data to calculate density and sound velocity.

Program / Module	Function
1. SEASAVE or SEATERM	Acquire real-time raw data (SEASAVE) or upload data from memory (Upload button in SEATERM).
2. Data Conversion	Convert raw data to a .cnv file, selecting ASCII as data conversion format. Converted data includes: • pressure, temperature, and conductivity • (if applicable) dissolved oxygen current and dissolved oxygen temperature (SBE 13 or 23); dissolved oxygen signal (SBE 43) • (if applicable) light transmission, pH, fluorescence, etc.
3. Derive	Compute: • salinity, density, and other parameters. • oxygen from oxygen current and oxygen temperature (SBE 13 or 23) or oxygen signal (SBE 43) Note that input file must include conductivity, temperature, and pressure.
4. SeaPlot	Plot data.

Processing SBE 37-SM, 37-SMP, 37-IM, and 37-IMP Data

Program / Module	Function
1. SEATERM	Use Upload button to upload data (in engineering units) in ASCII (.asc) format. Use Convert button to convert .asc to .cnv file, which can be used by SBE Data Processing.
2. Derive	Compute salinity, density, and other parameters. **Note**: An SBE 37-SM, 37-SMP, 37-IM, and 37-IMP stores calibration coefficients internally, and does not have a .con file. However, Derive **requires** you to select a .con file before it will process data. You can use a .con file from **any** other Sea-Bird instrument; the contents of the .con file will not affect the results. If you do not have a .con file for another Sea-Bird instrument, create one: 1. Click SBE Data Processing's Configure menu and select **any** instrument. 2. In the Configuration dialog box, click Save As, and save the .con file with the desired name and location.
3. SeaPlot	Plot data.

Processing SBE 39 and 48 Data

Note:
The .cnv file from an SBE 39 or 48 cannot be processed by any SBE Data Processing modules other than SeaPlot and ASCII Out.

Program / Module	Function
1. SEATERM	Use Upload button to upload data (in engineering units) in ASCII (.asc) format. Use Convert button to convert .asc to .cnv file, which can be used by SBE Data Processing.
2. SeaPlot	Plot data.

Section 4: Configuring Instrument (Configure)

Module Name	Module Description
Configure (equivalent to SEACON in SEASOFT-DOS)	Define instrument configuration and calibration coefficients.

Introduction

Configure creates or modifies a configuration (.con) file to define the instrument configuration and sensor calibration coefficients. The .con file is used in both SBE Data Processing and in SEASAVE. Configure is applicable to the following instruments:

- SBE 9*plus* with SBE 11*plus* Deck Unit **or** SBE 17*plus* SEARAM (SBE 9*plus* is listed as the 911/917plus in the Configure menu)
- SBE 16
- SBE 16*plus* (including 16*plus*-IM)
- SBE 19
- SBE 19*plus*
- SBE 21
- SBE 25
- SBE 45
- SBE 49

Notes:
- Sea-Bird supplies a .con file with each instrument. **The .con file must match the existing instrument configuration and contain current sensor calibration information.**
- An existing .con file can be modified in Configure; in Data Conversion, Derive, or Bottle Summary; or in SEASAVE.
- *Appendix II: Configure (.con) File Format* contains a line-by-line description of the contents of the .con file.
- An SBE 37-SM, 37-SMP, 37-IM, 37-IMP, 39, and 48 stores calibration coefficients internally, and does not have a .con file.

The discussion of Configure is in four parts:

- *Instrument Configuration* covers the Configuration dialog box - number and type of sensors on the instrument, etc. - for each of the instruments listed above. Unless noted otherwise, SBE Data Processing supports only one of each brand and type of auxiliary sensor (for example, you cannot specify two Chelsea Minitracka fluorometers, but you can specify a Chelsea Minitracka and a Chelsea UV Aquatracka fluorometer). See the individual sensor descriptions in *Calibration Coefficients for Voltage Sensors* for those sensors that SBE Data Processing supports in a redundant configuration (two or more of the same sensor interfacing with the CTD).

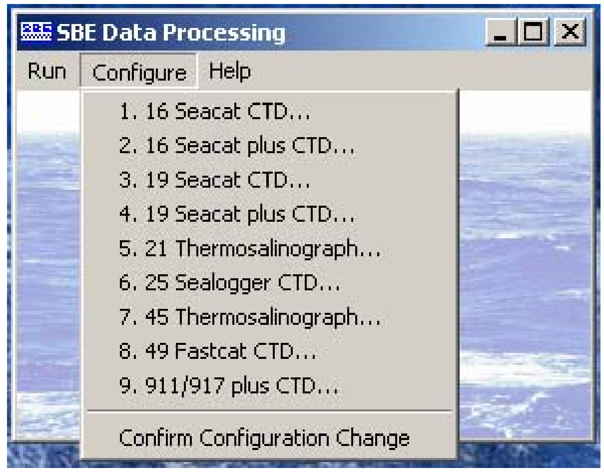
- *Calibration Coefficients for Frequency Sensors* covers calculation of coefficients for each type of frequency sensor (temperature, conductivity, Digiquartz pressure, IOW sound velocity, etc.).

- *Calibration Coefficients for A/D Count Sensors* covers calculation of coefficients for A/D count sensors (temperature and strain gauge pressure) used on the SBE 16*plus* (and -IM), 19*plus*, and 49.

- *Calibration Coefficients for Voltage Sensors* covers calculation of coefficients for each type of voltage sensor (strain gauge pressure, oxygen, pH, etc.).

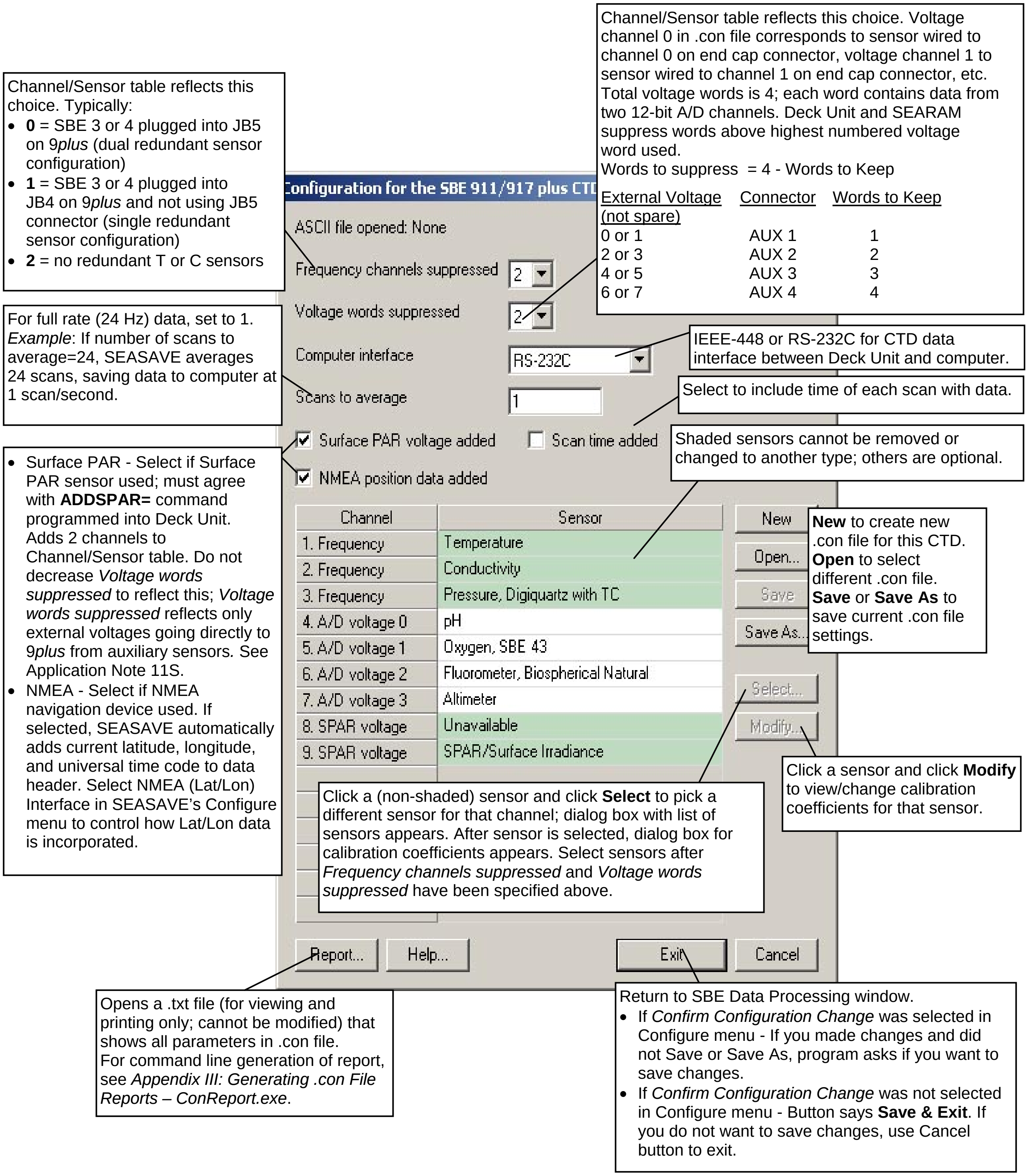
Access Configure by selecting the desired instrument in the Configure menu in the SBE Data Processing window.

- Before selecting the instrument, review the status of *Confirm Configuration Change* in the Configure menu. If *Confirm Configuration Change* is selected, the program provides a prompt to save the configuration (.con) file if you make changes and then click the Exit button in the Configuration dialog box without clicking Save or Save As. **If not selected, the program changes the *Exit* button to *Save & Exit*; to exit without saving changes, use the Cancel button**.

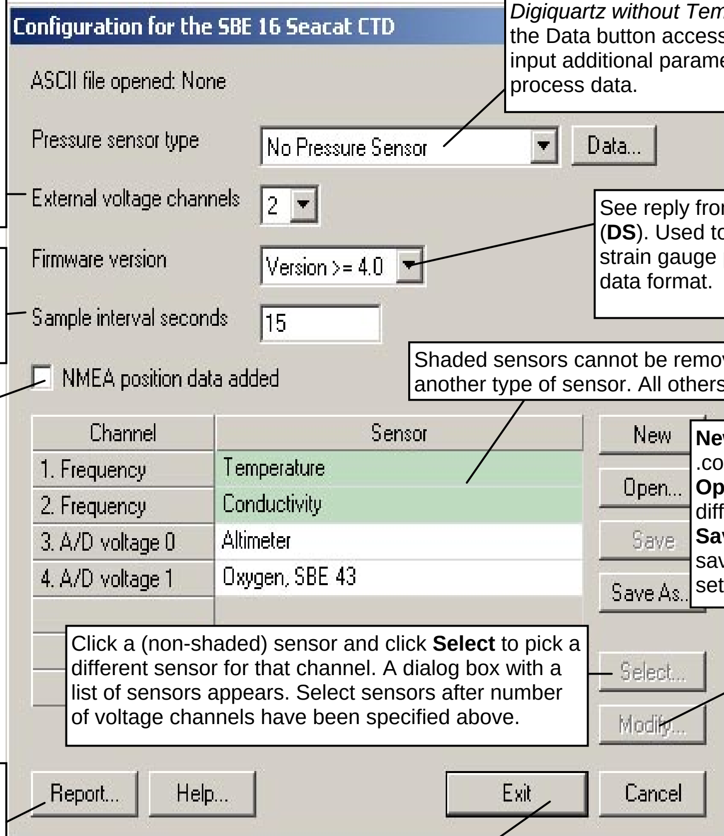


Instrument Configuration

SBE 9*plus* Configuration



SBE 16 SEACAT C-T Recorder Configuration



Channel/Sensor table reflects this choice. Must agree with number programmed into SBE 16 with **SVn** (n=0, 1, 2, 3, or 4) command; see reply from status command (**DS**). Voltage channel 0 in .con file corresponds to sensor wired to channel 0 on end cap connector, voltage channel 1 in .con file corresponds to sensor wired to channel 1 on end cap connector, etc.

Time between scans. Must agree with number programmed into SBE 16 with **SI** command; see reply from status command (**DS**).

Select if using with a deck unit 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.

Opens a .txt file (for viewing and printing only; cannot be modified) that shows all parameters in .con file. For command line generation of report, see *Appendix III: Generating .con File Reports – ConReport.exe*.

Select strain gauge, Digiquartz with or without temperature compensation, or no pressure sensor. If *no pressure sensor* or *Digiquartz without Temp Comp* is selected, the Data button accesses a dialog box to input additional parameter(s) needed to process data.

See reply from status command (**DS**). Used to determine strain gauge pressure sensor data format.

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

New to create new .con file for this CTD. **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 channels have been specified above.

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

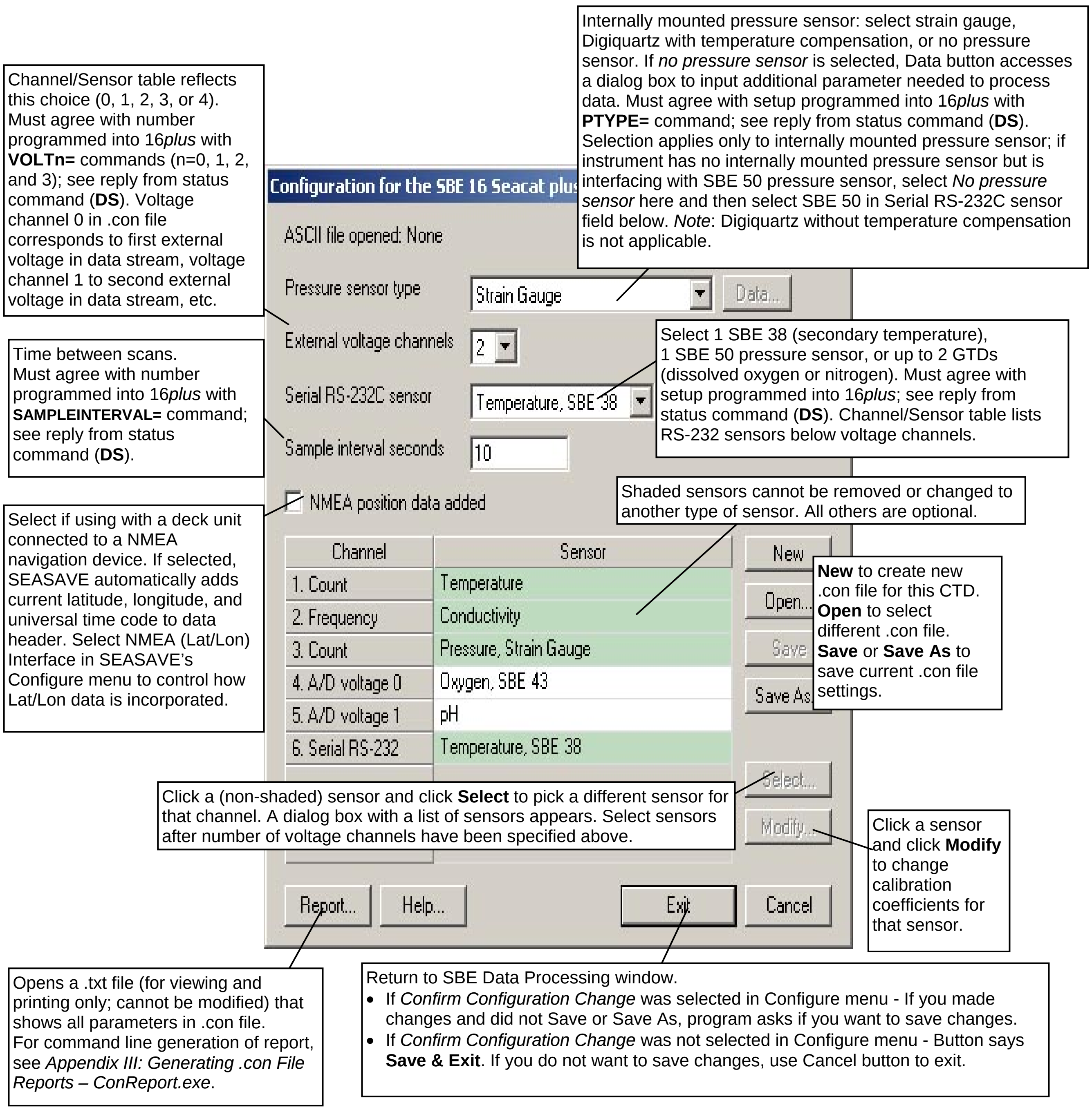
Return to SBE Data Processing window.

- If *Confirm Configuration Change* was selected in Configure menu - If you made changes and did not Save or Save As, program asks if you want to save changes.
- If *Confirm Configuration Change* was not selected in Configure menu - Button says **Save & Exit**. If you do not want to save changes, use Cancel button to exit.

SBE 16*plus* or 16*plus*-IM SEACAT C-T Recorder Configuration

The SBE 16*plus* can interface with one SBE 38 secondary temperature sensor, one SBE 50 pressure sensor, **or** up to two Pro-Oceanus Gas Tension Devices (GTDs) through the SBE 16*plus* optional RS-232 connector. Data from an SBE 50 pressure sensor is appended to the data stream, and does not replace the (optional) internally mounted pressure sensor data.

The SBE 16*plus*-IM can interface with one SBE 38 secondary temperature sensor through the 16*plus*-IM optional RS-232 connector, but **cannot interface with an SBE 50 or GTD**. All commands to a particular 16*plus*-IM are preceded by **#ii**, where ii = instrument ID (0-99). Therefore, commands mentioned in the dialog box description below (**DS**, **PTYPE=**, **VOLTn=**, and **SAMPLEINTERVAL=**) have a slightly different form for the 16*plus*-IM (**#iiDS**, **#iiPTYPE=**, **#iiVOLTn=**, and **#iiSAMPLEINTERVAL=**).

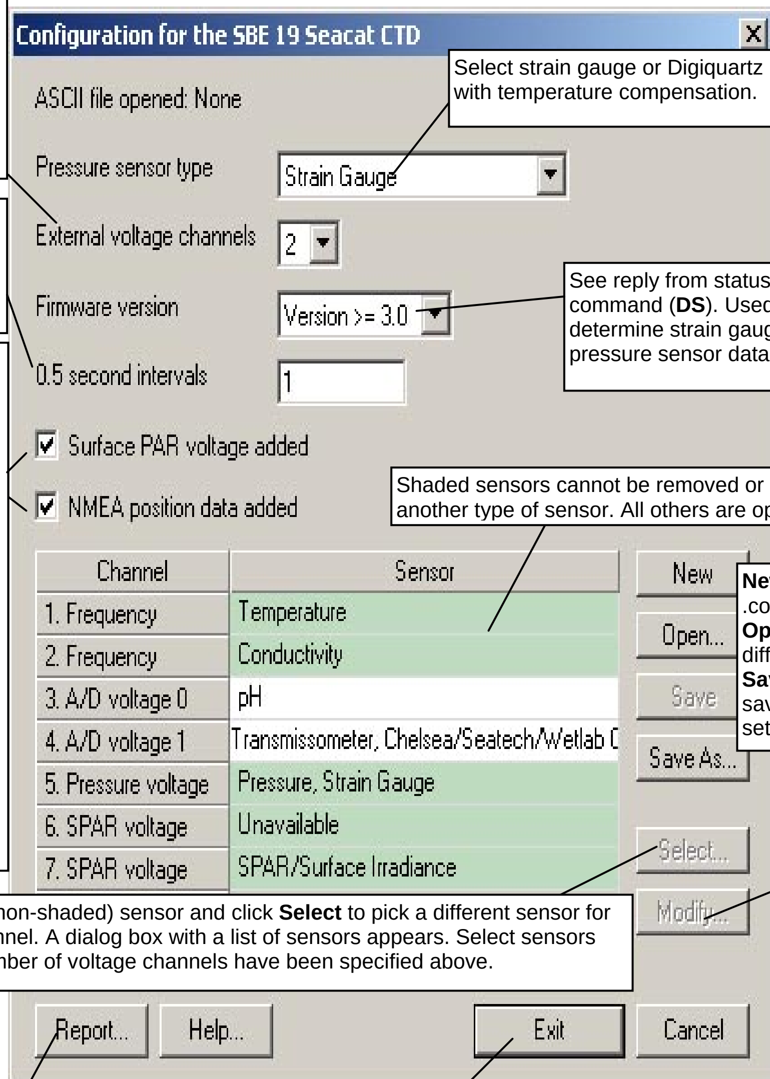


SBE 19 SEACAT Profiler Configuration

Channel/Sensor table reflects this choice. Must agree with number programmed into SBE 19 with **SVn** (n=0, 2, or 4) command; see reply from status command (**DS**). Voltage channel 0 in .con file corresponds to sensor wired to channel 0 on end cap connector, voltage channel 1 in .con file corresponds to sensor wired to channel 1 on end cap connector, etc.

Number of 0.5 second intervals between samples. Must agree with number programmed into SBE 19 with **SR** command; see reply from status command (**DS**).

- Surface PAR - Select if surface PAR voltage added by deck unit. Selecting Surface PAR voltage adds 2 channels to Channel/Sensor table. Do not increase *External voltage channels* to reflect this; *External voltage channels* reflects only external voltages going directly to SBE 19 from auxiliary sensors. See Application Note 47.
- NMEA - Select if using with a deck unit 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.



Select strain gauge or Digiquartz with temperature compensation.

See reply from status command (**DS**). Used to determine strain gauge pressure sensor data format.

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

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

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

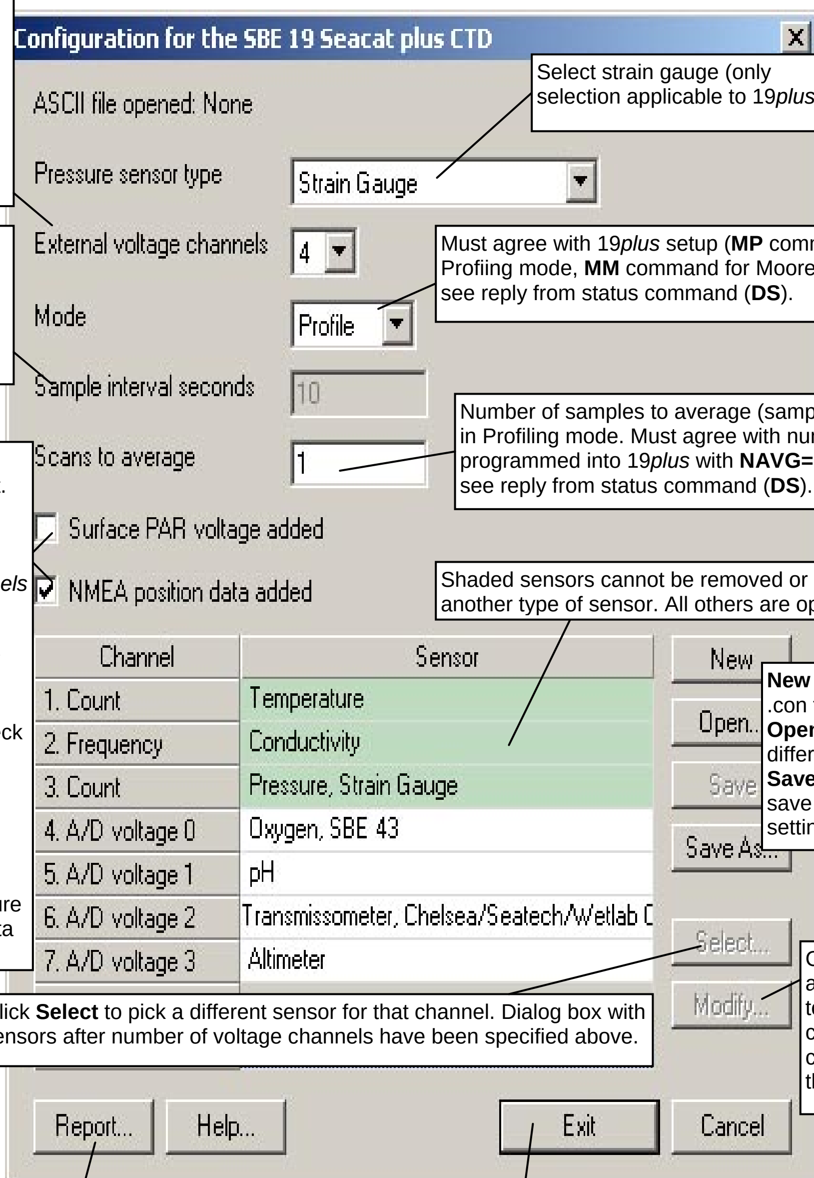
Click a (non-shaded) sensor and click **Select** to pick a different sensor for that channel. A dialog box with a list of sensors appears. Select sensors after number of voltage channels have been specified above.

Opens a .txt file (for viewing and printing only; cannot be modified) that shows all parameters in .con file. For command line generation of report, see *Appendix III: Generating .con File Reports – ConReport.exe*.

Return to SBE Data Processing window.

- If *Confirm Configuration Change* was selected in Configure menu - If you made changes and did not Save or Save As, program asks if you want to save changes.
- If *Confirm Configuration Change* was not selected in Configure menu - Button says **Save & Exit**. If you do not want to save changes, use Cancel button to exit.

SBE 19*plus* SEACAT Profiler Configuration



Channel/Sensor table reflects this choice (0, 1, 2, 3, or 4). Must agree with number programmed into 19*plus* with **VOLTn=** commands (n=0, 1, 2,and 3); see reply from status command (**DS**). Voltage channel 0 in .con file corresponds to first external voltage in data stream, voltage channel 1 to second external voltage in data stream, etc.

Select strain gauge (only selection applicable to 19*plus*).

Interval between scans in Moored mode. Must agree with number programmed into 19*plus* with **SAMPLEINTERVAL=** command; see reply from status command (**DS**).

Must agree with 19*plus* setup (**MP** command for Profiing mode, **MM** command for Moored mode); see reply from status command (**DS**).

Number of samples to average (samples at 4 Hz) in Profiling mode. Must agree with number programmed into 19*plus* with **NAVG=** command; see reply from status command (**DS**).

- Surface PAR - Select if surface PAR voltage added by deck unit. Selecting Surface PAR voltage adds 2 channels to Channel/Sensor table. Do not increase *External voltage channels* to reflect this; *External voltage channels* reflects only external voltages going directly to 19*plus* from auxiliary sensors. See Application Note 47.
- NMEA - Select if using with a deck unit 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 for this CTD. **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. Dialog box with a list of sensors appears. Select sensors after number of voltage channels have been specified above.

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

Opens a .txt file (for viewing and printing only; cannot be modified) that shows all parameters in .con file.
For command line generation of report, see *Appendix III: Generating .con File Reports – ConReport.exe*.

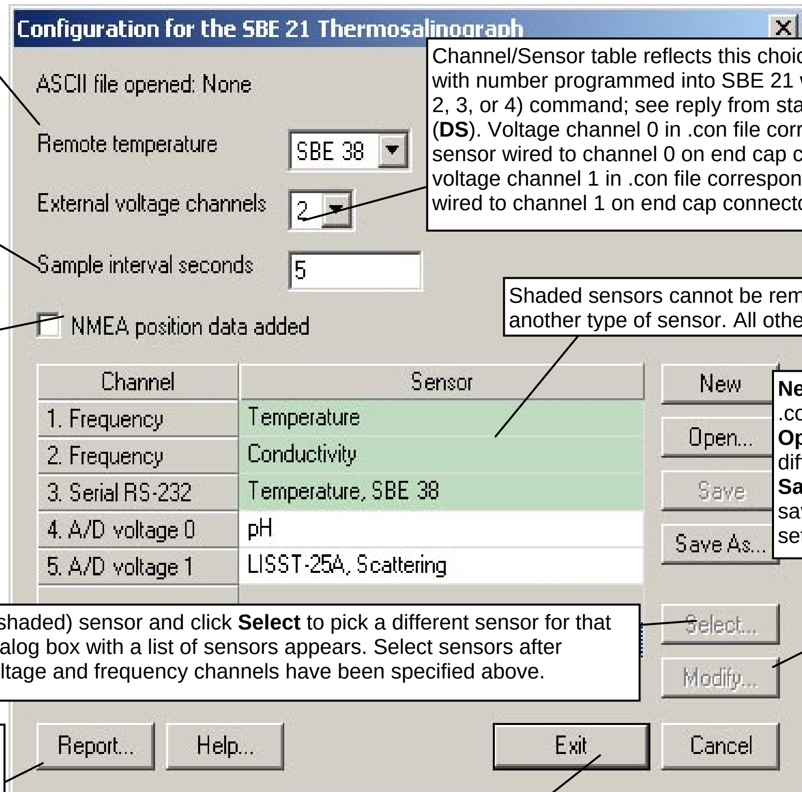
Return to SBE Data Processing window.
- If *Confirm Configuration Change* was selected in Configure menu - If you made changes and did not Save or Save As, program asks if you want to save changes.
- If *Confirm Configuration Change* was not selected in Configure menu - Button says **Save & Exit**. If you do not want to save changes, use Cancel button to exit.

SBE 21 Thermosalinograph Configuration

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 or disable external temperature sensor; see reply from status command (**DS**).
If remote temperature is selected, SEASAVE, Data Conversion, and Derive use remote temperature data when calculating density and sound velocity.

Time between scans. Must agree with number programmed into SBE 21 with **SI** command; see reply from status command (**DS**).

Select if using with a deck unit 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.



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**). Voltage channel 0 in .con file corresponds to sensor wired to channel 0 on end cap connector, voltage channel 1 in .con file corresponds to sensor wired to channel 1 on end cap connector, etc.

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.

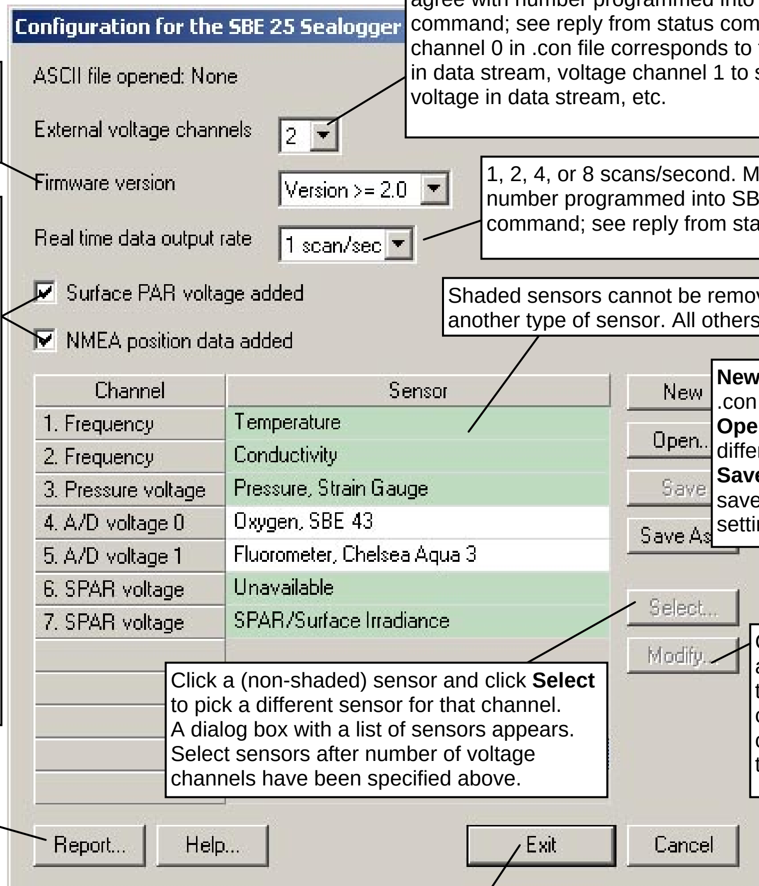
Click a sensor and click **Modify** to change calibration coefficients for that sensor.

Opens a .txt file (for viewing and printing only; cannot be modified) that shows all parameters in .con file.
For command line generation of report, see *Appendix III: Generating .con File Reports – ConReport.exe*.

Return to SBE Data Processing window.

- If *Confirm Configuration Change* was selected in Configure menu - If you made changes and did not Save or Save As, program asks if you want to save changes.
- If *Confirm Configuration Change* was not selected in Configure menu - Button says **Save & Exit**. If you do not want to save changes, use Cancel button to exit.

SBE 25 SEALOGGER Configuration



Channel/Sensor table reflects this choice (0 - 7). Must agree with number programmed into SBE 25 with **CC** command; see reply from status command (**DS**). Voltage channel 0 in .con file corresponds to first external voltage in data stream, voltage channel 1 to second external voltage in data stream, etc.

Used to determine strain gauge pressure sensor data format. See reply from status command (**DS**).

1, 2, 4, or 8 scans/second. Must agree with number programmed into SBE 25 with **CC** command; see reply from status command (**DS**).

- Surface PAR - Select if Surface PAR voltage added by deck unit. Selecting Surface PAR voltage adds 2 channels to Channel/Sensor table. Do not increase *External voltage channels* to reflect this; *External voltage channels* reflects only external voltages going directly to SBE 25 from auxiliary sensors. See Application Note 47.
- NMEA - Select if using with a deck unit connected to a NMEA navigation device. 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 for this CTD. **Open** to select different .con file. **Save** or **Save As** to save current .con file settings.

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

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 channels have been specified above.

Opens a .txt file (for viewing and printing only; cannot be modified) that shows all parameters in .con file. For command line generation of report, see *Appendix III: Generating .con File Reports – ConReport.exe*.

Return to SBE Data Processing window.

- If *Confirm Configuration Change* was selected in Configure menu - If you made changes and did not Save or Save As, program asks if you want to save changes.
- If *Confirm Configuration Change* was not selected in Configure menu - Button says **Save & Exit**. If you do not want to save changes, use Cancel button to exit.

SBE 45 MicroTSG Configuration

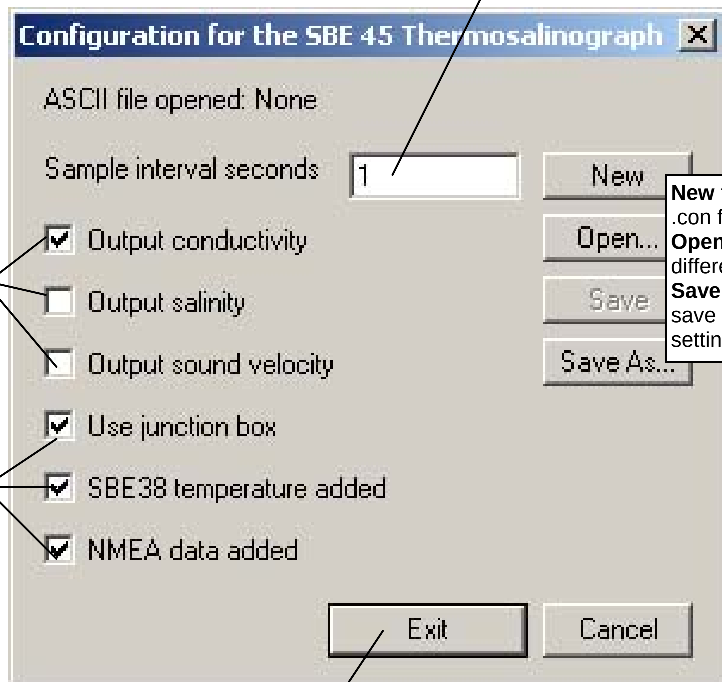
The SBE 45 transmits ASCII converted data in engineering units. It converts the raw data internally to engineering units, based on the programmed calibration coefficients. See the SBE 45 manual.

Time between scans. Must agree with number programmed into SBE 45 with **INTERVAL=** command; see reply from status command (**DS**).

Define data in SBE 45 data stream:

- Output conductivity with each scan. - Must agree with **OUTPUTCOND=** command programmed into SBE 45.
- Output salinity with each scan – Must agree with **OUTPUTSAL=** command programmed into SBE 45.
- Output sound velocity with each scan – Must agree with **OUTPUTSV=** command programmed into SBE 45.

See reply from status command (**DS**) for setup programmed into SBE 45.



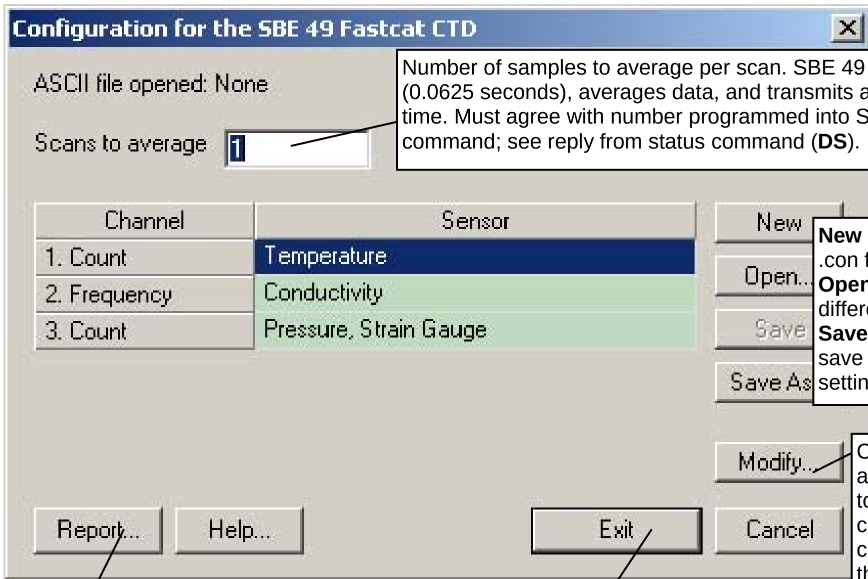
New to create new .con file.
Open to select different .con file.
Save or **Save As** to save current .con file settings.

- Use junction box - Select if SBE 45 data is transmitted to computer through optional 90402 – SBE 45 Interface Box. Interface Box can append optional SBE 38 and NMEA data to SBE 45 data stream.
- SBE 38 temperature added – Select if 90402 – SBE 45 Interface Box is connected to SBE 38 remote temperature sensor. Interface Box appends SBE 38 data to data stream.
  SEASAVE, Data Conversion, and Derive use remote temperature data when calculating density and sound velocity.
- NMEA data added - Select if 90402 – SBE 45 Interface Box is connected to a NMEA navigation device. Interface Box appends NMEA data to data stream. SEASAVE adds current latitude, longitude, and universal time code to data header.

Return to SBE Data Processing window.

- If *Confirm Configuration Change* was selected in Configure menu - If you made changes and did not Save or Save As, program asks if you want to save changes.
- If *Confirm Configuration Change* was not selected in Configure menu - Button says **Save & Exit**. If you do not want to save changes, use Cancel button to exit.

SBE 49 FastCAT Configuration



Number of samples to average per scan. SBE 49 samples at 16 Hz (0.0625 seconds), averages data, and transmits averaged data real-time. Must agree with number programmed into SBE 49 with **NAVG=** command; see reply from status command (**DS**).

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

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

Opens a .txt file (for viewing and printing only; cannot be modified) that shows all parameters in .con file. For command line generation of report, see *Appendix III: Generating .con File Reports – ConReport.exe*.

Return to SBE Data Processing window.

- If *Confirm Configuration Change* was selected in Configure menu - If you made changes and did not Save or Save As, program asks if you want to save changes.
- If *Confirm Configuration Change* was not selected in Configure menu - Button says **Save & Exit**. If you do not want to save changes, use Cancel button to exit.

Calibration Coefficients for Frequency Sensors

View and/or modify the sensor calibration coefficients by selecting the sensor and clicking the Modify button in the instrument Configuration dialog box. For all calibration dialog boxes, enter the sensor serial number and calibration date. Many sensor calibration equations contain an *offset* term. Unless noted otherwise, use the offset (default = 0.0) to make small corrections for sensor drift between calibrations.

Calibration coefficients are discussed below for each type of sensor. Temperature, conductivity, and Digiquartz pressure sensors are covered first, followed by the remaining frequency sensor types in alphabetical order.

