CTD General Practices

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CTD General Practices: System Description, Deployment, Data Aquisition, & Maintenance

SUMMARY: Since 1993, the CalCOFI program has deployed a Seabird 911 CTD mounted on a 24-bottle rosette during seasonal, quarterly cruises off California. The CTD-rosette is lowered into the ocean to 515m, depth-permitting, on 75 hydrographic stations using the ship's conductive-wire winch. Data from the sensors are transmitted up the conductive wire and displayed real-time on a data acquistion computer. Discrete seawater samples are collected in 10L bottles at specific depths determined by the chlorophyll maximum and mixed layer depth. These samples are analyzed at sea and used to assess the CTD sensor data quality plus measure additional properties. Processed CTD sensor data are compared to the seawater sample data and corrected when necessary. Preliminary data are available on CalCOFI's website, calcofi.org, while the cruise is at sea when internet is available. Preliminary processed data files are online shortly after the cruise returns. Final, publication-quality bottle & CTD data are available once the bottle data have been fully processed & scrutinized.

1. Basic CTD Components

The Seabird 911/911*plus* CTD configuration has evolved since 1993. Components are added or upgraded as new sensor technology becomes available.

The current (since Nov 2009) CTD & sensors configuration:

SBE9*plus* CTD with SBE11 v2 Deck Unit (CTD 911*plus*); rated to 6800m

dual SBE3*plus* fast response **temperature** sensors (T); rated to 6800m

dual SBE4C **conductivity** sensors (C); rated to 6800m

dual SBE43 **oxygen** sensors (O2); rated to 7000m

dual SBE5T pumps; rated to 10,500m

Seapoint **Chlorophyll** Fluorometer; passive flow (not pumped), mounted on rosette, not shuttered; rated to 6000m

Wetlabs C-Star **Transmissometer**; 25cm 660nm, passive flow; rated to 6000m

Satlantic ISUS **Nitrate** sensor; since 0411; v1 ISUS powered by an external 12v battery, passive flow; rated to 1000m

Seabird SBE-18 **pH** sensor; since 0911; rated to 1200m

Datasonics/Teledyne-Benthos PSA-916 **Altimeter**; mounted unobstructed & low; rated to 6000m

Biospherical **Remote Photoradiometer** (PAR) QSP-2300; rated to 2000m; alternate model QSP-200L; rated to 1000m

Biospherical **Surface Photoradiometer** (PAR) QSR-240; attached to deck unit

Remote Depth Readout SBE14; attached to deck unit; allows winch operator to see CTD depth

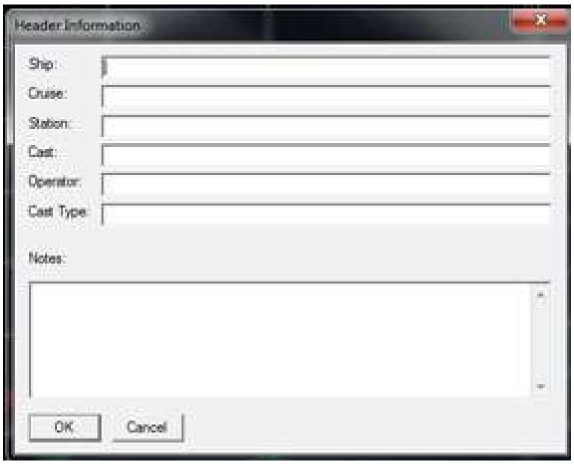
The SBE9*plus* ('fish') is mounted on the rosette horizontally and plumbed accordingly, with pump output at the same height as temperture sensor intake. Temperature, conductivity, & oxygen sensors plus pumps are affixed to the SBE9*plus* housing.Other sensors are mounted on the rosette frame so they have unobstructed water flow particularly during the downcast. Remote PAR is attached as high on the rosette frame as possible with a protected but unobstructed surface view. The altimeter is mounted as low as possible so the acoustic signal is not impeded by the rosette frame.

