

Sea-Bird Seasoftware

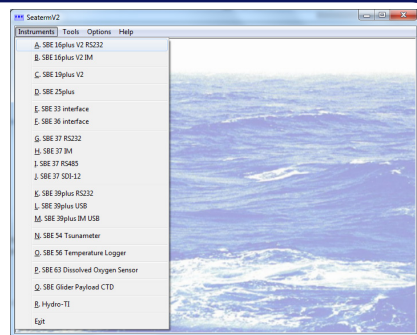
Seasoftware® V2 is a powerful Windows 7/8/10 modular program for instrument communication and data retrieval, real-time data acquisition and display, and data processing and plotting. An extensive list of seawater parameters can be calculated, dozens of auxiliary sensors are supported, and a variety of color plots can be graphed, printed, and exported in common graphic file formats. Seasoftware is provided at no charge, and is available for download on our website. The main components include:

- **Seaterm, SeatermAF, and SeatermV2** – Terminal programs for CTD setup, data retrieval, and diagnostic tests.
- **Seasave V7** – Acquires, converts, and displays real-time or archived raw CTD data.
- **SBE Data Processing** – Converts, edits, processes, and plots CTD data.
- **Seasoftware for Waves** – Full software suite for wave and tide recorders.

Seaterm, SeatermAF, and Seaterm V2

These terminal programs provide setup, data retrieval, and diagnostic tests. Menus and toolbars contain shortcuts for frequently executed tasks, while status bars provide information on current selections and communication protocols.

- **Seaterm** – for most older Sea-Bird instruments.
- **SeatermAF V2** – for autonomous operation setup of an SBE 32 Carousel or SBE 55 ECO Water Sampler on non-conducting cable.
- **SeatermV2** – for SBE 16plus V2, 16plus-IM V2, 19plus V2; 25plus; 37 (firmware ≥ 3.0), 37 IDO, and 37 ODO; 39plus; 39plus-IM; 54; PN 90588; 56; 63; Glider Payload CTD; Hydro-TI.



Seasave V7

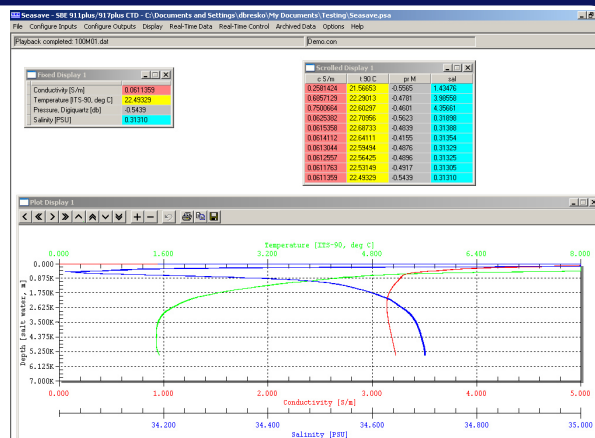
Seasave V7 acquires real-time, raw data (frequencies and voltages) and saves it to the computer for later processing. It uses an instrument configuration file, which defines the sensors, sensor channels, and calibration coefficients, to convert the real-time data to engineering units for text and plot display. This allows you to view data during the cast, and make adjustments to cast speed or water sampling depths to capture interesting features. Additional features include the ability to:

- Send commands to close water sampler bottles
- Save NMEA navigation data with CTD data
- Output data to a computer COM port, file, or remote display
- Set up alarms, and mark real-time data to note significant events
- Use TCP/IP to control Seasave V7, and output data via TCP/IP

Seasave V7 supports:

- CTDs - SBE 911plus and 917plus CTD system, SBE 16plus V2, 16plus, and 16 SeaCAT C-T Recorder; SBE 19plus V2, 19plus, and 19 SeaCAT CTD Profiler; SBE 25 and 25plus Sealogger CTD; SBE 49 FastCAT CTD Sensor
- Thermosalinographs - SBE 21 SeaCAT and SBE 45 MicroTSG

Seasave V7 supports many auxiliary sensors interfacing with these instruments, including oxygen, pH, turbidity, fluorescence, oil, PAR, nitrates, altimeter, etc. Auxiliary sensor selection also includes a user polynomial, allowing you to define the relationship between sensor output voltage and calculated engineering units for a sensor that is not directly supported by the software.