Temperature Calibration Coefficients

Notes:

- Coefficients g, h, i, j, and f0 provide ITS-90 (T_{90}) temperature; a, b, c, d, and f0 provide IPTS-68 (T_{68}) temperature. The relationship between them is: $T_{68} = 1.00024\ T_{90}$
- See Application Note 31 for computation of slope and offset correction coefficients from pre- and post-cruise calibrations supplied by Sea-Bird.
- See *Calibration Coefficients for A/D Count Sensors* below for information on strain gauge pressure sensors used on the SBE 16*plus* (and –IM), 19*plus*, and 49.

Enter g, h, i, j (or a, b, c, d), and f0 from the calibration sheet.
Enter values for slope (default = 1.0) and offset (default = 0.0) to make small corrections for temperature sensor drift between calibrations:

Corrected temperature = (slope * computed temperature) + offset
where
slope = true temperature span / instrument temperature span
offset = (true temperature – instrument reading) * slope; measured at 0 °C

Temperature Slope and Offset Correction Example
At true temperature = 0.0 °C, instrument reading = 0.0015 °C
At true temperature = 25.0 °C, instrument reading = 25.0005 °C
Calculating the slope and offset:
Slope = (25.0 – 0.0) / (25.0005 – 0.0015) = + 1.000040002
Offset = (0.0 – 0.0015) * 1.000040002 = - 0.001500060

Sea-Bird temperature sensors usually drift by changing offset, typically resulting in higher temperature readings over time for sensors with serial number less than 1050 and lower temperature readings over time for sensors with serial number greater than 1050. Sea-Bird's data indicates that the drift is smooth and uniform with time, allowing users to make very accurate corrections based only on pre- and post-cruise laboratory calibrations. Calibration checks at sea are advisable to ensure against sensor malfunction; however, data from reversing thermometers is rarely accurate enough to make calibration corrections that are better than those possible from shore-based laboratory calibrations.

Sea-Bird temperature sensors rarely exhibit span errors larger than ± 0.005 °C over the range –5 to +35 °C (0.005 °C/(35 -[-5])C/year = 0.000125 °C/C/year), even after years of drift. A span error that increases more than ± 0.0002 °C/C/year may be a symptom of sensor malfunction.

Conductivity Calibration Coefficients

Note:
Use coefficients g, h, i, j, Ctcor, and Cpcor (if available on calibration sheet) for most accurate results; conductivity for older sensors was calculated based on a, b, c, d, m, and Cpcor.

Enter g, h, i, j, Ctcor (or a, b, c, d, m) and Cpcor from the calibration sheet.

- Cpcor makes a correction for the highly consistent change in dimensions of the conductivity cell under pressure. The default is the compressibility coefficient for borosilicate glass (-9.57e-08). Some sensors fabricated between 1992 and 1995 (serial numbers between 1100 and 1500) exhibit a compression that is slightly less than pure borosilicate glass. For these sensors, the (hermetic) epoxy jacket on the glass cell is unintentionally strong, creating a composite pressure effect of borosilicate and epoxy. For sensors tested to date, this composite pressure coefficient ranges from -9.57e-08 to -6.90e-08, with the latter value producing a correction to deep ocean salinity of 0.0057 PSU in 5000 dbars pressure (approximately 0.001 PSU per 1000 dbars).
  Before modifying Cpcor, confirm that the sensor behaves differently from pure borosilicate glass. Sea-Bird can test your cell and calculate Cpcor. Alternatively, test the cell by comparing computed salinity to the salinity of water samples from a range of depths, calculated using an AutoSal.

Enter values for slope (default = 1.0) and offset (default = 0.0) to make small corrections for conductivity sensor drift between calibrations:

Corrected conductivity = (slope * computed conductivity) + offset
where
slope = true conductivity span / instrument conductivity span
offset = (true conductivity – instrument reading) * slope; measured at 0 S/m

Conductivity Slope and Offset Correction Example
At true conductivity = 0.0 S/m, instrument reading = -0.00007 S/m
At true conductivity = 3.5 S/m, instrument reading = 3.49965 S/m
Calculating the slope and offset:
Slope = (3.5 – 0.0) / (3.49965 - [- 0.00007]) = + 1.000080006
Offset = (0.0 - [-0.00007]) * 1.000080006 = + 0.000070006

Note:
See Application Note 31 for computation of slope and offset correction coefficients from pre- and post-cruise calibrations supplied by Sea-Bird or from salinity bottle samples taken at sea during profiling.

The sensor usually drifts by changing span (slope of the calibration curve), typically resulting in lower conductivity readings over time. Offset error (error at 0 S/m) is usually due to electronics drift, and is typically less than ± 0.0001 S/m per year. Because offsets greater than ± 0.0002 S/m are a symptom of sensor malfunction, Sea-Bird recommends that drift corrections be made by assuming no offset error, unless there is strong evidence to the contrary or a special need.

Wide Range Conductivity Sensors

A wide range conductivity sensor has been modified to provide conductivity readings to 15 Siemens/meter by inserting a precision resistor in series with the conductivity cell. Therefore, the equation used to fit the calibration data is different from the standard equation. The sensor's High Range Conductivity Calibration sheet includes the equation as well as the cell constant and series resistance to be entered in the program.

If the conductivity sensor serial number includes a **w** (an indication that it is a wide range sensor):

1. After you enter the calibration coefficients and click OK, the Wide Range Conductivity dialog box appears.
2. Enter the cell constant and series resistance (from the High Range Conductivity Calibration sheet) in the dialog box, and click OK.

Note:
See *Calibration Coefficients for A/D Count Sensors* below for information on strain gauge pressure sensors used on the SBE 16*plus*, 19*plus*, and 49.
See *Calibration Coefficients for Voltage Sensors* below for information on strain gauge pressure sensors used on other instruments.

Pressure (Paroscientific Digiquartz) Calibration Coefficients

Enter the sets of C, D, and T coefficients from the calibration sheet. Enter zero for any higher-order coefficients that are not listed on the calibration sheet. Enter values for slope (default = 1.0; do not change unless sensor has been recalibrated) and offset (default = 0.0) to make small corrections for sensor drift.

- For the SBE 9*plus*, also enter AD590M and AD590B coefficients from the configuration sheet.

Bottles Closed (HB - IOW) Calibration Coefficients

No calibration coefficients are entered for this parameter.
The number of bottles closed is calculated by Data Conversion based on frequency range.

Sound Velocity (IOW) Calibration Coefficients

Enter coefficients a0, a1, and a2.
Value = a0 + a1 * frequency + a2 * frequency ^{2}

Calibration Coefficients for A/D Count Sensors

View and/or modify the sensor calibration coefficients by selecting the sensor and clicking the Modify button in the instrument Configuration dialog box. For all calibration dialog boxes, enter the sensor serial number and calibration date. Many sensor calibration equations contain an *offset* term. Unless noted otherwise, use the offset (default = 0.0) to make small corrections for sensor drift between calibrations.

Calibration coefficients are discussed below for each type of sensor: temperature and strain gauge pressure sensor.

Temperature Calibration Coefficients

Notes:
- These coefficients provide ITS-90 (T_{90}) temperature.
- See Application Note 31 for computation of slope and offset correction coefficients from pre- and post-cruise calibrations supplied by Sea-Bird.

For SBE 16*plus* (and -IM), 19*plus*, and 49:
Enter a0, a1, a2, and a3 from the calibration sheet.
Enter values for slope (default = 1.0) and offset (default = 0.0) to make small corrections for temperature sensor drift between calibrations:

Corrected temperature = (slope * computed temperature) + offset
where
slope = true temperature span / instrument temperature span
offset = (true temperature – instrument reading) * slope; measured at 0 °C

Temperature Slope and Offset Correction Example
At true temperature = 0.0 °C, instrument reading = 0.0015 °C
At true temperature = 25.0 °C, instrument reading = 25.0005 °C
Calculating the slope and offset:
Slope = (25.0 – 0.0) / (25.0005 – 0.0015) = + 1.000040002
Offset = (0.0 – 0.0015) * 1.000040002 = - 0.001500060

Sea-Bird temperature sensors usually drift by changing offset, typically resulting in lower temperature readings over time. Sea-Bird's data indicates that the drift is smooth and uniform with time, allowing users to make very accurate corrections based only on pre- and post-cruise laboratory calibrations. Calibration checks at sea are advisable to ensure against sensor malfunction; however, data from reversing thermometers is rarely accurate enough to make calibration corrections that are better than those possible from shore-based laboratory calibrations.

Sea-Bird temperature sensors rarely exhibit span errors larger than ± 0.005 °C over the range –5 to +35 °C (0.005 °C/(35 -[-5])C/year = 0.000125 °C/C/year), even after years of drift. A span error that increases more than ± 0.0002 °C/C/year may be a symptom of sensor malfunction.

Pressure (Strain Gauge) Calibration Coefficients

Note:
See *Calibration Coefficients for Voltage Sensors* below for information on strain gauge pressure sensors used on other instruments. See *Calibration Coefficients for Frequency Sensors* above for information on Paroscientific Digiquartz pressure sensors.

For SBE 16*plus* (and -IM) and 19*plus* configured with a strain gauge pressure sensor, and for all SBE 49s: Enter pA0, pA1, pA2, ptempA0, ptempA1, ptempA2, pTCA0, pTCA1, pTCA2, pTCB0, pTCB1, and pTCB2 from the calibration sheet. Offset is normally zero, but may be changed for non-zero sea-surface condition. For example, if the in-air pressure reading is negative, enter an equal positive value.

Calibration Coefficients for Voltage Sensors

View and/or modify the sensor calibration coefficients by selecting the sensor and clicking the Modify button in the instrument Configuration dialog box. For all calibration dialog boxes, enter the sensor serial number and calibration date. Many sensor calibration equations contain an *offset* term. Unless noted otherwise, use the offset (default = 0.0) to make small corrections for sensor drift between calibrations.

Calibration coefficients are discussed below for each type of sensor. Strain gauge pressure sensors are covered first, followed by the remaining voltage sensor types in alphabetical order.

Note:
See *Calibration Coefficients for A/D Count Sensors* above for information on strain gauge pressure sensors used on the SBE 16*plus* (and -IM), 19*plus*, and 49. See *Calibration Coefficients for Frequency Sensors* above for information on Paroscientific Digiquartz pressure sensors.

Pressure (Strain Gauge) Calibration Coefficients

Enter coefficients:

- Pressure sensor without temperature compensation
  - Enter A0, A1, and A2 coefficients from the calibration sheet
  - For older units with a linear fit pressure calibration, enter M (A1) and B (A0) from the calibration sheet, and set A2 to zero.
  - For all units, offset is normally zero, but may be changed for non-zero sea-surface condition. For example, if the in-air pressure reading is negative, enter an equal positive value.
- Pressure sensor with temperature compensation
  Enter ptempA0, ptempA1, ptempA2, pTCA0, pTCA1, pTCA2, pTCB0, pTCB1, pTCB2, pA0, pA1, and pA2 from the calibration sheet.

Note:
In SEASAVE, enter the altimeter alarm set point, alarm hysteresis, and minimum pressure to enable alarm.

Altimeter Calibration Coefficients

Enter the scale factor and offset.
altimeter height = [300 * voltage / scale factor] + offset
where
scale factor = full scale voltage * 300/full scale range
full scale range is dependent on the sensor (e.g., 50m, 100m, etc.)
full scale voltage is from calibration sheet (typically 5V)

Fluorometer Calibration Coefficients

- **Biospherical Natural Fluorometer**
  Enter Cfn (natural fluorescence calibration coefficient), A1, A2, and B from calibration sheet.
  natural fluorescence Fn = Cfn * 10^V
  production = A1 * Fn / (A2 + PAR)
  chlorophyll concentration Chl = Fn / (B * PAR)
  where
  V is voltage from natural fluorescence sensor

> **Note:**
> See Application Note 39 for complete description of calculation of calibration coefficients for Chelsea Aqua 3.

- **Chelsea Aqua 3**
  Enter VB, V1, Vacetone, slope, offset, and SF.
  Concentration (µg/l) = slope*[($10.0^{(V/SF)}$ - 10.0^{VB})/(10.0^{V1} - $10.0^{Vacetone}$)]
  + offset
  where
  VB, V1, and Vacetone are from calibration sheet
  Slope (default 1.0) and offset (default 0.0) adjust readings to conform to measured concentrations
  Scale factor SF = 1.0 if CTD gain is 1; SF = 2 if CTD gain is 2.0
  V is output voltage measured by CTD
  Note: SBE Data Processing can process data for an instrument interfacing with up to two Chelsea Aqua 3 fluorometers

> *Chelsea Aqua 3 Example* - *Calculation of Slope and Offset*
> Current slope = 1.0 and offset = 0.0
> Two in-situ samples:
> *Sample 1* –
> Concentration (from SBE Data Processing) = 0.390
> Concentration (from water sample) = 0.450
> *Sample 2* –
> Concentration (from SBE Data Processing) = 0.028
> Concentration (from water sample) = 0.020
> Linear regression to this data yields slope = 1.188 and offset = - 0.013

- **Chelsea UV Aquatracka**
  Enter A and B.
  Concentration (µg/l) = A * 10.0^{V} - B
  where
  A and B are from calibration sheet
  V is output voltage measured by CTD

> **Note:**
> See Application Note 61 for complete description of calculation of calibration coefficients for Chelsea Minitracka.

- **Chelsea Minitracka**
  Enter Vacetone, Vacetone100, and offset.
  Concentration = (100 *[V - Vacetone]/[Vacetone100 - Vacetone]) + offset
  where
  Vacetone (voltage with 0 µg/l chlorophyll) and Vacetone100 (voltage with 100 µg/l chlorophyll) are from calibration sheet

- **Dr Haardt Fluorometer - Chlorophyll a, Phycoerythrin, or Yellow Substance**
  Enter A0, A1, B0, and B1.
  These instruments may have automatic switching between high and low gains. Select the gain range switch:
  - *Output Voltage Level* if the instrument indicates gain by output voltage level (< 2.5 volts is low gain, > 2.5 volts is high gain)
    Low gain: value = A0 + (A1 * V)
    High gain: value = B0 + (B1 * V)
  - *Modulo Bit* if the instrument has control lines custom-wired to bits in the SBE 9*plus* modulo word
    Bit set: value = A0 + (A1 * V)
    Bit not set: value = B0 + (B1 * V)
  - *None* if the instrument does not change gain
    value = A0 + (A1 * V)

  where
  V = voltage from sensor

> *Dr Haardt Voltage Level Switching Examples*
> *Example: Chlorophyll a*
> Low range scale = 10 mg/l and Gain = 10/2.5 = 4 mg/l/volt
> A0 = 0.0 A1 = 4.0
> High range scale = 100 mg/l and Gain = 100/2.5 = 40 mg/l/volt
> B0 = -100 B1 = 40.0

Note:
See Application Note 54 for complete description of calculation of calibration coefficients for Seapoint fluorometer.

- **Seapoint**
  Enter gain and offset.
  Concentration = (V * 30/gain) + offset
  where
  Gain is dependent on cable used (see cable drawing, pins 5 and 6)
  Note: SBE Data Processing can process data for an instrument interfacing with up to two Seapoint fluorometers.

- **Seapoint Rhodamine**
  Enter gain and offset.
  Concentration = (V * 30/gain) + offset
  where
  Gain is dependent on cable used (see cable drawing, pins 5 and 6)

Notes:
- See Application Note 9 for complete description of calculation of calibration coefficients for WET Labs FLF and Sea Tech fluorometer.
- Offset and scale factor may be adjusted to fit a linear regression of fluorometer responses to known chlorophyll *a* concentrations.

- **WET Labs Flash Lamp Fluorometer (FLF) and Sea Tech**
  Enter scale factor and offset.
  Concentration = (voltage * scale factor / 5) + offset
  where
  Scale factor is dependent on fluorometer range

Fluorometer	Switch-Selectable Range (milligrams/m^3 or micrograms/liter)	Scale Factor
Sea Tech	0 – 3	3
	0 – 10 (default)	10
	0 - 30	30
	0-100	100
	0-300	300
	0-1000	1000
WET Labs FLF	0 – 100	100
	0 – 300 (default)	300
	0 - 1000	1000

  Offset is calculated by measuring voltage output when the light sensor is completely blocked from the strobe light with an opaque substance such as heavy black rubber: offset = - (scale factor * voltage) / 5

- **Turner 10-005**
  This sensor requires two channels - one for the fluorescence voltage and the other for the range voltage. Make sure to select both when configuring the instrument.
  For the fluorescence voltage channel, enter scale factor and offset.
  concentration = [fluorescence voltage * scale factor / (range * 5)] + offset
  where
  range is defined in the following table

Range Voltage	Range
< 0.2 volts	1.0
≥ 0.2 volts and < 0.55 volts	3.16
≥ 0.55 volts and < 0.85 volts	10.0
≥ 0.85 volts	31.0

- **Turner 10-AU-005**
  Enter full scale voltage, zero point concentration, and full scale concentration from the calibration sheet.
  concentration = [(1.195 * voltage * (FSC – ZPC)) / FSV] + ZPC
  where
  voltage = measured output voltage from fluorometer
  FSV = full scale voltage; typically 5.0 volts
  FSC = full scale concentration
  ZPC = zero point concentration

Note:
See Application Note 63 for complete description of calculation of calibration coefficients for Turner SCUFA.

- **Turner SCUFA**
  Enter scale factor, offset, units, mx, my, and b from the calibration sheet.
  chlorophyll = (scale factor * voltage) + offset
  corrected chlorophyll = (mx * chlorophyll) + (my * NTU) + b
  where
  NTU = results from optional turbidity channel in SCUFA (see Turner SCUFA in OBS equations below)
  Note: SBE Data Processing can process data for an instrument interfacing with up to two Turner SCUFA sensors.

- **WET Labs AC3**
  This sensor requires two channels - one for fluorometer voltage (listed under fluorometers in the dialog box) and the other for transmissometer voltage (listed under transmissometers). Make sure to select both when configuring the instrument.
  Enter kv, Vh2o, and A^X.
  concentration (mg/m^3) = kv * (Vout - Vh20) / A^X
  where
  Vout = measured output voltage
  kv = absorption voltage scaling constant (inverse meters/volt)
  Vh20 = measured voltage using pure water
  A^X = chlorophyll specific absorption coefficient

Notes:
- For complete description of calibration coefficient calculation, see Application Note 41 for WetStar and Application Note 62 for ECO-AFL, ECO-FL, and ECO-FL-NTU.
- For ECO-FL-NTU, a second channel is required for turbidity. Set up the second channel as a User Polynomial, with:
  a0 = - Vblank * scale factor
  a1 = scale factor (NTU/volts)
  a2 = a3 = 0
  where scale factor and Vblank are for the turbidity measurement.

- **WET Labs WetStar, ECO-AFL, and ECO-FL**
  Enter Vblank and scale factor.
  Concentration (µg/l) = (Vsample - V blank) * scale factor
  where
  Vsample = in situ voltage output
  Vblank = clean water blank voltage output
  Scale factor = multiplier (µg/l/Volt)
  The calibration sheet lists either:
  - Vblank and scale factor, **OR**
  - Vblank and Vcopro (voltage output measured with known concentration of coproporphyrin tetramethyl ester). Determine an initial value for the scale factor by using the chlorophyll concentration corresponding to Vcopro:
    scale factor = chlorophyll concentration / (Vcopro - Vblank)

  Perform calibrations using seawater with phytoplankton populations that are similar to what is expected in situ.
  Note: SBE Data Processing can process data for an instrument interfacing with up to two WET Labs WetStar sensors.

- **WET Labs CDOM (colored dissolved organic matter)**
  Enter Vblank and scale factor.
  Concentration (µg/l) = (Vsample - V blank) * scale factor
  where
  Vsample = in situ voltage output
  Vblank = clean water blank voltage output
  Scale factor = multiplier (µg/l/Volt)
  The calibration sheet lists Vblank and Vcdom (voltage output measured with known concentration of colored dissolved organic matter). Determine an initial value for the scale factor by using the colored dissolved organic matter concentration corresponding to Vcdom:
  scale factor = cdom concentration / (Vcdom - Vblank)
  Perform calibrations using seawater with cdom types that are similar to what is expected in situ.

Methane Sensor Calibration Coefficients

The **Capsum METS** sensor requires two channels – one for the methane concentration and the other for the temperature measured by the sensor. Make sure to select both when configuring the instrument.
For the concentration channel, enter D, A0, A1, B0, B1, and B2.

Methane concentration

$$= \exp \{D \ln [(B0 + B1 \exp \frac{-Vt}{B2}) * (\frac{1}{Vm} - \frac{1}{A0 - A1 * Vt})]\} \quad [\mu mol / l]$$

Where
Vt = Capsum METS temperature voltage
Vm = Capsum METS methane concentration voltage

For the temperature channel, enter T1 and T2.
Gas temperature = (Vt * T1) + T2 [°C]

OBS/Nephelometer Calibration Coefficients

In general, turbidity sensors are calibrated to a standard (formazin). However, particle size, shape, refraction, etc. in seawater varies. These variations affect the results unless field calibrations are performed on typical water samples.

> **Note:**
> See Application Note 16 for complete description of calculation of calibration coefficients for D&A Backscatterance.

- **Backscatterance (Downing & Associates [D&A])**
  Enter gain and offset.
  output = (volts * gain) + offset
  where
  gain = range/5; see calibration sheet for range

- **Chelsea**
  Enter clear water value and scale factor.
  turbidity [F.T.U.] = (10.0^V – C) / scale factor
  where
  V = voltage from sensor
  See calibration sheet for C (clear water value) and scale factor

- **Dr. Haardt Turbidity**
  Enter A0, A1, B0, and B1. Select the gain range switch:
  - *Output Voltage Level* if the instrument indicates gain by output voltage level (< 2.5 volts is low gain, > 2.5 volts is high gain)
    Low gain: value = A0 + (A1 * V)
    High gain: value = B0 + (B1 * V)
  - *Modulo Bit* if the instrument has control lines custom-wired to bits in the SBE 9*plus* modulo word
    Bit set: value = A0 + (A1 * V)
    Bit not set: value = B0 + (B1 * V)
  - *None* if the instrument does not change gain
    value = A0 + (A1 * V)

  where
  V = voltage from sensor

- **IFREMER**
  This sensor requires two channels - one for the direct voltage and the other for the measured voltage. Make sure to select both when configuring the instrument.
  For the direct voltage channel, enter vm0, vd0, d0, and k.
  diffusion = [k * (vm – vm0) / (vd – vd0)] – d0
  where
  k = scale factor
  vm0 = measured voltage offset
  vd0 = direct voltage offset
  vm = measured voltage
  vd = direct voltage
  d0 = diffusion offset

Note:
See Application Note 48 for complete description of calculation of calibration coefficients for Seapoint Turbidity.

- **Seapoint Turbidity**
  Enter gain setting and scale factor.
  output = (volts * 500 * scale factor)/gain
  where
  Scale factor is from calibration sheet
  Gain is dependent on cable used (see cable drawing)
  Note: SBE Data Processing can process data for an instrument interfacing with up to two Seapoint Turbidity sensors.

- **Seatech LS6000**
  Enter gain setting, slope, and offset.
  Output = [volts * (range / 5) * slope] + offset
  where
  Slope is from calibration sheet.
  Range is based on sensor ordered (see calibration sheet) and cable-dependent gain (see cable drawing to determine if low or high gain):

Range for High Gain	Range for Low Gain
2.25	7.5
7.5	25
75	250
225	750
33	100

  Note: SBE Data Processing can process data for an instrument interfacing with up to two Seatech LS6000 sensors.

Note:
See Application Note 63 for complete description of calculation of calibration coefficients for Turner SCUFA.

- **Turner SCUFA**
  Enter scale factor and offset.
  NTU = (scale factor * voltage) + offset
  corrected chlorophyll = (mx * chlorophyll) + (my * NTU) + b
  where
  mx, my, and b = coefficients entered for Turner SCUFA fluorometer
  chlorophyll = results from fluorometer channel in SCUFA (see Turner SCUFA in fluorometer equations above)
  Note: SBE Data Processing can process data for an instrument interfacing with up to two Turner SCUFA sensors.

Note:
See Application Note 19 for complete description of calculation of calibration coefficients for ORP.

Oxidation Reduction Potential (ORP) Calibration Coefficients

Enter M, B, and offset (mV).
Oxidation reduction potential = [(M * voltage) + B] + offset
Enter M and B from calibration sheet.

Notes:

- Enter soc and boc values from the most recent field calibration for Beckman-type, YSI-type, or Sea-Bird (SBE 43) oxygen sensor.
- See Application Notes 13-1 and 13-3 for complete description of calculation of calibration coefficients for Beckman- or YSI-type sensors.
- See Application Notes 64 and 64-2 for complete description of calculation of calibration coefficients for the SBE 43.
- Oxygen values computed by SEASAVE and Data Conversion differ from values computed by Derive. Both algorithms use the derivative of the oxygen signal with respect to time:
  - Quick estimate - SEASAVE and Data Conversion compute the derivative looking back in time, because they share common code and SEASAVE cannot use future values while acquiring real-time data.
  - Most accurate results - Derive uses a user-input centered window (equal number of points before and after scan) to compute the derivative.

Oxygen Calibration Coefficients

Enter the coefficients, which vary depending on the type of oxygen sensor, from the calibration sheet:

- **Beckman- or YSI-type sensor** (*manufactured by Sea-Bird or other manufacturer*) - These sensors require two channels - one for oxygen current (enter m, b, soc, boc, tcor, pcor, tau, and wt) and the other for oxygen temperature (enter k and c). Make sure to select both when configuring the instrument.
  Note: SBE Data Processing can process data for an instrument interfacing with up to two Beckman- or YSI-type oxygen sensors.

- **IOW sensor** - These sensors require two channels - one for oxygen current (enter b0 and b1) and the other for oxygen temperature (enter a0, a1, a2, and a3). Make sure to select both when configuring the instrument.
  Value = b0 + [b1 * (a0 +a1 * T + a2 * T^2 + a3 * T^3) * C]
  where
  T is oxygen temperature voltage, C is oxygen current voltage

- **Sea-Bird sensor (SBE 43)** - This sensor requires only one channel.
  Enter Soc, Boc, Voffset, tcor, pcor, and tau.
  OX =
  [Soc*{(V+Voffset)+(tau*δV/δt)}+Boc*exp(-0.03T)]*exp(tcor*T+pcor*P)*Oxsat(T,S)
  where
  OX = dissolved oxygen concentration (ml/l)
  T = measured temperature from CTD (ºC)
  P = measured pressure from CTD (decibars)
  S = calculated salinity from CTD (PSU)
  V = temperature-compensated oxygen signal (volts)
  δV/δt = derivative of oxygen signal (volts/sec)
  Oxsat(T,S) = oxygen saturation (ml/l)
  Note: SBE Data Processing can process data for an instrument interfacing with up to two SBE 43 oxygen sensors.

Note:
See Application Notes 11 LICOR (LI-COR sensor), 11 QSP-L (Biospherical sensor with built-in log amplifier), and 11-QSP-PD (Biospherical sensor without built-in log amplifier) for complete description of calculation of calibration coefficients.

PAR/Irradiance Calibration Coefficients

Underwater PAR Sensor
Enter M, B, calibration constant, multiplier, and offset.
PAR = [multiplier * (10^9 * $10^{(V-B)/M}$) / calibration constant] + offset
where
Calibration constant, M, and B are dependent on sensor type:

- **Biospherical PAR sensor**
  \- *PAR sensor with built-in log amplifier* (QSP-200L, QSP-2300L, QCP-2300L, or MCP-2300)]:
  Typically, M = 1.0 and B = 0.0.
  Calibration constant
  = 10^5 / wet calibration factor from Biospherical calibration sheet.
  \- *PAR sensor without built-in log amplifier* (QSP-200PD, QSP-2200 (PD), or QCP 2200 (PD)):
  M and B are taken from Sea-Bird calibration sheet.
  Calibration constant
  = C_S calibration coefficient from Sea-Bird calibration sheet
  = 10^9 / calibration coefficient from Biospherical calibration sheet
- **LI-COR PAR sensor**
  Calibration constant is LI-COR *in water* calibration constant.
  Enter calibration constant, M, and B from calibration sheet.

Notes:
- Selection of *Par / Irradiance, Biospherical / Licor* as the voltage sensor is also applicable to the Chelsea PAR sensor.
- For complete description of calculation of calibration coefficients for surface PAR, see Application Note 11S (SBE 11*plus* Deck Unit) or 47 (SBE 33 or 36 Deck Unit).

- **Chelsea PAR sensor**
  Calibration constant
  = 10^9 / 0.01 (for units of microEinsteins/sec–m^2) **or**
  = 10^9 / 0.04234 (for units of quanta/sec–m^2)
  M = 1.0 / (log e * A1 * 1000) = 1.0 / (0.43429448 * A1 * 1000)
  B = - M * log e * A0 = - M * 0.43429448 * A0
  where A0 and A1 are constants from Chelsea calibration sheet with an equation of form: PAR = A0 + (A1 * mV)

Multiplier can be used to scale output, and is typically set to 1.0.
Note: SBE Data Processing can process data for an instrument interfacing with up to two PAR/irradiance sensors.

Biospherical Surface PAR Sensor
A surface PAR sensor is selected by clicking *Surface PAR voltage added* in the Configure dialog box. Enter conversion factor and ratio multiplier.

pH Calibration Coefficients

Notes:
- See Application Notes 18-1, 18-2, and 18-4 for complete description of calculation of calibration coefficients for pH.
- SEASOFT-DOS < version 4.008 ignored temperature compensation of a pH electrode. The relationship between the two methods is:
  pH = pH old + (7 – 2087/°K)
  For older sensors, run pHfit version 2.0 (in SEASOFT-DOS) using Vout, pH, and temperature values from the original calibration sheet to compute the new values for offset and slope.

Enter the slope and offset from the calibration sheet:
pH = 7 + (Vout – offset) / (°K * 1.98416e-4 * slope)
where
°K = temperature in degrees Kelvin

Pressure/FGP (voltage output) Calibration Coefficients

Enter scale factor and offset.
output [Kpa] = (volts * scale factor) + offset
where:
scale factor = 100 * pressure sensor range [bar] / voltage range [volts]
Note: SBE Data Processing can process data for an instrument interfacing with up to eight pressure/fgp sensors.

Suspended Sediment Calibration Coefficients

The **Sequoia LISST-25** sensor requires two channels – one for scattering output and the other for transmission output. Make sure to select both when configuring the instrument.
For the scattering channel, enter Total volume concentration constant (Cal), Sauter mean diameter calibration (α), Clean H_2O scattering output (V_{S0}), and Clean H_2O transmission output (V_{T0}) from the calibration sheet. For the transmission channel, no additional coefficients are required; they are all defined for the scattering channel.
Optical transmission = $\tau = V_T / V_{T0}$
Beam C = - ln (τ) / 0.025 [1 / meters]
Total Volume Concentration = TV = Cal * [(V_S / τ) - V_{S0}] [µliters / liter]
Sauter Mean Diameter = SMD = α * [TV / (- ln (τ)] [microns]
where
V_T = transmission channel voltage output
V_S = scattering channel voltage output
The calibration coefficients supplied by Sequoia are based on water containing spherical particles. Perform calibrations using seawater with particle shapes that are similar to what is expected in situ.

Transmissometer Calibration Coefficients

Note:
See Application Note 7 for complete description of computation of M and B.

- **Sea Tech, Chelsea (Alphatracka), and WET Labs Cstar**
  Enter M, B, and path length (in meters)
  Path length (distance between lenses) is based on sensor size
  (for example, 25 cm transmissometer = 0.25m path length, etc.).
  light transmission (%) = M * volts + B
  beam attenuation coefficient (c) = **-** (1/z) * ln (light transmission [decimal])
  where
  M = (Tw / [W0 – Y0]) (A0 – Y0) / (A1 – Y1)
  B = - M * Y1
  and
  A0 = factory voltage output in **air** (factory calibration from transmissometer manufacturer)
  A1 = current (most recent) voltage output in **air**
  Y0 = factory **dark or zero** (blocked path) voltage (factory calibration from transmissometer manufacturer)
  Y1 = current (most recent) **dark or zero** (blocked path) voltage
  W0 = factory voltage output in pure **water** (factory calibration from transmissometer manufacturer)
  Tw = % transmission in pure water
  (for transmission **relative to water**, Tw = 100%; **or**
  for transmission **relative to air**, Tw is defined by table below.

	Tw = % Transmission in Pure Water (relative to AIR)	
Wavelength	**10 cm Path Length**	**25 cm Path Length**
488 nm (blue)	99.8%	99.6%
532 nm (green)	99.5%	98.8%
660 nm (red)	96.0 - 96.4%	90.2 - 91.3%

Transmissometer Example
(from calibration sheet) A0 = 4.743 volts, Y0 = 0.002 volts,
W0 = 4.565 volts
Tw = 100% (for transmission **relative to water**)
(from current calibration) A1 = 4.719 volts and Y1 = 0.006 volts
M = 22.046
B = - 0.132

Note: SBE Data Processing can process data for an instrument interfacing with up to two transmissometers in any combination of Sea Tech, Chelsea Alphatracka, and WET Labs Cstar.

- **WET Labs AC3**
  This sensor requires two channels - one for fluorometer voltage (listed under fluorometers in the dialog box) and the other for transmissometer voltage (listed under transmissometers). Make sure to select both when configuring the instrument.
  Enter Ch2o, Vh2o, VDark, and X from calibration sheet.
  Beam attenuation = {[log (Vh2o - VDark) - log (V - VDark)] /X} + Ch2o
  Beam transmission (%) = exp (-beam attenuation * X) * 100

User Polynomial (for user-defined sensor) Calibration Coefficients

The user polynomial allows you to define an equation to relate the sensor output voltage to calculated engineering units, if your sensor is not pre-defined in Sea-Bird software.
Enter a0, a1, a2, and a3.
Val = a0 + (a1 * V) + (a2 * V^2) + (a3 * V^3)
where:
V = voltage from sensor
a0, a1, a2, and a3 = user-defined sensor polynomial coefficients
If desired, enter the sensor name. This name will appear in the data file header.
Note: SBE Data Processing can process data for an instrument interfacing with up to three sensors defined with user polynomials.

Wet Labs ECO-FL-NTU Example
For the turbidity channel, NTU = (Vsample – Vblank) * scale factor
Set this equal to user polynomial equation and calculate a0, a1, a2, and a3.
(Vsample – Vblank) * scale factor = a0 + (a1 * V) + (a2 * V^2) + (a3 * V^3)
Expanding left side of equation and using consistent notation (Vsample = V):
scale factor * V – scale factor * Vblank = a0 + (a1 * V) + (a2 * V^2) + (a3 * V^3)
Left side of equation has no V^2 or V^3 terms, so a2 and a3 are 0; rearranging:
(– scale factor * Vblank) + (scale factor * V) = a0 + (a1 * V)
a0 = – scale factor * Vblank   a1 = scale factor   a2 = a3 = 0

Zaps Calibration Coefficients

Enter M and B from calibration sheet.
z = (M * volts) + B [nmoles]

Section 5: Raw Data Conversion Modules

Module Name	Module Description
Data Conversion	Convert raw data from CTD (.hex or .dat file) to engineering units, storing the converted data in .cnv file (all data) and/or .ros file (water bottle data).
Bottle Summary	Summarize data from water sampler bottle .ros file, storing the results in .btl file.
Mark Scan	Create .bsr bottle scan range file from .mrk data file.

Data Conversion

Note:
Previous versions (5.30a and earlier) of SBE Data Processing used program setup files with a .psu extension instead of a .psa extension. Program setup files with a .psa extension can be opened, viewed, and modified in any text editor or XML editor.
SBE Data Processing can still use your existing .psu files. However, if you make any changes to the setup (for example, change output variables), SBE Data Processing will save the changes to a new .psa file.

Data Conversion:

1. Converts raw data from an input .dat file (from an SBE 911*plus*) or .hex file (from other CTDs) to engineering units, and
2. Stores the converted data in a .cnv file and (optional) .ros file.

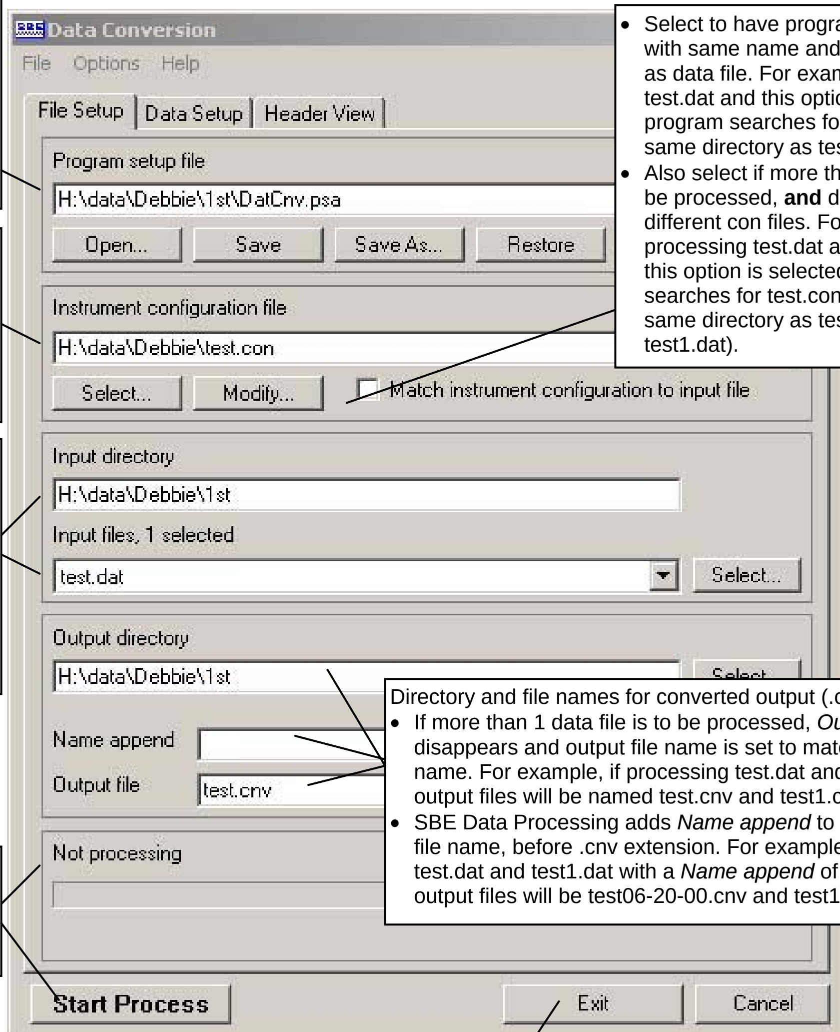
The File Setup tab in the dialog box looks like this:

Location to store all information input in File Setup and Data Setup tabs. **Open** to select different .psa file, **Save** or **Save As** to save current settings, or **Restore** to reset all settings to match last saved version. **See note above.**

Instrument configuration file location. **Select** to pick a different .con file, or **Modify** to view and/or modify instrument configuration. See *Section 4: Configuring Instrument (Configure)*.

Directory and file names for raw data (.dat or .hex). **Select** to pick a different file. To process multiple raw data files from same directory:
1. Click **Select**.
2. In Select dialog box, hold down Ctrl key while clicking on each desired file.

Click **Start Process** to begin processing data. Status field shows *Processing complete* when done.