2. Preparation & Deployment

Weather-permitting, the CTD and bottles are prepared for deployment 20 minutes prior to station arrival.
CTD-rosette preparations on CalCOFI cruises include:

Prep the electronics: removal of fresh-water rinse tubes attached to the pumps; removal of the PAR protective cap;removal of the pH sensor cap; RBS rinse (using a squirt bottle) the transmissometer lenses to eliminate surface film.

Prep the rosette bottles: 24-10 liter bottles are propped open by stretching the spring-loaded end caps back and securing their nylon lanyards to the proper carousel position. Bottle breathers & sample-drawing valves are checked for closure. Tag lines are attached to the rosette and once secured, the deck straps are removed. ISUS nitrate sensor battery deck charging cable is disconnected and set out of the way and the battery connected to the sensor.



Electronics warmup: after bottle prep, ~fifteen minutes prior to station arrival, the CTD deck unit is turned on, powering up the CTD electronics. Seabird has recommended at least a 10min warmup to improve SBE43 oxygen data at surface. After filling out the header form (see example), data aquisition is started. The ISUS nitrate sensors power cable is attached to the battery to allow several minutes warmup prior to deployment if not done after bottle prep.

Before deployment, the CTD's pressure reading on-deck is logged on the console ops form. This value is monitored at the beginning and end of the cast for shifts in the pressure baseline. It's median on-deck reading should be ~0. If the on-deck pressure become greater than +-0.3db, a corrective pressure sensor offset should be applied and documented in the CTD cast notes. It is important to wait several minutes after turning on the CTD deck unit before assessing the deck pressure.

Deploying the CTD-rosette:

The CTD-rosette is launched and held just below surface; enough wire is paid out so the bottle tops do not break surface when the ship rolls. SIO-CalCOFI uses high visibility yellow tape above the cable grip as a visual guide for the winch operator to adjust 0m.

The winch readout is zeroed and the CTD is sent to 10 meters for ~2 minutes to purge air from the system, allow the pumps to turn on (triggered by seawater contact; status is verified on the CTD computer screen). This gives the sensors a few minutes to stabilize and thermally equilibrate after sitting on-deck. (Please note that some CTD operators do not power-up the CTD system until the unit is in the water. This a a precaution recommended by some programs and UNOLS but not practiced by SIO-CalCOFI. Since 1990, SIO-CalCOFI has powered up the system on-deck then deployed and never had a problem.)

Communicating with the winch operator using intercom or radio, the CTD operator requests the CTD return to just below surface. **Data archiving is initialted** by selecting ***Real-Time Data/Start Archiving*** in Seasave (**IMPORTANT** if data archiving has not already started) and *Display*/*Erase All Plots* clears the surface & 10m soak noisy plots. Hold at surface for ~one minute to log data and verify T, C, & O2 sensor correctness & agreement between the primary and secondary pairs.

If everything looks good, the CTD is lowered to 515m, depth-permitting, at 30m/min for the first 100m then 60m/min to terminal depth.

If the bottom depth is less than 515m, the CTD is lowered to 10m above the bottom, according to the altimeter reading, not wire readout. After the wire settles and **if conditions permit**, the CTD depth may be adjusted to ~5m above the bottom if a standard level is attainable.

3. Data Acquistion & Seawater Collection

Our CTD data acquistion system is a Intel (ASUS) blade PC running Windows 7 64-bit and Seasave v7, Seabird's data acquisiton program. Calibration coefficients for each sensor are entered during CTD setup and termination before the first cast. Data are logged at 24hz to insure maximum resolution & flexibility in post-cast data processing; 24Hz data allow re-calculation of derived values using different post-cast or post-cruise coefficients. The SBE11 deck unit v1 auto-applies a 0.073ms offset to the primary conductivity only. The SBE11 deck unit v2, used since Jul 2009, auto-applies a 0.073ms offset to both primary & secondary conductivity sensors.