SBE Data Processing

SBE Data Processing consists of modular, menu-driven routines to convert, edit, process, and plot oceanographic data acquired with Sea-Bird instruments (CTD data as well as auxiliary sensor data). SBE Data Processing was developed by oceanographers, incorporating input from years of collaboration and consultation with customers around the world and applying fundamental principles of oceanography to data analysis. Each module was designed to perform the necessary data manipulation based on our understanding of the real oceanographic features involved, and with sound physical reasons for applying specific corrections to each type of error. The software is continuously refined to reflect the latest oceanographic research, as well as to incorporate new auxiliary sensors that can interface with our CTDs.

SBE Data Processing modules fall into five categories: Raw data conversion, Data processing, File manipulation, Data plotting, and Seawater calculator.

1. Raw Data Conversion

Data Conversion performs the first step in data processing, converting the raw CTD and auxiliary sensor data (typically frequencies and voltages) to engineering units. This raw data can be real-time data obtained via Seasave V7, or data uploaded from the CTD memory via Seaterm V2, Seaterm, or SeatermAF. Data Conversion uses the instrument configuration file (same as used by Seasave V7), which defines sensors, sensor channels, and calibration coefficients, to convert raw data to engineering units.

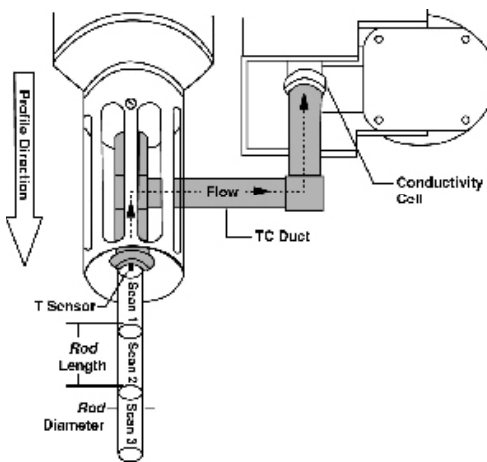
Data Conversion also outputs separately blocks of data associated with water bottle closures, for easy comparison with lab tests you perform on collected water samples.

2. Data Processing

Many oceanographic data parameters (e.g., salinity, density, sound velocity) are calculated from a set of temperature, pressure, and conductivity measurements. The highest accuracy in the derived parameters is obtained when those measurements are made on the same parcel of seawater. There are two characteristics of every CTD (Sea-Bird's as well as any other manufacturer) that must be overcome to get the highest accuracy:

- The temperature sensor and conductivity sensor have different time constants — Sensors do not react infinitely quickly to a new environmental condition. For example, a thermistor is housed in a thin metal sheath; the delay in response to a sharp change in temperature from warm to cold is due to the time required for the heat in the thermistor to diffuse into the environment. For a conductivity cell, there is flushing time of the cell.
- The temperature sensor and conductivity sensor are in physically different places.

Evidence of the mismatch of temperature and conductivity measurements is seen in salinity spikes and density inversions in processed data.



You can low-pass-filter temperature and conductivity to make their time constants match and you can advance conductivity data to account for the fact that for a given parcel of water the temperature is measured before the conductivity, if you collect your data as a time series of equally spaced measurements. To ensure that the temperature and conductivity measurements are made on a constrained water sample, we plumb them together with a T-C Duct; the *T-C pair* has water drawn through them with a pump that moves water at a consistent, known speed. One way to visualize this is as a rod of water that moves into the duct and flows past the thermometer and into the conductivity cell. Because the water sample is pumped through the duct and conductivity cell, it is not subject to accelerations (sloshing) due to ship heave. Controlling the flow rate of water past the sensors ensures that the time constants and measurement timing is constant. Filtering and aligning data is particularly successful for Sea-Bird instruments, because of this technique of constraining the sample as it is measured.

SBE Data Processing includes two modules to ensure that subsequent derived parameters are calculated based on matching temperature and conductivity:

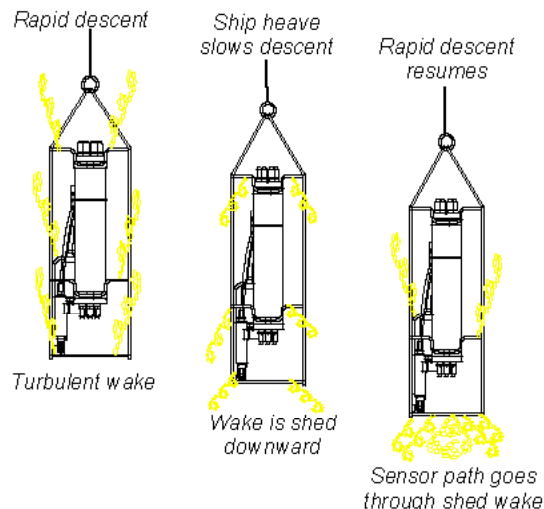
- **Filter** applies a low-pass filter to temperature and conductivity data to make their time constants match.
- **Align CTD** compensates for physical misalignment of sensors in depth, inherent time delay of sensor responses, and water transmit time delays in pumped plumbing. It aligns data relative to pressure to ensure that later calculations of salinity are made with measurements from the same parcel of water. Align CTD can also be used to align data from auxiliary instruments. For example, for a dissolved oxygen sensor, it compensates for sensor response time and for transit time of the water sample in the plumbing.



Conductivity is a function of temperature. The conductivity cell is constructed of glass and plastic, and as such has a thermal mass. When the cell goes from warm water into cold, the water is warmed slightly as it passes through the cell. Conversely, when the cell goes from cold water into warm, the water that passes through the cell is cooled slightly. This causes the water in the cell to be a different temperature than the thermometer measured before the water reached the conductivity cell. This heat transfer can be modeled and corrected by running **Cell Thermal Mass**.

In the real world, errors that are completely unrelated to the CTD often creep into the data:

- Ship heave, the rocking motion of the ship, causes errors. Most CTD deployments are made with a small boom or an A-frame that leans out from the ship, giving some distance between the sea cable and the side of the ship. Ship rocking has the effect of pulling up on the sea cable when the ship rocks in one direction and slackening the sea cable when it rocks in the other direction. This heaving action causes the underwater package to decelerate when the sea cable is pulled up and accelerate when it goes slack. As the instrument decelerates, water that is entrained within the package can continue downward past the sensors; this water is of different temperature and conductivity than the water at the bottom of the package, and it causes a sampling error. In cases of radical ship heave, the instrument package can actually *loop* through the water, passing through the same segment of the water column more than once.
- Additional data errors are caused by slip ring noise, other electrical interference, computer data port problems, etc. These errors often result in *wild* data points, which are completely out of range of the expected data values.



SBE Data Processing includes two modules to deal with marking data associated with ship heave and other real world deployment problems:

- **Loop Edit** tests the data for pressure reversals (loops in the instrument's trajectory) and for velocities that fall below a user-defined minimum. It marks scans that fail these tests, so they can be eliminated in later processing steps if desired.
- **Wild Edit** tests for data that falls outside of user-defined limits, specified as standard deviations on a window of data. It marks data that fail this test, so they can be eliminated in later processing steps if desired.

After the corrections have been made to account for the real-world deployment of the CTD, you are ready to calculate parameters derived from the basic measurements of the CTD and auxiliary sensors. **Derive** uses the pressure, temperature, conductivity, and auxiliary sensor data to calculate a large number of parameters using EOS-80 (Practical Salinity) equations, including:

- salinity
- density (density, sigma-theta, sigma-t, sigma-1, sigma-2, sigma-4)
- depth (salt water or fresh water)
- dynamic meters
- sound velocity (Chen-Millero, DelGrosso, Wilson)
- average sound velocity
- descent rate and acceleration
- potential temperature and potential temperature anomaly
- geopotential anomaly
- specific volume anomaly
- thermosteric anomaly
- oxygen

Derive TEOS-10 was introduced in 2013. It uses temperature, conductivity or salinity (Practical, EOS-80), pressure, latitude, and longitude to compute the following thermodynamic parameters using TEOS-10 equations:

- Absolute Salinity
- Absolute Salinity Anomaly
- adiabatic lapse rate
- Conservative Temperature
- Conservative Temperature freezing
- density
- dynamic enthalpy
- enthalpy
- entropy
- gravity
- internal energy
- isentropic compressibility
- latent heat of evaporation
- latent heat of melting
- potential temperature
- Preformed Salinity
- Reference Salinity
- saline contraction coefficient
- sound speed
- specific volume
- specific volume anomaly
- temperature freezing
- thermal expansion coefficient

Often, the last step in processing data is to average the data, to reduce the data set to a usable size. **Bin Average** makes a statistical estimate of data values at user-defined intervals based on pressure range, depth range, scan number range, or time range.

SBE Data Processing includes a few more data processing modules for specialized applications:

- **Buoyancy** computes Brunt Väisälä buoyancy and stability frequency.
- **Window Filter** filters data with a triangle, cosine, boxcar, Gaussian, or median window to smooth data.