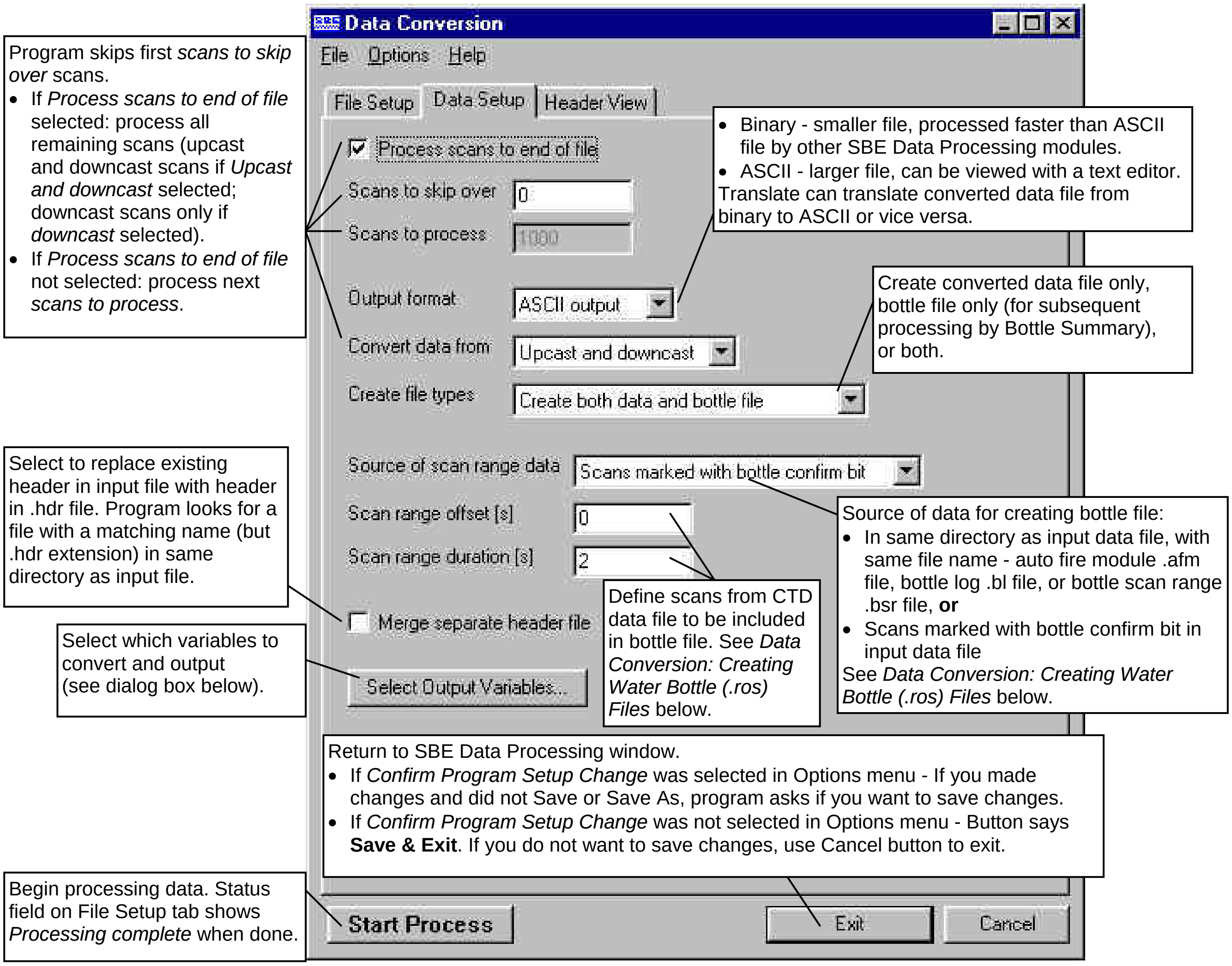


- Select to have program find .con file with same name and in same directory as data file. For example, if processing test.dat and this option is selected, program searches for test.con (in same directory as test.dat).
- Also select if more than 1 data file is to be processed, **and** data files have different con files. For example, if processing test.dat and test1.dat, and this option is selected, program searches for test.con and test1.con (in same directory as test.dat and test1.dat).

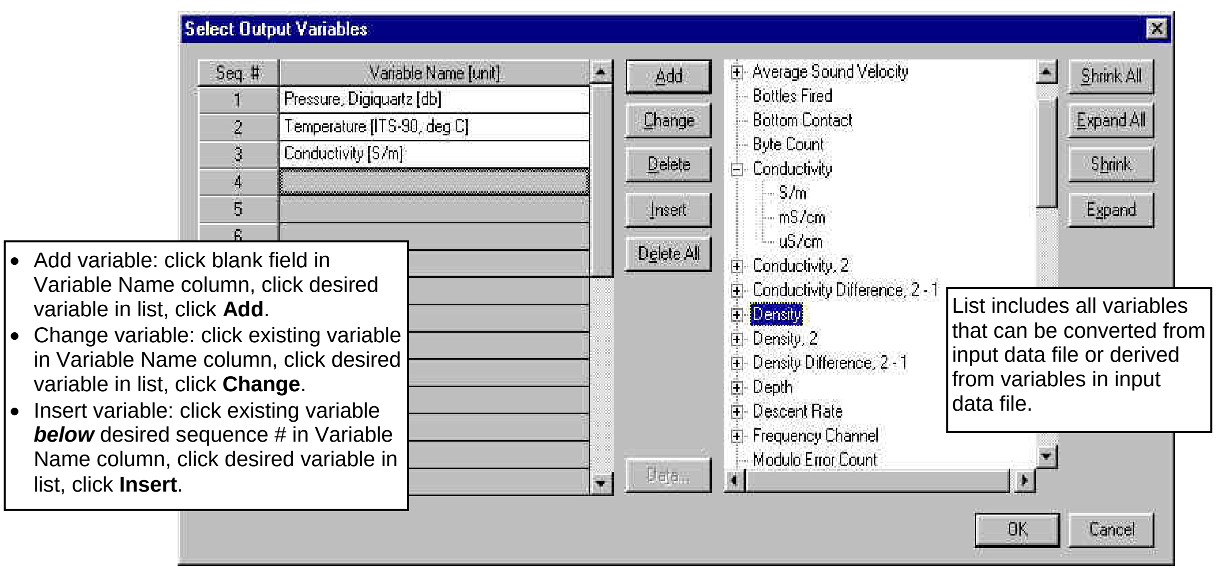
Directory and file names for converted output (.cnv) data.
- If more than 1 data file is to be processed, *Output file* field disappears and output file name is set to match input file name. For example, if processing test.dat and test1.dat, output files will be named test.cnv and test1.cnv.
- SBE Data Processing adds *Name append* to (each) output file name, before .cnv extension. For example, if processing test.dat and test1.dat with a *Name append* of 06-20-00, output files will be test06-20-00.cnv and test106-20-00.cnv.

Return to SBE Data Processing window.
- If *Confirm Program Setup Change* was selected in Options menu - If you made changes and did not Save or Save As, program asks if you want to save changes.
- If *Confirm Program Setup Change* was not selected in Options menu - Button says **Save & Exit**. If you do not want to save changes, use Cancel button to exit.

The Data Setup tab in the dialog box looks like this:



The Select Output Variables dialog box (which appears when you click **Select Output Variables** on the Data Setup tab) looks like this:



Data Conversion: Creating Water Bottle (.ros) Files

A .ros water bottle file contains:

- data for each scan associated with a bottle firing, and
- data for user-selected range of scans before and after each bottle firing

Scan range data for creation of a water bottle file can come from:

- *Scans marked with bottle confirm bit in input data file* - if used SBE 911*plus* **or** SBE 9*plus* with SBE 17*plus* to interface with water sampler. For these systems, the bottle confirm bit in the input (.dat or .hex) data file is set for all scans within a 1.5-second duration after a bottle firing confirmation is received from the water sampler.
- *Bottle log (.bl) file* - if used SEASAVE to interface with water sampler with SBE 911*plus*, 19, 19*plus*, or 25. For these systems, SEASAVE creates the .bl file. Each time a bottle fire confirmation is received, the bottle sequence number, position, date, time, and beginning and ending scan numbers (1.5-second duration for each bottle) are written to the .bl file.
- *Auto Fire module (.afm) file* - if used Carousel Auto Fire Module (AFM) with SBE 19, 19*plus*, or 25 to interface with water sampler. For these systems, the .afm file contains five scans of data recorded by the AFM for each bottle firing.
- *Bottle scan range (.bsr) file* - if used Mark Scan feature in SEASAVE during data acquisition to create a .mrk file; use Mark Scan to convert the .mrk file to a .bsr file before running Data Conversion. The format for the .bsr file is:
  beginning scan # for bottle #1, ending scan # for bottle #1
  …
  beginning scan # for last bottle, ending scan # for last bottle
  Example: test.bsr contains -
  ```
  1000, 1020
  2000, 2020
  4000, 4020
  ```
  The .ros file created using test.bsr would contain scans 1000 - 1020 for bottle #1, 2000 - 2020 for bottle #2, and 4000 - 4020 for bottle #3.

Notes:
- You may have more than one source of scan range data available. For example, if SEASAVE is used with a 911*plus* and water sampler, bottle confirm bits are set in the data file **and** a bottle log (.bl) file is created. Additionally, if you used the Mark Scan feature in SEASAVE, a .mrk file is created.
- You can create a .bsr file in a text editor if scan range data is not available in any of these forms.

The amount of data written to the .ros file is based on:

- *Scan range offset* - determines the first scan output to the .ros file for each bottle, relative to the first scan with a confirmation bit set or written to a .afm, .bsr, or .bl file.
- *Scan range duration* - determines the number of scans output to the .ros file for each bottle.

Example: A bottle confirmation for an SBE 911*plus* is received at scan 10,000 (scan 10,000 and subsequent scans for 1.5 seconds have confirmation bit set). In Data Conversion, *Scan range offset* is set to -2 seconds, and *Scan range duration* is set to 5 seconds. If the scan rate is 24 scans/second,
10,000 - 2 second offset (24 scans/second) = 9,952
9,952 + 5 second duration (24 scans/second) = 10,072
Therefore, scans 9,952 through 10,072 will be written to the .ros file.

Data Conversion: Notes and General Information

Data Conversion was written to accommodate most sensors that have been installed on Sea-Bird products. See the configuration page at the beginning of your instrument manual for the sensors that were installed on your system.

Note:
If you choose to compute derived parameters in Data Conversion, note that the algorithms are the same as used in Derive (with the exception of the oxygen, descent rate, and acceleration calculations); **see *Appendix V: Derived Parameter Formulas* for algorithms for derived variables**.

- If you plan to process the data with other modules, select only the primary variables to be converted, and then use Derive to compute derived parameters such as salinity, density, sound velocity, and oxygen.
- If desired, you can select the same variable multiple times for the output .cnv file. If you do, data processing operations on that variable in other modules will use the *last* occurrence of the variable in the file.
  Example: Select Primary Conductivity, Primary Temperature, Pressure, and Primary Conductivity (again) for output variables (columns 1, 2, 3, and 4 respectively). Then, if you run Cell Thermal Mass, it will correct the conductivity in column 4 only, leaving column 1 uncorrected; you could plot the corrected and uncorrected conductivity to see the changes. If you then run Derive to calculate salinity, it will use the corrected conductivity in column 4 in the salinity calculation.
- If you will use Derive to compute:
  - ➢ Salinity, density, or other parameters that depend on salinity - include pressure, temperature, and conductivity in the output file.
    For a moored instrument without optional pressure sensor (SBE 16, 16*plus*, or 16*plus*-IM), if you select pressure as an output variable, Data Conversion inserts a column with the moored pressure (entered in the .con file *Data* dialog) in the output .cnv file. For a thermosalinograph (SBE 21 or 45), if you select pressure as an output variable, Data Conversion inserts a column of 0's for the pressure in the output .cnv file. The pressure column is needed for Derive to calculate salinity, density, etc.
  - ➢ Oxygen - include in the output file (along with pressure, temperature, and conductivity)
    For SBE 13 or 23 - oxygen current and oxygen temperature
    For SBE 43 - oxygen value
- If you will use Bin Average:
  - ➢ With depth bins - include depth in the output file
  - ➢ With pressure bins - include pressure in the output file
- Pressure temperature is computed using a backward-looking, 30-second running average, to prevent bit transitions in pressure temperature from causing small jumps in computed pressure. Because the heavily insulated pressure sensor has a thermal time constant on the order of one hour, the 30-second average does not significantly alter the computed pressure temperature.
- Oxygen, descent rate, and acceleration computed by SEASAVE and Data Conversion are somewhat different from values computed by Derive, because the algorithms calculate the derivative of the signal (oxygen signal for oxygen, pressure signal for descent rate and acceleration) with respect to time, using a linear regression to determine the slope. SEASAVE and Data Conversion compute the derivative looking backward in time, since they share common code and SEASAVE cannot use future values while acquiring data in real time. Derive uses a centered window (equal number of points before and after the scan; time window size is user input) to obtain a better estimate of the derivative. Use SEASAVE and Data Conversion to obtain a quick look at oxygen, descent rate, and acceleration; use Derive to obtain the most accurate values.
- For an SBE 21 or 45 with a remote temperature sensor, SEASAVE, Data Conversion, and Derive all use the remote temperature data when calculating density and sound velocity.

Note:
Each SBE Data Processing module that modifies a .cnv file adds information to the header and updates nquan, nvalues, name n, span n, interval, and file_type, as applicable.

Data Conversion has the following /x parameters when run from the Command Line Options dialog box, from the command line, or with batch file processing:

/x Parameter	Description
/xdatcnv:skipN	N = number of scans to skip.
/xdatcnv:pump	For SBE 911*plus*, do not output scans if pump status = off.
/xdatcnv:nomatch	Disable matching of header information to .con file - program will continue to run even if there is a discrepancy in header information.

See *Appendix I: Command Line Options, Command Line Operation, and Batch File Processing* for details on using parameters.

Data Conversion adds the following to the data file header for a **.cnv converted data file**:

Label	Description
Nquan	Number of columns (fields) of converted data. **Note**: Data Conversion automatically adds 1 field to number selected by user (i.e., if user selects 3 variables to convert, then nquan=4). This added field, initially set to 0, is used by Loop Edit to mark bad scans.
Nvalues	Number of scans converted.
Units	Specified (indicates units are specified separately for each variable; SEASOFT-DOS required all units to be English or metric).
Name n	Sensor (and units) associated with data in column n.
Span n	Span (highest - lowest value) of data in column n.
Interval	Scan rate (seconds).
Start_time	Data start time.
Bad_flag	For information only; value that Loop Edit and Wild Edit will use to mark bad scans and bad data values.
Sensor n	Sensor description, serial number, and calibration date.
Datcnv_date	Date and time that module was run.
Datcnv_in	Input .dat (or .hex) and .con files.
Datcnv_skipover	Number of scans to skip over in processing.
File type	Selected output file type - ASCII or binary.

Data Conversion adds the following to the data file header for a **.ros water bottle file**:

Label	Description
Nquan	Number of columns (fields) of converted data. **Note**: Data Conversion automatically adds 1 field to number selected by user (i.e., if user selects 3 variables to convert, then nquan=4). This added field, initially set to 0, is used by Loop Edit to mark bad scans.
Nvalues	Number of scans converted.
Units	Specified (indicates units are specified separately for each variable; SEASOFT-DOS required all units to be English or metric).
Name n	Sensor (and units) associated with data in column n.
Interval	Scan rate (seconds).
Start_time	Data start time.
Sensor n	Sensor description, serial number, and calibration date.
Datcnv_date	Date and time that module was run.
Datcnv_in	Input .dat (or .hex) and .con files.
Datcnv_bottle_ scan_range_source	Source of data for creating bottle file, and scan range offset and duration.

Bottle Summary

Note:
Bottle Summary was previously called *Rosette Summary*.

Bottle Summary reads a .ros file created by Data Conversion and writes a bottle data summary to a .btl file. The .ros file must contain (as a minimum) temperature, pressure, and conductivity (or salinity).
The output .btl file includes:

- Bottle position, optional bottle serial number, and date/time
- User-selected derived variables - computed for each bottle from mean values of input variables (temperature, pressure, conductivity, etc.)
- User-selected averaged variables - computed for each bottle from input variables

The maximum number of scans processed per bottle is 1440.

In addition to the .ros input file:

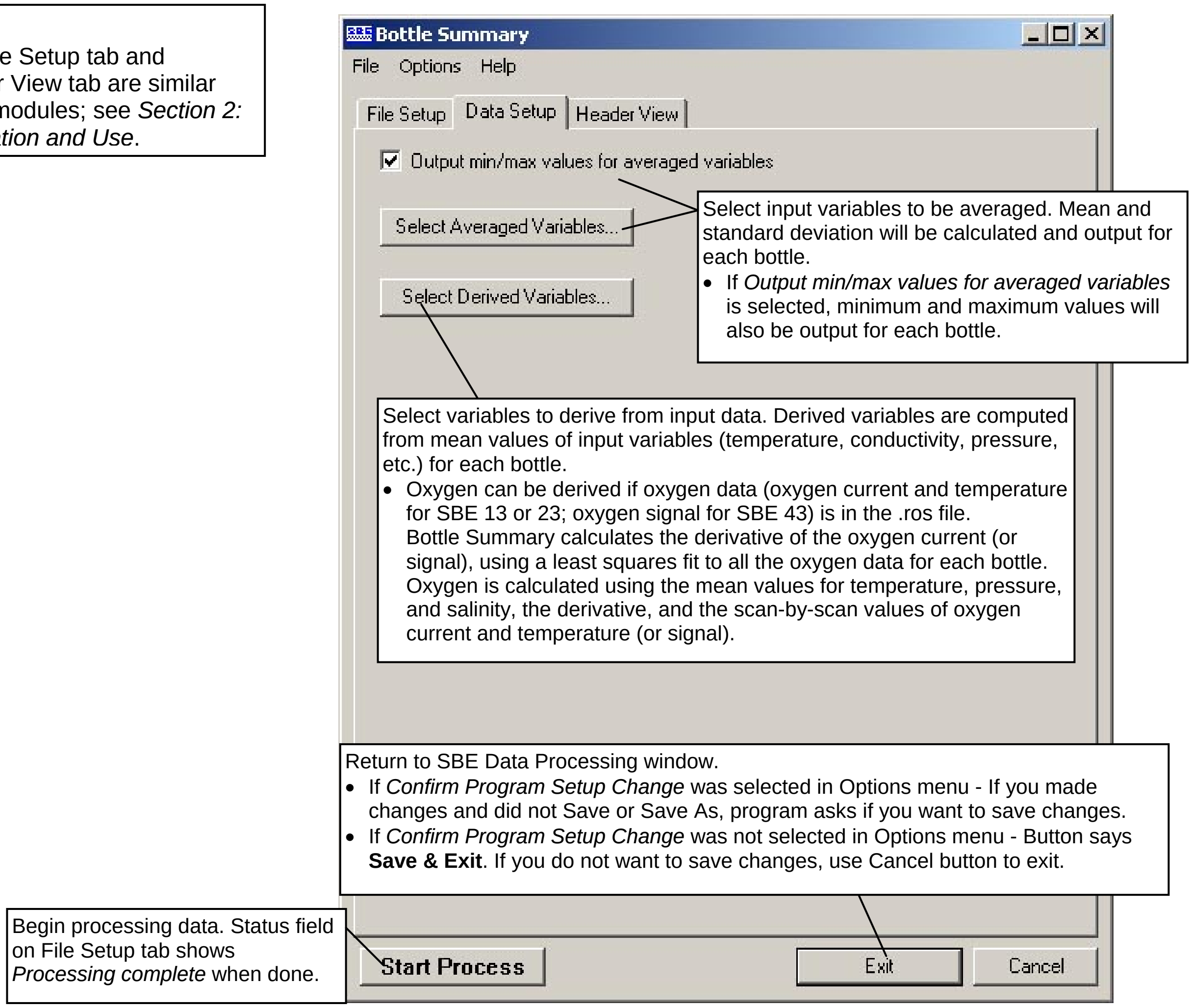
- If a .bl file created by SEASAVE (same name as input data file, with .bl extension) is found in the input file directory, Bottle Summary uses bottle position data from the .bl file. The bottle position data defines the bottle firing sequence - the .bl file contains the bottle firing sequence number, bottle position, date and time, and beginning and ending scan number for each bottle.

Note:
You can create a .sn file in a text editor.

- If a .sn file (same name as input data file, with .sn extension) is found in the input file directory, bottle serial numbers are inserted between the bottle position and date/time columns in the .btl file output. The format for the .sn file is:
  Bottle position, serial number (with a comma separating the two fields)

Note:
The File Setup tab and Header View tab are similar for all modules; see *Section 2: Installation and Use*.

The Data Setup tab in the dialog box looks like this:



Bottle Summary adds the following to the data file header:

Label*	Description
Bottlesum_date	Date and time that module was run.
Bottlesum_in	Input .ros and .con files.

*Labels were previously rossum_date and rossum_in.

Mark Scan

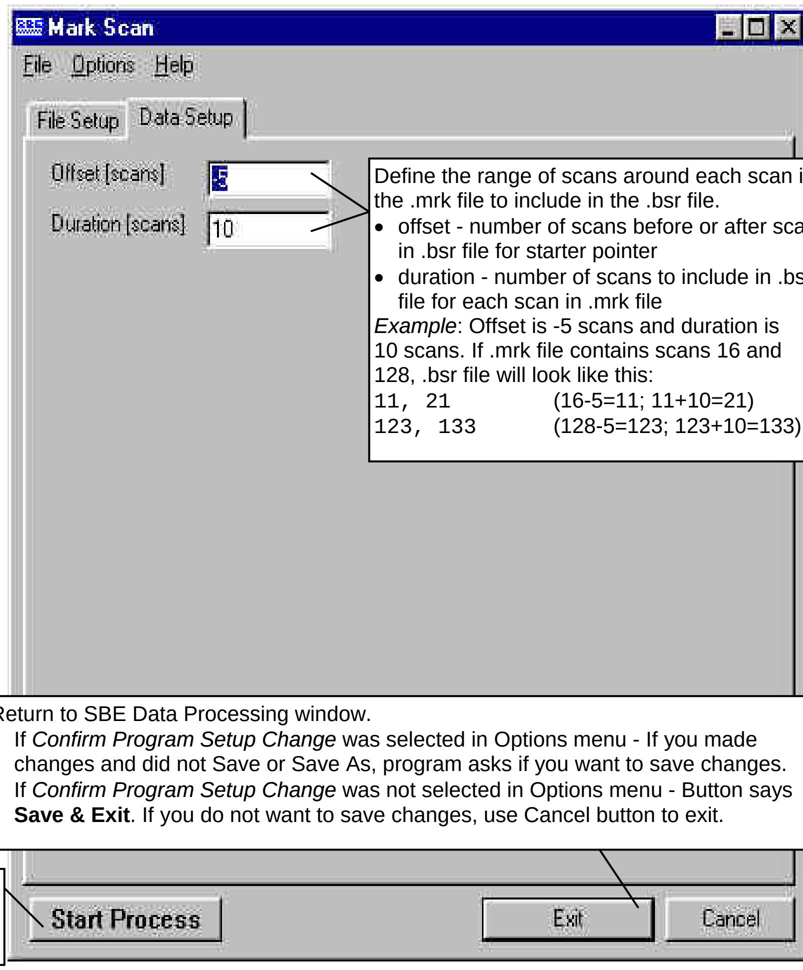
> **Note:**
> Alternatively, an ASCII text editor can be used to create the .bsr file. The format for the output .bsr file is:
>
> Beginning scan for bottle 1, ending scan for bottle 1
> Beginning scan for bottle 2, ending scan for bottle 2
> .
> Beginning scan for last bottle, ending scan for last bottle
>
> Note that a comma must separate the beginning and ending scan numbers.

> **Note:**
> The File Setup tab is similar for all modules; see *Section 2: Installation and Use*.

Mark Scan creates a bottle scan range (.bsr) file from a .mrk data file created in SEASAVE. The data in the .bsr file can be used by Data Conversion to create a .ros file, and the .ros file can be used by Bottle Summary to create a bottle data summary .btl file.

The input .mrk file contains one scan with the mark number, system time, and scan number for each time Mark Scan was clicked while in SEASAVE's Mark Scan Control dialog box (accessed by selecting Mark Scan Control in SEASAVE's View menu). Mark Scan's output .bsr file *points to* a user-defined range of adjacent scans for each marked scan. Note that the output .bsr file only contains the pointers to the scans, and does not contain the data.

The Data Setup tab in the dialog box looks like this:



Mark Scan's output .bsr file does not have a header.

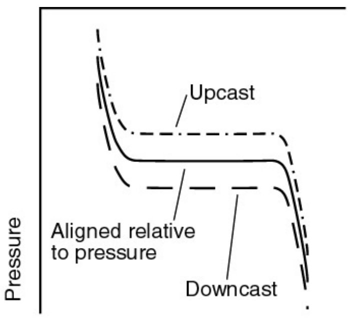
Section 6: Data Processing Modules

All data processing is performed on converted data from a .cnv file.

Module Name	Module Description
Align CTD	Align data relative to pressure (typically used for conductivity, temperature, and oxygen).
Bin Average	Average data, basing bins on pressure, depth, scan number, or time range.
Buoyancy	Compute Brunt Väisälä buoyancy and stability frequency.
Cell Thermal Mass	Perform conductivity thermal mass correction.
Derive	Calculate salinity, density, sound velocity, oxygen, potential temperature, dynamic height, etc.
Filter	Low-pass filter columns of data.
Loop Edit	Mark a scan with *badflag* if scan fails pressure reversal or minimum velocity tests.
Wild Edit	Mark a data value with *badflag* to eliminate wild points.
Window Filter	Filter data with triangle, cosine, boxcar, Gaussian, or median window.

Align CTD

Note:
Align CTD cannot be run on files that have been averaged into pressure or depth bins in Bin Average. If alignment is necessary, run Align CTD before running Bin Average.



Upcast and Downcast mismatch with Respect to Pressure

Note:
The File Setup tab and Header View tab are similar for all modules; see *Section 2: Installation and Use*.

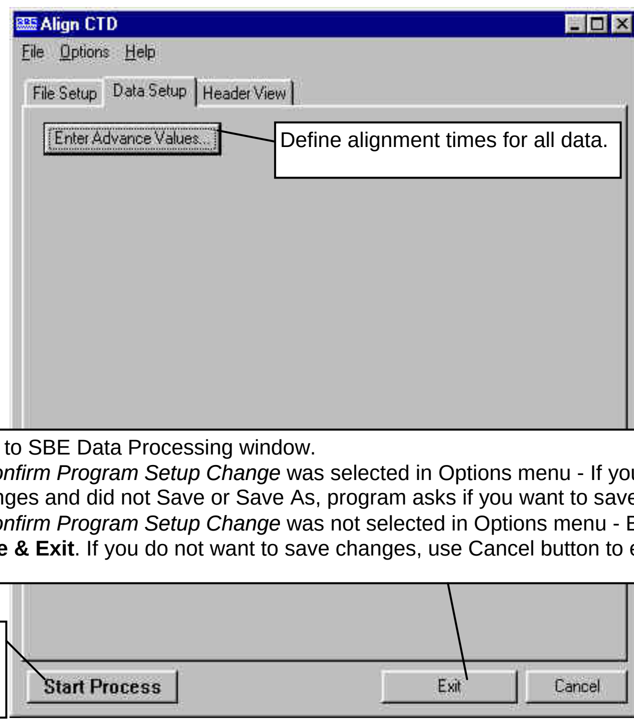
Align CTD aligns parameter data in time, relative to pressure. This ensures that calculations of salinity, dissolved oxygen concentration, and other parameters are made using measurements from the same parcel of water. Typically, Align CTD is used to align temperature, conductivity, and oxygen measurements relative to pressure.

There are three principal causes of misalignment of CTD measurements:

- physical misalignment of the sensors in depth
- inherent time delay (time constants) of the sensor responses
- water transit time delay in the pumped plumbing line - the time it takes the parcel of water to go through the plumbing to each sensor (or, for free-flushing sensors, the corresponding flushing delay, which depends on profiling speed)

When measurements are properly aligned, salinity spiking (and density) errors are minimized, and oxygen data corresponds to the proper pressure (e.g., temperature vs. oxygen plots agree between down and up profiles).

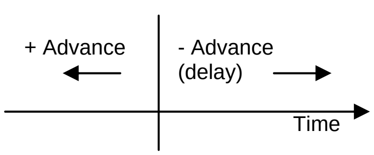
The Data Setup tab in the dialog box looks like this:



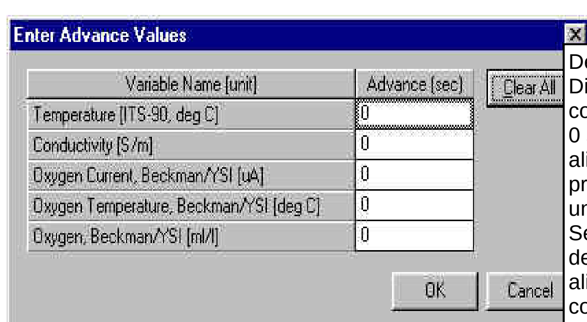
Define alignment times for all data.

Return to SBE Data Processing window.
- If *Confirm Program Setup Change* was selected in Options menu - If you made changes and did not Save or Save As, program asks if you want to save changes.
- If *Confirm Program Setup Change* was not selected in Options menu - Button says **Save & Exit**. If you do not want to save changes, use Cancel button to exit.

Begin processing data. Status field on File Setup tab shows *Processing complete* when done.



The Enter Advance Values dialog box looks like this:



Define alignment times. Diagram shows sign convention for Advance. If 0 seconds is entered, alignment relative to pressure (and time) remains unchanged for that variable. See discussion below to determine appropriate alignment times for conductivity, temperature, and oxygen.

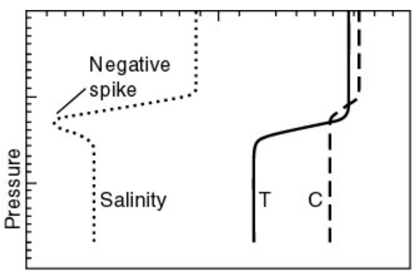
Align CTD: Conductivity and Temperature

Temperature and conductivity are often misaligned with respect to pressure. Shifting temperature and conductivity relative to pressure can compensate. As shown in the figures, indications of misalignment include:

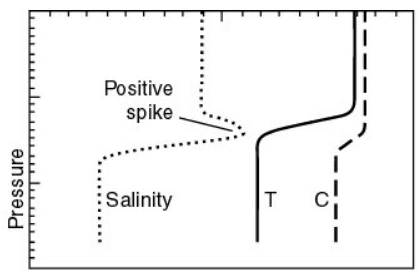
- Depth mismatch between downcast and upcast data
- Spikes in the calculated salinity (which is dependent on temperature, conductivity, and pressure) - caused by misalignment of temperature and conductivity *with each other*

The best diagnostic of proper alignment is the elimination of salinity spikes that coincide with very sharp temperature steps. To determine the best alignment, plot 10 meters of temperature and salinity data at a depth that contains a very sharp temperature step. For the downcast, when temperature and salinity increase with increasing pressure:

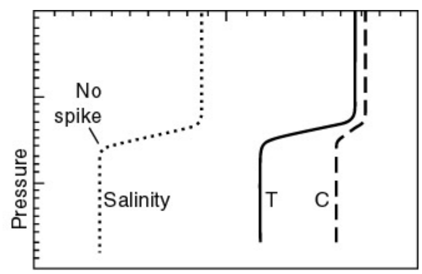
- A negative salinity spike at the conductivity step means that conductivity leads temperature (conductivity sensor *sees* step before temperature sensor does). Advance conductivity *relative to temperature* a **negative** number of seconds.
- Conversely, if the salinity spike is positive, advance conductivity *relative to temperature* a **positive** number of seconds.



Downcast, Conductivity leads Temperature



Downcast, Conductivity lags Temperature



Downcast, C and T Aligned

The best alignment of conductivity with respect to temperature is obtained when the salinity spikes are minimized. Some experimentation with different advances is required to find the best alignment.

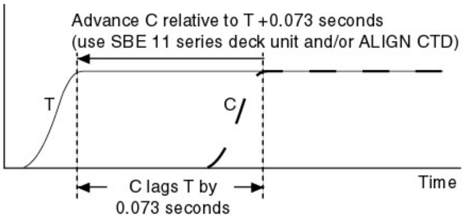
Typical Temperature Alignment

The SBE 19 and 19*plus* use a temperature sensor with a relatively slow time response, while the SBE 9*plus*, 25, and 49 use a temperature sensor with a faster time response. Typical advances are:

Instrument	Advance of Temperature Relative to Pressure (seconds)
9*plus*	0
19 and 19*plus*	+ 0.5
25	0
49 *	+ 0.0625

*The SBE 49 can be programmed to advance temperature relative to pressure in real-time, eliminating the need to run Align CTD. See the SBE 49 manual for details.

> **Note:**
> All SBE 11 series deck units can advance **primary** conductivity, which *may* eliminate the need to use Align CTD for conductivity. The SBE 11*plus* does not advance secondary conductivity. The SBE 11*plus* V2 can advance secondary conductivity and all voltage channels; the advance time is user-programmable.



Typical Conductivity Alignment

- SBE 9*plus* - For an SBE 9*plus* with TC-ducted temperature and conductivity sensors and a 3000-rpm pump, the typical lag of conductivity relative to temperature is 0.073 seconds. The Deck Unit can be programmed to advance conductivity relative to pressure, eliminating the need to run Align CTD.
  Following is an example of determining the value to enter in Align CTD:
  Example: The SBE 11*plus* is factory-set to advance the primary conductivity +1.75 scans (at 24 Hz, this is 1.75 / 24 = 0.073 seconds).
  Advance conductivity relative to temperature in Align CTD:
  0.073 - 1.75/24 = 0.0 seconds (enter 0 seconds for conductivity).

- SBE 19*plus* – For an SBE 19*plus* with a standard 2000-rpm pump, do not advance conductivity.

- SBE 19 (not *plus*) – For an unpumped SBE 19, the conductivity measurement may lead or lag that of temperature, because the flushing rate of the conductivity cell depends on drop speed. If the SBE 19 is lowered very slowly (< 20 cm/second, typically from a fixed platform or ice), conductivity lags temperature. If the SBE 19 is lowered fast, conductivity leads temperature. Typical advances of conductivity *relative to temperature* range from 0 seconds at a lowering rate of 0.75 meters/second to -0.6 seconds for 2 meters/second (if temperature was advanced +0.5 seconds, these correspond to conductivity advances of +0.5 seconds and -0.1 seconds respectively).

- SBE 25 - For an SBE 25 with a standard 2000-rpm pump, a typical advance of conductivity *relative to temperature* is +0.1 seconds.

- SBE 49 – For a typical SBE 49 with TC duct and 3000 rpm pump, do not advance conductivity.

If temperature is advanced relative to pressure and you do not want to change the relative timing of temperature and conductivity, you must add the same advance to conductivity.

Example (typical of an unpumped SBE 19):

Advance temperature relative to pressure +0.5 seconds to compensate for slow response time of sensor.

- If the CTD is lowered at 0.75 m/s, advance conductivity *relative to temperature* 0 seconds. Calculate advance of conductivity *relative to pressure* to enter in Align CTD: +0.5 + 0 = +0.5 seconds
- If the CTD is lowered at 2 m/s, advance conductivity *relative to temperature* -0.6 seconds. Calculate advance of conductivity *relative to pressure* to enter in Align CTD: +0.5 + (-0.6) = -0.1 seconds

Align CTD: Oxygen

Oxygen data is also systematically delayed with respect to pressure. The two primary causes are the long time constant of the oxygen sensor (for the SBE 43, ranging from 2 seconds at 25 ºC to approximately 5 seconds at 0 ºC) and an additional delay from the transit time of water in the pumped plumbing line. As with temperature and conductivity, you can compensate for this delay by shifting oxygen data relative to pressure. Typical advances for the SBE 43, 13, or 23 are:

Instrument	Advance of Oxygen Relative to Pressure (seconds)
9*plus*	+2 to +5
19*plus*	+3 to +7
19 (not *plus*)	+3 to +7 (pumped), +1 to +5 (unpumped)
25	+3 to +7

Align CTD adds the following to the data file header:

Label	Description
Alignctd_date	Date and time that module was run.
Alignctd_in	Input .cnv file.
Alignctd_adv	Variables aligned and their respective alignment times.

Bin Average

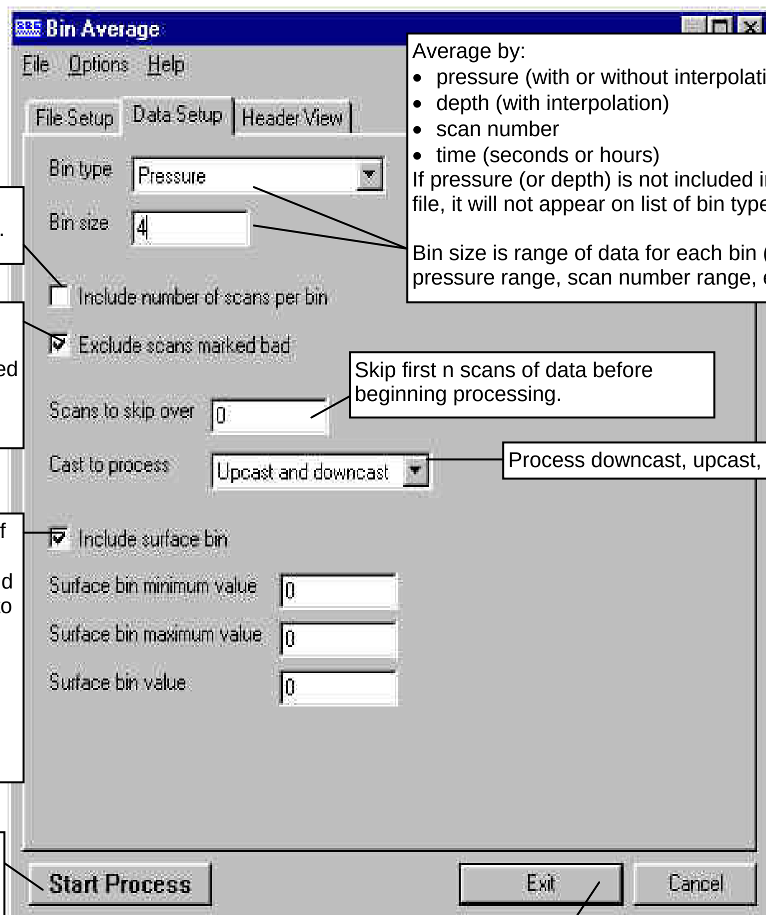
Note:
Align CTD, which aligns parameter data in time, relative to pressure, cannot be run on files that have been averaged into pressure or depth bins in Bin Average. If alignment is necessary, run Align CTD before running Bin Average.

Bin Average averages data, using averaging intervals based on:

- pressure range,
- depth range,
- scan number range, or
- time range

Note:
The File Setup tab and Header View tab are similar for all modules; see *Section 2: Installation and Use*.

The Data Setup tab in the dialog box looks like this:



Average by:
- pressure (with or without interpolation)
- depth (with interpolation)
- scan number
- time (seconds or hours)

If pressure (or depth) is not included in input file, it will not appear on list of bin types.

Bin size is range of data for each bin (i.e., pressure range, scan number range, etc.).

If selected, a column containing number of scans in each bin will be added to output data.

If selected, data from **scans** marked with *badflag* in Loop Edit will not be used in calculating average. Note that **values** marked with *badflag* by Wild Edit are never included in calculating average.

Skip first n scans of data before beginning processing.

Process downcast, upcast, or both.

If selected, include surface bin (applicable only if averaging by pressure or depth). Input:
- minimum and maximum values - minimum and maximum (pressure or depth, as applicable) to be used in calculating surface bin
- value - target value (pressure or depth) to be associated with averages

Note that surface bin minimum, maximum, and value do not affect minimum, maximum, and center of first or subsequent bins.

Begin processing data. Status field on File Setup tab shows *Processing complete* when done.

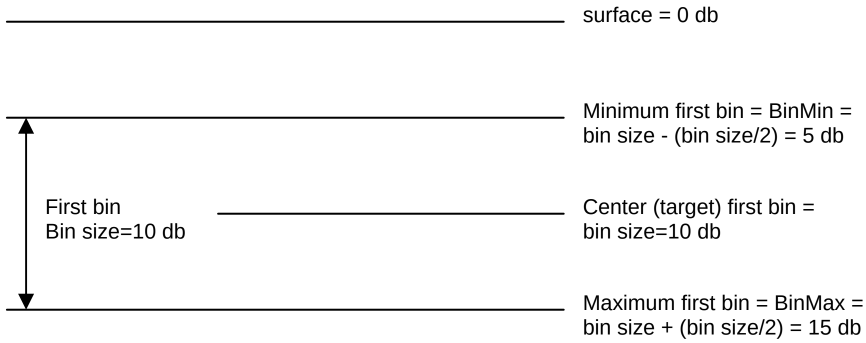
Return to SBE Data Processing window.
- If *Confirm Program Setup Change* was selected in Options menu - If you made changes and did not Save or Save As, program asks if you want to save changes.
- If *Confirm Program Setup Change* was not selected in Options menu - Button says **Save & Exit**. If you do not want to save changes, use Cancel button to exit.