During the cast, Seasave's main plot window displays real-time temperature, salinity, oxygen, and fluorometry versus depth. Seasave has a 4 parameters-per-plot limitation so additional plots are used to display other sensor profiles. A fixed-data window lists real-time data in numeric form so T, C, & S values may be transcribed to the CTD console operations log prior to bottle closure.

1. When the CTD arrives to the target depth, time, wire out, depth, T, C, S, & alt (if near bottom) are written on the console ops form. This usually takes at least 20secs, the minimum mandated flushing time before closing a bottle.
2. In Seasave, the 'create marker' command is initiated followed by the 'fire bottle' command. When the bottle closure confirmation is received by the deck unit, the 'bottles fired' will increment by one. The CTD operator records the confirmation time on the bottle depth record, then checkmarks the bottle confirmation boxes.
3. When the first bottle has closed, the bottle-closure confirmation time, latitude, longitude, and bottom depth (from echo sounder), are recorded on the form's CTD-At-Depth sidebar. If a cruise event log is running, a CTD AT DEPTH event is

logged. A 500m CTD cast takes ~50mins so the GPS position & time recorded during the first bottle trip becomes the primary cast information for the bottle data.

4. The CTD-rosette is raised to the next target bottle depth at ~60m/min, conditons permitting. Console ops logging and bottle closure steps (1 & 2) are repeated until the CTD-rosette is back at surface and final bottle closed.
5. The CTD-rosette is recovered using taglines and once on deck, re-secured to the deck eyes with short lines or strap.
6. The deck pressure is recorded on the console ops form and data aquisition is halted.
7. SIO-CalCOFI-authored CTD backup program (CTDbackup.exe) is used to immediately zip all cast files and archive the zip file to other media. This program also generates an electronic sample log using the CTD AT DEPTH event plus .hdr & .mrk files to log seawater samples (see CESL: CalCOFI Electronic Sample Log).
8. The ISUS power cable is disconnected, PAR & pH sensors are capped.

4. Water Sampling

Seawater samples are drawn from the 10L rosette bottles once the CTD-rosette has been secured. Oxygen samples are drawn first, followed by DIC/pHs, salts, nutrients, chlorophylls (from depths 200m or less), and LTER's suite of samples. Please refer to the specific water sampling or analytical method for more information.

5. Quality Control

The CTD electronics and sensors are reliable and stable when properly serviced and maintained. CalCOFI has established some standard practices over time to keep the CTD functioning properly.

De-ionized or freshwater rinses: post-cast the plumbed-pumped sensors (2 pairs of T, C, O2, & pump) are flushed with de-ionized or Milli-Q water to minimize bio-fouling.

The carousel is hosed with fresh water to reduce mis-trips from bio-fouling or inorganic particulate buildup. A vinyl rosette cover is used when the CTD-rosette needs protection from contaminants or debris.

PAR and pH sensor (stored in buffer) are capped when on-deck.

Deck tests are performed before the first cast to derive transmissometer coefficients based on in-air and blocked light path voltage readings. A chlorophyll standard, finger or palm (yes - your finger or hand can be used max out the fluorometer, just avoid touching the optical surfaces) in front of the fluorometer optics can test the maximum response voltage. Deck tests are performed occasionally during the cruise to monitor transmissometer and fluorometer stability and response.

At-sea analyses of seawater samples allow bottle data to be compared to sensor data quickly, particularly salinities. When bottle salts are analyzed, the bottle salinity calculation is immediately compared to the CTD value and flagged if significantly different. This allows early detection of analytical equipment or CTD sensor malfunction. Oxygen, chlorophyll, and nutrients data comparisons are less immediate but when data look suspect, this ability helps identify real vs faulty measurements. Oxygen sample draw temperature (temperature of the seawater sample at the time the O2 sample is taken) is the first indicator of bottle mistrip. If the O2 draw temperature does not follow the trend indicated by the CTD temperture displayed on the sample log. The bottle may have closed at the wrong depth.