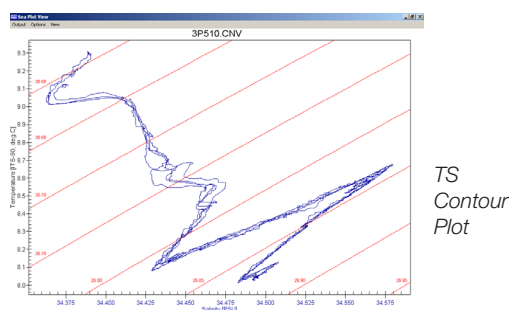
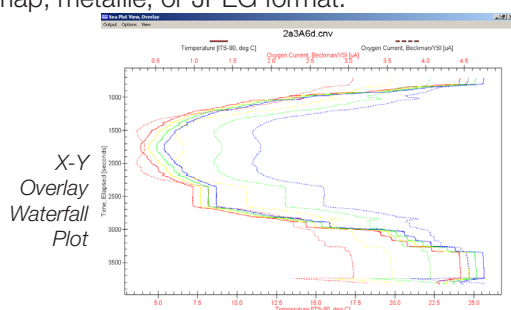
3. File Manipulation

File manipulation modules can be used to add descriptive information to a file or extract the desired information from the data:

- **ASCII In** adds header information to an ASCII data file. It is useful for preparing a data file that was generated by other (non-Sea-Bird) software for further processing or plotting by SBE Data Processing.
- **ASCII Out** outputs data and/or header from a converted data file to an ASCII file. It is useful for exporting converted data for processing by non-Sea-Bird software.
- **Section** extracts rows of data from a converted data file.
- **Split** splits data in a converted data file into upcast and downcast files.
- **Strip** extracts columns of data from a converted data file.
- **Translate** converts data in a converted data file from ASCII to binary, or vice versa.

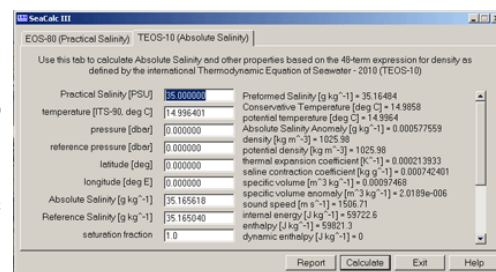
4. Data Plotting

Sea Plot plots up to 5 variables, with 1 X axis and up to 4 Y axes or 1 Y axis and up to 4 X axes, using linear and/or logarithmic scales. It can create contour plots, generating density or thermocline contours on temperature-salinity (TS) plots. Overlay plots allow the user to view multiple data sets at the same time; each file can be offset to create a waterfall plot. Plots can be sent to a printer, saved to the clipboard for insertion in another program (such as Microsoft Word), or saved as graphic files in bitmap, metafile, or JPEG format.



5. Seawater Calculator

SeaCalc III is a seawater calculator that calculates derived variables (salinity, depth, density, etc.) from one user-input scan of temperature, conductivity, pressure, etc. It allows you to calculate variables based on EOS-80 (Practical Salinity) or TEOS-10 (Absolute Salinity). It can be used as a quick check on the expected range of derived data, as well as evaluation of the sensitivity of derived parameters to small changes in the basic measurements.



Seasoft for Waves

Seasoft for Waves® is a powerful modular program for use with the SBE 26plus (or older SBE 26) Seagauge Wave and Tide Recorder or SBE 53 BPR Bottom Pressure Recorder. It includes:

- **Plan Deployment** (SBE 26/26plus) – Calculates and plots pressure attenuation ratio and predicts surface wave analysis parameters for user-input wave sampling scheme.
- **Battery and Memory Endurance Calculator** – Calculates nominal battery and memory endurance for user-input sampling scheme.
- **SeatermW** – Communicates, providing setup, data retrieval, and diagnostic tests.
- **Convert Hex** – Converts uploaded data into separate wave and tide files (SBE 26/26plus) or tide and reference frequency files (SBE 53), with data in engineering units.
- **Merge Barometric Pressure** – Removes barometric pressure from tide data.
- **Process Wave Burst Data** (SBE 26/26plus) – Calculates wave statistics.
- **Create Reports** (SBE 26/26plus) – Calculates surface wave time series and/or wave burst auto-spectrum statistics for each wave burst.
- **Plot Data** – Plots data.