Bin Average: Formulas

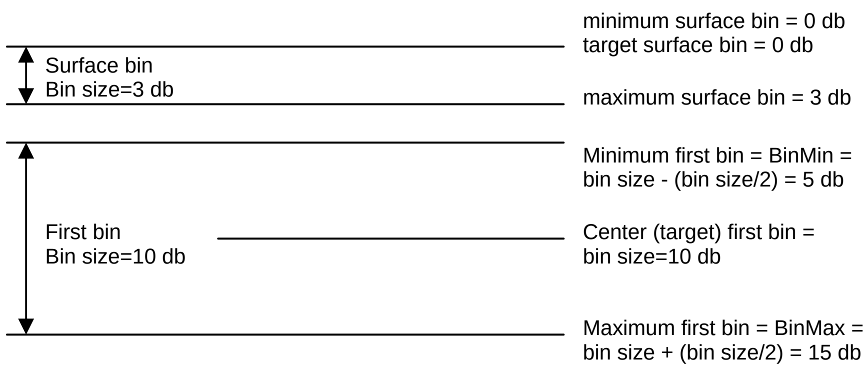
Note:
If *Exclude scans marked bad* is selected in the dialog box, data from **scans** marked with *badflag* in Loop Edit are not used in calculating average. **Values** marked with *badflag* by Wild Edit are never included in calculating the average. If the number of points included in the average is 0 (all data and/or scans in the bin are marked with *badflag*), the average value is set to *badflag.*

The center value of the first (not surface) bin is set equal to the bin size.

Example (pressure bin, surface bin not included):
Bin size is 10 db. The first bin is defined as follows:



Example (pressure bin, surface bin included):
Bin size is 10 db. Surface bin is included, and surface bin parameters are 0 db minimum, 3 db maximum, and 0 db value. The bins are defined as follows:



The algorithms used for each type of averaging follow.

Pressure Bins (no interpolation)
For each bin:
BinMin = center value - (bin size / 2)
BinMax = center value + (bin size / 2)

1. Add together valid data for scans with BinMin < pressure $\leq$ BinMax.
2. Divide the sum by the number of valid data points to obtain the average, and write the average to the output file.
3. Repeat Steps 1 through 2 for each variable.
4. For the next bin, compute the center value and repeat Steps 1 through 3.

Pressure Bins (with interpolation)

For each bin:

BinMin = center value - (bin size / 2)

BinMax = center value + (bin size / 2)

1. Add together valid data for scans with BinMin < pressure $\leq$ BinMax.
2. Divide the sum is by the number of valid data points to obtain the average.
3. Interpolate as follows, and write the interpolated value to the output file:
   P_p =average pressure of previous bin
   X_p =average value of variable in previous bin
   P_c =average pressure of current bin
   X_c =average value of variable in current bin
   P_i = center value for pressure in current bin
   X_i =interpolated value of variable (value at center pressure P_i)
   $= ((X_c - X_p) * (P_i - P_p) / (P_c - P_p)) + X_p$
4. Repeat Steps 1 through 3 for each variable.
5. Compute the center value and Repeat Steps 1 through 4 for the next bin.

Values for the first bin are interpolated *after* averages for the second bin are calculated; values from the *next* (second) bin instead of the *previous* bin are used in the equations.

Depth Bins

Depth bin processing is similar to processing pressure bins with interpolation, but bin size and center values are based on depth.

Scan Number Bins

Scan number bin processing is similar to processing pressure bins without interpolation. If *exclude scans marked bad* is selected, Bin Average averages *bin size* good scans (not marked with *badflag* in Loop Edit).

Example: Bin size is 100. First bin should include scans 50 - 149. However, scans 93, 94, and 126 are marked with *badflag* in Loop Edit, and the user selected *exclude scans marked bad*. To include 100 valid scans in the average, Bin Average includes scans 50 - 152 in the first bin.

Time Bins

Time bin processing is similar to processing pressure bins without interpolation. Bin Average determines the number of scans to include based on the input bin size and the data sampling interval:

Number of scans = bin size [seconds] / interval *or*

Number of scans = (bin size [hours] x 3600 seconds/hour) / interval

Bin Average has the following /x parameter when run from the Command Line Options dialog box, from the command line, or with batch file processing:

/x Parameter	Description
/xbinavg:cN	N = center value for first bin.

See *Appendix I: Command Line Options, Command Line Operation, and Batch File Processing* for details on using parameters.

Bin Average adds the following to the data file header:

Label	Description
Binavg_date	Date and time that module was run.
Binavg_in	Input .cnv file.
Binavg_bintype	Bin type (pressure, depth, scan time in seconds or hours).
Binavg_binsize	Bin size.
Binavg_excl_ bad_scans	If yes, values from scans marked with *badflag* in Loop Edit are not included in average.
Binavg_skipover	Number of scans skipped over.
Binavg_surface_ bin	Surface bin included? Minimum and maximum values for surface bin.

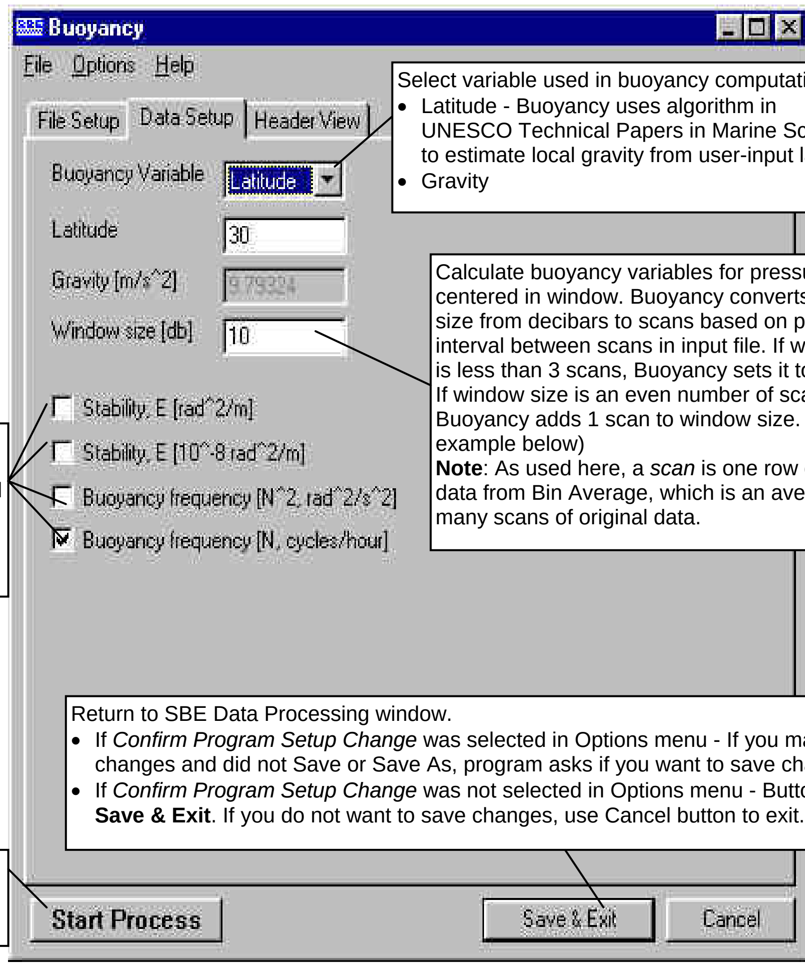
Buoyancy

> **Note:**
> The input .cnv file for Buoyancy must have been processed with Bin Average on pressure bins (with or without interpolation) and must contain pressure, temperature, and either salinity or conductivity.

Buoyancy calculates buoyancy (Brunt-Väisälä) frequency (N) and stability (E) using the Fofonoff adiabatic leveling method (Bray N. A. and N. P. Fofonoff (1981) Available potential energy for MODE eddies. *Journal of Physical Oceanography*, 11, 30-46.).

The Data Setup tab in the dialog box looks like this:

> **Note:**
> The File Setup tab and Header View tab are similar for all modules; see *Section 2: Installation and Use*.



Select variable used in buoyancy computation:
- Latitude - Buoyancy uses algorithm in UNESCO Technical Papers in Marine Science 44 to estimate local gravity from user-input latitude
- Gravity

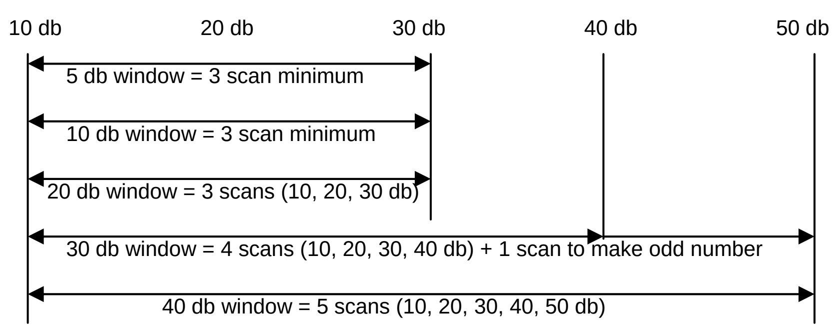
Calculate buoyancy variables for pressure values centered in window. Buoyancy converts window size from decibars to scans based on pressure interval between scans in input file. If window size is less than 3 scans, Buoyancy sets it to 3 scans. If window size is an even number of scans, Buoyancy adds 1 scan to window size. (see example below)
Note: As used here, a *scan* is one row of output data from Bin Average, which is an average of many scans of original data.

Select buoyancy variables to be computed and added to .cnv file - 1, 2, 3, or 4 variables can be computed.

Return to SBE Data Processing window.
- If *Confirm Program Setup Change* was selected in Options menu - If you made changes and did not Save or Save As, program asks if you want to save changes.
- If *Confirm Program Setup Change* was not selected in Options menu - Button says **Save & Exit**. If you do not want to save changes, use Cancel button to exit.

Begin processing data. Status field on File Setup tab shows *Processing complete* when done.

Example: For an interval of 10 db between scans, buoyancy window sizes of 5, 10, or 20 db result in a window size of 3 scans. Window sizes of 30 or 40 db result in a window size of 5 scans.



Buoyancy: Formulas

The relationship between frequency N and stability E is:

$N^2 = gE \quad [rad^2/s^2]$

where g = gravity [m / s^2]

The algorithm used to compute N^2 for the pressure value centered in the buoyancy window is:

1. Compute averages:
   p_bar = average pressure in the buoyancy window [decibars]
   t_bar = average temperature in the buoyancy window [deg C]
   s_bar = average salinity in the buoyancy window [PSU]
   rho_bar = density (s_bar, t_bar, p_bar) [Kg / m^3]

2. Compute the vertical gradient:
   theta = potential temperature (s, t, p, p_bar)
   v = 1 / density(s, theta, p_bar)
   where s, t, and p are the averaged values for salinity, temperature, and pressure calculated in Bin Average

   Use a least squares fit to compute the linear gradient dv/dp in the buoyancy window.

3. Compute N^2, N, E, and 10^{-8}E:

$$N^2 = -1.0e^{-4}\, rho\_bar^2\, g^2\, \frac{\delta v}{\delta p} \qquad [rad^2/s^2]$$

$$N = \frac{3600}{2\Pi}\sqrt{N^2} \qquad [cycles/hour]$$

$$E = \frac{N^2}{g} \qquad [rad^2/m]$$

$$E = 10^8\, \frac{N^2}{g} \qquad [10^{-8}\, rad^2/m]$$

Buoyancy adds the following to the data file header:

Label	Description
Buoyancy_date	Date and time that module was run.
Buoyancy_in	Input .cnv file.
Buoyancy_vars	Gravity value (input value or value based on input latitude) and buoyancy window size (adjusted to provide a minimum of three scans and an odd number of scans).

Cell Thermal Mass

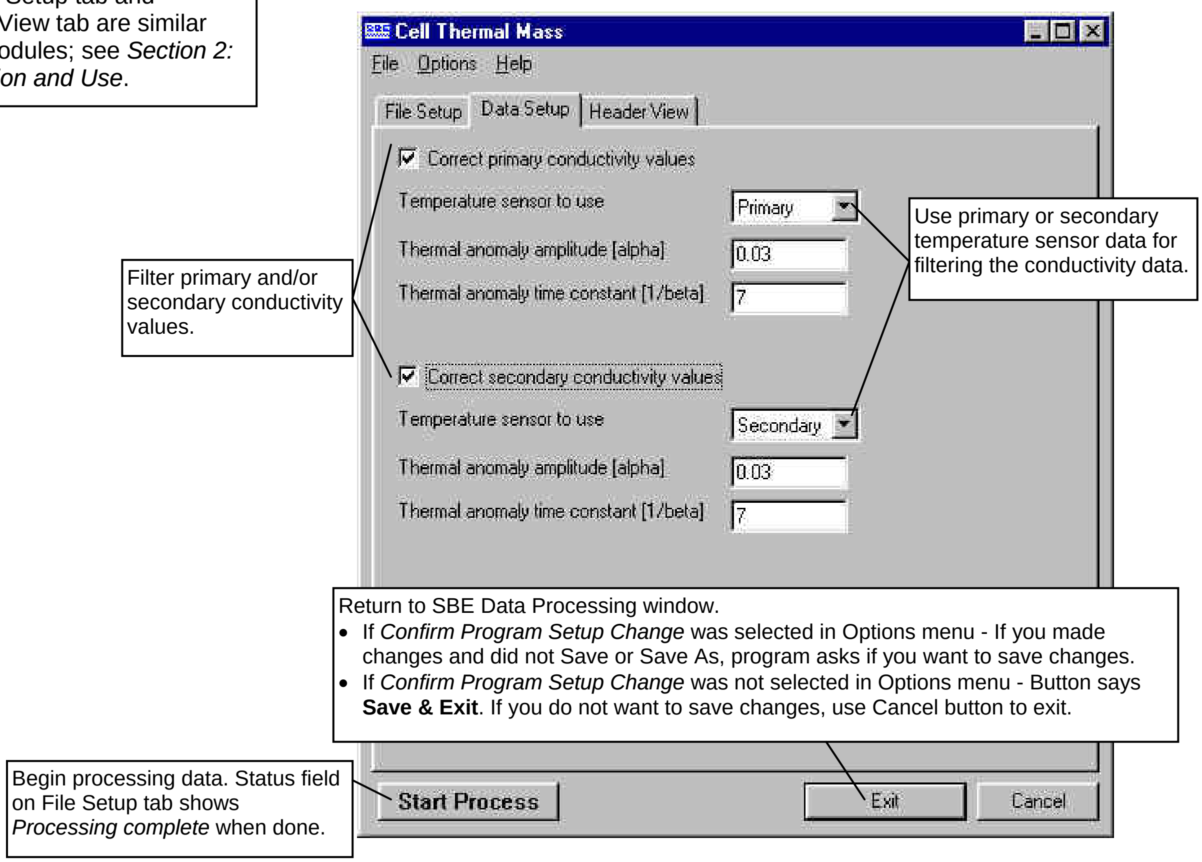
Cell Thermal Mass uses a recursive filter to remove conductivity cell thermal mass effects from the measured conductivity. In areas with steep temperature gradients, the correction is on the order of 0.005 PSU. In other areas the correction is negligible. Typical values for alpha and 1/beta are:

Instrument	alpha	1/beta
SBE 9*plus* with TC duct and 3000 rpm pump	0.03	7.0
SBE 19*plus* with TC duct and 2000 rpm pump	0.04	8.0
SBE 19 (not *plus*) with TC duct and 2000 rpm pump	0.04	8.0
SBE 19 (not *plus*) with no pump, moving at 1 m/sec	0.042	10.0
SBE 25 with TC duct and 2000 rpm pump	0.04	8.0
SBE 49 with TC duct and 3000 rpm pump *	0.03	7.0

*The SBE 49 can be programmed to correct for conductivity cell thermal mass effects in real-time, eliminating the need to run Cell Thermal Mass. See the SBE 49 manual for details.

Note:
The File Setup tab and Header View tab are similar for all modules; see *Section 2: Installation and Use*.

The Data Setup tab in the dialog box looks like this:



Cell Thermal Mass: Formulas

The algorithm used is:

a = 2 * alpha / (sample interval * beta + 2)
b = 1 - (2 * a / alpha)
dc/dt = 0.1 * (1 + 0.006 * [temperature - 20])
dt = temperature - previous temperature
ctm [S/m] = -1.0 * b * previous ctm + a * (dc/dt) * dt

where
sample interval is measured in seconds and temperature in °C
ctm is calculated in S/m

If the input file contains conductivity in units other than S/m, Cell Thermal Mass applies the following scale factors to the calculated ctm:
ctm [mS/cm] = ctm [S/m] * 10.0
ctm [µS/cm] = ctm [S/m] * 10000.0

corrected conductivity = c + ctm

To determine the values for alpha and beta, see:
Lueck, R.G., 1990: Thermal Inertia of Conductivity Cells: Theory., American Meteorological Society Oct 1990, 741-755.

Cell Thermal Mass adds the following to the data file header:

Label	Description
Celltm_date	Date and time that module was run.
Celltm_in	Input .cnv file.
Celltm_alpha	Value used for alpha.
Celltm_tau	Value used for 1/beta.
Celltm_temp_sensor_use_for_cond	Temperature sensor for primary conductivity filter, temperature sensor for secondary conductivity filter.

Derive

Notes:

- The File Setup tab for Derive **requires** selection of both an input data file and an instrument configuration (.con) file before it will process data. However, an **SBE 37-SM, 37-SMP, 37-IM, and 37-IMP** stores calibration coefficients internally, and does not have a .con file. You can use a .con file from **any** other Sea-Bird instrument; the contents of the file will not affect the results. If you do not have a .con file for another Sea-Bird instrument, create one in SBE Data Processing's Configure menu (select **any** instrument in the Configure menu, then click Save As in the Configuration dialog box).
- Derive is not compatible with a .cnv file from an **SBE 39 or 48**.
- For an SBE 21 or 45 with a remote temperature sensor, SEASAVE, Data Conversion, and Derive all use the remote temperature data when calculating density and sound velocity.

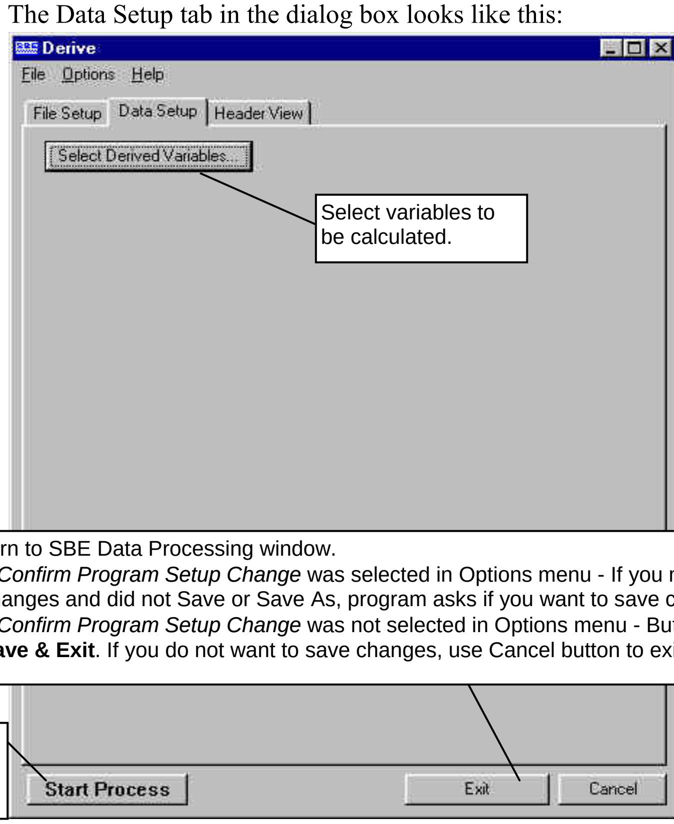
Derive uses pressure, temperature, and conductivity from the input .cnv file to compute the following oceanographic parameters:

- density (density, sigma-theta, sigma-1, sigma-2, sigma-4, sigma-t)
- thermosteric anomaly
- specific volume
- specific volume anomaly
- geopotential anomaly
- dynamic meters
- depth (salt water, fresh water)
- salinity
- sound velocity (Chen-Millero, DelGrosso, Wilson)
- average sound velocity
- potential temperature (reference pressure = 0.0 decibars)
- potential temperature anomaly
- specific conductivity
- derivative variables (descent rate and acceleration) - if input file has not been averaged into pressure or depth bins
- oxygen (if input file contains pressure, temperature, and either conductivity or salinity, and has not been averaged into pressure or depth bins) - also requires oxygen current and oxygen temperature (for SBE 13 or 23) or oxygen signal (for SBE 43)
- corrected irradiance (CPAR)

See *Appendix V: Derived Parameter Formulas* for the formulas used by Derive, Data Conversion, and SEASAVE in calculating these parameters.

Note:
The File Setup tab and Header View tab are similar for all modules; see *Section 2: Installation and Use*.

The Data Setup tab in the dialog box looks like this:

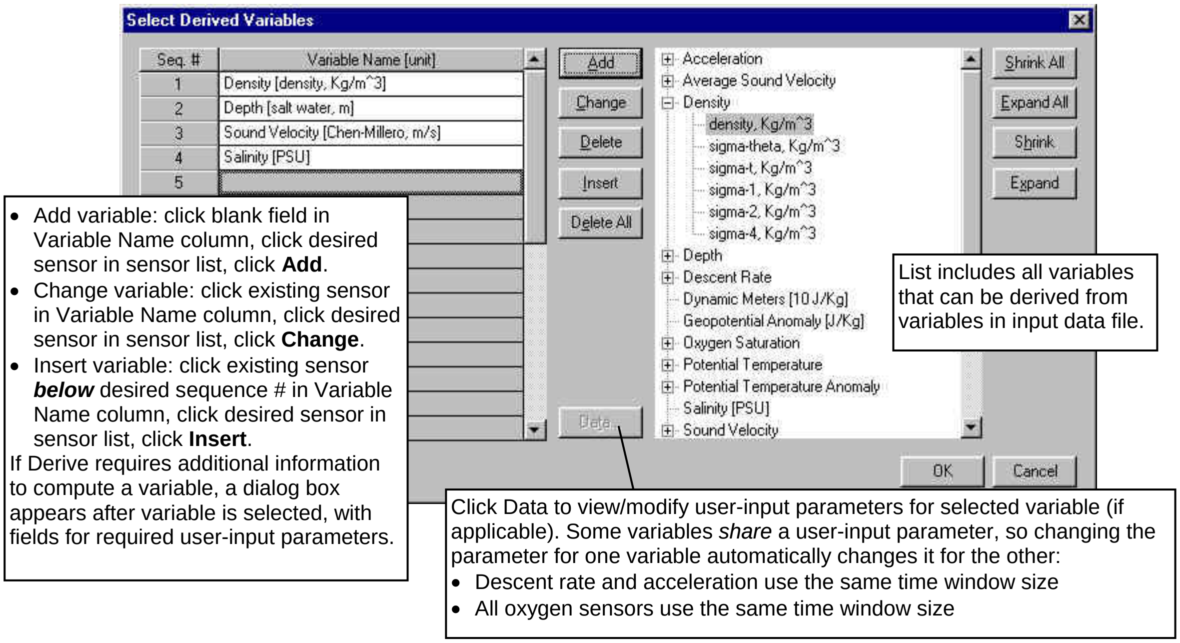


Return to SBE Data Processing window.

- If *Confirm Program Setup Change* was selected in Options menu - If you made changes and did not Save or Save As, program asks if you want to save changes.
- If *Confirm Program Setup Change* was not selected in Options menu - Button says **Save & Exit**. If you do not want to save changes, use Cancel button to exit.

Begin processing data. Status field on File Setup tab shows *Processing complete* when done.

The Select Derived Variables dialog box looks like this:



Derivative variables (oxygen, descent rate, and acceleration) are computed by looking at data centered around the current data point with a time span equal to the user-input time window size and using a linear regression to determine the slope.

Derive has the following /x parameter when run from the Command Line Options dialog box, from the command line, or with batch file processing:

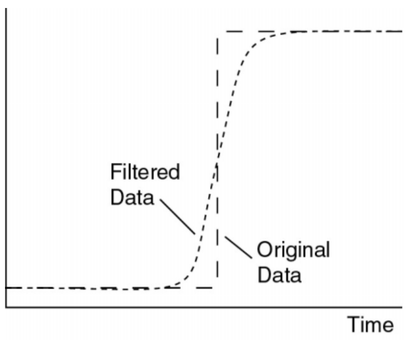
/x Parameter	Description
/xderive:pump	For SBE 911*plus*, do not output scans if pump status = off.

See *Appendix I: Command Line Options, Command Line Operation, and Batch File Processing* for details on using parameters.

Derive adds the following to the data file header:

Label	Description
Derive_date	Date and time that module was run.
Derive_in	Input .cnv and .con files.
Derive_time_window_docdt	Window size for oxygen derivative calculation (seconds).
Derive_time_window_dzdt	Window size for descent rate and acceleration calculation (seconds).

Filter



Filter runs a low-pass filter on one or more columns of data. A low-pass filter smoothes high frequency (rapidly changing) data. To produce zero phase (no time shift), the filter is first run forward through the data and then run backward through the data. This removes any delays caused by the filter.

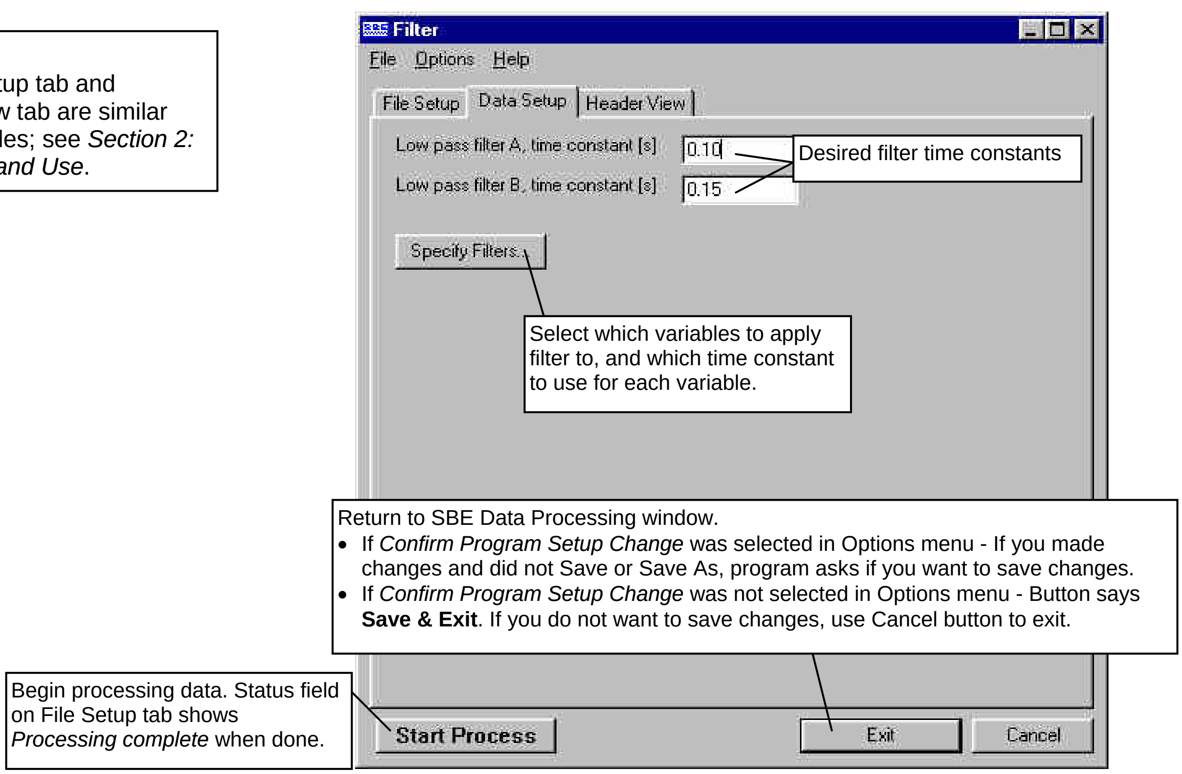
Pressure data is typically filtered with a time constant equal to four times the CTD scan rate. Conductivity and temperature are typically filtered for *some* CTDs. Two time constants can be specified, so different parameters can be filtered with different time constants in one run of Filter. Typical time constants are:

Instrument	Temperature (seconds)	Conductivity (seconds)	Pressure (seconds)
SBE 9*plus*	-	-	0.15
SBE 19*plus*	0.5	0.5	1.0
SBE 19 (not *plus*) with or without TC duct and pump	0.5	0.5	2.0
SBE 25	-	0.03	0.5
SBE 49 with TC duct and 3000 rpm pump *	0.085	0.085	0.25

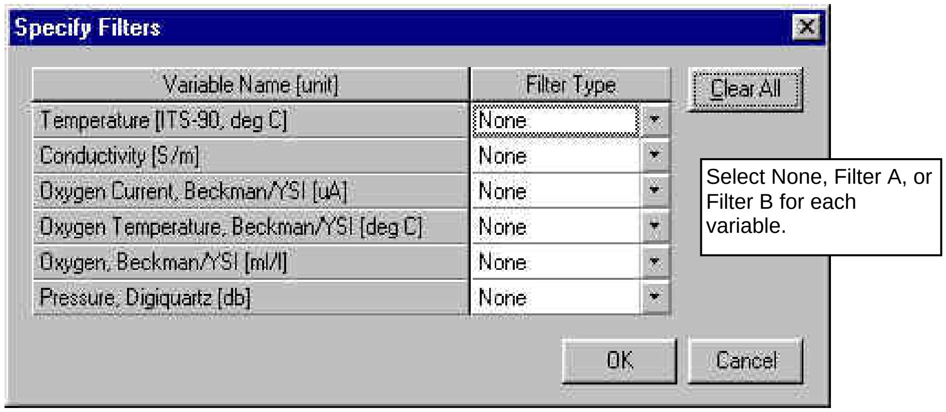
*The SBE 49 can be programmed to filter the data in real-time with a cosine window filter (see *WFilter*), eliminating the need to run Filter on temperature and conductivity data. See the SBE 49 manual for details.

Note:
The File Setup tab and Header View tab are similar for all modules; see *Section 2: Installation and Use*.

The Data Setup tab in the dialog box looks like this:



The Specify Filters dialog box looks like this:



Filter: Formulas

For a low-pass filter with time constant Γ:

$\Gamma = 1/\omega \qquad \omega = 2\pi f$
T = sample interval (seconds)
$S_0 = 1/\Gamma$

Laplace transform of the transfer function of a low-pass filter (single pole) with a time constant of Γ seconds is:

$$H(s) = \frac{1}{1 + (S/S_0)}$$

Using the bilinear transform:

$$S - f(z) \stackrel{\Delta}{=} \frac{2\,(1 - z^{-1})}{T\,(1 + z^{-1})} = \frac{2\,(z - 1)}{T\,(z + 1)}$$

$$H(z) = \frac{1}{1 + \dfrac{2\,(z - 1)}{T\,(z + 1)\,S_0}} = \frac{z^{-1} + 1}{1 + \dfrac{2}{TS_0}\left\{1 + \left(\dfrac{1 - 2/TS_0}{1 + 2/TS_0}\right) z^{-1}\right\}}$$

If: $A = \dfrac{1}{1 + \dfrac{2}{TS_0}}$ $\qquad B = \dfrac{1 - \dfrac{2}{TS_0}}{1 + \dfrac{2}{TS_0}}$

Then: $H(z) = \dfrac{Y(z)}{X(z)} = \dfrac{A\,(z^{-1} + 1)}{(1 + Bz^{-1})}$

Where z^{-1} is the unit delay (one scan behind).

y[N] = current output
y[N-1] = previous output
x[N] = input data (current scan)
x[N-1] = previous input data (from previous scan)

$Y(z)\,(1 + Bz^{-1}) = X(z)\,A\,(z^{-1} + 1)$
y[N] + By[N-1] = Ax[N-1] + Ax[N]
y[N] = A(x[N] + x[N-1]) - By[N-1]

Example: Time constant = 0.5 second, sample interval = 1/24 second

$$A = \frac{1}{(1 + 2 * 0.5 * 24)} = \frac{1}{(1 + 24)} = 0.04$$

$$B = (1 - 2 * 0.5 * 24)\ A = \frac{1 - 24}{1 + 24} = -0.92$$

Filter adds the following to the data file header:

Label	Description
Filter_date	Date and time that module was run.
Filter_in	Input .cnv file.
Filter_low_pass_tc_A	Time constant for filter A.
Filter_low-Pass_tc_B	Time constant for filter B.
Filter_low_pass_A_vars	List of variables filtered with time constant A.
Filter_low_pass_B_vars	List of variables filtered with time constant B.

Loop Edit

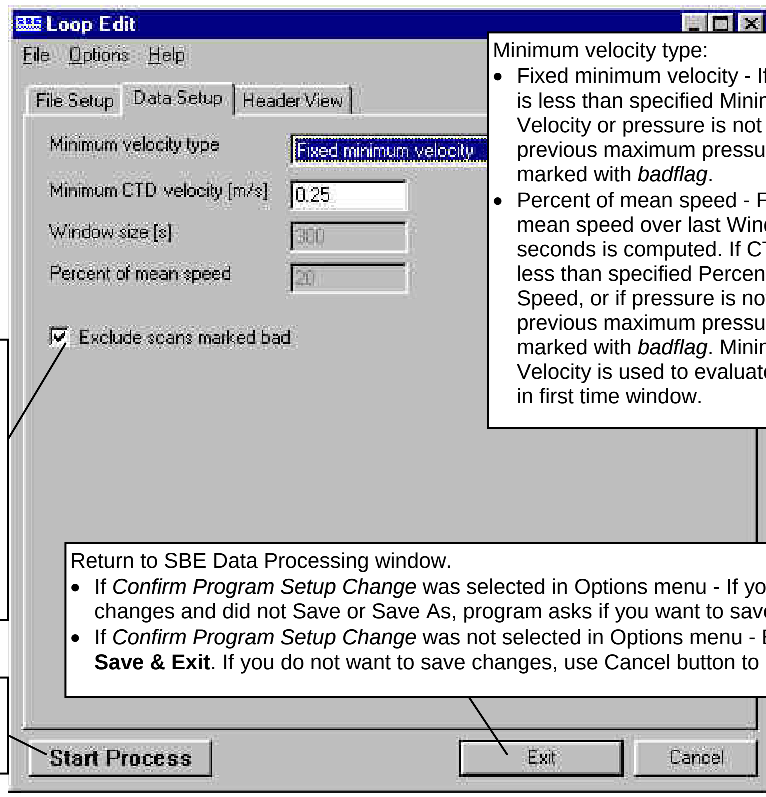
Loop Edit marks scans *bad* by setting the flag value associated with the scan to *badflag* in input .cnv files that have pressure slowdowns or reversals (typically caused by ship heave). The *badflag* value is documented in the input .cnv header.

Note:
Data Conversion calculates velocity with a 2-second window (e.g., 48 scans for an SBE 9*plus*), giving a much smoother measure of velocity.

Loop Edit operates on three successive scans to determine velocity. This is such a fine scale that noise in the pressure channel from counting jitter or other unknown sources can cause Loop Edit to mark scans with *badflag* in error. **Therefore, you must run Filter on the pressure data to reduce noise before you run Loop Edit**. See *Filter* for pressure filter recommendations for each instrument.

Note:
The File Setup tab and Header View tab are similar for all modules; see *Section 2: Installation and Use*.

The Data Setup tab in the dialog box looks like this:



Minimum velocity type:
- Fixed minimum velocity - If CTD velocity is less than specified Minimum CTD Velocity or pressure is not greater than previous maximum pressure, scan is marked with *badflag*.
- Percent of mean speed - For each scan, mean speed over last Window Size seconds is computed. If CTD velocity is less than specified Percent of Mean Speed, or if pressure is not greater than previous maximum pressure, scan is marked with *badflag*. Minimum CTD Velocity is used to evaluate data points in first time window.

- If selected, scans previously marked with *badflag* (for example, in a previous run of Loop Edit) will not be evaluated.
- If not selected, scans previously marked with *badflag* will be reevaluated, and scan's flag will be reset accordingly.

Return to SBE Data Processing window.
- If *Confirm Program Setup Change* was selected in Options menu - If you made changes and did not Save or Save As, program asks if you want to save changes.
- If *Confirm Program Setup Change* was not selected in Options menu - Button says **Save & Exit**. If you do not want to save changes, use Cancel button to exit.

Begin processing data. Status field on File Setup tab shows *Processing complete* when done.

Loop Edit adds the following to the data file header:

Label	Description
Loopedit_date	Date and time that module was run.
Loopedit_in	Input .cnv file.
Loopedit_minVelocity	If *Fixed Minimum Velocity* was selected - minimum CTD velocity for good scans; scans with velocity less than this are marked with *badflag*.
Loopedit_percentMeanSpeed	If *Percent of Mean Speed* was selected - minimum CTD velocity for first time window, window size, and percent of mean speed for good scans; scans that do not meet this criteria are marked with *badflag*.
Loopedit_excl_bad_scans	If yes, do not evaluate scans marked with *badflag* in a previous run of Loop Edit.

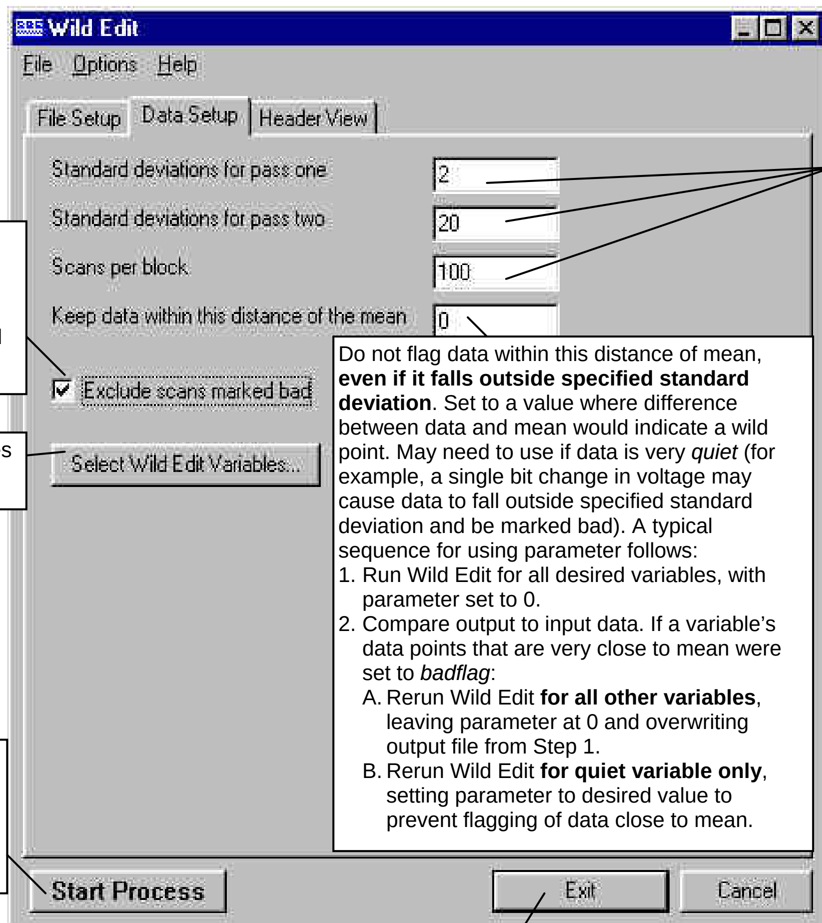
Wild Edit

Note:
Wild Edit marks **individual data** (for example, a conductivity value) with *badflag*, but does not mark the entire scan (which may include other data that is valid, such as temperature, pressure, etc.).

Note:
The File Setup tab and Header View tab are similar for all modules; see *Section 2: Installation and Use*.