6. Equipment/Supplies

Conditions at sea can be rough and gear can break so CalCOFI prefers to have backups of all mission-critical components to conserve shiptime. Replacing defective gear often takes less time then troubleshooting or repairs. All sensors include their respective sensor-to-CTD interface cables plus spares.

1. 2 - Seabird SBE9*plus* CTDs with sensors; the primary package is inventoried in section 1; sensors without backups: ISUS nitrate sensor, pH sensor, deck unit remote depth readout
2. 2 - deck units: primary SBE11v2; backup SBE11v1
3. 2 - Windows 7 (ASUS blade) computers with 2 serial ports; deck unit, & GPS interface cables.
4. 2 - SBE32 carousels; plus spare trigger assemblies
5. Console operations forms plus clipboard
6. Timer, for 2 minute soak at surface
7. 2 - 24 place aluminum rosette frame
8. 2 - sets of 24 10L Niskin bottles; plus 4 spare bottles; multitude of spare parts
9. 2 - sets of 24 nylon lanyards for Niskin bottles
10. Termination toolkit and supplies - please refer to termination documentation for info on CalCOFI CTD wire termination techniques.
    a. butane soldering wand, solder, butane
    b. adhesive-lined shrink tubing: 1/8"
    c. Scotch 130 electrical splicing tape
    d. Scotch 33 electrical tape
    e. Scotch-kote electrical coating
11. Cable grips, stainless steel thimbles, and shackles to attached sea cable to the rosette
12. 3 - taglines with detachable hooks
13. 3 - 1m deck lines to secure the rosette on deck; straps
14. 4L Milli-Q filled carbuoy with hose for flushing the plumbed sensors post-cast
15. Hose, for freshwater rinse of carousel and other components post-cast
16. Stainless steel hose clamps: 100 - size 88 for mounting Niskin bottles to the rosette; misc others to mounted the CTD, ISUS, battery, and sensors to the frame.
17. ~~Turner Designs fluorometer standard for SCUFA (fits Seapoint fluorometer) for deck calibration;~~ Black rubber "card" for transmissometer deck test. Currently we using Wetlabs ECO-FI fluorometer which does not have an optical path that works

with the Turner Designs standard so fingers an inch away from the detector is used to max out the voltage. Seapoint flurometer is backup.

18. RBS or Micro in a squirt bottle for rinsing the transmissometer lenses before deployment. RBS or Micro are residue-free soaps in dilute Milli-Q solutions.
19. CTD cable servicing kit containing silicone grease; electrical contact cleaner; cotton swabs; Kim-wipes
20. 3 - Wetlabs 12v batteries, multi-battery charging station, on-deck weather-proof battery charging cable for ISUS nitrate sensor batteries.

7. Maintenance

CalCOFI sends all CTD electronics to their respective manufacturer for service and maintenance. The conductivity, and oxygen sensors are serviced & re-calibrated after use on **two consecutive cruises** (~150-200 deployments). SBE3plus temperature sensor calibration has changed to annually since the stability of these sensors is well documented. Routine Seabird carousel maintainance is performed by the CalCOFI-SIO Technical Group (CSTG). When repairs or five-year service are needed, the carousel is sent to Seabird. PAR sensors are serviced by Biospherical every three years.
General protocol is any sensor is returned for repair if the sensor fails or data quality diminishes. The SBE9+ CTD ('fish') is routinely serviced every five years. The aluminum-frame rosette is repaired or modified at SIO's Research Support Shop whenever necessary.

8. References

1. Sea-Bird Electronics, Inc, 2009. SBE 9plus Underwater Unit Users Manual, Version 012
2. Sea-Bird Electronics, Inc, 2009. SBE 11plus V2 Deck Unit Users Manual, Version 012
3. Sea-Bird Electronics, Inc, 1998. SBE 32 Carousel Water Sampler Operating and Maintenance Manual