

# CTD Standard Sensors

Parent Category: Methods (</about-calcofi/methods.html>)

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CalCOFI's primary hydrographic instrument is a Seabird 911+ CTD equipped with dual temperature, conductivity and oxygen sensors mounted on a 24-10L bottle rosette. Additional CTD sensors mounted on the rosette frame include a fluorometer, transmissometer, nitrate sensor, PAR, pH and altimeter.

The CTD-Rosette is lowered into the ocean measuring a suite of seawater properties throughout the water column. Occupying the same stations (specific GPS locations) four times a year - Winter, Spring, Summer, Fall - we measure physical & biological properties: temperature, salinity, oxygen, fluorescence (chlorophyll), nutrients, and productivity from surface to 500m. Additional measurements from seawater samples collected using the rosette are combined with CTD sensor data, filling out the dataset. These seasonal measurements are published in Cruise Data Reports

(<http://new.data.calcofi.org/index.php/reporteddata/hydrographic-data/cruise-data-reports>) & added to our time-series database

(<http://new.data.calcofi.org/index.php/reporteddata#database>), both available online.

The CTD-Rosette is electronically tethered to the ship using a winch with conductive wire. This allows a computer on the ship to control the CTD and monitor the temperature, conductivity, oxygen sensor arrays plus single fluorometer, transmissometer, altimeter & nitrate sensors. As the CTD-Rosette is lowered to 500m, the temperature, salinity, oxygen, chlorophyll, nitrate, and other measurements are displayed real-time & stored on the ship's computer. Depending on the downcast profiles, mainly the depth of highest chlorophyll & mixed layer, bottles are closed at standard depths as the CTD-Rosette is brought back to surface. The seawater samples collected will be analysed & used to calibrate the various sensors or provide measurements that cannot be measured electronically.



- Temperature (T) - Seabird Electronic SBE 3plus (<http://seabird.com/sbe3plus-ctd-temperature-sensor>) temperature sensors: are dependable, requiring no additional calibration other than annual service and calibration performed by Seabird. Dual T sensors are plumbed horizontally, separately to SBE 5T submersible pumps. Measurements are reported in degC.
- Conductivity (C) - Seabird SBE 4C (<http://seabird.com/sbe4-conductivity-sensor>): paired/plumbed with SBE 3plus temperature sensor, measure seawater pumped by the SBE 5T pump. Standard SBE Data Processing offsets are applied to this measurement prior to deriving salinities as PSU. When using the SBE11 v2 Deck Unit, a SBE Data Processing Alignctd offset is **not** applied to secondary conductivity sensor since it is applied by the deck unit.
  - Salinities (in PSU) - are derived from T & C after standard SBE Data Processing modules are applied. Although salinities directly from the CTD are considered excellent, when bottle salts from greater than 350m are available, bottle-correction offsets are applied. These data are reported alongside the uncorrected salinities in our CTD data products.
- Oxygen - Seabird SBE 43 Dissolved Oxygen Sensor (<http://seabird.com/sbe43-dissolved-oxygen-sensor>): dual SBE 43 O2 sensors are plumbed inline with the paired T & C sensors, between the T-C pair and pump. Since the response time of the SBE 43 oxygen sensor is slower than T & C, SBE Data Processing's AlignCTD module is used to apply a 4-second to sensor data before oxygen measurements are derived.

In addition to standard Seabird SBE Data Processing recommended data processing, when seawater oxygen samples are analysed during the cruise. They are used to calibrate sensor oxygen values: cruise-corrected CTD oxygen & station-corrected CTD oxygen data are derived and included in the CTD data products.

- Wetlabs ECO AFL/FL Fluorometer: measures fluorescence-chlorophyll-a; used during the downcast to identify the depth of the chlorophyll-a maximum, which determines the bottle sample depths. Although an estimated chlorophyll-a can be derived using the fluorometer factory calibration. CalCOFI uses cold-extracted chlorophyll-a sample data versus fluorometer voltages to derive estimated chlorophyll-a measurements.
- WetLabs C-Star 25cm 440nm Transmissometer measures % light transmission & beam attenuation coefficients. Before the first cast, CalCOFI measures the dark & light voltages on deck, calculates the M & B coefficients and enters these values under the transmissometer calibration in the CTD .xmlcon file. This is the only calibration done on the transmissometer during a cruise. A Triton or RBS (mild soap, squirt bottle) rinse of the transmissometer optics is done routinely before a cast to clean the optical surfaces.
- Satlantic MBARI-ISUS v3 Nitrate Sensor: recently upgraded to firmware version 3, the ISUS can now be recalibrated by CalCOFI. MBARI-ISUS Version 2 deployed on cruises prior to 1708SR required calibration by Satlantic (prior to Seabird Electronics merger). Estimated nitrate may be displayed real-time using user-polynomial coefficients (from the previous cruise) entered into Seasave .xmlcon. Estimated nitrate data are derived post-cruise from the ISUS voltages using seawater nitrate samples plotted versus average ISUS voltages. Cruise-corrected and station-corrected values are calculated and reported in the CTD data products. The ISUS has been deployed on most cruises since 2004, on casts 1000m or less.
- Seabird SBE 18 pH Sensor (<http://seabird.com/sbe18-ph-sensor>): has been deployed on all cast (1000m or less) since 2009. This sensor is serviced annually and is checked before each cruise using 3 buffer solutions (pHs 4, 8, 10). The sensor electrode is stored in buffer solution between casts to prevent drying out.
- Biospherical Single-Channel Photoradiometers (QSP-2300 PAR & QSR 2200 Surface PAR): a remote PAR is deployed on casts up to 1000m; surface PAR is interfaced with the SBE 11 Deck Unit on most cruises. Factory calibration and coefficients are entered into Seasoft .xmlcon file for both sensor. No additional calibration is performed; standard SBE Data Processing is performed but nothing specific to either PAR other than WFilter.
- Benthos Altimeter (PSA-916): used on all cruises and all casts unless a oxygen optode is deployed (CC1210NH, CC1611SR) then only on stations less than 500m deep. Factory calibration coefficients are entered into Seasave .xmlcon but no calibration is performed. Height off the bottom typically is displayed ~50m from bottom but depends on sea state, bottom composition or wire angle.