Wild Edit marks wild points in the data by replacing the data value with *badflag*. The *badflag* value is documented in the input .cnv header.
Wild Edit's algorithm requires two passes through the data: the first pass obtains an accurate estimate of the data's true standard deviation, while the second pass replaces the appropriate data with *badflag*.

The Data Setup tab in the dialog box looks like this:



Wild Edit operates as follows:
1. Compute mean and standard deviation of data in block (specified by Scans per Block) for each selected variable. **Temporarily** flag values that differ from mean by more than standard deviations specified for pass 1.
2. Recompute mean and standard deviation, excluding temporarily flagged values. Mark values that differ from mean by more than standard deviations specified for pass 2 by replacing data value with *badflag*.
3. Repeat Steps 1 and 2 for next block of scans.
   - If last block of data in input file has less than specified number of scans, use data from previous block to fill in block.

If selected, data from scans marked with *badflag* in Loop Edit will not be used in calculating mean and standard deviation.

Select which variables to run Wild Edit on.

Do not flag data within this distance of mean, **even if it falls outside specified standard deviation**. Set to a value where difference between data and mean would indicate a wild point. May need to use if data is very *quiet* (for example, a single bit change in voltage may cause data to fall outside specified standard deviation and be marked bad). A typical sequence for using parameter follows:
1. Run Wild Edit for all desired variables, with parameter set to 0.
2. Compare output to input data. If a variable's data points that are very close to mean were set to *badflag*:
   A. Rerun Wild Edit **for all other variables**, leaving parameter at 0 and overwriting output file from Step 1.
   B. Rerun Wild Edit **for quiet variable only**, setting parameter to desired value to prevent flagging of data close to mean.

Begin processing data. Status field on File Setup tab shows *Processing complete* when done.

Return to SBE Data Processing window.
- If *Confirm Program Setup Change* was selected in Options menu - If you made changes and did not Save or Save As, program asks if you want to save changes.
- If *Confirm Program Setup Change* was not selected in Options menu - Button says **Save & Exit**. If you do not want to save changes, use Cancel button to exit.

If the data file is particularly corrupted, you may need to run Wild Edit more than once, with different block sizes and number of standard deviations.

If the input file has some variables with large values and some with relatively smaller values, it may be necessary to run Wild Edit more than once, varying the value for *Keep data within this distance of mean* so that it is meaningful for each variable. Better results may also be obtained by increasing *Scans per block* from 100 to around 500.

> *Example*
> Sensor A's range is approximately 1000 and Sensor B's range is approximately 10. Run Wild Edit on Sensor A, using *Keep data within this distance of mean* = 10. Then run Wild Edit on Sensor B, using *Keep data within this distance of mean* = 0.1

Wild Edit adds the following to the data file header:

Label	Description
Wildedit_date	Date and time that module was run.
Wildedit_in	Input .cnv file.
Wildedit_pass1_nstd	Number of standard deviations for pass 1 test.
Wildedit_pass2_nstd	Number of standard deviations for pass 2 test.
Wildedit_pass2_mindelta	Keep data within this distance of mean.
Wildedit_npoint	Number of points to include in each test.
Wildedit_vars	List of the variables tested for wild points.
Wildedit_excl_bad_scans	If yes, values in scans marked with *badflag* (in Loop Edit) will not be used to determine standard deviation.

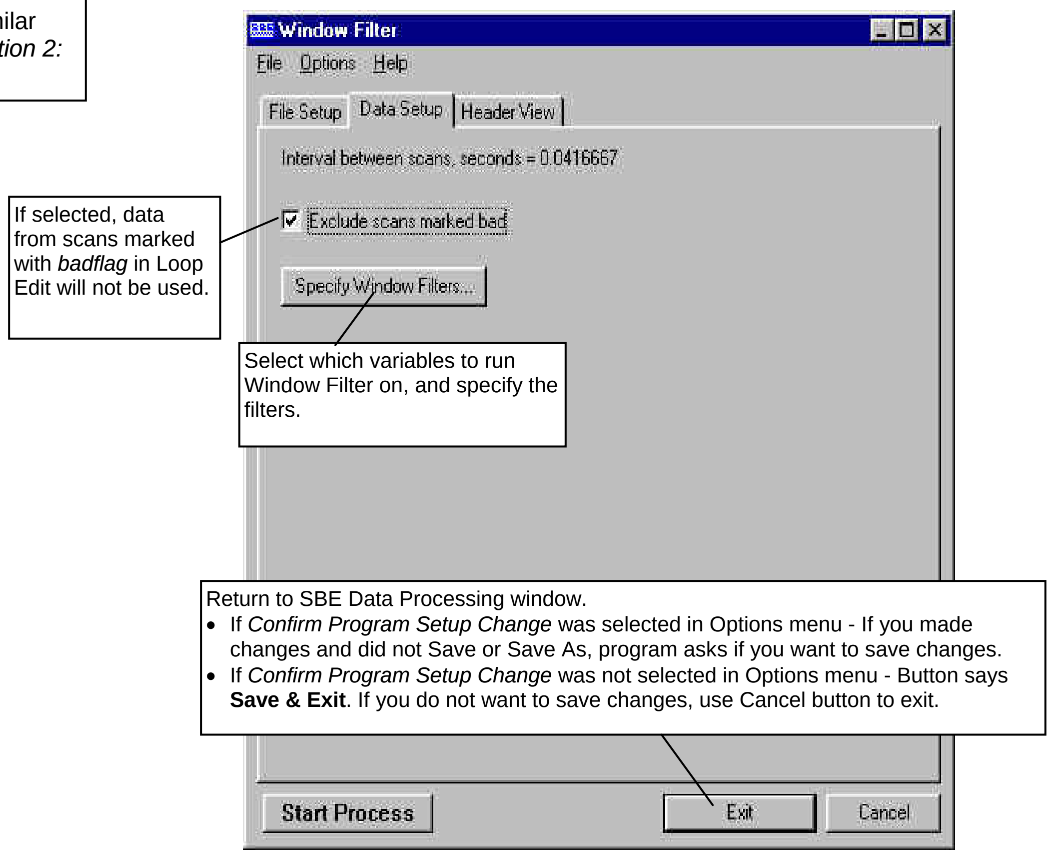
Window Filter

Window Filter provides four types of window filters and a median filter for data smoothing of .cnv files:

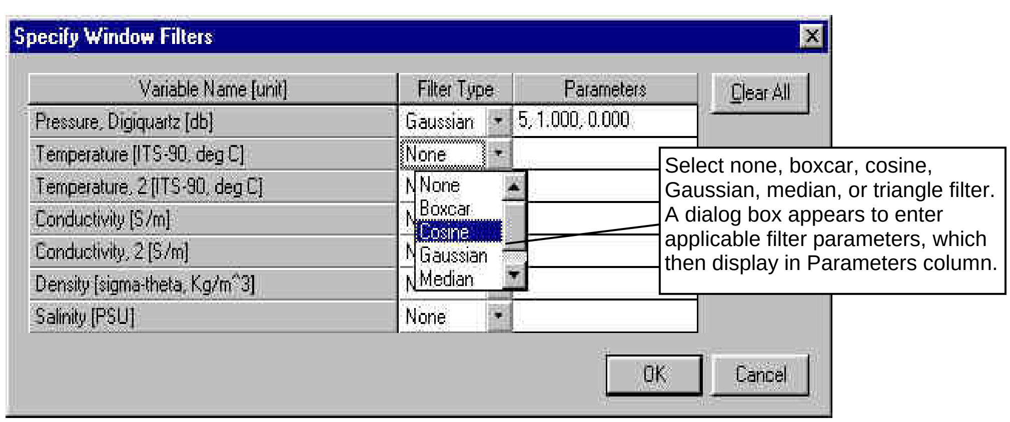
- Window filters calculate a weighted average of data values about a center point and replace the data value at the center point with this average.
- The median filter calculates a median for data values about a center point and replaces the data value at the center point with the median.

Note:
The File Setup tab and Header View tab are similar for all modules; see *Section 2: Installation and Use*.

The Data Setup tab in the dialog box looks like this:



The Specify Window Filters dialog box looks like this:



Window Filters: Descriptions and Formulas

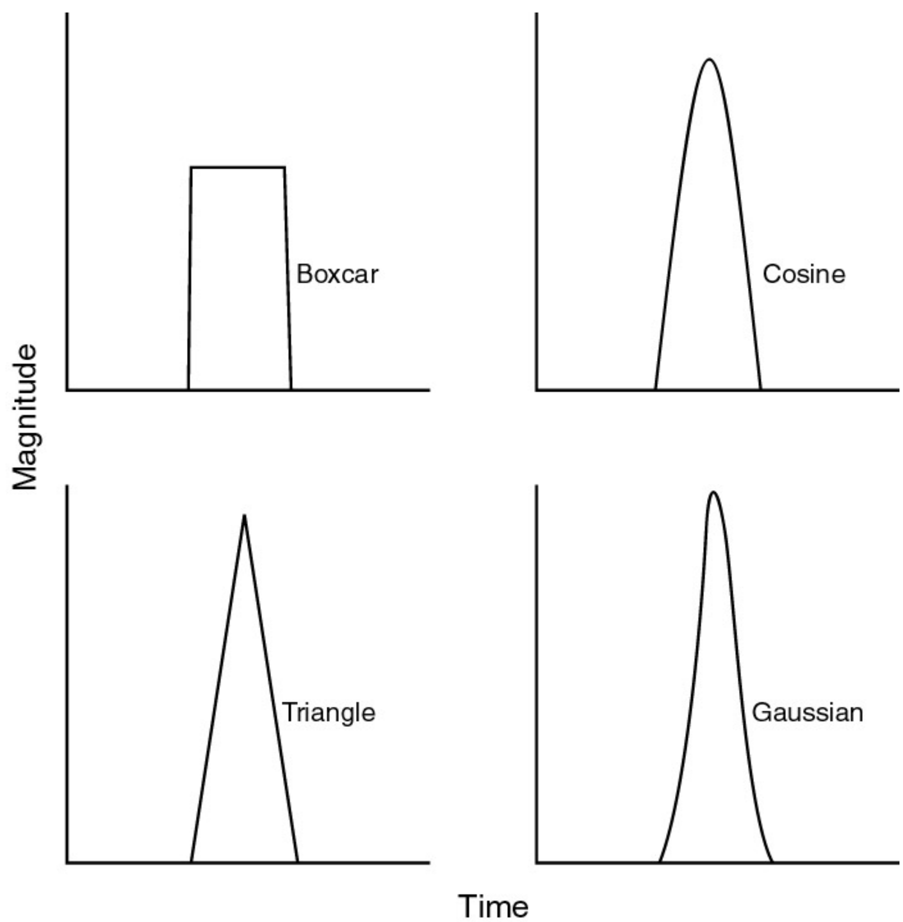
Shape and length define filter windows:

- Window Filter provides four window **shapes**: boxcar, cosine, triangle, and Gaussian.
- The minimum window **length** is 1 scan, and the maximum is 511 scans. Window length must be an odd number, so that the window has a center point. If a window length is specified as an even number, Window Filter automatically adds 1 to make the length odd.

The window filter calculates a weighted average of data values about a center point, using the following transfer function:

$$y(n) = \sum_{k=-L/2}^{L/2} w(k)\, x(n-k)$$

The figure below shows the impulse response of each of the four filter types for a filter of length 17 scans. The impulse response of a filter is obtained by filtering a data set that has zeros everywhere except one data value that is set to 1.



Note:
In the window filter equations:
- L = window length in scans, (always an odd number)
- n = window index, -L/2 to +L/2, with 0 the center point of the window
- w(n) = set of window weights

The window filtering process is similar for all filter types:
1. Filter weights are calculated (see the equations below).
2. Filter weights are normalized to sum to 1.
   - When a bad data point is encountered (scan marked with *badflag* if *exclude scans marked bad* was selected **or** data value marked with *badflag*), the weights are renormalized, excluding the filter element that would operate on the bad data point.

Boxcar Filter

$$w(n) = \frac{1}{L} \quad \textit{for } n = -\frac{L-1}{2} \;..\; \frac{L-1}{2}$$

Cosine Filter

$$w(n) = 1 \quad \textit{for } n = 0$$

$$w(n) = \cos \frac{n \times \pi}{L+1} \quad \textit{for } n = -\frac{L-1}{2} \;..\text{-}1,\ 1\;..\; \frac{L-1}{2}$$

Triangle Filter

$$w(n) = 1 \quad \textit{for } n = 0$$

$$w(n) = \frac{|n|}{K} \quad \textit{for } n = -\frac{L-1}{2} \;..\text{-}1,\ 1\;..\; \frac{L-1}{2}$$

$$\textit{where } K = \frac{L-1}{2} + 1$$

Gaussian Filter

$$phase = \frac{\textit{offset}\ (\text{sec})}{\textit{sample interval}\ (sec)}$$

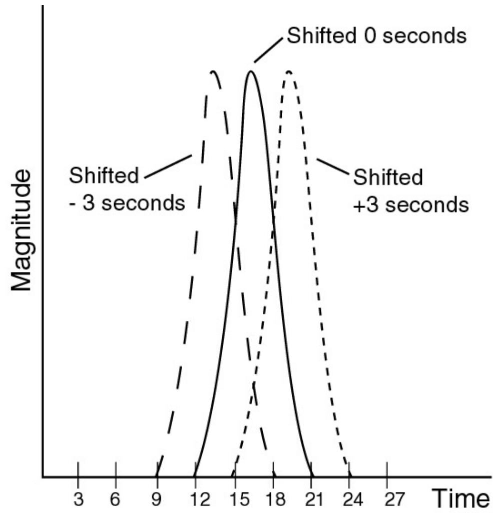
$$scale = log(2) \times \left(2 \times \frac{\textit{sample rate}}{\textit{half width}\ (\text{scans})}\right)^2$$

$$w(n) = e^{-phase \times phase \times scale} \quad \textit{for } n = 0$$

$$w(n) = e^{-(n - phase)^2 \times scale} \quad \textit{for } n = -\frac{L-1}{2} \;..\text{-}1,\ 1\;..\; \frac{L-1}{2}$$

The Gaussian window has parameters of halfwidth (in scans) and offset (in time), in addition to window length (in scans). These extra parameters allow data to be filtered and shifted in time in one operation. Halfwidth determines the width of the Gaussian curve. A window length of 9 and halfwidth of 4 produces a set of filter weights that fills the window. A window length of 17 and halfwidth of 4 produces a set of filter weights that fills only half the window. If the filter weights do not fill the window, the offset parameter may be used to shift the weights within the window without clipping the edge of the Gaussian curve.

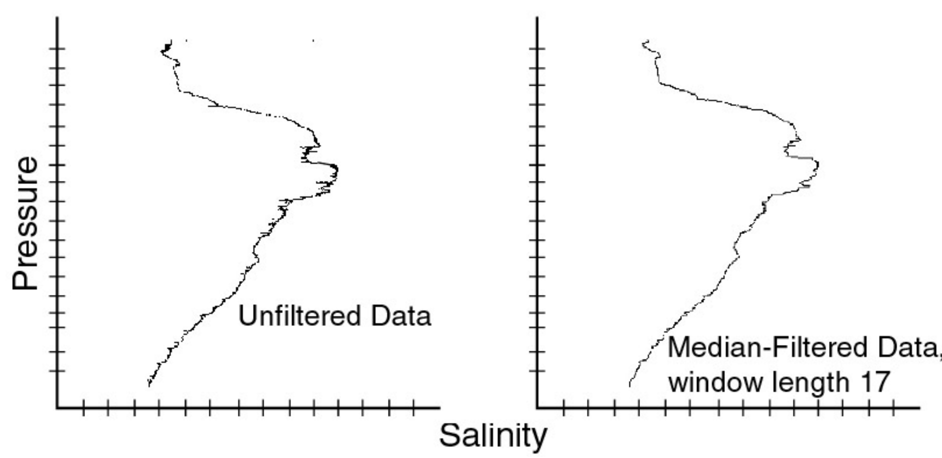
Example: Window length is 33 scans and halfwidth is 4 scans. Offset is -3 seconds in left curve, 0 in middle curve, and +3 seconds in right curve.



Note that the window length in the example is larger than the halfwidth. This allows the complete Gaussian curve to be expressed in the window when the offset parameter shifts the curve forward or backward in time. If the halfwidth was larger, the trailing edge of the -3 second offset curve would be truncated and the leading edge of the +3 second curve would be truncated. The offset parameter moves the Gaussian shape of the window weights forward or backward in time. Since the weighted average is calculated for a data value in the center of the window, this has the effect of shifting the data that the filter is operating on forward or backward in time relative to the other data in the file. This capability allows filtering and time shifting to be done in one step.

Median Filter: Description

The median filter is not a smoothing filter in the same sense as the window filters described above. Median filtering is most useful in spike removal.
A median value is determined for a specified window, and the data value at the window's center point is replaced by the median value.



Window Filter has the following /x parameter when run from the Command Line Options dialog box, from the command line, or with batch file processing:

/x Parameter	Description
/xwfilter:diff	Output difference between original and filtered value instead of outputting filtered value.

See *Appendix I: Command Line Options, Command Line Operation, and Batch File Processing* for details on using parameters.

Window Filter adds the following to the data file header:

Label	Description
Wfilter_date	Date and time that module was run.
Wfilter_in	Input .cnv file.
Wfilter_excl_ bad_scans	If yes, values in scans marked with *badflag* in Loop Edit will not be used.
Wfilter_action	Data channel identifier, filter type, filter parameters.

Section 7: File Manipulation Modules

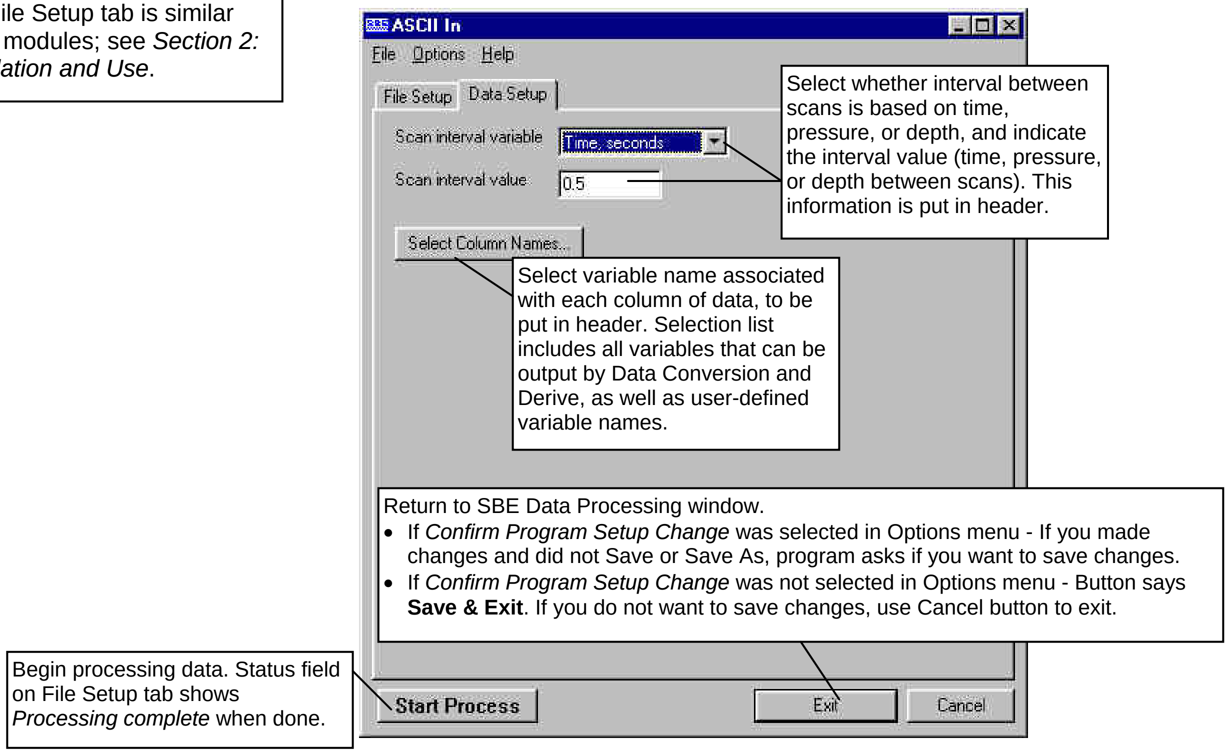
Module Name	Module Description
ASCII In	Add header information to a .asc file containing rows and columns of ASCII data.
ASCII Out	Output data portion and/or header portion from .cnv file to an ASCII file (.asc for data, .hdr for header). Useful for exporting converted data for processing by other (non-Sea-Bird) software.
Section	Extract rows of data from .cnv file.
Split	Split data in .cnv file into upcast and downcast files.
Strip	Extract columns of data from .cnv file.
Translate	Convert data format in .cnv file from ASCII to binary, or vice versa.

ASCII In

> **Note:**
> The File Setup tab is similar for all modules; see *Section 2: Installation and Use*.

ASCII In adds a header to a .asc file that contains rows of ASCII data. The data can be separated by spaces, commas, or tabs (or any combination of spaces, commas, and tabs). The output file, which contains both the header and the data, is a .cnv file. ASCII In can be used to add a header to data that was generated by a non-SEASOFT program.

The Data Setup tab in the dialog box looks like this:



ASCII In creates a data file header containing the following information:

Label	Description
Nquan	Number of columns (fields) of data. **NOTE**: ASCII In automatically adds 1 field to the number of fields in the input .asc file (i.e., if the .asc file contains 3 columns of data, then nquan=4). This field, initially set to 0, is used by Loop Edit to mark bad scans.
Nvalues	Number of scans converted.
Units	Specified (indicates units are specified separately for each variable; SEASOFT-DOS required all units to be English or metric).
Name n	Sensor (and units) associated with data in column n.
Span n	Span (highest - lowest value) of data in column n.
Interval	Scan rate (seconds).
Start_time	Start time for when ASCII In was run.
Bad_flag	Provided for information only; value that Loop Edit will use to mark bad scans and Wild Edit will use to mark bad data values.
Asciiin_in	Input .asc file.
File type	Selected output file type - ASCII data.

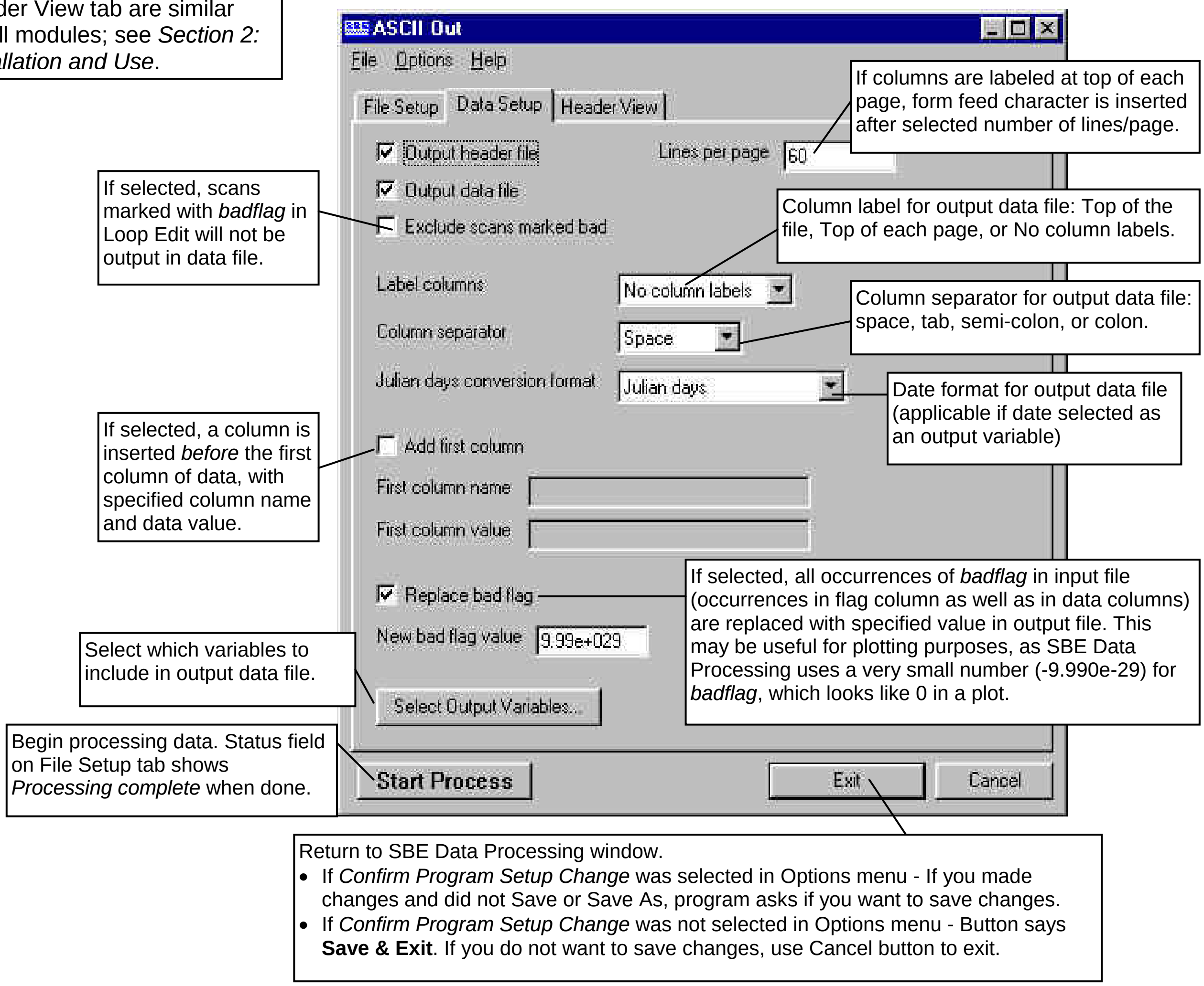
ASCII Out

ASCII Out outputs the header portion and/or the data portion of a converted data file (.cnv).

- The data portion is written in ASCII engineering units to a .asc file, and may be useful if you are planning to export converted data for processing by other (non-Sea-Bird) software.
- The header portion is written to a .hdr file.

Note:
The File Setup tab and Header View tab are similar for all modules; see *Section 2: Installation and Use*.

The Data Setup tab in the dialog box looks like this:



ASCII OUT has the following /x parameter when run from the Command Line Options dialog box, from the command line, or with batch file processing:

/x Parameter	Description
/xascii_out:first_ column_value=string	string = value (maximum of 11 characters) placed in each row of column inserted before first column of data.

See *Appendix I: Command Line Options, Command Line Operation, and Batch File Processing* for details on using parameters.

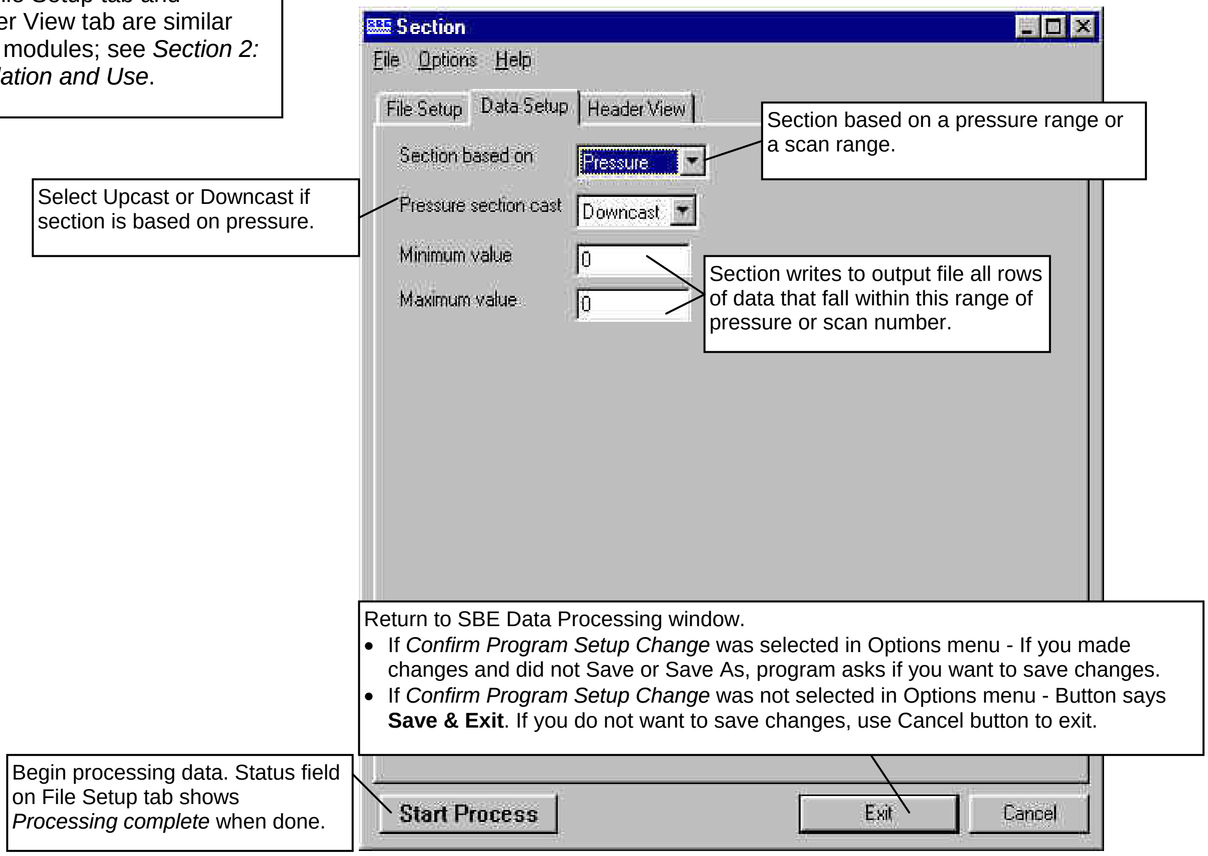
ASCII Out does not add anything to the data file header. The output header (.hdr) file contains the header from the input (.cnv) file.

Section

Note:
The File Setup tab and Header View tab are similar for all modules; see *Section 2: Installation and Use*.

Section extracts **rows** of data from the input .cnv file, based on a pressure range or scan number range, and writes the rows to an output .cnv file.

The Data Setup tab in the dialog box looks like this:



Section adds the following to the data file header:

Label	Description
Section_date	Date and time that module was run.
Section_in	Input .cnv file.
Section_type	Evaluate data based on pressure or scan range.
Section_range	Range of (pressure or scan count) data to keep.

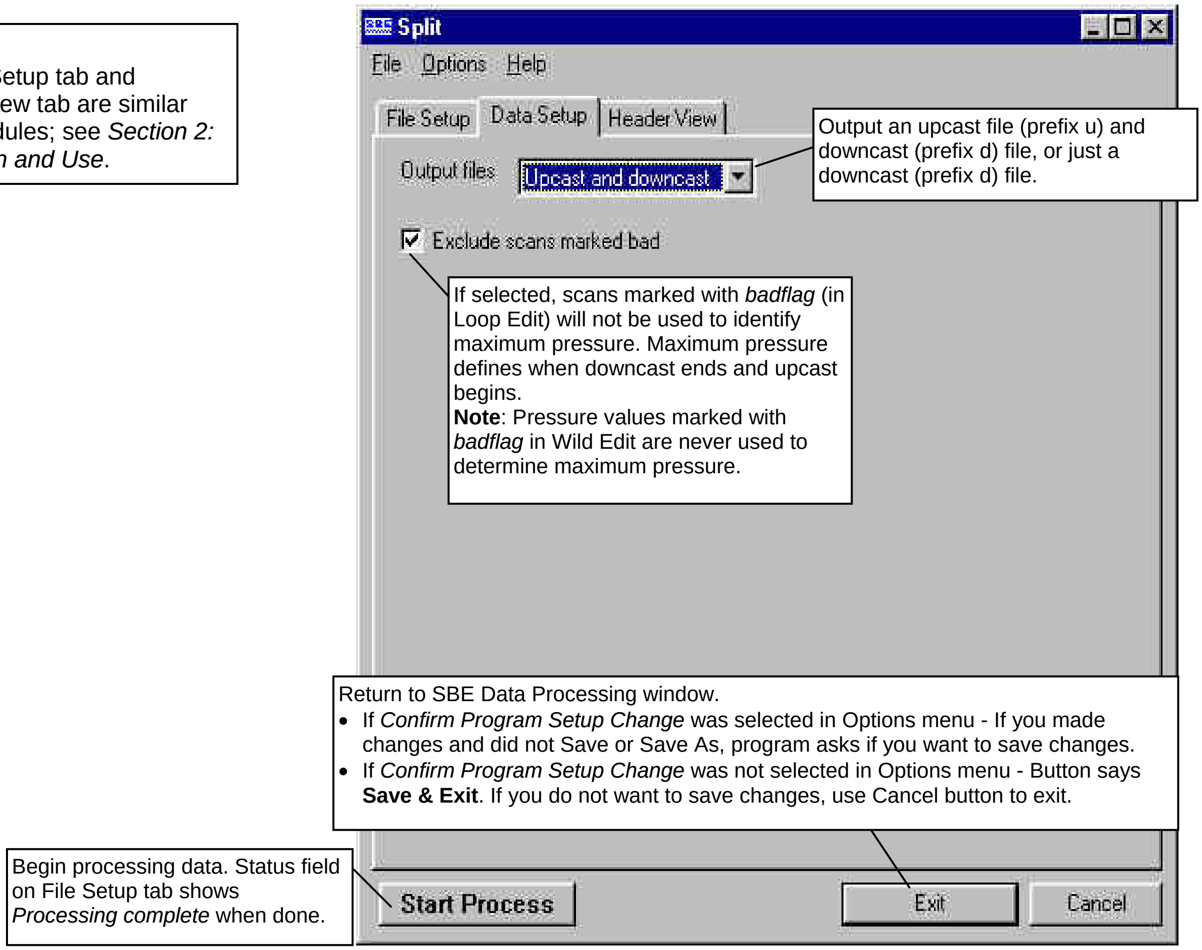
Split

Note:
Bin Average provides the option of processing upcast, downcast, or both, possibly removing the need to run Split.

Note:
The File Setup tab and Header View tab are similar for all modules; see *Section 2: Installation and Use*.

Split separates the data from an input .cnv file into upcast (pressure decreasing) and downcast (pressure increasing) files. Split writes the data to an output .cnv file(s). The upcast output file name is the input file name prefixed by **u**. The downcast output file name is the input file name prefixed by **d**.

The Data Setup tab in the dialog box looks like this:



Split adds the following to the data file header:

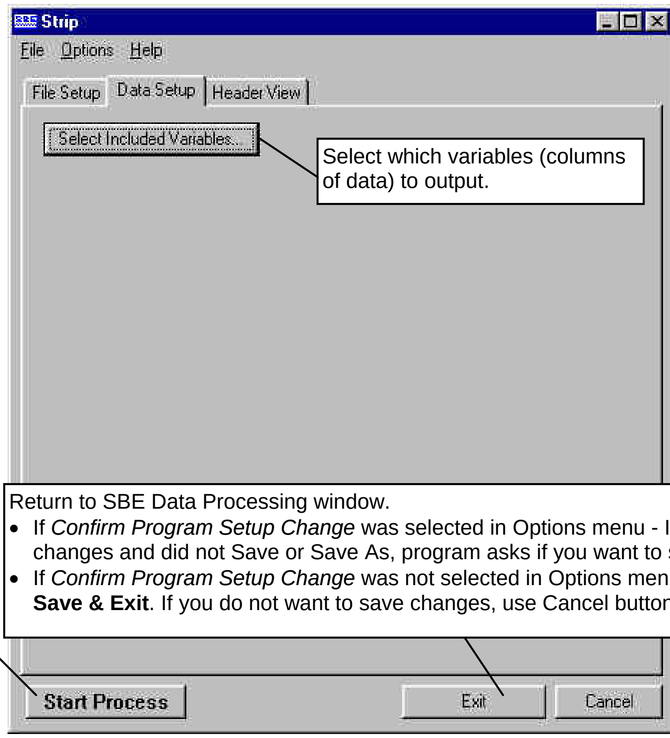
Label	Description
Split_date	Date and time that module was run.
Split_in	Input .cnv file.
Split_excl_bad_scans	If *Yes*, pressure from scans marked with *badflag* (in Loop Edit) were not used to determine maximum pressure (for determining when downcast ends and upcast begins).

Strip

Strip outputs selected columns of data from the input .cnv file. Strip writes the data to an output .cnv file.

> **Note:**
> The File Setup tab and Header View tab are similar for all modules; see *Section 2: Installation and Use*.

The Data Setup tab in the dialog box looks like this:



Select which variables (columns of data) to output.

Return to SBE Data Processing window.
- If *Confirm Program Setup Change* was selected in Options menu - If you made changes and did not Save or Save As, program asks if you want to save changes.
- If *Confirm Program Setup Change* was not selected in Options menu - Button says **Save & Exit**. If you do not want to save changes, use Cancel button to exit.

Begin processing data. Status field on File Setup tab shows *Processing complete* when done.

Strip adds the following to the data file header:

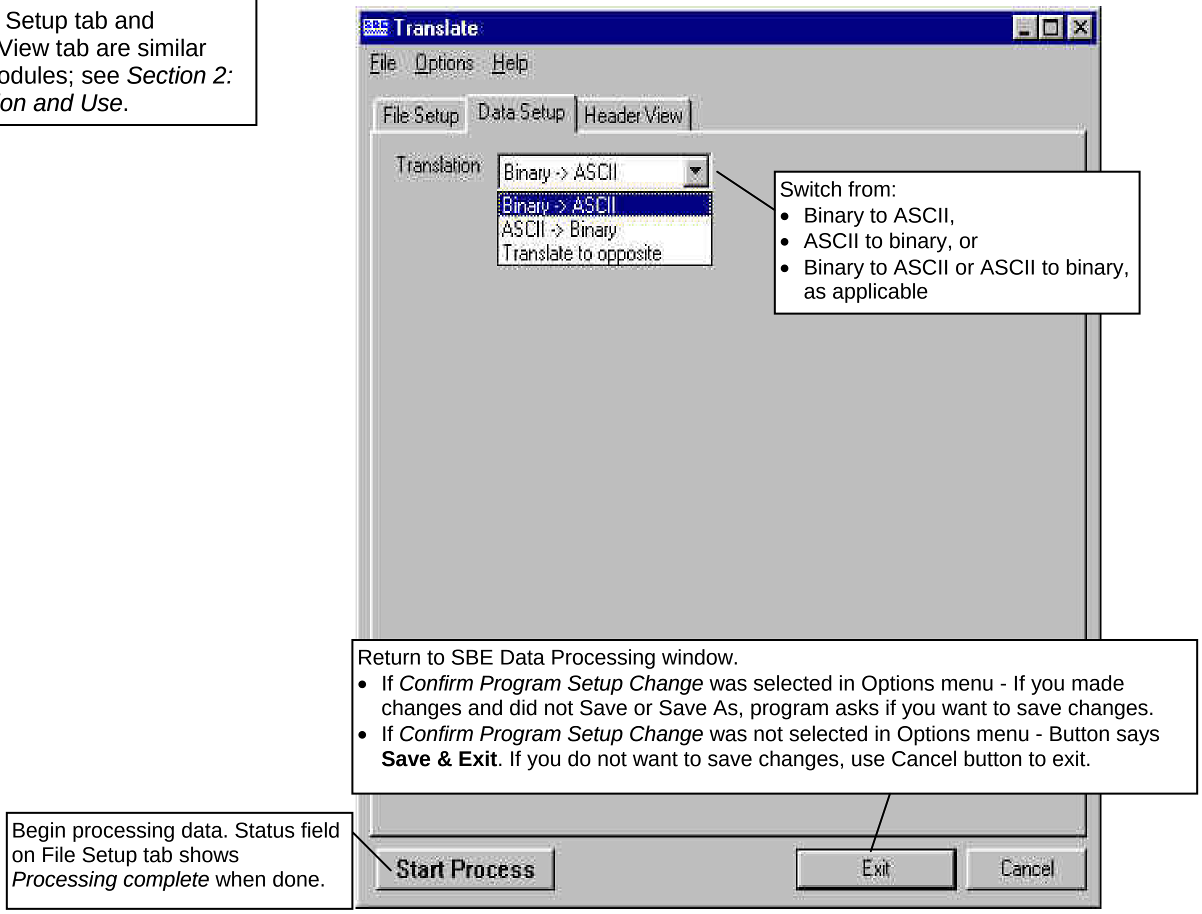
Label	Description
Strip_date	Date and time that module was run.
Strip_in	Input .cnv file.

Translate

Translate changes the converted data file format from binary to ASCII or vice versa, and writes the data to an output .cnv file.

> **Note:**
> The File Setup tab and Header View tab are similar for all modules; see *Section 2: Installation and Use*.

The Data Setup tab in the dialog box looks like this:



Translate changes the following in the data file header:

Label	Description
File_type	File type - changes to ASCII or binary, as applicable.

Section 8: Data Plotting Module - SeaPlot

Note:
Converted data (.cnv) files are typically created in Data Conversion and manipulated in other SBE Data Processing modules. SeaPlot can plot data at any point after Data Conversion has been run.
For SBE 37-IM, 37-IMP, 37-SM, 37-SMP, 39, and 48, a converted (.cnv) data file is created from an uploaded .asc file using the Convert button in SEATERM's Toolbar.

Note:
When plotting date and time, the following restrictions apply:
- On the Plot Setup tab, select *Single X – Multiple Y* or *Single X – Multiple Y, Overlay* for plot type
- On the X Axis tab, select *Julian days* or *Elapsed time* for the variable, and select *Show as Date/Time.*
- On the X Axis tab, **do not** select *Reverse scale direction*.

SeaPlot can be used to plot C, T, and P, as well as derived variables and data from auxiliary sensors, from any converted .cnv data file. SeaPlot can:

- Plot up to 5 variables on one plot, with a single X axis and up to four Y axes or a single Y axis and up to four X axes.
- Plot any variable on a linear or logarithmic scale (logarithmic scale not applicable to TS plots).
- Derive and plot *derived salinity* and/or *derived density*, if conductivity, temperature, and pressure data are in the input file. This allows you to skip running Derive if salinity and density are the only derived parameters you are interested in. Alternatively, you can calculate and plot *derived salinity* and/or *derived density* even if salinity and density are already in the input file; the values may differ because of processing steps performed on C, T, or P after Derive was run.
- Plot time series data; the time scale selections include Julian Days, elapsed time in hours, minutes, or seconds, or date and time.
- Create contour plots, generating density (sigma-t or sigma-theta) or thermosteric anomaly contours on temperature-salinity (TS) plots.
- Process and plot multiple input files that contain the same variables and with the same setup parameters, each on their own plot, allowing the user to quickly switch the view from one file to the next.
- Process and plot multiple input files that contain the same variables on an overlay plot, allowing the user to view multiple sets of data at the same time. If desired, the user can offset each file on the plot to create a *waterfall* plot.
- Zoom in on plot features.
- Send plots to a printer, save plots to the clipboard for insertion in another program (such as Microsoft Word), or save plots as graphic files in bitmap, metafile, or JPEG format.
- Run in batch processing mode. See *Appendix I: Command Line Options, Command Line Operation, and Batch File Processing*.

The SeaPlot dialog box differs somewhat from the other SBE Data Processing modules. Each tab of the SeaPlot dialog box is described below, as well as options for viewing, printing, and saving a plot.

SeaPlot File Setup Tab

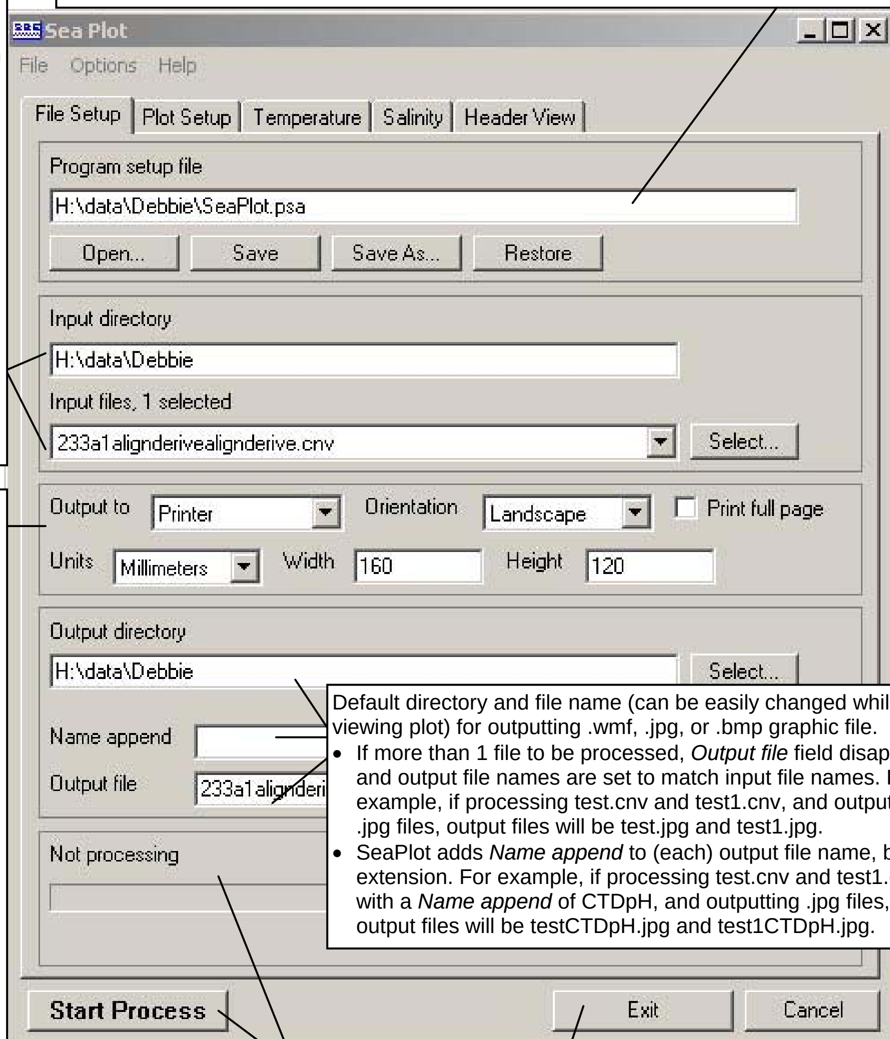
Note:
Previous versions (5.30a and earlier) of SBE Data Processing used program setup files with a .psu extension instead of a .psa extension. Program setup files with a .psa extension can be opened, viewed, and modified in any text editor or XML editor.
SBE Data Processing can still use your existing .psu files. However, if you make any changes to the setup (for example, change output variables), SBE Data Processing will save the changes to a new .psa file.

The File Setup tab defines the Program Setup file; input data file(s); and output type, orientation, and (if applicable) file name. The File Setup tab looks like this:

Input data directory and file names. **Select** to pick a different file.
To process multiple files from same directory:
1. Click **Select**.
2. In Select dialog box, hold down Ctrl key while clicking on each desired file.

If multiple files selected, header in each file must contain same set of sensors and variables.
For overlay plots:
- If *Sort Input Files* selected in Options menu: SeaPlot sorts input files in alphabetical order.
- If *Sort Input Files* **not** selected in Options menu: SeaPlot maintains order of files as you selected them using Ctrl key. Use this feature if there is a particular data set you want to use as *base* on a waterfall overlay plot. Note that using Shift key to select files will not maintain selected order.

File to store **all** information input in File, Plot, and Axis Setup tabs. **Open** to select a different .psa file, **Save** or **Save As** to save current settings, or **Restore** to reset all settings to match last saved version. As a default, .psa file is stored in same directory as SBEDataProc.exe (default is c:/Program Files/Sea-Bird/SBEDataProcessing-Win32). PostProcSuite.ini, located in Windows directory, contains location and file name of last saved .psa file and options settings for each module.



Output Information is default only, and can be easily changed while viewing plot.
- **Output to**: Printer, Metafile (.wmf), JPEG (.jpg), or Bitmap (.bmp). When viewing plot, you can also output to clipboard; from clipboard, you can paste plot into another application (such as Microsoft Word).
- **Orientation**: if outputting to printer. Driver default, Landscape, or Portrait. If Driver default selected, orientation determined by default for printer you select.
- **Print full page**: Applicable for outputting to printer. If selected, SeaPlot sizes plot to fit $8^1/_2$ x 11 inch paper. If not selected, input desired plot size (**Units**, **Width**, and **Height**).
- **Units**, **Width**, and **Height**: Plot size. Applicable when outputting to printer (if *Print full page* was not selected), or to graphics file.

Default directory and file name (can be easily changed while viewing plot) for outputting .wmf, .jpg, or .bmp graphic file.
- If more than 1 file to be processed, *Output file* field disappears and output file names are set to match input file names. For example, if processing test.cnv and test1.cnv, and outputting .jpg files, output files will be test.jpg and test1.jpg.
- SeaPlot adds *Name append* to (each) output file name, before extension. For example, if processing test.cnv and test1.cnv with a *Name append* of CTDpH, and outputting .jpg files, output files will be testCTDpH.jpg and test1CTDpH.jpg.

Click **Start Process** to begin processing data. Status field shows *Processing complete* when done.

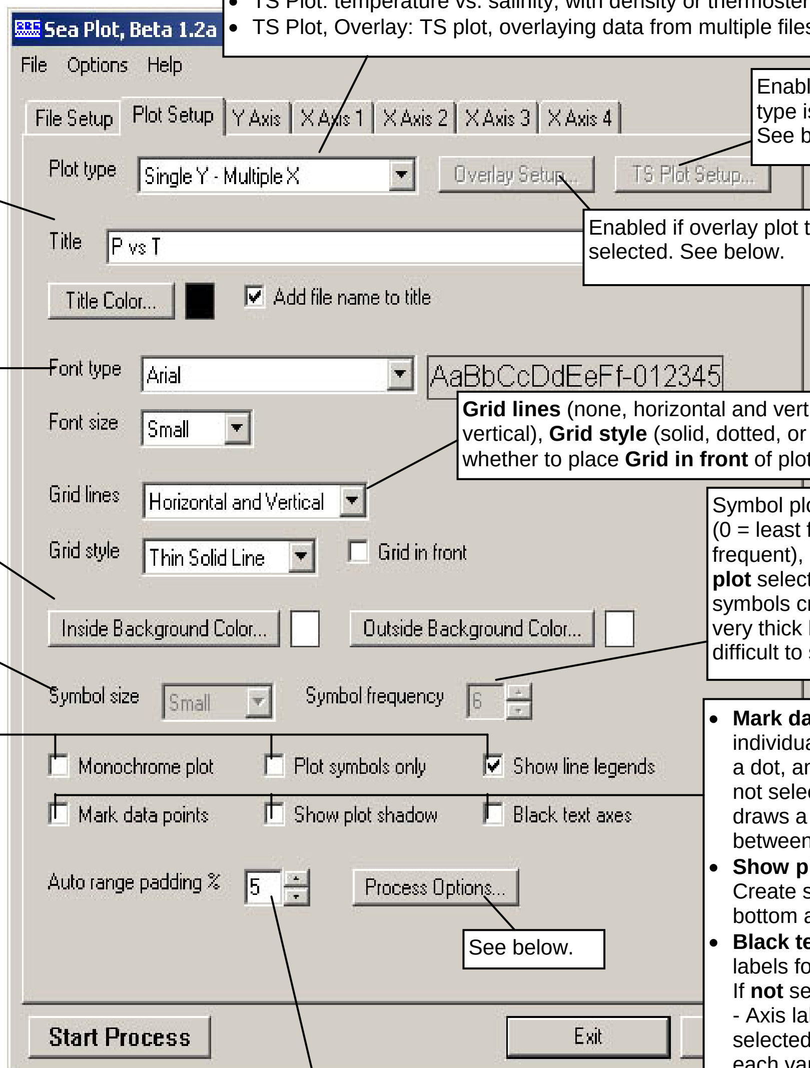
Return to SBE Data Processing window.
- If *Confirm Program Setup Change* selected in Options menu - If you made changes and did not Save or Save As, program asks if you want to save changes.
- If *Confirm Program Setup Change* not selected in Options menu - Button says **Save & Exit**. If you do not want to save changes, use Cancel button to exit.

SeaPlot Plot Setup Tab

The Plot Setup tab defines the plot type, scans to be included, and plot layout (title, color, font grid lines, etc.). The Plot Setup tab looks like this:

- Single X - Multiple Y: 1 X axis and up to 4 Y axes
- Single X - Multiple Y, Overlay: 1 X axis and up to 4 Y axes, overlaying data from multiple files on 1 plot
- Single Y - Multiple X: 1 Y axis and up to 4 X axes
- Single Y - Multiple X, Overlay: 1 Y axis and up to 4 X axes, overlaying data from multiple files on 1 plot
- TS Plot: temperature vs. salinity, with density or thermosteric anomaly contours
- TS Plot, Overlay: TS plot, overlaying data from multiple files on 1 plot

Plot **Title** and **Title color**. Select **Add file name to title** to add input data (.cnv) file name to title (for overlay plots, it adds *first* file name to title). For example, if you enter title as P vs T, select *Add file name to title*, and data file name is October1.cnv, title will be *P vs T, October 1.cnv*.



Enabled if TS plot type is selected. See below.

Enabled if overlay plot type is selected. See below.

Plot **Font type** and **Font size** (small, medium, or large). SeaPlot displays example of font type to right of selection. List of fonts depends on what fonts are installed on your computer.

Grid lines (none, horizontal and vertical, horizontal, or vertical), **Grid style** (solid, dotted, or dashed line), and whether to place **Grid in front** of plotted data.

Inside Background Color defines color within axes. **Outside Background Color** defines color outside axes.

Symbol plotting frequency (0 = least frequent, 9 = most frequent), if **Monochrome plot** selected. If too frequent, symbols create illusion of very thick line, making details difficult to see.

Size (small, medium, or large) of symbol for each variable, if **Monochrome plot** or **Plot symbols only** selected.

- **Monochrome plot**: Substitute black lines with symbols for colors (Colors and symbols are defined on Axis setup tabs for non-overlay plots. For overlay plots, click Overlay Setup button to define). Enables you to set up axes with colors for viewing on screen, and then switch to black lines with symbols for black and white printing.
- **Plot symbols only**: Mark each individual data point with a symbol, and do not connect symbols with a line (Symbols are defined on Axis setup tabs for non-overlay plots. For overlay plots, click Overlay Setup button to define).
- **Show line legends**: Show line legends below plot title. Legend indicates line color and type (for color plots) or line symbol and type (for monochrome plots). For overlay plots, legend indicates line color or symbol only for first file.

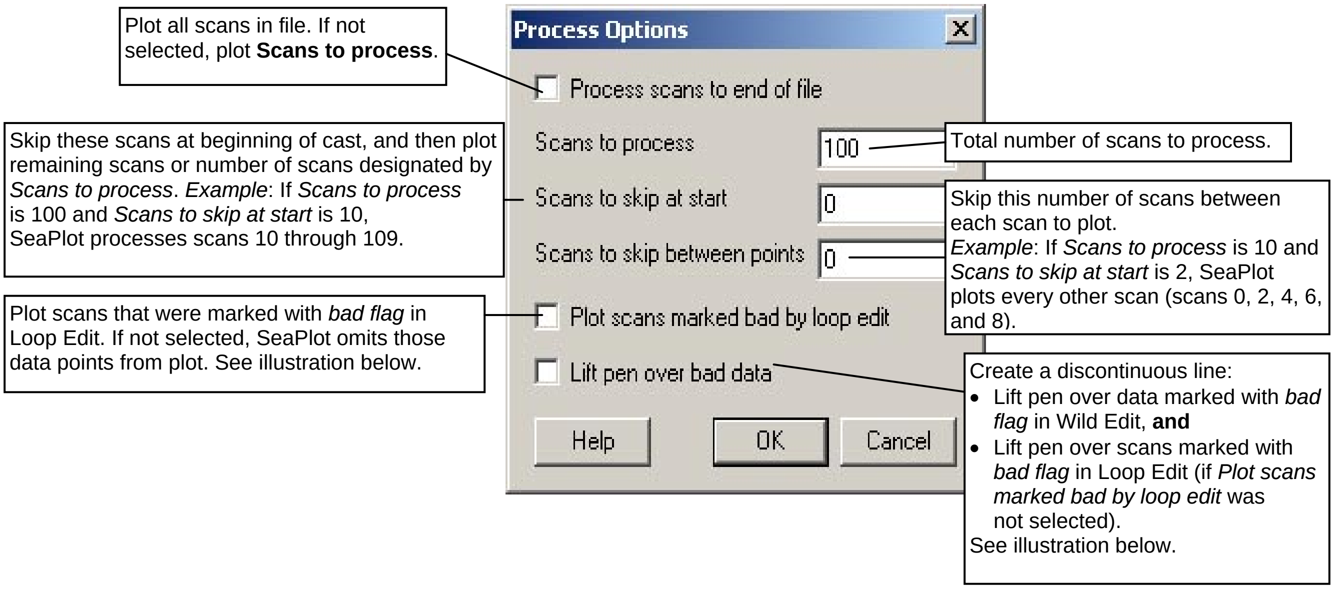
- **Mark data points**: Mark individual data points with a dot, and connect dots. If not selected, SeaPlot just draws a continuous line between data points.
- **Show plot shadow**: Create shadow effect to bottom and right of axes.
- **Black text axes** – Create labels for all axes in black. If **not** selected:
  - Axis label color matches selected plot color for each variable.
  - For overlay files, colors match colors for variables in *first* file.

See below.

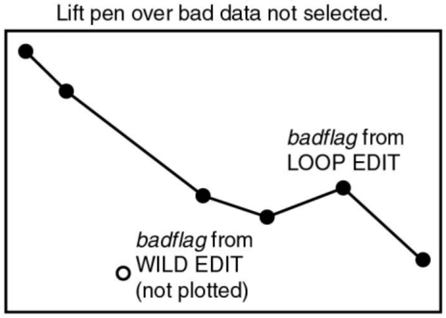
Define space between axes and maximum and minimum plotted values, if *Auto range* selected on Axis setup tabs. For 0%, maximum and minimum values plot on axes.

Process Options

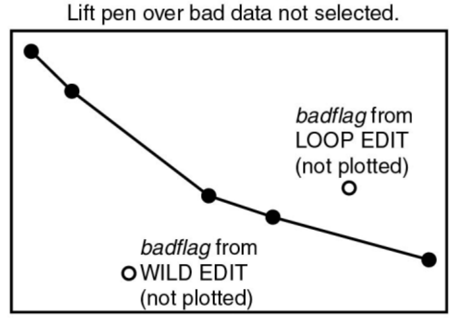
If the **Process Options** button is clicked on the Plot Setup tab, the following dialog box appears:



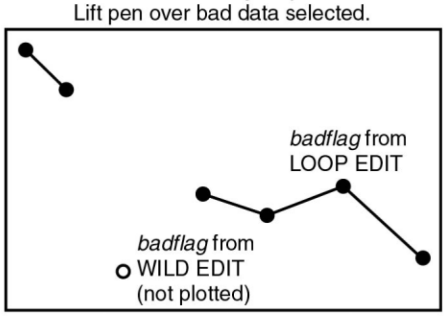
Plot scans marked bad by loop edit selected.
Lift pen over bad data not selected.



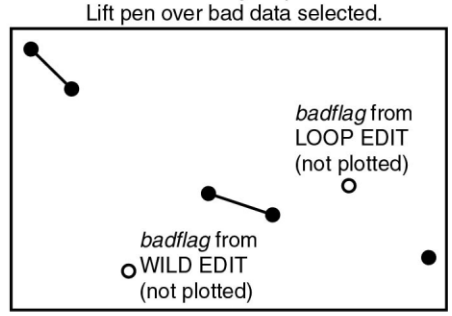
Plot scans marked bad by loop edit not selected.
Lift pen over bad data not selected.



Plot scans marked bad by loop edit selected.
Lift pen over bad data selected.

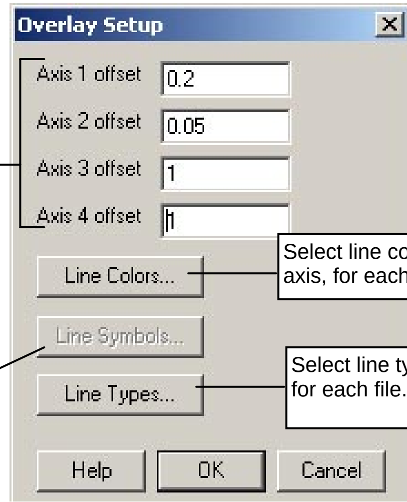


Plot scans marked bad by loop edit not selected.
Lift pen over bad data selected.



Overlay Setup

If an overlay plot type is selected on the Plot Setup tab, the **Overlay Setup** button is enabled. If clicked, the following dialog box appears:



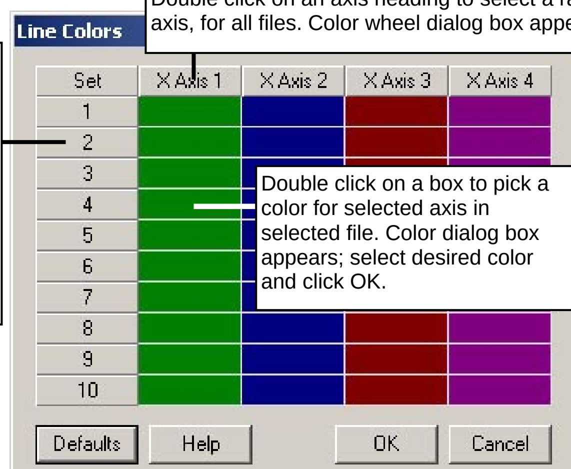
Axis offsets define distance to separate plot from each file, for each axis. Offset units match axis units. For example, if Axis 1 is temperature in °C, a 0.2 offset means that file 1 plots at actual data points, file 2 plots at 0.2 °C more than actual data points, file 3 plots at 0.4 °C more than actual data points, etc. This creates a *waterfall* effect and allows user to see changes in shape that would be difficult to see if plots were not offset from each other. ***Note:*** Axis offsets are not applicable for TS plots.

Select line colors for each axis, for each file. See below.

Select line symbols for each axis, for each file. Applicable if *Monochrome Plot* or *Plot symbols only* selected on Plot Setup tab. See below.

Select line types for each axis, for each file. See below.

Line Colors

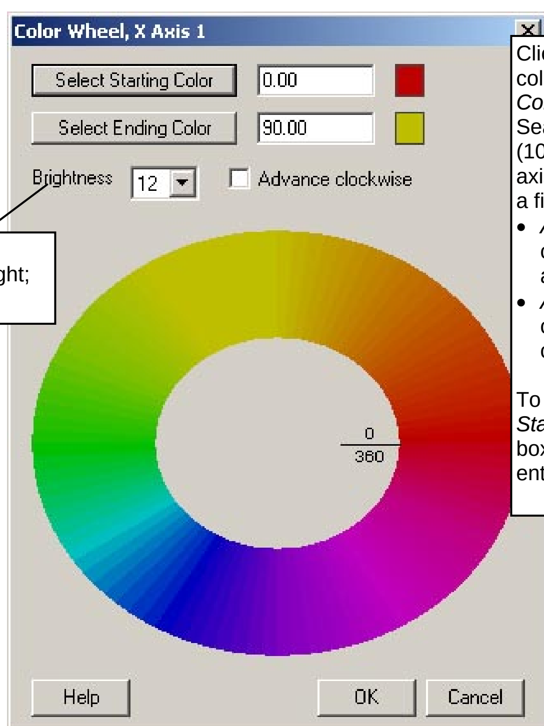


Double click on an axis heading to select a range of colors for that axis, for all files. Color wheel dialog box appears (see below).

Note:
If more than 10 files were selected on the File Setup tab, SeaPlot repeats the colors defined for files 1-10. For example, if 20 files were selected, files 1 and 11 have the same color, 2 and 12 have the same color, etc.

Double click on a file (*Set*) heading to select a range of colors for that file, for all axes. Color wheel dialog box appears (see below).

Double click on a box to pick a color for selected axis in selected file. Color dialog box appears; select desired color and click OK.



Select desired color brightness (1 = least bright; 15 = brightest).

Click *Select Starting Color* and click desired color in color wheel; then click *Select Ending Color* and click desired color in color wheel. SeaPlot calculates evenly spaced colors (10 evenly spaced colors if you selected an axis or 4 evenly spaced colors if you selected a file).

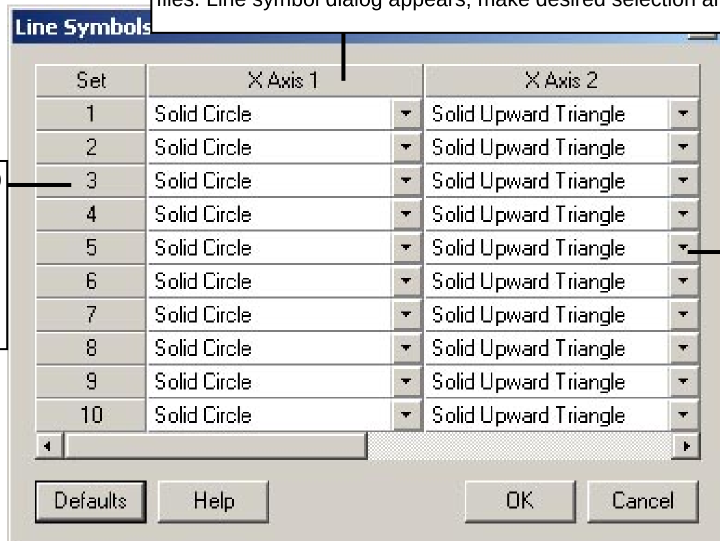
- *Advance clockwise* **not selected**: SeaPlot calculates colors moving counterclockwise around circle from starting to ending color.
- *Advance clockwise* **selected**: SeaPlot calculates colors moving clockwise around circle from starting to ending color.

To set 1 color for all selected lines, click *Select Starting Color* and enter desired color value in box; then tab to *Select Ending Color* box and enter same value again.

Line Symbols

Double click on axis heading to select same line symbol for that axis, for all files. Line symbol dialog appears; make desired selection and click OK.

Double click on file (*Set*) heading to select same line symbol for that file, for all axes. Line symbol dialog appears; make desired selection and click OK.



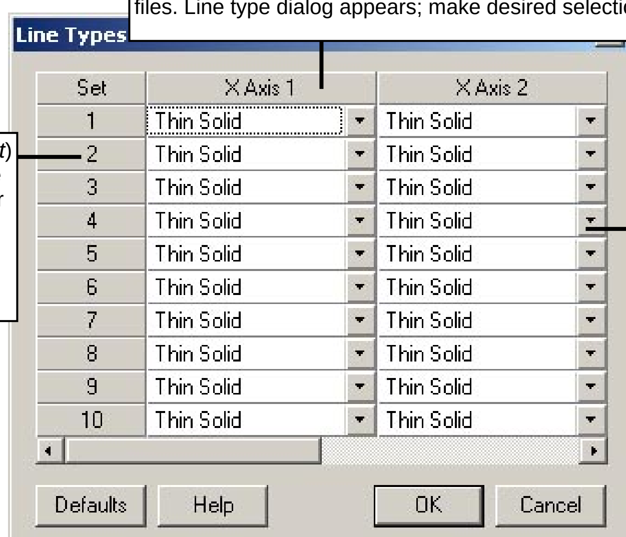
Pull down on box to pick line symbol for selected axis in selected file.

Note:
If more than 10 files were selected on the File Setup tab, SeaPlot repeats the line symbols and types defined for files 1-10. For example, if 20 files were selected, files 1 and 11 have the same line symbol and type, 2 and 12 have the same line symbol and type, etc.

Line Types

Double click on axis heading to select same line type for that axis, for all files. Line type dialog appears; make desired selection and click OK.

Double click on file (*Set*) heading to select same line type for that file, for all axes. Line type dialog appears; make desired selection and click OK.



Pull down on box to pick line type for selected axis in selected file.

TS Plot Setup

If a TS plot type is selected on the Plot Setup tab, the **TS Plot Setup** button is enabled. The TS Plot Setup defines the contour lines for the plot; the user selects from the following contour types:

- Density contours – SeaPlot calculates and plots sigma-t contours if temperature is plotted, or sigma-theta contours if potential temperature is plotted (see *Axis Setup Tabs* below for selection of temperature parameter).
- Thermosteric anomaly contours

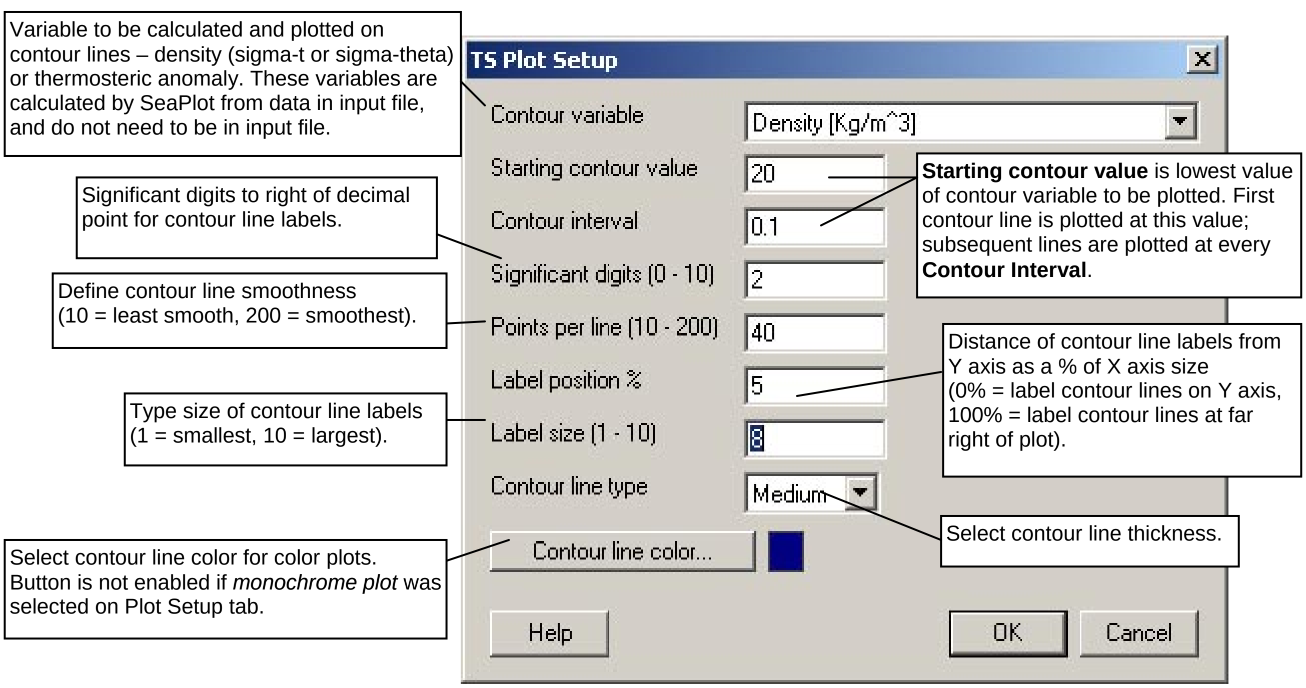
The units for the parameters in the input data file do not affect the contour calculations. For example, temperature could be in °C or °F, ITS-90 or ITS-68; SeaPlot performs the required conversions to calculate the contours.

The following table defines the required input parameters for various combinations of temperature, salinity, and contours:

To plot:	Input .cnv file must include:
temperature, salinity, density sigma-t **or** temperature, salinity, thermosteric anomaly	temperature, salinity
temperature, derived salinity, density sigma-t **or** temperature, derived salinity, thermosteric anomaly	temperature, conductivity, pressure
potential temperature, salinity, density sigma-theta **or** potential temperature, salinity, thermosteric anomaly	potential temperature, salinity
potential temperature, derived salinity, density sigma-t **or** potential temperature, derived salinity, thermosteric anomaly	potential temperature, temperature *, conductivity, pressure

*Derived salinity requires actual temperature in the input file. Potential temperature cannot be used in calculation of derived salinity.

If the TS Plot Setup button is clicked, the following dialog box appears:



SeaPlot Axis Setup Tabs

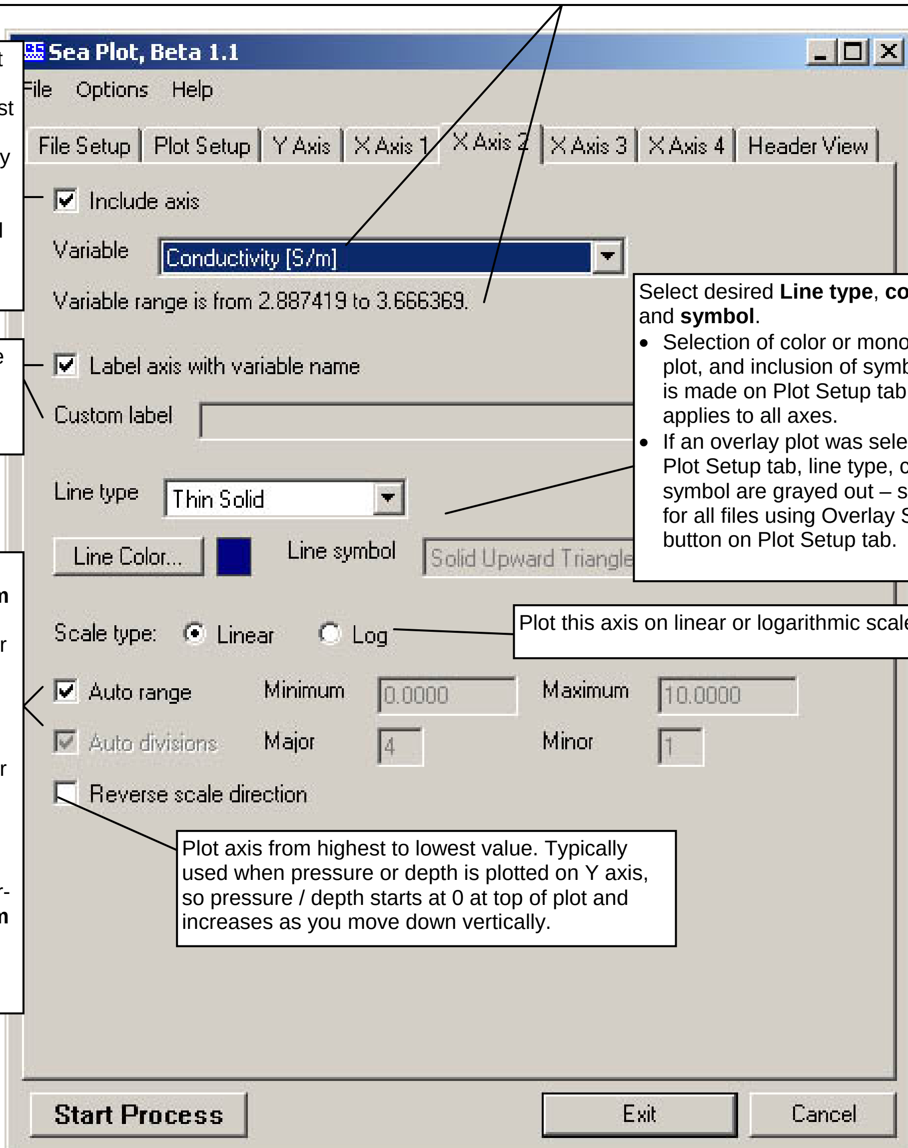
Each Axis Setup tab defines a plot variable, scale, and line type.

- Axis tabs are labeled X Axis and Y Axis if an X-Y plot was selected on the Plot Setup tab.
- Axis tabs are labeled Temperature and Salinity if a TS plot was selected on the Plot Setup tab.

X-Y Axis Setup Tabs

An Axis Setup tab looks like this for **X-Y** plots (X Axis 2 tab shown; other axis tabs are similar):

Drop down list includes all variables in data (.cnv) file. SeaPlot indicates range of data for selected variable, to assist setup of plot scale. **Range is full range of data in file(s)**, and does not reflect your selection of *Scans to process*, *Scans to skip at start*, *Scans to skip between points*, etc. in Process Options dialog box. If file contains data collected while instrument was in air, range reflects these values. If multiple files were selected on File Setup tab, range is lowest value in all files to highest value in all files. If selected variable is *derived salinity* or *derived density*, variable range shown is 0 to 0, because SeaPlot does not know derived salinity or density values until you click Start Process and it begins to calculate derived values.
Order in drop down list reflects order of variables in file. If file contains multiple occurrences of a variable (for example, you calculated salinity in Data Conversion and then again in Derive, after aligning and filtering data), list adds a suffix (1st, 2nd, 3rd, etc.) to variable name; do not confuse this with labeling for data from duplicate sensors (for example, *Salinity, 2 [PSU] 1st* is first occurrence in file of salinity calculated from secondary temperature and conductivity sensor data). Make sure to select desired variable for plotting.



Include this axis in plot. SeaPlot can plot up to 5 variables (1 Y and 4 X, or 1 X and 4 Y). At least 1 X and 1Y variable is required, so this selection is available only on Axis Setup tab for third, fourth, and fifth axis.
Note: If you deselect an axis, all axes numbered above that axis are automatically deselected.

Select to label axis with variable name as listed in drop down Variable list, or enter a **Custom label** for axis.

- **Auto range**: SeaPlot selects axis **Minimum** and **Maximum** values, number of **Major** divisions on axis, and number of **Minor** divisions between major divisions.
- **Auto divisions**: SeaPlot selects number of major divisions on axis, and number of minor divisions between major divisions. User selects axis **Minimum** and **Maximum** values.

Any values that fall outside user-selected **Minimum** to **Maximum** range will plot at minimum or maximum, as applicable.

Select desired **Line type**, **color**, and **symbol**.

- Selection of color or monochrome plot, and inclusion of symbols in plot, is made on Plot Setup tab, and applies to all axes.
- If an overlay plot was selected on Plot Setup tab, line type, color, and symbol are grayed out – select these for all files using Overlay Setup button on Plot Setup tab.

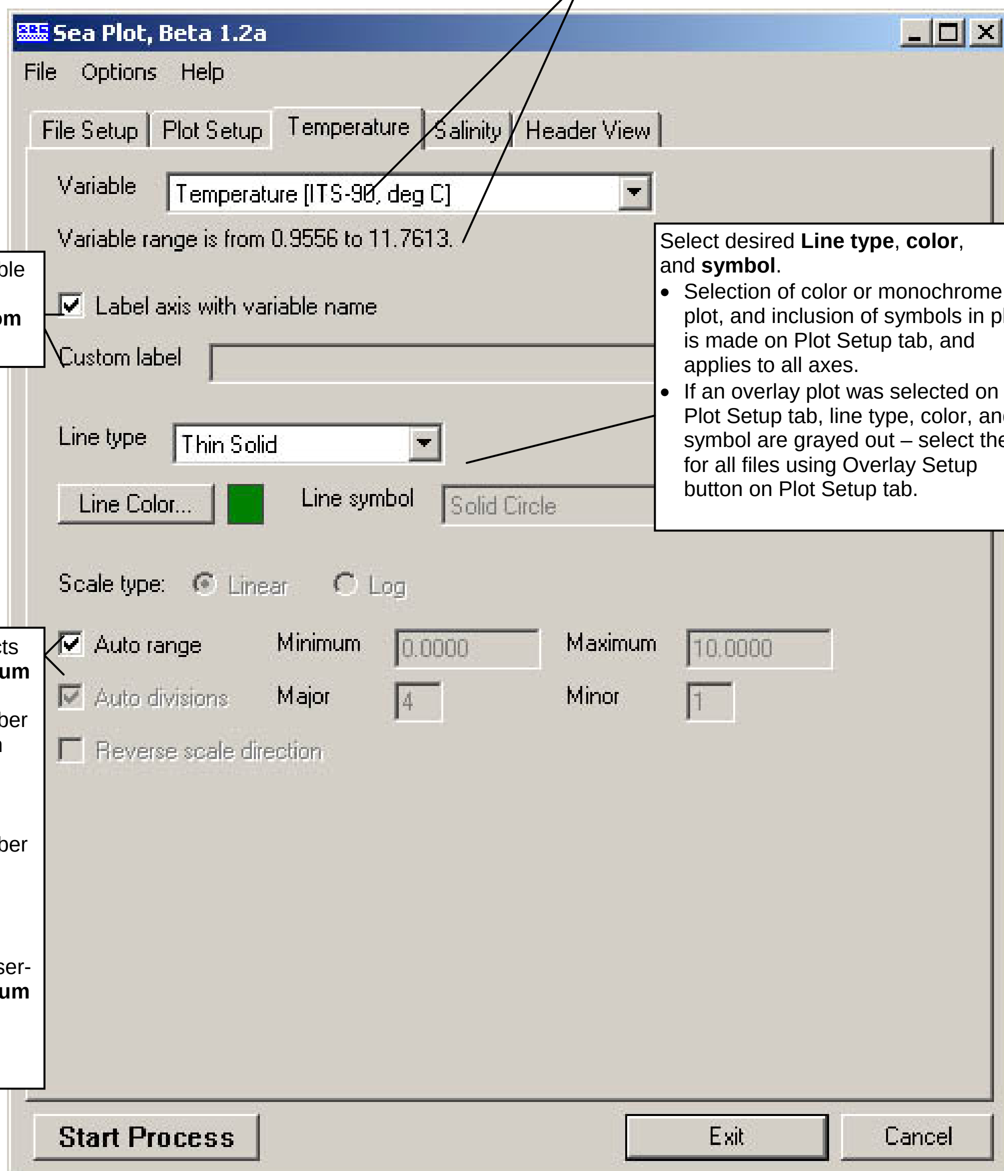
Plot this axis on linear or logarithmic scale.

Plot axis from highest to lowest value. Typically used when pressure or depth is plotted on Y axis, so pressure / depth starts at 0 at top of plot and increases as you move down vertically.

TS Plot Axis Setup Tabs

An Axis Setup tab looks like this for **TS plots** (Temperature axis tab shown; Salinity axis tab is similar):

Drop down list includes all applicable variables in data (.cnv) file - temperature and potential temperature (for Temperature tab) and salinity (for Salinity tab), as well as derived salinity (for Salinity tab). SeaPlot indicates range of data for selected variable, to assist you in setup of plot scale. **Range is full range of data in .cnv file(s)**, and does not reflect your selection of *Scans to process*, *Scans to skip at start*, *Scans to skip between points*, etc. in Process Options dialog box. If file contains data collected while instrument was in air, range reflects these values. If multiple files were selected on File Setup tab, range is lowest value in all files to highest value in all files. If selected variable (on Salinity tab) is *derived salinity*, variable range shown is 0 to 0, because SeaPlot does not know derived salinity values until you click Start Process and it begins to calculate derived values.
Order in drop down list reflects order of variables in file. If file contains multiple occurrences of a variable (for example, you calculated salinity in Data Conversion and then again in Derive, after aligning and filtering data), list adds a suffix (1^{st}, 2^{nd}, 3^{rd}, etc.) to variable name; do not confuse this with labeling for data from duplicate sensors (for example, *Salinity, 2 [PSU] 1^{st}* is first occurrence in file of salinity calculated from secondary temperature and conductivity sensor data). Make sure to select desired variable for plotting.



Select to label axis with variable name as listed in drop down Variable list, or enter a **Custom label** for axis.

Select desired **Line type**, **color**, and **symbol**.

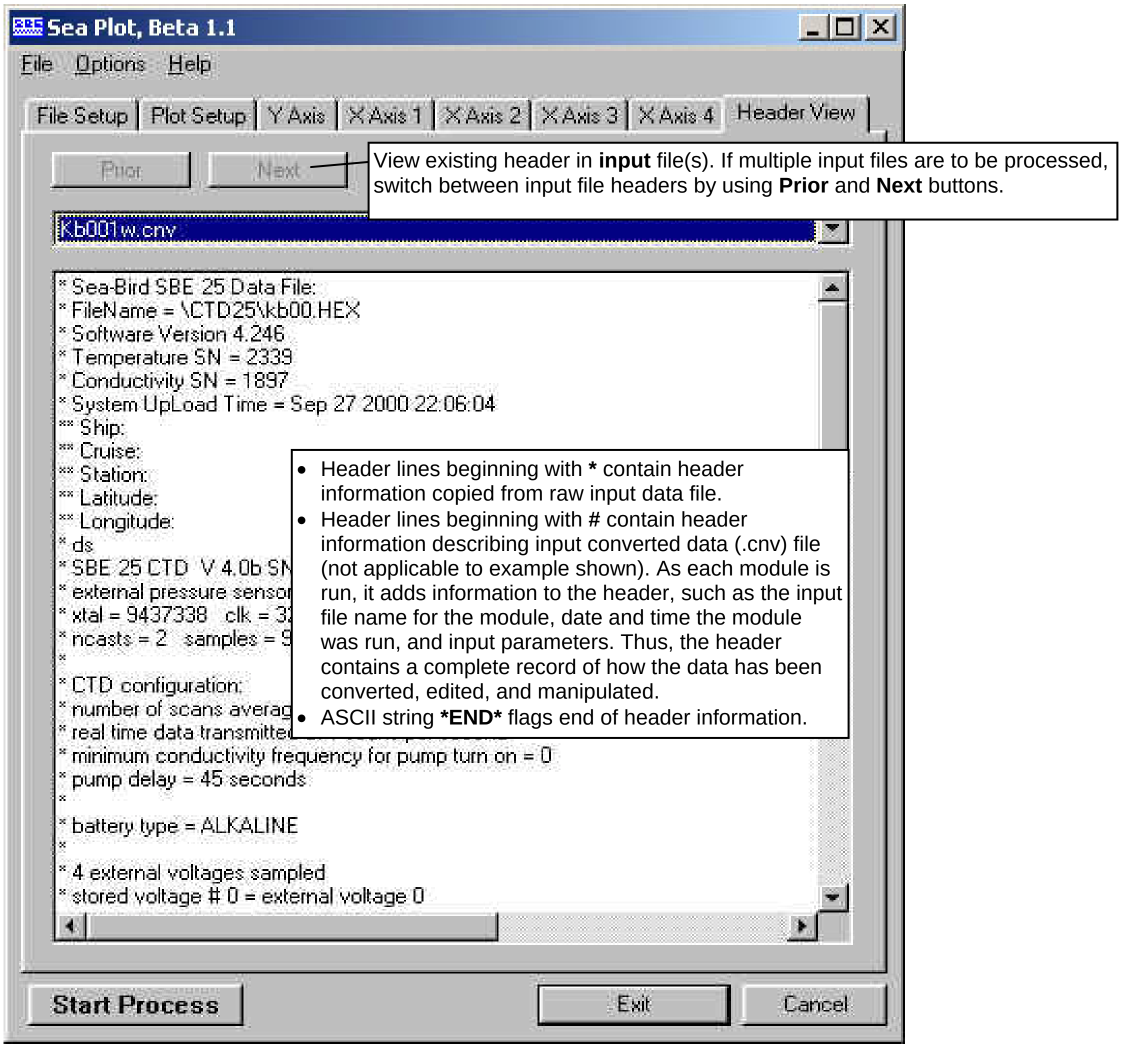
- Selection of color or monochrome plot, and inclusion of symbols in plot, is made on Plot Setup tab, and applies to all axes.
- If an overlay plot was selected on Plot Setup tab, line type, color, and symbol are grayed out – select these for all files using Overlay Setup button on Plot Setup tab.

- **Auto range**: SeaPlot selects axis **Minimum** and **Maximum** values, number of **Major** divisions on axis, and number of **Minor** divisions between major divisions.
- **Auto divisions**: SeaPlot selects number of major divisions on axis, and number of minor divisions between major divisions. User selects axis **Minimum** and **Maximum** values.

Any values that fall outside user-selected **Minimum** to **Maximum** range will plot at minimum or maximum, as applicable.

SeaPlot Header View Tab

The Header View tab allows you to view the existing header in the input file(s). The Header View tab looks like this:



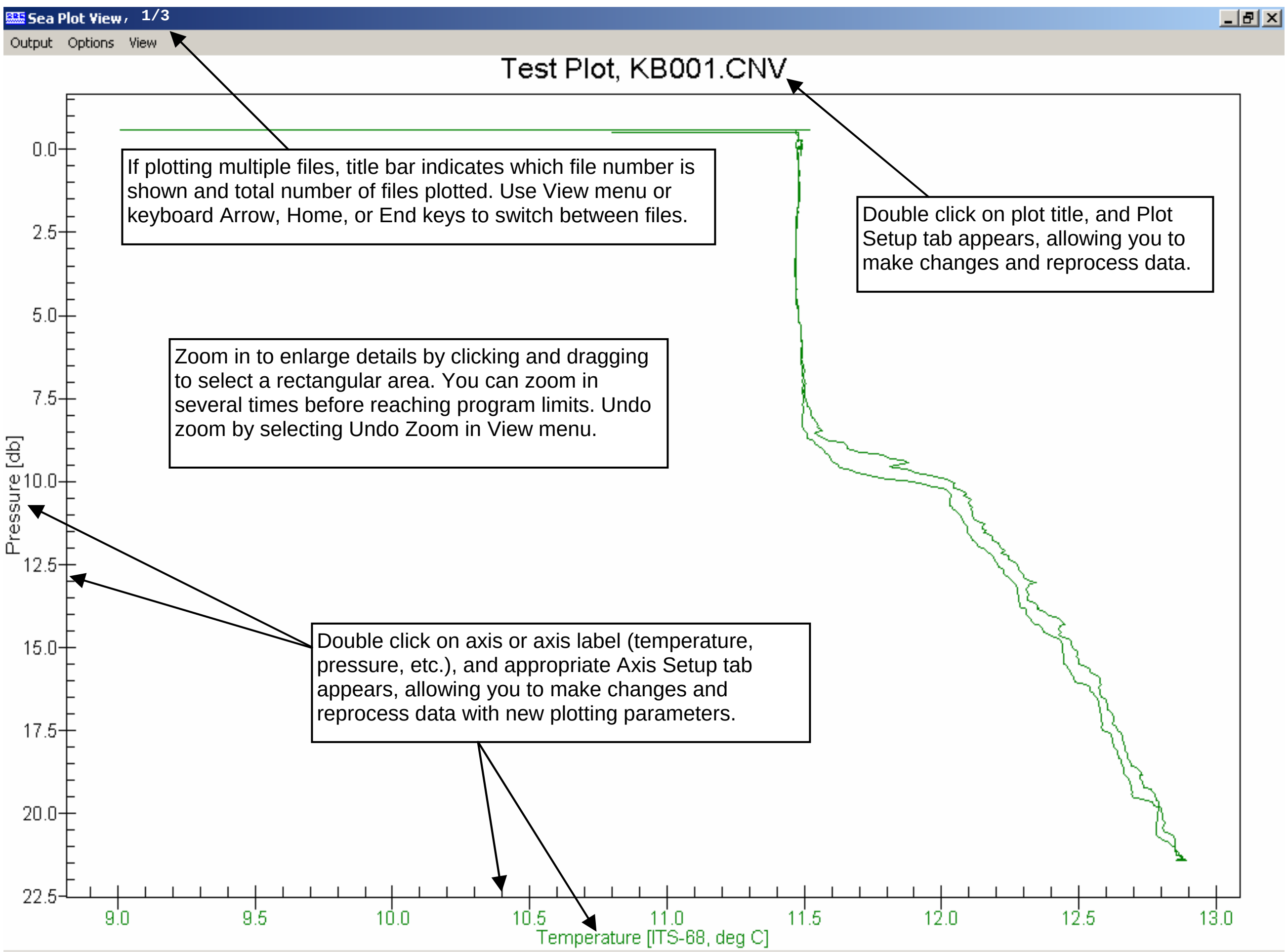
Viewing SeaPlot Plots

Shown below are three examples:

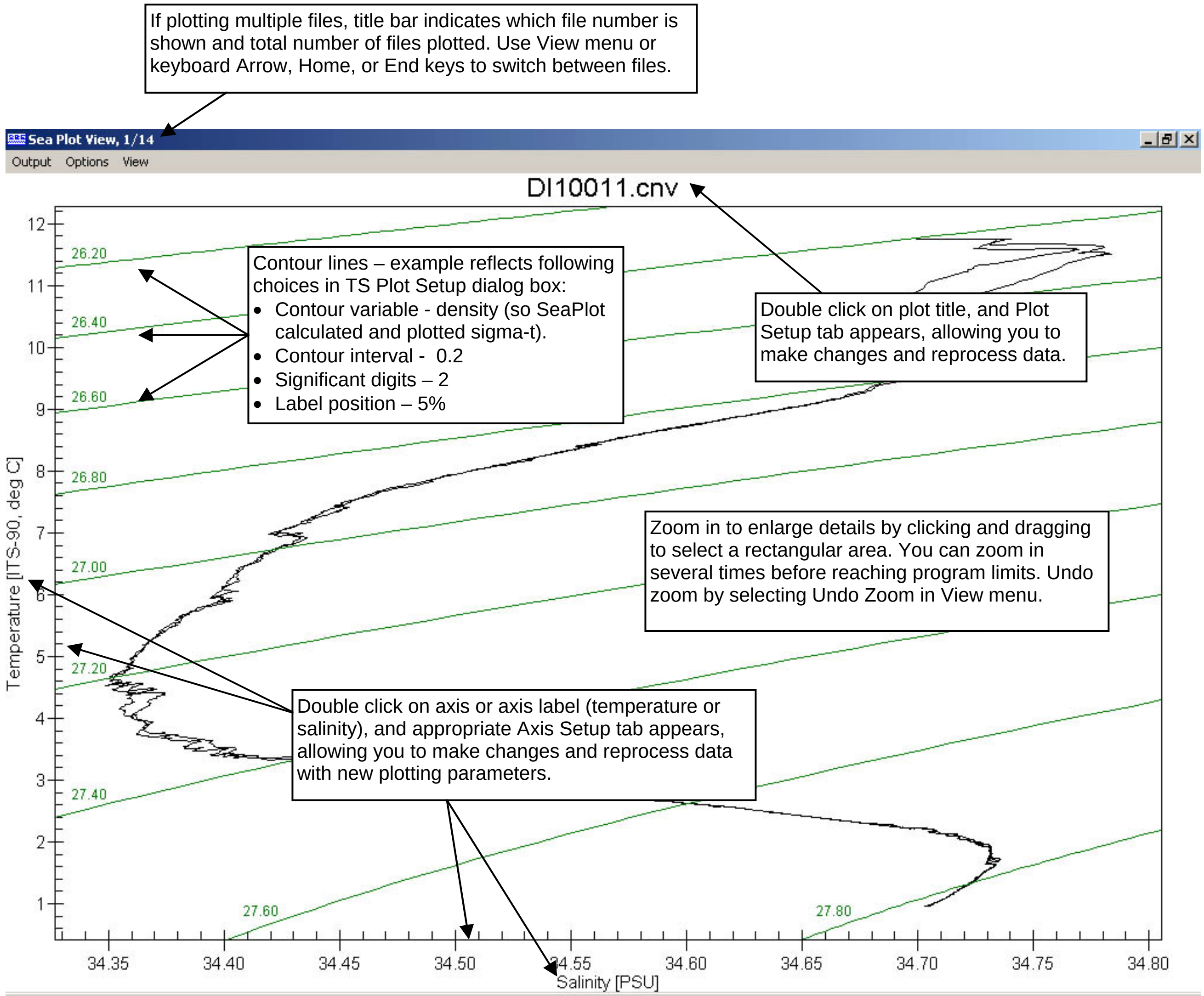
- Multiple X-Y plots, no overlay
- Multiple TS plots, no overlay
- X-Y overlay plot

Following the examples is a detailed description of the plot's menus.

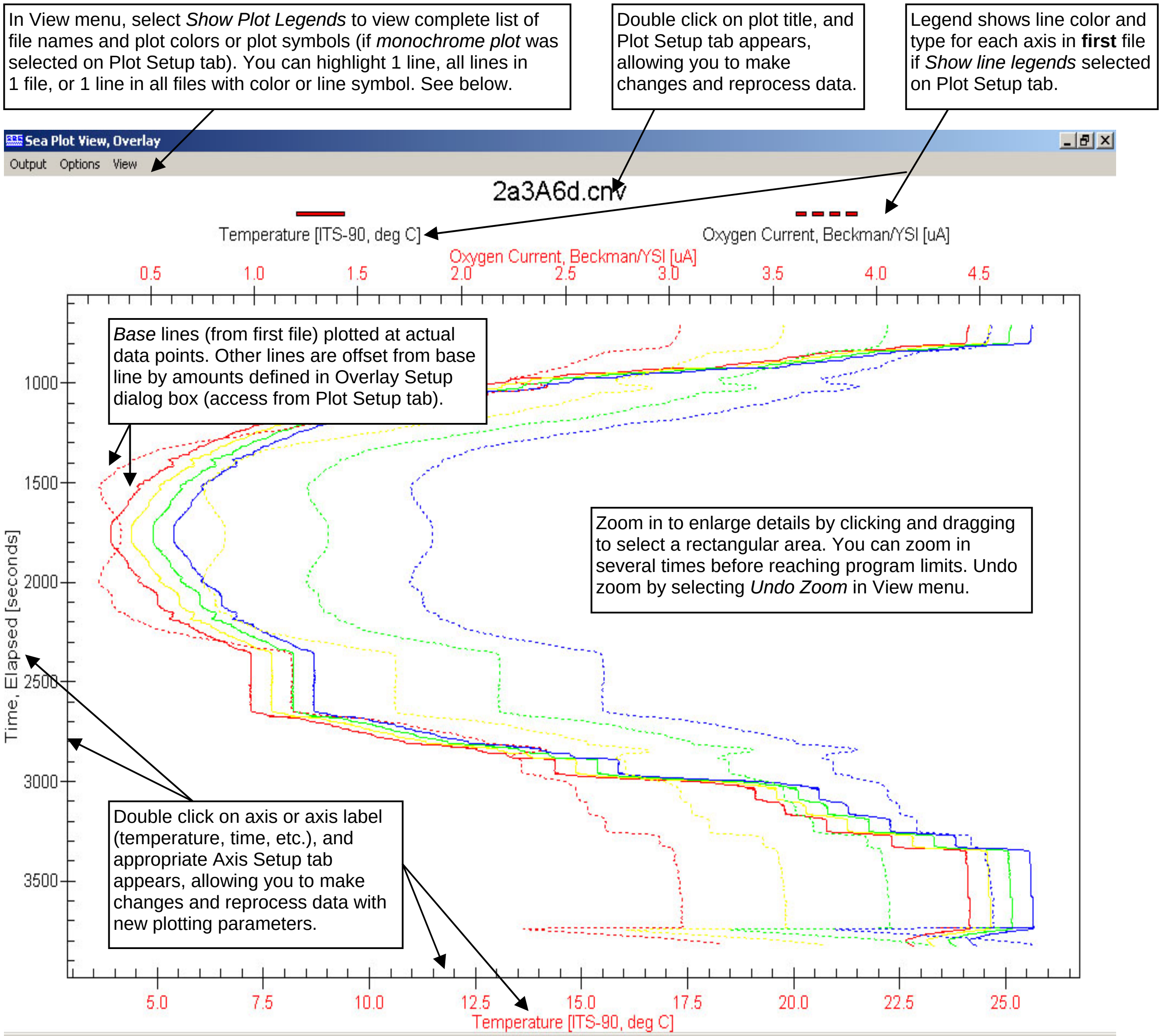
Multiple X-Y Plots, No Overlay



Multiple TS Plots, No Overlay

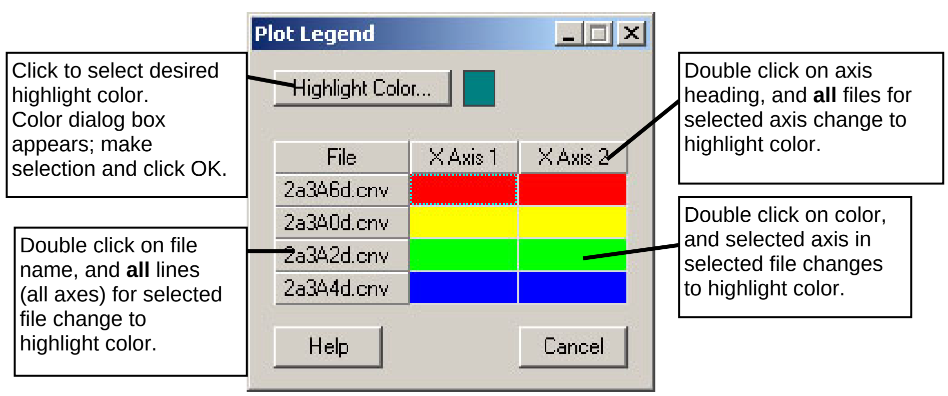


X-Y Overlay Plot



Note:
If *Monochrome plot* or *Plot symbols only* were selected on the Plot Setup tab, the Plot Legend dialog box shows each line symbol instead of each line color, and provides for user selection of a highlight symbol instead of a highlight color.

If you select *Show Plot Legend* in the View menu, the Plot Legend dialog box shows the color for each line in each file, and allows you to apply a highlight color to a selected line or lines. The dialog box looks like this:



With the highlight color applied, you can view the plot on screen and output to the printer, file, or clipboard. When you click Cancel in the Plot Legend dialog box, the colors return to what they were before you applied the highlight.

Plot Menus

The SeaPlot View window's menus are described below:

Output - Directs SeaPlot to output plot now to printer, clipboard, or a file. If multiple files are plotted (but not as an overlay), you can output plot shown on screen or plots for all files. How plot is output (size, file type, etc.) is controlled by Options menu.

Options - Sets up how plot is output to printer, clipboard, or a file.

- *Print* -
  - Orientation – landscape, portrait, or print driver default
  - Print full page - scale plot to fit 8 1/2 x 11 inch page. If not selected, Size determined by -
    SeaPlot View Dimensions - dimensions of plot as shown on screen
    File Setup tab entries - entries on File Setup tab for Width and Height
    Values Entered Below - dimensions entered in dialog box (in mm)
- *File* -
  - Data format - Metafile (.wmf), Jpeg (.jpg), or Bitmap (.bmp)
  - Size determined by
    SeaPlot View Dimensions - dimensions of plot as shown on screen
    File Setup tab entries - entries on File Setup tab for Width and Height
    Values Entered Below - dimensions entered in dialog box (in mm)
- *Clipboard* -
  - Data format - Metafile (.wmf), Jpeg (.jpg), or Bitmap (.bmp)
  - Size determined by -
    SeaPlot View Dimensions - dimensions of plot as shown on screen
    File Setup tab entries - entries on File Setup tab for Width and Height
    Values Entered Below - dimensions entered in dialog box (in mm)

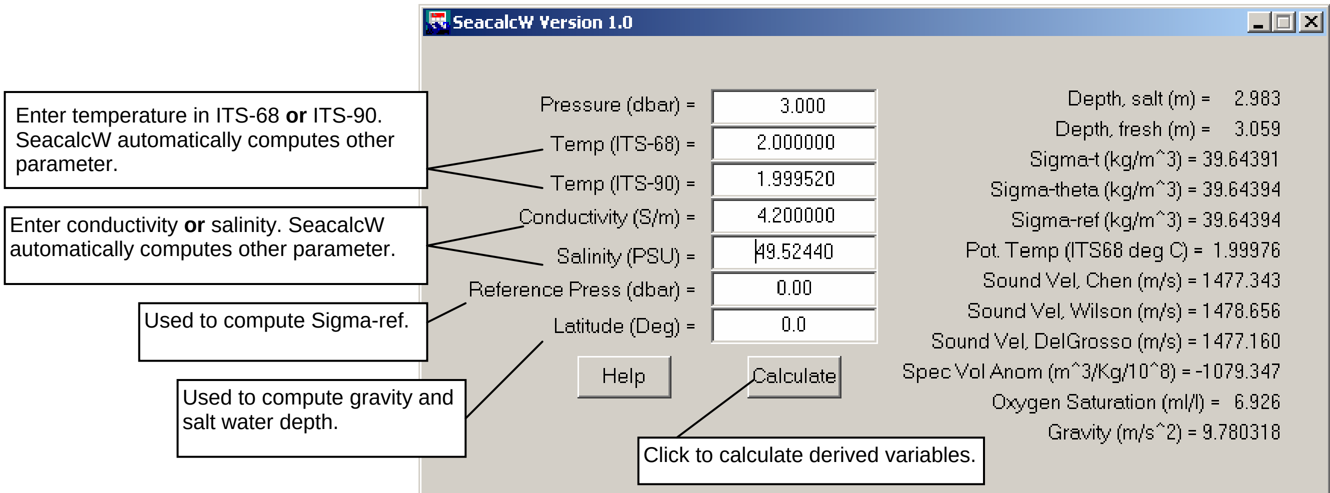
View – Sets up viewing options.

- *Show cursor position* – Directs SeaPlot to show the coordinates of the cursor as you move the cursor around when viewing a plot.
- *Next Plot*, *Prior Plot* – Directs SeaPlot to switch between plots, if you selected multiple files on File Setup tab but are not doing an overlay plot.
- *File name* – Lists, and allows you to select from, all input files, if you selected multiple files on File Setup tab but are not doing an overlay plot.
- *Show plot legends* – For overlay plots only, allows you to view a complete list of file names and plot colors or plot symbols (if monochrome plot was selected on Plot Setup tab).
- *Undo Zoom* – Directs SeaPlot to return plot to original ranges specified on Axis Setup tabs. *Undo Zoom* is grayed out unless you have zoomed in (by clicking and dragging to select a rectangular area) to enlarge details.
- *Set Zoomed Ranges* – Directs SeaPlot to substitute current zoomed ranges of plot for Minimum and Maximum plot ranges on Axis Setup tabs. This gives you ability to save ranges of zoomed view, so you can go to exactly same view next time you run SeaPlot. *Set Zoomed Ranges* is grayed out unless you have zoomed in (by clicking and dragging to select a rectangular area) to enlarge details.

Section 9: Miscellaneous Module – SeacalcW

SeacalcW is a seawater calculator that computes a number of derived variables from one user-input scan of temperature, pressure, etc.

The dialog box looks like this:



SeacalcW *remembers* whether the user last changed conductivity or salinity, and calculates other parameters based on this. For example, if you change conductivity, salinity is recalculated; if you then change temperature, salinity is recalculated again (based on the input conductivity and temperature). Conversely, if you change salinity, conductivity is recalculated; if you then change temperature, conductivity is recalculated again (based on the input salinity and temperature).

See *Appendix V: Derived Parameter Formulas* for formulas used by SeacalcW.

Appendix I: Command Line Options, Command Line Operation, and Batch File Processing

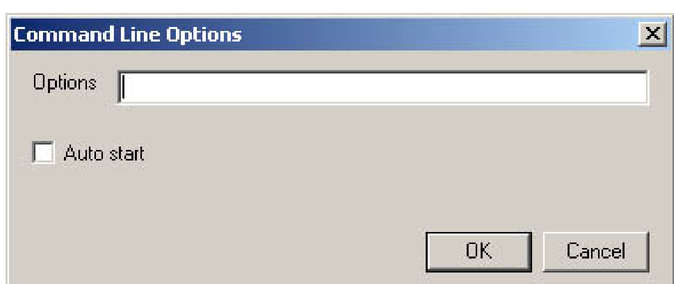
Command Line Options

Notes:
- The default program setup (.psa) file is the last saved .psa file for the module. PostProcSuite.ini, located in the Windows directory, contains the location and file name of the last saved .psa file for each module.
- Previous versions (5.30a and earlier) of SBE Data Processing used program setup files with a .psu extension instead of a .psa extension. Program setup files with a .psa extension can be opened, viewed, and modified in any text editor or XML editor. SBE Data Processing can still use your existing .psu files. However, if you make any changes to the setup (for example, change output variables), SBE Data Processing will save the changes to a new .psa file.

Command line options can be used to assist in automating processing, by overriding information in an existing program setup (.psa) file or designating a different .psa file.

Access the Command Line Options dialog box by selecting Command Line Options in the SBE Data Processing window's Run menu:

The Command Line Options dialog box looks like this:



The option parameters are:

Parameter	Description
/cString	Use String as instrument configuration (.con) file. String must include full path **and** file name. **Note**: If using this parameter, you must also specify input file name (using /iString).
/iString	Use String as input file name. String must include full path **and** file name. The /iString option supports standard wildcard expansion: • ? matches any single character in specified position within file name or extension. • * matches any set of characters starting at specified position within file name or extension and continuing until end of file name or extension or another specified character.
/oString	Use String as output directory (not including file name).
/fString	Use String as output file name (not including directory).
/aString	Append String to output file name (before extension).
/pString	Use String as Program Setup (.psa) file. String must include full path **and** file name.
/xModule: String	Use String to define an additional parameter to pass to Module. Not all modules have x parameters; see module descriptions. If specifying multiple x parameters, enclose in double quotes and separate with a space; do not specify x parameter more than once. *Example*: Run Data Conversion, telling it to skip first 1000 scans, and also run Window Filter, telling it to output difference between original and filtered value: /x“datcnv:skip1000 wfilter:diff” *Correct* /xdatcnv:skip1000 /xwfilter:diff *Incorrect*

If specifying multiple parameters, insert one or more spaces or tabs between each parameter in the list.

Example: You set up and saved .psa files for Filter, Loop Edit, Bin Average, and Derive within each module’s dialog box, and ran each module successively. The input and output file names in all the .psa files were the same - c:/1st/test.cnv (this has the effect of overwriting the module input with the module output).
You now want to run each process again, using a different input and output file - c:\2nd\test1.cnv. You enter the following in SBE Data Processing’s Command Line Options dialog box:

```
/ic:\2nd\test1.cnv  /ftest1.cnv  /oc:\2nd
```

When you pull down on the Run menu and select Filter, you see in the Filter dialog box that the program substituted c:\2nd\test1.cnv for c:\1st\test.cnv as the input data and output data path and file. Similarly, test1.cnv is shown as the input and output data file in all the modules. You can run each process rapidly in succession, without needing to enter the new path and file name individually in each module.

Note:
If you do not select Auto Start, when you select a module the module dialog box appears, allowing you to review the selected input files and data setup before beginning processing.

***Auto Start** (for running a module)*

Select this and then select the desired module to have SBE Data Processing *automatically* run the module with the last saved setup parameters (defined by the .psa file) and any entered Command Line Options.

- If you select Auto Start, a *Run Minimized* selection box appears. If selected, SBE Data Processing minimizes its window while processing the data, allowing you to do other work on the computer. When processing is complete, the SBE Data Processing window reappears.

Command Line Operation

The following modules can be run from the command line (default location for files is c:/Program Files/Sea-Bird/SBEDataProcessing-Win32):

Module	Executable File Name
Align CTD	AlignCTDW.exe
ASCII In	ASCII_InW.exe
ASCII Out	ASCII_OutW.exe
Bin Average	BinAvgW.exe
Bottle Summary	BottleSumW.exe *
Buoyancy	BuoyancyW.exe
Cell Thermal Mass	CellTMW.exe
Data Conversion	DatCnvW.exe
Derive	DeriveW.exe
Filter	FilterW.exe
Loop Edit	LoopEditW.exe
Mark Scan	MarkScanW.exe
SeacalcW	SeacalcW.exe
SeaPlot	SeaPlotW.exe
Section	SectionW.exe
Split	SplitW.exe
Strip	StripW.exe
Translate	TransW.exe
Wild Edit	WildEditW.exe
Window Filter	W_FilterW.exe

* Bottle Summary's executable file name was previously RosSumW.exe. BottleSumW.exe will run if BottleSumW.exe **or** RosSumW.exe is typed on command line.

Notes:
- The default program setup (.psa) file, used when running a module from the command line, is the last saved .psa file for the module. PostProcSuite.ini, located in the Windows directory, contains a list of the location and file name of the last saved .psa file for each module.
- Previous versions (5.30a and earlier) of SBE Data Processing used program setup files with a .psu extension instead of a .psa extension. Program setup files with a .psa extension can be opened, viewed, and modified in any text editor or XML editor. SBE Data Processing can still use your existing .psu files. However, if you make any changes to the setup (for example, change output variables), SBE Data Processing will save the changes to a new .psa file.

Command line parameters can be used to override existing information in the .psa file. The command line parameters are:

Parameter	Description
/cString	Use String as instrument configuration (.con) file. String must include full path **and** file name. **Note**: If using /cString, must also specify input file name (using /iString).
/iString	Use String as input file name. String must include full path **and** file name. This parameter supports standard wildcard expansion: • ? matches any single character in specified position within file name or extension • * matches any set of characters starting at specified position within file name or extension and continuing until end of file name or extension or another specified character
/oString	Use String as output directory (not including file name).
/fString	Use String as output file name (not including directory).
/aString	Append String to output file name (before file name extension).
/pString	Use String as Program Setup (.psa) file. String must include full path **and** file name.
/xModule: String	Use String to define an additional parameter to pass to Module. Not all modules have x parameters; see module descriptions. If specifying multiple x parameters, enclose in double quotes and separate with a space. *Example*: Run Data Conversion from command line, telling it to skip first 1000 scans: datcnvw.exe /xdatcnv:skip1000
/s	Start processing now.

If specifying multiple parameters, insert one or more spaces or tabs between each parameter in the list.

Example: The specified input file directory contains test.dat, test1.dat, and test2.dat. Select Run in the Windows Start menu. The Run dialog box appears.

> **Note:**
> If you have not modified your autoexec.bat file to put the .exe files in the path statement, specify the full path of the .exe file in the Run dialog box.

For the command line shown (datcnvw.exe /itest*.dat /s), SBE Data Processing will process test.dat, test1.dat, and test2.dat using Data Conversion. If the ? wildcard symbol is used (datcnvw /itest?.dat) instead of the *, Data Conversion will process only test1.dat and test2.dat.

Batch File Processing

> **Note:**
> A duplicate copy of SBEBatch.exe is placed in the Windows folder when SBE Data Processing is installed. This allows the user to run SBEBatch.exe from anywhere, without having to specify its path.

Traditional DOS batch file processing cannot be used with the 32-bit processing modules because Win 95/98/NT/2000/XP will start the second process before the first process is finished. The program SBEBatch.exe (default location c:/Program Files/Sea-Bird/SBEDataProcessing-Win32) or the Windows Scripting Host can be used to process a batch file to automate data processing tasks. The format for SBEBatch is:

sbebatch filename parameters

The parameters are referenced in the batch file in the same way as the DOS batch file, using the percent sign (%) followed by numbers 1 through 9. %1 in the batch file is replaced by the first command line parameter, %2 in the batch file is replaced by the second command line parameter, and so on until %9.

> **Note:**
> SBEBatch can also launch system commands, such as copying or renaming a file, deleting a file from an intermediate step, etc. Additionally, it can launch non-Sea-Bird programs, such as Word Pad. If you call a program that does not run and then shut down automatically, such as Word Pad, you must manually close the program before batch processing will continue to the next step.

Each line in the batch file contains the process name followed by command line arguments. The process names are:

Module	Process Name
Align CTD	Alignctd
ASCII In	Asciiin
ASCII Out	Asciiout
Bin Average	Binavg
Bottle Summary	Bottlesum *
Buoyancy	Buoyancy
Cell Thermal Mass	Celltm
Data Conversion	Datcnv
Derive	Derive
Filter	Filter
Loop Edit	Loopedit
Mark Scan	Markscan
SeaPlot	Seaplot
Section	Section
Split	Split
Strip	Strip
Translate	Trans
Wild Edit	Wildedit
Window Filter	Wfilter

* Bottle Summary's process name was previously Rossum. Bottlesum will run if Bottlesum **or** Rossum is used in the batch file.

The batch file can also contain comment lines to document the file purpose. Any line beginning with **@** is a comment line, and does not affect the results.

Notes:
- The default program setup (.psa) file is the last saved .psa file for the module. PostProcSuite.ini, located in the Windows directory, contains a list of the location and file name of the last saved .psa file for each module.
- Previous versions (5.30a and earlier) of SBE Data Processing used program setup files with a .psu extension instead of a .psa extension. Program setup files with a .psa extension can be opened, viewed, and modified in any text editor or XML editor. SBE Data Processing can still use your existing .psu files. However, if you make any changes to the setup (for example, change output variables), SBE Data Processing will save the changes to a new .psa file.

Parameters specified **in the batch file** can be used to override existing information in the .psa file. These parameters are:

Parameter	Description
/cString	Use String as instrument configuration (.con) file. String must include full path **and** file name. **Note**: If using /cString, must also specify input file name (using /iString).
/iString	Use String as input file name. String must include full path **and** file name. This parameter supports standard wildcard expansion: • ? matches any single character in specified position within file name or extension • * matches any set of characters starting at specified position within file name or extension and continuing until the end of file name or extension or another specified character
/oString	Use String as output directory (not including file name).
/fString	Use String as output file name (not including directory).
/aString	Append String to output file name (before extension).
/pString	Use String as Program Setup (.psa) file. String must include full path **and** file name.
/xModule: String	Use String to define an additional parameter to pass to Module. Not all modules have x parameters; see module descriptions. If specifying multiple x parameters, enclose in double quotes and separate with a space. *Example*: Run Data Conversion, telling it to skip first 1000 scans: /xdatcnv:skip1000
/w	Wait for user input at start of Module, allowing user to review setup before processing data for a particular Module. After reviewing setup, user clicks *Start Process* in Module dialog box to continue.
/d	Pause processing data at end of Module, allowing user to review output from a particular Module before continuing with rest of processing.

If specifying multiple parameters, insert one or more spaces or tabs between each parameter in the list.

Parameters specified **on the Run line** can also be used to control the process:

#m	Minimize SBE Data Processing window while processing data, allowing you to do other work on computer.
#w	Wait for user input at start of **each** Module, allowing user to review setup before processing data for each Module. After reviewing setup, user clicks *Start Process* in Module dialog box to continue.
#d	Pause processing data at end of **each** Module, allowing user to review output from each Module before continuing with rest of processing.

Note:
For SeaPlot, enter the desired choices in the File Setup, Plot Setup, and Axis Setup tabs.

To process data using a batch file:

1. Run each software module, entering the desired choices in the File Setup and Data Setup dialog boxes. Upon completing setup, press Save or Save As on the File Setup tab. The configuration is stored in the Program Setup File (.psa).

2. Create a batch file to process the data.

Following are two examples of typical batch files.

Example 1 – Process Single File, and Save All Intermediate Files

The data file is c:\leg1\cast5.dat, and the .con file is c:\leg1\cast5.con.

1. Set up each software module, entering desired choices in Setup dialog boxes. In the File Setup dialog boxes, delete the output file name (this allows program to base output file name on input file name and any appended text), and set the output file path as c:\leg1.

2. Create a batch file named prcast.txt in c:\leg1, which contains:
   ```
   @ Lines starting with @ are comment lines
   @ Comment lines have no effect on the result
   datcnv  /ic:\leg1\%1.dat  /cc:\leg1\%1.con  /a%2
   wildedit  /ic:\leg1\%1%2.cnv  /as1
   filter  /ic:\leg1\%1%2s1.cnv  /as2
   loopedit  /ic:\leg1\%1%2s1s2.cnv  /as3
   derive  /ic:\leg1\%1%2s1s2s3.cnv  /cc:\leg1\%1.con  /as4
   seaplot  /ic:\leg1\%1%2s1s2s3s4.cnv
   ```
   Module names and options are separated by one or more spaces or tabs.

3. Select Run in the Windows Start menu. The Run dialog box appears.

4. Type in the program name and parameters as shown:
   sbebatch c:\leg1\prcast.txt cast5 test1
   (batch filename is c:\leg1\prcast1.txt; parameter %1 is cast5; parameter %2 is test1)

5. The data is processed as follows (all input and output files are in c:\leg1):

Module	Input File(s)	Output File
Data Conversion (datcnv)	cast5.dat cast5.con	cast5test1.cnv
Wild Edit (wildedit)	cast5test1.cnv	cast5test1s1.cnv
Filter (filter)	cast5test1s1.cnv	cast5test1s1s2.cnv
Loop Edit (loopedit)	cast5test1s1s2.cnv	cast5test1s1s2s3.cnv
Derive (derive)	cast5test1s1s2s3.cnv cast5.con	cast5test1s1s2s3s4.cnv
SeaPlot (seaplot)	cast5test1s1s2s3s4.cnv	cast5test1s1s2s3s4.jpg (if File Setup tab was set to output to jpeg)

Example 2 – Process Several Files, and Overwrite All Intermediate Files

Process all data files in c:\leg1. The data files are c:\leg1\cast1.dat and c:\leg1\cast2.dat, and the .con file is c:\leg1\cast.con.

1. Set up each software module, entering desired choices in Setup dialog boxes. In the File Setup dialog boxes, delete the output file name (this allows program to base output file name on input file name and any appended text). Set the output file path as c:\leg1.

2. Create a batch file named prallcasts.txt in c:\leg1, which contains:
   ```
   @ Lines starting with @ are comment lines
   @ Comment lines have no effect on the result
   datcnv  /i%1\*.dat  /c%1\cast.con  /o%1
   wildedit  /i%1\*.cnv  /o1%
   filter  /i%1\*.cnv  /o1%
   loopedit  /i%1\*.cnv  /o1%
   binavg  /i%1\*.cnv  /aavg  /o%1
   derive  /i%1\*avg.cnv  /c%1\cast.con  /o%1
   seaplot  /i%1\*.cnv
   ```
   Module names and options are separated by one or more spaces or tabs.

3. Select Run in the Windows Start menu. The Run dialog box appears.

4. Type in the program name and parameters as shown:
   sbebatch c:\leg1\prallcasts.txt c:\leg1
   (batch filename is c:\leg1\prallcasts.txt; parameter %1 is c:\leg1)

5. The data is processed as follows (all input and output files are in c:\leg1):

Module	Input File(s)	Output File
Data Conversion (datcnv)	cast1.dat cast2.dat cast.con	cast1.cnv cast2.cnv
Wild Edit (wildedit)	cast1.cnv cast2.cnv	cast1.cnv cast2.cnv
Filter (filter)	cast1.cnv cast2.cnv	cast1.cnv cast2.cnv
Loop Edit (loopedit)	cast1.cnv cast2.cnv	cast1.cnv cast2.cnv
Bin Average (binavg)	cast1.cnv cast2.cnv	cast1avg.cnv cast2avg.cnv
Derive (derive)	cast1avg.cnv cast2avg.cnv cast.con	cast1.cnv cast2.cnv
SeaPlot (seaplot)	cast1.cnv cast2.cnv	cast1.jpg cast2.jpg (if File Setup tab was set to output to jpeg)

Appendix II: Configure File Format

> **Note:**
> For an easier-to-read report of .con file contents, see *Appendix III: Generating .con File Reports – ConReport.exe*.

Shown below is a line-by-line description of the .con file contents, which can be viewed in a text editor.

Line	Contents
1	Conductivity sensor serial number
2	Conductivity M, A, B, C, D, CPCOR
3	Conductivity cell_const, series_r, slope, offset, use GHIJ coefficients?
4	Temperature sensor serial number
5	Temperature F0, A, B, C, D, slope, offset, use GHIJ coefficients?
6	Secondary conductivity sensor serial number
7	Secondary conductivity M, A, B, C, D, PCOR
8	Secondary conductivity cell_const, series_r, slope, offset, use GHIJ coefficients?
9	Secondary temperature sensor serial number
10	Secondary temperature F0, A, B, C, D, slope, offset, use GHIJ coefficients?
11	Pressure sensor serial number
12	Pressure T1, T2, T3, T4, T5
13	Pressure C1 (A1), C2 (A0), C3, C4 (A2) - parameters in parentheses for strain gauge sensor
14	Pressure D1, D2, slope, offset, pressure sensor type, AD590_M, AD590_B
15	Oxygen (Beckman/YSI type) sensor serial number
16	Oxygen (Beckman/YSI type) M, B, K, C, SOC, TCOR
17	Oxygen (Beckman/YSI type) WT, PCOR, TAU, BOC
18	pH sensor serial number
19	pH slope, offset, VREF
20	PAR light sensor serial number
21	PAR cal const, multiplier, M, B, surface_cc, surface_r, offset
22	Transmissometer (SeaTech, Chelsea AlphaTracka, WET Labs Cstar) sensor serial number
23	Transmissometer (SeaTech, Chelsea AlphaTracka, WET Labs Cstar) M, B, path length
24	Fluorometer SeaTech sensor serial number
25	Fluorometer SeaTech scale factor, offset
26	Tilt sensor serial number
27	Tilt XM, XB, YM, YB
28	ORP sensor serial number
29	ORP M, B, offset
30	OBS/Nephelometer D&A Backscatterance sensor serial number
31	OBS/Nephelometer D&A Backscatterance gain, offset
32	Altimeter scale factor, offset, hyst, min pressure, hysteresis
33	Microstructure temperature sensor serial number
34	Microstructure temperature pre_m, pre_b
35	Microstructure temperature num, denom, A0, A1, A3
36	Microstructure conductivity sensor serial number
37	Microstructure conductivity A0, A1, A2
38	Microstructure conductivity M, B, R
39	Number of external frequencies, number of bytes, number of voltages, instrument type, computer interface, scan rate, interval, store system time?
40	Data format channels 0 - 9
41	Data format channels 10 - 19
42	Data format channels 20 - 39
43	SBE 16: use water temperature?, fixed pressure, fixed pressure temperature
44	Firmware version
45	SBE 911plus: number of frequencies from SBE 9, number of frequencies to be suppressed, number of voltages to be suppressed, voltage range, add surface PAR voltage?, NMEA interface installed?, include IOW sensors? Note: *NMEA interface installed* applies to all instruments, not just SBE 911plus
46	OBS/Nephelometer IFREMER sensor serial number
47	OBS/Nephelometer IFREMER VM0, VD0, D0, K
48	OBS/Nephelometer Chelsea sensor serial number
49	OBS/Nephelometer Chelsea clear water voltage, scale factor
50	ZAPS sensor serial number
51	ZAPS m, b
52	Conductivity sensor calibration date
53	Temperature sensor calibration date
54	Secondary conductivity sensor calibration date
55	Secondary temperature sensor calibration date
56	Pressure sensor calibration date
57	Oxygen (Beckman/YSI type) sensor calibration date
58	pH sensor calibration date
59	PAR light sensor calibration date

60	Transmissometer (SeaTech, Chelsea AlphaTracka, WET Labs Cstar) sensor calibration date
61	Fluorometer (SeaTech) sensor calibration date
62	Tilt sensor calibration date
63	ORP sensor calibration date
64	OBS/Nephelometer D&A Backscatterance sensor calibration date
65	Microstructure temperature sensor calibration date
66	Microstructure conductivity sensor calibration date
67	IFREMER OBS/nephelometer sensor calibration date
68	Chelsea OBS/nephelometer sensor calibration date
69	ZAPS sensor calibration date
70	Secondary oxygen (Beckman/YSI type) sensor serial number
71	Secondary oxygen (Beckman/YSI type) sensor calibration date
72	Secondary oxygen(Beckman/YSI type) M, B, K, C, SOC, TCOR
73	Secondary oxygen(Beckman/YSI type) WT, PCOR, TAU, BOC
74	User polynomial 1 sensor serial number
75	User polynomial 1 sensor calibration date
76	User poly1 A0, A1, A2, A3
77	User polynomial 2 sensor serial number
78	User polynomial 2 sensor calibration date
79	User polynomial 2 A0, A1, A2, A3
80	User polynomial 3 sensor serial number
81	User polynomial 3 sensor calibration date
82	User polynomial 3 A0, A1, A2, A3
83	Dr. Haardt Chlorophyll fluorometer sensor serial number
84	Dr. Haardt Chlorophyll fluorometer sensor calibration date
85	Dr. Haardt Chlorophyll fluorometer A0, A1, B0, B1, which modulo bit, gain range switching
86	Dr. Haardt Phycoerythrin fluorometer sensor serial number
87	Dr. Haardt Phycoerythrin fluorometer sensor calibration date
88	Dr. Haardt Phycoerythrin fluorometer A0, A1, B0, B1, which modulo bit, gain range switching
89	Dr. Haardt Turbidity OBS/nephelometer sensor serial number
90	Dr. Haardt Turbidity OBS/nephelometer sensor calibration date
91	Dr. Haardt Turbidity OBS/nephelometer A0, A1, B0, B1, which modulo bit, gain range switching
92	IOW oxygen sensor serial number
93	IOW oxygen sensor calibration date
94	IOW oxygen A0, A1, A2, A3, B0, B1
95	IOW sound velocity sensor serial number
96	IOW sound velocity sensor calibration date
97	IOW sound velocity A0, A1, A2
98	Biospherical natural fluorometer sensor serial number
99	Biospherical natural fluorometer sensor calibration date
100	Biospherical natural fluorometer Cfn, A1, A2, B
101	Sea tech ls6000 OBS/nephelometer sensor serial number
102	Sea tech ls6000 OBS/nephelometer sensor calibration date
103	Sea tech ls6000 OBS/nephelometer gain, slope, offset
104	Fluorometer chelsea Aqua 3 sensor serial number
105	Fluorometer chelsea Aqua 3 sensor calibration date
106	Fluorometer chelsea Aqua 3 scale factor, slope, offset, Vacetone, VB (static), V1ug/l
107	Fluorometer turner sensor serial number
108	Fluorometer turner sensor calibration date
109	Fluorometer turner scale factor, offset; or turner-10au-005 full scale concentration, full scale voltage, zero point concentration
110	Conductivity G, H, I, J, ctcor, cpcor
111	Temperature F0, G, H, I, J
112	Secondary conductivity G, H, I, J, ctcor, cpcor
113	Secondary temperature F0, G, H, I, J
114	WET Labs AC3 beam transmission transmissometer sensor serial number
115	WET Labs AC3 beam transmission transmissometer sensor calibration date
116	WET Labs AC3 beam transmission transmissometer Ch2o, Vh2o, Vdark, x, chlorophyll absorption Kv, Vh2o, a^x
117	WET Labs WETStar fluorometer sensor serial number
118	WET Labs WETStar fluorometer sensor calibration date
119	WET Labs WETStar Vblank, scale factor
120	Primary conductivity sensor using g, h, i, j coefficients calibration date
121	Primary temperature sensor using g, h, i, j coefficients calibration date
122	Secondary conductivity sensor using g, h, i, j coefficients calibration date
123	Secondary temperature sensor using g, h, i, j coefficients calibration date
124	FGP pressure sensor #0 serial number
125	FGP pressure sensor #0 calibration date
126	FGP pressure sensor #0 scale factor, offset
127	FGP pressure sensor #1 serial number
128	FGP pressure sensor #1 calibration date
129	FGP pressure sensor #1 scale factor, offset
130	FGP pressure sensor #2 serial number
131	FGP pressure sensor #2 calibration date
132	FGP pressure sensor #2 scale factor, offset

133	FGP pressure sensor #3 serial number
134	FGP pressure sensor #3 calibration date
135	FGP pressure sensor #3 scale factor, offset
136	FGP pressure sensor #4 serial number
137	FGP pressure sensor #4 calibration date
138	FGP pressure sensor #4 scale factor, offset
139	FGP pressure sensor #5 serial number
140	FGP pressure sensor #5 calibration date
141	FGP pressure sensor #5 scale factor, offset
142	FGP pressure sensor #6 serial number
143	FGP pressure sensor #6 calibration date
144	FGP pressure sensor #6 scale factor, offset
145	FGP pressure sensor #7 serial number
146	FGP pressure sensor #7 calibration date
147	FGP pressure sensor #7 scale factor, offset
148	OBS/Nephelometer seapoint turbidity meter sensor serial number
149	OBS/Nephelometer seapoint turbidity meter sensor calibration date
150	Primary OBS/Nephelometer seapoint turbidity meter gain, scale
151	Secondary OBS/Nephelometer seapoint turbidity meter sensor serial number
152	Secondary OBS/Nephelometer seapoint turbidity meter sensor calibration date
153	Secondary OBS/Nephelometer seapoint turbidity meter gain, scale
154	Fluorometer Dr. Haardt Yellow Substance sensor serial number
155	Fluorometer Dr. Haardt Yellow Substance sensor calibration date
156	Fluorometer Dr. Haardt Yellow Substance A0, A1, B0, B1, which modulo bit, gain range switching
157	Fluorometer Chelsea Minitraka serial number
158	Fluorometer Chelsea Minitraka calibration date
159	Fluorometer Chelsea Minitraka vacetone, vacetone100, offset
160	Seapoint fluorometer serial number
161	Seapoint fluorometer calibration date
162	Seapoint fluorometer gain, offset
163	Primary Oxygen (SBE 43) serial number
164	Primary Oxygen (SBE 43) calibration date
165	Primary Oxygen (SBE 43) Soc, Tcor, offset
166	Primary Oxygen (SBE 43) Pcor, Tau, Boc
167	Secondary Oxygen (SBE 43) serial number
168	Secondary Oxygen (SBE 43) calibration date
169	Secondary Oxygen (SBE 43) Soc, Tcor, offset
170	Secondary Oxygen (SBE 43) Pcor, Tau, Boc
171	Secondary sea tech ls6000 OBS/nephelometer sensor serial number
172	Secondary sea tech ls6000 OBS/nephelometer sensor calibration date
173	Secondary sea tech ls6000 OBS/nephelometer gain, slope, offset
174	Secondary Chelsea Transmissometer sensor serial number
175	Secondary Chelsea Transmissometer calibration date
176	Secondary Chelsea Transmissometer M, B, path length
177	Altimeter serial number
178	Altimeter calibration date
179	WET Labs AC3 serial number
180	WET Labs AC3 calibration date
181	Surface PAR serial number
182	Surface PAR calibration date
183	SEACAT*plus* temperature sensor serial number
184	SEACAT*plus* temperature sensor calibration date
185	SEACAT*plus* temperature sensor A0, A1, A2, A3, slope, offset
186	SEACAT*plus* serial sensor, scans to average, mode
187	Pressure (strain gauge with span TC) serial number
188	Pressure (strain gauge with span TC) calibration date
189	Pressure (strain gauge with span TC) ptempA0, ptempA1, ptempA2, pTCA0, pTCA1, PTCA2
190	Pressure (strain gauge with span TC) pTCB0, pTCB1, pTCB2, pA0, pA1, pA2, offset
191	SBE 38 temperature sensor serial number
192	SBE 38 temperature sensor calibration date
193	Turner SCUFA fluorometer serial number
194	Turner SCUFA fluorometer calibration date
195	Turner SCUFA fluorometer scale factor, offset, units, mx, my, b
196	Turner SCUFA OBS serial number
197	Turner SCUFA OBS calibration date
198	Turner SCUFA OBS scale factor, offset
199	WET Labs ECO-AFL fluorometer serial number
200	WET Labs ECO-AFL fluorometer calibration date
201	WET Labs ECO-AFL fluorometer vblank, scale factor
202	Userpoly 0 name
203	Userpoly 1 name
204	Userpoly 2 name
205	CAPSUM METS serial number
206	CAPSUM METS calibration date
207	CAPSUM METS D, A0, A1, B0, B1, B2, T1, T2

208	Secondary PAR sensor serial number
209	Secondary PAR sensor calibration date
210	Secondary PAR sensor cal const, multiplier, M, B, offset
211	Secondary WET Labs WETStar Fluorometer sensor serial number
212	Secondary WET Labs WETStar Fluorometer sensor calibration date
213	Secondary WET Labs WETStar Fluorometer Vblank, scale factor
214	Secondary Seapoint Fluorometer sensor serial number
215	Secondary Seapoint Fluorometer sensor calibration date
216	Secondary Seapoint Fluorometer gain, offset
217	Secondary Turner SCUFA Fluorometer sensor serial number
218	Secondary Turner SCUFA Fluorometer sensor calibration date
219	Secondary Turner SCUFA Fluorometer scale factor, offset, units, mx, my, b
220	WET Labs WETStar CDOM sensor serial number
221	WET Labs WETStar CDOM sensor calibration date
222	WET Labs WETStar CDOM Vblank, scale factor
223	Seapoint Rhodamine Fluorometer sensor serial number
224	Seapoint Rhodamine Fluorometer sensor calibration date
225	Seapoint Rhodamine Fluorometer gain, offset
226	Primary Gas Tension Device sensor serial number
227	Primary Gas Tension Device sensor calibration date
228	Primary Gas Tension Device type
229	Secondary Gas Tension Device sensor serial number
230	Secondary Gas Tension Device sensor calibration date
231	Secondary Gas Tension Device type
232	Sequoia LISST-25A sensor serial number
233	Sequoia LISST-25A sensor calibration date
234	Sequoia LISST-25A Total Volume Conc Const, Sauter Mean Diameter Cal, Clean Water Scattering, Clean Water Trans
235	SBE 45 output conductivity? Output salinity? Output sound velocity? Use 90402 junction box? SBE 38 remote temperature?
236	SBE 21 remote temperature type
237	SBE 50 serial number
238	SBE 50 calibration date
239	Secondary Chelsea Aqua 3 fluorometer serial number
240	Secondary Chelsea Aqua 3 fluorometer calibration date
241	Secondary Chelsea Aqua 3 fluorometer scale factor, slope, offset, vacetone, vb, v1
242	Chelsea UV Aquatracka serial number
243	Chelsea UV Aquatracka calibration date
244	Chelsea UV Aquatracka a, b
245	SBE 49 temperature sensor serial number
246	SBE 49 temperature sensor calibration date.
247	SBE 49 temperature sensor A0, A1, A2, A3, slope, and offset.

Appendix III: Generating .con File Reports – ConReport.exe

The .con file report is an ASCII .txt file that shows all parameters in the .con file in an easy-to-read form. The .txt report is for viewing and printing only, and cannot be used to modify parameters in the .con file for processing data. The .txt file is generated by:

- Clicking Report in a Configuration dialog box (see *Instrument Configuration* in *Section 4: Configuring Instrument (Configure)*), **or**
- Using ConReport.exe.

ConReport.exe is run from the command line, and accepts wildcards for the file names, so multiple reports can be produced at one time, and reports can be placed into a specified directory. ConReport.exe is automatically installed when you install SBE Data Processing (default location c:/Program Files/Sea-Bird/SBEDataProcessing-Win32). The format for running ConReport is:

Conreport InputFilename OutputDirectory /S

Parameter	Description
InputFilename	InputFilename is .con file for which you want to generate a report. Must include full path **and** file name. This parameter supports standard wildcard expansion with *: • * matches any set of characters starting at specified position within file name or extension and continuing until the end of file name or extension or another specified character.
OutputDirectory	(optional) Full path to location to store output .txt file(s). If not specified, defaults to location of input .con file(s).
/S	(optional) Do not echo messages to screen.

If specifying multiple parameters, insert one or more spaces or tabs between each parameter in the list.

Example – Generate Reports for All .con Files in Directory, and Save to Different Directory

The .con files test1.con, test2.con, and test3.con are in c:\leg1, and you want to generate the .txt reports and save them to c:\CruiseSummary.

At the DOS prompt, starting in the directory where ConReport is located (default c:/Program Files/Sea-Bird/SBEDataProcessing-Win32), type in the program name and parameters as shown:

conreport c:\leg1*.con c:\CruiseSummary

The program responds:

```
c:\CruiseSummary\test1.txt
c:\CruiseSummary\test2.txt
c:\CruiseSummary\test3.txt
3 reports written to c:\CruiseSummary
```

Appendix IV: Software Problems

Considerable effort has been made to test and check this software before its release. However, because of the wide range of instruments that Sea-Bird produces (and interfaces with) and the many applications that these instruments are used in, there may be software problems that have not been discovered and corrected. If a problem occurs, please contact us via phone (425-643-9866), email (seabird@seabird.com), or fax (425-643-9954) with the following information:

- Instrument serial number
- Version of the software originally shipped with the instrument
- Version of the software you are attempting to run
- Complete description of the problem you are having

If the problem involves the configuration or setup of the software, in most cases a phone call to Sea-Bird will be sufficient to solve the problem. If you phone, we would appreciate it if you would be ready to run the software during the phone conversation.

If the problem involves data processing, you may be asked to send a sample of the data to Sea-Bird for evaluation.

Known Bugs/Compatibility Issues

1. Some users have reported that SBE Data Processing is incompatible with Windows NT when:

   - Internet Explorer is installed on Windows NT, **and**
   - Active Desktop was installed from Internet Explorer 4.0.

   Problem Symptoms: SBE Data Processing works, but Internet Explorer does not operate properly. Problems include error messages upon opening Internet Explorer, and/or the inability to cut, paste, copy, delete, or rename files in Internet Explorer. Uninstalling SBE Data Processing eliminates the problem with Internet Explorer.

   Solution: Uninstall Active Desktop before installing SBE Data Processing. Internet Explorer and SBE Data Processing will work properly.

Appendix V: Derived Parameter Formulas

Note:
Algorithms used for calculation of derived parameters in Data Conversion, Derive, SeacalcW, and SEASAVE are identical, except as noted.

For formulas for the calculation of conductivity, temperature, and pressure, see the calibration sheets for your instrument.

Formulas for the computation of salinity, density, potential temperature, specific volume anomaly, and sound velocity were obtained from "Algorithms for computation of fundamental properties of seawater", by N.P. Fofonoff and R.C Millard Jr.; Unesco technical papers in marine science #44, 1983.

- Temperature used for calculating derived variables is IPTS-68. Following the recommendation of JPOTS, T_{68} is assumed to be 1.00024 * T_{90} (-2 to 35 °C).

Equations are provided for the following oceanographic parameters:

- density (density, sigma-theta, sigma-1, sigma-2, sigma-4, sigma-t)
- thermosteric anomaly
- specific volume
- specific volume anomaly
- geopotential anomaly
- dynamic meters
- depth (salt water, fresh water)
- salinity
- sound velocity (Chen-Millero, DelGrosso, Wilson)
- average sound velocity
- potential temperature (reference pressure = 0.0 decibars)
- potential temperature anomaly
- specific conductivity
- derivative variables (descent rate and acceleration) - if input file has not been averaged into pressure or depth bins
- oxygen (if input file contains pressure, temperature, and either conductivity or salinity, and has not been averaged into pressure or depth bins) - also requires oxygen current and oxygen temperature (for SBE 13 or 23) or oxygen signal (for SBE 43)
- corrected irradiance (CPAR)

density = ρ = ρ (s, t, p) **[*kg/m*^{3}]**
(density of seawater with salinity s, temperature t, and pressure p, based on the equation of state for seawater (EOS80))

Density calculation:
Using the following constants -

```
B0 = 8.24493e-1, B1 = -4.0899e-3, B2 = 7.6438e-5, B3 = -8.2467e-7, B4 = 5.3875e-9,
C0 = -5.72466e-3, C1 = 1.0227e-4, C2 = -1.6546e-6, D0 = 4.8314e-4, A0 = 999.842594,
A1 = 6.793952e-2, A2 = -9.095290e-3, A3 = 1.001685e-4, A4 = -1.120083e-6, A5 = 6.536332e-9,
FQ0 = 54.6746, FQ1 = -0.603459, FQ2 = 1.09987e-2, FQ3 = -6.1670e-5, G0 = 7.944e-2, G1 = 1.6483e-2,
G2 = -5.3009e-4, i0 = 2.2838e-3, i1 = -1.0981e-5, i2 = -1.6078e-6, J0 =1.91075e-4, M0 = -9.9348e-7,
M1 = 2.0816e-8, M2 = 9.1697e-10, E0 = 19652.21, E1 = 148.4206, E2 = -2.327105, E3 = 1.360477e-2,
E4 = -5.155288e-5, H0 = 3.239908, H1 = 1.43713e-3, H2 = 1.16092e-4, H3 = -5.77905e-7,
K0 = 8.50935e-5, K1 =-6.12293e-6, K2 = 5.2787e-8
```

C Computer Code -

```
double Density(double s, double t, double p)
// s = salinity PSU, t = temperature deg C ITPS-68, p = pressure in decibars
{
       double t2, t3, t4, t5, s32;
       double sigma, k, kw, aw, bw;
       double val;
       t2 = t*t;
       t3 = t*t2;
       t4 = t*t3;
       t5 = t*t4;
       if (s <= 0.0)  s = 0.000001;
       s32 = pow(s, 1.5);
       p /= 10.0;                    /* convert decibars to bars */
       sigma = A0 + A1*t + A2*t2 + A3*t3 + A4*t4 + A5*t5 + (B0 + B1*t + B2*t2 + B3*t3 + B4*t4)*s +
(C0 + C1*t + C2*t2)*s32 + D0*s*s;
       kw = E0 + E1*t + E2*t2 + E3*t3 + E4*t4;
       aw = H0 + H1*t + H2*t2 + H3*t3;
       bw = K0 + K1*t + K2*t2;
       k = kw + (FQ0 + FQ1*t + FQ2*t2 + FQ3*t3)*s + (G0 + G1*t + G2*t2)*s32 + (aw + (i0 + i1*t +
i2*t2)*s + (J0*s32))*p + (bw + (M0 + M1*t + M2*t2)*s)*p*p;
       val = 1 - p / k;
       if (val)  sigma = sigma / val - 1000.0;
       return sigma;
}
```

Sigma-theta = σ_θ = ρ (s, θ(s, t, p, 0), 0) - 1000 **[*kg/m*^{3}]**

Sigma-1 = σ_1 = ρ (s, θ(s, t, p, 1000), 1000) - 1000 **[*kg/m*^{3}]**

Sigma-2 = σ_2 = ρ (s, θ(s, t, p, 2000), 2000) - 1000 **[*kg/m*^{3}]**

Sigma-4 = σ_4 = ρ (s, θ(s, t, p, 4000), 4000) - 1000 **[*kg/m*^{3}]**

Sigma-t = σ_t = ρ (s, t, 0) - 1000 **[*kg/m*^{3}]**

thermosteric anomaly = 10^5 ((1000/(1000 + σ_t)) - 0.97266) [*10^{-8} m^3/kg*]

specific volume = V(s, t, p) = 1/ρ **[*m^3/kg*]**

specific volume anomaly = δ = 10^8 (V(s, t, p) - V(35, 0, p)) **[*10^{-8} m^3/kg*]**

geopotential anomaly = $10^{-4} \sum_{\Delta p,\, p=0}^{p=p} (\delta \times \Delta p)$ **[*J/kg*] = [*m^2/s^2*]**

dynamic meters = geopotential anomaly / 10.0
(1 dynamic meter = 10 J/kg;
(Sverdup, Johnson, Flemming (1946), UNESCO (1991)))

depth = [*m*]

Depth calculation:

C Computer Code –

```
// Depth
double Depth(int dtype, double p, double latitude)
// dtype = fresh water or salt water, p = pressure in decibars, latitude in degrees
{
	double x, d, gr;
	if (dtype == FRESH_WATER)     /* fresh water */
		d = p * 1.019716;
	else {                                                 /* salt water  */
		x = sin(latitude / 57.29578);
		x = x * x;
		gr = 9.780318 * (1.0 + (5.2788e-3 + 2.36e-5 * x) * x) + 1.092e-6 * p;
		d = (((-1.82e-15 * p + 2.279e-10) * p - 2.2512e-5) * p + 9.72659) * p;
		if (gr)  d /= gr;
	}
	return(d);
}
```

salinity = [*PSU*]

(Salinity is PSS-78.)

Salinity calculation:

Using the following constants -

A1 = 2.070e-5, A2 = -6.370e-10, A3 = 3.989e-15, B1 = 3.426e-2, B2 = 4.464e-4, B3 = 4.215e-1, B4 = -3.107e-3, C0 = 6.766097e-1, C1 = 2.00564e-2, C2 = 1.104259e-4, C3 = -6.9698e-7, C4 = 1.0031e-9

C Computer Code –

```
static double a[6] = { /* constants for salinity calculation */
	0.0080, -0.1692, 25.3851, 14.0941, -7.0261, 2.7081
};
static double b[6]={   /* constants for salinity calculation */
	0.0005, -0.0056, -0.0066, -0.0375, 0.0636, -0.0144
};
double Salinity(double C, double T, double P)               /* compute salinity */
// C = conductivity S/m, T = temperature deg C ITPS-68, P = pressure in decibars
{
	double R, RT, RP, temp, sum1, sum2, result, val;
	int i;
	if (C <= 0.0)
		result = 0.0;
	else {
		C *= 10.0;     /* convert Siemens/meter to mmhos/cm */
		R = C / 42.914;
		val = 1 + B1 * T + B2 * T * T + B3 * R + B4 * R * T;
		if (val)  RP = 1 + (P * (A1 + P * (A2 + P * A3))) / val;
		val = RP * (C0 + (T * (C1 + T * (C2 + T * (C3 + T * C4)))));
		if (val)  RT = R / val;
		if (RT <= 0.0)  RT = 0.000001;
		sum1 = sum2 = 0.0;
		for (i = 0;i < 6;i++) {
			temp = pow(RT, (double)i/2.0);
			sum1 += a[i] * temp;
			sum2 += b[i] * temp;
		}
		val = 1.0 + 0.0162 * (T - 15.0);
		if (val)
			result = sum1 + sum2 * (T - 15.0) / val;
		else
			result = -99.;
	}
return result;
}
```

sound velocity = [*m/sec*]
(sound velocity can be calculated as Chen-Millero, DelGrosso, or Wilson)

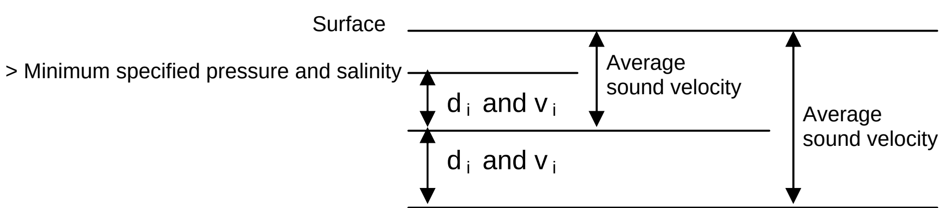
Sound velocity calculation:
C Computer Code –

```
// Sound Velocity Chen and Millero
double SndVelC(double s, double t, double p0)        /* sound velocity Chen and Millero 1977 */
                                                      /* JASA,62,1129-1135 */
// s = salinity, t = temperature deg C ITPS-68, p = pressure in decibars
{
       double a, a0, a1, a2, a3;
       double b, b0, b1;
       double c, c0, c1, c2, c3;
       double p, sr, d, sv;
       p = p0 / 10.0;        /* scale pressure to bars */
       if (s < 0.0)   s = 0.0;
       sr = sqrt(s);
       d = 1.727e-3 - 7.9836e-6 * p;
       b1 = 7.3637e-5 + 1.7945e-7 * t;
       b0 = -1.922e-2 - 4.42e-5 * t;
       b = b0 + b1 * p;
       a3 = (-3.389e-13 * t + 6.649e-12) * t + 1.100e-10;
       a2 = ((7.988e-12 * t - 1.6002e-10) * t + 9.1041e-9) * t - 3.9064e-7;
       a1 = (((-2.0122e-10 * t + 1.0507e-8) * t - 6.4885e-8) * t - 1.2580e-5) * t + 9.4742e-5;
       a0 = (((-3.21e-8 * t + 2.006e-6) * t + 7.164e-5) * t -1.262e-2) * t + 1.389;
       a = ((a3 * p + a2) * p + a1) * p + a0;
       c3 = (-2.3643e-12 * t + 3.8504e-10) * t - 9.7729e-9;
       c2 = (((1.0405e-12 * t -2.5335e-10) * t + 2.5974e-8) * t - 1.7107e-6) * t + 3.1260e-5;
       c1 = (((-6.1185e-10 * t + 1.3621e-7) * t - 8.1788e-6) * t + 6.8982e-4) * t + 0.153563;
       c0 = ((((3.1464e-9 * t - 1.47800e-6) * t + 3.3420e-4) * t - 5.80852e-2) * t + 5.03711) * t +
1402.388;
       c = ((c3 * p + c2) * p + c1) * p + c0;
       sv = c + (a + b * sr + d * s) * s;
       return sv;
}

// Sound Velocity Delgrosso
double SndVelD(double s, double t, double p) /* Delgrosso JASA, Oct. 1974, Vol 56, No 4 */
// s = salinity, t = temperature deg C ITPS-68, p = pressure in decibars
{
       double c000, dct, dcs, dcp, dcstp, sv;
       c000 = 1402.392;
       p = p / 9.80665;              /* convert pressure from decibars to KG / CM**2 */
       dct = (0.501109398873e1 - (0.550946843172e-1 - 0.22153596924e-3 * t) * t) * t;
       dcs = (0.132952290781e1 + 0.128955756844e-3 * s) * s;
       dcp = (0.156059257041e0 + (0.244998688441e-4 - 0.83392332513e-8 * p) * p) * p;
       dcstp = -0.127562783426e-1 * t * s + 0.635191613389e-2 * t * p + 0.265484716608e-7 * t * t *
p * p - 0.159349479045e-5 * t * p * p + 0.522116437235e-9 * t * p * p * p - 0.438031096213e-6 * t *
t * t * p - 0.161674495909e-8 * s * s * p * p + 0.968403156410e-4 * t * t * s + 0.485639620015e-5 *
t * s * s * p - 0.340597039004e-3 * t * s * p;
       sv = c000 + dct + dcs + dcp + dcstp;
       return sv;
}

// sound velocity Wilson
double SndVelW(double s, double t, double p) /* wilson JASA, 1960, 32, 1357 */
// s = salinity, t = temperature deg C ITPS-68, p = pressure in decibars
{
       double pr, sd, a, v0, v1, sv;
       pr = 0.1019716 * (p + 10.1325);
       sd = s - 35.0;
       a = (((7.9851e-6 * t - 2.6045e-4) * t - 4.4532e-2) * t + 4.5721) * t + 1449.14;
       sv = (7.7711e-7 * t - 1.1244e-2) * t + 1.39799;
       v0 = (1.69202e-3 * sd + sv) * sd + a;
       a = ((4.5283e-8 * t + 7.4812e-6) * t - 1.8607e-4) * t + 0.16072;
       sv = (1.579e-9 * t + 3.158e-8) * t + 7.7016e-5;
       v1 = sv * sd + a;
       a = (1.8563e-9 * t - 2.5294e-7) * t + 1.0268e-5;
       sv = -1.2943e-7 * sd + a;
       a = -1.9646e-10 * t + 3.5216e-9;
       sv = (((-3.3603e-12 * pr + a) * pr + sv) * pr + v1) * pr + v0;
       return sv;
}
```

$$\textbf{average sound velocity} = \frac{\sum_{\Delta p, p=min}^{p=p} \mathbf{d_i}}{\sum_{\Delta p, p=min}^{p=p} \mathbf{d_i / v_i}} \quad [m/s]$$

Average sound velocity is the harmonic mean (average) **from the surface** to the current CTD depth. The average is calculated on the downcast only. The first window begins when pressure is greater than a minimum specified pressure **and** salinity is greater than a minimum specified salinity. Depth is calculated from pressure based on user-input latitude.

- In Derive, the algorithm is based on the assumption that the data has been bin averaged already. Average sound velocity is computed scan-by-scan:
  $\mathbf{d_i}$ = depth of current scan – depth of previous scan [meters]
  $\mathbf{v_i}$ = sound velocity of this scan (bin) [m/sec]
- In SEASAVE and Data Conversion, the algorithm also requires user input of a pressure window size and time window size. It then calculates:
  $\mathbf{d_i}$ = depth at end of window – depth at start of window [meters]
  $\mathbf{v_i}$ = (sound velocity at start of window + sound velocity at end of window) / 2 [m/sec]



potential temperature [IPTS-68] = θ (s, t, p, p_r) [*°C*]
(Potential temperature is the temperature an element of seawater would have if raised adiabatically with no change in salinity to reference pressure p_r.
Sea-Bird software uses a reference pressure of 0 decibars).

Potential Temperature [IPTS-68] calculation:
C Computer Code -

```
// ATG (used in potential temperature calculation)
double ATG(double s, double t, double p)     /* adiabatic temperature gradient deg C per decibar */
                                             /* ref broyden,h. Deep-Sea Res.,20,401-408 */
// s = salinity, t = temperature deg C ITPS-68, p = pressure in decibars
{
       double ds;
       ds = s - 35.0;
       return((((-2.1687e-16 * t + 1.8676e-14) * t - 4.6206e-13) * p + ((2.7759e-12 * t - 1.1351e-
10) * ds + ((-5.4481e-14 * t + 8.733e-12) * t - 6.7795e-10) * t + 1.8741e-8)) * p + (-4.2393e-8 * t
+ 1.8932e-6) * ds + ((6.6228e-10 * t - 6.836e-8) * t + 8.5258e-6) * t + 3.5803e-5);
}
// potential temperature
double PoTemp(double s, double t0, double p0, double pr)    /* local potential temperature at pr */
                                             /* using atg procedure for adiabadic lapse rate */
                                             /* Fofonoff,N.,Deep-Sea Res.,24,489-491 */
// s = salinity, t0 = local temperature deg C ITPS-68, p0 = local pressure in decibars, pr =
reference pressure in decibars
{
       double p, t, h, xk, q, temp;
       p = p0;
       t = t0;
       h = pr - p;
       xk = h * ATG(s,t,p);
       t += 0.5 * xk;
       q = xk;
       p += 0.5 * h;
       xk = h * ATG(s,t,p);
       t += 0.29289322 * (xk-q);
       q = 0.58578644 * xk + 0.121320344 * q;
       xk = h * ATG(s,t,p);
       t += 1.707106781 * (xk-q);
       q = 3.414213562 * xk - 4.121320344 * q;
       p += 0.5 * h;
       xk = h * ATG(s,t,p);
       temp = t + (xk - 2.0 * q) / 6.0;
       return(temp);
}
```

potential temperature [ITS-90] = θ (s, t, p, p_r) / 1.00024 [*°C*]

potential temperature anomaly =
potential temperature - a0 - a1 x salinity
or
potential temperature - a0 - a1 x Sigma-theta
(a0, a1, and the selection of salinity or sigma-theta are user-input.)

specific conductivity = (C * 10,000) / (1 + A * [T – 25]) [*microS/cm*]
(C = conductivity (S/m), T = temperature (° C),
A = thermal coefficient of conductivity for a natural salt solution
[0.019 - 0.020]; Sea-Bird software uses 0.020.)

Descent rate and **acceleration** computed by SEASAVE and Data Conversion are somewhat different from values computed by Derive, because the algorithms calculate the derivative of the pressure signal with respect to time, using a linear regression to determine the slope. SEASAVE and Data Conversion compute the derivative looking backward in time, since they share common code and SEASAVE cannot use future values of pressure while acquiring data in real time. Derive uses a centered window (equal number of points before and after the scan; time window size is user-input) to obtain a better estimate of the derivative. Use SEASAVE and Data Conversion to obtain a quick look at descent rate and acceleration; use Derive to obtain the most accurate values.

oxygen [*ml/l*] = (As applicable, see *Application Note 64: SBE 43 Dissolved Oxygen Sensor* **or** *Application Note 13-1: SBE 13, 23, 30 Dissolved Oxygen Sensor Calibration & Deployment*)
(Oxygen computed by SEASAVE and Data Conversion is somewhat different from values computed by Derive, because the algorithm calculates the derivative of the oxygen signal with respect to time, using a linear regression to determine the slope. SEASAVE and Data Conversion compute the derivative looking backward in time, since they share common code and SEASAVE cannot use future values of oxygen while acquiring data in real time. Derive uses a centered window [equal number of points before and after the scan; window size is user-input] to obtain a better estimate of the derivative. Use SEASAVE and Data Conversion to obtain a quick look at oxygen values; use Derive to obtain the most accurate values.)

$$\text{oxygen } [\mu moles/kg] = \frac{44660}{\textit{Sigma-theta} + 1000} \text{ oxygen } [ml/l]$$

Note:
For complete description of ratio multiplier, see Application Note 11S (SBE 11*plus* Deck Unit) or 47 (SBE 33 or 36 Deck Unit).

Corrected Irradiance [CPAR] =
100 * ratio multiplier * underwater PAR / surface PAR [%]
(Ratio multiplier = scaling factor used for comparing light fields of disparate intensity, input in .con file entry for surface PAR sensor;
Underwater PAR = underwater PAR data;
Surface PAR = surface PAR data)

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